BALTIMORE CITY PROJECT 658
COMPREHENSIVE PLAN FOR WATER FACILITIES

CENTRAL SYSTEM REPORT

TABLE OF CONTENTS

BALTIMORE CITY PROJECT 658
COMPREHENSIVE PLAN FOR WATER FACILITIES

CENTRAL SYSTEM REPORT

TABLE OF CONTENTS

BALTIMORE CITY PROJECT 658
COMPREHENSIVE PLAN FOR WATER FACILITIES

CENTRAL SYSTEM REPORT

TABLE OF CONTENTS

BALTIMORE CITY PROJECT 658
COMPREHENSIVE PLAN FOR WATER FACILITIES

CENTRAL SYSTEM REPORT

TABLE OF CONTENTS

BALTIMORE CITY PROJECT 658
COMPREHENSIVE PLAN FOR WATER FACILITIES

CENTRAL SYSTEM REPORT

TABLE OF CONTENTS

BALTIMORE CITY PROJECT 658
COMPREHENSIVE PLAN FOR WATER FACILITIES

CENTRAL SYSTEM REPORT

TABLE OF CONTENTS

BALTIMORE CITY PROJECT 658
COMPREHENSIVE PLAN FOR WATER FACILITIES

CENTRAL SYSTEM REPORT

TABLE OF CONTENTS

BALTIMORE CITY PROJECT 658
COMPREHENSIVE PLAN FOR WATER FACILITIES

CENTRAL SYSTEM REPORT

TABLE OF CONTENTS

BALTIMORE CITY PROJECT 658
COMPREHENSIVE PLAN FOR WATER FACILITIES

CENTRAL SYSTEM REPORT

TABLE OF CONTENTS

BALTIMORE CITY PROJECT 658
COMPREHENSIVE PLAN FOR WATER FACILITIES

CENTRAL SYSTEM REPORT

TABLE OF CONTENTS

BALTIMORE CITY PROJECT 658
COMPREHENSIVE PLAN FOR WATER FACILITIES

CENTRAL SYSTEM REPORT

TABLE OF CONTENTS

BALTIMORE CITY PROJECT 658
COMPREHENSIVE PLAN FOR WATER FACILITIES

CENTRAL SYSTEM REPORT

TABLE OF CONTENTS

APPENDIX

EXECUTIVE SUMMARY

A. Background

The City of Baltimore Project No. 658, the Comprehensive Plan for Water Facilities, was conducted to evaluate the City's entire water system and develop a comprehensive strategy to guide future operations and facility improvements. The overall scope of this project was to conduct a detailed study of all City owned or operated water facilities from source to tap. The investigation was completed with the objective of maximizing water quality throughout the system and maintaining compliance with requirements of the Safe Drinking Water Act.

The City's Comprehensive Plan was completed in two phases. The focus of Phase I was to evaluate each system component and identify both short-term and long-term improvement recommendations that will ensure safe and reliable water supplies through the planning year of 2025. The goal of Phase II of the Comprehensive Plan was the development of a master plan for the entire Baltimore water system, referred to as the Central System.

The major component of the Phase II study was the development of the *Central System Report* and hydraulic model to identify the capital and operational improvements necessary to meet future demand conditions through the planning year 2025. This section provides a summary of those recommendations useful in the development of future Capital Improvement Programs (CIP), as well as system-wide recommendations which will enhance the City's distribution system.

The largest and probably most influential project needed in the Central System is the Fullerton Treatment Plant. It is imperative that the City begin the preparatory stages of developing this project as the plant needs to be in service no later than the year 2015. In addition, there are many pending regulations. One example is the Long Term 2 Enhanced Surface Water Treatment Rule (LT2ESWTR) which could have the largest financial impact on the City. The City should be evaluating covering or replacing the open finished water reservoirs because the LT2ESWTR could require the City to either cover or provide treatment for their open reservoirs if water quality standards cannot be met. Recent current events will also have their fair share of impact on the City. Emergency planning, drought mitigation, raw water management strategy and security are all a top priority considering recent events such as September 11th and the 2002 drought. Lastly, additional basic modifications to the system could have immense benefits and will allow the City to use the existing system more efficiently. Those modifications include: revising operational procedures such as pump controls, rehabilitation projects such as lining old transmission mains and increasing reliability of pumping stations such as providing redundant power sources.

B. Long Range Recommendations by Year

A summary list of the current CIP and other recommended projects discussed in the *Central System Report* is presented in Table 1. The total estimated construction cost for these 38 improvement projects is over $300 million, of which approximately $160 million is not currently included in the City's CIP. This project list does not include many of the short-term and system-wide improvement projects recommended in the *Central System Report*. Those recommendations are presented in Section C and should also be incorporated in the City's CIP. Costs for these projects will depend on when they are implemented and which options are chosen.

The projects listed in Table 1 are listed by zone. The descriptions below present the proposed improvement projects by year.

1. Year 2005

Two thirds of the recommended and previously proposed projects listed in Table 1 should be completed by the year 2005. Several projects are already under construction and they include the Owings Mills Reservoir in the Pikesville Fourth Zone and the Hillen/Ashburton By-Pass Main located in the Second Zone. The Owings Mills Reservoir should be in service by June 2003.

There are also many projects currently under design which should be completed by 2005. The Montebello Filtration Plant Improvements and Fullerton Reservoir designs are currently almost complete. It is important to note that the Montebello Filtration Plants project is needed to meet growing demands. Until this project is constructed, the City may need to implement higher filtration rates to meet future maximum day demands. The design for the Belair Road Main from Whitemarsh to Joppa is also well underway. In addition, two Catonsville Transmission Mains are under design and two Rolling Road Transmission Mains are also under design. Baltimore County is designing a fourth pump at the Catonsville Pumping Station in-house and a third pump is under design at the Falls Fifth Pumping Station.

In addition, there are several projects currently on the CIP list that have not begun construction, but are planned to be in service by 2005. They include: the Leakin Park Pumping Station upgrades for which design will begin soon, the Putty Hill Main to Towson Reservoir, the Chapel Hill Tank, the Bond Avenue Tank, and upgrades to the Deer Creek Pumping Station which will also be under design soon. Several other projects have been proposed but are not in the CIP list yet and should be added. They include: the Honeygo Boulevard Main Extension, the Perry Hall Road Main, and the Belair Road Main. As a result of the hydraulic analysis performed during this project, additional mains are being recommended in the Pot Springs Fifth Zone in Hartfell and Killoran Road. Although those mains are not required for hydraulic capacity or fire flows, they should still be added to the City's future CIP as a lower priority project.

2. *Year 2010*

Only one project is recommended to be completed between 2005 and 2010. That project is a proposed transmission main in Pulaski highway in the First Zone.

3. *Year 2015*

Several major improvement projects are recommended for the time period between 2010 and 2015. The biggest project will be the proposed Fullerton Treatment Plant in the First Zone which is recommended to be in service by 2015. Funding for this project needs to be in place now for the design of the treatment plant. The initial capacity of this plant should be 120 mgd, with expansion capabilities built in for the future. In addition, upgrades to the Deer Creek raw water pumping station, which are scheduled for 2005, must be completed before the Fullerton Treatment Plant is operational.

The Reisterstown Fifth Zone will also require substantial improvements by 2015, including the Pleasant Hill Pumping Stations which should be upgraded, along with improvements to the associated piping. A new discharge main will be needed to supply ample flows to this zone.

4. *Year 2020*

Only one project, a transmission main in Marriottsville Road, is recommended for the time period between 2015 and 2020. This project is a result of the hydraulic analysis performed during this project for the Pikesville Fourth Zone. This main is needed to improve flow distribution between the existing Deer Creek Tank and the future Owings Mills Reservoir.

5. *Year 2025*

There is only one project proposed for 2025. This project is another transmission main located in the Second Zone in Perry Hall and Philadelphia Roads.

C. System-Wide and Short-Term Recommendations

Several system-wide recommendations proposed in the *Central System Report* relate to the overall operation of the Central System or relate to large areas of the system and not a specific zone. For most of these recommendations, no time requirement is associated with them; however they are items that should be completed in the near future. A few of the recommendations presented below are considered critical and should be completed in the short-term future.

1. *Rehabilitate Older Transmission Mains*

For zones with high head losses and/or low fire flow availability, immediate action should be taken to improve the system. Water mains can be rehabilitated by lining or other means. Lining water mains will decrease head losses and improve the fire flow availability. The City and Baltimore County have already taken an active role to rehabilitate water mains in the Central System, but more rehabilitation still needs to be done. Recommended locations for rehabilitation are presented in both Section IV and Section X of the *Central System Report*.

2. *Construct Additional Transmission/Discharge Mains*

Additional water mains should be constructed for those areas where lining will not result in significant improvement, especially in fire flow availability, or mains have already been lined. The following table presents the zones and locations where additional transmission capacity is required to improve fire flows immediately. These mains are also included in Table 1.

Table 2, Transmission Mains Required for Fire Flow Improvements

Zone	Location	Size	Length
Second	Yale Avenue	16"	1,000 LF
Second	Elm Tree Street	12"	1,000 LF
Colgate 2nd	47th Street	12"	1,400 LF
Western 3rd	Old Pimlico Road	16"	4,000 LF
Western 3rd	Liberty Road	12"	2,000 LF
Catonsville 4th	Clays Road	12"	1,600 LF
Towson 4th	Near Mays Chapel Reservoir 36" Discharge	12"	100 LF
Towson 4th	Timonium Road	12"	900 LF

The City should also evaluate constructing dual discharge mains at several pumping stations to increase the reliability of the system in the event of an emergency. Several major pumping stations, including Leakin Park and Catonsville Pumping

Stations, do not have dual discharge mains. In addition, all five fifth zones are supplied solely by pumping stations with solitary discharge mains. Constructing a second discharge main would reduce the risks associated with emergency situations if a discharge main were to break.

3. *Modify Pump Controls*

Several zones, especially the upper zones, would benefit from pump control modifications. They include the Second Zone, Falls Fifth Zone, Sherwood Fifth Zone and Sparks Fifth Zone. The existing and recommended pump controls for those zones requiring improvements are illustrated in Table 3 below. Although the City currently operates the Fullerton Pumping Station in a manual mode, it is recommended that this station be switched to an automatic mode to improve the system in the eastern portion of the zone.

4. *Storage Recommendations*

The distribution system storage evaluation resulted in several recommendations to improve the existing storage and supply capacity in the Central System. Some of these recommendations are included in Table 1 and the City's current CIP. However, several recommendations, such as covering reservoirs and increasing reliability of pumping stations, are not included in the table above. Therefore, they are presented in Table 4 below, along with the other storage recommendations presented previously.

Possibly the most important storage recommendation involves the open finished water reservoirs. With the proposed LT2ESWTR legislation, the City may be forced to cover these reservoirs if not in compliance with water quality standards, which could be costly. The City should begin to implement a program to evaluate whether replacing or covering the remaining uncovered reservoirs will be required and the cost benefit of the alternatives. This could be performed either through one joint project or as separate projects for each reservoir. Certain reservoirs may need elaborate investigations performed, such as Guilford Reservoir due to possible elevation adjustments, therefore, separate projects may be more beneficial. The design to replace the uncovered Pikesville Reservoir is already underway.

Table 3, Pump Control Modifications

Pumping Station	Zone Supplied	Pump ID	Control Node or Tank	On Elevation or Pressure	Off Elevation or Pressure
Existing Pump Controls					
Fullerton	Second	A	Controlled Manually		
		B	Controlled Manually		
		C	Controlled Manually		
		D	Standby – typically off		
Falls	Fifth	A	Falls	745 ft	748 ft
		B	Falls	743 ft	746 ft
		C (future)	Falls	Standby – typically off	
Sherwood	Fifth	A	Sherwood	695 ft	698 ft
		B	Sherwood	692 ft	695 ft
Sparks	Fifth	A	Sparks	641 ft	645 ft
		B	Sparks	638 ft	643 ft
		C	Sparks	Standby – typically off	
Recommended Pump Control Modifications					
Fullerton	Second	A	Perry Hall	340	346
		B	Perry Hall	342	348
		C	Perry Hall	Standby – typically off	
		D	Perry Hall	338	344
Falls	Fifth	A	Falls	740 ft	748 ft
		B	Falls	738 ft	746 ft
		C (future)	Falls	Standby – typically off	
Sherwood	Fifth	A	Sherwood	694 ft	700 ft
		B	Sherwood	692 ft	698 ft
Sparks	Fifth	A	Sparks	643 ft	647 ft
		B	Sparks	645 ft	649 ft
		C	Sparks	Standby – typically off	

Table 4, Storage Recommendations

Zone	Recommendation
First	• Cover or replace Druid Lake • Cover or replace Montebello Plant 2 Reservoir
Second	• Cover or replace Lake Ashburton • Cover or replace Guilford Reservoir and raise walls to increase overflow elevation to match other facilities in zone and modify present operating control valve to operate in a throttle mode rather than open/closed
Colgate Second	• Construct additional 170,000 gallons of elevated storage OR Expand Colgate Pumping Station and related piping and increase reliability of station by providing on-site standby generators or redundant power feeders (emergency generator connections being added)
Eastern Third	• Cover or replace Towson Reservoir
Western Third	• Cover or replace Pikesville Reservoir (currently under design) • Construct additional 600,000 gallons of storage OR Increase reliability of both pumping station by providing on-site standby generators or redundant power feeders
Catonsville Fourth	• Increase reliability of Catonsville Pumping Station by providing permanent on-site standby generators or redundant power feeders (mobile generator currently on site)
Pikesville Fourth	• Increase reliability of Pikesville Pumping Station 1 and 2 by providing on-site standby generators or redundant power feeders
Towson Fourth	• None at this time
Falls Fifth	• By 2015, construct additional 150,000 gallons of storage OR Increase reliability of station by providing on-site standby generators (currently under design)
Pot Springs Fifth	• None at this time
Reisterstown Fifth	• By 2005, construct proposed Bond Avenue Tank with 2.0 million gallons of storage
Sherwood Fifth	• Increase reliability of Sherwood Pumping Station by providing on-site standby generators or redundant power feeders (emergency generator connections available)
Sparks Fifth	• None at this time

5. *Operational Efficiency Improvements*

The operation of the Central System should be modified to improve the efficiency and increase the energy cost savings. Several operational recommendations in the *Central System Report* include maximizing gravity flow versus pumped flow in the Second Zone, utilizing newer stations over older less-efficient stations, investigating if alternate energy consumption reduction programs through BGE would be beneficial to the City and modifying existing pump controls as described previously.

6. *Establish System Service Boundary*

The current system boundary is often in question. Currently, Baltimore County is using the Urban-Rural Demarcation Line (URDL) as the ultimate boundary of the Central System. The City should support and enforce this decision. This boundary has been violated in several areas in the past due to special circumstances.

7. *Raw Water Management Strategy*

The proper operating schedule for the Deer Creek Pumping Station is important when it comes to drought management. Two operating schedules are presented in this report which address projected future average monthly water demands during drought conditions before and after the construction of the proposed Fullerton Treatment Plant.

In non-drought conditions for the pre-Fullerton scenario, the operating schedule maximizes water storage at the Liberty, Prettyboy and Loch Raven Reservoirs so that raw water supplies are maintained during drought conditions. Pumping at Deer Creek Pumping Station should be initiated early before the reservoirs begin to drop significantly. The Susquehanna River should be utilized as much as possible as long as trigger restrictions are not in effect.

For the second scenario, operating schedules were developed to maximize efficiency of the raw water supply system once the Fullerton Treatment Plant begins operation. At least one pump at the Deer Creek Pumping Station will be running at all times. As found in the other scenario, the Susquehanna River should be utilized as much as possible.

8. Revise Water Quality Sampling Locations

Water quality sampling for chlorine residual is currently performed at 120 sites on a weekly basis. However, with the proposed Stage 2 DBP Rule, the existing sampling locations will probably need to be revised. These new sampling locations should be in compliance with the proposed legislation. In addition, two zones, Falls Fifth and Sparks Fifth Zones, presently have no sampling sites and at least one site should be established in each zone.

The model results shows that areas around several of the storage facilities have high residence times and could have a low chlorine residual. Most of these facilities do not currently have rechlorination stations; therefore the following facilities should be investigated to determine if there is a need for a rechlorination station:

- Curtis Bay Tank (First Zone)
- Melvin Tank (Western Third)
- Cub Hill Tank (Towson Fourth)
- Reisterstown Tank (Reisterstown 5th)
- Perry Hall Tank (Second Zone)
- Deer Park Tank (Pikesville Fourth)
- Chartley Tank (Reisterstown Fifth)

Table 1, Recommended Central System Improvement Projects

Zone	Project Description	Already in CIP	Year Needed	Size/ Capacity	Approx. Length (LF)	Estimated Cost	Status (if applicable)	General Notes
1	Montebello WTP	Yes	2005	318 MGD		$88,000,000	currently under design (RK&K)	
1	Fullerton Reservoir	Yes	2005	40 MG	n/a	$18,600,000	currently under design (Gannett Fleming)	
1	Fullerton WTP		2015	120 MGD	n/a	$130,000,000		WAO recommendation, 2010 by WAO
1	Pulaski Highway Main		2010	16"/20"/24"/36"	4,000/2,500/3,800/6,200	$3,600,000		WAO recommendation
1	Ebenezer Road		2025	12"	8,500	$1,500,000		WAO recommendation
2	Chapel Hill Tank	Yes	2005	2.0 MG	n/a	$1,800,000	currently under design (WRA)	
2	Hillen/Ashburton By-Pass Main	Yes	2005	64"	3,400	$5,500,000	design almost complete (WRA)	
2	Honeygo Boulevard Main Extension		2005	16"/20"	3,300/4,600	$820,000	20 inch main has been installed	Chapel Hill Tank area, WAO recommendation
2	Gerst Main (north of Chapel Hill Tank)		2005	12"	3,400	$300,000		WAO recommendation
2	Perry Hall & Philadelphia Road Main		2025	24"/30"	15,600/9,000	$9,000,000		WAO recommendation
2	Yale Avenue Main		2005	16"	1,000	$200,000		improves fire flows
2	Elmtree Street Main		2005	12"	1,000	$100,000		improves fire flows
2C	47th Street Main		2005	12"	1,400	$140,000		improves fire flows
3W	Leakin Park Pumping Station		2005	80 MGD	n/a	$3,750,000	currently under negotiations (RK&K)	adding 2 pumps (20 MGD each), WAO recomm.
3W	Catonsville Main (LP PS to Rt. 40)	Yes	2005	48"	8,300	$5,000,000	currently under design (PHRA)	
3W	Catonsville Main (parallel to Rt. 40)	Yes	2005	42"	10,200	$4,900,000	currently under design (WRA)	
3W	Rolling Road Transmission	Yes	2005	16"	11,000	$1,180,000	currently under design (Wallace Montg.)	
3W	Liberty Road Main		2005	12"	2,000	$200,000		improves fire flows
3W	Old Pimlico Road Main		2005	16"	4,000	$530,000		improves fire flows
3E	Belair Road Main (W.Marsh to Joppa)	Yes	2005	24"	8,800	$3,000,000	currently under design (RK&K)	
3E	Putty Hill Main (to Towson Reservoir)	Yes	2005	24"	8,400	$1,700,000	currently under design (in-house)	
3E	Perry Hall Road Main to Belair Road		2005	42"	17,150	$6,500,000		WAO recommendation
3E	Belair Road Main (to Northern Parkway)	Yes	2005	24"	5,150	$1,100,000	currently under negotiations (WRA)	
4C	Catonsville Pumping Station	Yes	2005	20 MGD	n/a	$500,000	design almost complete (in-house)	adding 4th pump (11 MGD)
4C	Catonsville Reservoir		n/a	n/a	n/a	-		not required before 2025, WAO recommendation
4C	Rolling Road Tank Transmission	Yes	2005	24"	7,800	$1,450,000	currently under design (PHRA)	
4C	Lord Baltimore Extension Main		2025	12"	5,600	$1,000,000		WAO recommendation, not req'd but helps system
4C	Clays Road Main		2005	12"	1,600	$160,000		improves fire flows and pressures
4P	Owings Mills Reservoir	Yes	2005	5.6 MG	n/a	$3,000,000	under constr.(Chicago Bridge and Iron)	
4P	Marriottsville Road Main		2020	24"	3,500	$900,000		Lyons Mill Rd and Liberty Rd
4T	New Connection at Rutledge Road		2005	12"	100	$10,000		with Mays Chapel Discharge, improves fire flows
4T	Timonium Road Main		2005	12"	900	$90,000		improves fire flows
5F	Falls Pumping Station	Yes	2005	5.3 MGD	n/a	$615,000	currently under design (RK&K)	adding 3rd pump (2.7 MGD)
5P	Hartfell and Killoran Road Parallel Mains		2005	16"	3,300	$400,000		not required, reduces high headloss near PS
5R	Bond Avenue Tank		2005	2 MG	n/a	$1,800,000		WAO recommendation
5R	Pleasant Hill Pumping Station 1		2015	13 MGD	n/a	$1,000,000		replacing 2 pumps (4.3 MGD each)+assoc. piping
5R	Reisterstown and Pleasant Hill Rd. Main		2015	16"	4,300	$600,000		addt'l transmission main required w/PS upgrade
RAW	Deer Creek Pumping Station	Yes	2015	200 MGD	n/a	$4,000,000	currently under negotiations (PHRA)	renovate intake, add two pumps (50 MGD each)

NOTE: General Notes column lists reason for project, all projects recommended by RK&K, 'WAO recommendation' means project previously recommended by the Water Analyzer Office (WAO) but has not been included in CIP yet; costs include escalation 3.2% per year

I. INTRODUCTION

A. Project Background

The City of Baltimore Project No. 658, the Comprehensive Plan for Water Facilities, was conducted to evaluate the City's entire water system and develop a comprehensive strategy to guide future operations and facility improvements. The overall scope of this project was to conduct a detailed study of all City owned or operated water facilities from source to tap. The investigation was completed with the objective of maximizing water quality throughout the system and maintaining compliance with requirements of the Safe Drinking Water Act.

The City's Comprehensive Plan was completed in two phases. The focus of Phase I was to evaluate each system component and identify both short-term and long-term improvement recommendations that will ensure safe and reliable water supplies through the planning year of 2025. The findings and recommendations developed in Phase I of the Comprehensive Plan for Water Facilities can be found in the following reports:

Volume 1 – Modernization Report
Volume 2 – Regulatory Compliance Report
Volume 3 – Water Treatment Facilities Baseline Evaluation Report
Volume 4 – Computerization Report
Volume 5 – Water Treatment Facilities Operations Assessment Report
Volume 6 – Plant-Scale Testing Report
Volume 7 – Pilot Testing Report
Volume 8 – Watershed and Raw Water Reservoir Assessment Report
Volume 9 – Finished Water Facilities Assessment Report

This report presents the findings of Phase II of the Comprehensive Plan. The goals of Phase II of the Comprehensive Plan was the development of a master plan for the entire Baltimore water system, referred to as the Central System.

The major component of the Phase II study was the development of a Baltimore Central System Report to identify the capital and operational improvements necessary to meet future demand conditions through the planning year 2025. To assist in this effort, a computer hydraulic model was developed to simulate operation of the entire water system so that hydraulic and water quality deficiencies under anticipated future conditions could be identified and possible improvements to remedy those deficiencies could be determined.

The hydraulic modeling software WaterCAD, by Haestad Methods, was used to develop the water distribution system model and perform the system evaluations. The following tasks were performed:

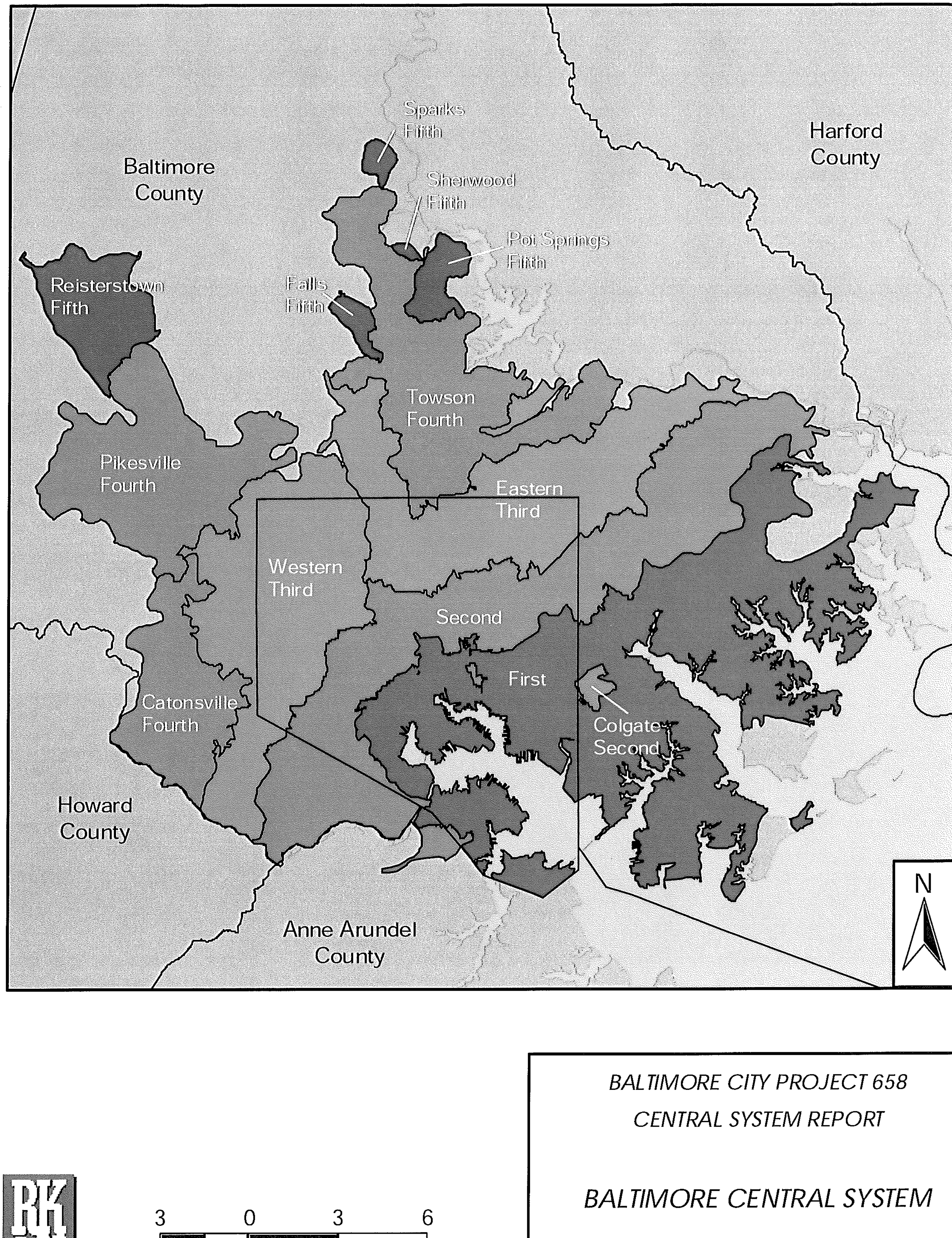
- Projected population and demands
- Researched jurisdictional agreements
- Evaluated the system's existing storage capacity
- Developed storage requirements
- Studied raw water operations
- Established model performance criteria
- Examined water quality parameters
- Evaluated operational efficiency

As a result, future trends and system modifications necessary to meet evolving conditions were predicted and identified.

B. Description of Central System

The Baltimore Water System, also known as the Central System, consists of 4,100 miles of distribution pipe that spans over 291 square miles and serves approximately 1,800,000 people. In the year 2000, the system supplied an average of 241 million gallons per day (mgd) of safe drinking water to four political jurisdictions. The jurisdictions include Baltimore City, Baltimore County, Anne Arundel County and Howard County. Baltimore City also supplies raw water to Harford County and Carroll County. The Central System is divided into 13 pressure zones and is currently supplied by 3 treatment plants, 3 raw water reservoirs, 28 storage facilities and 23 finished water pumping stations. Current zonal boundaries are illustrated in Figure I-1.

Under normal conditions, two rivers supply the three raw water reservoirs. The Prettyboy Reservoir and Lock Raven Reservoir receive water from the Gunpowder Falls and provide raw water for Montebello Filtration Plants 1 and 2 which currently have a combined rated capacity of 240 mgd.



BALTIMORE CITY PROJECT 658

CENTRAL SYSTEM REPORT

BALTIMORE CENTRAL SYSTEM

MARCH, 2003

FIGURE I-1

Baltimore City Water Contract 1111 is currently underway to expand these plants to have a combined maximum treatment capacity of 318 mgd. The Liberty Reservoir receives water from the North Branch of the Patapsco River and provides raw water to the Ashburton Filtration Plant which has a rated maximum capacity of 165 mgd. A third river source, the Susquehanna River, is currently only used in cases of extreme drought as a supplemental source to the Montebello Plants. In the future the Susquehanna supply will be the source for the proposed Fullerton Treatment Plant. Today, the three existing plants have a raw water treatment capacity of 405 mgd of water, which will be expanded to 483 mgd upon the completion of Project 1111.

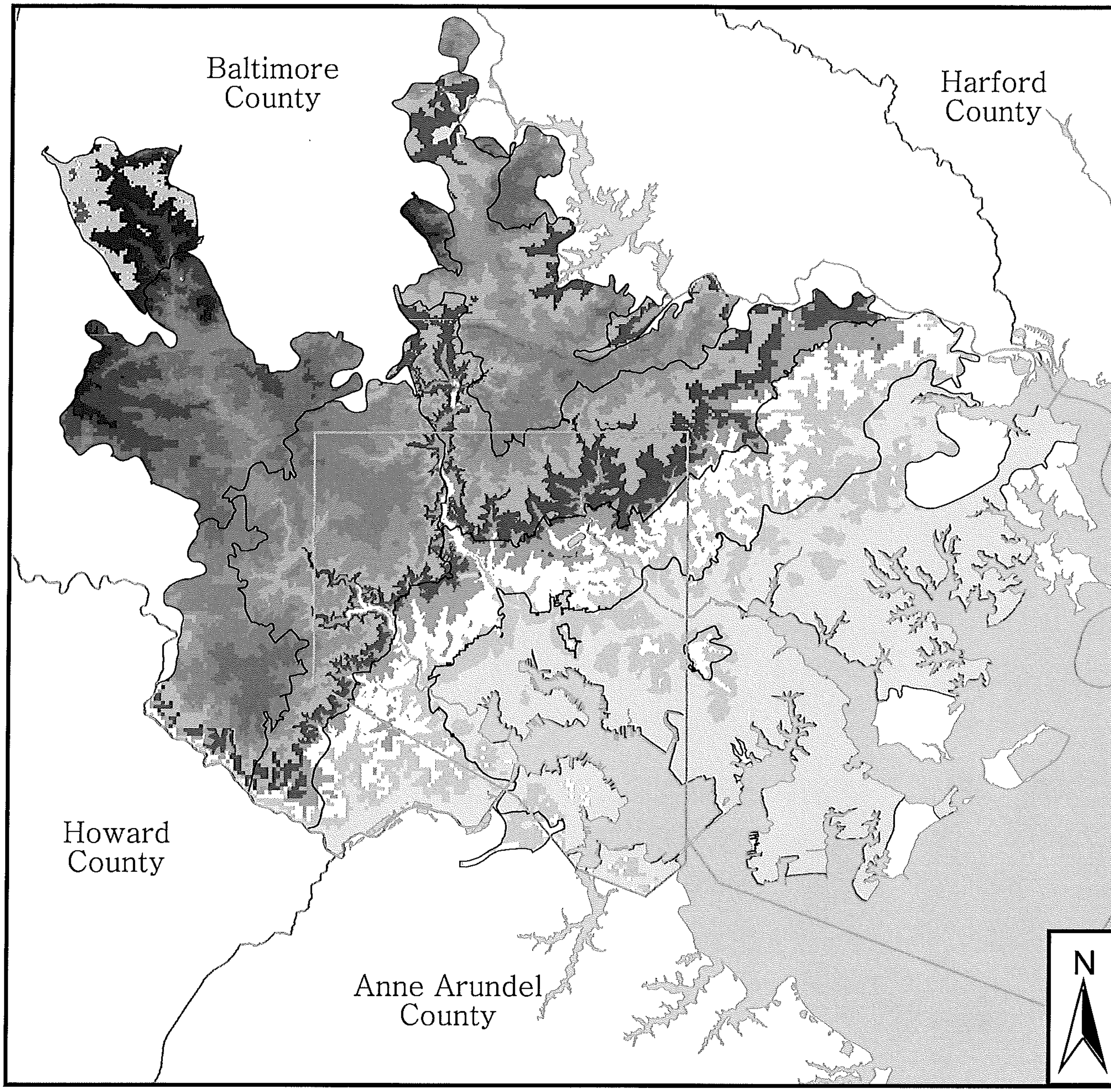
The service area of the Central System is generally limited to the boundary set by Baltimore County called the Urban-Rural Demarcation Line (URDL). Currently the service has extended beyond the line in a few areas, but within the URDL there is still 11.5 square miles of unserviced area. For future demands, it is assumed that by 2025 all available land within the URDL will be serviced.

Ground elevations within the Central System range from sea level in the First Zone to 752 feet in the Reisterstown Fifth Zone. The ranges of ground elevations supplied by the Central System are shown on Figure I-2. The unique topography allows the First Zone and a major portion of the Second Zone, or roughly half of the total water supplied, to be supplied by gravity. The upper zones are all supplied by pumping from a lower zone. Currently, there are a few active pressure regulating valves (PRVs) in the system. A schematic of the Central System pumping stations and treatment plants and the zones they supply is shown in Figure I-3.

The year 2000 consumer base of the Central System consists of approximately 11 percent industrial, 38 percent commercial, public and wholesale and approximately 51 percent residential. A large majority of the industrial users are located in the First Zone, whereas the upper fifth zones are mostly residential. The intermediate zones have varying proportions of commercial and residential users.

C. History of the Baltimore Central System

Records indicate that the first attempt to establish public water supply in Baltimore was made in 1787 when the Maryland Legislative Assembly authorized the Baltimore Insurance Company to supply the City with water. This effort, along with subsequent other early efforts failed, however.



2 0 2 4 6

Miles

	0 - 60		421 - 480
	61 - 120		481 - 540
	121 - 180		541 - 600
	181 - 240		601 - 660
	241 - 300		661 - 720
	301 - 360		721 - 760
	361 - 420		Feet Above Sea Level

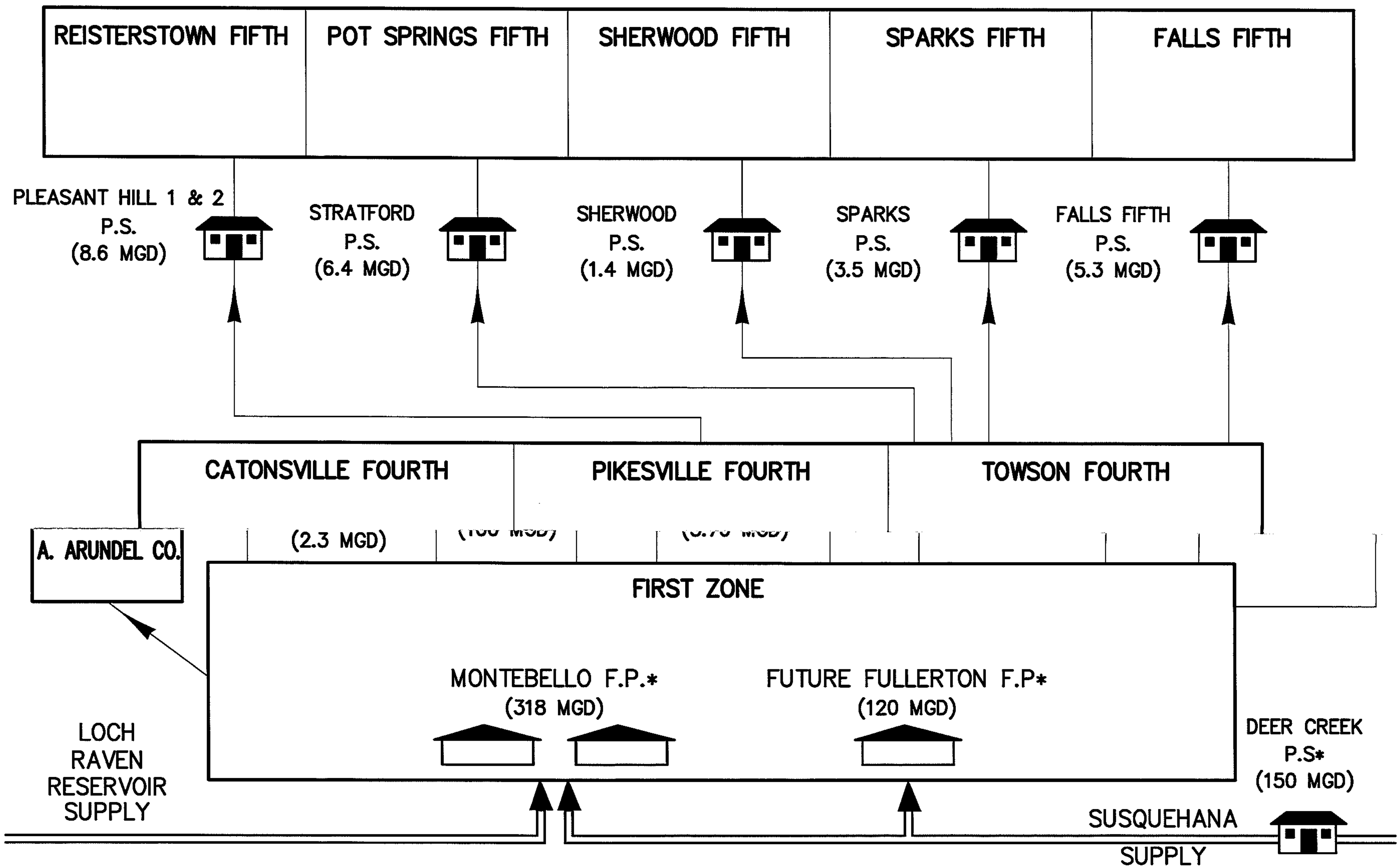
BALTIMORE CITY PROJECT 658

CENTRAL SYSTEM REPORT

GROUND ELEVATIONS SUPPLIED BY CENTRAL SYSTEM

MARCH, 2003

FIGURE I-2



NOTES:

1. Values In Parenthesis Represent Current Nominal Capacity Of Facility.
2. Montebello F. P. Reflects Working Capacity After Completion Of Contract 1111.
3. The Temporary Pumping Stations Are Currently Out Of Service.
4. * Denotes a Raw Water Facility.

RK&K

BALTIMORE CITY PROJECT 658

CENTRAL SYSTEM REPORT

SUPPLY SCHEMATIC OF CENTRAL SYSTEM

MARCH, 2003

FIGURE I – 3

PROJECTS:/CM9638/PHASEII/PSDATA/ SCHEMATC.DWG
07/12/2002 .DWG 11:08 ENV .PC

After incorporation in 1797, the City began to erect and maintain pumps in designated public thoroughfares. In the early eighteen hundreds, a stock company known as the Baltimore Water Company was formed, land and water privileges were acquired and a reservoir was constructed to receive water from the Jones Falls. After much study and debate, improvements were made to the Jones Falls supply in 1862 including the construction of Lake Roland Dam and Reservoir and the Jones Falls conduit. Druid Hill Reservoir was constructed in 1873 to provide high service water supplies. As demand increased coupled with recurring droughts, additional water supplies were sought by the City. Construction of a permanent supply from the Gunpowder Falls was completed in 1881. Completed works consisted of the construction of a dam across Gunpowder Falls, formation of Loch Raven Reservoir, construction of a tunnel connecting the reservoir with Lake Montebello, and construction of a conduit connecting Lake Montebello to Lake Clifton. Due to public health concerns, chlorination of the water supply was instituted in 1910 followed by construction of a water filtration plant at the Montebello site.

Montebello Filtration Plant 1, situated on the east side of Hillen Road, was placed into operation in 1915 after a two-year construction period. Construction of Loch Raven Dam was also completed in 1915 with the spillway crest extended to its present elevation in 1923. Annexation of additional land by the City in 1918 spurred the construction of Montebello Filtration Plant 2 which was placed into operation in 1928. Other major construction projects occurring the first half of this century included construction of the Montebello-Druid Lake conduit and Prettyboy Dam in 1932, construction of the Gunpowder-Montebello Tunnel in 1941 and construction of the Patapsco-Montebello tunnel in 1950. In 1956 Liberty Dam was constructed.

The Ashburton Filtration Plant is located on Druid Park Drive near Druid Hill Park in Baltimore City. This facility along with Liberty Dam and Reservoir was completed in 1956. Since that time, there have been no new major modifications in the basic unit processes at this facility. Modifications were made to the filter underdrains, fluoride and chlorination system and additional media was added in 1970. However, the facility is presently being upgraded to improve the sedimentation basins and filters.

Additional major projects completed in the last half of this century include several upgrades to the Montebello Plants and construction of the Deer Creek Pumping Station in 1966. Construction of this pumping station allowed the City to withdrawal raw water from the Susquehanna River. Since 1970, the Montebello Filtration Plants have undergone extensive improvements and repairs (Phases

I – V). Phase I consisted of improvements to the chemical, filter and washwater buildings at Plant 1 along with the construction of a lime tower and a grounds maintenance facility. Phase II work included improvements to the Plant 2 chemical building in addition to extensive sitework. Phase III work involved both Plants 1 and 2 and included rehabilitation of the 20.9 and 16 million gallon finished water reservoirs, improvements to the flocculators, sand filters, heating and ventilation systems, and replacement of roofs and windows. Phase IV work involved the replacement of the existing sedimentation basins at Plant 2 along with the construction of new fluoride storage facilities, new chemical feed systems, and a new raw water venturi meter. Recently completed, Phase V work included the construction of four new flocculators and sedimentation basins at Plant 1, replacement of grounds maintenance buildings, replacement of washwater pumps, relocation of a 13.8 KV conduit, and improvements to the telephone and telemetering conduit system as well as extensive site improvements. Other work performed at the Montebello Plants includes the installation of new fluoride and chemical feed systems. Also, as mentioned previously, design of improvements to the filters and chemical feed systems is currently underway. In addition, improvements to the low lift pumping stations are currently under design.

A fourth proposed treatment plant, the Fullerton Plant, is planned to be constructed in the next couple decades. This plant will treat raw water from the Susquehanna River on a full time basis. Currently, the design has begun for the proposed Fullerton Reservoir on the future Fullerton site.

II. WATER DEMANDS

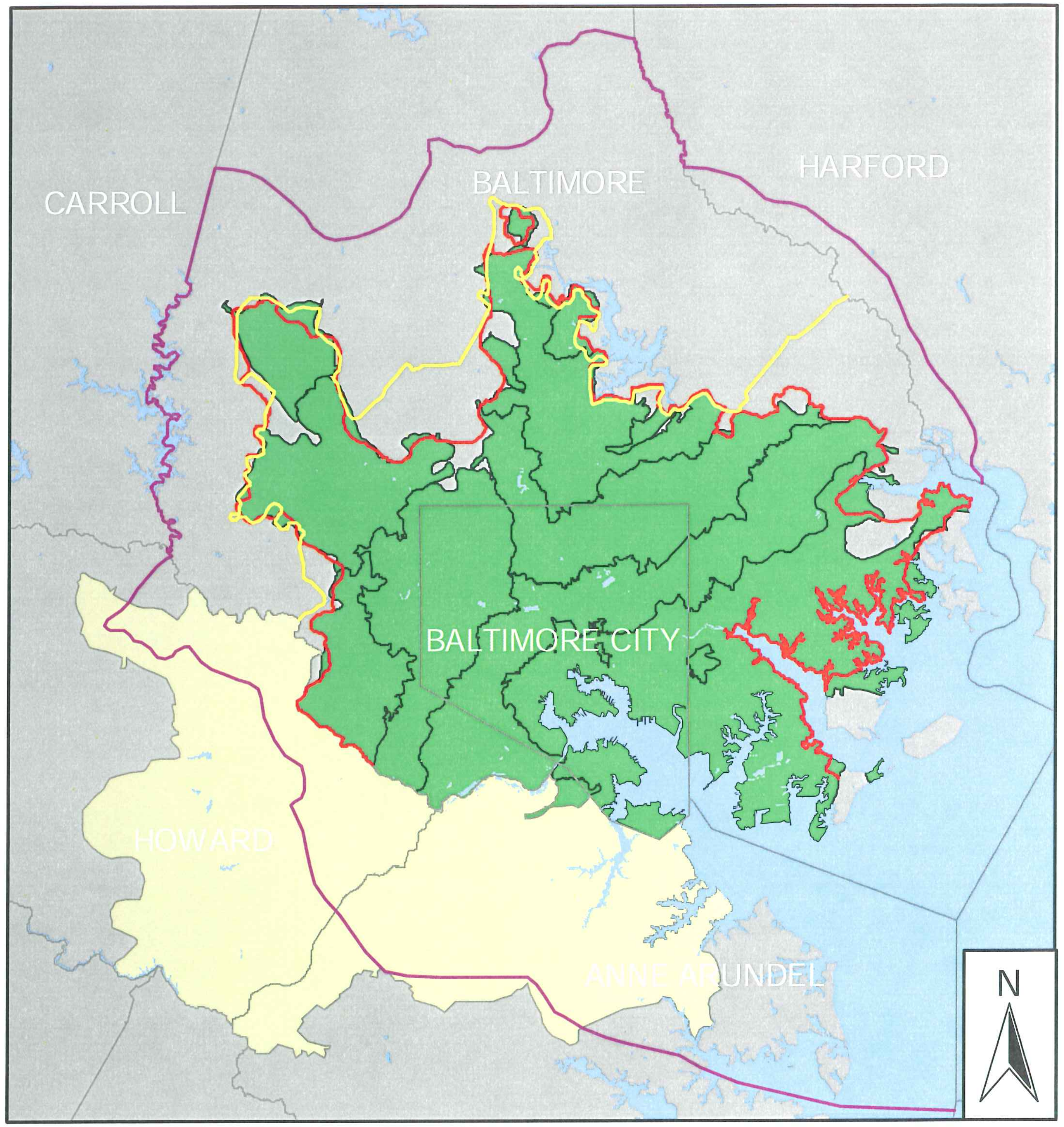
A. Service Area

The present service area comprising the Central System is divided into thirteen pressure zones and encompasses all of the jurisdictional area of Baltimore City and a major portion of Baltimore County. The political jurisdictions of Anne Arundel County and Howard County are also supplied drinking water, in part, by the Central System on a wholesale account basis. In addition, the City supplies raw water to Harford County and Carroll County. For the purposes of this report, the definition of the land area served by the Central System is limited to only that area within the political jurisdictions of the City and Baltimore County.

The boundary of the areas presently served by the Central System is shown on Figure II-1. Also shown are the areas within Howard County and Anne Arundel County that are serviced by the Central System. As illustrated in Figure II-1, the Central System encompasses an extensive area in the central portion of the State of Maryland. Predicting future service area expansions is an important planning step in determining future water system requirements.

First and foremost, the ultimate boundary of the area to be provided water service needs to be established. Previous studies and water agreements have established several boundaries to define the ultimate limits of the area to be served. These boundaries are shown on Figure II-1. In a report dated December 15, 1953 by the Board of Advisory Engineers *(Report on Future Sources of Water Supply and Appurtenant Problems)*, an ultimate service boundary was established that encompassed an area of 709 square miles. By comparison, the area that is presently served by the Central System today is 499.5 square miles, which includes 96.0 square miles and 112.4 square miles for the service areas of Anne Arundel County and Howard County, respectively.

The City is required by statute to furnish water to the Baltimore County Metropolitan District (BCMD) under a 1923 Legislative Act by the Maryland General Assembly. The boundary line used to define the limits of the BCMD extends, in certain portions, well beyond another boundary Baltimore County established two decades ago as a "line in the sand" against development called the Urban-Rural Demarcation Line (URDL). Present Baltimore County zoning limits proposed water service to only that area contained within the URDL. Despite a few areas where water service has already extended beyond the URDL, Baltimore County, for the most part, has been successful in limiting water service to within the intended growth boundary (URDL). Today there remains only



3 0 3 6

Miles

- Baltimore Water Service Area Adopted By The Advisory Engineers On Water Supply June, 1952
- Baltimore County Metropolitan District
- Baltimore County Urban Rural Demarcation Line (URDL)
- Present Service Area Of Baltimore Water System, Year 2000
- Areas Served On A Wholesale Basis By The Baltimore Water System

BALTIMORE CITY PROJECT 658

CENTRAL SYSTEM REPORT

BALTIMORE WATER SERVICE AREA

MARCH, 2003

FIGURE II-1

about 11.5 square miles of unserviced area that lies inside the URDL. In the determination of future demands, it was assumed that by the year 2025, all available land within the URDL would be serviced and that water service outside the URDL would not extend beyond what is already being supplied. Figure II-2 shows those areas that remain to be provided public water service in the future as well as those areas presently serviced but outside the URDL.

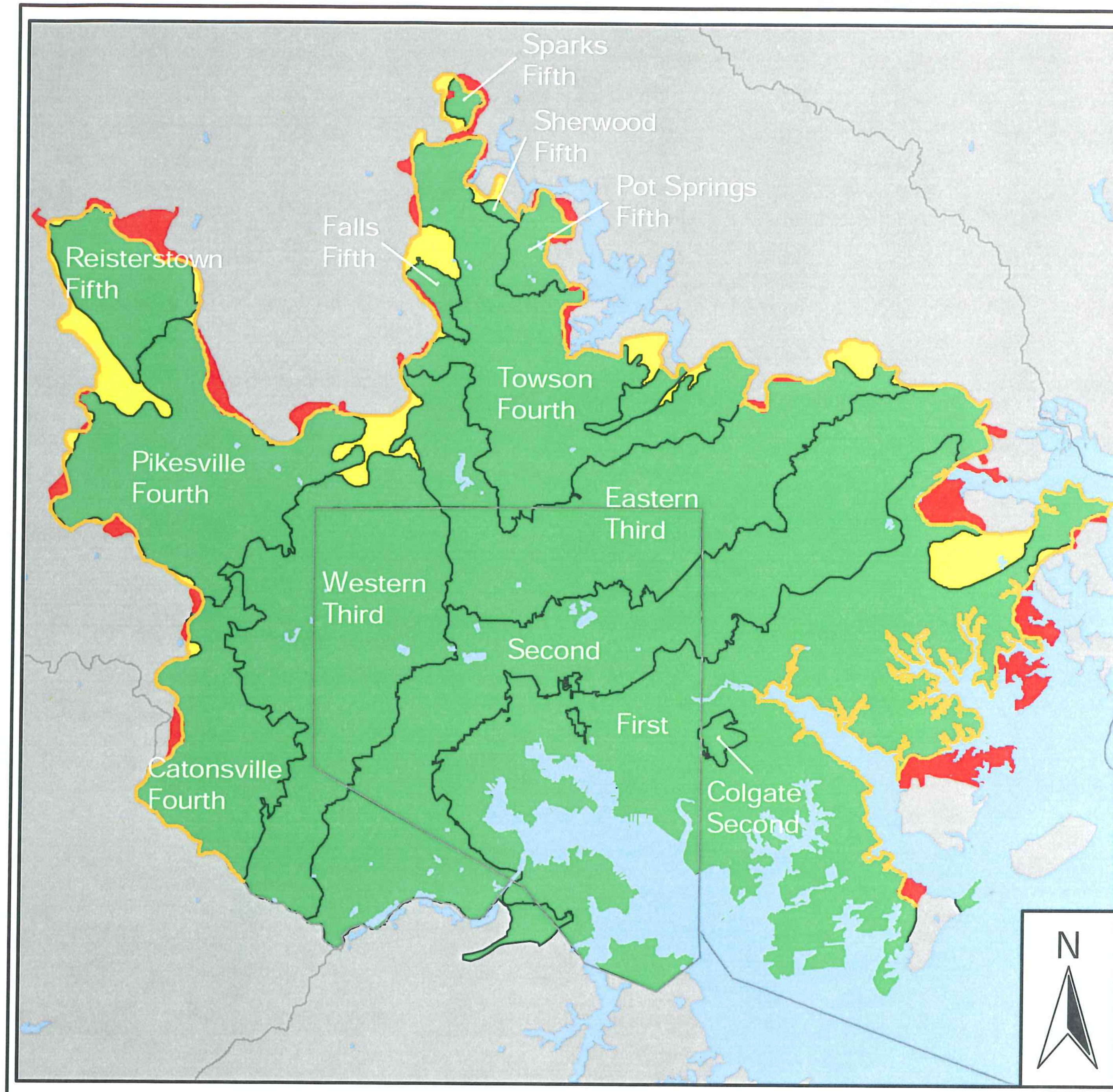
The incongruity between the BCMD line and the URDL has existed for a long time and represents a significant issue in establishing future service population and ultimate system demands. The Baltimore County Water Analyzers Office has indicated that there are no plans, current or future, to extend water service beyond the URDL. The development of future projected demands, therefore, reflects only that area within the URDL plus any areas where water service has already been provided outside the URDL. Future projected demands and the timing of additional capital facilities and capacity development is dependant on Baltimore County's ability to control growth beyond present URDL limits.

Presented in Table II-1 are the existing and ultimate areas of service by jurisdiction for each of the thirteen pressure zones. The area within the City's border is presently fully serviced and no further expansion of the water system is possible. All service area growth that is expected will occur in the outlying regions in Baltimore County. The region of greatest expected growth is the Sherwood Fifth Zone, which will nearly double in size, followed by the Sparks Fifth and Falls Fifth Zones. Overall though, the service area of the Central System is only expected to grow 4.0 percent until it reaches the limits of the defined service boundary (URDL). However, it should be noted that other variables will affect the demand projections in the larger zones more than the service area will.

The expanding service areas in the surrounding counties were not evaluated in this report. Projecting those demands was performed solely using the jurisdictional agreements discussed in the next section.

B. Supply Agreements with Surrounding Jurisdictions

The City presently supplies raw or treated water on a wholesale basis to the four surrounding counties of Anne Arundel, Howard, Carroll and Harford. The areas supplied by the Central System are shown in Figure II-3. The allowable withdrawals by these surrounding jurisdictions have a significant impact when estimating the future projected demands of the Central



3 0 3 6

Miles

Baltimore County Urban Rural Demarcation Line (URDL)

Present Service Area Of Baltimore Water System, Year 2000

Serviced Areas Outside The URDL Boundary

Non-Serviced Areas Within The URDL Boundary

BALTIMORE CITY PROJECT 658

CENTRAL SYSTEM REPORT

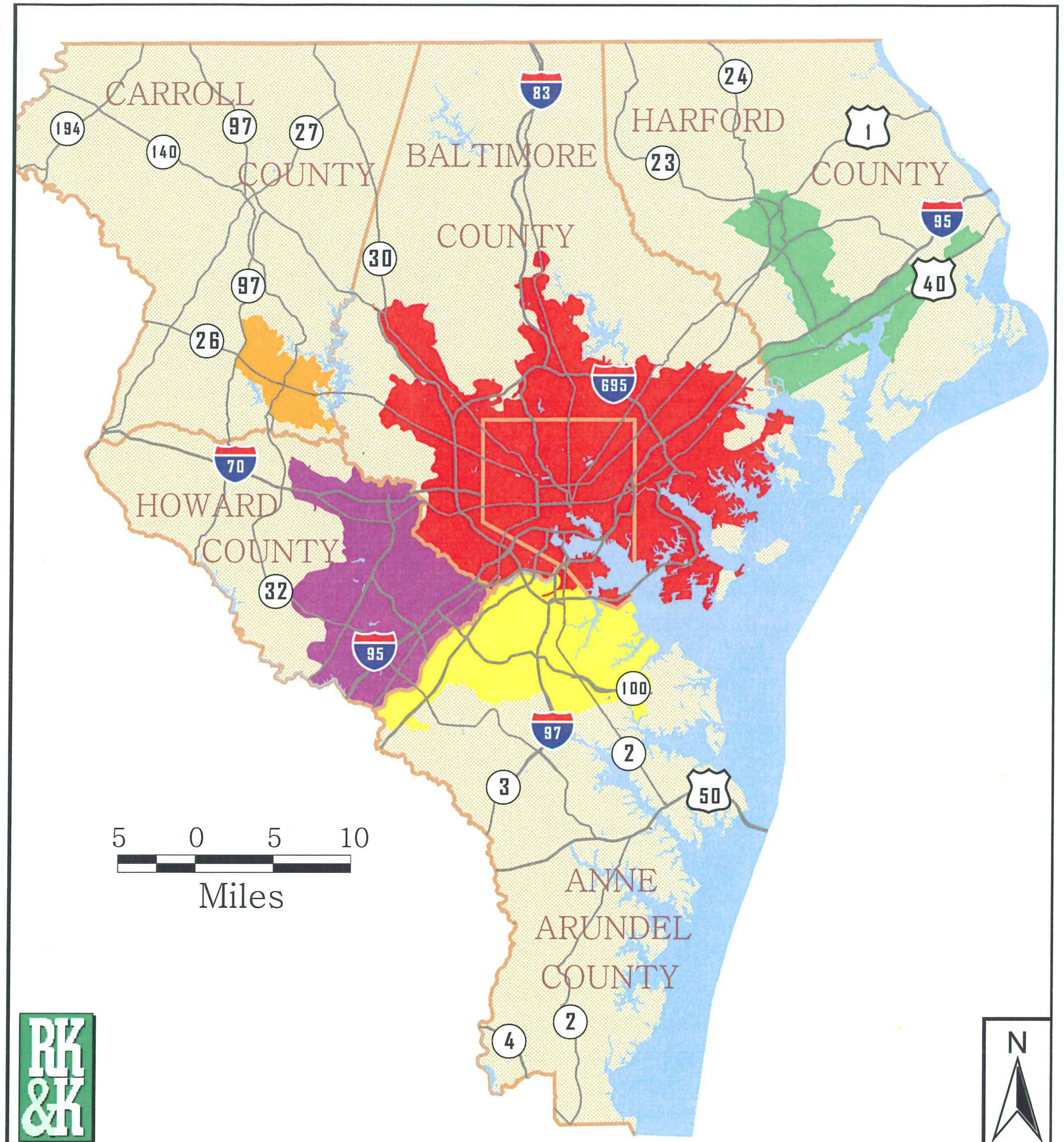
BALTIMORE WATER FUTURE SERVICE AREA

MARCH, 2003

FIGURE II-2

Table II-1, Existing and Ultimate Service Areas by Pressure Zone

	Zone	Existing (sq mi)	Ultimate (sq mi)	Growth (%)
Baltimore City	First	27.23	27.23	0.0%
	Second	21.25	21.25	0.0%
	Colgate Second	0.02	0.02	0.0%
	Eastern Third	14.34	14.34	0.0%
	Western Third	18.33	18.33	0.0%
	Towson Fourth	0.33	0.33	0.0%
City Total		81.51	81.51	0.0%
Baltimore County	First	55.26	58.03	5.0%
	Second	29.74	29.82	0.3%
	Colgate Second	0.86	0.86	0.0%
	Eastern Third	21.34	22.68	6.3%
	Western Third	17.23	18.56	7.7%
	Catonsville Fourth	15.26	15.37	0.7%
	Pikesville Fourth	26.29	28.01	6.5%
	Towson Fourth	28.20	30.09	6.7%
	Falls Fifth	1.39	1.86	33.6%
	Pot Springs Fifth	3.09	3.09	0.0%
	Reisterstown Fifth	9.70	11.02	13.6%
	Sherwood Fifth	0.29	0.54	82.4%
	Sparks Fifth	0.97	1.30	33.7%
Baltimore County Total		209.63	221.22	5.5%
Overall Total		291.14	302.74	4.0%



SERVICE AREA

- Baltimore Central System
- Anne Arundel
- Carroll
- Harford
- Howard

BALTIMORE CITY PROJECT 658
CENTRAL SYSTEM REPORT

CENTRAL SYSTEM AND SURROUNDING COUNTIES SERVED

MARCH, 2003 *FIGURE II-3*

System. Accordingly, RK&K performed a search to locate all known water agreements between the City and the surrounding counties and reviewed each to determine the City's obligatory requirements for supplying water to these jurisdictions. Presented in Table II-2 are a listing of all the water agreements that RK&K was able to locate and includes the signatory parties to each agreement and an abbreviated summary of the issues set forth in those documents.

Anne Arundel County is supplied treated water from the First and Second Zones through a total of six metered locations, some of which contain multiple meters. Water that is supplied to northern Anne Arundel County is blended with other supply sources owned and operated by Anne Arundel County. Howard County is supplied treated water from the Second and Western Third Zones through a total of four metered connections. Howard County also has interconnections with the WSSC system which supplies water to the north Laurel area, east of Interstate 95 and south of the Patuxent River. For the most part though, the entire Howard County service area shown in Figure II-3 is supplied by the Central System.

In regards to the sale of treated water to Anne Arundel County and Howard County, none of the agreements reviewed were explicit in identifying the specific quantities of water that the City is currently obligated to provide. Rather, each of the agreements relate more to the sharing of costs for the design and construction of jointly used facilities based on assumed usages. The City is not legally bound to furnish any given quantity and the Counties are not bound to use any. Only the 1957 Agreement is explicit in limiting demands to Howard County to a maximum daily rate of 8.5 mgd. The 1957 Agreement was superceded in 1986 however, by a new agreement allowing Howard County to exceed 8.5 mgd by an unspecified amount "only if unused capacity is available in the Western Third Zone". The ambiguities that exist in the agreements with Anne Arundel County were previously recognized and summarized in an October 26, 1979 inter-office correspondence from the Anne Arundel County Office of Law.

The City also has existing agreements to supply raw water to Carroll County and Harford County. The water agreements for the sale of raw water to Carroll County and Harford County are more clear in terms of spelling-out the maximum and average withdrawals allowed. According to the July 3, 1968 Agreement, Carroll County is entitled to withdrawal raw water from Liberty Reservoir at an average rate of 2.4 mgd and shall not exceed a maximum rate of 90 million gallons over a 30 day period. RK&K understands that Carroll County has made several previous attempts to increase their allowable average day withdrawals to 4.1 mgd, but the City has not approved nor denied such

Table II-2, Legislative Acts and Water Agreements Between Baltimore City and Surrounding Jurisdictions

Date of Agreement	Signatory Parties						Identified Wholesale Withdrawals on the Baltimore System			
	City	Baltimore Co.	Anne Arundel Co.	Howard Co.	Harford Co.	Carroll Co.	Avg (mgd)	Max (mgd)	Zone From	
Act of 1923										Chapter 539 of the Acts of 1923 of the Maryland General Assembly requires the City to furnish water to the Baltimore County Metropolitan District.
June 18, 1929	✔		✔				-	-	-	Relates to supply of Brooklyn Heights, Hillcrest and vicinity.
August 14, 1934	✔			✔						Agreement to furnish water to the 1st election district in Howard County
Act of 1955	✔				✔					Chapter 203 of the Acts of 1955 of the Maryland General Assembly authorizing City to take water from the Susquahanna River and mandating that the City must make water available at least 10 mgd to Harford County
September 2, 1964	✔		✔				-	-	-	Relates to cost sharing of improvements to western Second Zone
July 3, 1968	✔					✔	2.4	3	(raw)	Withdrawal from Liberty Reservoir
October 22,1969	✔	✔	✔	✔			18.8	-	Second	Relates to cost sharing of Southwest Transmission Main - Proportions 10.0 mgd to Anne Arunel Co. and 8.8 mgd to Howard Co.
November 17,1971	✔		✔				-	68	First	Relates to cost sharing of Under-the-Harbor Main
September 20,1972	✔	✔					-	-	-	Identifies method for cost sharing of capital facilities
January 30,1980	✔	✔	✔	✔			-	-	-	Relates to cost sharing of final sections of Southwest T.M.
July 9,1986	✔	✔		✔			-	> 8.5	W. Third	Relates to cost sharing of certain Western Third improvements. Allows previous withdrawal limits to be exceeded based on availability.
February 3, 1993	✔				✔		-	20	(raw)	Agreement includes option to purchase additional 10 mgd.
November 17,1999	✔		✔				8.6	15	Second	Identifies demands used in Tables 1,3 & 5 of *1989 Central System Report* for cost allocation of Hillen P.S.
November 24,1999	✔			✔			8.8 29.7	13.2 50.5	Second W. Third	Identifies demands used in Tables 1,3 & 5 of *1989 Central System Report* for cost allocation of Hillen P.S.

action.

The City's February 3, 1993 Agreement with Harford County entitles them to withdrawal a maximum of 20 mgd of raw water from the Susquehanna Transmission Main at Abingdon, Maryland. There is also an option that allows Harford County to increase its withdrawals to 30 mgd upon City approval. Currently, Harford County is supplied water from Loch Raven Reservoir that flows backwards through the Susquehanna pipeline from Montebello Water Treatment Plant towards Abingdon, although this is not the original intended design.

RK&K's estimation of the future water needs of the Central System, as presented in this report, incorporate all known water agreements between the City and the surrounding Counties. However, the quantities of water that the City is obligated to provide Anne Arundel County and Howard County is not specifically identified in any existing water agreement, and the development of individual projections for each of these jurisdictions is beyond the scope of this project. Therefore, it is recommended that the City draft new water agreements with each jurisdiction explicitly describing the amounts of water the City is obligated to provide. The values developed and used in this report should be used to create the new agreements.

Table II-3, Allowable Withdrawals from the Central System (mgd)

County	Zone							
	Raw Water		First		Second		Western Third	
	Avg	Max	Avg	Max	Avg	Max	Avg	Max
Anne Arundel	-	-	10.0	17.5	7.1	12.2	-	-
Howard	-	-	-	-	8.8	13.2	29.7	50.5
Carroll	2.4	3.0[1]	-	-	-	-	-	-
Harford	N/S	20	-	-	-	-	-	-

N/S – not specific

1. Based on a maximum of 90 million gallons over 30-day period

As such, for this project the estimated future withdrawals on the Central System by Anne Arundel County and Howard County are based on and reflect the same demand values presented in Table 1 of the *1989 Central System Report*. This is the same source for demand projections used in the development of cost allocation percentages in the 1999 Hillen Pumping Station Agreement, and it appears to be the most recent estimate agreed to by all parties. Presented in Table II-3 is a listing of allowable withdrawal quantities based on current agreements or previous historical precedence.

C. Future Population to be Served

The Baltimore Metropolitan Council's (BMC), Cooperative Forecasting Group, supplied the population projection data that was used in the report to derive future system demands. The Cooperative Forecasting Group is a technical committee serving the Metropolitan Planning Organization (MPO) whose task is to produce long-range small-area socioeconomic forecasts which serve as inputs primarily to the transportation demand modeling process of the MPO. This committee consists of Baltimore Metropolitan Council staff members, state and local planning staff including members from Baltimore City and Baltimore County, and others who have specific responsibility for generating forecasts of population and other variables of growth. The source document from which future population estimates were derived was the *October 1997 Final Report, Forecasts of Population, Households, Labor Force and Employment, 1995-2020.* Presented below are the participating members that were involved in the development of the forecast data:

<u>Cooperative Forecasting Group</u>

Alexander D. Speer,	Anne Arundel County
Jeff Mahew,	Baltimore County
Daniel E. Rooney,	Harford County
Gloria Griffin,	Baltimore City
Jeanne Joiner,	Carroll County
Roselle George,	Howard County
Mark Goldstein,	Maryland Office of Planning
Dunbar Brooks,	Project Coordinator
Jane Ndunda,	Contributing Staff
Josef Nathanson,	Director, Economic Research and Information Systems

Population forecast data provided by the BMC was detailed in five-year increments through the year 2020 and broken down by Regional Planning District. The 1990 Census data was available by census tract which was used to break down the Regional Planning Districts further. The areas of individual planning districts and census tracts were correlated to the areas of individual pressure zones to determine population within each zone. Year 2025 population estimates were derived by linear extrapolation of the previous five data points per census tract.

It should be noted that the overall population projections for the City are based on the assumption that the City will succeed in stabilizing and revitalizing neighborhoods that have experienced high levels of vacancies and abandonment. To the extent that these goals are not realized, there is a risk that the population projections presented here are overestimated.

However, as already seen by the recently available 2000 Census data, the original population projections submitted in the October 18, 2000 *Interim Report on Future Demands of the Baltimore Water System* were already underestimated. Both the City and Baltimore County 2000 Census data was approximately three percent higher than the overall estimated population based on the BMC projections. With the new 2000 Census information, the population projections were modified and subsequently, the demand forecast presented in the October report was revised.

The projected population growth by pressure zone is summarized in Table II-4. The year 2000 population census is based on the present service area of 291 square miles whereas the year 2025 population estimate assumes an area of 303 square miles representing full expansion within the defined service area boundary. As indicated in Table II-4, the population within the City=s jurisdictional boundary is expected to decline by an estimated 20,000 persons, or 3.05 percent, over the next 25 years. Of the six pressure zones that serve the City, four show a decline in population. The service population within Baltimore County, on the other hand, is expected to increase by an estimated 62,000 persons, or 9.47 percent, by the year 2025. Except for the First Zone, Colgate Second Zone and Pot Springs Fifth Zone which show slight declines, all Baltimore County zones show an increase in population. The greatest population increases are expected in the Eastern Third and Pikesville Fourth Zones. The largest percent increases are expected in the Pikesville Fourth Zone and Reisterstown Fifth Zone, which increased by more than 25% of their population in the year 2000.

D. Methodology for Developing Future Demands

This report identifies projected water demands respective to each pressure zone and political jurisdiction in five-year increments through the year 2025. In all, a total of 23 separate sets of projections were developed for the 13 pressure zones and four political jurisdictions comprising the Central System. In addition to five-year projections through year 2025, anticipated demands under ultimate or saturated development conditions were also developed. Saturated conditions represent the maximum demands ever to be expected and should never be exceeded. The demand projection results, compiled by zone, are presented in Appendix A. Howard County and Anne

Arundel County demands are included in the projections based on the agreements previously discussed; however, they are not included in the land area served or per capita figures.

Table II-4, Existing and Projected Future Population by Pressure Zone

		CENSUS DATA	DEVELOPED FROM BALTIMORE METROPOLITAN COUNCIL DATA				
	Zone	2000	2005	2010	2015	2020	2025
B.City	1st	174,251	171,501	170,198	172,757	174,257	175,989
	2nd	229,068	226,940	222,983	221,191	219,493	217,812
	C2nd	491	480	471	484	491	498
	E3rd	116,045	113,615	111,807	111,158	110,585	110,018
	W3rd	137,536	134,777	132,696	133,099	133,249	133,469
	T4th	1,472	1,452	1,439	1,438	1,435	1,432
	City Total	658,863	648,763	639,594	640,127	639,510	639,218
B.County East	1st	147,486	145,585	145,127	145,201	145,109	145,036
	2nd - E	50,123	53,010	56,177	59,224	62,383	65,808
	C2nd	7,849	7,662	7,599	7,557	7,495	7,433
	E3rd	85,730	88,113	91,475	94,670	97,880	101,360
	T4th	87,458	87,010	87,127	87,334	87,167	87,019
	F5th	4,821	4,936	5,102	5,282	5,454	5,638
	PS5th	10,776	10,687	10,687	10,643	10,554	10,466
	SH5th	419	428	441	428	462	472
	SP5th	2,303	2,498	2,592	2,498	2,680	2,743
	BC East Total	396,965	399,929	406,328	412,837	419,184	425,975
B.County West	2nd - W	34,859	34,166	33,968	33,869	33,572	33,277
	W3rd	69,156	69,416	69,951	70,646	71,238	71,848
	C4th	44,766	44,497	44,553	44,641	44,698	44,756
	P4th	75,452	79,487	83,547	87,898	92,107	96,616
	R5th	30,176	32,013	33,785	35,484	37,268	39,139
	BC West Total	254,409	259,578	265,804	272,538	278,882	285,637
	County Total	651,373	659,507	672,132	685,375	698,067	711,611
	Overall Total	1,310,236	1,308,271	1,311,726	1,325,502	1,337,577	1,350,829

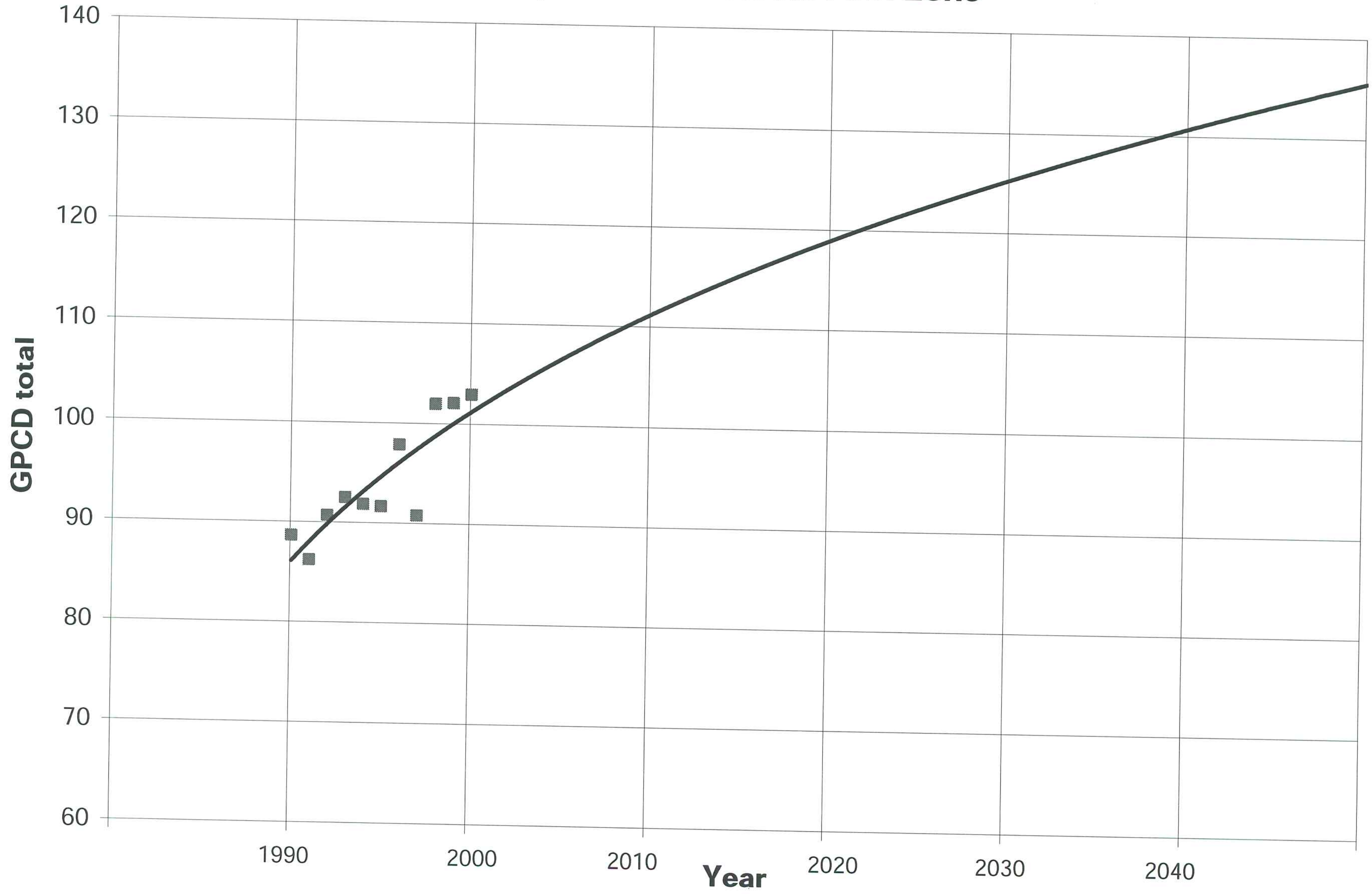
Demands for the Central System were developed based on the population projections, as discussed in the previous section, and trends derived from multiple forms of historical data. Average day, maximum day, peak hour and saturated demands were all calculated. The various parameters used to develop these demands are discussed in the sections below. In each zone, population projections for both the City and Baltimore County were multiplied by per capita demands to calculate average day demands. The maximum day demands were calculated from those average day demands by applying a maximum to average day demand ratio. Peaking factors, derived from diurnal patterns developed for each zone, were used to determine peak hour demands. Instead of projecting demands beyond the year 2025, saturated demands were developed based on current land zoning and record peak demands. And lastly, the projected demand estimated and discussed thus far reflects the total water consumed, not supplied. Unaccounted for water estimates were also developed and added to the consumed demand numbers to calculate supplied demands.

1. *Per Capita Demands*

Average day demand projections were calculated by multiplying population by a corresponding per capita, or per person demand. Per capita demands represent the amount of water being used per person and is typically expressed in gallons per person per day (or GPCD). Traditionally, the per capita demands for the Central System have been held constant when projecting; however, historical data shows that the per capita demands do fluctuate. For those zones deemed appropriate, the per capita demands were trended. An increase in GPCD could be possible due to changes in water usage or consumer base distribution over time. Per capita demands were evaluated based on total demand and also on a residential demand basis for each zone individually.

The total per capita unit demands for the City and Baltimore County were computed for each pressure zone for the years 1990 through 2000. The known total average annual demands for those years were divided by the population to determine the total per capita demand for each zone. The zones were evaluated individually to identify the ongoing trends in per capita demand growth or decline. Per capita demands were then extrapolated for future years based on the previous ten years of data using statistical regression methods, as shown in Figure II-4. For a few zones, the trend was declining and considered unrealistic. Instead of projecting the per capita demands for those zones, an average value for the ten years of data was used and held constant through the year 2025. Results of the computation are presented in Appendix A.

Figure II-4, Total Per Capita Unit Demands
Example: Reisterstown Fifth Zone



The residential per capita demand was calculated in a slightly different way and was used to determine the consumer base percentages shown on the tables in Appendix A. Demands for the years 1980 to 1999 were provided in reports from the Water Analyzer Office, known as WB050 reports, on a consumer type basis: residential, commercial or industrial. From these reports, a per capita demand based solely on residential demands was computed. The known average annual residential demands for those years were divided by the population to determine a residential per capita demand for each zone. An average of the 20 years of data was used and held constant over the next 25 years. The residential per capita demands were held constant as a conservative measure. It is expected that residential demands may actually decrease in the future due to more efficient devices, such as dishwashers and showerheads, and an increased conservation participation and awareness.

2. *Maximum to Average Day Ratios*

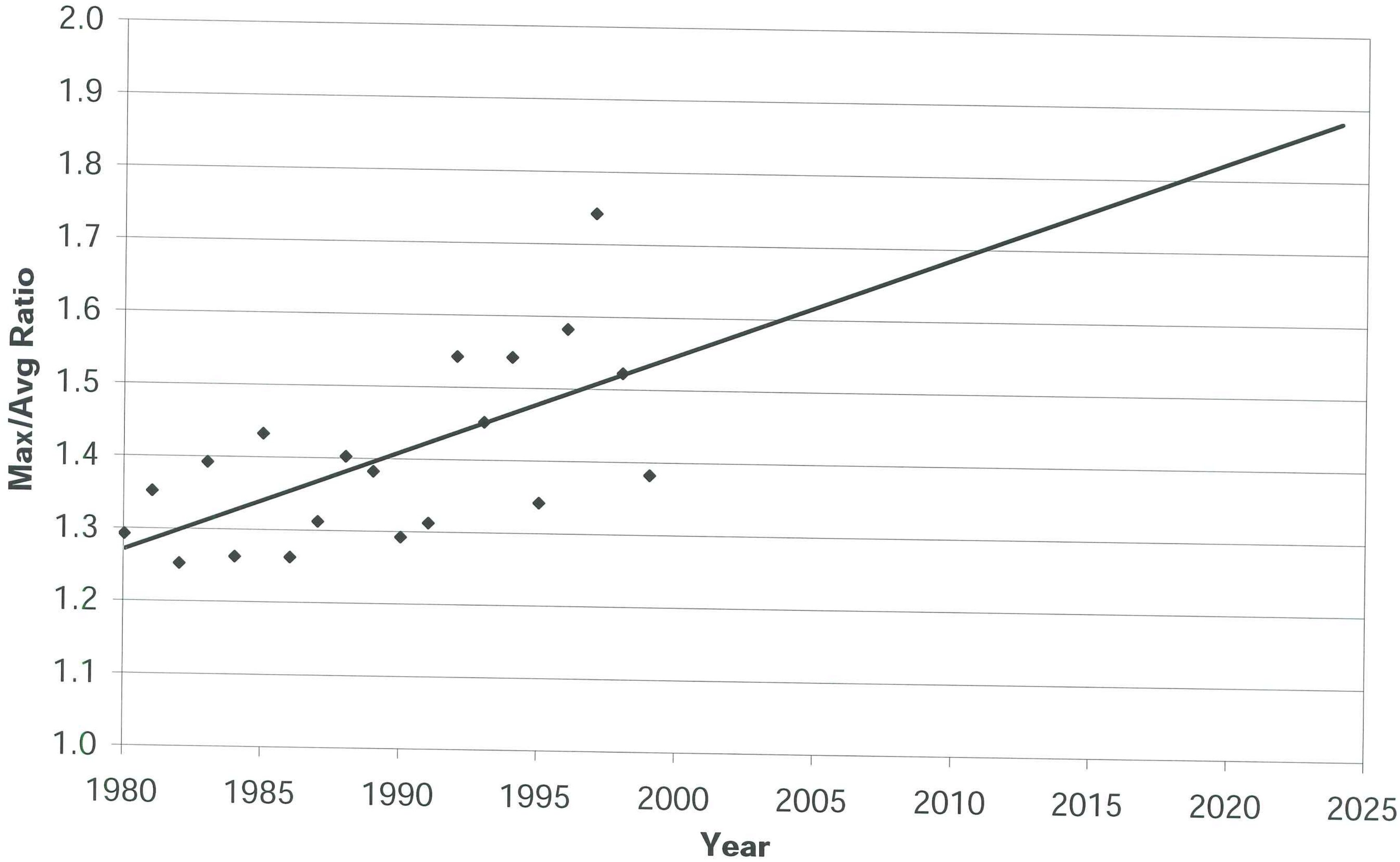
The maximum day demand to average day demand ratio (max/avg ratio) was derived from historical data provided for the Central System. Data from 1980-1999 was obtained from the Water Analyzer Office. Annual maximum day demands were divided by the average day demands to develop a max/avg ratio for each of the thirteen zones. This data was plotted and projected through the year 2025 and the results are presented in Appendix A. For example, the historical data for the First Zone and the trend line developed to determine the max/avg ratio for future years is illustrated in Figure II-5. This trend was used to calculate the maximum day demands for each zone in the Central System by multiplying the max/avg ratio for a given year by the average demands for that year.

3. *Diurnal Patterns and Peaking Factors*

Diurnal curves are patterns reflecting changes in demands over the course of the day, which relate to times when people are using more or less water than the average demand. The patterns are based on a multiplication factor versus time relationship where a factor of unity (1.0) represents the base or average demand value. The largest factor over unity represents the maximum water usage hour of the day and is used as the peaking factor to calculate the projected peak hour demands.

Peaking factors vary from zone to zone because the diurnal demand patterns are created from the type of development and water usage within that zone. High fluctuations in demand

Figure II-5, Maximum to Average Day Demand Ratio
Example: First Zone



throughout the day are normally associated with residential development. Whereas, more constant demands are associated with commercial/ industrial development. Diurnal demands also vary from day to day depending on weather conditions as well as many other factors.

RK&K developed composite average and maximum day diurnal demand patterns for each of the Central System's 13 pressure zones based on hourly telemetry data developed by the City's Telemetry Control Center (TCC). Except for when there are technical problems, the City's TCC produces an Hourly Report at the end of each day that summarizes the average hourly demand for each zone as well as the operating status of all the facilities in the system over that day. This data was used to develop hourly demand factors for each zone by dividing the average hourly demand by the average demand for that particular day. Composite average and maximum day diurnal patterns were then developed, as shown in Figure II-6, by averaging the demand factors using data from several representative days. The average days used were chosen based on available TCC data for the month of October. Historically, average demands typically occur during the month of October. The maximum days used were chosen based on input from the Water Analyzer Office as to when maximum day demands occurred. The following days had acceptable data available and were chosen to represent average and maximum day demand conditions:

Average Day	Maximum Day
10/31/98	7/19/97
10/20/97	7/17/97
10/10/97	7/14/97
	7/6/88
	8/16/97
	8/1/97

No data beyond October 1998 was used because the hourly reports have not been generated by the TCC since the IBM Series I computer crashed several years ago. Since no diurnal water demand data was evaluated for the wholesale users, i.e. Howard and Anne Arundel County, the same diurnal pattern as the rest of the zone

The diurnal patterns computed for each zone, as based on the Hourly Reports for the above listed days, are presented in Table II-5. The shaded numbers shown are the peaking factors used for each zone to determine the projected peak hour demand. This factor was held constant through the year 2025 and also used for the saturated demands. It is noted that some of the data were adjusted somewhat to account for suspected metering errors and to produce a smoother curve. The

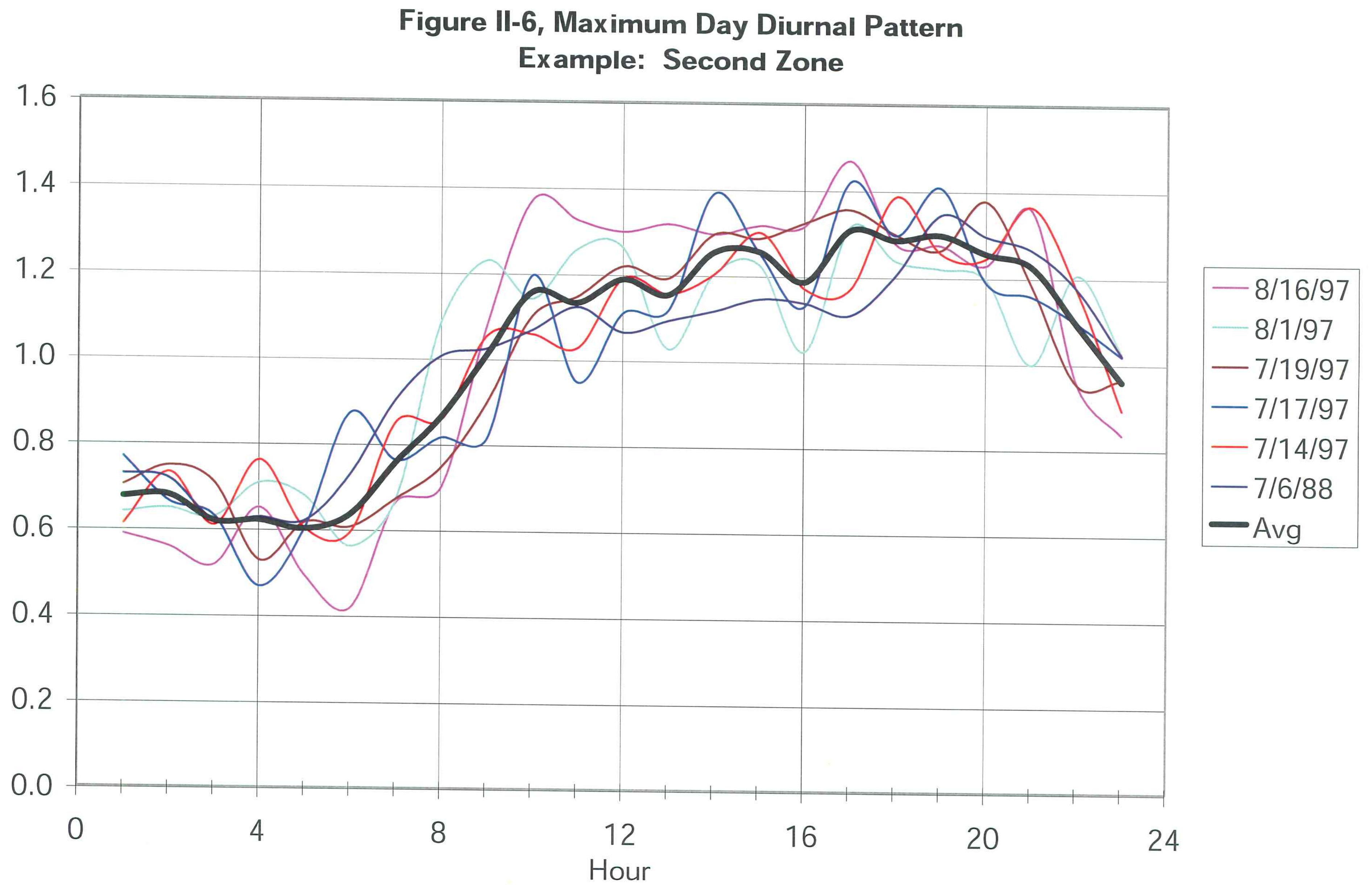


Figure II-6, Maximum Day Diurnal Pattern
Example: Second Zone
1.6
1.4
1.2
1.0
0.8
0.6
0.4
0.2
0.0
0
4
8
12
16
20
24
Hour
8/16/97
8/1/97
7/19/97
7/17/97
7/14/97
7/6/88
Avg

Table II-5, Zonal Diurnal Demand Patterns

Time from Start (Hrs)	Zone																								
	First		Second		Colgate 2nd		Eastern 3rd		Western 3rd		Catonsville 4th		Pikesville 4th		Towson 4th		Falls 5th		Pot Springs 5th		Reisterstown 5th		Sparks 5th	
	Avg.	Max.	Avg.	Max.	Avg.	Max.	Avg.	Max.	Avg.	Max.	Avg.	Max.	Avg.	Max.	Avg.	Max.	Avg.	Max.	Avg.	Max.	Avg.	Max.	Avg.	Max.
Midnight	0.759	0.857	0.892	0.801	0.786	0.733	0.523	0.762	1.020	0.926	0.607	0.725	0.889	0.756	0.856	0.818	0.798	0.633	0.798	0.705	0.854	0.684	0.798	0.835
1:00	0.675	0.728	0.861	0.656	0.606	0.548	0.433	0.693	0.805	0.796	0.589	0.517	0.760	0.540	0.751	0.647	0.772	0.402	0.772	0.532	0.662	0.406	0.772	0.764
2:00	0.562	0.661	0.821	0.660	0.531	0.535	0.307	0.614	0.546	0.606	0.583	0.442	0.663	0.526	0.764	0.523	0.702	0.368	0.702	0.463	0.442	0.344	0.702	0.672
3:00	0.478	0.641	0.712	0.602	0.504	0.402	0.376	0.537	0.486	0.543	0.544	0.428	0.489	0.555	0.694	0.531	0.642	0.304	0.642	0.408	0.363	0.349	0.642	0.593
4:00	0.505	0.591	0.717	0.600	0.429	0.465	0.535	0.594	0.552	0.522	0.514	0.401	0.546	0.489	0.602	0.489	0.579	0.364	0.579	0.469	0.369	0.222	0.579	0.763
5:00	0.511	0.557	0.752	0.584	0.542	0.555	0.584	0.694	0.719	0.573	0.612	0.422	0.577	0.537	0.548	0.477	0.385	0.391	0.385	0.653	0.434	0.345	0.385	0.893
6:00	0.659	0.613	0.884	0.618	0.821	0.588	0.931	0.816	0.822	0.656	0.739	0.521	0.746	0.560	0.658	0.645	0.622	0.418	0.622	0.757	0.703	0.452	0.622	0.948
7:00	1.052	0.793	1.187	0.773	1.062	0.803	1.002	0.927	0.952	0.895	1.142	0.790	1.118	0.873	0.965	0.864	1.027	0.702	1.027	0.952	1.127	0.802	1.027	1.029
8:00	1.214	0.910	1.254	0.881	1.150	1.029	1.179	1.197	1.056	1.130	1.236	1.001	1.316	1.064	1.234	1.069	1.243	1.177	1.243	1.128	1.368	1.055	1.243	1.126
9:00	1.383	1.048	1.267	1.015	1.285	1.167	1.258	1.223	1.219	1.156	1.277	1.203	1.176	1.178	1.342	1.213	1.424	1.239	1.424	1.205	1.466	1.127	1.424	1.190
10:00	1.421	1.224	1.279	1.171	1.262	1.213	1.305	1.324	1.216	1.190	1.219	1.213	1.155	1.221	1.294	1.198	1.501	1.250	1.501	1.281	1.472	1.320	1.501	1.244
11:00	1.372	1.268	1.063	1.138	1.278	1.280	1.412	1.220	1.164	1.142	1.163	1.256	1.348	1.262	1.209	1.124	1.337	1.507	1.337	1.238	1.207	1.189	1.337	1.175
Noon	1.272	1.213	1.031	1.200	1.202	1.245	1.623	1.158	1.170	1.167	1.134	1.218	1.234	1.227	1.168	1.168	1.184	1.355	1.184	1.211	1.254	1.153	1.184	1.122
13:00	1.258	1.206	1.022	1.154	1.298	1.146	1.536	1.111	1.162	1.120	1.178	1.200	1.177	1.175	1.265	1.133	1.167	1.341	1.167	1.173	1.168	1.162	1.167	1.027
14:00	1.215	1.184	1.065	1.255	1.225	1.110	1.534	1.098	1.111	1.084	1.208	1.185	1.152	1.138	1.303	1.168	1.143	1.172	1.143	1.135	1.170	1.072	1.143	1.040
15:00	1.140	1.160	1.068	1.249	1.178	1.091	1.241	1.072	1.083	1.090	1.130	1.178	1.130	1.121	1.218	1.183	1.150	1.172	1.150	1.102	1.002	1.055	1.150	1.027
16:00	1.078	1.175	1.139	1.186	1.100	1.099	1.248	1.092	1.129	1.071	1.205	1.157	1.020	1.095	1.227	1.102	1.144	1.105	1.144	1.076	1.217	1.069	1.144	1.051
17:00	1.148	1.175	1.195	1.309	1.224	1.170	1.148	1.160	1.157	1.099	1.180	1.231	1.095	1.099	1.122	1.236	1.109	1.157	1.109	1.099	1.080	1.240	1.109	1.095
18:00	1.136	1.198	1.115	1.291	1.207	1.271	1.137	1.207	1.137	1.178	1.248	1.311	1.130	1.238	0.937	1.309	1.180	1.324	1.180	1.234	0.958	1.450	1.180	1.241
19:00	1.140	1.216	1.093	1.319	1.169	1.441	1.312	1.331	1.074	1.225	1.229	1.454	1.109	1.366	1.051	1.302	1.097	1.439	1.097	1.374	1.172	1.604	1.097	1.170
20:00	1.055	1.248	0.946	1.280	1.123	1.587	1.005	1.210	1.197	1.331	1.192	1.528	1.102	1.444	0.843	1.385	1.086	1.647	1.086	1.460	1.157	1.825	1.086	1.132
21:00	1.090	1.242	0.927	1.235	1.025	1.478	0.855	1.105	1.140	1.289	1.066	1.486	1.033	1.420	0.927	1.285	0.963	1.501	0.963	1.414	1.206	1.746	0.963	1.039
22:00	1.034	1.105	0.885	1.079	1.028	1.127	0.780	0.976	1.077	1.154	1.170	1.202	1.020	1.146	0.920	1.145	0.912	1.165	0.912	1.104	1.103	1.366	0.912	0.971
23:00	0.844	0.987	0.824	0.945	0.965	0.917	0.737	0.881	1.005	1.056	0.937	0.933	1.017	0.972	0.960	0.989	0.833	0.864	0.833	0.829	1.046	0.962	0.833	0.854
Total	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24

NOTES: [shaded] Denotes peak hour - max day

Patterns based on City Telemetry Control Center (TCC) hourly report data. Some hourly data adjusted to account for suspected metering errors.

No pattern could be derived from Pot Springs 5th average day telemetry data. Average day pattern for Sparks 5th zone used instead.

Second zone includes Perryhall Second Zone

Sherwood 5th Zone not shown due to insufficient data. Falls 5th zone used to represent Sherwood 5th zone.

patterns indicated in Table II-5 also reflect a composite of residential, commercial and industrial demands within each zone. Actual demands in localized areas may differ from the patterns indicated depending on the type of development in those areas.

4. *Saturated Demands*

Saturated demand conditions were developed to represent the ultimate buildout water requirements for each zone. Separate approaches were taken when developing the ultimate demands for the City and Baltimore County. In the case of Baltimore County, saturated buildout is defined as the complete development of all lands within the service boundary in accordance with current zoning ordinances. For the City, the current zoning was not used because it does not accurately reflect the existing conditions and it is unlikely that it will reflect future conditions either.

Baltimore County buildout demand conditions were derived by multiplying water duties for each land use category, established on a per acre basis, by the total land area for that category of zoning. The individual demands for all the land zoning classifications were then added to derive the total demand for the zone. Water duties of 2,040 and 2,270 gallons per acre (GPD/AC) were applied to commercial/public and industrial/manufacturing land zoning respectively.[1] For residential land, the maximum allowable tract density in houses per acre was multiplied by an assumed 2.29 persons per household[2] to get a total population, which was then multiplied by the residential per capita demand respective to that zone. Variations in the saturated consumer base percentage and existing demand, or 2025 demands, can be attributed to differences in zoning classification and water billing classification. For example, schools are considered to be commercial or public demands, but can be located in areas zoned residential because they are an exception to typical zoning regulations.

For the City, defining the buildout demand of its service area requires a different approach. For the last half of the century, the population and economic structure of the City has undergone drastic changes resulting from continued decompression and suburbanization common to most industrial cities in the eastern United States. The City's population, as counted by the U.S. Bureau of the Census, peaked in 1950 at 949,708. Since 1960, the City=s population has continued to decrease to 743,629 in 1990, and 658,863 in 2000. There are presently no signs that decompression of the City has stopped or is approaching the stopping point.

---

1. Handbook of Water Distribution Systems, Larry May, McGraw Hill, 1999
2. Maryland Office of Planning

Probably the most influential factor in causing the changes to the City's demographic structure over the last fifty years is the advent of modern transportation systems that make low density development possible. The consensus among all planning estimates is that the City will most likely never return to the same level of intense development of the 1950's and 1960's. Therefore, basing an ultimate buildout demand for the City on outdated zoning would be overly conservative and unrealistic because those development densities will most likely never again be achieved. Rather, the long term water needs of the City should be based on likely development scenarios with an added measure of safety to account for any unforeseen future events that may one day cause growth to shift back to a more densely populated urban environment.

Based on the records available, filtered water delivered to the City (including unaccounted for water) peaked in 1951 at 194.21 mgd. In 1980, filtered water delivered was 149.67 mgd, and by 2000 was 115 mgd. From 1953 through 1979, no water consumption data is available but it is assumed that City demands continued to decline steadily over that period.

For the City, where demands have been continually decreasing for the past four decades, it is assumed that demand growth in the City will eventually return but that ultimate demands will never again exceed those that occurred in 1980. The City saturated demand, therefore, has been assumed to be the same as 1980 demand conditions. Census data for year 1990 has been used to represent population saturation based on the assumption that future City development will be less densely populated.

Using 1980 demand and 1990 population data to represent saturated development conditions for the City is a very reasonable assumption. As with all assumptions however, there remains the possibility that future development could one day exceed the saturated estimates presented here. On the other hand, there is also the possibility that saturated demands may never be reached. The ultimate consequences that saturated demand conditions for the City are over- or under-estimated are not totally clear. To the extent that saturated demands are overstated, the City may be overly conservative in reserving future system capacity for demands that will never materialize. If the saturated demands are understated, the City may be restricting future growth. The approach presented herein, presents the most reasonable approach to an otherwise uncertain future.

The saturated demands developed for this project are presented in Table II-6. These are consumed demands and include Howard County and Anne Arundel County. More detailed results can be found in Appendix A.

Table II-6, Saturated Demands

Zone	Average Day (mgd)	Maximum Day (mgd)
First	120.75	226.82
Second	71.32	122.56
Colgate Second	0.69	0.98
Eastern Third	24.73	45.01
Western Third	58.08	90.80
Catonsville Fourth	11.26	18.01
Pikesville Fourth	20.51	38.14
Towson Fourth	21.30	36.00
Falls Fifth	0.74	1.92
Pot Springs Fifth	1.61	3.25
Reisterstown Fifth	6.04	12.15
Sherwood Fifth	0.11	0.21
Sparks Fifth	1.15	3.46
Total	338	599

5. *Lost and Unaccounted for Water*

The total water delivered includes any unaccounted for water, which is water that is lost to unmetered uses such as fire fighting, leaks, main breaks, main flushing, and meter inaccuracies.

The demands developed thus far represent water consumed and does not take into account lost water. Lost and unaccounted water usage is estimated by comparing the average annual water supplied to each zone with the average annual metered consumption. The difference between the two values is lost and unaccounted for water.

Presented in Table II-7 are five years of unaccounted water data for each pressure zone. As illustrated in Table II-7, year-to-year lost water can range anywhere from minus 6 percent to over 44 percent. Typical values for a system the size and age of Baltimore's are expected between 15% and 20% with a maximum loss of 25%. These values are not acceptable and the City should make the effort to reduce them. Some of the wide variations shown in Table II-7 are probably the result of metering errors and most likely do not represent actual conditions. The Falls Fifth Zone appears to have the highest lost water averaging over 31%. This is surprising considering the Falls Fifth Zone is relatively new in comparison to the rest of the system. More than likely, the high lost water percentages of the Falls Fifth Zone are due to pumping and telemetry inaccuracies or unmetered water supplied to the chlorinator station ejectors. The Pikesville Fourth Zone has the lowest average lost water of the last five years at 8.3%. This value appears unreasonably low and again is probably affected by metering and telemetry errors.

The unaccounted water percentages used for the zonal water supplied demand projections are shown at the bottom of Table II-7. These values assume that true lost water ranges between 15% and 25%. When calculating the supplied water demand, the unaccounted water percentages were not applied to Anne Arundel County and Howard County. Demands for these counties are wholesale quantities and already take into account any lost water in those systems after it leaves the City and Baltimore County.

Valve checking programs, improved data collection and storage, better system controls, enforcement of applicable local statutes (example: illegal opening of fire hydrants) and scheduled meter maintenance can all help reduce lost and unaccounted for water. The City is currently conducting a water audit, Project No. 869. The City should make Anne Arundel and Howard Counties financially responsible for their shares of unaccounted water on the supply side of their meters as an incentive to decrease unaccounted for water. By partaking in these efforts, the City will reduce the amount of excess water produced on a daily basis and the associated cost incurred.

Table II-7, Historic Unaccounted Water as Percent of Total Supplied to Zone

YEAR	FIRST	SECOND	COLGATE SECOND	EASTERN THIRD	WESTERN THIRD	CATONSVILLE FOURTH	PIKESVILLE FOURTH	TOWSON FOURTH	FALLS FIFTH	POT SPRINGS FIFTH	REISTERSTOWN FIFTH	SHERWOOD FIFTH	SPARKS FIFTH	TOTAL SYSTEM
1994	10.2	29.5	-1.1	24.6	19.7	22.3	7.6	17.1	36.5	18.7	23.0	N/A	14.7	18.3
1995	7.3	21.4	12.4	14.7	21.1	13.9	16.4	14.2	36.0	15.9	16.3	N/A	13.4	14.6
1996	11.3	24.8	20.8	14.6	18.8	14.6	0.6	19.5	30.1	12.7	16.4	N/A	9.1	16.1
1997	16.4	23.3	20.6	11.5	18.1	20.9	6.6	27.9	31.8	20.6	15.4	N/A	14.6	18.3
1998	24.1	23.6	11.4	17.4	23.7	19.4	4.2	17.4	26.0	9.7	9.9	N/A	13.2	21.9
1999	20.0	32.9	7.8	10.8	31.8	18.0	23.8	16.7	30.4	11.6	17.1	N/A	16.0	24.2
2000	-2.0	43.7	-6.2	23.4	17.4	19.9	-1.3	14.7	26.1	15.0	16.3	88.2	16.9	18.0
HIGH	24.1	43.7	20.8	24.6	31.8	22.3	23.8	27.9	36.5	20.6	23.0	N/A	16.9	24.2
LOW	-2.0	21.4	-6.2	10.8	17.4	13.9	-1.3	14.2	26.0	9.7	9.9	N/A	9.1	14.6
AVERAGE	12.5	28.5	9.4	16.7	21.5	18.4	8.3	18.2	31.0	14.9	16.3	N/A	14.0	18.8
USE	15%	25%	15%	20%	20%	20%	15%	20%	25%	15%	20%	15%	15%	20%

Note: The Sherwood Fifth Zone was created from a portion of the Pot Springs Fifth Zone in 1999.

E. Projected Water Demands of the Baltimore System

Projected average and maximum day demands for each of the Central System=s 13 pressure zones are summarized in Table II-8. The demands shown reflect both water consumed and water supplied, based on assumed lost water percentages discussed in the previous section, as well as water sold to Anne Arundel County and Howard County. A detailed breakdown of the individual projections in Table II-8 are presented in Appendix A. Projected average day and saturated demands for each zone have also been shown graphically in Appendix A in order to compare the projections against actual record demands. The demands presented on the individual zone sheets in Appendix A all reflect water consumed.

Over the next 25 years, the average day demands of the entire Central System are expected to increase by 19.3 percent. Maximum day demands are expected to increase by 31.5 percent. The larger increase in maximum day demands is associated with anticipated future declines in industrial demand which tends to dampen the seasonal highs and lows of residential consumers. The maximum day demand of the entire system presented in Table II-8 assumes that maximum day events from the individual zones all occur on the same day. Typically, this is not the case for the Central System. As such, the total system maximum day demand shown herein may be conservative.

Based on current growth trends none of the zones is expected to reach saturated development before 2025. Assuming these trends continue, the Falls Fifth, Reisterstown Fifth, Pot Springs Fifth and Western Third Zones will reach saturated development by the year 2050, while the demands for all the other zones will still be below saturation at that time. Listed in Table II-9 is the anticipated year when saturated demands are expected to be achieved.

The demands presented in Table II-8 were compared against previous demand projections, developed for the City, to identify significant changes or discrepancies. Prior to the implementation of Project 658, the most reliable source of projected demand data was considered to be the *1989 Central System Report* prepared by the staff of the Water Analyzer Office. Comparisons between the data developed in the *1989 Central System Report* and the data developed for this report are shown on Tables II-10 and II-11. Comparisons are illustrated for average and maximum day demands (Table II-10) and population projections (Table II-11).

Table II-8, Summary of Projected System Demands

AVERAGE DAY DEMANDS (MGD)

ZONE	Water Consumed/Demand 2000	2005	2010	2015	2020	2025	SATURATION	UNACCOUNTED WATER RATE	Water Supplied 2000	2005	2010	2015	2020	2025	SATURATION
FIRST	76.5	80.1	80.8	82.7	84.0	84.5	120.7	15%	87.2	91.1	91.7	93.8	95.1	95.7	142.1
SECOND	40.1	44.5	46.8	49.1	49.8	50.5	71.3	25%	48.3	53.2	55.4	57.7	58.4	59.1	95.1
COLGATE SECOND	0.58	0.59	0.59	0.59	0.59	0.59	0.69	15%	0.66	0.68	0.68	0.68	0.68	0.68	0.81
EASTERN THIRD	19.0	19.5	19.8	20.3	20.7	21.2	24.7	20%	22.7	23.4	23.8	24.3	24.8	25.4	30.9
WESTERN THIRD	38.4	42.3	45.0	47.7	50.4	51.5	58.1	20%	42.7	46.7	49.3	52.1	54.7	55.9	72.6
CATONSVILLE FOURTH	6.37	6.40	6.53	6.66	6.79	6.91	11.3	20%	7.64	7.68	7.83	7.99	8.14	8.30	14.1
PIKESVILLE FOURTH	9.33	10.2	10.7	11.2	11.8	12.3	20.5	15%	10.7	11.7	12.3	12.9	13.5	14.2	24.1
TOWSON FOURTH	12.5	13.0	13.1	13.1	13.1	13.0	21.3	20%	15.1	15.6	15.7	15.7	15.7	15.6	26.6
FALLS FIFTH	0.48	0.51	0.54	0.56	0.59	0.61	0.74	25%	0.60	0.64	0.67	0.71	0.73	0.77	0.99
POT SPRINGS FIFTH	1.19	1.28	1.32	1.35	1.37	1.39	1.61	15%	1.37	1.48	1.52	1.55	1.58	1.60	1.89
REISTERSTOWN FIFTH	3.10	3.41	3.75	4.09	4.43	4.78	6.04	20%	3.72	4.09	4.50	4.90	5.31	5.73	7.56
SHERWOOD FIFTH	0.05	0.05	0.05	0.05	0.06	0.06	0.11	15%	0.05	0.06	0.06	0.06	0.07	0.07	0.12
SPARKS FIFTH	0.31	0.39	0.40	0.39	0.42	0.43	1.15	15%	0.36	0.45	0.47	0.45	0.48	0.49	1.36
TOTAL	**207.9**	**222.4**	**229.4**	**237.8**	**243.9**	**247.8**	**338.3**		**241.1**	**256.9**	**264.0**	**272.8**	**279.2**	**283.5**	**418.2**

MAXIMUM DAY DEMANDS (MGD)

ZONE	Water Consumed/Demand 2000	2005	2010	2015	2020	2025	SATURATION	UNACCOUNTED WATER RATE	Water Supplied 2000	2005	2010	2015	2020	2025	SATURATION
FIRST	118.6	129.8	136.6	145.6	152.1	158.3	226.8	15%	135.2	147.5	155.1	165.0	172.3	179.4	266.8
SECOND	65.8	73.9	78.6	82.1	84.1	86.1	122.6	25%	79.2	88.4	93.1	96.9	99.0	101.2	163.4
COLGATE SECOND	0.82	0.85	0.85	0.85	0.85	0.85	0.98	15%	0.95	0.97	0.97	0.98	0.98	0.97	1.16
EASTERN THIRD	31.1	32.6	33.9	35.3	36.8	38.5	45.0	20%	37.3	39.2	40.7	42.3	44.2	46.2	56.3
WESTERN THIRD	59.3	64.1	68.2	72.6	77.1	81.5	90.8	20%	65.2	70.1	74.2	78.7	83.2	87.7	113.5
CATONSVILLE FOURTH	10.2	10.2	10.4	10.7	10.9	11.1	18.0	20%	12.2	12.3	12.5	12.8	13.0	13.3	22.5
PIKESVILLE FOURTH	16.1	17.8	19.0	20.2	21.5	23.0	38.1	15%	18.5	20.4	21.9	23.3	24.8	26.4	44.9
TOWSON FOURTH	20.9	21.9	21.9	22.0	21.9	22.0	36.0	20%	25.1	26.3	26.3	26.4	26.3	26.4	45.0
FALLS FIFTH	1.00	1.13	1.24	1.35	1.47	1.59	1.92	25%	1.26	1.42	1.55	1.69	1.84	1.99	2.57
POT SPRINGS FIFTH	2.38	2.57	2.65	2.71	2.77	2.81	3.25	15%	2.73	2.95	3.05	3.11	3.18	3.24	3.83
REISTERSTOWN FIFTH	5.40	6.10	6.94	7.76	8.68	9.60	12.1	20%	6.48	7.32	8.33	9.31	10.4	11.5	15.2
SHERWOOD FIFTH	0.09	0.10	0.11	0.11	0.12	0.13	0.21	15%	0.11	0.12	0.13	0.13	0.14	0.15	0.25
SPARKS FIFTH	0.80	1.07	1.15	1.13	1.23	1.28	3.46	15%	0.92	1.23	1.33	1.30	1.42	1.48	4.07
TOTAL	**332.4**	**362.2**	**381.6**	**402.4**	**419.6**	**436.7**	**599.3**		**385.1**	**418.2**	**439.1**	**461.8**	**480.8**	**500.0**	**739.5**

1. Zonal demands include supply to Anne Arundel County and Howard County
2. Unaccounted water rate not applied to Anne Arundel County and Howard County demands, these demands already include unaccounted water

Table II-9, Timeframe for Expected Saturated Development to Occur

Zone	Year When Ultimate Demands Are Expected
Total System	> 2050
First	> 2050
Second	> 2050
Colgate Second	> 2050
Eastern Third	> 2050
Western Third	2040
Catonsville Fourth	> 2050
Pikesville Fourth	> 2050
Towson Fourth	> 2050
Falls Fifth	2030
Pot Springs Fifth	2050
Reisterstown Fifth	2040
Sherwood Fifth	> 2050
Sparks Fifth	> 2050

Table II-10, Comparison of Projected Demands Against Previous Estimates

WATER SUPPLIED – TOTAL SYSTEM (mgd)				
		1989 Central System Report	Project 658	% Difference
Year 2000	Avg. Max.	314.7 455.5	241.1 385.1	-23.4% -15.5%
Year 2025	Avg. Max.	359.6 531.3	283.7 500.3	-21.1% -5.8%

Note: All demands shown include unaccounted for water
Project 658 year 2000 information is from actual Census data

Table II-11, Comparison of Projected Population Against Previous Estimates

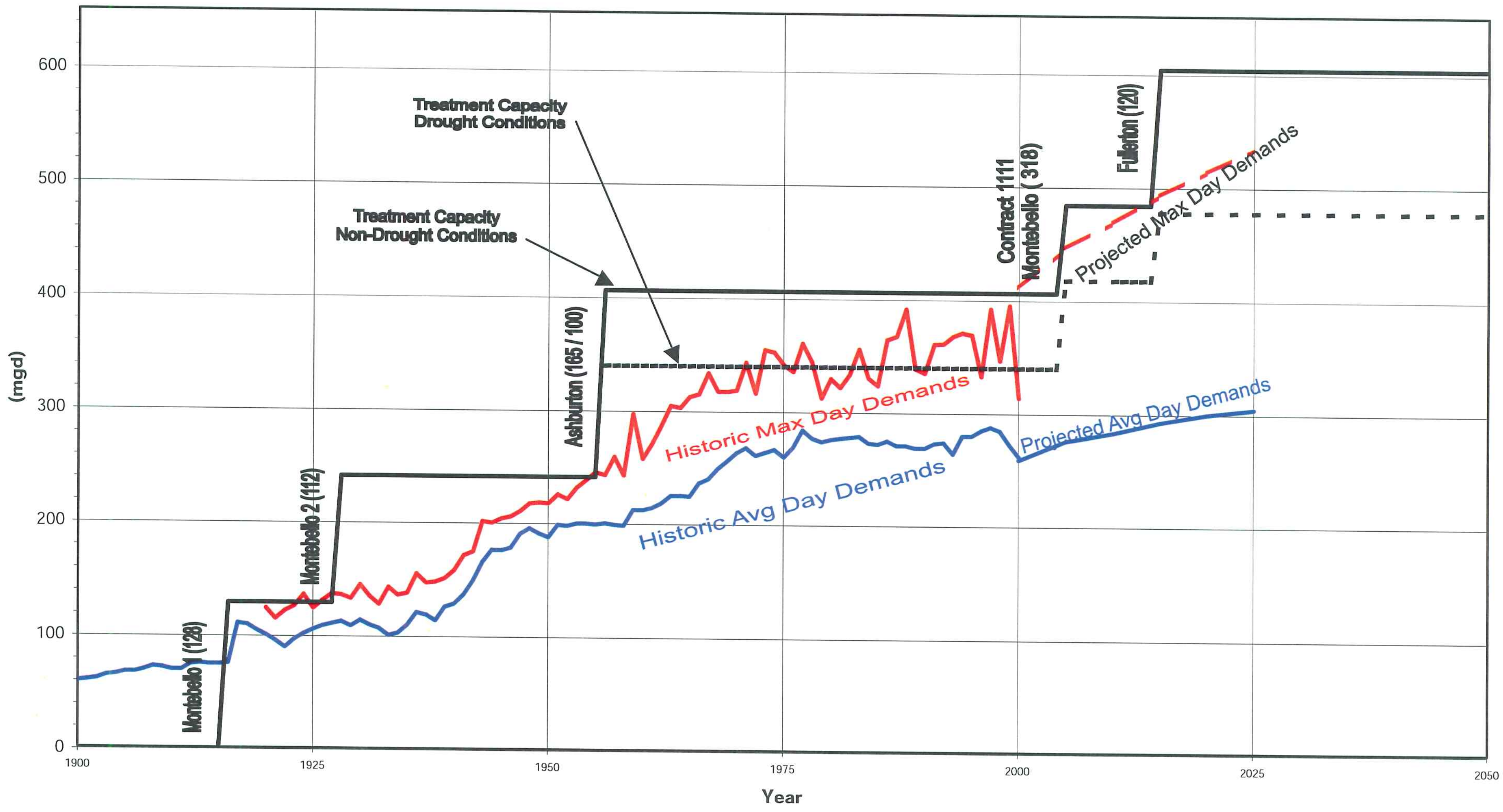
POPULATION				
		1989 Central System Report	**Project 658**	**% Difference**
Year 2000	City County	757,400 723,940	658,863 651,373	-13.0% -10.0%
Year 2025	City County	738,100 847,210	639,218 711,611	-13.4% -16.0%
Note: Project 658 year 2000 information is from actual Census data				

F. Raw Water Demands

Raw water demand is the amount of water required by the treatment plants to sufficiently serve the Central System. The supplied demands described up to now included unaccounted for water, but do not take into account water losses at the treatment plants. A percentage of the treatment plant flows are lost during the physical processes of water treatment, mainly filter backwashing, flow to drain filter operations and sedimentation basin underflows. Illustrated in Table II-12 is the total raw water demand for the Central System based on the supplied demand projections previously discussed. It was assumed that approximately seven percent of the flows are lost during the water treatment process.

Illustrated in Figure II-7 are the Central System's historical and projected demands overlaid on top of the available treatment capacity versus time. The total available raw water treatment capacity of the three existing treatment plants is currently 483 mgd. This presumes the capacity of Ashburton Filtration Plant is 165 mgd and the Baltimore City Water Contract 1111, now under design, will increase the Montebello Filtration Plant capacity to 318 mgd in the near future. Based on this capacity, the maximum day raw water demands are not expected to exceed the current available treatment capacity until the year 2015. At that time, the proposed 120 mgd Fullerton

Figure II-7, Future Raw Water Demands and Available Treatment Capacity



Treatment Plant should be on-line and the demand would be satisfied through 2025.

Table II-12, Projected Raw Water Demands

YEAR	AVERAGE DAY DEMAND		MAXIMUM DAY DEMAND	
	SUPPLIED WATER[1] (MGD)	RAW WATER[2] (MGD)	SUPPLIED WATER (MGD)	RAW WATER (MGD)
2000	241.1	258.0	385.1	412.1
2005	256.9	274.9	418.2	447.5
2010	264.0	282.5	439.1	469.8
2015	272.9	292.0	461.8	494.1
2020	279.3	298.9	480.8	514.5
2025	283.7	303.6	500.0	535.0
Saturation	418.2	447.5	739.5	791.3

1. Demands from Table II-8, Section E
2. Assumes WTP production efficiencies of 93% (7% lost due to backwashing, etc)
3. Demands include Anne Arundel County and Howard County
4. Demands exclude the raw water supply to Carroll County and Harford County
5. Supplied water includes unaccounted water

The average day raw water demands shown in Table II-12 reflect the annual average demands. Raw water demands fluctuate from month to month. Historically, the time of year peak raw water demands occur is during the summer months of June, July or August as shown in Figure II-8. However, maximum demands can occur anytime of the year due to the unpredictable nature of weather patterns and emergency scenarios.

G. Summary of Projected Demands

The demand projections for the Central System are expected to increase gradually over the next 25 years. Only a few zones are anticipated to reach their saturation limit during the planning period. Most zones will not reach saturation until well after 2050, if they continue to follow current trends. Currently, the Central System serves over 1.8 million people and supplies an average day demand of 241 mgd in Howard County, Anne Arundel County, Baltimore County and the City. The population in the City and Baltimore County is 1.3 million people and has an average day demand of

178 mgd. By zone, the population in the City and Baltimore County is expected to increase over 3% and 6%, respectively. Total demands for the Central System are expected to increase by 20% or 40 mgd with approximately half that growth expected in Howard County and almost one fourth in Anne Arundel County. If the complete saturation of the Central System is ever fully attained, the largest projected raw water demands expected on a maximum day would be approximately 791 mgd.

A summary of the projected water supply demands is shown in Table II-13. Demands are broken down by the thirteen service zones and four political jurisdictions: Baltimore City, Baltimore County, Anne Arundel County and Howard County. The year 2000, year 2015 and year 2025 demands are presented, along with land area served, population and per capita consumption information. A more detailed summary of the projected demands broken down by zone is provided in Appendix A.

The process of projecting demands is not an exact science. There are many factors that can and often do affect demand projections. Several of those keys factors which affect the outcome of demand projections are listed below:

- land zoning – affects saturation numbers
- population and per capita – directly affect demands
- zone boundaries – if expanded will increase area and population served
- economic factors – affect water usage rates
- political pressures – affect growth patterns and area served

Demand projections will always be subject to continual revision. The demands presented in this report reflect the best estimate based on the available resources available at the time of analysis.

Figure II-8, Average Monthly Raw Water Demands

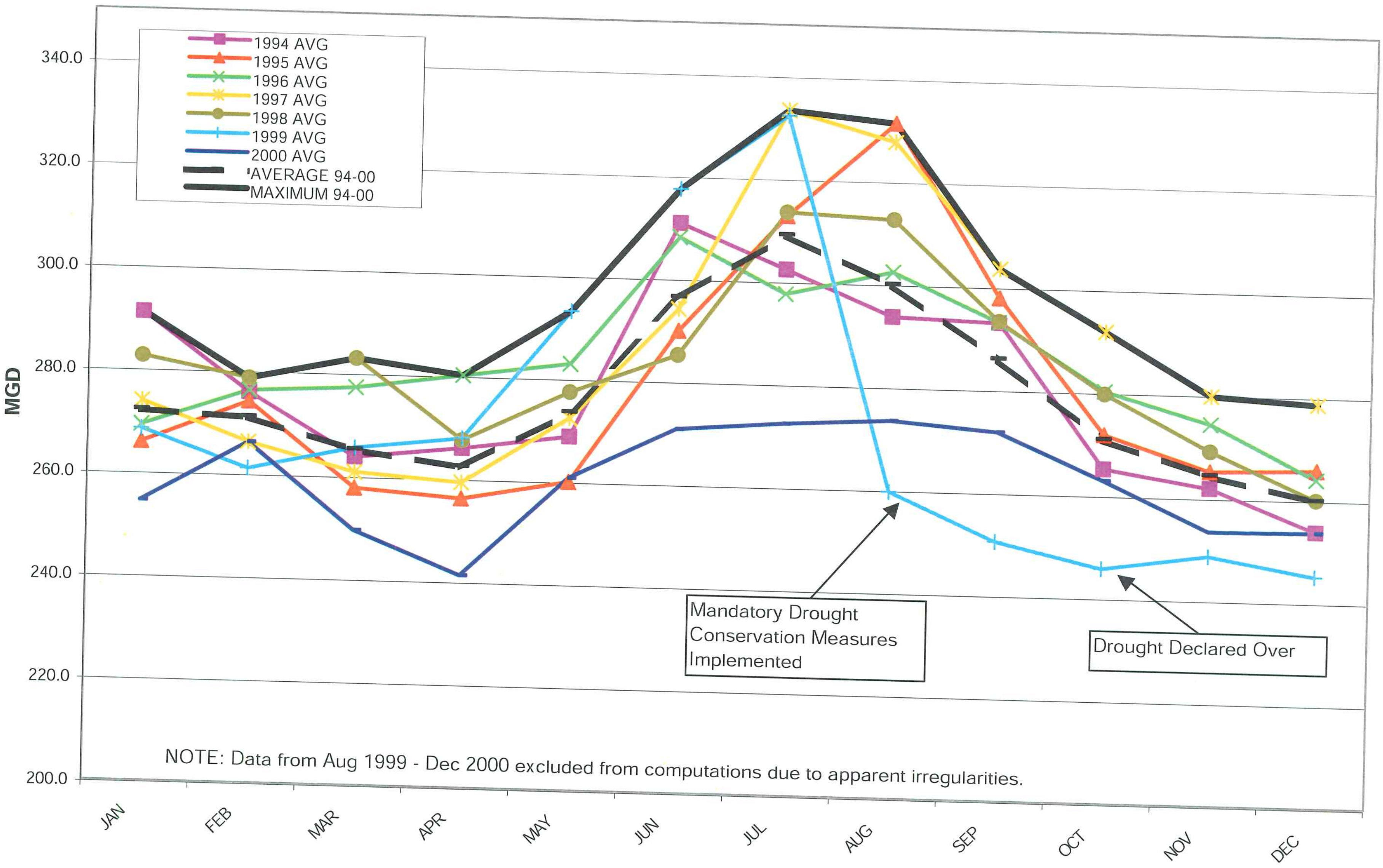


Table II-13, Filtered Water Supplied by Zone

		Year	ALL ZONES Total	FIRST ZONE BALTO. CITY	FIRST ZONE BALTO. E CO.	FIRST ZONE A.A. CO.	FIRST ZONE TOTAL	SECOND ZONE BALTO. CITY	SECOND ZONE BALTO. CO.	SECOND ZONE A.A. CO.	SECOND ZONE HOW. CO.	SECOND ZONE TOTAL	COLGATE 2ND ZONE CITY	COLGATE 2ND ZONE BALTO. E CO.	COLGATE 2ND ZONE TOTAL
LAND AREA SERVED (sq. mi.)		2000	291.14	27.23	55.26		82.49	21.25	29.74			50.99	0.02	0.86	0.88
		2015	298.29	27.23	56.92		84.16	21.25	29.79			51.04	0.02	0.86	0.88
		2025	302.74	27.23	58.03		85.26	21.25	29.82			51.08	0.02	0.86	0.88
POPULATION		2000 [1]	1,310,236	174,251	147,486		321,737	229,068	84,983			314,051	491	7,849	8,340
		2015	1,325,502	172,757	145,201		317,958	221,191	93,093			314,284	484	7,557	8,041
		2025	1,350,829	175,989	145,036		321,025	217,812	99,085			316,897	498	7,433	7,931
PER CAPITA CONSUMPTION (GPCD)	RESIDENTIAL	2000	69	70	76		73	69	74			70	66	63	64
		2015	69	70	76		73	69	74			70	66	63	64
		2025	69	70	76		73	69	74			71	66	63	64
	TOTAL	2000	153	273	162		222	74	105			83	69	69	69
		2015	172	278	175		231	110	108			110	74	74	74
		2025	175	279	175		232	109	108			109	75	75	75
ASSUMED UNACCOUNTED FOR WATER (PERCENT)			20	15	15			25	25				15	15	
WATER SUPPLIED[2] (mgd)	AVERAGE DAY	2000	241.10	54.67	27.42	5.10	87.20	30.00	10.80	3.79	3.69	48.28	0.04	0.62	0.66
		2015	272.84	55.33	29.24	9.18	93.75	30.50	12.62	5.81	8.80	57.73	0.04	0.64	0.68
		2025	283.54	56.45	29.21	10.00	95.66	29.75	13.43	7.12	8.80	59.10	0.04	0.64	0.68
	MAXIMUM DAY	2000	385.12	84.74	42.50	7.91	135.15	49.19	17.72	6.21	6.06	79.18	0.06	0.89	0.95
		2015	461.85	97.37	51.47	16.16	165.00	52.16	21.57	9.93	13.20	96.86	0.06	0.92	0.98
		2025	500.02	106.69	55.20	17.50	179.39	52.07	23.50	12.46	13.20	101.23	0.06	0.91	0.97
	PEAK HOUR	2000	513.11	107.46	53.89	10.03	171.38	64.89	23.37	8.20	7.99	104.44	0.09	1.42	1.51
		2015	615.42	123.47	65.26	20.50	209.22	68.80	28.46	13.10	17.41	127.76	0.09	1.46	1.55
		2025	666.91	135.28	70.00	22.19	227.47	68.68	31.00	16.44	17.41	133.52	0.10	1.45	1.55

		Year	EASTERN THIRD ZONE CITY	EASTERN THIRD ZONE BALTO. E CO.	EASTERN THIRD ZONE TOTAL	WESTERN THIRD ZONE CITY	WESTERN THIRD ZONE BALTO. W CO.	WESTERN THIRD ZONE HOW. CO.	WESTERN THIRD ZONE TOTAL	CATONSVILLE FOURTH ZONE BALTO. W CO.	CATONSVILLE FOURTH ZONE TOTAL	PIKESVILLE FOURTH ZONE BALTO. W CO.	PIKESVILLE FOURTH ZONE TOTAL	TOWSON FOURTH ZONE CITY	TOWSON FOURTH ZONE BALTO. E CO.	TOWSON FOURTH ZONE TOTAL	FI BAL E C
LAND AREA SERVED (sq. mi.)		2000	14.34	21.34	35.68	18.33	17.23		35.57	15.26	15.26	26.29	26.29	0.33	28.20	28.53	1.
		2015	14.34	22.15	36.49	18.33	18.03		36.36	15.33	15.33	27.32	27.32	0.33	29.34	29.66	1.
		2025	14.34	22.68	37.03	18.33	18.56		36.90	15.37	15.37	28.01	28.01	0.33	30.09	30.42	1.
POPULATION		2000 [1]	116,045	85,730	201,774	137,536	69,156		206,692	44,766	44,766	75,452	75,452	1,472	87,458	88,930	4,8
		2015	111,158	94,670	205,828	133,099	70,646		203,745	44,641	44,641	87,898	87,898	1,438	87,334	88,772	5,2
		2025	110,018	101,360	211,377	133,469	71,848		205,317	44,756	44,756	96,616	96,616	1,432	87,019	88,451	5,6
PER CAPITA CONSUMPTION (GPCD)	RESIDENTIAL	2000	54	78	64	57	72		62	98	98	80	80	80	87	87	6
		2015	54	78	65	57	72		62	98	98	80	80	80	87	87	6
		2025	54	78	65	57	72		62	98	98	80	80	80	87	87	6
	TOTAL	2000	91	98	94	103	107		104	142	142	124	124	141	141	141	9
		2015	96	102	98	105	111		107	149	149	128	128	147	147	147	10
		2025	96	105	100	104	111		106	154	154	128	128	147	147	147	10
ASSUMED UNACCOUNTED FOR WATER (PERCENT)			20	20		20	20			20		15		20	20		2
WATER SUPPLIED[2] (mgd)	AVERAGE DAY	2000	12.70	10.05	22.75	17.01	8.84	16.83	42.68	7.64	7.64	10.73	10.73	0.25	14.80	15.05	0.6
		2015	12.75	11.56	24.31	16.69	9.39	26.01	52.09	7.99	7.99	12.92	12.92	0.25	15.45	15.70	0.7
		2025	12.62	12.78	25.40	16.64	9.55	29.70	55.89	8.30	8.30	14.20	14.20	0.25	15.39	15.64	0.7
	MAXIMUM DAY	2000	20.83	16.48	37.31	23.30	12.11	29.80	65.21	12.23	12.23	18.46	18.46	0.42	24.72	25.14	1.2
		2015	22.19	20.11	42.30	23.37	13.14	42.22	78.73	12.79	12.79	23.26	23.26	0.43	25.95	26.38	1.6
		2025	22.97	23.25	46.23	23.63	13.56	50.50	87.69	13.28	13.28	26.41	26.41	0.43	26.01	26.44	1.9
	PEAK HOUR	2000	27.72	21.94	49.66	31.02	16.12	39.66	86.80	18.68	18.68	26.66	26.66	0.58	34.24	34.81	2.0
		2015	29.54	26.77	56.31	31.11	17.49	56.19	104.79	19.54	19.54	33.58	33.58	0.59	35.94	36.53	2.7
		2025	30.58	30.95	61.53	31.45	18.04	67.22	116.71	20.28	20.28	38.14	38.14	0.59	36.03	36.62	3.2

1. Data based on Year 2000 Census results
2. Water supplied includes unaccounted and lost water, unaccounted water rate not applied to Anne Arundel County and Howard County demands because these demands already include unaccounted water

A.A. CO. - ANNE ARUNDEL COUNTY
HOW. CO. - HOWARD COUNTY

III. DISTRIBUTION STORAGE

A. Description of Existing Storage

The Baltimore Central System currently contains 28 storage facilities. At the time of this report, two additional facilities are under design, Fullerton Reservoir and Owings Mills Reservoir, and three more are already proposed for the future, Chapel Hill Tank, Catonsville Reservoir 2 and Bond Avenue Tank. Of the existing 28 storage facilities, 14 are considered ground level storage and six of those 14 are currently open finished water reservoirs. Plans to replace and cover the Pikesville Reservoir are underway. Combined, these storage facilities provide over 420 million gallons of storage to the Central System. Information regarding all the storage facilities is presented in Table III-1 and their locations are depicted on Figure III-1.

B. Recommended Storage Criteria

Storage in water distribution systems is generally divided into three components for analysis purposes. The three components are equalization, fire and emergency storage. Each component serves a distinct purpose. Accordingly, each component is determined independently for each zone of the Central System based upon a combination of engineering standards and local conditions.

The methodology followed for establishing the recommended total storage volumes for each pressure zone is based on the sum of equalization storage and the larger of either fire or emergency storage. The reasoning for including the larger of fire or emergency storage rather than both together is because the probability of a fire and major system emergency occurring on the same day is remote. A discussion of equalization, fire and emergency storage and the criteria used to determine each of these components for the Central System is provided below.

1. *Equalization Storage*

Equalization storage is the volume of water necessary to meet demands in excess of the zonal supply capacity. Water usage rates and consumption patterns in a distribution system vary continuously throughout the day. Supply output from pumping stations and treatment plants, however, are generally limited to a more constant rate due to mechanical and

Table III-1, Storage Facility Summary

Facility	Zone	Type	Usable Storage (mg)
Curtis Bay Tank	First	Ground Level	3.70
Fullerton Reservoir (future)	First	Ground Level	32.0
Montebello Plant Reservoir 1	First	Ground Level	4.55
Montebello Plant Reservoir 2	First	Open Reservoir	10.9
Druid Lake	First	Open Reservoir	218.5
Chapel Hill Tank (proposed)	Second	Elevated	-
Perry Hall Tank	Second	Elevated	1.00
Lake Ashburton	Second	Open Reservoir	70.4
Guilford Reservoir	Second	Open Reservoir	6.5
Colgate Tank	Colgate Second	Elevated	0.30
Towson Reservoir	Eastern Third	Open Reservoir	9.0
Catonsville Reservoir 1	Western Third	Ground Level	17.9
Catonsville Reservoir 2 (proposed)	Western Third	Ground Level	-
Melvin Avenue Tank	Western Third	Ground Level	2.10
Pikesville Reservoir	Western Third	Open Reservoir	17.4
Dorchester Avenue Tank	Catonsville Fourth	Elevated	1.00
Rolling Road Tank	Catonsville Fourth	Elevated	1.50
Deer Park Tank	Pikesville Fourth	Elevated	1.00
Owings Mills Reservoir (future)	Pikesville Fourth	Ground Level*	2.80
Pleasant Hill Tank 1	Pikesville Fourth	Elevated	0.30
Pleasant Hill Tank 2	Pikesville Fourth	Elevated	1.00
Randallstown Tank	Pikesville Fourth	Elevated	0.30
Cub Hill Tank	Towson Fourth	Elevated	1.00
Mays Chapel Reservoir	Towson Fourth	Covered Resevoir	11.0
Stratford Tank	Towson Fourth	Elevated	1.00
Falls Tank	Falls Fifth	Elevated	0.50
Springdale Tank	Pot Springs Fifth	Elevated	1.00
Spring Lake Tank	Pot Springs Fifth	Elevated	0.40
Bond Avenue Tank (proposed)	Reisterstown Fifth	Elevated	-
Chartley Tank	Reisterstown Fifth	Elevated	1.00
Reisterstown Tank	Reisterstown Fifth	Elevated	0.30
Sherwood Tank	Sherwood Fifth	Elevated	0.25
Sparks Tank	Sparks Fifth	Elevated	1.00

* Not considered ground storage when evaluating emergency storage

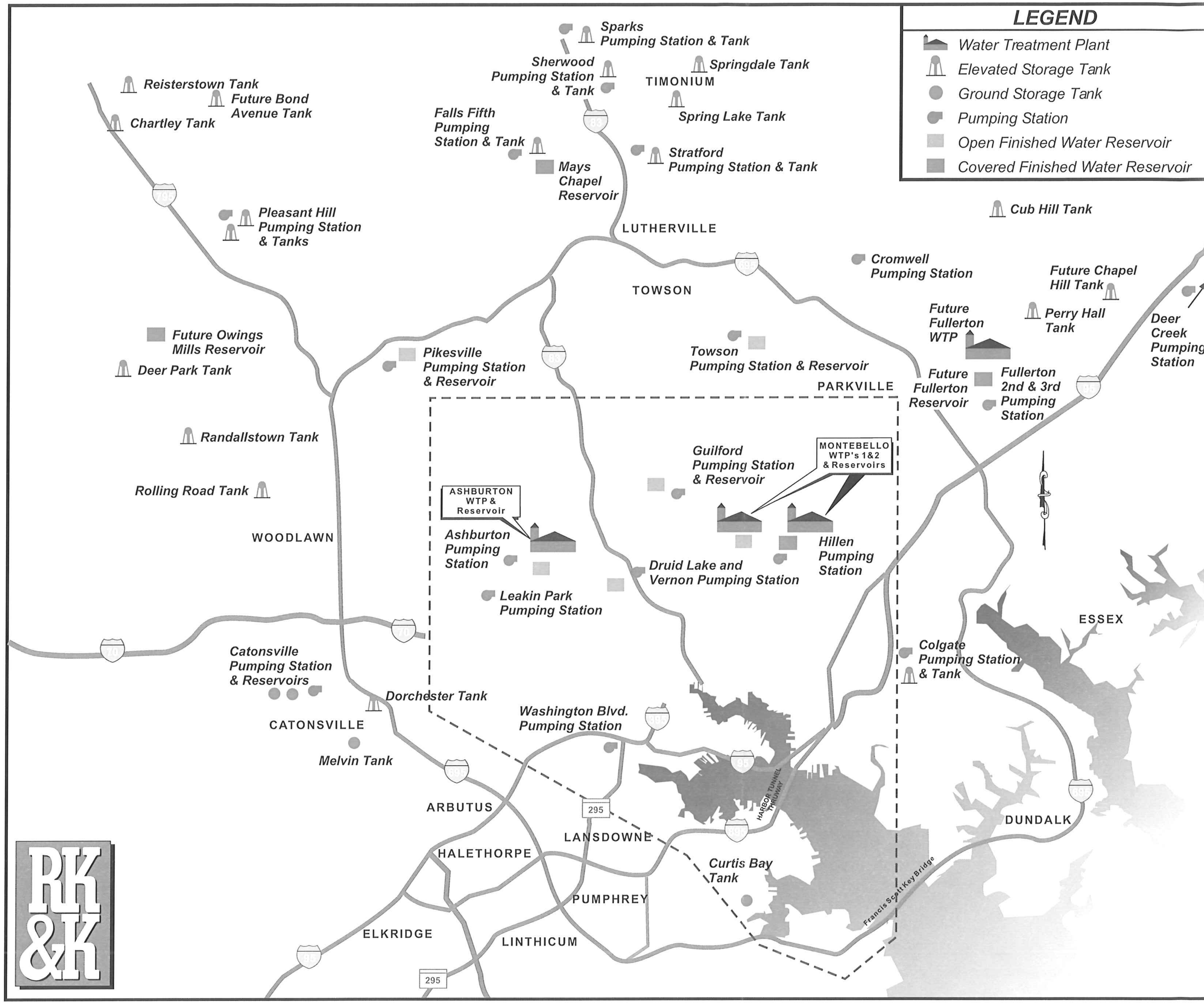
operational considerations. Equalization storage, in other words, "shaves" the peaks and "fills" the valley of the daily diurnal demand patterns thereby allowing a relatively constant supply of water from the pumping stations and treatment plants. The total storage available in a specific pressure zone should be at least be equal to the volume necessary to equalize variations in normal consumer demand.

Assuming constant supply, required equalization storage generally ranges from approximately 10 to 25 percent of the maximum daily demand and can account for up to one-half of the total storage required. In several cases, such as the Pot Springs and Reisterstown Fifth Zones, equalization storage exceeds half the total storage required. Heavy industrial areas require less equalization storage while residential areas require more. Quantities of lost water due to leakage will also effect equalization requirements. As such, each community has a unique diurnal pattern that must be determined based on a review of record flow data.

Each of the Central System's 13-pressure zones was analyzed separately to determine the equalization storage volumes necessary within each zone assuming constant supply to the zones. It is noted that more or less equalization storage may be necessary if alternative supply strategies are employed such as pumping only during off-peak hours or varying pumping rates to match hourly demands. From a capital cost perspective, constant pumping is generally the most economical approach.

Equalization volumes for each zone are based on the computed maximum day diurnal patterns described in *Section II D.3. Diurnal Patterns and Peaking Factors.* By integrating the area between the diurnal demand curve and the average demand line (unity demand factor), equalization volume expressed as a percentage of total maximum day demand is determined. This point is best illustrated in Figure III-2, which shows the maximum day diurnal pattern for the Reisterstown Fifth Zone and the area representing necessary equalization storage.

Presented in Table III-2 below are the computed equalization percentages as well as the recommended percentages used in calculating recommended equalization storage for each of the 13 pressure zones. Overall, the computed equalization storage percentages for each of the zones are very low in comparison to expected range of 10 to 25 percent. In each case, the computed equalization percentage was rounded upward by typically a small amount to arrive at



BALTIMORE CITY PROJECT 658
CENTRAL SYSTEM REPORT

LOCATION OF STORAGE FACILITIES

March 2003 Figure III-1

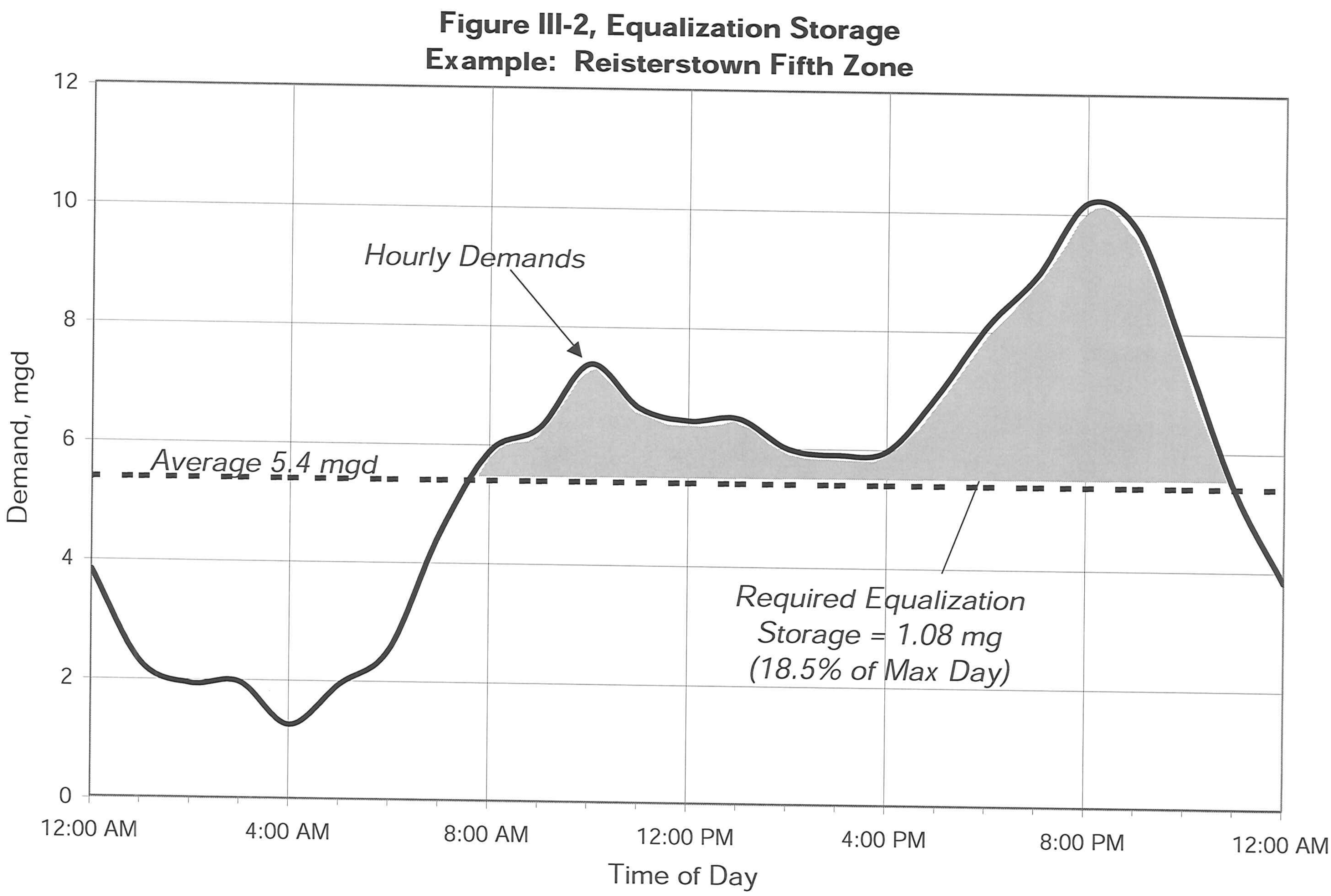


Figure III-2, Equalization Storage
Example: Reisterstown Fifth Zone
Hourly Demands
Average 5.4 mgd
Required Equalization
Storage = 1.08 mg
(18.5% of Max Day)
Demand, mgd
Time of Day
0
2
4
6
8
10
12
12:00 AM
4:00 AM
8:00 AM
12:00 PM
4:00 PM
8:00 PM
12:00 AM

a recommended equalization criterion that accounted for discrepancies in the source data and possible future variations in demand patterns. As discussed below, recommended criteria for certain zones however, were increased rather significantly due to suspected inconsistencies in the computed results and existing zonal development.

Table III-2, Equalization Storage

	Required Equalization Storage (Expressed as % of Maximum Day Demand)	
Zone	**Computed**	**Recommended**
First	11.1	12.5
Second	12.0	15.0
Colgate Second	14.4	20.0
Eastern Third	10.4	15.0
Western Third	10.3	15.0
Catonsville Fourth	15.9	20.0
Pikesville Fourth	13.3	20.0
Towson Fourth	12.6	15.0
Falls Fifth	19.0	20.0
Pot Springs Fifth	13.5	20.0
Reisterstown Fifth	18.5	20.0
Sherwood Fifth	13.5	20.0
Sparks Fifth	7.1	20.0

As mentioned previously, zones with higher levels of industrial development are expected to have less equalization storage requirements than zones with mostly commercial and residential development. Despite a few exceptions, the computed equalization percentages for most of the zones seem to be consistent with the types of development in each. Surprisingly though, the Sparks Fifth Zone had by far the lowest computed equalization requirement of all the zones. Although the Sparks Fifth Zone is characterized by a relatively high level of industrial development, a computed equalization requirement of 7.1 percent is extremely low by any standard. Zonal leakage does not appear to be a factor because the average unaccounted-for-water of the Sparks Fifth Zone is measured to be approximately 15 percent, which is relatively low compared to the other Central System zones. Most likely, the unusual equalization percentage is due to poor accuracy of the telemetry data. As such, it was decided with input from the City that a recommended equalization criteria of 20 percent of maximum day demands for the Sparks Fifth Zone would be more reasonable. A similar explanation is also applied for the Colgate Second, Pikesville Fourth, Sherwood Fifth and Pot Springs Fifth Zones to justify their large discrepancies between computed and recommended equalization percentages.

Another method for determining the equalization storage, which yields similar results to those in Table III-2, is presented below. This methodology was developed by the Water Analyzer Office.

Supply Zones w/Multiple Treatment Plants	12.5% of Maximum Day
Remaining Zones with Ground Storage	15% of Maximum Day
All Other Zones	20% of Maximum Day

2. Fire Storage

Fire reserve storage is provided to enable the system to supply adequate fire flows in addition to normal system demands. The fire reserve storage is typically utilized infrequently but is critical to public safety and the operation of the system. It serves as a constantly available source of water to meet the high localized demand, short duration characteristics of fire flows, while allowing the supply facilities to operate at relatively constant rates. It is important that fire reserve storage be distributed among the storage tanks in the zone in relation to each tank's zone of influence.

In lieu of providing fire reserve, larger transmission mains and greater zonal supply capacity can be provided instead, as is the case with the larger Central System zones where the rate of fire flow needed is only a tiny fraction of the maximum daily demands of the zone. This same approach can also be applied to the smaller zones but the relative cost of providing greater supply and transmission capacity is generally much more significant.

The recommended method for establishing fire storage volumes is based on a fixed set of fire flow rates and durations for each zone. The fire flow rates and durations used in the analyses closely resemble those previously established under the 1956 Geyer Wolff Report but were revised somewhat to reflect the guidelines of the American Water Works Association (AWWA) Manual M31, Distribution System Requirements for Fire Protection and to address the various concerns expressed by the Analyzers Office. Listed in Table III-3 above is the recommended fire storage criterion for each zone.

Table III-3, Recommended Fire Reserve Storage

Zone	Needed Fire Flow (gpm)	Duration (Hours)	Recommended Fire Storage (MG)
First	12000	10	7.2
Second	12000	10	7.2
Colgate Second	2500	2	0.3
Eastern Third	9000	9	4.9
Western Third	9000	9	4.9
Catonsville Fourth	5000	5	1.5
Pikesville Fourth	6000	6	2.2
Towson Fourth	6000	6	2.2
Falls Fifth	2500	2	0.3
Pot Springs Fifth	2500	2	0.3
Reisterstown Fifth	4000	4	1.0
Sherwood Fifth	2500	2	0.3
Sparks Fifth	2500	2	0.3

Another method for determining the fire storage, which yields similar results, is presented below. The Water Analyzer Office also developed this methodology. It allows for fire storage to be adjusted based on future variations in zonal demand. Fire storage is based on the following criteria, where demand does not include Howard or Anne Arundel County demands:

Zonal Demand $\geq$ 30 mgd	25% of Average Day
30 mgd Zonal Demand $\underline{>/=}$ 15 mgd	20% of Average Day
Demand < 15 mgd	15% of Average Day

The value calculated above is then rounded up to the nearest volume value in Table III-4 and this volume is used for the recommended storage. Flow rate and duration are included for information purposes only.

Table III-4, Water Analyzer Office Fire Storage

VOLUME	FIRE FLOW RATE		DURATION
(mg)	(gpm)	(mgd)	(hrs)
0.3	2500	3.60	2
0.5	3000	4.32	3
1.0	4000	5.76	4
1.5	5000	7.20	5
2.2	6000	8.64	6
2.9	7000	10.08	7
3.8	8000	11.52	8
4.9	9000	12.96	9
6.0	10000	14.40	10
7.2	12000	17.28	10

3. *Emergency Storage*

Emergency storage is the portion of the total storage that is held in reserve to supply the system during emergencies other than fire. Emergency storage can be considered as a factor of safety against system disruptions such as main failures, power outages and short-term loss of supply. More storage is not always better, however, because of competing demands with water quality. Greater amounts of storage increase overall detention times in the system thereby increasing the opportunity for bacterial regrowth, inadequate mixing and disinfection by-product formation. A balance between water quality and system reliability should be maintained when establishing recommended emergency storage criteria.

Recommended emergency storage criteria for the various zones of the Central System were developed following extensive discussions with the Water Analyzers Office. The emergency storage criteria are based on maintaining a desired minimum level of service or system performance during certain possible emergency scenarios. A listing of the emergency scenarios and the desired level of service to be maintained are provided below in Table III-5.

Table III-5, Emergency Scenarios

Emergency Scenario	Desired Level of Service
Complete loss of supply from either the Montebello, Ashburton or proposed Fullerton WTP.	Provide reserve storage to meet average demands of the First Zone and Second Zone for minimum of 24 hours. Scenario assumes that upper dependent zones will rely on their own emergency storage or be supplied in whole or in part from other operating WTP.
Complete loss of supply to zone caused by failure or shutdown of one or more pumping stations.	For zones having ground storage: provide reserve storage to meet average demands for minimum of 12 hours. For zones with no ground storage: provide reserve storage to meet average demands for a minimum of 6 hours. Scenario assumes that upper dependent zone(s) will rely on their own emergency storage for supply.
Major main break equivalent to spillage of 30,000 gpm for two-hour period. (36" pipe free flowing at 10 fps)	For zones having ground storage: provide minimum reserve storage equivalent to 3.6 MG to maintain supply during major main break.

The most likely emergency scenarios are failure at a pumping station or failure at the treatment plant. Of these two types of events, generally, loss of supply from a treatment plant is far more devastating. Pumping station failures, though more common, generally can be repaired or overcome relatively quickly - usually in a few hours or so.

On the other hand, a catastrophic failure at one of the City's WTP's could have far-reaching and much more devastating consequences. Based on the 2000 census data, 48.6 percent of the Central System population is located in the First and Second Zones. Fortunately, emergencies requiring partial or total disruption of supply from a treatment plant are extremely rare and there is no record of past unplanned occurrences when the City has had to completely halt operations at either Ashburton or Montebello Filtration Plants. Regardless, one possible scenario would be the collapse or failure of the raw water tunnel supplying the Montebello Plants. It is reasonable and prudent to desire the highest degree of reliability in the zones from which all others are supplied, i.e. the raw water supply zones.

In response to achieving the desired performance standards under the above listed emergency scenarios, the following recommended criteria for establishing emergency storage volumes are provided:

		Zones
Supply Zones w/ Treatment Plants	100 % of Average Day	1, 2
Remaining Zones w/ ex. Ground Storage	50 % of Average Day	3E, 3W, 4T
All Other Zones	25 % of Average Day	2C, 4C, 4P 5F, 5P, 5R 5W, 5S

4. *Summary of Total Storage Recommended for Each Zone*

Presented on the next page in Table III-6 and III-7 is a summary of the total storage recommended for each zone under year 2000 and 2025 demand conditions respectively.

First Zone

The First Zone currently has over 237 mg of storage capacity located in four storage facilities, with a 32-mg storage facility at the Fullerton site presently under design. Based on the data in Tables III-6 and III-7, the First Zone appears to have a very significant surplus in necessary storage. This is due to the extreme size of Druid Lake, which has a usable capacity of 218.5 mg between elevations 215 – 200 and an additional 150 mg of dead storage below elevation 200. The useable capacity of Druid Lake is typically less depending on the hydraulic gradient of the Montebello Filtration Plant which affects the level in the lake. An elevation of 210 feet in the Lake results in approximately 75 mg less storage capacity. It is noted that Druid Lake was constructed in the 1880s for the purpose of retaining raw water storage from the Jones Falls so that the intake at Lake Roland could be turned-off during periods of high stream turbidities. Druid Lake was converted to a finished water reservoir around 1915 after the completion of the Montebello Filtration Plant.

Table III-6, Storage Requirements, Year 2000

Zone	Max Day (mgd)	Avg Day (mgd)	Equal. (mg)	Fire (mg)	Emerg. (mg)	Required Storage (mg)	Current Storage (mg)	Balance Surplus (+) Deficit (-)
1	118.56	76.49	14.82	7.2	76.49*	91.31	237.7	146.39
2	65.80	40.12	9.87	7.2	40.12*	49.99	71.4	21.41
2C	0.82	0.58	0.16	0.3*	0.2	0.46	0.30	-0.16
3E	31.1	18.96	4.67	4.9	9.48*	14.15	9.0	-5.15
3W	59.31	38.37	8.90	4.9	19.19*	28.09	37.4	9.31
4C	10.19	6.37	2.04	1.5	1.59*	3.63	2.51	-1.12
4T	20.95	12.54	3.14	2.2	6.27*	9.41	13.0	3.59
4P	16.05	9.33	3.21	2.2	2.33*	5.54	5.4	-0.14
5F	1.00	0.48	0.20	0.3*	0.12	0.50	0.50	0.00
5P	2.38	1.19	0.48	0.3	0.30*	0.78	1.40	0.62
5R	5.40	3.10	1.08	1.0*	0.78	2.08	1.31	-0.77
5W	0.09	0.05	0.02	0.3*	0.013	0.32	0.25	-0.07
5S	0.80	0.31	0.16	0.3*	0.078	0.46	1.00	0.54
Total		207.89				206.72		

Table III-7, Storage Requirements, Year 2025

Zone	Max Day (mgd)	Avg Day (mgd)	Equal. (mg)	Fire (mg)	Emerg. (mg)	Required Storage (mg)	Current Storage (mg)	Balance Surplus (+) Deficit (-)
1	158.28	84.49	19.79	7.2	84.49*	104.28	269.7	165.42
2	86.14	50.48	12.92	7.2	50.48*	63.40	71.4	8.00
2C	0.85	0.59	0.17	0.3*	0.2	0.47	0.30	-0.17
3E	38.52	21.17	5.78	4.9	10.59*	16.37	9.0	-7.37
3W	81.50	51.53	12.23	4.9	25.77*	38.0	37.4	-0.60
4C	11.06	6.91	2.21	1.5	1.73*	3.94	2.51	-1.43
4T	22.06	13.05	3.31	2.2	6.53*	9.84	13.0	3.16
4P	22.97	12.35	4.59	2.2	3.09*	7.68	5.4	-2.28
5F	1.59	0.61	0.32	0.3*	0.15	0.62	0.50	-0.12
5P	2.81	1.39	0.56	0.3	0.35*	0.91	1.40	0.49
5R	9.60	4.78	1.92	1.0	1.20*	3.12	1.31	-1.81
5W	0.13	0.06	0.03	0.3*	0.015	0.33	0.25	-0.08
5S	1.28	0.43	0.26	0.3*	0.11	0.56	1.00	0.44
Total		247.97				249.52		

* Denotes larger component of fire and emergency storage used in total

Including the proposed Fullerton Reservoir, 81 percent of the total storage in the First Zone is currently located in Druid Lake. The primary problem with having such a significant amount of storage situated at one location is that water quality problems can arise due to long turnover times. Plug flow detention times in the reservoir range from three to almost ten days depending on water level and pumpage at Vernon Pumping Station. Loss of chlorine residual and algal growth is a common occurrence during the summer months. More importantly, the large storage volumes in Druid Lake only provide limited benefit because its location is hydraulically too remote from the eastern and southern portions of the First Zone to equalize demands or to provide supply to the rest of the zone during emergencies. Despite the significant storage at Druid Lake, this facility is not capable of maintaining service to the zone in the event of total loss of supply at Montebello Filtration Plant. Under this emergency scenario, portions of the First Zone would lose water pressure after only a few hours.

Another major problem with storage in the First Zone is that both Druid Lake and the Montebello Plant Reservoir 2 are uncovered facilities. There is pending federal legislation that will likely require that these facilities be covered, replaced or additional treatment provided. Greater discussion on this topic is provided in later sections of this report.

In light of the current operational problems and limitations associated with Druid Lake, and the pending federal legislation that will likely require open finished water reservoirs to be covered, the City should initiate a study to investigate alternative possibilities for replacing the storage at Druid Lake. Based on year 2025 storage requirements, approximately 53 mg of additional storage would be needed if Druid Lake were eliminated from the system. The City should also consider a capital project to cover the Montebello Plant Reservoir 2.

<u>Second Zone</u>

The Second Zone currently has three storage facilities. Both Lake Ashburton and Guilford Reservoir are considered ground storage facilities. The Perry Hall Tank and Lake Ashburton have a combined usable storage capacity of 71.4 mg. Guilford Reservoir is not included in the Second Zone storage capacity due to the present overflow elevation.

A review of the storage data for the Second Zone indicates that this zone also has a surplus in available storage capacity, and like the First Zone, a large percentage of the available storage is located in a single open finished water reservoir. Excluding Guilford Reservoir, approximately 98 percent of the current available storage in the Second Zone is located in Ashburton Reservoir. Though not as severe, Ashburton Reservoir also faces many of the same water quality issues as Druid Lake including long detention times, loss of disinfectant residual and algal growth. The Second Zone service area is also long and narrow, which makes it difficult for Ashburton Reservoir to have any meaningful hydraulic benefit to distant portions of the zone east of Hillen Road. Ashburton Reservoir, similar to Druid Lake, would be difficult to cover because of its large size, shape and aesthetic value to the surrounding community. The City should include Ashburton Reservoir, along with Druid Lake, in a study to investigate possible solutions to either covering or replacing these facilities.

Guilford Reservoir provides no equalization storage for the Second Zone because its present overflow of 341.4 is approximately 12 feet below the normal hydraulic grade of the zone. The normal operating mode of Guilford Reservoir consists of an inlet control valve that continually opens and closes to maintain water levels between approximately 338 and 341 feet. Because Guilford Pumping Station constantly draws suction from the reservoir, water levels are continually rising and falling throughout the day with the opening and closing of the inlet control valve. The result is drastic shifts occurring in the flow patterns of the transmission mains that supply the eastern half of the zone. Another disadvantage is that filling and emptying Guilford Reservoir to supply the Guilford Pumping Station wastes almost $35,000 per year in energy costs. This cost was developed assuming that water is dropped into Guilford Reservoir and then pumped up ten feet to the normal hydraulic grade of the zone. This calculation is based on an average flow of 25 mgd through Guilford Pumping Station, with energy costs of $0.08 per kilowatt-hour and a wire-to-water efficiency of 70 percent.

In the short term, the City should modify the present control of the inlet valve to operate in a throttling mode rather than open/closed to maintain water levels in the reservoir. This will help to soften the sudden shifts in demand on the Second Zone. Long term, the City should develop a strategy to ultimately cover Guilford Reservoir and to possibly raise its present overflow to be consistent with the rest of the Second Zone. This would require raising the overflow more than ten feet, which would help equalize demands east of Hillen Road and reduce energy costs at Guilford Pumping Station by almost $35,000 per year.

Colgate Second Zone

The Colgate Second Zone currently has one storage tank with a capacity of 0.30 mg. The current recommended storage requirement for this zone is 0.46 mg, which is more than the capacity. Therefore, levels of elevated storage are projected to be adequate to meet equalization and emergency storage needs through the year 2025. However, in order to maintain the specified level of fire protection during maximum day demand conditions, an additional 170,000 gallons of storage appears to be needed. Rather than constructing an additional elevated tank, the more economical solution would be to utilize the surplus capacity in the First Zone and expand the capacity of the Colgate Pumping Station to supply projected maximum day demands plus that portion of fire flow not available in elevated storage. The City should improve the reliability of the Colgate Pumping Station by installing on-site standby power generators or redundant power feeders to the station from separate Baltimore Gas and Electric (BGE) grids to minimize supply disruption due to power failure. The design for an improvement project is currently underway at the Colgate Pumping Station which will provide connections for an emergency generator.

Eastern Third Zone

The Eastern Third Zone currently has one ground storage facility, Towson Reservoir, with a capacity of 9 mg, but the current recommended storage requirement for this zone is 14.15 mg. Therefore, the present level of storage is adequate to meet equalization plus fire demands but appears to be severely deficient in meeting the desired level of emergency service. The construction of additional storage in the zone is not recommended however, because a significant surplus in supply capacity presently exists that can be utilized to meet expected demands during emergencies. The Eastern Third Zone is presently supplied from the Guilford, Fullerton Third and Cromwell Pumping Stations. These facilities comprise a total supply capacity of approximately 122 mgd, which exceeds the year 2025 maximum day demands of the Eastern Third Zone and dependent zones by approximately 61 mgd. The loss of any one of the three pumping stations could be compensated by additional output from the remaining other two stations. This scenario presumes that adequate transmission capacity for the Fullerton Third Pumping Station discharge will be constructed and that the required storage would be available from the First and Second Zones to feed the pumping stations in the Eastern

Third Zone. It is also recommended that Towson Reservoir be covered. This topic is discussed in greater detail in a later section of this report.

Western Third Zone

The Western Third Zone currently has 37.4 mg of storage capacity located in three storage facilities and the current recommended storage requirement for this zone is 28.09 mg. Based on the information in Table III-6, this zone presently has adequate storage. To meet future growth, an additional 600,000 gallons of storage is necessary to meet year 2025 demands. The present supply capacity of the Ashburton Pumping Station and Leakin Park Pumping Station is only 124 mgd, but with the addition of two more pumps at Leakin Park Pumping Station that capacity will increase to 164 mgd. This future supply capacity exceeds the projected year 2025 maximum day demands of the Western Third Zone and dependant upper zones. In lieu of constructing the proposed Catonsville Reservoir 2, the City may wish to take advantage of this surplus supply capacity. However, the City should improve the reliability of both pumping stations in this zone by installing on-site standby generators or redundant power feeders from separate BGE grids to minimize supply disruption due to power failure. This scenario presumes that the required storage would be available from the Second Zone.

Catonsville Fourth Zone

The Catonsville Fourth Zone currently has 2.51 mg of storage capacity located in two storage tanks. The current recommended storage requirement for this zone is 3.63 mg, which exceeds the current capacity of the zone. Therefore, this zone presently has adequate storage within the zone to equalize system demands. Additional storage is necessary however, to meet the specified emergency storage criteria or fire demand. Because the capacity of the Catonsville Pumping Station currently exceeds projected year 2025 maximum day demands by approximately 9 mgd, it is recommended that the surplus supply capacity be utilized to satisfy emergency demand conditions. To ensure the reliability of Catonsville Pumping Station, the City should provide permanent on-site standby power generation or redundant power feeds to the station from separate BGE grids to minimize supply disruption due to power failure. There is currently a mobile generator on the grounds of the Catonsville Pumping Station, but this should be made permanent. This scenario presumes that required storage would be available from the Catonsville Reservoir in the Western Third Zone.

Pikesville Fourth Zone

The Pikesville Fourth Zone currently has 5.4 mg of storage capacity located in four storage tanks. A fifth storage facility, Owings Mill Reservoir, is under construction and will have a capacity of 2.80 mg. The current recommended storage requirement for this zone is 5.54 mg, which is more than the capacity of the zone. A storage deficiency of 0.1 mg exists and is expected to increase to over 2.0 mg by the year 2025. Additional storage is necessary to meet emergency demand conditions due to a main break or pump station failure. The present supply capacity of the Pikesville Pumping Stations 1 and 2 is approximately 58.7 mgd, which exceeds the projected maximum day demands of the Pikesville and dependent Reisterstown Fifth Zone by approximately 26 mgd. In lieu of constructing additional storage, the City may wish to take advantage of the surplus supply capacity by improving the reliability of the Pikesville pumping stations including the installation of on-site standby power generators or redundant power feeders from separate BGE grids to minimize supply disruption due to power failure. This scenario presumes that required storage would be available from the Pikeville Reservoir in the Western Third Zone.

Towson Fourth Zone

The Towson Fourth Zone currently has 13.0 mg of storage capacity located in three storage facilities, which is adequate to meet system demands beyond the year 2025. No additional storage is necessary through 2025.

Falls Fifth Zone

The Falls Fifth Zone currently has 0.50 mg of storage capacity located in the Falls Fifth Tank which equals the current recommended storage requirement. Therefore, storage levels are presently adequate. To meet future growth, an additional 120,000 gallons of elevated storage is necessary to meet year 2025 demands. Preferably, it is recommended that an additional 150,000 gallons of elevated storage be provided by the year 2015. In lieu of constructing additional elevated storage, the City may wish to utilize the surplus storage capacity in the Towson Fourth Zone and the excess pumping capacity of the Falls Fifth Pumping Station. This can be accomplished by improving the reliability of the Falls Fifth Pumping Station by installing on-site standby generation which is currently under design. This scenario presumes that adequate storage would be available from Mays Chapel Reservoir in the Towson Fourth Zone.

Pot Springs Fifth Zone

The Pot Springs Fifth Zone has 1.40 mg of storage capacity located in two storage tanks. The current recommended storage requirement for this zone is 0.78 mg as shown in Table III-6. This zone has adequate elevated storage to meet zonal needs through at least the year 2025. No additional storage improvements are recommended.

Reisterstown Fifth Zone

The Reisterstown Fifth Zone currently has 1.31 mg of storage capacity located in two storage tanks. A third tank, Bond Avenue, is proposed for the near future. The current level of elevated storage in this zone is adequate for equalization purposes, but significantly deficient in meeting necessary fire or emergency demands. It is recommended that the City expand the planned Bond Avenue Tank to be a 2.0 mg facility which should be completed by the year 2005.

Sherwood Fifth Zone

The Sherwood Fifth Zone currently has 0.25 mg of storage capacity located in the Sherwood Tank. The current recommended storage requirement for this zone as shown in Table III-6 is 0.32 mg, which is more than the capacity of the zone. Therefore, the present level of elevated storage is slightly deficient to meet equalization plus fire flow requirements. However, the present capacity of the Sherwood Pumping Station is approximately 1.4 mgd, which exceeds projected year 2025 maximum day demands by almost 1.0 mgd. Rather than construct additional storage, the zone should take advantage of the available surplus supply capacity to meet maximum day demands plus fire demand conditions. If additional storage is not constructed for the Sherwood Fifth Zone, steps should be taken to reinforce the reliability of the pumping station by providing on-site power generation or redundant feeders from separate BGE grid to minimize disruption. Emergency generator connections were installed when the station was built. This scenario presumes that required storage would be available from the Towson Fourth Zone.

Sparks Fifth Zone

The Sparks Fifth Zone currently has 1.0 mg of storage capacity located in the Sparks Tank. This capacity is adequate to meet projected demands to beyond the year 2025. No further improvements are recommended.

C. Uncovered Finished Water Reservoirs

The Central System presently has a total of six uncovered finished water reservoirs, although design is underway to replace the Pikesville Reservoir with two covered reservoirs. These reservoirs comprise a total combined surface area of almost 100 acres and 332.7 million gallons of usable storage. Information for each of the uncovered reservoirs is presented in Table III-8.

Table III-8, Uncovered Finished Water Reservoirs

	Reservoir	Zone	Area (sf)	Usable Storage (mg)
1	Druid Lake	First	2,221,560	218.5
2	Montebello Plant 2 Reservoir	First	238,905	10.9
3	Lake Ashburton	Second	1,132,560	70.4
4	Guilford Reservoir	Second	313,632	6.5
5	Towson Reservoir	Eastern Third	131,500	9.0
6	Pikesville Reservoir	Western Third	217,500	17.4

There is presently an ongoing initiative by the Environmental Protection Agency (EPA) to eliminate the perceived threat to public health caused by microbial contamination to open finished water reservoirs. Current federal regulations no longer allow the construction of uncovered reservoirs and in May 2002, the EPA published for public comment a proposed rule that requires all existing uncovered reservoirs to be evaluated. The Long Term 2 Enhanced Surface Water Treatment Rule (LT2ESWTR) will likely require systems containing uncovered finished water reservoirs to either cover them, eliminate them, or get a waiver from the primacy state by demonstrating that the reservoirs do not pose a threat to public health. This legislation has the potential of significantly impacting the Central System's ability to maintain compliance with federal drinking water regulations. The City would have less than three years to meet these new requirements once the rule is promulgated.

Although a waiver from the Maryland Department of the Environment (MDE) is a possibility, the additional monitoring and operational hurdles required for compliance will likely be extreme, and compliance is still not guaranteed. Rather, the more prudent approach would be to initiate a program to rehabilitate those reservoirs that are conducive to being covered, and to investigate the possibility of modifying, eliminating, or replacing those reservoirs where covering is less feasible. Of the five (excluding Pikesville Reservoir) open finished water reservoirs in the system, Druid Lake and Lake Ashburton probably pose the greatest challenge to being covered because of their size, shape and aesthetic significance to the community. The remaining three reservoirs however, are much smaller and only Guilford Reservoir would require significant community involvement.

In addition, recent terrorist activities support the need to eliminate open finished water reservoirs. The cost of compliance with these regulations is expected to be significant. With the LT2ESWTR looming, the City should begin immediately to implement a program to cover or eliminate the open finished water reservoirs in the system. Due to the special difficulties anticipated with covering Druid Lake and Lake Ashburton, the City may wish to implement a separate engineering study to investigate the alternative possibilities available for addressing these facilities, including elimination and replacement of the open finished water reservoirs with more traditional storage facilities. Therefore, a plan will be in place and the City will have the opportunity to begin allocating the funds necessary.

D. Possible Storage Facility Locations

An investigation of the Central System was performed to locate possible storage facility sites in each zone, except the First and Second Zones. These two zones were not included because additional storage is not required through the year 2025. However, both of these zones have open finished water reservoirs which will need to be addressed. Possible replacement sites were not investigated because these facilities may be not be removed

Table III-9, Proposed Storage Facility Locations

ZONE	SITE	LOCATION	ADC MAP/ GRID	OWNER & PARCEL NUMBER	COMMENTS
COLGATE SECOND	Colgate Tank	End Of Simmons Avenue	36 E-13	Baltimore County Map 96, P.454, 494	Open Space Available To Add Another Tank On This Site
EASTERN THIRD	Towson Reservoir	Hillen Road & Stevenson Lane	27 E-7	City Of Baltimore Map 70, P.989	Open Space Available To Add An Elevated Tank On This Site
WESTERN THIRD	Catonsville High School	S. Rolling Road & Bloomsbury Avenue	41 E-5	Baltimore County Map 101, P.515	Area Bounded By Bloomsbury Avenue, Lurman Woodland Theater And Maintenance Building
WESTERN THIRD	Wellwood Elementary School	Smith Avenue & Lisburne Road	25 K-11	Baltimore County Map 78, P.153	Southern Part Of Site Is Undeveloped
WESTERN THIRD	Woodlawn Middle School	St. Lukes Lane & Essex Road	33 D-5	Baltimore County	Good Site, Highest Elevation Unoccupied By Buildings
CATONSVILLE FOURTH	Catonsville Park	Rolling Road At Old Frederick Road	41 B-2	Baltimore County Map 100, P.127	Southwestern Corner Is The Best Location, High Elevation
CATONSVILLE FOURTH	Hillcrest Elementary School	Frederick Road Opposite S. Rolling Road	41 C-4	Baltimore County Map 100, P.213	Northeastern Corner Is The Best Location, High Elevation
TOWSON FOURTH	Cub Hill Tank	End Of Old Harford Road	28 F-3	State Of Maryland	Open Space Available To Add Another Tank On This Site
TOWSON FOURTH	Krause Park	Old Harford Road At Malton Court	28 E-5	Baltimore County Map 71, P.829, 400	Wooded Park Land
TOWSON FOURTH	Stratford Tank	Westdale Court	19 A-10	Baltimore County Map 51, P.33, 34	Open Space Available To Add Another Tank On This Site
FALLS FIFTH	Future Mays Chapel Elementary School Site	Padonia Road Near Jenifer Road	18 D-9	Baltimore County Map 51, P.609	Out Of Zone; But Probably The Best Option Unless Another Tank Can Be Built On The Site Of Existing Falls 5th Tank, This Site Is Presently Undeveloped But Heavily Wooded

Table III-9, Proposed Storage Facility Locations, continued

ZONE	SITE	LOCATION	ADC MAP/ GRID	OWNER & PARCEL NUMBER	COMMENTS
POT SPRINGS FIFTH	Dulaney Springs Park	Old Bosley & Pot Spring Roads	19 D-7	Baltimore County Map 52, P.136, 138, 141 And 71	Best Site In This Zone, Rear Of Site Is High And Undeveloped
POT SPRINGS FIFTH	Warren Elementary School	Bosley Road & Lakespring Way	19 C-6	Baltimore County Map 52, P.108 And 120	Open Space On Eastern Edge Of Property
POT SPRINGS FIFTH	Dulaney High School	Padonia Road	19 B-9	Baltimore County Map 52, P.62	Northeastern End Of Site Could Work If Conflicts With Athletic Fields Can Be Avoided
REISTERSTOWN FIFTH	Bond Avenue Tank (Proposed)	Bond Avenue	16 F-7	Baltimore County	Consider Providing Space For A Future Second Tank During Design Of Current Proposed Tank
REISTERSTOWN FIFTH	Chartley Tank	Owings Avenue, Reisterstown	16 A-9	Baltimore County Map 48, P.603	Another Tank Could Be Built In Front Of The Existing Tank
REISTERSTOWN FIFTH	Reisterstown Tank	1st Avenue, Reisterstown	16 A-6	Baltimore County Map 48, P. 471	Consider Replacing Existing Tank With A Larger One Because Minimal Room For A Second Tank
SHERWOOD FIFTH	North Side Of Sherwood Road	Between Powers Avenue & Hollow Road	18 K-4	Maurice L. Bailey – Various Parcels Map 42, P.1, 104 & 105	These Parcels Are The Only Areas In The Zone With High Enough Elevations (Parcel 320, Lot 1 Has The Property Owner's Residence)
SPARKS FIFTH	Loveton Business Center-Lot 1	York Road	12 H-10	Merritt LVI LLC Map 34, P.47, Lot 1	Parcel Across York Road From Sparks Tank
SPARKS FIFTH	Sparks Tank	York Road	12 H-10	Baltimore County Map 34, P.313	Open Space Available To Add Another Tank On This Site

pending additional studies. Three other zones, Towson Fourth, Pot Springs Fifth and Sparks Fifth, do not require additional storage before 2025 either, but they were investigated anyway because they are much smaller zones and could possibly need additional storage eventually.

Several assumptions were made when investigating the storage locations. It was assumed that any new storage facilities would be elevated storage tanks. The additional storage requirements for most zones do not exceed 1 mg; therefore, the proposed sites can be small plots. The criteria used to investigate possible locations is listed below:

- Publicly owned land – no land acquisition required
- Open land – not much clearing required
- Adequate space – enough room for at least a 1.0 mg elevated tank
- High ground elevation – similar to other elevated storage tanks in the same zone

A summary of the proposed storage tank locations is provided in Table III-9. It was discovered that many of the zones do not have any room available for additional storage. For most zones investigated, the only location available is to build additional storage on the site of an existing storage facility. For aesthetic reasons, consideration should be given to replacing an older tank with a new larger capacity tank on the same site, instead of building a second tank, as long as there is available space on the site.

E. Recommendations

The distribution storage evaluation resulted in several recommendations to improve the existing storage and supply capacity in the Central System. The previous section presents the current and future storage problems by zone and the recommendations to resolve those problems. A summary of the recommendations is provided in Table III-10.

In addition, the City should implement a program to evaluate replacing or covering the five remaining uncovered finished water reservoirs in the system to ensure future compliance with the LT2ESWTR and minimize the threat from biological or chemical contaminants. This could be performed either through one joint project or as separate projects for each reservoir. Certain reservoirs may need elaborate investigations performed, such as Guilford Reservoir; therefore, separate projects may be more beneficial.

Table III-10, Storage Recommendations

Zone	Recommendation
First	• Cover or replace Druid Lake • Cover or replace Montebello Plant 2 Reservoir
Second	• Cover or replace Lake Ashburton • Cover or replace Guilford Reservoir and raise walls to increase overflow elevation to match other facilities in zone and modify present operating control valve to operate in a throttle mode rather than open/closed
Colgate Second	• Construct additional 170,000 gallons of elevated storage OR Expand Colgate Pumping Station and related piping and increase reliability of station by providing on-site standby generators or redundant power feeders (emergency generator connections being added)
Eastern Third	• Cover or replace Towson Reservoir
Western Third	• Cover or replace Pikesville Reservoir (currently under design) • Construct additional 600,000 gallons of storage OR Increase reliability of both pumping station by providing on-site standby generators or redundant power feeders
Catonsville Fourth	• Increase reliability of Catonsville Pumping Station by providing permanent on-site standby generators or redundant power feeders (mobile generator currently on-site)
Pikesville Fourth	• Increase reliability of Pikesville Pumping Station 1 and 2 by providing on-site standby generators or redundant power feeders
Towson Fourth	• None at this time
Falls Fifth	• By 2015, construct additional 150,000 gallons of storage OR Increase reliability of station by providing on-site standby generators (currently under design)
Pot Springs Fifth	• None at this time
Reisterstown Fifth	• By 2005, construct proposed Bond Avenue Tank with 2.0 million gallons of storage
Sherwood Fifth	• Increase reliability of Sherwood Pumping Station by providing on-site standby generators or redundant power feeders (emergency generator connections available)
Sparks Fifth	• None at this time

IV. HYDRAULIC ANALYSIS

A. Model Description

The hydraulic evaluations of the Central System were performed using the water distribution system modeling software WaterCAD by Haestad Methods. A new updated model for the Central System was created using the City's GIS database and from digitizing Baltimore County's plat maps. The updated model replaces the current KYRUN model, which is a modified version of the KYPIPE program originally developed by Dr. Wood at the University of Kentucky. The development of an updated hydraulic model allows the City to capitalize on many of the powerful features available with today's modeling software.

The updated model will provide the City with a powerful tool to analyze the Central System and proposed future improvement projects. All water mains eight inches and larger are included in the updated model, as well as four treatment plants, 21 pumping stations (two temporary pumping stations are not modeled) and 32 storage facilities. With the aid of GIS software, demands based on water meter locations and billing addresses were distributed to all the model nodes. The current and future zone boundaries were also updated. Calibration of the model was performed against pressure monitoring data obtained during testing performed for this project, and recent fire flow data provided by the Water Analyzer Office.

For the purpose of this project and the model analysis performed, a more detailed description of the model, model development and model calibration is presented in *Volume II Model Development*.

B. Performance Criteria

The development of alternatives to improve the hydraulics of the Central System are predicated on maintaining an established set of minimum system performance criteria. The criteria are only intended to be guidelines and are not necessarily absolute values. The criteria also are a benchmark used to identify system inadequacies against which the model results can be compared. Criteria for pressures, head loss gradients and fire flow residual pressures were established. In addition, tank levels and fluctuations and the net positive suction head at pumping stations were also used as a sign of system problems or deficiencies.

The established range of pressures used to evaluate the maximum day demand model scenarios are illustrated in Table IV-1. For this analysis, maximum day and peak hour demands were used because that is when the system is the most stressed and deficiencies would be apparent. In a typical system, pressures should range between 40 psi and 80 psi. The Uniform Plumbing Code requires that pressure reducing devices be provided if water pressures exceed 80 psi at the service connections. Therefore, system pressures exceeding 80 psi are not desired; however, up to 120 psi is acceptable because many locations throughout the system already experience pressures that high and they have been functioning adequately. High pressures may result in wasted water through system leaks, cause additional main breaks and waste energy. High pressures also cause customer faucets to leak and valve seats to wear out quicker. On the other hand, low pressure can cause problems as well with low water availability when multiple water devices are being used.

Table IV-1, Established Hydraulic Performance Criteria

	Maximum Day Demand Conditions		
	Average Hour	**Peak Hour**	**Fire Flow @ 1,500 gpm**
Minimum Pressures	40 psi	30 psi	20 psi
Maximum Pressures	120 psi	120 psi	N/a

The head loss gradient in pipes is also an indication of a deficient system. The head loss gradient, or friction factor, of a pipe is measured in feet of head loss per 1,000 feet of pipe length. Head loss in a pipe is caused by dissipation of energy due to the resistance of the pipe wall against the flow. Head losses will affect the flow efficiency and capacity of a pipe. Older pipes have lower efficiencies because their condition decreases over time (due to sediment deposits, encrustation, tuberculation) thus increasing the head loss. The criteria used to evaluate the head loss gradient is as follows: for pipes larger than 18 inches, the head loss gradient should be less than two feet per 1,000 feet of pipe and for pipes 18 inches and smaller, the head loss gradient should be less than four feet per 1,000 feet of pipe. This criteria will ensure that ample water can be supplied at a reasonable flow rate.

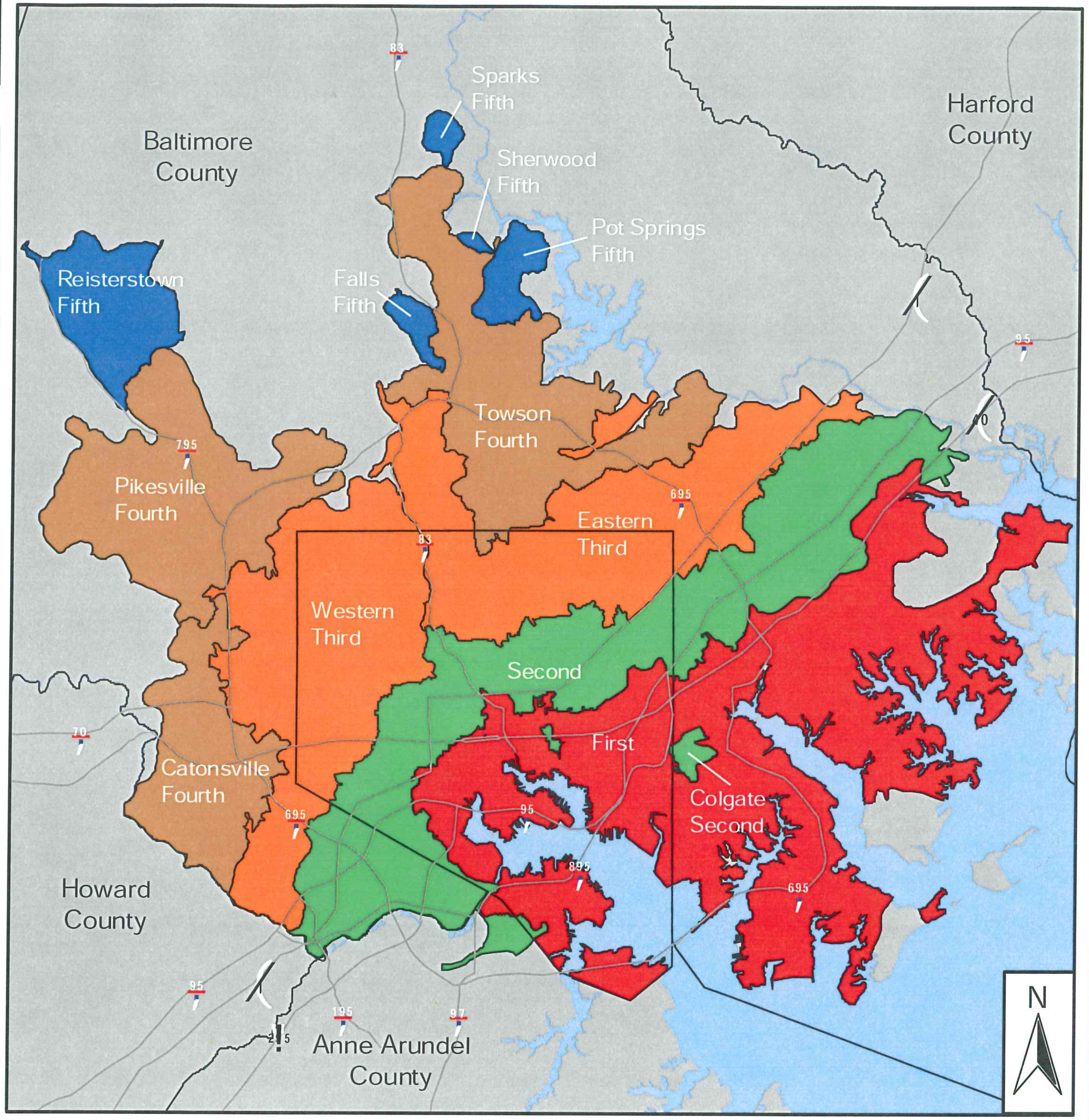
Not only does the system need to provide sufficient water on a maximum day, but also during emergencies such as fires. A fire flow analysis was performed and evaluated based on the criteria shown in Table IV-1. A standard residential fire flow of 1,500 gpm was used as the minimum required fire flow, along with a minimum residual pressure of 20 psi. The minimum pressure should be greater than 20 psi to prevent untreated water from entering the water distribution system by seepage or pipe failure. In addition, fire flow tests were evaluated to see if the recommended fire reserve storage, discussed in *Section III.B.2. Fire Storage*, could be provided.

Tank level fluctuation is also a good indication of how well the system is operating. The water levels in all elevated tanks and ground water reservoirs should fluctuate throughout the day according to variations in demand, so that the stored supply does not become stagnant and high water quality is maintained. Storage facilities were evaluated to see how much storage was utilized during a 24-hour period, using 20% of the volume as the acceptable guideline. In addition, all storage facilities should return to full, or their equivalent starting elevation, at the end of the day under maximum day demand conditions. This ensures that ample storage will be available during emergencies.

The net positive suction head (NPSH) for each pumping station was also evaluated to check system operation. If the pressure on the suction side of a pump is too low, cavitation may occur and cause pump deficiencies and impeller damage. Cavitation can also reduce the efficiency of the pump. Although the NPSH varies from pump to pump, generally pressures were checked to verify they were larger than 10 psi so there should be no threat of cavitation.

C. Zonal Analysis

Each zone in the Central System was evaluated in the hydraulic model on an individual basis. All 13 zones are illustrated on Figure IV-1, along with major roads and highways. The results of the model analysis are described in the sections below and also represented graphically in Appendix B. The recommendations for hydraulic improvements are discussed under each zone and summarized at the end of this section.



BALTIMORE CITY PROJECT 658

CENTRAL SYSTEM REPORT

ZONE BOUNDARIES

March, 2003

FIGURE IV-1

1. *First Zone*

<u>First Zone Description</u>

The First Zone system serves over 82 square miles in the tidal areas of Baltimore City and Baltimore County. The boundaries of this zone are illustrated in Figure IV-1. Two-thirds of the zone lies in Baltimore County, which is only projected to grow three additional square miles by 2025. The City portion of this zone is fully developed. The extent of the First Zone reaches the Patapsco River to the southwest, the harbor to the south and southeast, and beyond Middle River to the east. To the north and northeast, this zone is bordered by the Second Zone. The elevations in this area range from a minimum of sea level up to a maximum of 150 feet above mean sea level.

The present First Zone population is approximately 322,000 people. More than half of the people live in the City portion of the zone, which is projected to fluctuate over the next 25 years. The remaining population live in Baltimore County, which is projected to decrease slightly in the coming years and then level off. Both of these projections create a total population that waivers between 315,000 and 322,000 people over the next 25 years. The average day demand for the year 2000 was recorded at approximately 76 mgd and is projected to increase 12% to over 84 mgd by 2025. The maximum day demand is currently over 118 mgd and should exceed 158 mgd by 2025. These increases are a result of the maximum to average day ratio trend, the per capita trend for Baltimore County and also an increase in Anne Arundel County demands.

The distribution of water users is currently as follows: 33% residential, 42% commercial and 25% industrial. With industry slowly continuing to leave the City and surrounding areas, this percentage is estimated to drop over the next 25 years. Principal industrial areas in the City portion of the First Zone are located in the Locust Point, Camden, Brooklyn and Canton areas. In Baltimore County, major areas are located in the Sparrows Point and Dundalk areas. This zone also provides wholesale water to portions of northern Anne Arundel County. Approximately 7% of the total flow in the First Zone goes to Anne Arundel County. Unaccounted for water is 15% of the total flow supplied to this zone.

Until the Susquehanna River is used on a full time basis for water supply after the proposed Fullerton Treatment Plant is constructed, the First Zone will be supplied primarily by gravity flow from the Montebello Filtration Plants 1 and 2 located on Hillen Road in Baltimore City. The current raw water treatment capacity of the Montebello Plants is 240 mgd, but that will increase to 318 mgd with the completion of the current project to design a new filter building, Baltimore City Contract 1111.

Treated water leaving the treatment plants is stored in the Montebello Finished Water Reservoirs 1 and 2. Water then leaves these finished water reservoirs and is transported through three main conduits: Druid Conduit (84"), Herring Run Conduit (84") and Clifton Conduit (72"). A fourth conduit also leaves the treatment plants heading north, the old Loch Raven tunnel (120"), which provides flow to the Cromwell Pumping Station in the Eastern Third Zone. The Hillen Pumping Station also draws suction from this tunnel but closer to the treatment plants. The Clifton Conduit was originally a 108-inch main that was slip lined with a 72-inch main. This conduit flows directly south of the treatment plants and supplies the central portion of the First Zone. The Druid Conduit transports water to Druid Lake, which feeds the southwest portion of the system and provides suction for the Vernon Pumping Station in the Second Zone. The Herring Run Conduit transports water to Baltimore County and the eastern portion of the zone. It connects into the Fullerton Transmission Main, an 84- and 96-inch main, which feeds the Fullerton Second and Third Pumping Stations located on the proposed Fullerton Treatment Plant site.

The First Zone also supplies water to Anne Arundel County through four meters located near the City line. Two meters, 16-inch and 12-inch, are located in Fort Smallwood Road just south of the Baltimore beltway (Interstate 695). A 10-inch meter is located in Quarantine Road, north of the beltway. The fourth meter is a 10-inch meter located in East Ordnance Road inside the beltway near Pennington Avenue.

The First Zone presently has four storage facilities, including the two finished water reservoirs at the Montebello Filtration Plants. The four facilities provide a total of over 238 mg of usable storage to this zone. Montebello Reservoir 1, which is a covered reservoir, has a usable capacity of 4.55 mg, based on operating elevations of 210 to 215 feet. Montebello Reservoir 2 is almost three times the size of the Reservoir 1, with a usable capacity of 10.9 mg, based on the same operating range. This reservoir is an open reservoir. Both reservoirs are located on

Hillen Road near the Montebello Filtration Plants and have a maximum operating level of 215 feet, though they typically operate a few feet lower. Druid Lake by far is the largest storage facility in the entire Central System. With a usable capacity of 218.5 mg, Druid Lake contains over half the system's storage and 91% of the First Zone storage. Druid Lake has an overflow elevation of 215 feet, although this reservoir typically operates several feet lower. Druid Lake provides storage for the western portion of the zone. The fourth storage facility is the Curtis Bay Tank, one of the oldest tanks in the system. This tank has a usable capacity of 3.7 mg and an overflow elevation of almost 209 feet. Curtis Bay Tank balances storage in the area south of the inner harbor known as Curtis Bay.

A proposed fifth storage facility is currently under design at the proposed Fullerton Treatment Plant site and construction should be completed by 2004. This facility, which will be known as the Fullerton Reservoir, will have 32 mg of usable storage. Currently, the proposed overflow elevation is 225 feet; however, this reservoir will not be able to operate at that elevation until the proposed Fullerton Treatment Plant is in service. This reservoir, along with the proposed treatment plant will help balance diurnal flows in Baltimore County and the eastern portion of this zone.

Two additional transmission mains are proposed in the eastern portion of the zone to improve flows but are not currently on the Capital Improvement Projects (CIP) list. Both mains, the Pulaski Highway main (ranging from 16- to 36-inch) and the Ebenezer Road main (12-inch), are included in the hydraulic model.

First Zone Previous Reports

With respect to the First Zone, there were several areas of concern raised in the 1955 *Central System Report* by Geyer and Wolff. Three main high growth areas were identified as having supply problems: Curtis Bay, Dundalk and Locust Point. All three areas at that time had high potential for increased industrial activity. In 1955, the entire Dundalk area was only supplied by two 36-inch mains and two 16-inch mains. The Locust Point area was supplied by only two 20-inch mains. There were also limitations in the mains supplying the Curtis Bay area. Today, all three areas have improved transmission capabilities and supply is no longer a problem.

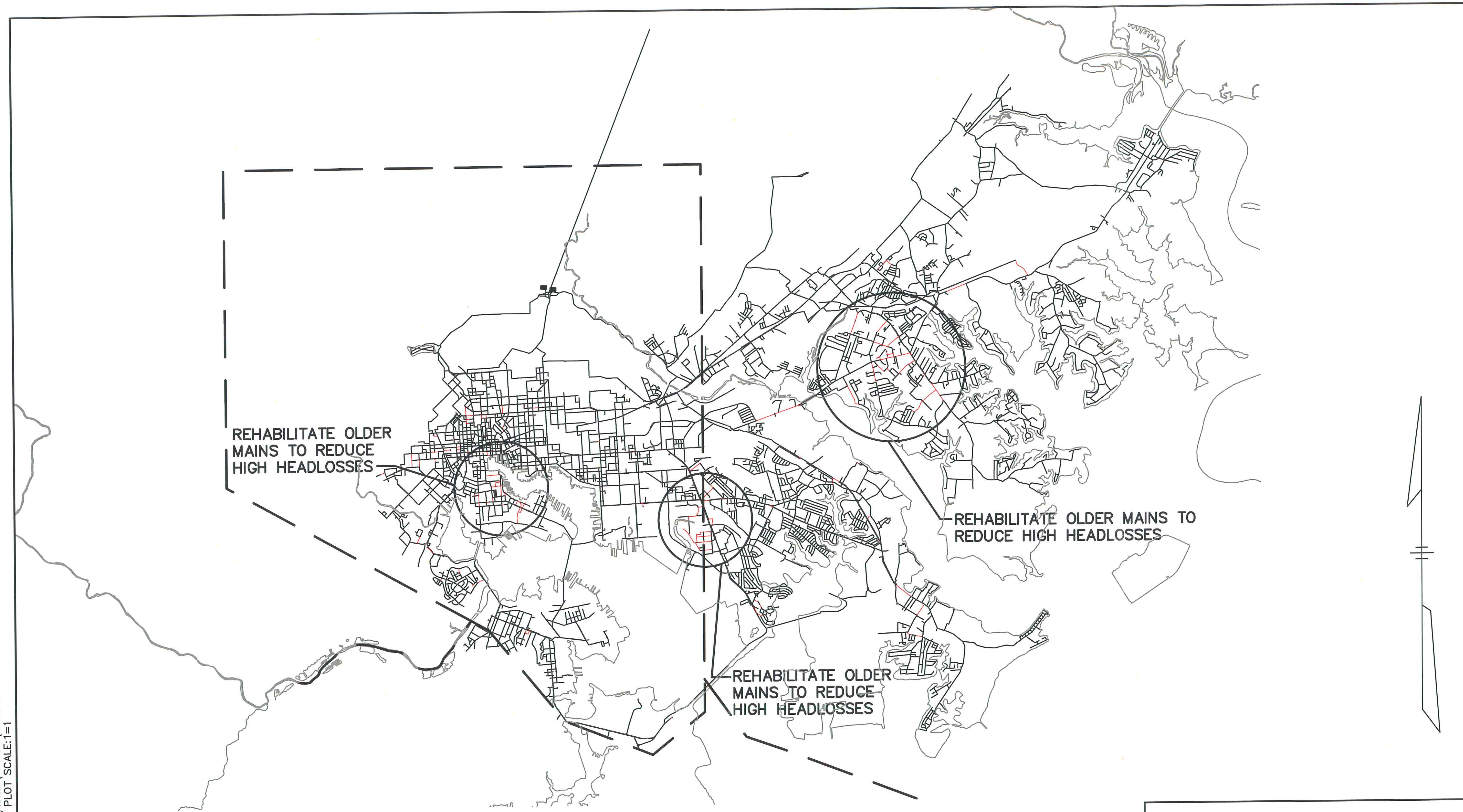
Additional improvements and major changes have been made to the First Zone since the 1955 report. In that report, the Clifton conduit was identified as having high head losses. Since then, this transmission main has been slip lined with a 72-inch pipe. At that time there was also concern that the Anne Arundel County demands would increase and cause supply problems in this zone. Instead, Anne Arundel County demands are lower than were projected because the County now provides a large percentage of their own supply from groundwater sources. Several new large mains have also been constructed to help supply a growing service area and population base, for example, the under-the-harbor main and the Fullerton Transmission main.

First Zone Model Analysis

A comprehensive evaluation of the First Zone hydraulic model was conducted to identify hydraulic deficiencies and improvement projects. The model results were compared against the performance criteria discussed above in *Section B. Performance Criteria* to determine the hydraulic condition of the zone. The analysis found pressures and head losses are not a significant problem. Treatment and storage capacity are not a problem either at the present time; however, additional treatment capacity will be required in the future. Fire flows are adequate throughout more than two-thirds of the zone, but severe problems exist on the eastern side of the zone. Mapping illustrating the hydraulic modeling results can be found in Appendix B.

The pressure range in this zone is satisfactory based on the established criteria. The pressures in this zone range from around 0 psi near the Montebello Filtration Plants and Druid Lake, up to 88 psi in the lower elevations near the water. High pressures are not a problem in this zone. Low pressures exist near the treatment plants in the northern end of the zone where there are minimal service connections. Only a few nodes, with low pressures, have possible service connections. Minimum pressures at those nodes is only 25 psi. By 2025, however, pressures drop in Cherry Hill and Brooklyn Park (Curtis Bay) areas to less than 30 psi. These areas should be rehabilitated to improve pressures.

Head loss gradients in this zone are not excessive. There are very few large pipes, greater than 18 inches, with significant head loss gradients. There are scattered smaller pipes,



1"=10,000'
10,000' 5000' 0 10,000' 20,000'

Color Coding Legend
Link: Headloss Gradient (ft/1000ft)
>= 4.00

BALTIMORE CITY PROJECT 658
CENTRAL SYSTEM REPORT

FIRST ZONE HEADLOSS GRADIENTS

MARCH, 2003

Figure IV–2

RKK2\SYS – ... \projects\49638\PHASEII\MODELING\HL1ST.DWG
07/12/2002 11:18 ENV.PCP PLOT SCALE:1=1

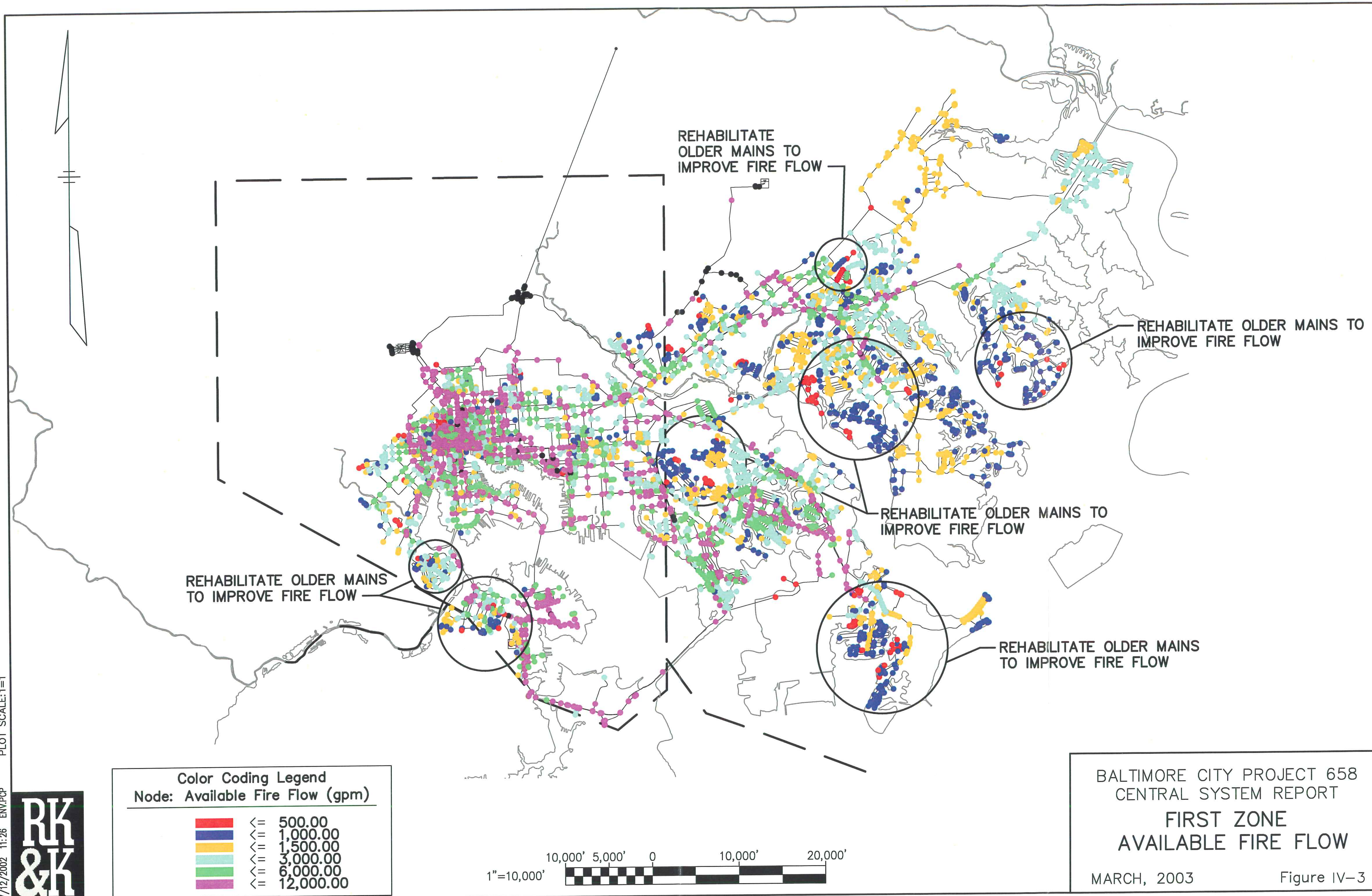
less than 18 inches, that have head loss gradients greater than the established minimum. There are three potential problem areas where high head loss gradients are concentrated in a small area. These areas, listed below, should be rehabilitated via lining to lower the head losses and are shown on Figure IV-2.

- Essex area, south of Stemmers Run Rd., near the intersection with Eastern Ave.
- West of Dundalk Avenue, south of Holabird Avenue
- Locust Point Area

The usable storage capacity is not a problem in this zone; however, the location of storage facilities and water quality are a concern. The majority of the storage capacity is in one location in this zone, Druid Lake. This does not help during times of emergency when 81% of the storage is in the western portion of the zone and hydraulically cannot be transported to the east side. Also, Druid Lake is so large that turn over rates are estimated at 7 or 8 days, which leads to possible water quality concerns. Due to pending regulations that will likely require all open finished water reservoirs to be covered in the near future, this storage facility may need to be covered or eliminated and replaced with new storage facilities. This issue is discussed further in *Section III.C. Uncovered Finished Water Reservoirs*.

The treatment capacity will be a future problem in this zone. By 2015, the projected demands will exceed the available treatment capacity as discussed in Section II and the proposed Fullerton Treatment Plant will be needed. This plant will improve the hydraulics and supply capabilities in the eastern half of the zone, primarily in the Baltimore County portion of the zone. The proposed Fullerton Treatment Plant will also provide redundancy if the Montebello Filtration Plants, or even the Ashburton Filtration Plant in the Second Zone, are out of service for repairs and construction or emergencies. The capacity and other issues regarding the proposed Fullerton Treatment Plant are discussed in further detail in Section V.

The fire flow analysis of the First Zone found large portions of the zone to be deficient. Only approximately 70% of the model nodes could supply the minimum residential fire flow of 1,500 gpm. Approximately 17% of the model nodes could meet 12,000 gpm and many of these nodes are located in the industrial areas of the City where higher flow might be required during a fire. The available fire flow for each model node, up to 12,000 gpm, is illustrated on Figure IV-3, including locations for the improvement projects recommended herein.



BALTIMORE CITY PROJECT 658
CENTRAL SYSTEM REPORT

FIRST ZONE
AVAILABLE FIRE FLOW

MARCH, 2003 Figure IV-3

RKK2\SYS - ... \projects\49638\PHASEII\MODELING\FF1.DWG
07/12/2002 11:26 ENV.PCP PLOT SCALE: 1=1

The eastern portion of this zone, primarily in Baltimore County, has severe fire flow deficiencies. With the construction of the Fullerton Reservoir, these problems should be alleviated some, but model results indicate that improvements are still needed. Several areas will require rehabilitation to increase fire flow availability. Two other low fire flow areas are located in the City. They are located in the Cherry Hill area, south of Waterview Avenue and the Brooklyn area, near the Anne Arundel County border. The mains in these small neighborhoods should be rehabilitated to increase fire flow availability and pressures as stated earlier. In Baltimore County, five areas require rehabilitation to increase fire flow availability to acceptable levels and they are:

- The Edgemere area, west of North Point State Park
- Area surrounding Dundalk Community College
- The Essex area and south of Deep Creek
- Area east of Martin State Airport, around Seneca Creek
- Area surrounding Middle River Middle School

<u>First Zone Recommendations</u>

- Construct the proposed Fullerton Treatment Plant by 2015 (this recommendation is discussed in more detail in *Section V. Fullerton Plant and Drought Conditions)*

- Rehabilitate three areas in this zone which have mains smaller than 18 inches in the Essex area south of Stemmers Run Road near the intersection with Eastern Avenue, in the area west of Dundalk Avenue and south of Holabird Avenue and in the Locust Point area

- Rehabilitate seven areas requiring improved fire flows
  - The Cherry Hill and Brooklyn areas in the City
  - The Edgemere area, west of North Point State Park
  - Area surrounding Dundalk Community College
  - The Essex area and south of Deep Creek
  - Area east of Martin State Airport, around Seneca Creek
  - Area surrounding Middle River Middle School

2. *Second Zone*

Second Zone Description

The Second Zone presently serves an area of approximately 51 square miles. This zone lies in both the City and Baltimore County, as shown in Figure IV-1. Approximately 42% of the zone is in the City, which will not increase in size. The remaining 58% is in Baltimore County, which still has a small amount of room for expansion inside the Urban Rural Demarcation Line (URDL). The projected growth within the County portion of the zone is only one tenth of a square mile by 2025. This zone is bordered by the First Zone to the south and the Third Zone to the north. It stretches from the Patapsco River (Baltimore County and Howard County line) in the west to the Little Gunpowder River in the east. Ground surface elevations in this zone range from a minimum of 18 feet near the Patapsco River in the southwest and a maximum of 285 feet near Druid Hill Park in central Baltimore City.

The current population in the Second Zone is approximately 314,000 based on the 2000 Census. The population is projected to increase by only 3,000 by 2025. Average day demand is presently just over 40 mgd, while the maximum day demand is almost 66 mgd. This amounts to 20% of the overall consumption in the Central System. Over the next 25 years, the demand is projected to increase to over 50 mgd for average day and over 86 mgd for maximum day. The majority of this increase will occur in Anne Arundel County and Howard County where demands will double. This zone currently supplies approximately 9% of its flows to Anne Arundel County and another 9% to Howard County. The distribution of demands in this zone is: 68% residential, 29% commercial and 3% industrial. This zone is primarily residential with supporting commercial districts. Unaccounted for water in this zone comprises approximately 25% of the total flow supplied, which is very high.

Demands are supplied to this zone by gravity flow from the Ashburton Filtration Plant located on Druid Park Drive and also by three pumping stations, which are all supplied by the First Zone. These pumping stations are: Vernon Pumping Station, Hillen Pumping Station and Fullerton Second Pumping Station. The Ashburton Filtration Plant has a 165 mgd raw water treatment capacity. Located on Druid Park Drive in western Baltimore City, it feeds the western portion of the Second Zone and also Lake Ashburton, Ashburton Pumping Station, Guilford Reservoir and Leakin Park Pumping Station. The Vernon Pumping Station, built in 1932, is one of the oldest pumping stations in the Central System and has a nominal capacity of 70 mgd. This station has three pumps with capacities of 30 mgd, 40 mgd and 50 mgd, respectively. There is also one empty slot for a future pump, if required. This station is located on Wyman Park Drive in the City and primarily feeds the central portion of this zone. The Hillen Pumping Station is located near the Montebello Filtration Plants on Hillen Road in the City. Recently completed in 2000, this station has five pumps, two 20-mgd pumps and three 30-mgd pumps resulting in a nominal capacity of 100 mgd. One 30-mgd pump is a standby pump. This station primarily supplements the Ashburton Filtration Plant, by transporting water from the Montebello Filtration Plants in the First Zone to the western portion of the Second Zone. The Fullerton Second Pumping Station is also a relatively recent station, only being completed in 1998. This station has four pumps, two 5.6 mgd and two 12 mgd (nominal capacity of 23 mgd). One 12-mgd pump functions as a standby pump. This station is located on Perry Hall Boulevard in Baltimore County and feeds the eastern portion of this zone, replacing the temporary Perry Hall and Rossville Pumping Stations. Neither of those two pumping stations were included in the hydraulic model because they are no longer needed. A fourth station, which was included in the hydraulic model but assumed to be inoperative during the modeling analysis, is the Washington Boulevard Pumping Station located on Washington Boulevard. This station has three pumps with a nominal capacity of 2.3 mgd. One is a standby pump and another pump is not operational.

Water in this zone is currently stored in three storage facilities: Lake Ashburton, Guilford Reservoir and Perry Hall Tank. Lake Ashburton, located on Powhatan Avenue, has a 70 mg usable storage capacity and an overflow elevation at 353 feet. This storage facility supplies the western portion of the zone, as well as the Ashburton and Leakin Park Pumping Stations, which pump water to the Western Third Zone. Guilford Reservoir has 6.5 mg of usable storage and an overflow of 341.4 feet. This reservoir, located at the intersection of Millbrook Road and Old Coldspring Lane, operates between the elevations of 338.4 and 341.4 feet and serves as a suction well for the Guilford Pumping Station, which lifts water to the Eastern Third Zone. Located on Ebenezer Road, the Perry Hall Tank has 1.0 mgd of usable storage and an overflow of 353 feet. This tank used to supply an isolated section of the Second Zone, known as the Eastern Second Zone. This area was fed by a pressure reducing valve (PRV) from the Eastern Third Zone. With the Fullerton Second Pumping Station now in service, this portion of the zone is connected with the rest of the Second Zone again. A future fourth tank, the Chapel Hill Tank, is to be located off New Gerst Road in Baltimore County in the eastern portion of the Second

Zone. When completed in 2005, this tank will have a capacity of 2.0 mgd and will have the same overflow elevations as the Perry Hall Tank (353 feet).

In addition to the Chapel Hill Tank, a new main is proposed in Gerst Road north of the tank. Two other transmission mains, the Honeygo Boulevard extension and Perry Hall and Philadelphia Road main, are also proposed but are not on the CIP list yet. A portion of the Honeygo Boulevard main extension has already been installed.

Second Zone Previous Reports

Historically, there have been few distribution problems in the Second Zone. The *1955 Central System Report* by Geyer and Wolff attributed this to the lack of heavy industry in this zone, the slow extension of the zone eastward, and the delayed development of the area in the City east of Herring Run and south of Belair Road. In that report, it was recommended that the Second Zone be supplied on the eastern side by a pumping station and a reservoir near the proposed Fullerton site. One project, the Fullerton Second Pumping Station, is already in service and the other project, the proposed Fullerton Reservoir, is currently under design.

Second Zone Model Analysis

A comprehensive evaluation of the Second Zone resulted in minimal problems based on the established criteria discussed in *Section B. Performance Criteria*. The system pressures and head loss gradients are not excessive in most areas. Storage and pumping capacity are adequate. Several areas require minor fire flow improvements. Model results can be found on the mapping located in Appendix B.

On a maximum day, there are a few areas with pressures outside the acceptable range and only minimal mains with head loss gradients that are slightly excessive. The pressures exceed the recommended maximum pressure of 120 psi in the southwest corner of the zone, along the Patapsco River, where the ground elevation is much lower than the rest of the zone. There are a few other scattered solitary model nodes showing high pressures, but all are barely over 120 psi. The model shows low pressures near Guilford Reservoir and Lake Ashburton, but there should be no service connections affected. One low pressure area is south of Frederick Road, along Yale Avenue and requires improvements because pressures are as low as 17 psi on a maximum day. The model analysis also revealed that this area also exhibits low fire flows. Recommended improvements are discussed later in this section. Mains in this area also have very high head loss gradients. High head loss gradients are not a problem in rest of this zone. There are very few pipes with head loss gradients exceeding the recommended performance criteria. Almost no mains greater than 18 inches have excessive head loss gradients. Several pipes less than 18 inches which have excessive head loss are located between Lake Ashburton and Guilford Reservoir and scattered throughout the City portion of this zone. No highly concentrated areas exist currently.

There is currently adequate pumping and storage capacity in this zone. The Perry Hall Tank drops significantly unless at least one pump is on at the Fullerton Second Pumping Station. Currently, there are no pump controls at this station and it is recommended that this station be controlled by the Perry Hall Tank and also the proposed Chapel Hill Tank once constructed. Pump controls should be established to fluctuate the tank between 342 and 348 feet, allowing almost a 30% turnover in the tank. The NPSH at each pumping station was evaluated and determined to be adequate. Even at the Fullerton Second Pumping Station, which is slightly below 10 psi, there should be no threat of cavitation because the hydraulic grade line is well above the pump centerline. The NPSH results at the peak hour on a maximum day were as follows:

Hillen Pumping Station: 14 psi
Vernon Pumping Station: 40 psi
Fullerton Second Pumping Station: 7 psi

One issue of great concern is that the Hillen Pumping Station causes reverse flow at the Ashburton Filtration Plant which in turn disrupts finished water meter readings at the plant (refer to Figure IV-4). Currently, on a maximum day, the model shows no reverse flow at the Ashburton Plant from the Hillen Pumping Station when only one pump is running. However, if flows at Ashburton Plant are reduced by 20 or 30 mgd and more than one pump is running at Hillen Pumping Station, then reverse flows at the effluent meter could occur. When the 64-inch Hillen By-Pass is completed in 2005, the possibility of reverse flows at the effluent meter will be eliminated and Hillen Pumping Station should not affect the Ashburton Plant finished water meter readings.

A fire flow analysis of this zone demonstrated that approximately 78% of the model nodes can provide the minimum residential fire flow of 1,500 gpm, although approximately 17% of the model nodes can provide a fire flow of 12,000 gpm. The amount of fire flow available at each model node is depicted on Figure IV-5. Also shown on Figure IV-5 are the recommended fire flow improvement projects listed below. There are six areas that require rehabilitation via lining to improve fire flow availability. These areas generally are:

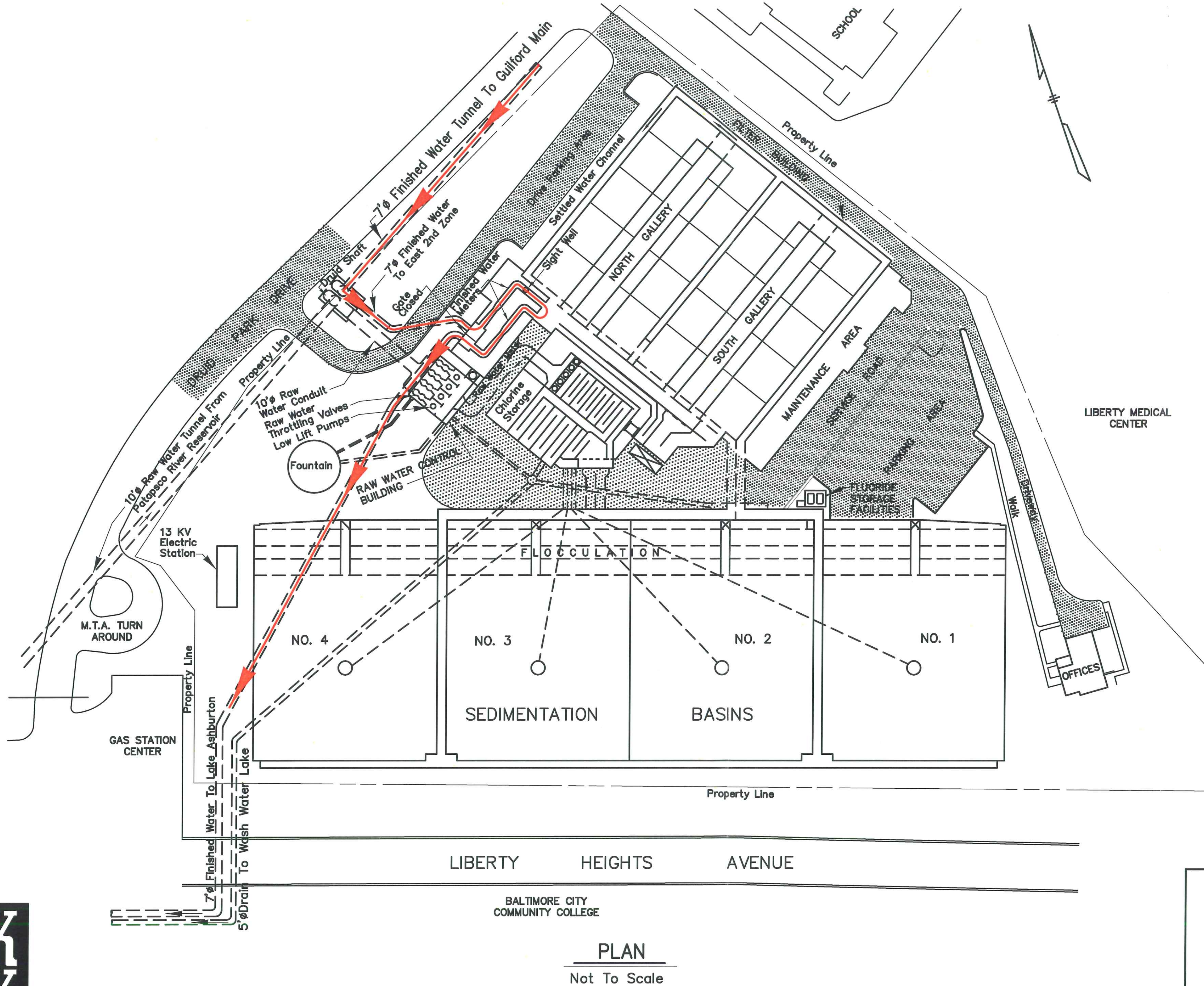
- The Brooklyn/Curtis Bay Area
- A small area in Arbutus, north of Sulphur Spring Road
- Neighborhoods south and west of Frederick Road and Yale Avenue
- The area around Poplar Grove Street, between North Avenue and Gywnns Falls Parkway
- Television Hill, north of Druid Hill Park
- The neighborhood east of I-95/I-895 split, north of Philadelphia Road
- The neighborhood near Philadelphia Road, just inside the beltway

One of these areas, near Yale Avenue, requires additional improvements beyond rehabilitation to provide ample fire flow to that area. This area also has low pressures and is connected to the rest of the zone by only a 6-inch main. These mains are very old, anywhere from 70 to over 90 years old and should be replaced. To improve fire flows to this area, a new 16-inch main approximately 1,000 feet long should be constructed, or instead a 12-inch main could be constructed parallel to the existing 6-inch main. A second area, near Brooklyn Park, requires approximately 1,000 feet of new 12-inch main to loop the area off Elmtree Street and raise the fire flow to acceptable levels or the existing 6-inch main in Church Street could be replaced with a new 16-inch main.

Second Zone Recommendations

- Complete the construction of the 64-inch Hillen By-Pass (CIP) as soon as possible to aid the western half of this zone and also to eliminate the possibility of reverse flow into Ashburton Filtration Plant from Hillen Pumping Station

- Establish pump controls for the Fullerton Second Pumping Station based on elevations in the Perry Hall Tank



PLAN

Not To Scale

RKK2\SYS – ...rojects\49638\PHASEII\FINALRPT\FIG5–X.DWG
07/12/2002 11:13 u32.ctb PLOT SCALE:1=1

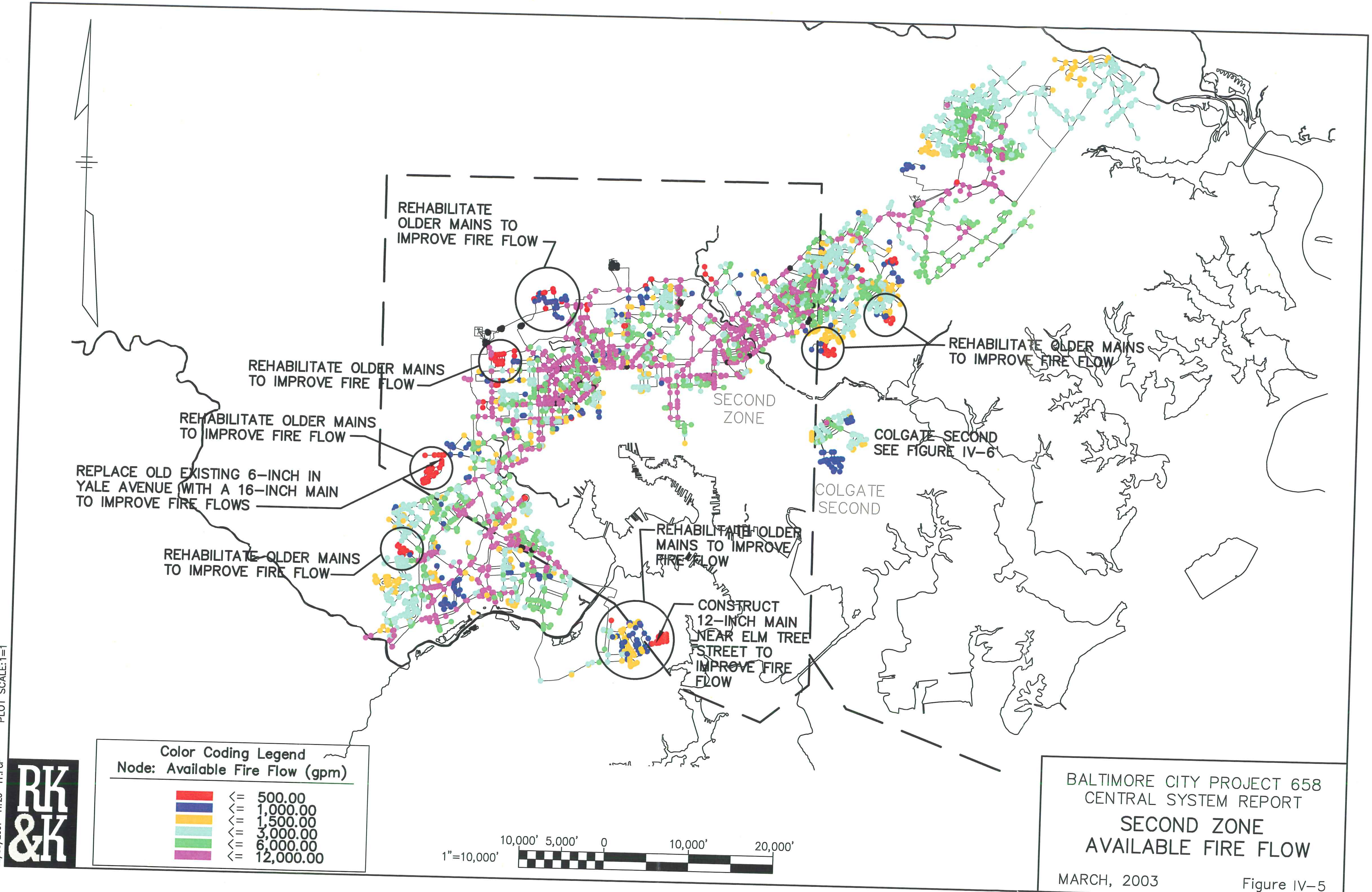
RK&K

BALTIMORE CITY PROJECT 658
CENTRAL SYSTEM REPORT

REVERSE FLOWS THROUGH ASHBURTON

MARCH, 2003

Figure IV–4


REHABILITATE OLDER MAINS TO IMPROVE FIRE FLOW
REHABILITATE OLDER MAINS TO IMPROVE FIRE FLOW
REHABILITATE OLDER MAINS TO IMPROVE FIRE FLOW
REPLACE OLD EXISTING 6-INCH IN YALE AVENUE WITH A 16-INCH MAIN TO IMPROVE FIRE FLOWS
REHABILITATE OLDER MAINS TO IMPROVE FIRE FLOW
SECOND ZONE
REHABILITATE OLDER MAINS TO IMPROVE FIRE FLOW
COLGATE SECOND SEE FIGURE IV-6
COLGATE SECOND
REHABILITATE OLDER MAINS TO IMPROVE FIRE FLOW
CONSTRUCT 12-INCH MAIN NEAR ELM TREE STREET TO IMPROVE FIRE FLOW
Color Coding Legend
Node: Available Fire Flow (gpm)
<= 500.00
<= 1,000.00
<= 1,500.00
<= 3,000.00
<= 6,000.00
<= 12,000.00
10,000' 5,000' 0 10,000' 20,000'
1"=10,000'
RK&K
PLOT SCALE:1=1
FF.PCP
BALTIMORE CITY PROJECT 658
CENTRAL SYSTEM REPORT
SECOND ZONE
AVAILABLE FIRE FLOW
MARCH, 2003
Figure IV-5

- Rehabilitate seven areas listed below requiring increased fire flows
  - The Brooklyn/Curtis Bay Area
  - A small area in Arbutus, north of Sulphur Spring Road
  - Neighborhoods south and west of Frederick Road and Yale Avenue
  - The area around Poplar Grove Street
  - Television Hill
  - The neighborhood east of I-95/I-895 split
  - The neighborhood near Philadelphia Road, just inside the beltway

- Replace approximately 1,000 feet of the existing 6-inch main in Yale Avenue with a new 16-inch main because lining alone is not enough to raise fire flow availability

- Construct approximately 1,000 feet of new 12-inch main to loop the Elmtree Street area to increase fire flow availability

- Find possible unaccounted for or unauthorized sources of water usage in this zone and eliminate them because the unaccounted for water percentage is very high

3. *Colgate Second Zone*

<u>Colgate Zone Description</u>

The Colgate Second Zone presently serves an area of approximately one square mile, as illustrated in Figure IV-1. The majority of this zone lies in Baltimore County, with approximately 2% in the City. The area is not projected to increase in size over the next 25 years because it is completely surrounded by the First Zone and there is no room for expansion. This zone lies in the area known as Colgate, where North Point Boulevard and Eastern Avenue intersect (between I-95 and I-695). The ground surface elevations in this zone range from a minimum of 52 feet and a maximum of 160 feet above mean sea level.

The current population in the Colgate Second Zone is over 8,000 people based on the 2000 Census. This zone is projected to decrease slightly by 2025 to less than 8,000, with all the decline taking place in the Baltimore County portion of the zone. Average day demands are approximately 0.6 mgd and are projected to stay fairly constant over the next 25 years. The current maximum day demands are approximately 0.8 mgd and are only projected to increase slightly. The current distribution of demands is as follows: residential 92%, commercial 8% and industrial 0%. These percentages are not projected to change drastically over the next 25 years. The consumer base is primarily residential, as most zones are, with a small amount of commercial usage. Unaccounted for water makes up 15% of the total flow supplied to this zone, which is acceptable.

Demands are supplied to this zone by the Colgate Pumping Station which pulls suction from the First Zone through a 12-inch main. The pumping station is located off of Northpoint Road in Colgate and has a nominal capacity of 0.7 mgd. There are two pumps at this station, both with a rated capacity of 0.7 mgd. One pump acts as a standby pump. The pumping station pumps water to the Colgate Tank located off Simmons Avenue. The usable storage in the tank is 0.3 mg and the overflow elevation is located at 258 feet. This zone does not supply any other zones.

Colgate Previous Reports

There are no major problems in the Colgate Second Zone reported in previous studies.

Colgate Model Analysis

A comprehensive evaluation of the Colgate Second Zone hydraulic model found no major problems in this zone, except limited fire flow availability. Pressures, head losses, storage capacity and pumping capacity are all sufficient currently and should be in the future. Hydraulic modeling results are presented graphically in Appendix B.

Pressures and head loss gradients for this zone were evaluated based on the criteria discussed in *Section B. Performance Criteria*. Pressures range from 41 psi to 87 psi on an average day. During peak hour demands on a maximum day, pressures drop to 35 psi, but that is still above the minimum performance criteria of 30 psi. High pressures are not a problem in this zone. Some mains in this zone exceed the established performance criteria for the head loss gradient. Those pipes are all smaller than 18 inches in diameter and most are located near the tank and pumping station where flows are higher and the friction would be greater.

The pumping capacity and NPSH in this zone are adequate. The only issue is that the pumps at the Colgate Pumping Station are inefficient and operate fairly far out on their pump curves. This is due to the relatively high pressures on the suction side of the pumping station and the design point of the existing pumps. These pumps could be replaced with higher efficiency pumps to remedy this situation if a reasonable payback period could be realized. The NPSH at this pumping station is 50 psi, well above the established minimum.

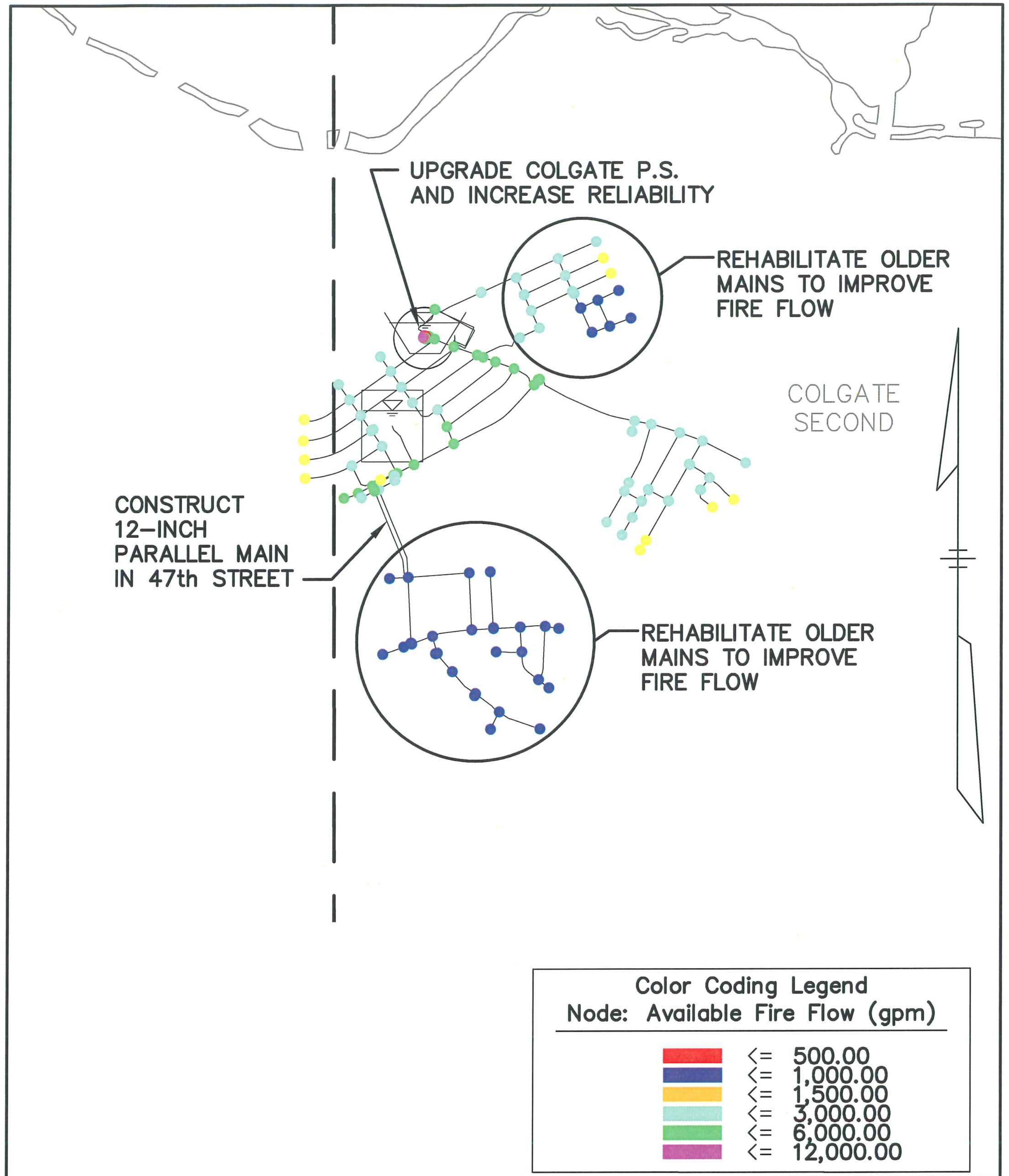
Storage is not shown to be a problem in this zone either; however, the tank fluctuates eight feet on an average day. This utilizes almost 50% of the usable storage capacity, but the tank recovers and returns to the starting elevation at the end of the day. On a maximum day, the tank fluctuates almost 14 feet, but also returns to full. This large fluctuation is not a problem and it only limits the amount of available storage during peak demands. However, large fluctuation can be good for tank turnover and reduces the age of water in the tank.

A fire flow analysis was performed to see if the minimum residential fire flow of 1,500 gpm could be satisfied in this zone. Approximately one third of the model nodes could not satisfy this requirement, although almost half the model nodes can supply 2,500 gpm. The minimum fire flow available in this zone is only 500 gpm. The amount of fire flow available at each model node up to 2,500 gpm is illustrated on Figure IV-6 along with any recommended fire flow improvement projects. The City should line the older water mains in this zone to improve fire flow availability, mainly in the areas near Quinton Street and Pembrooke Boulevard. However several water mains in this zone have already been rehabilitated and additional improvements are required. One area which has already been lined, along 47th Street, should have approximately 1,400 feet of parallel main constructed to improve fire flow availability.

<u>Colgate Recommendations</u>

- Investigate the cost/benefit of replacing pumps at Colgate Pumping Station with more efficient pumps

- Rehabilitate older water mains, via lining, to improve the amount of fire flow available in the area near Quinton Street and Pembrooke Boulevard



2,000' 1,000' 0 2,000'

1"=2,000'

BALTIMORE CITY PROJECT 658
CENTRAL SYSTEM REPORT

COLGATE SECOND ZONE AVAILABLE FIRE FLOW

MARCH, 2003 Figure IV-6

RKK2\SYS - ...rojects\49638\PHASEII\MODELING\FF2COLG.DWG
07/12/2002 14:54 FF.PCP PLOT SCALE:1=1

- Construct 1,400 feet of 12-inch parallel water main in 47th Street, where the existing mains have already been lined and there is still low fire flow availability

4. Eastern Third Zone

<u>Eastern Third Zone</u>

The Eastern Third Zone currently serves approximately 36 square miles and is only expected to grow one additional square mile by the year 2025. This zone lies in both Baltimore City and Baltimore County, with the City comprising of two-thirds of the population but only one-third of the area (see Figure IV-1). The boundaries of this U-shaped zone are the Eastern Second Zone to the south and east, the Gunpowder Falls to the northeast, the Jones Falls stream valley to the northwest and the Western Third Zone and Falls Road to the west. The center of the U-shape extends to the City line and the arms include the Ruxton area in the western arm and the Fullerton area in the eastern arm. The land surface elevation of this area ranges from 136 feet near the Jones Falls and Herring Run streams to as high as 440 feet near Roland Park.

The population of the Eastern Third Zone is currently over 202,000 people and is projected to increase by 9,000 people over the next 25 years. The average day demand in this zone is currently 19 mgd and maximum day demand is 31 mgd. By 2025, average day demand is projected to reach 21 mgd and maximum day demand will reach 39 mgd based on historical trends. The current distribution of Eastern Third Zone demands is as follows: 68% residential, 29% commercial and 3% industrial. These percentages are projected to remain about the same over the next 25 years. The consumer base is mostly residential in this zone, with supporting commercial districts and a small amount of light industry. The unaccounted for water is high and is estimated to be approximately 20% of the total demand supplied to this zone.

Both the First and Second Zones supply water to the Eastern Third Zone through three pumping stations: Guilford Pumping Station, Cromwell Pumping Station and the recently completed Fullerton Third Pumping Station. All three pumping stations supply the Towson Reservoir, currently the only storage facility in this zone. The overflow elevation of this reservoir is 515.5 feet with a usable storage capacity of 9.0 mg. This reservoir is located at the intersection of Stevenson Lane and Hillen Road in Baltimore County and supplies the Towson Pumping Station which feeds the Towson Fourth Zone.

The Guilford Pumping Station, located on Old Coldspring Lane in the City, provides a nominal pumping capacity of 44 mgd via two 10.8-mgd pumps and two 25-mgd pumps. One 25-mgd pump is a standby pump. This station takes suction from the Guilford Reservoir which is located in the Second Zone. Discharge from the pumping station is through two 36-inch diameter mains. The Cromwell and Fullerton Third Pumping Stations are both fed by the First Zone. Cromwell Pumping Station supplies a nominal capacity of 27 mgd and takes suction from the old 144-inch unlined Loch Raven-Montebello Tunnel. Filtered water from the Montebello Treatment Plant flows approximately 4.5 miles through this tunnel to the pumping station. Cromwell Pumping Station also has four pumps, two 15 mgd and two 6 mgd, and discharges through two 30-inch mains. One of the 15-mgd pumps is a standby pump. This station is located on Cromwell Bridge Road in Baltimore County. Also located in Baltimore County on Perry Hall Boulevard is the Fullerton Third Pumping Station, which takes suction from the 96-inch Fullerton Transmission Main and has a 50-mgd nominal capacity. This station has four pumps as well, two 14 mgd and two 22 mgd, and discharges into a 48-inch main. One 22-mgd pump is a standby pump.

Eastern Third Previous Reports

Historically there have been major pumping capacity problems in the Eastern Third Zone. In 1955, the *Central System Report* by Geyer and Wolff found serious water deficiencies because of inadequate pumping capacity at the Guilford Pumping Station. To improve this zone, the Cromwell Pumping Station was constructed in 1962. But according to the *1989 Central System Report* published by the Analyzer Office, inadequate pumping capacity was again a problem in this zone due to rising demands in eastern Baltimore County. Based on the recommendations of this report, the Fullerton Third Pumping Station was constructed and in service by 1998. The Guilford Pumping Station has also been recently upgraded. However, both pumping stations still need additional transmission mains to operate at full design capacity.

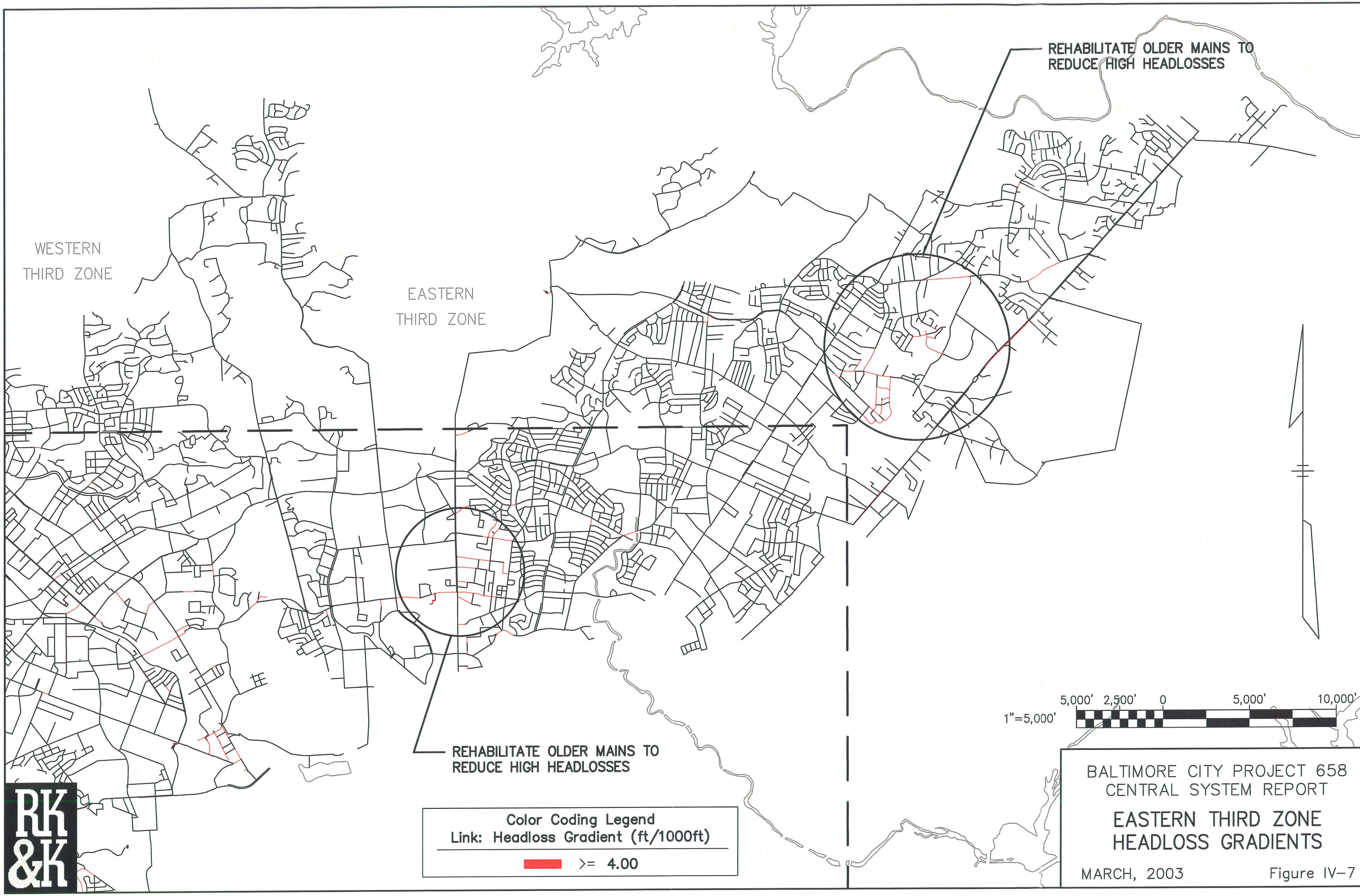
Eastern Third Model Analysis

The evaluation of the Eastern Third Zone hydraulic model revealed that high pressures were the main issue of concern in this zone. High pressures are located in the areas of lower elevation along the boundary with the Western Third Zone. Pumping and storage capacity are adequate in this zone. Fire flow availability is a problem in over 10% of the zone. The hydraulic model results are presented graphically in Appendix B.

Pressures currently range from 3 psi to 176 psi in the Eastern Third Zone, rising well above the established maximum pressure of 120 psi in several areas, discussed in *Section B. Performance Criteria*. These high pressures occur mostly along Belair Road and along the Western Third Zone border, which coincides with the Jones Falls stream valley. These areas could be moved to the Second Zone in the locations where the pressure in the Second Zone exceeds 50 psi. Field testing performed under this project verified the existence of high pressures along Belair Road because pressures ranged from 125 to 140 psi near monitoring site at the intersection of Belair Road and Blakely Road. Service connections in this area probably already have PRVs. Low pressures do not appear to be a problem; however, there are a minimal number of scattered model nodes with pressures below the recommended minimum of 30 psi. None of these nodes should have any service connections.

Most of this zone is well below the acceptable head loss gradient criteria with the exception of two major problem areas, as illustrated on Figure IV-7. The main area of high head loss is located on the western side, near Guilford Pumping Station. In this area, a high concentration of deficient mains are located along the east side of Greenmount Avenue and west of the Alameda. It is recommended that they be rehabilitated to reduce high head losses. Another high head loss area is located in the eastern half of the zone, between Belair Road and Harford Road, south of Joppa Road extending just inside the beltway. Most of these mains are smaller than 18 inches in diameter. Pressures in this second area are high however, high head losses are not a significant problem.

This zone has ample pumping and storage capacity. Currently, the Towson Reservoir operates between 510 and 514 feet, which are acceptable levels. Approximately 20% of the storage capacity in this reservoir is being used. The pumping stations actually have excess capacity in this zone. The NPSH at the peak hour is currently barely sufficient at all three pumping stations and remains so during the future years analyzed. The NPSH at the Guilford



BALTIMORE CITY PROJECT 658
CENTRAL SYSTEM REPORT

EASTERN THIRD ZONE
HEADLOSS GRADIENTS

MARCH, 2003

Figure IV-7

RKK2\SYS - \projects\49638\PHASEII\MODELING\HL3E.DWG
07/12/2002 11:49 ZRPTMAP.POP PLOT SCALE: 1=5500

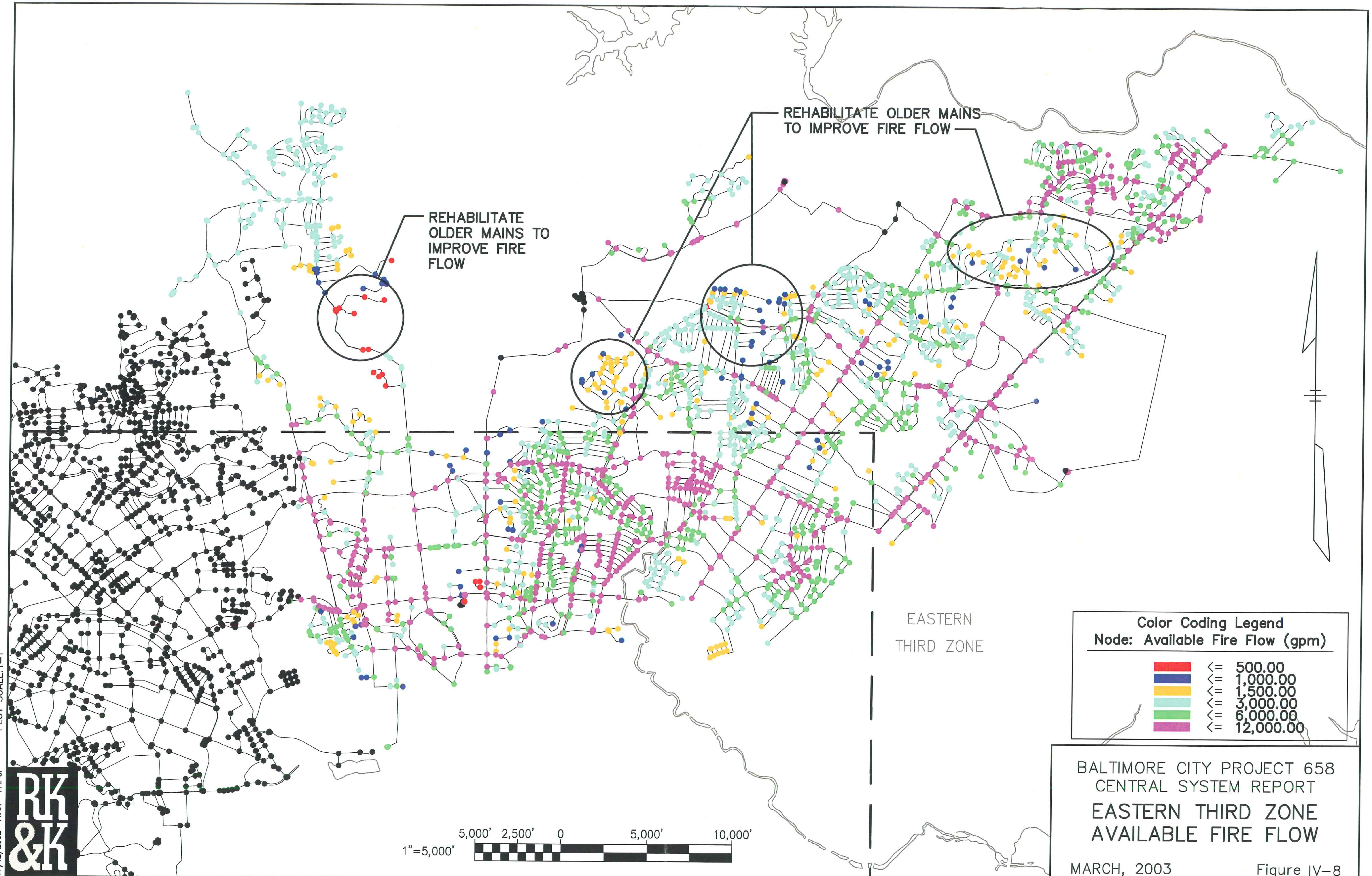
Pumping Station ranges between 1.2 psi and 2.2 psi depending on whether the valve is open or closed. At the Cromwell Pumping Station, the NPSH is over 12 psi, which is above the recommended minimum to avoid problems. The Fullerton Third Pumping Station has a NPSH of 7 psi, but there is no threat of cavitation. Due to high head losses near Guilford Pumping Station and the current hydraulic limitations of the Fullerton Third Pumping Station discharge, four additional transmission mains have been recommended by the Water Analyzer Office. These mains should increase the pumping capabilities of the Fullerton Third Pumping Station.

The fire flow analysis proved that this zone can provide sufficient fire flow in the majority of the zone. Approximately 88% of the model nodes can provide the minimum residential fire flow of 1,500 gpm and 19% can provide the 9,000 gpm. There are over two dozen nodes with less than 500 gpm of fire flow available. Four low fire flow availability areas, listed below, are shown on Figure IV-8 and should be rehabilitated to increase fire flow availability to acceptable levels. The available fire flow at each model node, up to 9,000 gpm, is also shown on Figure IV-8.

- Area along Bellona Avenue in Ruxton
- The Glenmont area west of Loch Raven Boulevard
- Area around Putty Hill Road, near the intersection with the Perring Parkway
- The Perry Hall area, north of Joppa Road

Eastern Third Recommendations

- To reduce excessive pressures, conduct an in-depth evaluation to possibly relocate division valves in the following intersections and incorporate these areas into the Second Zone
    - Remove three division valves on Chardel Road at the intersections with Blakely Avenue, Darleigh Road and Cottington Road; replace them with division valves on Belair Road at the intersections with Cottington Road, Verdel Road and Blakely Road
    - Remove the division valve at the intersection south of Horn Avenue and Haycoke and replace it with a division valve on the north and east side of the intersection; remove another division valve at the intersection of Carlisle Avenue and Penn Avenue; install two division valves on Belair Road at the intersections with Penn Avenue and a second with Darnall Road



BALTIMORE CITY PROJECT 658
CENTRAL SYSTEM REPORT

EASTERN THIRD ZONE
AVAILABLE FIRE FLOW

MARCH, 2003

Figure IV-8

RKK2\SYS - ...\projects\49638\PHASEII\MODELING\FF3RDE.DWG
07/12/2002 11:01 FF.PCP PLOT SCALE:1=1

- Rehabilitate older pipes in this zone which have not yet been lined, especially the area near Guilford Pumping Station between Greenmount Avenue and the Alameda, and also the area south of Joppa Road between Belair Road and Harford Road

- Improve low fire flow availability in the four areas listed below by rehabilitating mains
  - Area along Bellona Avenue in Ruxton
  - The Glenmont area west of Loch Raven Boulevard
  - Area around Putty Hill Road, near the intersection with the Perring Parkway
  - The Perry Hall area, north of Joppa Road

- Construct four additional recommended transmission mains to improve hydraulics and pumping capacity at Fullerton Third Pumping Station
  - 24-inch main in Putty Hill
  - 24-inch parallel main in Belair Road (White Marsh Blvd. to Joppa Road)
  - 24-inch parallel main in Belair Road (to Northern Parkway)
  - 42-inch main in Perry Hall Boulevard

- Find possible unauthorized sources of water usage in this zone and eliminate them because the unaccounted for water percentage is too high

5. *Western Third Zone*

Western Third Zone Description

The Western Third Zone serves both Baltimore City and Baltimore County, as well as provides wholesale treated water to Howard County. Currently, this zone is approximately 35 square miles, roughly half in the City and half in Baltimore County, and is expected to increase by two additional square miles. The boundary generally extends to the Patapsco River on the south side, the Pikesville area to the northwest, the Eastern Third Zone and western Second Zone to the east and the Catonsville Fourth Zone to the west (See Figure IV-1 for zonal boundaries). The elevation of the land surface in this area ranges from 36 feet above mean sea level near the river to 492 feet closer to Pikesville.

The current population of the Western Third Zone based on the 2000 Census is 207,000. By 2025, this population is projected to decrease by 2,000 people to 205,000. Approximately two-thirds of the population lives in the City while the remaining one-third resides in Baltimore County. The population in Baltimore County is actual projected to increase over the next 25 years; however, the City population is decreasing at a greater rate resulting in an overall decline in the population for the entire zone. The average day demand was recorded at approximately 38 mgd and maximum day demand was over 59 mgd. By 2025, average day demand will approach 52 mgd, while maximum day demand will exceed 81 mgd. This zone also supplies flow to Howard County, where the primary increase in demands is expected. Approximately 44% of the total flow in this zone goes to Howard County. Current average demands in Howard County are almost 17 mgd. By 2025, these demands are projected to almost double to 30 mgd. The current distribution of demands is as follows: 33% residential, 66% commercial and 1% industrial with the commercial percentage increasing and the residential percentage decreasing over the next 25 years. The consumer base of the Western Third Zone is primarily residential, with numerous commercial shopping centers and mercantile districts and some light industry. Unaccounted for water is approximately 20% of the total flow supplied to this zone, which is high.

Demands are supplied to the Western Third Zone from the Ashburton and Leakin Park Pumping Stations, both located in the City. These pumping stations are supplied by the Second Zone through a 60-inch main to Leakin Park Pumping Station and two 48-inch mains to Ashburton Pumping Station. Ashburton Pumping Station, located on Liberty Heights Avenue, has four 28-mgd pumps and a nominal capacity of 84 mgd with one pump serving on standby. This station primarily feeds the Pikesville Reservoir. The Leakin Park Pumping Station currently provides 40-mgd nominal capacity to the system and primarily feeds the Catonsville Reservoir on Powers Lane and the Melvin Avenue Tank on Melvin Avenue, both situated in Baltimore County. Their useable storage capacities are approximately 18 mg and 2 mg, respectively, and both of these tanks have an overflow elevation of 567 feet. The Leakin Park Pumping Station, located on Winterbourne Road, has only three pumps and two remaining empty slots. All three pumps are approximately 20 mgd pumps and one is a standby pump. The Pikesville Reservoir, located on Village Road in Baltimore County, has the same overflow elevation as the other storage facilities, 567 feet, and has a useable capacity of over 17 mgd. This reservoir is currently under design to be covered and replaced with two reservoirs. Both pumping stations draw suction from Lake Ashburton in the Second Zone. This zone supplies water to the Catonsville and Pikesville Fourth Zones.

Western Third Previous Reports

The Western Third Zone has been an important zone of concern for many years. The *Central System Report* found that in 1955 the Western Third Zone had a severe hydraulic imbalance between the Pikesville Reservoir and the Melvin Avenue Tank. In addition, the *1989 Central System Report* and *A Study of the Western Third Zone*, August 1984, both found major deficiencies in this zone relating to the amount of available storage and the existing transmission capacity or lack thereof. Since those reports, the Catonsville Reservoir has been constructed and storage capacity is no longer a major concern in this zone, as was illustrated in *Section III.B.4. Summary of Total Storage Recommended for Each Zone*. Also, additional transmission mains have been designed or are currently being designed to provide increased transmission to the upper dependant zones and also to Howard County.

Western Third Model Analysis

A comprehensive evaluation of the hydraulic model for the Western Third Zone resulted in significant problems, including low fire flow availability. The system experiences high pressures and minimal excessive head loss. Pumping and storage capacity are sufficient, but are still issues of concern and fire flow availability is a problem in several areas. Graphical model results are located in Appendix B.

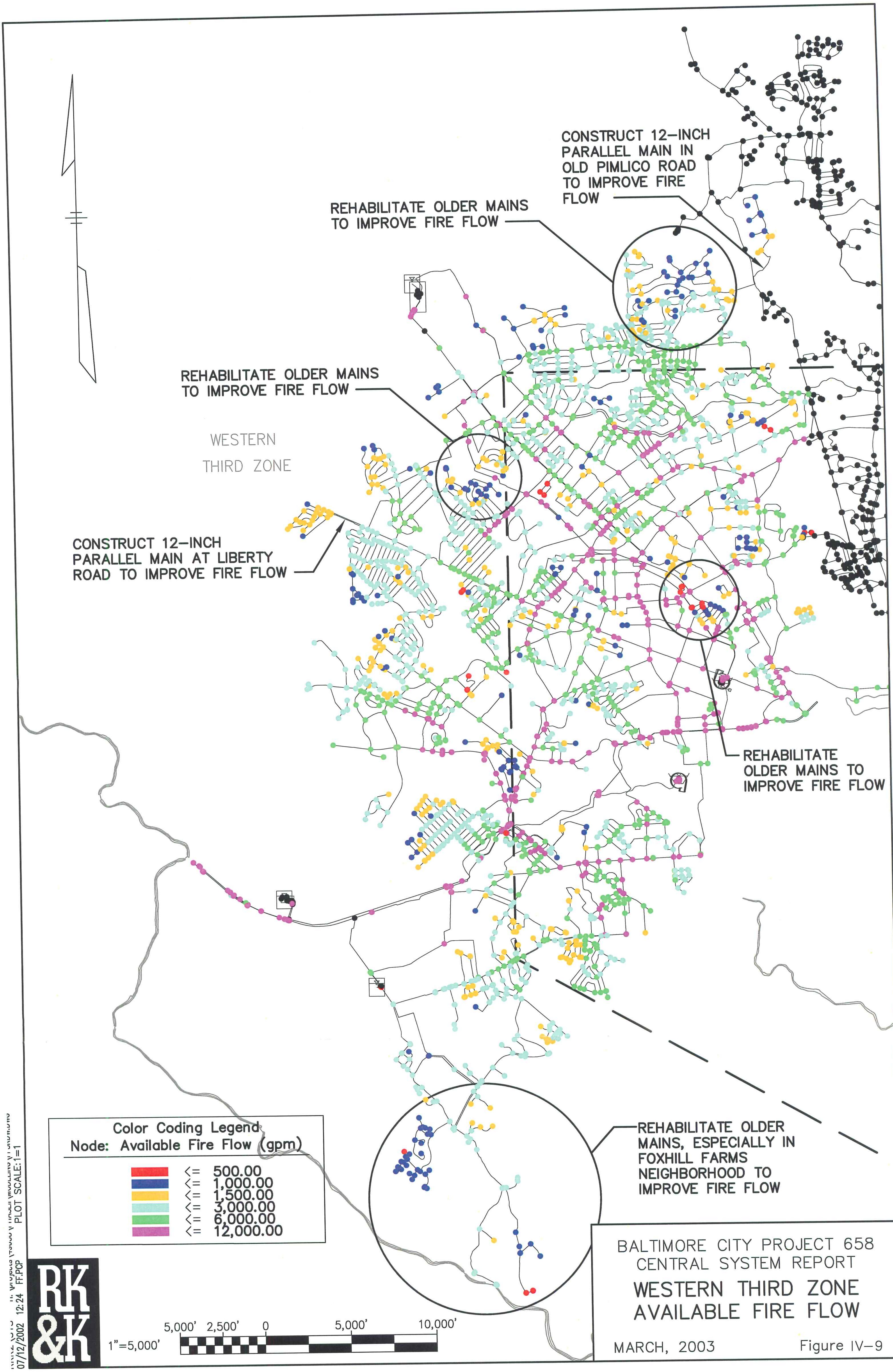
According to the established performance criteria discussed *in Section B. Performance Criteria*, there are approximately 5% of the model nodes with pressures above the maximum 120 psi. All of these nodes lie near the boundary with the Second Zone along the southern side, which has lower elevations, and the boundary with the Eastern Third Zone along the eastern side (Jones Falls stream valley), which also has lower elevations. These areas could be moved to the Second Zone in the locations where the pressure in the Second Zone exceeds 50 psi. There are scattered low pressures in this zone, but most of these model nodes have almost 30 psi of pressure. They all are located near each of the three storage facilities, so there should not be any service connections in these areas. Pressures in this zone range from approximately 12 psi to 212 psi.

The head loss gradients in this zone are currently minimal; however, there are several pipes with excessive head loss according to the performance criteria. There are only a few mains larger than 18 inches which are deficient. These mains are scattered throughout the zone. There are also only a few mains less than 18 inches that have high head loss gradients. They are also scattered throughout the zone. By 2025, the deficient areas increase, but there is still not a heavily concentrated area which would cause concern.

The pumping and storage capacity in this zone are currently adequate; however, improvements should be implemented to keep the Catonsville Reservoir operating within acceptable water levels. The Catonsville Reservoir currently drops significantly and does not recover to the starting elevation by the end of the day. Meanwhile, the Pikesville Reservoir stays full most of the day when the Ashburton Pumping Station is operating at a higher level than the Leakin Park Pumping Station. The Melvin Avenue Tank appears to operate sufficiently. Therefore, the pumping capacity of the Leakin Park Pumping Station should be increased to keep Catonsville Reservoir operating at acceptable water levels, while the pumping at Ashburton Pumping Station should be reduced to keep the Pikesville Reservoir fluctuating properly. The two proposed additional 20 mgd pumps should be added at the Leakin Park Pumping Station in the near future. The NPSH is adequate at both pumping stations. The NPSH at the Ashburton Pumping Station is just above the recommended minimum of 10 psi. At the Leakin Park Pumping Station, the NPSH is over 40 psi. The additional Catonsville Transmission Mains currently under design will also help the Catonsville Reservoir water levels. One main will parallel US Route 40 from Johnny Cake Road to the Catonsville Reservoir and the other will provide a parallel discharge main from the Leakin Park Pumping Station along Franklintown Road most of the way, to the intersection of Cooks Lane and Security Boulevard.

A fire flow analysis performed on this zone yielded several deficiencies. Only 78% of the model nodes can supply the minimum residential fire flow of 1,500 gpm. In addition, 12% of the model nodes can supply 9,000 gpm. There are several model nodes with less than 500 gpm of available fire flow. Four areas should be rehabilitated via lining to increase this low fire flow availability above the minimum 1500 gpm:

- The Millford Mill/Bedford area
- Area north of Sugarcone Road and west of I-83
- Along South Rolling Road west of I-95/Foxhill Farm
- The Ashburton area, north of Liberty Heights Avenue



BALTIMORE CITY PROJECT 658
CENTRAL SYSTEM REPORT

WESTERN THIRD ZONE AVAILABLE FIRE FLOW

MARCH, 2003

Figure IV–9

These areas are shown on Figure IV-9, along with the amount of fire flow available at each model node, up to 9,000 gpm. Two additional areas with more severe fire flow problems require additional mains or replacement mains to improve the fire flow availability to acceptable levels. One area which is already lined is located south of Liberty Road just outside the beltway and requires a 12-inch main to parallel approximately 2,000 feet of existing water main in Liberty Road. The other area, which has also already been lined, is south of Ruxton Road and east of Falls Road and requires a parallel 16-inch main along Old Pimlico Road for approximately 4,000 feet. A proposed transmission main in Rolling Road in the southern portion of the zone will also improve fire flow availability.

<u>Western Third Recommendations</u>

- To reduce excessive pressures, conduct an in depth evaluation to possibly relocate division valves in the following intersections and incorporate these areas into the Second Zone
  - Replace the division valves at intersection of Maiden Choice Lane and Grouse Court and Wilton Farm Drive near Badger Gate Court with a division valve in Maiden Choice Lane north of Laurence Brooke Road
  - Remove three division valves at the intersections of Rockrose Avenue east of Parkdale Avenue, Girard Avenue west of Parkdale Avenue and Druid Park at Parkdale Avenue; install a new division valve on Druid Park Drive approximately 300 feet west of Maiden Avenue
  - Remove two division valves at the intersection of South College Road and Beechfield Avenue and replace them with one division valve 100 feet west of Beechfield Avenue on South College Road; remove four other division valves at the intersections of Beechfield Avenue at Airy Hill Avenue, Beechfield Avenue at Yale Avenue, Parkton Street at Eldone Road and Parkton Street approximately 400 feet east of Eldone Road; install three new division valves on Frederick Avenue at the intersection with Chapelgate Lane, Long Island Avenue and Beechfield Avenue

- Install the two remaining 20 mgd pumps at the Leakin Park Pumping Station by 2005 to improve the operation of the Catonsville Reservoir. (This project is currently under design)

- Increase the output of the Leakin Park Pumping Station and decrease the output of the Ashburton Pumping Station because a larger portion of the demand (including wholesale to

Howard County) is located in the area the Leakin Park Pumping Station supplies

- Rehabilitate four mains listed below where fire flow availability is low
  - The Millford Mill/Bedford area
  - Area north of Sugarcone Road and west of I-83
  - Along South Rolling Road west of I-95/Foxhill Farm
  - The Ashburton area, north of Liberty Heights Avenue

- Construct parallel mains in two locations, one 12-inch main along 2,000 feet of Liberty Road and the other a 16-inch main along 4,000 feet of Old Pimlico Road

- Find possible sources of unaccounted for or unauthorized water usage in this zone and eliminate them because the unaccounted for water is too high

6. *Catonsville Fourth Zone*

Catonsville Zone Description

The Catonsville Fourth Zone lies entirely within Baltimore County and currently serves an area of approximately 15 square miles (See Figure IV-1). By the year 2025, this area is expected to grow less than a quarter square mile. This zone does not provide any service to Howard County, even though it borders this zone to the west and south along the Patapsco River. The Western Third Zone creates the boundary to the east, and the Pikesville Fourth Zone to the north. The land surface elevation in this zone varies from 124 feet near the river to 534 feet above mean sea level.

The present population of Catonsville Fourth Zone is over 45,000 and is estimated to remain fairly constant until 2025. Average and maximum day demands are currently over 6 mgd and 10 mgd, respectively. By 2025, those demands are projected to increase to almost 7 mgd for average day and over 11 mgd for maximum day. The current distribution of demands in the Catonsville Fourth Zone is as follows: 69% residential, 30% commercial and only 1% industrial with the residential percentage decreasing and the commercial percentage increasing 6% over the next 25 years. The consumer base is largely residential, with supporting commercial districts and a small quantity of light industry. An average of 20% of the total flow supplied to this zone is unaccounted for water, which is a high percentage.

Demand is supplied to the Catonsville Fourth Zone from the Catonsville Pumping Station, located on Powers Lane, which takes suction from the Catonsville Reservoir in the Western Third Zone. This pumping station has a nominal capacity of 10 mgd, which will double to 20 mgd with the addition of a proposed 10 mgd pump in the near future. There are currently three pumps at this station, two 5-mgd pumps and one 10-mgd pump. The 10-mgd pump is a standby pump. Water is pumped from the pumping station through a 30-inch discharge main and fills two elevated tanks which provide equalization storage for this zone. The tanks are: the Rolling Road Tank and the Dorchester Avenue Tank, both with an overflow elevation of 630 feet. The Rolling Road Tank is located on Rolling Road in Hebbville and has a usable capacity of 1.5 mgd. The Dorchester Avenue Tank has a usable capacity of 1.0 mgd and is located on Dorchester Avenue, just south of US Route 40 in Catonsville. This zone does not supply water to any upper zones.

Catonsville Previous Reports

The 1955 *Central System Report* by Geyer and Wolff found this zone to have many problems. There was insufficient pumping capacity and inadequate flows to and from the Western Third Zone. Since then, the Leakin Park Pumping Station has been built to supply additional flows to the Western Third Zone. An additional pump has been added to the Catonsville Pumping Station and a fourth pump is currently under design. Another problem found was an insufficient piping network which decreases the ability to meet fire flows. As detailed in the section below, this problem still persists. Finally, the available storage was considered inadequate, but improvements since 1955 have been made in this zone to correct the problems identified in the *Central System Report*. The storage facility on Ingleside Avenue was replaced with the Dorchester Tank and more recently, the Rolling Road Tank was constructed in 1985.

Catonsville Model Analysis

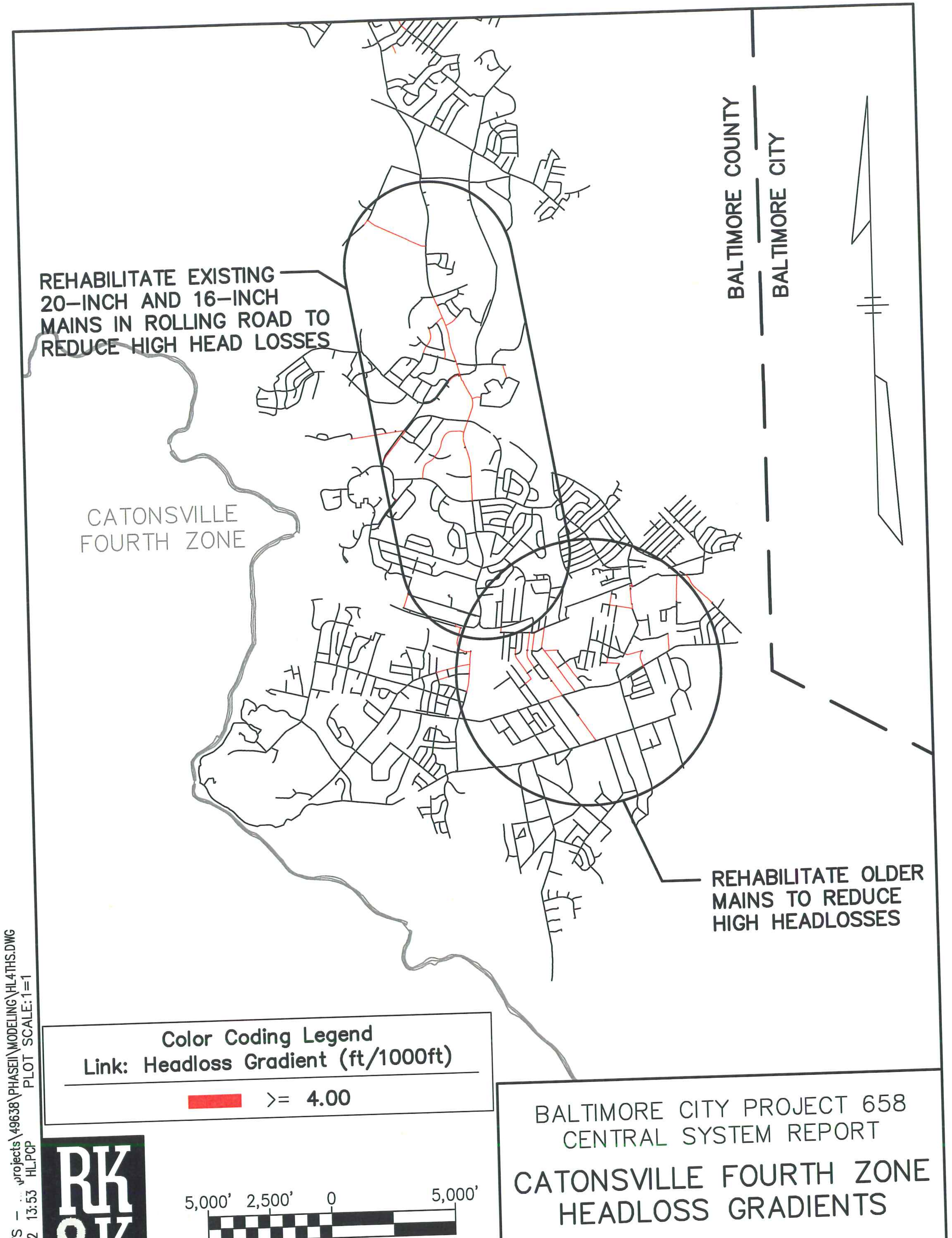
A comprehensive evaluation of the Catonsville Fourth Zone hydraulic model revealed deficiencies in many areas. Compared to the performance criteria discussed in *Section B.*

Performance Criteria, some of the pressures and head loss gradients are high. The storage capacity in this zone is adequate, but improvements are required to keep the Rolling Road Tank operating within optimum levels. Also, the pumping capacity is sufficient but the results of the fire flow analysis revealed many areas that did not meet the fire flow requirements established in Section B. Model results are presented on the mapping in Appendix B.

Pressures in the Catonsville Fourth Zone range from 19 psi to 155 psi on a maximum day, except in one area discussed below, with the majority of the nodes between the acceptable 30 psi and 120 psi. Approximately 4% of the model nodes yielded pressures above the maximum pressure criteria of 120 psi. Most of these nodes are located in low lying areas along the Patapsco River in the southwestern corner of the zone. Some of this area is isolated by two PRVs which create the Oella (Catonsville reduced) Fourth Zone. Even with the PRVs operating at 60 psi, the pressures at several nodes in this area remain above 150 psi. Pressure testing conducted during this project verified pressures over 110 psi along Frederick Avenue near River Road. There are several nodes with minimal pressures below the recommended 30 psi. Most of these nodes are located in and around the Catonsville Pumping Station which should not affect any service connections. A few other model nodes located off Fairbrook Road, near the Western Area Park, have negative pressures. An 8-inch main off Tudsbury Road, with high head loss, supplies this small area which has significant demand (greater than 1 mgd). Improvements should be made by constructing an additional main to loop the system to the north in Clays Road. The analysis demonstrated that adding approximately 1,600 feet of 12-inch main in Clays Road raised system pressures to at least 50 psi.

There are many pipes with high head loss gradients in this zone. A large concentration of those mains are located along Rolling Road between the pumping station and Rolling Road Tank. With the proposed 24-inch Rolling Road Tank Transmission Main to be located in Johnny Cake Road and the nearby roads, the head loss gradient decreases in those areas. In addition to this proposed project, the 16-inch and 20-inch mains in Rolling Road should be rehabilitated via lining to reduce head losses in this area even further. An additional area located south of US Route 40 and north of Edmonson Avenue would also benefit from rehabilitation. The head loss gradients and recommended improvements are shown on Figure IV-10.

There is currently ample storage and pumping capacity in this zone. With the addition of the fourth pump at Catonsville Pumping Station, no pumping capacity issues arise. Prior to that



BALTIMORE CITY PROJECT 658
CENTRAL SYSTEM REPORT

CATONSVILLE FOURTH ZONE
HEADLOSS GRADIENTS

MARCH, 2003

Figure IV–10

RK&K

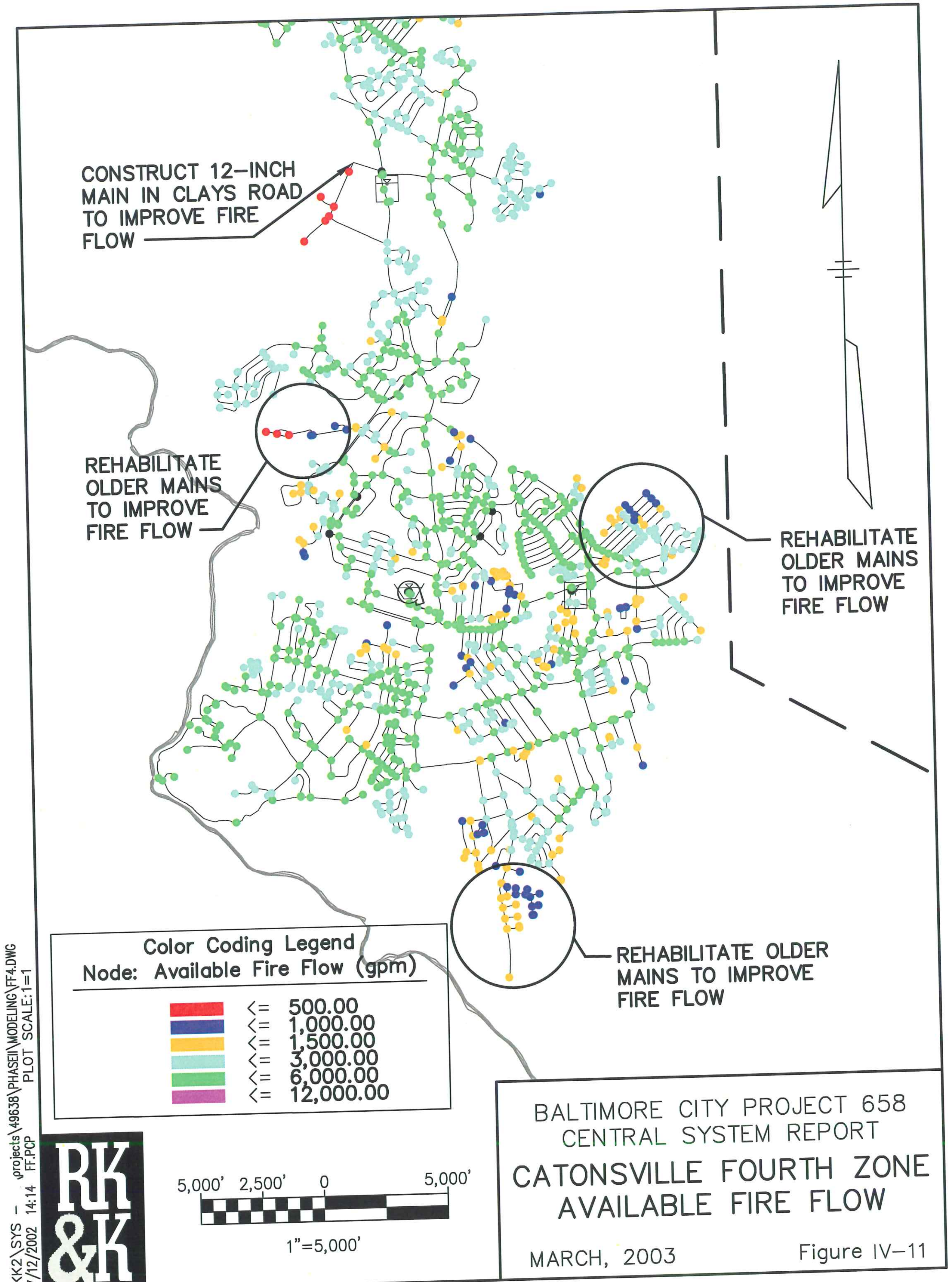
RKK2\SYS – ...projects\49638\PHASEII\MODELING\HL4THS.DWG
07/12/2002 13:53 HLPCP PLOT SCALE:1=1

pump installation; however, this zone may experience inadequate pumping capacity problems. Even with the fourth pump, the Rolling Road Tank currently drops below 35% full during a maximum day scenario. This is due to the high head losses and significant demands in the upper end of the zone, north of Route 40. The Rolling Road tank typically operates several feet below the Dorchester Tank, but the model shows that the Dorchester Tank recovers to full capacity while the Rolling Road Tank drops over 15 feet during a 24-hour period. The Rolling Road Tank does not fully recover, ending approximately six feet below starting elevation. Assuming that maximum day demands will not occur more than a few days in a row, this tank would eventually fully recover. Once the proposed 24-inch main in the Johnny Cake Road area is constructed, tank levels in the Rolling Road Tank will improve. On a maximum day, the tank recovers to the starting elevation and utilizes approximately 30% capacity of the tank with the proposed 24-inch main. The Dorchester Tank still does not fluctuate properly during this or any of the scenarios investigated. The tank achieves full capacity after only a few hours and does not drop all day. Hydraulically isolating the tank by closing the 24-inch main in Kent Avenue just north of tank and causing water to travel a greater distance to this tank did not appear to improve tank operation. Eliminating or relocating this tank should be considered. The pressures and fire flows in this zone were not adversely affected by eliminating this tank. Possible relocation sites are discussed in *Section III.D. Possible Storage Facility Locations.*

A fire flow analysis of this zone found several areas to have insufficient fire flow availability. Approximately 13% of the model nodes could not supply the minimum residential fire flow of 1,500 gpm. However, approximately 12% of the mode nodes could supply 6,000 gpm. Figure IV-11 illustrates the amount of fire flow available at each model node, up to 6,000 gpm. Those areas which could not even supply 1,500 gpm were:

- In the southern tip of the zone, southwest of South Rolling Road
- Along Inwood Avenue, west of Johnnycake Road
- The Catonsville area, north of US Route 40, south of I-70 and east of I-695

Rehabilitating the older mains, with low Hazen-Williams C factors, in these areas would improve the fire flow availability. An additional area near the Rolling Road Tank has high demands and is served by a inadequately sized single 8-inch main. This is the same area in Fairbrook Road that had low pressures discussed previously. The model analysis demonstrated that installing approximately 1,600 feet of 12-inch main in Clays Road would improve fire flows to almost


CONSTRUCT 12-INCH MAIN IN CLAYS ROAD TO IMPROVE FIRE FLOW
REHABILITATE OLDER MAINS TO IMPROVE FIRE FLOW
REHABILITATE OLDER MAINS TO IMPROVE FIRE FLOW
REHABILITATE OLDER MAINS TO IMPROVE FIRE FLOW
Color Coding Legend
Node: Available Fire Flow (gpm)
<= 500.00
<= 1,000.00
<= 1,500.00
<= 3,000.00
<= 6,000.00
<= 12,000.00
5,000' 2,500' 0 5,000'
1"=5,000'
RK &K
RKK2\SYS - \projects\49638\PHASEII\MODELING\FF4.DWG
07/12/2002 14:14 FF.PCP PLOT SCALE:1=1
BALTIMORE CITY PROJECT 658
CENTRAL SYSTEM REPORT
CATONSVILLE FOURTH ZONE
AVAILABLE FIRE FLOW
MARCH, 2003
Figure IV-11

1,500 gpm at the worst model node. These areas requiring improvements are illustrated on the mapping in Appendix B.

<u>Catonsville Recommendations</u>

- Investigate ways to improve hydraulics to Dorchester Tank to insure circulation or possibly relocate the tank to a better hydraulic location (Possible sites are presented in Table III-8)

- By 2025, construct a 16-inch main between the Rolling Road Tank and Catonsville Pumping Station along Lord Baltimore Drive in addition to the proposed 24-inch Rolling Road main that will be constructed in and around Johnny Cake Road currently under design

- Rehabilitate the older mains along Rolling Road between the Catonsville Pumping Station and the Rolling Road Tank to reduce head losses, as well as perform rehabilitation in the area south of Route 40 and north of Edmonson Avenue

- Rehabilitate the areas which have low fire flow availability
  - Area in the southern tip of the zone, southwest of South Rolling Road
  - Along Inwood Avenue, west of Johnnycake Road
  - The Catonsville area, north of US Route 40, south of I-70 and east of I-695

- Construct approximately 1,600 feet of 12-inch main in Clays Road to improve fire flows and pressures in that area

- Find possible unaccounted for or unauthorized sources of water usage in this zone and eliminate them because the unaccounted for water percentage is too high

7. *Pikesville Fourth Zone*

<u>Pikesville Zone Description</u>

The Pikesville Fourth Zone serves an area completely within Baltimore County, which lies northwest of the City as shown in Figure IV-1. It is currently over 26 square miles and generally encompasses the Interstate 795 corridor and surrounding residential areas between

Pikesville and Owings Mills. To the southwest, the zone extends to Liberty Road and to the southeast and east, to the Western Third Zone. By 2025, this area is expected to grow to approximately 28 square miles in this zone. Elevations of the land surface range from 392 to 652 feet above mean sea level.

The population of this zone is approximately 75,000 people and is projected to grow by over 20,000 by 2025, an almost 30% increase. Similarly, demands are expected to increase 30% from over 9 mgd on an average day currently to over 12 mgd by 2025. Maximum day demands are approximately 16 mgd now and projected by 2025 to be approximately 23 mgd. The present distribution of demands is as follows: 65% residential, 34% commercial and 1% industrial. The industrial percentage is projected to increase slightly over the next 25 years. The consumer base in this zone is mainly residential, with a small area of commercial and light industrial developments scattered all along the I-795 corridor. Unaccounted for water in this zone averages 15% of the total flow supplied which is considered acceptable.

The Pikesville Fourth Zone demand is supplied from the Pikesville Pumping Stations 1 and 2, both located in the Pikesville area. Station 1 is located in an alley off the 1700 block of Reisterstown Road and has a nominal capacity of 17.8 mgd, with one 6.2 mgd standby pump. This station has four pumps total, two 5.8 mgd and two 6.2 mgd. Station 2 is located on Village Road just north of Station 1 and has a nominal capacity of 40.9 mgd, with one 17.5 mgd standby pump. This station also has four pumps total, two 11.8 mgd and two 17.5 mgd, and one empty slot for a fifth future pump if required. These pumping stations take suction from the Pikesville Reservoir located in the Western Third Zone. Four discharge mains provide flows to this zone. Station 1 has 20-inch and 24-inch discharge mains, while Station 2 has 24-inch and 42-inch discharge mains.

The Pikesville Pumping Stations pump water to four elevated storage tanks in this zone that provide a total usable capacity of 2.6 mg. The four tanks are: the Pleasant Hill Tanks 1 and 2, which have a usable capacity of 0.3 mg and 1.0 mg, respectively, and are located on Pleasant Hill Road, the Randallstown Tank, which has a usable capacity of 0.3 mg and is located on Tower Road, and the Deer Park Tank, which has a usable capacity of 1.0 mg and is located on Liberty Road in Harrisonville. All tanks have an overflow elevation of 740 feet, except Pleasant Hill Tank 1, which is slightly lower at 739.84 feet. A fifth storage facility, the Owings Mills Reservoir, is currently under design and is to be located on Tavern Keep Road in

Owings Mills. The proposed usable capacity of the Owings Mills Reservoir is 2.8 mg with the same overflow elevation, 740 feet, as the other tanks in this zone.

<u>Pikesville Previous Reports</u>

This zone was predicted to be a high growth area in the 1955 *Central System Report* by Geyer and Wolff. In this report, the population and service area were estimated to be 72,000 people and 58 square miles, respectively, by the year 2000. The current population is close, 75,000 people, in a service area half the size that the Geyer-Wolff report predicted. Although the land area served will probably not expand much more, this zone is expected to continue to grow in population and therefore, a close eye should be kept on the demand projections presented herein.

<u>Pikesville Model Description</u>

One modification was made since the initial hydraulic model set up and calibration, which is discussed in *Volume II Model Development*. Due to the close proximity of the two Pleasant Hill Tanks in the hydraulic model, it was necessary to combine these tanks to simulate one tank hydraulically. The same elevations were used for the combined tank, but the size was increased to represent the storage capacity of both tanks. Hydraulically the model cannot handle two tanks so close together because one tank fills the second tank and when that storage tank drains, the second tank then drains to fill the first tank.

<u>Pikesville Model Analysis</u>

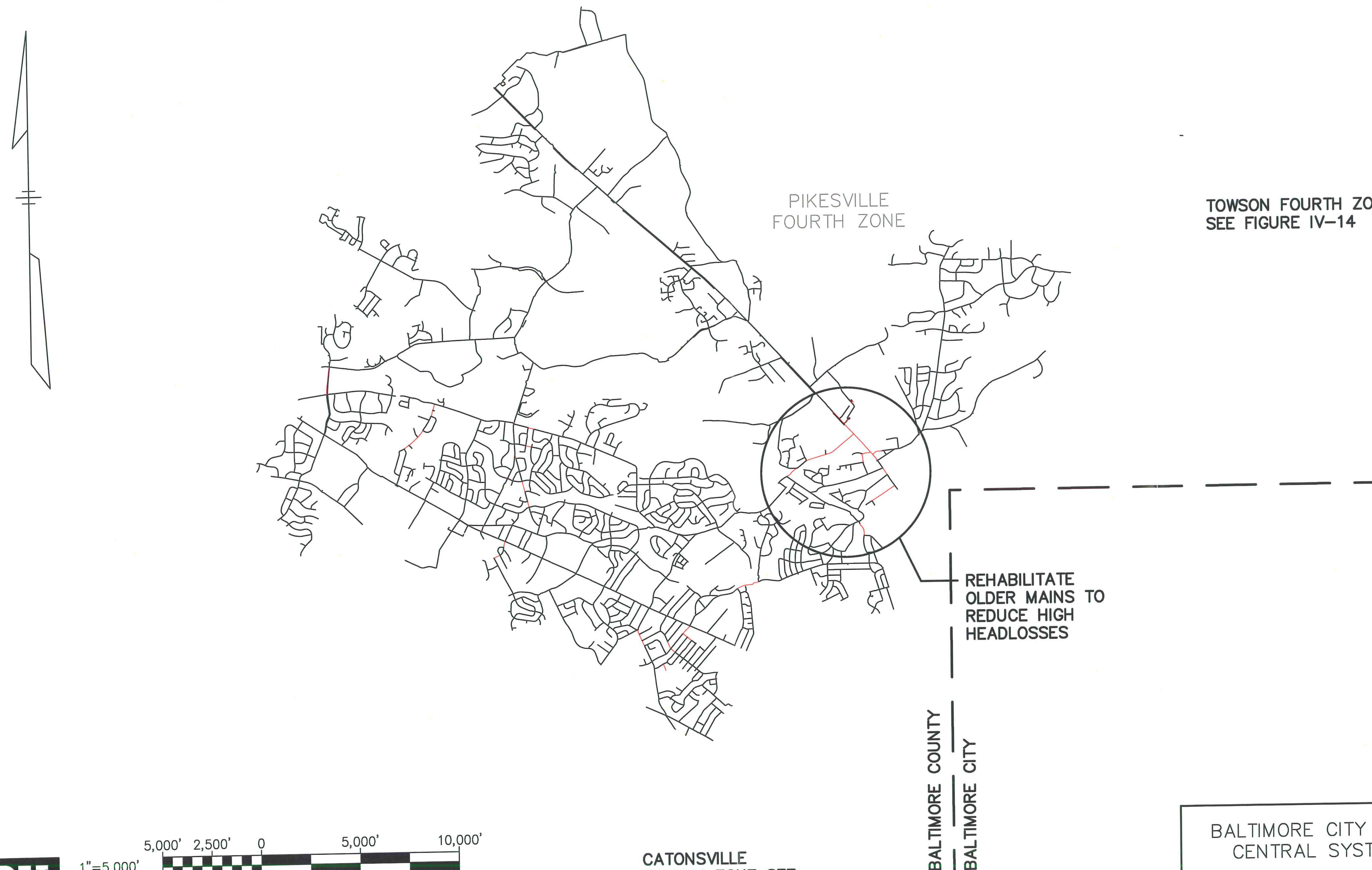
A comprehensive evaluation of the Pikesville Fourth Zone hydraulic model demonstrated minimal problems. There is scattered high head loss gradients and high pressure problems in this zone. There is ample storage and pumping capacity, but hydraulically the system does not operate well. In addition, significant growth is expected in this zone and the dependant Reisterstown Fifth Zone which will amplify the current problems. Model results can be found on the mapping in Appendix B.

Several model nodes in this zone currently exceed the recommended maximum pressure and head loss gradient criteria discussed previously. Approximately 12% of the model nodes exceed 120 psi and these are located in the central-eastern side of the zone, which is a low-lying area along the Gwynns Falls stream valley. Low pressures are not a problem in this zone.

The main area exhibiting high head loss gradients occurs near the pumping station as shown on Figure IV-12. The discharge mains from the pumping stations have high head loss, but not as severe as some other areas nearby. Several pipes have over ten feet of head loss through 1,000 feet of pipe. These pipes, along Reisterstown Road, Woodholm Avenue and Old Court Road, should be lined to decrease the head losses.

This zone has sufficient pumping and storage capacity through the year 2025. There is currently adequate pumping capacity at the two Pikesville Pumping Stations. However, on an average day, the tanks cycle several times a day and both the Pleasant Hill Tank and Randallstown Tank reach their overflow several times. On a maximum day, the same situation occurs. The Deer Park Tank is the only tank that does not reach its overflow. On a maximum day, the Deer Park Tank fluctuates almost ten feet and only returns within three feet of the starting elevation of 735 feet. Over 30% of the storage capacity in this tank is used. The fluctuation in the Pleasant Hill Tank is also over 10 feet, but only 20% of the storage capacity is used, leaving at least 10% of additional equalization storage in the tank which could be utilized. The Randallstown Tank fluctuates only six feet and also uses approximately 20% of the storage in the tank. The Owings Mills Reservoir, in operation by 2005, is predicted to fluctuate five feet and return within two feet of its starting elevation. Approximately 10% of the usable capacity in this tank would be used, which is not acceptable.

In order to better operate the storage facilities in this zone, a 24-inch main is recommended to link Deer Park Tank with the future Owings Mills Reservoir. This recommended main would be 3,500 feet long, located in Marriottsville Road between Lyons Mill Road and Liberty Road, and would connect a 20-inch and a 16-inch main. The modeling analysis demonstrated that with the addition of the recommended 24-inch main in Marriottsville Road, tank level fluctuations improved throughout the zone; however, the hydraulic gradient dropped in several tanks. This does not adversely affect pressures in this zone because low pressures are not currently a problem. It does keep certain tanks from going to overflow during the day, while others were dropping too low.



Color Coding Legend
Link: Headloss Gradient (ft/1000ft)

>= 4.00

RK &K

BALTIMORE CITY PROJECT 658
CENTRAL SYSTEM REPORT

PIKESVILLE FOURTH ZONE HEADLOSS GRADIENTS

MARCH, 2003

Figure IV–12

RKK2\SYS – ojects\49638\PHASEII\MODELING\HL4THS.DWG
07/12/2002 13.. HL.PCP PLOT SCALE: 1=1

The fire flow analysis discovered that approximately 37% of the model nodes can provide 6,000 gpm of fire flow. Only 6% of the nodes in this zone cannot provide the minimum residential fire flow of 1,500 gpm. These nodes are shown on Figure IV-13, which indicates the amount of fire flow available at each model node up to 6,000 gpm. Almost all the areas with low fire flow availability are older sections of pipe with low Hazen-Williams C factors reflecting the age of the pipe. These areas, listed below, should be rehabilitated to improve the fire flow capacity as shown on Figure IV-13.

- The area surrounding intersection of Mount Wilson Lane and Iron Horse Lane
- The area east of Pikeswood Drive, north of Liberty Road
- The area north of Winands Road near Mary Ridge Drive

Pikesville Recommendations

- Construct a 24-inch main in Marriottsville Road (to finish loop) between Lyons Mill Road and Liberty Road which will provide a direct connection between the Deer Park Tank and the Owings Mills Reservoir which is currently under construction

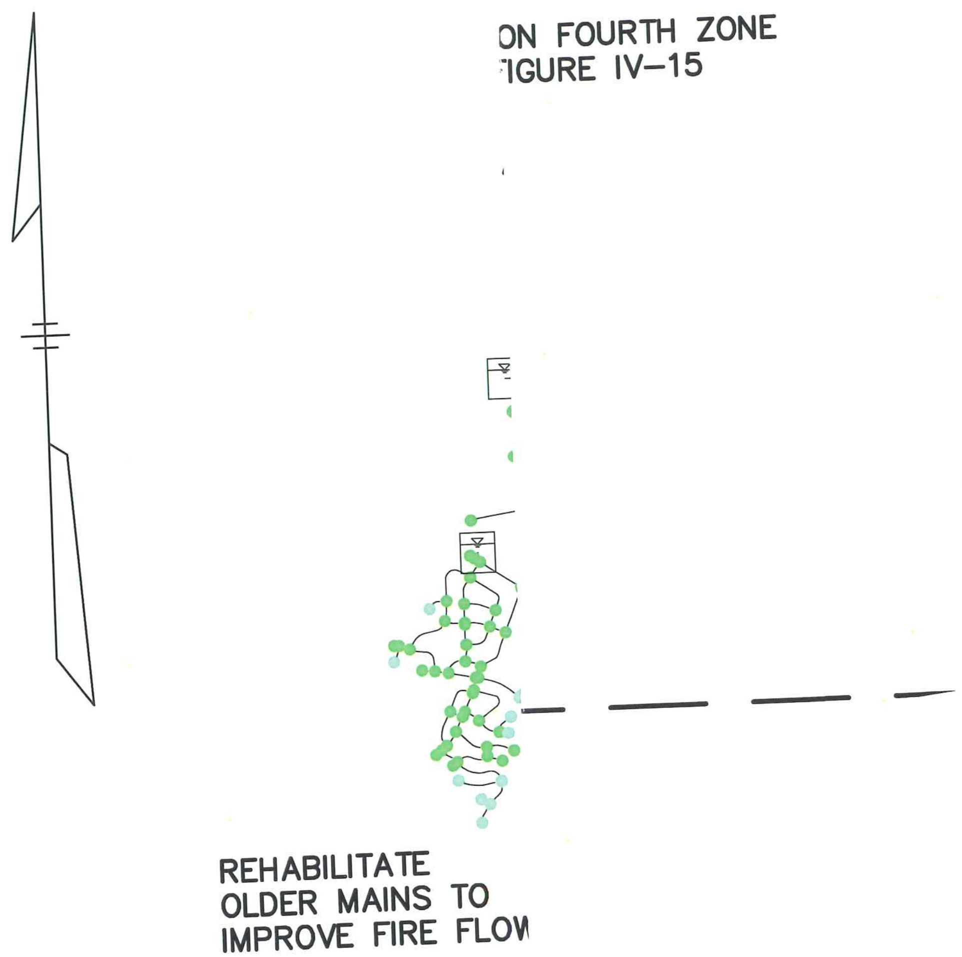
- Rehabilitate older mains near the Pikesville Pumping Station along Reisterstown Road, Woodholm Avenue and Old Court Road to reduce head loss

- Rehabilitate mains in the areas listed below to increase low fire flow availability
    - The area surrounding intersection of Mount Wilson Lane and Iron Horse Lane
    - The area east of Pikeswood Drive, north of Liberty Road
    - The area north of Winands Road near Mary Ridge Drive

8. Towson Fourth Zone

Towson Zone Description

As shown in Figure IV-1, the Towson Fourth Zone serves a large portion of the Interstate 83 corridor north of Baltimore City. This zone has an area of almost 29 square miles, with 99% of the zone located in Baltimore County. By 2025, this zone is projected to increase to over 30 square miles, only growing in the County portion of the zone. The Towson Fourth Zone is



Color Coding Legend

Node: Available Fire Flow (gpm)

Color		Value
Red	<=	500.00
Blue	<=	1,000.00
Yellow	<=	1,500.00
Light blue	<=	3,000.00
Green	<=	6,000.00
Magenta	<=	12,000.00

1"=5,000'   5,000' 2,500' 0

BALTIMORE CITY PROJECT 658
CENTRAL SYSTEM REPORT

PIKESVILLE FOURTH ZONE AVAILABLE FIRE FLOW

MARCH, 2003

Figure IV–13

RK&K

RKK2\SYS – n:\projects\49638\PHASEII\MODELING\FF4.DWG
07/12/2002 14:14 FF.PCP PLOT SCALE:1=1

bordered on the eastern side by Loch Raven Reservoir, the northern side by various upper zones and the rest of the zone is encircled by the Eastern Third Zone. The elevation of the land surface in this zone ranges from 548 feet down to 250 feet in the areas near Loch Raven Reservoir.

The population of the Towson Fourth Zone is currently just over 89,000. This population is projected to decrease slightly to 88,000 by 2025. The 2000 average day demands were recorded at 13 mgd and maximum day demands were 21 mgd. Demands in this zone are not expected to increase significantly, only 1 mgd by 2025, and this is because of the increase in projected per capita demand. The current distribution of demands is as follows: 61% residential, 38% commercial and 1% industrial. Those distributions are only projected to change by 2% over the next 25 years. The distribution shows the zone is predominantly residential, as are most of the other upper zones. However, there are several industrial plants in this zone and large commercial areas along I-83, stretching from the city of Towson north to the Hunt Valley area. Unaccounted for water is high in this zone averaging 20% of the total flows supplied.

The Towson Fourth Zone demands are met from water supplied from the Towson Pumping Stations 2 and 3. Both pumping stations take suction through a 42-inch main from the Towson Reservoir in the Eastern Third Zone. These pumping stations are both located on Hillen Road in the Towson area. The total nominal capacity of these stations is 43.0 mgd, with one standby 17.9 mgd pump at Station 3. Station 2 has two 8.6 mgd pumps with a nominal capacity of 17.2 mgd. Station 3 has two 12.9-mgd pumps with a nominal capacity of 25.8 mgd. The Towson Pumping Stations also supply four of the five upper fifth zones: Falls, Pot Springs, Sherwood and Sparks.

The Towson Pumping Stations pump water to three storage facilities that provide a total usable storage capacity of 13.0 mg to this zone: Mays Chapel Reservoir and Stratford Tank to the north and Cub Hill Tank to the east. The Mays Chapel Reservoir is located off Jenifer Road in Timonium and has recently been covered and expanded to a usable storage capacity of 11.0 mg. The overflow elevation of this reservoir is 601 feet. The Falls Fifth Pumping Station draws suction from this reservoir to feed the Falls Tank and Falls Fifth Zone. The Stratford Tank provides 1.0 mg of usable storage capacity to the zone from its location on Westdale Court in Timonium. The overflow elevation of this tank is 600 feet. The Stratford Pumping Station in the

Pot Springs Fifth Zone draws suction from this tank. The Cub Hill Tank is one of the most recent storage facilities in the Central System, built in 1997. This tank supplies 1.0 mg of usable storage capacity to the Towson Fourth Zone and has an overflow elevation of 600 feet as well. It is located off of Old Harford Road. The Ware Avenue Tank has been removed from the system.

Towson Previous Reports

Previous studies have shown that this zone used to have major deficiencies. The findings of the 1955 *Central System Report* by Geyer and Wolff were that the biggest problem at that time was the underestimation of demands. This zone was growing at a rapid rate and system improvements were not keeping up with increasing demands which caused supply problems in the zone. Today, this zone is almost fully developed and little additional demand increases are anticipated in this zone over the planning period.

Towson Model Analysis

A comprehensive evaluation of the Towson Fourth Zone hydraulic model revealed few problems. The main issue to be addressed is the availability of fire flows in certain areas within the zone. There are also high head losses and high pressures, which is a common problem in the Central System. Pumping and storage capacity in this zone do not appear to be a problem at this time. Because minimal growth is projected to occur in this zone, future deficiencies are not anticipated. Model results can be found on the mapping located in Appendix B.

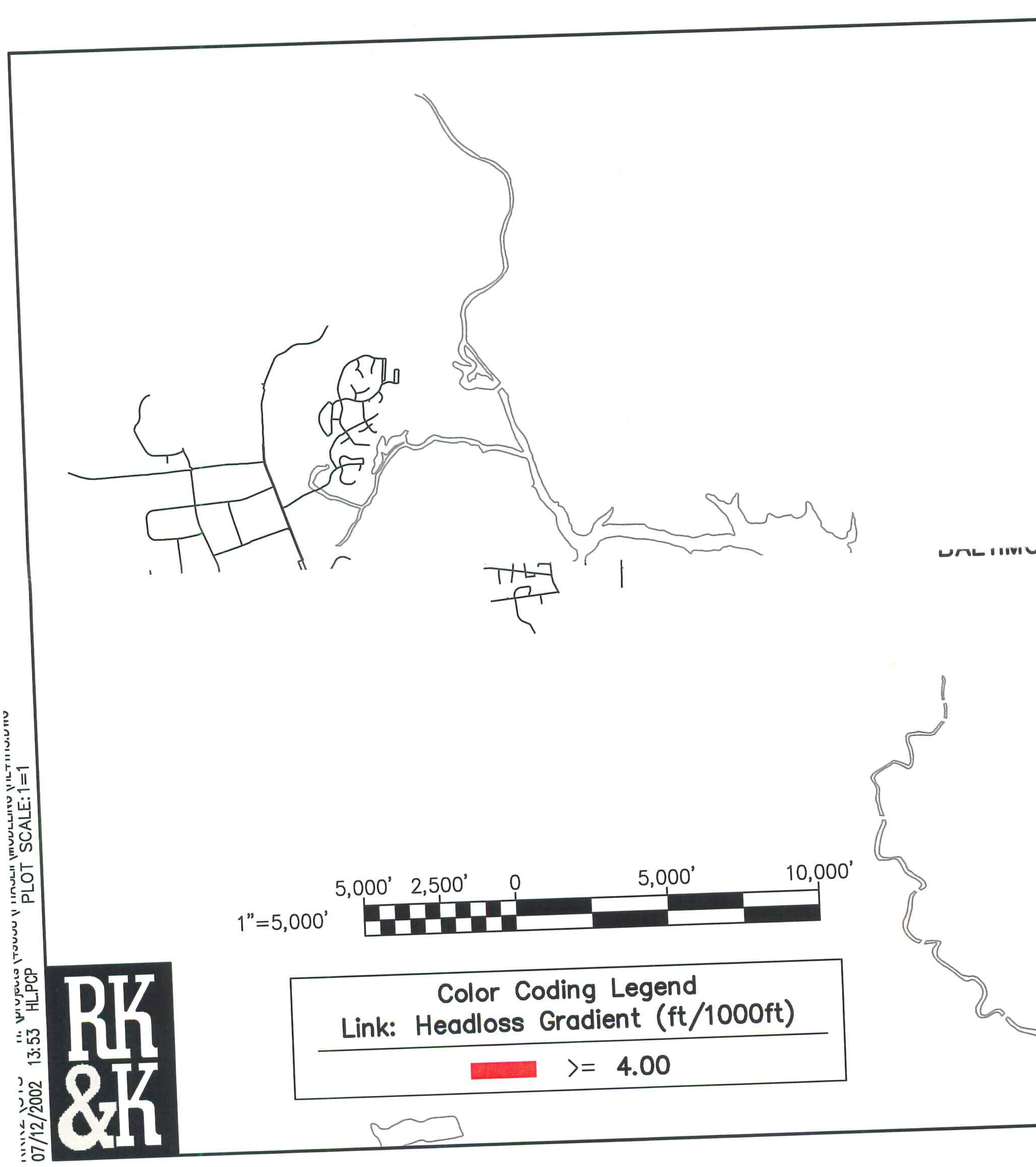
This zone experiences high pressures in some model nodes, which are larger than the maximum recommended allowable service pressure of 120 psi, according to the established hydraulic performance criteria discussed in Section B. The high pressures are observed in the northern and eastern portions of the zone due to the low ground elevation near Loch Raven Reservoir, as illustrated in Figure I-2 located in Section I. These results match the high pressures found during the field testing performed for this project. There currently appears to be very few nodes with low pressures with all of these located near the pumping station and Mays Chapel Reservoir. These areas have high ground elevations and a limited number of service connections. The lowest pressure at a service connection is approximately 20 psi. The pressure ranges between 1 and 143 psi during the peak hour and are not expected to increase or decrease drastically over the next 25 years.

There are several pipes with excessive head loss gradients in this zone. Most of these pipes are 16-inch mains that are located in the southern portion of the zone near the pumping stations and the Towson Town Center. Many pipes in this zone are more than 50 years old and should be rehabilitated to lower the head losses. Head loss gradients are illustrated on Figure IV-14, along with the areas which should be rehabilitated.

The hydraulic analysis of the Towson Fourth Zone found sufficient pumping capacity and storage capacity to meet the system demands on an average or maximum day. Towson Pumping Station currently only uses three pumps on a maximum day, leaving the remaining two pumps for future demand increases or emergencies. All three storage facilities fluctuate during the day and operate adequately. Mays Chapel Reservoir fluctuates almost four feet during maximum day demands, but returns to within at least 1.5 feet of the starting elevation. Approximately 20% of the storage capacity is used in this reservoir. Stratford Tank returns to an average of 1.5 feet from the starting elevation. This tank fluctuates over twelve feet for maximum day demands and utilizes almost 30% of its storage capacity. The third tank, Cub Hill Tank, does not quite return to the starting elevation at the end of a maximum day. This tank drops nine feet and uses approximately 20% of its storage capacity; however, it finishes the day approximately two feet lower than the initial elevation.

The fire flow analysis discovered that 89% of the zone can supply over 1,500 gpm, which is the minimum residential fire flow required. Approximately 26% of the model nodes in this zone can supply 6,000 gpm. Figure IV-15 highlights these problem areas by indicating the amount of fire flow available at each model node, up to 6,000 gpm. Many of the areas with fire flow availability problems have low Hazen-Williams C factors reflecting that they are older mains. Four general areas with low fire flows below 1,000 gpm include:

- Around Satyr Hill Road and Smith Avenue east of Cromwell Bridge Road
- On Bellona Avenue near Essex Park north of Joppa Road
- Area between Charles Street and Bellona Avenue just north of City line
- Area between Cowpens Avenue and beltway near Loch Raven High School

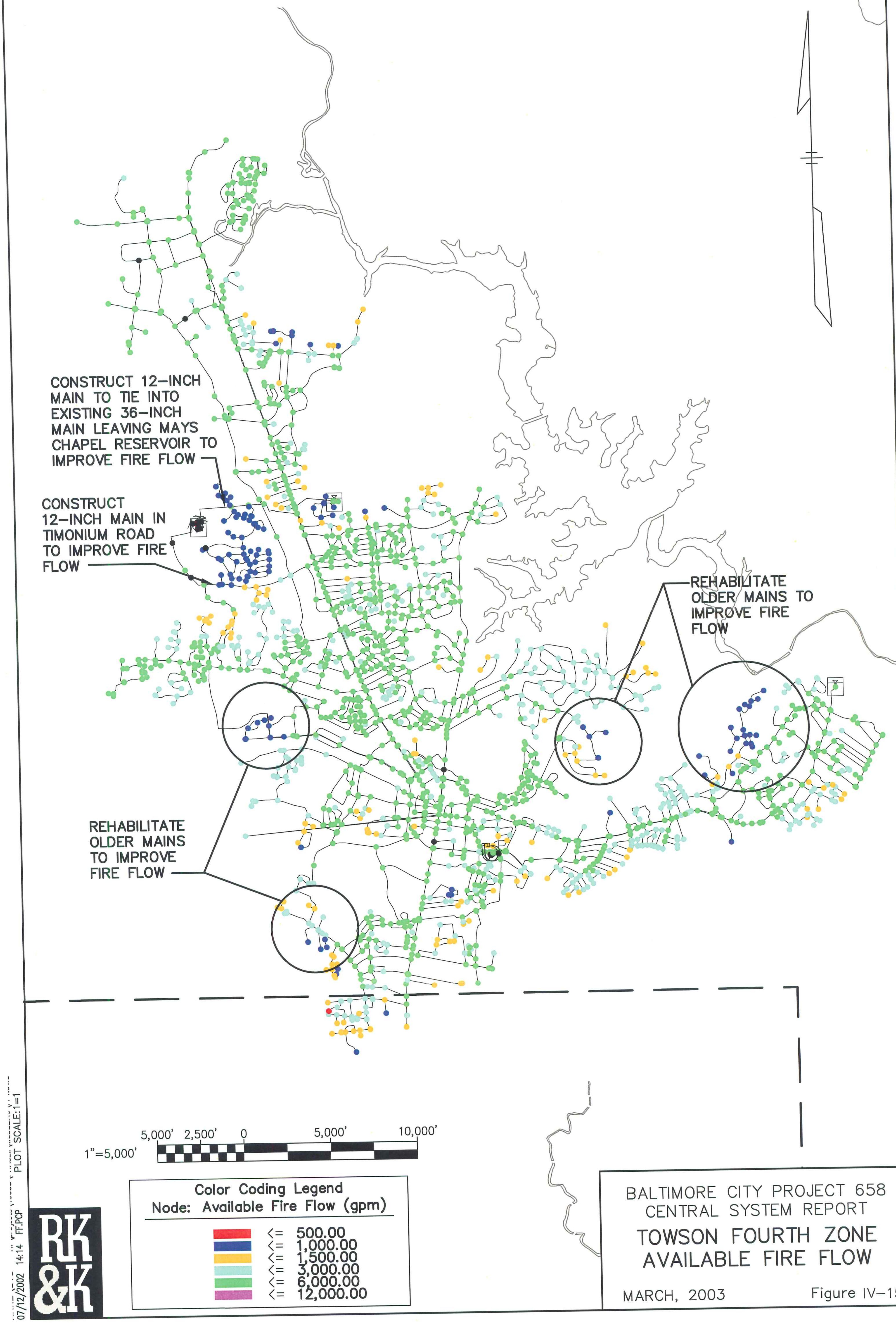


BALTIMORE CITY PROJECT 658
CENTRAL SYSTEM REPORT

TOWSON FOURTH ZONE
HEADLOSS GRADIENTS

MARCH, 2003

Figure IV–14



BALTIMORE CITY PROJECT 658
CENTRAL SYSTEM REPORT

TOWSON FOURTH ZONE AVAILABLE FIRE FLOW

MARCH, 2003

Figure IV-15

These areas, shown on Figure IV-15, should be rehabilitated to improve fire flow availability. One newer area, which is fairly large, has fire flow capacity problems that cannot be attributed to low C factors. Average fire flow availability in this area is only 800 gpm. This area is located near Mays Chapel but is hydraulically an average of two miles away from a source and only has two connections to the rest of the system. Based on the modeling analysis, two new 12-inch mains, approximately 100 and 900 feet long, should be constructed. One main will link this area to the 36-inch main leaving Mays Chapel Reservoir just north of this neighborhood and the other is located in Timonium Road. The average fire flow availability increases to 3,000 gpm as a result of constructing the 12-inch main.

<u>Towson Recommendations</u>

- Rehabilitate the older pipes that have not been rehabilitated, especially in the Towson Town Center area and also the discharge mains near the Towson Pumping Stations 2 and 3

- Rehabilitate four general areas that have low fire flow availability:
    - Around Satyr Hill Road and Smith Avenue
    - On Bellona Avenue near Essex Park
    - Area between Charles Street and Bellona Avenue
    - Area between Cowpens Avenue and beltway

- To improve fire flows, construct two 12-inch mains, approximately 100 and 900 feet long, with one connecting to the 36-inch main leaving Mays Chapel Reservoir and the other located in Timonium Road

- Find possible unaccounted for or unauthorized sources of water usage in this zone and eliminate them because the unaccounted for water percentage is too high

9. Falls Fifth Zone

<u>Falls Fifth Zone Description</u>

The Falls Fifth Zone presently serves an area just under one and a half square miles, as illustrated in Figure IV-1. This zone is in the Timonium area, west of York Road, located completely in Baltimore County. The zone boundary is created by the Towson Fourth Zone to the south and east and the URDL on the other two sides. With minimal room for expansion within the URDL, this zone is projected to reach 1.8 square miles by 2025. Elevations at the ground surface range from 444 feet to 630 feet above mean sea level in this area.

The 2000 Census recorded the population of the Falls Fifth Zone at approximately 4,800 people. By 2025, the population is expected to increase to over 5,600. On an average day, just under 0.5 mgd of water is supplied to this zone. Demands are projected to increase 20% to over 0.6 mgd over the next 25 years. Maximum day demands are currently 1 mgd, twice the average day demands, and are projected to increase 60% to approximately 1.6 mgd, based on conservative historical trends. The current distribution of the consumer demands is a 67%/33% split between residential and commercial, respectively. This area is primarily residential neighborhoods with their supporting commercial districts. Presently there are minimal industrial consumers (<1%); however, that is projected to increase over the next few years. The estimated unaccounted for water in this zone comprises 25% of the total flow supplied to the zone, which is very high.

Demands to this zone are supplied from the Falls Fifth Pumping Station located inside the base of the Falls Tank. Located off Jenifer Road in Timonium, the pumping station takes suction from the adjacent Mays Chapel Reservoir in the Towson Fourth Zone through a 16-inch main. The pumping station has three 2.7 mgd pumps, including one proposed pump currently under design, and a nominal capacity of 5.3 mgd. One 2.7 mgd pump acts as a standby pump. The Falls Tank has a usable storage capacity of 0.5 mg and an overflow elevation of 755 feet. This zone does not supply any other zones.

Falls Fifth Previous Reports

There are no major problems in the Falls Fifth Zone reported in previous studies.

Falls Fifth Model Analysis

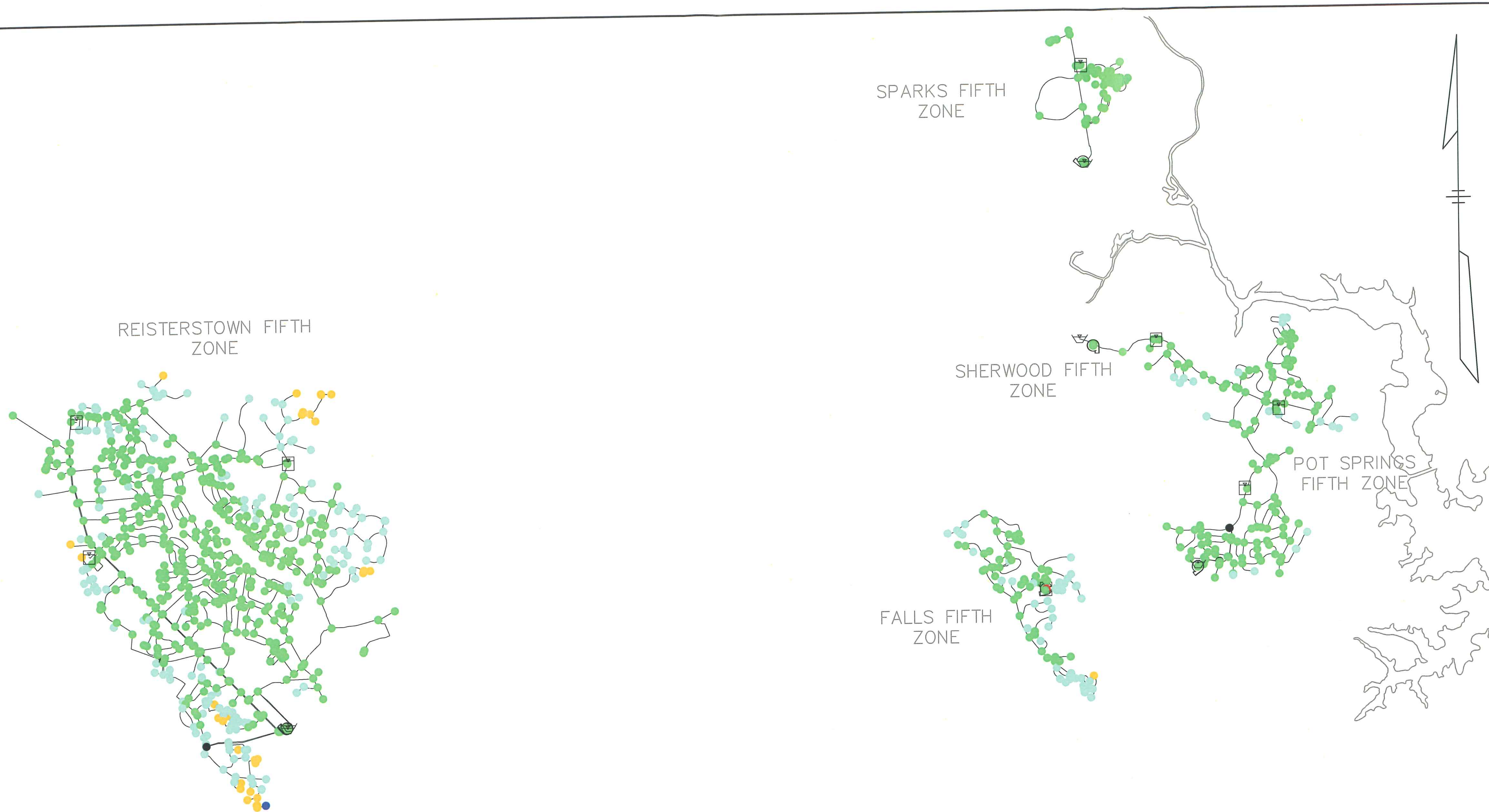
A comprehensive hydraulic model evaluation found the Falls Fifth Zone to be operating with minimal deficiencies. Most pressures and head losses are within the established performance criteria. There is ample storage and pumping capacity as well as plenty of available fire flow. However, operational improvements in this zone should be made. Model results can be found on the mapping in Appendix B.

The pressures in this zone range between 47 psi and 128 psi on an average day. There are two model nodes with pressures exceeding 120 psi, both by less than 10 psi, on Rutledge Road and Greenpoint Road. These locations have a much lower ground elevation than the rest of the zone. Pressures do not change significantly over time and by 2025, they are approximately the same. Similarly, the head losses in this zone are minimal. There are a few pipes smaller than 18 inches with excessive head loss gradients, but all of these are located in and around the pumping station where flows are typically high.

Pumping and storage capacity in this zone are adequate; however, operational changes could be made to improve the system. The Falls Tank currently operates over seven feet below the overflow elevation. With the current pump controls, the tank only fluctuates three feet and cycles over five times during a 24 hour period. This only utilizes approximately 8% of the tank, which is far less than the recommended turn over volume of 20%. Also, the tank drops below 50% full, which minimizes the available flows during emergencies. Therefore, the pump controls should be modified to maintain the tank at a higher elevation and a fluctuation range of eight feet. Not only will this utilize more storage in the tank, but it will minimize the number of times pumps turn on and off which reduces pump maintenance and electrical costs.

The NPSH at the Falls Fifth Pumping Station drops as low as 5 psi, which is below the established criteria of 10 psi and below the NPSH requirement for this station which is 7 psi. Therefore, this low pressure is borderline and the suction pressure at the pumping station should be closely watched.

All nodes in the model can provide more than the minimum 1,500 gpm residential fire flow required. Approximately half the nodes can provide at least 6,000 gpm, which was the highest fire flow availability analyzed. The available fire flow at each model node, up to 6,000 gpm, is illustrated on Figure IV-16.



Color Coding Legend
Node: Available Fire Flow (gpm)

- <= 500.00
- <= 1,000.00
- <= 1,500.00
- <= 3,000.00
- <= 6,000.00
- <= 12,000.00

5,000' 2,500' 0 5,000' 10,000'

1"=5,000'

RK &K

RKK2\SYS – n:\projects\49638\PHASEII\MODELING\FF5TH.DWG
07/12/2002 14:21 FF.PCP PLOT SCALE:1=1

BALTIMORE CITY PROJECT 658
CENTRAL SYSTEM REPORT

FIFTH ZONES AVAILABLE FIRE FLOW

MARCH, 2003

Figure IV–16

Falls Fifth Recommendations

- Modify existing pump controls to utilize more storage in the tank and operate the pumps less frequently

- Find possible unaccounted for or unauthorized sources of water usage in this zone and eliminate them because the unaccounted for water percentage is very high

10. Pot Springs Fifth Zone

Pot Springs Zone Description

The Pot Springs Fifth Zone is located entirely within Baltimore County, to the north of Baltimore City. The current zone boundary is illustrated in Figure IV-1. It lies in the area between Timonium Road in Timonium and Warren Road in Cockeysville, on the east side of Interstate 83. This zone serves an area just over three square miles and the area is not projected to increase over the next 25 years. This zone is bordered by the Towson Fourth Zone to the south and southwest, the Sherwood Fifth Zone to the west and Loch Raven Reservoir and surrounding parklands to the east and northeast. The ground elevation in the zone ranges from 350 feet to 540 feet above mean sea level.

The current population of the Pot Springs Fifth Zone is over 11,000 people based on the 2000 Census. By the year 2025, the Baltimore Metropolitan Council (BMC) projects the population to decrease below 10,000. The average annual demand is approximately 1.2 mgd presently. Even though the population is decreasing, average demands in this zone are expected to increase 33% over the next 25 years, to approximately 1.6 mgd, based on the projected per capita water consumption trends. Maximum day demands are expected to increase from 2.4 mgd presently to 2.8 mgd in 2025. The demand distribution in this zone is as follows: 70% residential, 29% commercial and 1% industrial. This area is predominantly residential with supporting commercial areas. Due to the decreasing population, the residential portion of the demand is projected to decrease, while the commercial usage is expected to increase over the next 25 years. Unaccounted for water is estimated to be approximately 15% of the water supplied to this zone, which is acceptable.

Demands are supplied to this zone through a 20-inch discharge main from the Stratford Pumping Station, which takes suction from the Stratford Tank in the Towson Fourth Zone. The Stratford Pumping Station has a nominal capacity of 6.4 mgd and is located on Westdale Court in Baltimore County. This pumping station has two 3.2 mgd primary pumps and one additional 4.8 mgd standby pump. Water is pumped to two elevated tanks in this zone, Springdale Tank and Spring Lake Tank, which have a combined useable capacity of 1.4 mg. The Springdale Tank is located off of Old Bosley Road and has a usable storage capacity of 1.0 mg. The Spring Lake Tank is located off Cardigan Avenue and has a usable storage capacity of 0.4 mg. The overflow elevation for both tanks is 650 feet. This zone does not supply any other zones.

Pot Springs Previous Reports

There are no major problems in the Pot Springs Fifth Zone reported in previous studies.

Pot Springs Model Analysis

A comprehensive evaluation of the Pot Springs Fifth Zone resulted in minimal problems, with high head loss being the only issue of concern. The system experienced high head losses near the pumping station and some of the surrounding pipes. There are a few high pressure areas in this zone also. Storage and pumping capacity, as well as fire flow availability, are adequate. Model results can be found in the mapping located in Appendix B.

According to the established hydraulic performance criteria discussed *in Section B. Performance Criteria*, there are four nodes with pressures larger than the maximum recommended service pressure of 120 psi. The high pressures were seen near the intersection of Bosley Road and Gateridge Road due to the low ground elevations in this area. Pressures in this zone currently range from 35 psi to 125 psi during peak hour demands. Minimum pressures are not a problem in this zone.

There are several pipes with excessive head loss gradients in this zone compared to the established criteria. Most pipes around the pumping station that are larger than 18 inches in diameter have head loss gradients over the 2 feet per 1000 feet criteria. There are also several pipes smaller than 18 inches in diameter which have well over a 4 feet per 1000 feet head loss gradient. Piping between the pumping station and closest storage tank varies between 8 inches and 20 inches in diameter. New parallel mains in this area would lower head losses through the smaller pipes and help maintain levels in the storage tanks, which rehabilitation alone could not accomplish. Two 16-inch parallel mains should be constructed in Hartfell and Killoran Roads with an approximate total length of 3,300 feet.

There is adequate pumping capacity in this zone, only the high head losses limit the water getting out into the system. The NPSH at the pumping station is over 30 psi which is sufficient.

A fire flow analysis showed that all model nodes could still provide the minimum residential fire flow of 1,500 gpm, even though there are high head losses in this zone. In addition, over 30% of the model nodes could supply 6,000 gpm, the maximum amount used for this evaluation. Figure IV-16 illustrates how much fire flow is available at each model node, up to 6,000 gpm.

Pot Springs Recommendation

- Although not required to improve fire flows in this zone, the head losses between Stratford Pumping Station and storage tanks would be decreased if two 16-inch parallel mains were constructed in Hartfell and Killoran Roads for a total length of approximately 3,300 feet

11. Reisterstown Fifth Zone

Reisterstown Zone Description

The Reisterstown Fifth Zone lies completely within Baltimore County, northwest of Baltimore City, generally encompassing the town known as Reisterstown. The zone, as illustrated in Figure IV-1, falls completely on the northeast side of I-795 and currently covers almost 10 square miles of the area along Reisterstown Road between Pleasant Hill Road and Butler Road. By the year 2025, this zone is projected to grow to over 11 square miles. The ground elevations in the zone range between 526 feet and 752 feet above mean sea level.

The Reisterstown Fifth Zone serves a current population of approximately 30,000 people, based on the 2000 Census. The current average and maximum day demands are approximately 3.0 mgd and 5.4 mgd, respectively. The high maximum day to average day peaking factor of 1.8 for this zone is based on historical data which shows that the current ratio is almost two. Demands in this zone are expected to increase significantly over the next 25 years due to the population and service area increasing. By 2025, population is projected to increase to approximately 39,000 if the zone follows current trends. Future average day demands are estimated at 4.8 mgd and maximum day demands at 9.6 mgd. The current distribution of demands is 68% residential, 29% commercial and 3% industrial. Those percentages are projected to remain the same over the next 25 years. The consumer base is predominantly residential, with minimal commercial users mostly along Main Street in downtown Reisterstown. Unaccounted for water is estimated to be approximately 20% of the water supplied to this zone, which is too high.

Demands are supplied to the Reisterstown Fifth Zone via the two Pleasant Hill Pumping Stations, with a combined nominal capacity of 8.6 mgd. The Pleasant Hill Station 1 has two, 2.2 mgd pumps and Station 2 has two, 4.3 mgd pumps. One of the 4.3 mgd pumps is a standby pump. Water is drawn from the two Pleasant Hill Tanks located in the Pikesville Fourth Zone and fed through two 24-inch transmission mains to the pumping stations off of Pleasant Hill Road. The total usable storage capacity in the zone is 1.2 mg and is provided by the Reisterstown and Chartley elevated tanks. The Reisterstown Tank is located off First Avenue, south of Butler Road and has a usable storage capacity of 0.3 mg. The Chartley Tank is located off Owings Avenue and has a usable storage capacity of 0.9 mg. The overflow elevation for both tanks is 850 feet. A third tank, Bond Avenue Tank, is proposed to be constructed in the near future. This tank will be located near the intersection of Bond Avenue and Timber Grove Road. The proposed Bond Avenue Tank will have 1.0 mg useable storage and the same overflow elevation of 850 feet as the existing tanks. This zone does not supply any other zones.

Reisterstown Previous Reports

The Reisterstown Fifth Zone was a small zone in 1955 when the *Central System Report* was published, only encompassing two square miles. The main concern for this zone was to examine the demands periodically to determine when the existing pumping capacity would be exceeded. As will be proven below, the demands are still increasing in this zone and the pumping capacity needs to be closely watched.

Reisterstown Model Analysis

A comprehensive evaluation of the hydraulic model resulted in significant problems in the Reisterstown Fifth Zone, with inadequate pumping capacity being the main issue. The system experienced high head losses near the pumping station and in the older pipes along Reisterstown Road. Storage capacity is a problem in this zone as well. Graphical model results are located in Appendix B.

According to the established hydraulic performance criteria discussed in Section B above, there are five nodes with pressures larger than the recommended allowable service pressure of 120 psi. The high pressures were scattered in the east and southeast sections of the zone due to low ground elevations. Pressures in this zone typically range from 36 psi to 131 psi during peak hour demands.

By the year 2015, projected maximum day demands are expected to exceed the current nominal capacity of the Pleasant Hill Pumping Stations. Instead of constructing a third pumping station in this zone, the almost 40 year old pumps at the Pleasant Hill Pumping Station 1 should be replaced with larger capacity pumps to meet the projected demand. In addition, transmission improvements will be required in and around the pumping station. These transmission mains will help reduce high head losses in this zone near the pumping station, including a parallel 16-inch main along 4,300 feet of Pleasant Hill Road. The NPSH at both pumping stations is over 40 psi which is well above the established minimum.

Storage capacity in this zone also appears to be lacking. The Reisterstown Tank goes empty during simulations evaluated for future years. Conditions improve with the proposed Bond Avenue Tank, but the Reisterstown Tank still drops low and does not fully recover on a maximum day demand. The Bond Avenue Tank should be in service by 2005 to improve the storage deficit in this zone discussed in *Section III.B.4. Summary of Total Storage Recommended for Each Zone.*

A fire flow analysis of this zone found several deficiencies. Only four percent of the model nodes cannot supply the minimum residential fire flow of 1,500 gpm, with the lowest fire flow availability being just under 1,000 gpm in the southern tip of the zone. However, two thirds of the model nodes can satisfy a fire flow of 6,000 gpm. The amount of fire flow available at each model node, up to 6,000 gpm, is illustrated on Figure IV-16. There are only a few scattered nodes with low fire flow availability in isolated locations with high elevation; therefore, there are no improvements recommended.

Reisterstown Recommendations

- Construct the proposed Bond Avenue Tank by 2005
- Replace two existing 2.2 mgd pumps at Pleasant Hill Pumping Station 1 with two 4.3 mgd pumps
- Construct additional transmission capacity in and around pumping station, including a parallel 16-inch main along 4,300 feet of Pleasant Hill Road
- Find possible unaccounted for or unauthorized sources of water usage in this zone and eliminate them because the unaccounted for water percentage is too high

12. Sherwood Fifth Zone

Sherwood Zone Description

The Sherwood Fifth Zone is the Central System's newest zone, with the pumping station and storage tank being completed only three years ago, in 1998. Located in Cockeysville, north of the Baltimore beltway (Interstate 695), this zone lies completely in Baltimore County. The zone, as illustrated in Figure IV-1, is bordered on the south and west sides by the Towson Fourth Zone and to the east by Pot Springs Fifth Zone. Currently, the area served is less than one third a square mile, but by 2025, this zone is expected to almost double in size and reach over one half square mile. Land surface elevations in the Sherwood Fifth Zone range from 410 feet to 600 feet above mean sea level.

The present population of the Sherwood Fifth Zone is approximately 400. This population is expected to increase 25% to a little over 500 by 2025. Similarly, the projected average demands are expected to increase from 50,000 gal/day to 60,000 gal/day and maximum demands from 90,000 gal/day to 130,000 gal/day over the next 25 years. The distribution of demands is 70% residential and 30% commercial, with no industrial users at the present time. This area is primarily residential with supporting commercial districts. Unaccounted for water in this zone is estimated at 15% of the total flow supplied, which is acceptable. Because this zone has been in service for such a short time, there is limited historical data. Many of the trends used for this zone are similar to the Pot Springs Fifth Zone.

The Sherwood Fifth Zone demand is supplied by the Sherwood Pumping Station which pumps water to the Sherwood Tank. Both the tank and pumping station are located on Sherwood Road, approximately 0.7 miles apart. The Sherwood Pumping Station has a nominal capacity of 1.4 mgd and three 0.7 mgd pumps. One pump is a standby pump. This station pulls suction from the Towson Fourth Zone through a 16-inch main. Flow is stored in the 0.25 mg Sherwood Tank with an overflow elevation of 705 feet. This zone does not supply any other zones.

Sherwood Previous Reports

The Sherwood Fifth Zone has only been in service since 1998 and there are no previous studies which discuss possible problems in this zone.

Sherwood Model Analysis

Since this zone is rather new, minimal problems are expected. The hydraulic evaluation resulted in no major supply problems. Because this zone is so small, any growth is not expected to drastically affect the system. Both pressures and head losses were close to the acceptable ranges. The highest head losses occurred near the pumping station, but were below the established criteria. Pressures range from 41 psi to 124 psi, with only three nodes above 120 psi located at the pumping station. Storage and pumping capacity do not appear to be a problem; however, operationally there are a few changes that could be made. Model results are illustrated on mapping in Appendix B.

The Sherwood Tank currently fluctuates between 695 feet and 698 feet, over seven feet below the overflow. The pump controls at the Sherwood Pumping Station should be modified to utilize more storage in the tank. With a three-foot operating range, only 10% of the tank is being utilized and the pump cycles several times a day. A greater turnover in the tank also means an increase in water quality issues such as reducing trihalomethane (THM) and halo acetic acid

(HAA). With a wider pump control range, the tank will operate closer to 20% capacity and electrical costs will be decreased because the pump is turning off and on less often. In addition, the pumping capacity of the Sherwood Pumping Station significantly exceeds the projected 2025 maximum day demands. Demands are not expected to increase as much as previously projected. Therefore, improvements to the pumping station could be made such as trimming the impellers or installing smaller motors. The NPSH at this pumping station is well over the established minimum of 10 psi.

The fire flow evaluation showed ample fire flow is available in this zone. All but three model nodes can supply 2,500 gpm and those nodes are only barely below 2,500 gpm. Therefore, all model nodes can satisfy the minimum residential fire flow of 1,500 gpm. Approximately 40% of the model nodes can supply 6,000 gpm, which was the maximum fire flow analyzed. The amount of fire flow available at each model node, up to 6,000 gpm, can be found on Figure IV-16.

<u>Sherwood Recommendations</u>

- To utilize the existing pumps at the Sherwood Pumping Station more efficiently, the impellers could be trimmed or smaller motors installed because the current pumps are oversized

- Modify existing pump controls to utilize more of the Sherwood Tank

13. Sparks Fifth Zone

<u>Sparks Zone Description</u>

The Sparks Fifth Zone serves an area a little less than one square mile, located completely in Baltimore County. This zone, as shown on Figure IV-1, envelopes the area known as Sparks, north of the Hunt Valley area. Not touching any other zones, except a small piece of the Towson Fourth Zone where the zones are interconnected, this zone is surrounded mostly by open land and horse farms. Due the URDL and limiting public water to those areas outside the line, this zone only expected to grow to 1.3 square miles by 2025. Typically, ground elevations range from 340 feet to 520 feet above mean sea level in this zone.

The population of the Sparks Fifth Zone is currently 2,300 and is expected to increase by no more than 500 people over the next 25 years. The average day demands in 2000 were recorded at 0.3 mgd, and maximum day demands were 0.8 mgd. By 2025, these demands are projected to be 0.4 mgd and 1.3 mgd, respectively. The demand distribution is currently 52% residential, 35% commercial and 13% industrial. The industrial usage percentage is expected to double by 2025, while the commercial and residential percentages should decrease. This zone is a mix of housing developments and industries, with supporting commercial districts. Of the total flow supplied to this zone, an average of 15% is unaccounted for water, which is acceptable.

This zone's demand is supplied by the Sparks Pumping Station which pulls suction from the north end of the Towson Fourth Zone. The pumping station is located in the 14500 block of York Road and provides a nominal capacity of 3.5 mgd. There are three pumps, two 1.8 mgd pumps and one standby 4.3 mgd pump. Water is discharged through a 16-inch main and pumped to the Sparks Tank located on York Road in Sparks. The Sparks Tank has an overflow elevation of 655 feet and provides 1.0 mg of usable storage to this zone. This zone does not supply any other zones.

Sparks Previous Reports

The Sparks Fifth Zone is a relatively new zone and there are no major problems reported in previous studies.

Sparks Model Analysis

The evaluation of the Sparks Fifth Zone found this zone to be in excellent shape. Because the zone is relatively new and small, minimal problems are expected. Pressures, head losses, storage and pumping capacity and fire flow are all satisfactory. Model results are presented graphically in Appendix B.

Pressures range from 47 psi to 109 psi in this zone. No pressures rise above or fall below the established performance criteria during the 25 years evaluated. Head losses are well below the acceptable head loss gradient criteria in all mains except four mains in and around the pumping station, but only in the latter years analyzed. The NPSH is adequate with the suction pressure being almost 50 psi.

This zone has ample storage and pumping capacity. Currently, the tank operates between 641 and 645 feet, which is five feet below the altitude valve and the altitude valve is five feet below the overflow. This operation results in the utilization of 20% of the tank which is typical; however, the tank drops below 50% full on a maximum day because it is so far below the overflow elevation to begin with. Although this zone has ample pumping capacity, the operating procedures could be modified to improve the tank operation. Modifying the pump controls will also limit the number of pump cycles during a day. During the course of an average day, the tank cycles two times. Electric costs and maintenance on the pumps will be decreased if pump controls are modified.

The fire flow analysis proved that this zone can provide sufficient fire flow. All model nodes had over 2,500 gpm of fire flow availability, well above the minimum residential fire flow of 1,500 gpm. Approximately half the model nodes can supply 6,000 gpm, which was the maximum fire flow evaluated for this zone. The available fire flow at each model node is illustrated on Figure IV-16.

<u>Sparks Recommendations</u>

- Modify pump controls to utilize higher elevations in the Sparks Tank

D. Emergency Scenarios

Several scenarios were run to simulate emergency conditions in the Central System. The effects of emergencies on the system, such as loosing a pumping station due to a power outage or large transmission main due to a break, were evaluated. One of the most significant emergency situations for a water system is drought. This topic is discussed in *Section V. Fullerton Plant and Drought Conditions.*

Table IV-2 below lists the reaction time of the storage facilities in each zone for various emergency scenarios during average day demands. For example, if the First Zone were to loose both Montebello Treatment Plants, the storage capacity in that zone would only be able to support the system for 55 hours. All scenarios were evaluated for a three-day time period, presuming most accidents and emergencies could be corrected in that time.

Table IV-2, Emergency Scenarios (Average Day, Year 2000)

Zone	Scenario	Time Until Storage Depleted	General Comments
1	Montebello WTP 1 & 2 out of service	55 hours	Druid Lake empty (below 200' elevation) and Ashburton WTP near maximum capacity
	Montebello WTP 1 only out of service	*	Druid Lake empty (below 200' elevation) and Ashburton WTP near maximum capacity
2	Ashburton WTP out of service	*	Two pumps on at both Vernon PS and Hillen PS, Ashburton Reservoir 70% full at end of 72 hours, could turn on more pumps if available from 1st Zone
	Vernon PS out of service	*	Two pumps on at Hillen PS
	Fullerton Second PS out of service	10 hours	Perry Hall Tank empty, turning on additional pumps at Hillen PS does not help
2C	Pumping station out of service	9 hours	Storage tank empty
3E	Guilford PS out of service	*	Three pumps on at Cromwell PS, pressure drops below 30 psi in a few areas
	Cromwell PS out of service	*	Two pumps on at Guilford PS, Towson Reservoir drops but recovers
3W	Ashburton PS out of service	40 hours	All three storage facilities empty, two pumps on at Leakin Park PS
	Leakin Park PS out of service	60 hours	All three storage facilities empty, ¾ of system below 30 psi, system partially recovers due to Ashburton PS
4C	Pumping station out of service	6 hours	Both tanks empty within two hours of each other
4P	Both pumping stations out of service	4 hours	All four tanks empty within one hour of each other
4T	Both pumping stations out of service	14 hours	All three tanks empty within one hour of each other
5F	Pumping station out of service	12 hours	Storage tank empty
5P	Pumping station out of service	17 hours	Both tanks empty within same hour
5R	Both pumping stations out of service	6 hours	Both tanks empty within one hour of each other
5W	Pumping station out of service	29 hours	Storage tank empty
5S	Pumping station out of service	40 hours	Storage tank empty

* Scenario did not fail prior to 72 hours

Table IV-3, Emergency Scenarios (Maximum Day, Year 2000)

Zone	Scenario	Time Until Storage Depleted	General Comments
1	Montebello WTP 1 & 2 out of service	17 hours	Druid Lake empty (below 200' elevation) and Ashburton WTP near maximum capacity, complete zone failure, wide spread pressure drop after only one hour
	Montebello WTP 1 only out of service	25 hours	Druid Lake empty (below 200' elevation) and Ashburton WTP near maximum capacity
2	Ashburton WTP out of service	20 hours	Two pumps on at both Vernon PS and Hillen PS, Lake Ashburton empty and pressures drops throughout most of system
	Vernon PS out of service	*	Two pumps on at Hillen PS, Lake Ash. 76% full after 72 hrs
	Fullerton Second PS out of service	6 hours	Perry Hall Tank empty, pressures drop in northeast portion of zone
2C	Pumping station out of service	6.5 hours	Storage tank empty
3E	Guilford PS out of service	15 hours	Three pumps on at Cromwell PS, Towson Reservoir empty after 15 hours, wide spread pressure drop
	Cromwell PS out of service	*	Three pumps on at Guilford PS, Towson Reservoir drops to 50% but recovers
3W	Ashburton PS out of service	30 hours	Two pumps on at Leakin Park PS, all three storage facilities empty, Catonsville Reservoir empty after only 16 hours
	Leakin Park PS out of service	40 hours	Three pumps on at Ashburton PS, all three storage facilities empty, Catonsville Reservoir empty after only 15 hours
4C	Pumping station out of service	5 hours	Both tanks empty
4P	Both pumping stations out of service	3 hours	All four tanks empty, Pleasant Hill in two hours
4T	Both pumping stations out of service	9 hours	All three tanks empty, Stratford in three hours
5F	Pumping station out of service	6.5 hours	Storage tank empty
5P	Pumping station out of service	9 hours	Both tanks empty within one hour, Spring Lake in 8 hours
5R	Both pumping stations out of service	5 hours	Both tanks empty within one hour of each other, Reisterstown Tank in 4 hours
5W	Pumping station out of service	19 hours	Storage tank empty
5S	Pumping station out of service	15 hours	Storage tank empty

* Scenario did not fail prior to 72 hours

Table IV-3 above lists the same scenarios presented in Table IV-2, but for maximum day demands. Again, all scenarios were evaluated for a three-day time period, presuming most accidents and emergencies could be corrected in that time. As shown in the table, maximum demands can make a large difference on the effect on the zone. Storage facilities empty much quicker and pumping stations are already at maximum capacity.

Pumping stations are a vital component of the Central System. Besides an electrical outage, a pumping station discharge main could break which could shut down the whole station if there is only one discharge main. Having dual discharge mains, as the majority of the pumping stations already do, increases the reliability of the station and could prevent this from happening. The following stations do not currently have dual discharge mains: Leakin Park Pumping Station (Western Third), Catonsville Pumping Station (Catonsville Fourth), Stratford Pumping Station (Pot Springs Fifth), Sherwood Pumping Station (Sherwood Fifth), Sparks Pumping Station (Sparks Fifth) and Falls Fifth Pumping Station (Falls Fifth). Improvements to these stations would reduce the risk of an accident or emergency closing off the supply to any of these zones. In the fifth zones, these pumping stations are the sole source of water entering the zone and if closed, the zone would only last as long as the storage capacity. The Leakin Park Pumping Station, on the other hand, is not the sole source in the Western Third Zone because this zone is also fed by the Ashburton Pumping Station. However, without this station, as shown in Tables IV-2 and IV-3, this zone would have severe problems and the wholesale water supply to Howard County may be affected as well.

Several miscellaneous other emergency scenarios were also evaluated to simulate large main breaks throughout strategic portions of the system. Presented below is a list of the zones, scenarios evaluated and the effect on the system for both average day and maximum day demand conditions.

- First Zone – closing Herring Run Conduit, affects a large portion of the eastern half of the zone causing pressures to drop below 40 psi during average day; pressures being to drop immediately during maximum day, with the majority of the zone below 30 psi after only four hours

- First Zone – closing Clifton Conduit, only affects the pressures at a few nodes during average day as well as maximum day, those nodes are the ones at higher elevations
- Second Zone – closing several of the large mains around Ashburton Treatment Plant and Ashburton Reservoir individually, does not adversely affect the zone during average day; closing the 72-inch Southwest Transmission Main causes pressures to drop significantly in the southwest area during maximum day; closing the 84-inch from the plant to the lake causes high pressure problems on the east side during maximum day because additional pumps turn on to compensate
- Eastern Third Zone – closing 30-inch main in Proctor Road, headed east from the Cromwell Pumping Station, causes pressures to drop in the area between Putty Hill and Joppa Road, south of the Cromwell Pumping Station, during average day; during maximum day additional pumps turn on and pressures only drop a little
- Western Third Zone – closing 48-inch main in Franklintown Road, between the Leakin Park Pumping Station and Catonsville Reservoir, causes the Catonsville Reservoir to go empty in less than 20 hours during average day; this same scenario during maximum day causes the Catonsville Reservoir to go empty in 10 hours and additional pumping does not help
- Catonsville Fourth Zone – closing 20-inch in Rolling Road, north of Powers Road, causes head loss gradients to increase on the eastern side, but tank levels and pressures are not adversely affected during average day; the Rolling Road Tank is empty after 15 hours but recovers slightly during maximum day
- Pikesville Fourth Zone – closing 42-inch main in McDonogh Road during average day, does not adversely affect the zone; during maximum day Deer Park and Randallstown Tanks are empty after 17 hours but recover by the end of the day
- Pikesville Fourth Zone – closing 36-inch north discharge main from the Pikesville Pumping Station, causes all four storage facilities to go empty after only 15 hours, but three of them recover by the end of the day during average day; maximum day causes the storage facilities to empty after only 5 hours
- Towson Fourth Zone – during average day, closing 36-inch main in Land Street, east of I-83 near Mays Chapel, does not adversely affect the zone; during maximum day Stratford Tank is empty after only 6 hours but Mays Chapel Reservoir levels are okay

- Towson Fourth Zone – closing 36-inch main leaving Mays Chapel Reservoir, also does not adversely affect the zone during average day; during maximum day Mays Chapel Reservoir drops to 40% and Stratford Tank drops to 70%
- Towson Fourth Zone – closing 48-inch north discharge main from the Towson Pumping Station during average day, causes high head loss gradients to occur near the pumping station and causes Mays Chapel Reservoir to drop significantly, but it recovers by the end of the day; during maximum day all three storage facilities are empty after 14 hours

These results illustrate that most zones can handle an emergency scenario for at least a short period of time during average day demands. As evident by the affects of an emergency during maximum day demands, the consequences are much worse if emergencies occur during the summer months.

Five zones: Colgate Second, Western Third, Catonsville Fourth, Pikesville Fourth and Reisterstown Fifth, are of concern because they would experience more problems than other zones when an emergency occurs. A new reservoir is currently being constructed in the Pikesville Fourth Zone which should alleviate some of the problems in this zone. Previously made recommendations for additional storage in the Reisterstown Fifth Zone would improve emergency situations in this zone. In the Western Third Zone, improvements could be made by constructing a dual discharge main while upgrading the Leakin Park Pumping Station capacity. Transmission main improvements in the Catonsville Fourth Zone already under design will improve this zone. Recommendations made in a previous section to provide additional storage or increase pumping capacity would alleviate problems in the Colgate Second Zone. Finally, recommendations made in Section III to improve pumping station reliability in the Colgate Second, Western Third, Catonsville Fourth and Pikesville Fourth Zones would reduce the risk of loosing a pumping station because of a power failure. Even with these improvement projects, unforeseen emergencies could still occur which could drastically affect the system. It is imperative that the City have an up-to-date emergency response plan in place to prepare for those such occasions.

E. Summary of Recommended Improvement Projects

A summary list of the CIP and other recommended projects discussed in this report for the Central System is presented in Table IV-4. The total estimated construction cost for these 38 improvement projects is over $300 million, of which approximately $160 million is not currently included in the City's CIP. This project list does not include the general improvement projects recommended herein such as rehabilitation projects and pump control modifications. The general projects are included below.

1. *General Projects*

For zones with high head losses and/or low fire flow availability, immediate action should be taken to improve the system. Water mains can be rehabilitated by lining or other means. Lining water mains will decrease head losses and improve the fire flow availability. The City and Baltimore County have already taken an active role to rehabilitate water mains in the Central System, but more rehabilitation still needs to be done.

For those areas where lining will not result in significant improvement or mains have already been lined, additional water mains should be constructed. The following zones had locations where additional transmission capacity is required to improve fire flows: Second Zone, Colgate Second Zone, Western Third Zone, Catonsville Fourth Zone, Towson Fourth Zone and Pot Springs Fifth Zone.

Several zones, especially the upper zones, would benefit from pump control modifications. They include the Second Zone, Falls Fifth Zone, Sherwood Fifth Zone and Sparks Fifth Zone. The existing and recommended pump controls are illustrated in Table IV-5.

The City should also evaluate constructing dual discharge mains to increase the reliability of the system in the event of an emergency. Several major pumping stations, including Leakin Park and Catonsville Pumping Stations, do not have dual discharge mains. In addition, all five fifth zones are supplied solely by pumping stations with solitary discharge mains. Constructing a second discharge main would reduce the risks associated with emergency situations if a discharge main were to break.

Table IV-4, Recommended Central System Improvement Projects								
Zone	Project Description	Already in CIP	Year Needed	Size/ Capacity	Approx. Length (LF)	Estimated Cost	Status (if applicable)	General Notes
1	Montebello WTP	Yes	2005	318 MGD		$88,000,000	currently under design (RK&K)	
1	Fullerton Reservoir	Yes	2005	40 MG	n/a	$18,600,000	currently under design (Gannett Fleming)	
1	Fullerton WTP		2015	120 MGD	n/a	$130,000,000		WAO recommendation, 2010 by WAO
1	Pulaski Highway Main		2010	16"/20"/24"/36"	4,000/2,500/3,800/6,200	$3,600,000		WAO recommendation
1	Ebenezer Road		2025	12"	8,500	$1,500,000		WAO recommendation
2	Chapel Hill Tank	Yes	2005	2.0 MG	n/a	$1,800,000	currently under design (WRA)	
2	Hillen/Ashburton By-Pass Main	Yes	2005	64"	3,400	$5,500,000	design almost complete (WRA)	
2	Honeygo Boulevard Main Extension		2005	16"/20"	3,300/4,600	$820,000	20 inch main has been installed	Chapel Hill Tank area, WAO recommendation
2	Gerst Main (north of Chapel Hill Tank)		2005	12"	3,400	$300,000		WAO recommendation
2	Perry Hall & Philadelphia Road Main		2025	24"/30"	15,600/9,000	$9,000,000		WAO recommendation
2	Yale Avenue Main		2005	16"	1,000	$200,000		improves fire flows
2	Elmtree Street Main		2005	12"	1,000	$100,000		improves fire flows
2C	47th Street Main		2005	12"	1,400	$140,000		improves fire flows
3W	Leakin Park Pumping Station		2005	80 MGD	n/a	$3,750,000	currently under negotiations (RK&K)	adding 2 pumps (20 MGD each), WAO recomm.
3W	Catonsville Main (LP PS to Rt. 40)	Yes	2005	48"	8,300	$5,000,000	currently under design (PHRA)	
3W	Catonsville Main (parallel to Rt. 40)	Yes	2005	42"	10,200	$4,900,000	currently under design (WRA)	
3W	Rolling Road Transmission	Yes	2005	16"	11,000	$1,180,000	currently under design (Wallace Montg.)	
3W	Liberty Road Main		2005	12"	2,000	$200,000		improves fire flows
3W	Old Pimlico Road Main		2005	16"	4,000	$530,000		improves fire flows
3E	Belair Road Main (W.Marsh to Joppa)	Yes	2005	24"	8,800	$3,000,000	currently under design (RK&K)	
3E	Putty Hill Main (to Towson Reservoir)	Yes	2005	24"	8,400	$1,700,000	currently under design (in-house)	
3E	Perry Hall Road Main to Belair Road		2005	42"	17,150	$6,500,000		WAO recommendation
3E	Belair Road Main (to Northern Parkway)	Yes	2005	24"	5,150	$1,100,000	currently under negotiations (WRA)	
4C	Catonsville Pumping Station	Yes	2005	20 MGD	n/a	$500,000	design almost complete (in-house)	adding 4th pump (11 MGD)
4C	Catonsville Reservoir		n/a	n/a	n/a	-		not required before 2025, WAO recommendation
4C	Rolling Road Tank Transmission	Yes	2005	24"	7,800	$1,450,000	currently under design (PHRA)	
4C	Lord Baltimore Extension Main		2025	12"	5,600	$1,000,000		WAO recommendation, not req'd but helps system
4C	Clays Road Main		2005	12"	1,600	$160,000		improves fire flows and pressures
4P	Owings Mills Reservoir	Yes	2005	5.6 MG	n/a	$3,000,000	under constr.(Chicago Bridge and Iron)	
4P	Marriottsville Road Main		2020	24"	3,500	$900,000		Lyons Mill Rd and Liberty Rd
4T	New Connection at Rutledge Road		2005	12"	100	$10,000		with Mays Chapel Discharge, improves fire flows
4T	Timonium Road Main		2005	12"	900	$90,000		improves fire flows
5F	Falls Pumping Station	Yes	2005	5.3 MGD	n/a	$615,000	currently under design (RK&K)	adding 3rd pump (2.7 MGD)
5P	Hartfell and Killoran Road Parallel Mains		2005	16"	3,300	$400,000		not required, reduces high headloss near PS
5R	Bond Avenue Tank		2005	2 MG	n/a	$1,800,000		WAO recommendation
5R	Pleasant Hill Pumping Station 1		2015	13 MGD	n/a	$1,000,000		replacing 2 pumps (4.3 MGD each)+assoc. piping
5R	Reisterstown and Pleasant Hill Rd. Main		2015	16"	4,300	$600,000		addt'l transmission main required w/PS upgrade
RAW	Deer Creek Pumping Station	Yes	2015	200 MGD	n/a	$4,000,000	currently under negotiations (PHRA)	renovate intake, add two pumps (50 MGD each)

NOTE: General Notes column lists reason for project, all projects recommended by RK&K, 'WAO recommendation' means project previously recommended by the Water Analyzer Office (WAO) but has not been included in CIP yet; costs include escalation 3.2% per year

Table IV-5, Pump Control Modifications

Pumping Station	Zone Supplied	Pump ID	Control Node or Tank	On Elevation or Pressure	Off Elevation or Pressure
Existing Pump Controls					
Fullerton	Second	A	Controlled Manually		
		B	Controlled Manually		
		C	Controlled Manually		
		D	Standby – typically off		
Falls	Fifth	A	Falls	745 ft	748 ft
		B	Falls	743 ft	746 ft
		C (future)	Falls	Standby – typically off	
Sherwood	Fifth	A	Sherwood	695 ft	698 ft
		B	Sherwood	692 ft	695 ft
Sparks	Fifth	A	Sparks	641 ft	645 ft
		B	Sparks	638 ft	643 ft
		C	Sparks	Standby – typically off	
Recommended Pump Control Modifications					
Fullerton	Second	A	Perry Hall	340	346
		B	Perry Hall	342	348
		C	Perry Hall	Standby – typically off	
		D	Perry Hall	338	344
Falls	Fifth	A	Falls	740 ft	748 ft
		B	Falls	738 ft	746 ft
		C (future)	Falls	Standby – typically off	
Sherwood	Fifth	A	Sherwood	694 ft	700 ft
		B	Sherwood	692 ft	698 ft
Sparks	Fifth	A	Sparks	643 ft	647 ft
		B	Sparks	645 ft	649 ft
		C	Sparks	Standby – typically off	

2. Year 2005

Two thirds of the recommended and previously proposed projects listed in Table IV-4 should be completed by 2005. Several projects are already under construction and they include the Owings Mills Reservoir in the Pikesville Fourth Zone and the Hillen/Ashburton By-Pass Main located in the Second Zone.

There are also many projects currently under design which will be completed by 2005. The Montebello Filtration Plant Improvements are being designed by Rummel, Klepper and Kahl. The Fullerton Reservoir, which is almost complete, is being designed by Gannett

Fleming. The design for the Belair Road Main from Whitemarsh to Joppa has just begun and is being performed by Rummel, Klepper and Kahl. The two Catonsville Transmission Mains are under design, one being designed by Reimer, Muegge and Associates and the other by Whitman, Requardt and Associates. The two Rolling Road Transmission Mains are also under design, one being designed by Wallace Montgomery and the other by Reimer, Muegge and Associates. Baltimore County is designing a fourth pump at the Catonsville Pumping Station in-house and Rummel, Klepper and Kahl is designing a third pump at the Falls Fifth Pumping Station.

In addition, there are several projects currently on the CIP list that have not begun construction, but are planned to be in service by 2005. They include: the Leakin Park Pumping Station upgrades, the Putty Hill Main to Towson Reservoir, the Chapel Hill Tank, the Bond Avenue Tank, and upgrades to the Deer Creek Pumping Station. Several other projects have been proposed but are not in the CIP list yet. They include: the Honeygo Boulevard Main Extension, the Perry Hall Road Main, and the Belair Road Main. As a result of the hydraulic analysis performed during this project, additional mains are being recommended in the Pot Springs Fifth Zone in Hartfell and Killoran Road.

3. Year 2010

Only one project is proposed to be completed between 2005 and 2010. That project is a transmission main in Pulaski highway in the First Zone.

4. Year 2015

Two major improvement projects are recommended for the time period between 2010 and 2015. The biggest project will be the proposed Fullerton Treatment Plant which is recommended to be in service by 2015. This project and the related recommendations are discussed in more detail in *Section V. Fullerton Plant and Drought Conditions.*

The Reisterstown Fifth Zone will also require substantial improvements by 2015. The Pleasant Hill Pumping Stations should be upgraded, along with improvements to the associated piping. A new discharge main will be needed to supply ample flows to this zone.

5. Year 2020

Only one project, a transmission main in Marriottsville Road, is recommended for the time period between 2015 and 2020. This project is a result of the hydraulic analysis performed during this project for the Pikesville Fourth Zone.

6. Year 2025

There is only one project proposed for 2025, as shown in Table IV-4. This project is another transmission main located in the Second Zone in Perry Hall and Philadelphia Roads.

V. FULLERTON PLANT AND DROUGHT CONDITIONS

A. Proposed Fullerton Treatment Plant

The proposed Fullerton Treatment Plant has been a key topic of discussion for many years. Visions of the future treatment plant began over 40 years ago when the City and Baltimore County purchased the proposed site, the Fullerton Site, located northeast of the City in Baltimore County.

It was predicted in 1989 in the *Central System Report* by the Water Analyzer Office that this treatment plant would need to be online as early as the year 2000. The County has already initiated design for a storage facility at the proposed Fullerton Site. Two 20 mg storage facilities, with a total of 32 mg usable storage, to be known as Fullerton Reservoir, are to be constructed and in service by 2004. This reservoir will serve the suction side of the Fullerton Pumping Stations as well as the First Zone of the water distribution system. These two reservoirs will become the finished water storage for the proposed Fullerton Treatment Plant once constructed.

There are four main parameters that influence the implementation of the proposed Fullerton Treatment Plant: source, year, capacity and drought. The source, the Susquehanna River, has already been determined and the requisite infrastructure has been in place for several years. The date that the Fullerton Treatment Plant must be operational was determined to be 2015 based on the modeling analysis provided in this report. Additional discussion regarding the implementation timing is provided below. The needed capacity is a function of several factors which are also discussed in the sections that follow. Finally, drought conditions can impact both the timing and size of the proposed Fullerton Treatment Plant and these impacts are addressed throughout the discussion that follows.

1. *Raw Water Source*

The Susquehanna River will be the primary raw water source for the proposed Fullerton Treatment Plant. Plans to utilize the Susquehanna River as a raw water source for the Central System began as early as 1953 with the Report *on Future Sources of Water Supply and Appurtenant Problems* by the Board of Advisory Engineers on Future Water Supply. That report prompted the construction of the Deer Creek Pumping Station and the 108-inch Susquehanna Transmission Main to transport raw water from Deer Creek Pumping Station to the Fullerton Site. From the Fullerton Site, the transmission main turns into a 96-inch diameter pipe and continues to the Montebello Filtration Plants.

The Susquehanna River is currently considered a supplementary source for the two Montebello Filtration Plants. Since the construction of the transmission main, the Susquehanna River has only been used on rare occasions, such as during severe drought or equipment tests. In more recent years, the Susquehanna River has been used in 1999 and 2002 during drought conditions. Upon construction of the proposed Fullerton Treatment Plant, the Susquehanna River raw water would be used on a full time basis and be treated primarily at the new plant.

2. *Proposed Year*

The results of the demand projections, discussed in *Section II. Water Demands*, show that the proposed Fullerton Treatment Plant is required prior to the year 2015. The model results do not show any significant hydraulic deficiencies prior to 2015. Therefore, it will be necessary for the City to initiate design of this facility no later than 2005 and construction by 2010, so that the plant will be in-service no later than 2015. From a budgetary standpoint, the City should be adding this project to their Capital Improvements Project (CIP) list since the development of next years budget is already underway.

The projected demands also show that the Fullerton Treatment Plant would be needed now under drought conditions. However, the demand projections are very conservative, as they are derived by summing the maximum day demand for each zone. Theoretically, each zone's maximum day demand could occur simultaneously, but the probability of this occurring is minimal. It is more likely that three or four zonal maximum day demands would occur on the same day, not all thirteen zones. If this were to occur, the raw water supply is currently available to meet this demand, as long as the Susquehanna supply is not under trigger flow restrictions. As seen during the current drought, the City could authorize mandatory conservation measures if the raw water supply and treatment capacity were going to be exceeded. These issues are addressed in further detail in *Section V.B. Drought and Conservation.*

3. *Proposed Capacity*

The proposed capacity of the proposed Fullerton Treatment Plant is not only dependant upon the amount of water demanded, but also on the hydraulic balance in the First Zone. Careful consideration of how the new treatment plant will operate within the existing Central System needs to be evaluated to address affects to the existing hydraulic balance. Any water quality concerns are addressed in Section VII of the report.

Determining the size of the proposed Fullerton Treatment Plant based on demands cannot be determined from a simplified hydraulic deficit projection. By 2025, supplied maximum day demand is projected to reach 535 mgd, including 7% for plant losses. The current treatment capacity (without the Fullerton Treatment Plant) is only 483 mgd, as mentioned in *Section II.F. Raw Water Demands*, the previous section, leaving a 52 mgd deficit. Therefore, the proposed Fullerton Treatment Plant should have a raw water capacity of at least 52 mgd. However, previous studies (1989 *Central System Report* and *Fullerton Site Utilization Study*, November 1991) suggested that an initial capacity of 120 mgd would be required based on past drought conditions, population projections, and hydraulic performance.

With these treatment capacities in mind, maintaining a hydraulic balance in the existing system is equally important as meeting the demand criteria. If the flows cannot be successfully transported out into the system, then it would not be beneficial to have excess capacity that cannot be utilized. Problems can also arise if too little capacity is available. If water production and water elevations at the proposed Fullerton Treatment Plant are too high, the system will become unbalanced and the Montebello Filtration Plants will have difficulty transporting water away from the finished water reservoirs to meet the demands in that portion of the zone. In addition, before spending the time and money to construct a new plant with excess capacity, existing capacity utilization at the Montebello Filtration Plants should be maximized while still maintaining finished water quality goals. The hydraulic model results show that adequate supply can be provided by the Montebello Filtration Plants and no significant pressure problems exist through 2015.

Using a water production ratio between the Montebello and Fullerton Plants based on the First Zone demands, including Anne Arundel County demands, several scenarios with varying ratios were modeled for the year 2025. The various ratio combinations are illustrated below in Table V-1. The total First Zone maximum day demands used in the hydraulic model for this analysis, including Anne Arundel County, were approximately 198 mgd, slightly higher than the projected demands discussed in Section II of the report. These demands are slightly higher indicating that the model is more conservative in its predictions.

Table V-1, Montebello/Fullerton Water Production Ratios

Ratio	Montebello % of First Zone Demands	Fullerton % of First Zone Demands	First Zone Montebello (mgd)	First Zone Fullerton (mgd)	Montebello Total Production (mgd)	Fullerton Total Production (mgd)
90/10	90	10	178	20	305	49
85/15	85	15	168	30	295	59
80/20	80	20	158	40	285	69
75/25	75	25	149	49	276	78
70/30	70	30	139	59	266	88
65/35	65	35	129	69	256	98
60/40	60	40	119	79	246	108
55/45	55	45	109	89	236	118
50/50	50	50	99	99	226	128

Note: Total Production includes pumping station demands to upper dependant zones

The results of the hydraulic model analysis for these scenarios are illustrated in Figures V-1, V-2 and V-3, which shows model results for the storage facilities with the initial elevation at both Fullerton Reservoir and the combined Montebello Reservoir being 212 feet. Based on the reservoir levels and fluctuation, the 75/25 ratio between the Montebello Treatment Plants and the Fullerton Plant water production appears to provide the best hydraulic balance in the system. The elevation in the proposed Fullerton Reservoir, however, would never reach the proposed overflow elevation of 225 feet. Instead, water levels would only reach approximately 212 feet according to the hydraulic model for a 75/25 ratio. At this ratio, the production at the Fullerton Treatment Plant is 78 mgd and at the Montebello Filtration Plants is 276 mgd. At the Montebello Filtration Plants, over 90% of the available treatment capacity would be used, which is close to the maximum flow by gravity.

Figure V-1, Montebello Reservoirs, Initial Fullerton Elevation 212 Feet

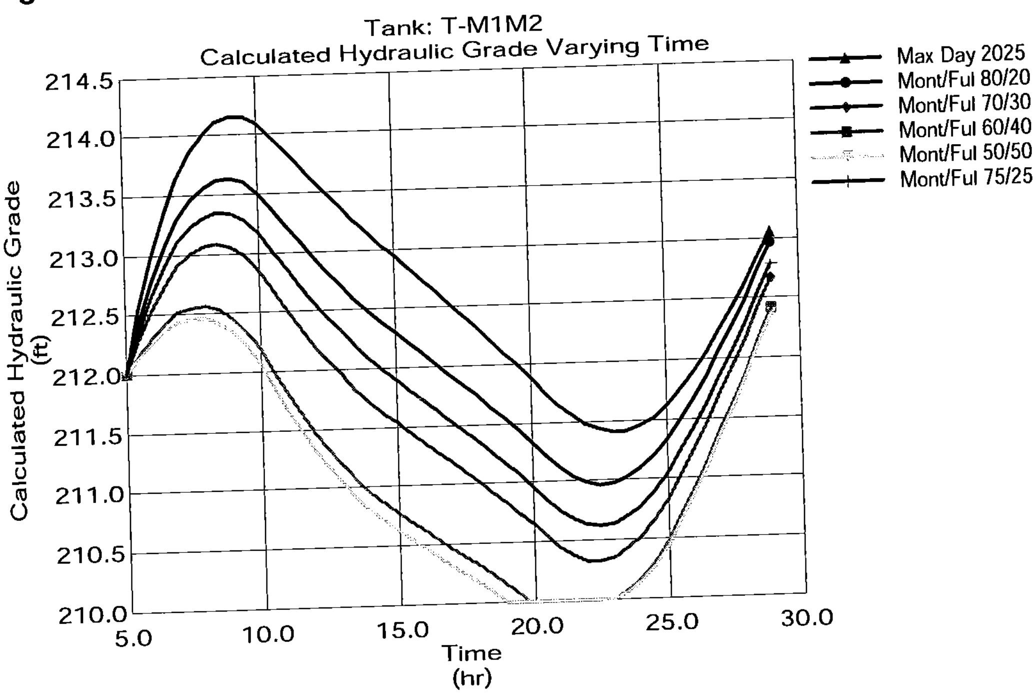


Figure V-2, Fullerton Reservoir, Initial Elevation 212 Feet

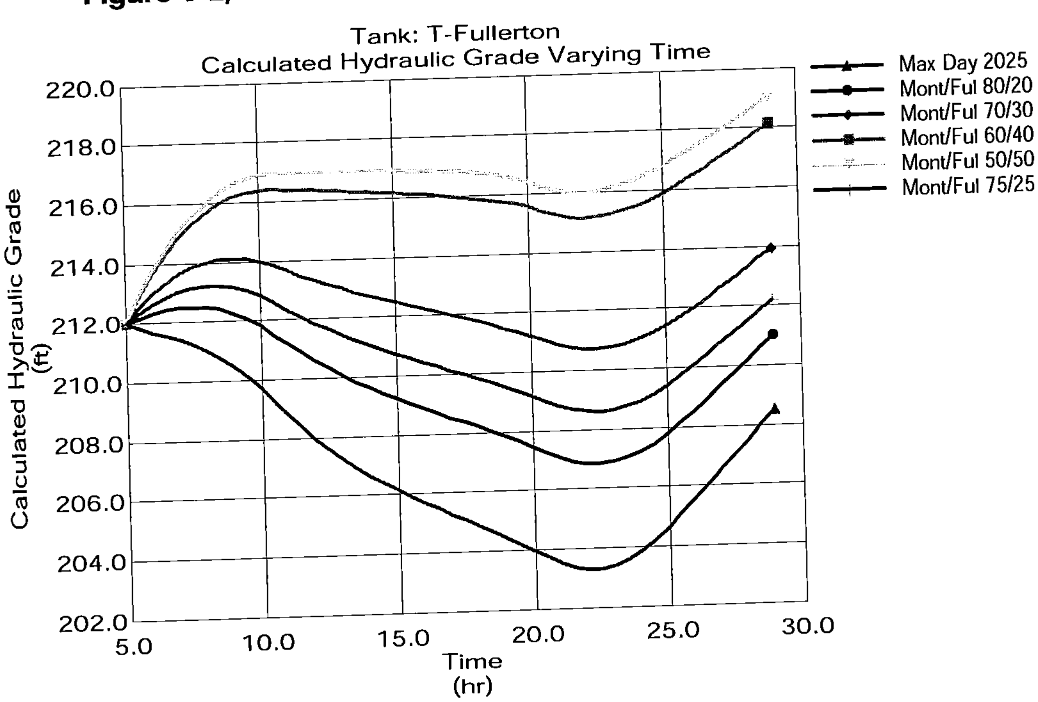
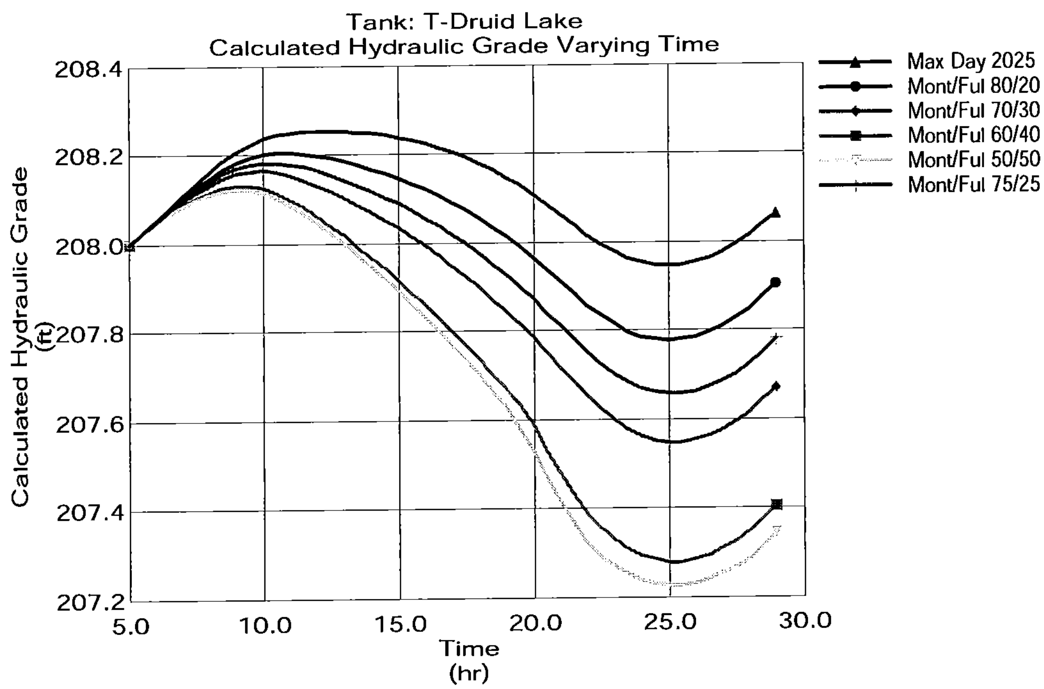


Figure V-3, Druid Lake, Initial Fullerton Elevation 212 Feet



Another set of scenarios was modeled with the initial elevation of Fullerton Reservoir raised to 221 feet, which is four feet below the overflow elevation. This scenario was modeled to determine what production rate would be required to achieve a higher water level in the reservoir and utilize a smaller percentage of the available treatment capacity at the Montebello Treatment Plants. As illustrated in Figures V-4, V-5 and V-6, a 60/40 ratio appears to operate at the best hydraulic balance under these conditions with the Fullerton Reservoir only dropping a few feet and Druid Lake and the Montebello Reservoir operating sufficiently. At this higher initial elevation in the Fullerton Reservoir, the 75/25 ratio does not appear to work as well as the 60/40 ratio. With the 60/40 ratio, the production rate at the Fullerton Treatment Plant would have to be 108 mgd and the Montebello Treatment Plants only 246 mgd. At the Montebello Treatment Plants, approximately 80% of the available treatment capacity would be used under this scenario, which is acceptable.

Figure V-4, Montebello Reservoirs, Initial Fullerton Elevation 221 Feet

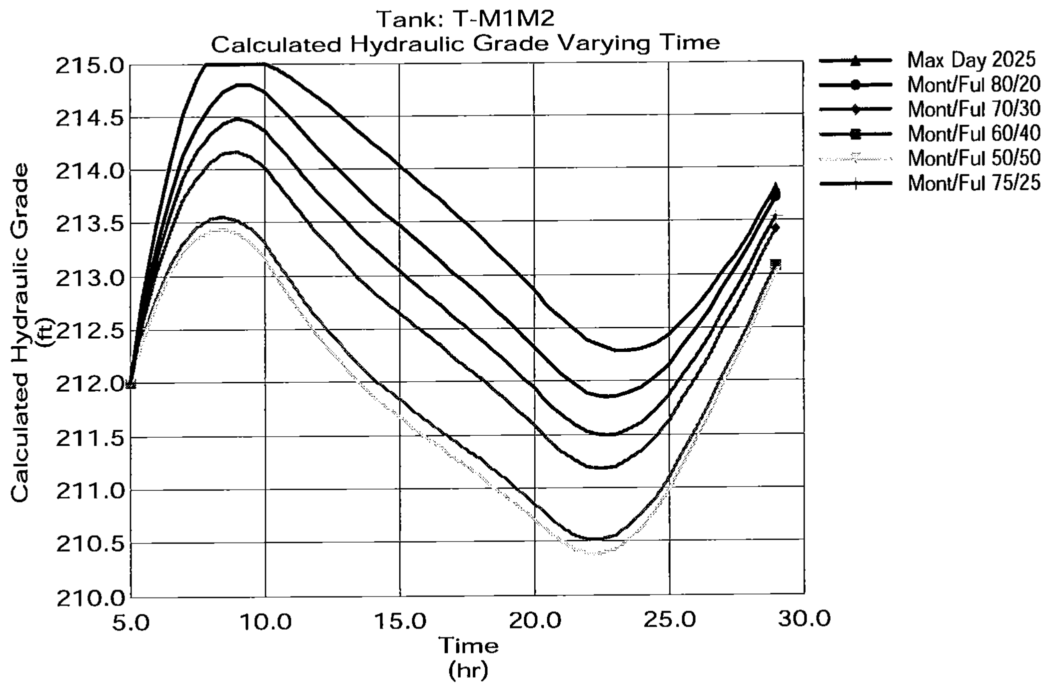


Figure V-5, Fullerton Reservoir, Initial Elevation 221 Feet

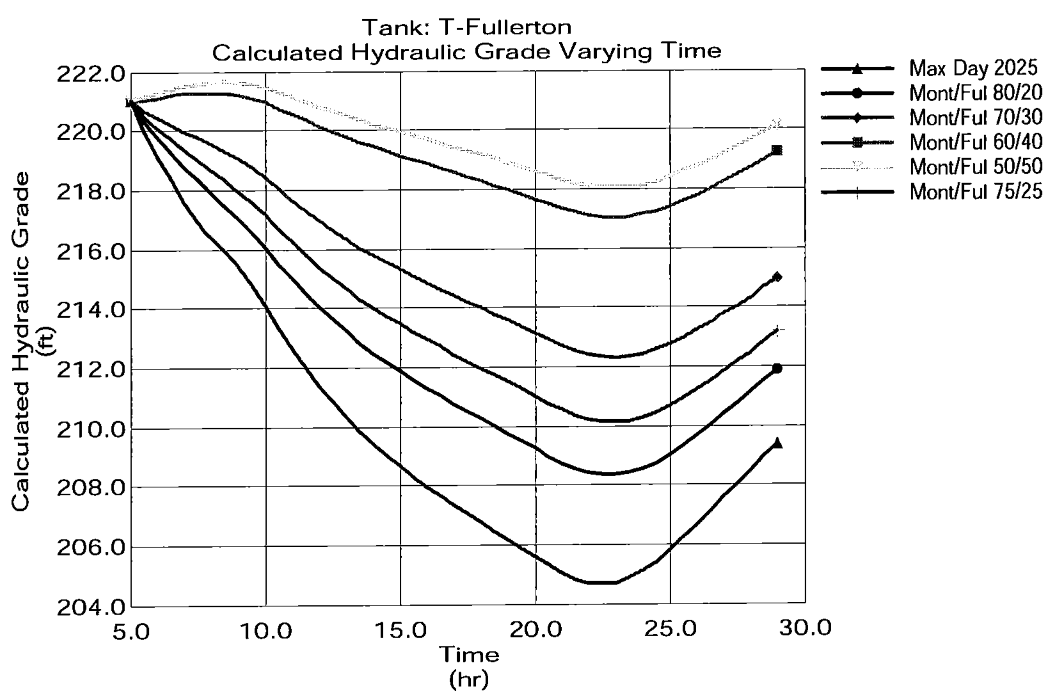
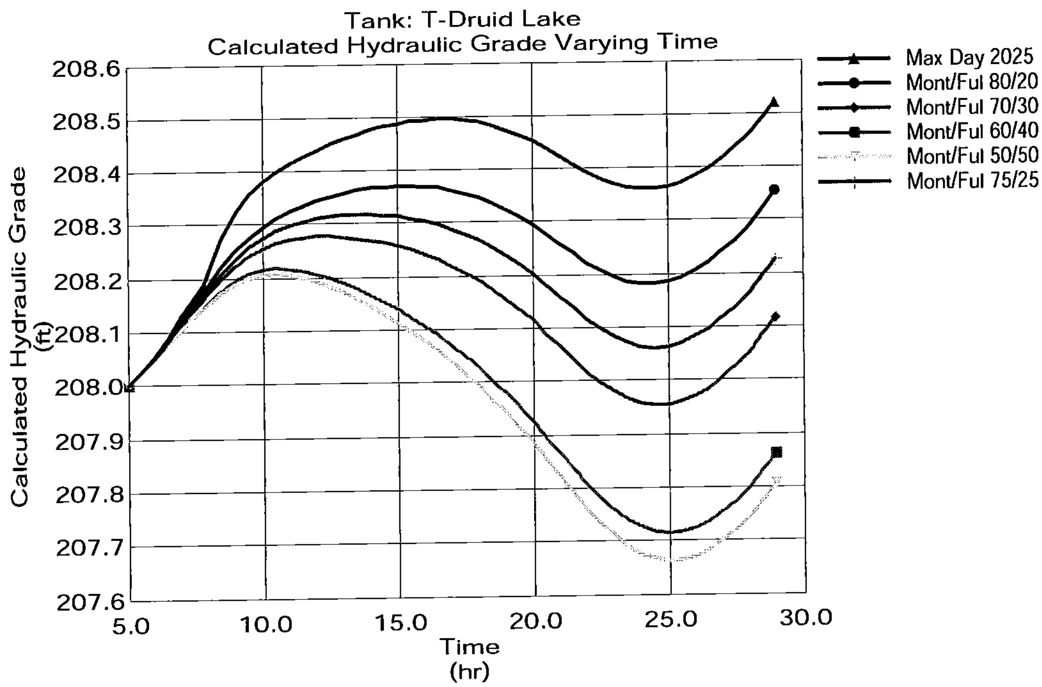


Figure V-6, Druid Lake, Initial Fullerton Elevation 221 Feet



Based on this analysis, it is recommended that the Fullerton and Montebello Plants be operated with a 60/40 ratio of the First Zone demands, including Anne Arundel County. Using this ratio, the production at the Fullerton Treatment Plant in 2015 would be 100 mgd and by 2025, 120 mgd. Therefore, the recommended initial capacity of the proposed Fullerton Treatment Plant should be 120 mgd based on the demand requirements and hydraulic balance of the system.

4. *Proposed Future Capacity*

Expansion capabilities to enlarge the proposed Fullerton Treatment Plant should be planned for in the initial design to account for any unexpected growth or future emergency needs. Previous reports (1989 *Central System Report* and *Fullerton Site Utilization Study*) recommended that expansion up to 160 mgd would be needed. The ultimate, or saturated, demand for the Central System should also be considered in determining the ultimate expansion size of the Fullerton Treatment Plant. Saturated demands were estimated to be approximately 740 mgd in the Central System, which would require the Fullerton Treatment Plant to be over 200 mgd, even with a future expansion of the Montebello Filtration Plants to 360 mgd. This is very conservative since saturated demands are not likely to be met. The plant should not be constructed with a capacity larger than its practical use because that would absorb valuable Capital Improvement Project (CIP) money which may be needed elsewhere. In addition, constructing a large capacity plant when raw water availability during drought conditions is limited would not be an effective use of funds. This topic is discussed further in the next section. Therefore, the expansion capacity of the Fullerton Treatment Plant should be re-evaluated at a later date.

B. Drought and Conservation

Drought, conservation and the proposed Fullerton Treatment Plant are all interrelated. Drought is one of the major determinants impacting the capacity and timeline required for the proposed Fullerton Treatment Plant. The City can prepare for a drought, but can never predict when one might occur. Conservation is an important tool to reduce the water demands especially during emergencies such as drought.

The most recent drought, starting in the summer of 1999 and continuing today, tested the limits of the Central System. Available water from both Liberty Reservoir and Loch Raven Reservoir was drastically reduced. Even though the demand did not exceed the available treatment capacity of the plants, the supply was limited due to depleted raw water sources. Therefore, additional raw water from the Susquehanna River was required to supplement the Loch Raven Reservoir supply. This illustrates that the proposed Fullerton Treatment Plant is not necessarily needed currently. Though, future droughts may cause problems because of trigger flow restrictions and also because demands will continue to increase until permanent conservation measures are taken. In addition, water quality issues are of concern if blending ratios at Montebello Filtration Plant are too high. This is discussed further in Section VII of the report.

However, with the newly imposed Susquehanna River Basin Commission (SRBC) restrictions, withdrawal from the river will be significantly limited during drought conditions. The City will only be able to withdrawal 64 mgd if the river is below its established trigger flows. This topic is discussed in further detail in *Section VI. Raw Water Source Management.*

To test these new restrictions an evaluation of a "worst case" scenario was conducted. For this scenario, raw water at the Ashburton Plant was limited to 100 mgd, 240 mgd at the Montebello Treatment Plants and the proposed Fullerton Treatment Plant was limited to 50 mgd, with 14 mgd of the 64 mgd allowable withdrawal going to Harford County. Therefore, the total raw water was only 390 mgd during this worse case drought scenario. The projected 2025 raw water maximum demands used in this analysis were 535 mgd. This exceeds the raw water capabilities during a severe drought by 145 mgd. Therefore, excess treatment capacity at the Fullerton Treatment Plant is irrelevant since there would be insufficient supply available under drought conditions.

Although, this occurrence has not happened in the last 80 years, a contingency plan should be developed. To alleviate this possible problem, the City should negotiate with the SRBC to possibly increase the withdrawal limit on the rare occasion it would be needed. This could be an approval process by a review board on an emergency as-needed basis. If this is not an option, the City should investigate alterative raw water supplies that would provide water to the Fullerton Treatment Plant during drought conditions or would supply a new plant located somewhere else in the Central System.

In many instances, severe deficiencies caused by drought could have been avoided if conservation measures were implemented prior to the decline of the raw water source availability. The City should conduct a study of possible conservation measures to reduce demand, especially during emergency situations such as drought. A drought management plan should also be developed. This plan should indicate when the City should recommend voluntary water restrictions and when to impose mandatory restrictions. It is recommended that public stakeholder involvement be incorporated into the process of developing a drought management plan.

C. Recommendations

- Recommended capacity of the proposed Fullerton Treatment Plant is 120 mgd, with flexibility to allow for future expansion.

- Plans should begin for the Fullerton Treatment Plant project with the design beginning no later than 2005 and construction initiated by 2010, so that the plant will be in-service no later than 2015

- The operational balance between the Montebello Filtration Plants and the proposed Fullerton Treatment Plant should be a 60/40 ratio of the First Zone demands, including Anne Arundel County

- The City should negotiate with the SRBC to have the ability to withdrawal more than 65 mgd from the Susquehanna River during trigger flow conditions on the rare occasion that it would be needed

- The City should investigate an alternative water supply that could provide additional water supply capacity under drought conditions

- The City should conduct a study to evaluate and develop conservation measures that could be taken to decrease demands, in addition to developing a drought management plan for future emergencies

VI. RAW WATER SOURCE MANAGEMENT

A. Introduction

Recent dry weather patterns in the mid-Atlantic region climaxed in precipitously low water levels at the three reservoirs serving the Baltimore Central System in the summer of 2001. Despite implementing water restrictions, water storage continued to decline until the wet weather season began. It is highly probable that drought conditions such as those recently experienced and more severe conditions will occur again. Additionally, Baltimore City's agreement with the Susquehanna River Basin Commission limits the volume of water drawn from the Susquehanna River, the only significant alternative source of raw water for the Central System. Despite growing demand and withdrawal limitations, the raw water supply system must continue delivering adequate water supplies. Meeting these conflicting goals will require significant adjustments to the current operating schedules for the Prettyboy Reservoir and the Deer Creek Pumping Station. The following sections present the operating schedules and their computer-modeled effects to the Central System raw water distribution system.

B. Background

The Susquehanna River Basin Commission (SRBC) was created in 1970 to coordinate water resource management in the Susquehanna River Basin. The SRBC developed the *Comprehensive Plan for the Management and Development of the Water Resources of the Susquehanna Basin* to address flood plain management, watershed protection and water supply. In accordance with the water supply directive, the SRBC proposed operating conditions limiting water withdrawals at the Baltimore City Conowingo intake facility located immediately upstream of the Conowingo Dam. The proposed limits were based on pre-determined flows in the Susquehanna River, known as trigger flows, which were previously imposed by the Federal Energy Regulatory Commission. On May 8, 2001, Baltimore City (City) officials met with SRBC representatives to discuss the effects of the proposed withdrawal limits on the City's raw water supply system. The discussions culminated with the following agreements:

- Limit the City's average monthly water withdrawals to 64 million gallons per day (mgd) when Susquehanna River flows are less than the trigger flows shown in Table VI-1.
- Limit the City's maximum withdrawal from the Susquehanna River to 250 mgd during non-trigger flow restriction periods. There were no provisions (i.e., consumptive loss charges) for withdrawing more than the agreed upon maximum rate.

Table VI-1, Trigger Flow Restrictions

TIME PERIOD	TRIGGER FLOW
April 1 – April 30	10,000 cubic feet per second (cfs)
May 1 – May 31	3,500 cfs
June 1 – September 15	5,000 cfs
September 16 – November 30	3,500 cfs
December 1 – February 28	1,600 cfs
March 1 – March 31	3,500 cfs

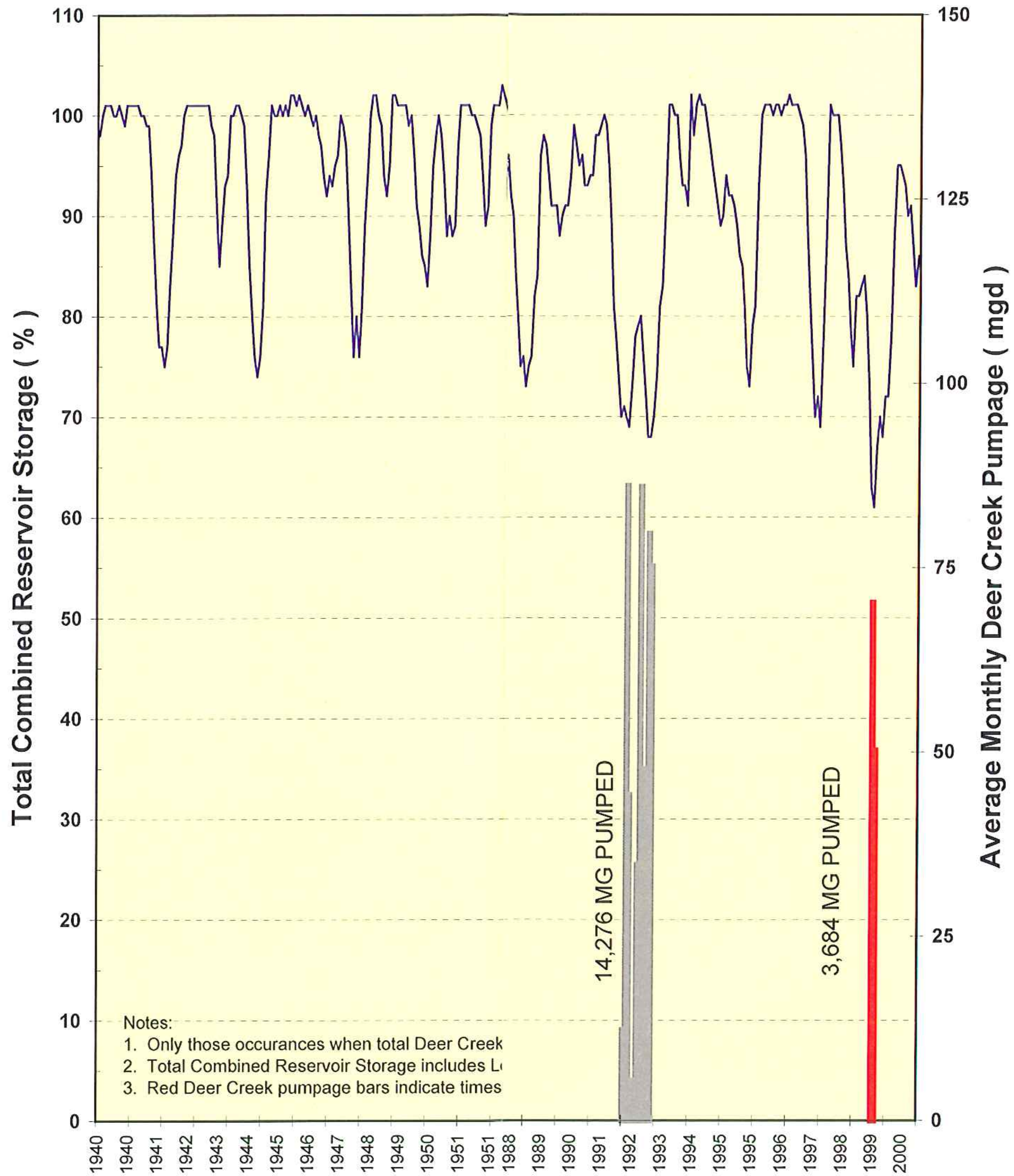
Only three times in the previous 60 years - during the 1966, 1999 and 2002 droughts - were Susquehanna River flows less than the trigger flows as shown in Figure VI-1 (data for Deer Creek pump volumes is not available for 2002 and therefore is not shown). Though the droughts that produce trigger flow restrictions are rare; it is probable that the same weather pattern will repeat.

C. Description of Central System Raw Water Supply Facilities

Liberty and Loch Raven Reservoirs and the Susquehanna River supply raw water to the Baltimore Central System. Raw water is also supplied by the Prettyboy Reservoir, which discharges into Gunpowder Falls and ultimately to Loch Raven Reservoir. The following is a brief summary of the Central System's primary water facilities:

1. *Liberty Reservoir*

Liberty Reservoir, located on the North Branch of the Patapsco River in Baltimore County, is the sole source of raw water supply to the Ashburton Filtration Plant. The reservoir, Fje


Total Combined Reservoir Storage (%)
Average Monthly Deer Creek Pumpage (mgd)
14,276 MG PUMPED
3,684 MG PUMPED
Notes:
1. Only those occurances when total Deer Creek
2. Total Combined Reservoir Storage includes L
3. Red Deer Creek pumpage bars indicate times

completed in 1953, has a spillway crest elevation at 420 feet above mean sea level (msl), a tributary drainage area of approximately 164 square miles and a capacity of approximately 43.3 billion gallons. The reservoir can safely yield 82 mgd by gravity flow and 94 mgd using the low lift pumps. Figures VI-2 and VI-3 show the reservoir's intake structure and stage-storage curve, respectively.

2. Prettyboy Reservoir

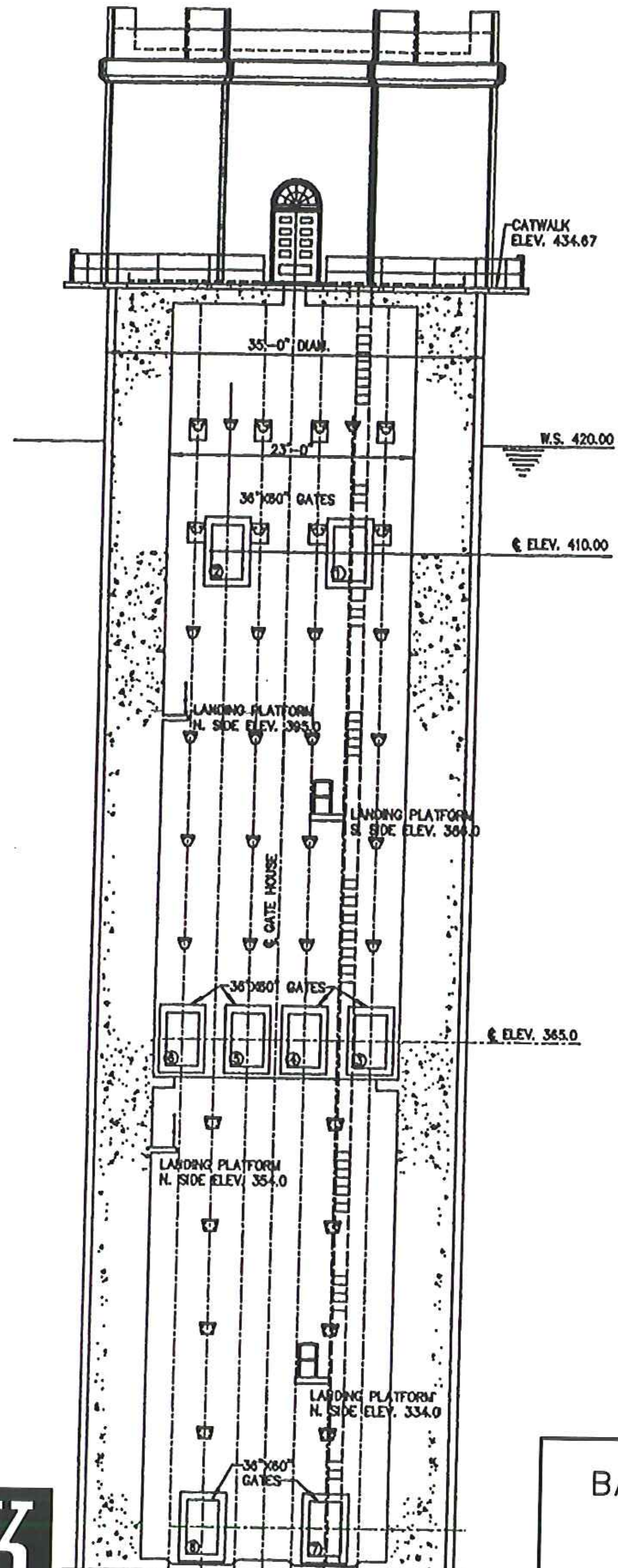
Prettyboy Reservoir is located within the tributary drainage area of Loch Raven Reservoir. Two 4-foot diameter pipes at the reservoir's base release water into the Gunpowder Falls which is the largest single raw water source for the Loch Raven Reservoir. The Prettyboy Reservoir, constructed in 1936, has a spillway crest elevation at 520 feet above msl (reference Figure VI-4), a capacity of approximately 19.7 billion gallons and a tributary drainage area of approximately 80 square miles. The reservoir can safely yield 46 mgd by gravity flow. The reservoir's stage-storage curve is shown on Figure VI-5.

3. Loch Raven Reservoir

Loch Raven Reservoir, which supplies raw water to Montebello Filtration Plants 1 and 2, is located on the Gunpowder Falls in Baltimore County. The reservoir, originally constructed in 1910, was raised to its current crest elevation of 240 feet above msl (reference Figure VI-6) in 1923. The reservoir has a capacity of approximately 23.7 billion gallons and a tributary area of approximately 303-square miles and can safely yield 97 mgd. The reservoir's stage-storage curve is shown on Figure VI-7.

4. Ashburton Filtration Plant

The Ashburton Filtration Plant, located on Druid Park Drive, began operation in 1956. The plant receives raw water from Liberty Reservoir and supplies finished water to the Second Zone. Although designed for a maximum capacity of 180 mgd, the recorded peak flow at the filtration plant is only 165 mgd due to hydraulic limitations at the plant.



RKK2\SYS - projects\49638\PHASEII\DAMOPER\2003\FIGURES\Fig6-2.dwg
03/06/2003 13:18 ENV.PCP PLOT SCALE:1=1

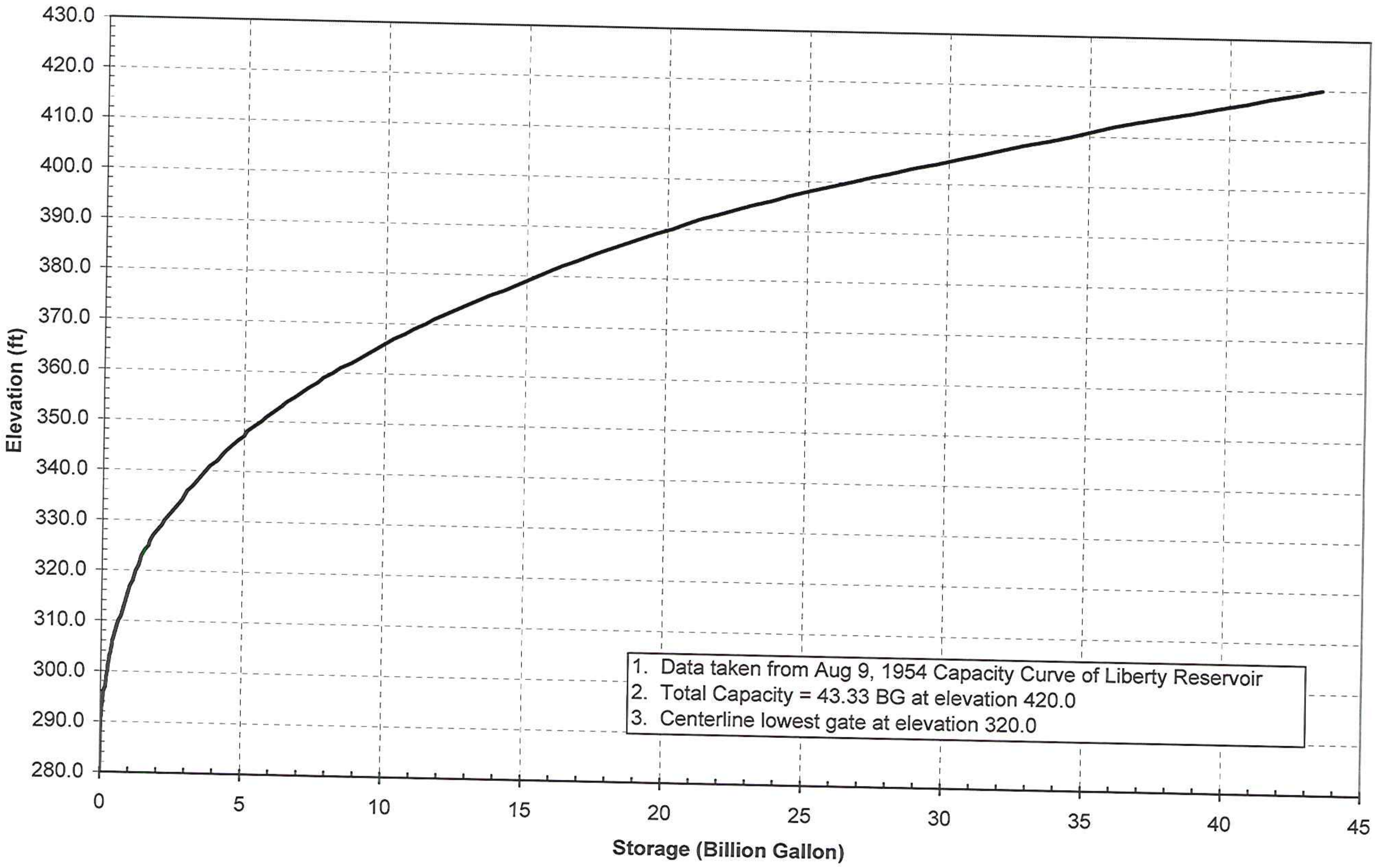
BALTIMORE CITY PROJECT 658
CENTRAL SYSTEM REPORT

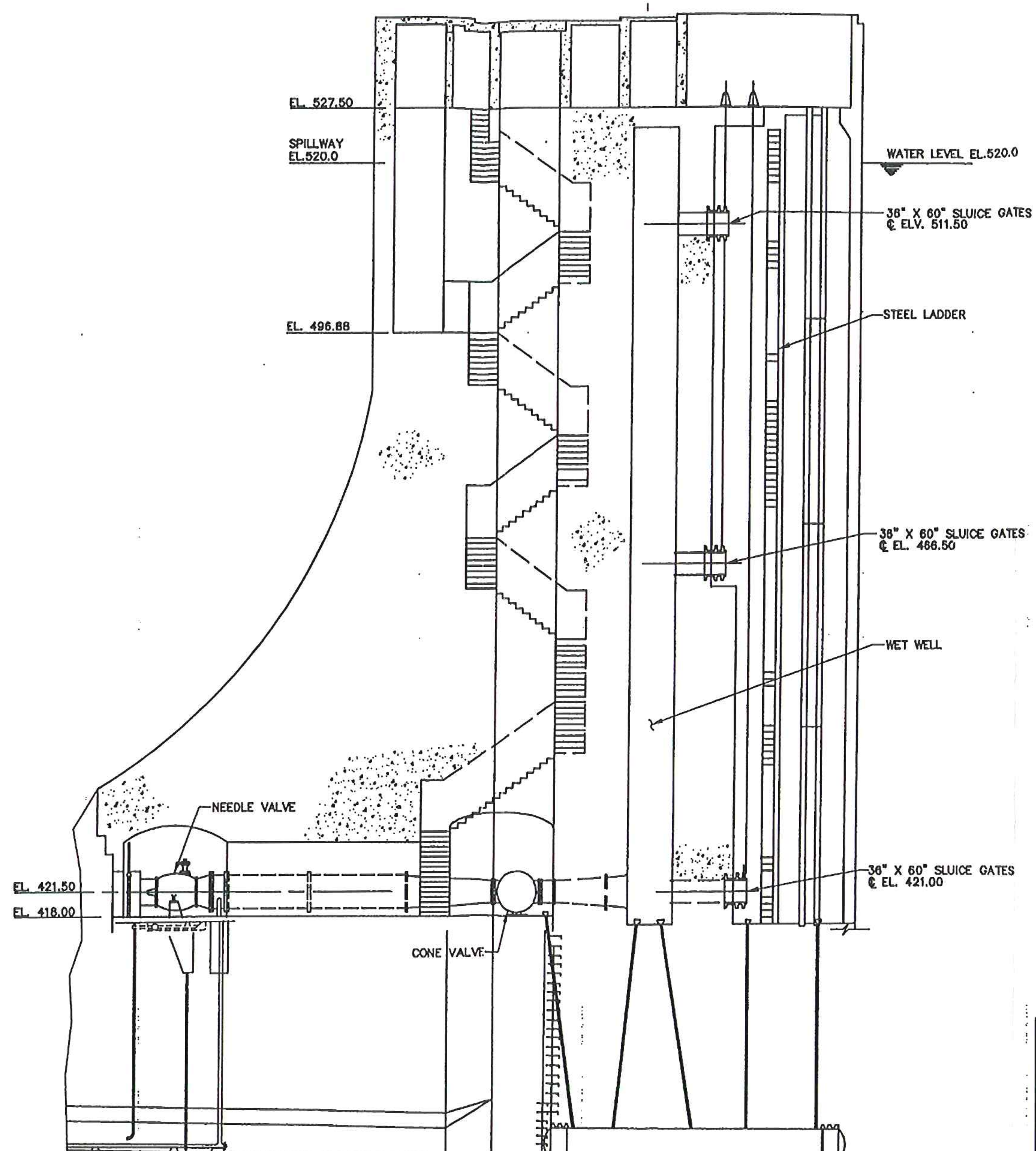
LIBERTY RESERVOIR
INTAKE STRUCTURE

MARCH, 2003

Figure VI–2

FIGURE VI-3, Liberty Reservoir Storage Curve





BALTIMORE CITY PROJECT 658
CENTRAL SYSTEM REPORT

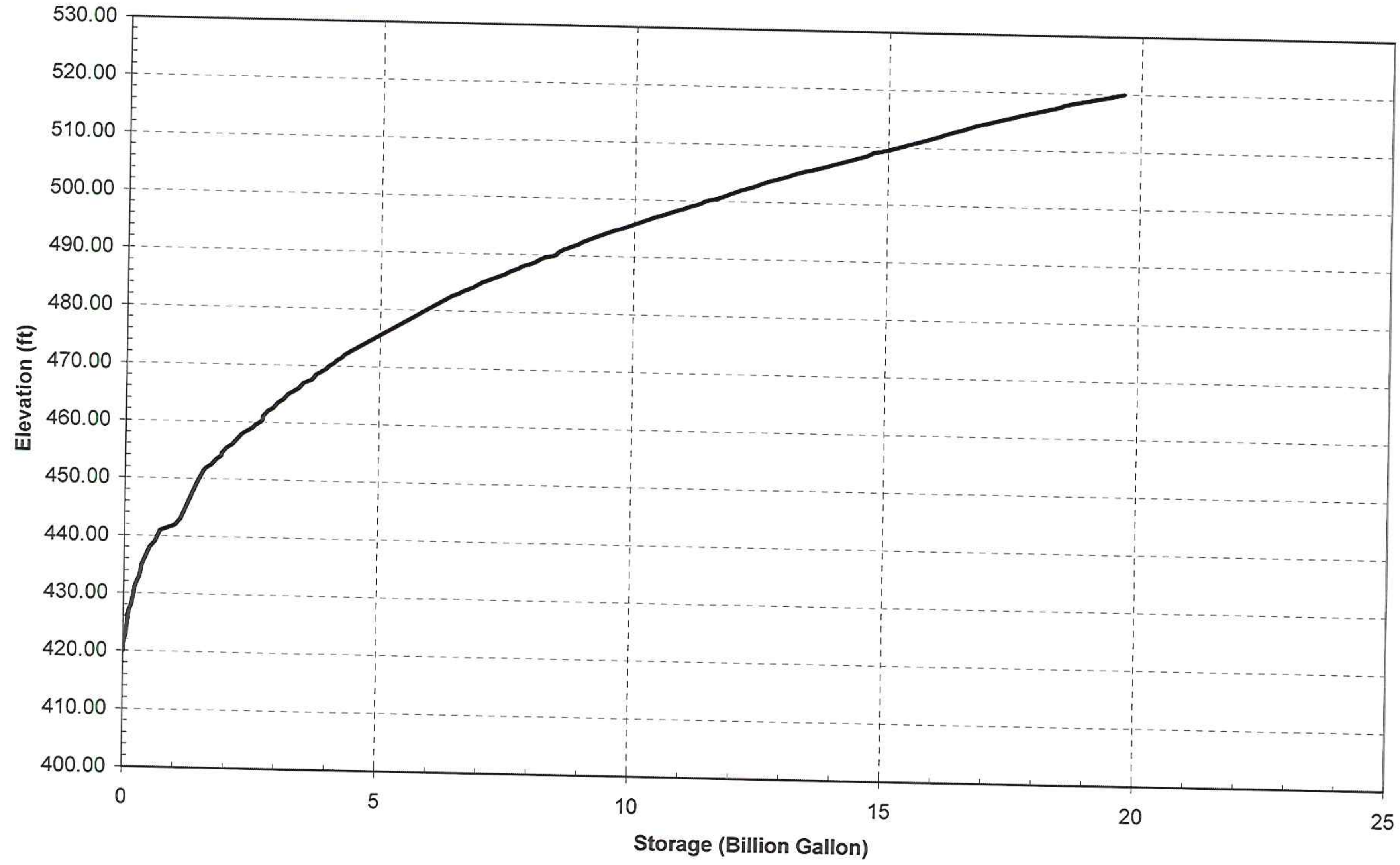
PRETTYBOY DAM
CROSS SECTION SHOWING GATES

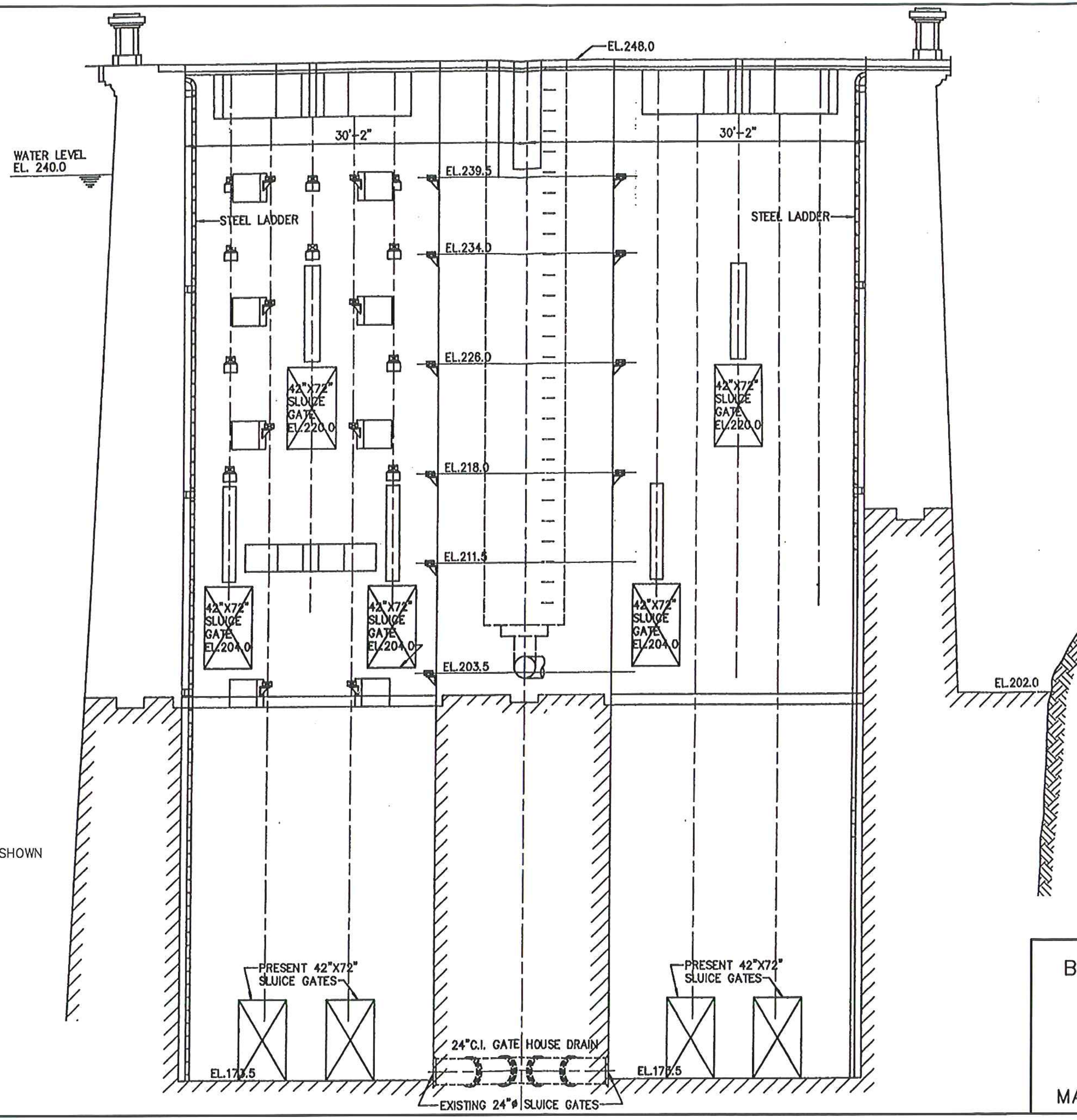
MARCH, 2003 — Figure VI–4

RK&K

RKK2\SYS — ...projects\49638\PHASEII\DAMOPER\2003\FIGURES\Fig6-4.dwg
03/06/2003 13:21 ENV.PCP PLOT SCALE:1=1

Figure VI-5, Prettyboy Reservoir Storage Curve





NOTES

1. ELEV. 190.0 GATES NOT SHOWN
2. TWO GATES AT ELEV. 220.0 NOT SHOWN

BALTIMORE CITY PROJECT 658
CENTRAL SYSTEM REPORT

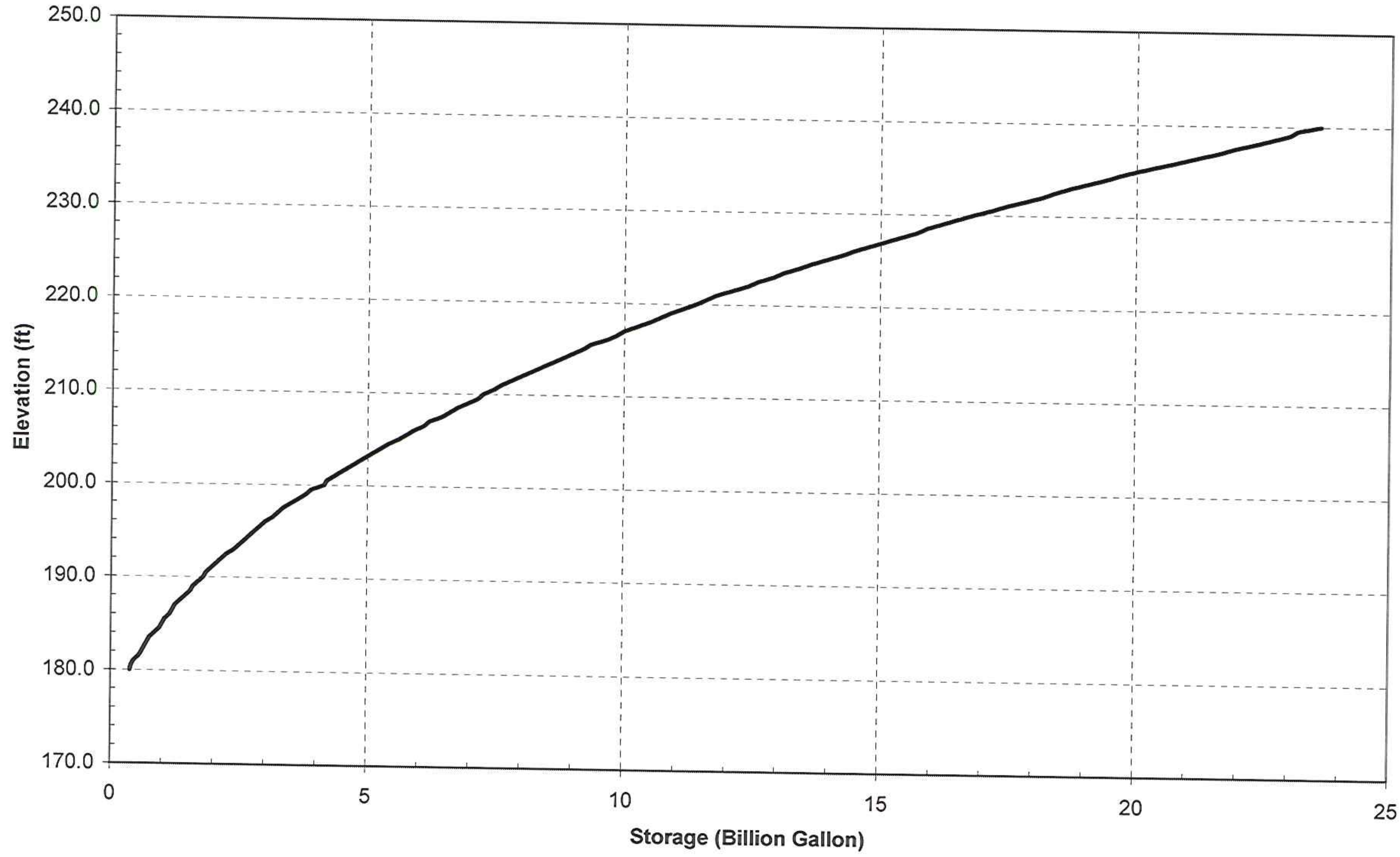
LOCH RAVEN DAM
INTAKE STRUCTURE

MARCH, 2003

Figure VI-6

RKK2\SYS – ...jects\49638\PHASEII\DAMOPER\2003\FIGURES\Fig6-6.dwg
03/06/2003 13:... ...dNV.PCP PLOT SCALE:1=1

FIGURE VI-7, Loch Raven Storage Curve



5. *Montebello Filtration Plants 1 and 2*

Montebello Filtration Plants 1 and 2 are located on Hillen Road between Argonne Drive and 33rd Street. During normal operation, the filtration facilities receive most of their raw water from Loch Raven Reservoir. When high demand necessitates, water withdrawn from the Susquehanna River is mixed with reservoir water; however, filtration operations are altered to properly mix and filter the two waters. Plant 1, located on the east side of Hillen Road, was constructed in 1915. Plant 2, located on the west side of Hillen Road, was constructed in 1928. Extensive repairs and improvements have been made to both plants since 1970; however, the most recent improvement will increase raw water filtration capacity to 318 mgd.

6. *Susquehanna Transmission Main and Deer Creek Pumping Station*

Baltimore City's Conowingo intake facility is located on the Susquehanna River along the Cecil/Harford County boundary. The Susquehanna River intake structure includes four sluice gates. Each gate measures eight feet wide by eight feet high with a centerline elevation of 64.7 feet above msl. Raw water flows by gravity from this intake structure to the Deer Creek Pumping Station.

The Deer Creek Pumping Station, built in 1961, is located along Deer Creek approximately 3 miles south of the Conowingo Dam and 1 mile west of the Susquehanna River. From the pumping station, raw water is pumped through 28 miles of 108-inch diameter pipe and 7 miles of 96-inch diameter pipe to the Montebello Filtration Plants. An existing 96-inch diameter capped wye in the 108-inch diameter pipeline will eventually be tapped to provide raw water to the proposed Fullerton Treatment Plant.

Currently, the Deer Creek Pumping Station includes three 50-mgd horizontal split-case pumps, each operated by one 2,000-horsepower motor. However, plans currently under design, will add two additional pumps. When expanded to full capacity, the Deer Creek Pumping Station will have a nominal pumping capacity of approximately 184 mgd with four pumps operating at normal speed.

7. *Proposed Fullerton Treatment Plant*

As currently planned, the Fullerton Treatment Plant will be located northeast of the Interstate 95 and Interstate 695 interchange in Baltimore County. The plant will be capable of treating raw water from the Susquehanna River and the Gunpowder Falls and supply finished water to the First Zone and upper dependent zones. The capacity is unknown at this time; however, previous estimates range from 60 to 180-mgd.

8. *Montebello Raw Water Distribution Center*

When water levels in Loch Raven Reservoir cannot provide adequate pressure head for gravity flow, the Montebello Raw Water Distribution Center pumps water from the reservoir to the Montebello Plants. However, since high water levels at Loch Raven Reservoir are maintained by continuously discharging from the Prettyboy Reservoir, the low-lift pumps have not been used for an extended period of time since the 1960's.

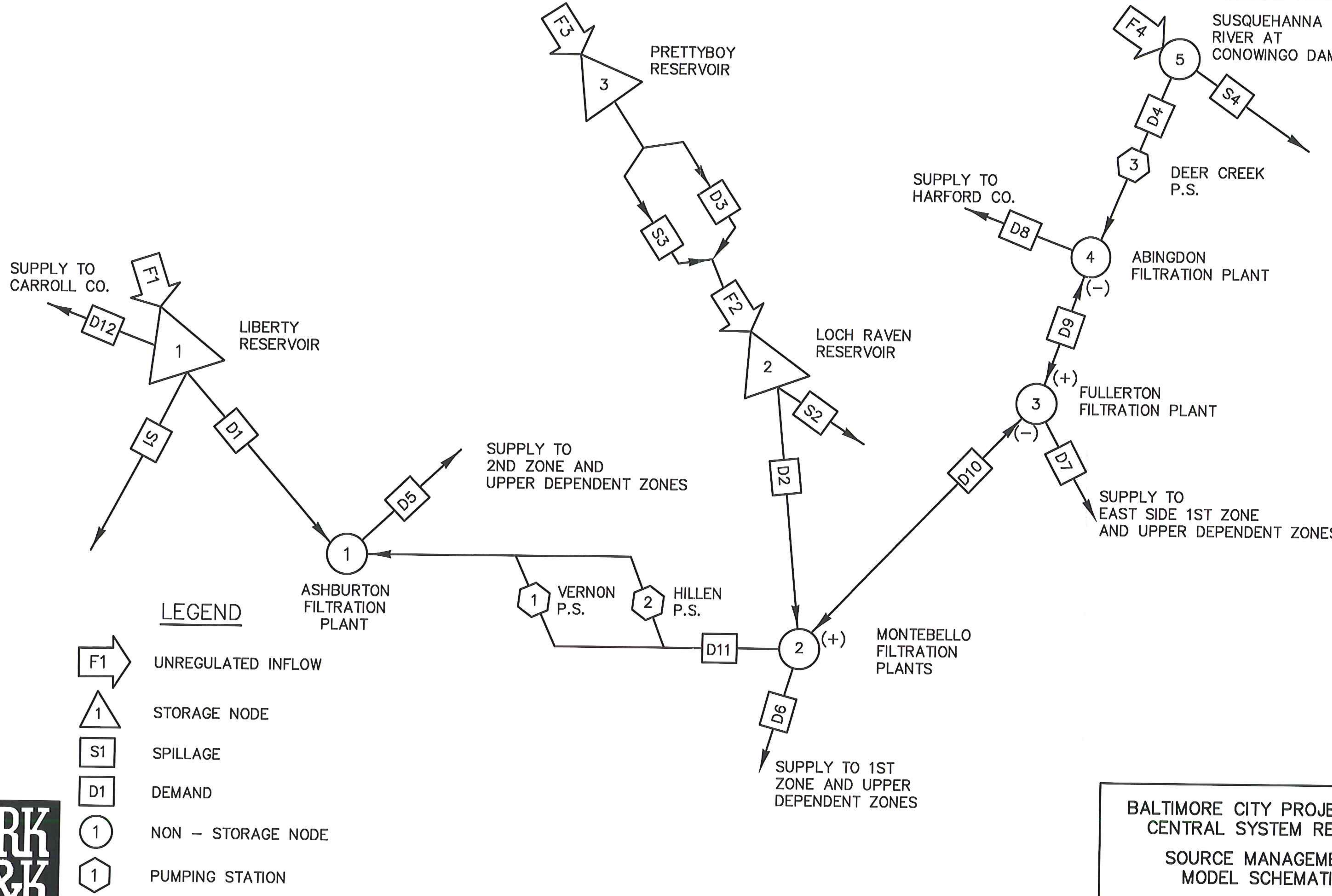
The Loch Raven-Montebello raw water tunnel is capable of transporting approximately 240 to 280 mgd by gravity depending upon the pressure head at the Loch Raven Reservoir. Flow capacity is reduced to approximately 200 mgd when the water elevation at Loch Raven Reservoir drops 10 feet below the crest (230 feet above msl). Gravity flow is not possible when water elevations at the reservoir drop below 219 feet above msl.

9. *Vernon and Hillen Water Pumping Stations*

During emergency (i.e. drought, fire, etc.) conditions or maintenance activities at the Ashburton Filtration Plant, the Hillen and Vernon Pumping Stations can transfer approximately 180 mgd of finished water from the First Zone to Second Zone. The stations currently operate on a regular basis, but at significantly lower pumping rates.

D. Program Operation

Developing the pump operating schedules is an iterative process designed to minimize pumping costs while accommodating acceptable water storage levels and demand. To simulate the operation of the main water supply components, RK&K developed the RESMODEL



BALTIMORE CITY PROJECT 658
CENTRAL SYSTEM REPORT

SOURCE MANAGEMENT
MODEL SCHEMATIC

MARCH, 2003

Figure VI–8

computer program specifically for the City of Baltimore. Each simulation interacts with other simulations, as graphically illustrated in Figure VI-8, to replicate the entire water system operation.

The RESMODEL program analyzes historical stream inflow data at the Liberty and Prettyboy Reservoirs and recorded daily Susquehanna River flow over 72 years (1928 to 2000). In theory, past stream flow conditions are representative of future conditions. Based on the historical stream flows and the user inputted operating schedules, the RESMODEL program determines:

- Reservoir water storage levels
- Water spillage over the dams
- Flow transfer between each system component
- Power costs associated with the operation of the Montebello Raw Water Distribution Center and Deer Creek Pumping Station
- Compensation costs to the Philadelphia Electric Company (PECO) for withdrawals from the Susquehanna River

On July 1, 2002, electrical rates for Baltimore Gas and Electric Company (BGE) Schedule P customers were deregulated. Assuming electrical service is transferred to BGE's Default Service, electricity rates will fluctuate according to the prevailing market rates. Therefore, to simplify the electrical cost calculations, the electrical rates in the RESMODEL program are based on BGE's Schedule P effective July 2001, a copy of which is presented in Figure VI-9. The service schedule identifies three rating periods: Peak, Intermediate-Peak and Off-Peak. The hours of each rating period vary from summer months (June through September) to non-summer months (October through May) with the highest charges applied during the summer month On-Peak rating period. The City is charged a minimum service rate of $750 per month by BGE to maintain electrical service to the Distribution Center, regardless of pump activity. .

PECO Energy Company receives financial compensation when water withdrawals from the Susquehanna River cause the water level behind the Conowingo Dam to drop, resulting in lost energy generating capacity. The compensation costs are based on the established rate

PRIMARY VOLTAGE SERVICE

SCHEDULE P

Availability: For use for all purposes, for demands of 1,500 kW or more. (Service hereunder will be continued for customers with demands of less than 1,500 kW, who originally took Schedule T service prior to February 11, 1982, but not to their successors or assigns).

Delivery Voltage: Three-phase, 13,200 Volts and over as specified by Company.

Monthly Net Rates:

(Option 3 is the Standard for new Customers and those Customers who do not elect a specific option. Rates for generation will be determined by the Customer's CTC.)

Delivery Service Customer Charge: $750.00 per month,

Less: Competitive Billing (where applicable) $ 0.47 per month, plus,
(See Section 7.7 for details)

Demand Charges (July 2001 to June 2002):

Option 3	Summer	Non-Summer
Generation Price Freeze Service	$10.52 per kW	$ 4.65 per kW
Transmission Price Freeze Service:	$ 1.17 per kW	$ 1.17 per kW
Delivery Service:	$ 2.33 per kW	$ 2.33 per kW

Energy Charges (July 2001 to June 2002):

Generation(¢/kWh): Price Freeze Service	Option 3 Summer	Option 3 Non-Summer
Peak	4.063	2.586
Intermediate-Peak	3.053	2.374
Off-Peak	1.825	1.542

Competitive Transition Charge (¢ / kWh) : See Rider 2 for details

Option 1	July 2001 to June 2002	0.758
Option 2	July 2001 to June 2002	0.619
Option 3	July 2001 to June 2002	0.528

Delivery Service Charge: 0.449 ¢ / kWh

Minimum Charge: Net Delivery Service Customer Charge plus the Demand Charges.

Transmission Service: For Customers served at 115 kV and above, the Delivery Service Demand Charge does not apply.

Billing Seasons: Summer rates are billed for usage from June 1 through September 30. Non-Summer rates are billed for usage from October 1 through May 31.

Holidays

All hours on Saturdays and Sundays and the following National holidays are Off-Peak: New Year's Day, President's Day, Good Friday, Memorial Day, Independence Day, Labor Day, Thanksgiving, Christmas, and the Monday following such of these as fall on Sunday.

(Continued on Next Page)

FIGURE VI-9

Schedule P continued

Rating Periods:

Summer

Peak - Between the hours of 10 am and 8 pm on weekdays, excluding the National holidays listed below.

Intermediate - Between the hours of 7 am and 10 am, and the hours of 8 pm and 11 pm on weekdays, excluding the National holidays listed below.

Off-Peak - All times other than those defined for the On-Peak and Intermediate-Peak rating periods.

Non-Summer

Peak - Between the hours of 7 am and 11 am, and the hours of 5 pm and 9 pm on weekdays, excluding the National holidays listed below.

Intermediate - Between the hours of 11 am and 5 pm on weekdays, excluding the National holidays listed below.

Off-Peak - All times other than those defined for the On-Peak and Intermediate-Peak rating periods.

Billing Demand: The maximum 30-minute Measured Demand, adjusted to the nearest whole kW, in each applicable rating period for the month is the Billing Demand. Measured Demand is the Customer's rate of use of electric energy as shown by or computed from readings of the Company's demand meter, but in no case less than 1,500 kW. (For customers with demands of less than 1,500 kW orginally taking service prior to February 11, 1982, the minimum Billing Demand is 200 kW.) Generation and Transmission Demand are billed for each kW of Billing Demand occurring during the Peak rating period. Delivery Service Demand is for each kW of Billing Demand recorded during any rating period..

During the first 6 months of service under Schedule P, the Billing Demand may be less than 1,500 kW, but in that event is not subject to decrease. When it reaches 1,500 kW, this provision no longer applies.

Average Shopping Credit (Price to Compare): includes Demand, Energy, and Transmission (¢/kWh):

Option 3 - July 2001 to June 2002	**3.87 ¢ / kWh**

Late Payment Charge: Standard. (Sec. 7.4)

Payment Terms: Standard. (Sec. 7)

Term of Contract: Five years and thereafter until terminated by at least 30 days' notice from the Customer.

Subject to Riders applicable as listed below

1. Standard Offer Service
2. Competitive Transition Charge
3. Miscellaneous Taxes and Surcharges
5. Controlled Air Conditioning Service
7. Economic Development
9. Customer Billing and Consumption Data Requests
11. Measured Demand
13. Change of Schedule
14. Emergency Generation
15. Temperature Controlled Service
16. Curtailable Service
17. Best Efforts Service
18. Net Energy Metering
19. Demonstration and Trial Installations
21. Billing in Event of Service Interruption
22. Minimum Charge for Short-Term Uses
23. Advanced Meter Services
24. Load Response Program
25. Deferred Fuel Costs Surcharge

schedule entitled "Formula for Charges to the City of Baltimore for Water Withdrawal From Conowingo Reservoir."

Based on the financial compensation and electrical costs, the RESMODEL program calculates the monthly operational costs for the Deer Creek Pumping Station and the Montebello Filtration Plants' low-lift pumps. From the monthly costs the average and maximum annual operational costs are calculated. The maximum average operational cost occurs during drought conditions when the facilities operate at peak capacity.

To minimize the financial costs and operational effects, the operating schedules are revised and inputted into the RESMODEL program and a new simulation analyzed. The process is repeated several times to refine the operating schedules.

E. RESMODEL Program Logic

The RESMODEL program uses a series of conditional checks and algorithms to simulate the Central System's raw water supply operation. A general logic diagram of the program is presented in Figure VI-10.

Initially, RESMODEL determines the allowable withdrawal from Liberty Reservoir following Operating Schedule 1 (O.S. 1) and verifies that this rate does not exceed the related system demand (D5). Any supply deficiencies to the Second Zone and dependent zones are provided by the Vernon and Hillen Pumping Stations (D11). Release from Prettyboy Reservoir, D3, is based on the water elevation in Loch Raven Reservoir (O.S. 2). The RESMODEL program then determines if trigger-flow restrictions are in effect. Withdrawal from the Susquehanna River (D4) is limited to either the maximum allowable withdrawal rate based upon current trigger-flow conditions (250 mgd maximum) or Operating Schedule 3 (O.S. 3), whichever is less. As currently programmed, RESMODEL recalculates D4 every 4 weeks to minimize operational changes to the Deer Creek Pumping Station.

Lastly, the program verifies that flows leaving the Montebello Filtration Plants (node 2) do not exceed the allowable capacity of the plants. All required flows above the Montebello Filtration Plants' capacities (D7) are supplied by the proposed Fullerton Treatment Plant (node 3). Therefore, the minimum capacity of the Fullerton Treatment Plant must be no less than D7.

The pumps at the Montebello Raw Water Distribution Center follow a user-inputted schedule (Schedule 13) as shown below.

Table VI-2, Schedule 13

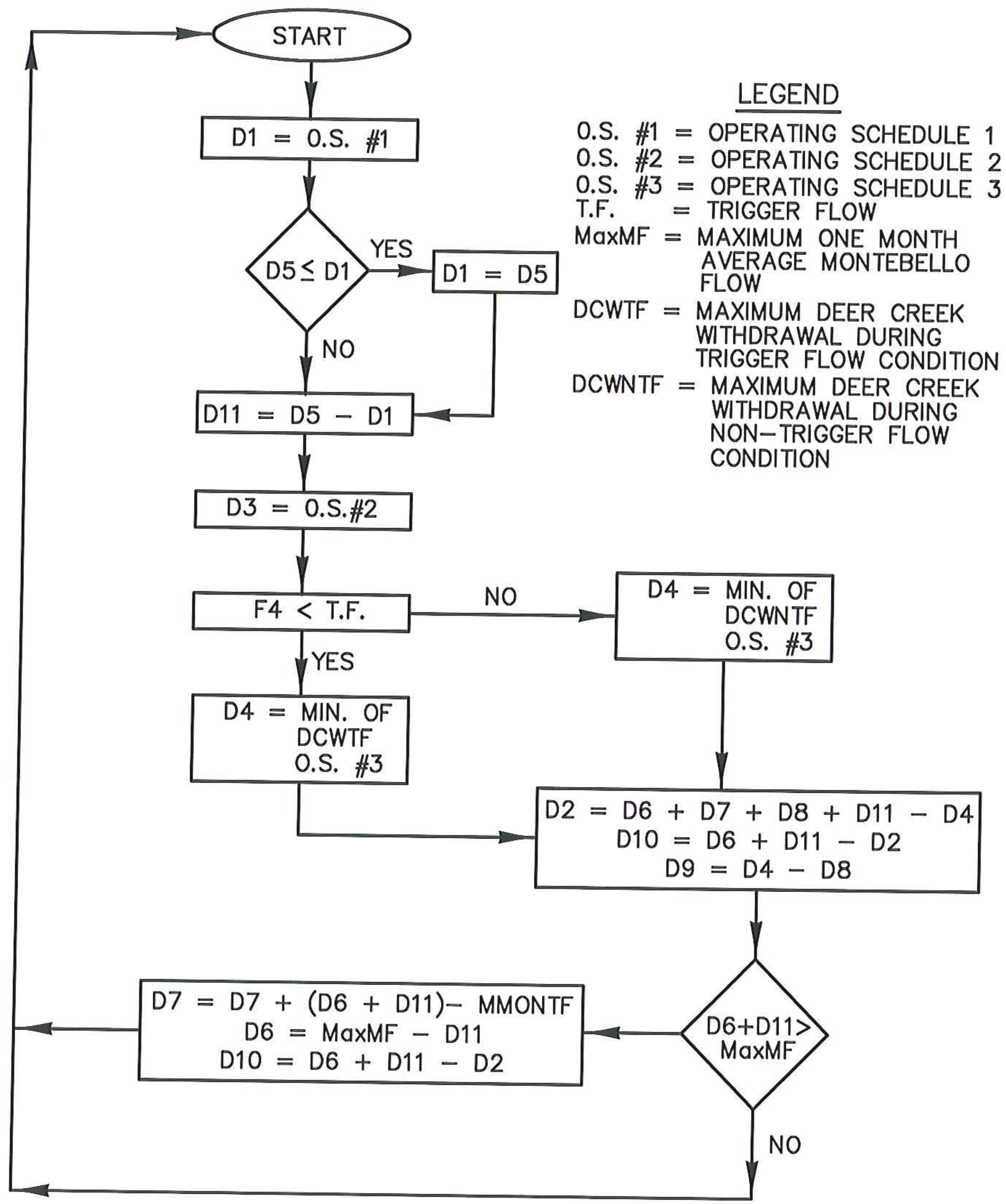
Pump Activation Curve

Loch Raven Water Elev. (ft.)	Loch Raven Demand (D2)	
	Summer (mgd)	Winter (mgd)
221.8	0	0
222	25.27	25.27
224	90.38	90.38
226	127.40	127.40
228	156.64	156.64
230	181.68	181.68
232	203.98	203.98
234	224.29	224.29
236	243.09	243.09
238	260.67	260.67
240	277.77	277.77

The schedule defines the minimum water elevation at Loch Raven Reservoir necessary to maintain gravity flow for a given demand (D2). For example, if D2 is 260 mgd, the water elevation at Loch Raven Reservoir must be at least 238 feet above msl for adequate gravity flow. If the elevation is lower than 238 feet, gravity flow will follow Schedule 13 and the Distribution Center will pump the additional necessary flow to the Montebello Plants.

F. RESMODEL Operating Criteria

Results obtained by the RESMODEL program were based upon the water demands shown in Table VI-3. The maximum monthly raw water demand is determined by multiplying the average day demands, shown in Table VI-4, by a maximum monthly demand factor and a treatment plant wastage factor. The demand factor is based on the 6-year average water demand for each month, as graphically illustrated in Figure II-9. To provide more realistic conditions, the maximum monthly demand factors were increased so that the calculated



BALTIMORE CITY PROJECT 658
CENTRAL SYSTEM REPORT

LOGIC DIAGRAM OF SOURCE MANAGEMENT COMPUTER MODEL

DECEMBER, 2001

Figure VI−10

Table VI-3, Projected Maximum Raw Water Monthly Demands
Data for Input into RESMODEL Computer Model

	DEMAND FACTOR	2000 D5	2000 D6 + D7	2000 Total	2005 D5	2005 D6 + D7	2005 Total	2010 D5	2010 D6 + D7	2010 Total
JAN	0.973	160.8	132.8	293.6	173.4	138.2	311.6	180.7	140.9	321.6
FEB	0.961	158.9	131.2	290.1	171.3	136.5	307.8	178.4	139.1	317.5
MAR	0.947	156.6	129.3	285.9	168.8	134.5	303.3	175.8	137.1	312.9
APR	0.941	155.6	128.5	284.1	167.7	133.7	301.4	174.7	136.2	310.9
MAY	0.975	161.2	133.1	294.3	173.8	138.5	312.3	181.0	141.2	322.2
JUN	1.064	175.9	145.2	321.1	189.7	151.2	340.9	197.6	154.0	351.6
JUL	1.114	184.2	152.1	336.3	198.6	158.3	356.9	206.8	161.3	368.1
AUG	1.108	183.2	151.2	334.4	197.5	157.4	354.9	205.7	160.4	366.1
SEP	1.047	173.1	142.9	316.0	186.6	148.8	335.4	194.4	151.6	346.0
OCT	0.982	162.3	134.1	296.4	175.0	139.5	314.5	182.3	142.2	324.5
NOV	0.954	157.7	130.2	287.9	170.1	135.5	305.6	177.1	138.1	315.2
DEC	0.934	154.4	127.5	281.9	166.5	132.7	299.2	173.4	135.2	308.6
AVG	1.000	165.3	136.5	301.8	178.3	142.1	320.3	185.7	144.8	330.4

	DEMAND FACTOR	2015 D5	2015 D6 + D7	2015 Total	2020 D5	2020 D6 + D7	2020 Total	2025 D5	2025 D6 + D7	2025 Total
JAN	0.973	188.4	144.0	332.4	193.8	146.3	340.1	197.6	147.8	345.4
FEB	0.961	186.0	142.2	328.2	191.4	144.5	335.9	195.2	145.9	341.1
MAR	0.947	183.3	140.1	323.4	188.6	142.4	331.0	192.3	143.8	336.1
APR	0.941	182.2	139.3	321.5	187.4	141.5	328.9	191.1	142.9	334.0
MAY	0.975	188.7	144.3	333.0	194.2	146.6	340.8	198.0	148.1	346.1
JUN	1.064	206.0	157.5	363.5	211.9	160.0	371.9	216.1	161.6	377.7
JUL	1.114	215.6	164.9	380.5	221.9	167.5	389.4	226.2	169.2	395.4
AUG	1.108	214.5	164.0	378.5	220.7	166.6	387.3	225.0	168.3	393.3
SEP	1.047	202.7	154.9	357.6	208.5	157.4	365.9	212.6	159.0	371.6
OCT	0.982	190.1	145.3	335.4	195.6	147.7	343.3	199.4	149.1	348.5
NOV	0.954	184.7	141.2	325.9	190.0	143.5	333.5	193.7	144.9	338.6
DEC	0.934	180.8	138.2	319.0	186.0	140.5	326.5	189.7	141.8	331.5
AVG	1.000	193.6	148.0	341.6	199.2	150.4	349.5	203.1	151.9	354.9

NOTES:

1. Monthly Demand Factors were derived from record demand data for years 1994 - 1999
2. D5 = Demand from Ashburton Filtration Plant (reference Table IV-3)
3. D6 + D7 = Combined demand output from Montebello Plants 1 & 2 and Future Fullerton Filtration Plant
4. Demands include additional 7 percent for treatment plant wastage
5. Demands include additonal 17 percenet for average to maximum demand adjustment
6. All demands are in MGD

Table VI-4, Projected Average Day Water Supplied by Zone (All Demands in MGD)

ZONE	YEAR 2000	2005	2010	2015	2020	2025	SATURATION
R. 5TH	3.72	4.09	4.50	4.90	5.31	5.73	7.56
P. 4TH	10.73	11.68	12.28	12.92	13.54	14.20	24.12
C. 4TH	7.64	7.68	7.83	7.99	8.14	8.30	14.07
W. 3RD	42.68	46.71	49.30	52.09	54.72	55.89	72.60
FULL. P.S. 2ND (-)	-6.00	-6.00	-6.00	-6.00	-6.00	-6.00	-6.00
GUIL. P.S. (+)	25.00	25.00	25.00	25.00	25.00	25.00	25.00
2ND	48.28	53.23	55.41	57.73	58.38	59.10	95.09
TOTAL (D5)	**132.05**	**142.39**	**148.32**	**154.63**	**159.09**	**162.22**	**232.44**
F 5TH	0.60	0.64	0.67	0.71	0.73	0.77	0.99
SP 5TH	0.36	0.45	0.47	0.45	0.48	0.49	1.36
SH 5TH	0.05	0.06	0.06	0.06	0.07	0.07	0.12
PS 5TH	1.37	1.48	1.52	1.55	1.58	1.60	1.89
T. 4TH	15.05	15.65	15.67	15.70	15.67	15.64	26.62
E. 3RD	22.75	23.45	23.82	24.31	24.83	25.40	30.92
C. 2ND	0.66	0.68	0.68	0.68	0.68	0.68	0.81
1ST	87.20	91.08	91.75	93.75	95.08	95.66	142.06
FULL P.S. 2ND (+)	6.00	6.00	6.00	6.00	6.00	6.00	6.00
GUIL. P.S. (-)	25.00	26.00	25.00	25.00	25.00	25.00	25.00
TOTAL (D6 + D7)	**109.04**	**113.49**	**115.64**	**118.21**	**120.12**	**121.31**	**185.77**
TOTAL SYSTEM	**241.09**	**255.88**	**263.96**	**272.84**	**279.21**	**283.53**	**418.21**

maximum monthly demand matched the maximum monthly demand recorded between 1994 and 2000 (approximately 330 mgd in July, 1999 according to Figure II-9). The wastage factor, estimated at 1.7, assumes that 7-percent of the raw water entering the filtration plants is lost due to filter backwash and leakage. The RESMODEL program also assumes a constant flow of 3 mgd is supplied to Carroll County. According to their current water agreement with Baltimore City (reference Table II-2), Carroll County can withdraw a maximum of 3 mgd from the Central Water System.

Based on past operational performance at the reservoirs and the City's preferred operational strategy, the following criteria were followed as closely as possible to develop the RESMODEL operating schedules:

1. If the water level at the Liberty Reservoir drops below elevation 380 feet above msl, increase withdrawal from Loch Raven Reservoir.
2. If the water level at the Loch Raven Reservoir drops below elevation 234.50 feet above msl, increase water discharge at the Prettyboy Reservoir.
3. If the water level at the Prettyboy Reservoir drops below 50-percent capacity (approximately elevation 500 feet above msl) and the water level at Loch Raven Reservoir cannot be maintained at elevation 234.50 feet, start one pump (65 mgd) at the Deer Creek Pumping Station.
4. If Criteria 3 cannot be met, start a second pump at the Deer Creek Pumping Station unless restricted by trigger flow restrictions.
5. If trigger flow restrictions are implemented, operate one pump at the Deer Creek Pumping Station and allow the water elevation at the Prettyboy Reservoir to drop.

Water storage capacity in a reservoir is continuously lost due to sediment accumulation. Theoretically, without dredging activities, a reservoir will eventually fill with sediment. In 1998 the U.S. Geologic Survey (USGS) performed a bathymetric survey to determine total sediment accumulation at the Loch Raven Reservoir. According to the USGS survey, total water storage volume at the Loch Raven Reservoir decreased from 21.45 billion gallons in 1913 to 19.18 billion gallons in 1998 (bathymetric surveys for the Prettyboy and Liberty Reservoirs were not available). The storage loss represents an 11-percent decrease over the past 85 years.

However, the survey provided insufficient data to revise the existing reservoir stage storage curve. Therefore, it was conservatively assumed that sediment accumulation accounted for 10-percent of the total storage capacity at each reservoir.

G. Model Results and Analysis

1. *Overview of Operating Schedules*

Based on the 2015 Fullerton Treatment Plant startup date recommended in *Section IV Hydraulic Modeling*, two operating schedules were developed for the Liberty and Prettyboy Reservoirs and the Deer Creek Pumping Station. The first set of operating schedules, based on 2015 projected water demands, assumes the Fullerton Treatment Plant is not operating. Conversely, the second operating schedule, based on 2025 water demands, assumes the Fullerton Treatment Plant is fully operational.

2. *Operating Schedules Based on 2015 Demand Conditions*

A copy of the RESMODEL input file used to develop the 2015 operating schedules is presented in Figure VI-11. According to lines 20 through 22 of that figure, the maximum raw water flow at the Montebello Filtration Plants is 262 mgd. The flow was derived by the following equation:

$$(318 \text{ mgd}/1.36) \times 1.114 = 262 \text{ mgd}$$

where:

318 mgd = maximum raw water supply at the Montebello Plants

1.36 = maximum day to average annual raw water demand ratio

1.114 = raw water monthly demand factor for July

(the demand factor is calculated by dividing the average raw water demand in July by the total monthly average raw water demand for the year)

This equation assumes that the proposed improvements to the Montebello Filtration Plants, currently under design, are complete.

FIGURE VI-11
D2015 RESMODEL INPUT FILE

```
;Operating Plan 1 with SRBC modification (for RESMODEL1)
;      1-19-3-RC7, CP-A
;
; MODEL START DATE (Year  Month  QtrMonth)
   1928  1  1
;
; MODEL END DATE (Year  Month  QtrMonth)
   1999  12  4
;
; LIBERTY RESERVOIR STARTING ELEVATION
   420
;
; LOCH RAVEN RESERVOIR STARTING ELEVATION
   240
;
; PRETTYBOY RESERVOIR STARTING ELEVATION
   520
;
;
;MONTEBELLO MAX. MONTH  (MGD)
;      (MMAXM)
       262
;
;
; Maximum Deer Creek withdrawal when Susquehanna's flow is less than the trigger flow
;      (MGD)
        64
;
;
; Maximum Deer Creek withdrawal at anytime
;      (MGD)
        250
;
;
; Number of model passes between calculating the demand at Deer Creek (if 1, it will be calculated each time)
        4
;
; Schedule    1  -  LIBERTY WITHDRAWALS
;  Per 1989 Central System Report and Vol. II, Hillen P.S. Report
;                       D1 (MGD)
;      Elev. (ft)     summer    winter
```

FIGURE VI-11
CONTINUED

```
;  (LIBEL)
     415      160     140
     410      140     120
     405      120     100
     400      105      75
     395      100      70
     390       95      70
     382       85      60
     380       80      55
;
;
; Schedule   2  -  PRETTYBOY RELEASE
; Per Vol. II Hillen P.S. Report
;     LR Elev.  (ft)    D3 (MGD)
;     (LREL)         summer  winter
      235              0       0
      234             35      35
      233             50      50
      232             95      95
;
; Schedule 3 Format:  0 - LR Elev vs Winter/Summer Demands
;                     1 - Total Reservior Storage vs Demand (SRBC's rule curve)
    1
;
; Schedule   3  -  PUMPAGE FROM DEER CREEK
;     Alt3-RC2
; D4          Total Storage of All Three Reservoirs (at which to start pumps)
;(mgd)                       (BG)
;        J      F      M      A      M      J      J      A      S      O      N      D
0       86.8   86.8   86.8   86.8   86.8   86.8   86.8   86.8   86.8   86.8   86.8   86.8
64      61     63     65     67     69     75     71     71     69     67     60     60
105     54     56     58     60     62     68     64     64     62     60     53     53
137     47     49     51     53     55     61     57     57     55     53     46     46
184     40     42     44     46     48     54     50     50     48     46     39     39
214     33     35     37     39     41     47     43     43     41     39     32     32
233     26     28     30     32     34     40     36     36     34     32     25     25
;
;
;     SCHEDULE 4 - Trigger Flows  (cfs)
;          (TF)
;     J      F      M      A      M      J      J      A      S      O      N      D
```

FIGURE VI-11
CONTINUED

```
; WEEK
1     1600   1600   3500   10000  3500   5000   5000   5000   5000   3500   3500   1600
2     1600   1600   3500   10000  3500   5000   5000   5000   5000   3500   3500   1600
3     1600   1600   3500   10000  3500   5000   5000   5000   3500   3500   3500   1600
4     1600   1600   3500   10000  3500   5000   5000   5000   3500   3500   3500   1600
;
;
;     Schedule 5 - Conservation Plan A
; LIB elev. (ft)   Demand Reduction Factor (%)
;    (LIBEL)       (affects D5, D6, D7, D8 & D12)
      420              0
      405              6
      396              11
;
;
;Miscellaneous System Demands  (MGD)
;     J      F      M      A      M      J      J      A      S      O      N      D
;D5  SECOND AND UPPER DEPENDENT ZONES
      188.4  186.0  183.3  182.2  188.7  206.0  215.6  214.5  202.7  190.1  184.7  180.8
;D6  FIRST AND UPPER DEPENDENT ZONES FROM MONTEBELLO
      144.0  142.2  140.1  139.3  144.3  157.5  164.9  164.0  154.9  145.3  141.2  138.2
;D7  FIRST AND UPPER DEPENDENT ZONES FROM FULLERTON
      0.0    0.0    0.0    0.0    0.0    0.0    0.0    0.0    0.0    0.0    0.0    0.0
;D8  HARFORD COUNTY PLUS BGE COOLING WATER
      12.4   12.53  12.26  12.4   13.87  14.53  15.47  15.2   14.93  12.8   11.87  11.73
;D12 CARROLL COUNTY WATER
      3.0    3.0    3.0    3.0    3.0    3.0    3.0    3.0    3.0    3.0    3.0    3.0
;
;
;     MINIMUM PB DEMAND BY MONTH FOR TROUT POPULATION  (MGD)
;              (min. S5)
;JAN  FEB  MAR  APR  MAY   JUN   JUL   AUG   SEP   OCT   NOV  DEC
0     0    0    0    14.9  14.9  14.9  14.9  14.9  14.9  0    0
;
;
; Schedule 13 - Montebello Raw Water Distribution Center Pump Activation Curve
;   LR Elev.        LR Release
;                 Summer        Winter
;   LREL (ft)     D2 (mgd)      D2 (mgd)
     221.8         0             0
     222           25.27         25.27
```

FIGURE VI-11
CONTINUED

```
      224       90.38      90.38
      226      127.40     127.40
      228      156.64     156.64
      230      181.68     181.68
      232      203.98     203.98
      234      224.29     224.29
      236      243.09     243.09
      238      260.67     260.67
      240      277.77     277.77
;
; Schedule 14 - Power to Run Montebello Raw Water Distribution Center Pumps (3)
;   LR Release      Power
;   D2 (mgd)       E3 (kW)
      0             0
     84.6          490
     95.8          489
    109.1          474
    119.3          453
    133.2          402
    143.6          352
    167.6          974
    194.5          967
    217.0          942
    239.1          888
    265.4          782
    286.5          679
    286.6          1459
    323.9          1421
    359.4          1341
    397.9          1188
    429.1          1022
;
;
; Energy to Start a Pump at Deer Creek (kW)
;        (E1)
         000
;
;
;     Schedule 6 - Power to run Deer Creek Pumps
; Deer Creek Pumpage   Power
;  D4  (MGD)         E2  (kW)
```

FIGURE VI-11
CONTINUED

```
     0          0
    64       1420
   105       2740
   137       4175
   184       7104
   214       9659
   233      11495
;
;
;   Schedule 7 - BG&E On-Peak Rating Period and Energy Charges
;     Summer        Winter
;       Price (cents/kWhr)
;         (ONPR)
   4.069        2.592
;
;   Schedule 8 - BG&E Intermediate-Peak Rating Period and Energy Charges
;     Summer      Winter
;       Price (cents/kWhr)
;         (INTERPR)
   3.059        2.380
;
;   Schedule 9 - BG&E Off-Peak Rating Period and Energy Charges
;     Summer      Winter
;       Price (cents/kWhr)
;         (OFFPR)
   1.831        1.548
;
;
;   Schedule 10 - BG&E Distribution Demand Charge ($/kW)
;                 (DDPR)
;        Summer            Winter
         2.33             2.33
;
;   Schedule 11 - BG&E Production and Transmission Demand Charge ($/kW)
;                 (PTDPR)
;        Summer            Winter
         11.69             5.82
;
;
;    BG&E Riders  ($/kWhr)
; Fuel Rate  Conservation Surcharge   Electric Env. Surcharge
```

```
  .0522        .00000          .00000
;
;
; BG&E Customer Charge ($/month)
;      (BGEC1)
        750
;
;
;      Schedule 12 - PECO Unadjusted Energy Loss Charge
; Susquehanna Flow (cfs)    Price for Susq. Withdrawel ($/MG)
;      (F4)              (PECOP1)
        0               1.80
       5001              1.20
      85000               0
;
;
; PECO Energy Factor (PECOF)
; Energy Loss Charge Adjustment ($/MBTU)  Dividing Factor ($)
;      (F)                      (FDF)
      1.40                       .37
;
; PECO Capacity Factor (PECOC)
; Capacity Loss Charge ($/yr/kW)  Multiplying factor ($)
;      (C)                  (CMF)
     65.335                   .8333
;
; End of File
_
```

The Liberty Reservoir operating schedule described in lines 38 through 50 in Figure VI-11 and summarized in Table VI-5, was based on the June 1996 *Impact Study of Susquehanna Trigger Flow Restrictions* report.

Table VI-5, Liberty Reservoir
2015 Operating Schedule (O.S. 1)

Water Elev.	Withdrawal (mgd)	
(ft)	Summer	Winter
415	160	140
410	140	120
405	120	100
400	105	75
395	100	70
390	95	70
382	85	60
380	80	55

The operating schedule for the Prettyboy Reservoir, described on lines 53 through 60 in Figure VI-11 and summarized in Table VI-6, was derived from the operating schedule developed in the 1996 trigger flow restrictions report (see Table VI-7). Following the direction stated in Section E Criteria 1, the revised schedule decreases withdrawals from Prettyboy Reservoir resulting in larger withdrawals from Loch Raven Reservoir in support of Prettyboy Reservoir.

Table VI-6 Prettyboy Reservoir
Operating Schedule (O.S. 2)
From 2015 RESMODEL

Water Elev. At Loch Raven Reservoir (ft)	Withdrawal (mgd)	
	Summer	Winter
235	0	0
234	35	35
233	50	50
232	95	95

Table VI-7 Prettyboy Reservoir
Operating Schedule (O.S. 2)
From June 1996 Report

Water Elev. At Loch Raven Reservoir (ft)	Withdrawal (mgd)	
	Summer	Winter
234	0	0
233	75	75
232	100	100
231	150	150

The Deer Creek Pumping Station operating schedule (O.S. 3) described in lines 66 through 77 in Figure VI-11 and summarized in Table VI-8 was developed through numerous RESMODEL simulations comparing reservoir storage levels and costs.

Table VI-8 Deer Creek Pumping Station Operating Schedule 3 (O.S. 3) Based on 2015 Water Demands

Alternate	Deer Creek Pumpage (mgd)	Total Storage (BG) of all Three Reservoirs at which to Start Pumps											
		Jan.	Feb.	Mar.	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
D2015	0	86.8	86.8	86.8	86.8	86.8	86.8	86.8	86.8	86.8	86.8	86.8	86.8
	64	61	63	65	67	69	75	71	71	69	67	60	60
	105	54	56	58	60	62	68	64	64	62	60	53	53
	137	47	49	51	53	55	61	57	57	55	53	46	46
	184	40	42	44	46	48	54	50	50	48	46	39	39
	214	33	35	37	39	41	47	43	43	41	39	32	32
	233	26	28	30	32	34	40	36	36	34	32	25	25

The second column describes the withdrawal rate from the Susquehanna River, which is dependent upon the total water stored at the three reservoirs (columns 3 through 14). For instance, if, in April, the combined water storage at the three reservoirs drops to 66 billion gallons, the Deer Creek Pumping Station will withdraw 64 mgd from the Susquehanna River. The pumping station withdrawal amounts are based on the pump capacities at the Deer Creek Pumping Station which are summarized below:

Table VI-9 Deer Creek Pumping Station Withdrawal Pump Operation

*Withdrawal Rate (mgd)	Number Of Pumps In Operation	Level Of Operation
0	0	---
64	1	High
105	2	Low
137	3	Low
184	4	Low
214	4	High
233	5	High

* Withdrawal rates are based on the original main system curve

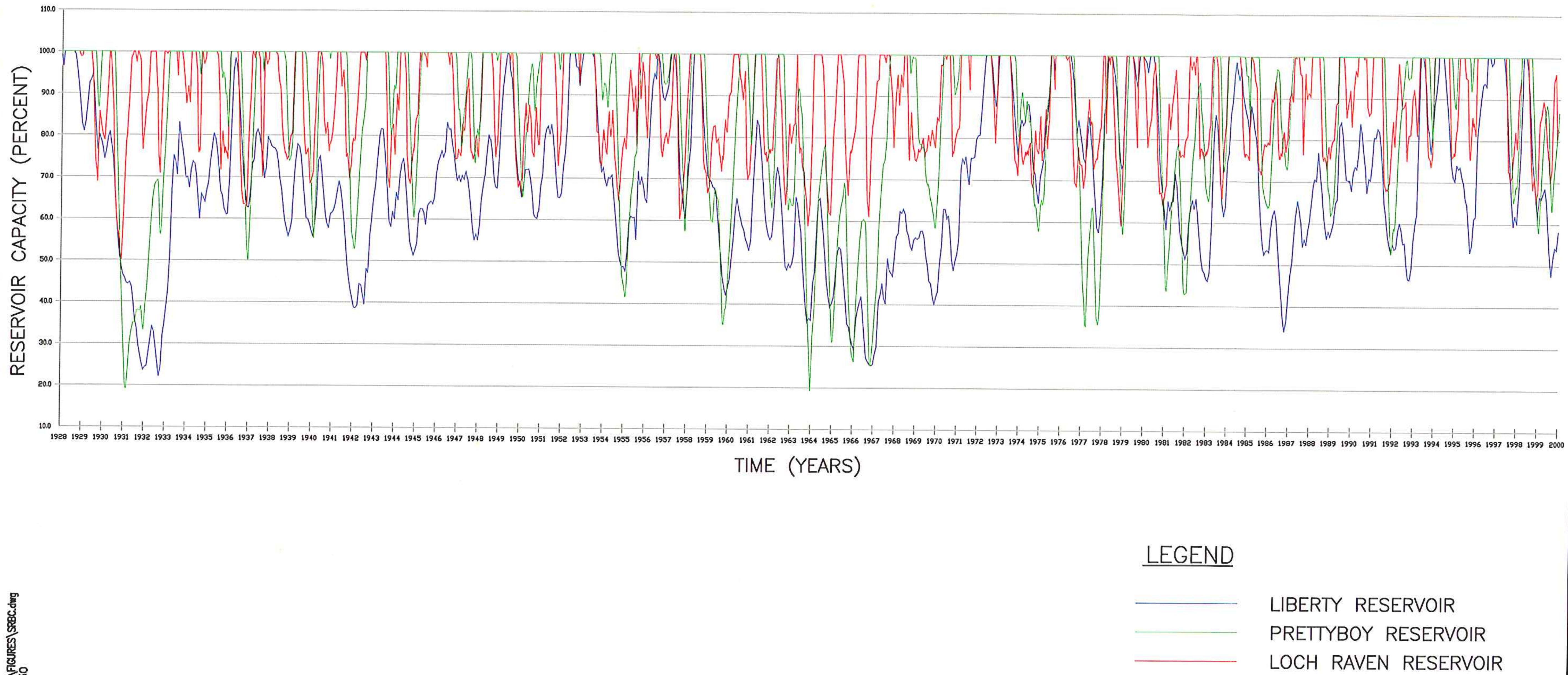
The 2015 RESMODEL simulation includes a 2-stage water conservation plan as described in lines 90 through 95 in Figure VI-11. In the first-stage, the conservation plan assumes water restrictions are implemented when the water elevation at the Liberty Reservoir drops to 405 feet above msl and that the restrictions will result in a 6-percent reduction in demand. If water levels at Liberty Reservoir continue declining, the plan's second-stage assumes tighter water restrictions and further demand reductions. The conservation plan's second-stage is triggered when water elevation at Liberty Reservoir drops to 396 feet above msl and that the tighter restrictions will reduce demand by an additional 5-percent, resulting in an overall water demand reduction of 11-percent.

Based on the three operating schedules summarized in Tables VI-5 VI-6and VI-8, the conservation plan and 2015 projected water demands, the RESMODEL program simulated storage fluctuations at the Liberty, Loch Raven and Prettyboy Reservoirs as shown in Figure VI-12.

The combination of the projected water demands and the trigger flow restrictions will require greater dependency on stored water. During non-drought conditions, Prettyboy and Liberty Reservoirs must remain at maximum capacity despite possible spillage to provide sufficient raw water through severe drought conditions. For example, simulating 1930-32 drought conditions, water storage at Liberty Reservoir reaches a maximum of approximately 81-percent (35.1 billion gallons of stored water) in April before steadily declining for the remainder of the year and throughout the following year. In mid-July, water elevation at the Liberty Reservoir drops below 405 feet above msl thereby triggering the water conservation plan's first-stage and reducing demand (D1) from 140 mgd to 120 mgd. Despite the reduced demands, the conservation plan's second-stage is triggered in October again reducing Liberty Reservoir demand from 105 mgd to 70 mgd.

As shown in Figure VI-13, first-stage and second-stage water restrictions will be triggered during mild and severe drought conditions, respectively. According to the RESMODEL simulation, trigger flow restrictions occur less than 40 times over 72 years. In most instances, water restrictions are already in effect before trigger flow restrictions occur.

Typically, the reduced water storage levels at Liberty Reservoir, caused by increased summer demands, are recovered during the winter months; however, the dry winter months similar to those in 1930-31 only maintain water levels at elevation 388 feet above msl. By the end of the following May (during 1931 drought conditions) and with the summer months



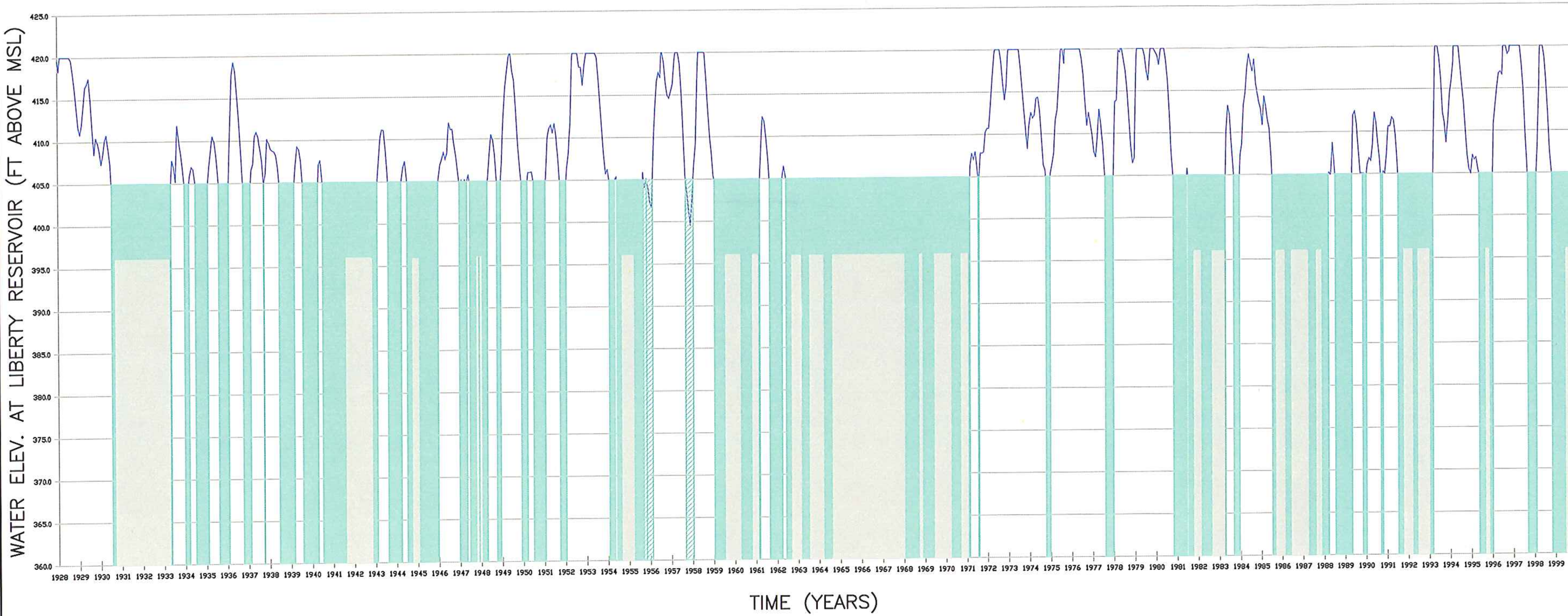
RKK2\SYS – H:\projects\49638\PHASEII\DAMOPER\2003\FIGURES\SRBC.dwg
03/10/2003 10:25 SRBC.CTB PLOT SCALE:1=230

SIMULATED RESERVOIR FLUCTUATIONS USING PROPOSED 2015 OPERATING SCHEDULE

RK&K RUMMEL, KLEPPER & KAHL, LLP
CONSULTING ENGINEERS

MARCH, 2003

Figure VI–12



LEGEND

STAGE 1 CONSERVATION PLAN IN EFFECT (6% DROP IN WATER DEMAND)

STAGE 2 CONSERVATION PLAN IN EFFECT (ADDITIONAL 5% DROP IN DEMAND)

RKK2\SYS – H:\projects\49638\PHASEII\DAMOPER\2003\FIGURES\SRBC.dwg
03/10/2003 10:25 SRBC.CTB PLOT SCALE:1=230

RK&K RUMMEL, KLEPPER & KAHL, LLP
CONSULTING ENGINEERS

SIMULATED FREQUENCY OF WATER CONSERVATION PLAN BASED ON PROPOSED 2015 OPERATING SCHEDULES

MARCH, 2003

Figure VI–13

forthcoming, Liberty Reservoir is approximately 44-percent full (18.9 billion gallons). According to the RESMODEL simulation, despite second-stage water restrictions throughout the year, storage levels at Liberty Reservoir steadily decline to approximately 24-percent (10.2 billion gallons) by the end of the year.

When simulating 1930 drought conditions, Loch Raven Reservoir is at full capacity until the beginning of May when withdrawals to support Liberty Reservoir cause the reservoir storage levels to steadily decline to approximately 50-percent (11.9 billion gallons at elevation 221 feet above msl) by the end of November. Withdrawals from Prettyboy Reservoir then increase in support of Loch Raven Reservoir and storage levels in that reservoir begin to steadily decline from full capacity in mid-July to approximately 20-percent (3.8 billion gallons) by the beginning of the following March. During the dry winter months, second-stage water restrictions remain in effect and withdrawals from Prettyboy Reservoir and the Susquehanna River continue; thereby allowing Loch Raven Reservoir to fully recover by the following May. The Loch Raven Reservoir remains at full capacity until the beginning of October when reduced pumping rates at the Deer Creek Pumping Station slightly decrease storage levels at the reservoir.

When Loch Raven Reservoir reaches full capacity in May (during 1931 drought conditions), withdrawals at Prettyboy Reservoir decrease from 95 mgd in mid-February to 15 mgd in May. The lower withdrawals allow storage levels at Prettyboy Reservoir to rise. By mid-November, storage levels rise to approximately 38-percent (7.5 billion gallons) before slightly declining to support Loch Raven Reservoir.

Assuming 1930 drought conditions, pumping at the Deer Creek Pumping Station is not required until the beginning of August. However, trigger flow restrictions for 13 of the next 16 weeks limit Susquehanna River withdrawals to 64 mgd. In December, when trigger flow restrictions are lifted, Susquehanna River withdrawals increase to 137 mgd to support the Loch Raven and Liberty Reservoirs and allow storage levels to increase. The pumping station continues operating throughout the next year withdrawing an average of 160 mgd per week from the Susquehanna River.

Based on the scenario described above, electrical service at the Deer Creek Pumping Station costs approximately $307,000 in the first year of the drought (1930) and $3.1 million the following year (1931). Electrical costs for the Montebello Raw Water Distribution Center total approximately $437,000 for the first year. In the second year of the drought the distribution center does not operate; therefore, $750 per month is assessed, totaling $9,000 for the year. Treating the more turbid Susquehanna River water for any long duration may increase overall operational costs at the Montebello Filtration Plants. Additional treatment requires higher amounts of flocculent, more frequent filtration backwashes and will reduce the residuals storage capacity in the waste lakes. As stated in Section IV of this report, a blending ratio of 3:2 (180 mgd from Loch Raven Reservoir and 120 mgd from the Susquehanna River) results in an acceptable total hardness of approximately 95 mg/L. However, during severe drought conditions such as that experienced in 1931, the large volume of water pumped from the Susquehanna River produces a blending ratio of 3:13 (39 mgd from Loch Raven Reservoir and 184 mgd from the Susquehanna River). Assuming a total hardness of 57 mg/L in the water at Loch Raven Reservoir and 140 mg/L in the Susquehanna River water, the theoretical total hardness of the blended raw water is 125 mg/L. While the blended water hardness may be higher than desired, recent drought conditions are requiring similarly large Susquehanna River withdrawals and high blending ratios. The Susquehanna venturi meter at the Montebello Plants recently recorded a maximum flow of 138 mgd from the Deer Creek Pumping Station producing a blending ratio of 1:4.5 (31 mgd from Loch Raven Reservoir and 138 mgd from the Susquehanna River) and a theoretical total hardness of 125 mg/L. While blending large volumes of Susquehanna River water is not standard practice, it is necessary to accommodate future water demands during severe droughts.

Typically, severe drought conditions are sustained for several years. Each successive drought year compounds the lost water storage from the previous year. Without reliable long-term weather forecasts it is imperative that (1) the operating schedules presented in Tables VI-6 and VI-8 are implemented and (2) a water conservation plan as previously described is developed and implemented.

3. *Year 2025 Demand Conditions*

The 2025 Liberty Reservoir operating schedule shown in lines 38 through 50 in Figure VI-14 is identical to the schedule developed in the June 1996 *Impact Study of Susquehanna Trigger Flow Restrictions* report. (reference Table VI-5). The 2025 Prettyboy Reservoir operating schedule (lines 53 through 60) is identical to the plan developed in the 2015 RESMODEL simulation.

As previously mentioned, the 2025 Deer Creek Pumping Station operating schedule, shown in Table VI-10, assumes the Fullerton Treatment Plant is operating. Therefore, 64 mgd is continuously withdrawn from the Susquehanna River and pumped to the Fullerton Plant.

Table VI-10, Operating Schedule 3 (O.S. 3)
Deer Creek Pumping Station
Based on 2025 Water Demands

Alternate	Deer Creek Pumpage (mgd)	Total Storage (BG) of all Three Reservoirs at which to Start Pumps											
		Jan.	Feb.	Mar.	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
D2025 O.S. 3	64	86.8	86.8	86.8	86.8	86.8	86.8	86.8	86.8	86.8	86.8	86.8	86.8
	105	65	68	70	71	73	75	77	75	74	73	70	70
	137	57	60	62	63	65	67	69	67	66	65	62	62
	184	49	52	54	55	57	59	61	59	58	57	54	54
	214	41	44	46	47	49	51	53	51	50	49	46	46
	233	33	36	38	39	41	43	45	43	42	41	38	38

Similar to the 2015 simulation, the 2025 RESMODEL simulation includes a water conservation plan as described on lines 90 through 94 in Figure VI-14. The conservation plan has one stage that is triggered when the water elevation at the Liberty Reservoir drops to 395 feet above msl. When initiated, the plan assumes demands are reduced by 6-percent. Second-stage water restrictions are not required for the 2025 simulation because of the continuous withdrawal from the Susquehanna River which helps maintain higher water levels at the reservoirs.

Based on the previously described operating schedules, historical weather patterns and projected water demands, the RESMODEL program simulated water storage levels at the three reservoirs as shown in Figure VI-15. Simulating 1965-67 drought conditions, dry weather patterns similar to those experienced in 1963 to 1965 reduce the water storage level at Liberty Reservoir to approximately 53-percent (23.2 billion gallons of water) by the beginning of May. Despite water restrictions throughout the year, storage levels at the reservoir steadily decline to approximately 30-percent (13.0 billion gallons) by the end of the year. However, the continued water restrictions and winter months increase water storage at Liberty Reservoir to approximately 42-percent (18.1 billion gallons) by the following June. Despite water restrictions throughout the remainder of the year, drought conditions and increased summer demand reduce Liberty Reservoir storage levels again to approximately 25-percent (10.9 billion gallons) by the end of November. As shown in Figure VI-16, water restrictions are not limited to severe

FIGURE VI-14
D2025 RESMODEL INPUT FILE

```
;Operating Plan 1 with SRBC modification (for RESMODEL1)
;      1-19-3-RC7, CP-A
;
; MODEL START DATE (Year  Month  QtrMonth)
   1928  1  1
;
; MODEL END DATE (Year  Month  QtrMonth)
   1999  12  4
;
; LIBERTY RESERVOIR STARTING ELEVATION
   420
;
; LOCH RAVEN RESERVOIR STARTING ELEVATION
   240
;
; PRETTYBOY RESERVOIR STARTING ELEVATION
   520
;
;
;MONTEBELLO MAX. MONTH  (MGD)
;      (MMAXM)
       262
;
;
; Maximum Deer Creek withdrawal when Susquehanna's flow is less than the trigger flow
;      (MGD)
        64
;
;
; Maximum Deer Creek withdrawal at anytime
;      (MGD)
        250
;
;
; Number of model passes between calculating the demand at Deer Creek (if 1, it will be calculated each time)
       4
;
; Schedule    1  -  LIBERTY WITHDRAWALS
;  Per 1989 Central System Report and Vol. II, Hillen P.S. Report
;                      D1 (MGD)
;      Elev. (ft)     summer    winter
```

FIGURE VI-14
CONTINUED

```
;  (LIBEL)
     415      160     140
     410      140     120
     405      120     100
     400      105     75
     395      100     70
     390       95     70
     382       85     60
     380       80     55
;
;
; Schedule   2  -  PRETTYBOY RELEASE
; Based On Vol. II Hillen P.S. Report
;    LR Elev.  (ft)    D3 (MGD)
;    (LREL)        summer  winter
     235           0       0
     234           35      35
     233           50      50
     232           95      95
;
; Schedule 3 Format:  0 - LR Elev vs Winter/Summer Demands
;                     1 - Total Reservior Storage vs Demand (SRBC's rule curve)
   1
;
; Schedule   3  -  PUMPAGE FROM DEER CREEK
;    Alt3-RC2
; D4        Total Storage of All Three Reservoirs (at which to start pumps)
;(mgd)                       (BG)
;       J     F     M     A     M     J     J     A     S     O     N     D
64     86.8  86.8  86.8  86.8  86.8  86.8  86.8  86.8  86.8  86.8  86.8  86.8
105    65    68    70    71    73    75    77    75    74    73    70    70
137    57    60    62    63    65    67    69    67    66    65    62    62
184    49    52    54    55    57    59    61    59    58    57    54    54
214    41    44    46    47    49    51    53    51    50    49    46    46
233    33    36    38    39    41    43    45    43    42    41    38    38
;
;
;
;    SCHEDULE 4 - Trigger Flows  (cfs)
;        (TF)
;     J     F     M     A     M     J     J     A     S     O     N     D
```

FIGURE VI-14
CONTINUED

```
; WEEK
1     1600   1600   3500   10000  3500   5000   5000   5000   5000   3500   3500   1600
2     1600   1600   3500   10000  3500   5000   5000   5000   5000   3500   3500   1600
3     1600   1600   3500   10000  3500   5000   5000   5000   3500   3500   3500   1600
4     1600   1600   3500   10000  3500   5000   5000   5000   3500   3500   3500   1600
;
;
;     Schedule 5 - Conservation Plan A
; LIB elev. (ft)    Demand Reduction Factor (%)
;    (LIBEL)        (affects D5, D6, D7, D8 & D12)
      420                0
      395                6
;
;
;Miscellaneous System Demands  (MGD)
;     J      F      M      A      M      J      J      A      S      O      N      D
;D5  SECOND AND UPPER DEPENDENT ZONES
      197.6  195.2  192.3  191.1  198.0  216.1  226.2  225.0  212.6  199.4  193.7  189.7
;D6  FIRST AND UPPER DEPENDENT ZONES FROM MONTEBELLO
      147.8  145.9  143.8  142.9  148.1  161.6  169.2  168.3  159.0  149.1  144.9  141.8
;D7  FIRST AND UPPER DEPENDENT ZONES FROM FULLERTON
       0.0    0.0    0.0    0.0    0.0    0.0    0.0    0.0    0.0    0.0    0.0    0.0
;D8  HARFORD COUNTY PLUS BGE COOLING WATER
       12.4  12.53  12.26   12.4  13.87  14.53  15.47   15.2  14.93   12.8  11.87  11.73
;D12 CARROLL COUNTY WATER
        3.0    3.0    3.0    3.0    3.0    3.0    3.0    3.0    3.0    3.0    3.0    3.0
;
;
;     MINIMUM PB DEMAND BY MONTH FOR TROUT POPULATION  (MGD)
;              (min. S5)
; JAN  FEB   MAR   APR   MAY   JUN   JUL   AUG   SEP   OCT   NOV   DEC
  0    0     0     0     14.9  14.9  14.9  14.9  14.9  14.9  0     0
;
;
; Schedule 13 - Montebello Raw Water Distribution Center Pump Activation Curve
;   LR Elev.        LR Release
;                   Summer       Winter
;   LREL (ft)       D2 (mgd)     D2 (mgd)
     221.8          0            0
     222            25.27        25.27
     224            90.38        90.38
```

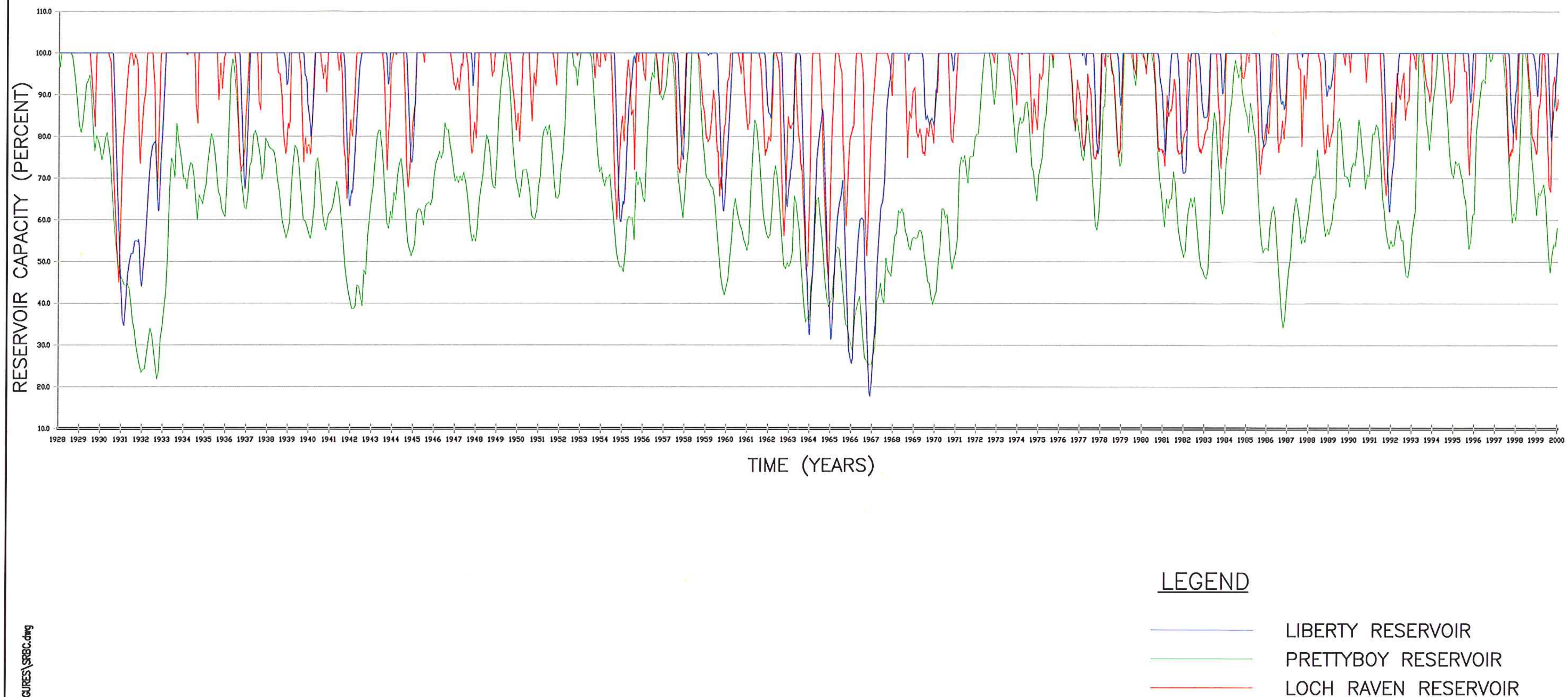
```
        226       127.40      127.40
        228       156.64      156.64
        230       181.68      181.68
        232       203.98      203.98
        234       224.29      224.29
        236       243.09      243.09
        238       260.67      260.67
        240       277.77      277.77
 ;
 ; Schedule 14 - Power to Run Montebello Raw Water Distribution Center Pumps (3)
 ;   LR Release     Power
 ;    D2 (mgd)     E3 (kW)
        0           0
        84.6        490
        95.8        489
        109.1       474
        119.3       453
        133.2       402
        143.6       352
        167.6       974
        194.5       967
        217.0       942
        239.1       888
        265.4       782
        286.5       679
        286.6       1459
        323.9       1421
        359.4       1341
        397.9       1188
        429.1       1022
 ;
 ;
 ; Energy to Start a Pump at Deer Creek (kW)
 ;           (E1)
             000
 ;
 ;
 ;     Schedule 6 - Power to run Deer Creek Pumps
 ; Deer Creek Pumpage    Power
 ;   D4  (MGD)          E2  (kW)
         0                0
```

FIGURE VI-14
CONTINUED

```
     64          1420
     105         2740
     137         4175
     184         7104
     214         9659
     233         11495
;
;
;    Schedule 7 - BG&E On-Peak Rating Period and Energy Charges
;     Summer        Winter
;       Price (cents/kWhr)
;          (ONPR)
     4.069         2.592
;
;    Schedule 8 - BG&E Intermediate-Peak Rating Period and Energy Charges
;     Summer       Winter
;       Price (cents/kWhr)
;         (INTERPR)
     3.059        2.380
;
;    Schedule 9 - BG&E Off-Peak Rating Period and Energy Charges
;     Summer        Winter
;       Price (cents/kWhr)
;          (OFFPR)
     1.831         1.548
;
;
;    Schedule 10 - BG&E Distribution Demand Charge ($/kW)
;                (DDPR)
;         Summer             Winter
          2.33               2.33
;
;    Schedule 11 - BG&E Production and Transmission Demand Charge ($/kW)
;                (PTDPR)
;         Summer             Winter
          11.69              5.82
;
;
;      BG&E Riders  ($/kWhr)
; Fuel Rate  Conservation Surcharge  Electric Env. Surcharge
   .0522        .00000              .00000
```

FIGURE V.
CONTINUED

```
;
;
; BG&E Customer Charge ($/month)
;      (BGEC1)
        750
;
;
;     Schedule 12 - PECO Unadjusted Energy Loss Charge
; Susquehanna Flow (cfs)    Price for Susq. Withdrawel ($/MG)
;     (F4)                  (PECOP1)
        0                  1.80
       5001                  1.20
      85000                    0
;
;
; PECO Energy Factor (PECOF)
; Energy Loss Charge Adjustment ($/MBTU)  Dividing Factor ($)
;      (F)                          (FDF)
      1.40                           .37
;
; PECO Capacity Factor (PECOC)
; Capacity Loss Charge ($/yr/kW)  Multiplying factor ($)
;      (C)                        (CMF)
      65.335                        .8333
;
; End of File
□
```



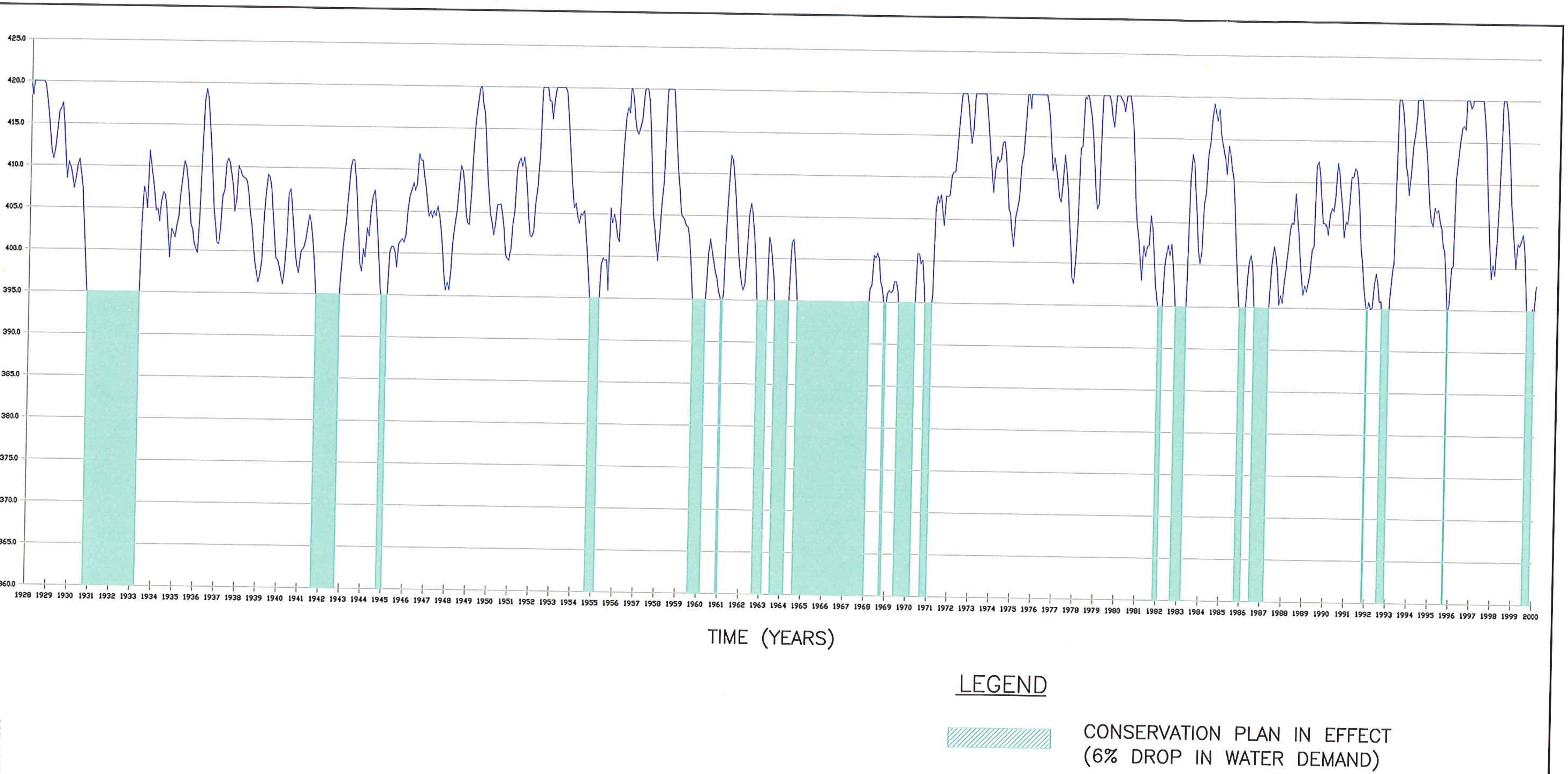
RKK2\SYS – H:\projects\49638\PHASEII\DAMOPER\2003\FIGURES\SRBC.dwg
03/10/2003 10:25 SRBC.CTB PLOT SCALE:1=230

RK &K RUMMEL, KLEPPER & KAHL, LLP
CONSULTING ENGINEERS

SIMULATED RESERVOIR FLUCTUATIONS USING PROPOSED 2025 OPERATING SCHEDULES

MARCH, 2003

Figure VI–15



RKK2\SYS – H:\projects\49638\PHASEII\DAMOPER\2003\FIGURES\SRBC.dwg
03/10/2003 10:25 SRBC.CTB PLOT SCALE:1=230

SIMULATED FREQUENCY OF WATER CONSERVATION PLAN BASED ON PROPOSED 2025 OPERATING SCHEDULES

RK &K RUMMEL, KLEPPER & KAHL, LLP
CONSULTING ENGINEERS

MARCH, 2003

Figure VI–16

drought conditions such as those experienced in 1965-67. As a result of the projected high water demands, water restrictions are triggered more frequently to reduce the rate at which reservoir storage levels are withdrawn.

Following 1930 drought conditions, Loch Raven Reservoir is at full capacity by the beginning of May. With Loch Raven Reservoir at or near full capacity for the first half of the year and water restrictions in effect, storage levels at Prettyboy Reservoir rise to approximately 70-percent (18.1 billion gallons) by the beginning of August. However, withdrawals to support the Liberty Reservoir and trigger flow restrictions from July through mid-August reduce storage levels at Loch Raven Reservoir to approximately 59-percent (13.9 billion gallons) by the beginning of October. The declining water level at Loch Raven Reservoir increases withdrawals at Prettyboy Reservoir; thereby reducing storage levels to approximately 26-percent (5.2 billion gallons) by the end of December. Continued pumping at the Deer Creek Pumping Station and water restrictions throughout the winter months allow Loch Raven Reservoir to fully recover by the following June and storage levels at Prettyboy Reservoir rise to approximately 60-percent (11.9 billion gallons) by mid-June. However, despite continued water restrictions and pumping at the Deer Creek Pumping Station throughout the entire year, storage levels decrease at Loch Raven Reservoir (12.2 billion gallons by the beginning of October) and Prettyboy Reservoir (3.5 billion gallons by mid-December).

The dry weather experienced in the 2½ years prior to the 1965 drought conditions substantially lowers combined reservoir water storage levels by the beginning of the year. As a result of the low storage levels, 214 mgd is withdrawn from the Susquehanna River at the beginning of the year. The withdrawal rate steadily decreases to 137 mgd by the beginning of May before increasing to support summer demand; however, between July and mid-September, trigger flow restrictions limit withdrawals to 64 mgd. In mid-September the restrictions are lifted; however, the RESMODEL programming logic does not allow increased withdrawals until the beginning of October (see *Section E*, Criteria 6). Once lifted, 233 mgd is withdrawn from the Susquehanna River for a month before reducing to 214 mgd for the remainder of the year. Despite water restrictions throughout the winter months, the Deer Creek Pumping Station pumps between 184 and 214 mgd per week from October to the following July. Trigger flow restrictions starting in mid-July and ending in September again limit withdrawals to 64 mgd. When lifted, the pumping station withdraws 233 mgd per week from the Susquehanna River for the remainder of the year.

Based on the drought scenario previously described, electrical service at the Deer Creek Pumping Station costs approximately $3.5 million in the first year of the drought (1965) and $4.4 million the following year. Electrical costs at the Montebello Raw Water Distribution Center total approximately $171,000 in the first year and $178,000 in the second year. Similar to the 2015 plan, additional treatment expenses may be necessary to filter the more turbid Susquehanna River water. At this time, it is unknown what type of treatment processes will be utilized at the Fullerton Plant and what the operating costs will be compared to the City's existing water plants. According to the RESMODEL simulation, under worst-case conditions, 127 of the 233 mgd discharged from the Deer Creek Pumping Station is conveyed to the Montebello Plants and 41 mgd is discharged fromthe Loch Raven Reservoir. Combining these two flows results in a blending ratio of approximately 1:3 and a total hardness of 120 mg/L. While the hardness is higher than typically produced, recent data shows that the Montebello Plants are able to process the harderwater.

H. Recommendations

SRBC trigger flow restrictions combined with projected demand increases continued water demand growth and future drought conditions will require significant changes to the City's current operating schedules for the Prettyboy Reservoir and the Deer Creek Pumping Station. To meet the SRBC agreements, while maintaining an adequate raw water supply, it is recommended that:

1. The 2015 Prettyboy Reservoir and Deer Creek Pumping Station operating schedules presented in this report (Tables VI-6 and VI-8 respectively) are immediately adopted.
2. A conservation plan that attains the following demand reductions be developed and implemented.

Liberty Res. Elev. (feet above msl)	Total Demand Reduction (%)
405	6
396	11

3. The 2025 Deer Creek Operating schedule presented in this report (Table VI-10) be adopted after the Fullerton Treatment Plant is operational.

The results from the RESMODEL simulations shows a short time delay between the start of a severe drought and substantial water storage depletion at the Liberty and Prettyboy Reservoirs and the lack of accurate future weather forecasts only magnifies a drought's effect. Therefore, the first two recommendations should be implemented immediately. The 2025 pumping schedulecould be revisited can be developed after the Fullerton Treatment Plant is operational.

VII. WATER QUALITY

A. Age of Water

The age of water is an important indicator of water quality. After the finished water leaves the treatment plant it may reside in pipes or storage tanks when the demand is low. This reduces the chlorine residual that is in the water which is necessary to help kill bacteria and reduce taste and odor problems. Also, as finished water ages, increased levels of disinfection by-products (DBPs) are observed. DBPs are a regulated contaminant and have been linked to adverse health effects in humans.

1. *Regulations and Current Sampling Data*

Disinfectant residual and disinfection by-products are two key water quality parameters which are affected by the age of water. When chlorine disinfection is practiced, the organic by-products formed include total trihalomethanes (TTHM) and haloacetic acids (HAA). Current regulations and proposed rules assure that the highest quality water leaves the treatment facilities and that these by-products are kept to a minimum while maintaining a certain disinfectant concentration level in the water entering the distribution system.

These water quality issues and regulations are addressed in several of the Comprehensive Plan for Water Facilities Phase I reports, including the *Regulatory Compliance Report*, *Plant-Scale Testing Report*, *Pilot Testing Report* and *Finished Water Facilities Assessment Report*, which contains Information Collection Rule (ICR) results.

The City samples the Central System distribution system on a monthly basis as required under EPA's Total Coliform Rule (TCR). One of the parameters analyzed is chlorine residual which is determined at 120 locations throughout the distribution system. These results were summarized in the *Finished Water Facilities Assessment Report*, Volume 9. Twenty-one sampling sites had 10 percent or more zero chlorine residual measurements in one calendar year. Four sampling locations had 80 percent zero chlorine residual in one calendar year. This topic is also discussed in the *Regulatory Compliance Report*, Volume 2. The Surface Water Treatment Rule (SWTR) requires that the Entrance-Point Disinfectant Residual Minimum is not less than 0.2 mg/L for more than four hours. The testing discussed in Volume 2 shows that the City is in compliance with SWTR.

In 1979, the EPA promulgated a maximum contaminant level (MCL) for trihalomethanes (THMs) of 100 **m**g/L. In addition, the proposed Disinfectants/Disinfection By-Products (D/DBP) rule further reduces the MCL for total trihalomethanes and establishes additional DBP-related regulations. The D/DBP rule consists of two stages, a short-term (Stage 1) and a long-term (Stage 2) rule. The TTHM and HAA levels of 80 and 60 **m**g/L, respectively, are the MCLs allowable under the Stage 1 D/DBP rule. The Stage 2 Rule requires different sampling locations and averaging methods which will likely result in higher sampling values for the Central System, thus the age of water in the system is now even more crucial.

In the *Plant-Scale Testing Report*, Volume 6, testing for TTHM and HAA was performed in the finished water at several points in the distribution system. TTHM levels in the distribution system for Montebello Filtration Plants after 65 hours almost reached the maximum contaminant level of 80 **m**g/L TTHM. In the *Finished Water Facilities Assessment Report*, Volume 9, the ICR results showed that the Ashburton Plant distribution system reached 80 **m**g/L TTHM in August of 1993, but the average HAA did not exceed the MCL. The annual average of quarterly samples taken by the City between January 1993 and June 1996 did not exceed the MCL also, for either TTHM or HAA.

2. Hydraulic Model Analysis

The Haestad Methods WaterCAD hydraulic model was utilized to determine the age of the water in the Central System distribution system. Current and future scenarios were evaluated as part of this analysis. The year 2000 hydraulic model was utilized to simulate current conditions using average day demands. For the future scenario in 2025, it was presumed that the proposed Fullerton Treatment Plant would be in service. Both current and future average day models were analyzed after running a five-day scenario. Model results from the fifth day (or hour 120) were evaluated to determine how long the water had been stagnant in each pipe.

The hydraulic model calculates the age of the water at each model node. The initial age of water is set at zero throughout the system. The age of water at each node is calculated by taking the age from the upstream node and combining it with the distance between the nodes divided by the velocity. If there are several paths coming into one node then the model takes the weighted average.

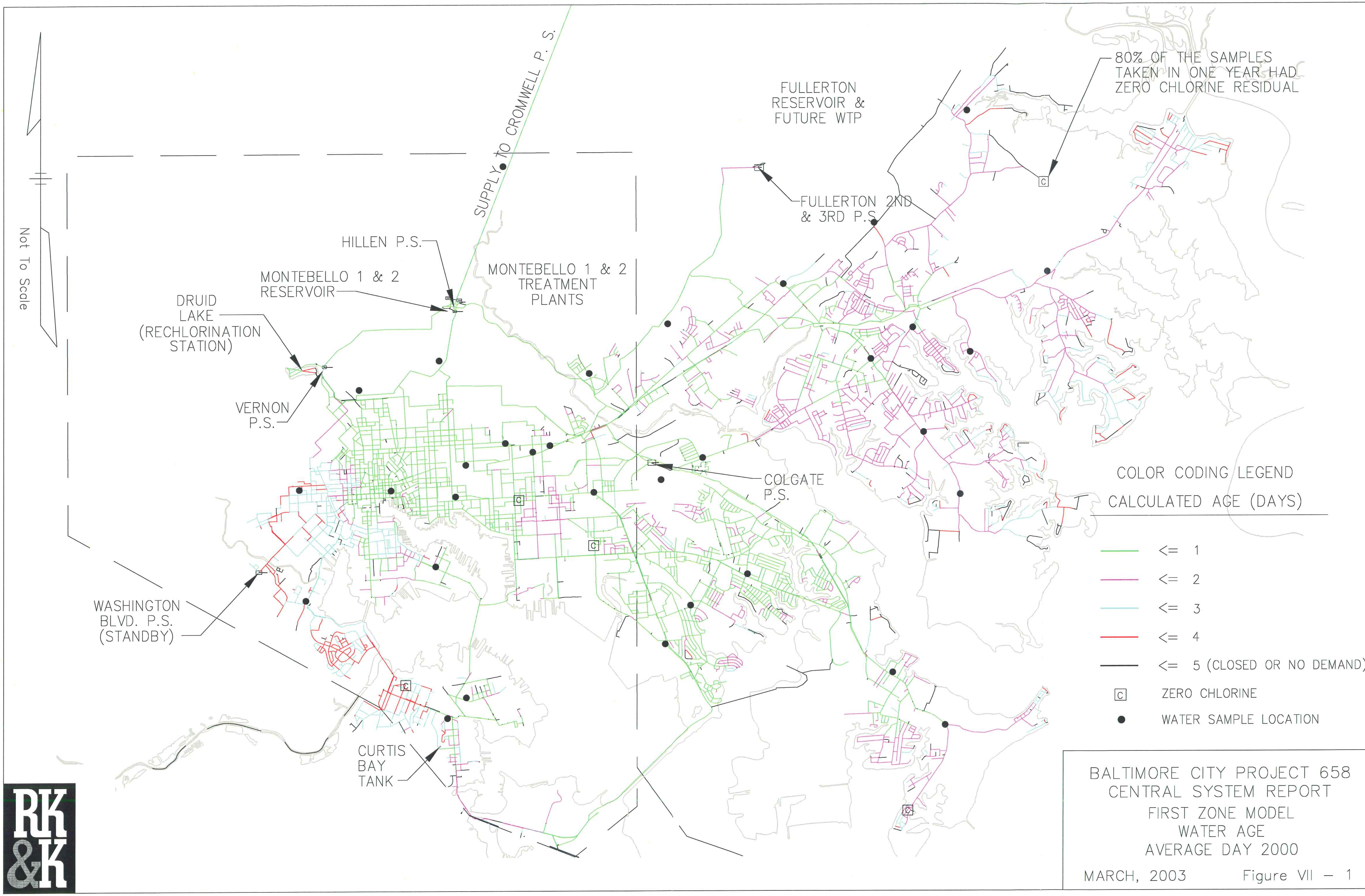
3. *Model Results*

Four scenarios were analyzed for each of the thirteen zones. The graphical results of the two average day scenarios, current and future, are illustrated in the Figures VII 1-10. The current scenario evaluated the system during year 2000 demands and the year 2025 demands were evaluated for the future scenario. Sampling locations presented in the *Finished Water Facilities Assessment Report*, Volume 6, were compared to the hydraulic model results.

<u>First Zone</u>

The testing presented in the *Finished Water Facilities Assessment Report*, Volume 6, identified five sample locations in the First Zone that had 10 percent or more zero chlorine residual measurements in one calendar year. One sample location, on Ebenezer Road, had over 80 percent zero chlorine residual samples. In this area the hydraulic model results show a residence time over five days in both the current, 2000, and future, 2025, average day models which agrees with the sampling results. Two other sample locations also agreed with the hydraulic model results which show a residence time between three and four days that had at least 10 percent zero chlorine residual samples, located on North Point Road and Chesapeake Avenue. The model results also show that the percentage of pipe length with a residence time over 65 hours increases from 12 percent in 2000 to 15 percent in 2025. This increase can be attributed to one area in the County, White Marsh, where average day demands actually decreased slightly. There are also proposed transmission mains in this area which change the flow pattern so all the flow is not transported through one pipe to this area.

The First Zone has two storage facilities that have a calculated residence time over 65 hours, Druid Lake and Curtis Bay Tank. Druid Lake has the largest detention time of any storage facility, but the water is rechlorinated before it enters and as it leaves the lake. The Curtis Bay Tank, in the southwest portion of the First Zone, and the surrounding pipes have high residence times and water is not rechlorinated in this area.

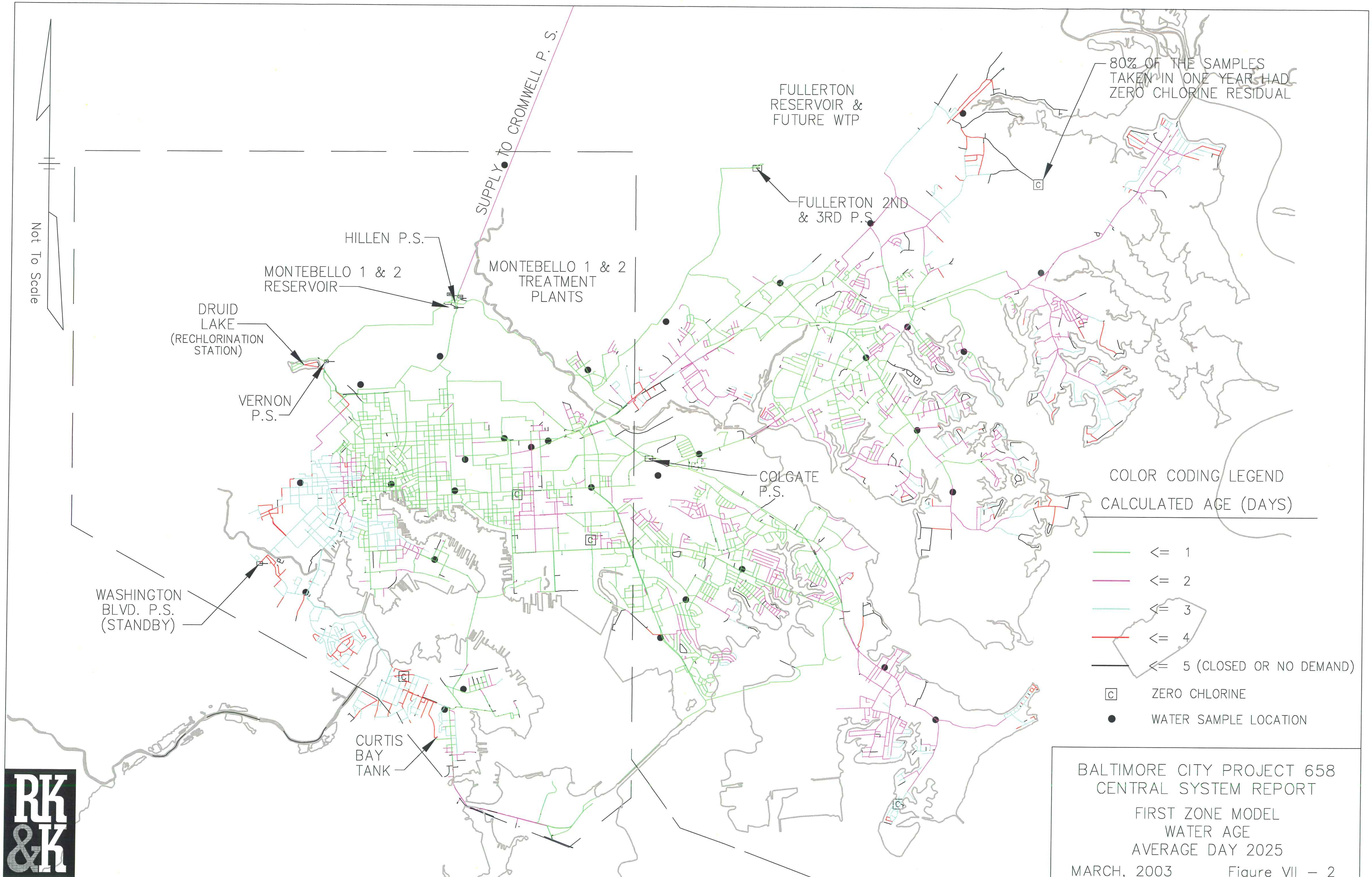


BALTIMORE CITY PROJECT 658
CENTRAL SYSTEM REPORT
FIRST ZONE MODEL
WATER AGE
AVERAGE DAY 2000

MARCH, 2003 Figure VII – 1

RK&K

RKK2\SYS \COMMNOS\CM9638\PHASEII\FINALRPT\Age\1map00.dwg
12/09/2001 16:09 ZRPTMAP.PCP PLOT SCALE:1=5500



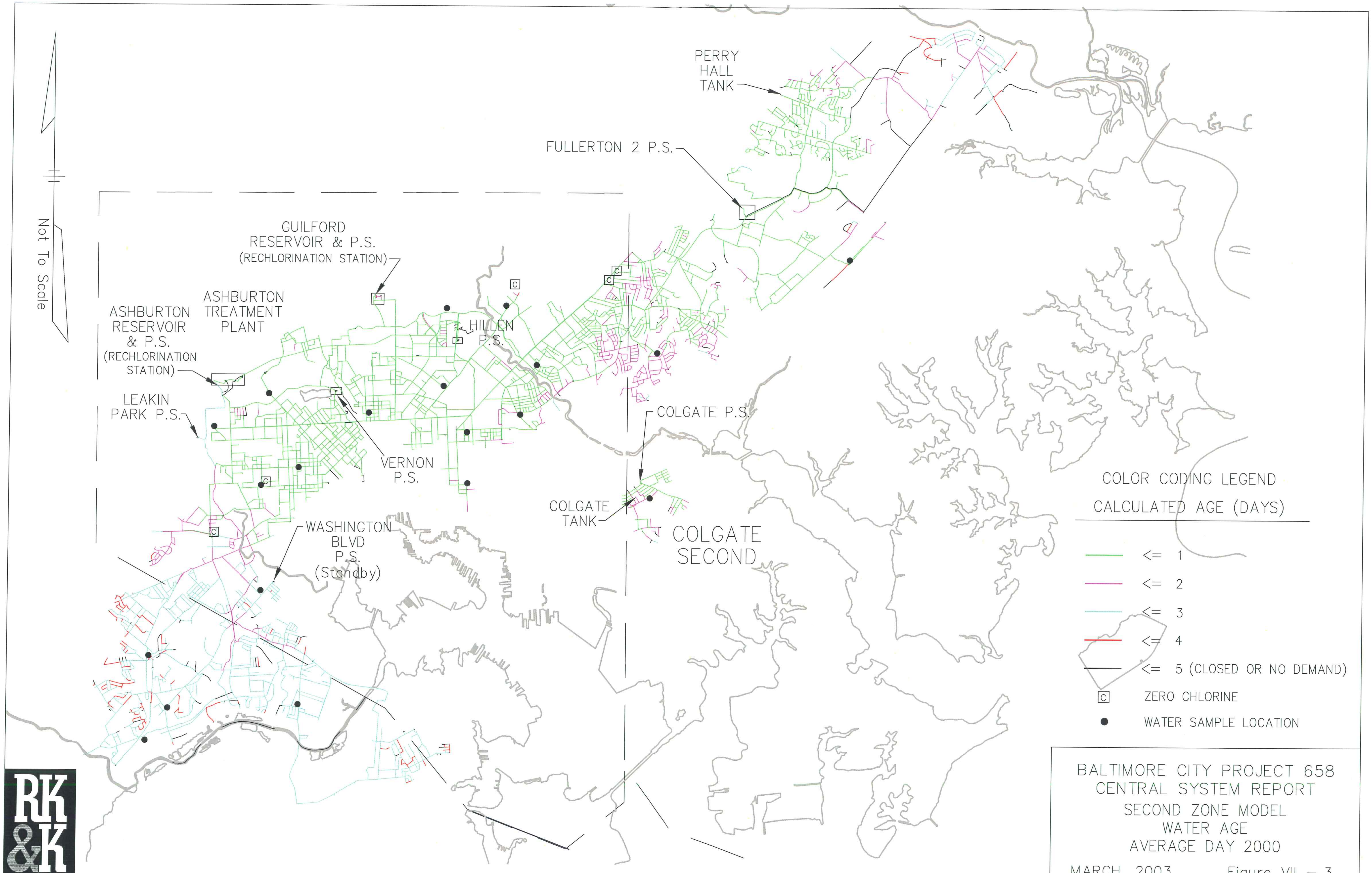
RKK2\SYS \COMMONS\CM9638\PHASEII\FINALRPT\Age\1map25.dwg
12/09/2001 ZRPTMAP.PCP PLOT SCALE:1=5500

RK&K

BALTIMORE CITY PROJECT 658
CENTRAL SYSTEM REPORT

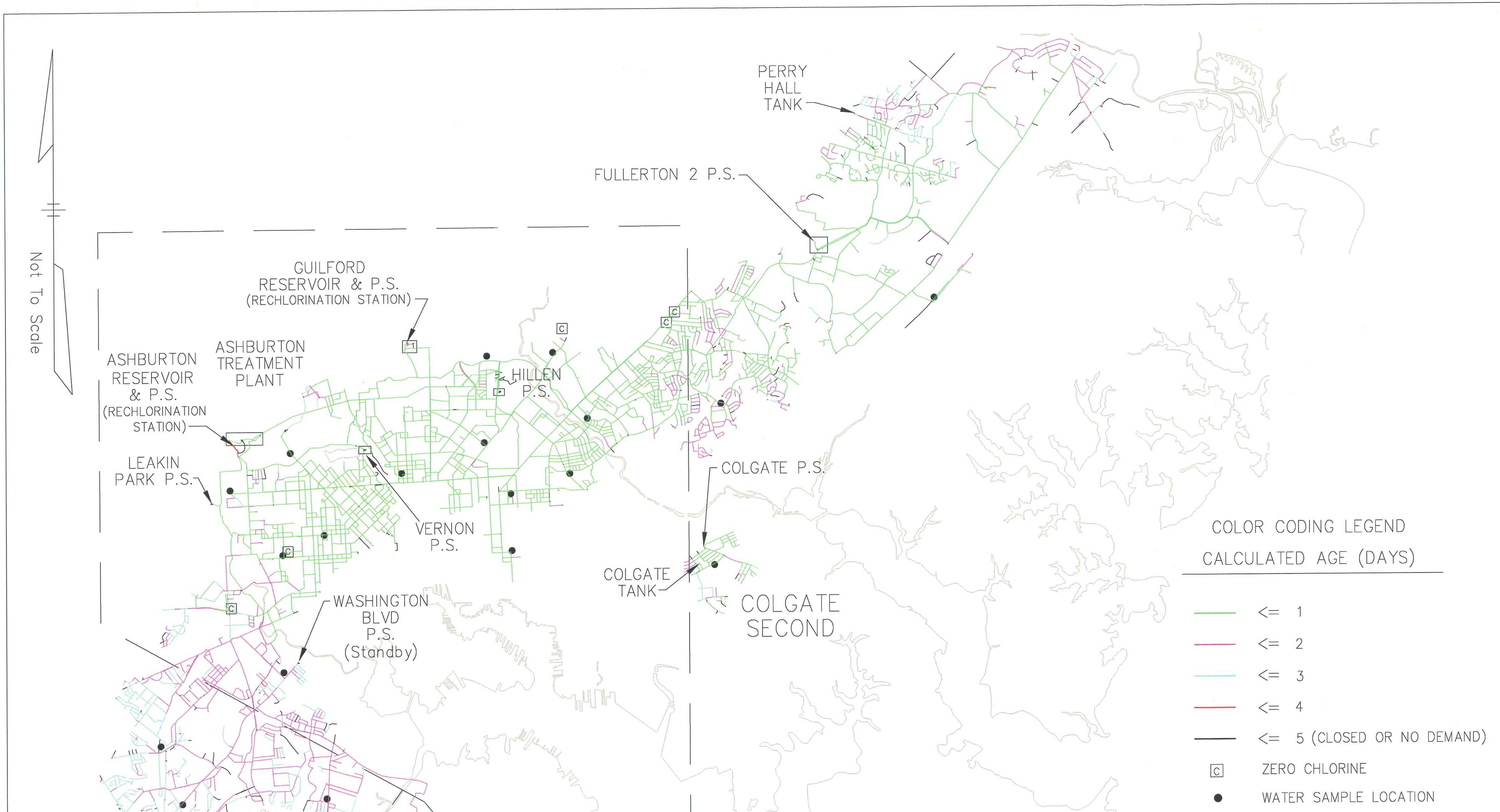
FIRST ZONE MODEL
WATER AGE
AVERAGE DAY 2025

MARCH, 2003 Figure VII – 2



BALTIMORE CITY PROJECT 658
CENTRAL SYSTEM REPORT
SECOND ZONE MODEL
WATER AGE
AVERAGE DAY 2000

MARCH, 2003 Figure VII – 3



BALTIMORE CITY PROJECT 658
CENTRAL SYSTEM REPORT

SECOND ZONE MODEL
WATER AGE
AVERAGE DAY 2025

MARCH, 2003 Figure VII – 4

RK&K

RKK2\SYS – ...OMMNOS\CM9638\PHASEII\FINALRPT\Age\2MAP25.DWG
12/09/2001 16:20 ZRPTMAP.PCP PLOT SCALE: 1=5500

Second Zone

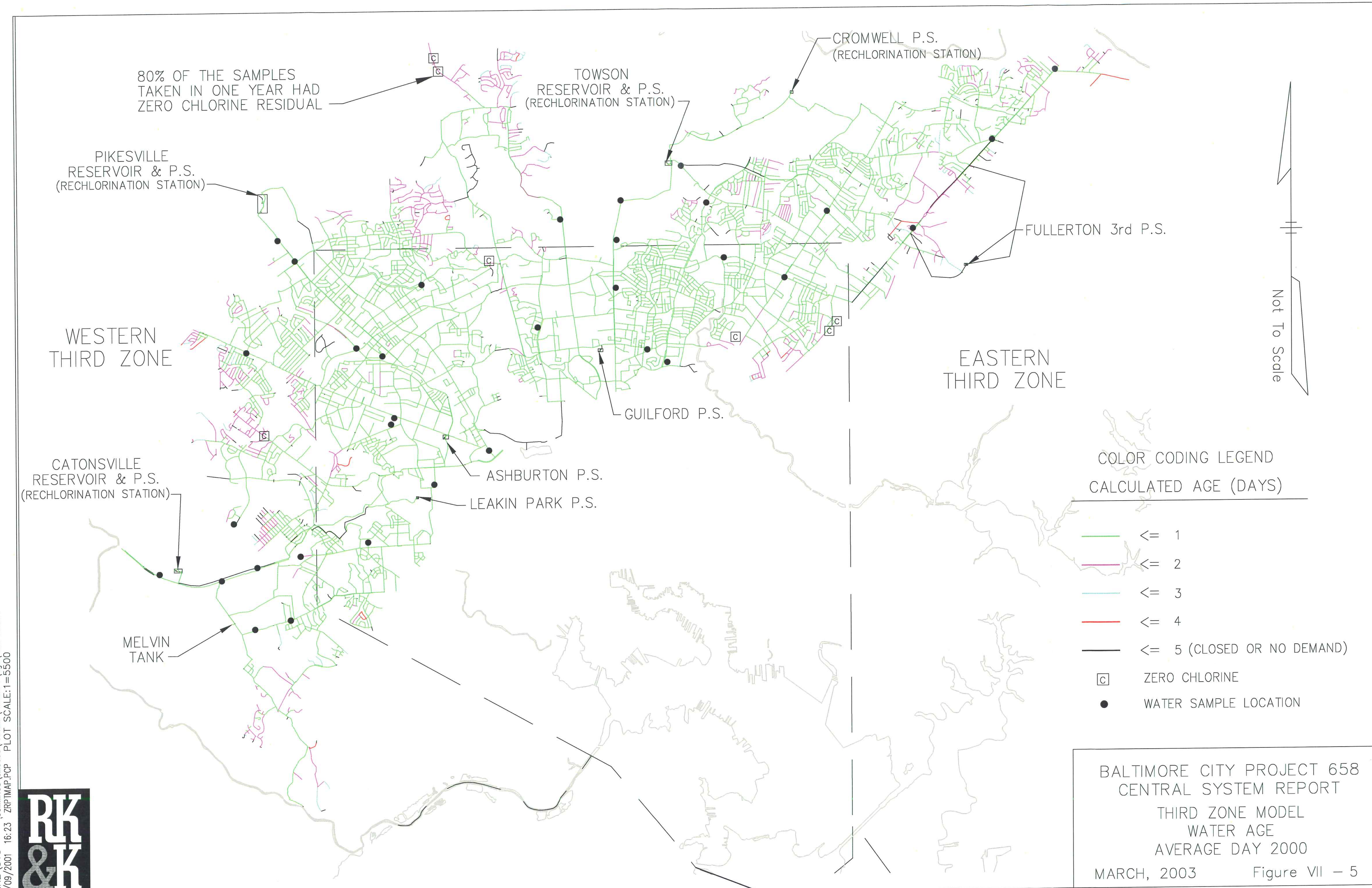
The *Finished Water Facilities Assessment Report,* Volume 6, identified five sample locations in the Second Zone that had 10 percent or more zero chlorine residual measurements in one calendar year. The sample locations in the southern portion of the Second Zone do not have any zero chlorine samples; however, the model results show residence times exceeding three days. The model results show that the residence time in the pipes in the northeast portion of the zone exceed three days as well. The model results also show the percentage of pipe length over 65 hours old decreasing from 12 percent in 2000 to three percent in 2025.

Three out of five tanks in the Second Zone have detention times over 65 hours: Lake Ashburton, Perry Hall Tank and Chapel Hill Tank. Currently the Perry Hall Tank is not rechlorinated and the future Chapel Hill Tank has no plans proposed for rechlorination capabilities. The third facility, Lake Ashburton, has a rechlorination station which rechlorinates the water just after it leaves the reservoir. The detention times at the other two facilities, Guilford Reservoir and Colgate Tank, are low.

Third Zone

The *Finished Water Facilities Assessment Report,* Volume 6, identified eight sample locations in the Third Zone that had 10 percent or more zero chlorine residual measurements in any calendar year. The hydraulic model results show only one percent of the pipe length over 65 hours old. The outlying areas of the zone which have lower demands also have longer residence times. The residence time in most areas decreases in 2025, except the area around Fullerton. One sample location, on Joppa Road, had over 80 percent zero chlorine residual samples, but this does not correspond with the hydraulic model results. The residence time in the hydraulic model is only two days during a current average day demand scenario. This discrepancy could be due to a sampling artifact or sampling conditions may have been different than the flow conditions and demands evaluated in the hydraulic model.

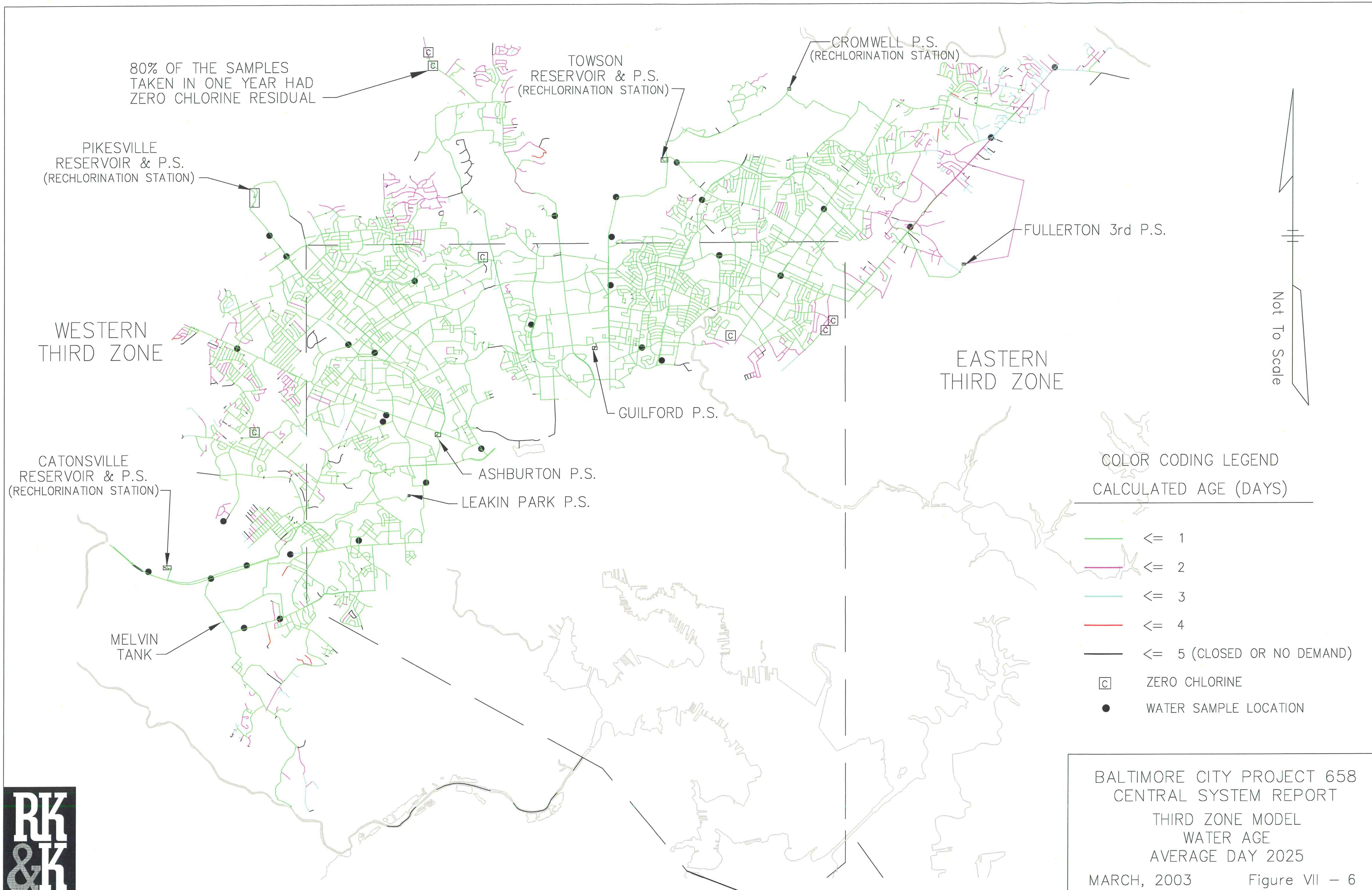
Three out of four storage facilities in the Third Zone have a water detention time over 65 hours: Pikesville Reservoir, Catonsville Reservoir, Melvin Tank and Towson Reservoir. Both the Pikesville and Catonsville Reservoirs have rechlorination capabilities, but the Melvin Tank does not. The fourth facility, Towson Reservoir, has a short detention time.



BALTIMORE CITY PROJECT 658
CENTRAL SYSTEM REPORT

THIRD ZONE MODEL
WATER AGE
AVERAGE DAY 2000

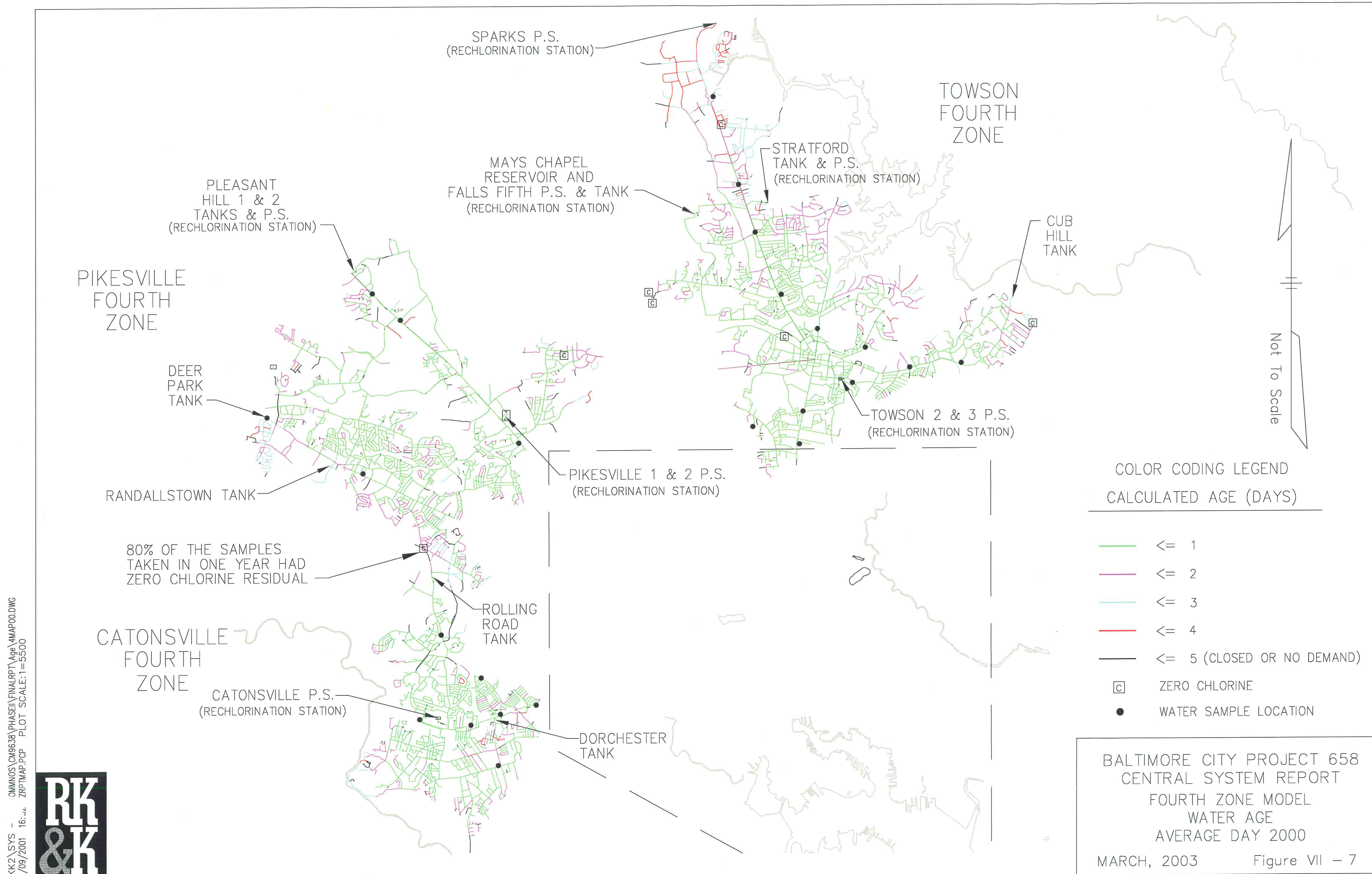
MARCH, 2003 Figure VII – 5

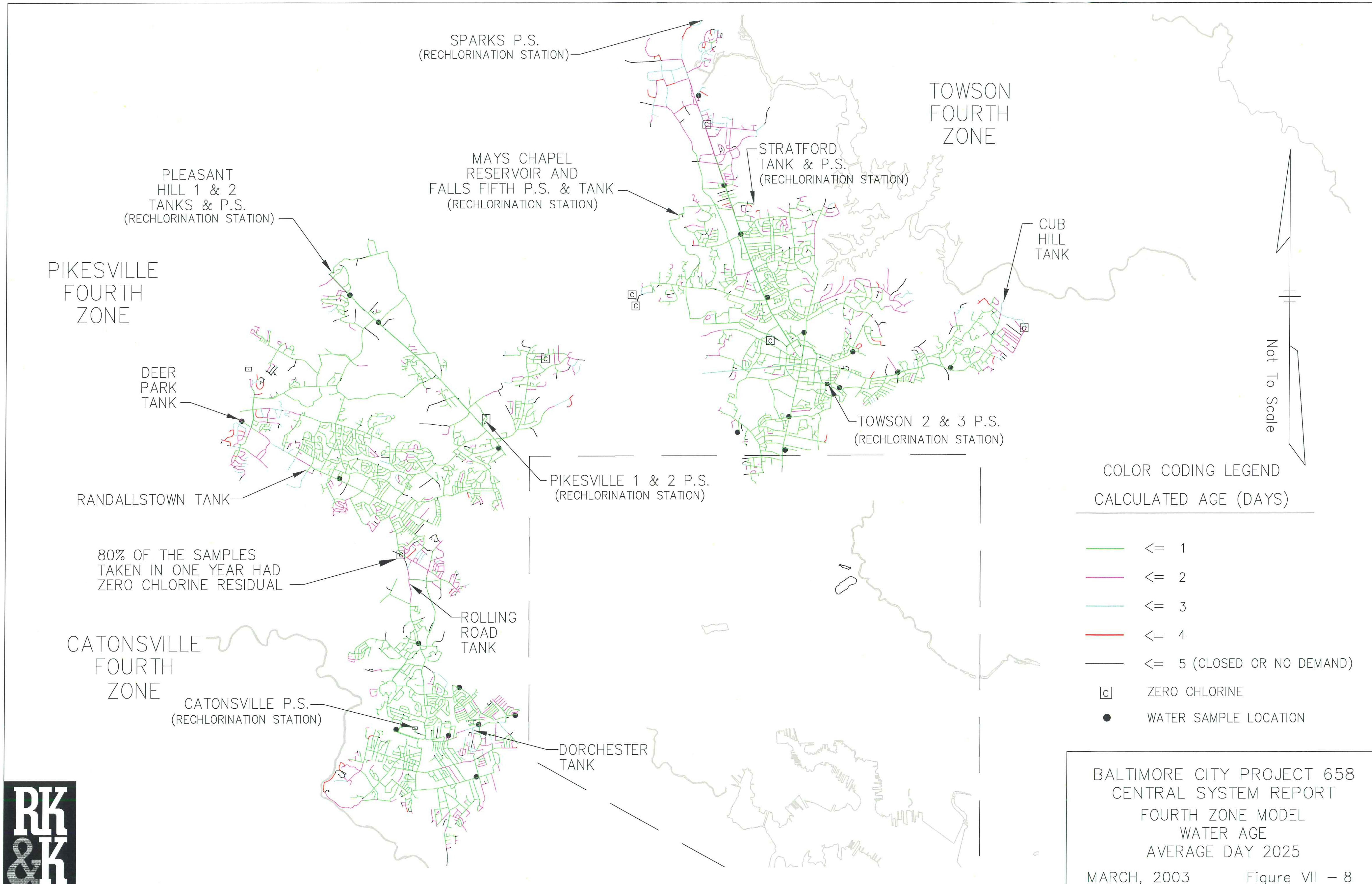


BALTIMORE CITY PROJECT 658
CENTRAL SYSTEM REPORT

THIRD ZONE MODEL
WATER AGE
AVERAGE DAY 2025

MARCH, 2003 Figure VII – 6


SPARKS P.S.
(RECHLORINATION STATION)
TOWSON
FOURTH
ZONE
STRATFORD
TANK & P.S.
(RECHLORINATION STATION)
MAYS CHAPEL
RESERVOIR AND
FALLS FIFTH P.S. & TANK
(RECHLORINATION STATION)
PLEASANT
HILL 1 & 2
TANKS & P.S.
(RECHLORINATION STATION)
CUB
HILL
TANK
PIKESVILLE
FOURTH
ZONE
DEER
PARK
TANK
TOWSON 2 & 3 P.S.
(RECHLORINATION STATION)
Not To Scale
PIKESVILLE 1 & 2 P.S.
(RECHLORINATION STATION)
RANDALLSTOWN TANK
COLOR CODING LEGEND
CALCULATED AGE (DAYS)
<= 1
<= 2
<= 3
<= 4
<= 5 (CLOSED OR NO DEMAND)
C ZERO CHLORINE
WATER SAMPLE LOCATION
80% OF THE SAMPLES
TAKEN IN ONE YEAR HAD
ZERO CHLORINE RESIDUAL
ROLLING
ROAD
TANK
CATONSVILLE
FOURTH
ZONE
CATONSVILLE P.S.
(RECHLORINATION STATION)
DORCHESTER
TANK
BALTIMORE CITY PROJECT 658
CENTRAL SYSTEM REPORT
FOURTH ZONE MODEL
WATER AGE
AVERAGE DAY 2000
MARCH, 2003
Figure VII – 7
RK&K
RKK2\SYS - OMMNOS\CM9638\PHASEII\FINALRPT\Age\4MAP00.DWG
12/09/2001 16:.. ZRPTMAP.PCP PLOT SCALE:1=5500



BALTIMORE CITY PROJECT 658
CENTRAL SYSTEM REPORT
FOURTH ZONE MODEL
WATER AGE
AVERAGE DAY 2025

MARCH, 2003 Figure VII – 8

RKK2\SYS – OMMNOS\CM9638\PHASEII\FINALRPT\Age\4MAP25.DWG
12/09/2001 16:.. ZRPTMAP.PCP PLOT SCALE:1=5500

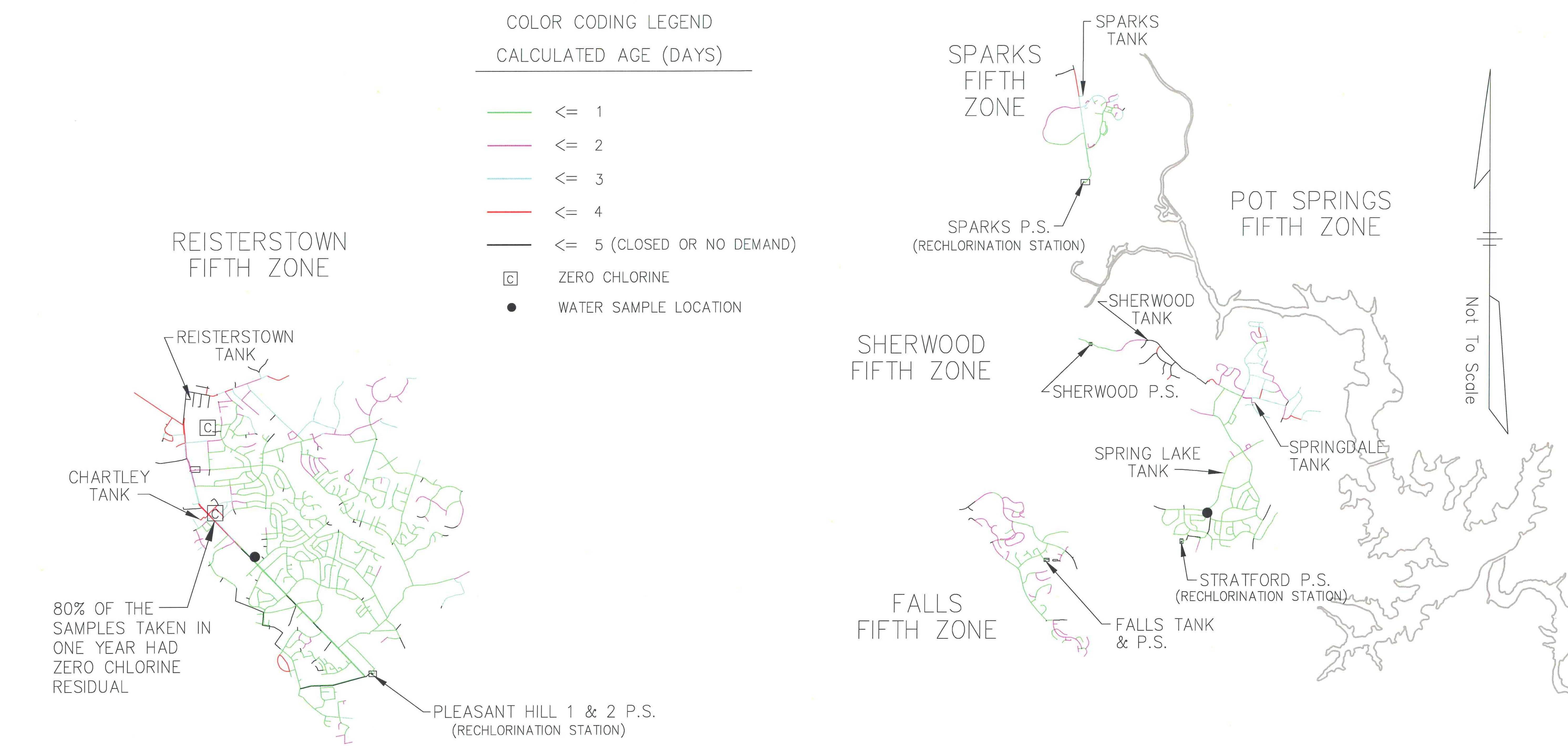
Fourth Zone

The model results show that the percentage of pipe length with residence times over 65 hours will decrease by 2025, from five percent in 2000 to only four percent in 2025. The *Finished Water Facilities Assessment Report*, Volume 6, identified seven sample locations in the Fourth Zone that had ten percent or more zero chlorine residual measurements in any calendar year. Two of the sampling locations with occasional zero chlorine residual samples are also indicated as possible problem areas in the model. They are both located in the Towson Fourth Zone, one near Cub Hill Tank and the other north of the Stratford Tank. The sample location in Pikesville at the intersection of Rolling Road and Windsor Mill Road had over 80 percent zero chlorine residual samples identified in Volume 6. However, the hydraulic model results show a residence time of only two days during a current average day demand scenario. This discrepancy could be due to a sampling artifact or sampling conditions may have been different than the flow conditions and demands evaluated in the hydraulic model.

The model results show four of the nine existing storage facilities in the Fourth Zone have a detention time over 65 hours: Mays Chapel Reservoir, Cub Hill, Stratford Tank and Deer Park Tank. Water is rechlorinated at the Stratford Pumping Station after it leaves the Stratford Tank. Mays Chapel Reservoir has rechlorination capabilities, but Cub Hill Tank and Deer Park Tank do not. The detention times at the remaining three facilities is short.

Fifth Zone

The *Finished Water Facilities Assessment Report,* Volume 6, identified three sample locations in the Fifth Zone that had 10 percent or more zero chlorine residual measurements in any calendar year. One sample location, on Reisterstown Road near the Chartley Tank, had over 80 percent zero chlorine residual measured in one year. The model results agree with the sampling results and shows a residence time over four days during a current average day. The model results also show the percentage of pipe length with residence times over 65 hours decreasing from 10 percent in 2000 to five percent in 2025.

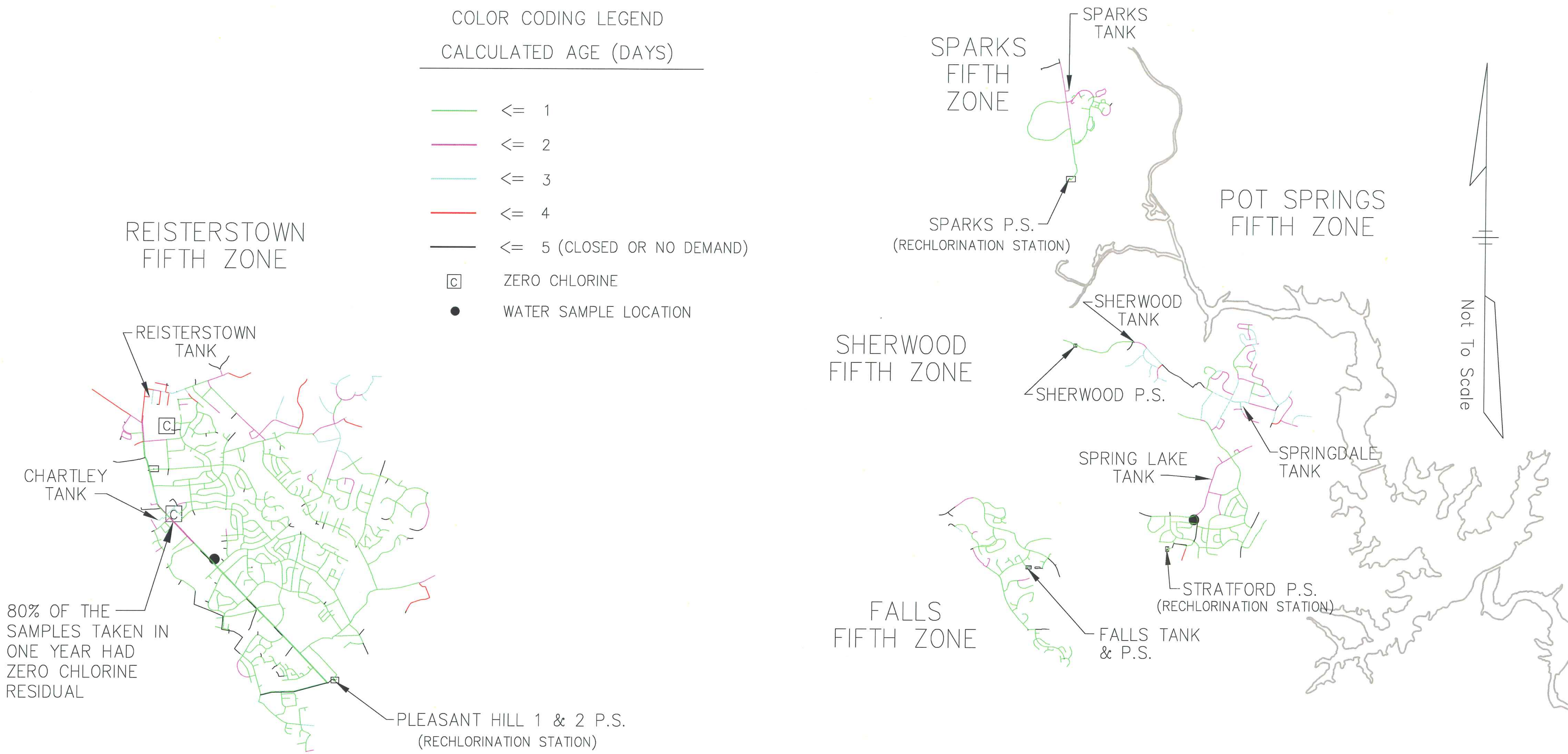


RKK2\SYS - \COMMNOS\CM9638\PHASEII\FINALRPT\Age\5MAP00.DWG
12/09/2001 16:36 ZRPTMAP.PCP PLOT SCALE:1=5500

BALTIMORE CITY PROJECT 658
CENTRAL SYSTEM REPORT

FIFTH ZONE MODEL
WATER AGE
AVERAGE DAY 2000

MARCH, 2003 Figure VII – 9



BALTIMORE CITY PROJECT 658
CENTRAL SYSTEM REPORT
FIFTH ZONE MODEL
WATER AGE
AVERAGE DAY 2025

MARCH, 2003 Figure VII – 10

RKK2\SYS – ...OMMNOS\CM9638\PHASEII\FINALRPT\Age\5MAP25.DWG
12/09/2001 16:3? ZRPTMAP.PCP PLOT SCALE:1=5500

RK&K

In the Fifth Zone, the model results show that four of the seven existing tanks have a detention time over 65 hours: Sparks Tank, Sherwood Tank, Chartley Tank and Reisterstown Tank. A rechlorination station is located at the Sparks Pumping Station which pumps water to the Sparks Tank. The Sherwood Tank, Chartley Tank and Reisterstown Tank do not have rechlorination capabilities, but the Pleasant Hill Pumping Station which pumps water to these tanks does have a rechlorination station. The detention times in the remaining three tanks is short.

Conclusion

The sampling locations with a zero chlorine residual generally agree with the hydraulic model results. Areas in the system where zero chlorine residuals were detected, typically the age or water exceeds two days. For those sampling locations which were not in agreement with the hydraulic model results, further investigation is warranted. In many instances, dead ends could account for zero chlorine residuals where there is little or no circulation.

4. Recommendations

Routine sampling should be conducted in the areas where the model results indicate that the water has a residence time over 48 hours. Also, sampling should be conducted at the locations with zero chlorine residual even if the model results do not agree. Those areas are described in the previous section and are also illustrated on Figures VII 1-10. With the Stage 2 Rule, new sampling locations will probably be required. The hydraulic model can be a useful tool to determine appropriate locations and aid the City in mapping out a plan to meet the requirements of this rule.

First Zone

The Curtis Bay Tank should be sampled to test water quality and assess the need for a rechlorination station. A sampling location should be established in the area of Curtis Bay to test the water quality in these pipes. Other sampling locations should be established in the areas indicated on Figure VII-1 that have residence times greater than two days.

Second Zone

Water samples should be tested near the Perry Hall Tank and in the proposed area of the future Chapel Hill Tank to assess the need for rechlorination stations. Other sampling locations should be established in the areas indicated on Figure VII-3 that have residence times greater than two days.

Third Zone

Water samples should be tested at the Melvin Avenue Tank to assess the need for a rechlorination station. Other sampling locations should be established in the areas indicated on Figure VII-5 that have residence times greater than two days.

Fourth Zone

Water samples should be tested at the Cub Hill and Deer Park Tanks to assess the need for rechlorination stations. The surrounding areas should also be tested for water quality. A sampling location should be established on the suction side of the Sparks Pumping Station. Other sampling locations should be established in the areas indicated on Figure VII-7 that have a residence time greater than two days.

Fifth Zone

Water samples should be tested at the Chartley and Reisterstown Tanks and surrounding areas to assess the need for rechlorination stations. The Fifth Zone as a whole has a minimal number of sampling locations and the Falls Fifth and Sparks Fifth Zones do not have any locations tested. Therefore, more sampling locations should be established, especially in the Falls and Sparks Fifth Zones and also the areas indicated on Figure VII-9 that have residence times greater than two days.

B. Susquehanna River Water Blending at the Montebello Plants

During times of drought when additional supply is needed, water from the Susquehanna River is blended with surface water from Loch Raven Reservoir and treated at the Montebello Filtration Plants. Typically, river water sources are more dynamic and exhibit variable water quality and generally, poorer water quality than obtained from a mesotrophic reservoir. This poses treatability challenges at the Montebello Filtration Plants.

Currently, the primary water sources of the Central System are from surface water reservoirs and the present treatment strategy has been developed for these sources. When the Susquehanna supply is introduced at the Montebello Filtration Plants, operational changes are needed to meet finished water quality goals and regulations.

The City and the Philadelphia Electric Company conduct routine sampling of the Susquehanna River. Based on these results, water quality parameters of primary concern include, iron and manganese, turbidity, seasonal hardness, and DBP precursors. Pilot studies conducted by Malcolm Pirnie on this supply in the early 1980's demonstrated that conventional treatment could be successfully employed to treat this supply except for the high hardness levels observed from July through October when river flows are reduced. Historically, the hardness levels observed during low river flows (<10,000 cfs) were as much as three to four times greater than the hardness concentration seen at the Montebello and Ashburton Filtration Plants. The maximum observed hardness concentrations reach a peak at approximately 160 mg/l as $CaCO_3$. This is considerably greater than the maximum recommended hardness level of 100 mg/L as $CaCO_3$. During low river flow conditions, blending ratios will need to be adjusted to maintain finished water hardness concentrations below this water quality goal. For example, assuming Loch Raven Reservoir and Susquehanna River total hardness is 75 mg/L and 150 mg/L, respectively, a blending ratio of approximately 3:1 (180 mgd from Loch Raven Reservoir and 60 mgd from Susquehanna River) would result in a raw water hardness of approximately 94 mg/L. This is less than 20 mg/L greater than when the Loch Raven Reservoir is the sole supply source. However, if a higher blending ratio of 3:2 is used, total hardness would be approximately 105 mg/L which is slightly over the maximum recommended hardness level.

Another major issue is high turbidity levels during rainfall events. Historic turbidity levels have exceeded 100 NTUs for the Susquehanna River. Chemical feed dosages will need to be adjusted to maintain settled water turbidity levels below the City's goal of 1 NTU. The blending ratio will impact the chemical feed dose, the amount of residuals generated and filter run length. The pilot study conducted by Malcolm Pirnie revealed that ferric chloride was the coagulant of choice for this supply. Similar recommendations were made during the pilot study conducted on the Loch Raven supply for the Comprehensive Plan for Water Facilities Phase I. The City presently uses alum as their primary coagulant, but switching to ferric chloride may provide better removal of turbidity particularly for the blended water and also total organic carbon (TOC), which is a DBP precursor.

Disinfection By-Products are also a concern. This water supply source includes dissolved organic chemicals (precursors) which will combine with chlorine used as a disinfectant and form THMs and HAAs. Pilot studies conducted in the early 80s demonstrated that treatment of this supply would require discontinuing the practice of prechlorination or switching to chloramination. Blending ratios would dictate whether the point of chlorination would need to be moved to maintain compliance with D/DBP Rule under the Safe Drinking Water Act.

Iron and manganese found in the Susquehanna supply can be treated by conventional chlorine disinfection and pH adjustment if blending ratios do not drop the concentration of these species below the regulatory limit. Chlorine oxidizes reduced forms (soluble) of iron and manganese and causes these species to precipitate out of solution. The precipitated oxidized forms of iron and manganese are removed during sedimentation and filtration. Similar treatment is provided at the Montebello and Ashburton plants when iron and manganese levels increase during reservoir turnover in the spring and fall.

In addition, filtration operations will be affected by the blending of the raw water sources. There will be a loss of production due to shorter filter runs and more frequent backwashes. This will necessitate a greater raw water volume to provide a given finished water volume, which will in turn increase the blending ratio.

Once the proposed Fullerton Treatment Plant is constructed, blending source water will not be as critical an issue. Susquehanna River water will be used primarily at this proposed facility and only when demands increase above current raw water availability at the Montebello Filtration Plants will it be used there.

VIII. OPERATIONAL EFFICIENCY

A. Introduction

A review of the Central System's operational efficiency was conducted to evaluate current energy demands and recommend improvements to provide energy cost savings.

B. Topics Evaluated

1. *Pump Controls*

Many pumping stations, particularly those in the upper pressure zones, operate intermittently throughout a typical day. Pump startups demand large amounts of energy and add substantially to the total energy costs. Since electrical costs for pump startups are charged per event due to the spike in energy demand, the City will realize significant energy cost savings if the number of daily pump startups are reduced. In addition, the life of the pump motors will be extended.

At most pumping stations, the pump controls are regulated by the water elevation in a nearby storage facility. For example, one pump at the Falls Fifth Pumping Station maintains the water elevation at the Falls Tank between 745 feet and 748 feet above mean sea level (msl). Operating between these two levels, the pump starts an average of 12 times per day, driving up the energy costs for the Falls Fifth Pumping Station. However, the pump control could be modified so that the pump does not startup until the water elevation inside the Falls Tank is 740 feet above msl. This will reduce the number of daily pump startups resulting in lower energy charges. In addition, the water quality will also be improved.

The stations where pump control modifications are being recommended include: Second Zone, Falls Fifth Zone, Sparks Fifth Zone and Sherwood Fifth Zone. The existing and proposed pump controls are discussed in more detail in *Section IV. Hydraulic Analysis.*

2. *Gravity Flow versus Pumped Flow*

The Second Zone is fed by gravity flow from the Ashburton Filtration Plant and pumped flow from the Vernon Pumping Station, the Hillen Pumping Station and the Fullerton Second Pumping Station. Currently, the City operations personnel are trained to start additional pumps at these pumping stations when the demand in the Second Zone increases. However, the higher demand could also be met by increasing production at the Ashburton Treatment Plant if possible, which would reduce or eliminate the need to start an additional pump. Typically, in the summer months during peak demands, a second pump is automatically turned on at the Vernon Pumping Station. During this time of year, the Ashburton Plant only operates around 140 mgd based on the daily pumping operations log for July 2000. Instead of turning on another pump at the Vernon Pumping Station, the production at Ashburton could be increased to 160 mgd, provided the raw water is available from the Liberty Reservoir and water quality is not adversely affected. Since the Ashburton Plant feeds the second zone by gravity flow, the City will realize energy cost savings at each of the three pumping stations if this operational plan is implemented.

3. *Reduce Head Losses and Unaccounted Water*

Rehabilitation recommendations previously made in *Section IV. Hydraulic Analysis* regarding head loss reduction will improve the operational efficiency. These improvements, if implemented, will reduce frictional losses thereby increasing the pump efficiency. The higher pump efficiency will result in lower energy consumption and cost. However, as un-rehabilitated mains age, the frictional losses will continue to increase.

Another way to reduce energy costs is to eliminate unaccounted water. Many zones have high unaccounted water percentages, which can be attributed to main breaks or leaking pipes for example. If the unaccounted water amounts were reduced, less water would have to be pumped, thus reducing energy costs. Also, leaking division valves could lead to high unaccounted water percentages and would require excess pumping.

4. Age of Facilities

The Central System has multiple pumping stations in six of the 13 pressure zones. All but two of these zones have at least one pumping station less than 15 years old. In some instances, however, the older, less efficient pumping stations are relied on to supply water during times of increased demand. Though these operational practices work, energy costs could be reduced if the newer pumps are utilized. For example, the Hillen and Vernon Pumping Stations both supply water to the Second Zone. During times of high demand, production at the Hillen Pumping Station, which operates closer to its optimum design efficiency, should be increased over the Vernon Pumping Station once the Hillen Bypass has been completed. By relying on the more efficient pumps at the Hillen Pumping Station, the City will reduce some energy costs. However, keeping one pump at Vernon Pumping Station in operation improves the water quality in Druid Lake. In addition, the older pumping stations could be rehabilitated to improve their efficiency by replacing the older pumps and updating electrical systems. Cost comparisons should be conducted prior to any rehabilitation project to determine, for example, if replacing or retrofitting would be a better alternative.

5. *Treatment Plants*

Operation of the treatment plants is considered a very efficient energy use since water treatment under normal conditions is accomplished without any major pumping systems. Typically treatment plant energy consumption is a very low kilowatt-hour per gallon per day process.

6. *Reduction Programs*

Baltimore Gas and Electric (BGE) has several programs, such as the Company Load Response Program, which compensates large energy users for voluntarily reducing electricity demand during specified times or emergency situations. The City should contact BGE to learn more about available programs at (800) 265-6177 or (410) 265-4100 or MYBIZREP@BGE.COM. Information regarding the Company Load Response Program and Curtailable Service are included in Appendix C. If the City were to enter into an agreement with BGE, the City should be given a priority status against turnoffs.

C. Recommendations

- Modify the existing pump controls at four pumping stations in the Central System (Second, Falls Fifth, Sparks Fifth and Sherwood Fifth Zones) as previously discussed in *Section IV. Hydraulic Modeling*

- Maximize the Ashburton Filtration Plant production prior to starting additional pumps at Vernon, Hillen or Fullerton Second Pumping Stations

- Rehabilitate the water mains with high head loss discussed in *Section IV. Hydraulic Modeling*

- Decrease unaccounted water in each zone to reduce unnecessary pumping

- Maximize production at pumping stations with high efficiency pumps before increasing production at pumping stations with less efficient pumps, which are typically the older stations

- Contact primary energy provider, BGE, to explore alternative energy consumption reduction programs

IX. SOURCE WATER TRACKING

A. Hydraulic Model

The hydraulic modeling software WaterCAD, by Haestad Methods, has the capability to perform source water tracking. The software can identify, or track, the percentage of the total flow arriving at any model node in the system from a specified contributing source node or "source." This feature proves useful when determining jurisdictional cost allocations for the construction and rehabilitation of the Central System's facilities. These jurisdictional areas include Baltimore City, Baltimore County, Anne Arundel County and Howard County.

In the hydraulic model, typically nodes receive water from multiple "sources." "Sources" are defined as the flow inputs into the hydraulic model, the treatment plants and pumping stations. These "sources" also feed the storage facilities, but since the storage facilities are not flow inputs into the model, they are not included in the source water tracking model results. In addition, it would be difficult to determine the percentage supplied by each storage facility at a certain time because they are constantly filling and draining at various times during the day.

B. Analysis

Both current and future demand scenarios were evaluated for the source water tracking analysis. The year 2000 hydraulic model was analyzed to simulate current conditions during maximum and average day demands. For the future scenario in 2025, it was presumed that the proposed Fullerton Treatment Plant would be in service. Typical operating procedures were used for this evaluation. Results may vary greatly if additional pumps are turned on or turned off anywhere in the system.

To determine jurisdictional allocations, the percentage of the demand supplied by each "source" was compiled for each model node. This percentage at each model node was then multiplied by the demand at that node to determine how much flow was supplied by the "source." This flow was summed for all nodes within each jurisdiction and for each "source." Using these summations, the total percent supplied by each "source" to each jurisdiction was calculated. For lower zones, the percentages include the source distributions of the upper dependant zones.

The upper zones that lie entirely within Baltimore County were not analyzed because 100% of their flow would be supplied to Baltimore County. Two other zones were not analyzed either, Towson Fourth Zone and Colgate Second Zone, because such a small portion of the zone lies in the City and the majority is in Baltimore County. Two percent of the Colgate Second Zone area lies in the City and only 1% of the Towson Fourth Zone.

C. Results

Under maximum day demand conditions, the Montebello Filtration Plants 1 and 2 currently supply approximately half their flows to the City and half to Baltimore County as shown in Figure IX-1. The Guilford and Ashburton Pumping Stations also have an even split, supplying approximately half their flows to the City and half to Baltimore County. Vernon and Hillen Pumping Stations provide flow mostly to the City, while Fullerton Third Pumping Station provides mostly to the County. Both Cromwell and Fullerton Second Pumping Stations supply only Baltimore County. Howard County is primarily supplied by the Leakin Park Pumping Station and Ashburton Filtration Plant, while Anne Arundel County is supplied by all three treatment plants and also Vernon Pumping Station.

Figure IX-2 illustrates that the future distribution of flows changes drastically for the First Zone after the proposed Fullerton Treatment Plant is in service. The future combined Montebello Filtration Plant would primarily feed the City and Fullerton Treatment Plant would supply Baltimore County, which is what would be expected. Source water tracking results in the upper zones were not affected by the addition of the Fullerton Treatment Plant to the system because, although their sources might have changed, they are still supplying to the same places.

The average day demand conditions alter the source water tracking somewhat as illustrated in Figures IX-3 and IX-4. Two major pumping stations, Hillen and Fullerton Third Pumping Stations, are not required to operate during these scenarios because only one pump at Vernon Pumping Station is required; therefore they are not a source for any jurisdiction.

Graphical results showing the areas of influence for each "source" are located in Appendix D. Also included in Appendix D is mapping for most storage facilities illustrating their areas of influence during their peak discharges or peak demand. All figures in the appendix represent the maximum day 2000 conditions. The following storage facilities are not included in the appendix because they primarily supply upper zones: Guilford Reservoir, Catonsville Reservoir, Pikesville Reservoir, Towson Reservoir, Pleasant Hill Tanks, Mays Chapel Reservoir and Stratford Tank.

It should be noted that the Catonsville Reservoir, Pikesville Reservoir and Towson Reservoir also serve the zones in which they are located. However, the hydraulic model results for the conditions being evaluated do not show this.

Table IX-1, Current Maximum Demands Source Water Tracking by Jurisdiction (Year 2000) (based on current operating procedures)

Facility	Zone	Percentage Supplied by Facility				
		B. City	B. County	AA Co	How Co	Total
Montebello WTP 1	1	50%	46%	4%	0%	100%
Montebello WTP 2	1	62%	34%	4%	0%	100%
Ashburton WTP	2	30%	42%	4%	24%	100%
Vernon PS	2	87%	8%	4%	1%	100%
Hillen PS	2	96%	4%	0%	0%	100%
Fullerton Second PS	2	0%	100%	0%	0%	100%
Cromwell PS*	3E	0%	100%	-	-	100%
Guilford PS*	3E	49%	51%	-	-	100%
Fullerton Third PS*	3E	16%	84%	-	-	100%
Leakin Park PS*	3W	4%	33%	-	63%	100%
Ashburton PS*	3W	44%	55%	-	1%	100%

* County % includes 4th and 5th Zone demands

Table IX-2, Future Maximum Demands Source Water Tracking by Jurisdiction (Year 2025) (based on current operating procedures)

Facility	Zone	Percentage Supplied by Facility				
		B. City	B. County	AA Co	How Co	Total
Montebello WTP	1	77%	18%	5%	0%	100%
Fullerton WTP**	1	17%	76%	7%	0%	100%
Ashburton WTP	2	30%	42%	4%	24%	100%
Vernon PS	2	87%	8%	4%	1%	100%
Hillen PS	2	96%	4%	0%	0%	100%
Fullerton Second PS	2	0%	100%	0%	0%	100%
Cromwell PS*	3E	0%	100%	-	-	100%
Guilford PS*	3E	49%	51%	-	-	100%
Fullerton Third PS*	3E	16%	84%	-	-	100%
Leakin Park PS*	3W	4%	33%	-	63%	100%
Ashburton PS*	3W	44%	55%	-	1%	100%

* County % includes 4th and 5th Zone demands

** Assumes proposed Fullerton Treatment Plant will be in-service

Table IX-3, Current Average Demands Source Water Tracking by Jurisdiction (Year 2000) (based on current operating procedures)

Facility	Zone	Percentage Supplied by Facility				
		B. City	B. County	AA Co	HO Co	Total
Montebello WTP 1	1	48%	46%	6%	0%	100%
Montebello WTP 2	1	57%	35%	7%	1%	100%
Ashburton WTP	2	49%	40%	1%	10%	100%
Vernon PS	2	72%	18%	4%	6%	100%
Hillen PS **	2	0%	0%	0%	0%	0%
Fullerton Second PS	2	2%	98%	0%	0%	100%
Cromwell PS*	3E	0%	100%	-	-	100%
Guilford PS*	3E	51%	49%	-	-	100%
Fullerton Third PS* **	3E	0%	0%	-	-	0%
Leakin Park PS*	3W	18%	34%	-	48%	100%
Ashburton PS*	3W	45%	55%	-	0%	100%

* County % includes 4th and 5th Zone demands

** Pump not running during an average day scenario

Table IX-4, Future Average Demands Source Water Tracking by Jurisdiction (Year 2025) (based on current operating procedures)

Facility	Zone	Percentage Supplied by Facility				
		B. City	B. County	AA Co	HO Co	Total
Montebello WTP	1	72%	17%	10%	1%	100%
Fullerton WTP***	1	18%	75%	7%	0%	100%
Ashburton WTP	2	49%	40%	1%	10%	100%
Vernon PS	2	72%	18%	4%	6%	100%
Hillen PS **	2	0%	0%	0%	0%	0%
Fullerton Second PS	2	2%	98%	0%	0%	100%
Cromwell PS*	3E	0%	100%	-	-	100%
Guilford PS*	3E	51%	49%	-	-	100%
Fullerton Third PS* **	3E	0%	0%	-	-	0%
Leakin Park PS*	3W	18%	34%	-	48%	100%
Ashburton PS*	3W	45%	55%	-	0%	100%

* County % includes 4th and 5th Zone demands

** Pump not running during an average day scenario

*** Assumes proposed Fullerton Treatment Plant will be in-service

X. SUMMARY OF RECOMMENDED IMPROVEMENTS

A. General Recommendations

Several general recommendations are being proposed that relate to the overall operation of the Central System. For most of these recommendations, no specific zone or time requirement is associated with them; however they are items that should be completed in the near future. These recommendations are in reference to:

- Existing system service boundary
- Current withdrawal agreements for wholesale users
- Operational efficiency of the system
- Raw water management
- Water quality sampling locations

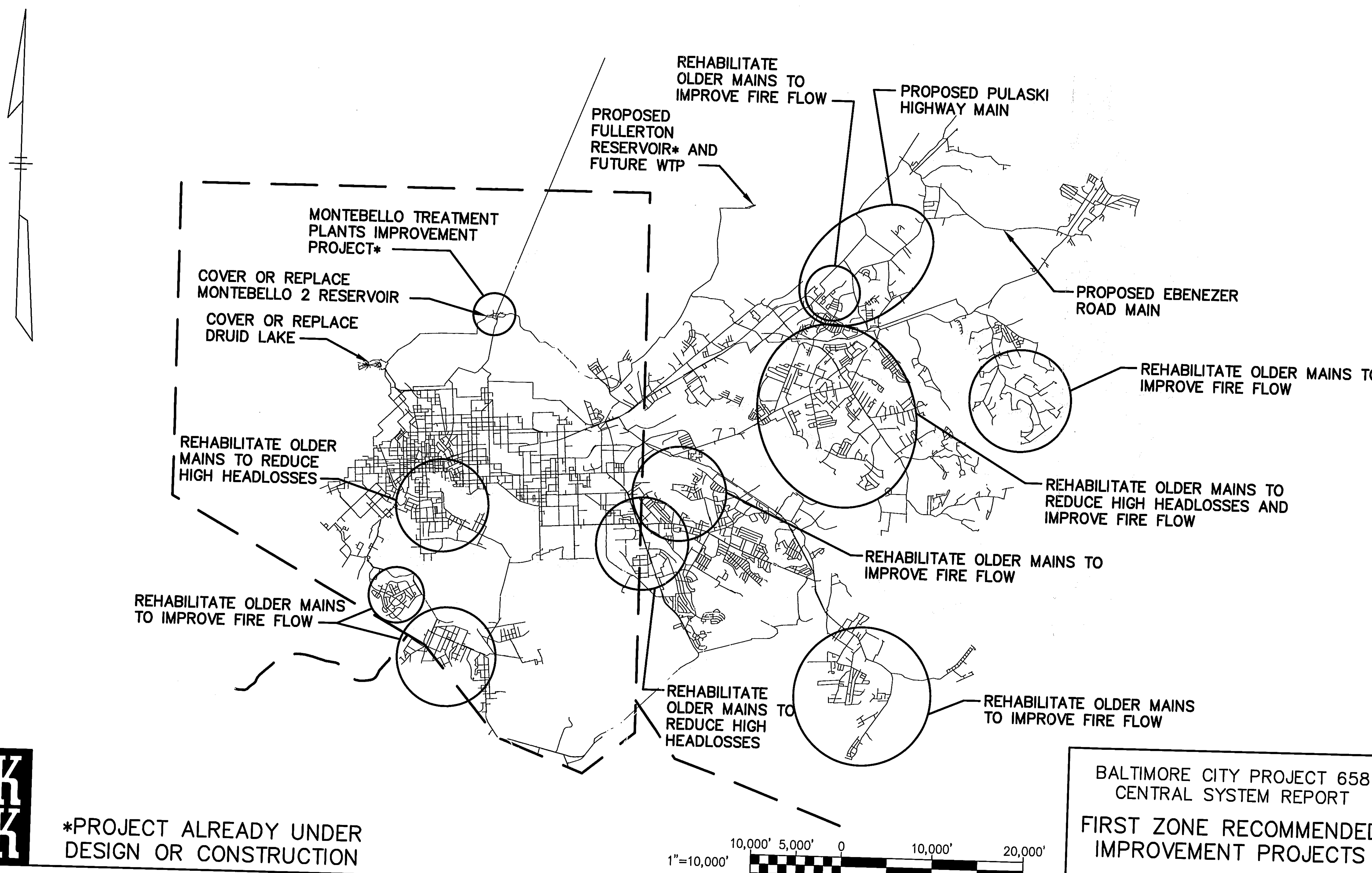
The current system boundary is often in question. Currently, Baltimore County is using the Urban-Rural Demarcation Line (URDL) as the ultimate boundary of the Central System. The City should support and enforce this decision. This boundary has been violated in several areas in the past due to special circumstances.

The City is also urged to revisit existing water withdrawal agreements with the surrounding jurisdictions. Many withdrawal agreements are vague and/or outdated. As the demands in the Central System increase, it will be more important to know exactly how much the wholesale users will be demanding to determine when the current capacity of the system will be exceeded and an alternate raw water supply will be needed. Also, these agreements will help determine cost allocation for the wholesale users.

The operation of the Central System should be modified to improve the efficiency and increase the energy cost savings. Several operational recommendations include maximizing gravity flow versus pumped flow in the Second Zone, utilizing newer stations over older less-efficient stations, investigating if alternate energy consumption reduction

Table X-1, Summary of Recommended Central System Improvement Projects							
Year Needed	Project Description	Zone	Size/ Capacity	Approx. Length (LF)	Estimated Cost	Status (if applicable)	General Notes
2005	Montebello WTP (CIP)	1	318 MGD		$88,000,000	currently under design (RK&K)	
2005	Fullerton Reservoir (CIP)	1	40 MG	n/a	$18,600,000	currently under design (Gannett Fleming)	
2005	Chapel Hill Tank (CIP)	2	2.0 MG	n/a	$1,800,000	currently under design (WRA)	
2005	Hillen/Ashburton By-Pass Main (CIP)	2	64"	3,400	$5,500,000	design almost complete (WRA)	
2005	Honeygo Boulevard Main Extension	2	16"/20"	3,300/4,600	$820,000	20 inch main has been installed	Chapel Hill Tank area, WAO recommendation
2005	Gerst Main (north of Chapel Hill Tank)	2	12"	3,400	$300,000		WAO recommendation
2005	Belair Road Main (W. Marsh to Joppa) (CIP)	3E	24"	8,800	$3,000,000	currently under design (RK&K)	
2005	Putty Hill Main (to Towson Reservoir) (CIP)	3E	24"	8,400	$1,700,000	currently under design (in-house)	
2005	Perry Hall Road Main to Belair Road	3E	42"	17,150	$6,500,000		WAO recommendation
2005	Belair Road Main (to Northern Parkway) (CIP)	3E	24"	5,150	$1,100,000	currently under negotiations (WRA)	
2005	Leakin Park Pumping Station	3W	80 MGD	n/a	$3,750,000	currently under negotiations (RK&K)	adding 2 pumps (20 MGD each), WAO recomm.
2005	Catonsville Main (LP PS to Rt. 40) (CIP)	3W	48"	8,300	$5,000,000	currently under design (PHRA)	
2005	Catonsville Main (parallel to Rt. 40) (CIP)	3W	42"	10,200	$4,900,000	currently under design (WRA)	
2005	Rolling Road Transmission (CIP)	3W	16"	11,000	$1,180,000	currently under design (Wallace Montg.)	
2005	Catonsville Pumping Station (CIP)	4C	20 MGD	n/a	$500,000	design almost complete (in-house)	adding 4th pump (11 MGD)
2005	Rolling Road Tank Transmission (CIP)	4C	24"	7,800	$1,450,000	currently under design (PHRA)	
2005	Owings Mills Reservoir (CIP)	4P	5.6 MG	n/a	$3,000,000	under constr.(Chicago Bridge and Iron)	
2005	Falls Pumping Station (CIP)	5F	5.3 MGD	n/a	$615,000	currently under design (RK&K)	adding 3rd pump (2.7 MGD)
2005	Hartfell and Killoran Road Parallel Mains	5P	16"	3,300	$400,000		not required, reduces high headloss near PS
2005	Bond Avenue Tank	5R	2 MG	n/a	$1,800,000		WAO recommendation
2005	Yale Avenue Main	2	16"	1,000	$200,000		improves fire flows
2005	Elmtree Street Main	2	12"	1,000	$100,000		improves fire flows
2005	47th Street Main	2C	12"	1,400	$140,000		improves fire flows
2005	Liberty Road Main	3W	12"	2,000	$200,000		improves fire flows
2005	Old Pimlico Road Main	3W	16"	4,000	$530,000		improves fire flows
2005	Clays Road Main	4C	12"	1,600	$160,000		improves fire flows and pressures
2005	New Connection at Rutledge Road	4T	12"	100	$10,000		with Mays Chapel Discharge, improves fire flows
2005	Timonium Road Main	4T	12"	900	$90,000		improves fire flows
2010	Pulaski Highway Main	1	16"/20"/24"/36"	4,000/2,500/3,800/6,200	$3,600,000		WAO recommendation
2015	Fullerton WTP	1	120 MGD	n/a	$130,000,000		WAO recommendation
2015	Pleasant Hill Pumping Station 1	5R	13 MGD	n/a	$1,000,000		replacing 2 pumps (4.3 MGD each)+assoc. piping
2015	Reisterstown and Pleasant Hill Road Main	5R	16"	4,300	$600,000		addt'l transmission main required w/PS upgrade
2015	Deer Creek Pumping Station (CIP)	RAW	200 MGD	n/a	$4,000,000	currently under negotiations (PHRA)	renovate intake, add two pumps (50 MGD each)
2020	Marriottsville Road Main	4P	24"	3,500	$900,000		Lyons Mill Rd and Liberty Rd
2025	Ebenezer Road	1	12"	8,500	$1,500,000		WAO recommendation
2025	Perry Hall & Philadelphia Road Main	2	24"/30"	15,600/9,000	$9,000,000		WAO recommendation
2025	Lord Baltimore Extension Main	4C	12"	5,600	$1,000,000		WAO recommendation, not req'd but helps system

NOTE: General Notes column lists reason for project, all projects recommended by RK&K, 'WAO recommendation' means project previously recommended by the Water Analyzer Office (WAO) but has not been included in CIP yet; costs include escalation 3.2% per year



*PROJECT ALREADY UNDER DESIGN OR CONSTRUCTION

RK&K

RKK2\SYS — ...projects\49638\PHASEII\MODELING\P1.DWG
07/12/2002 14:24 ENV.PCP PLOT SCALE:1=1

BALTIMORE CITY PROJECT 658
CENTRAL SYSTEM REPORT

FIRST ZONE RECOMMENDED IMPROVEMENT PROJECTS

MARCH, 2003

Figure X-1

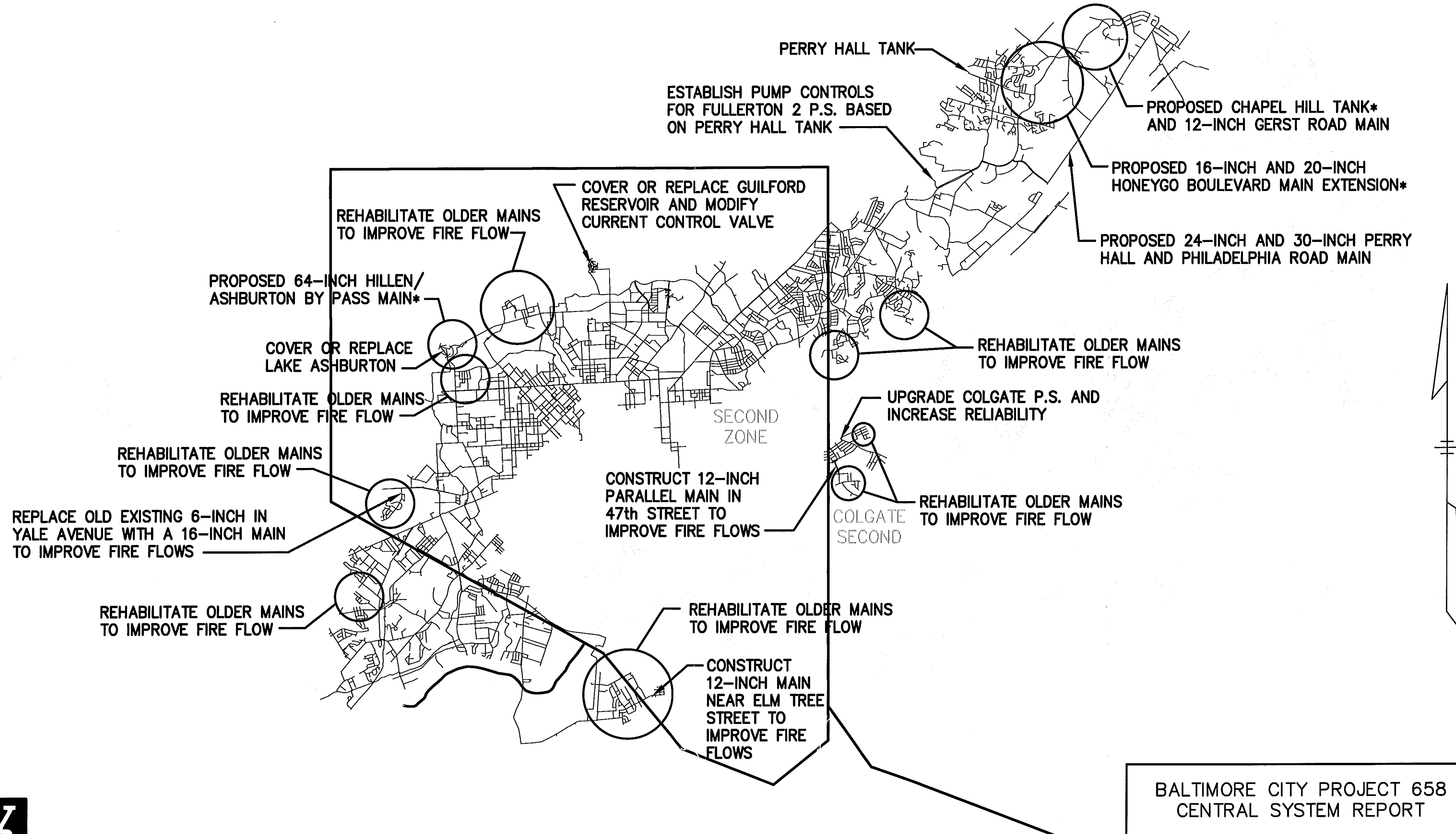
2. *Second Zone*

Improvement projects in the Second Zone are illustrated on Figure X-2. Two projects are already under design: the 64-inch Hillen/Ashburton by-pass main and the 2.0 mg Chapel Hill Tank, and portions of the Hillen by-pass have already been constructed. Two of the most important projects recommended include the investigation of covering Lake Ashburton and the Guilford Reservoir. In conjunction with covering the Guilford Reservoir, the walls at this reservoir should be raised to increase the overflow elevation to match the other facilities in this zone. Also, to improve the operation of the Second Zone and Guilford Reservoir, the current valve control at Guilford Reservoir should be modified to operate in a throttle mode rather than open or closed. In addition, it is recommended that the City establish pump controls at the Fullerton Second Pumping Station based on elevations in the existing Perry Hall Tank, and future Chapel Hill Tank once constructed. This will help improve the system operation, especially in the eastern portion of the zone.

There are five areas shown on Figure X-2 which should be rehabilitated to improve the fire flow availability. Two other areas should be improved by constructing a new main to increase the fire flow availability because rehabilitation is not enough or the area has already been lined. Both of these mains are included in Table X-1. The Water Analyzer Office has recommended several proposed mains which are shown on Figure X-2 as well. They include the 12-inch Gerst Road main, the 16- to 20-inch Honeygo Boulevard main extension and the 24- to 30-inch Perry Hall and Philadelphia Road main. In addition, this zone has high unaccounted for water which should be reduced to decrease higher electrical costs associated with pumping excess water.

3. *Colgate Second Zone*

The Colgate Second Zone recommended improvement projects are also illustrated on Figure X-2. There are only a few improvements being recommended in this zone. Two areas should be rehabilitated to improve fire flow availability and one also requires the construction of a new 12-inch main. Storage capacity improvements are also required in the Colgate Second Zone. Instead of constructing additional storage, the Colgate Pumping Station should be upgraded and the reliability of the



* PROJECT ALREADY UNDER DESIGN OR CONSTRUCTION

1"=10,000' — 10,000' 5,000' 0 10,000' 20,000'

BALTIMORE CITY PROJECT 658
CENTRAL SYSTEM REPORT

SECOND ZONE RECOMMENDED IMPROVEMENT PROJECTS

MARCH, 2003

Figure X-2

RK&K

RKK2\SYS ..\projects\49638\PHASEII\MODELING\IP2.DWG
07/12/2002 14:29 ENV.PCP PLOT SCALE:1=1

station increased by providing on-site standby power generation or redundant power feeds from separate BGE grids to minimize supply disruption due to power failure. Emergency generator connections are being added at this pumping station. Also, the existing pumps at this station operate fairly far out on their pump curve and could be replaced with more efficient pumps when upgraded.

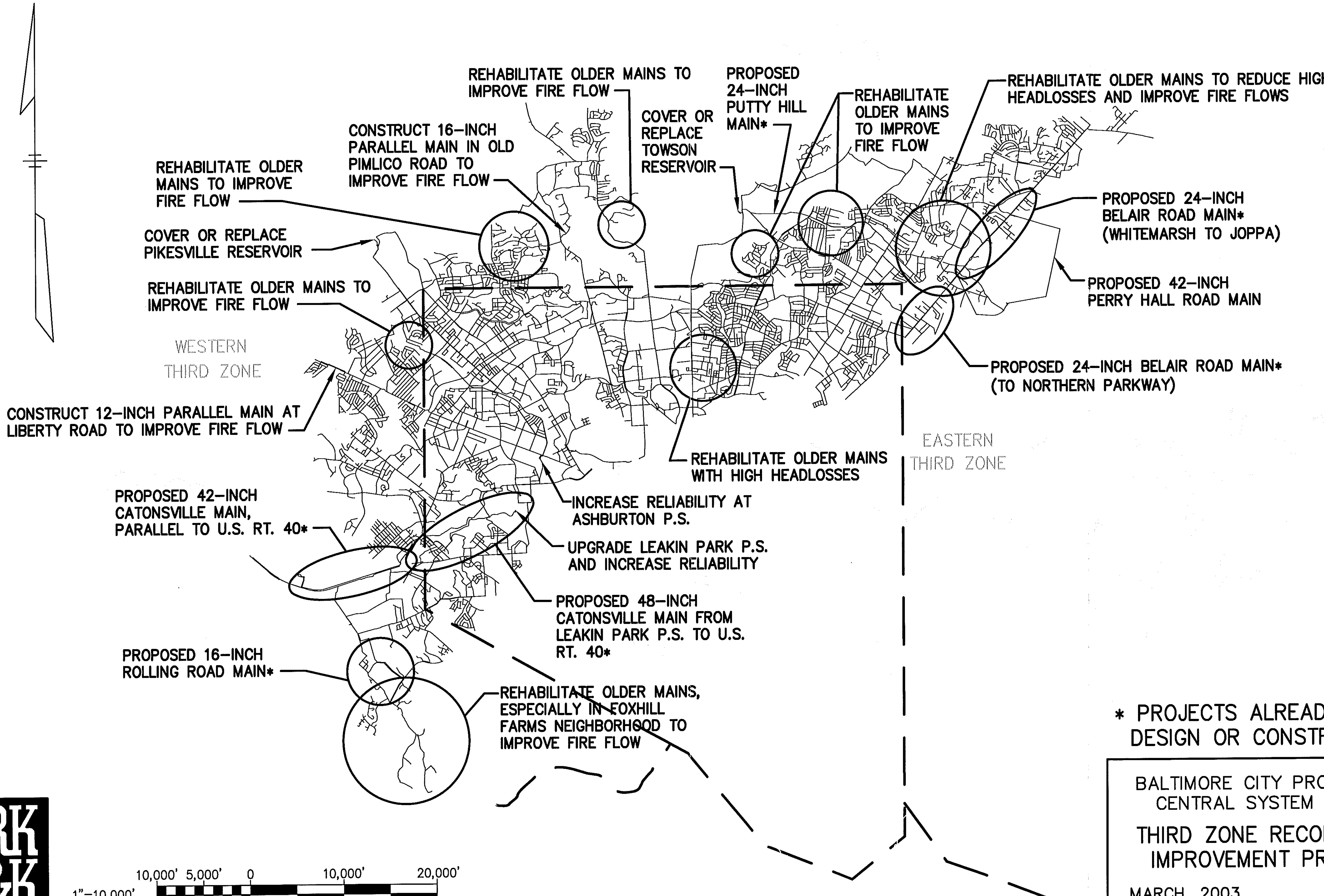
4. *Eastern Third Zone*

The recommended improvement projects for the Eastern Third Zone are shown on Figure X-3. One of the most important recommendations in this zone is to investigate covering the Towson Reservoir. Improvements to the Fullerton Third Pumping Station are also important. Presently, there is not adequate piping to provide transmission capacity for this station. To alleviate this problem, four transmission mains are proposed, three of which are already under design and should be constructed by 2005. The fourth main, a 42-inch main from the Perry Hall Road area to Belair Road, should also be constructed by 2005, therefore, it should be added to the City CIP as soon as possible.

Figure X-3 shows several areas in this zone which should be rehabilitated, two areas to reduce high head losses and four areas to increase low fire flow availability. This zone also has high unaccounted for water which should be reduced to decrease higher electrical costs associated with pumping excess water. Recommendations to incorporate portions of this zone which experience high pressures into the Second Zone would also decrease pumping costs and this should be investigated further.

5. *Western Third Zone*

Figure X-3 illustrates the recommended improvement projects in the Western Third Zone as well. One of the most important recommendations, which design will begin shortly, is to upgrade the Leakin Park Pumping Station. Two pumps should be added by 2005 because the capacity of this station needs to be increased to meet growing demands. Instead of constructing additional storage to meet the storage requirements, the reliability of the Leakin Park and Ashburton Pumping Stations should be increased by providing on-site standby generators or redundant power feeders. The



* PROJECTS ALREADY UNDER DESIGN OR CONSTRUCTION

BALTIMORE CITY PROJECT 658
CENTRAL SYSTEM REPORT

THIRD ZONE RECOMMENDED IMPROVEMENT PROJECTS

MARCH, 2003 Figure X-3

RK&K

RKK2\SYS - ..projects\49638\PHASEII\MODELING\IP3.DWG
07/12/2002 14:34 ZRPTMAP.PCP PLOT SCALE:1=5500

construction of a second discharge main at the Leakin Park Pumping Station is also recommended to improve reliability. Also, the design to replace the uncovered Pikesville Reservoir with two enclosed storage tanks is already underway.

Four areas, shown on Figure X-3, should be rehabilitated to increase fire flows. Two of these areas require the construction of a new main to adequately increase fire flows because rehabilitation will not provide a substantial improvement and lining in one area has already been performed. Figure X-3 also illustrates three proposed transmission mains which are already under design.

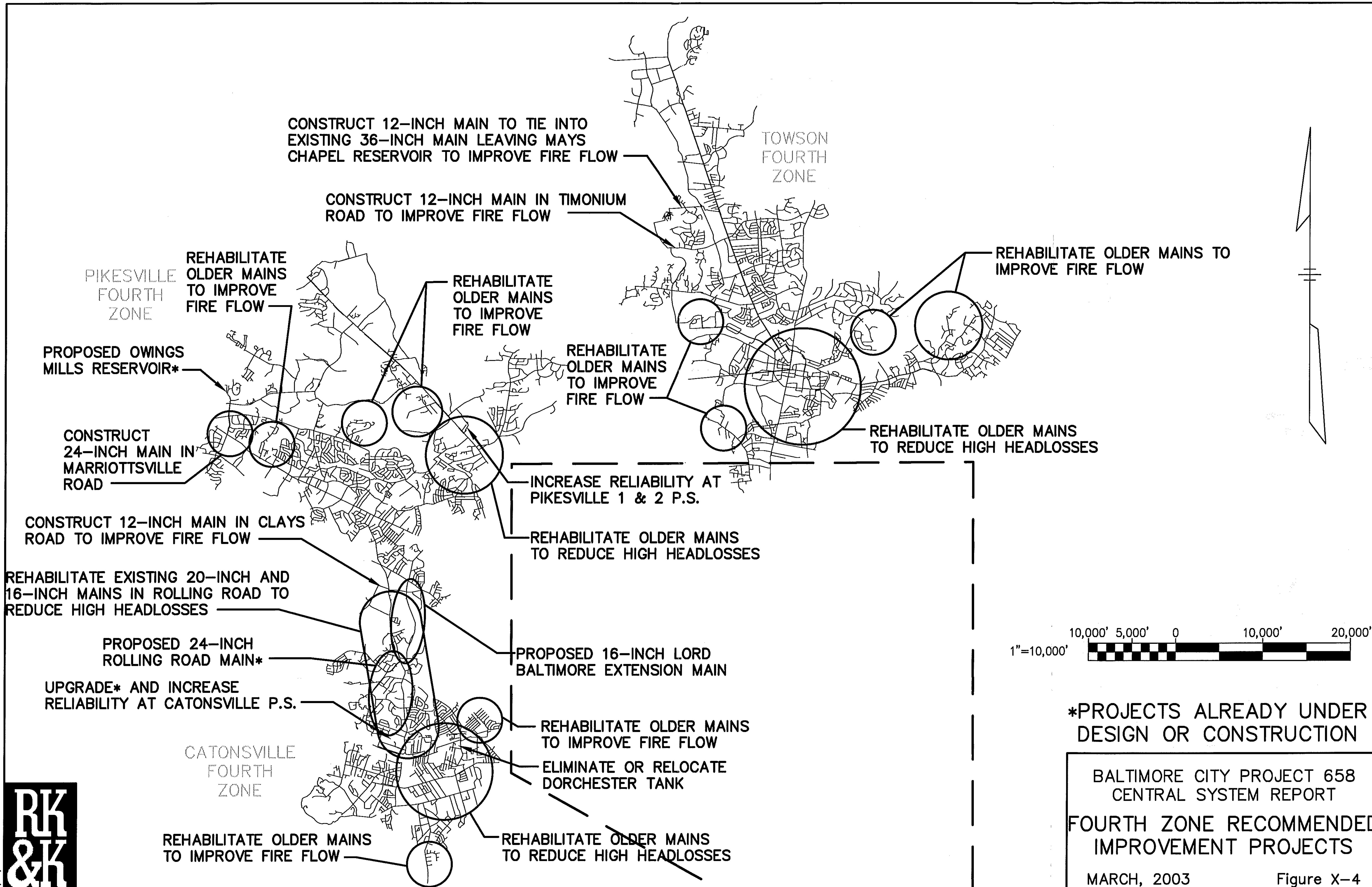
This zone has high unaccounted for water that should be reduced to decrease higher electrical costs associated with pumping excess water. Recommendations to incorporate portions of this zone which experience high pressures into the Second Zone would also decrease pumping costs and this should be investigated further.

6. Catonsville Fourth Zone

The recommended improvement projects for the Catonsville Fourth Zone are illustrated on Figure X-4. Several projects are already under design, including the addition of a fourth pump at the Catonsville Pumping Station and the proposed 24-inch Rolling Road main. In addition to the Rolling Road main, a 12-inch transmission main is recommended in Lord Baltimore Drive. Also, this zone has high unaccounted for water which should be reduced to decrease higher electrical costs associated with pumping excess water.

Figure X-4 illustrates three areas requiring rehabilitation to improve fire flow availability. One area requires the construction of a new main to adequately increase fire flows because lining alone will not provide a substantial improvement. Pressures in this area are low and the proposed main will improve this also. Two other areas require rehabilitation because the head losses in those areas are too high.

Several recommendations relate to the storage capacity in this zone. Instead of constructing additional storage facilities, the reliability of the Catonsville Pumping Station should be increased by providing permanent on-site standby generators or redundant


CONSTRUCT 12-INCH MAIN TO TIE INTO EXISTING 36-INCH MAIN LEAVING MAYS CHAPEL RESERVOIR TO IMPROVE FIRE FLOW
TOWSON FOURTH ZONE
CONSTRUCT 12-INCH MAIN IN TIMONIUM ROAD TO IMPROVE FIRE FLOW
PIKESVILLE FOURTH ZONE
REHABILITATE OLDER MAINS TO IMPROVE FIRE FLOW
REHABILITATE OLDER MAINS TO IMPROVE FIRE FLOW
REHABILITATE OLDER MAINS TO IMPROVE FIRE FLOW
PROPOSED OWINGS MILLS RESERVOIR*
REHABILITATE OLDER MAINS TO IMPROVE FIRE FLOW
CONSTRUCT 24-INCH MAIN IN MARRIOTTSVILLE ROAD
REHABILITATE OLDER MAINS TO REDUCE HIGH HEADLOSSES
INCREASE RELIABILITY AT PIKESVILLE 1 & 2 P.S.
CONSTRUCT 12-INCH MAIN IN CLAYS ROAD TO IMPROVE FIRE FLOW
REHABILITATE OLDER MAINS TO REDUCE HIGH HEADLOSSES
REHABILITATE EXISTING 20-INCH AND 16-INCH MAINS IN ROLLING ROAD TO REDUCE HIGH HEADLOSSES
PROPOSED 24-INCH ROLLING ROAD MAIN*
PROPOSED 16-INCH LORD BALTIMORE EXTENSION MAIN
UPGRADE* AND INCREASE RELIABILITY AT CATONSVILLE P.S.
REHABILITATE OLDER MAINS TO IMPROVE FIRE FLOW
ELIMINATE OR RELOCATE DORCHESTER TANK
CATONSVILLE FOURTH ZONE
REHABILITATE OLDER MAINS TO IMPROVE FIRE FLOW
REHABILITATE OLDER MAINS TO REDUCE HIGH HEADLOSSES
10,000' 5,000' 0 10,000' 20,000'
1"=10,000'
*PROJECTS ALREADY UNDER DESIGN OR CONSTRUCTION
BALTIMORE CITY PROJECT 658
CENTRAL SYSTEM REPORT
FOURTH ZONE RECOMMENDED IMPROVEMENT PROJECTS
MARCH, 2003
Figure X-4

power feeders. The Catonsville Pumping Station does currently have a mobile generator on site. The construction of a second discharge main is also recommended to improve reliability. Also, an investigation needs to be performed to determine if the Dorchester Tank should be relocated or eliminated.

7. *Pikesville Fourth Zone*

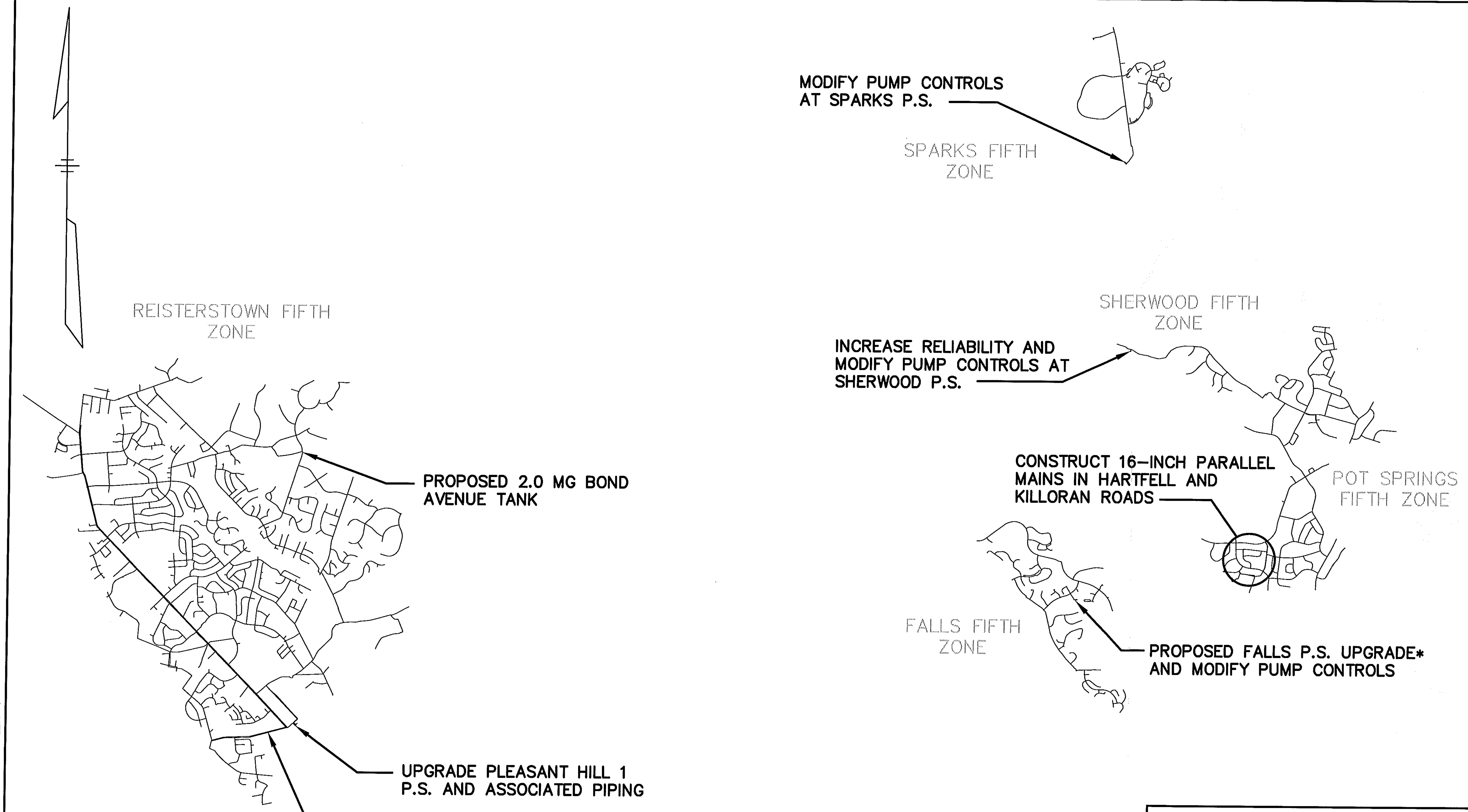
Figure X-4 also illustrates the recommended improvement projects for the Pikesville Fourth Zone. The reliability of the Pikesville Pumping Stations should be increased by providing on-site standby generators or redundant power feeders for both stations. Also, the piping around the pumping stations should be rehabilitated to reduce high head losses in these areas. Once the Owings Mills Reservoir is in service, which is expected in June 2003, a 24-inch transmission main between this reservoir and the Deer Creek Tank should be constructed to improve the flow distribution between these storage facilities.

8. *Towson Fourth Zone*

The recommended improvement projects for the Towson Fourth Zone are also shown on Figure X-4. Minimal improvements are required in this zone. The construction of two short mains is required to increase fire flow availability in the Mays Chapel area. The older mains located in the Towson Town Center area should be rehabilitated to reduce high head losses. Also the unaccounted for water in this zone is high and should be reduced to decrease higher electrical costs associated with pumping excess water.

9. *Falls Fifth Zone*

Figure X-5 illustrates the improvement projects recommended for all the Fifth Zones, including the Falls Fifth Zone. One project currently under design is to add a third pump to the Falls Fifth Pumping Station. This project will also add on-site standby generators. Additional improvements are recommended at the Falls Fifth Pumping Station. The pump controls should be modified to utilize more capacity in the Falls Fifth Tank and cycle the pumps less often which will reduce the maintenance and electrical



*PROJECT ALREADY UNDER
DESIGN OR CONSTUCTION

1"=5,000' 5,000' 2,500' 0 5,000' 10,000'

BALTIMORE CITY PROJECT 658
CENTRAL SYSTEM REPORT

FIFTH ZONE RECOMMENDED
IMPROVEMENT PROJECTS

MARCH, 2003 Figure X–5

RK&K

RKK2\SYS – ...projects\49638\PHASEII\MODELING\P5.DWG
07/12/2002 14:44 ENV.PCP PLOT SCALE:1=1

costs. By the year 2015 additional storage is required; however the pumping station could be expanded or the added reliability of the proposed on-site generators could be utilized. In addition, the City should consider constructing a second discharge main from the pumping station to increase the reliability of the system. This zone also has high unaccounted for water which should be reduced to decrease higher electrical costs associated with pumping excess water.

10. *Pot Springs Fifth Zone*

There is only one improvement project included in Table X-1 and it is not essential. As illustrated on Figure X-5, two 16-inch parallel mains should be constructed in Hartfell and Killoran Roads to decrease the high head losses between the Stratford Pumping Station and the Springdale and Spring Lake Tanks. Although this project is not required for storage or fire flow purposes, it will improve the operation of this zone and reduce electrical costs.

In addition, the City should consider constructing a second discharge main from the Stratford Pumping Station to increase the reliability of the system.

11. *Reisterstown Fifth Zone*

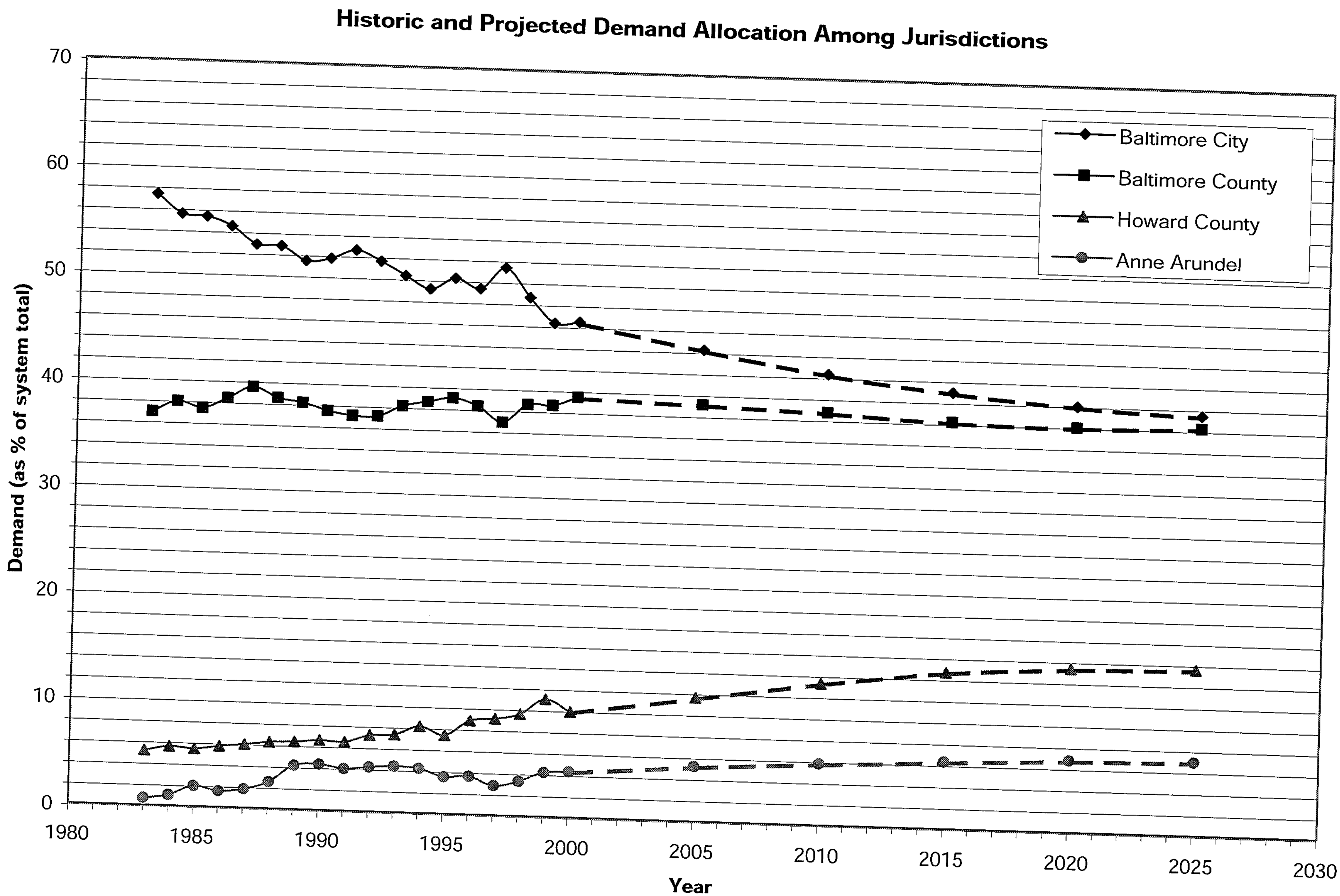
The recommended improvement projects for the Reisterstown Fifth Zone are also illustrated on Figure X-5. The demands in this zone are projected to exceed the pumping capacity by 2015; therefore, additional pumping capacity will be required. The Pleasant Hill Pumping Station 1 should be upgraded by replacing the existing pumps with larger ones. In addition, the associated mains in and around the pumping station should be upgraded, as well as constructing a 16-inch new transmission main in Pleasant Hill Road. This pumping station currently only has one discharge main, therefore, the City should consider construction a second discharge main to increase the reliability of the system. The storage capacity in this zone is also inadequate; therefore, the proposed Bond Avenue Tank should be in service by 2005 and the proposed capacity should be increased to 2.0 mg.

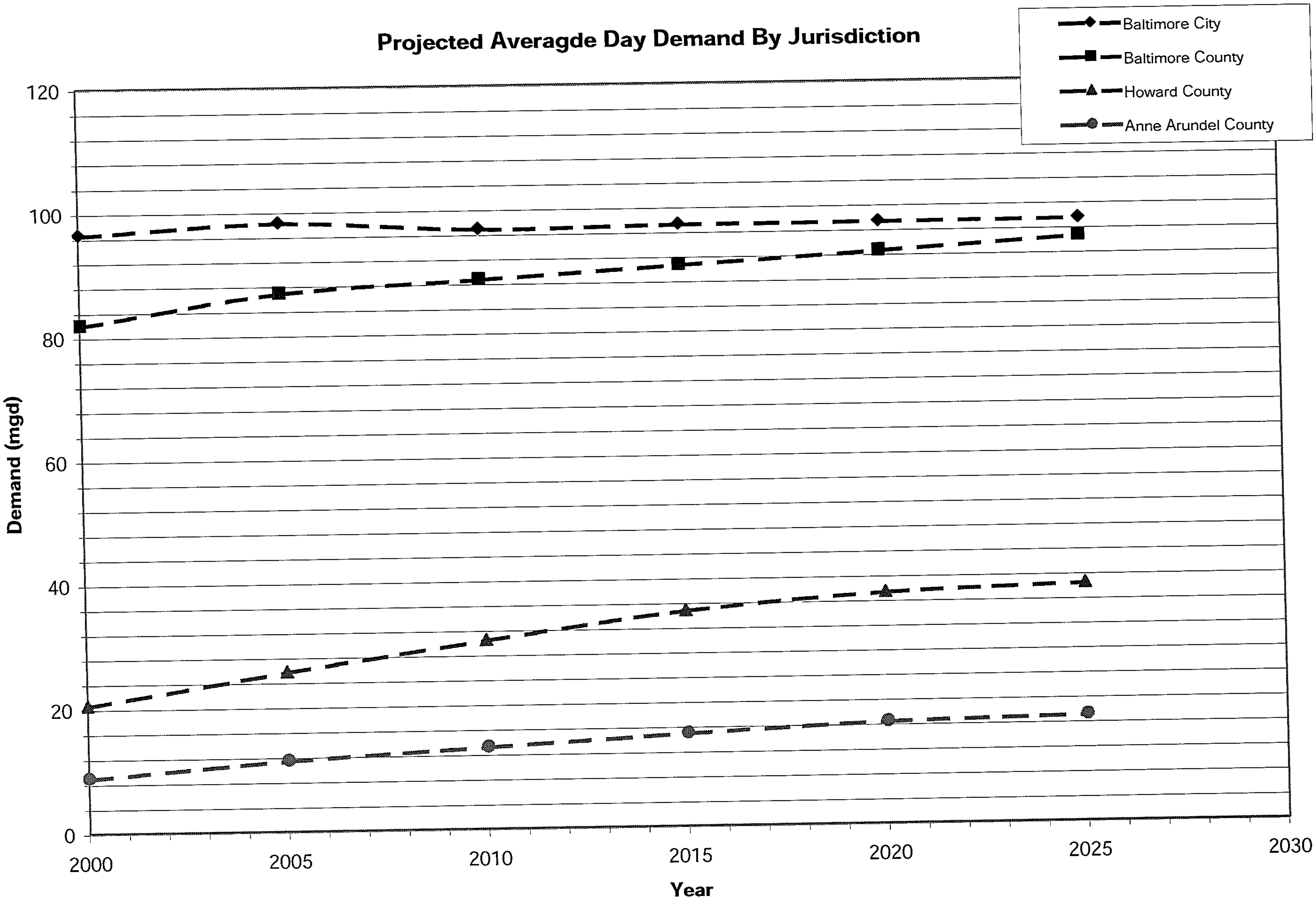
12. *Sherwood Fifth Zone*

The Sherwood Pumping Station is the only component of the Sherwood Fifth Zone requiring improvements, as illustrated on Figure X-5. The pump controls at this pumping station should be modified to improve the operation of the Sherwood Tank and the reliability of the station should be improved by providing on-site standby generators or redundant power feeders. Emergency generator connections are already available at this site. The reliability of this station could also be improved by constructing a second discharge main. Also, the existing pumps are oversized and could be modified by trimming the impellers or installing smaller motors.

13. *Sparks Fifth Zone*

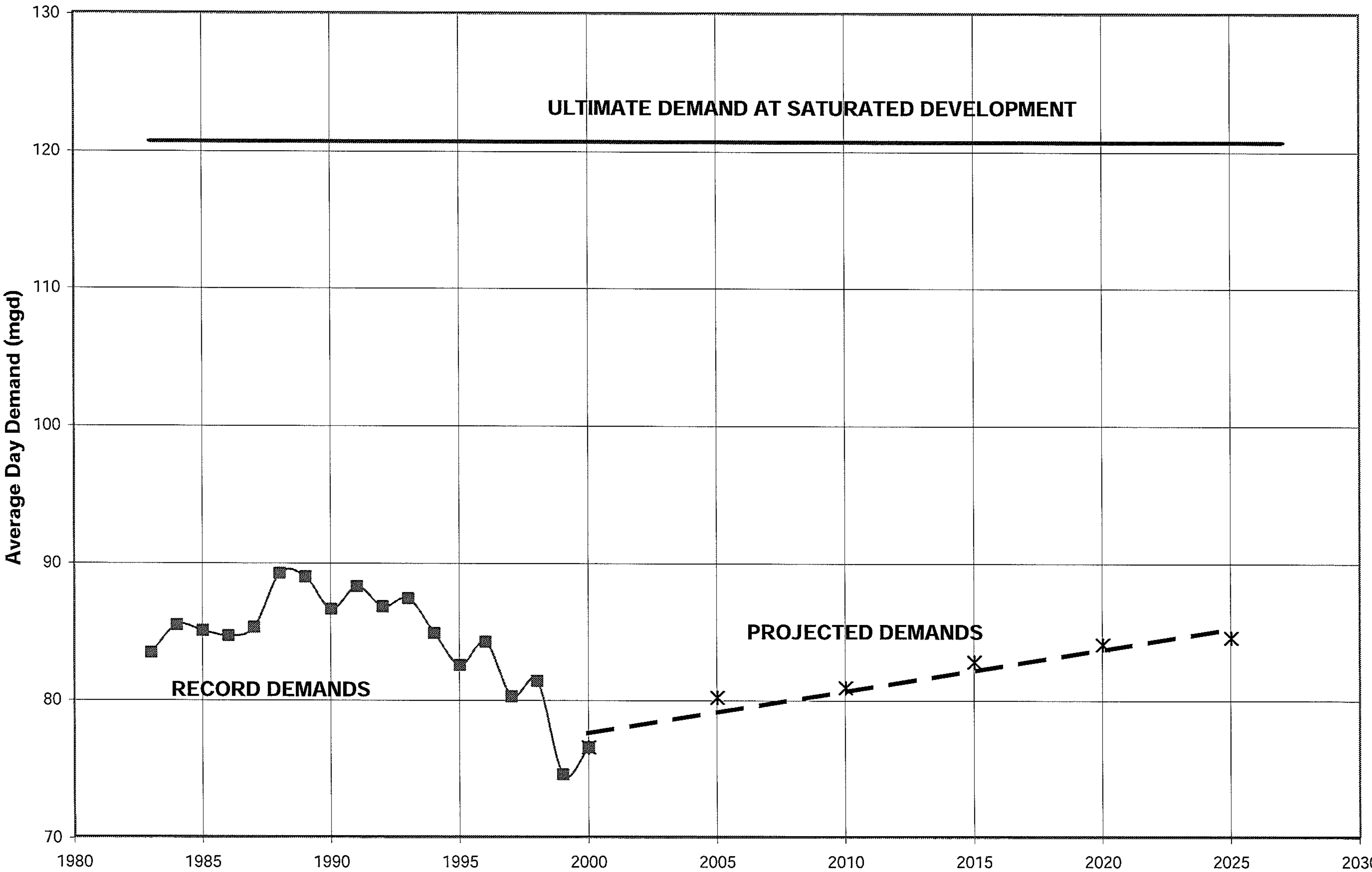
Only two improvements are recommended for the Sparks Fifth Zone. The pump controls at the Sparks Pumping Station should be modified to improve the operation of the Sparks Tank. In addition, modifying the pump controls will limit the number of pump cycles during a day which will decrease electric and maintenance costs. In addition, the City should consider constructing a second discharge main to improve the reliability of the system.


Historic and Projected Demand Allocation Among Jurisdictions
Demand (as % of system total)
70
60
50
40
30
20
10
0
1980
1985
1990
1995
2000
2005
2010
2015
2020
2025
2030
Year
Baltimore City
Baltimore County
Howard County
Anne Arundel



Projected Averagde Day Demand By Jurisdiction
Baltimore City
Baltimore County
Howard County
Anne Arundel County
120
100
80
60
40
20
0
Demand (mgd)
2000
2005
2010
2015
2020
2025
2030
Year

FIRST ZONE



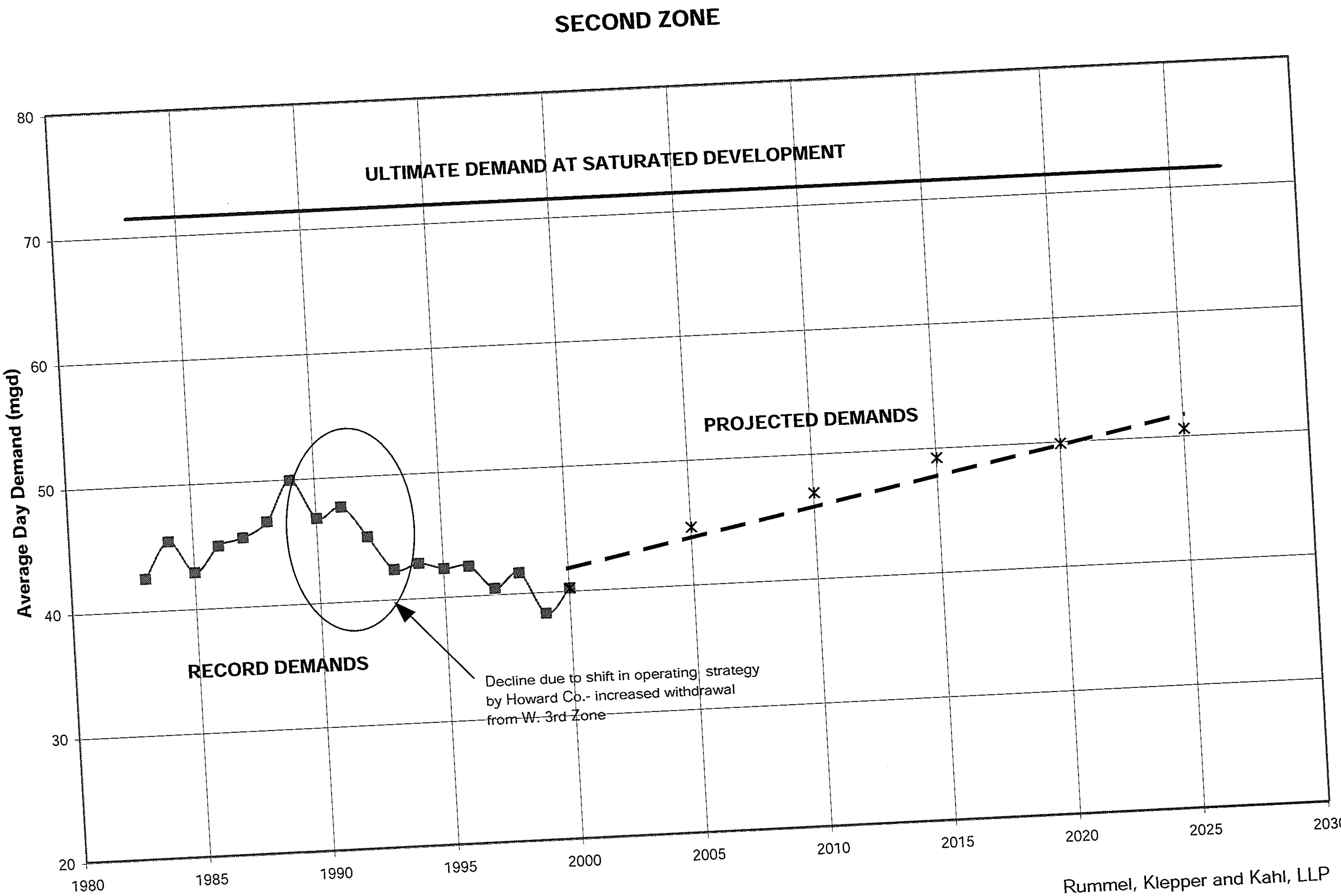
Average Day Demand (mgd)
130
120
110
100
90
80
70
1980
1985
1990
1995
2000
2005
2010
2015
2020
2025
2030
ULTIMATE DEMAND AT SATURATED DEVELOPMENT
PROJECTED DEMANDS
RECORD DEMANDS

FILTERED WATER METERED DEMAND OF THE BALTIMORE WATER SERVICE AREA

FIRST ZONE

	YEAR						
	2000	2005	2010	2015	2020	2025	Saturation
LAND AREA SERVED (sq. mi.)							
CITY	27.23	27.23	27.23	27.23	27.23	27.23	27.23
BALTIMORE COUNTY - EAST	55.26	55.81	56.37	56.92	57.48	58.03	58.03
TOTAL	82.49	83.05	83.60	84.16	84.71	85.26	85.26
POPULATION (X 1,000)							
CITY	174	172	170	173	174	176	202
BALTIMORE COUNTY - EAST	147	146	145	145	145	145	225
TOTAL	322	317	315	318	319	321	427
GALLONS PER CAPITA PER DAY (GPCD)							
City GPCDresidential	70	70	70	70	70	70	70
County GPCDresidential	76	76	76	76	76	76	76
City GPCDtotal	273	278	278	278	279	279	308
County GPCDtotal	162	175	175	175	175	175	215
DEMANDS (mgd)							
AVERAGE DAY							
CITY	47.54	47.66	47.35	48.11	48.57	49.09	62.30
BALTIMORE COUNTY - EAST	23.84	25.50	25.41	25.43	25.41	25.40	48.45
ANNE ARUNDEL COUNTY	5.10	6.95	8.07	9.18	10.00	10.00	10.00
TOTAL	76.49	80.11	80.83	82.72	83.98	84.49	120.75
Max Day/Avg Day Ratio	1.55	1.62	1.69	1.76	1.82	1.89	1.89
MAXIMUM DAY							
CITY	73.69	77.21	80.02	84.67	88.39	92.77	117.75
BALTIMORE COUNTY - EAST	36.96	41.30	42.95	44.75	46.25	48.00	91.57
ANNE ARUNDEL COUNTY	7.91	11.26	13.64	16.16	17.50	17.50	17.50
TOTAL	118.56	129.77	136.61	145.59	152.14	158.28	226.82
Peak Hour/Max Day Ratio	1.268	1.268	1.268	1.268	1.268	1.268	1.268
PEAK HOUR							
CITY	93.44	97.90	101.47	107.36	112.08	117.64	149.30
BALTIMORE COUNTY - EAST	46.86	52.37	54.46	56.75	58.64	60.87	116.11
ANNE ARUNDEL COUNTY	10.03	14.28	17.29	20.50	22.19	22.19	22.19
TOTAL	150.33	164.55	173.22	184.61	192.92	200.70	287.60
CONSUMER BASE (% of Average Day)							
RESIDENTIAL	33%	32%	32%	32%	31%	31%	28%
COMMERCIAL/ PUBLIC	42%	43%	43%	45%	46%	47%	47%
INDUSTRIAL	25%	25%	25%	23%	23%	22%	25%
	100%	100%	100%	100%	100%	100%	100%

Anne Arundel County average & maximum day demand of 10.00 and 17.50 mgd respectively based on 1989 Central System Report, Water Analyzers Office
Consumer Base includes wholesale demands to Anne Arundel County and Howard County under Commercial/Public



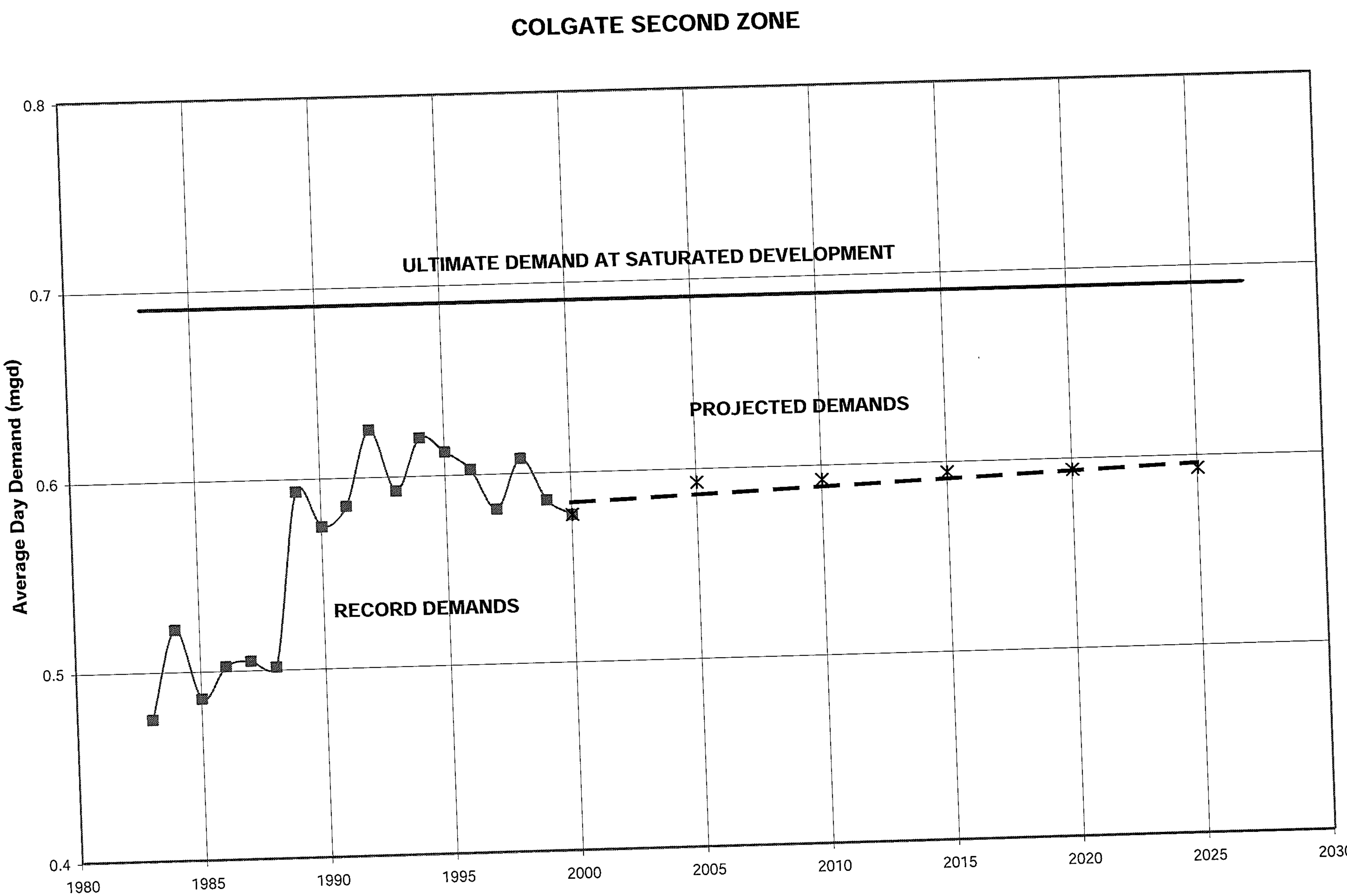
Rummel, Klepper and Kahl, LLP

FILTERED WATER METERED DEMAND OF THE BALTIMORE WATER SERVICE AREA

SECOND ZONE

	YEAR 2000	2005	2010	2015	2020	2025	Saturation
LAND AREA SERVED (sq. mi.)							
CITY	21.25	21.25	21.25	21.25	21.25	21.25	21.25
BALTIMORE COUNTY - EAST	19.49	19.51	19.52	19.54	19.55	19.57	19.57
BALTIMORE COUNTY - WEST	10.25	10.25	10.25	10.25	10.25	10.25	10.25
TOTAL	50.99	51.01	51.03	51.04	51.06	51.08	51.08
POPULATION (X 1,000)							
CITY	229	227	223	221	219	218	268
BALTIMORE COUNTY - EAST	50	53	56	59	62	66	113
BALTIMORE COUNTY - WEST	35	34	34	34	34	33	58
TOTAL	314	314	313	314	315	317	439
GALLONS PER CAPITA PER DAY (GPCD)							
City GPCDresidential	69	69	69	69	69	69	69
County GPCDresidential	74	74	74	74	74	74	74
City GPCDtotal	105	112	111	110	110	109	113
County GPCDtotal	102	108	108	108	108	108	138
DEMANDS (mgd)							
AVERAGE DAY							
CITY	24.0	25.4	24.7	24.4	24.1	23.8	30.3
BALTIMORE COUNTY - EAST	5.1	5.7	6.1	6.4	6.8	7.1	15.0
BALTIMORE COUNTY - WEST	3.5	3.7	3.7	3.7	3.6	3.6	8.6
ANNE ARUNDEL COUNTY	3.8	4.5	5.2	5.8	6.5	7.1	8.6
HOWARD COUNTY	3.7	5.2	7.1	8.8	8.8	8.8	8.8
TOTAL	40.12	44.53	46.78	49.10	49.76	50.47	71.32
Max Day/Avg Day Ratio	1.64	1.66	1.68	1.71	1.73	1.75	1.75
MAXIMUM DAY							
CITY	39.35	42.09	41.57	41.73	41.68	41.66	53.03
BALTIMORE COUNTY - EAST	8.36	9.54	10.23	10.98	11.70	12.49	26.23
BALTIMORE COUNTY - WEST	5.81	6.15	6.19	6.28	6.30	6.31	15.11
ANNE ARUNDEL COUNTY	6.21	7.46	8.65	9.93	11.18	12.46	15.00
HOWARD COUNTY	6.06	8.67	11.95	13.20	13.20	13.20	13.20
TOTAL	65.80	73.91	78.59	82.12	84.06	86.12	122.56
Peak Hour/Max Day Ratio	1.32	1.32	1.32	1.32	1.32	1.32	1.32
PEAK HOUR							
CITY	51.91	55.52	54.83	55.04	54.98	54.94	69.94
BALTIMORE COUNTY - EAST	11.03	12.58	13.50	14.48	15.43	16.47	34.59
BALTIMORE COUNTY - WEST	7.67	8.11	8.16	8.28	8.31	8.33	19.93
ANNE ARUNDEL COUNTY	8.20	9.84	11.41	13.10	14.75	16.44	19.79
HOWARD COUNTY	7.99	11.44	15.76	17.41	17.41	17.41	17.41
TOTAL	86.79	97.49	103.66	108.31	110.88	113.59	161.66
CONSUMER BASE (% of Average Day)							
RESIDENTIAL	68%	63%	64%	64%	64%	65%	58%
COMMERCIAL/ PUBLIC	29%	34%	33%	33%	33%	32%	39%
INDUSTRIAL	3%	3%	3%	3%	3%	3%	3%
	100%	100%	100%	100%	100%	100%	100%

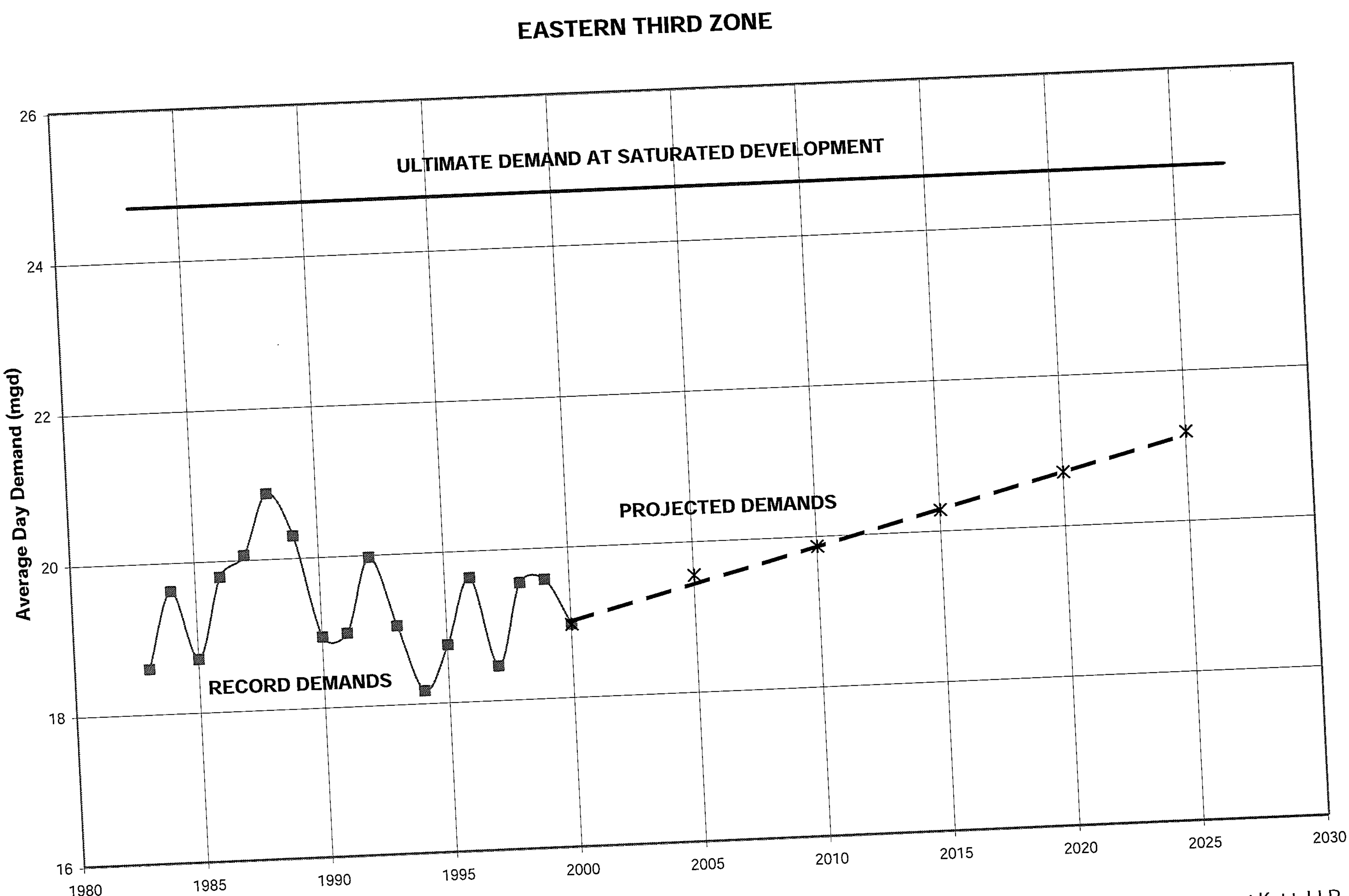
Ultimate Anne Arundel County average & maximum day demand of 8.57 and 15.00 mgd respectively based on Hillen Pumping Station Agreement, November 17, 1999.
Ultimate Howard County average & maximum day demand of 8.80 and 13.20 mgd respectively based on Hillen Pumping Station Agreement, November 17, 1999.
Consumer Base includes wholesale demands to Anne Arundel County and Howard County under Commercial/Public


COLGATE SECOND ZONE
ULTIMATE DEMAND AT SATURATED DEVELOPMENT
PROJECTED DEMANDS
RECORD DEMANDS
Average Day Demand (mgd)
0.8
0.7
0.6
0.5
0.4
1980
1985
1990
1995
2000
2005
2010
2015
2020
2025
2030

FILTERED WATER METERED DEMAND OF THE BALTIMORE WATER SERVICE AREA

COLGATE SECOND ZONE

	YEAR 2000	2005	2010	2015	2020	2025	Saturation
LAND AREA SERVED (sq. mi.)							
CITY	0.02	0.02	0.02	0.02	0.02	0.02	0.02
BALTIMORE COUNTY - EAST	0.86	0.86	0.86	0.86	0.86	0.86	0.86
TOTAL	0.88	0.88	0.88	0.88	0.88	0.88	0.88
POPULATION (X 1,000)							
CITY	0.49	0.48	0.47	0.48	0.49	0.50	0.60
BALTIMORE COUNTY - EAST	7.85	7.66	7.60	7.56	7.50	7.43	8.20
TOTAL	8.34	8.14	8.07	8.04	7.99	7.93	8.80
GALLONS PER CAPITA PER DAY							
City GPCDresidential	66	66	66	66	66	66	66
County GPCDresidential	63	63	63	63	63	63	63
City GPCDtotal	69	73	73	74	74	75	67
County GPCDtotal	69	73	73	74	74	75	79
DEMANDS (mgd)							
AVERAGE DAY							
CITY	0.03	0.03	0.03	0.04	0.04	0.04	0.04
BALTIMORE COUNTY - EAST	0.54	0.56	0.56	0.56	0.56	0.56	0.65
TOTAL	0.58	0.59	0.59	0.59	0.59	0.59	0.69
Max Day/Avg Day Ratio	1.43	1.43	1.43	1.43	1.43	1.43	1.43
MAXIMUM DAY							
CITY	0.05	0.05	0.05	0.05	0.05	0.05	0.06
BALTIMORE COUNTY - EAST	0.78	0.80	0.80	0.80	0.80	0.79	0.93
TOTAL	0.82	0.85	0.85	0.85	0.85	0.85	0.98
Peak Hour/Max Day Ratio	1.59	1.59	1.59	1.59	1.59	1.59	1.59
PEAK HOUR							
CITY	0.08	0.08	0.08	0.08	0.08	0.08	0.09
BALTIMORE COUNTY - EAST	1.23	1.26	1.26	1.27	1.26	1.26	1.47
TOTAL	1.31	1.34	1.34	1.35	1.35	1.34	1.56
CONSUMER BASE (% of Average Day)							
RESIDENTIAL	92%	87%	87%	86%	85%	85%	81%
COMMERCIAL/ PUBLIC	8%	13%	13%	14%	15%	15%	18%
INDUSTRIAL	0%	0%	0%	0%	0%	0%	0%
	100%	100%	100%	100%	100%	100%	99%



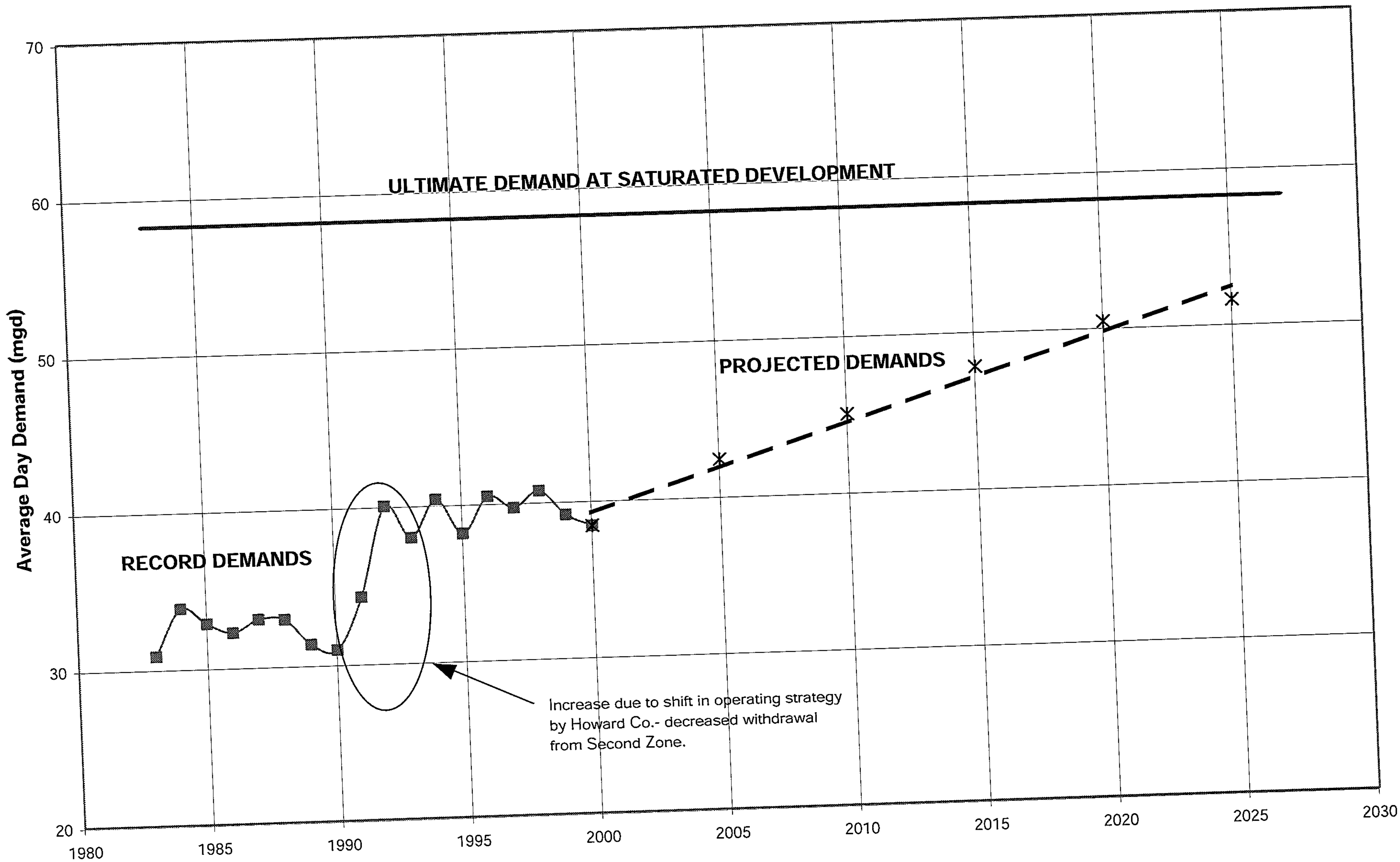
Rummel, Klepper and Kahl, LLP

FILTERED WATER METERED DEMAND OF THE BALTIMORE WATER SERVICE AREA

EASTERN THIRD ZONE

	YEAR 2000	2005	2010	2015	2020	2025	Saturation
LAND AREA SERVED (sq. mi.)							
CITY	14.34	14.34	14.34	14.34	14.34	14.34	14.34
BALTIMORE COUNTY - EAST	21.34	21.61	21.88	22.15	22.41	22.68	22.68
TOTAL	35.68	35.95	36.22	36.49	36.76	37.03	37.03
POPULATION (X 1,000)							
CITY	116	114	112	111	111	110	119
BALTIMORE COUNTY - EAST	86	88	91	95	98	101	132
TOTAL	202	202	203	206	208	211	251
GALLONS PER CAPITA PER DAY (GPCD)							
City GPCDresidential	54	54	54	54	54	54	54
County GPCDresidential	78	78	78	78	78	78	78
City GPCDtotal	91	96	96	96	96	96	101
County GPCDtotal	98	98	100	102	103	105	96
DEMANDS (mgd)							
AVERAGE DAY							
CITY	10.6	10.9	10.7	10.6	10.6	10.5	12.0
BALTIMORE COUNTY - EAST	8.4	8.7	9.2	9.6	10.1	10.6	12.7
TOTAL	18.96	19.54	19.85	20.26	20.69	21.17	24.73
Max Day/Avg Day Ratio	1.64	1.67	1.71	1.74	1.78	1.82	1.82
MAXIMUM DAY							
CITY	17.36	18.14	18.28	18.49	18.82	19.15	21.84
BALTIMORE COUNTY - EAST	13.73	14.49	15.66	16.76	18.01	19.38	23.17
TOTAL	31.09	32.63	33.94	35.25	36.83	38.52	45.01
PEAK HOUR Peak Hour/Max Day Ratio	1.33	1.33	1.33	1.33	1.33	1.33	1.33
CITY	23.10	24.15	24.33	24.61	25.05	25.48	29.07
BALTIMORE COUNTY - EAST	18.28	19.28	20.84	22.31	23.98	25.79	30.85
TOTAL	41.38	43.43	45.17	46.92	49.03	51.27	59.91
CONSUMER BASE (% of Average Day)							
RESIDENTIAL	68%	66%	66%	66%	66%	65%	67%
COMMERCIAL/ PUBLIC	29%	30%	29%	28%	27%	27%	23%
INDUSTRIAL	3%	4%	5%	6%	7%	8%	9%
	100%	100%	100%	100%	100%	100%	99%

WESTERN THIRD ZONE

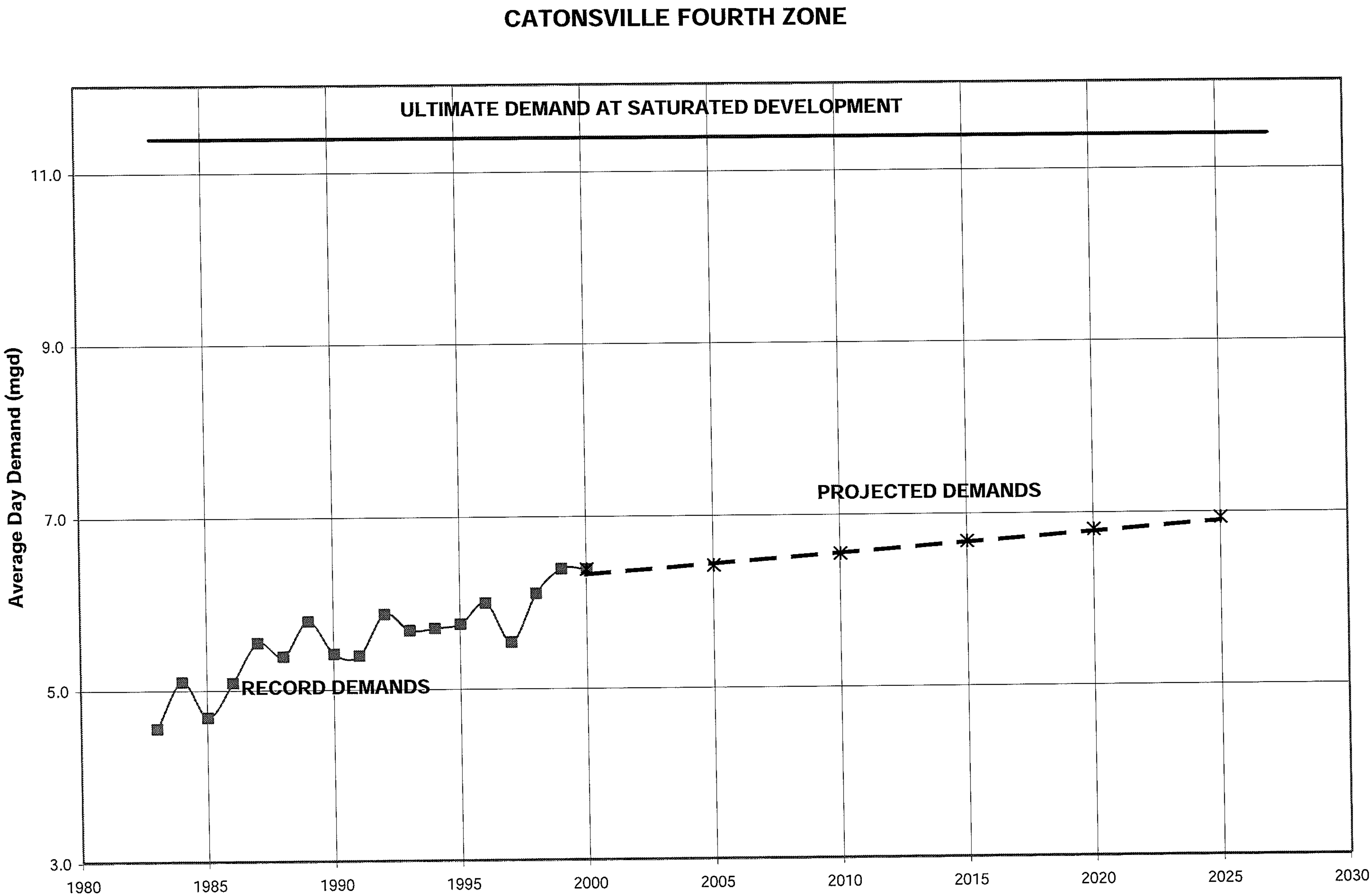


FILTERED WATER METERED DEMAND OF THE BALTIMORE WATER SERVICE AREA

WESTERN THIRD ZONE

	YEAR 2000	2005	2010	2015	2020	2025	Saturation
LAND AREA SERVED (sq. mi.)							
CITY	18.33	18.33	18.33	18.33	18.33	18.33	18.33
BALTIMORE COUNTY - WEST	17.23	17.50	17.76	18.03	18.30	18.56	18.56
TOTAL	35.57	35.83	36.10	36.36	36.63	36.90	36.90
POPULATION (X 1,000)							
CITY	138	135	133	133	133	133	153
BALTIMORE COUNTY - WEST	69	69	70	71	71	72	112
TOTAL	207	204	203	204	204	205	265
GALLONS PER CAPITA PER DAY (GPCD)							
City GPCDresidential	57	57	57	57	57	57	57
County GPCDresidential	72	72	72	72	72	72	72
City GPCDtotal	103	105	105	105	104	104	115
County GPCDtotal	107	111	111	111	111	111	96
DEMANDS (mgd)							
AVERAGE DAY							
CITY	14.2	14.2	13.9	13.9	13.9	13.9	17.60
BALTIMORE COUNTY - WEST	7.4	7.7	7.7	7.8	7.9	8.0	10.78
HOWARD COUNTY	16.8	20.5	23.3	26.0	28.6	29.70	29.70
TOTAL	38.37	42.34	44.97	47.74	50.37	51.52	58.08
Max Day/Avg Day Ratio	1.37	1.38	1.39	1.40	1.41	1.42	1.42
MAXIMUM DAY							
CITY	19.42	19.55	19.33	19.48	19.58	19.69	24.99
BALTIMORE COUNTY - WEST	10.09	10.61	10.77	10.95	11.12	11.30	15.30
HOWARD COUNTY*	29.80	33.94	38.08	42.22	46.36	50.50	50.50
TOTAL	59.31	64.10	68.18	72.65	77.06	81.49	90.80
PEAK HOUR Peak Hour/Max Day Ratio	1.33	1.33	1.33	1.33	1.33	1.33	1.33
CITY	25.85	26.02	25.73	25.92	26.06	26.21	33.26
BALTIMORE COUNTY - WEST	13.43	14.12	14.33	14.58	14.80	15.04	20.37
HOWARD COUNTY	39.66	45.17	50.68	56.19	61.71	67.22	67.22
TOTAL	78.94	85.32	90.75	96.69	102.57	108.46	120.85
CONSUMER BASE (% of Average Day)							
RESIDENTIAL	33%	30%	28%	26%	25%	25%	29%
COMMERCIAL/ PUBLIC	66%	69%	70%	72%	72%	72%	66%
INDUSTRIAL	1%	1%	2%	2%	3%	3%	5%
	100%	100%	100%	100%	100%	100%	100%

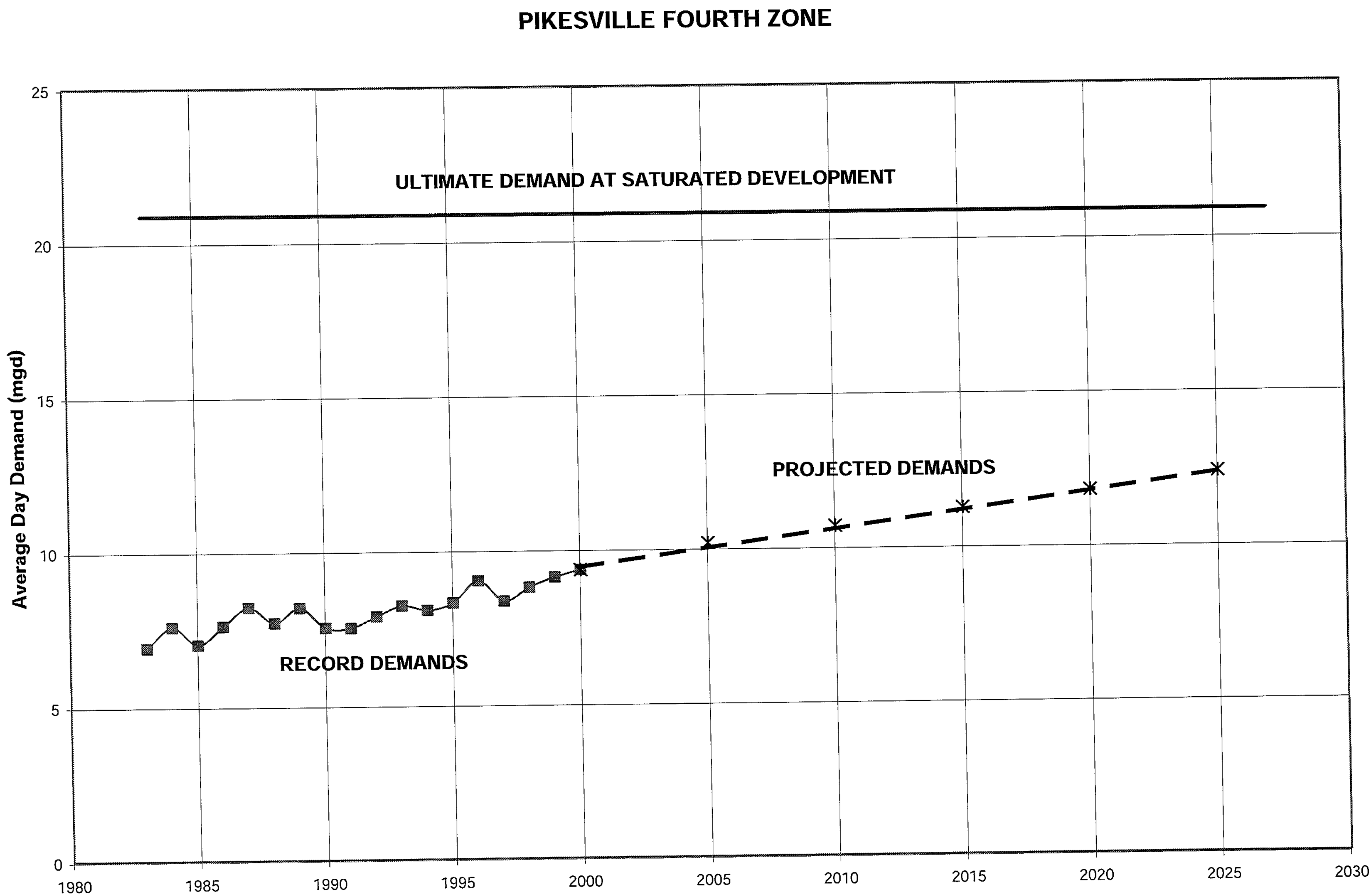
*Ultimate Howard County average and maximum day demands of 29.7 and 50.5 mgd based on Hillen Pumping Station Agreement, November 17, 1999
Consumer Base includes wholesale demands to Anne Arundel County and Howard County under Commercial/Public


CATONSVILLE FOURTH ZONE
ULTIMATE DEMAND AT SATURATED DEVELOPMENT
PROJECTED DEMANDS
RECORD DEMANDS
Average Day Demand (mgd)
11.0
9.0
7.0
5.0
3.0
1980
1985
1990
1995
2000
2005
2010
2015
2020
2025
2030

FILTERED WATER METERED DEMAND OF THE BALTIMORE WATER SERVICE AREA

CATONSVILLE FOURTH ZONE

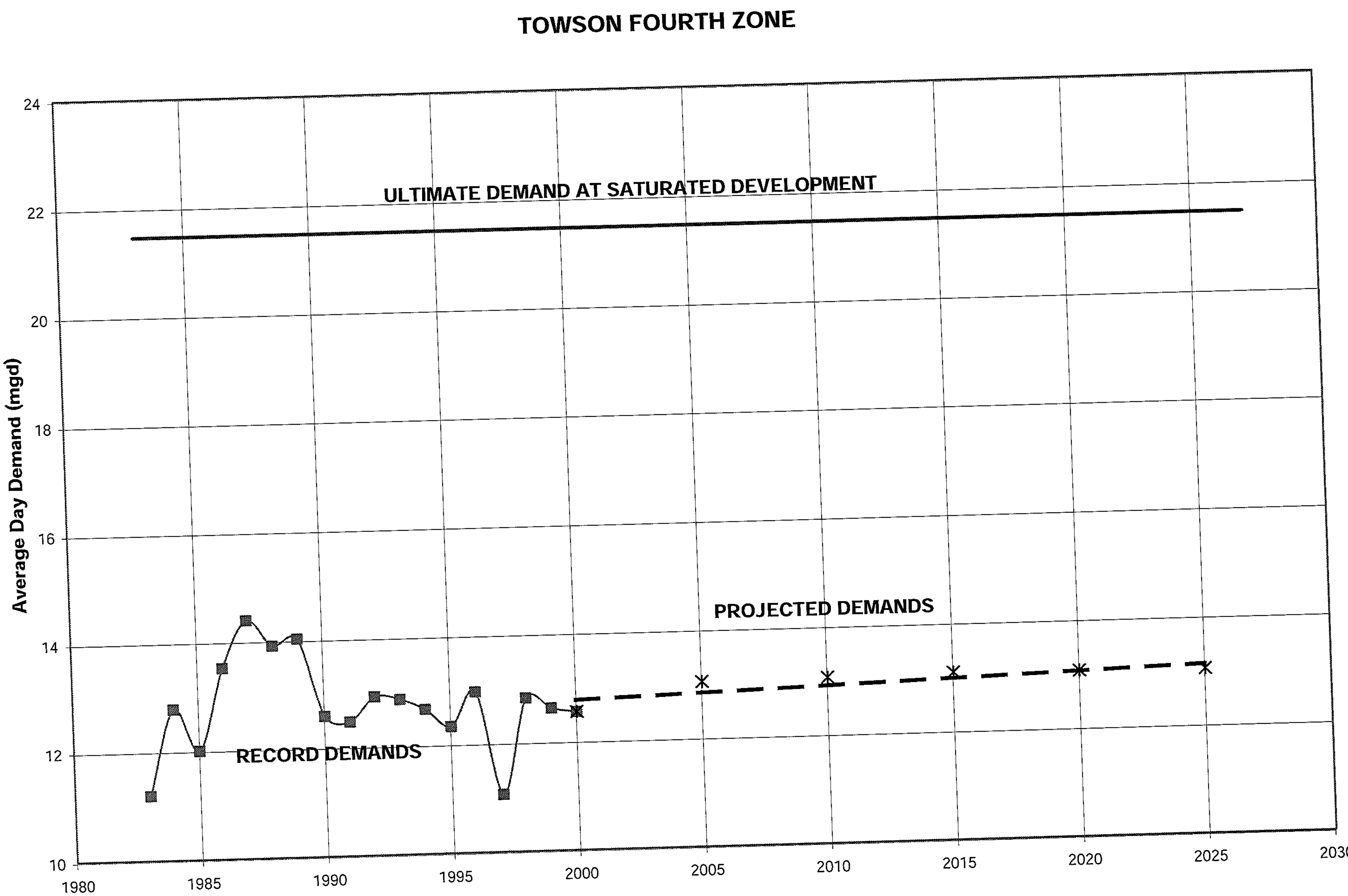
	YEAR						
	2000	2005	2010	2015	2020	2025	Saturation
LAND AREA SERVED (sq. mi.)							
BALTIMORE COUNTY - WEST	15.26	15.28	15.30	15.33	15.35	15.37	15.37
TOTAL	15.26	15.28	15.30	15.33	15.35	15.37	15.37
POPULATION (X 1,000)							
BALTIMORE COUNTY - WEST	45	44	45	45	45	45	82
TOTAL	45	44	45	45	45	45	82
GALLONS PER CAPITA PER DAY (GPCD)							
County GPCDresidential	98	98	98	98	98	98	98
County GPCDtotal	142	144	147	149	152	154	137
DEMANDS (mgd)							
AVERAGE DAY							
BALTIMORE COUNTY - WEST	6.37	6.40	6.53	6.66	6.79	6.91	11.26
COUNTY TOTAL	6.37	6.40	6.53	6.66	6.79	6.91	11.26
Max Day/Avg Day Ratio	1.60	1.60	1.60	1.60	1.60	1.60	1.60
MAXIMUM DAY							
BALTIMORE COUNTY - WEST	10.19	10.24	10.45	10.66	10.86	11.06	18.01
COUNTY TOTAL	10.19	10.24	10.45	10.66	10.86	11.06	18.01
Peak Hour/Max Day Ratio	1.53	1.53	1.53	1.53	1.53	1.53	1.53
PEAK HOUR							
BALTIMORE COUNTY - WEST	15.57	15.65	15.96	16.28	16.59	16.90	27.53
COUNTY TOTAL	15.57	15.65	15.96	16.28	16.59	16.90	27.53
CONSUMER BASE (% of Average Day)							
RESIDENTIAL	69%	68%	67%	65%	64%	63%	67%
COMMERCIAL/ PUBLIC	30%	31%	32%	33%	34%	35%	21%
INDUSTRIAL	1%	1%	1%	2%	2%	2%	12%
	100%	100%	100%	100%	100%	100%	100%


PIKESVILLE FOURTH ZONE
ULTIMATE DEMAND AT SATURATED DEVELOPMENT
PROJECTED DEMANDS
RECORD DEMANDS
Average Day Demand (mgd)
25
20
15
10
5
0
1980
1985
1990
1995
2000
2005
2010
2015
2020
2025
2030

FILTERED WATER METERED DEMAND OF THE BALTIMORE WATER SERVICE AREA

PIKESVILLE FOURTH ZONE

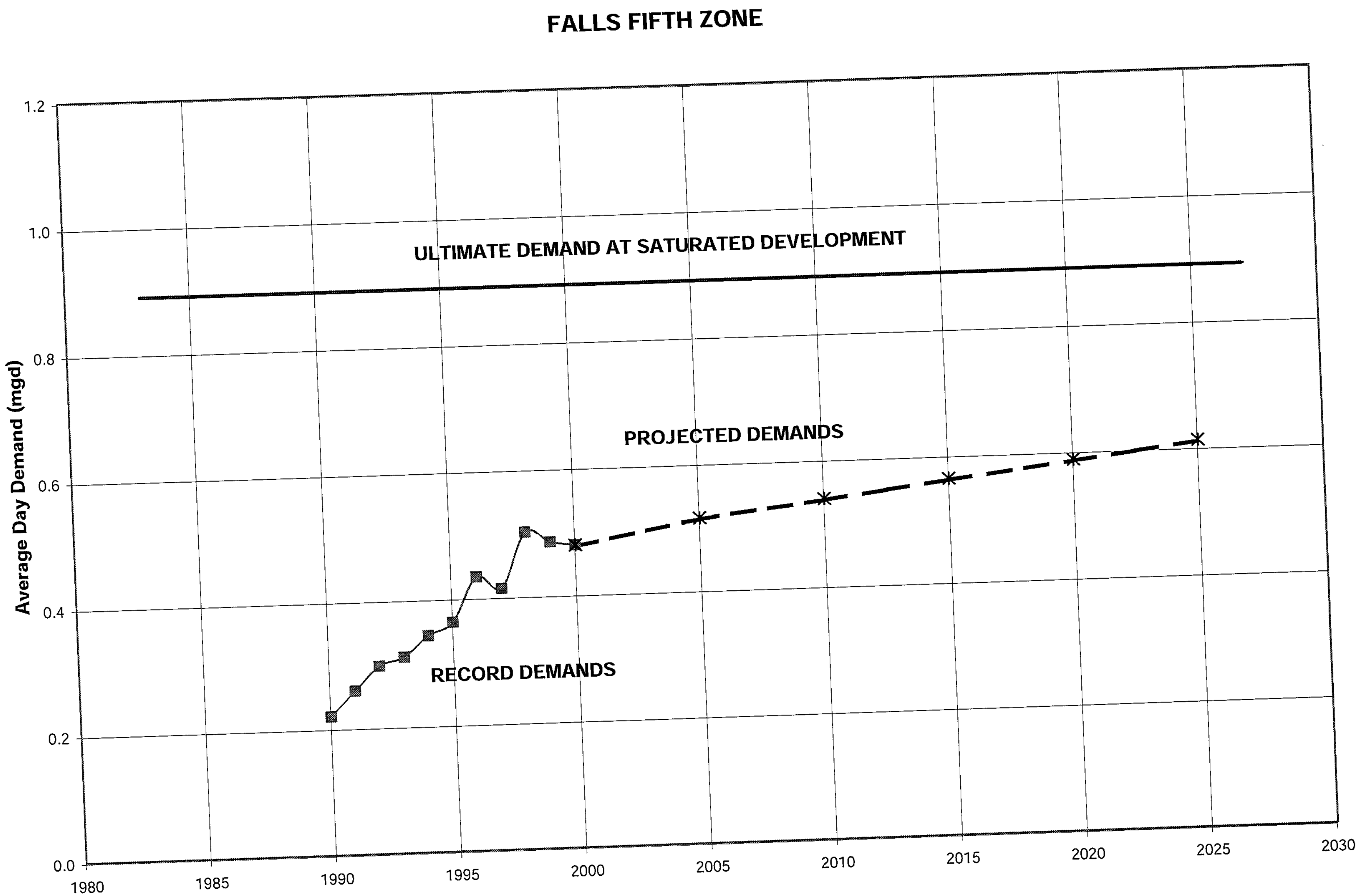
	YEAR						
	2000	2005	2010	2015	2020	2025	Saturation
LAND AREA SERVED (sq. mi.)							
BALTIMORE COUNTY - WEST	26.29	26.64	26.98	27.32	27.66	28.01	28.01
TOTAL	26.29	26.64	26.98	27.32	27.66	28.01	28.01
POPULATION (X 1,000)							
BALTIMORE COUNTY - WEST	75	79	84	88	92	97	174
TOTAL	75	79	84	88	92	97	174
GALLONS PER CAPITA PER DAY (GPCD)							
County GPCDresidential	80	80	80	80	80	80	80
County GPCDtotal	124	128	128	128	128	128	118
DEMANDS (mgd)							
AVERAGE DAY							
BALTIMORE COUNTY - WEST	9.33	10.16	10.68	11.23	11.77	12.35	20.51
COUNTY TOTAL	9.33	10.16	10.68	11.23	11.77	12.35	20.51
Max Day/Avg Day Ratio	1.72	1.75	1.78	1.80	1.83	1.86	1.86
MAXIMUM DAY							
BALTIMORE COUNTY - WEST	16.05	17.78	19.01	20.22	21.54	22.97	38.14
COUNTY TOTAL	16.05	17.78	19.01	20.22	21.54	22.97	38.14
Peak Hour/Max Day Ratio	1.44	1.44	1.44	1.44	1.44	1.44	1.44
PEAK HOUR							
BALTIMORE COUNTY - WEST	23.18	25.67	27.45	29.20	31.11	33.17	55.08
COUNTY TOTAL	23.18	25.67	27.45	29.20	31.11	33.17	55.08
CONSUMER BASE (% of Average Day)							
RESIDENTIAL	65%	63%	63%	63%	63%	63%	67%
COMMERCIAL/ PUBLIC	34%	35%	34%	33%	32%	31%	20%
INDUSTRIAL	1%	2%	3%	4%	5%	6%	13%
	100%	100%	100%	100%	100%	100%	100%


TOWSON FOURTH ZONE
ULTIMATE DEMAND AT SATURATED DEVELOPMENT
PROJECTED DEMANDS
RECORD DEMANDS
Average Day Demand (mgd)
24
22
20
18
16
14
12
10
1980
1985
1990
1995
2000
2005
2010
2015
2020
2025
2030

FILTERED WATER METERED DEMAND OF THE BALTIMORE WATER SERVICE AREA

TOWSON FOURTH ZONE

	YEAR						
	2000	2005	2010	2015	2020	2025	Saturation
LAND AREA SERVED (sq. mi.)							
CITY	0.33	0.33	0.33	0.33	0.33	0.33	0.33
BALTIMORE COUNTY - EAST	28.20	28.58	28.96	29.34	29.71	30.09	30.09
TOTAL	28.53	28.91	29.29	29.66	30.04	30.42	30.42
POPULATION (X 1,000)							
CITY	1	1	1	1	1	1	3
BALTIMORE COUNTY - EAST	87	87	87	87	87	87	137
TOTAL	89	88	89	89	89	88	140
GALLONS PER CAPITA PER DAY (GPCD)							
City GPCDresidential	80	80	80	80	80	80	80
County GPCDresidential	87	87	87	87	87	87	87
City GPCDtotal	141	147	147	147	147	147	153
County GPCDtotal	141	147	147	147	147	147	152
DEMANDS (mgd)							
AVERAGE DAY							
CITY	0.2	0.2	0.2	0.2	0.2	0.2	0.5
BALTIMORE COUNTY - EAST	12.3	12.8	12.8	12.9	12.8	12.8	20.8
TOTAL	12.54	13.04	13.05	13.08	13.06	13.04	21.30
Max Day/Avg Day Ratio	1.67	1.68	1.68	1.68	1.68	1.69	1.69
MAXIMUM DAY							
CITY	0.35	0.36	0.36	0.36	0.36	0.36	0.78
BALTIMORE COUNTY - EAST	20.60	21.55	21.57	21.63	21.58	21.68	35.22
TOTAL	20.95	21.91	21.93	21.98	21.94	22.03	36.00
Peak Hour/Max Day Ratio	1.39	1.39	1.39	1.39	1.39	1.39	1.39
PEAK HOUR							
CITY	0.48	0.50	0.49	0.49	0.49	0.49	1.08
BALTIMORE COUNTY - EAST	28.53	29.84	29.88	29.95	29.89	30.02	48.78
TOTAL	29.01	30.34	30.37	30.45	30.39	30.52	49.86
CONSUMER BASE (% of Average Day)							
RESIDENTIAL	61%	59%	59%	59%	59%	59%	57%
COMMERCIAL/ PUBLIC	38%	40%	40%	40%	40%	40%	17%
INDUSTRIAL	1%	1%	1%	1%	1%	1%	25%
	100%	100%	100%	100%	100%	100%	99%



Rummel, Klepper and Kahl, LLP

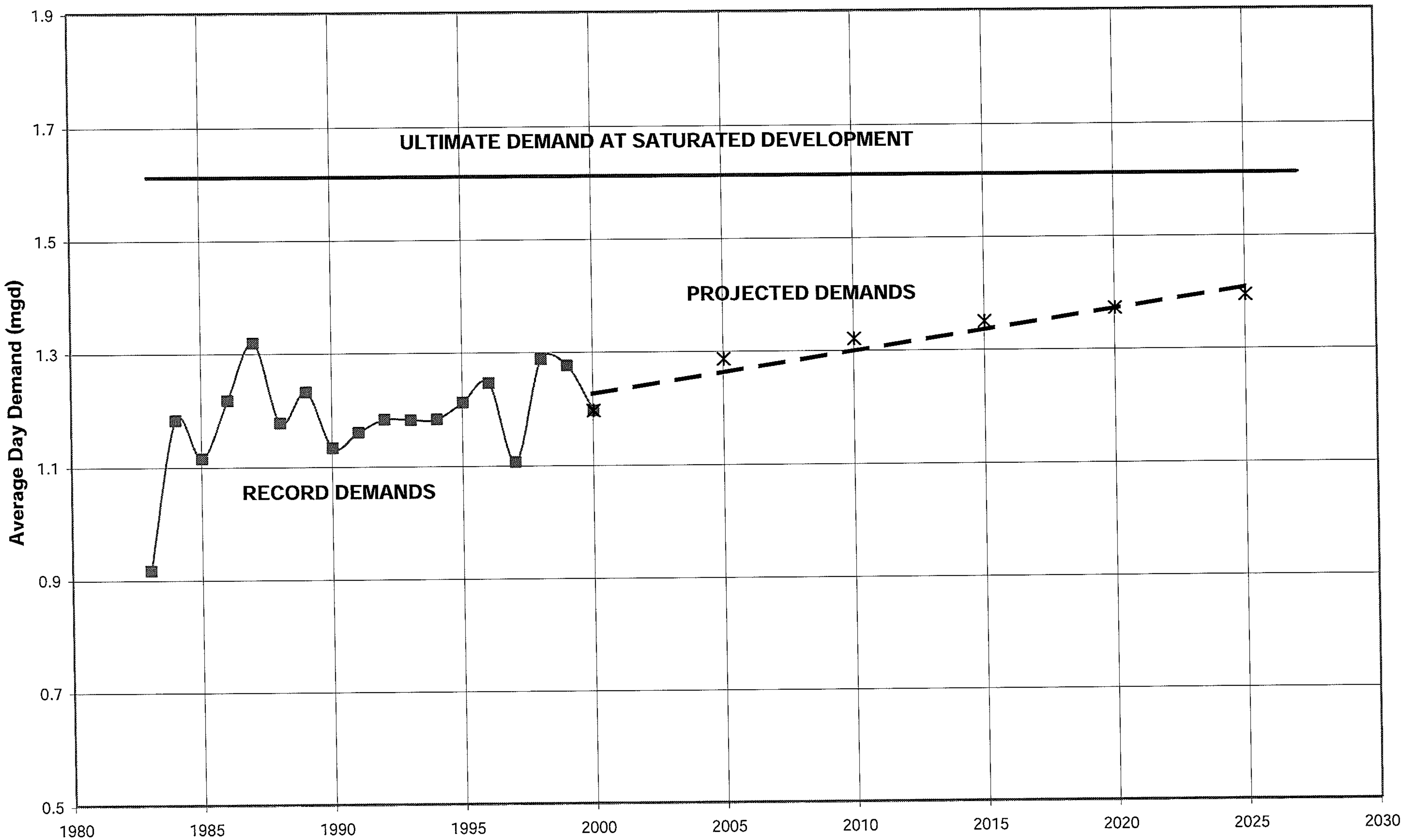
FILTERED WATER METERED DEMAND OF THE BALTIMORE WATER SERVICE AREA

FALLS FIFTH ZONE

	YEAR						
	2000	2005	2010	2015	2020	2025	Saturation
LAND AREA SERVED (sq. mi.)							
BALTIMORE COUNTY - EAST	1.39	1.54	1.70	1.86	1.86	1.86	1.86
TOTAL	1.39	1.54	1.70	1.86	1.86	1.86	1.86
POPULATION (X 1,000)							
BALTIMORE COUNTY - EAST	4.8	4.9	5.1	5.3	5.5	5.6	10.9
TOTAL	4.8	4.9	5.1	5.3	5.5	5.6	10.9
GALLONS PER CAPITA PER DAY (GPCD)							
County GPCDresidential	64	64	64	64	64	64	64
County GPCDtotal	99	104	106	107	108	109	68
DEMANDS (mgd)							
AVERAGE DAY							
BALTIMORE COUNTY - EAST	0.48	0.51	0.54	0.56	0.59	0.61	0.74
COUNTY TOTAL	0.48	0.51	0.54	0.56	0.59	0.61	0.74
Max Day/Avg Day Ratio	2.10	2.20	2.30	2.40	2.50	2.60	2.60
MAXIMUM DAY							
BALTIMORE COUNTY - EAST	1.00	1.13	1.24	1.35	1.47	1.59	1.92
COUNTY TOTAL	1.00	1.13	1.24	1.35	1.47	1.59	1.92
Peak Hour/Max Day Ratio	1.65	1.65	1.65	1.65	1.65	1.65	1.65
PEAK HOUR							
BALTIMORE COUNTY - EAST	1.65	1.87	2.04	2.23	2.42	2.62	3.17
COUNTY TOTAL	1.65	1.87	2.04	2.23	2.42	2.62	3.17
CONSUMER BASE (% of Average Day)							
RESIDENTIAL	65%	62%	61%	60%	60%	59%	96%
COMMERCIAL/ PUBLIC	35%	38%	38%	39%	38%	39%	0%
INDUSTRIAL	0%	0%	1%	1%	2%	2%	4%
	100%	100%	100%	100%	100%	100%	100%

NOTE: Saturation Consumer Base is based on land zoning which possibly includes hospitals, schools & apartment buildings as Residential properties whereas the City designates those properties as Commercial

POT SPRINGS FIFTH ZONE



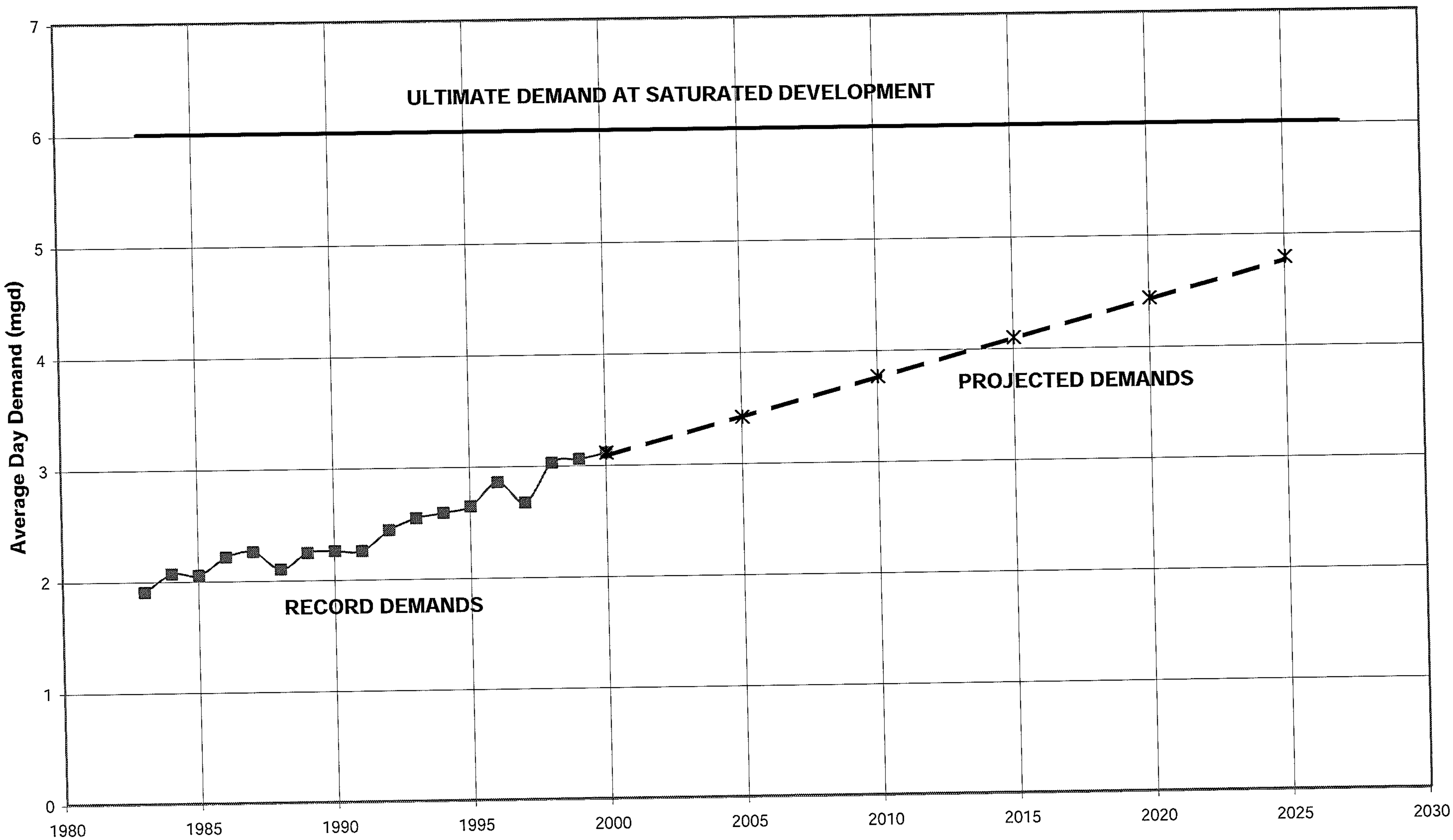
FILTERED WATER METERED DEMAND OF THE BALTIMORE WATER SERVICE AREA

POT SPRINGS FIFTH ZONE

	YEAR						
	2000	2005	2010	2015	2020	2025	Saturation
LAND AREA SERVED (sq. mi.)							
BALTIMORE COUNTY - EAST	3.09	3.09	3.09	3.09	3.09	3.09	3.09
TOTAL	3.09	3.09	3.09	3.09	3.09	3.09	3.09
POPULATION (X 1,000)							
BALTIMORE COUNTY - EAST	11	11	11	11	11	10	16
TOTAL	11	11	11	11	11	10	16
GALLONS PER CAPITA PER DAY (GPCD)							
County GPCDresidential	77	77	77	77	77	77	77
County GPCDtotal	111	120	123	127	130	133	101
DEMANDS (mgd)							
AVERAGE DAY							
BALTIMORE COUNTY - EAST	1.19	1.28	1.32	1.35	1.37	1.39	1.61
COUNTY TOTAL	1.19	1.28	1.32	1.35	1.37	1.39	1.61
Max Day/Avg Day Ratio	1.99	2.00	2.01	2.01	2.02	2.02	2.02
MAXIMUM DAY							
BALTIMORE COUNTY - EAST	2.38	2.57	2.65	2.71	2.77	2.81	3.25
COUNTY TOTAL	2.38	2.57	2.65	2.71	2.77	2.81	3.25
PEAK HOUR Peak Hour/Max Day Ratio	1.46	1.46	1.46	1.46	1.46	1.46	1.46
BALTIMORE COUNTY - EAST	3.47	3.75	3.87	3.95	4.04	4.11	4.75
COUNTY TOTAL	3.47	3.75	3.87	3.95	4.04	4.11	4.75
CONSUMER BASE (% of Average Day)							
RESIDENTIAL	70%	64%	63%	61%	60%	58%	99%
COMMERCIAL/ PUBLIC	29%	35%	36%	38%	39%	41%	1%
INDUSTRIAL	1%	1%	1%	1%	1%	1%	0%
	100%	100%	100%	100%	100%	100%	100%

NOTE: Saturation Consumer Base is based on land zoning which possibly includes hospitals, schools & apartment buildings as Residential properties whereas the City designates those properties as Commercial

REISTERSTOWN FIFTH ZONE



FILTERED WATER METERED DEMAND OF THE BALTIMORE WATER SERVICE AREA

REISTERSTOWN FIFTH ZONE

	YEAR 2000	2005	2010	2015	2020	2025	Saturation
LAND AREA SERVED (sq. mi.)							
BALTIMORE COUNTY - WEST	9.70	9.96	10.23	10.49	10.76	11.02	11.02
TOTAL	9.70	9.96	10.23	10.49	10.76	11.02	11.02
POPULATION (X 1,000)							
BALTIMORE COUNTY - WEST	30	32	34	35	37	39	53
TOTAL	30	32	34	35	37	39	53
GALLONS PER CAPITA PER DAY (GPCD)							
County GPCDresidential	78	78	78	78	78	78	78
County GPCDtotal	103	106	111	115	119	122	114
DEMANDS (mgd)							
AVERAGE DAY							
BALTIMORE COUNTY - WEST	3.10	3.41	3.75	4.09	4.43	4.78	6.04
COUNTY TOTAL	3.10	3.41	3.75	4.09	4.43	4.78	6.04
Max Day/Avg Day Ratio	1.74	1.79	1.85	1.90	1.96	2.01	2.01
MAXIMUM DAY							
BALTIMORE COUNTY - WEST	5.40	6.10	6.94	7.76	8.68	9.60	12.15
COUNTY TOTAL	5.40	6.10	6.94	7.76	8.68	9.60	12.15
Peak Hour/Max Day Ratio	1.83	1.83	1.83	1.83	1.83	1.83	1.83
PEAK HOUR							
BALTIMORE COUNTY - WEST	9.85	11.13	12.67	14.17	15.83	17.53	22.17
COUNTY TOTAL	9.85	11.13	12.67	14.17	15.83	17.53	22.17
CONSUMER BASE (% of Average Day)							
RESIDENTIAL	76%	73%	70%	68%	66%	64%	68%
COMMERCIAL/ PUBLIC	24%	26%	28%	29%	30%	31%	19%
INDUSTRIAL	0%	1%	2%	3%	4%	5%	13%
	100%	100%	100%	100%	100%	100%	100%

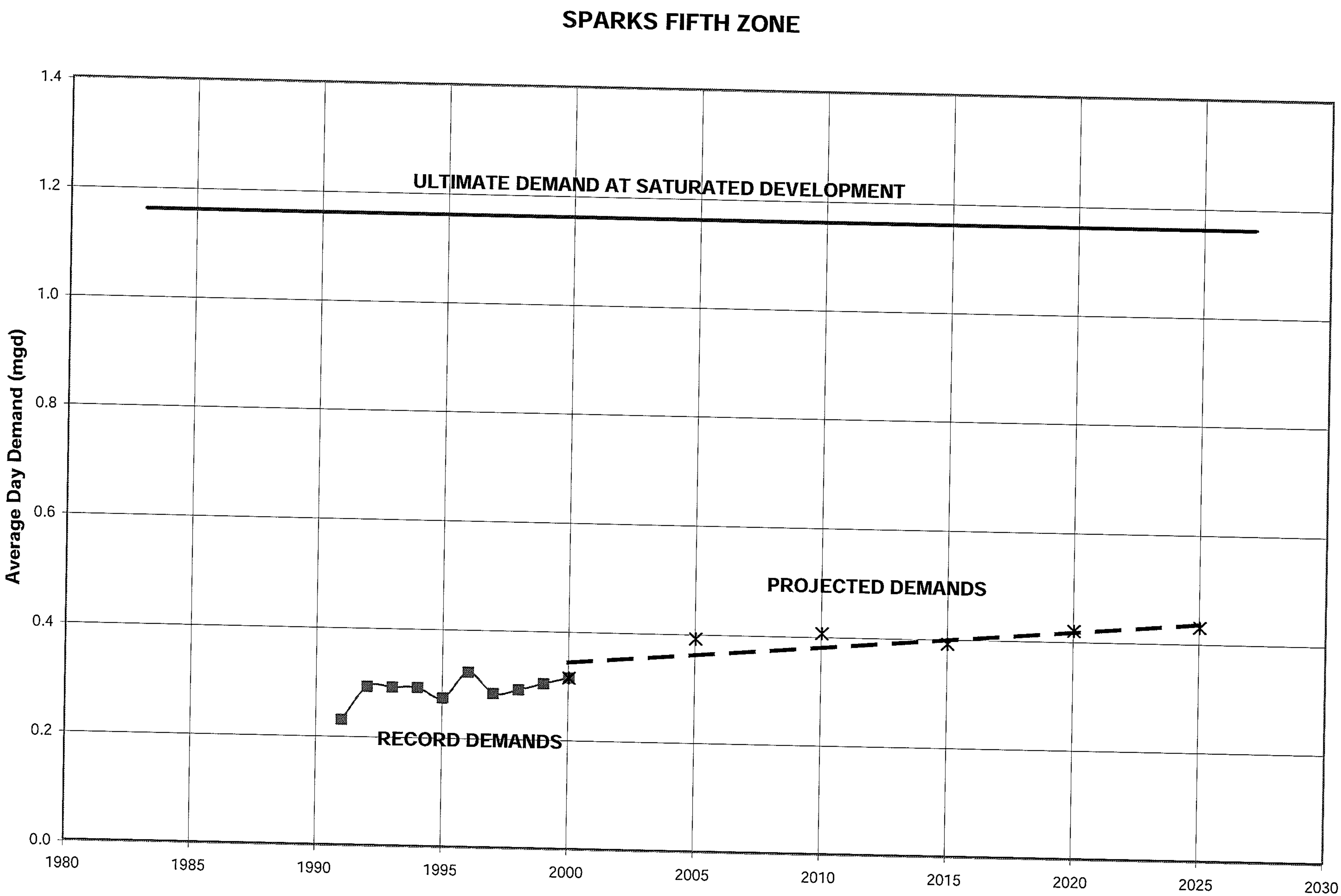
NOTE: Saturation Consumer Base is based on land zoning which possibly includes hospitals, schools & apartment buildings as Residential properties whereas the City designates those properties as Commercial

FILTERED WATER METERED DEMAND OF THE BALTIMORE WATER SERVICE AREA

SHERWOOD FIFTH ZONE

	YEAR						
	2000	2005	2010	2015	2020	2025	Saturation
LAND AREA SERVED (sq. mi.)							
BALTIMORE COUNTY - EAST	0.29	0.34	0.39	0.44	0.49	0.54	0.54
TOTAL	0.29	0.34	0.39	0.44	0.49	0.54	0.54
POPULATION (X 1,000)							
BALTIMORE COUNTY - EAST	0.4	0.4	0.4	0.4	0.5	0.5	1.4
TOTAL	0.4	0.4	0.4	0.4	0.5	0.5	1.4
GALLONS PER CAPITA PER DAY (GPCD)							
County GPCDresidential	111	111	111	111	111	111	111
County GPCDtotal	111	120	123	127	130	133	133
DEMANDS (mgd)							
AVERAGE DAY							
BALTIMORE COUNTY - EAST	0.05	0.05	0.05	0.05	0.06	0.06	0.15
COUNTY TOTAL	0.05	0.05	0.05	0.05	0.06	0.06	0.15
Max Day/Avg Day Ratio	1.99	2.00	2.01	2.01	2.02	2.02	2.02
MAXIMUM DAY							
BALTIMORE COUNTY - EAST	0.09	0.10	0.11	0.11	0.12	0.13	0.31
COUNTY TOTAL	0.09	0.10	0.11	0.11	0.12	0.13	0.31
PEAK HOUR Peak Hour/Max Day Ratio	1.46	1.46	1.46	1.46	1.46	1.46	1.46
BALTIMORE COUNTY - EAST	0.14	0.15	0.16	0.16	0.18	0.19	0.45
COUNTY TOTAL	0.14	0.15	0.16	0.16	0.18	0.19	0.45
CONSUMER BASE (% of Average Day)							
RESIDENTIAL	100%	93%	90%	87%	85%	83%	100%
COMMERCIAL/ PUBLIC	0%	8%	10%	13%	15%	17%	0%
INDUSTRIAL	0%	0%	0%	0%	0%	0%	0%
	100%	100%	100%	100%	100%	100%	100%

NOTE: Saturation Consumer Base is based on land zoning which possibly includes hospitals, schools & apartment buildings as Residential properties whereas the City designates those properties as Commercial


SPARKS FIFTH ZONE
Average Day Demand (mgd)
1.4
1.2
1.0
0.8
0.6
0.4
0.2
0.0
1980
1985
1990
1995
2000
2005
2010
2015
2020
2025
2030
ULTIMATE DEMAND AT SATURATED DEVELOPMENT
PROJECTED DEMANDS
RECORD DEMANDS

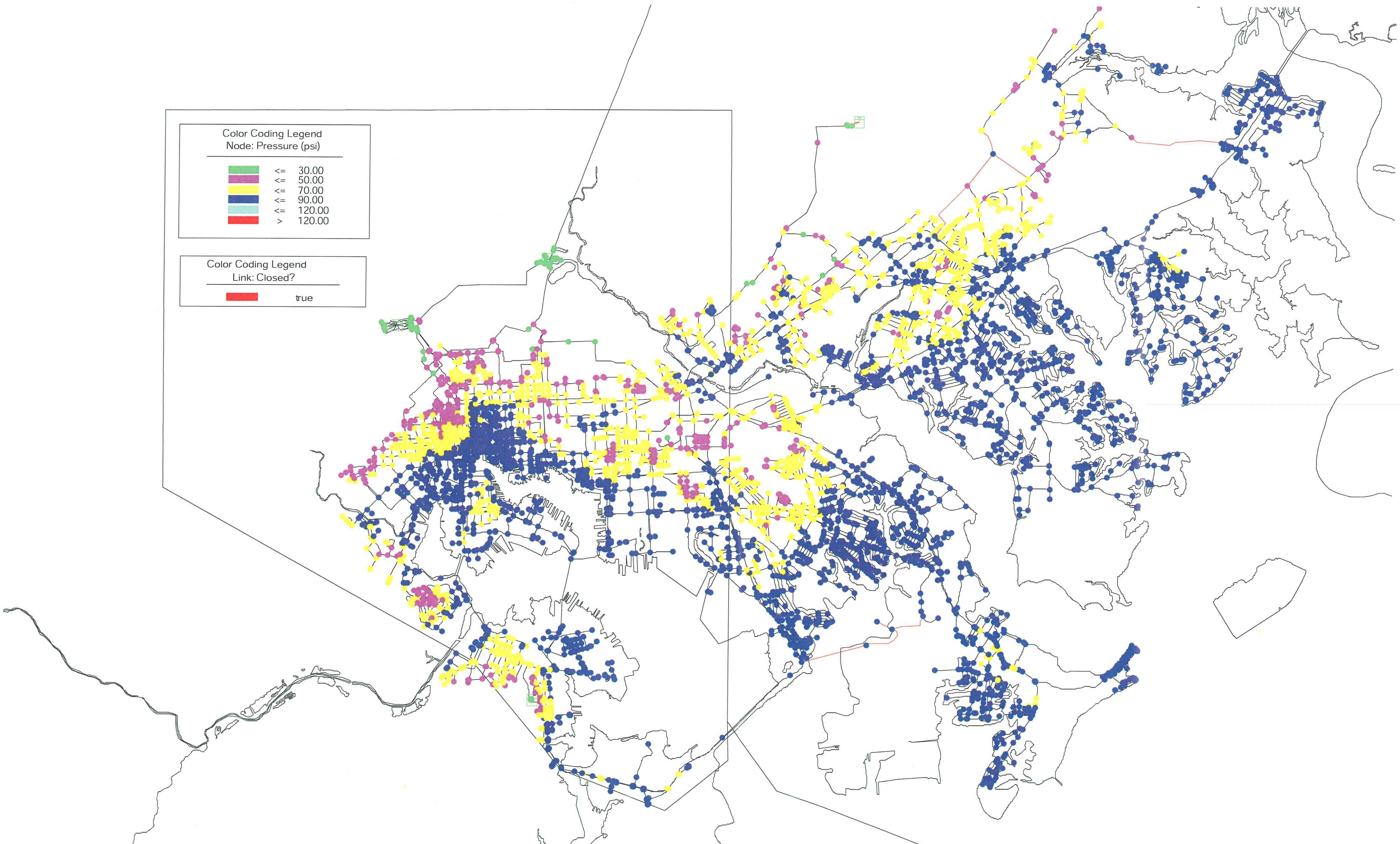
FILTERED WATER METERED DEMAND OF THE BALTIMORE WATER SERVICE AREA

SPARKS FIFTH ZONE

	YEAR 2000	2005	2010	2015	2020	2025	Saturation
LAND AREA SERVED (sq. mi.)							
BALTIMORE COUNTY - EAST	0.97	1.04	1.10	1.17	1.23	1.30	1.30
TOTAL	0.97	1.04	1.10	1.17	1.23	1.30	1.30
POPULATION (X 1,000)							
BALTIMORE COUNTY - EAST	2.30	2.50	2.59	2.50	2.68	2.74	2.80
TOTAL	2.30	2.50	2.59	2.50	2.68	2.74	2.80
GALLONS PER CAPITA PER DAY (GPCD)							
County GPCDresidential	71	71	71	71	71	71	71
County GPCDtotal	136	156	156	156	156	156	412
DEMANDS (mgd)							
AVERAGE DAY							
BALTIMORE COUNTY - EAST	0.31	0.39	0.40	0.39	0.42	0.43	1.15
COUNTY TOTAL	0.31	0.39	0.40	0.39	0.42	0.43	1.15
Max Day/Avg Day Ratio	2.56	2.75	2.85	2.90	2.95	3.00	3.00
MAXIMUM DAY							
BALTIMORE COUNTY - EAST	0.80	1.07	1.15	1.13	1.23	1.28	3.46
COUNTY TOTAL	0.80	1.07	1.15	1.13	1.23	1.28	3.46
Peak Hour/Max Day Ratio	1.24	1.24	1.24	1.24	1.24	1.24	1.24
PEAK HOUR							
BALTIMORE COUNTY - EAST	1.00	1.33	1.43	1.41	1.54	1.60	4.31
COUNTY TOTAL	1.00	1.33	1.43	1.41	1.54	1.60	4.31
CONSUMER BASE (% of Average Day)							
RESIDENTIAL	52%	45%	45%	45%	45%	45%	17%
COMMERCIAL/ PUBLIC	35%	37%	33%	30%	27%	25%	0%
INDUSTRIAL	13%	18%	22%	25%	28%	30%	83%
	100%	100%	100%	100%	100%	100%	100%

NOTE: Saturation Consumer Base is based on land zoning which possibly includes hospitals, schools & apartment buildings as Residential properties whereas the City designates those properties as Commercial

Scenario: Avg Day 2000

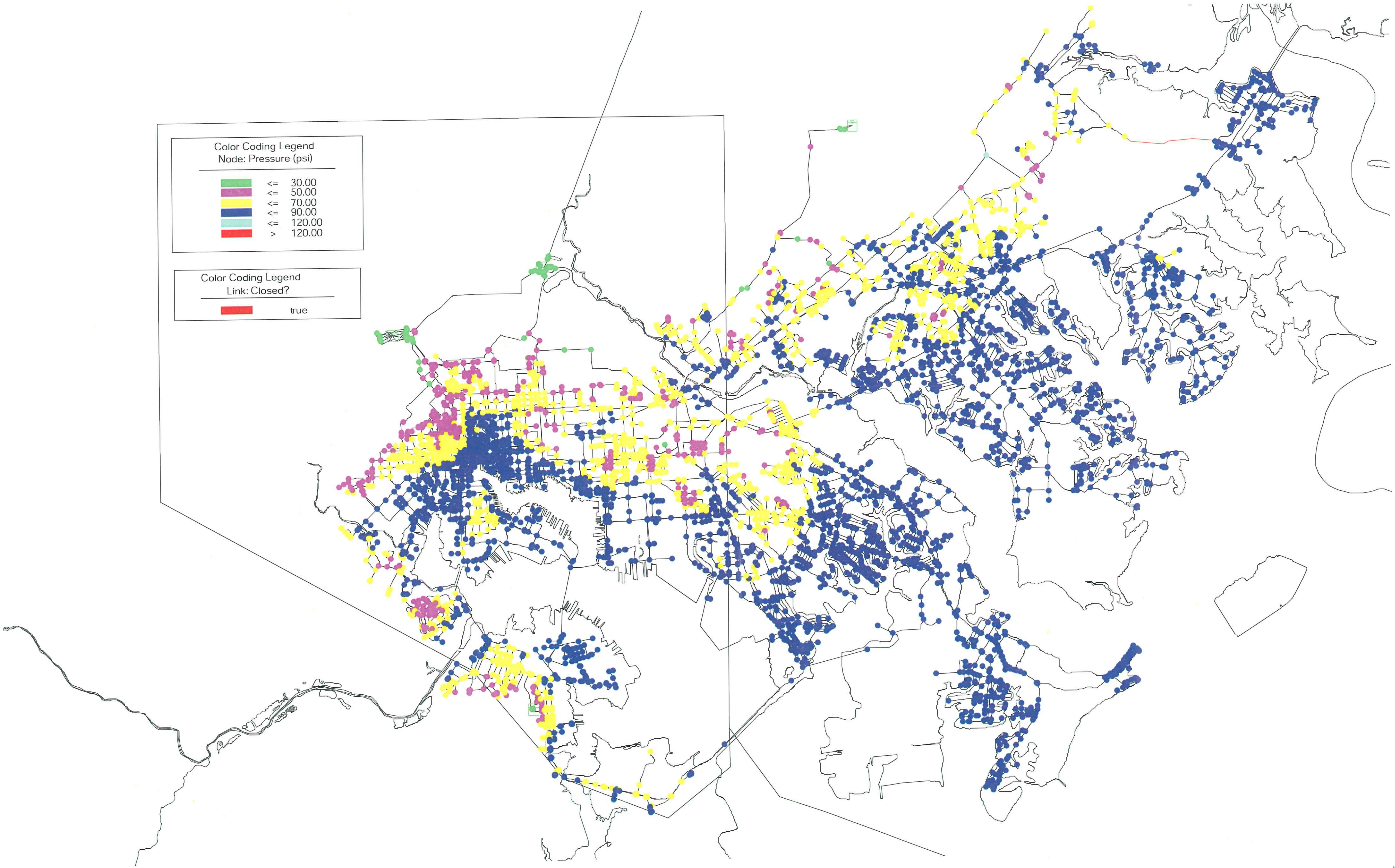


Title: Zone 1 - all
c:\watercad\baltcity\zone1\1stanalysis.wcd
02/27/03 03:30:27 PM

Rummel, Klepper & Kahl

Project Engineer: KK
WaterCAD v4.1 [424a]

Scenario: Avg Day 2025

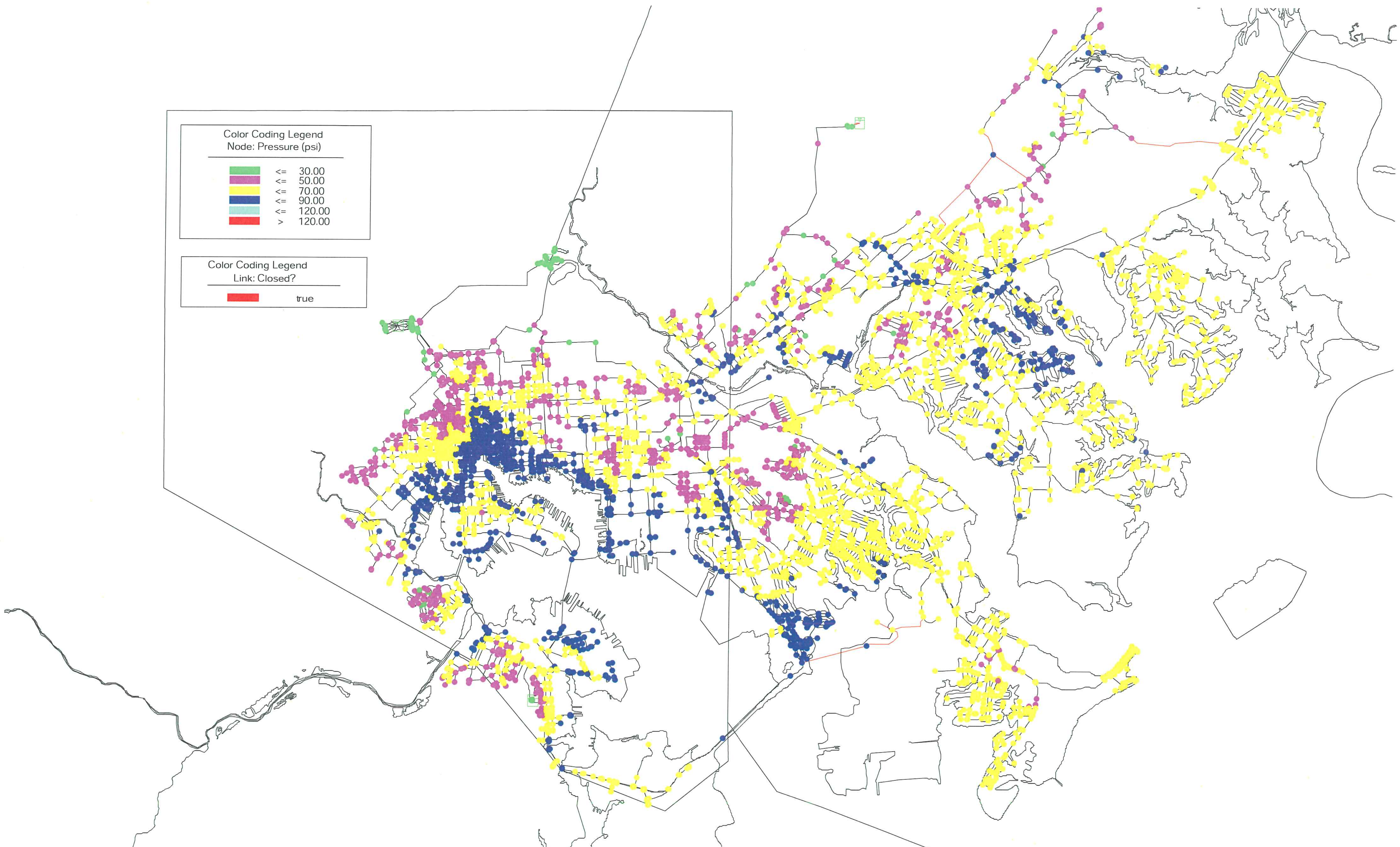


Title: Zone 1 - all
c:\watercad\baltcity\zone1\1stanalysis.wcd
02/27/03 03:32:17 PM

Rummel, Klepper & Kahl

Project Engineer: KK
WaterCAD v4.1 [424a]

Scenario: Max Day 2000

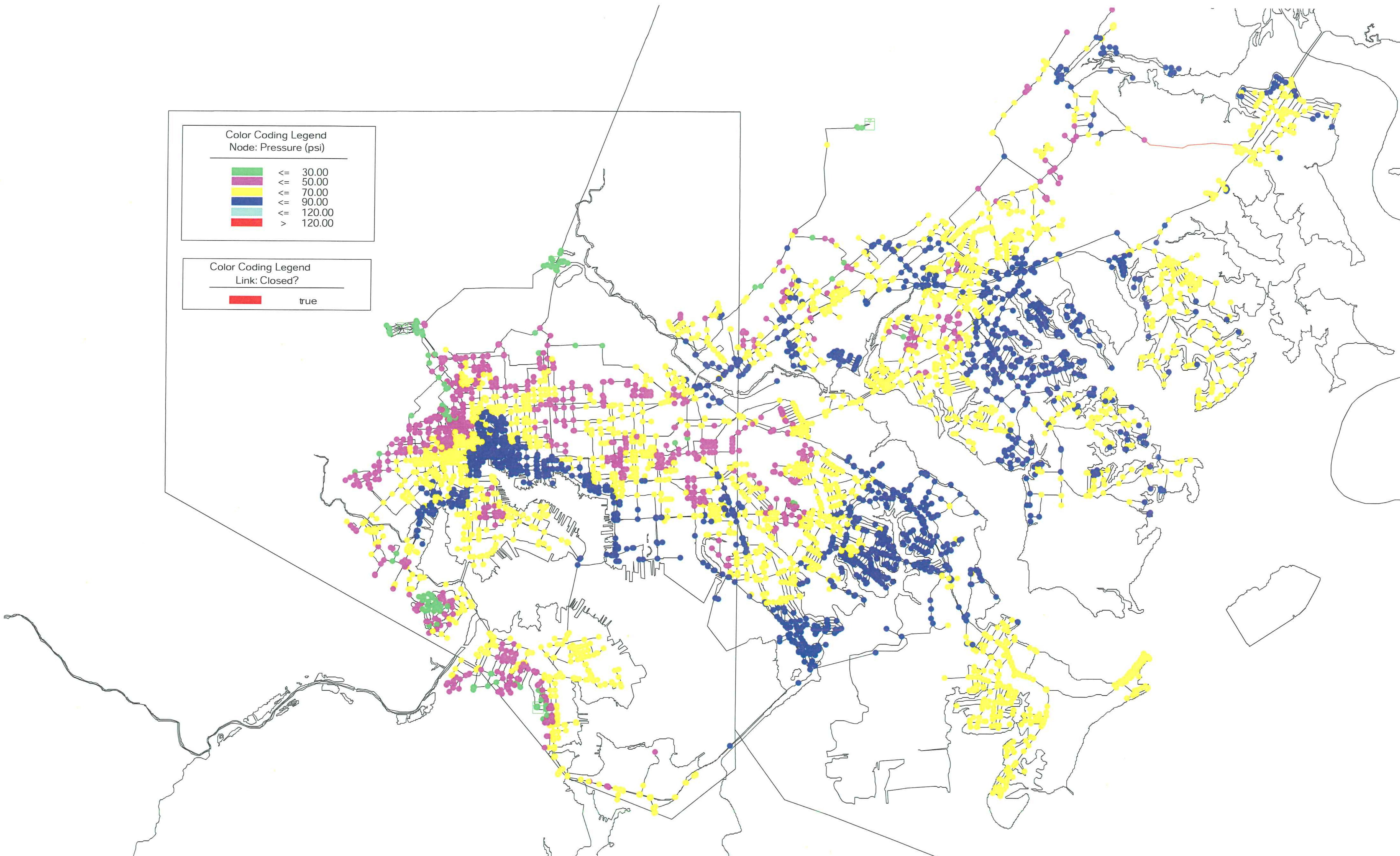


Title: Zone 1 - all
c:\watercad\baltcity\zone1\1stanalysis.wcd
02/27/03 03:29:06 PM

Rummel, Klepper & Kahl

Project Engineer: KK
WaterCAD v4.1 [424a]

Scenario: Max Day 2025



Title: Zone 1 - all
c:\watercad\baltcity\zone1\1stanalysis.wcd
02/27/03 03:31:46 PM

Rummel, Klepper & Kahl

Project Engineer: KK
WaterCAD v4.1 [424a]

Scenario: Avg Day 2000

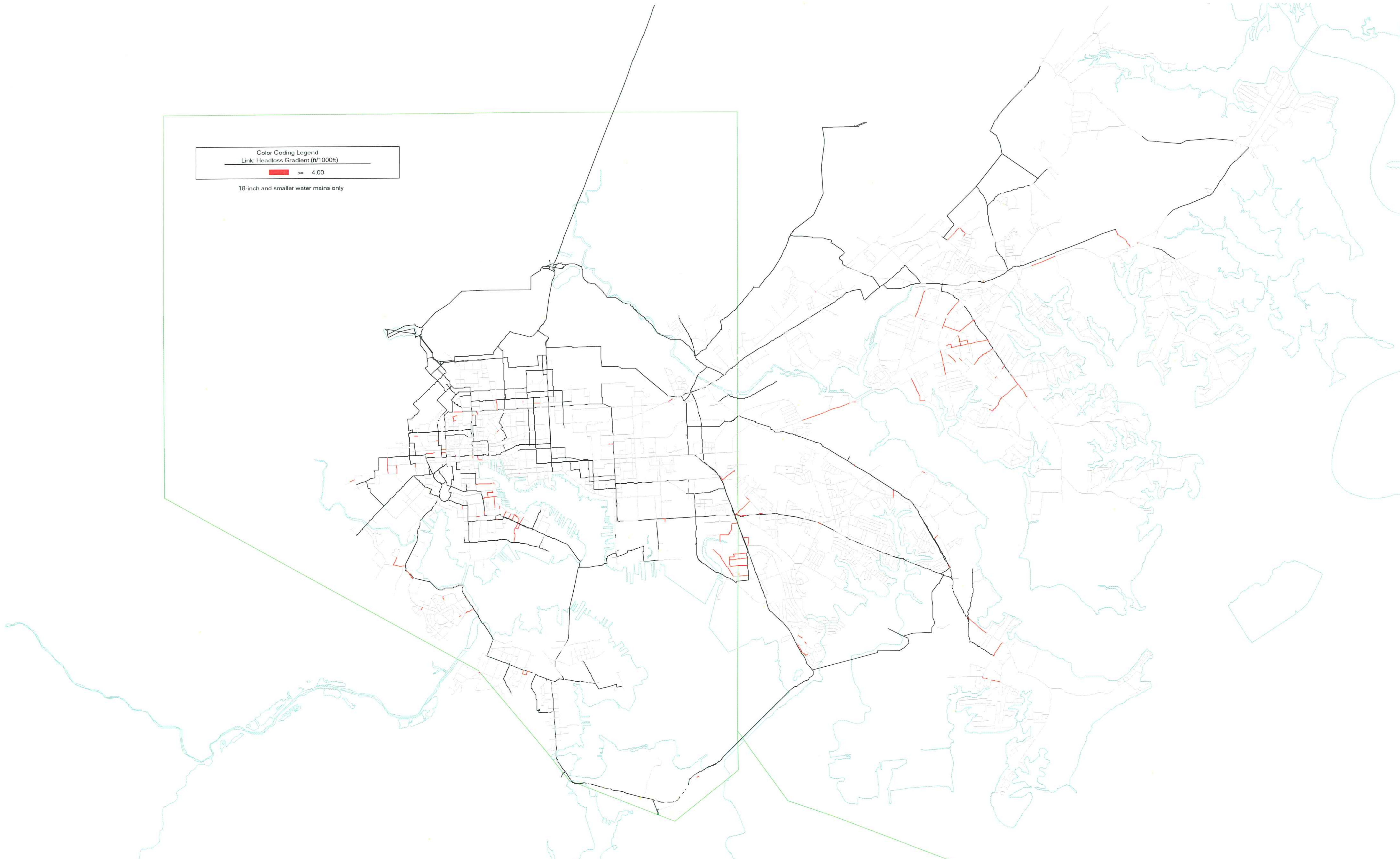
Scenario: Max Day 2000

Title: Zone 1 - all
c:\watercad\baltcity\zone1\1stanalysis.wcd
02/27/03 03:44:03 PM

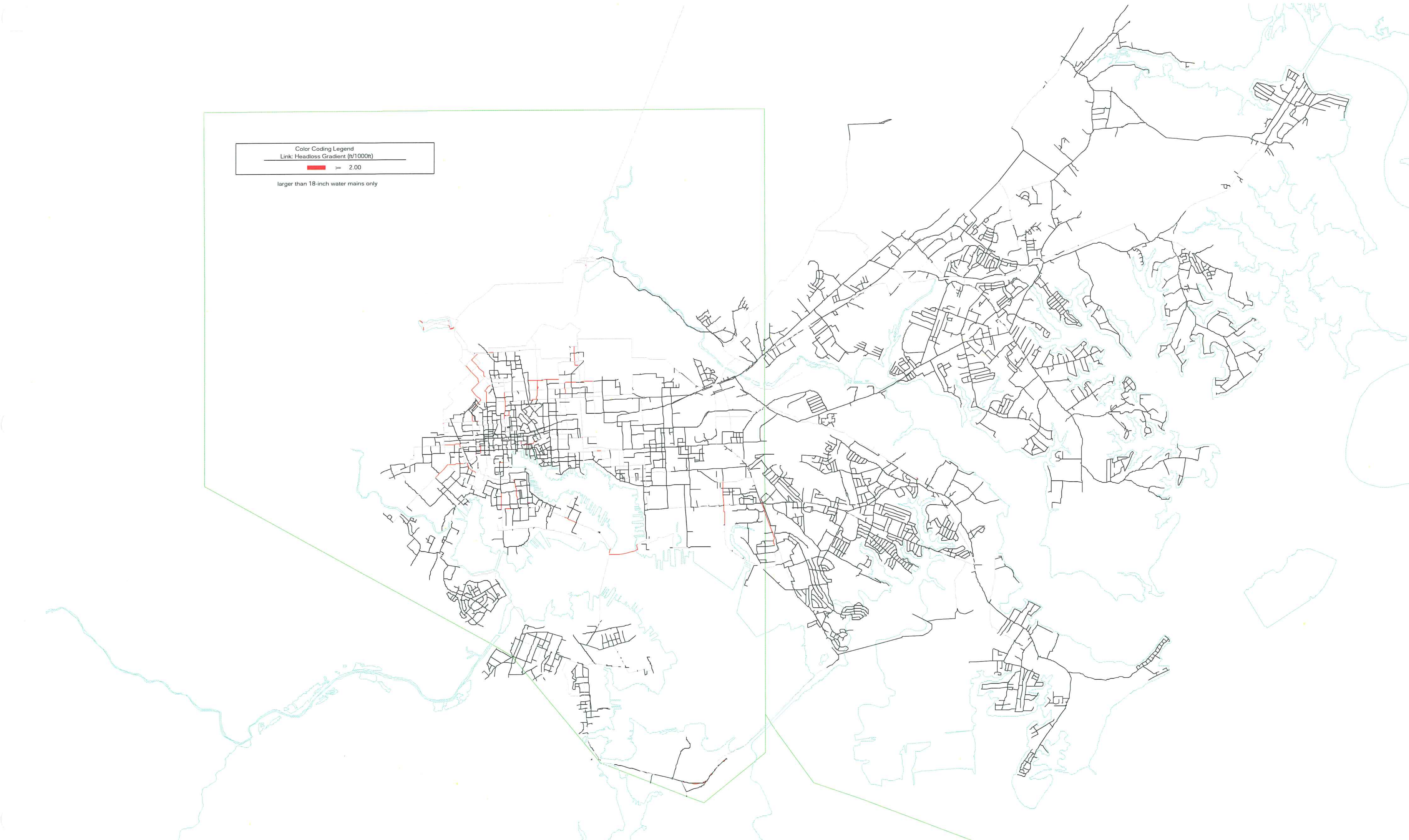
Rummel, Klepper & Kahl

Project Engineer: KK
WaterCAD v4.1 [424a]

Scenario: Max Day 2000



Scenario: Max Day 2025

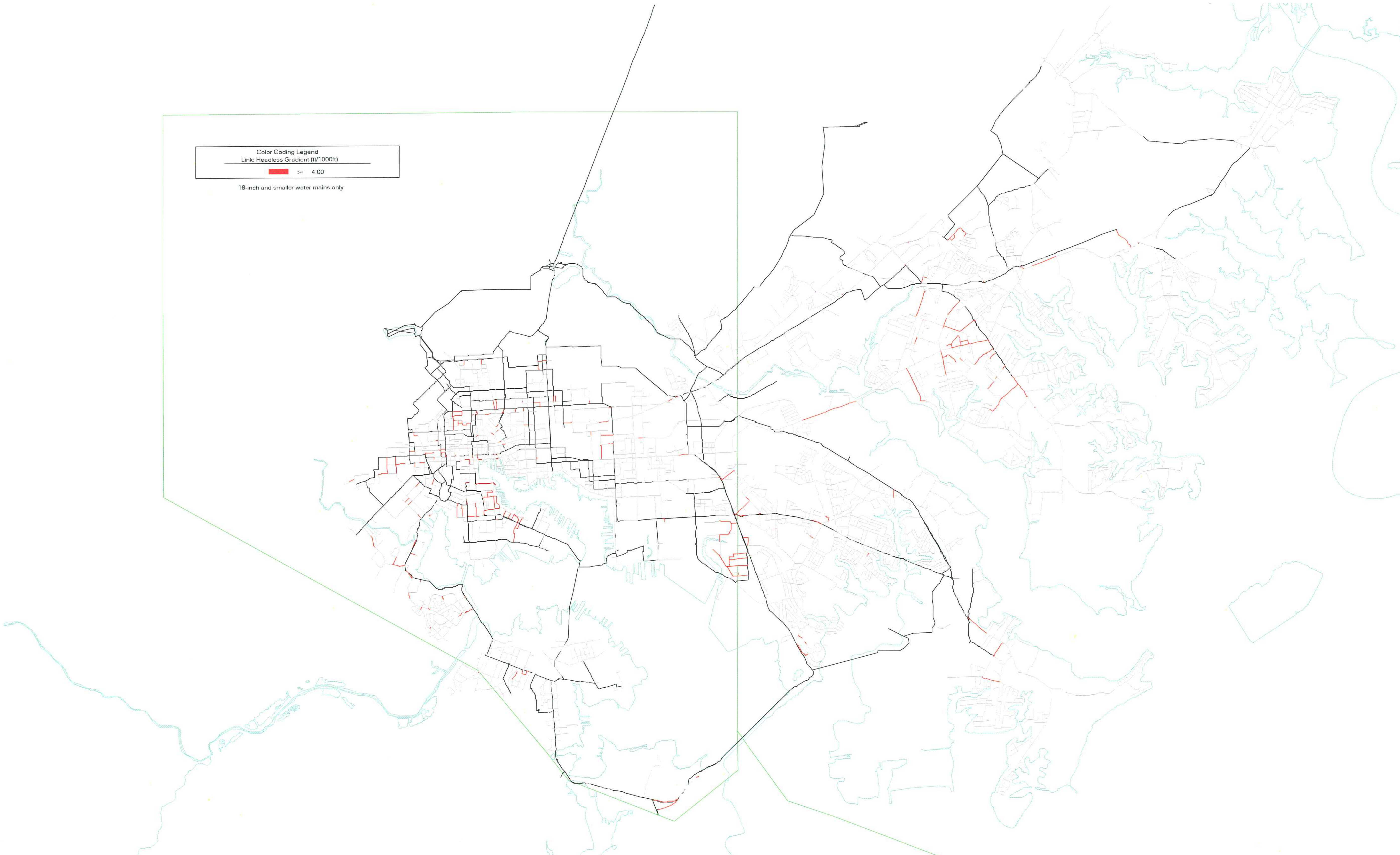


Title: Zone 1 - all
c:\watercad\baltcity\zone1\1stanalysis.wcd
02/27/03 03:43:40 PM

Rummel, Klepper & Kahl

Project Engineer: KK
WaterCAD v4.1 [424a]

Scenario: Max Day 2025

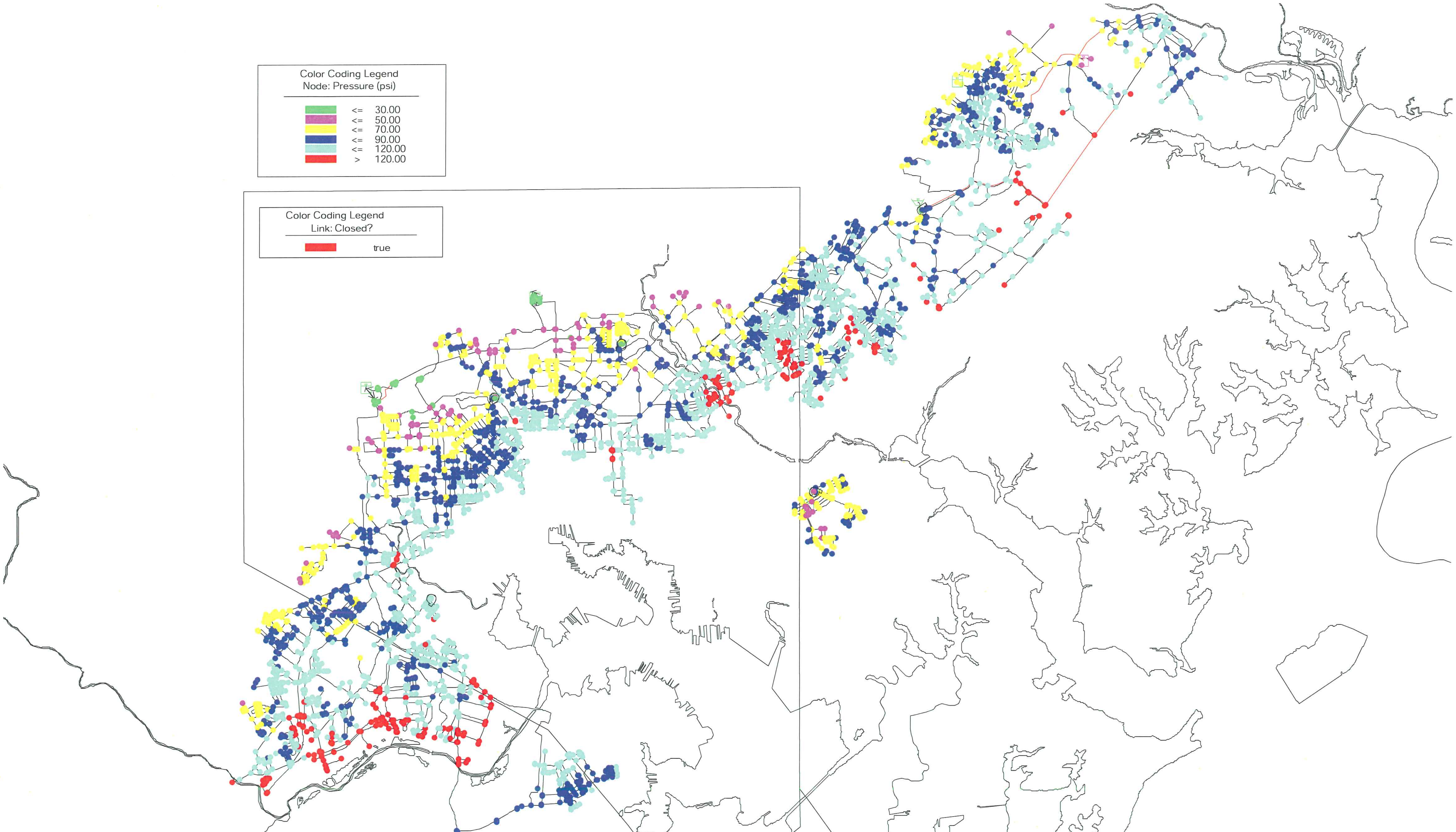


Title: Zone 1 - all
c:\watercad\baltcity\zone1\1stanalysis.wcd
02/27/03 03:41:36 PM

Rummel, Klepper & Kahl

Project Engineer: KK
WaterCAD v4.1 [424a]

Scenario: Avg Day 2000

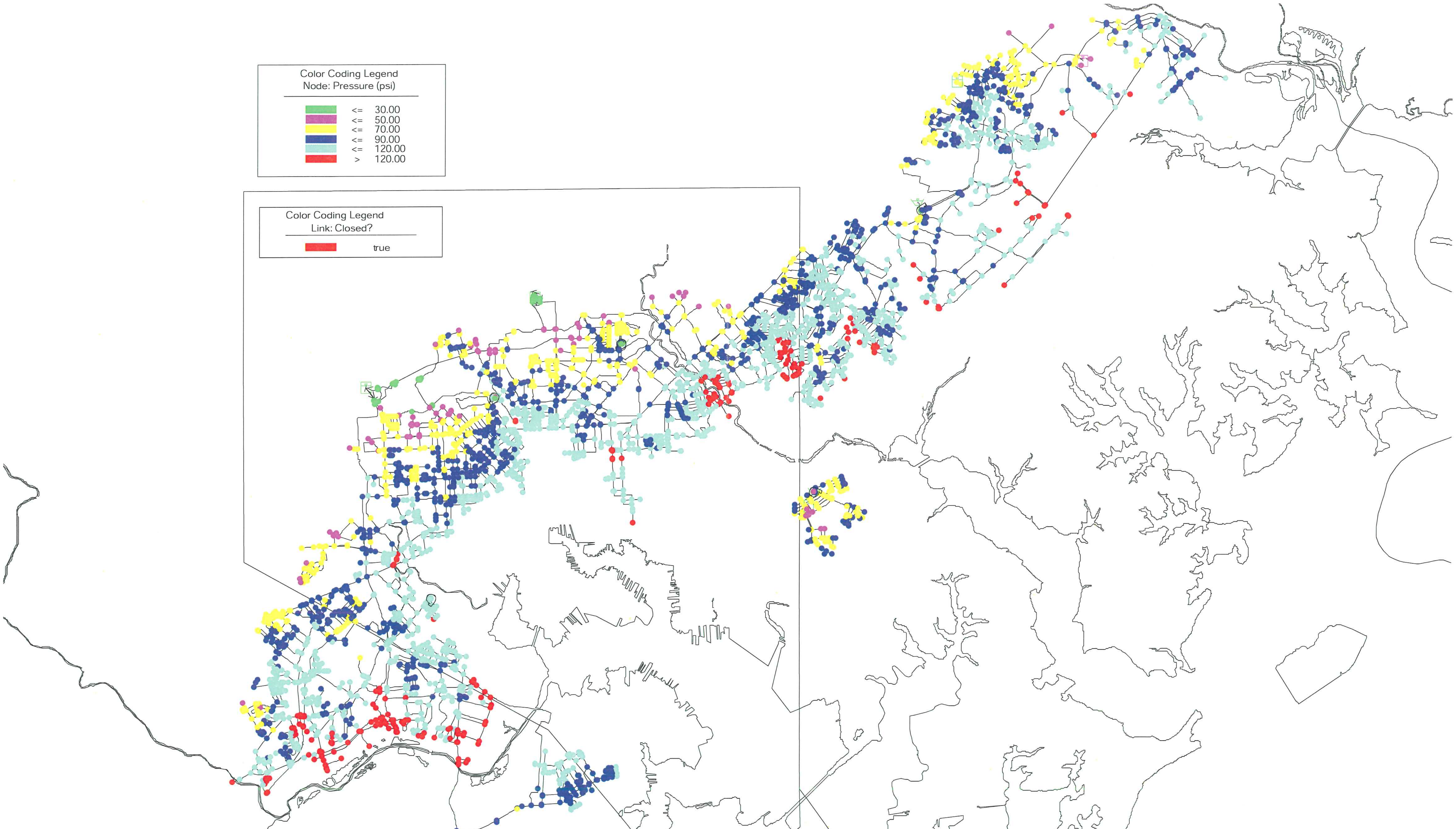


Title: Zone 2 - all
c:\watercad\baltcity\zone2\2ndanalysis.wcd
02/28/03 09:24:12 AM

Rummel, Klepper & Kahl

Project Engineer: KK
WaterCAD v4.1 [424a]

Scenario: Avg Day 2025

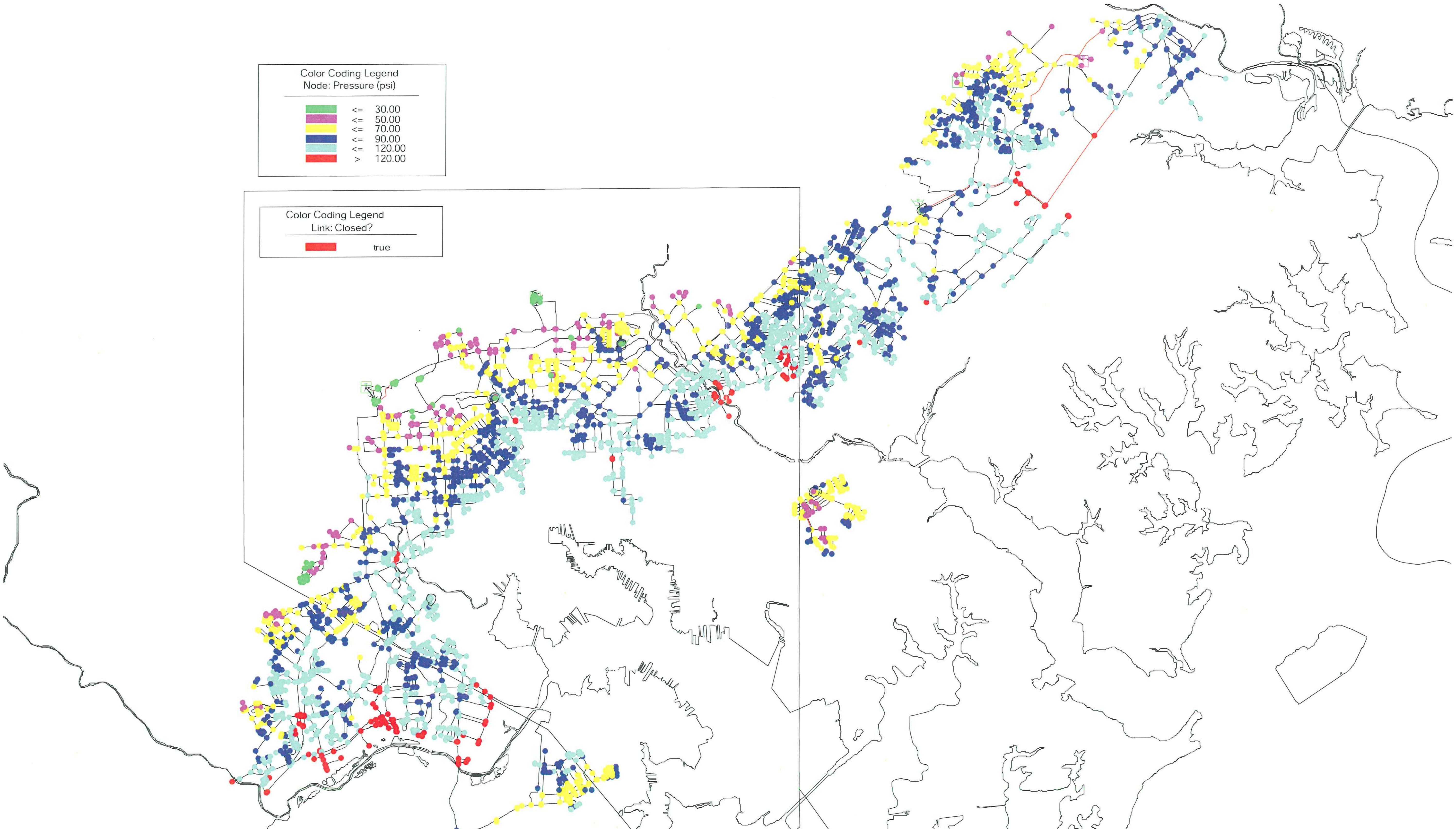


Title: Zone 2 - all
c:\watercad\baltcity\zone2\2ndanalysis.wcd
02/28/03 09:25:24 AM

Rummel, Klepper & Kahl
© Haestad Methods, Inc. 37 Brookside Road Waterbury, CT 06708 USA +1-203-755-1666

Project Engineer: KK
WaterCAD v4.1 [424a]
Page 1 of 1

Scenario: Max Day 2000

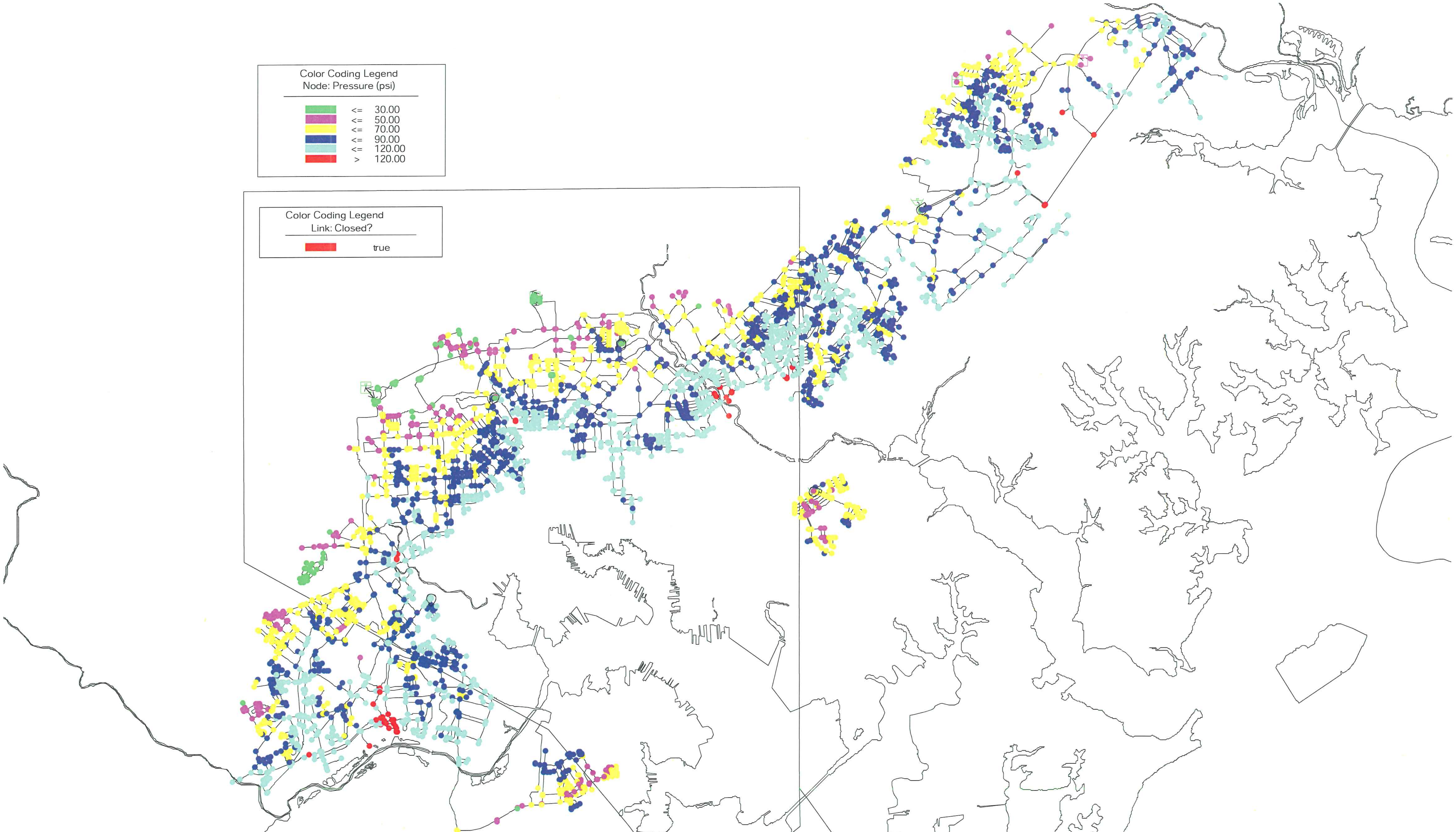


Title: Zone 2 - all
c:\watercad\baltcity\zone2\2ndanalysis.wcd
02/28/03 09:24:34 AM

Rummel, Klepper & Kahl

Project Engineer: KK
WaterCAD v4.1 [424a]

Scenario: Max Day 2025

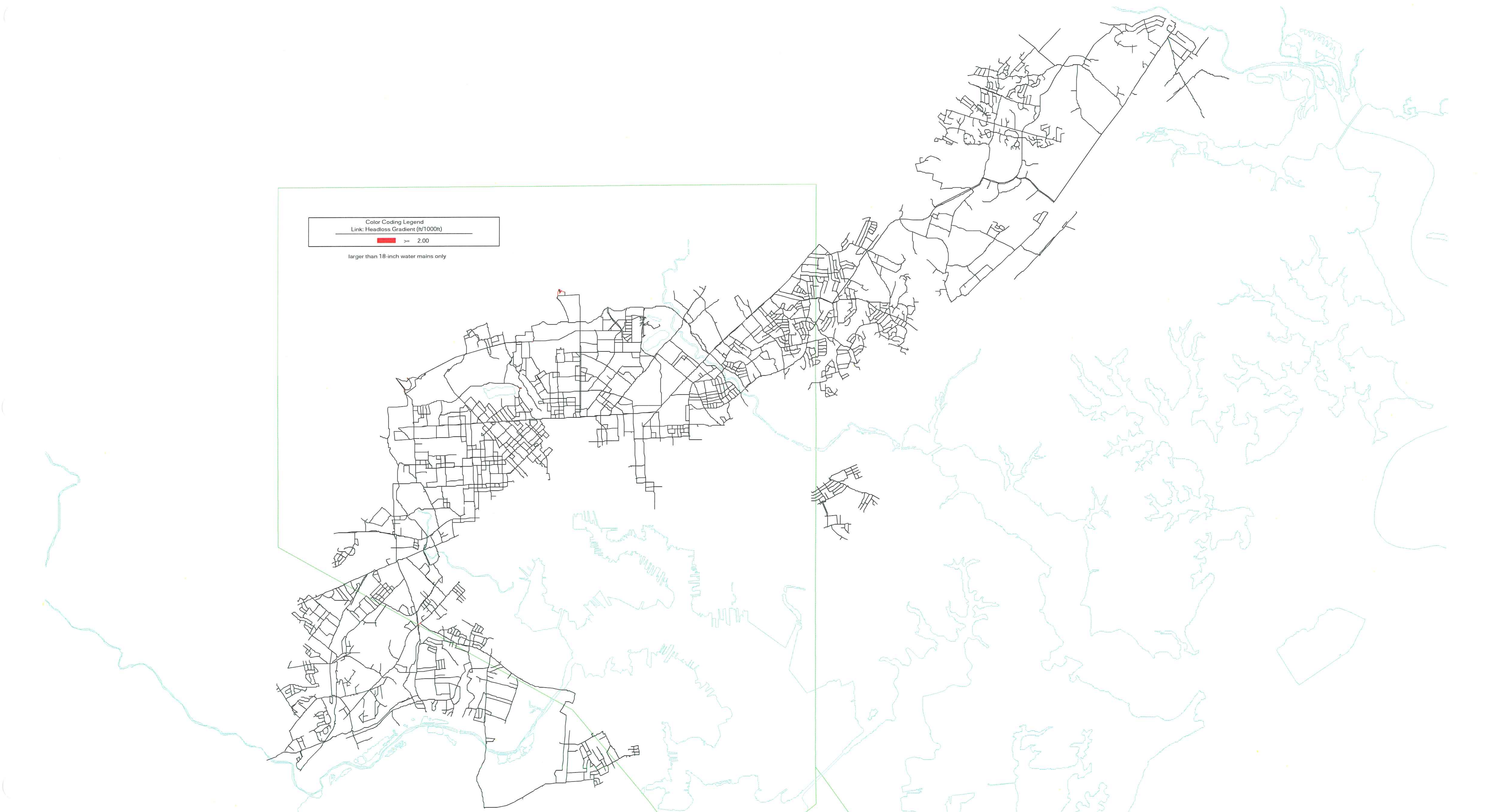


Title: Zone 2 - all
c:\watercad\baltcity\zone2\2ndanalysis.wcd
02/28/03 09:25:05 AM

Rummel, Klepper & Kahl

Project Engineer: KK
WaterCAD v4.1 [424a]

Scenario: Avg Day 2000

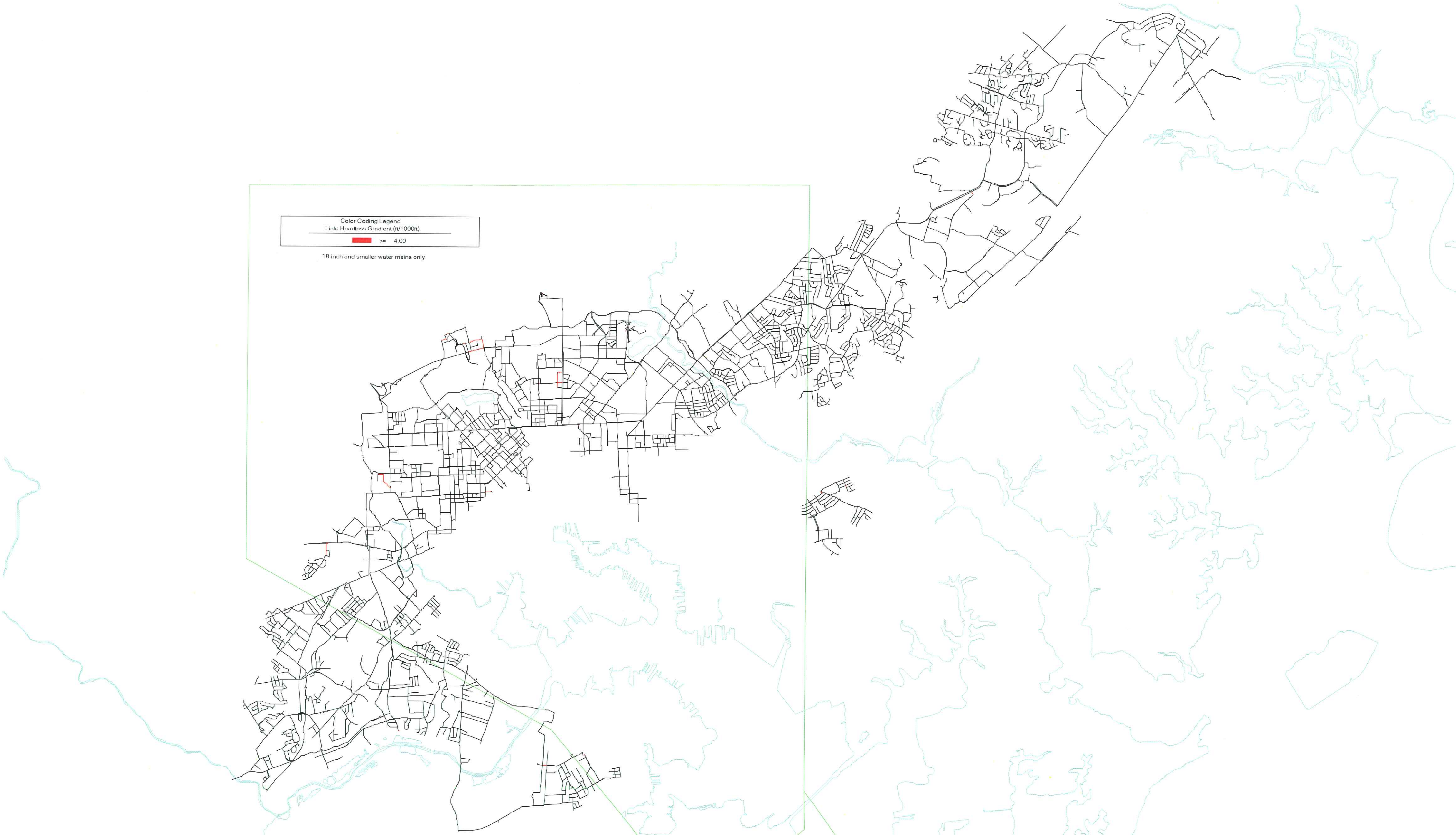


Title: Zone 2 - all
c:\watercad\baltcity\zone2\2ndanalysis.wcd
02/28/03 09:23:00 AM

Rummel, Klepper & Kahl

Project Engineer: KK
WaterCAD v4.1 [424a]

Scenario: Avg Day 2000



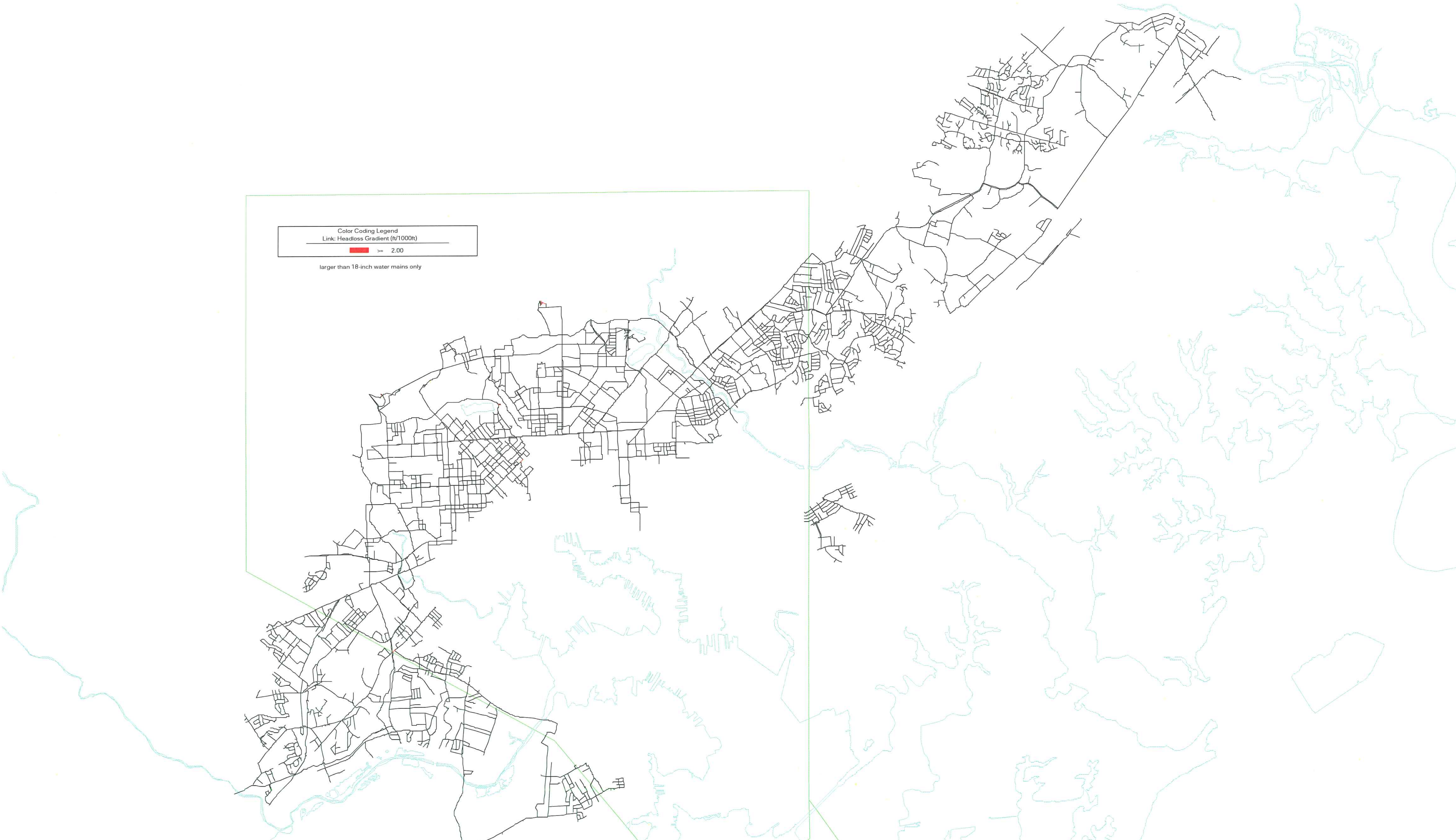
Title: Zone 2 - all
c:\watercad\baltcity\zone2\2ndanalysis.wcd
02/28/03 09:20:20 AM

Rummel, Klepper & Kahl

© Haestad Methods, Inc. 37 Brookside Road Waterbury, CT 06708 USA +1-203-755-1666

Project Engineer: KK
WaterCAD v4.1 [424a]
Page 1 of 1

Scenario: Avg Day 2025

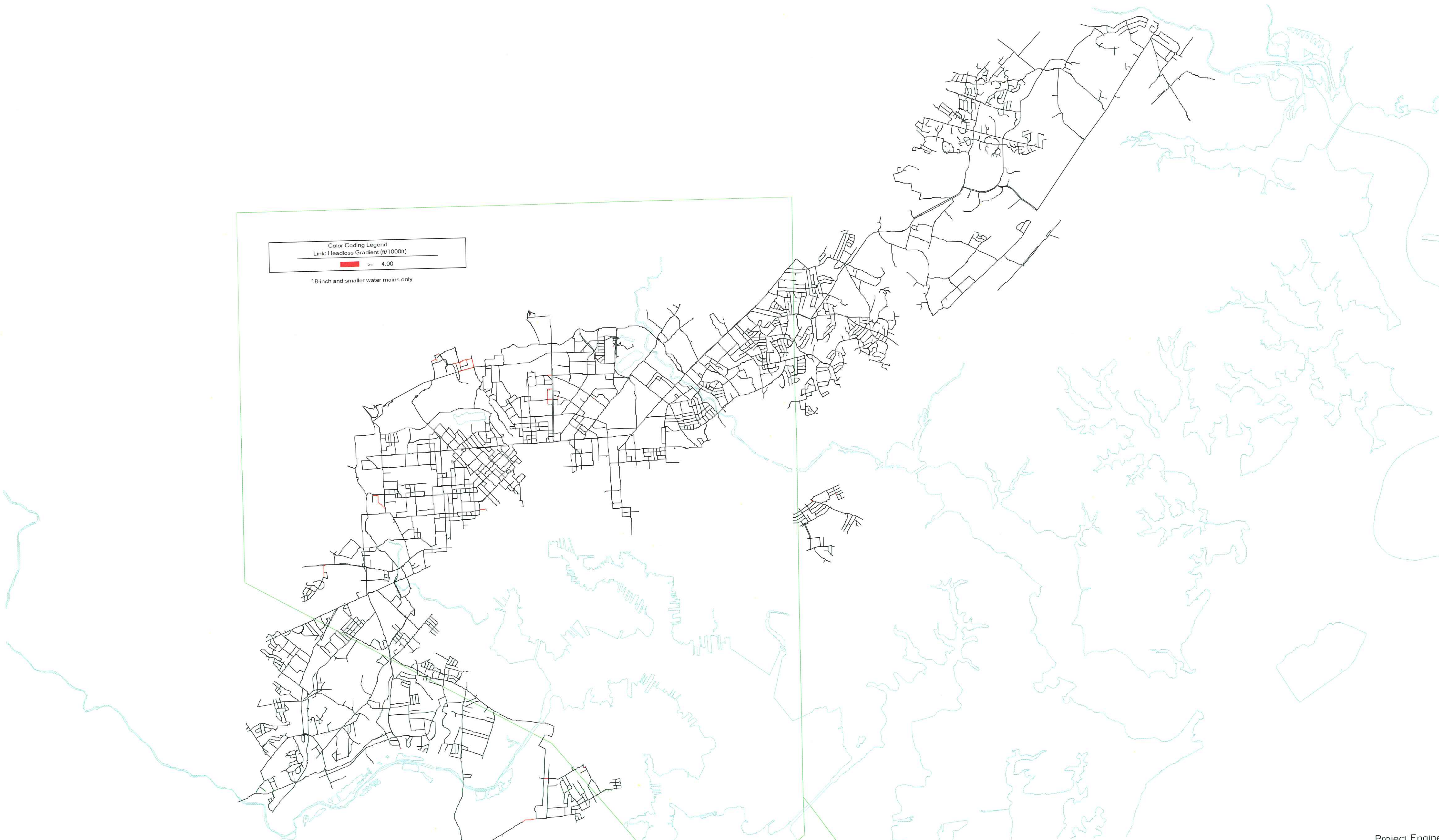


Title: Zone 2 - all
c:\watercad\baltcity\zone2\2ndanalysis.wcd
02/28/03 09:21:58 AM

Rummel, Klepper & Kahl

Project Engineer: KK
WaterCAD v4.1 [424a]

Scenario: Avg Day 2025

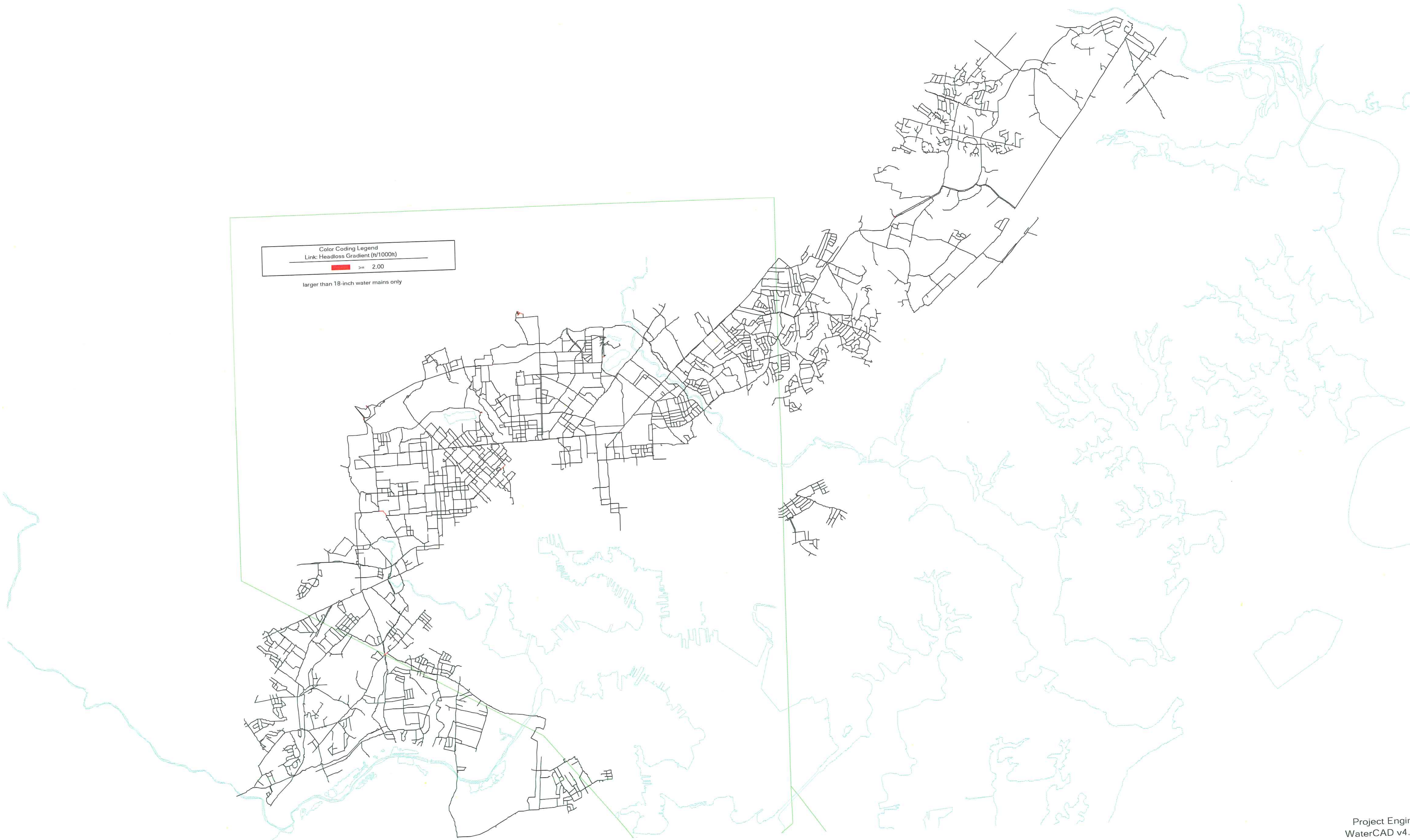


Title: Zone 2 - all
c:\watercad\baltcity\zone2\2ndanalysis.wcd
02/28/03 09:21:04 AM

Rummel, Klepper & Kahl

Project Engineer: KK
WaterCAD v4.1 [424a]

Scenario: Max Day 2000

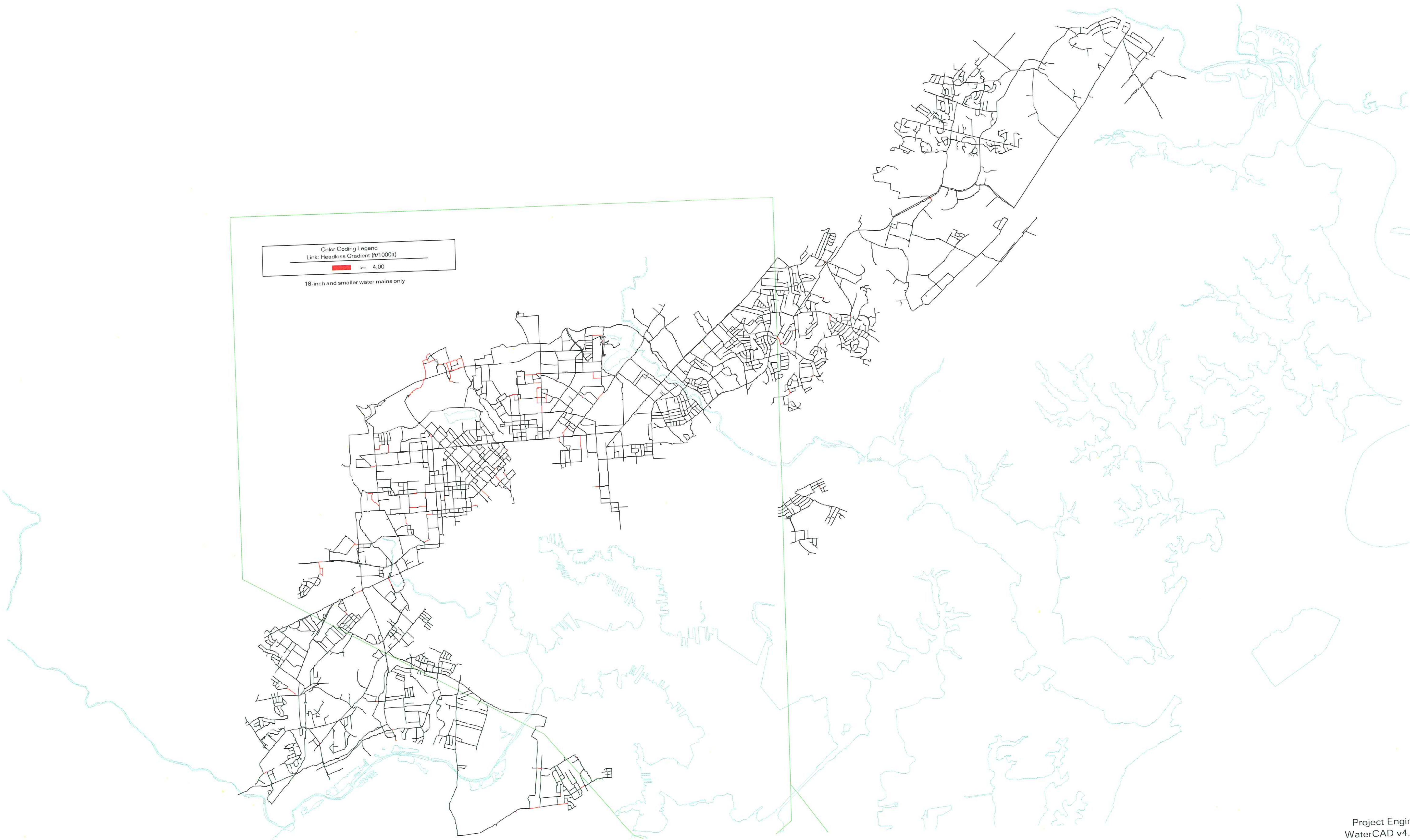


Title: Zone 2 - all
c:\watercad\baltcity\zone2\2ndanalysis.wcd
02/28/03 09:22:39 AM

Rummel, Klepper & Kahl

Project Engineer: KK
WaterCAD v4.1 [424a]

Scenario: Max Day 2000

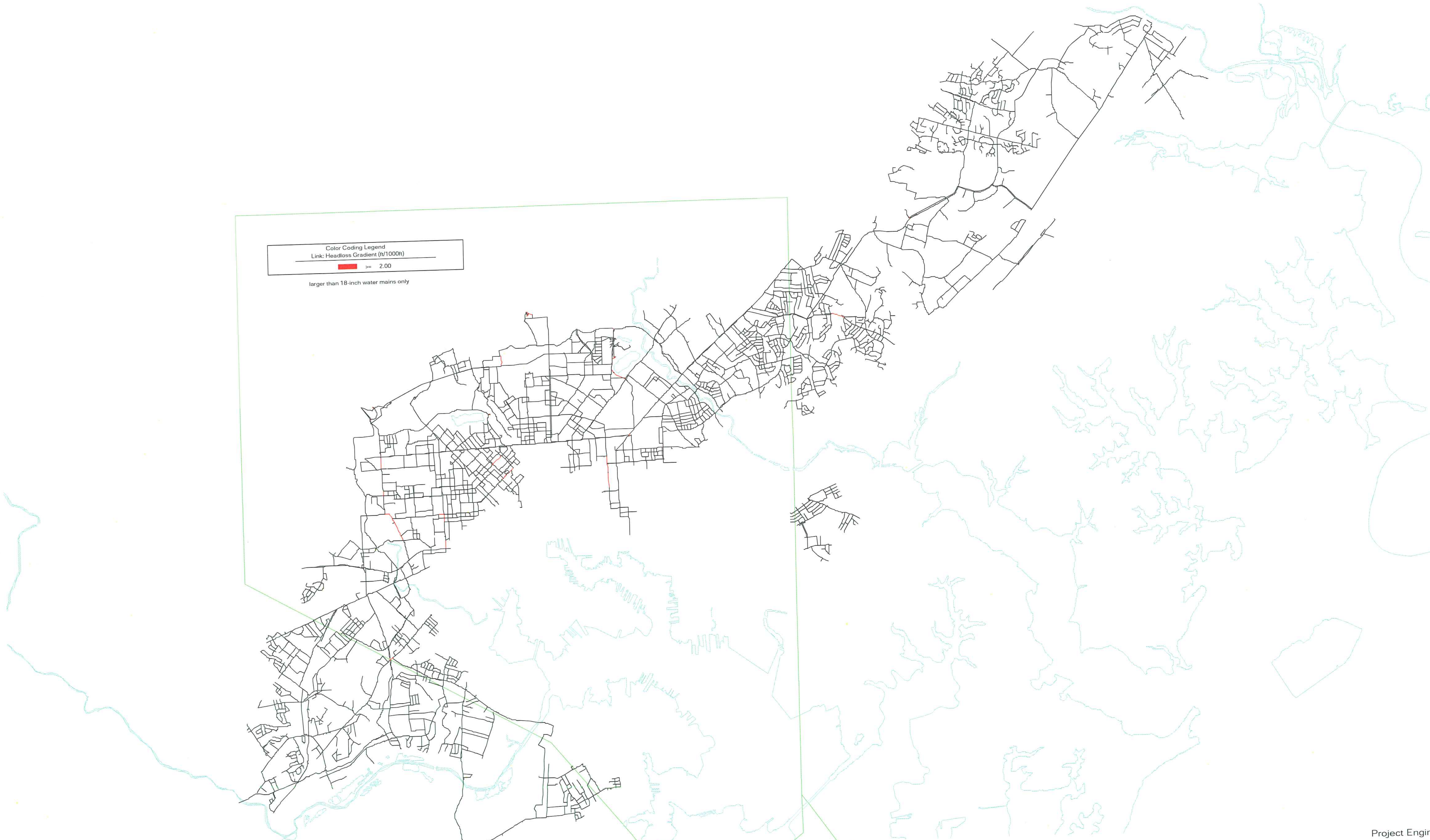


Project Engineer: KK
WaterCAD v4.1 [424a]
Page 1 of 1

Title: Zone 2 - all
c:\watercad\baltcity\zone2\2ndanalysis.wcd
02/28/03 09:19:52 AM

Rummel, Klepper & Kahl

Scenario: Max Day 2025

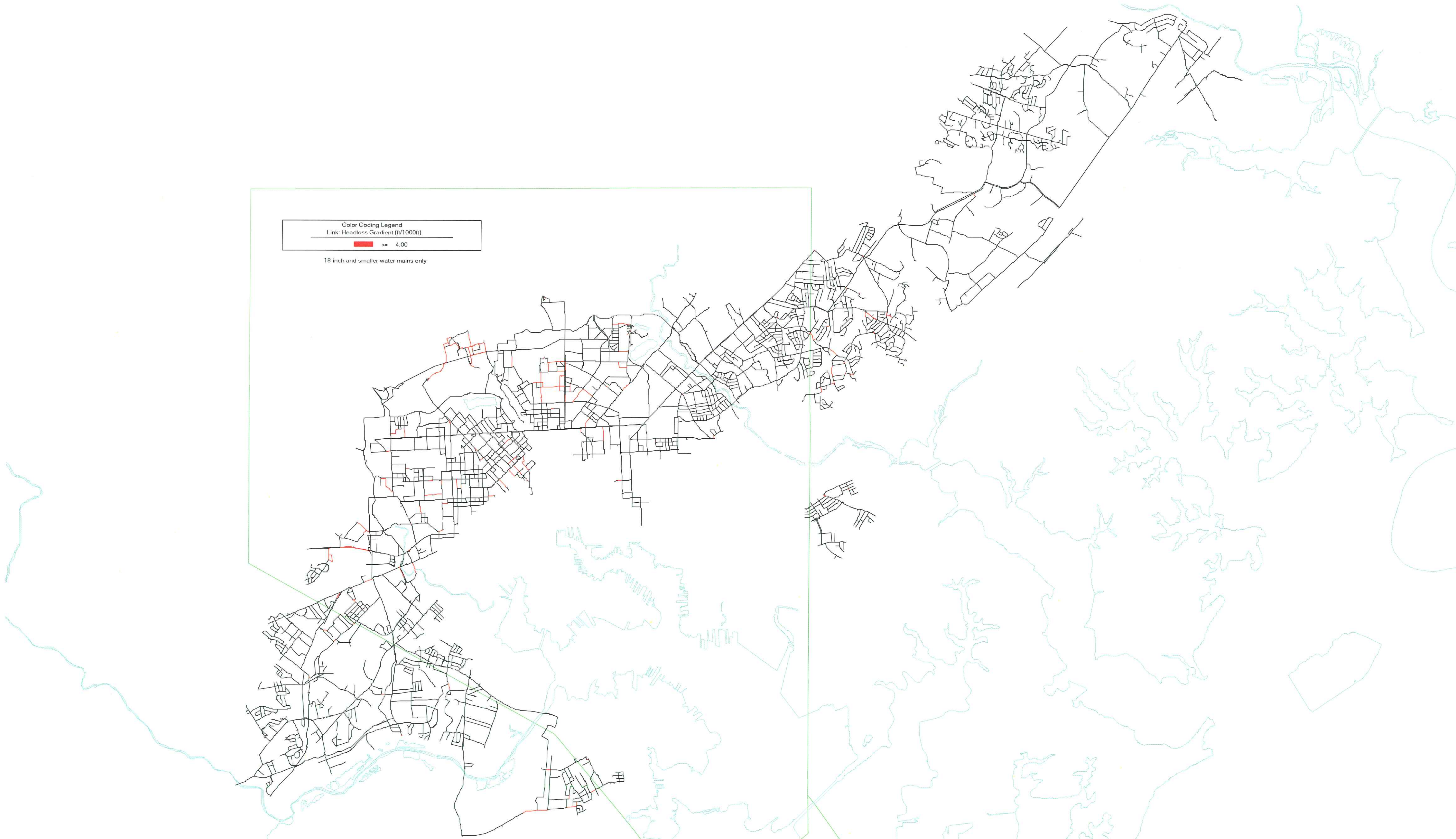


Project Engineer: KK
WaterCAD v4.1 [424a]
Page 1 of 1

Title: Zone 2 - all
c:\watercad\baltcity\zone2\2ndanalysis.wcd
02/28/03 09:22:19 AM

Rummel, Klepper & Kahl

Scenario: Max Day 2025

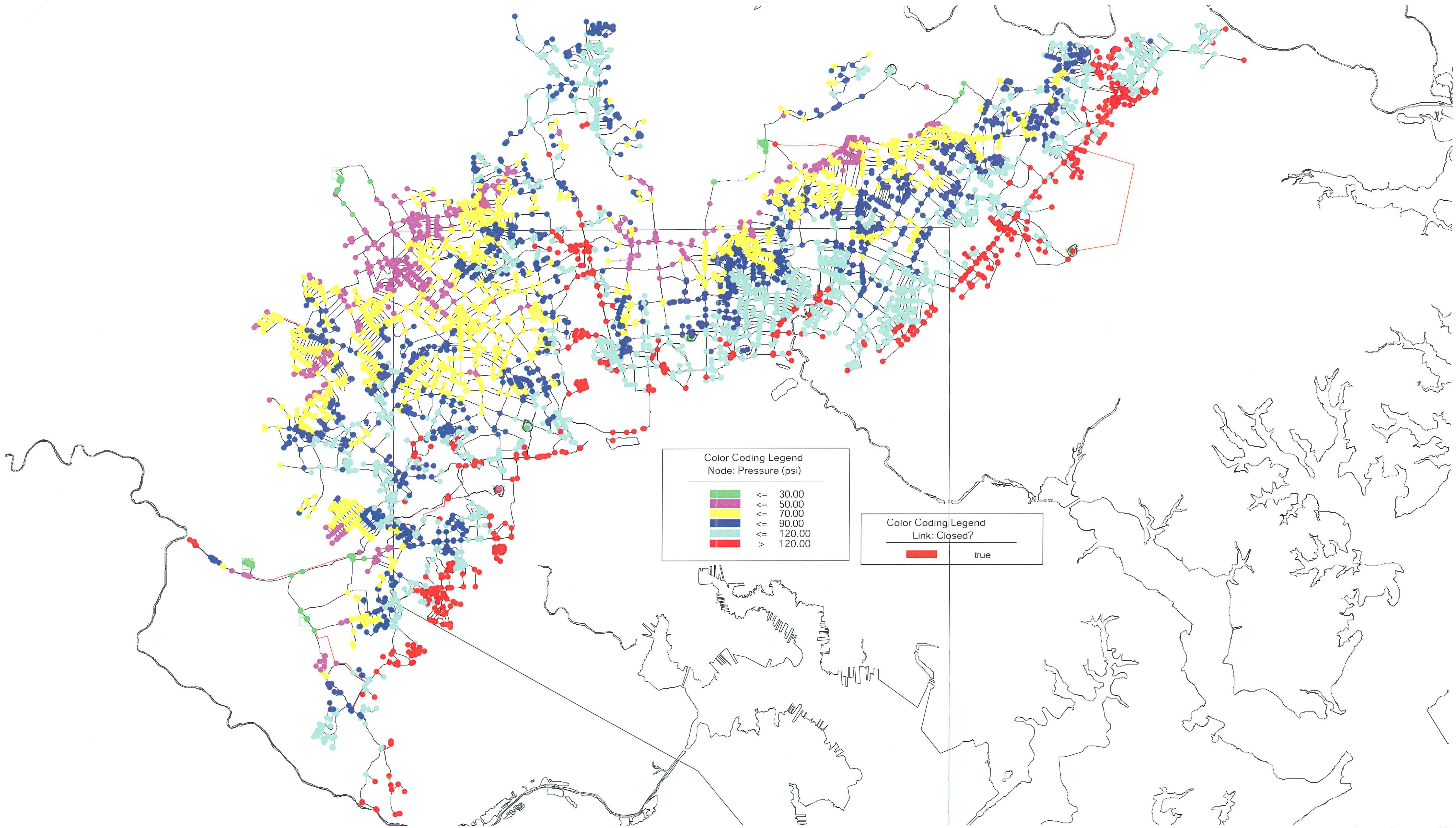


Title: Zone 2 - all
c:\watercad\baltcity\zone2\2ndanalysis.wcd
02/28/03 09:20:44 AM

Rummel, Klepper & Kahl

Project Engineer: KK
WaterCAD v4.1 [424a]

Scenario: Avg Day 2000

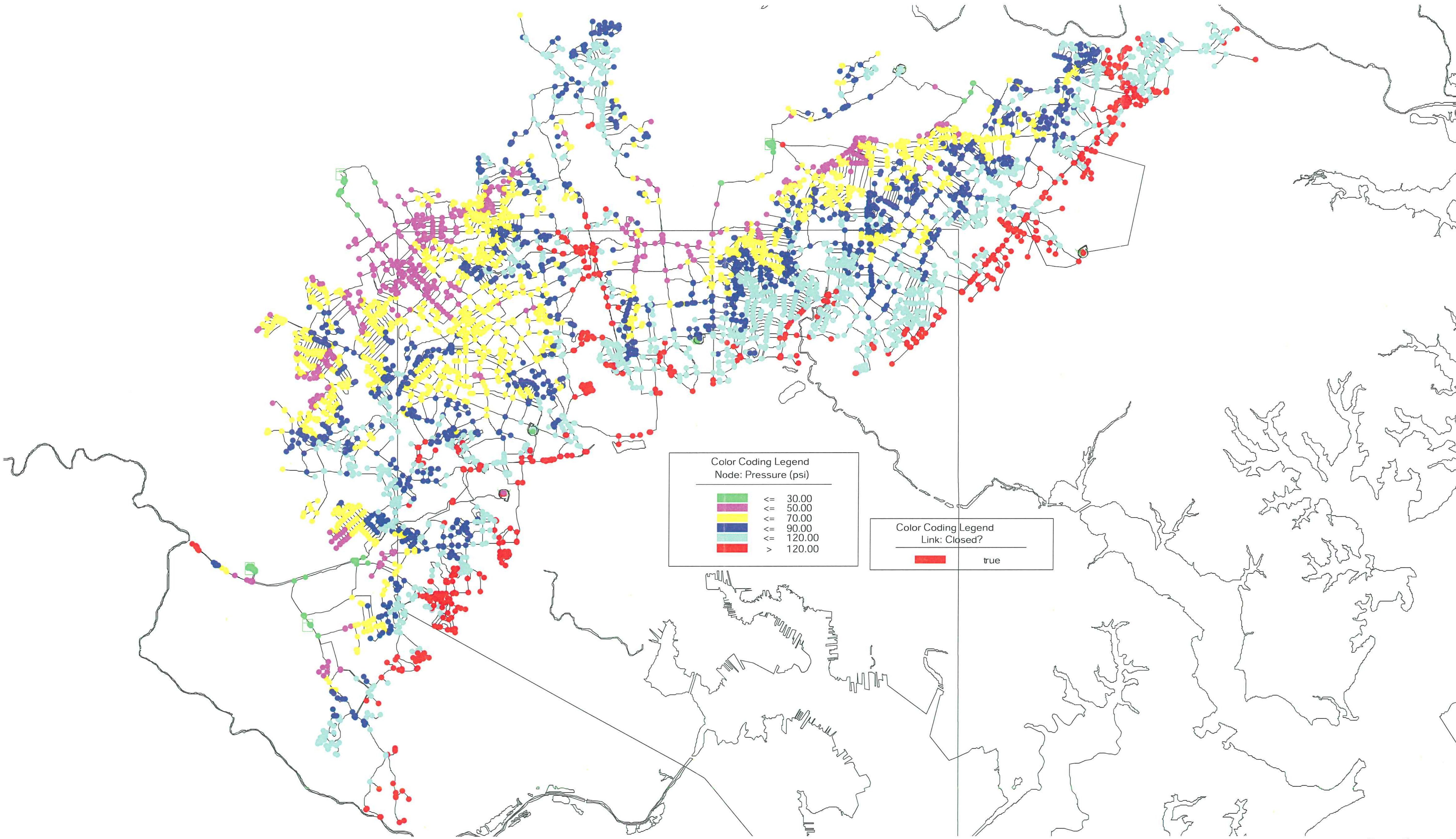


Title: Zone 3 - all
c:\watercad\baltcity\zone3\3rdanalysis.wcd
02/28/03 09:58:23 AM

Rummel, Klepper & Kahl

Project Engineer: KK
WaterCAD v4.1 [424a]

Scenario: Avg Day 2025

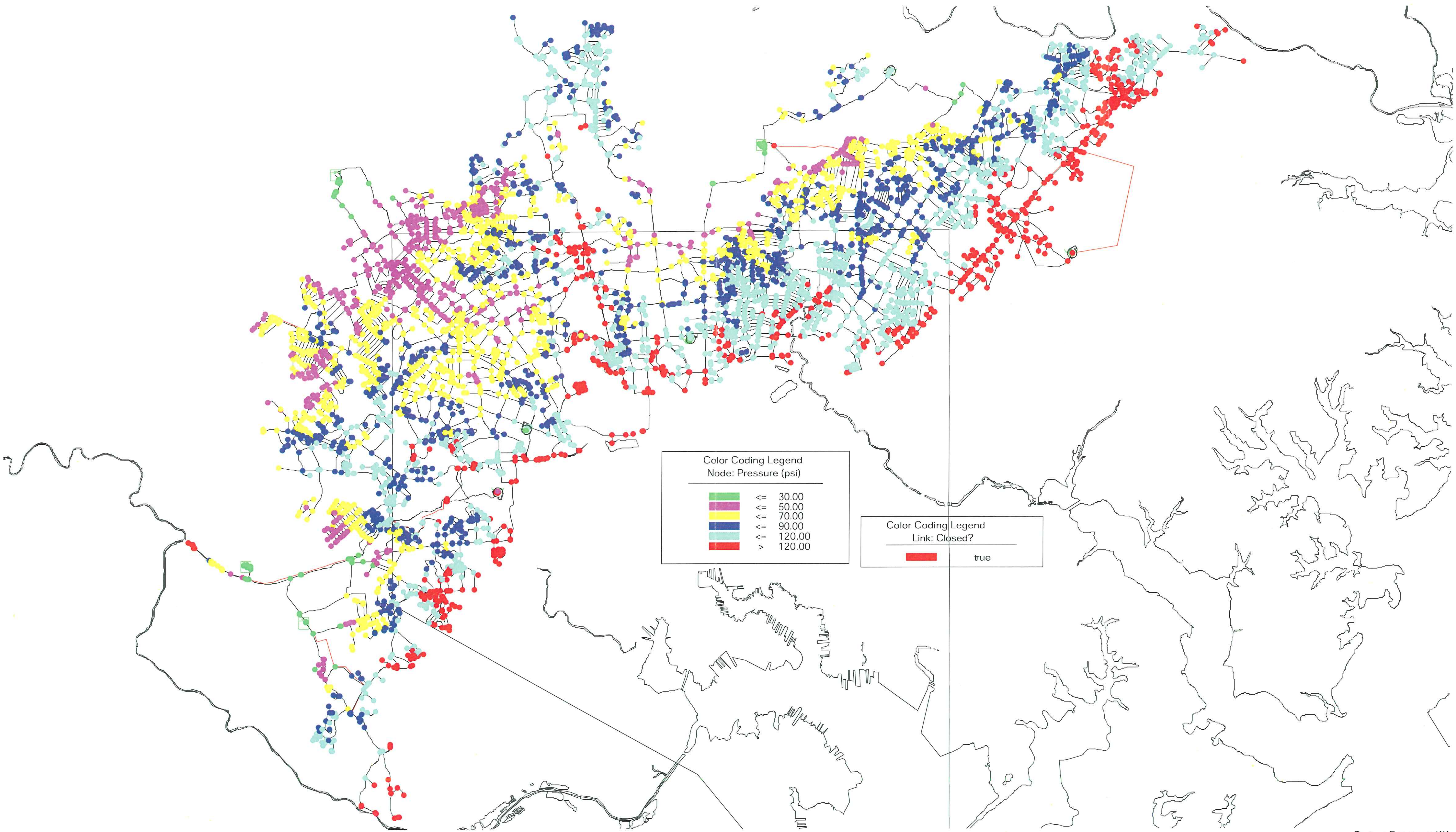


Title: Zone 3 - all
c:\watercad\baltcity\zone3\3rdanalysis.wcd
02/28/03 09:56:30 AM

Rummel, Klepper & Kahl

Project Engineer: KK
WaterCAD v4.1 [424a]

Scenario: Max Day 2000

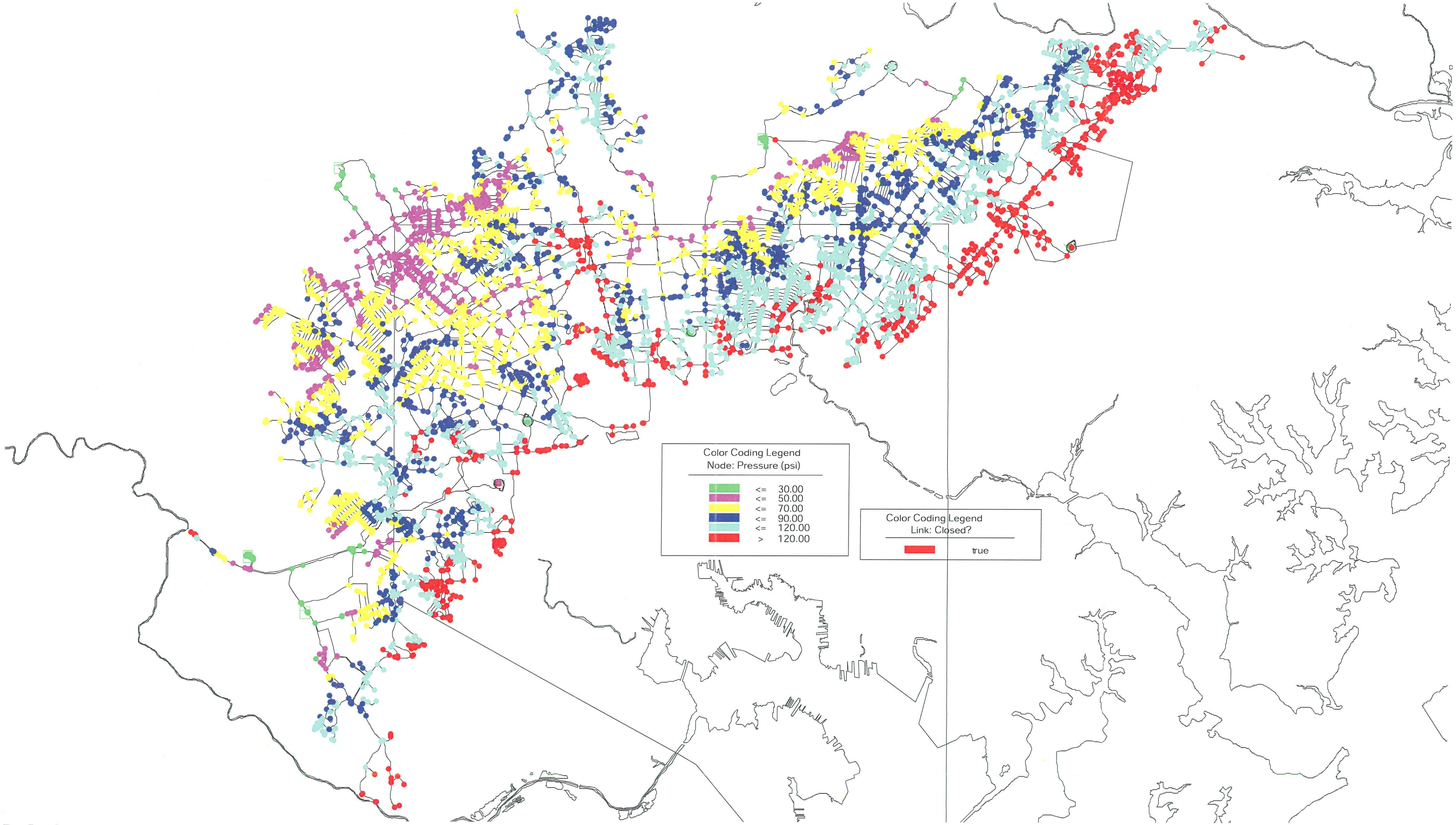


Title: Zone 3 - all
c:\watercad\baltcity\zone3\3rdanalysis.wcd
02/28/03 09:57:59 AM

Rummel, Klepper & Kahl

Project Engineer: KK
WaterCAD v4.1 [424a]

Scenario: Max Day 2025

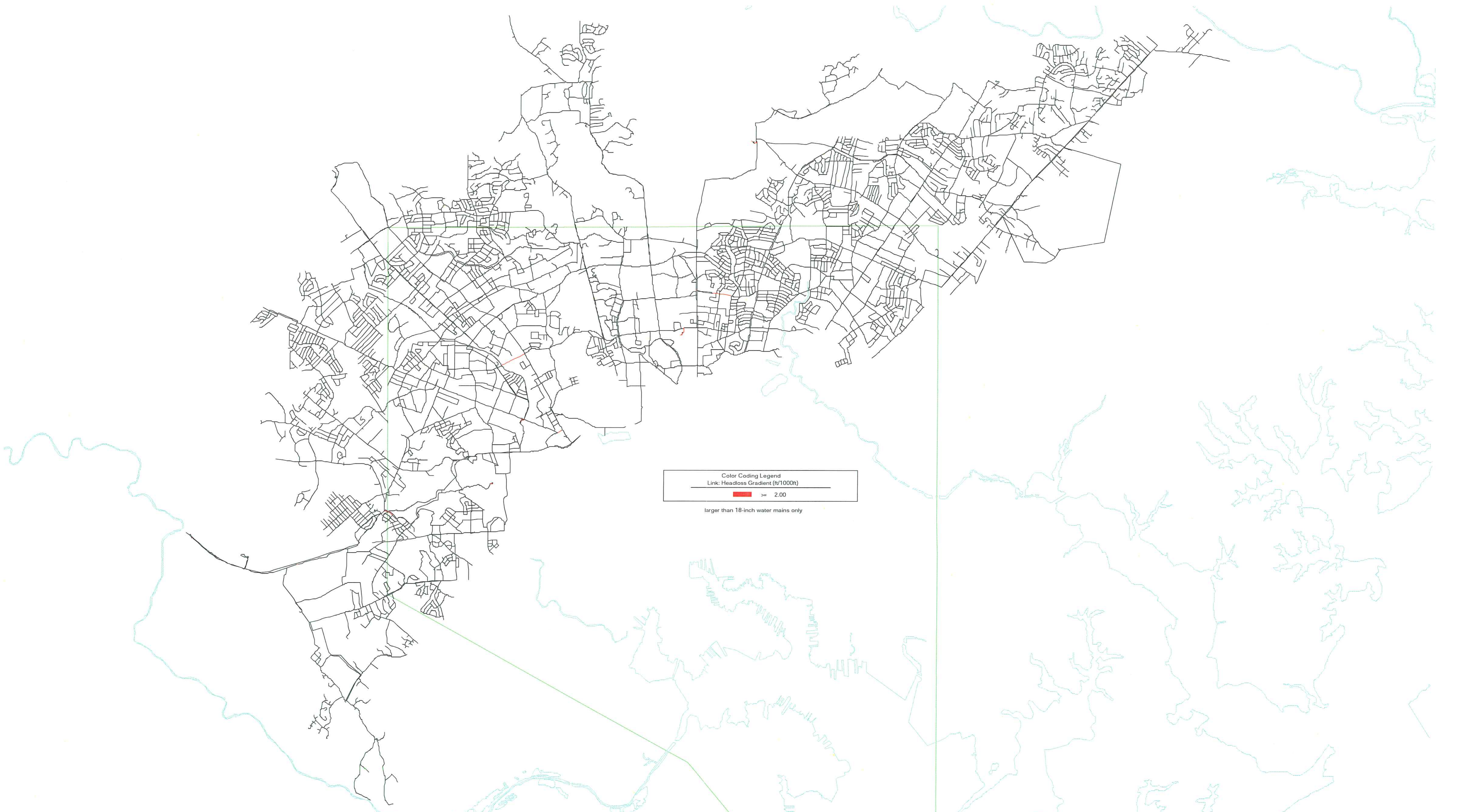


Title: Zone 3 - all
c:\watercad\baltcity\zone3\3rdanalysis.wcd
02/28/03 09:57:39 AM

Rummel, Klepper & Kahl

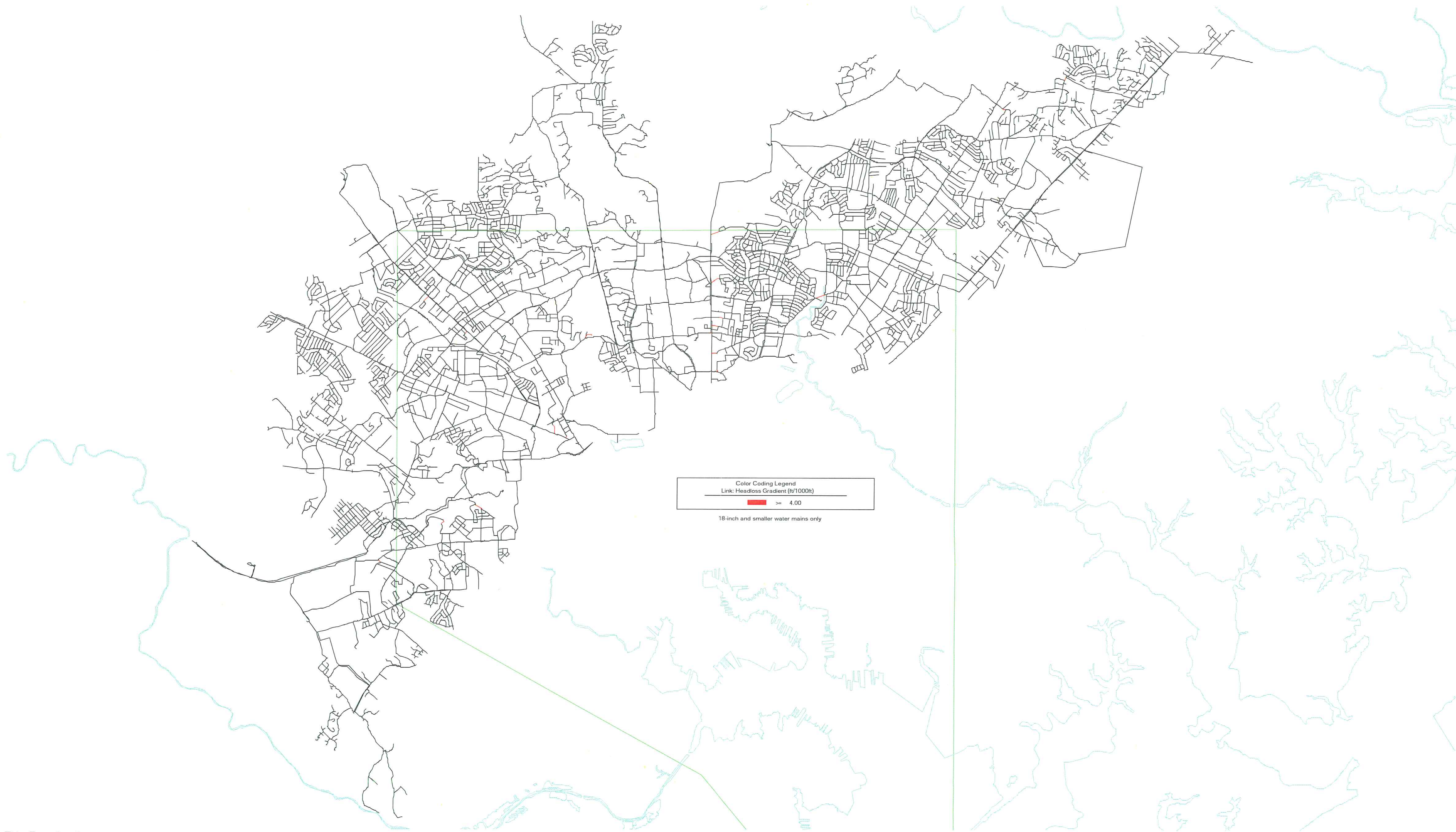
Project Engineer: KK
WaterCAD v4.1 [424a]

Scenario: Avg Day 2000



Title: Zone 3 - all
c:\watercad\baltcity\zone3\3rdanalysis.wcd
02/28/03 09:59:52 AM

Scenario: Avg Day 2000

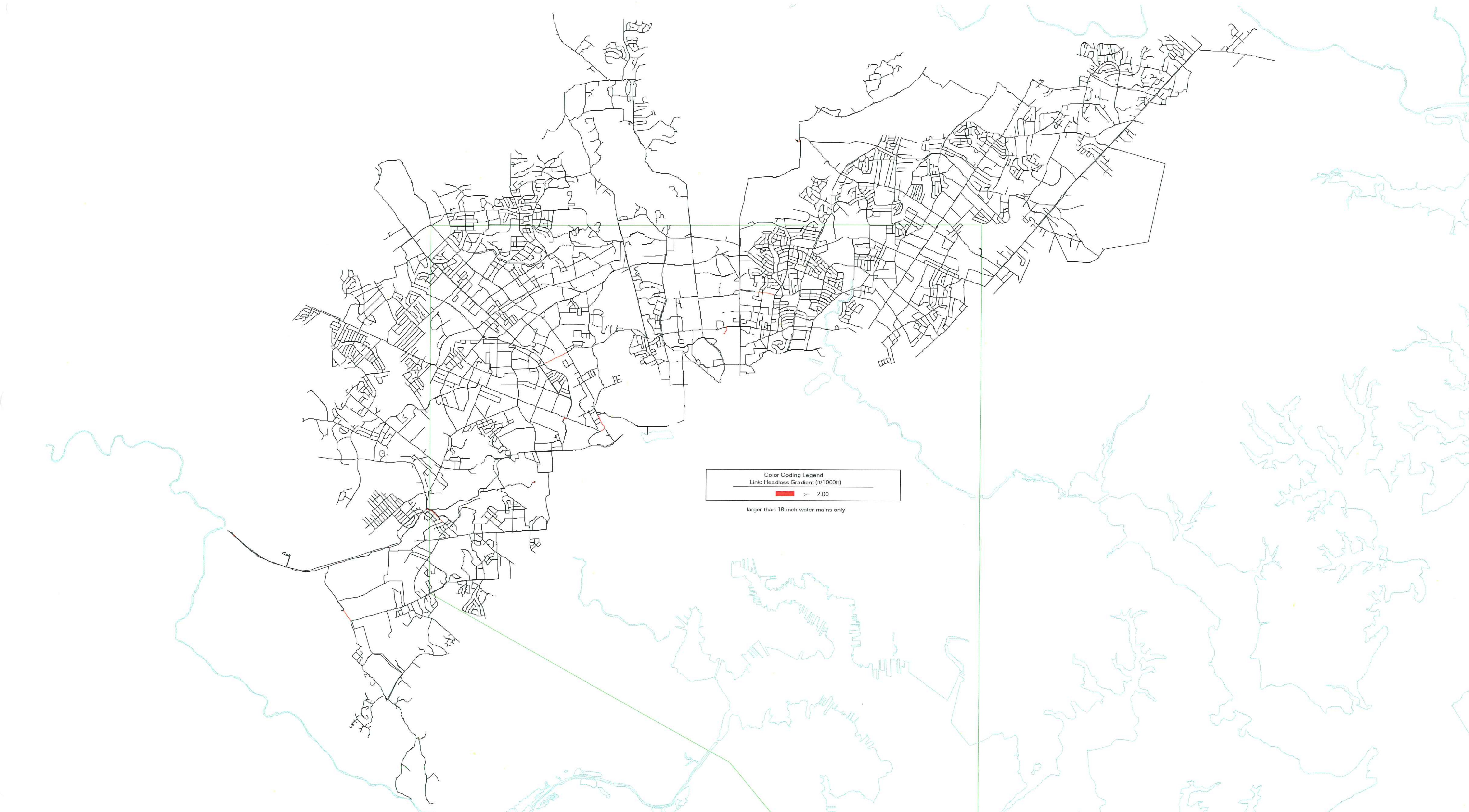


Title: Zone 3 - all
c:\watercad\baltcity\zone3\3rdanalysis.wcd
02/28/03 10:06:17 AM

Rummel, Klepper & Kahl

Project Engineer: KK
WatersCAD v4.1 [424a]

Scenario: Avg Day 2025

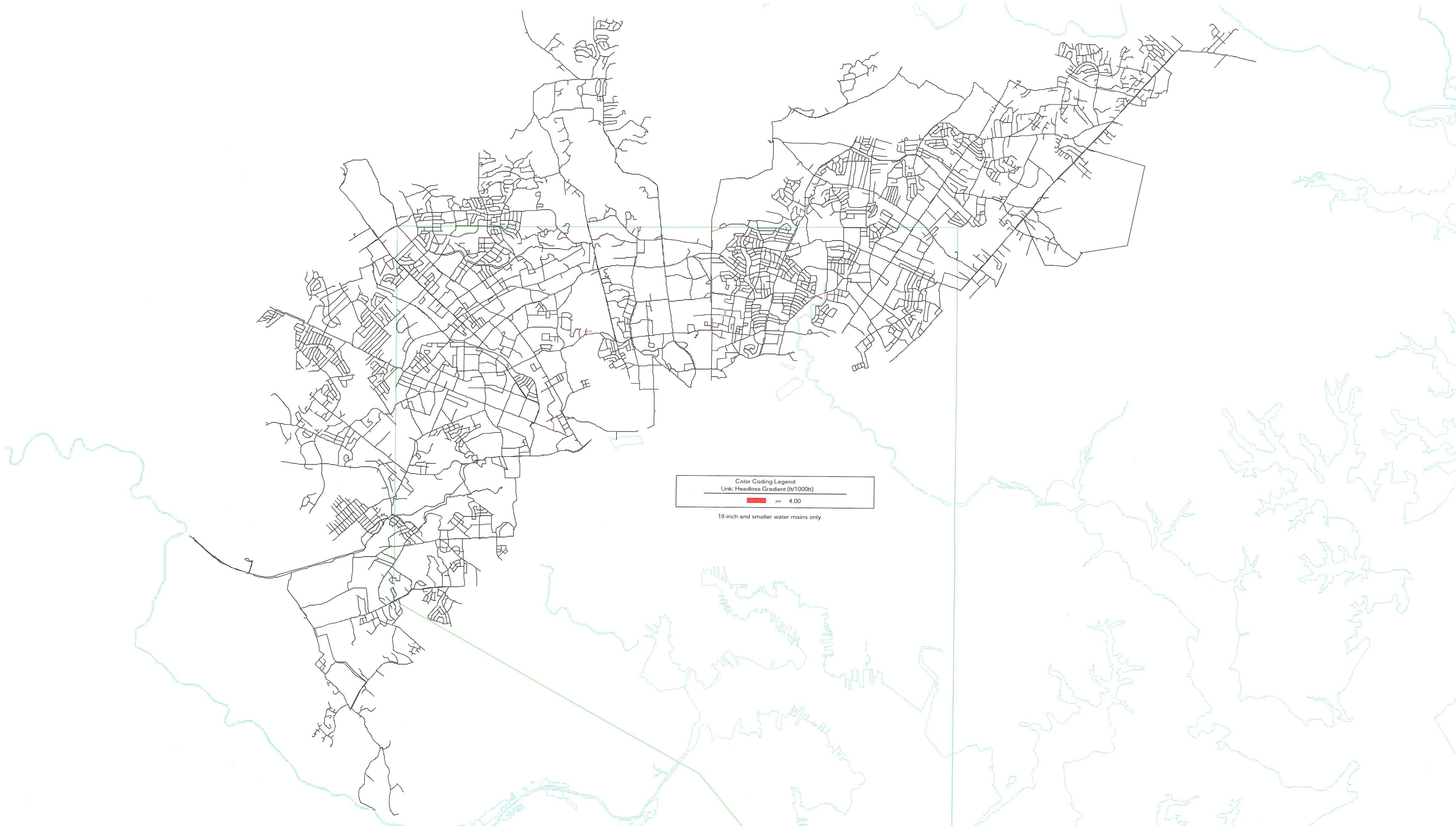


Title: Zone 3 - all
c:\watercad\baltcity\zone3\3rdanalysis.wcd
02/28/03 10:01:16 AM

Rummel, Klepper & Kahl

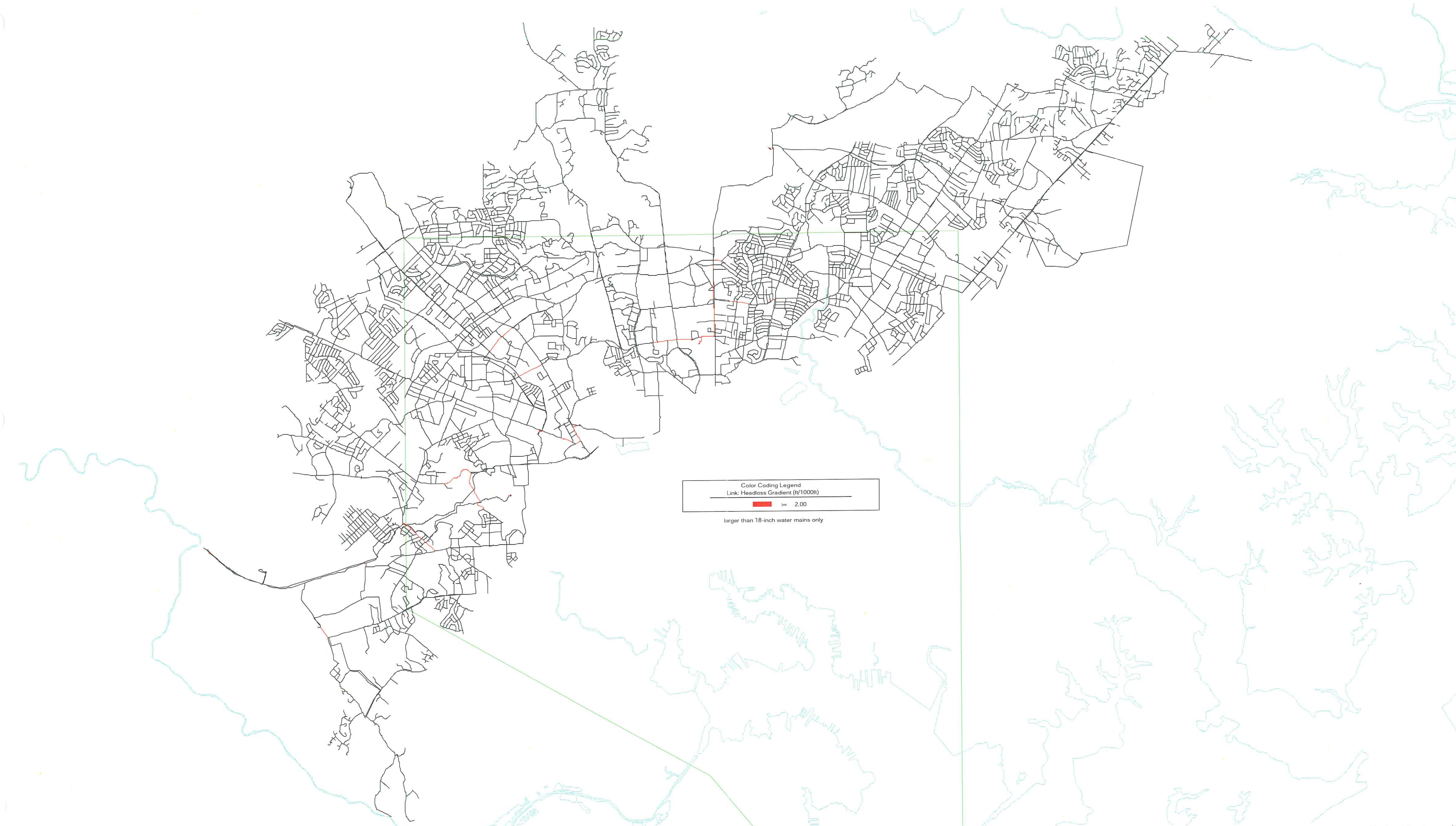
Project Engineer: KK
WaterCAD v4.1 [424a]

Scenario: Avg Day 2025



Title: Zone 3 - all
c:\watercad\baltcity\zone3\3rdanalysis.wcd
02/28/03 10:04:49 AM

Scenario: Max Day 2000

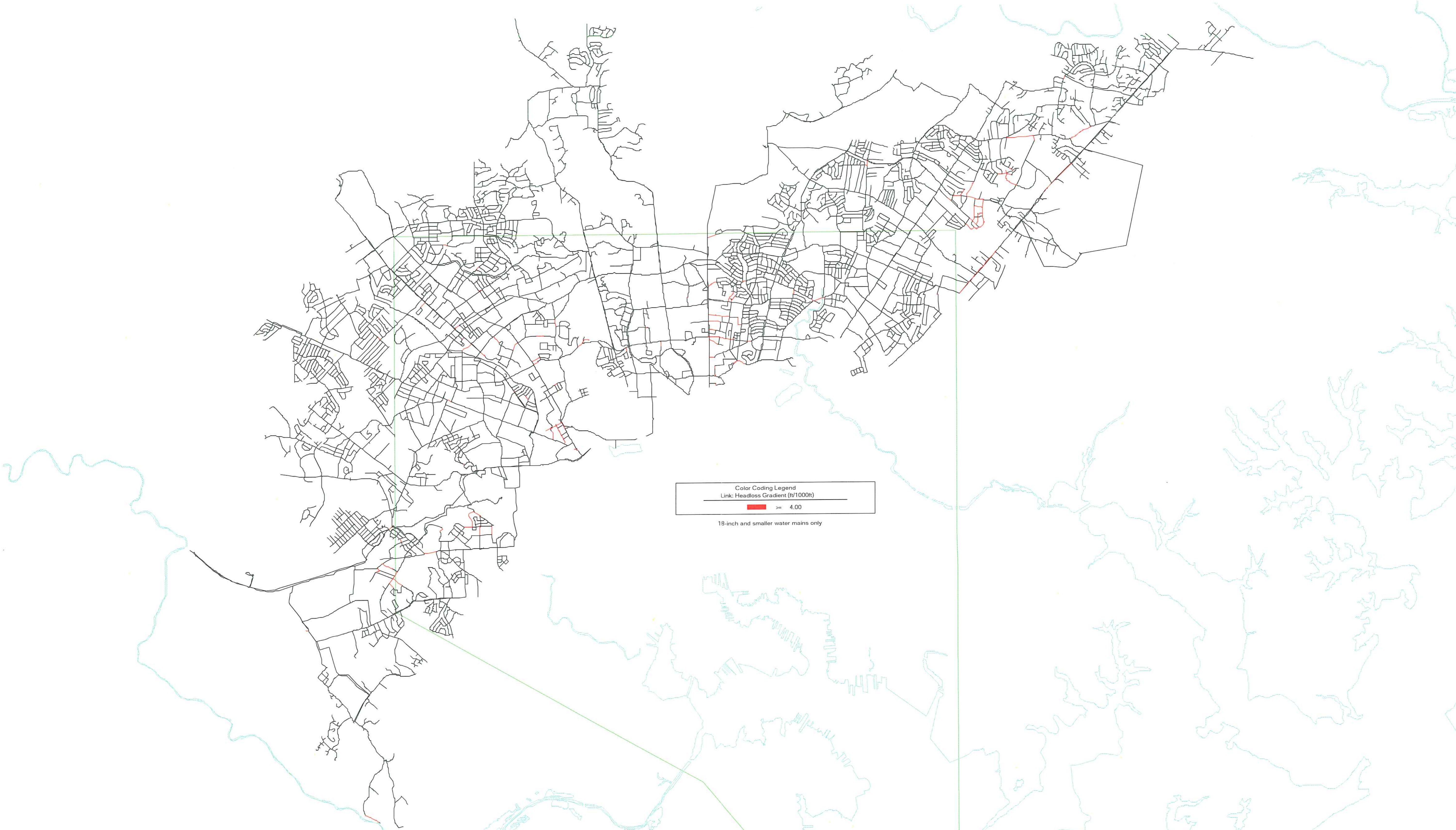


Title: Zone 3 - all
c:\watercad\baltcity\zone3\3rdanalysis.wcd
02/28/03 10:00:16 AM

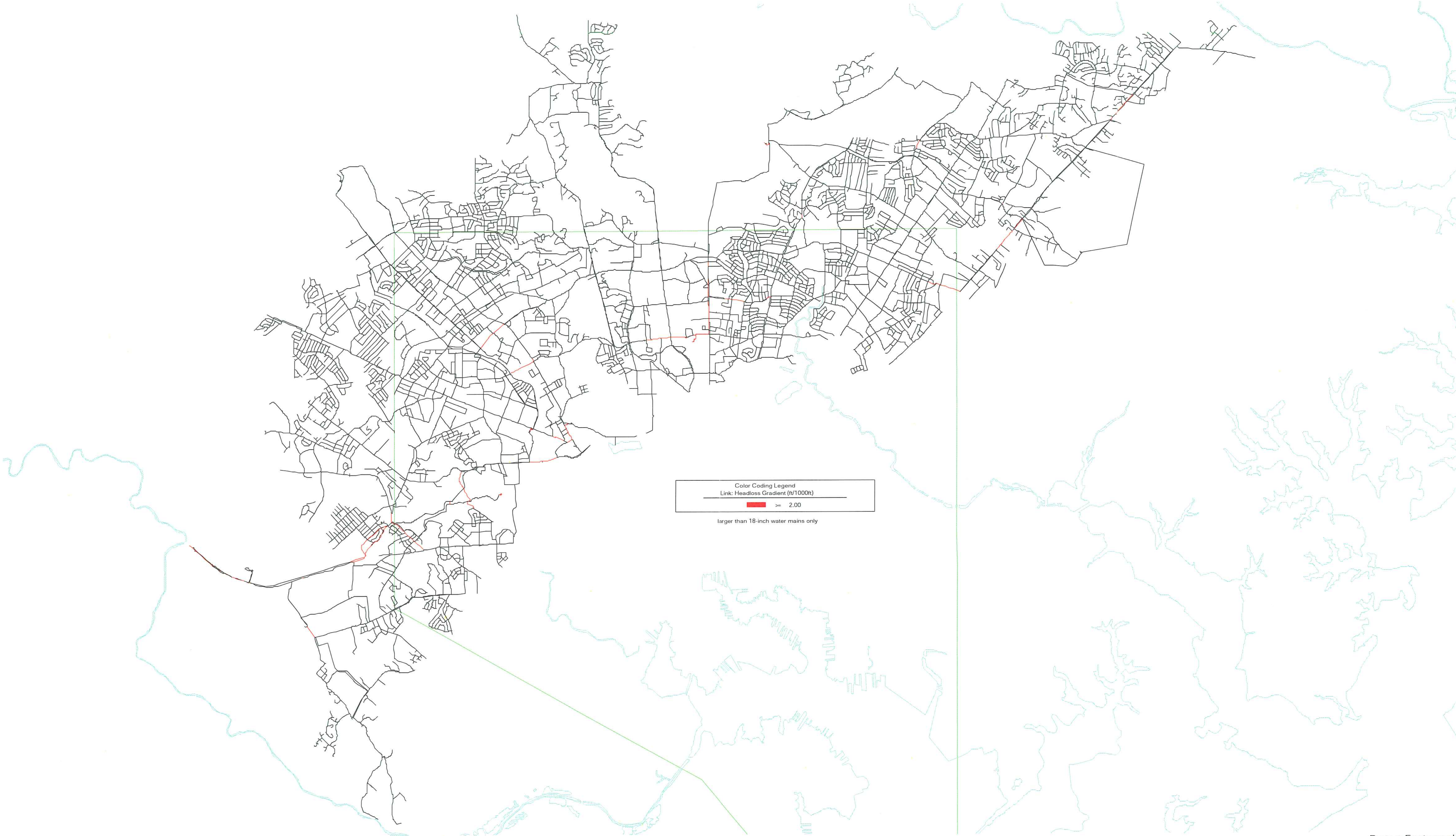
Rummel, Klepper & Kahl

Project Engineer: KK
WaterCAD v4.1 [424a]

Scenario: Max Day 2000



Scenario: Max Day 2025

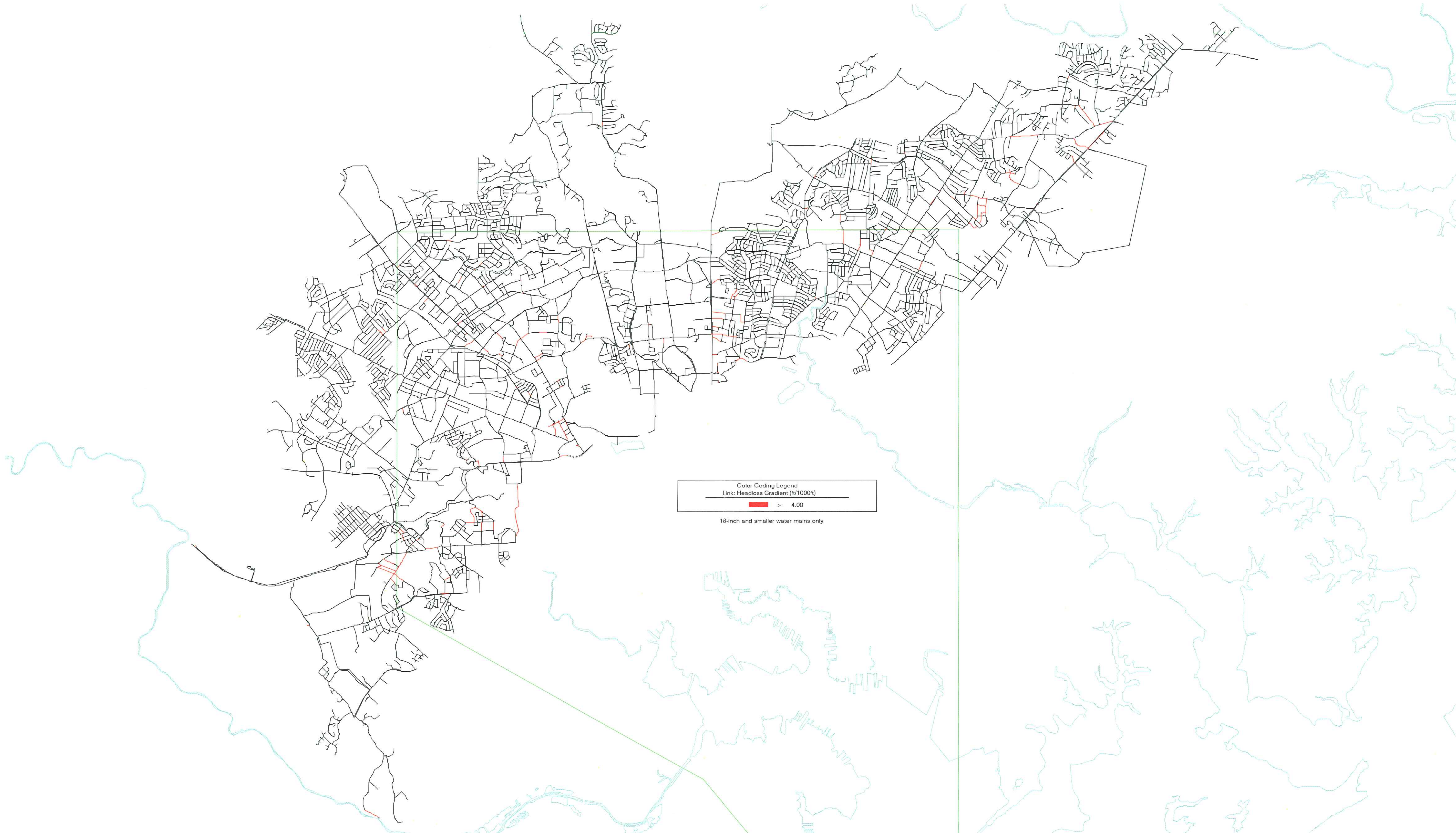


Title: Zone 3 - all
c:\watercad\baltcity\zone3\3rdanalysis.wcd
02/28/03 10:00:39 AM

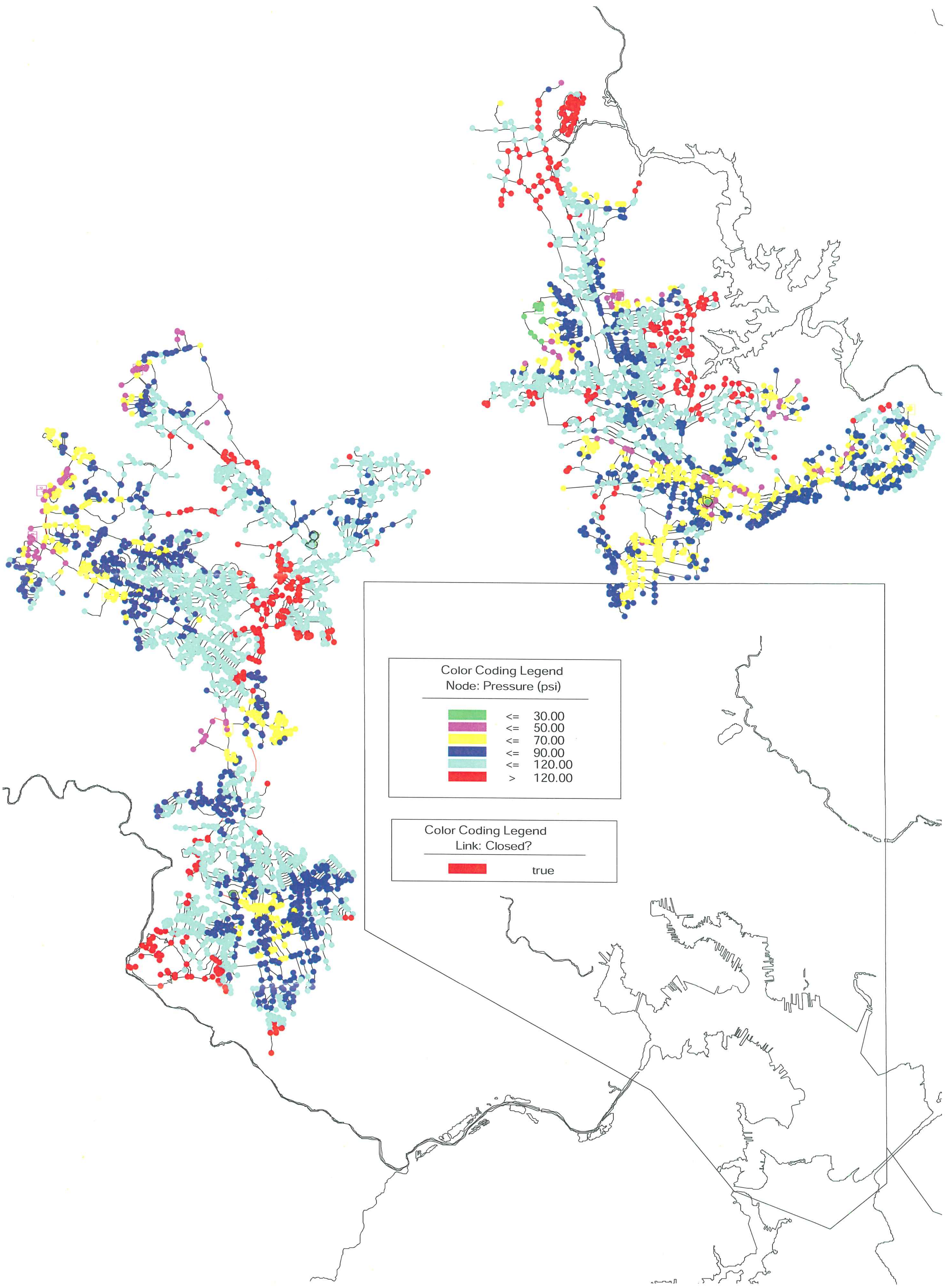
Rummel, Klepper & Kahl

Project Engineer: KK
WaterCAD v4.1 [424a]

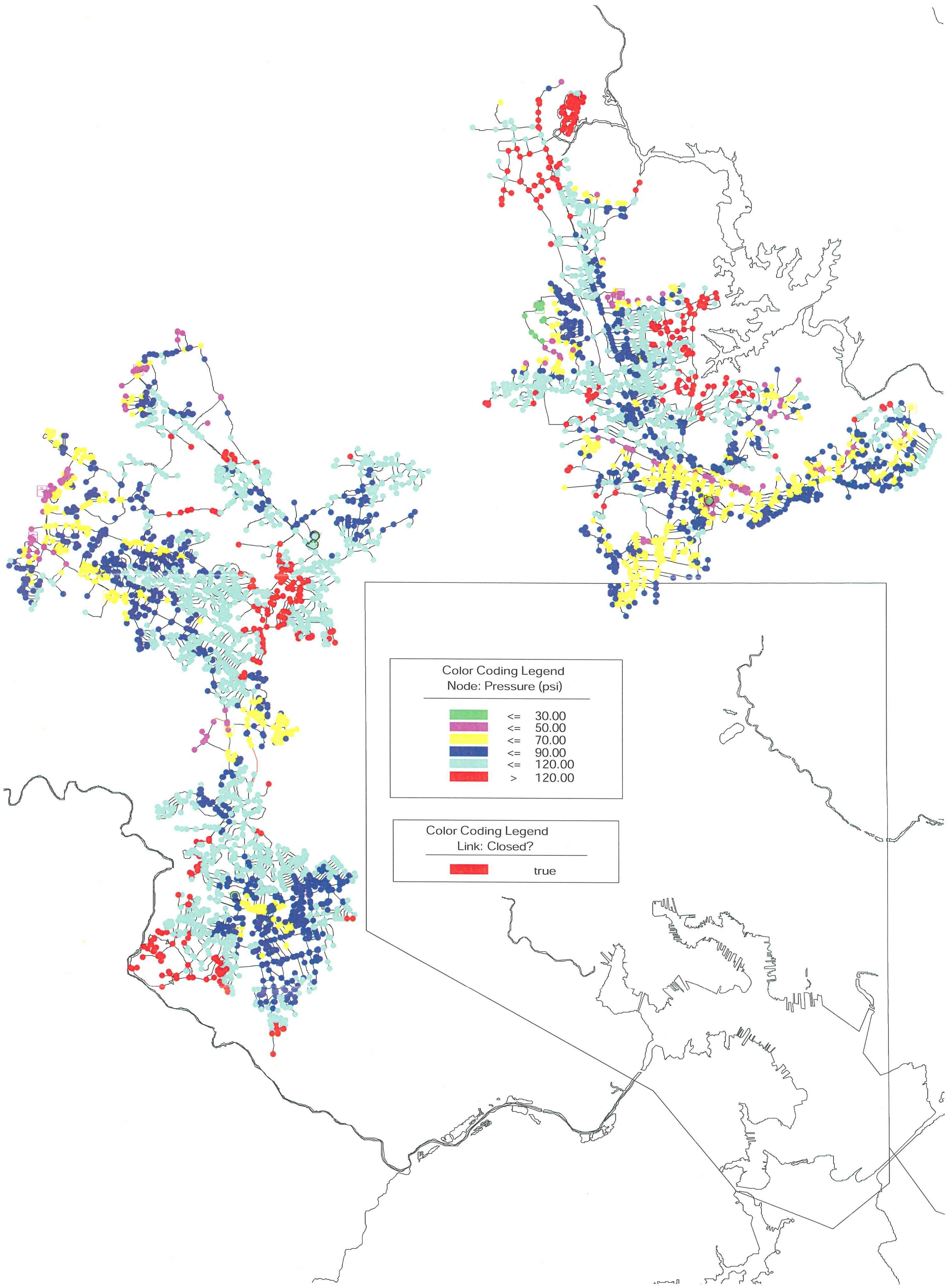
Scenario: Max Day 2025



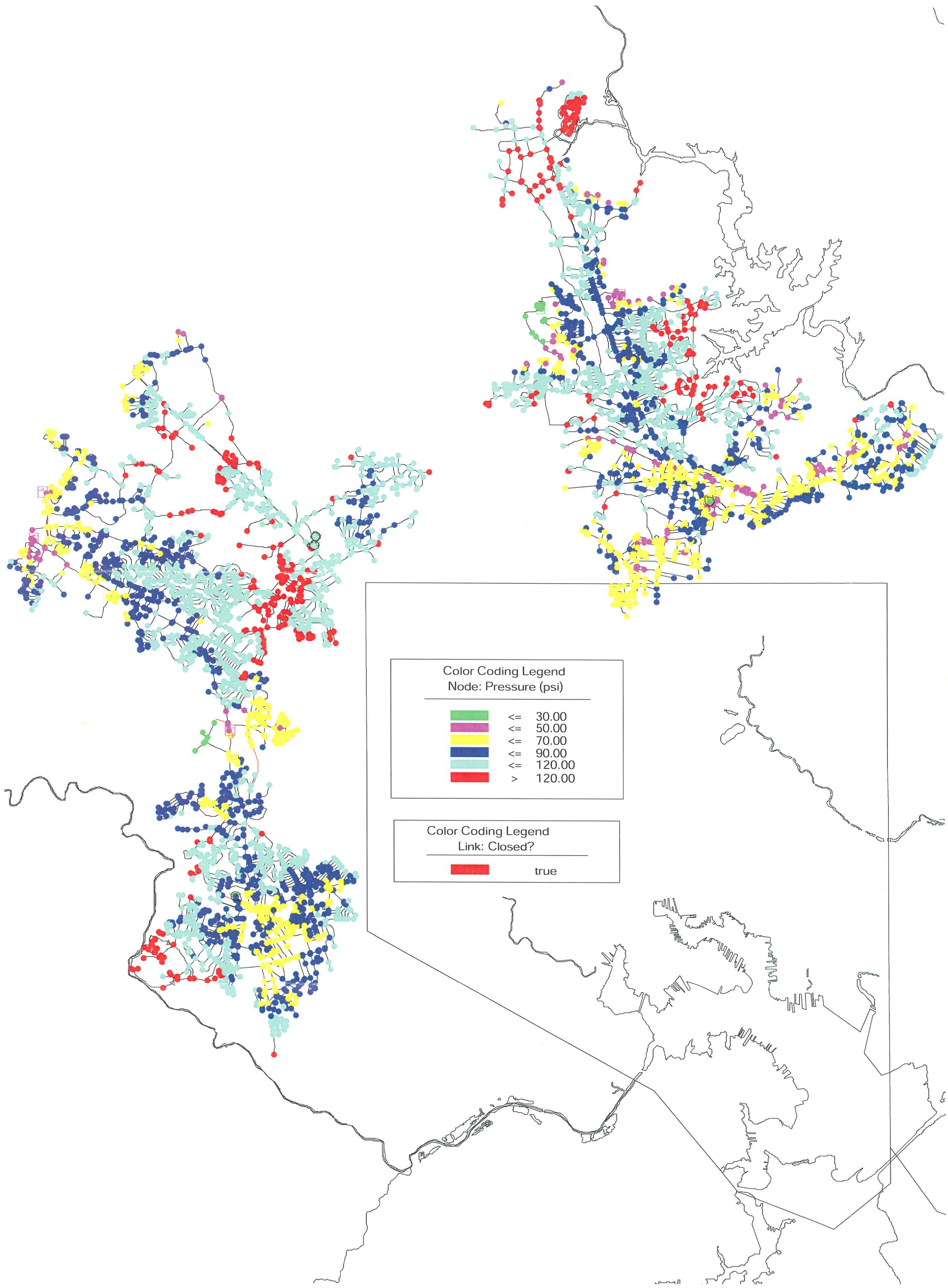
Scenario: Avg Day 2000



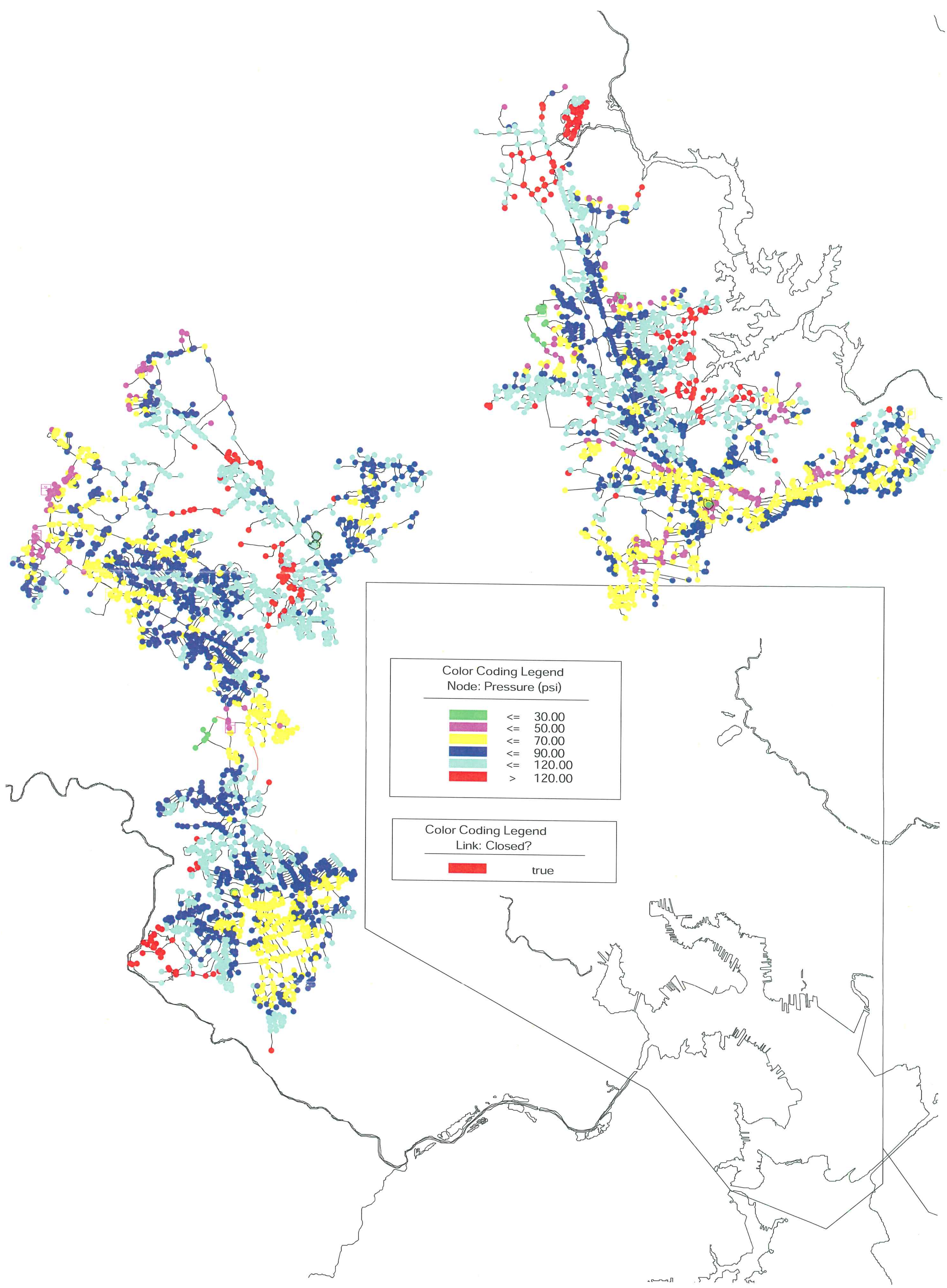
Scenario: Avg Day 2025



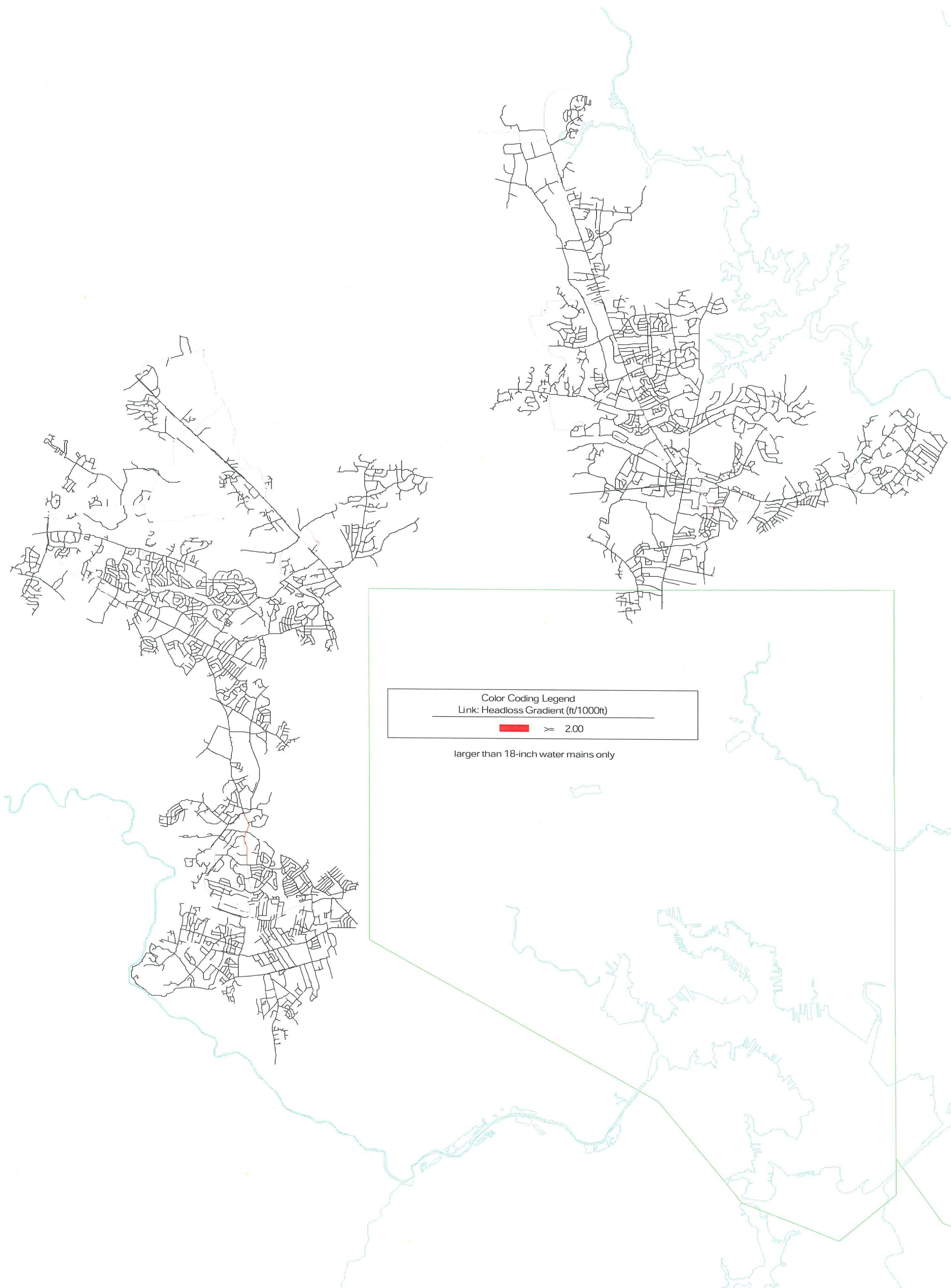
Scenario: Max Day 2000



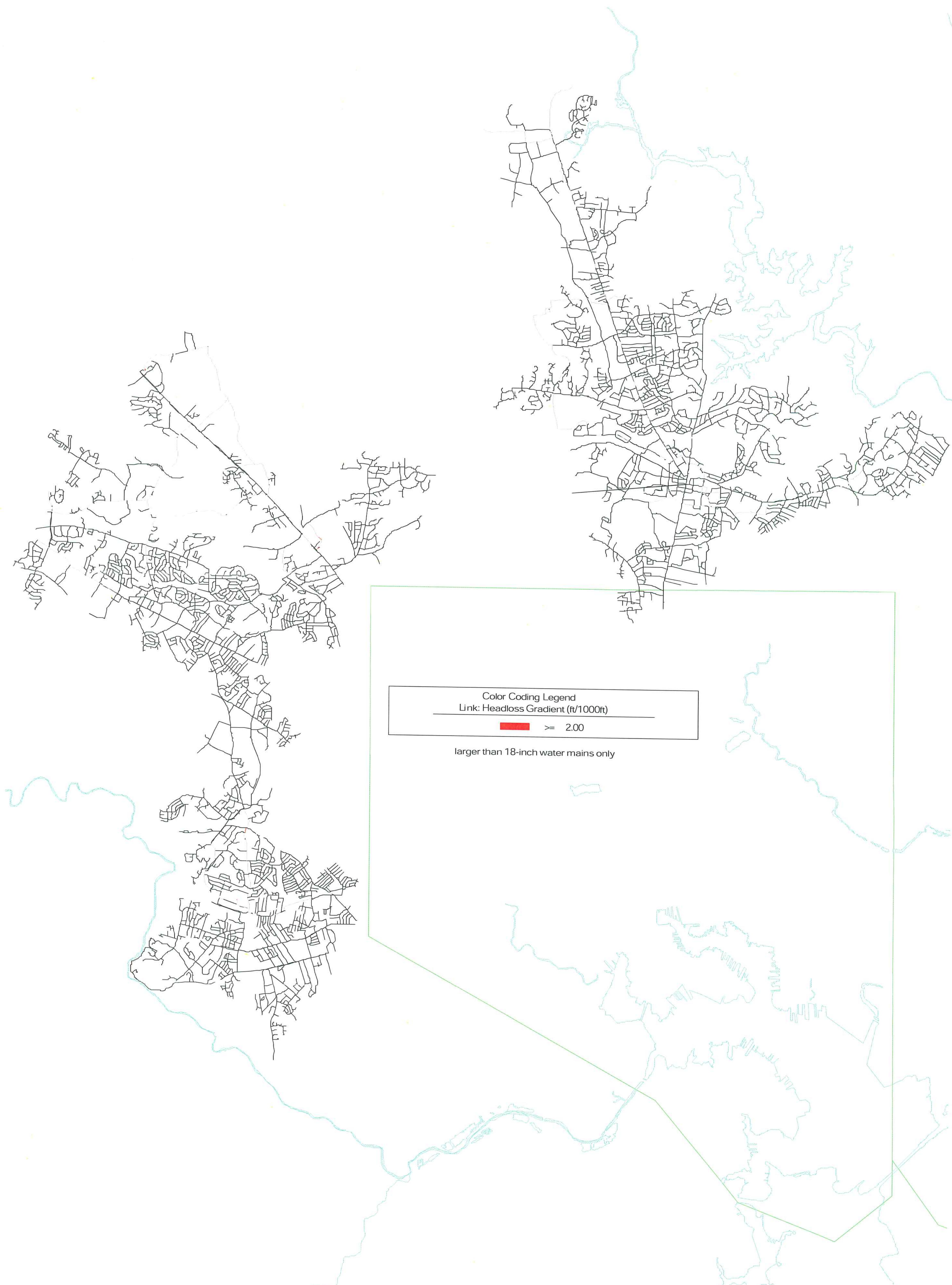
Scenario: Max Day 2025



Scenario: Avg Day 2000

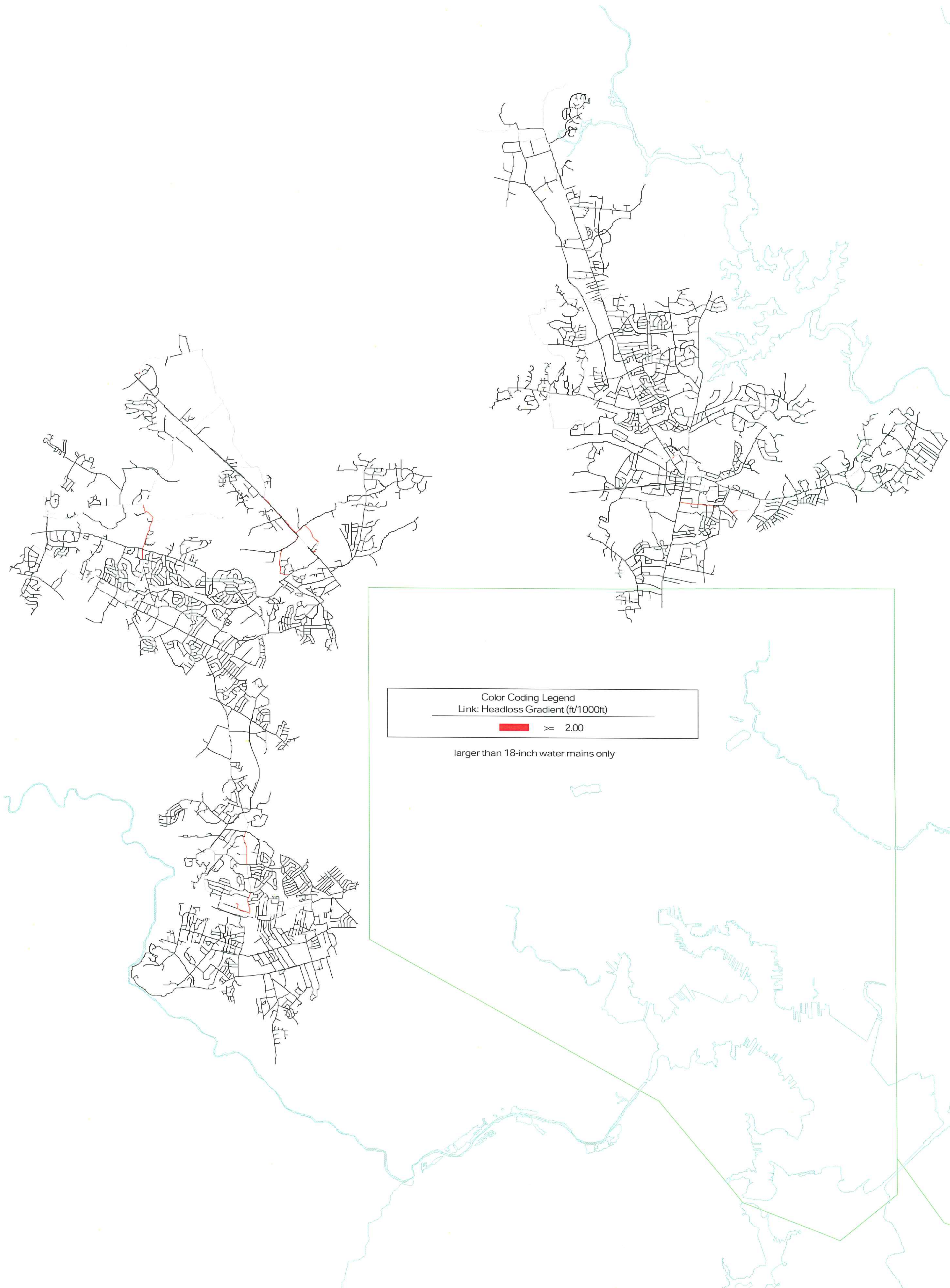


Scenario: Avg Day 2025



Title: Zone 4 - all
c:\watercad\baltcity\zone4\4thanalysis.wcd
02/28/03 11:10:39 AM

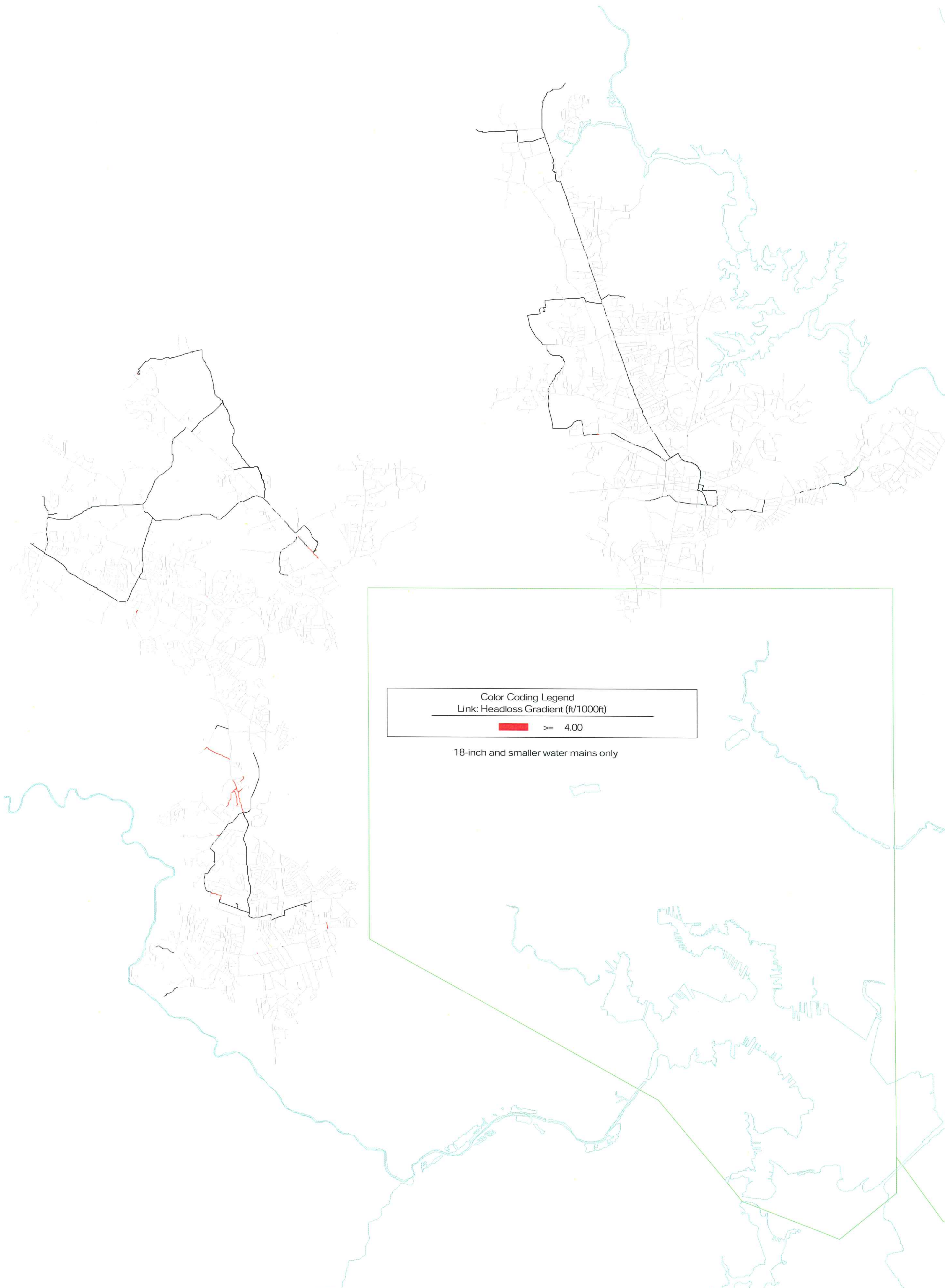
Scenario: Max Day 2025



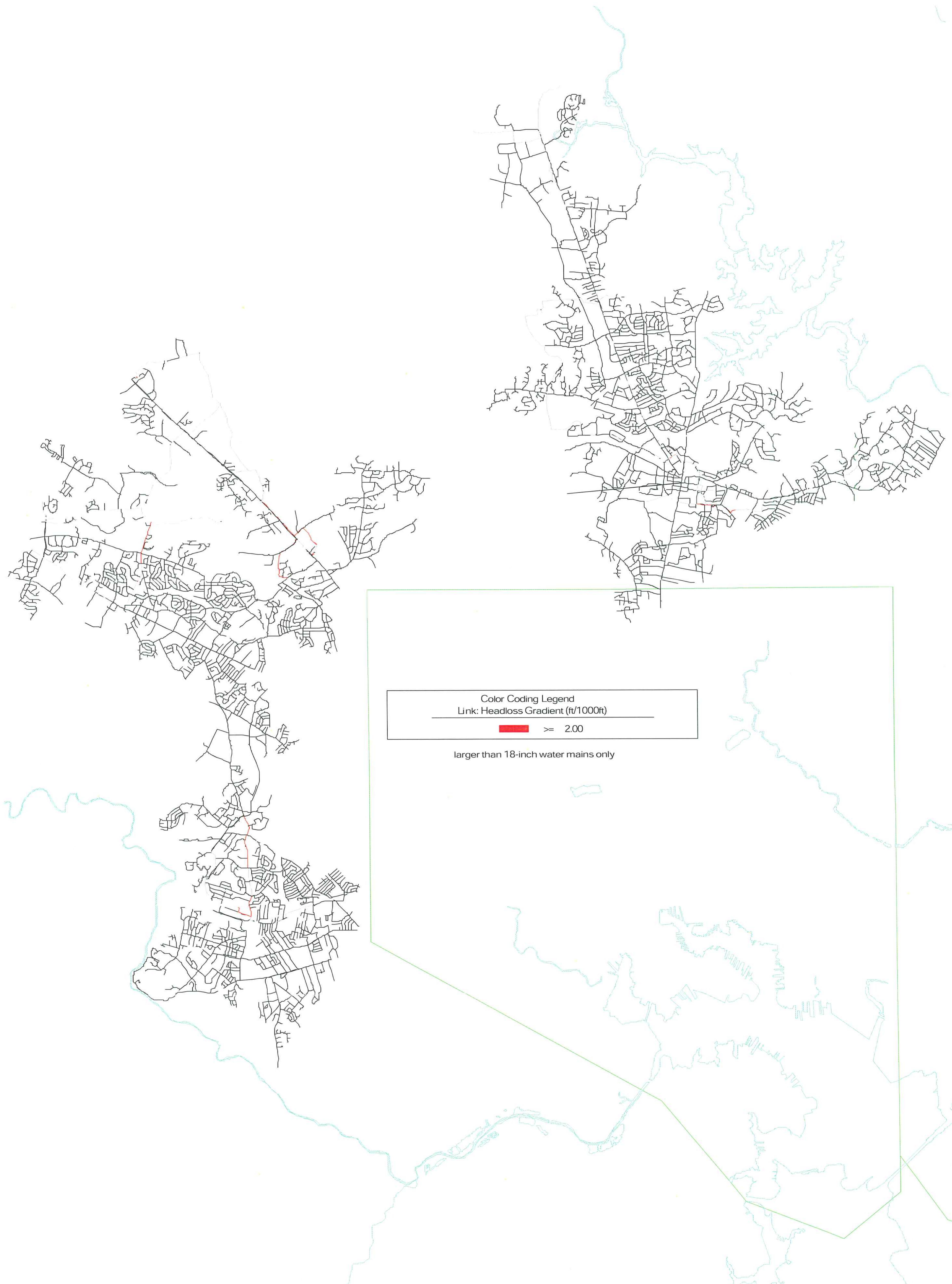
Title: Zone 4 - all
c:\watercad\baltcity\zone4\4thanalysis.wcd
02/28/03 11:10:06 AM

Project Engineer: KK
WaterCAD v4.1 [424a]

Scenario: Avg Day 2025



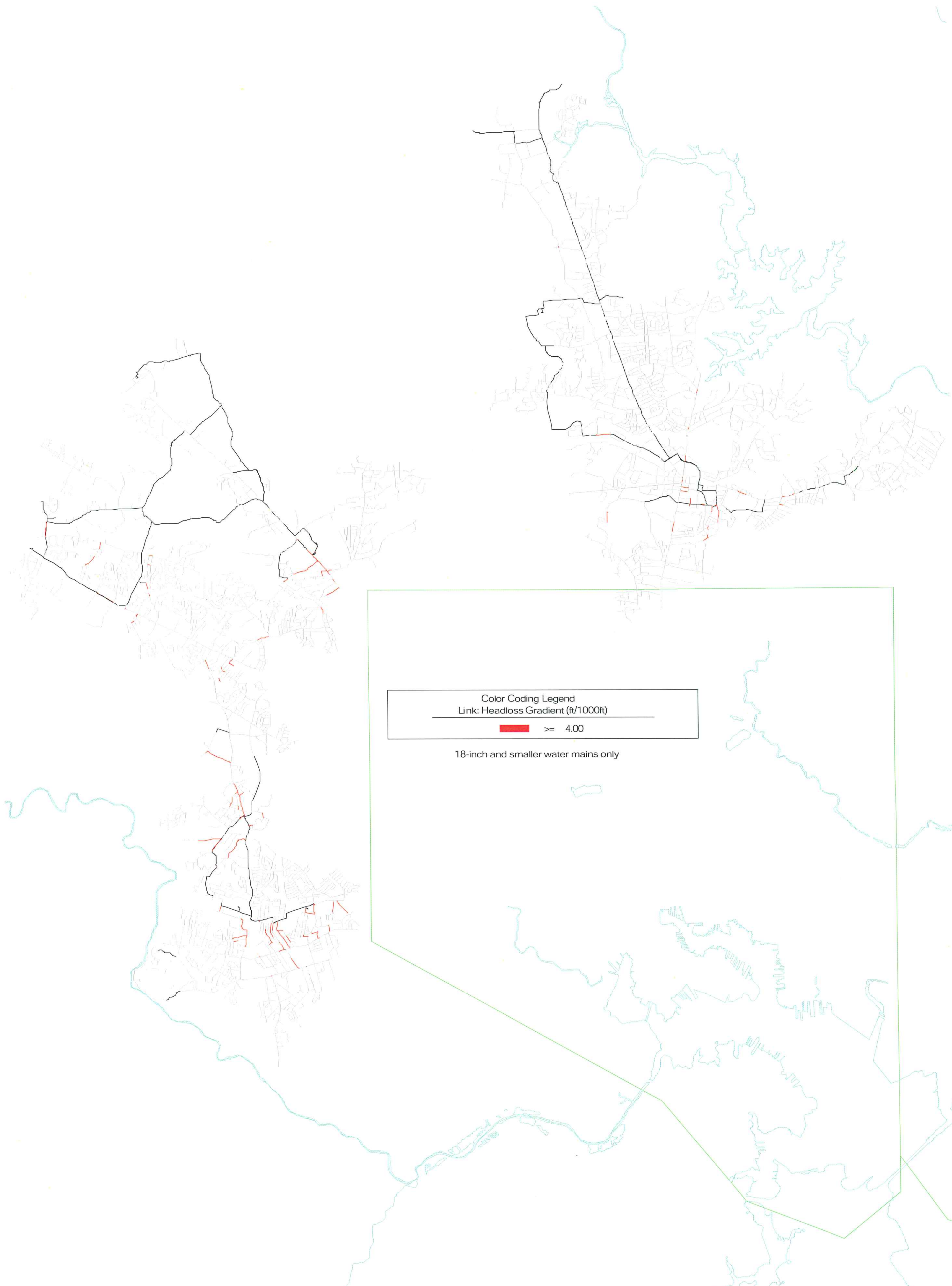
Scenario: Max Day 2000



Title: Zone 4 - all
c:\watercad\baltcity\zone4\4thanalysis.wcd
02/28/03 11:18:27 AM

Project Engineer: KK
WaterCAD v4.1 [424a]

Scenario: Max Day 2000



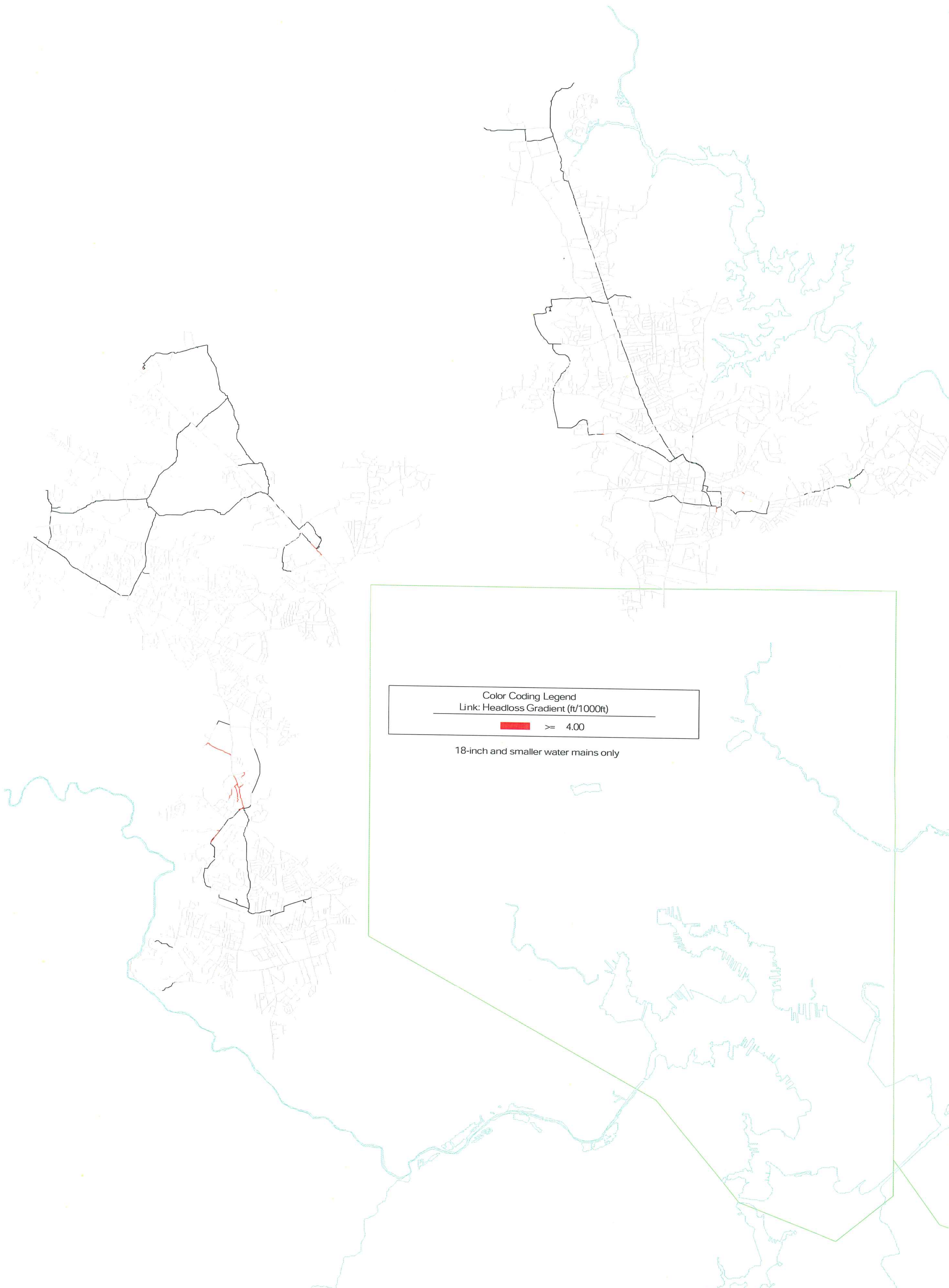
Title: Zone 4 - all
c:\watercad\baltcity\zone4\4thanalysis.wcd
02/28/03 11:18:00 AM

Rummel, Klepper & Kahl

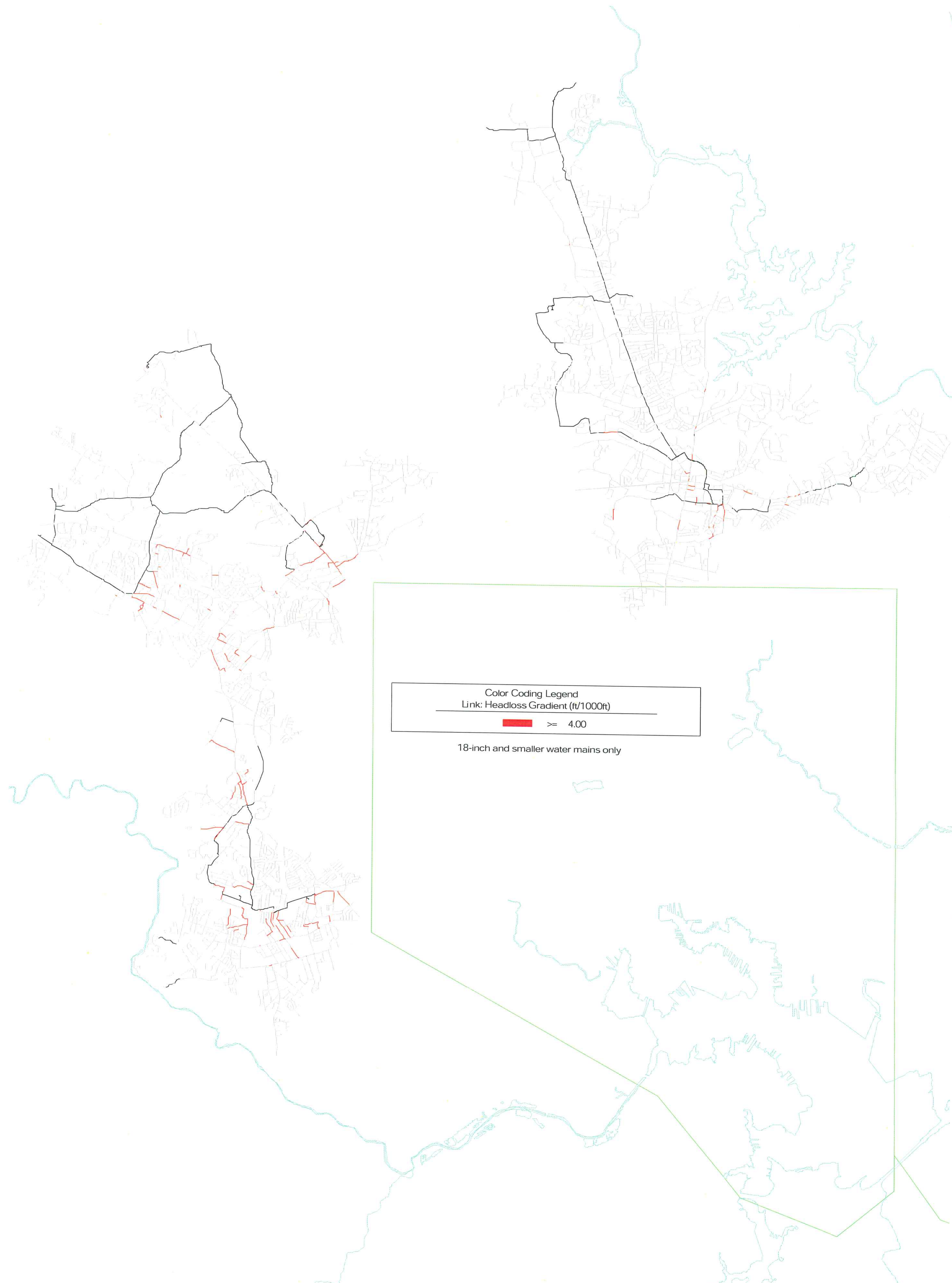
© Haestad Methods, Inc. 37 Brookside Road Waterbury, CT 06708 USA +1-203-755-1666

Project Engineer: KK
WaterCAD v4.1 [424a]
Page 1 of 1

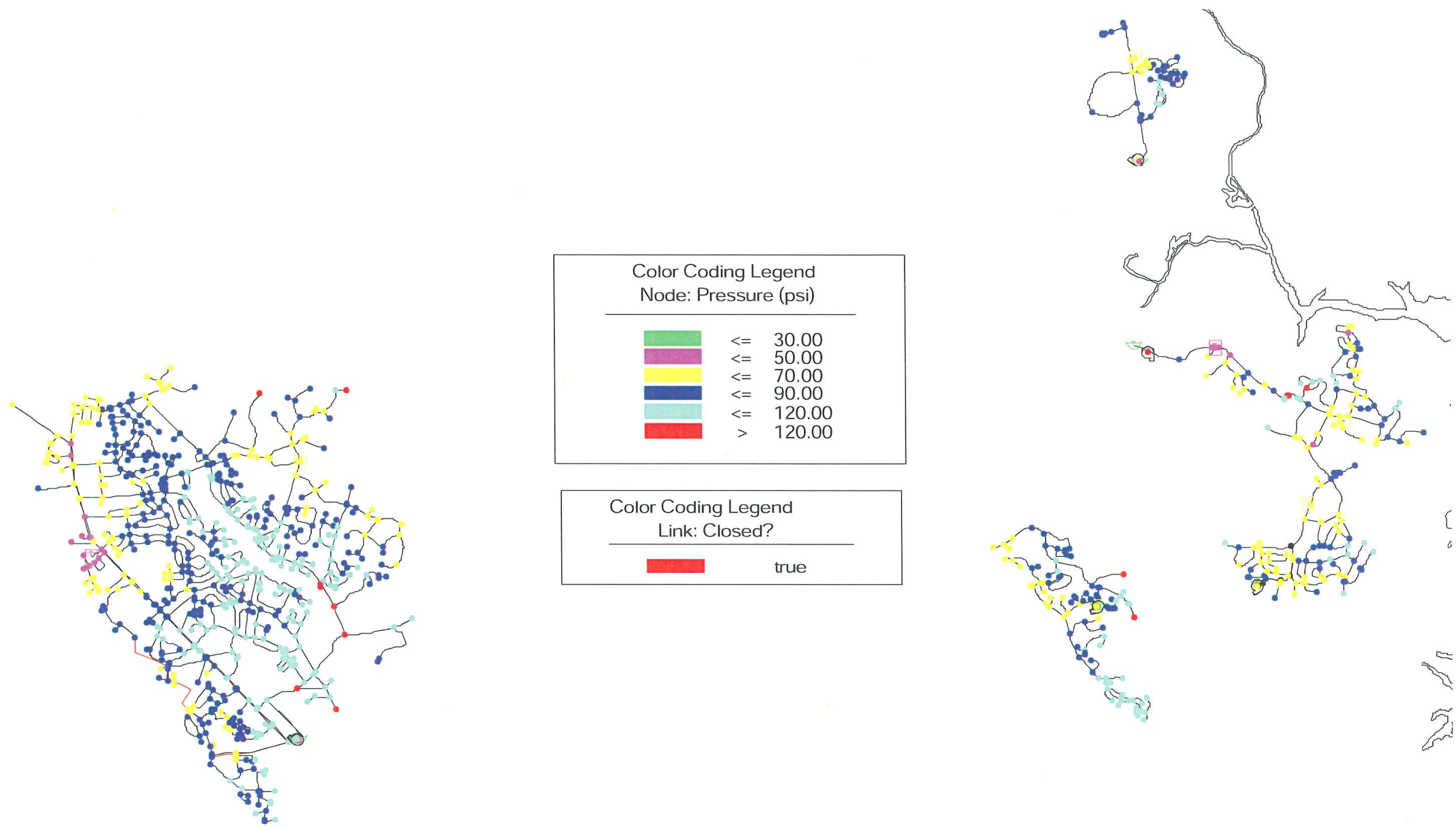
Scenario: Avg Day 2000



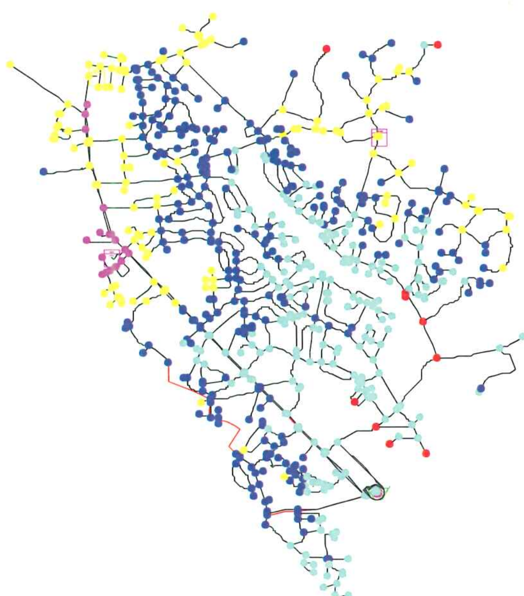
Scenario: Max Day 2025



Scenario: Avg Day 2000



Scenario: Avg Day 2025

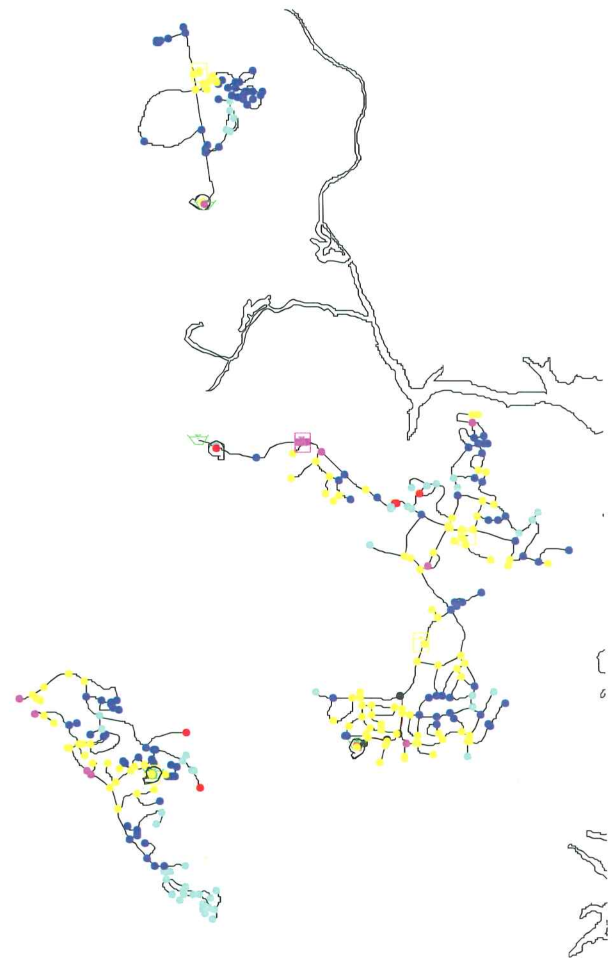


Color Coding Legend
Node: Pressure (psi)

(green)	<=	30.00
(magenta)	<=	50.00
(yellow)	<=	70.00
(blue)	<=	90.00
(cyan)	<=	120.00
(red)	>	120.00

Color Coding Legend
Link: Closed?

(red)	true



Title: Zone 5 - all
c:\watercad\baltcity\zone5\5thanalysis.wcd
02/28/03 12:21:07 PM

Rummel, Klepper & Kahl

Project Engineer: KK
WaterCAD v4.1 [424a]

Scenario: Max Day 2000

Color Coding Legend Node: Pressure (psi)		
green	<=	30.00
magenta	<=	50.00
yellow	<=	70.00
blue	<=	90.00
light blue	<=	120.00
red	>	120.00

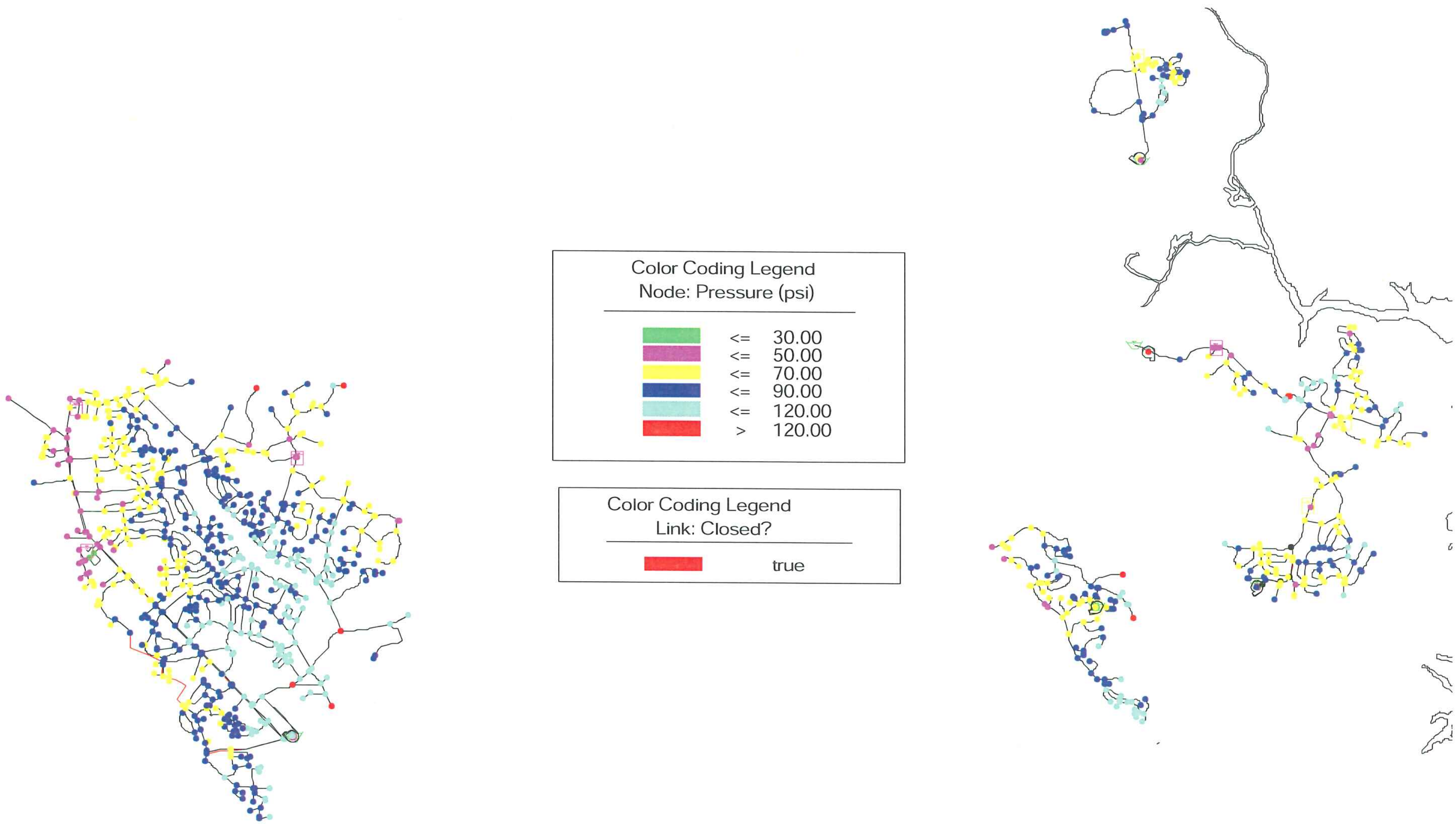
Color Coding Legend Link: Closed?	
red	true

Title: Zone 5 - all
c:\watercad\baltcity\zone5\5thanalysis.wcd
02/28/03 12:20:15 PM

Rummel, Klepper & Kahl
© Haestad Methods, Inc. 37 Brookside Road Waterbury, CT 06708 USA +1-203-755-1666

Project Engineer: KK
WaterCAD v4.1 [424a]

Scenario: Max Day 2025

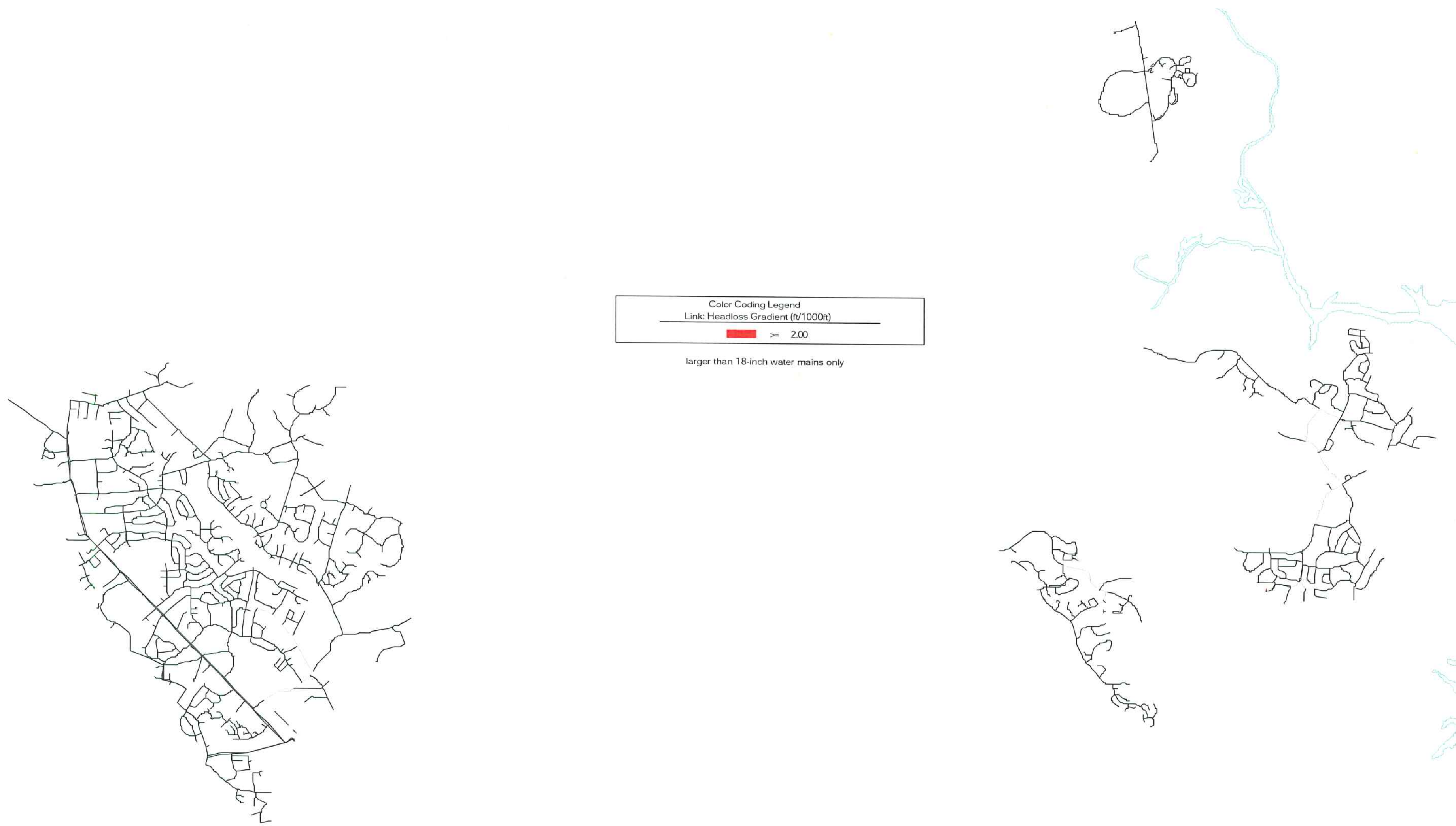


Title: Zone 5 - all
c:\watercad\baltcity\zone5\5thanalysis.wcd
02/28/03 12:20:53 PM

Rummel, Klepper & Kahl

Project Engineer: KK
WaterCAD v4.1 [424a]

Scenario: Avg Day 2000



Scenario: Avg Day 2000

Color Coding Legend
Link: Headloss Gradient (ft/1000ft)
>= 4.00

18-inch and smaller water mains only

Title: Zone 5 - all
c:\watercad\baltcity\zone5\5thanalysis.wcd
02/28/03 12:23:24 PM

Rummel, Klepper & Kahl

Project Engineer: KK
WaterCAD v4.1 [424a]

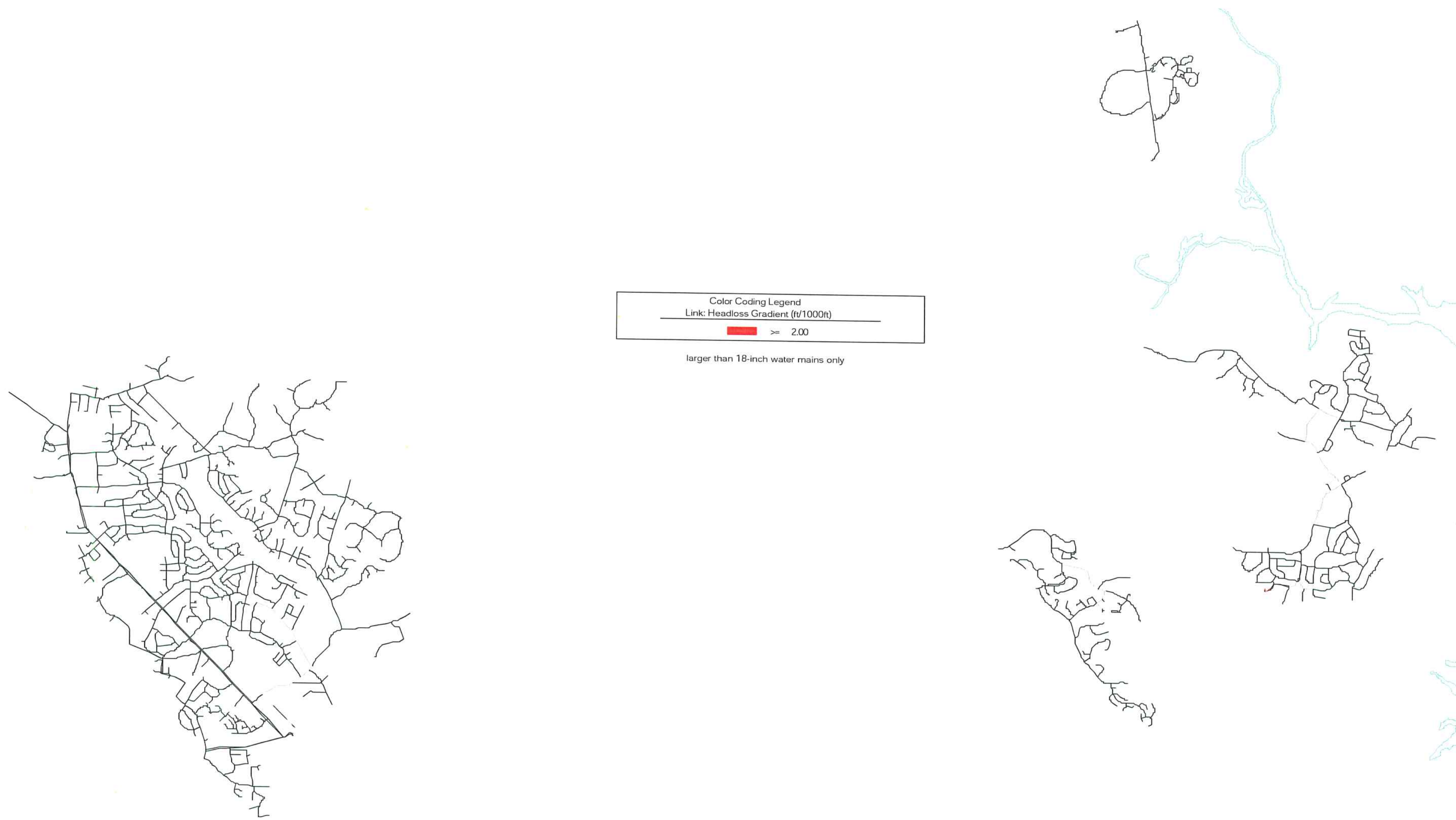
Scenario: Avg Day 2025

Color Coding Legend
Link: Headloss Gradient (ft/1000ft)
>= 2.00

larger than 18-inch water mains only

Scenario: Avg Day 2025

Scenario: Max Day 2000



Title: Zone 5 - all
c:\watercad\baltcity\zone5\5thanalysis.wcd
02/28/03 12:22:34 PM

Rummel, Klepper & Kahl

Project Engineer: KK
WaterCAD v4.1 [424a]

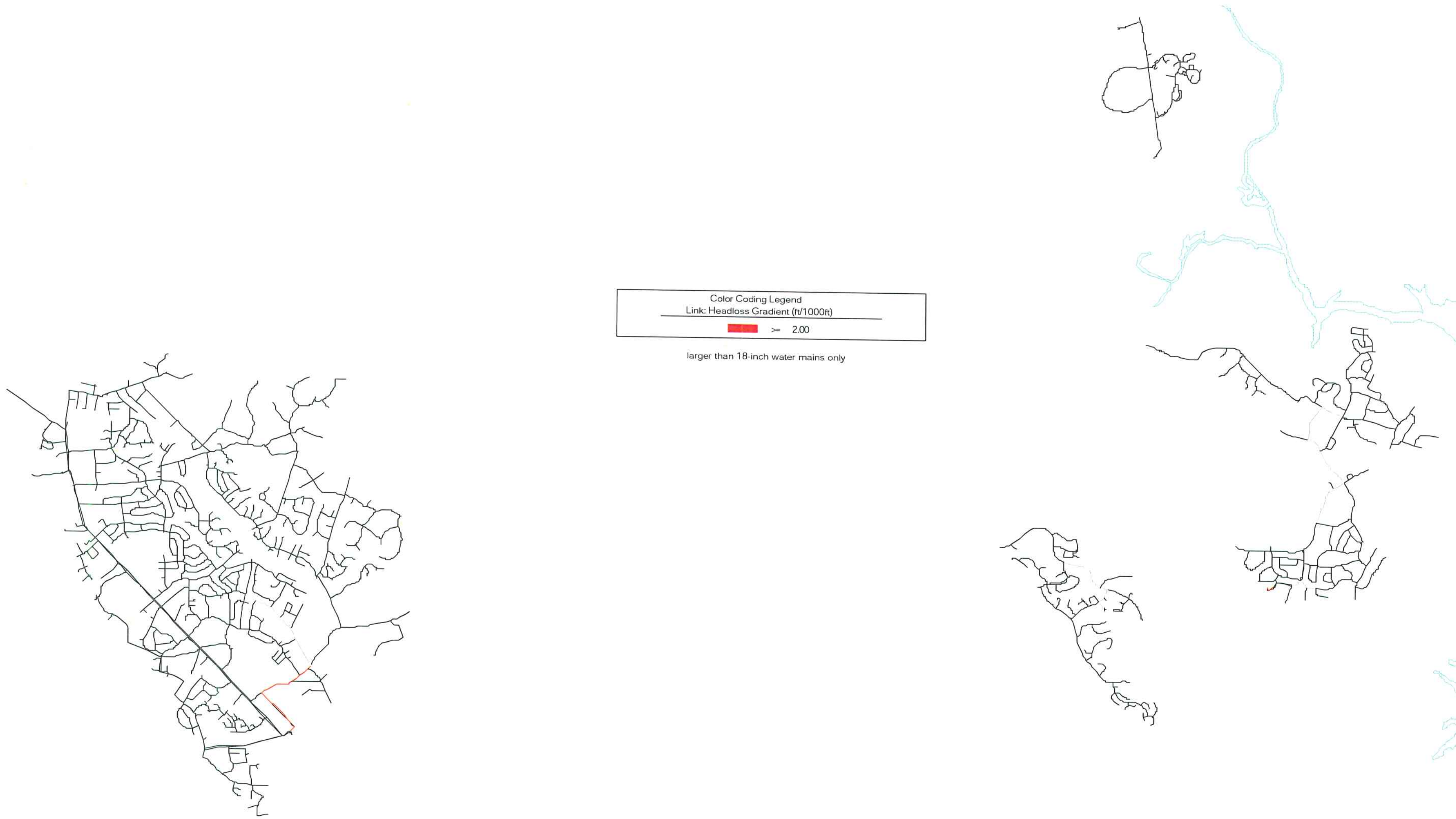
Scenario: Max Day 2000

Title: Zone 5 - all
c:\watercad\baltcity\zone5\5thanalysis.wcd
02/28/03 12:24:04 PM

Rummel, Klepper & Kahl

Project Engineer: KK
WaterCAD v4.1 [424a]

Scenario: Max Day 2025



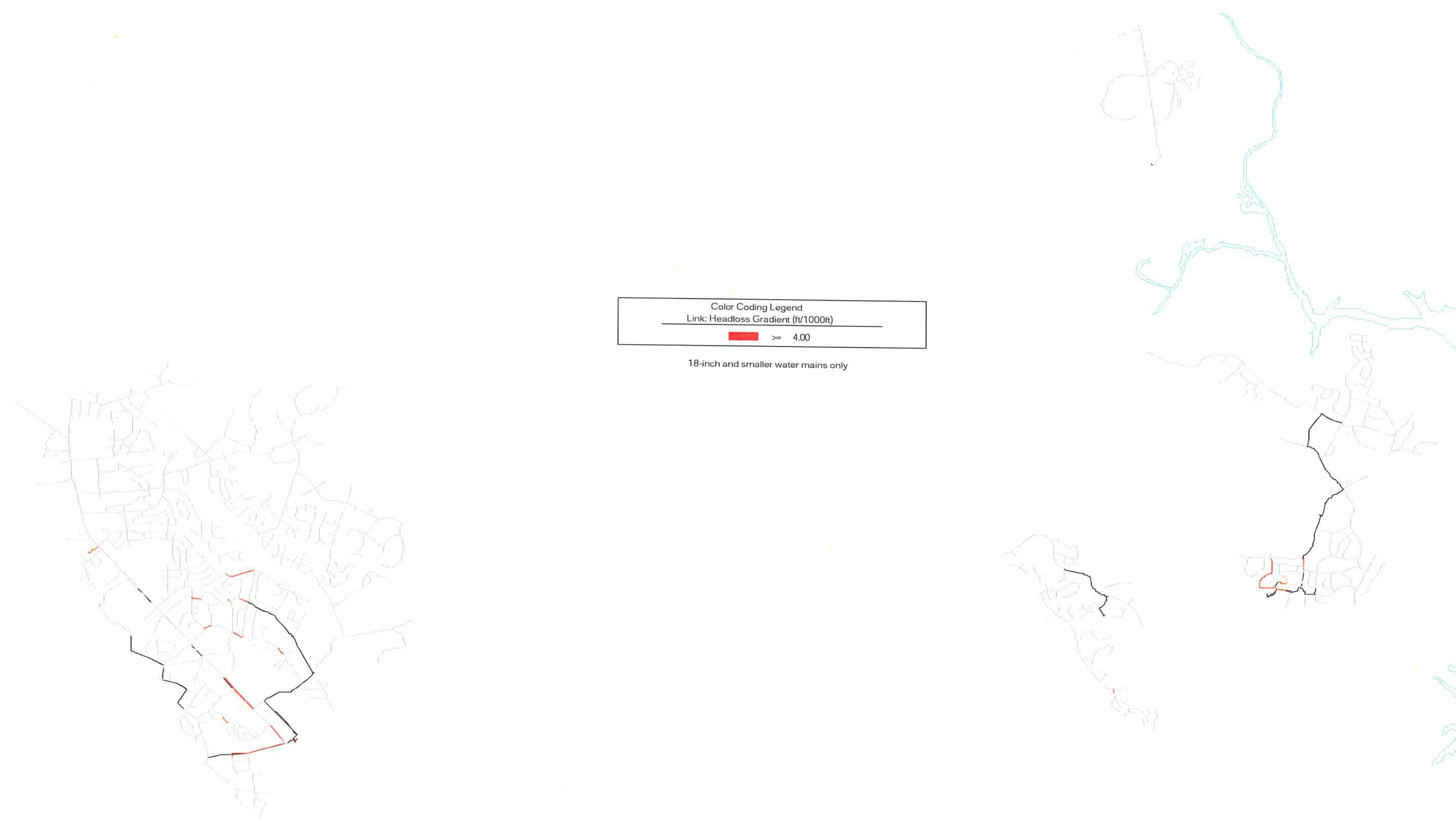
Title: Zone 5 - all
c:\watercad\baltcity\zone5\5thanalysis.wcd
02/28/03 12:22:16 PM

Rummel, Klepper & Kahl

 37 Brookside Road Waterbury, CT 06708 USA +1-203-755-1666

Project Engineer: KK
WaterCAD v4.1 [424a]

Scenario: Max Day 2025



Title: Zone 5 - all
c:\watercad\baltcity\zone5\5thanalysis.wcd
02/28/03 12:24:40 PM

Rummel, Klepper & Kahl

Project Engineer: KK
WaterCAD v4.1 [424a]

24. Load Response Program

The Company Load Response Program offers two options to Customers . Option 1 - PJM Load Response Programs offers Customers compensation for voluntarily reducing demand for electricity during specific periods. Option 2 - Firm Capacity Incentive offers Customers additional compensation for the Customer's firm commitment to reduce demand upon emergency electricity supply situations within the Pennsylvania, New Jersey, Maryland Interconnection (PJM) control area. Customers may participate in Option 1 or Option 2, or both. For the purpose of this Program, "load response" means demand reduction and/or on-site, self-supply generation. The effect of the Customer's load response shall be a net reduction of load on the Company's system.

Option 1 - PJM Load Response Programs

The PJM Load Response Programs are designed to provide an incentive to Customers or Curtailment Service Providers to enhance opportunities for Customers to reduce consumption when PJM Locational Marginal Prices (LMPs) are high. PJM's Economic Load Response Program – Real Time offers Customers the opportunity to reduce load during times of high wholesale market prices and to receive payment based on real time LMP for the load reductions. PJM's Economic Load Response Program – Day Ahead offers Customers the opportunity to commit to a reduction in load in advance of real time operations and to receive payments based upon day-ahead LMP for the load reductions. PJM's Emergency Load Response Program is designed to provide a method by which end-use Customers may be compensated for voluntarily reducing load during an emergency event.

Two primary types of distributed resources are candidates for participation in the PJM Load Response Programs. Customers may either have an on-site generator or the ability to reduce a measurable and verifiable portion of their load. The PJM Load Response Programs set forth specific requirements concerning, among other things, participant qualifications, metering requirements, verification, market settlements and reporting.

The Company, as an eligible PJM member, will act as the Curtailment Service Provider on behalf of Customers who wish to have the Company act as an agent on their behalf. In doing so, BGE will provide the necessary interface responsibilities to PJM including, but not limited to, the right for BGE to determine its own Customer Baseline Load (CBL) used in deriving the Customer's load reductions. A participating Customer will be responsible for any additional costs for metering, communications equipment or other direct costs associated with program participation. The Customer will also be responsible for any charges or penalties associated with non-performance in meeting load reductions committed in the day-ahead market.

Payments under the PJM Load Response Program will be made by PJM to the Company as the Curtailment Service Provider. A percentage of the payment received by the Company will then be paid by the Company to the participating Customer as compensation for the load response. The share percentage is 80%. Customers interested in participating in this Option must enroll with the Company. Participation in PJM Load Response Programs by a Customer may be independent of or complementary to participation by the Customer in other Company load curtailment or load response programs. Customers must meet their contractual obligations under any specific Company program and participation in PJM Load Response programs shall not result in any double payment for a specific load response.

Option 2 – Firm Capacity Incentive

Option 2 offers additional compensation to Customers who commit to reduce the electric energy supplied to their premises on a firm basis. During periods when PJM calls for Active Load Management (ALM) resources, the Customer is obligated to provide a specific load response. Noncompliance penalties are associated with this Firm Capacity Incentive Option. (See **Penalty Provision** below.)

Determination of Compensation

Compensation will be determined by BGE and offered to Customers on a non-discriminatory basis. The level of the payment will depend on the firm Load Response Amount, the prevailing market price for capacity in PJM and may vary depending on the initial effective date and the length of the contract.

Enrollment and Notification

1. Customers interested in participating in this Option must enroll with the Company. Customers participating in the Company's Riders 14 or 16 may not participate in this Option.
2. This Program requires a contract for a specific period of time, which may be renewed on the same or different terms upon mutual agreement between the Company and the Customer.
3. For Customers with installed generators equipped with interval recorders, the Customer must specify the load response amount in kW that the Customer is required to provide with his on-site generation during times when PJM is calling for ALM resources.
4. For Customers with interval recorders installed on their whole premises, the Customer commits to reduce demand requirements to a Contract Demand, in kW, during times when PJM calls for ALM resources.
5. The Customer must specify a Load Response Amount or a Contract Demand, respectively, for each of the following periods: June through September, October through December, and January through May.
6. During periods when PJM calls for ALM resources, the Company will notify the Customer by e-mail at least one hour (1 hour) prior to a mandatory load response.
7. The Customer agrees to limit operation of the Customer-owned generation to periods when PJM is calling for ALM resources, periods of electric emergency on the Customer's system, normal standby generation requirements, participation in Option 1 or as otherwise permitted by the Company. Failure to comply with these provisions may lead to the termination of the Customer's participation in this Option.

Determination of Contractual Compliance

1. For Customers with installed generators equipped with interval recorders:
   The load response amount will equal the recorded generation, (grossed up for system line losses) during times when PJM is calling for ALM resources. The load response amount must comply with the Customer's contractual obligation to avoid penalties under the Penalty Provision below.
2. For Customers with interval recorders installed on their whole premises:
   The Customer agrees to reduce demand requirements to the Contract Demand during times when PJM is calling for ALM resources. The effect of the Customer's curtailment shall be a net reduction of load on the Company's system. During periods of ALM activation, the work performed by the curtailed load shall not be transferred to any other electric service provided by the Company.
3. Should the Customer fail to reduce measured demand to the Contract Demand during any period when PJM is calling for ALM resources, the Penalty Provision below will apply.

Penalty Provision

The Customer's failure to meet its contractual load response obligation under this Rider shall result in a penalty from BGE. Such penalty shall be determined in accordance with PJM's prevailing "Reliability Assurance Agreement Among Load Serving Entities in the PJM Control Area", Schedule 11 and Schedule 14, as found at http://www.pjm.com/documents/agreements/raa.pdf, or any other applicable PJM penalty provisions which may change from time to time.

Additional Provisions Applicable to Option 1 and Option 2

1. Customers participating in the Company's Riders 14 or 16 may also participate in Option 1. However, compensation under this Option will not be made during times when Riders 14 and/or 16 are being called. All terms and conditions associated with Riders 14 and 16 shall take precedence over Option 1 during activation of Riders 14 and/or 16.
2. Participation in the Company's Load Response Program does not restrict the Customer from choosing an electricity supplier other than the Company. If the Customer chooses an electricity supplier other than the Company, and wishes to participate in this Rider, the Customer must notify the Company via the e-mail address provided during the Rider 24 enrollment process. The Customer must provide the Company with the name of any new supplier and the date on which the new supplier's services will begin.
3. All provisions of the Company's Retail Electric Service Tariff relating to safety and parallel operation of any on-site generation apply. Use of generation for self-supply other than Company-approved load reduction may subject the Customer to application of Schedule S – Standby Services.
4. The Customer must have Company-approved interval metering and communications equipment to participate in this Rider, with the exception of participation in PJM's Non-Hourly Metered Customer Pilot Program. All incremental metering costs and costs for any communication equipment required by the Company are the responsibility of the Customer. The Company will provide advanced metering and communication equipment pursuant to the Company's Rider 23.
5. Compensation for any on-site, self-supply generation under this Rider will be limited to generation used to offset the Customer's electric demand on the Company's system, and no compensation will be provided under this Rider for any generation exported to the Company's system.
6. The Customer is fully responsible for all environmental permits necessary to run on-site, self-supply generation under this Rider, and for all environmental costs associated with such generation.
7. The Company provides optional energy information management services that may facilitate the Customer's participation in Rider 24 or other third-party curtailment programs. Information on these services can be found in Rider 9 - Customer Billing and Consumption Data Requests.

Page 106 is reserved for future use

16. Curtailable Service

Monthly net rates for Price Freeze Service supplied under Schedule GL or P (the Controlling Schedule) are subject to adjustment for a Customer who agrees to the Availability conditions stated below.

Availability Conditions:

(A) The Customer agrees to reduce demand requirements to the Contract Demand, upon advance notice of no less than 2 hours for Rate Option 1, or 15 minutes for Rate Option 2, by the Company. The Contract Demand is at least 100 kW for Rate Option 1, or at least 5000 kW for Rate Option 2, below the Customer's maximum Measured Demand. The effect of the Customer's curtailment shall be a net reduction of load on the Company's system. During periods of curtailment, the work performed by the curtailed load shall not be transferred to any other electric service provided by the Company.

(B) The Contract Demand to which the Customer agrees to reduce demand requirements during periods of curtailment is stated separately for 1) the months of June to September, inclusive (Summer), and 2) the months of October to May, inclusive (Non-Summer). The Summer and Non-Summer Contract Demands are specified to the Company in writing by the Customer and are not increased without 2 years prior written notice, except as noted under item (C). The minimum demand reduction is applicable to both the Summer and Non-Summer periods.

(C) The Summer and Non-Summer Contract Demands may be increased to the extent that an increase in the Customer's connected load increases the Customer's maximum Measured Demand in the respective Summer and Non-Summer periods. Notice of such an increase in Contract Demand, or any decrease, must be specified to the Company in writing at least 6 months prior to any change in the Contract Demand for billing purposes, and is subject to the Company's approval.

(D) Service hereunder is subject to curtailment once each calendar day, at the option of the Company, but the Customer will not be curtailed more than 10 hours in one calendar day, nor more than 12 days from June 1 to May 31, inclusive. Curtailments resulting from orders or requests of Federal, State or local government are not considered as curtailment under the provisions of this Rider and will not reduce the number of annual curtailments available to the Company.

(E) For Customers initially selecting Price Freeze Service, the minimum Term of Contract for service provided under this Rider is 1 year and, thereafter, until terminated by at least 1 year written notice from either party to the other. In any event, this Rider terminates coincident with the term of the Price Freeze option chosen.

(F) Customers returning to Price Freeze Service after taking service from an Electricity Supplier other than BGE are eligible to participate in this Rider. However, the new initial Term of Contract for the Rider will be a minimum of one year and, thereafter, until terminated by at least 1 years written notice from either party to the other. Schedule GL Customers returning to Price Freeze Service after July 1, 2003, and Schedule P Customers returning to Price Freeze Service after July 1, 2001 are not eligible for this Rider. In any event, this Rider terminates coincident with the term of the Price Freeze Service option chosen.

(Continued on Next Page)

Rider 16. Curtailable Service -- continued

***Rate Adjustment Options*:**

Rates and terms for a Customer receiving service under this Rider are those contained in the Controlling Schedule, except as modified below.

Option 1 (Schedules GL or P)

The monthly credit is determined by applying a Demand Charge Credit to the excess of the maximum Measured Demand used for Generation and Transmission billing purposes for the billing month over the Customer's Contract Demand. The credit amounts are as follows:

	Summer For June 1 through September 30	Non-Summer For October 1 through May 31
Monthly Demand Charge Credits:	$7.87 per kW	$2.04 per kW
5 Year Fixed Rate Contract (closed to new Customers):	$6.58 per kW	$1.71 per kW

Where service is supplied under Schedule GL, the Customer Charge is increased to $145 per month and is the Minimum Charge.

Should the Customer fail to reduce his Measured Demand during any curtailment period at least to the specified Contract Demand, the bill for service in the monthly period is computed under the applicable provisions of Schedule GL or P, except as otherwise noted below, and is subject to the net adjustment resulting from (1) the total credit for demand reduction computed in paragraph one of this option and (2) a charge applicable to each curtailment period of $47.80 per kW applied to the excess of the maximum Measured Demand occurring during the curtailment period over the Contract Demand. Where failure to curtail to the Contract Demand occurs during the first hour curtailment, the maximum charge under item (2) is equal to the credit determined in paragraph one of this option.

Demand Free Days

For a Customer taking service hereunder, the Company may at its option designate up to 4 weekdays per week as "demand free", but with such days subject to the curtailment provisions noted above. The designation, if any, will be made by 2 p.m. of the day immediately preceding the "demand free" day. In addition, the Company may at its option designate up to 4 on-peak hours as "demand free".

(Continued on Next Page)

Rider 16 – Curtailable Service – continued

The designation, if any, will be made by 2 p.m. on the preceding Wednesday for the five weekdays beginning Monday. The demand created by the Customer on a designated day or hour will not be used for billing purposes. The Company will not designate a day or hour as "demand free" unless 1) for that period, the anticipated average marginal energy cost during the demand billing period is less than the Energy Charge in the applicable rate schedule for the same period, and 2) the local distribution system has existing capacity sufficient to meet the expected load.

Alternatively, Customers served under Option 2 may elect to establish a mutually agreed upon Minimum Billing Demand for Generation and Transmission and a separate Minimum Billing Demand for Distribution for both the Summer and Non-Summer periods. Under this alternative, all days are eligible for "demand free" designation. Minimum Billing Demands are based on average monthly demands over the most recent two year period and are updated biannually.

Option 2 (Schedule P only; This Option expires June 30, 2002)

(Customers participating under Option 2 prior to 6/01/97 will be billed until 9/01/00 under the terms of Option 2 Supplement 308.)

		Summer For June 1 through September 30	Non-Summer For October 1 through May 31
Demand Charges:			
Generation and Transmission:	Demand above Contract Demand	$3.55 per kW	$1.74 per kW
	Demand below Contract Demand	Standard	Standard
Delivery Service Charges:		Standard	Standard
Energy Charges:			
Super-Peak:	Energy above Contract Demand	Adjusted Marginal Cost	Adjusted Marginal Cost
	Energy below Contract Demand	Opt. 2 or 3 PFS Peak	Opt. 2 or 3 PFS Peak
On-Peak:	Energy above Contract Demand	Opt. 2 or 3 Inter. Peak	Opt. 2 or 3 Inter. Peak
	Energy below Contract Demand	Standard	Standard
Intermediate- and Off-Peak:		Standard	Standard

Super-Peak: Up to a maximum of 216 hours for an annual period beginning June 1 may be designated as Super-Peak hours. The Company will notify the Customer at least 15 minutes prior to the start of a designated Super-Peak period.

Billing Demand: Standard, except that Measured Demand occurring during an hour designated as Super-Peak will not be used for billing purposes, unless the hour is part of a period of curtailment. Measured Demand in excess of the specified Contract Demand during a period of curtailment is subject to an additional charge of $5 per kW per hour.

Adjusted Marginal Cost: The Adjusted Marginal Cost is subject to change hourly and is determined by multiplying (1) the forecasted Marginal Cost of service by (2) an Energy Cost Adjustment Factor (ECAF). The ECAF is the ratio of the Controlling Schedule Energy Rate to an annual average Marginal Cost for the same rating period.

17. Best Efforts Service: Rider 17 is closed to new customers.

Best Efforts Service is provided where a Customer otherwise eligible for service under Schedule S foregoes the opportunity to receive such service. Once a Customer selects Best Efforts Service under Section 3.7, Schedule S is available upon written request to the Company.

Service is provided under the terms and conditions of the Customer's Controlling Schedule (Schedule P or GL), except that service may be interrupted at the Company's sole discretion during the following periods or for the following reasons:

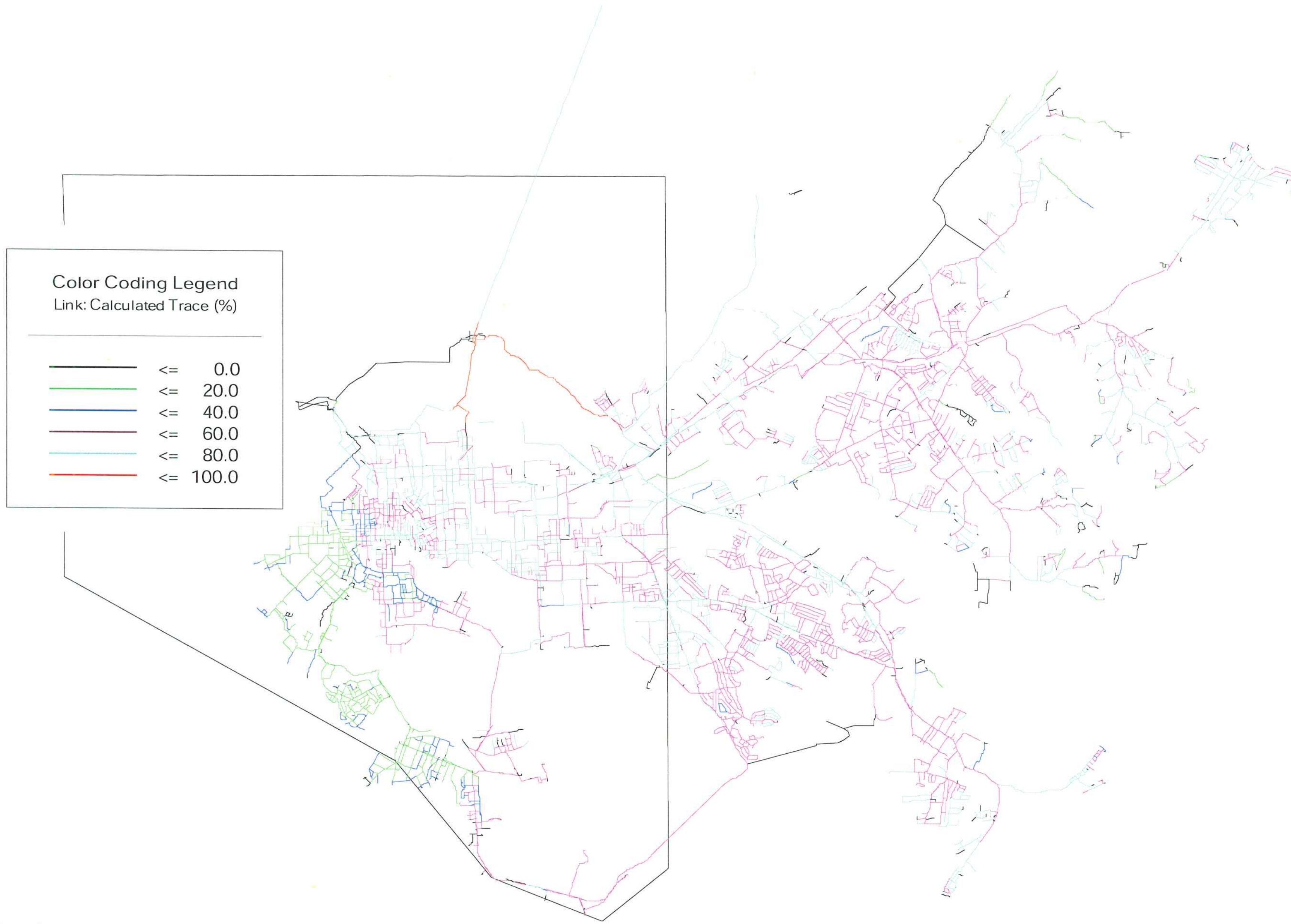
(1) when load control or load shedding programs are invoked, or to avoid the need for invoking such programs; and

(2) when the Company's estimated marginal costs of providing service are expected to exceed the revenue generated from the sale.

Periods of interruption may be designated on up to a maximum of 40 days during a calendar year. Customers receiving Best Efforts Service are not eligible for Riders 15 or 16.

The Company installs, at its expense, control devices necessary to effectuate the interruption of service.

Scenario: Source: Montebello 1 WTP

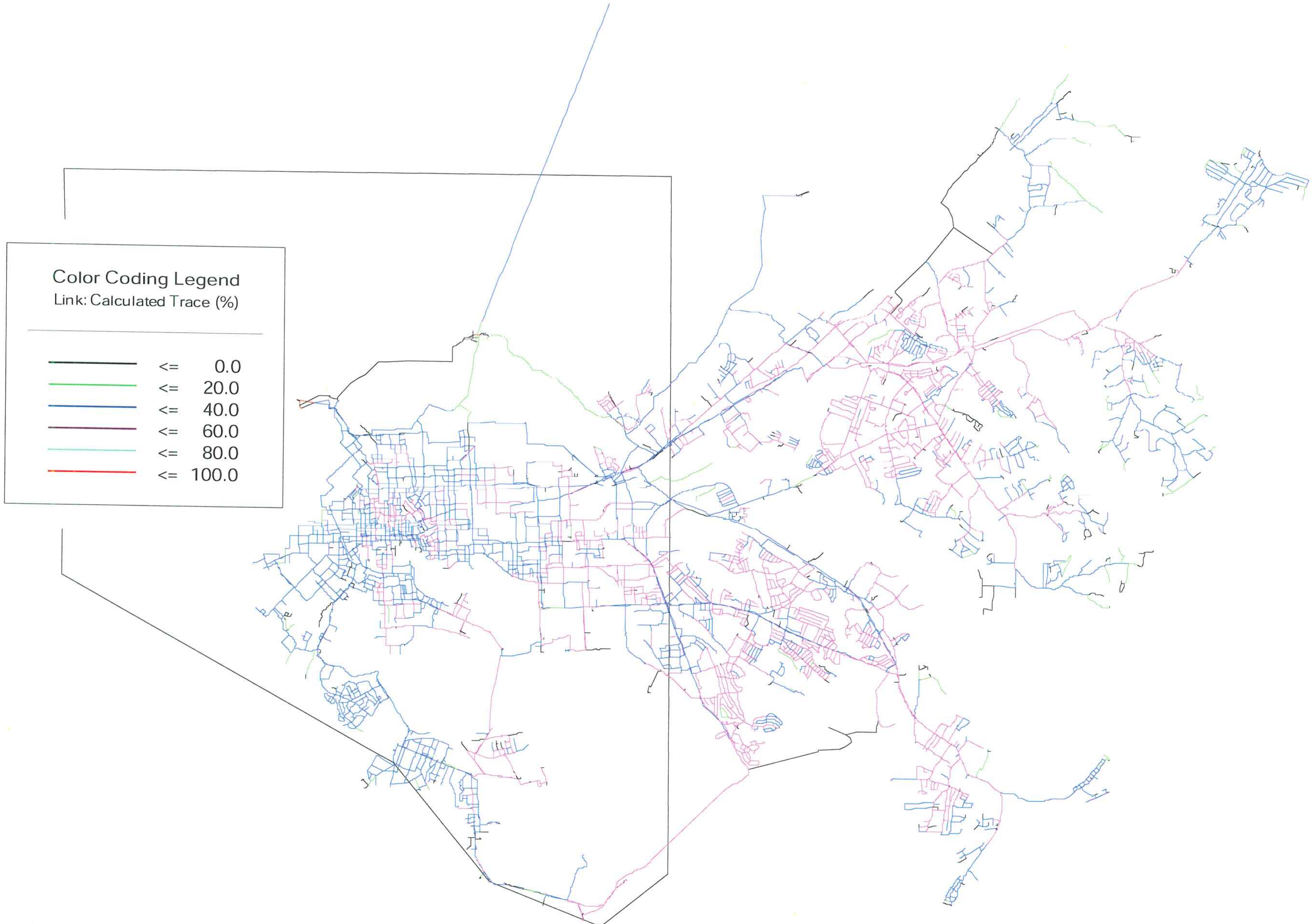


Title: Zone 1 - all
c:\watercad\baltcity\waterquality\wq1st.wcd
04/09/03 10:59:04 AM

Rummel, Klepper & Kahl
© Haestad Methods, Inc. 37 Brookside Road Waterbury, CT 06708 USA +1-203-755-1666

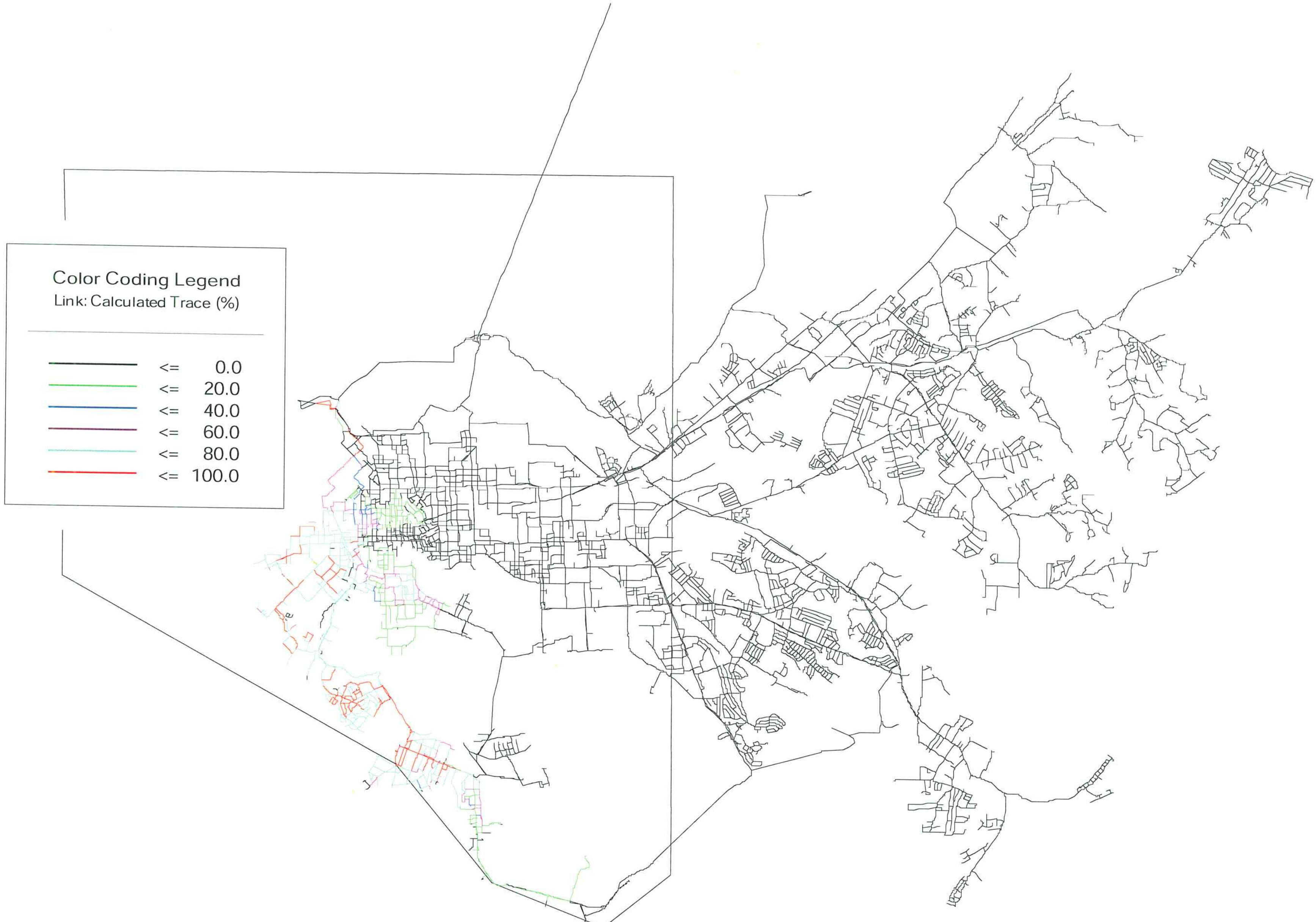
Project Engineer: TAB
WaterCAD v4.1 [424a]

Scenario: Source: Montebello 2 WTP



Title: Zone 1 - all
c:\watercad\baltcity\waterquality\wq1st.wcd
04/09/03 10:59:45 AM

Scenario: Source: Druid Lake

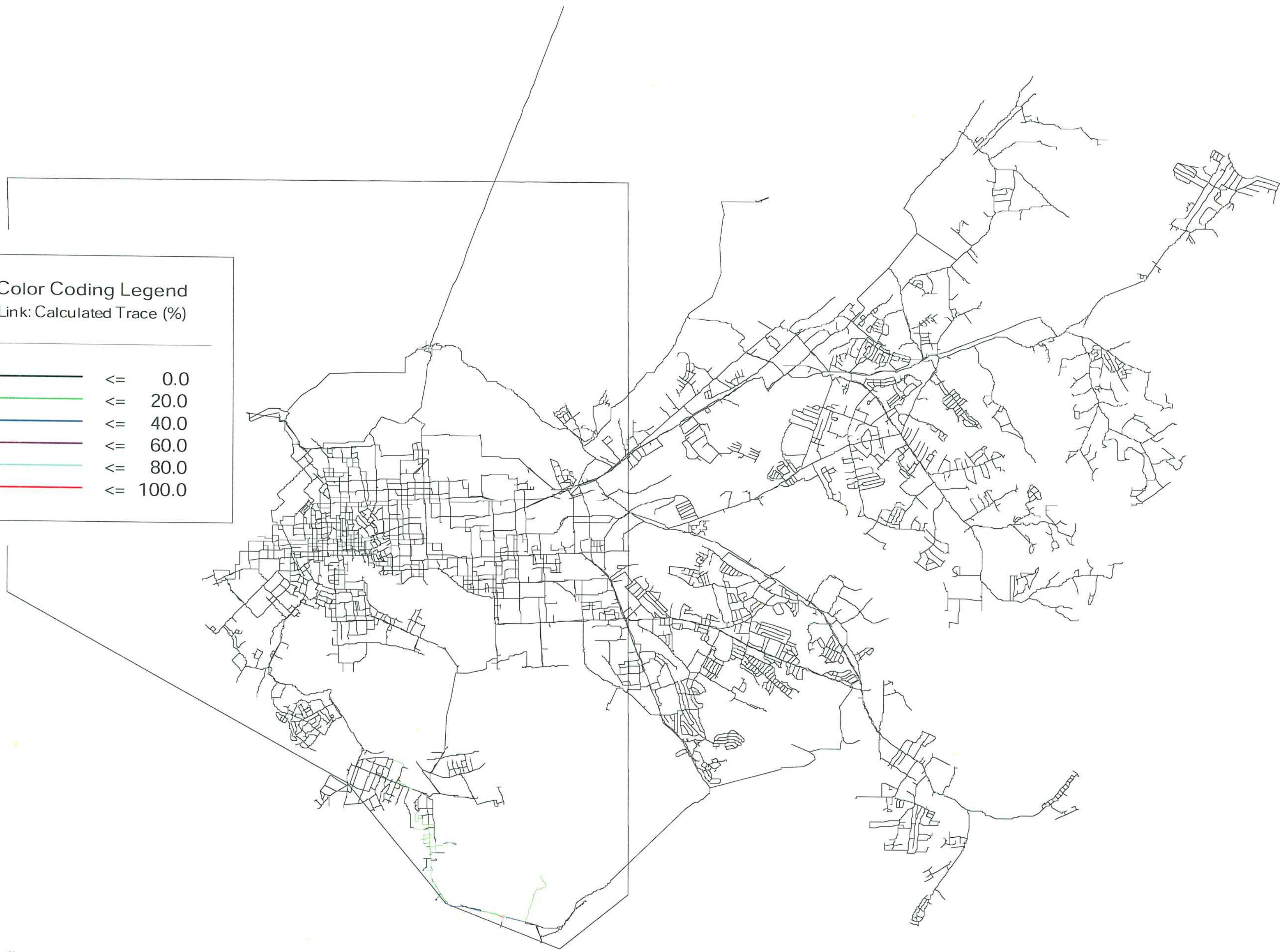


Title: Zone 1 - all
c:\watercad\baltcity\waterquality\wq1st.wcd
04/09/03 11:00:04 AM

Rummel, Klepper & Kahl

Project Engineer: TAB
WaterCAD v4.1 [424a]

Scenario: Source: Curtis Bay Tank

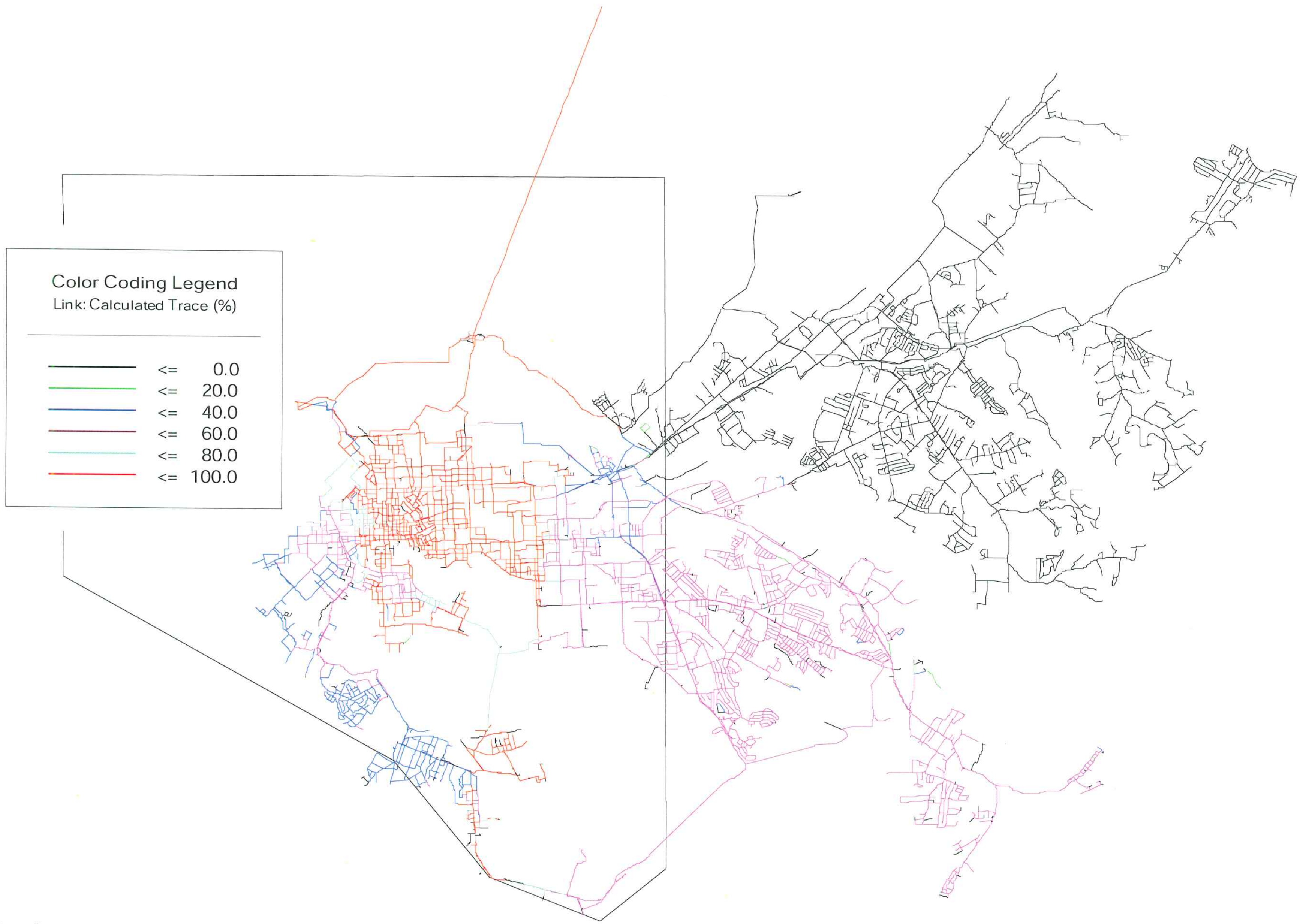


Color Coding Legend
Link: Calculated Trace (%)

(black)	<=	0.0
(green)	<=	20.0
(blue)	<=	40.0
(purple)	<=	60.0
(light blue)	<=	80.0
(red)	<=	100.0

Title: Zone 1 - all
c:\watercad\baltcity\waterquality\wq1st.wcd
04/09/03 11:00:30 AM

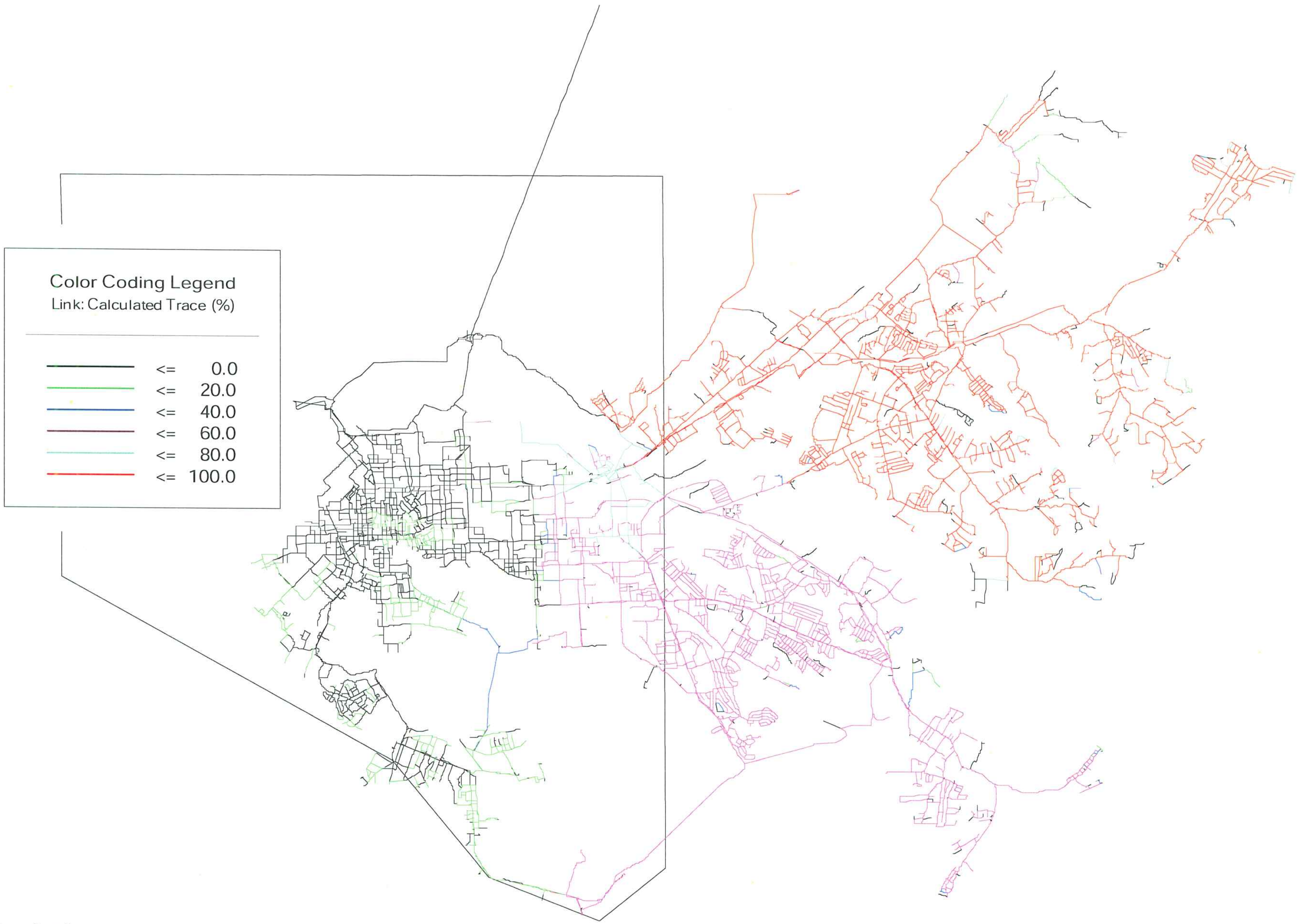
Scenario: 2025 Source: Montebello WTP



Title: Zone 1 - all
c:\watercad\baltcity\waterquality\wq1st.wcd
04/09/03 11:00:46 AM

Project Engineer: TAB
WaterCAD v4.1 [424a]

Scenario: 2025 Source: Fullerton WTP

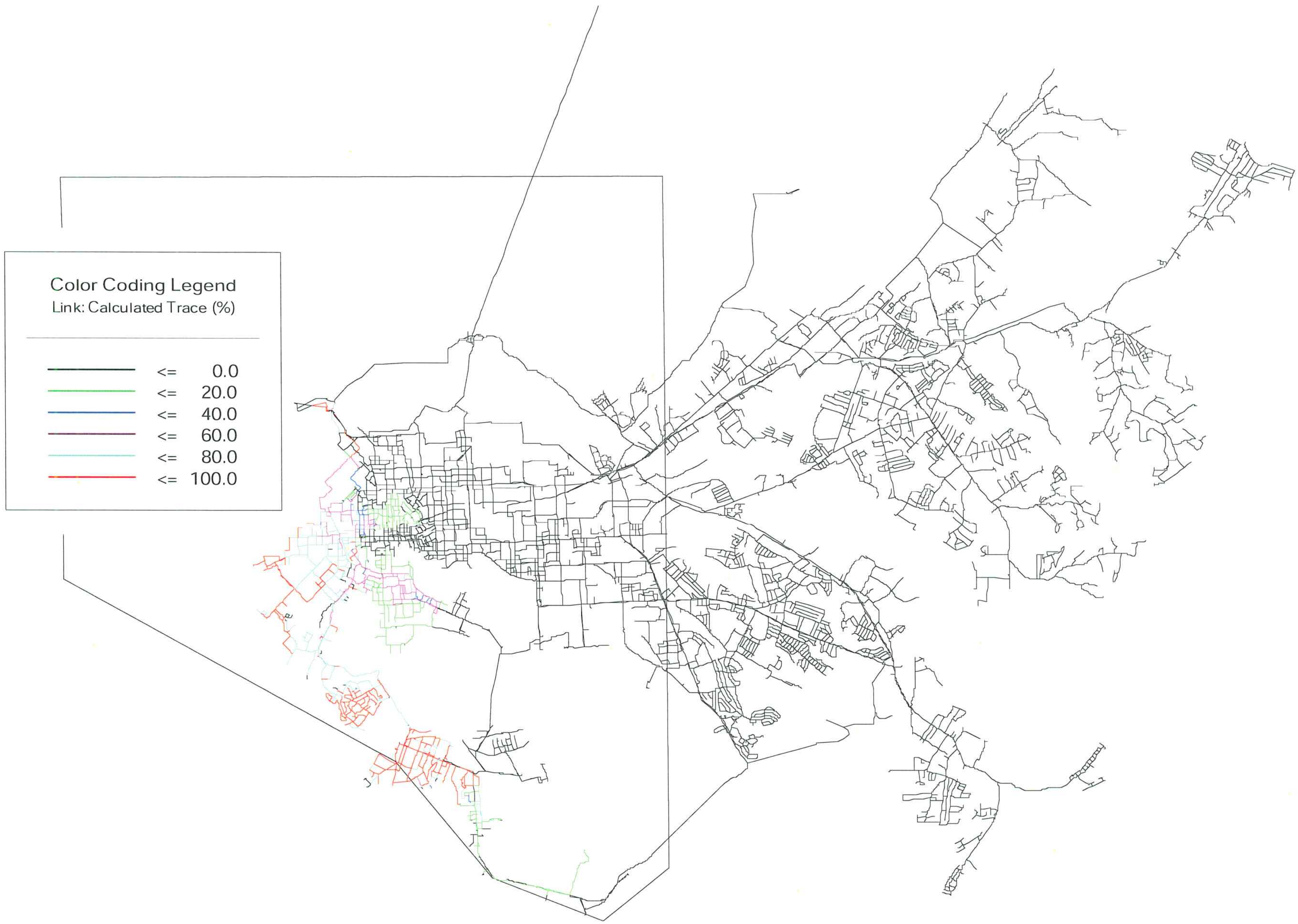


Title: Zone 1 - all
c:\watercad\baltcity\waterquality\wq1st.wcd
04/09/03 11:01:08 AM

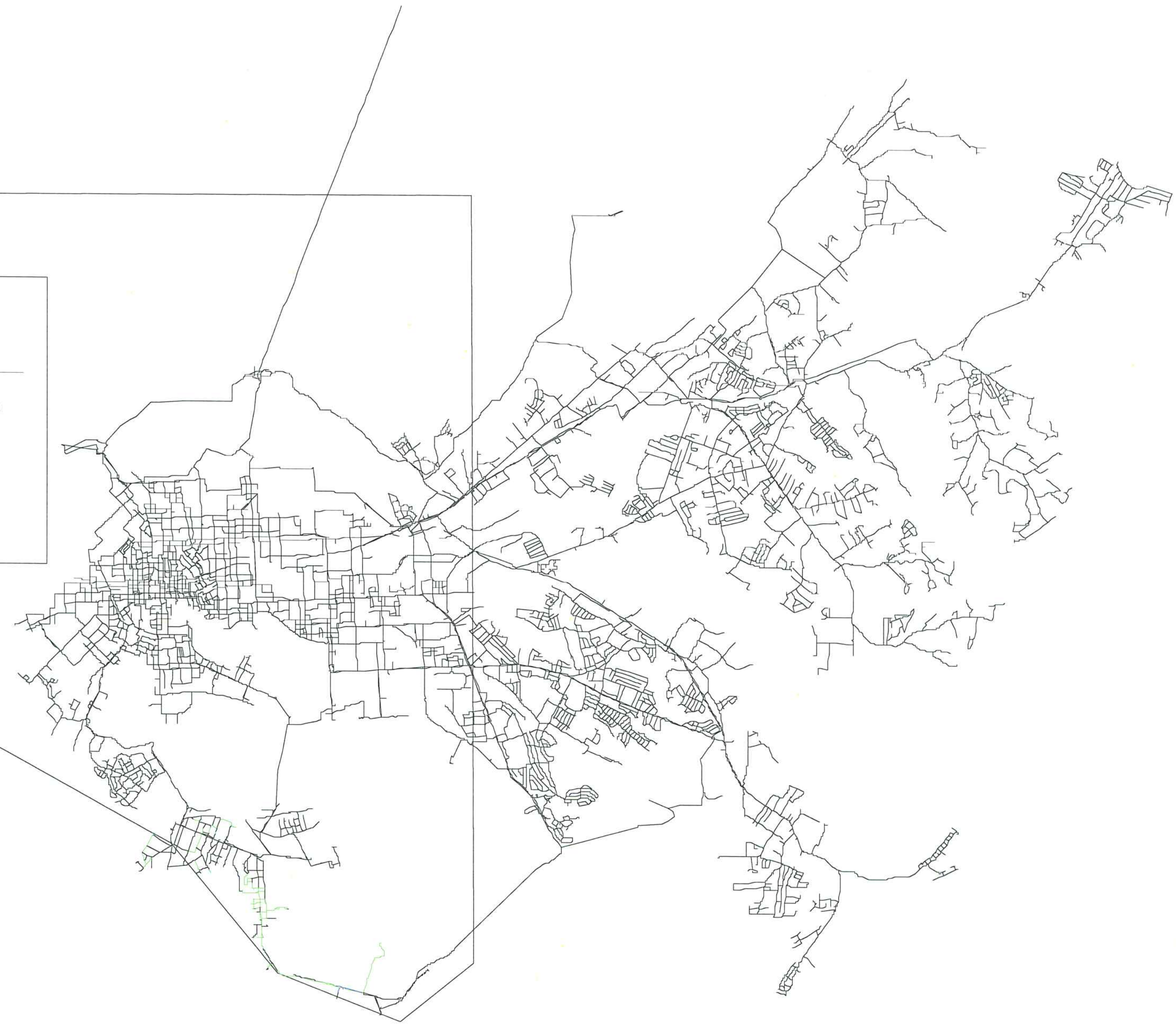
Rummel, Klepper & Kahl

Project Engineer: TAB
WaterCAD v4.1 [424a]

Scenario: 2025 Source: Druid Lake



Scenario: 2025 Source: Curtis Bay Tank



Color Coding Legend
Link: Calculated Trace (%)

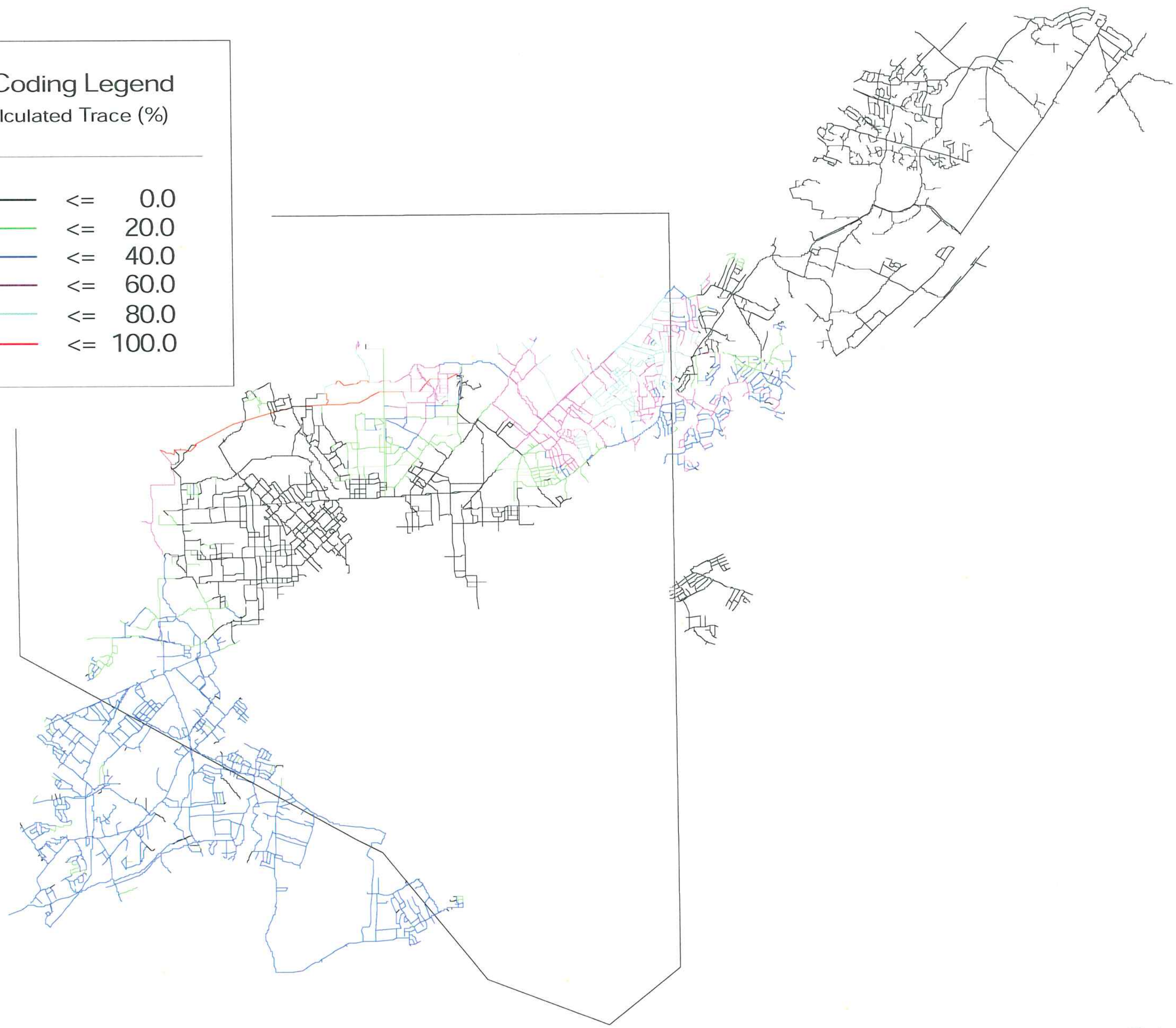
black	<= 0.0
green	<= 20.0
blue	<= 40.0
purple	<= 60.0
cyan	<= 80.0
red	<= 100.0

Title: Zone 1 - all
c:\watercad\baltcity\waterquality\wq1st.wcd
04/09/03 11:02:25 AM

Scenario: Source: Ashburton WTP

Color Coding Legend
Link: Calculated Trace (%)

black	<=	0.0
green	<=	20.0
blue	<=	40.0
purple	<=	60.0
cyan	<=	80.0
red	<=	100.0

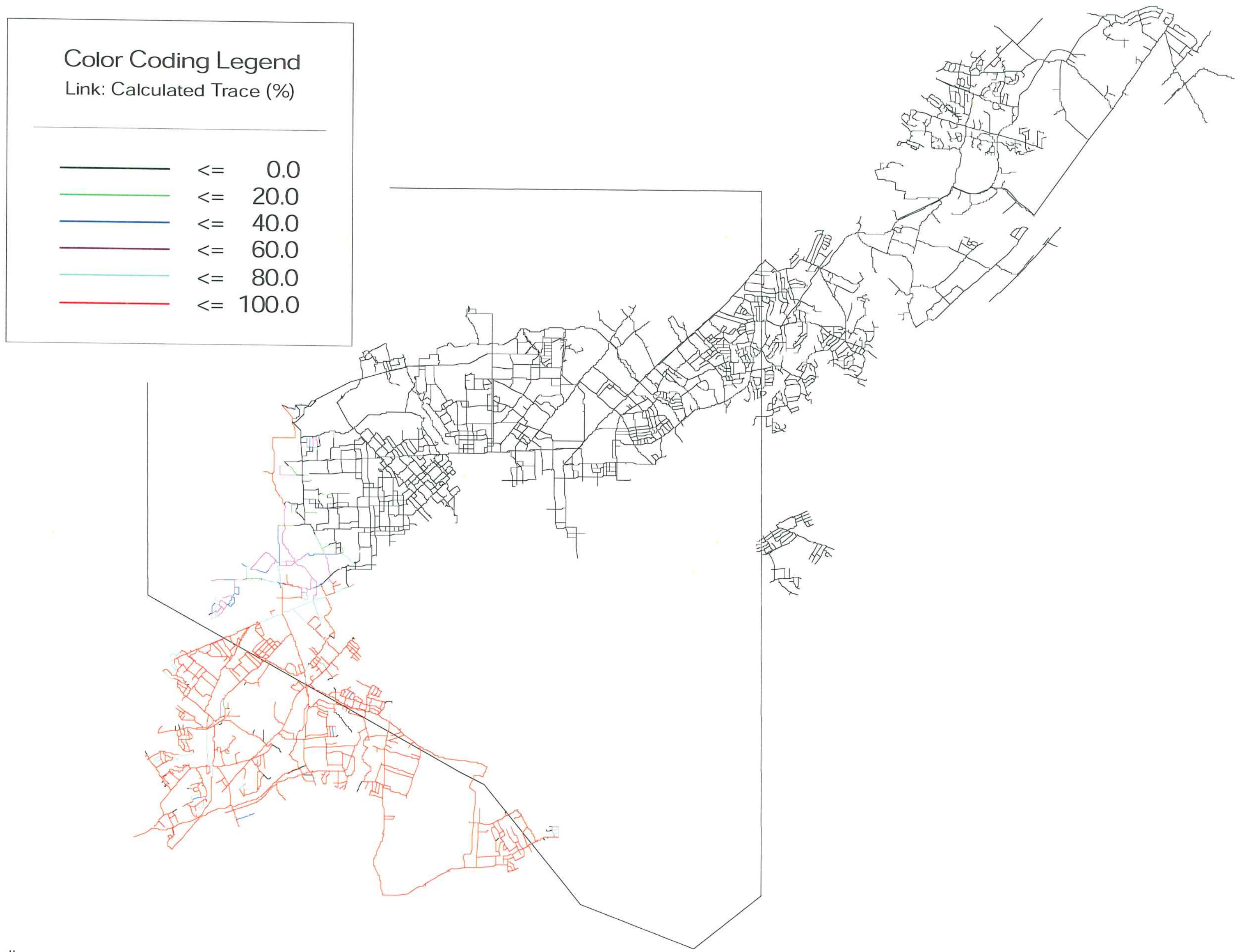


Title: Zone 2 - all
c:\watercad\baltcity\waterquality\wq2nd.wcd
04/15/03 10:49:29 AM

Rummel, Klepper & Kahl

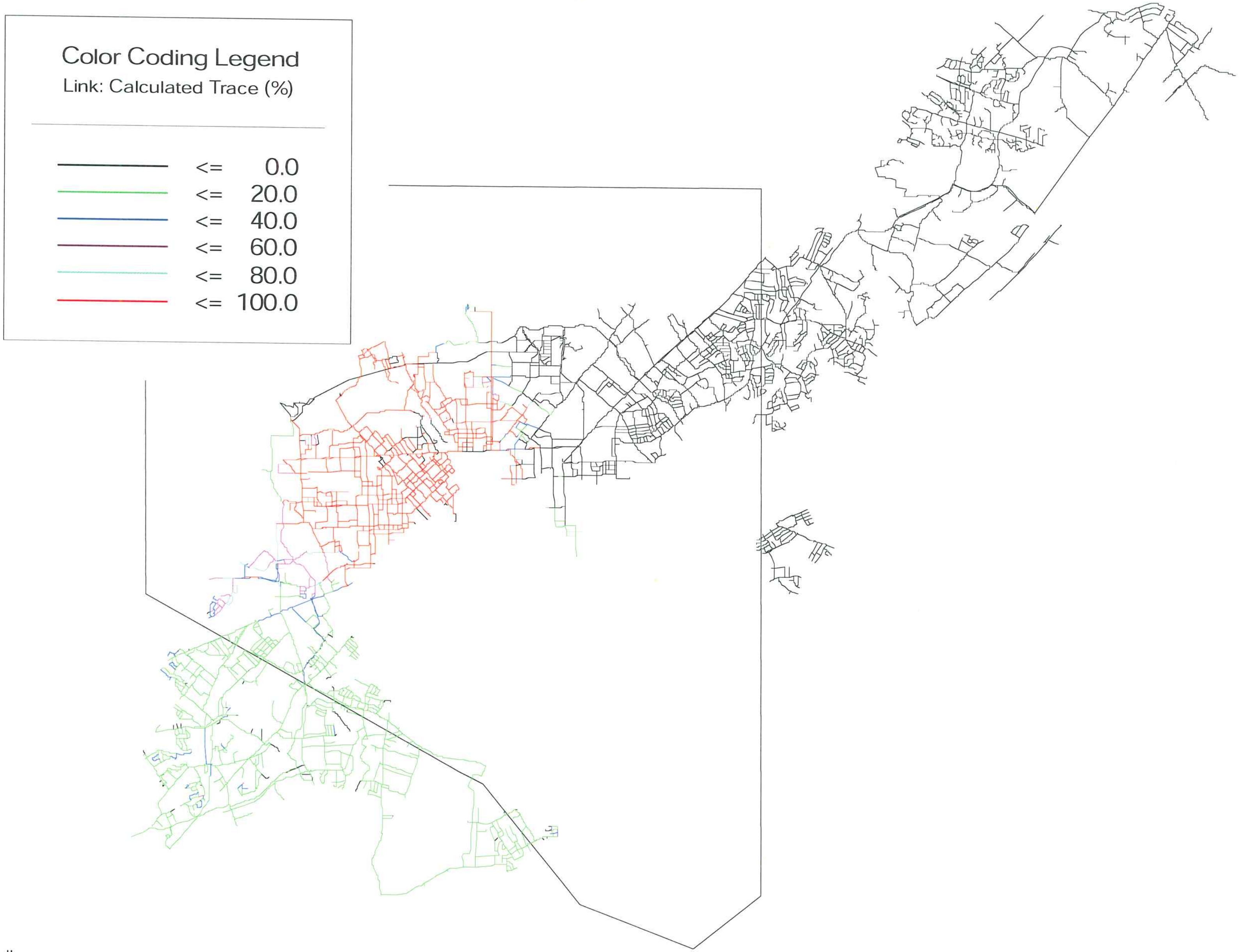
Project Engineer: TAB
WaterCAD v4.1 [424a]

Scenario: Source: Ashburton Reservoir



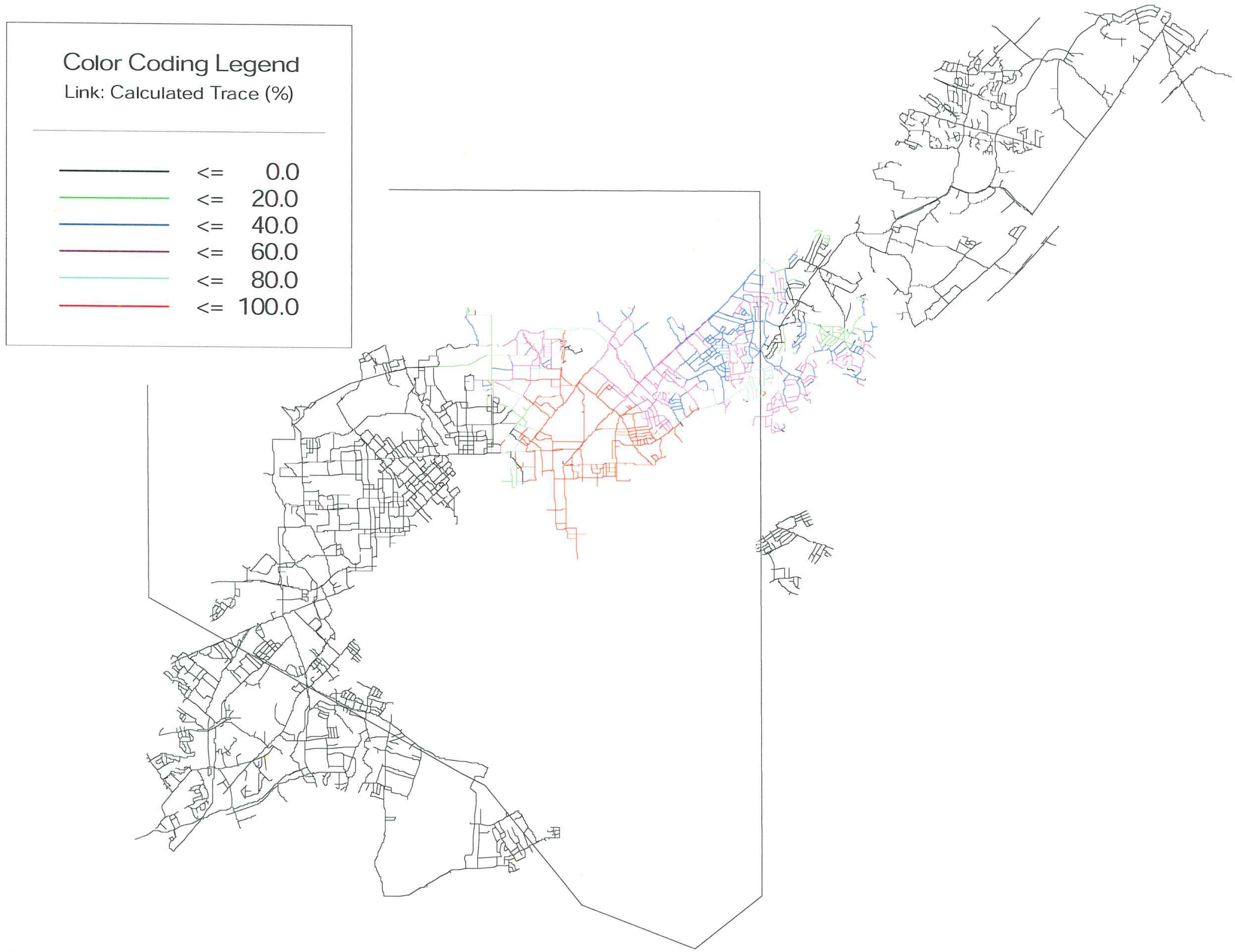
Title: Zone 2 - all
c:\watercad\baltcity\waterquality\wq2nd.wcd
04/15/03 10:51:43 AM

Scenario: Source: Vernon PS



Title: Zone 2 - all
c:\watercad\baltcity\waterquality\wq2nd.wcd
04/15/03 10:52:07 AM

Scenario: Source: Hillen PS

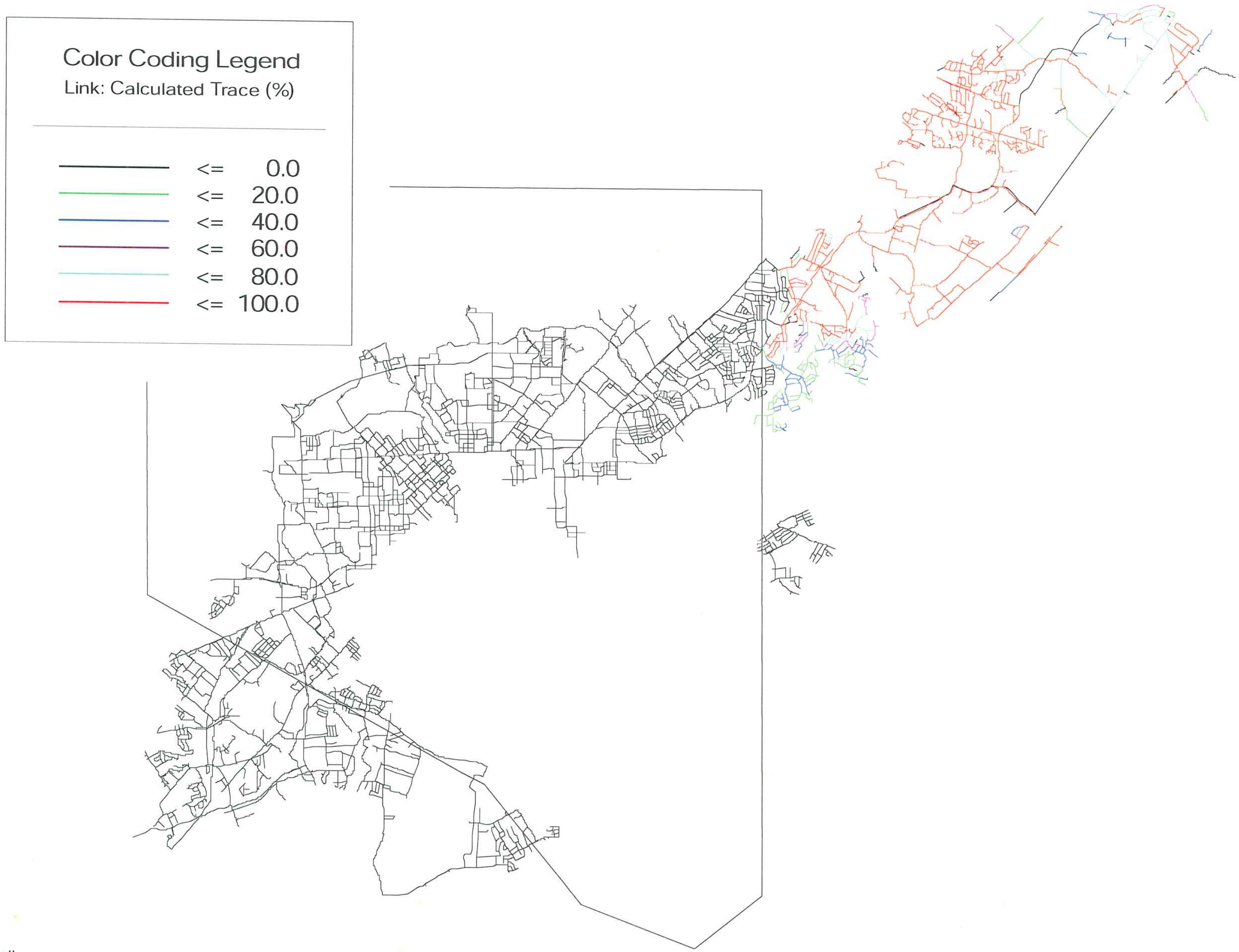


Title: Zone 2 - all
c:\watercad\baltcity\waterquality\wq2nd.wcd
04/15/03 10:52:24 AM

Rummel, Klepper & Kahl

Project Engineer: TAB
WaterCAD v4.1 [424a]

Scenario: Source: Fullerton2 PS

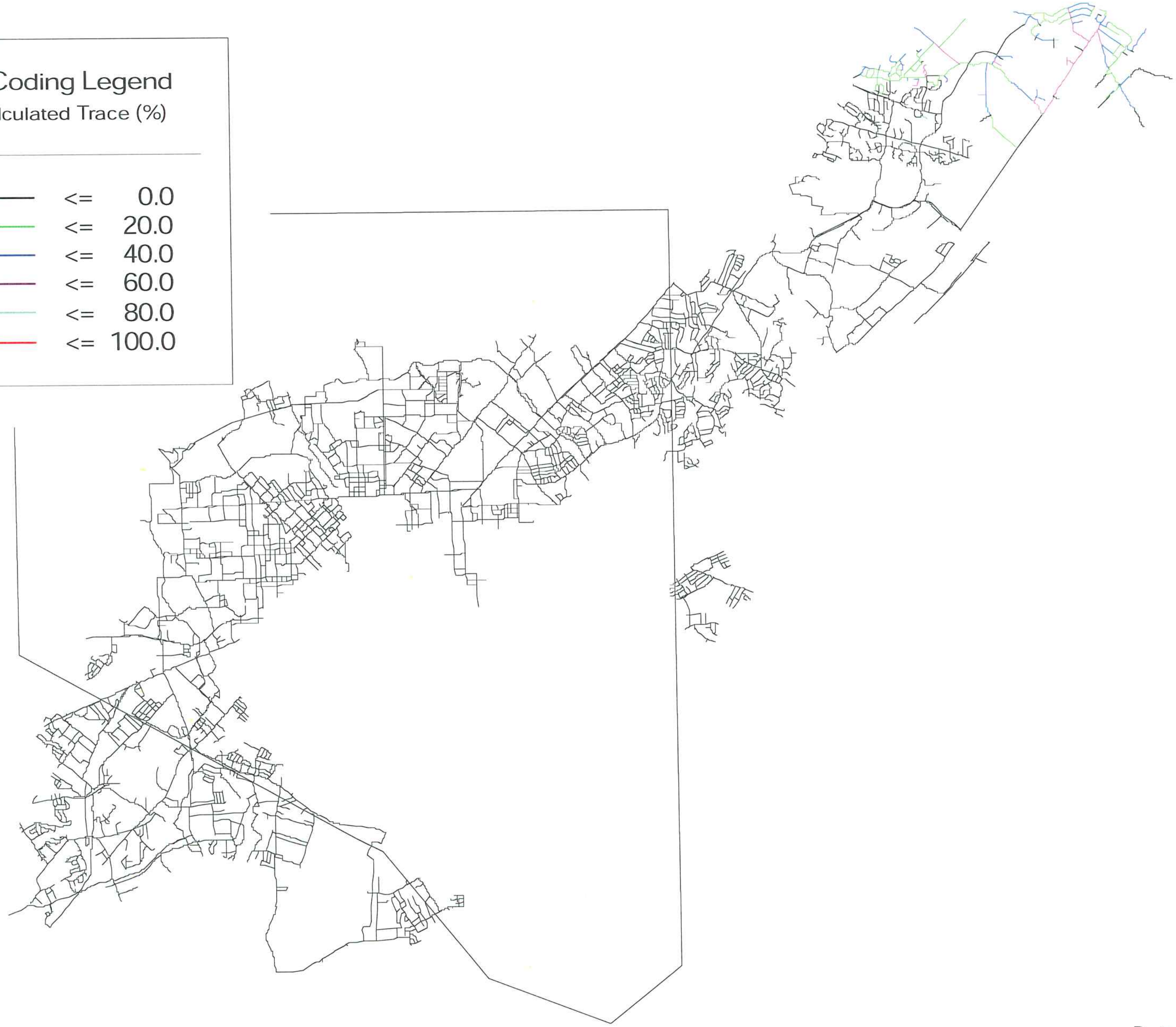


Title: Zone 2 - all
c:\watercad\baltcity\waterquality\wq2nd.wcd
04/15/03 10:52:43 AM

Rummel, Klepper & Kahl

Project Engineer: TAB
WaterCAD v4.1 [424a]

Scenario: Source: Perry Hall Tank



Color Coding Legend
Link: Calculated Trace (%)

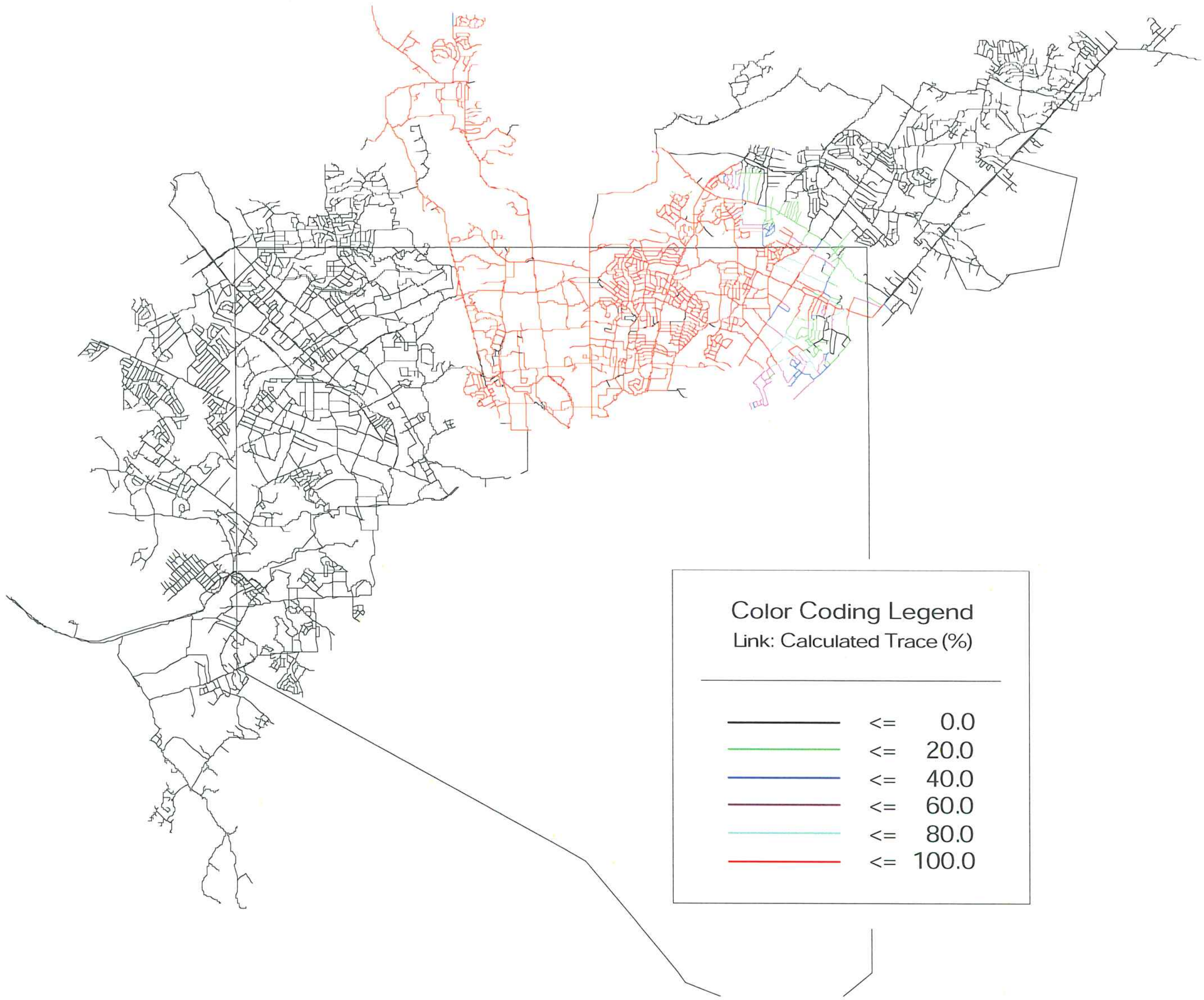
black	<= 0.0
green	<= 20.0
blue	<= 40.0
purple	<= 60.0
light green	<= 80.0
red	<= 100.0

Title: Zone 2 - all
c:\watercad\baltcity\waterquality\wq2nd.wcd
04/15/03 10:53:00 AM

Rummel, Klepper & Kahl

Project Engineer: TAB
WaterCAD v4.1 [424a]

Scenario: Source: Guilford PS



Color Coding Legend
Link: Calculated Trace (%)

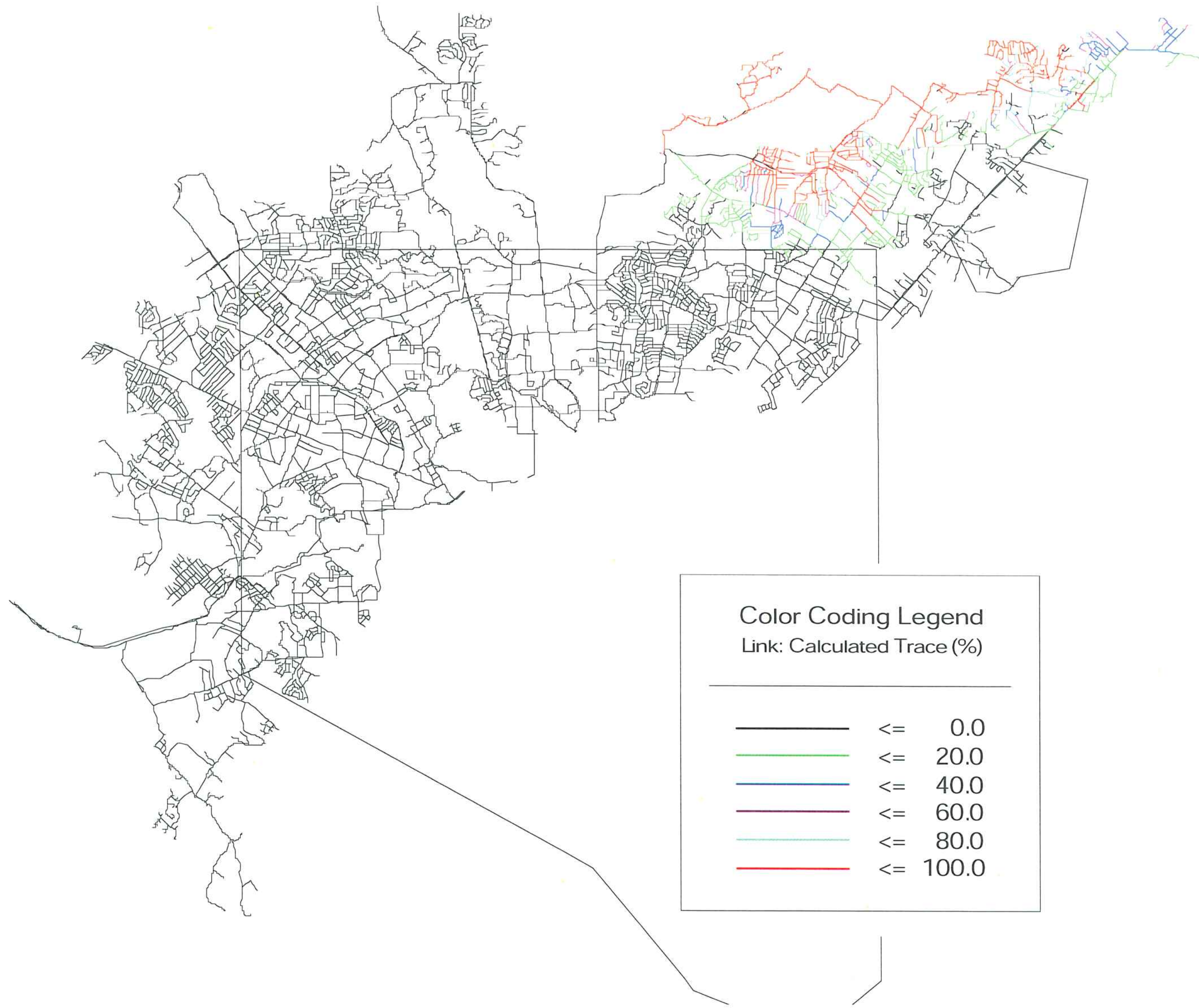
<=	0.0
<=	20.0
<=	40.0
<=	60.0
<=	80.0
<=	100.0

Title: Zone 3 - all
c:\watercad\baltcity\waterquality\wq3rd.wcd
04/09/03 11:55:15 AM

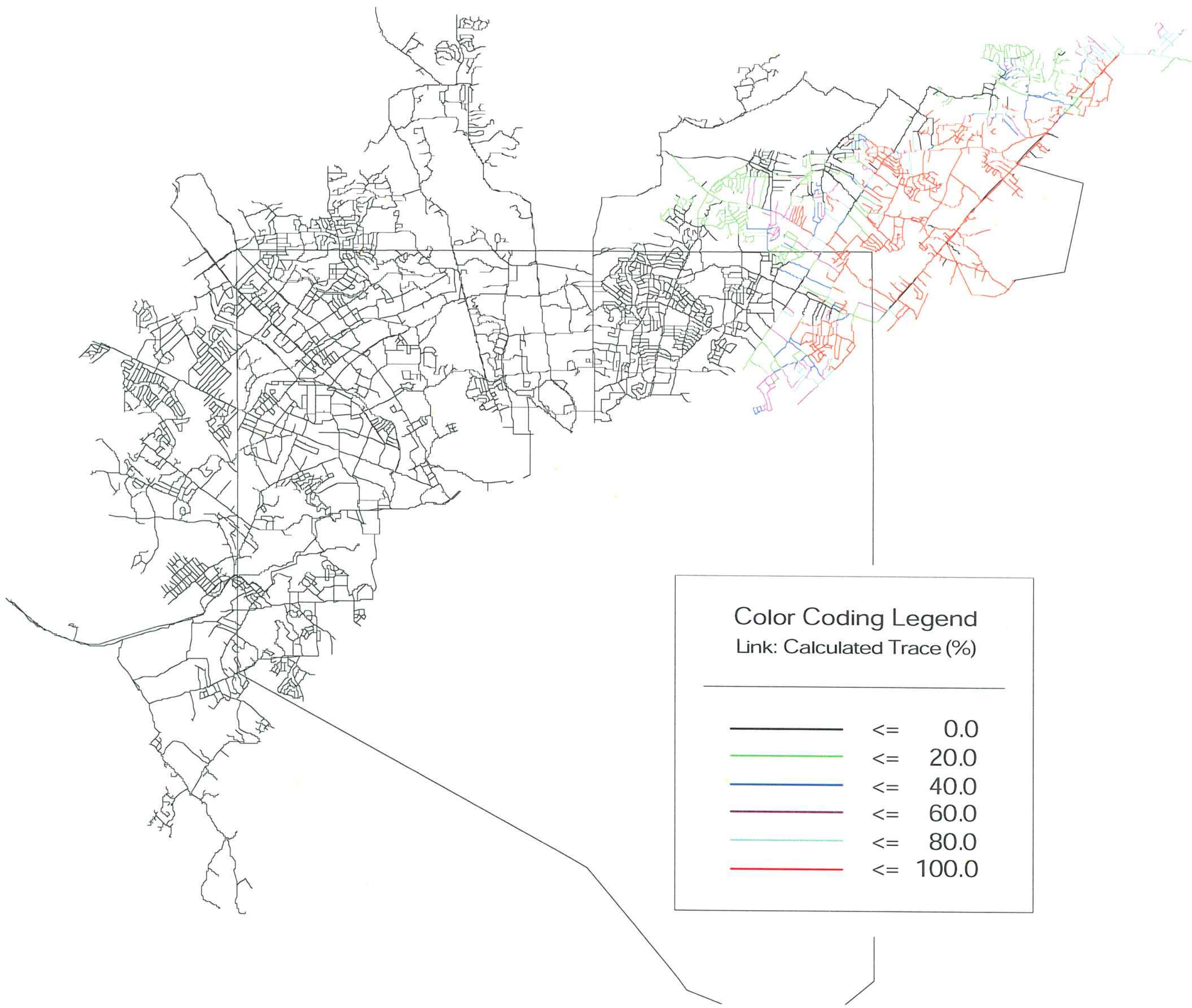
Rummel, Klepper & Kahl

Project Engineer: TAB
WaterCAD v4.1 [424a]

Scenario: Source: Cromwell PS



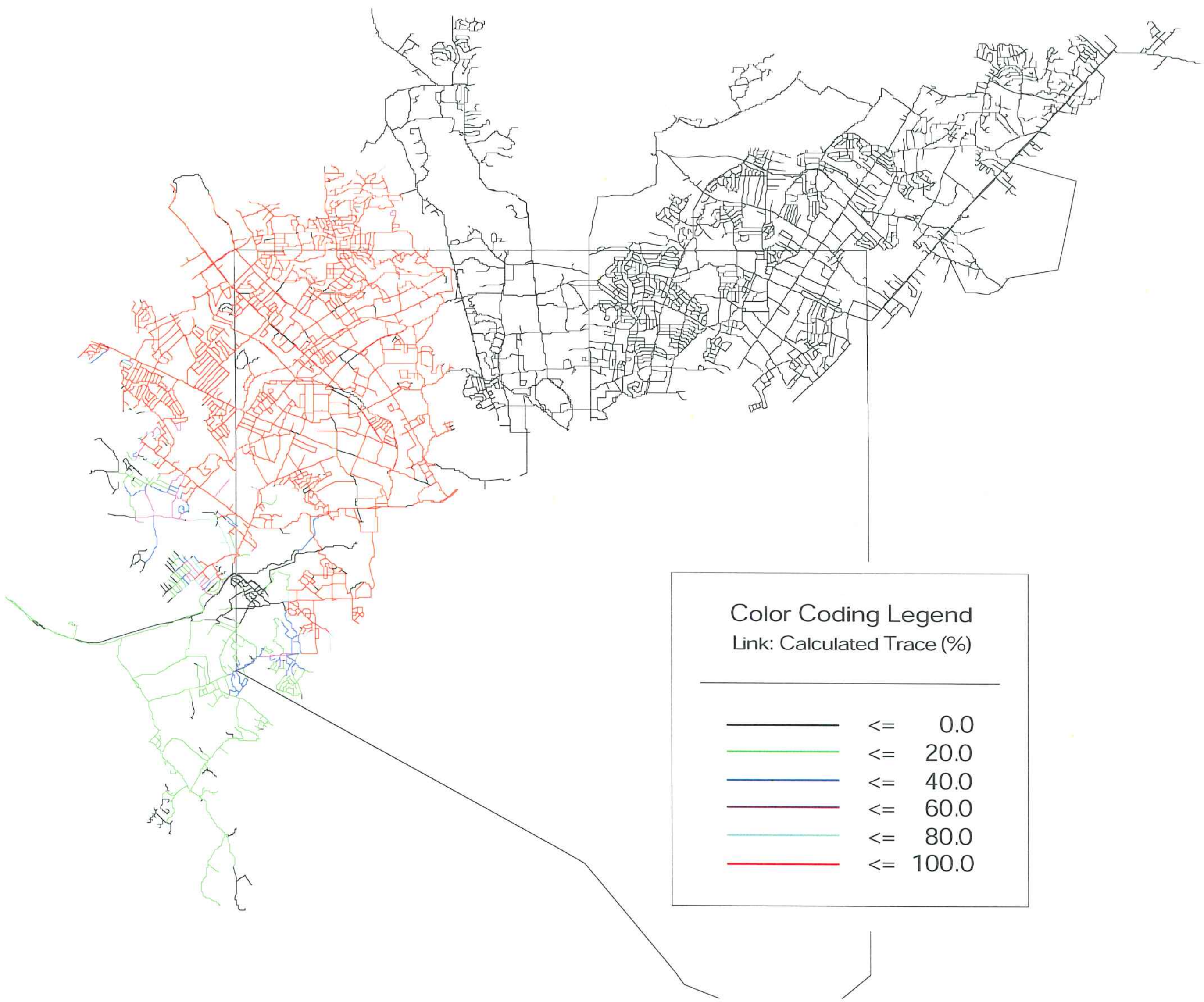
Scenario: Source: Fullerton3 PS



Title: Zone 3 - all
c:\watercad\baltcity\waterquality\wq3rd.wcd
04/09/03 11:55:55 AM

Project Engineer: TAB
WaterCAD v4.1 [424a]

Scenario: Source: Ashburton PS



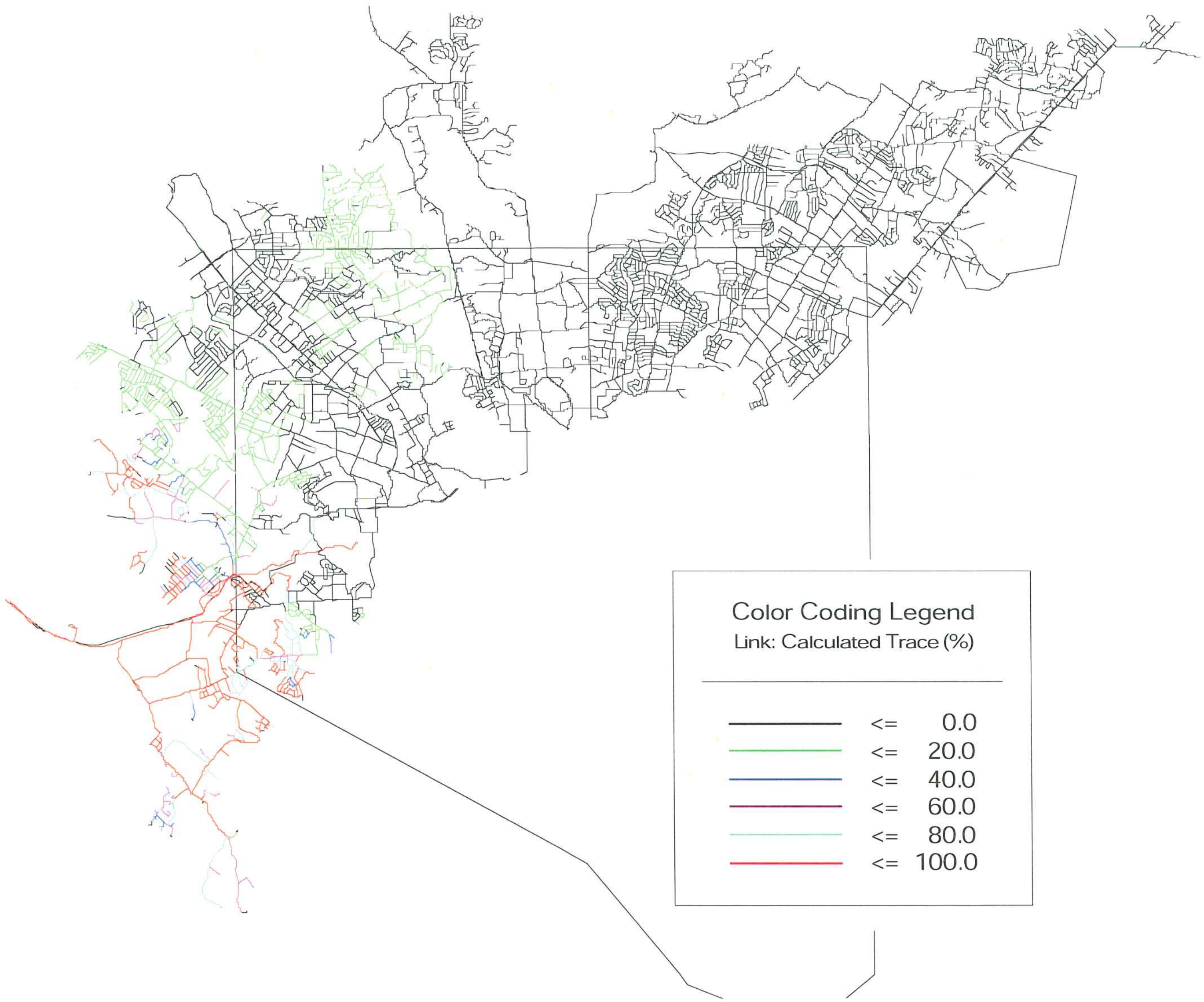
Color Coding Legend

Link: Calculated Trace (%)

Color		Value
black	<=	0.0
green	<=	20.0
blue	<=	40.0
purple	<=	60.0
cyan	<=	80.0
red	<=	100.0

Title: Zone 3 - all
c:\watercad\baltcity\waterquality\wq3rd.wcd
04/09/03 11:56:13 AM

Scenario: Source: Leakin Park PS

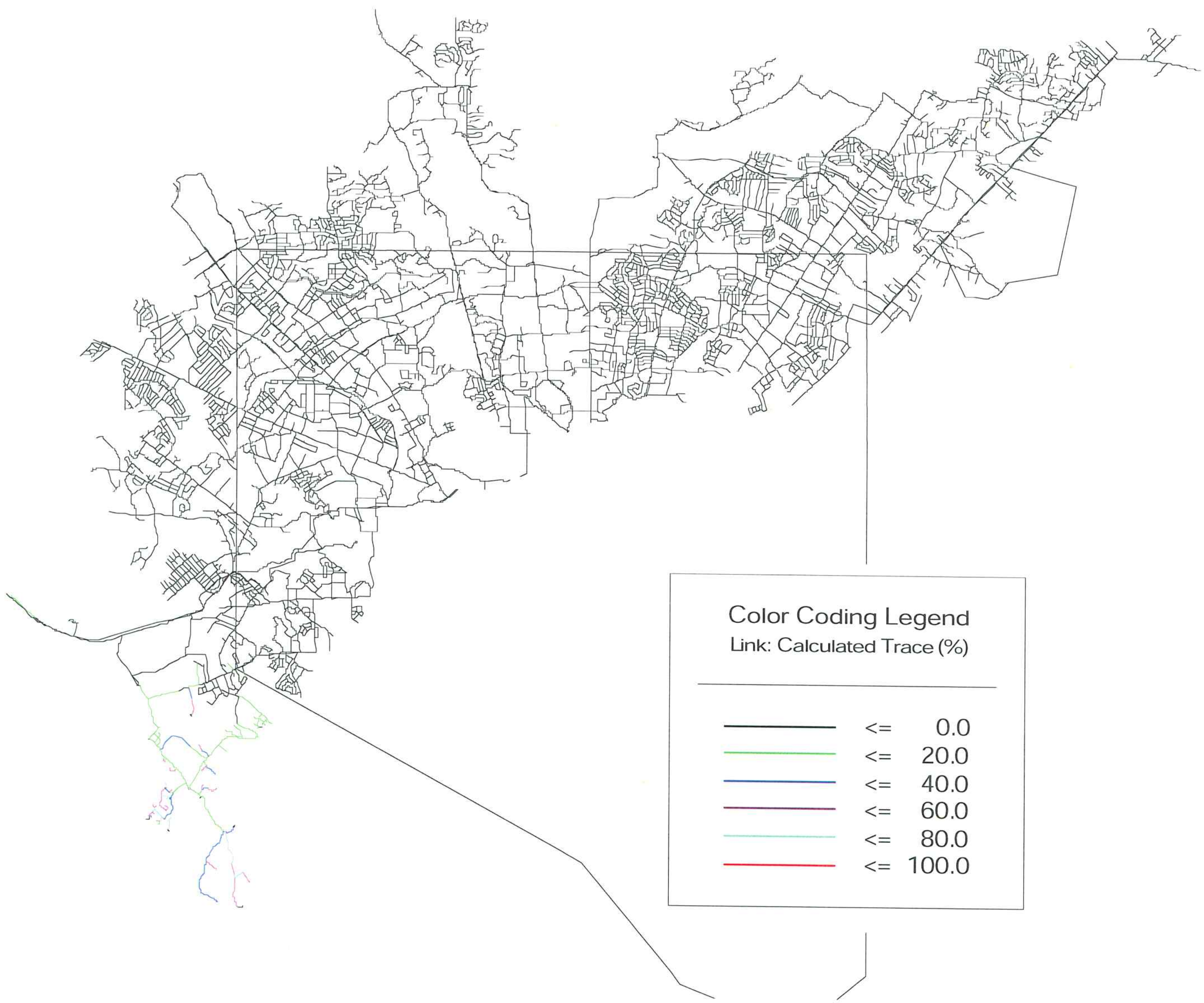


Title: Zone 3 - all
c:\watercad\baltcity\waterquality\wq3rd.wcd
04/09/03 11:56:29 AM

Rummel, Klepper & Kahl

Project Engineer: TAB
WaterCAD v4.1 [424a]

Scenario: Source: Melvin Tank

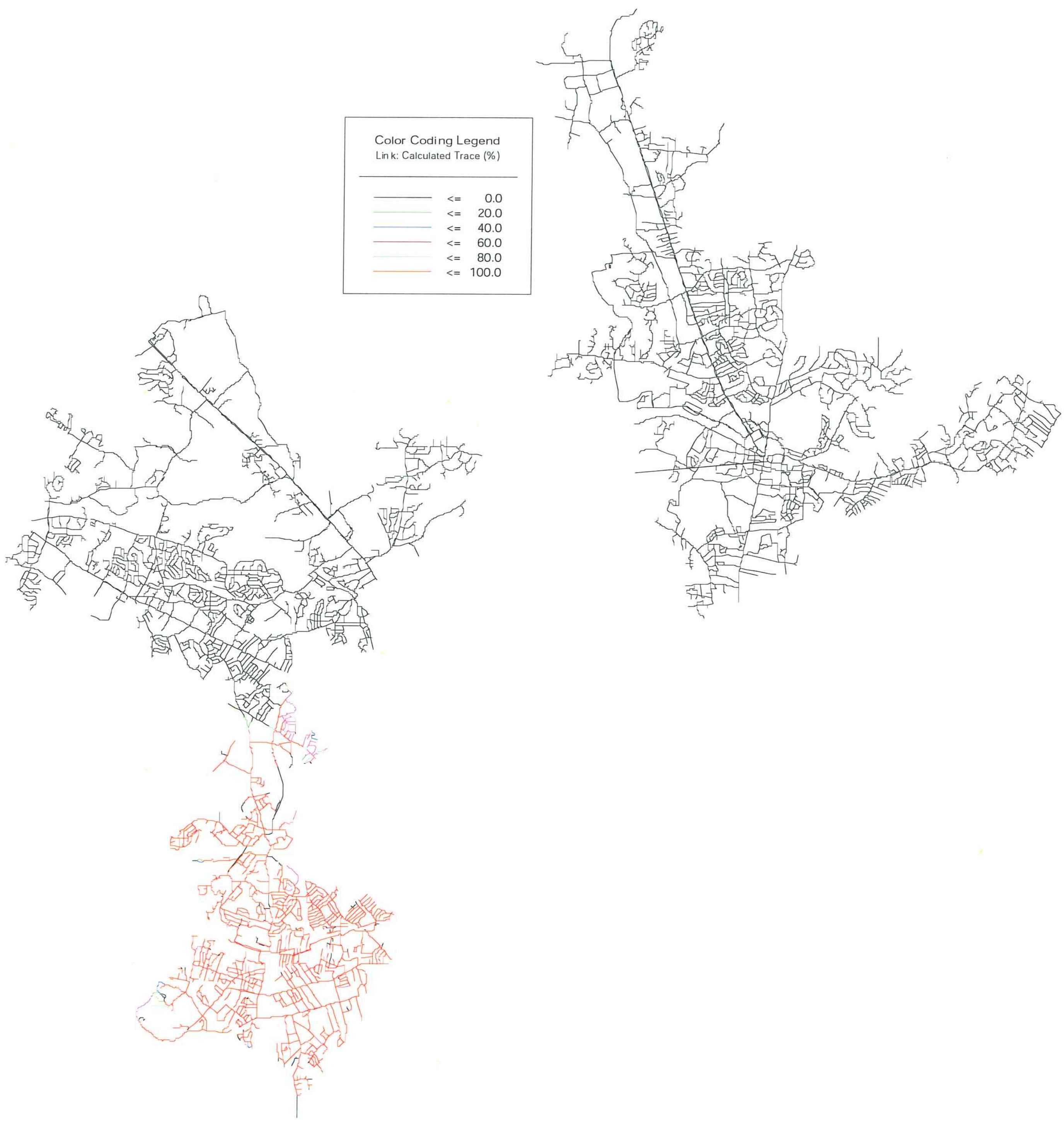


Title: Zone 3 - all
c:\watercad\baltcity\waterquality\wq3rd.wcd
04/09/03 11:56:46 AM

Rummel, Klepper & Kahl
© Haestad Methods, Inc. 37 Brookside Road Waterbury, CT 06708 USA +1-203-755-1666

Project Engineer: TAB
WaterCAD v4.1 [424a]

Scenario: Source: Catonsville PS



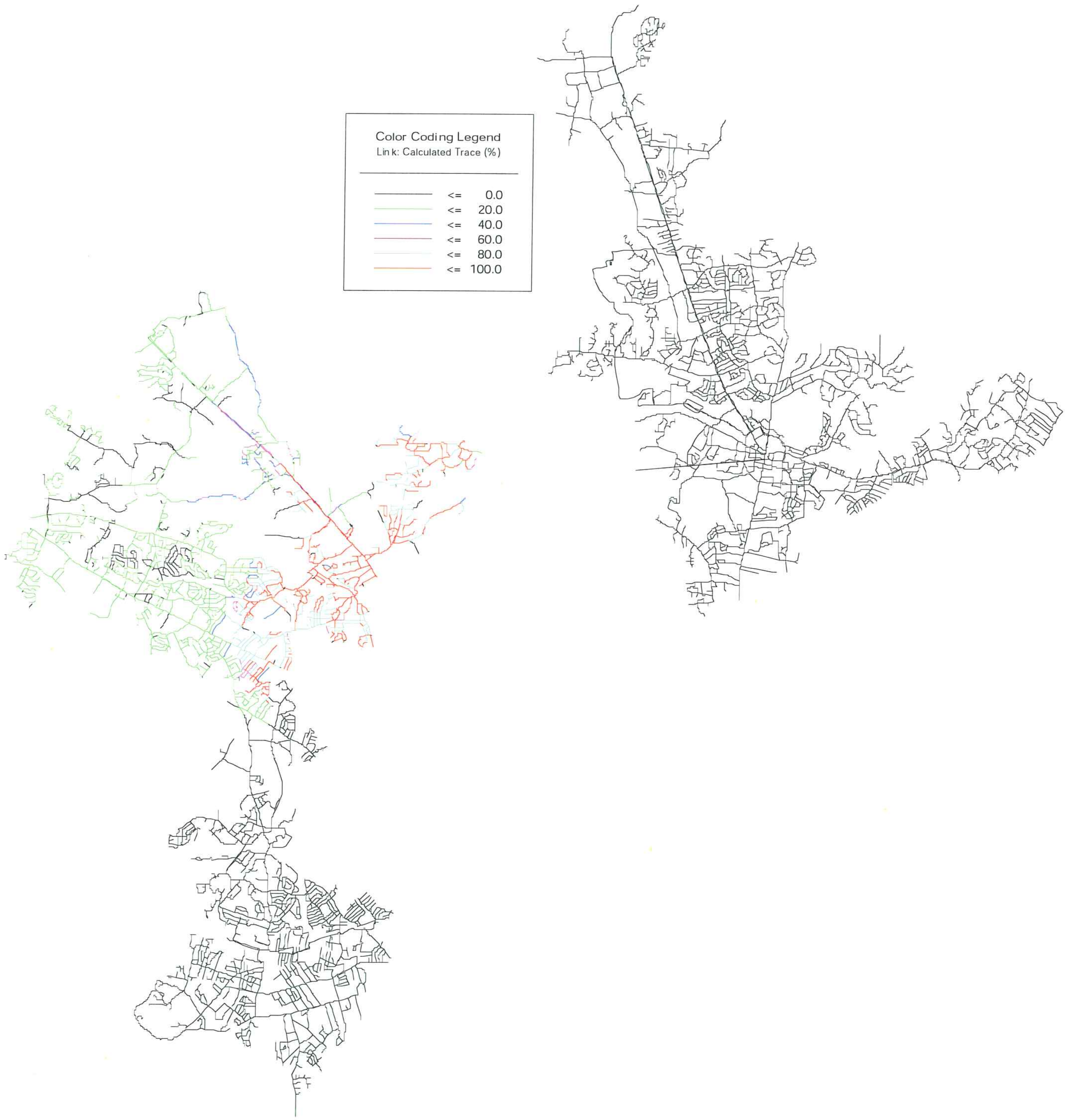
Title: Zone 4 - all
c:\watercad\baltcity\waterquality\wq4th.wcd
04/09/03 12:06:16 PM © Haestad Methods, Inc. 37 Brookside Road Waterbury, CT 06708 USA +1-203-755-1666

Rummel, Klepper & Kahl

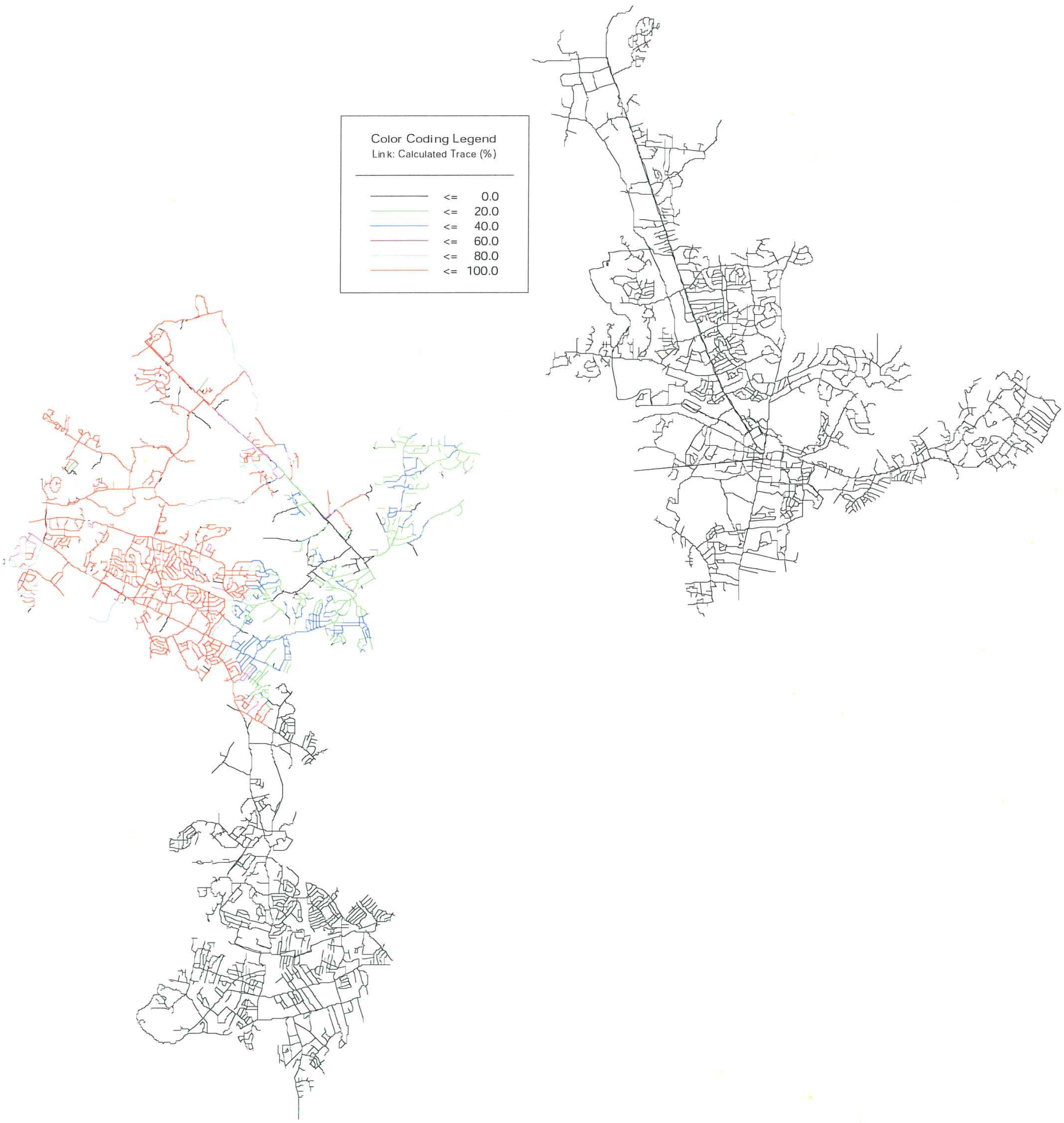
Project Engineer: TAB
WaterCAD v4.1 [424a]

Scenario: Source: Rolling Road Tank

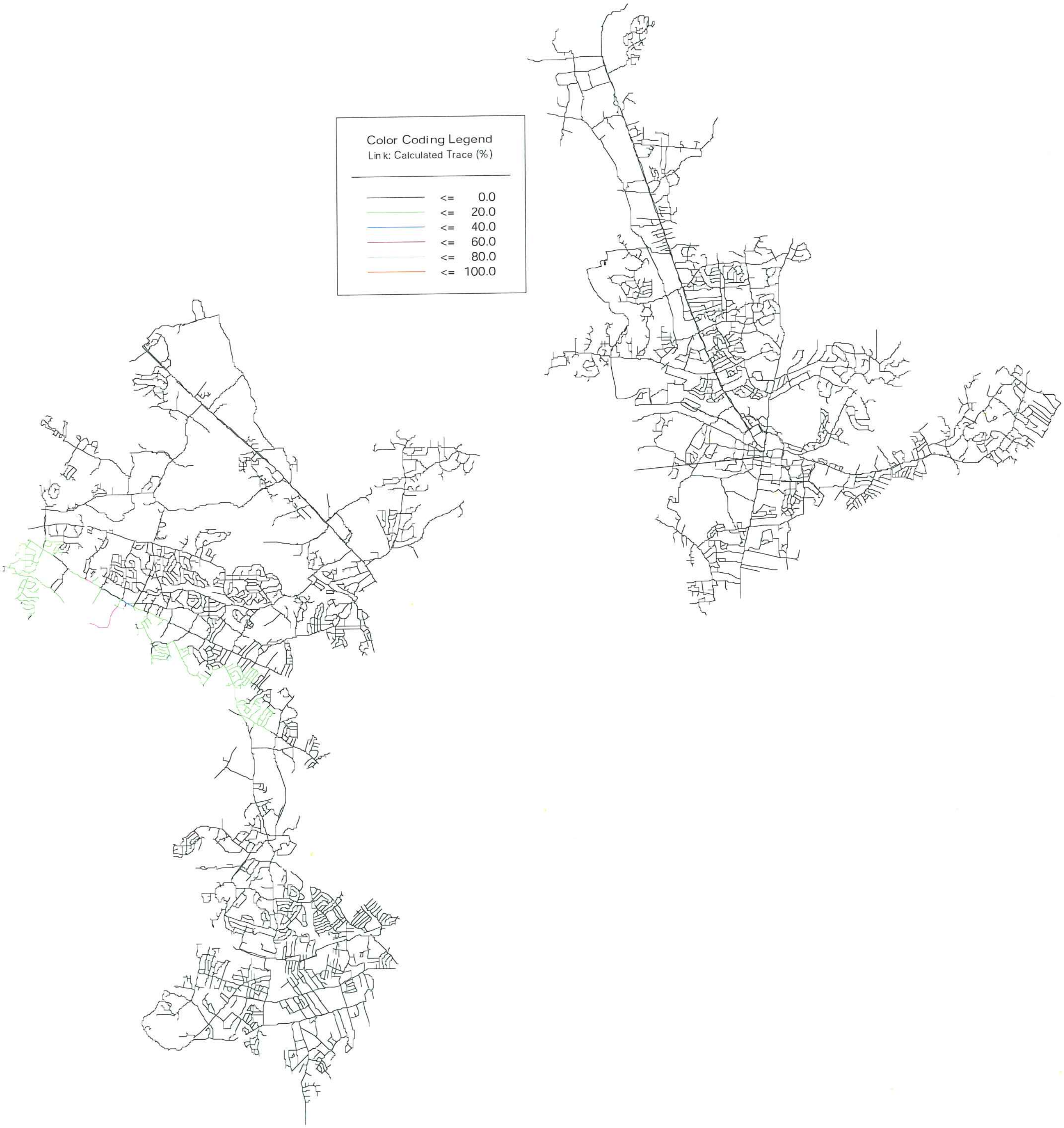
Scenario: Source: Pikesville #1 PS



Scenario: Source: Pikesville #2 PS



Scenario: Source: Randallstown Tank

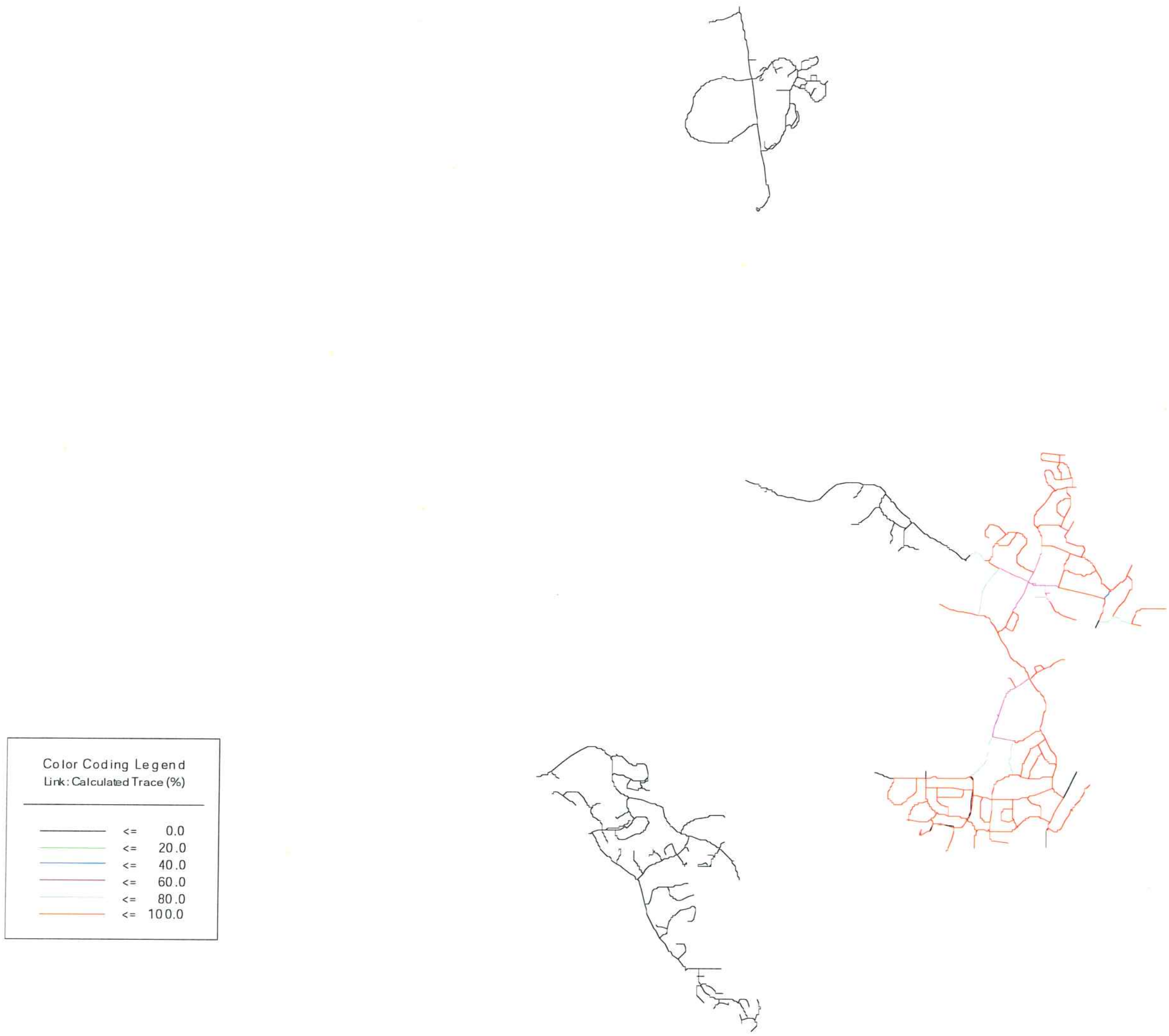


Scenario: Source: Deer Park Tank

Scenario: Source: Towson PS

Scenario: Source: Cub Hill Tank

Scenario: Source: Stratford PS



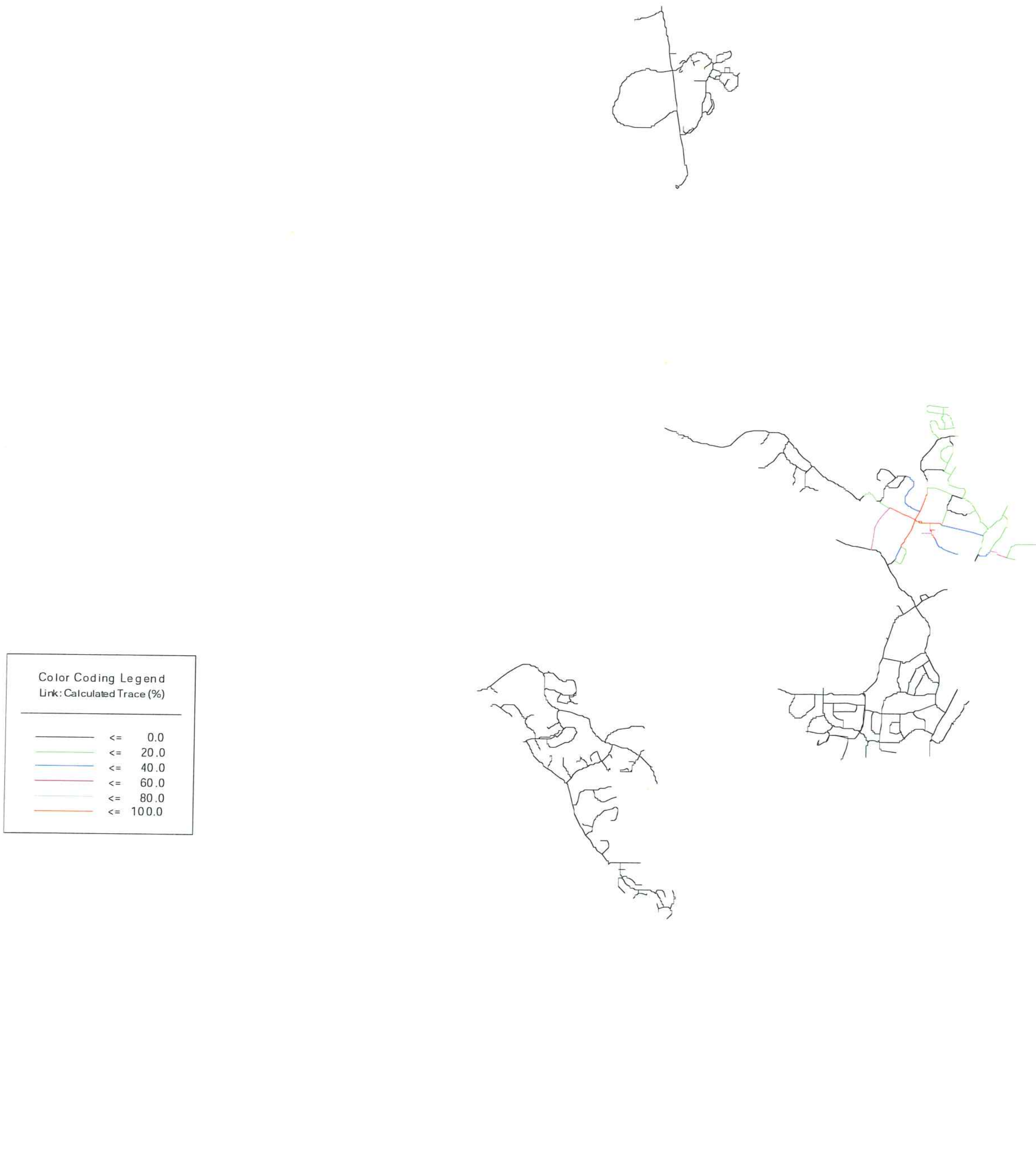
Scenario: Source: Spring Lake Tank

Title: Zone 5 - all
c:\watercad\baltcity\waterquality\wq5th.wcd
04/09/03 12:15:26 PM © Haestad Methods, Inc.

Rummel, Klepper & Kahl
37 Brookside Road Waterbury, CT 06708 USA +1-203-755-1666

Project Engineer: TAB
WaterCAD v4.1 [424a]

Scenario: Source: Springdale Tank

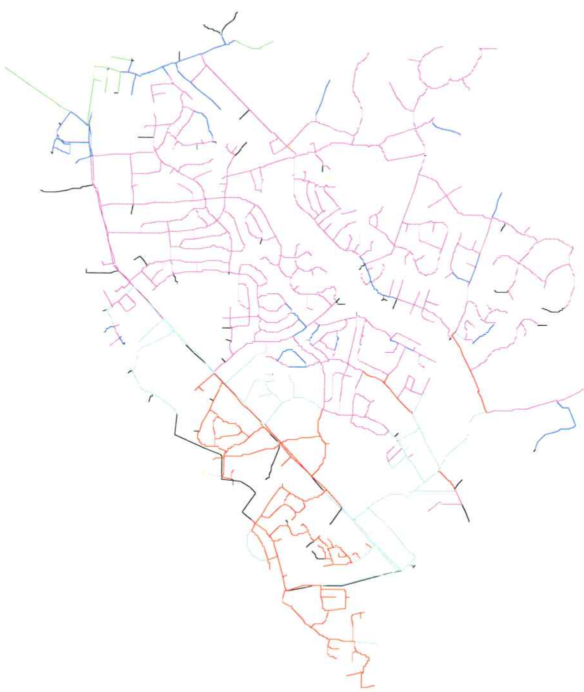


Title: Zone 5 - all
c:\watercad\baltcity\waterquality\wq5th.wcd
04/09/03 12:15:13 PM

Rummel, Klepper & Kahl
37 Brookside Road Waterbury, CT 06708 USA +1-203-755-1666

Project Engineer: TAB
WaterCAD v4.1 [424a]

Scenario: Source: Pleasant Hill #1 PS



Color Coding Legend
Link: Calculated Trace (%)

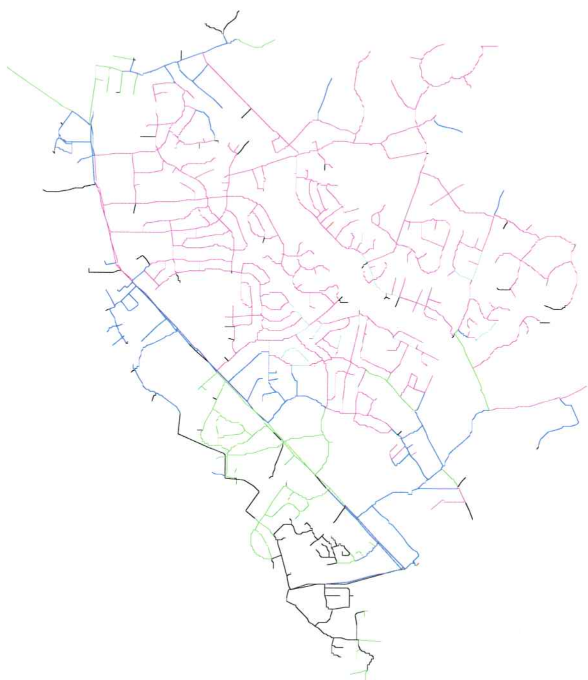
<=	0.0
<=	20.0
<=	40.0
<=	60.0
<=	80.0
<=	100.0

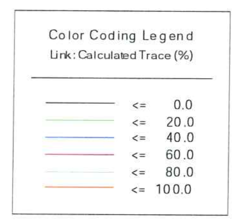
Title: Zone 5 - all
c:\watercad\baltcity\waterquality\wq5th.wcd
04/09/03 12:16:56 PM © Haestad Methods, Inc.

Rummel, Klepper & Kahl
37 Brookside Road Waterbury, CT 06708 USA +1-203-755-1666

Project Engineer: TAB
WaterCAD v4.1 [424a]

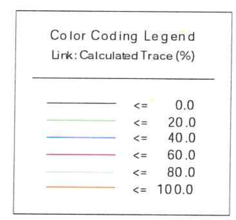
Scenario: Source: Pleasant Hill #2 PS





Scenario: Source: Chartley Tank

Scenario: Source: Reisterstown Tank



CITY OF BALTIMORE
DEPARTMENT OF PUBLIC WORKS
Water and Wastewater Engineering Division

COMPREHENSIVE WASTEWATER FACILITIES MASTER PLAN

VOLUME 1 OF 2

APRIL 2004

WHITMAN, REQUARDT AND ASSOCIATES, LLP
Baltimore, Maryland

WR&A

CITY OF BALTIMORE
DEPARTMENT OF PUBLIC WORKS
Water and Wastewater Engineering Division

COMPREHENSIVE
WASTEWATER FACILITIES
MASTER PLAN

APRIL 2004

PREPARED BY

WHITMAN, REQUARDT AND ASSOCIATES, LLP

COMPREHENSIVE WASTEWATER FACILITIES MASTER PLAN

VOLUME 1

Tables

Figures

[1] (B) – Back River Wastewater Treatment Plant
[2] (P) – Patapsco Wastewater Treatment Plant

CHAPTER 1

SUMMARY OF FINDINGS AND RECOMMENDATIONS

1.1. PURPOSE AND FOCUS OF THE PLAN

The purpose of this Comprehensive Wastewater Facilities Master Plan (Plan) is two-fold. The Plan is intended to determine, for the 20-year planning period (2000 – 2020), what improvements are needed to:

1. Enable the Back River and Patapsco collection, conveyance and treatment systems to continue to serve the needs of the service area.
2. Enable the Back River and Patapsco plants to produce treated effluent that will meet projected receiving water and Chesapeake Bay water quality requirements.

Although the Plan is intended to evaluate all aspects of the wastewater system, the emphasis is on nutrient reduction, and in particular, nitrogen reduction. Since future nitrogen reduction requirements have not yet been established by Maryland Department of the Environment (MDE), this Plan evaluates Biological Nutrient Removal (BNR) alternatives for various levels of plant effluent total nitrogen (TN). MDE is in the process of developing a strategy for implementing a higher degree of nutrient reduction, termed Enhanced Nutrient Removal (ENR). Although the requirements for ENR are not yet adopted, this Plan evaluates treatment alternatives that are applicable towards achieving the goals of ENR. The higher levels of BNR discussed in this Plan, are effectively what is currently identified as ENR. Therefore, the purpose of this plan is to provide the City with planning level information which is suitable for use in discussions with MDE regarding future treatment requirements for Back River and Patapsco River, and serve as a point of departure in continuing with future studies and evaluations.

Evaluations of the facilities at the Back River and Patapsco Plants for the planning period indicate they have adequate capacity to handle flows and anticipated treatment requirements, with the exception of total nitrogen reduction. Both plants have adequate facilities in place, in design or under construction, to provide solids handling. Therefore, the focus of the Plan and this Summary is on improvements to decrease the discharge of total nitrogen (TN) to the local receiving waters and the Chesapeake Bay.

Several significant factors affect the selection of the best BNR alternative. Although these appear to be the most important, others are considered and discussed in Chapter 6.

- Effluent requirements (to be determined by MDE)
- Timing of implementation of effluent requirements (to be determined by MDE)
- Plant operational considerations and preferences
- Costs

Other significant issues that are addressed in the Plan include the following, which are summarized hereinafter in this section: 1) water quality, 2) population, 3) wastewater flows and characteristics, 4) existing facilities, 5) nitrogen reduction issues, 6) solids production and sludge management, 7) costs to reduce, convey and treat inflow, and 8) alternative points of discharge for the Back River Plant.

1.2. WATER QUALITY

Sampling and testing were conducted to determine water quality conditions in Back River and Patapsco River. Data were provided to MDE for use in developing respective treatment requirements. Detailed reports and compiled data are contained in the Appendix. A significant finding was that, in general, levels of pollutants being released from the sediments in both Back River and Patapsco River exceeded the levels in the effluent discharge from the respective plant.

1.3. POPULATION

Population forecasts for the Back River and Patapsco Planning Areas, obtained from the Baltimore Metropolitan Council of Governments indicate that the respective predicted populations are about the same for 2020, but slightly less than the 201 Facility Plan (Back River dated 1984 and Patapsco dated 1985) and the Census 2000 populations. Therefore, current plant flows are expected to prevail throughout the planning period.

1.4. WASTEWATER FLOWS AND CHARACTERISTICS

Based on evaluation of operating reports for 1995 to 2003 and population forecasts for Back River and Patapsco planning areas, the adopted planning influent flows for the year 2020 for Back River and Patapsco Plants are as follows:

	Plant Influent Flow (MGD)			
	Current Design	Planning Year 2020		
Plant	Average Daily Flow	Average Daily Flow	Peak 5-Day Daily Flow	Maximum Instantaneous Flow
Back River	180	180	257	449
Patapsco	87.5	81	138	339

Conventional constituents (BOD_5, SS, TKN, and TP) are in the typical range and are evaluated and discussed within the Plan. MDE has issued letters regarding Whole Effluent Toxicity (WET) for the effluents for both plants, indicating that neither exhibited acute nor chronic toxicity (Appendix XII and XIII).

1.5. EXISTING FACILITIES

Descriptions of the existing facilities at both plants are included in the Plan. Inspections of both plants and designated pumping stations were conducted to determine the condition of the facilities and identify needs for Capital Improvement Program (CIP) projects. Copies of the reports are contained in the Appendix XIV to XVI.

In this chapter and subsequent ones, for Back River Plant, the three activated sludge plants are sometimes referred to as Plant, designated with a number (Nos. 1, 2, or 3).

1.6. NITROGEN REDUCTION ISSUES

The ability to reduce influent total nitrogen (TN) levels at Back River or Patapsco Plants by Biological Nutrient Removal (BNR) technology to effluent TN of 3 mg/l has not been demonstrated. Limited BNR optimization testing at Back River and plant scale demonstration testing at Patapsco were conducted under other contracts. Due to possible non-biodegradable organic nitrogen, the achievable TKN and TN concentrations may be limited to 3 to 4 mg/l and 4 to 5 mg/l, respectively. Further testing will be necessary to estimate the levels of performance that can be achieved.

1.7. NITROGEN REDUCTION – BACK RIVER WASTEWATER TREATMENT PLANT

1.7.1. Discussion

The suggested concept and basic assumptions for BNR upgrades at Back River are presented in the Plan. Since MDE has not yet provided final requirements/guidelines for BNR at Back River, the approach contained in the Plan is intended to give the City alternatives and associated costs for a range of TN goals to assist in planning discussions with MDE. The alternatives consider that the discharges for permitting purposes, to Back River and Patapsco River (through International Steel Group Sparrows Point, Inc., previously Bethlehem Steel Corporation), will continue at 130 mgd and 50 mgd, respectively. Goals and limits for both discharges will be based on pounds, and concentrations. Implementation of the upgrades for Back River is based on a three-level approach.

Level 1 considers that the existing MLE process will be optimized to lower TN concentration to about 6 mg/l for Back River (130 mgd) and 6 to 8 mg/l for Patapsco (50 mgd). Under Level 2, facilities would be provided to allow treatment to a TN concentration of 3 to 6 mg/l for Back River (130 mgd) and 6 to 8 mg/l for Patapsco (50 mgd). Level 3 alternatives provide treatment to a TN concentration of 3 to 6 mg/l for the entire plant flow (180 mgd).

Evaluation of the alternatives in each level considers which alternative is judged to be the best for a logical progression to Level 3. The Level 3 alternatives are thought to represent the best practical treatment technology which is applicable to the Back River Plant.

An important consideration in Level 1 is the future use of Activated Sludge Plant No. 1. In order to maintain the plant capacity at 180 mgd, Plant No. 1 needs to be restored to operational condition, primarily with regard to (1) renovation of Blower Building No. 1, (2) aeration basin and system repairs, and (3) other associated work. Blower Building No. 1 is to be renovated under Sanitary Contract No. 798. However, for all alternatives in Levels 2 and 3, except those involving the use of Plant No. 1 for sidestream BNR treatment of high ammonia dewatering recycles, Plant No. 1 is reconfigured as a suspended growth denitrification plant. This choice eliminates the need for the costly blower building renovations, and results in a process that will enable TN levels to 3 mg/l. Even though the planning capacity for Back River is 180 mgd, actual plant flows are lower, and conversion of Plant No. 1 to denitrification may be a beneficial consideration in improving the TN level for the Back River discharge. Plant No. 1 could be operated as a 50 mgd constant flow denitrification plant and reduce the TN level to Back River to 5 mg/l. This lower TN level could be accomplished by blending about 80 mgd of effluent from Plants Nos. 2 and 3 (6 mg/l) with the effluent from Plant No. 1 (3 mg/l) for a total discharge to Back River of 130 mgd (5 mg/l). This use of Plant No. 1 has benefits, but reduces the overall plant capacity to about 160 mgd.

Level 2 is an intermediate step to Level 3, so the real decisions lie in the Level 3 alternatives. Level 3 alternatives consider three fundamental approaches to the basic BNR process. One approach employs two separate suspended growth (activated sludge) systems, one to achieve carbon oxidation (carbonaceous BOD reduction) and complete nitrification, followed by the second to denitrify with supplemental methanol addition. Another approach utilizes a suspended growth system to achieve carbon oxidation/ nitrification, and then a fixed growth system for denitrification. The fixed growth system can be implemented in a deep bed filter or a fluidized bed reactor. A third approach utilizes a coupled system in which a fixed growth media is incorporated in the suspended growth system. This is discussed briefly and requires further evaluation.

Use of either deep bed filters or fluidized bed reactors appears to be the more economical system for denitrification. However, the evaluation of environmental and other non-monetary effects presented in Chapter 6 indicate suspended growth denitrification may offer other important advantages that could justify that selection.

Levels 1, 2, and 3 each include an alternative that incorporates separate sidestream BNR treatment in Plant No. 1 to reduce the high strength nitrogen load in the dewatering recycle. Based on the current recycle nitrogen strength and achieving Level 3 TN concentrations, sidestream BNR treatment is cost effective. It is anticipated that the addition of the two egg-shaped digesters and the conversion to two-phase digestion, currently under design, will result in an increase in nitrogen load in the dewatering recycle. This condition will likely increase the cost effectiveness of sidestream treatment.

1.7.2. Summary of Estimated Costs

The estimated cost for each alternative considers modifying and/or improving the existing treatment facilities to the respective level of treatment. Therefore, the estimated costs for treatments in Levels 1, 2, and 3 are not additive. The differences between the capital costs for Levels 2 and 3 alternatives reflect the incremental costs to upgrade treatment from Level 2 to 3. Cost estimates are based on ENR Index 6300 (mid 2001).

Alternative	Description	Millions of Dollars (ENR Index 6300) Total Present Worth	Capital	Annual O&M
Level 1				
1 - 1	Addition of Methanol to Activated Sludge Plants Nos. 1, 2 and 3	150.91	11.09	15.25
1 - 2	Sidestream BNR Treatment in Activated Sludge Plant No. 1	150.84	10.33	15.31
Level 2				
2 – 1	Two-Sludge Suspended Growth System	494.29	213.25	29.85
2 – 2	Carbon Oxidation/Nitrification Suspended Growth Plus Deep Bed Denitrification Filter (Downflow)	342.80	136.21	22.33
2 – 3	Carbon Oxidation/Nitrification Suspended Growth Plus Deep Bed Denitrification Filter (Upflow)	339.71	126.89	22.85
2 – 4	Carbon Oxidation/Nitrification Suspended Growth Plus Fluidized Bed Denitrification Reactor	360.04	144.68	23.22
2 – 5	Carbon Oxidation/Nitrification and Deep Bed Denitrification Filter (Upflow) Plus Sidestream BNR Treatment	359.68	136.30	23.88
Level 3				
3 – 1	Two-Sludge Suspended Growth System	496.18	213.25	30.03
3 – 2	Carbon Oxidation/Nitrification Suspended Growth Plus Deep Bed Denitrification Filter (Downflow)	442.65	173.48	28.37
3 – 3	Carbon Oxidation/Nitrification Suspended Growth Plus Deep Bed Denitrification Filter (Upflow)	436.61	167.20	28.96
3 – 4	Carbon Oxidation/Nitrification Suspended Growth Plus Fluidized Bed Denitrification Reactor	466.46	184.24	29.68

3 – 5	Carbon Oxidation/Nitrification and Deep Bed Denitrification Filter (Upflow) Plus Sidestream BNR Treatment	434.14	170.31	27.81

1.8. NITROGEN REDUCTION – PATAPSCO WASTEWATER TREATMENT PLANT

1.8.1. Discussion

BNR alternatives were evaluated for Patapsco only for the purpose of establishing several feasible BNR processes for achieving an effluent TN level of 3 mg/l or lowest value reasonably achievable, planning level space requirements and budgetary costs. Detailed evaluations and process selections are anticipated to be made under Project No. 877.

Preliminary evaluations in this Plan indicate that use of either deep bed filters or fluidized bed reactors appear to be more economical than a MLE or separate suspended growth denitrification system. Especially at Patapsco, space is a significant constraint. The site area occupied by the stockpiled contaminated material is needed to accommodate either a MLE or two sludge suspended growth system. In either case, the associated clarifiers require siting in the stockpile area. Removal of the waste is very costly and therefore renders those alternatives not cost-effective.

1.8.2. Summary of Estimated Costs

Five alternatives were initially considered; however, due to space requirements, and the need to utilize the area occupied by the containment soil stockpile, Alternatives 1 and 2 were eliminated from further evaluation. Cost estimates are based on ENR Index 6300 (mid 2001).

Alternative	Description	Millions of Dollars (ENR Index 6300) Total Present Worth	Capital	Annual O&M
3	Carbon Oxidation/Nitrification Suspended Growth and Fluidized Bed Reactor Denitrification	374.35	119.53	26.07
4	Carbon Oxidation/Nitrification Suspended Growth and Deep Bed Denitrification Filter (Downflow)	371.99	121.74	25.66
5	Carbon Oxidation/Nitrification Suspended Growth and Deep Bed Denitrification Filter (Upflow)	350.00	101.24	25.37

1.8.3. Preliminary Recommendations

Since the implementation of BNR at Patapsco will be performed under Project No. 877, no specific recommendations are provided in this Plan. Further information and decisions that are reached while pursuing the recommendations for Back River will benefit the planning for BNR at Patapsco and can be incorporated in this Plan, as appropriate.

1.9. SOLIDS PRODUCTION AND SLUDGE MANAGEMENT

Current sludge production data were obtained from monthly operating reports for both plants. Increases in sludge production resulting from possible BNR upgrades were estimated in order to predict quantities of sludge for treatment and disposal. Due to the slight decline in service area population for the planning period as compared to 201 Facility Plan (Back River dated 1984 and Patapsco dated 1985) predictions, and only insignificant increases in BNR sludge, quantities are anticipated to remain relatively constant throughout the period.

Sludge is currently allocated for beneficial reuse as follows:

	Back River		Patapsco	
Process	Dry Tons/Day [(1)]	$/Dry Ton	Dry Tons/Day [(1)]	$/Dry Ton
Heat Drying [(2)]	55	462	55	469
Composting [(3)]	35	526	---	---
Land Application [(4)]	20	163	---	---
Estimated Future Required Capacity	90 – 110		50 – 60	

(1) Annual average, based on 7 days/week
(2) 20-year privatization contract (Back River 1994-2014) (Patapsco 1996-2016)
(3) 20-year privatization contract (1987-2007)
(4) 1-year hauling contract, with provisions to extend 1 year

Based on the current successful sludge management plan for Back River and Patapsco, and previous evaluations of alternative methods of disposal in the 1989 Sludge Management Plan, continuation of the plan appears appropriate. The combination of the three methods at Back River offers the City the insurance of flexibility, reliability and redundancy in not relying on a sole method. Process redundancy in heat drying at both plants offers flexibility and reliability. Land application of a portion of the Back River sludge enables less costly reuse when possible. Therefore, the long-term heat drying privatization contracts, which will expire during the 20-year planning period, should be renewed.

1.10. COSTS TO REDUCE, CONVEY AND TREAT INFLOW

Analysis of periods of high inflow for Back River and Patapsco service areas indicated that a combination of significant storage volume along the conveyance system near the plants and additional treatment capacity would be required to enable the plants to meet weekly permit limits during maximum week flow conditions. Due to plant space constraints, the majority of the capacity for each plant would need to be provided as underground storage, configured as large diameter tunnels. Based on construction cost experience in similar tunneling projects in the U.S., the budgetary estimate of the justified cost to reduce 1 mgd of influent peak flow is about $6,000,000.

1.11. ALTERNATIVE POINT OF DISCHARGE FOR BACK RIVER PLANT

Issues related to the NPDES discharge permit suggest that the City pursue efforts to retain and increase the daily flow of the plant effluent discharge to International Steel Group Sparrows Point, Inc. (ISG, previously Bethlehem Steel Corporation). The issues revolve around the ability of the Back River Plant to meet current and future pound loading limits and TMDL requirements during periods of high flow to the Plant.

The current permit is based on an effluent discharge to Back River of 130 mgd. The balance, 50 mgd, is assumed to be discharged to ISG and subsequently to the Patapsco River through an ISG outfall. Indications are that, possibly, an additional 50 mgd might be utilized at ISG. Therefore, the primary benefit to the City would be additional flexibility in meeting the pount units for the discharge to Back River.

1.12. SUMMARY OF FINDINGS

- Current service area populations, wastewater flows and sludge production for Back River and Patapsco systems are predicted to remain relatively constant throughout the planning period.

- For TN reduction to levels of 3 to 5 mg/l at Back River, carbon oxidation/nitrification suspended growth plus deep bed denitrification filter is most cost effective. (Back River Alternatives 3-2, 3-3, and 3-5)

- Use of Back River Activated Sludge Plant No. 1 for sidestream treatment (Alternative 3-5) to reduce the nitrogen load in the dewatering process recycle is cost-effective based on current recycle nitrogen loads. Increased recycle nitrogen loads produced by two-phase digestion will likely improve the cost-effectiveness.

- Back River wastewater may contain sufficient non-biodegradable organic nitrogen to limit achievable effluent TN to 4 to 5 mg/l.

- Continued discharge of 50 mgd (±) of Back River Plant effluent to ISG (alternate point of discharge) will enable the City to implement Level 2 BNR upgrades (i.e., discharge to Back River at TN 3-6 mg/l, and Patapsco River through ISG at TN 6-8 mg/l).

- Increasing the discharge to ISG will offer the City flexibility to meet the NPDES permit pound loading limits.

- Due to the extent of recently completed and current improvement/rehabilitation contracts at both plants, in general,, they are in good condition to perform through the planning period.

- Construction of a second Primary Effluent Channel at the Back River Plant will offer reliability and the opportunity to add flow distribution facilities to enhance the balancing of flows between Activated Sludge Plants Nos. 1, 2 and 3.

- In general, the level of pollutants being released from sediments in Back River and Patapsco River exceeds the levels in the effluent discharge from the respective plants.

- The current sludge management plan for Back River and Patapsco Plants is successful, provides flexibility, reliability and redundancy and has adequate capacity to continue beneficial reuse of all sludge throughout the planning period. (Privatization contracts will require renewal when they expire).

- An estimated $6,000,000 is justified for measures to improve the wastewater collection and conveyance system to reduce influent peak flow by 1 mgd (i.e. inflow contributions), and prevent the need to provide the corresponding capacity to treat that high rate of flow arriving at either plant.

1.13. SUMMARY OF RECOMMENDATIONS

- Conduct pilot and demonstration testing to determine the achievable effluent TN level for Back River and Patapsco Plants, confirm/modify design, O&M assumptions, cost estimates, and confirm estimated performance of alternatives.
- Visit representative plants for each alternative.
- Pursue discussions with ISG to insure continuation, and possible increase, of discharge of Back River Plant effluent to the Patapsco River.
- After treatment goals and limits are finalized with MDE, determine apparent best BNR treatment alternative for Back River Plant.
- Implement remaining necessary improvements/rehabilitation contracts at Back River and Patapsco.
- Construct a second Primary Effluent Channel, Flow Distribution Structure and other related piping and appurtenances at the Back River Plant.
- Pursue improvements to the collection and conveyance systems to reduce peak flows arriving at each treatment plant.
- Continue current sludge management plan for both plants.
- Design of projects should incorporate energy conservation measures.

CHAPTER 2

INTRODUCTION

2.1. PURPOSE

The purpose of this Comprehensive Wastewater Facilities Master Plan (Plan) is two-fold. The Plan is intended to determine, for the 20-year planning period, what improvements are needed to:

1. Enable the Back River and Patapsco collection, conveyance and treatment systems to continue to serve the needs of the service area.
2. Enable the Back River and Patapsco plants to produce treated effluent that will meet projected receiving water and Chesapeake Bay water quality requirements.

Although the Plan is intended to evaluate all aspects of the wastewater system, the principal focus is on nutrient reduction, and in particular, nitrogen reduction. Since future nitrogen reduction requirements have not yet been established by Maryland Department of the Environment (MDE), this Plan evaluates Biological Nutrient Removal (BNR) alternatives for various levels of plant effluent total nitrogen (TN). MDE is in the process of developing a strategy for implementing a higher degree of nutrient reduction, termed Enhanced Nutrient Removal (ENR). Although the requirements for the ENR are not yet adopted, this Plan evaluates treatment alternatives that are applicable toward achieving the goals of ENR. The higher levels of BNR discussed in this Plan, are effectively what is currently identified as ENR. Therefore, the purpose of this plan is to provide the City with planning level information which is suitable for use in discussions with MDE regarding future treatment requirements for Back River and Patapsco River, and serve as a point of departure in continuing with further studies and evaluations.

2.2. SCOPE

The Plan develops and evaluates alternative management strategies for the continued operations of the Back River and Patapsco Wastewater Treatment Plants and associated conveyance systems. Flow projections are developed based on available population forecast through the year 2020, and water quality studies performed to confirm the capability of the receiving waters being utilized by the two plants to continue to receive the projected flows through the planning period. The impact on the receiving water was investigated through collection of water samples and mathematical modeling.

Different treatment strategies are analyzed to determine the most cost effective allocation of flows to the plants and points of discharge. The 201 Facility Plans for the Back River and Patapsco Conveyance Systems are updated with new design year flow estimates based on projected changes in service area population. These investigations are coordinated with other on-going studies, which are being conducted in the City and the Counties.

Potential impacts of regulatory issues and toxicity characteristics of the wastewater plants effluent are addressed.

2.3. AUTHORIZATION

Per a 1997 agreement, the City of Baltimore engaged the services of Whitman, Requardt and Associates, LLP (Consultant) to prepare the Comprehensive Wastewater Facilities Master Plan. During the development of the Plan, the Consultant was in regular contact with representatives of Baltimore City and Baltimore, Howard, and Anne Arundel Counties, since the Back River and Patapsco treatment facilities provide service to these jurisdictions.

2.4. PLANNING AREA

The planning area was established based on the System Maps for Back River Wastewater Treatment Plant and Patapsco Wastewater Treatment Plant as designated on Figures 2-1 and 2-2 (included in the back of this volume), respectively. This area consists of all the land ultimately draining to the Back River and Patapsco treatment plants, which can be served by the wastewater conveyance systems tributary to the two plants.

The designated planning area as shown on Figures 2-1 and 2-2 encompasses approximately 344 square miles. The portion of this area within the Baltimore City limits is approximately 80 square miles. Baltimore County's portion is approximately 196 square miles, Anne Arundel County's portion is approximately 19 square miles and Howard County's portion is approximately 49 square miles of the total planning area. Approximately 187 square miles of the planning area is served by the Back River Wastewater Treatment Plant and approximately 157 square miles is served by the Patapsco Wastewater Treatment Plant.

2.5. TREATMENT FACILITIES

2.5.1. Back River Wastewater Treatment Plant

The Back River Plant is a 180 mgd advanced wastewater treatment facility, owned and operated by the City of Baltimore and located in eastern Baltimore County in the Essex area. The plant is situated on the south shore of Back River, east of Eastern Boulevard (MD Route 150) and just south of the bridge over Back River.

The plant processes include screening, grit removal, and primary sedimentation, activated sludge treatment including biological nitrogen removal (BNR) and phosphorous removal by chemical precipitation with waste pickle liquor, dual media filtration and chlorination / dechlorination. Plant effluent is discharged to Back River (130 mgd) and Bethlehem Steel Corporation for ultimate discharge to Patapsco River (approximately 50 mgd) although current flow (2002 – 2003) to Back River is closer to 110 mgd.

Solids handling facilities offer flexibility in thickening for primary and waste activated sludge through the use of gravity thickeners, dissolved air flotation thickeners and gravity belt thickeners. Sludge stabilization is achieved by high rate anaerobic digestion in conventional circular tanks and egg-shaped units. The majority of digested sludge is conveyed to an on-site privatization contractor for dewatering, heat drying (pelletization), disposal and beneficial reuse. The balance of the digested sludge is dewatered by the City for subsequent hauling and composting under a privatization contract, or hauling and land application under another contract.

2.5.2. Patapsco Wastewater Treatment Plant

The Patapsco Wastewater Treatment Plant is rated at 87.5 mgd and is an advanced secondary wastewater treatment facility owned and operated by the City of Baltimore and located on Wagners Point in the predominantly industrial South Baltimore area of East Brooklyn. The plant site fronts the harbor portion of the Patapsco River, into which it discharges its treated effluent.

The plant receives its wastewater from two sources. Wastewater from the Low Level System is conveyed by a 54-inch gravity sewer with a hydraulic capacity of 56 mgd. Low Level wastewater is pumped at the Patapsco facility. The second source is a 96-inch diameter pressure sewer delivering flow from the Southwest Diversion Structure with a design capacity of 420 mgd.

The plant processes include screening and grit removal for the wastewater entering from the Southwest Diversion and screening for the Low Level. Following preliminary treatment the wastewater is combined. Primary sedimentation, oxygen activated sludge treatment including biological phosphorous removal, secondary clarification and chlorination and dechlorination are the remaining liquid treatment plant processes.

Solids handling facilities include gravity thickeners for both primary sludge and waste activated sludge. Sludge is combined and stored in sludge blending tanks prior to discharge into a heat drying facility (pelletization) owned and operated by a private contractor. All of the sludge is processed and transported for disposal and beneficial reuse by this contractor. The GST's are designed to handle a total of 99 dry tons per day (DTPD) while the sludge blending tanks have a storage capacity of 3.6 million gallons. The heat drying contract has minimum guarantee of 54.8 DTPD on a monthly basis.

CHAPTER 3

WATER QUALITY

3.1. WATER QUALITY DESIGNATION OF WATERWAYS

The federal Clean Water Act (CWA) requires that states, territories, and authorized tribes assess water quality every two years and publish a list of those waters failing to meet water quality standards. This list of impaired waters is called the "303 (d) List". Water bodies listed as impaired may require a detailed analysis of pollution sources known as a Total Maximum Daily Load (TMDLs).

In October of 2002, Maryland submitted its last 303 (d) List to the Environmental Protection Agency (EPA). Final EPA approval of the 2002 Integrated List was received by the Maryland Department of the Environment (MDE) on April 30, 2003. The 2004 update to the 303 (d) list will be submitted this year.

A water body or "water quality limited segment" (WQLS) is considered "impaired" when it does not attain the designated use assigned to it in Maryland regulation [Code of Maryland Regulations (COMAR) §26.08.02]. Use attainment is determined by comparison of field measured or projected values (e.g. modeling runs) of various water quality parameters to the numeric or narrative water criteria established in COMAR.

Maryland Department of Natural Resources (MDNR) identifies those water bodies that currently do not meet the designated uses established in the State's Water Quality Standards (WQS). WQS support the four following designated uses.

1. Use I waters: The minimum standard for all waters throughout the State, protects waterways for recreation, fishing, and aquatic life use.
2. Use II waters: Protected for shellfish harvesting and consumption.

3. Use III waters: Protected to maintain natural trout populations.
4. Use IV waters: Protect waters utilized for put-and-take trout fishing.

In addition, Uses I, III, and IV can also have "P" designation if used for public water supply.

Back River (Basin Code 02130901), considered Use I, is currently listed as impaired under Listing Category 5 which means TMDLs may be required. The Impairment Categories listed currently include metals (zinc), nutrients, sediments and toxics (PCBs – sediments).

Baltimore Harbor (Basin Code 02130903), considered Use 1, is also listed impaired under Listing Category 5. The Impairment Categories listed currently include biological, metals (chromium, zinc, lead), nutrients, sediments and toxics (PCBs – sediments, fish tissue).

3.2. EXISTING PERMITS AND GOALS

3.2.1. Back River Wastewater Treatment Plant

The Back River Wastewater Treatment Plant is currently operating under a discharge permit (State # 89-DP-0581 and NPDES # MD0021555) that expired on September 30, 2001. As required by MDE, the City applied for renewal by March 30, 2001. To date, MDE has not issued a new permit. A copy of the current permit is included in the Appendix I.

As shown, the permit requires the plant to achieve the following principal effluent limits:

Effluent Characteristics	Monthly Average (mg/l)	Weekly Average (mg/l)
BOD_5	10	15
Suspended Solids	10	15
TP	0.2	0.3
Ammonia Nitrogen	2.0	3.0

Monthly and weekly loading rates are based on 130 MGD plant effluent discharged to Back River. The balance of plant effluent is normally conveyed to the Bethlehem Steel Plant located at Sparrows Point. Following industrial use and subsequent treatment, the water is then discharged to the Patapsco River under a Bethlehem Steel permit.

The Back River Plant was upgraded, through a series of sanitary contracts, to achieve a total nitrogen reduction goal. Biological Nitrogen Removal (BNR) facilities are designed to meet a seasonal (May through October) average concentration of total nitrogen of 10 mg/l. According to the NPDES permit, upon completion of the BNR upgrade in 1998, the plant is to make every effort to meet a total nitrogen goal of 8 mg/l, whenever possible, as an annual average by operating the BNR processes at the facility on a year round basis. Total nitrogen is the sum of organic-N, ammonia-N, and (nitrate+nitrite)-N.

As of February 2004, MDE has not issued any guidance regarding TMDL/effluent limitations for the Back River Plant.

3.2.2. Patapsco Wastewater Treatment Plant

The Patapsco Wastewater Treatment Plant is currently operating under a discharge permit (State #93-DP-0580 and NPDES # MD0021601) that expired on July 31, 1998. As required by MDE, the City applied for renewal by January 31, 1998. To date MDE has not issued a new permit. A copy of the current permit is included in the Appendix II.

As shown, the permit requires the plant to achieve the following principal effluent limits:

Effluent Characteristics	Monthly Average (mg/l)	Weekly Average (mg/l)
BOD_5	30	45
Suspended Solids	30	45
TP	2.0	3.0

Currently there are no nitrogen limits in the Patapsco permit. It is anticipated that such requirements are imminent. The City is in the process of planning for BNR upgrades at the plant; however, goals have not been established.

3.3. WATER QUALITY ISSUES

The principal water quality issues are based on the condition of the Bay and the tributary to which each plant discharges. The controlling factor in the determination of the treatment requirements for each plant will be which condition requires the greatest degree of treatment. In other words, the treatment limits will be either effluent limit (Bay) or water quality (tributary) based.

3.4. WATER QUALITY INVESTIGATIONS

In order to assist in the determination of water quality conditions in Back River and Patapsco River (Baltimore Harbor), the City decided to conduct a series of investigations as part of the Plan and provide the data to MDE for use in developing the respective treatment requirements. This sampling program was completed in March 1999 and the data was conveyed to MDE shortly thereafter.

Generally, the program covered stream and sewer overflow sampling along the major tributaries to each plant. For Back River this was Herring Run, and for Patapsco, Jones Falls and Gwynns Falls. Additionally, it included extensive sampling in Back River and Patapsco River to determine conventional water quality constituents, toxics, sediment quality, and sediment fluxes and in-situ monitoring for dissolved oxygen and other parameters.

Summary reports and compiled data are included in the Appendix III to VII. The Appendix Index includes a detailed listing of the reports, which cover all of the water quality and sediment sampling conducted for the Plan.

3.5. WATER QUALITY DATABASE

A comprehensive database management system (DBMS) was developed to store historical and current data on the water quality of the Back River and Patapsco River estuaries. This database will be needed to simulate potential wastewater treatment/ conveyance strategies. The DBMS was implemented with commercially available software. The DBMS structure is compatible with the DBMS implemented by MDE for storing the 1994 – 1995 sampling data for the two estuaries. The data collected by sampling under this contract was entered into the database.

3.6. WATER QUALITY AND SEDIMENT SAMPLING

3.6.1. General

MDE's sampling program in the harbor and Back River was terminated prematurely in 1995 due to funding cutbacks. To determine the adequacy of the data to accurately estimate the current status of the two estuaries and estimate their waste assimilation capacities, additional data was collected as part of the development of the Plan. Sampling is intended to supplement MDE's abbreviated data set for conventional nutrients in the water column, as well as to collect unique data on the stream loadings to the harbor and Back River, metal levels in the water column and sediments, and nutrients and metals fluxes from the sediments.

3.6.2. Sampling Plan

A sampling plan was prepared that defines the methods for the sampling and analysis of water column and sediment constituents, streams, and point sources.

3.6.3. Stream Sampling

Water quality samples were taken periodically in the Patapsco River, Gwynns Falls, Jones Falls, and Herring Run, including both storm events and dry-weather periods. The Patapsco River was sampled at the fall line. The Gwynns Falls was sampled at the fall line, and the Dickeysville Dam. The Jones Falls was sampled at the fall line, and at the outflow from Lake Roland. Herring Run was sampled at the fall line, and two upstream tributaries were sampled at/near Loch Raven Boulevard, and Perring Parkway. Flow was measured at the sampling locations. Samples were taken and analyzed for the constituents for conventional pollutants, nutrients and metals as listed in the Special Conditions for Monitoring in the Back River Permit. Sampling of the four streams was conducted under dry-weather conditions two times/month for 12 months, and of up to two storm events/month from June to November. Sampling and analysis protocols were coordinated with ongoing DPW sampling being conducted as part of the City's municipal stormwater discharge permit.

3.6.4. Conventional Water Quality Constituents

Conventional water quality constituents (as listed in the Special Conditions for Monitoring in the Back River NPDES Permit) were sampled at the 24 MDE stations in the Harbor/Back River, in Bear Creek and near Bethlehem Steel's Outfall 014, and at/near the other existing wastewater discharges (Patapsco WWTP and Cox Creek WWTP). Three surveys were conducted in wet-weather months (e.g. April-June) and four in dry months (e.g., July-October) in 1997. Conventional constituents were sampled three additional times at five stations in Back River.

3.6.5. Toxics

The Back River WWTP currently has limitations on lead, mercury and selenium at Outfall 001, and monitoring requirements for copper, nickel, cyanide, zinc, silver and mercury. For Outfall 002, there are monitoring requirements for all of these metals (except silver), plus chromium naphthalene, and tetrachloroethylene. The Patapsco WWTP has monitoring requirements for copper and mercury at Point Source 001.

These limitations on Back River Outfall 001 were imposed because the outfall has been identified as contributing to elevated levels of the three metals in Back River (in MDE analyses conducted under Section 304(1) of the Clean Water Act). Further, the monitoring requirements for the other metals at the three outfalls was imposed because the outfalls are suspected of contributing to exceedances in Back River and Baltimore Harbor, and MDE is assembling a database to conduct a "Reasonable Potential to Exceed" analysis as the basis for possible future limitations.

Collection of toxics data and other information is intended to form a sufficient basis to assemble preliminary mass balances for the eight metals and cyanide; these mass balances can be used to determine whether the outfalls are significant contributors to the observed exceedances (relative to nonpoint and other point sources, and sediment fluxes), and would be sufficient to allow the later analysis in a Total Maximum Daily Load (TMDL) analysis.

Samples were taken of toxic metal constituents (listed above), and naphthalene and trichloroethylene, in the water column at the 24 MDE stations in the Harbor/Back River, in Bear Creek and near Bethlehem Steel Outfall 014, and at/near the other existing wastewater discharges (Patapsco WWTP and Cox Creek WWTP). Water column metal and organic samples were collected at the same times as conventional water quality constituents (see Task 203, above). Metals were sampled and analyzed following current MDE guidelines on "clean" analytical techniques as much as possible.

3.6.6. Sediment Quality

Conventional and toxic metal constituents were sampled once at each of the 28 stations described under Toxics Section.

3.6.7. Sediment Fluxes

Sediment fluxes of oxygen and nutrients were measured from all three locations in Back River (per Chesapeake Biological Laboratory Work Statement No. 95-149), and at two stations in the Harbor – one near the mouth of Curtis Creek (sampled by CBL in 1994-1995), and a new station in Bear Creek near Bethlehem Steel Outfall 014. Nutrient and oxygen fluxes were measured three times during June, July, and August of 1997.

The fluxes were measured for three metals (mercury, selenium and lead) regulated at the Back River outfall (001) once at the three stations in Back River and two in the Harbor, in conjunction with the oxygen/nutrient fluxes described above.

3.6.8. Overflows

The 12 designated wet weather overflow points within the City's Gwynns Falls (2 locations) and Gwynns Run (10 locations) drainage areas were sampled. Flow metering stations with data loggers were installed and maintained at these locations for four months. Sampling (either automatic or manual) was conducted during four significant rain events at these 12 stations. Approximately 40 samples per station were collected. These samples were analyzed for: BOD, Total Organic Carbon (TOC), TP, TKN, Nitrate, Nitrite, TSS, Total Coliform, and MBAS.

3.6.9. Data Analysis

Newly collected data (supplemented as needed by historical data) was compiled to enable model simulations to be done by MDE for different wastewater discharge scenarios. At this time MDE is not ready to conduct the modeling. When the modeling is underway, the consultant and the city shall meet with MDE to discuss interim results and to scope future analyses.

3.6.10. Clean Sampling/Analysis Techniques for Metals

A program was designed and implemented to sample and analyze water column metals concentrations following current EPA Guidance on "Clean" techniques to increase the accuracy and precision of metals analyses. MDE was consulted to ensure that the same techniques were available for implementation. MDE laboratory was provided with approximately 50 split samples for their analysis to ensure interlaboratory calibration.

3.6.11. In-Situ Monitors for Dissolved Oxygen, Etc.

In-site monitors with high frequency sensors to measure dissolved oxygen, and other variable parameters were deployed at various locations in Back River and the Harbor. Data was collected and analyzed.

3.6.12. Summary of Findings

Data from each of the water quality investigations are summarized in the respective reports, which are included in the Appendix. The majority of the data is simply compiled electronically for the use of MDE in evaluating various treatment and discharge scenarios.

However, some preliminary conclusions were apparent after examining the data relative to water column, sediments and treatment plant effluent. In general, levels of pollutants being released from the sediment in both Back River and Patapsco River exceeded the levels in the effluents of the respective plant.

3.7. TOTAL MAXIMUM DAILY LOAD (TMDL)

Maryland Department of the Environment (MDE) has not yet determined TMDLs for Back River or Patapsco plants. Information will be provided in this paragraph when available.

3.8. FUTURE EFFLUENT GOALS AND LIMITATIONS

The future effluent goals and limitations for the Back River and Patapsco plants are anticipated to be based on the TMDLs determined by MDE. In the interim, this Plan has assumed a range of total nitrogen limitations in order to develop possible BNR alternatives, estimate associated costs and provide preliminary findings to aid the City in evaluating the impacts of future goals and limitations.

CHAPTER 4

CURRENT SITUATION

4.1. CONDITIONS IN PLANNING AREA

4.1.1. Description of Planning Area

The limits of the Back River and Patapsco Planning Area were developed using GIS data received from Baltimore City, Baltimore County, Anne Arundel County and Howard County. Data was extracted and sorted to form system maps as shown previously in Figures 2-1 and 2-2.

The planning area for Back River WWTP drains to three major interceptors: Jones Falls, Herring Run and Stemmers Run. Other interceptors for the Back River WWTP include the High Level and Low Level interceptors. Flows from these interceptors enter the Main Outfall where they are conveyed to the plant for treatment. The Main Outfall is a gravity sewer flowing to Back River Wastewater Treatment Plant.

The planning area for Patapsco WWTP drains to two major interceptors: Gwynns Falls and Patapsco. Flows from these interceptors enter the Southwest Diversion (SWD) where they are conveyed to the plant for treatment. The SWD is a pressure sewer that does not require pumping at the treatment plant. However, flows from the Low Level Interceptor (LL) must be pumped at the treatment plant.

4.1.2. Demographic Data (Baltimore City, Baltimore County)

Based on 2000 census data, approximately 1.3 million people reside within the Back River and Patapsco planning areas and were divided as follows: Baltimore City – 548,320 Back River, 102,842 Patapsco; Baltimore County – 395,241 Back River, 248,876 Patapsco.

4.1.2.1. Population Projection Methodology (Baltimore City, Baltimore County)

Average population densities for 2000 were developed by land use categories based on Baltimore Metropolitan Council of Government Transportation Zone Populations (Round 5-D Small Area Forecast), Maryland State Office of Planning Land Use (1996), and Baltimore County Office of Planning Land Use (1993).

Baltimore City: The density factors (people/acre), for each residential classification, were derived by selecting the transportation zones with all or most of its land use of one residential classification. Density factors were calculated based on the quotient of the sum of transportation zones 2000 populations divided by the transportation zones acreage.

Baltimore County: For transportation zones completely within the areas planned for County's sewer service, allocation (density) factors were based on assuming that each residential classification within a transportation zone was developed to the same level of maximum build-out zoning density.

For transportation zones that straddle or extend into the areas of the County's with No Planned Service (NPS), it was assumed that 10% of the 2000 population resided in the NPS area. The remainder was allocated as described above for the City.

The 2000 population for each transportation zone was allocated proportional to the densities developed based on the Baltimore Metropolitan Council's BaseMap of current land use (1996) and the City Planning Department's population projections by Transportation Zone (TZ). Population was allocated into sub-sewersheds assuming uniform density across residentially developed areas. Sub-sewershed boundaries were obtained from Baltimore City and Baltimore County sewer service maps.

The 2020 population was calculated by sub-sewershed by applying the percentage change predicted by the City Planning Department, for each transportation zone population to the 2000 population for each sub-sewershed. The summary of the resulting demographic projections is located in Section 5.2 of this plan.

Population planning data for Anne Arundel and Howard Counties were provided by those counties, respectively. The summary of these resulting demographic projections is also located in Section 5.2 of this plan.

4.2. EXISTING WASTEWATER FLOWS AND CHARACTERISTICS

4.2.1. Back River Wastewater Treatment Plant

Annual average daily plant flow for calendar years 1995-2003 is summarized on Table 4-1. Also shown, is the plant effluent discharged to Bethlehem Steel Corporation (BSCo) for industrial water use and subsequent treatment and discharge to Patapsco River and total rainfall as measured at BWI (Baltimore Washington International) airport. As shown, the annual plant influent flow ranged from 137 to 189 mgd with an average of 159 mgd for the nine-year period. Discharge to BSCo ranged from about 49 to 75 mgd. For the purposes of evaluation in this Plan, the discharge to BSCo was assumed to be 50 mgd. As discussed in next section, a five-day peak factor of 1.4 was determined and assumed for evaluation purposes.

Plant influent characteristics for calendar years 1998 - 2003 are summarized in Table 4-2, and Table 4-3. Parameters include monthly average concentrations and loadings for five-day biochemical oxygen demand (BOD_5), total suspended solids (TSS), total Kjeldahl nitrogen (TKN), total nitrogen (TN) and total phosphorus (TP). The concentration ranges are as follows:

Range of Annual Average Influent Concentrations (mg/l) (1998 – 2003)

BOD_5	TSS	TKN	TP
147 - 229	103 - 212	24 - 33	3 - 4.4

The noticeable decline in plant influent flow could have resulted from less infiltration/inflow due to lower groundwater levels due to dry conditions and retention of inflow to sewers, restrictions in domestic water usage during drought seasons, increase in usage of water conservation fixtures, and industry relocation and water conservation measures. Reduction in pollutant loadings may have resulted from settling of solids in sewers caused by reduced flows and velocities.

4.2.1.1. Flow Variations

Peak Five-Day Period

In an effort to verify the flow variation factors established in the Back River Wastewater Treatment Plant 201 Facility Plan dated 1984, flow data from the most recent nine years were analyzed. Figures 4-1 through 4-9 illustrate the plant average daily influent flow for this time period. Also shown in each figure is the daily quantity of rainfall for the corresponding year. The rainfall is based on gauge measurements in Baltimore Washington International Airport (BWI) area. Lastly, the five-day period in which the greatest influent flow was observed has been highlighted. There appears to be frequent correlation between greatest observed five-day period flows and rainfall events. However, there is not always a direct response to influent flow and rainfall. The reason being, the geographic location the rainfall gauges measure does not monitor the entire sewer shed area. The ratio between the annual daily average and the average of the greatest observed five-day period has been calculated for each of the nine years and is shown in Table 4-4. The average ratio for this nine-year period is 1.37, which was calculated to be 1.43, published in the 201-facility plan dated 1984. For the Biological Nutrient Removal (BNR) evaluation (Chapter 6), the peak average flow was based on a conservative peaking factor of 1.5.

Maximum Instantaneous Flow Rate

The Back River 201 Facility Plan determined that the maximum instantaneous influent flow is 449 mgd. This flow is the estimated maximum flow that existing conveyance system can deliver to the plant. Review of plant records for the period 1995 – 2003, which includes several extremely wet years, reflects a maximum instantaneous flow rate of 406 mgd in January 1996. Since this value is within about 10% of the Facility Plan estimate, 449 mgd is adopted. Other high flows of similar values further support the decision.

TABLE 4-1
BACK RIVER WASTEWATER TREATMENT PLANT
ANNUAL FLOWS AND RAINFALL

Calendar Year	Annual Average Daily Flow MGD		Total Annual Rainfall (inches)
	Plant Influent	Plant Effluent to Bethlehem Steel	
1995	173	61.2	36.93
1996	189	68.9	58.31
1997	166	75.1	38.34
1998	152	75.7	34.37
1999	147	74.9	43.94
2000	150	66.6	41.91
2001	140	50.5	35.74
2002	137	51.3	39.60
2003	180	48.5	62.66

TABLE 4-2
BACK RIVER WASTEWATER TREATMENT PLANT
INFLUENT FLOW AND CONCENTRATIONS

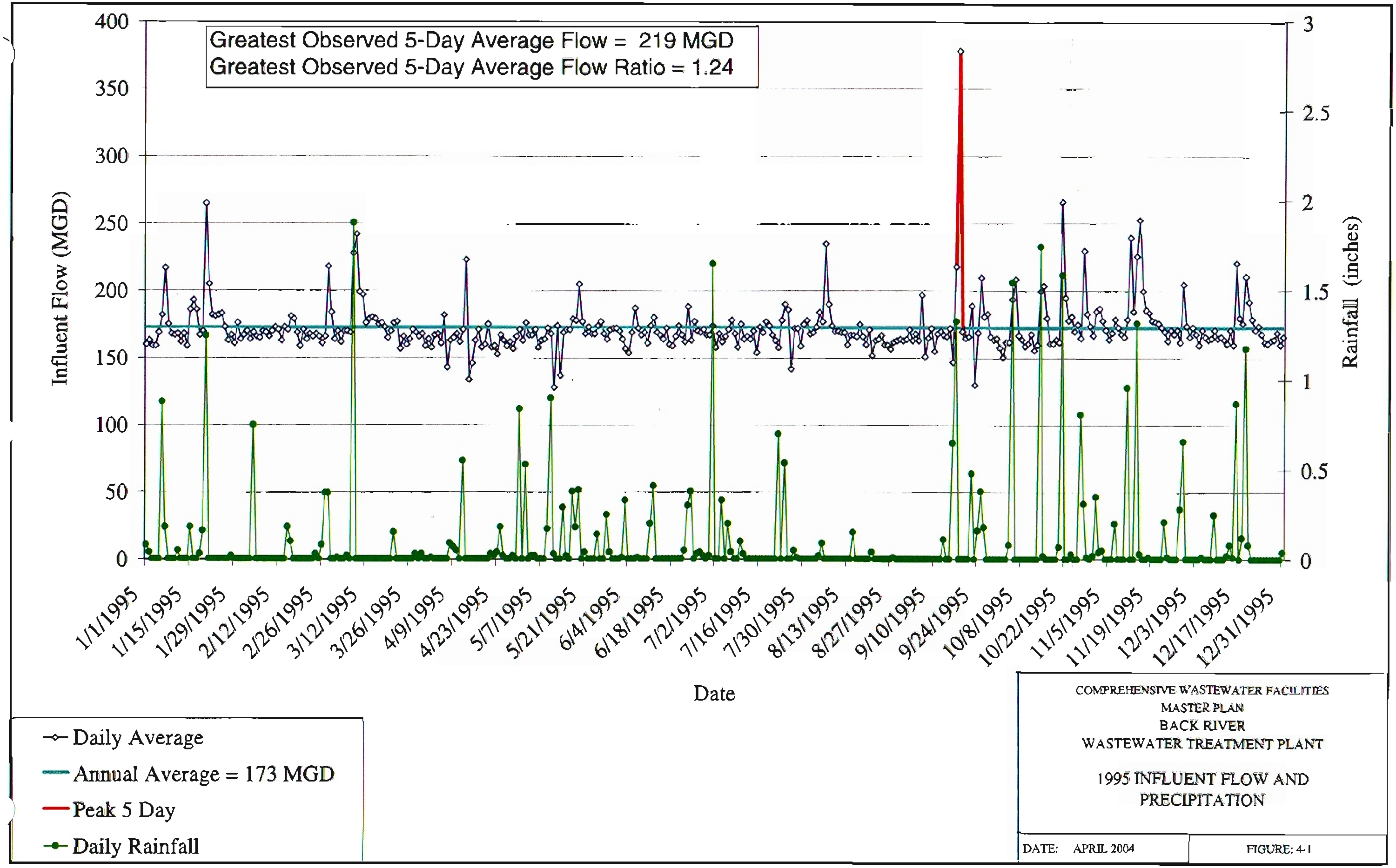
Month	Flow (MGD)						BOD_5 (mg/l)						TSS (mg/l					
	1998	1999	2000	2001	2002	2003	1998	1999	2000	2001	2002	2003	1998	1999	2000	2001	2002	2003
January	159	144	142	142	128	165	187	268	187	196	185	141	188	240	143	145	112	75
February	182	149	161	146	124	170	182	265	129	197	191	148	181	217	86	146	90	120
March	187	164	164	156	134	214	171	235	130	222	178	131	156	203	88	132	75	149
April	157	156	165	152	133	193	216	228	153	182	213	162	199	180	113	121	152	208
May	164	134	152	147	138	195	216	261	217	195	176	161	192	218	211	113	85	114
June	151	135	148	146	136	198	227	264	199	204	180	135	210	204	178	136	104	56
July	146	135	160	138	133	170	236	285	162	198	190	153	204	230	168	113	113	76
August	142	139	149	136	135	156	228	245	162	179	171	164	222	194	199	97	89	89
September	141	169	150	134	134	171	229	172	168	220	177	138	204	125	206	126	124	65
October	136	156	138	129	145	161	244	164	212	210	158	163	212	126	185	125	100	99
November	130	139	135	127	150	165	263	180	241	193	187	148	343	115	243	109	124	111
December	126	147	140	127	160	197	267	183	223	173	142	121	235	143	214	87	64	68
Average	152	147	150	140	137	180	222	229	182	197	179	147	212	183	170	121	103	103

Month	TKN (mg/l)						TN (mg/l)						TP (mg/l)					
	1998	1999	2000	2001	2002	2003	1998	1999	2000	2001	2002	2003	1998	1999	2000	2001	2002	2003
January	30.5	33.8	30.3	27.4	26.8	24.5	30.6	33.9	30.4	27.5	27.2	25.1	4.19	4.95	3.73	3.8	3.56	3.16
February	24.5	36.2	25	27.7	30.2	24.5	24.7	36.3	25.1	27.9	30.3	25.3	3.24	5.07	2.8	3.65	3.94	3.31
March	26.5	31.8	25	25.3	28.3	20.0	26.7	32	25.1	25.5	28.6	21.3	3.6	4.49	3.01	3.52	3.44	2.98
April	32.4	29.3	25.9	25.1	36.2	25.6	32.5	29.4	26	25.2	36.4	26.5	4.47	4.09	3.17	3.27	4.61	4.26
May	29	33.1	32.9	26.9	29.6	24.6	29.1	33.7	33	27	29.8	24.8	3.86	4.67	4.42	3.5	3.43	3.23
June	31.7	33.5	30.4	27.2	27.0	18.7	31.8	33.6	30.5	27.3	27.3	19.1	4.21	4.9	4.52	3.63	3.27	2.35
July	32.9	35.6	27.2	26.8	26.4	21.0	33	35.7	27.3	27	26.8	21.3	4.45	5.01	3.87	3.48	3.54	2.75
August	32.5	30.7	28.5	26.3	26.8	24.0	32.7	30.8	28.6	26.5	27.2	24.2	4.46	4.79	4.08	3.35	3.53	3.04
September	34.6	25.7	28	28.7	29.2	22.9	34.7	25.9	28.2	29	29.6	23.1	4.51	3.31	4	3.78	3.80	2.51
October	38	26.4	29.6	28.9	27.0	26.8	38.1	26.5	29.8	29	27.6	27.3	5.01	3.78	4.16	3.72	3.56	2.87
November	38	29.6	31.9	27.3	28.0	26.1	38.1	29.7	32.3	27.4	28.4	26.4,	5.14	3.6	4.4	3.42	3.82	2.71
December	39.6	28.3	32.8	27.9	25.2	23.9	39.7	28.4	33	28.2	25.7	24.4	5.33	4.2	4.56	3.48	3.14	2.25
Average	32.5	31.2	29	27.1	28.4	23.6	32.7	31.3	29.1	27.3	28.7	24.1	4.37	4.41	3.89	3.55	3.64	2.95

TABLE 4-3
BACK RIVER WASTEWATER TREATMENT PLANT
INFLUENT FLOW AND LOADINGS

Month	Flow (MGD)						BOD$_5$ (1000 lbs/day)						TSS (1000 lbs/day)					
	1998	1999	2000	2001	2002	2003	1998	1999	2000	2001	2002	2003	1998	1999	2000	2001	2002	2003
January	159	144	142	142	128	165	248	322	221	232	198	194	249	288	169	172	119	103
February	182	149	161	146	124	170	276	329	173	240	197	210	275	270	115	178	93	171
March	187	164	164	156	134	214	267	321	178	289	199	234	243	278	120	172	84	266
April	157	156	165	152	133	193	283	297	211	231	236	261	261	234	155	153	168	336
May	164	134	152	147	138	195	295	292	275	239	202	262	263	244	267	139	98	186
June	151	135	148	146	136	198	286	297	246	248	205	222	264	230	220	166	118	93
July	146	135	160	138	133	170	287	321	216	228	210	217	248	259	224	130	125	108
August	142	139	149	136	135	156	270	284	201	203	193	212	263	225	247	110	101	116
September	141	169	150	134	134	171	269	242	210	246	198	197	240	176	258	141	138	92
October	136	156	138	129	145	161	277	213	244	226	191	219	240	164	213	134	120	133
November	130	139	135	127	150	165	285	209	271	204	234	204	372	133	274	115	155	154
December	126	147	140	127	160	197	281	224	260	183	190	199	247	175	250	92	85	112
Average	152	147	150	140	137	180	277	279	226	231	204	219	264	223	209	142	117	156

Month	TKN (1000 lbs/day)						TN(1000 lbs/day)						TP (1000 lbs/day)					
	1998	1999	2000	2001	2002	2003	1998	1999	2000	2001	2002	2003	1998	1999	2000	2001	2002	2003
January	40.4	40.6	35.9	32.4	28.7	33.7	40.6	40.7	36.0	32.6	29.1	34.5	5.56	5.94	4.42	4.50	3.80	4.34
February	37.2	45.0	33.6	33.7	31.1	34.9	37.5	45.1	33.7	34.0	31.2	35.9	4.92	6.30	3.76	4.44	4.06	4.71
March	41.3	43.5	34.2	32.9	31.6	35.8	41.6	43.8	34.3	33.2	31.9	38.0	5.61	6.14	4.12	4.58	3.83	5.33
April	42.4	38.1	35.6	31.8	40.1	41.3	42.6	38.3	35.8	31.9	40.3	42.8	5.85	5.32	4.36	4.15	5.10	6.87
May	39.7	37.0	41.7	33.0	34.0	40.1	39.8	37.7	41.8	33.1	34.2	40.4	5.28	5.22	5.60	4.29	3.94	5.25
June	39.9	37.7	37.5	33.1	30.7	30.9	40.0	37.8	37.6	33.2	31.0	31.5	5.30	5.52	5.58	4.42	3.72	3.87
July	40.1	40.1	36.3	30.8	29.2	29.8	40.2	40.2	36.4	31.1	29.7	30.3	5.42	5.64	5.16	4.01	3.92	3.91
August	38.5	35.6	35.4	29.8	30.2	31.2	38.7	35.7	35.5	30.1	30.6	31.5	5.28	5.55	5.07	3.80	3.97	3.95
September	40.7	36.2	35.0	32.1	32.6	32.7	40.8	36.5	35.3	32.4	33.0	33.1	5.30	4.67	5.00	4.22	4.24	3.59
October	43.1	34.3	34.1	31.1	32.7	36.0	43.2	34.5	34.3	31.2	33.4	36.7	5.68	4.92	4.79	4.00	4.30	3.86
November	41.2	34.3	35.9	28.9	34.9	35.9	41.3	34.4	36.4	29.0	35.4	36.4	5.57	4.17	4.95	3.62	4.77	3.74
December	41.6	34.7	38.3	29.6	33.6	39.4	41.7	34.8	38.5	29.9	34.2	40.1	5.60	5.15	5.32	3.69	4.18	3.71
Average	40.5	38.1	36.1	31.6	32.4	35.2	40.7	38.3	36.3	31.8	32.8	35.9	5.45	5.38	4.85	4.14	4.15	4.43

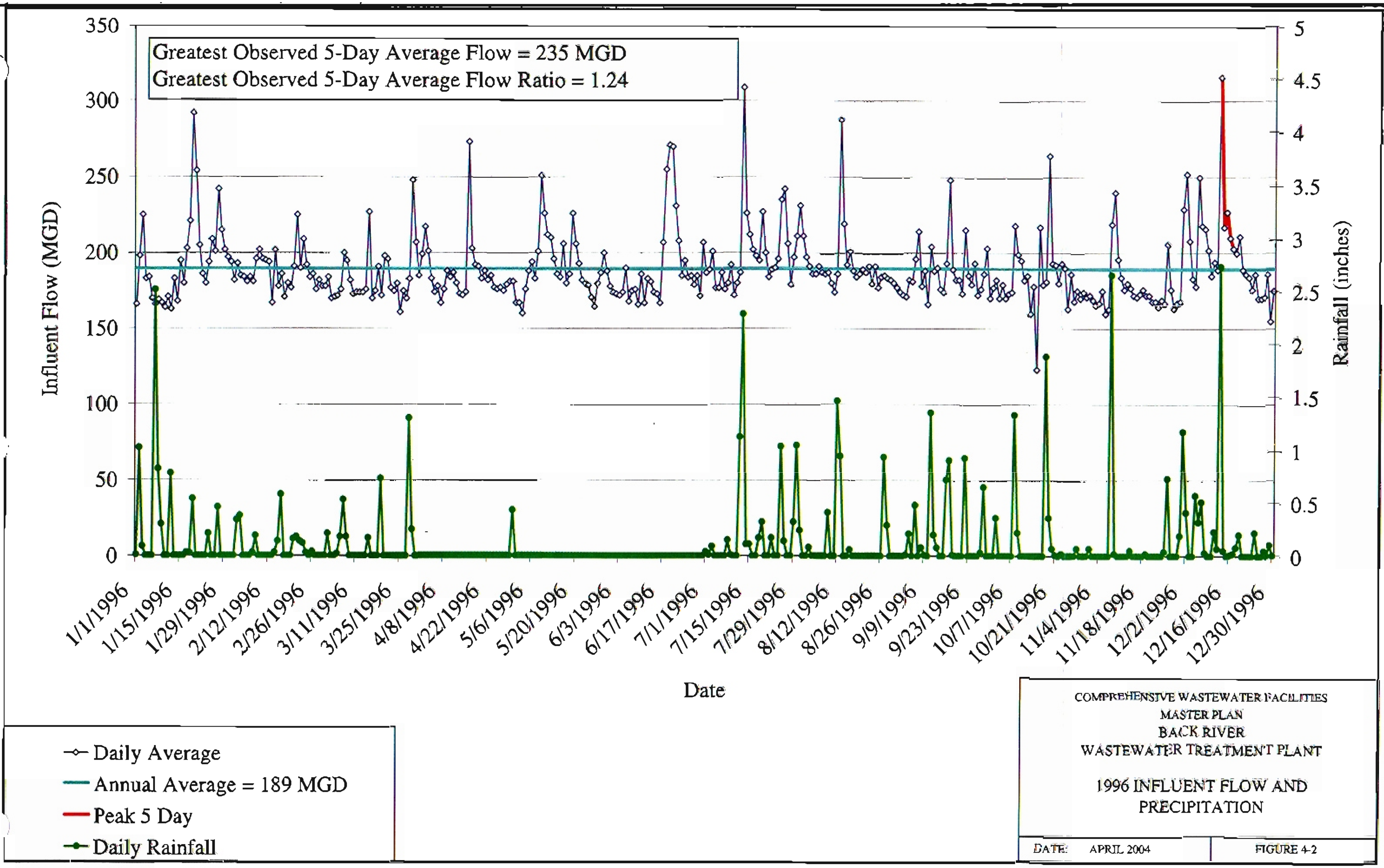


COMPREHENSIVE WASTEWATER FACILITIES
MASTER PLAN
BACK RIVER
WASTEWATER TREATMENT PLANT

1995 INFLUENT FLOW AND PRECIPITATION

DATE: APRIL 2004 | FIGURE: 4-1

Whitman Requardt and Associates
Figure 4-1,9.xls/1995 Chart

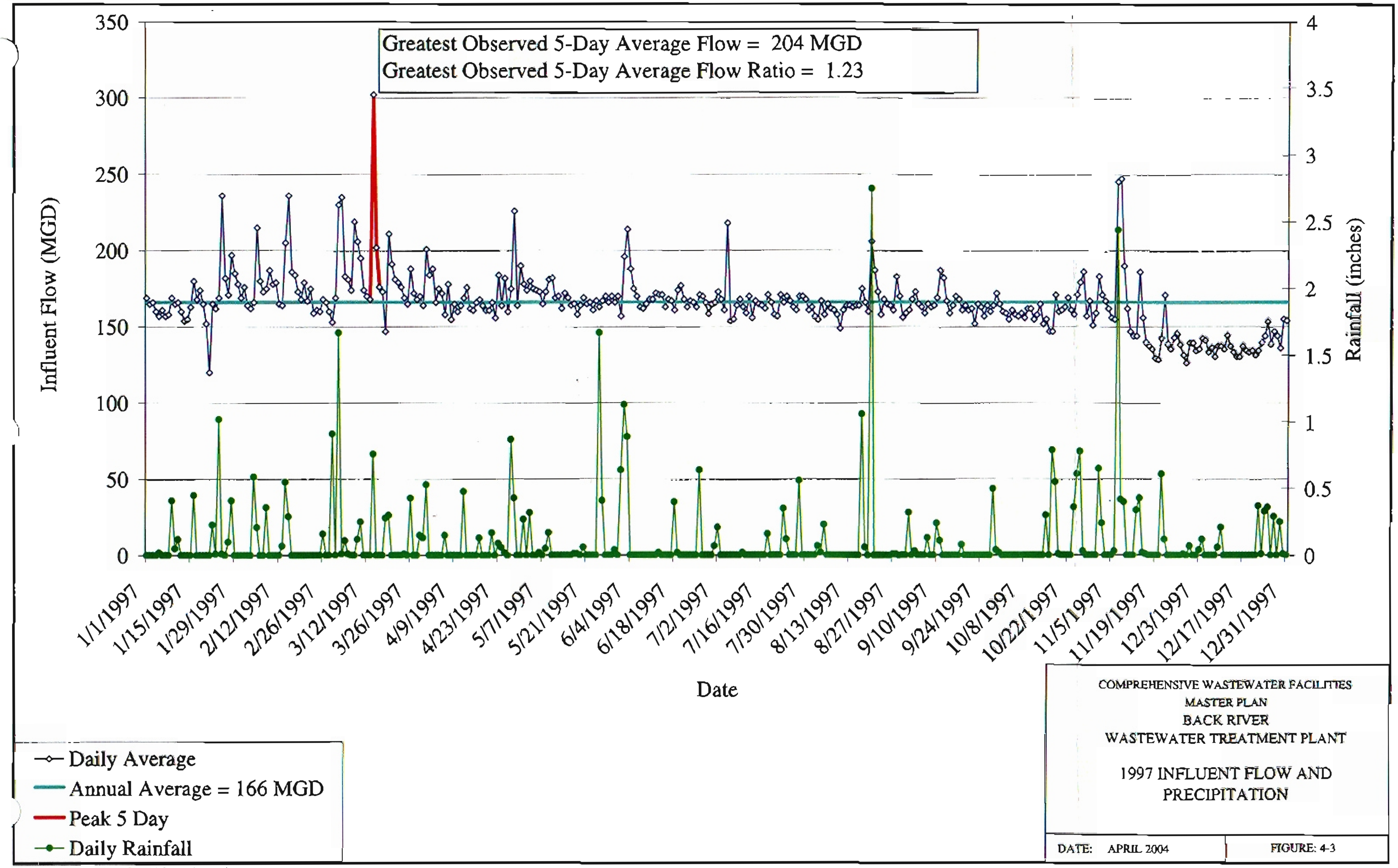


COMPREHENSIVE WASTEWATER FACILITIES MASTER PLAN
BACK RIVER WASTEWATER TREATMENT PLANT

1996 INFLUENT FLOW AND PRECIPITATION

DATE: APRIL 2004 | FIGURE 4-2

Whitman, Requardt and Associates, LLP
Figure 4-1,9.xls/1996 Chart

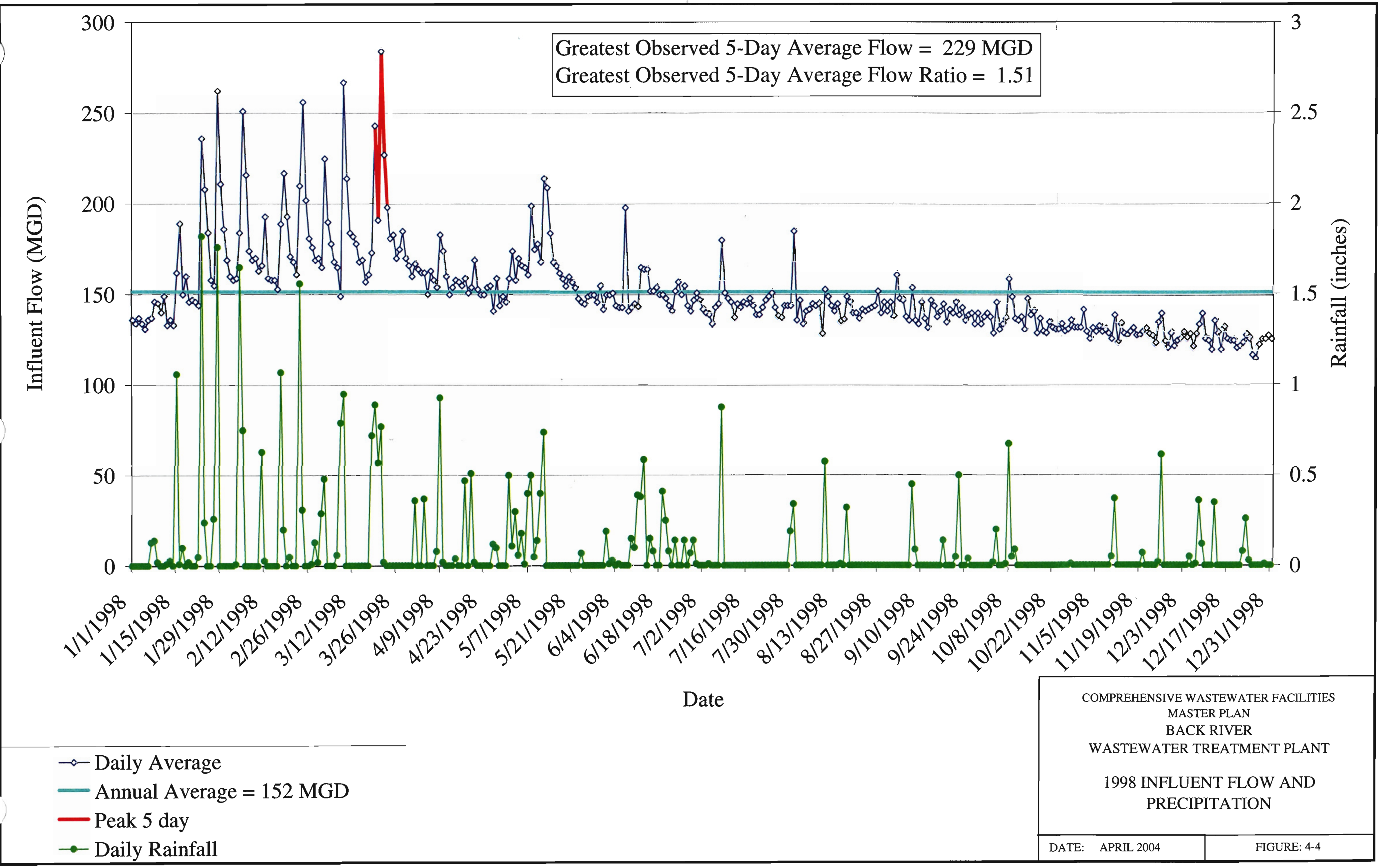


COMPREHENSIVE WASTEWATER FACILITIES MASTER PLAN
BACK RIVER WASTEWATER TREATMENT PLANT

1997 INFLUENT FLOW AND PRECIPITATION

DATE: APRIL 2004 | FIGURE: 4-3

Whitman, Requardt and Associates, LLP
Figure 4-1,9.xls/1997 Chart

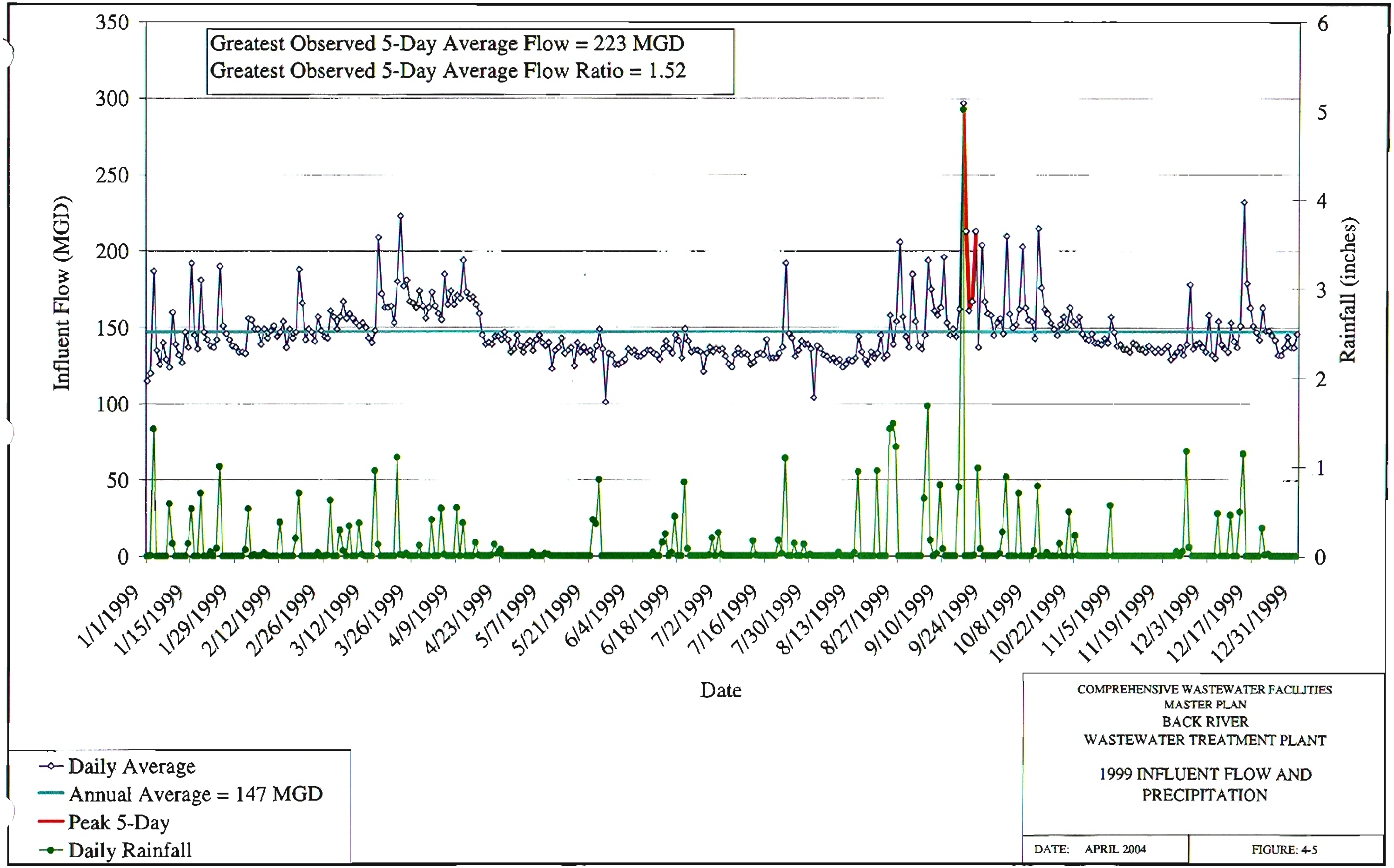


COMPREHENSIVE WASTEWATER FACILITIES MASTER PLAN
BACK RIVER WASTEWATER TREATMENT PLANT

1998 INFLUENT FLOW AND PRECIPITATION

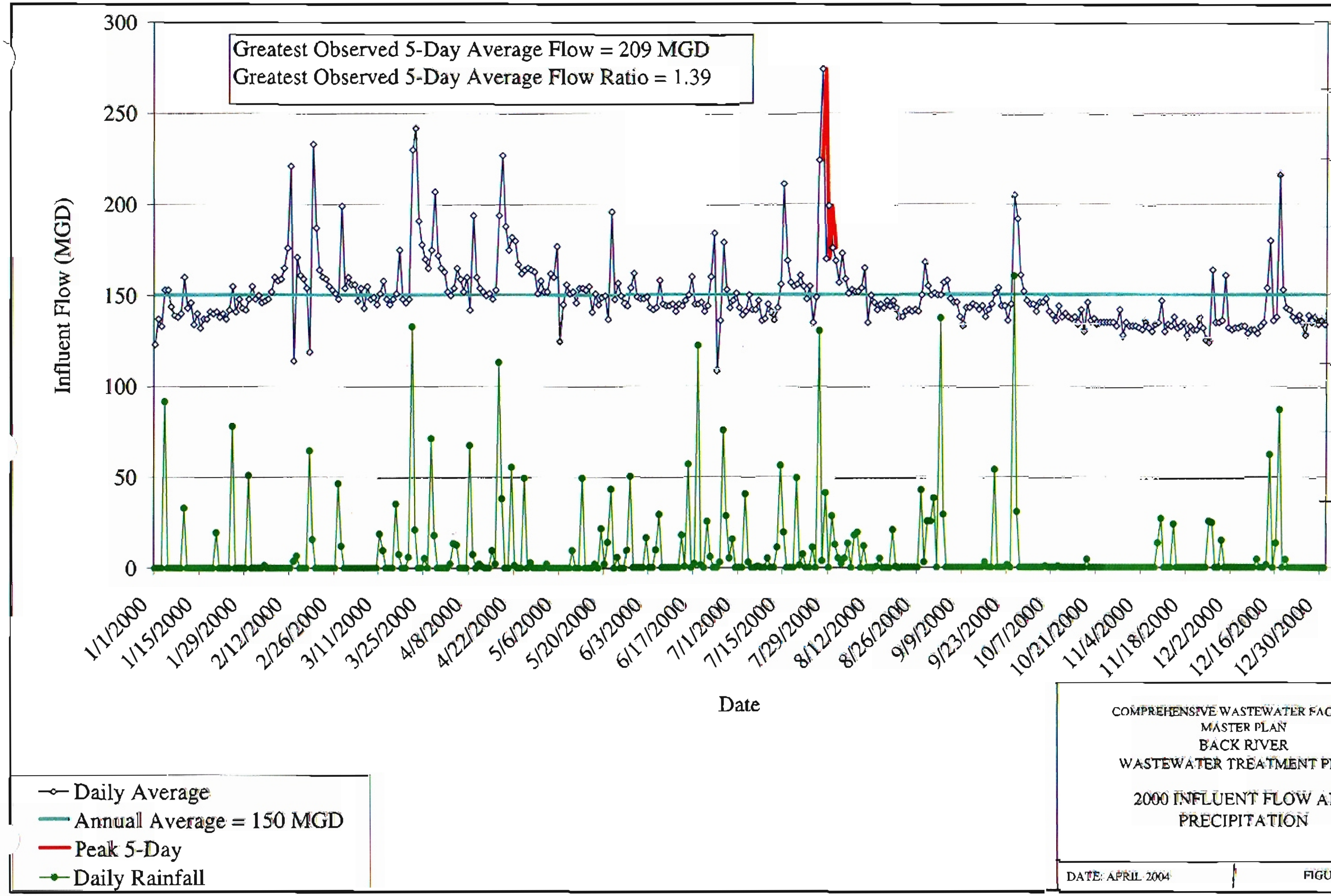
DATE: APRIL 2004	FIGURE: 4-4

Whitman, Requardt and Associates, LLP
Figure 4-1,9.xls/1998 Chart



COMPREHENSIVE WASTEWATER FACILITIES MASTER PLAN BACK RIVER WASTEWATER TREATMENT PLANT 1999 INFLUENT FLOW AND PRECIPITATION	
DATE: APRIL 2004	FIGURE: 4-5

Whitman, Requardt and Associates, LLP
Figure 4-1,9.xls/1999 Chart

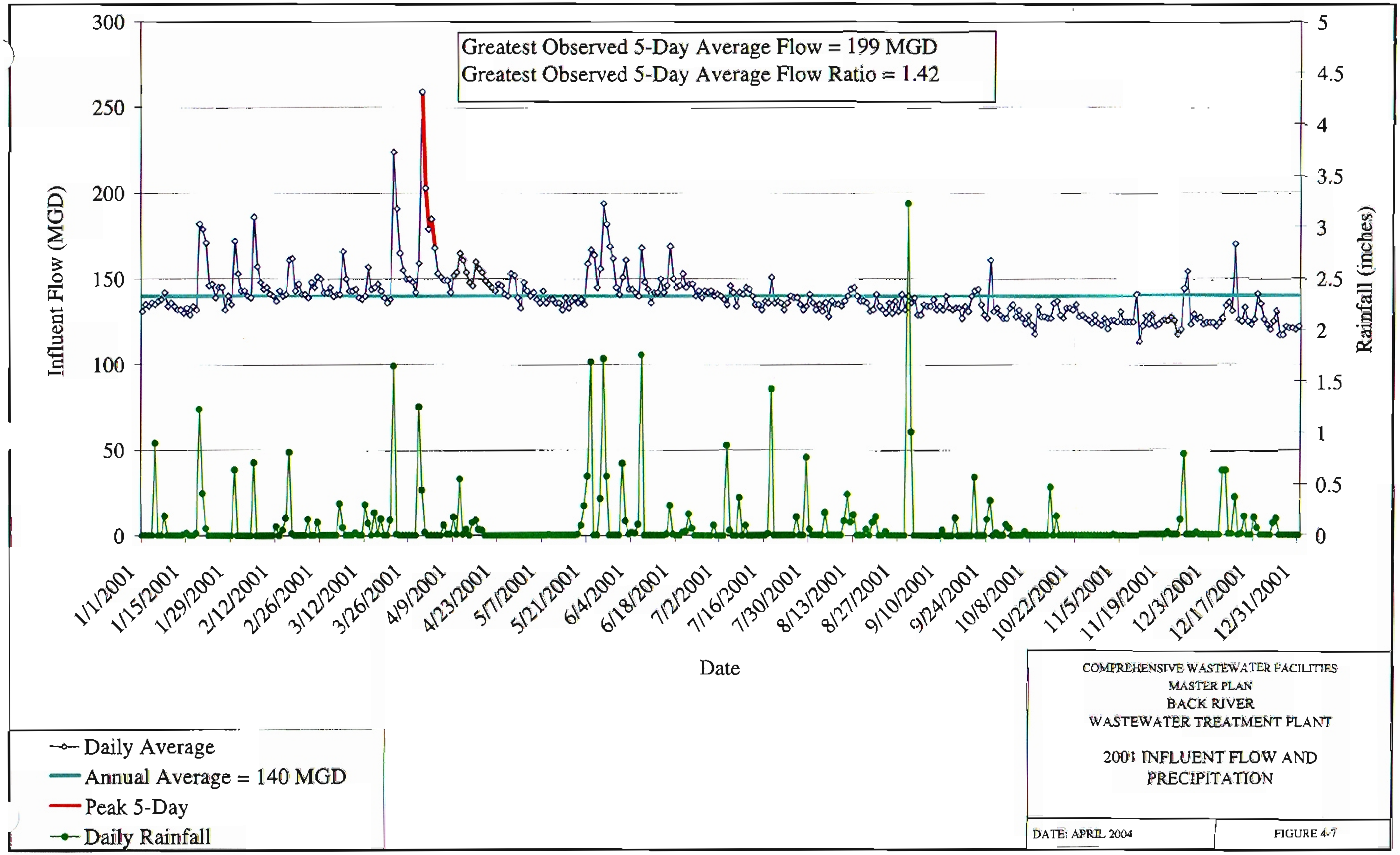


COMPREHENSIVE WASTEWATER FACILITIES
MASTER PLAN
BACK RIVER
WASTEWATER TREATMENT PLANT

2000 INFLUENT FLOW AND
PRECIPITATION

DATE: APRIL 2004 | FIGURE: 4-6

Whitman, Requardt and Associates, LLP
Figure 4-1,9.xls/2000 Chart

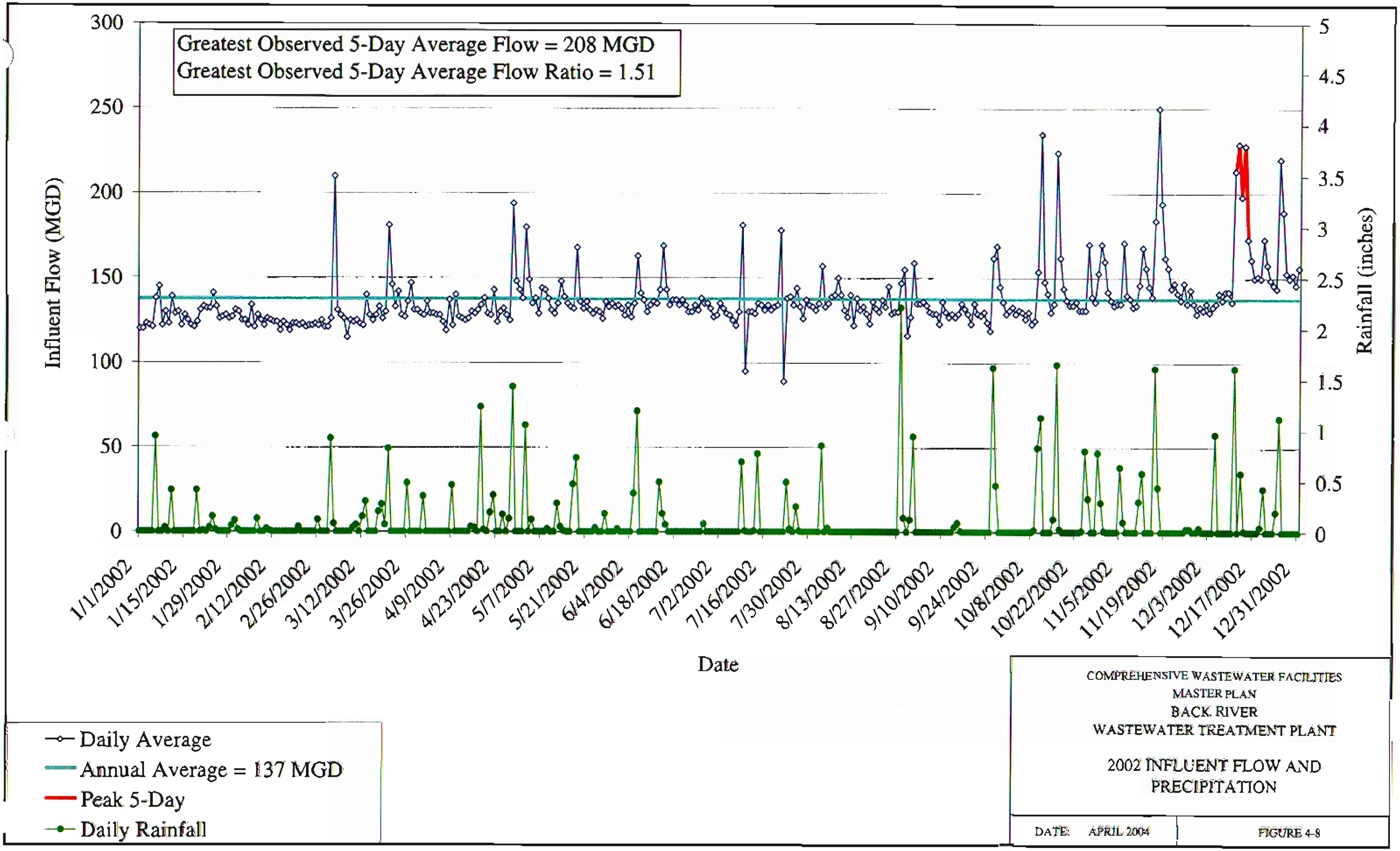


COMPREHENSIVE WASTEWATER FACILITIES MASTER PLAN
BACK RIVER WASTEWATER TREATMENT PLANT

2001 INFLUENT FLOW AND PRECIPITATION

DATE: APRIL 2004 | FIGURE 4-7

Whitman, Requardt and Associates, LLP
Figure 4-1,9.xls/2001 Chart

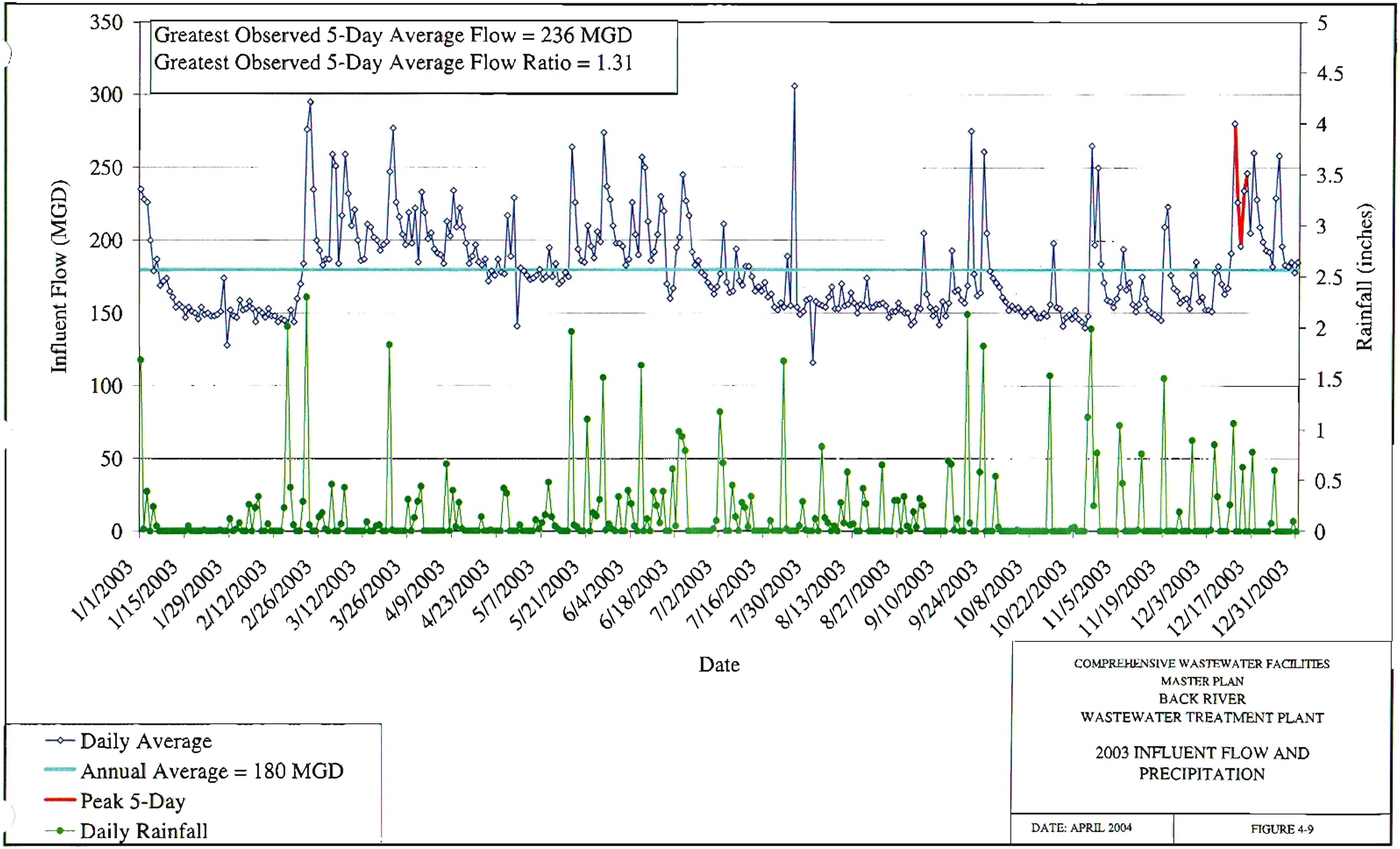


COMPREHENSIVE WASTEWATER FACILITIES
MASTER PLAN
BACK RIVER
WASTEWATER TREATMENT PLANT

2002 INFLUENT FLOW AND
PRECIPITATION

DATE: APRIL 2004	FIGURE 4-8

Whitman, Requardt and Associates, LLP
Figure 4-1,9.xls/2002 Chart



COMPREHENSIVE WASTEWATER FACILITIES
MASTER PLAN
BACK RIVER
WASTEWATER TREATMENT PLANT

2003 INFLUENT FLOW AND PRECIPITATION

DATE: APRIL 2004

FIGURE 4-9

Whitman, Requardt and Associates, LLP
Figure 4-1,9.xls/ 2003 Chart

TABLE 4-4
BACK RIVER WASTEWATER TREATMENT PLANT
INFLUENT FLOW PEAKING FACTORS

Calendar Year	Annual Daily Average Flow Rate (MGD)	Greatest Observed 5-Day Average Flow Rate (MGD)	Average Daily Flow for 5 Consecutive Days Flow Factor
1995	173	219	1.24
1996	189	235	1.24
1997	166	204	1.23
1998	152	229	1.51
1999	147	223	1.52
2000	150	209	1.39
2001	140	199	1.42
2002	137	208	1.51
2003	180	236	1.31
Averages	159	218	1.37

4.2.2. Patapsco Wastewater Treatment Plant

Annual average daily plant flow for calendar years 1995 – 2003 is summarized in Table 4-5. Also shown in this table is the annual quantity of rainfall for the area as measured at Baltimore Washington International (BWI) airport. As shown, the total annual plant influent flow ranged from 53 – 71 mgd with an average of 63 mgd over the nine-year period. As discussed in next section, a five-day peak factor of 1.7 was determined.

Plant influent characteristics for calendar years 1998 – 2001 are summarized in Table 4-6 and 4-7. The parameters include the monthly average concentrations and loadings for five-day biochemical oxygen demand (BOD_5), total suspended solids (TSS), total Kjeldhal nitrogen (TKN), total nitrogen (TN) and total phosphorous (TP). The concentration ranges are as follows:

Range of Annual Average Influent Concentrations (mg/l) (1998 – 2003)

BOD_5	TSS	TKN	TP
165 - 226	137 - 202	25 - 30	3 - 4.4

4.2.2.1. Flow Variations

Peak Five-Day Period

Analysis of the influent flow characteristics was conducted with data from Patapsco over a nine-year period between 1995 and 2003. The result of this analysis is shown in Table 4-8. Figures 4-10 through 4-18 illustrate the plants daily average influent flow for this time period. Also shown in these figures are the rainfall data as reported by BWI. The greatest observed five-day influent period is highlighted and the annual average for each year is also illustrated in each figure. There appears to be a correlation between rainfall events and greatest observed five-day influent period. However, there is not always a direct response to influent flow and rainfall. This may be explained by localized rain events that were picked up by the rain gauge located at BWI Airport and therefore shown in the figures but were not geographically dispersed to influence the entire sewershed and therefore the influent flow. The ratio between the annual daily average and the average of the greatest observed five-day period has been calculated for each of the nine years investigated and is shown in Table 4-8. The resulting ratio for this nine-year period is 1.7 which compared to a ratio of 1.37 at Back River Wastewater Treatment Plant indicates that the flow variations are more severe at Patapsco than Back River. This was expected and is due in large part to the combined sewers in this service area as compared with that of the Back River service area.

Maximum Instantaneous Flow Rate

The Patapsco 201 Facility Plan determined that the maximum instantaneous influent flow is 339 mgd. This flow is the estimated maximum flow that existing conveyance system can deliver to the plant. Review of plant records for the period 1995 – 2003, which includes several extremely wet years, reflects a maximum instantaneous flow rate of 305 mgd in June and July of 1996. Since this value is within about 10% of the Facility Plan estimate, 339 mgd is adopted. Other high flows of similar values further support the decision.

TABLE 4-5
PATAPSCO WASTEWATER TREATMENT PLANT
ANNUAL FLOWS AND RAINFALL

Calendar Year	Annual Average Daily Flow (MGD) Plant Influent	Total Annual Rainfall (inches)
1995	53.2	36.93
1996	63.1	58.31
1997	59.9	38.34
1998	70	34.37
1999	60	43.94
2000	66.5	41.91
2001	64	35.74
2002	63.1	39.60
2003	71.3	62.66

TABLE 4-6
PATAPSCO WASTEWATER TREATMENT PLANT
INFLUENT FLOW AND CONCENTRATIONS

Month	Flow (MGD)						BOD_5 (mg/l)						TSS (mg/l)					
	1998	1999	2000	2001	2002	2003	1998	1999	2000	2001	2002	2003	1998	1999	2000	2001	2002	2003
January	74	62	59	63	59	77	252	210	181	232	319	245	198	198	188	182	194	156
February	93	49	73	66	57	78	182	256	224	208	263	179	167	179	178	171	183	137
March	95	57	76	72	64	79	170	209	209	231	245	146	172	160	169	186	175	154
April	75	58	79	67	65	52	225	252	175	223	271	189	207	178	149	198	203	138
May	83	60	68	66	65	61	271	264	204	277	181	152	203	201	167	169	187	139
June	69	56	66	68	63	86	232	210	277	271	194	118	224	194	209	219	162	117
July	65	57	66	63	58	66	217	195	250	271	190	177	225	187	190	215	158	141
August	64	56	64	63	55	56	257	234	181	248	204	177	220	184	163	186	178	147
September	60	78	67	63	57	73	199	238	207	234	229	145	190	184	162	188	178	131
October	57	67	61	59	62	69	188	192	262	294	194	172	188	166	198	199	149	139
November	54	58	59	57	73	81	239	204	219	288	225	148	218	169	189	226	165	126
December	52	63	60	58	80	77	260	247	228	237	198	131	217	226	177	182	136	114
Average	70	60	66.5	64	63	71	224	226	218	251	226	165	202	186	178	193	172	137

Month	TKN (mg/l)						TN (mg/l)						TP (mg/l)					
	1998	1999	2000	2001	2002	2003	1998	1999	2000	2001	2002	2003	1998	1999	2000	2001	2002	2003
January	27.2	27.2	25.4	31.2	40.5	23.4	27.4	27.6	25.6	31.5	40.6	23.5	4.8	4.8	3.3	4.2	5.50	3.69
February	20.5	23.3	25.4	29.5	29.3	23.8	20.9	23.7	25.7	29.6	29.5	23.9	3.2	3.4	3.4	4	4.96	3.56
March	19.9	28.4	25.8	30.2	31.7	19.2	20.1	28.6	26	30.3	31.8	19.5	2.9	4.6	3.3	4.6	5.10	2.94
April	23.2	22.2	22.9	30.8	24.8	23.1	23.3	22.3	23.1	31	24.9	23.2	3.5	3.6	3.6	3.9	3.80	3.57
May	26	25.3	25.5	33.1	24.7	22.3	26.2	25.4	25.7	33.2	24.8	22.5	3.4	3.6	3.4	5.2	3.80	3.18
June	24.2	26	27.9	33	26.1	20.5	24.4	26.1	28.1	33.1	26.2	20.9	3.8	4	4.7	4.9	3.70	2.68
July	24.1	25.2	28.9	30.7	24.7	23.3	24.2	25.3	29.1	30.9	24.8	23.5	3.7	3.5	3.6	4.1	3.50	3.49
August	28.8	25.4	26.8	29.1	26.6	23.3	28.9	26.2	27	29.2	26.6	23.4	5.2	3.2	3.4	4.2	3.90	3.52
September	25.6	22.4	24.5	19.9	29.0	21.5	25.8	22.6	24.7	20	29.1	21.6	3.7	2.8	4	3.7	4.60	2.81
October	26.6	21.5	28.7	31.5	23.1	22.3	26.8	21.6	28.9	31.7	23.4	22.5	3.8	2.9	4.5	4.7	3.97	3.24
November	28.7	24.9	30.8	32.7	26.9	20.6	28.9	25	30.9	32.8	27.0	20.7	3.9	3.2	4.2	4.9	4.63	2.88
December	32.1	27.2	29.7	33.2	22.2	18.9	32.4	27.3	29.9	33.3	22.4	19.2	5.5	3.7	4.4	4.8	3.26	2.65
Average	25.6	24.9	26.9	30.4	27.5	21.8	25.8	25.2	27	30.5	27.6	22.0	4	3.6	3.8	4.4	4.2	3.2

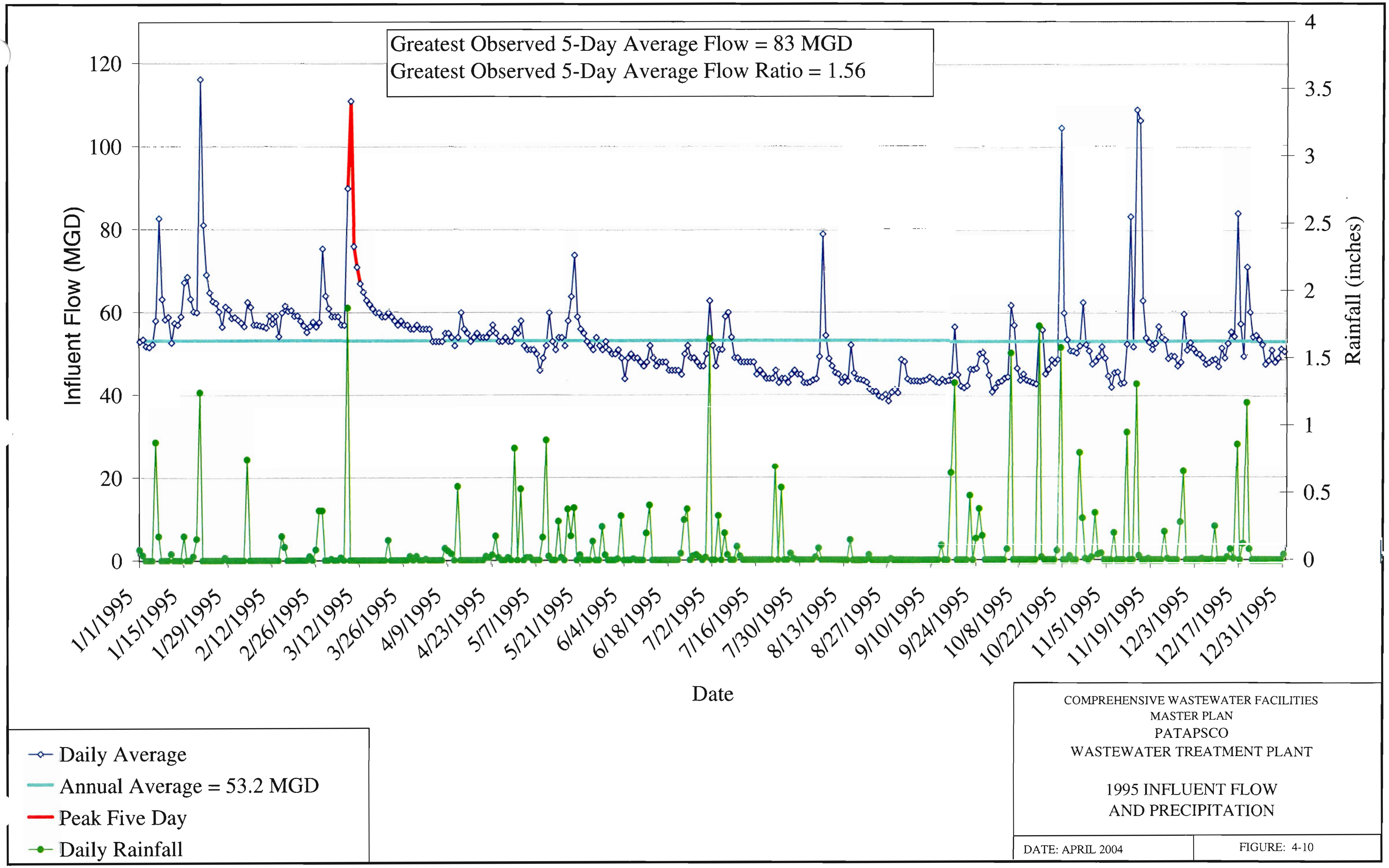
TABLE 4-7
PATAPSCO WASTEWATER TREATMENT PLANT
INFLUENT FLOW AND LOADINGS

Month	Flow (MGD)						BOD_5 (1000 lbs/day)						TSS (1000 lbs/day)					
	1998	1999	2000	2001	2002	2003	1998	1999	2000	2001	2002	2003	1998	1999	2000	2001	2002	2003
January	74	62	59	63	59	77	156	109	89	122	156	157	122	102	93	96	95	100
February	93	49	73	66	57	78	141	105	136	114	125	116	130	73	108	94	87	89
March	95	57	76	72	64	79	135	99	132	139	131	97	136	76	107	112	94	102
April	75	58	79	67	65	52	141	122	115	125	146	82	129	86	98	111	109	60
May	83	60	68	66	65	61	188	132	116	152	98	77	141	101	95	93	101	71
June	69	56	66	68	63	86	134	98	152	154	101	85	129	91	115	124	84	84
July	65	57	66	63	58	66	118	93	138	142	92	97	122	89	105	113	77	77
August	64	56	64	63	55	56	137	109	97	130	94	83	117	86	87	98	82	69
September	60	78	67	63	57	73	100	155	116	123	109	88	95	120	91	99	84	80
October	57	67	61	59	62	69	89	107	133	145	101	100	89	93	101	98	78	80
November	54	58	59	57	73	81	108	99	108	137	137	100	98	82	93	107	100	85
December	52	63	60	58	80	77	113	130	114	115	132	84	94	119	89	88	91	73
Average	70	60	66.5	64	63	71	130	113	121	133	118	97	117	93	98	103	90	81

Month	TKN (1000 lbs/day)						TN(1000 lbs/day)						TP (1000 lbs/day)					
	1998	1999	2000	2001	2002	2003	1998	1999	2000	2001	2002	2003	1998	1999	2000	2001	2002	2003
January	16.8	14.1	12.5	16.4	19.8	15.0	16.9	14.3	12.6	16.6	19.8	15.0	2.96	2.48	1.62	2.21	2.68	2.36
February	15.9	9.5	15.5	16.2	14.0	15.4	16.2	9.7	15.6	16.3	14.1	15.5	2.48	1.39	2.07	2.20	2.37	2.31
March	15.8	13.5	16.4	18.1	16.9	12.7	15.9	13.6	16.5	18.2	17.0	12.9	2.30	2.19	2.09	2.76	2.72	1.94
April	14.5	10.7	15.1	17.2	13.3	10.0	14.6	10.8	15.2	17.3	13.4	10.1	2.19	1.74	2.37	2.18	2.04	1.55
May	18.0	12.7	14.5	18.2	13.4	11.3	18.1	12.7	14.6	18.3	13.5	11.4	2.35	1.80	1.93	2.86	2.06	1.62
June	13.9	12.1	15.4	18.7	13.6	14.8	14.0	12.2	15.5	18.8	13.7	15.0	2.19	1.87	2.59	2.78	1.93	1.93
July	13.1	12.0	15.9	16.1	12.0	12.8	13.1	12.0	16.0	16.2	12.0	12.9	2.01	1.66	1.98	2.15	1.70	1.92
August	15.4	11.9	14.3	15.3	12.3	10.9	15.4	12.2	14.4	15.3	12.3	10.9	2.78	1.49	1.81	2.21	1.80	1.65
September	12.8	14.6	13.7	10.5	13.8	13.1	12.9	14.7	13.8	10.5	13.8	13.2	1.85	1.82	2.24	1.94	2.18	1.71
October	12.6	12.0	14.6	15.5	12.0	12.9	12.7	12.1	14.7	15.6	12.2	13.0	1.81	1.62	2.29	2.31	2.07	1.88
November	12.9	12.0	15.2	15.5	16.3	14.0	13.0	12.1	15.2	15.6	16.4	14.1	1.76	1.55	2.07	2.33	2.81	1.95
December	13.9	14.3	14.9	16.1	14.8	12.1	14.1	14.3	15.0	16.1	15.0	12.3	2.39	1.94	2.20	2.32	2.18	1.70
Average	14.6	12.4	14.8	16.2	14.4	12.9	14.8	12.6	14.9	16.2	14.4	13.0	2.25	1.80	2.11	2.36	2.21	1.88

TABLE 4-8
PATAPSCO WASTEWATER TREATMENT PLANT
INFLUENT FLOW PEAKING FACTORS

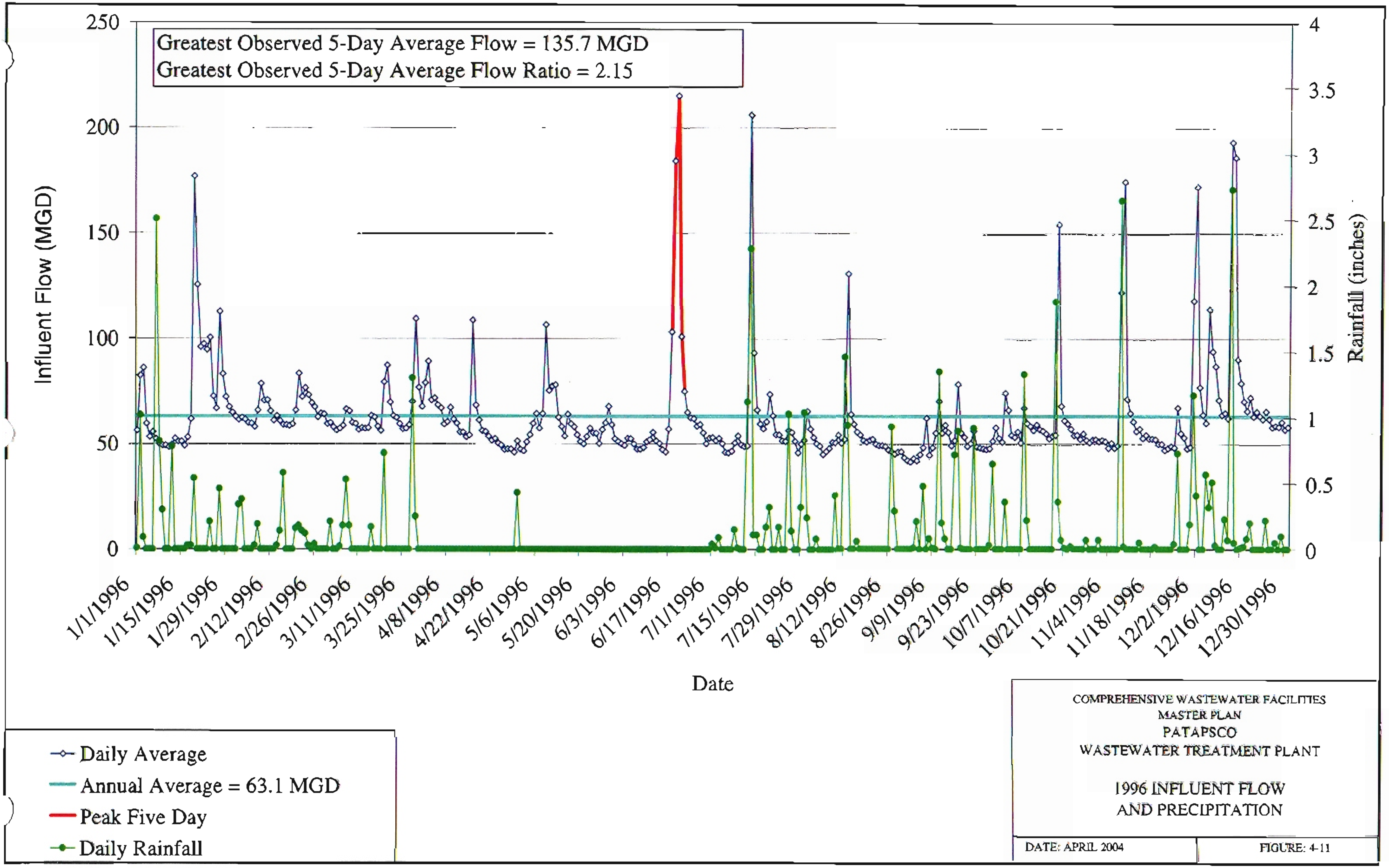
Calendar Year	Annual Daily Average Flow Rate (MGD)	Greatest Observed 5-Day Average Flow Rate (MGD)	Average Daily Flow for 5 Consecutive Days Flow Factor
1995	53.2	83	1.56
1996	63.1	135.7	2.15
1997	59.9	111.6	1.86
1998	70	113.2	1.62
1999	60.1	107.2	1.78
2000	66.5	102.2	1.54
2001	63.8	88.7	1.39
2002	63.1	113.5	1.80
2003	71.3	124.1	1.74
Averages	**63.4**	**109**	**1.72**



COMPREHENSIVE WASTEWATER FACILITIES
MASTER PLAN
PATAPSCO
WASTEWATER TREATMENT PLANT

1995 INFLUENT FLOW
AND PRECIPITATION

DATE: APRIL 2004 | FIGURE: 4-10

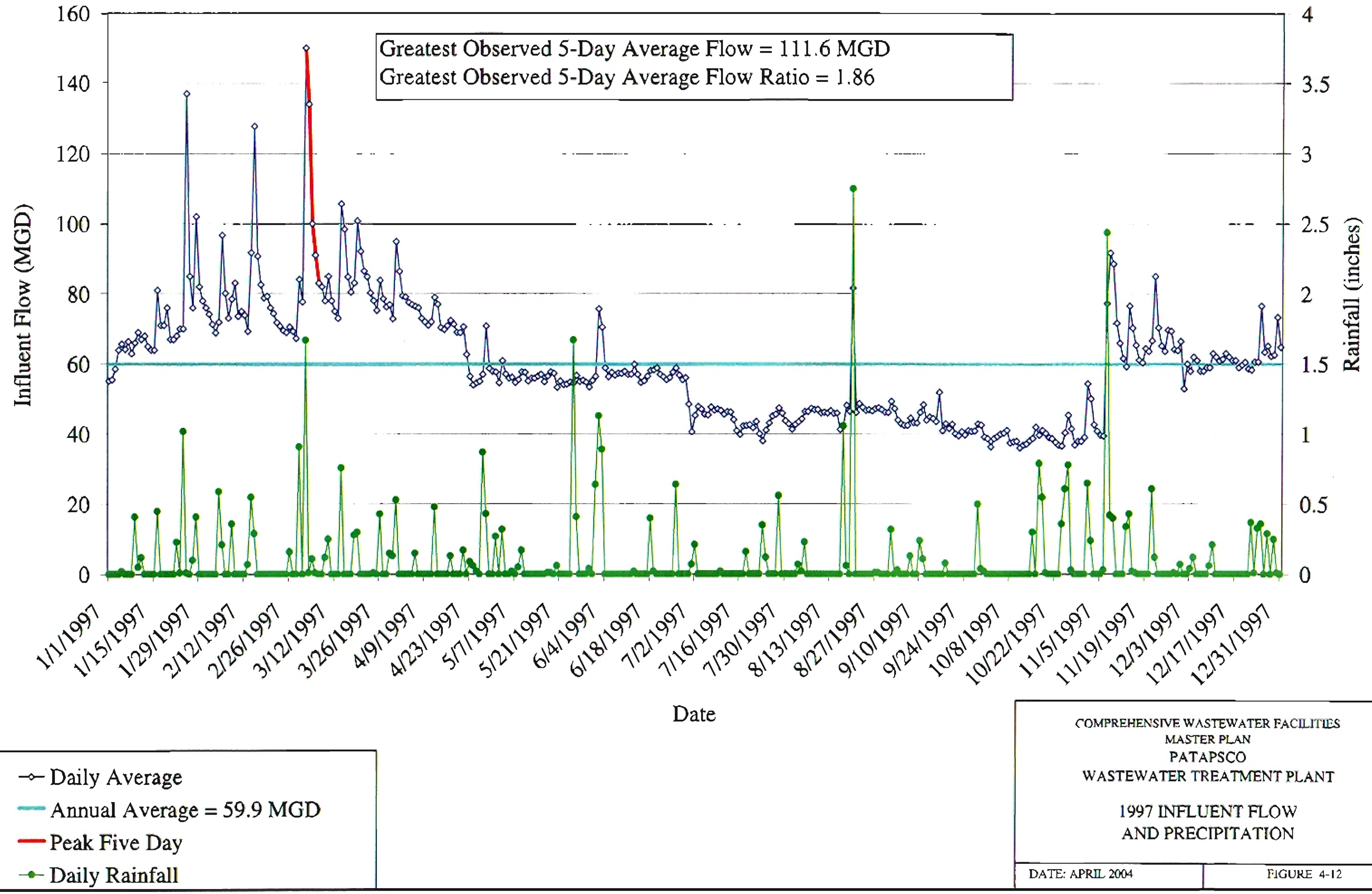


COMPREHENSIVE WASTEWATER FACILITIES
MASTER PLAN
PATAPSCO
WASTEWATER TREATMENT PLANT

1996 INFLUENT FLOW
AND PRECIPITATION

DATE: APRIL 2004 | FIGURE: 4-11

Whitman, Requardt and Associates, LLP
Figure 4-10,18.xls/1996 Chart

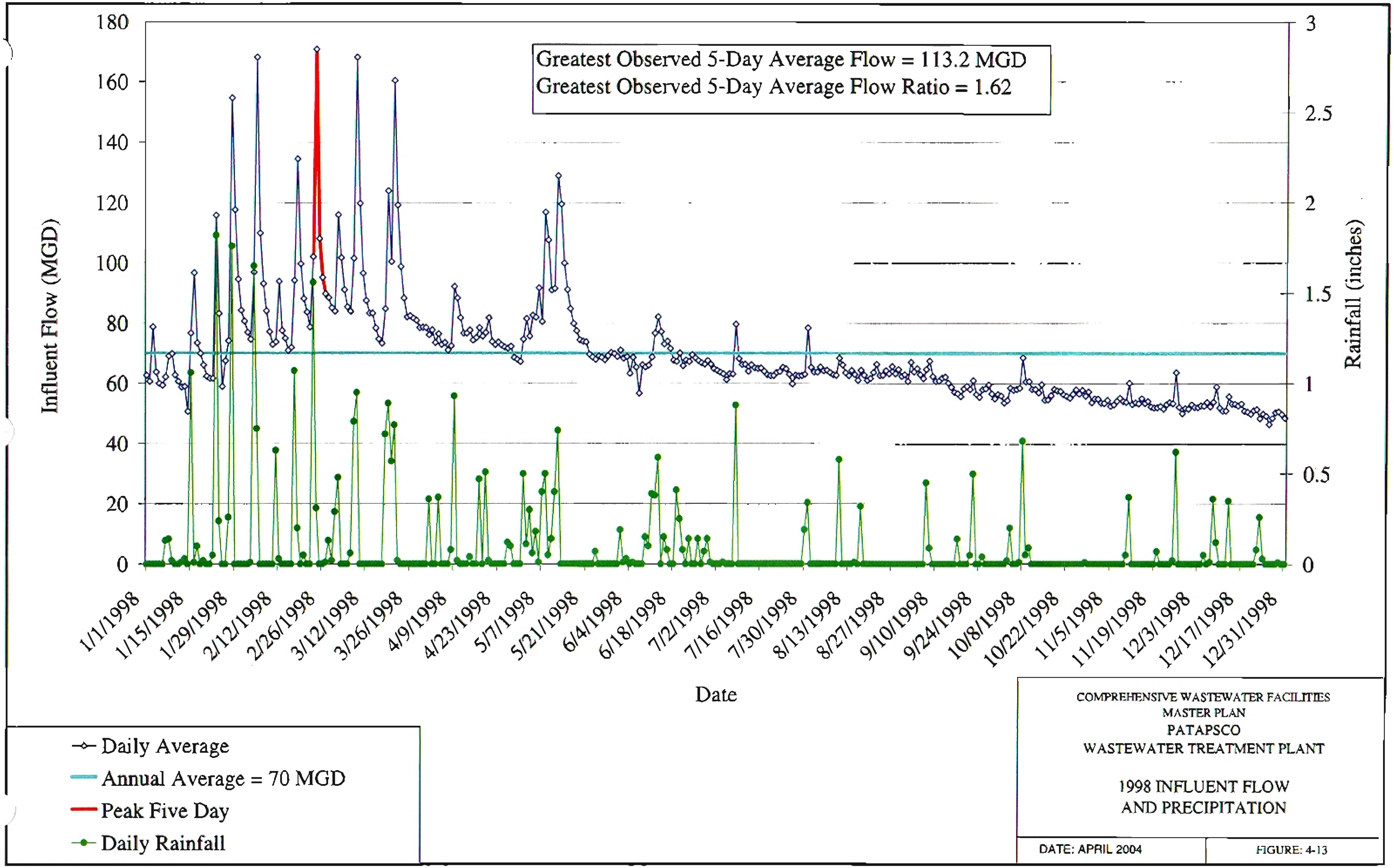


COMPREHENSIVE WASTEWATER FACILITIES
MASTER PLAN
PATAPSCO
WASTEWATER TREATMENT PLANT

1997 INFLUENT FLOW
AND PRECIPITATION

DATE: APRIL 2004 | FIGURE 4-12

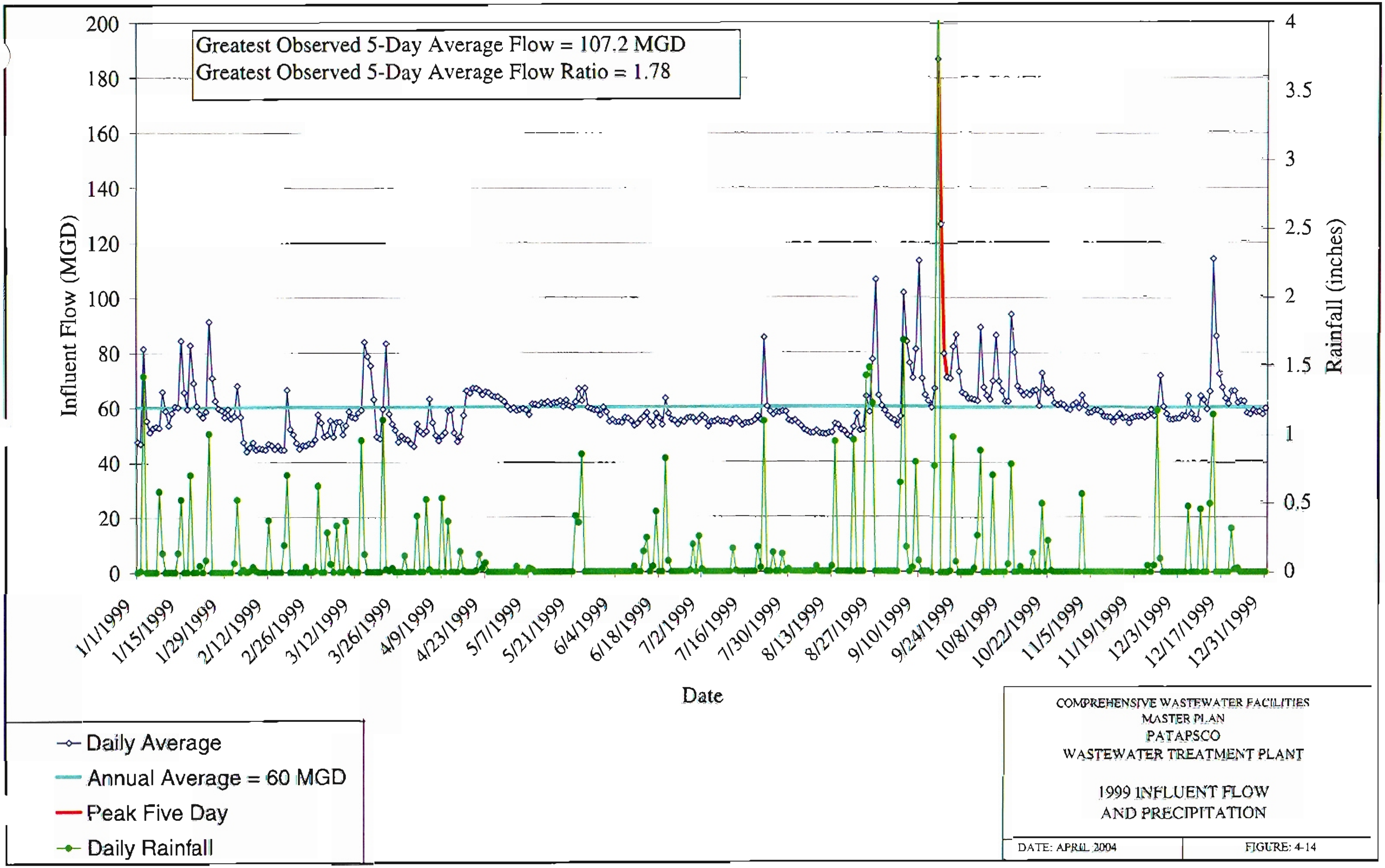
Whitman, Requardt and Associates, LLP
H:70317/Plant Data/Patapsco/5Day Average Verification.xls/1997 Chart



COMPREHENSIVE WASTEWATER FACILITIES
MASTER PLAN
PATAPSCO
WASTEWATER TREATMENT PLANT

1998 INFLUENT FLOW
AND PRECIPITATION

DATE: APRIL 2004 | FIGURE: 4-13

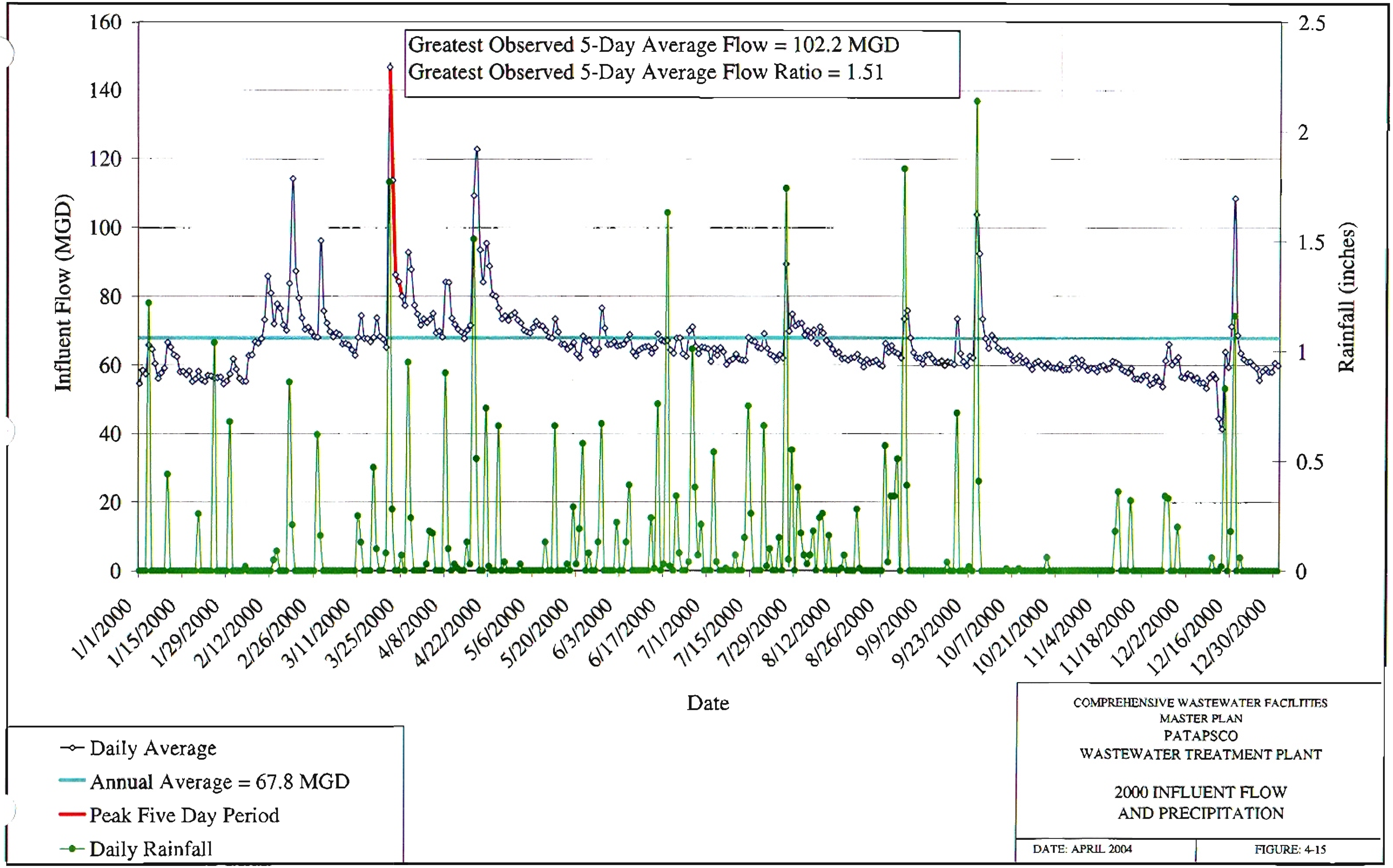


COMPREHENSIVE WASTEWATER FACILITIES
MASTER PLAN
PATAPSCO
WASTEWATER TREATMENT PLANT

1999 INFLUENT FLOW
AND PRECIPITATION

DATE: APRIL 2004	FIGURE: 4-14

Whitman, Requardt and Associates, LLP
H:70317/Plant Data/Patapsco/5Day Average Verification.xls/1999 Chart

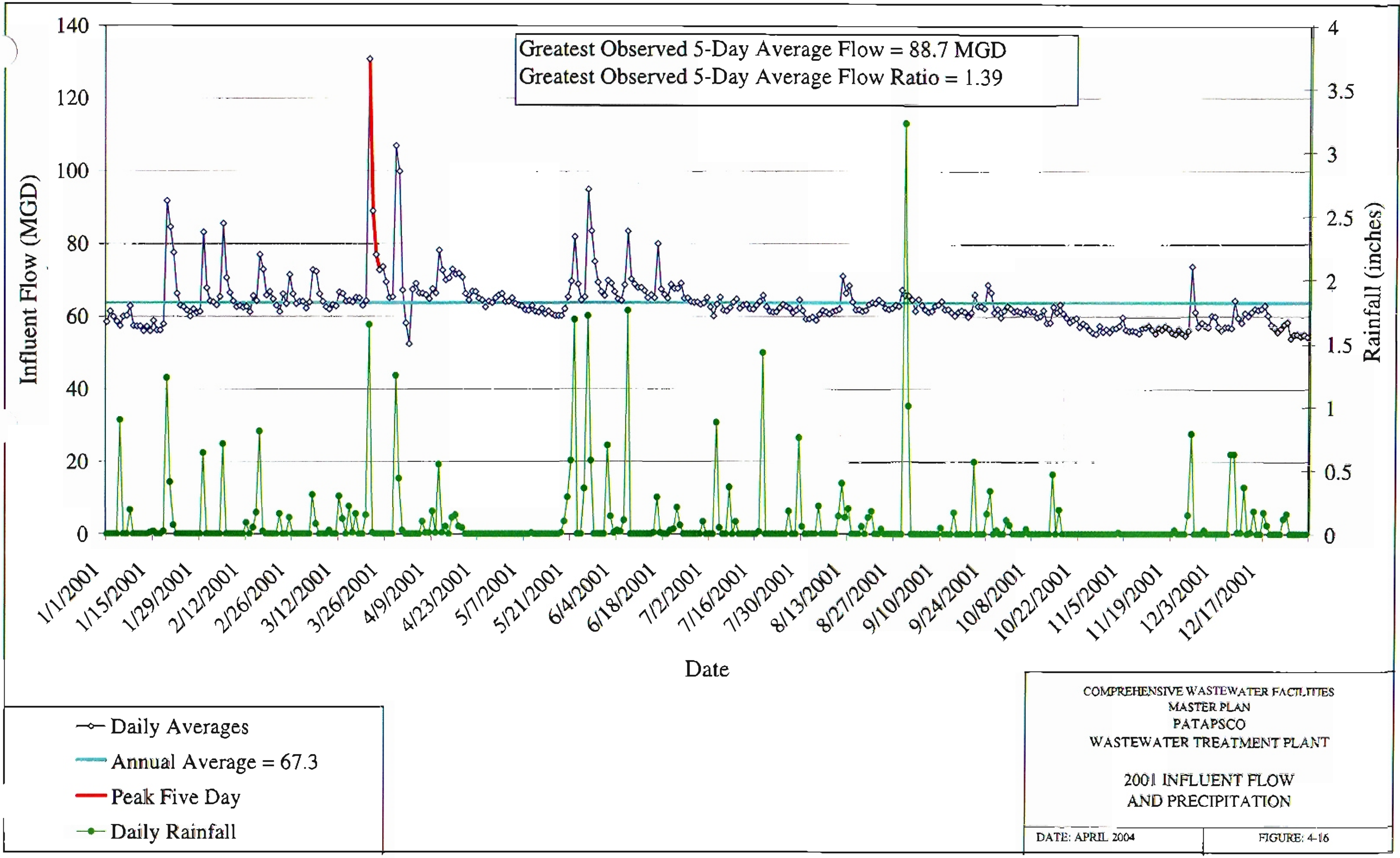


COMPREHENSIVE WASTEWATER FACILITIES MASTER PLAN
PATAPSCO WASTEWATER TREATMENT PLANT

2000 INFLUENT FLOW AND PRECIPITATION

DATE: APRIL 2004 | FIGURE: 4-15

Whitman, Requardt and Associates, LLP
H:70317/Plant Data/Patapsco/5Day Average Verification.xls/2000 Chart

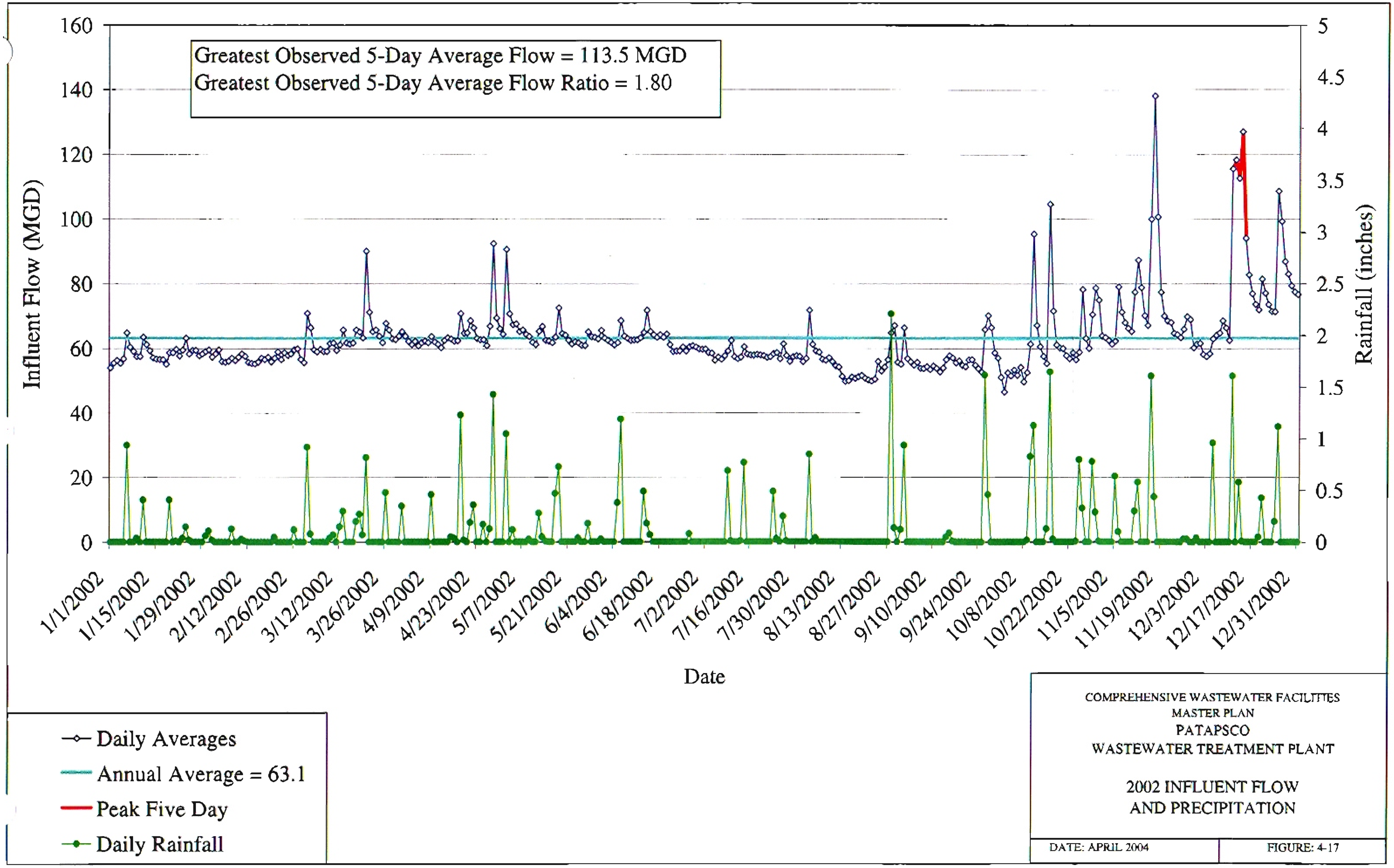


COMPREHENSIVE WASTEWATER FACILITIES MASTER PLAN
PATAPSCO WASTEWATER TREATMENT PLANT

2001 INFLUENT FLOW AND PRECIPITATION

DATE: APRIL 2004 | FIGURE: 4-16

Whitman, Requardt and Associates, LLP
H:70317/Plant Data/Patapsco/5Day Average Verification.xls/2001 Chart

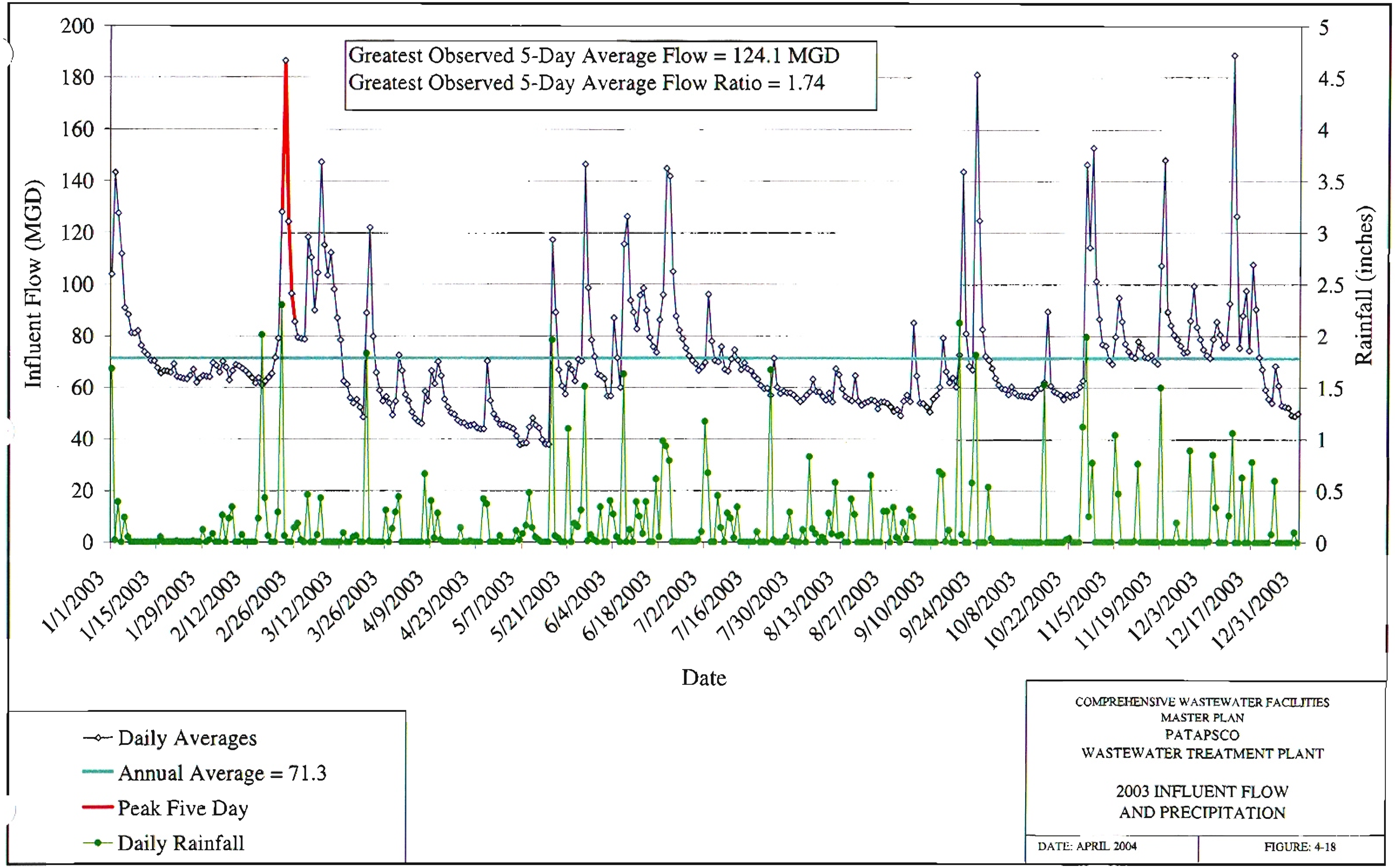


COMPREHENSIVE WASTEWATER FACILITIES
MASTER PLAN
PATAPSCO
WASTEWATER TREATMENT PLANT

2002 INFLUENT FLOW
AND PRECIPITATION

DATE: APRIL 2004	FIGURE: 4-17

Whitman, Requardt and Associates, LLP
H:70317/Plant Data/Patapsco/5Day Average Verification.xls/2002 Chart



COMPREHENSIVE WASTEWATER FACILITIES
MASTER PLAN
PATAPSCO
WASTEWATER TREATMENT PLANT

2003 INFLUENT FLOW
AND PRECIPITATION

DATE: APRIL 2004 | FIGURE: 4-18

Whitman, Requardt and Associates, LLP
H:70317/Plant Data/Patapsco/5Day Average Verification.xls/2003 Chart

4.2.3. Toxicity Evaluations

In accordance with the discharge permits, the City has conducted the required Whole Effluent Toxicity (WET) tests for both plants.

Reported results of the four quarterly tests for chronic WET conducted on the effluent from the Back River Plant indicated that the effluent was neither acutely nor chronically toxic based on standard tests. MDE has issued a letter indicating that the City has satisfied toxicity testing requirements. A copy of the letter is contained in Appendix XII.

At Patapsco, prior to 1997, testing indicated apparent toxicity in the effluent. The City conducted a Toxicity Reduction Evaluation (TRE). In May 1997, the effluent from the plant ceased to be acutely toxic. Further testing for chronic WET also showed the effluent to be not chronically toxic. As a result, MDE considered the TRE closed and discontinued the requirement for WET testing, and issued a letter to that effect. When the Patapsco permit is renewed, WET testing will again be required. A copy of the MDE letter is included in Appendix XIII.

4.3. CONVEYANCE SYSTEM

The main sewersheds for the Back River and Patapsco Wastewater Treatment Plants are Jones Falls, Gwynns Falls, Gwynns Run and Herring Run. Other sewersheds include: a portion of the High Level sewershed, Stemmers Run and Middle River. These sewersheds are shown on the System Maps for Back River and Patapsco, Figures 2-1 and 2-2. Several draft reports were prepared for these areas by other consultants, and are inserted in the Appendix. Final reports are not available.

The Jones Falls sewershed is located in the Back River system. Flow drains by gravity to the Jones Falls pumping station main outfall. This area was previously evaluated by other consultants. The cover sheet, table of contents, executive summary and conclusions/results for the following studies are contained in Appendix VIII:

- SC 639 – Flow Monitoring and Hydraulic Modeling Report
- SC 639 – Phase 2, Flow Monitoring and Hydraulic Modeling Report
- SC 8510 – Force Main and Pressure Sewer Study

The Gwynns Run sewershed and a portion of the High Level sewershed are located in the Back River system. Wastewater flows by gravity through the high level interceptor where it is conveyed to the main outfall. This area was evaluated in a report by another consultant. Refer to Appendix IX for the cover sheet, table of contents, executive summary, conclusions and results for the following report:

- Project No. 721 – Final Flow Monitoring Report

The Herring Run sewershed is located in the Back River system. This flow drains by gravity to the main outfall. This area was evaluated in a report by another consultant. Refer to Appendix X for the cover sheet, table of contents, executive summary and conclusions/results for the following report:

- SC 635 – Flow Monitoring Report

Gwynns Falls is located in the Patapsco service areas. The flow through the Gywnns Falls conveyance system drains by gravity to the Patapsco system. Some flow can be diverted at Baltimore Street to the Back River WWTP. The gate at Baltimore Street is slightly open to allow a portion of the flow to go to the Back River system. Approximately 3 mgd is conveyed to Back River. This area was evaluated in two reports by other consultants. Refer to Appendix XI for the cover sheet, table of contents, executive summary, conclusions and results for the following reports:

- SC 8509 – Infiltration/Inflow (I/I) Report
- Sanitary Sewer Evaluation Study

A network of pumping stations aid in the conveyance of wastewater to the two treatment plants. An inspection was conducted on the pumping stations that were not currently under contract for rehabilitation and the findings of this inspection are located in Appendix XVI. Table 4-9 summarizes the findings found in this inspection report and identifies any contracts that have since been added to rehabilitate the pumping stations inspected.

4.4. TREATMENT FACILITIES

4.4.1. Back River Wastewater Treatment Plant

4.4.1.1. Introduction

The Back River Wastewater Treatment Plant, a 180 mgd advanced wastewater treatment facility, owned and operated by Baltimore City, is located in Baltimore County. It occupies a 466-acre tract approximately two miles east of the Baltimore City line, on south side of Eastern Boulevard (Maryland Route 150) and has 35-foot elevation between the influent and outfall, allowing wastewater to flow through the plant by gravity. Hydraulically, the plant can handle peak flows up to 449 mgd. It adjoins the Back River estuary on the northeast, the Baltimore Beltway (I-695) on the west and south, and Norris Farm Landfill, a privately owned (closed) sanitary landfill, on the southeast.

Most wastewater flow arrives at the plant by gravity. However, force mains from six major Baltimore County pumping stations discharge into the Main Outfall on the Back River Plant property.

The original Back River Plant was constructed beginning in 1907, and was placed in operation in 1911 to serve the Baltimore City population of 600,000. The plant initially provided primary level treatment, sludge digesters and drying beds. Later, the plant was upgraded to include trickling filter secondary treatment. Activated Sludge Plant No. 1 was added and later expanded to increase plant capacity to 180 mgd. In 1988,

TABLE 4-9

MISCELLANEOUS CITY OF BALTIMORE PUMPING STATIONS

SUMMARY OF INSPECTIONS

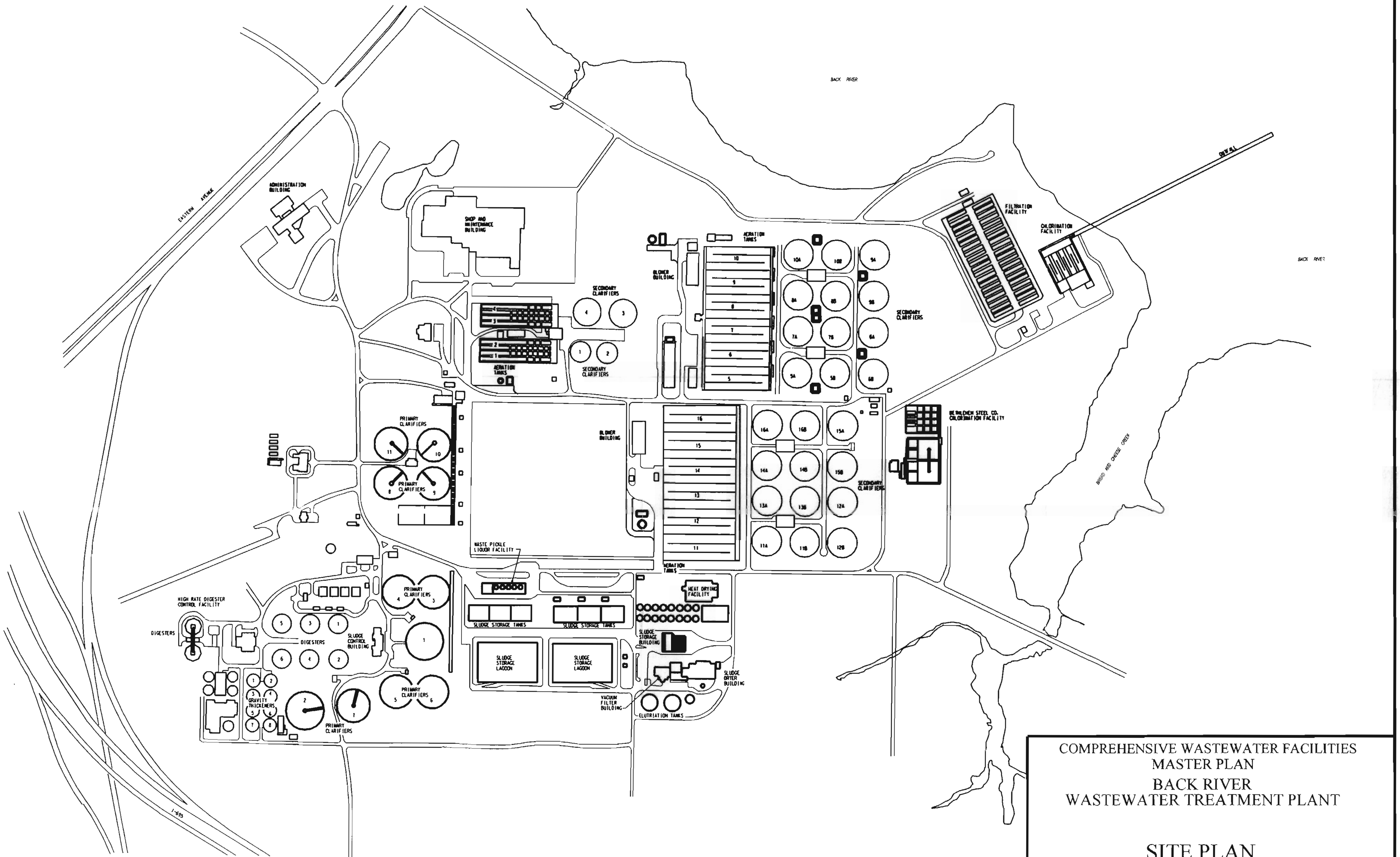
Pumping Station	Improvments Required	Improvments in Progress	Sanitary Contract No. / Project No.	Remarks
Eastern Avenue Sewage P.S.	Y	Y	Proj. No. 878	Currently in scope development with City
Locust Point Sewage P.S.	Y	N	*	Poor site grading and paving, Cone Valves in poor condition, motors need replaced
McComas Sewage P.S.	N	N		Good condition
Westport Sewage P.S.	Y	N	*	Mechanical Screen will require replacement during planning period
Charles Center Stormwater P.S.	N	N		Good condition
Colgate Stormwater P.S.	Y	N		MCC in poor condition, New pumps and motors will be required during planning period, station lighting in poor condition
Highlandtown Stormwater P.S.	Y	N		New transformer required; exposed wiring; doors, windows and walls are in poor condition, new paving required, groundwater intrusion evident, new pumps, motors and ventilation system required

* Pumping Stations currently under contract. Awaiting Contract Number from City

Activated Sludge Plant No. 2 went on-line and shortly after, the Trickling Filters were taken out of service. The combined capacity of Plants Nos. 1 and 2 was 180 mgd. During calendar year 1995, the plant treated an average flow of 183 million gallons per day and served an estimated population of 976,600 persons in Baltimore City and Baltimore County. In 1998, Activated Sludge Plant No. 3 became operational and later on Activated Sludge Plant No. 1 was taken out of service. The combined design capacity of Plant Nos. 2 and 3 is 180 mgd. During calendar year 2002, the average flow to Back River has decreased to 137 million gallons day, even though population remained essentially unchanged.

A Site Plan of the Back River Plant showing major facilities is presented in Figure 4-19. The major liquid train components are preliminary, primary, and secondary treatment units which include mechanically cleaned screens, grit removal units, primary settling tanks, activated sludge units, and final clarifiers. Sand filtration provides further suspended solids removal. Chlorination and dechlorination facilities provide disinfection of the treated wastewater prior to discharge into Back River. On site sludge handling facilities include gravity sludge thickeners, dissolved air floatation thickeners, gravity belt thickeners, conventional high rate anaerobic digesters, and egg-shaped digesters. The facilities treat primary and waste activated sludge. The digested sludge is dewatered and disposed by one of three methods, dewatering and heat drying by privatization contract, City dewatering and off-site composting by privatization contract, and City dewatering and contract hauling for land application. The digesters produce methane gas, which supplies fuel for the anaerobic digestion process and to heat the plant. A schematic illustrating the process flow of the liquid and solid portions of the wastewater is presented in Figure 4-20.

A summary of each facility at Back River Wastewater Treatment Plant is presented in the following sections. Wastewater treatment is discussed in Section 4.4.1.2 and solids treatment and handling in Section 4.4.1.3. The descriptions of the facilities include operation, performance, and condition and are based on City sanitary contracts (SC),



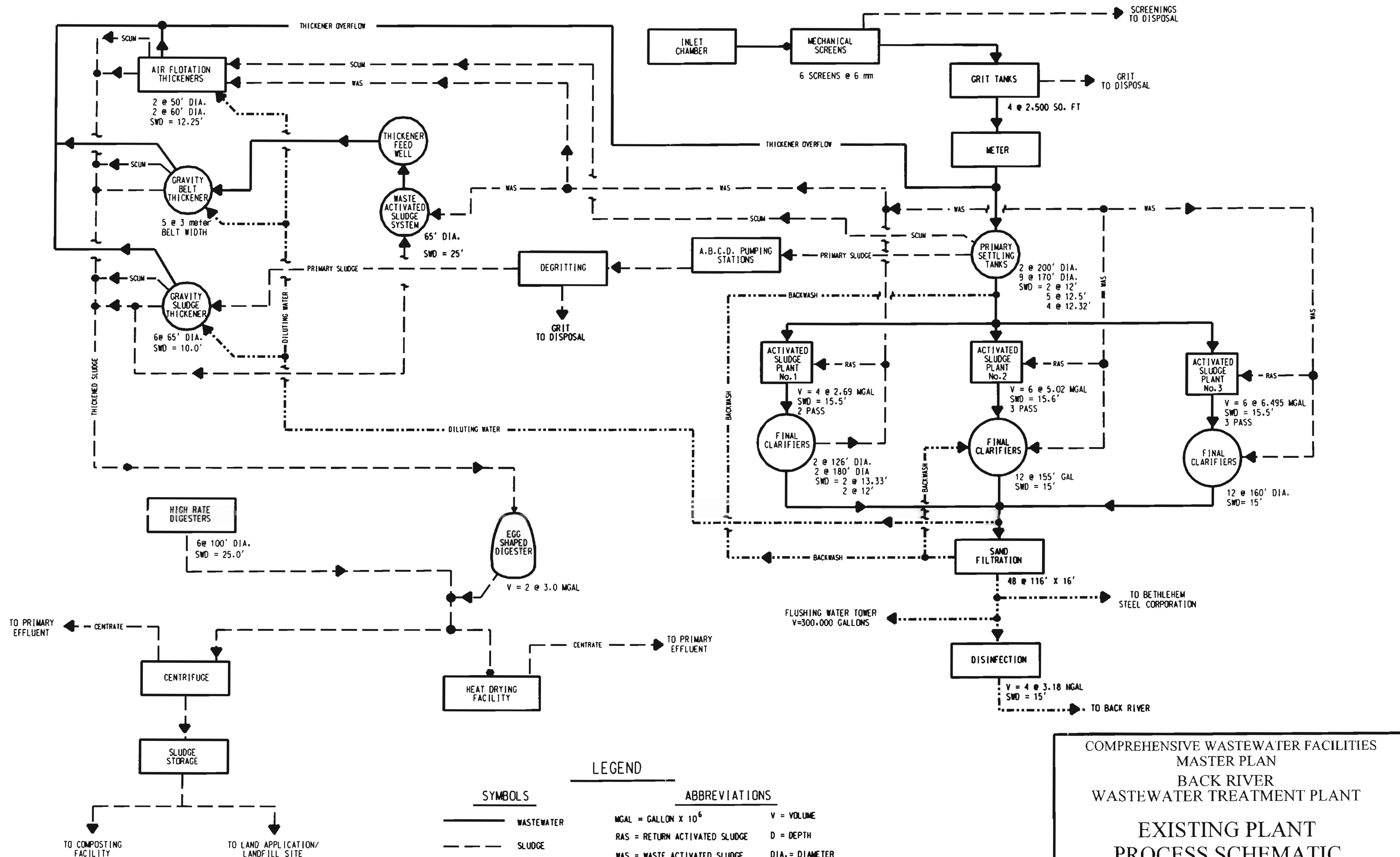
COMPREHENSIVE WASTEWATER FACILITIES MASTER PLAN

BACK RIVER WASTEWATER TREATMENT PLANT

SITE PLAN

WHITMAN, REQUARDT AND ASSOCIATES, LLP

DATE: APRIL 2004	SCALE: 1'= 500'	FIGURE: 4-19



LEGEND

SYMBOLS

- WASTEWATER (solid line)
- SLUDGE (dashed line)
- PROCESS WATER (dash-dot line)

ABBREVIATIONS

MGAL = GALLON X 10^6
RAS = RETURN ACTIVATED SLUDGE
WAS = WASTE ACTIVATED SLUDGE
SWD = SIDE WATER DEPTH
V = VOLUME
D = DEPTH
DIA. = DIAMETER

COMPREHENSIVE WASTEWATER FACILITIES MASTER PLAN

BACK RIVER WASTEWATER TREATMENT PLANT

EXISTING PLANT PROCESS SCHEMATIC

DATE: APRIL 2004 | SCALE: NONE | FIGURE: 4-20

WHITMAN, REQUARDT AND ASSOCIATES, LLP

specifications, Back River Wastewater Treatment Plant Monthly Operations Report, inspection reports and discussions with Plant Operations.

4.4.1.2. Description of Existing Liquid Treatment Facilities

Raw wastewater flows through the Main Outfall, into the plant to an inlet chamber. From the inlet chamber, the wastewater flows through mechanically cleaned screens for removal of submerged and floating debris and then through grit chambers where the heavier grit particles are settled out of the wastewater. The wastewater is conveyed to primary settling tanks where suspended material is separated from the waste flow by sedimentation. Clarified primary effluent passes over the primary settling tank weirs and is conveyed through a channel, where waste pickle liquor is added for phosphorus removal. The head chamber controls the rate of flows to Plant No. 1 through a 60-inch diameter pipeline and the flows to the activated Plants Nos. 2 and 3 through a 132-inch diameter conduit. Flow is then further split to Plants Nos. 2 and 3. Primary effluent is combined with recycle flow from: the gravity sludge thickeners, dissolved air flotation thickeners, City dewatering facility, and the privatized heat drying (pelletizing) facility, prior to entering the head of the activated sludge plants.

Currently, Plant No. 1 is not in operation. Plants Nos. 2 and 3 operate in the Modified Ludzack-Ettinger (MLE) mode to remove BOD_5, nitrogen, phosphorous and suspended solids. Waste activated sludge (WAS) is pumped to the solids processing facilities.

The final clarifier effluent is conveyed to sand filter facility for further suspended solids and phosphorous removal. The filtered wastewater flows via gravity into the metering vault where it is split into two streams, one portion flowing to Bethlehem Steel pumping station, while the remaining effluent flows through the chlorine contact tanks and over the five-step post aeration cascade and then to the outfall to Back River.

The National Pollutant Discharge Elimination System (NPDES) permit sets monthly average loads to Back River and to Bethlehem Steel. Table 4-10 summarizes the

TABLE 4-10

BACK RIVER WASTEWATER TREATMENT PLANT

PERMIT REQUIREMENTS AND PLANT PERFORMANCE

Parameters	Annual Average Performance To Back River (BR)							Annual Average Performance To Bethlehem Steel (BS)						
	Permit*	1998	1999	2000	2001	2002	2003	Permit*	1998	1999	2000	2001	2002	2003
Effluent Flow (MGD)	130	80	82	86	93	95	138	100	76	75	67	51	51	48
Monthly Avg BOD$_5$ (lbs/day)	11000	2469	3009	3228	3102	3090	1266	17000,25000**	2092	2252	2067	1233	1361	1321
Monthly Avg SS (lbs/day)	11000	2135	2325	2223	1551	1608	1957	25000	1648	1564	1397	766	893	881
Monthly Avg TP (lbs/day)	220	107	116	122	101	103	161	1700	95	100	89	51	60	60
Monthly Avg Ammonia Nitrogen (lbs/day)***	2200	1001	205	186	271	261	276	1700	1014	231	117	119	128	84
Monthly Avg BOD$_5$ (mg/l)	10	3.7	4.4	4.5	4.0	3.9	1.1	20,30**	3.3	3.6	3.7	2.9	3.2	3.3
Monthly Avg SS (mg/l)	10	3.2	3.4	3.1	2.0	2.0	1.7	30	2.6	2.5	2.5	1.8	2.1	2.2
Monthly Avg TP (mg/l)	0.2	0.16	0.17	0.17	0.13	0.13	0.14	2	0.15	0.16	0.16	0.12	0.14	0.15
Monthly Avg Ammonia Nitrogen (mg/l)***	2	1.5	0.30	0.26	0.35	0.33	0.24	2	1.6	0.37	0.21	0.28	0.3	0.21

* Monthly Average, expires 9/30/01

** 5/01-10/31, 11/01-4/30

***05/01 - 10/31

annual average loadings and concentrations to Back River and Bethlehem Steel over a six-year period (1998-2003) and permit limitations.

4.4.1.2.1. Preliminary Treatment

4.4.1.2.1.1. Mechanical Screens

Wastewater flows by gravity through the inlet chamber to a set of mechanical screens. The screens provide removal of submerged and floatable fine debris. Under SC 707, the Back River WWTP is equipped with six mechanically self cleaning 6-millimeter screens, rated at 30 mgd each.

The 4-ft wide screens are installed in pairs in a 10-ft wide channel. These channels are part of the original screen facility. Each pair of screens, although separate, operates in parallel. Influent and effluent slide gates have been installed to isolate the screen channels. The screens are designed with the following criteria:

Average flow per screen	30 mgd
Maximum flow per screen	75 mgd
Maximum water depth	13 feet
Maximum headloss through screen	18 inches

Air diffusers are located in each screen channel to minimize settling of solids on the screen. A system for monitoring headloss across the screen consists of bubble tube sensor on the upstream and downstream sides of screen.

The screenings are scraped from each screen and fall onto a conveyor which moves the material to a compactor for the reduction of water content before disposal. Two compactors are installed at the end of the belt conveyor with only one operating at a time. The compactor is designed to handle 60-cubic feet of wet screenings per hour, producing a dry solids content of not less than 40%.

The conveyor, with a belt width of 24 inches operates continuously at a design capacity of 0.75 tons of screenings per hour. A gas monitoring system with a built in alarm system detects for the presence of combustible gases (lower explosive limit), hydrogen sulfide, and oxygen.

Operational and performance data from calendar years 1998-2003 indicate that the volume of screenings removed averaged 0.85 cubic feet per million gallons of wastewater (ft^3/Mgal). This average is based on a typical screen density of 55 pounds per cubic ft[1]. This average is less than the design criteria of 2.5 ft^3/Mgal which is an indication that the facilities are adequate. Table 4-11 summarizes data collected from 1998-2003. The total average monthly pounds of screenings disposed and the quantity of screenings per million gallon of wastewater treated is shown. The six-year average is 47 lbs/Mgal.

Rehabilitation of the screens and gas detection system were both recommended in the inspection report dated 1998 shown in Appendix XIV. The odor control facility for screens and head chamber will also require rehabilitation within the planning period. The instrumentation and process mechanical equipment were found to be in relatively poor condition in this inspection and will therefore require rehabilitation within the planning period. Based on more recent inspections conducted in 2002, it was noted that replacement of Screens Nos. 1, 2 and 4 would be necessary in the near future and that operation of compactors was very labor intensive and will require rehabilitation within the planning period.

[1] Metcalf & Eddy, Inc.: *Wastewater Engineering Treatment, Disposal and Reuse*, 3rd Ed., McGraw Hill, New York, 1991.

TABLE 4-11
BACK RIVER WASTEWATER TREATMENT PLANT
SCREEN PRODUCTION

Year	Mechanical Screenings (lbs/day)					
	1998	1999	2000	2001	2002	2003
January	5048	7736	6821	9387	6378	8748
February	5490	3499	8079	8622	5267	7016
March	4041	6754	5616	10816	7154	9768
April	4467	13528	4253	8344	7941	8342
May	8085	4826	6299	10219	5994	9493
June	4943	9218	4482	8336	5208	4693
July	16924	7376	5027	7692	5896	4431
August	7489	7255	7056	7640	7343	4274
September	6869	5085	8147	6766	6833	5787
October	10019	4000	7228	5963	8184	6145
November	7905	5133	8891	6855	6185	3761
December	8987	4417	8189	5558	9694	5339
Avg	7522	6569	6674	8016.5	6840	6483
Max	16924	13528	8891	10816	9694	9768
lbs/Mgal of wastewater	49	45	44	57	50	36

4.4.1.2.1.2. Grit Tanks

The screened wastewater passes through a conduit to an influent chamber upstream of the grit tanks. The junction chamber divides the flow into two branches, one branch directs wastewater to the three older Grit Tanks (Nos. 1-3), while the other branch directs flow into Grit Tank No. 4.

These units are designed to remove 65 mesh (0.2 mm) and larger grit at a design flow rate of 45.5 mgd each. The 2,500 sq. ft. grit tanks are located outdoors with one of the units typically used as a standby. Each chamber is equipped with a peripheral grit collection mechanism that includes a screw conveyor. The conveyor moves the grit up an inclined channel to a conveyor belt. The grit is then transported to a dumpster located in the grit container building for disposal.

The existing grit removal facilities, designed under SC 636, are capable of handling 7,020 pounds per day (lbs/day) of grit at 195 mgd (36 lbs/Mgal) and 39,579 lbs/day at 457 mgd (87 lbs/Mgal). Six years (1998-2003) of grit removal operating data are shown in Table 4-12. At the time this plan was written, the grit removal facility was undergoing rehabilitation. At that time, some of the flow was diverted around the facility. Subsequently, the average grit production declined from 28.8 lbs/Mgal of wastewater in 1998 to 6.75 lbs/Mgal of wastewater in 2001. It should be noted that these values are both below the design average grit production of 36 lbs/Mgal, indicating excess capacity remains.

Due to the rehabilitation of the grit removal facility under SC 9535, inspections of this facility were not conducted. Because the rehabilitation of this facility was finished in 2002, it is not expected that any rehabilitation will be necessary during the planning period.

TABLE 4-12

BACK RIVER WASTEWATER TREATMENT PLANT

GRIT CHAMBER SOLIDS PRODUCTION

	Average Daily Solids Production (lbs/day)					
Year	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**
January	354	904	721	978	1486	3408
February	3150	124	1403	1031	1092	2979
March	2024	na	2048	2049	2099	2242
April	3604	400	1628	2114	2877	1154
May	15754	861	1045	1008	1582	583
June	9157	1407	1099	101	3023	1373
July	6770	2679	1017	208	1629	1295
August	1199	2968	1795	631	3603	3622
September	1006	2226	1501	350	4719	2734
October	1165	7707	2045	391	4039	3632
November	5861	1867	1763	799	4592	2347
December	2534	4477	1829	1684	6412	4997
Average	4382	2329	1491	945	3096	2531
Max	15754	7707	2048	2114	6412	4997
lbs/Mgal	29	16	10	7	23	14

na: not available

4.4.1.2.2. Primary Treatment

4.4.1.2.2.1. Primary Settling Tanks

Degritted wastewater is distributed to the eleven circular primary settling tanks (PST). PSTs Nos. 1 and 2 are each 200-ft and the other nine PSTs (Nos. 3-11) are each 170-feet in diameter. Each PST is the center feed type, with sludge scraped to the center where it is drawn off through a suction pipe. The scum is skimmed from the water surface to a collection trough, where it is pumped to the solids handling facilities. Since August of 2000, PST Nos. 1 or 2 has remained as a standby while the other ten clarifiers remain in continuous operation.

The PSTs were designed for a combined average flow capacity of 188.5-mgd with an overflow rate of 800 gallon per day per square foot (gpd/sq. ft.), when Tank No. 1 or 2 is on standby. Due to low flow conditions in calendar year 2000 and 2001, overflow rates were less than 800 gpd/ft^2. In calendar year 2003, the overflow rates were higher than 800 gpd/ft^2, annual average of 900 gpd/ft^2.

Based on the 1998 inspection (Appendix XIV), improvements in the flow distribution and scum collection will be required in the near future.

4.4.1.2.3. Secondary Treatment (BNR)

Secondary treatment at the Back River WWTP consists of three activated sludge plants (Plant Nos. 1, 2, and 3). Currently, Plants Nos. 2 and 3 are in operation. The principal purpose of the activated sludge plants is the reduction of nitrogen, phosphorus and suspended solids. The activated sludge plants operate in the Modified Ludzack-Ettinger (MLE) process and include aeration basins with internal recycle pumping stations, final clarifiers, sludge pumping stations, and blower buildings. Primary effluent is distributed to the aeration basins. Each basin is divided into oxic/aerobic and anoxic zones. Oxidation of organic compounds and TKN (organic nitrogen + ammonia-nitrogen) to carbon dioxide and nitrates, respectively, occur in oxic/aerobic zones. Anoxic zones reduce the nitrates to nitrogen gas. The aeration basin effluent flows to final clarifiers for separation of biological solids and liquid. The solids are withdrawn by the sludge pumping stations. Return activated sludge (RAS) pumps direct settled sludge to the head of each aeration basin. Waste activated sludge (WAS) pumps discharge sludge to the solids handling facilities.

4.4.1.2.3.1. Activated Sludge Plant No. 1

Activated Sludge Plant No. 1 is comprised of four aeration basins, four final clarifiers, pipe galleries and a blower building. The original plant was constructed under SC 323 and expanded under SC 545. Based on the Back River Monthly Operations Report, the plant has not been in operation since August 1999.

Under SC 709, the plant was upgraded for testing various single sludge biological nitrogen removal processes. Each basin was divided into thirteen zones which includes ten anoxic, two oxic and one reaeration zones (Nos. 1- 8, 11 and 12 as first- and second-stage anoxic, Nos. 9-10 as first-stage oxic zone, and No. 13 as reaeration zone). A recent contract, SC 798, was awarded to renovate the blower building to serve the future aeration requirements.

The future process function of Plant No. 1 was evaluated during the drafting of this plan. Several alternatives that incorporate the use of Plant No. 1 are discussed in the Chapter 6. Regardless of use, rehabilitation will be required for the plant to be fully functional. Improvements and replacements, such as structural, mechanical, and electrical, are discussed in 1998 inspection report (Appendix XIV).

4.4.1.2.3.2. Activated Sludge Plant No. 2

Activated Sludge Plant No. 2 was constructed to provide secondary activated sludge treatment under SC 657. The plant was upgraded to BNR as an MLE process under SC 749. The plant includes six aeration basins, six internal recycle pumping stations, twelve final clarifiers, two sludge pumping stations and blower building.

Each basin is a three-pass plug flow reactor with anoxic and oxic zones having a length of 350 feet and side water depth of 15.6 feet. The basins have switch zones where either anoxic or oxic conditions can be provided. Thirteen submersible mixers maintain microbial suspension in the anoxic and anoxic/oxic switch zones.

The internal recycle pumping stations each consist of submersible pumps positioned in a wet well located at the end of each basin. The recycle pumps send nitrate rich mixed liquor produced from the oxic zone back to the anoxic zones at the head of each basin for nitrogen reduction. The submersible pumps are centrifugal type with VFD controlled flow rate.

Twelve final clarifiers, each 155 feet in diameter, separate the biological solids from the liquid. The units are equipped with hydraulic header type sludge collectors. In calendar year 2003, the average overflow rate of 394 gpd/ft^2 was close to design average of 360 gpd/ft^2. Solids loading rate was 30% less than the design rate of 18.7 pounds per square foot per day (lbs/ft^2/day).

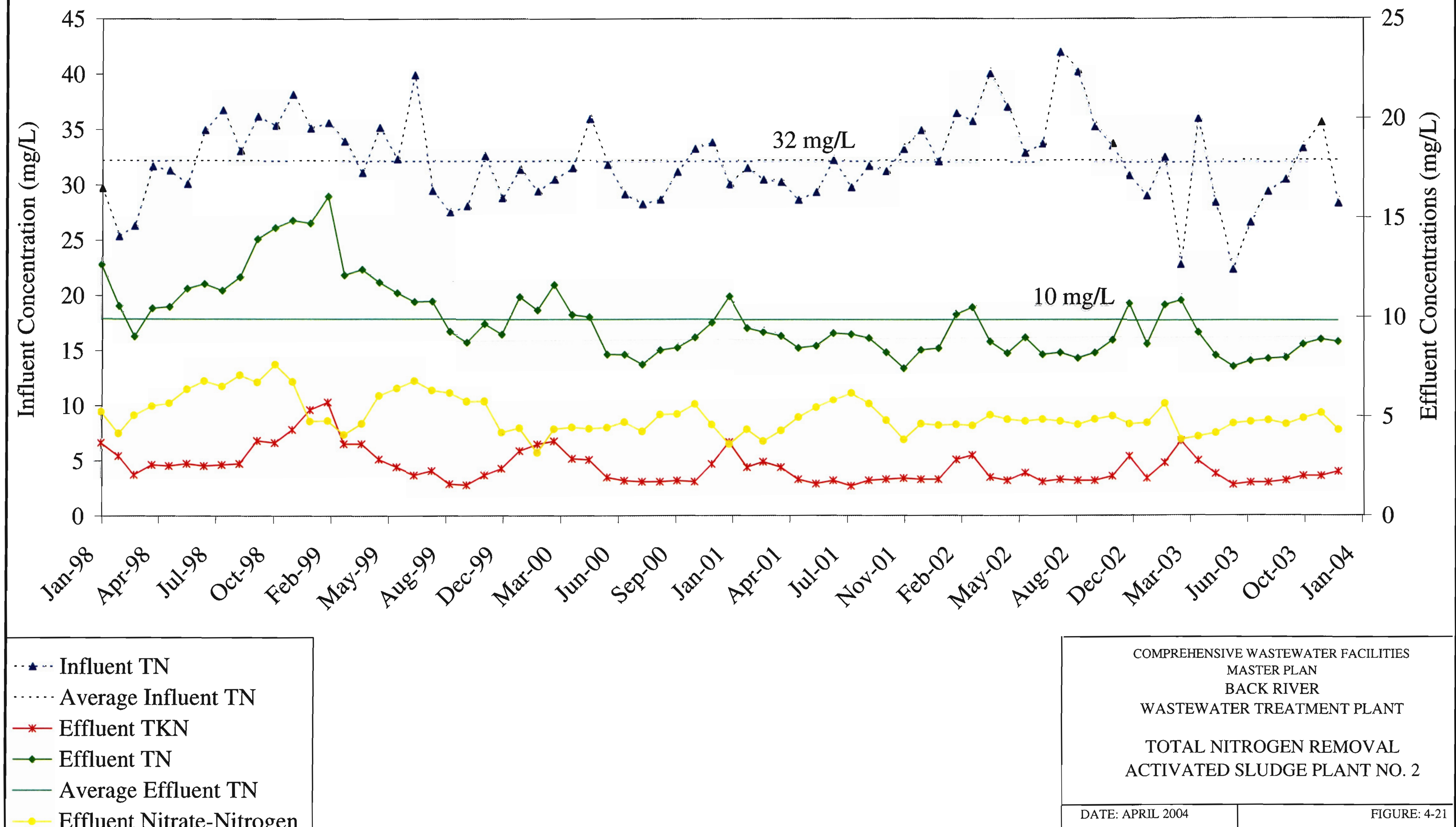
Sludge is withdrawn by direct pipe connection from each final clarifier to the two pumping stations, where the return activated sludge (RAS) pumps and waste activated sludge (WAS) pumps are located. Two sludge pumping stations (Nos. 1 and 2) serve all twelve secondary clarifiers (Nos. 5A-10B). Each pumping station has RAS pumps (6 operating and 3 standby) and four WAS pumps (3 operating and 1 standby). The return and waste activated sludge pumps are centrifugal type pumps with variable speed drives.

Five blowers, 1500 HP each, located in the Blower Building provide air to Basin Nos. 5-10. Air is supplied through coarse bubble diffusers, flexible membrane and ceramic diffusers located in the basins. Coarse bubble diffusers exist in pre-anoxic zones 1 and 2 and reaeration zone. Flexible membrane diffusers exist in reaeration and switch zones. Oxic and reaeration zones Nos. 13-16 are equipped with ceramic diffuser.

Plant No. 2 has been operating below the design capacity of 75.5 mgd and below the overall design SRT of 15 days. In the summer of 2001 (April to October), the plant treated an average flow of 43 mgd at an SRT of 10.7 days. In the winter of 2001 (November 2001 to March 2002), the plant treated an average flow of 40 mgd at an SRT of 8.9 days.

Figure 4-21 illustrates total nitrogen, TKN and nitrate-nitrogen removal in Plant No. 2. In the summer and winter months of 2001, the plant removed an average of 73% TN, 96% TKN, 95% BOD and 95% TP (total phosphorus). The plant has been achieving effluent TN of 8 mg/l, TKN of 3.3 mg/l (as low as 3 mg/l in summer 2001), BOD of 6 mg/L, and TP of 0.18 mg/l.

According to the 1998 inspection report, the structural components of Plant No. 2 are in good condition. Dewatering pumping stations, which includes RAS pumps discharge valves, pneumatic system, dewatering pump VFDs, and floor drainage systems require rehabilitation. Flow distribution to Plant No. 2 and Plant No. 3 needs improvement. The gates in the influent distribution box are operated manually to prevent excess flows to Plant No. 2. Internal recycle pumping stations require an increase in capacity and improved accessibility for maintenance. Other improvements and maintenance are summarized in Appendix XIV.



COMPREHENSIVE WASTEWATER FACILITIES
MASTER PLAN
BACK RIVER
WASTEWATER TREATMENT PLANT

TOTAL NITROGEN REMOVAL
ACTIVATED SLUDGE PLANT NO. 2

DATE: APRIL 2004	FIGURE: 4-21

4.4.1.2.3.3. Activated Sludge Plant No. 3

Activated Sludge Plant No. 3 became fully operational in May 1998. The plant includes six aeration basins, six internal recycle pumping stations, twelve final clarifiers, two sludge pumping stations and blower building.

The six aeration basins (Nos. 11-16) and twelve final clarifiers (Nos. 11A-16A, Nos. 11B-16B) were built under three different contracts. Final clarifier Nos. 16A and 16B were built under SC 721, aeration basin Nos. 14-16 and final clarifiers Nos. 14A and 14B under SC 722, and aeration basin Nos. 11-13 and final clarifier Nos. 12A, 12B, 13A and 13B under SC 728. Similar to Activated Sludge Plant No. 2, each reactor is a three-pass plug-flow basin with anoxic-oxic zones. Each reactor with pass length of 415 ft has side water depth of 15.5 ft. The reactors with anoxic and oxic zones are 23% larger than the reactors in Activated Sludge Plant No. 2. The basins have switch zones where anoxic and oxic conditions are interchangeable. Nine submersible mixers maintain microbial suspension in anoxic zones.

Each internal recycle pumping station consist of submersible pumps installed in a wet well located at the end of each basin. The recycle pumps send a portion of the wastewater, rich in nitrate, back to the head of the basin. The submersible pumps are centrifugal type and equipped with variable speed drives.

The basin effluent flows to twelve final clarifiers, each 160 ft in diameter and side water depth of 15 ft. The units are equipped with draft tube type hydraulic sludge collectors. In calendar year 2003, the average overflow rate was 30% higher than design average of 423 gpd/ft^2/day. Solids loading rate was close to the design value of 18.2 lbs/ft^2/day.

Sludge is withdrawn by direct pipe connection from each tank to the sludge pumping station, where return activated sludge pumps (RAS) and waste activated sludge pumps (WAS) are located. WAS is pumped to the solids handling facilities and the RAS is returned to the influent end of the aeration basins. Two sludge pumping stations (Nos. 3 and 4) serve the twelve secondary clarifiers. Each pumping station has nine RAS pumps (6 operating and 3 standbys) and six WAS pumps (3 operating and 3 standbys). The return and waste activated sludge pumps are centrifugal type with variable speed drives.

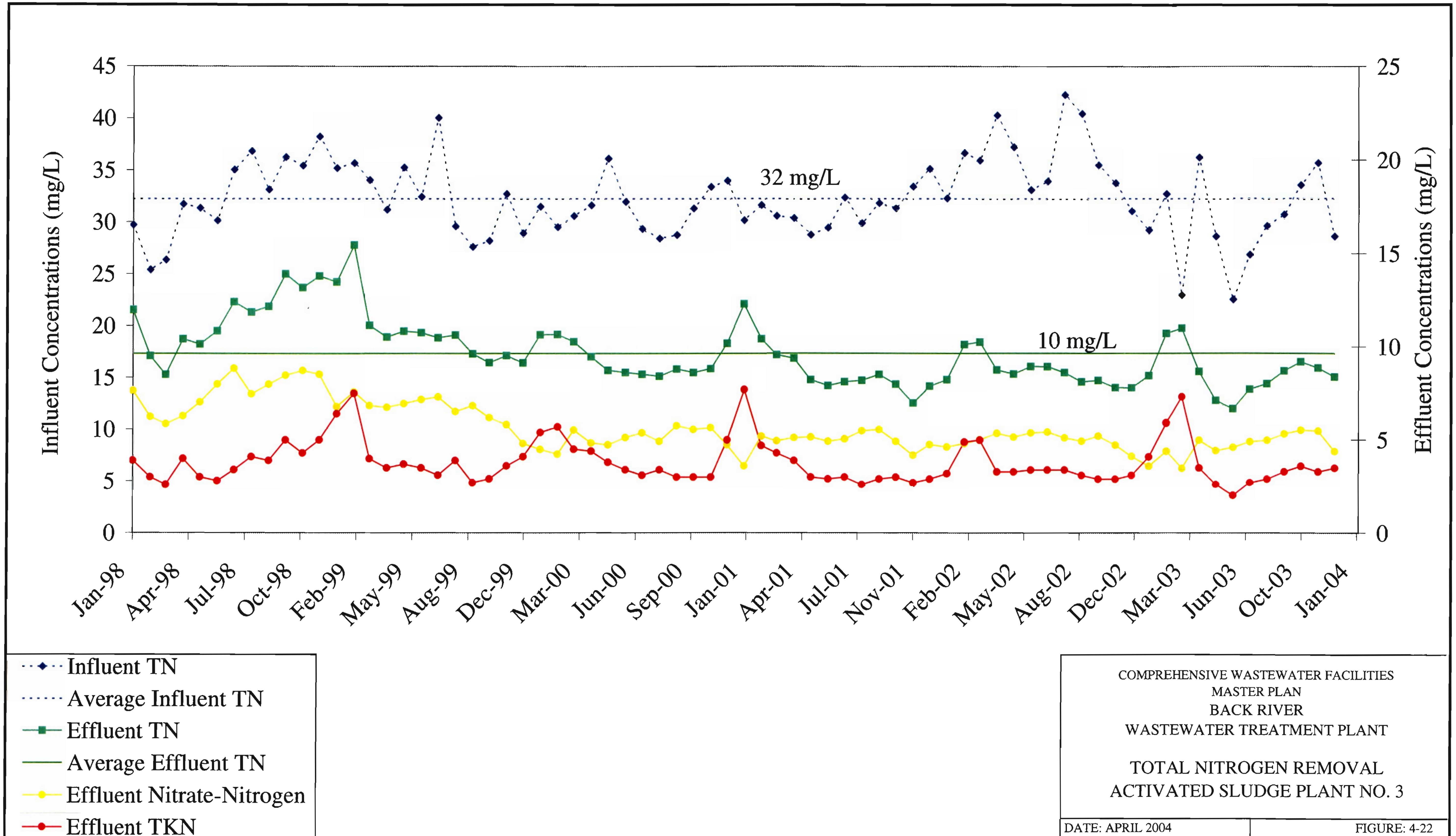
Five 1500 HP blowers, located in the Blower Building, provide air to Basin Nos. 11-16. Air to the reactors is supplied through coarse bubble diffusers and/or flexible membrane diffusers in the anoxic zones and ceramic diffusers in the oxic zones. Coarse bubble diffusers serve the anoxic/oxic switch zones and mixed liquor channel.

Plant No. 3 has been operating close to the design average of 98 mgd and below the overall design SRT of 14 days. In summer 2001, the plant treated an average flow of 107 mgd at an SRT of 8.1 days. In winter 2001, the plant treated an average flow of 101 mgd at an SRT of 6.6 days.

Figure 4-22 shows total nitrogen, TKN and nitrate-nitrogen removal in Plant No. 3. In the summer and winter months of 2001, Plant No. 3 removed an average of 74% TN, 90% TKN, 95% BOD and 95% TP. The plant has been achieving TN levels of 8.5 mg/l, TKN of 3.7 mg/l, BOD of 5 mg/l, and TP of 0.16 mg/l.

According to the 1998 inspection report, the mechanical and structural components of Plant No. 3 are in good condition. Other improvements and maintenance are summarized in Appendix XIV.

Based on the 2002 inspection, conducted with plant operations personnel, increase in the internal recycle capacity, easy accessibility to the internal recycle pumps and replacement of magmeters are recommended.



COMPREHENSIVE WASTEWATER FACILITIES
MASTER PLAN
BACK RIVER
WASTEWATER TREATMENT PLANT

TOTAL NITROGEN REMOVAL
ACTIVATED SLUDGE PLANT NO. 3

DATE: APRIL 2004	FIGURE: 4-22

4.4.1.2.4. Effluent Filtration

Final clarified effluent flows to the filters for further suspended solids removal. The dual media filtration system, built under SC 687, is equipped with travelling bridges for automatic backwashing (ABW) and 48 filters with a media depth of 11 inches. Each filter is compartmentalized into 116 cells each having a surface area of 16-sq.ft. The filters accommodate an average flow of 178 mgd and a maximum flow of 484 mgd resulting in filtration rates 1.5 gpm/sq. ft. and 3.9 gpm/sq. ft., respectively. The ABW operates at low headlosses of 6 to 10 inches of water.

During filtration, final clarifier effluent flows from the influent channel through ports onto the filter bed, downward through the filter media, and passes into the effluent channel through a port from each underdrain. The backwash mechanism is activated either by the predetermined head loss increase or by a preset time interval.

An automatic mechanism is used to backwash and clean individual compartments sequentially, while leaving the rest in service to continue filtering. Each filter, with a surface area of 1856 sq. ft., has a maximum backwash flow of 25 gpm/sq. ft. Seven (one standby) backwash pumps, with a capacity of 3840 gpm each, are located in the backwash return pumping station. Backwashing is initiated at a head loss increase of 2 to 6 inches over clean bed conditions. Once initiated, backwashing progresses from one end of the filter bed to the other. Backwashing typically occurs once every 2 to 6 hours and each cell is backwashed for 30 seconds. The backwash water can be returned to the head of Activated Plant No. 2, but typically is discharged to Clarifier No. 10A. Existing chlorinators in the disinfection system (SC 660) feed chlorine solution to filter influent channel to prevent any biological fouling in the media.

The filters are designed to produce an effluent with an average suspended solids concentration of 5 mg/l, and with average feed solids concentration of 20 mg/l. In calendar year 2003, the filters have been removing fewer solids from the final clarified effluent. Average feed solids concentrations of 7.5 mg/l to the filter produced effluent with suspended solids concentrations of 2.2 mg/l.

The outside structure of the filtration facility is in poor condition and requires rehabilitation. Other improvements such as algae growth control, rehabilitation of backwash return system and repairs to prevent media leakage are listed in Appendix XIV.

4.4.1.2.5. Disinfection Facilities

The disinfection (chlorination) system, built under SC 660, is the last stage of wastewater treatment. Filtered effluent is either chlorinated, provided with contact time, dechlorinated and then discharged to Back River or chlorinated and discharged to Bethlehem Steel for industrial water use and subsequent treatment and discharge to the Patapsco River. The total average design capacity for Back River and Bethlehem Steel disinfection is 170 mgd.

4.4.1.2.5.1. Chlorination/Dechlorination and Post Aeration

The chlorination/dechlorination facility is designed for an average flow of 70 mgd and peak flow of 280 mgd discharged to Back River. Four 90-ton tank cars store liquid chlorine and sulfur dioxide (two of each). Liquid chlorine passes through an evaporator, converting it to a gas. Gaseous chlorine mixes with the flushing water at the ejector forming a weak hypochlorous acid solution. Currently most chlorine for disinfection is applied upstream of the filters, although diffusers also exist in the mixing basins of the chlorine contact tanks. The portion of plant effluent that is pumped to Bethlehem Steel Corp. receives an additional chlorine application to aid in maintaining pipelines leading to the plant at Sparrows Point. Chlorine solution is also pumped to various chlorine application sites around the plant. Sulfur dioxide is similarly gasified in evaporators, mixed with flushing water to form a solution to be applied upstream of the post aeration cascade to dechlorinate the plant effluent.

After the filter effluent enters the chlorine-mixing basin, it flows through four three-pass contact basins. The length and width of each tank is 165 feet and 43 feet, respectively, with side water depth of 15 feet. Since contact time is critical (short-circuiting can occur and solids must remain suspension) the basin is designed for 65 minutes detention time at average flow of 70 mgd and 16 minutes at peak flow of 250 mgd. Scum is pumped to one of the Activated Sludge Plant No. 2 sludge pumping stations where it is added to the waste activated sludge line.

Secondary treatment and filtration are able to remove sufficient amounts of organic and suspended solids resulting in less chlorine demand in disinfection. Based on operations report in calendar year 2003, the effluent from the filters consisting of 2.2 mg/l of suspended solids required chlorine dosage of 6.6 mg/L, which is considerably less then design dosage of 15 mg/l. Chlorine solution is also applied in the plant influent, Bethlehem Steel influent, waste activated sludge, filter influent, and solids handling facilities.

The disinfection facility is also equipped for the removal of chlorine residuals by addition of sulfur dioxide (dechlorination). Addition of sulfur dioxide occurs at end of each contact basin. Based on the operation report, in calendar year 2003, the average sulfur dosage was 1.3 mg/L or 2.6 mg/l as sulfur dioxide. Under SC 778, the City is evaluating the use of sodium hypochlorite and sodium bisulfite instead of chlorine and sulfur dioxide for chlorination/dechlorination.

The Back River disinfected final effluent flows through a 5-step post-aeration cascade before entering the outfall. The required minimum effluent dissolved oxygen is 5 mg/L. In calendar year 2003, dissolved oxygen (DO) in the Back River effluent was 9 mg/l.

The 1998 inspections report indicated that chlorinators, sulfonators, evaporators for chlorine and sulfur dioxide, and flushing water booster pumps require replacement. Sulfur dioxide lines clog on regular basis and maintenance is recommended. Addition in the mixing bay is not required since the majority of chlorine is added earlier in the process. Other recommendations are reported in Appendix XIV.

4.4.1.2.5.2. Bethlehem Steel Pumping Station

The Bethlehem Steel pumping station is equipped with chlorine mixing basin, lift station, and pumps. The pumps are utilized when the hydraulic gradient exceeds the allowable, and additional discharge to Sparrows Point is required. Chlorination addition is used to control algae growth in the industrial water lines that convey effluent to Sparrows Point.

Based on the December 1998 inspection report, the overall condition of Bethlehem Steel pumping station and influent chamber is good, and one of the screen chamber sluice gates was closed and stuck, hence, flow could not be diverted to Bethlehem Steel when required. Other recommendations are reported in Appendix XIV.

4.4.1.3. Solids Handling Facilities

Solids facilities are basically grouped as thickening/digestion (High Rate area of the plant), dewatering/loading and heat drying (privatization contract).

The High Rate area includes raw sludge pumping, sludge degritting, scum pumping, diluting water pumping, sludge thickening, thickened sludge pumping, sludge recirculation pumping, sludge heating, anaerobic digestion (conventional high rate digesters and egg-shaped digesters), digested sludge pumping, hot flush process, digester gas handling, gas recirculation and related process functions.

Grit and screenings are transported for disposal in a landfill. Solids removed in the primary and secondary treatment systems are thickened and stabilized by anaerobic digestion. Primary sludge and waste activated sludge are thickened in gravity sludge thickeners (GST), dissolved air flotation thickeners (DAF) and gravity belt thickeners (GBT). Specifically, primary sludge is thickened in the GSTs and part of the waste activated sludge in the DAFs. Blended gravity thickened primary sludge and waste activated sludge is thickened in the GBTs. The GBT facilities offer other thickening options for flexibility.

The current anaerobic digestion facilities include conventional high-rate cylindrical digesters and egg-shaped digesters. The digesters produce methane gas, which is used to produce heat for the digestion process, and seasonally for heating in the plant buildings. The City is currently pursuing a privatization contract for the beneficial use of the excess digester gas.

After digestion, the biosolids are dewatered and disposed by one of three methods; dewatering and heat drying privatization contract, City dewatering and off-site composting by privatization contract, and City dewatering and hauling contract for land application.

4.4.1.3.1. Raw Sludge Pumping

Raw Sludge Pumping Stations A, B, C, and D pump primary sludge to the Sludge Degritters located in the Digester Control Building. Each of these pumping stations can discharge through either or both of two parallel force mains. The operator determines whether to use one or both force mains, depending on the pumping rate. All the raw sludge pumps are centrifugal. The flow rate from each pump is measured by a magnetic flow meter located on the discharge pipe. Flow rate and total flow are indicated and recorded on the Flow and Indication Panel in the Digester Control Building.

Based on the 1998 inspections (Appendix XIV), Raw Sludge Pumping Stations A-C requires mechanical, electrical, and other rehabilitation immediately. Scum lines clog for Station A-C. Station D is in good condition.

4.4.1.3.2. Sludge Degritting

Sludge from the primary clarifiers is degritted in the grit collecting room of Digester Control Building before entering the gravity sludge thickeners. Sludge flows through the grit separators, where the grit is removed and discharged to classifiers and then to a truck for disposal. The degritted sludge is conveyed to the gravity sludge thickeners through a 36-inch thickener influent line.

Sludge enters the cylindrical portion of the grit separator tangentially, and centrifugal forces cause the grit to be thrown against the separator walls and out the grit discharge. The less dense degritted sludge is discharged from the rear of the separator into the degritted sludge piping which conveys it to the thickener influent piping. The efficiency of the grit separators decreases as the sludge solids concentration rises above 1%. Diluting water from the flushing water system is added to sludge wet well when solids concentration becomes too great.

Three grit separators (cyclones) receive flow from the degritting sludge pumps. Four degritted sludge pumps, one for each separator, pump raw sludge from wet well to grit separators. The pumps are normally operated in an automatic, timer mode, however, at times they must run continuously.

Table 4-13 summarizes for calendar year 1998 to 2003 average wet pounds of grit removed from the primary sludge. The annual average pounds of grit removed for every million gallon of wastewater declined from 111 lbs/Mgal to 40 lbs/Mgal.

As of August 2002, sludge degritters, grit washers and pumps are operational but the grit collector room requires better ventilation. Inspections were not performed in December 1998 due to renovations. Under SC 9535, three degritters in the Digester Control Building are being replaced with new ones.

4.4.1.3.3. Scum Pumping

Scum from the primary settling tanks is ultimately discharged to the digesters. Scum pumps located in each raw sludge pumping station discharge into a common force main where it can be routed to any of several destinations. Additionally, it can be discharged to the hot recirculating sludge line or to the thickener influent line before entering the digesters. Normally, scum is discharged to dissolved air flotation Thickener No. 2 for thickening and then for to digestion.

Scum pumps, and other scum handling improvements should be considered in conjunction with the rehabilitation of the raw sludge pumping stations..

4.4.1.3.4. Diluting Water Pumping

Diluting water from the effluent filtration facility is currently pumped to the thickeners. The pumps are vertical, centrifugal type pumps with variable speed drives.

Based on inspection of this facility, the diluting water pumps will require replacement within the 20-year planning period.

TABLE 4-13

BACK RIVER WASTEWATER TREATMENT PLANT

DEGRITTER SOLIDS PRODUCTION

Year	Average Daily Solids Production (lbs/day)					
	1998	1999	2000	2001	2002	2003
January	14332	20366	6885	12125	10928	3408
February	30390	18075	8701	15349	8051	na
March	21152	19138	10495	12572	11847	11490
April	22041	30828	20908	9255	8991	7424
May	15171	9552	2901	8752	9519	9256
June	9710	4147	7767	8890	1395	3077
July	18928	4555	17397	5394	3321	538
August	12611	10499	14499	6271	2935	4545
September	9803	17278	13523	5979	2384	9771
October	15012	7465	8635	7741	3310	7121
November	20567	9435	9144	8826	3629	9061
December	13575	11107	9019	5905	na	12977
Average	16941	13537	10823	8922	6028	7152
Max	30390	30828	20908	15349	11847	12977
lbs/Mgal	111	92	72	64	44	40

na: not available

4.4.1.3.5. Sludge Thickening Facilities

The existing sludge thickening facilities consist of six 65 ft diameter gravity sludge thickeners (GST), two 65 ft diameter thickened sludge holding tanks, two 60 ft diameter and two 50 ft diameter dissolved air flotation (DAF) units, and five 3 meter wide gravity belt thickeners (GBT). Under SC 736 and SC 746, two former GSTs were retrofitted to thickened sludge holding tanks. Thickened sludge is stabilized in the conventional high-rate digesters and egg-shaped digesters.

Chlorine solution is added to the GST influent to reduce the potential for odor generation and gasification in the thickened sludge. This in turn improves sludge thickness and solids capture.

Based on the Back River Wastewater Treatment Plant Monthly Operations Report, 3500 lbs/day of alum residuals (solids) from Ashburton Treatment Plant is processed at the Back River Plant. From January 1998 to December 2003, the total Back River thickened sludge production averaged 163 dry tons/day (DTPD). During the same time period, an average of 1.8 dry tons of thickened sludge was produced per million gallon of wastewater treated.

The primary objective of the sludge thickening facilities is to produce the thickest possible sludge in order to increase the solids retention time (SRT) in the digesters, resulting in an increase in volatile solids destruction. Based on the operations report the highest annual average volatile solids destruction occurred in calendar year 2002. The high rate digesters destroyed an annual average of 57 % of volatile solids at an SRT of 17 days, and the egg shaped digesters 60 % at an SRT of 23 days.

4.4.1.3.5.1. Gravity Sludge Thickeners

Six existing 65 ft. diameter gravity thickeners are designed for solids loading of 12 lbs/ft^2/day and a hydraulic loading of 600-1,000 gpd/ft^2. Influent consists of diluting water and degritted raw primary sludge. Influent to each tank enters through the center column and influent well to be distributed over surface of tank. Polymer is added to improve solids capture. Sludge settles and thickens on the tank bottom where it is raked to discharge hopper by the thickener collector mechanism. Clarified effluent overflows the weir at the surface and is recycled to the primary clarifiers. Scum is collected in a scum well and pumped to digesters. Chlorine is added to the process to improve sludge freshness and reduce the potential for gasification.

A summary of solids loading and thickening performance for the GSTs for calendars year 1998 to 2003 is summarized in Table 4-14. Compared to typical values of 8-10% solids for well-thickened primary sludge, the average thickened sludge for calendar year 2003 was 5.1% solids. For the same time period, GSTs produced an average of 67 dry tons/day (DTPD) of thickened sludge with a solids capture efficiency of 93%. Gravity thickened primary sludge is blended with waste activated sludge for thickening in the GBT Building.

According to inspections in 1998 (Appendix XIV), rehabilitation of facility is recommended. Under Project No. 897, evaluation of the GST facility is in progress. This includes tank cover, gravity sludge thickener, electrical systems, and primary sludge degritters evaluations and options of replacing the deaeration tank.

Thickened Sludge Pumping

Thickened sludge pumps transfer thickened sludge into a thickened sludge holding tank, or the recirculating sludge line (loop line). The pumps are located

TABLE 4-14

BACK RIVER WASTEWATER TREATMENT PLANT

GRAVITY SLUDGE THICKENER PERFORMANCE

Parameter	Design	1998	1999	2000	2001	2002	2003
Influent Sludge Flow (MGD)		6.6	3.8	4.3	4.7	4.3	4.5
Influent Solids Concentration (%)		0.50	0.58	0.48	0.59	0.66	0.93
Solids Loading (lb/ft^2/day) (SC 528)	12	22	21	19	18	19	29
Hydraulic Loading (gpd/ft^2) (SC 528)	600-1000	542	297	332	359	342	387
Thickened Sludge Concentration (%)		4.8	4.5	4.7	4.7	5.2	5.1
Thickened Sludge Flow (MGD)		0.37	0.48	0.42	0.48	0.32	0.33
Solids Production (DTPD)		73	89	83	92	70	67
Thickener Overflow Loading (kips/day)		30	23	15	19	12	13
Solids Capture Efficiency (%)		89	91	92	91	93	93

For Calendar Years

in the thickener stations beneath the thickeners. Two pumps serve each thickener. Under normal conditions sludge is pumped from all six sludge thickeners simultaneously and at same rate. Varying conditions throughout the plant result in the need for varying the thickened sludge-pumping rate. Magnetic flow meters are installed on the thickened sludge pump discharge lines.

Thickened sludge pumps will require replacement in the 20-year planning period.

Thickener Scum Pumping

Scum pumps take suction from the scum boxes on the thickeners and deliver scum to the recirculating sludge line. Each thickener has one scum pump associated with it. The pumps are located at the thickener stations and are arranged in pairs. In the event of a pump failure, the piping is arranged to allow the second pump in the pair to serve as a back up unit.

The scum pumps are operated manually from the control stations located at thickener scum boxes. Frequency and duration of operation is determined by visual observation.

Based on the 1998 inspections (Appendix XIV), the scum pumps are in good condition and operate satisfactorily except during summer months when high solids occur on thickener surfaces.

GST Odor Facility

The GST Odor Control Facility was constructed under SC 736. The facility removes odorous gases, such as hydrogen sulfide, from gas produced from GSTs. Two counter current wet scrubbers containing plastic media packing clean the air from GSTs using caustic soda and bleach. De-odorized air is then passed through exhaust stack via an exhaust fan. Chemicals are added to the top of the scrubbers and recirculated through the bottom of the scrubber from a sump via recirculation pumps. Hydrogen sulfide monitors are located at the inlet of the two scrubbers and before the exhaust stack.

Two recirculation pumps for each scrubber are horizontal fiberglass-reinforced plastic centrifugal pumps with one of the two pumps serving as standby/backup.

Four transfer pumps convey caustic soda (NaOH) and bleach (NaOCl) from chemical storage tanks associated with the GBT Odor Control Facility to day tanks associated with GST Odor Control Facility. Two pumps are dedicated for caustic soda and two are for bleach with one of the two serving as standby. Chemical feed pumps are variable speed diaphragm metering pumps. The chemical metering pumps are suitable for 25% caustic soda and 15% bleach.

4.4.1.3.5.2. Dissolved Air Flotation Thickeners

The two 50 ft diameter DAF thickeners (Nos.1 and 2) are in operation since 1984 under SC 640 and the two 60-ft units (Nos. 3and 4), since 1988 under SC 677. DAF No. 2 serves to process scum pumped from Raw Sludge Pumping Stations A, B, C and D.

Waste activated sludge is pumped from the activated sludge plants to the DAF influent. Polymer is added prior to WAS entering the DAF tanks. In the DAF units, the feed sludge is mixed in with pressurized recycle flow (water supersaturated with air) before entering the flotation unit. When the mixture passes through a flow constraining device (valve) into the DAF tank, tiny gas bubbles form and these bubbles attach to sludge particles and float to surface. The floatable sludge is skimmed and discharged to an effluent well. The DAF sludge is pumped to the hot recirculating line in the thickener gallery where it is then conveyed to the digesters. The bottom sludge is pumped to the thickener feed well at the GBT Building and/or pumped to WAS Surge Tank (SC 736). The effluent well overflow is conveyed back to the primaries.

A summary of sludge loading and thickening performance of the DAFs for the calendar year 1998-2003 is shown in Table 4-15. Production of thickened sludge by the DAFs has decreased from 83 dry tons per day (DTPD) in 1998 to 31 DTPD in 2003. A large portion of WAS is thickened by the GBTs. From 1998 to 2003, polymer dosing also decreased by 70% which leads to higher solids in the overflows to the primaries. For calendar year 2003, the thickeners have produced an average float solids concentration of 4.5% and solids capture of 94%.

Thickened Sludge and Recycle Pumping

Each DAF tank has two rotary lobe sludge pumps with variable speed drives to pump thickened sludge to the hot recirculating sludge line to the digesters. Under SC 736, three DAF bottom sludge pumps were installed. These pumps, located in the existing DAF building, are double diaphragm positive displacement type.

Horizontal, centrifugal pumps recycle effluent flow to the thickener retention tank. Each DAF is equipped with one operating pump and one standby. Each has variable speed control.

Based on recent inspection and as noted in Appendix XIV, these pumps will require replacement during the planning period.

TABLE 4-15
BACK RIVER WASTEWATER TREATMENT PLANT
DISSOLVED AIR FLOTATION THICKENERS PERFORMANCE

Parameter	Design	1998	1999	2000	2001	2002	2003
Total Influent Flow (MGD)		2.55	2.55	2.45	1.36	1.31	1.10
Average Influent Conc.		9324	11003	7926	9999	9307	11051
Average Solids Loading (lbs/ft2/day)	28.8	24.8	29.9	21.6	19.2	17.5	23.5
Average Hydraulic Loading (gpd/ft2)	711* / 644**	326	326	324	229	225	256
Thickened Sludge Concentration (%)	4	4.02	4.57	4.17	3.97	4.64	4.53
Solids Production (DTPD)		83	72	54	30	40	31
Volatile Solids Production (DTPD)		61	55	40	23	30	24
% Volatile Solids		74%	77%	74%	77%	76%	78%
Solids Capture Efficiency (%)		93	89	87	89	88	94
Average Polymer Usage (lbs/dry ton)		18	20	19	7	12	5

For calendar years

* SC 640, DAF Nos. 1 and 2

**SC 677 DAF Nos. 3 and 4

DAF Odor Control Facility

Two odor control units are located beside the DAFs (SC 640 and 677). They are each comprised of a wet scrubber, exhaust fan, recirculation pump and chemical metering pump. The system is designed to clean 5000 cubic feet per minute (cfm) and 7150 cfm of gas, respectively.

Based on inspection report (Appendix XIV), the DAF facilities are in poor condition. The extent of rehabilitation needed is uncertain, since the GBTs have been constructed to alleviate the inadequate capacity and performance of the existing DAF units.

4.4.1.3.5.3. Thickened Sludge Holding Tanks

Each tank is 65 ft in diameter with a 15 ft side water depth and capacity of 250,000 gallons. They provide for storing and blending GBT thickened sludge to allow a controlled feed rate of thickened sludge to digesters and for storing of gravity thickened sludge to control the feed rate to GBT facility.

Four thickened sludge pumps convey sludge to digesters. Two are located under each holding tank, and are progressive cavity type with hydrostatic variable speed drives.

The sludge holding tanks are in operation and in good condition.

4.4.1.3.5.4. Waste Activated Sludge (WAS) Surge Tank

The WAS Surge Tank attenuates variations in WAS pumping rates from activated sludge plants to provide a constant sludge flow to the GBT facility. This tank (65 ft diameter, 20 ft side water depth) has 500,000 gallon capacity and is provided with 20 SCFM/1000 cu. ft. of air for mixing and maintaining the WAS fresh.

The WAS is pumped from the activated sludge plants through 12-in and 14-in pipelines to the DAFs, with excess to WAS surge tank. Bottom sludge from the DAFs also flows to this tank. The surge tank is aerated to prevent the sludge from becoming septic. The sludge is pumped to the thickener feed well that serves the GBTs.

The WAS Surge Tank pumps is served by five horizontal centrifugal pumps, suitable for pumping WAS having an average solids concentration of 0.85% and a maximum solids concentration of 2.7%.

The Waste Activated Sludge Surge Tank is in operation and in good condition.

4.4.1.3.5.5. Gravity Belt Thickeners

DAF bottom sludge, gravity thickened sludge, waste activated sludge, and/or blends of all three sludges are pumped from the two GBT thickener feed wells to each gravity belt thickener feed chamber located at the unit. Thickened sludge from the GBTs discharges to a hopper located in the basement below the unit, and then is pumped through an 8" pipeline to either the cold recirculating sludge line, and to the conventional high rate digesters, and/or thickened sludge holding tanks for subsequent pumping to the egg-shaped digesters.

The facility, under SC 736, is designed for ten thickeners feed pumps, eight GBTs, eight thickened sludge pumps and eight hoppers. Under SC 736, five process trains were installed. Each gravity belt thickener has a dedicated sludge conditioning system, consists of two polymer mixing assemblies with multiple points of addition to the GBT sludge feed.

The gravity belt thickeners installed at Back River WWTP are Ashbrook Aquabelt units with 3-meter width belts. The belts are porous so free water can be drained from the sludge. A thickened primary sludge and waste activated sludge blend of less than 3% solids is fed into the GBTs. Polymer is injected into the sludge feed line of each GBT. The sludge is pumped into a feed tank, located at the influent end of the GBT, that is sized to allow enough retention time for conditioning. The overflow from the tank discharges onto the belt through a chute. The chute spreads the slurry across the entire belt width to allow optimum gravity dewatering. Chicanes, plow-like devices, turn over the sludge to increase gravity dewatering. At the end of the gravity section, the process is optimized by an adjustable ramp, which rolls the thickened sludge back into itself for optimal dewatering and production of sludge cake with high solids content. The filtrate is captured in a drainage pan and conveyed through a 4-in drainage pipe connection to the main filtrate drain to return the flow to the primary influent, or effluent.
The belts are continuously washed to prevent blinding and loss of dewatering efficiency. Once the thickened sludge is removed with a scraper, the moving belt passes through a washbox where 90 psi flushing water is sprayed to remove any particles that may have been embedded in the porous belt. The clean belt exits the washbox to begin the process again.

The GBTs are designed to thicken GST sludge or blend (50% unthickened WAS: 50% gravity thickened sludge, GTS) to at least 9% solids with a 95% solids capture. GBTs are capable of treating GST sludge with 4% - 9% solids (typical of GST sludge) to sludge with solids as low as of 0.5% - 1.75% solids (typical of waste activated sludge). The design hydraulic loading is 140 gpm/meter of belt width. The solids loading for waste activated sludge is 596 lbs/hr/meter and for a blend of WAS and GST sludge, 1058 lbs/hr/meter.

The GBTs became fully operational in October 2000. The GBTs are capable of thickening either WAS or a blend of GTS and WAS, to 9% solids. Due to digester constraints, sludge is normally thickened to 7 to 8%. GBT thickened sludge is typically sent to sludge holding tank and then to Digesters Nos. 7 and 8 (Egg-shaped Digesters).

Thickener Feed Well

Two thickener feed wells are each equipped with two mixers. Sludge is pumped by the thickener feed pumps from these wells at a pre-set constant flow to the GBTs. The vertical, top-mounted type mixers have a primary mixing capacity of 8300 gpm at 56 rpm. These mixers are used to maintain a uniform bled of sludge. Gravity thickened sludge, DAF bottom sludge, sludge from WAS surge tank and/or WAS can be transferred to this well.

Thickener Feed Pumps

Sludge is pumped from the thickener feed wells by five thickener feed pumps (plus one standby) to the GBTs located on the first floor in the Gravity Belt Thickener Building.

Sludge Conditioning System (Polymer Feed System)

The sludge conditioning system for each GBT consists of two polymer mixing assemblies located on the GBT feed line, each including an in-line polymer injection ring and a variable orifice venturi type mixing valve, and a flocculation tank located at the GBT. The injection ring injects polymer at four equally spaced points around the circumference of the ring. The flocculation tank is located at the feed end of equipment and has minimum volume of 250 gal. The sludge is fed into the bottom of the tank, and discharged from the top of the tank onto the GBT.

GBT Odor Facility

The odor control facility is designed to treat exhaust air from the GBT building and the covered WAS Surge Tank. Constructed under SC 736, the odor control systems primary components are two packed tower scrubbers, mist eliminators, liquid distributors, chemical feed systems, recirculation pumps, transfer pumps, instrumentation and controls. The facility is designed to treat 24,000 cfm of air.

The two recirculation pumps for each scrubber are horizontal fiberglass-reinforced plastic centrifugal pumps with one of the two pumps serving as standby.

Scrubber water contains caustic soda (NaOH) and bleach (NaOCl). Chemicals feed pumps; variable speed diaphragm metering pumps convey the scrubber water to the tower. For caustic soda and bleach pumps the process-input signals are based on the scrubber pH and scrubber ORP (oxidation-reduction potential), respectively. The pumps are suitable for 25% caustic soda and 15% bleach.

Mist eliminators located on top of the tower remove 90 to 99% of the water droplets. Periodically the packing and the mist eliminators are acid washed.

The odor control facility is designed to achieve an H_2S (hydrogen sulfide) concentration of 0.1 ppm when inlet H_2S is less then or equal to 10 mg/l and for inlet concentrations 10-100 mg/l, the outlet is design to accomplish 0.1% of inlet concentration.

The GBT facility, including pumps, odor control facility, thickener feed well and sludge conditioning system is in operation and in good condition.

4.4.1.3.6. Sludge Digestion

Organic matter in the thickened sludge is converted biologically under anaerobic conditions to a variety of end products, primarily water, methane and carbon dioxide gas. The sludge digestion process takes place in six conventional cylindrical high rate digesters and two egg-shaped digesters (ESD). The sludge is heated, mixed completely, and retained for various periods of time. The digested sludge is approximately half as concentrated as the thickened sludge. Digested sludge then enters 12-in pipeline and flows to dewatering facility.

Table 4-16 shows quantities of thickened sludge pumped to digesters from 1998 to 2003. The annual average thickened sludge production per million gallons of wastewater increased from 2 DTPD/MGD to 2.5 DTPD/MGD, from 1998 – 2001. From 2001 to 2003 the annual average thickened sludge decreased back 1.0 DPTD/MGD. The seven year average was 1.8 DTPD/MGD.

As of 2002, the City is piloting a two-phase mesophilic anaerobic digestion process under SC 8526. The performance evaluation facility (PEF) is under construction and will help determine optimum operating conditions before the entire digestion process is converted. The new acid reactor tank is under construction and one existing digester (either Digester No. 3 or 4) will be used as the gas phase digester.

4.4.1.3.6.1. Conventional High Rate Anaerobic Digesters

Five of the six cylindrical digesters were originally operated as standard rate digester units. The sixth digester was constructed in 1972, when the original five were rehabilitated and converted to the high rate digestion process. The digesters are 100 ft in diameter and 25 ft deep. The floor slabs are essentially flat. Each of the six digesters is equipped with gas recirculation system to aid in digester mixing and promoting digestion. The digesters operate by circulating digester gas through Pearth lances extending within a few feet of the floor. The

ANT

ESTERS

	otal Sludge to Digesti… GST + DAF + GBT), DTPD						
Month	**1998**	**1999**	**2000**	[redacted]	**2001**	**2002**	**2003**
					148	232	141
					160	166	147
					185	177	167
					167	172	174
					169	91	201
					177	142	198
					152	138	173
					165	146	232
					205	155	212
					175	168	219
					213	144	214
					205	187	158
Annual Avg Sludge	[illegible]	155	142		177	160	186
Annual Max Sludge	184	182	170		213	232	232
Annual Average Sludge / Annual Average Flow (DTPD/MGD)	2.05	[illegible]	[illegible]		2.52	1.17	1.04
Annual Maximum Sludge / Annual Average Sludge	1.18	1.18	[illegible]		1.21	1.45	1.24

sludge gas produced is collected, metered and distributed to the process boilers and existing plant uses primarily heating for buildings. Excess gas is ignited and burned in waste gas flares burners.

Gravity thickened sludge is introduced into the cold recirculating line and conveyed to the steam injectors in the Digester Control Building. The sludge is heated, becoming hot recirculating sludge which is then transferred to the high rate digesters. The sludge is held to maintaining approximately 98^0 F within digesters. DAF thickened sludge mixes with the heated sludge before entering the digesters. Digested sludge is removed and raw sludge is added fairly continuously to maintain an annual average of 14 to 21 days SRT based on 80% effective volume in digesters. Sludge is withdrawn from each digester and pumped through the loop line to the Digester Control Building. Operators use magnetic flow meter and pinch valves to maintain a constant sludge level in the tanks. Liquid levels are measured manually. The current steam injection facilities replaced the original sludge heaters under SC 706.

The six conventional digesters are designed for dry solids loading rate 295 lb/1000 cu. ft., 70% volatile solids and 54,500 cu. ft/hr of gas production. Table 4-17 summarizes the high rate digester performance. From 1998-2003, the six year average volatile solids destruction was 50% for solids feed of 82 DTPD.

Currently, the concrete covers leak methane gas to the atmosphere, cracks exists in the floor slabs in five of the six tanks and the gas mixing systems are not effective. As of 2002, SC 8526 is under design to add two additional egg-shaped digesters and implement the two-phase digester process. As part of that project, two conventional high rate digesters will be converted and to sludge storage tanks and the other four will be abandoned/removed.

TABLE 4-17

BACK RIVER WASTEWATER TREATMENT PLANT

PERFORMANCE OF CONVENTIONAL HIGH RATE DIGESTERS

Parameter	1998	1999	2000	2001	2002	2003
Feed Flow (MGD)	0.44	0.43	0.36	0.42	0.42	0.47
% Feed Volatile Solids	76	77	76	80	79	76
Feed Solid (kips/day)	160	161	132	156	172	195
% Solids in Digested Sludge	2.5	2.5	2.4	2.4	2.4	2.9
% VS in Digested Sludge	64	64	64	66	66	64
VS Destroyed (kips/day)	61	60	48	67	77	76
SRT (days)	17	17	24	19	17	16

For calendar years.

As per City's performance data, before March 14, 2003 the digesters' feed included thickened sludge from GSTs and DAFs .

From March 14, 2003 to December 2003 the digesters' feed also included a blend of thickened sludge from Thickened Sludge Tank No. 2.

Recirculating Sludge Pumps

The recirculating sludge enters each digester through eight locations. The recirculation pumps withdraw sludge from seven selected locations in the digester and discharges the sludge to the cold recirculation line which conveys the sludge to the sludge heaters. The hot recirculating sludge returns through the loop line to the digesters.

There are two recirculating sludge pumping stations. Station No. 1 serves Digesters Nos. 1, 2, 3, and 4; station No. 2 serves Digester Nos. 5 and 6. Each digester has one pump associated with it. In addition, each recirculation pumping station has one multi-purpose pump that can serve as a backup unit for any of the other pumps. The flow rate from each pump is measured by a magnetic flow meter located in the pump discharge line. At a pumping rate of 450-gpm, the pump can recirculate the contents of digester in two days. Digester influent and effluent flow rates are equalized by selection of proper pumping rates.

Based on the inspection of these pumps and as annotated in Appendix XIV, these pumps will require replacement during the planning period. This is anticipated to occur, only as related to SC 8526.

Sludge Heating

Sludge is heated by steam injection in the Digester Control Building. Potable water from City is softened with sodium chloride (NaCl) ion exchange before entering the steam boilers. These two boilers have maximum rated capacity of 30 million BTU/hr (27,600 lbs. of steam/hour at 15 psi).

Digested Sludge Pumping

The digested sludge pumps are progressing cavity positive displacement units. They transfer digested sludge from the cold recirculating sludge pipeline to the digested sludge line, which leads to the dewatering facility.

The discharge from these pumps is metered by a magnetic flow meter. The digested sludge pumps are intended to operate continuously. To maintain a constant level in the digesters, the output from the digested sludge pumps must be the sum of all outputs from all thickened sludge pumps. These pumps will require replacement, only as related to SC 8576.

Hot Flush Process

A system is provided for periodically flushing out thickened sludge, raw sludge, and scum piping by pumping hot water through the system. Two hot flush pumps arranged to pump either in series or parallel are provided in the hot recirculating sludge network. The pumps are located in the Digester Control Building.

4.4.1.3.6.2. Egg Shaped Anaerobic Digesters

Egg-Shaped Digesters (ESDs) Nos. 7 and 8, constructed under SC 706, have been in service since 1992. They are 84 ft in diameter at their maximum dimension and 125 ft high and have a capacity of 3 million gallons each. A small portion of the base is below grade. The tanks are constructed of cast-in-place reinforced concrete.

The contents of each digester are mixed using a 60 HP draft tube mechanical mixer. The draft tube extends from just below the maximum liquid level to several feet above the bottom. The mixer's rated capacity is 20,800 gal/min. A backup mixing system is comprised of two 125 HP gas compressors and 29 digester-gas injection ports in each digester. The injection ports are halfway between the tank bottom and its largest diameter. Four liquid ring type compressors for Digesters Nos. 7 and 8 (two for each) are located in gas control rooms. The compressors compress and circulate the digester gas into the digesters to mix the contents. Through manual selection, the compressors may operate individually or simultaneously in parallel. Mechanical mixers are preferred over gas compressors due to its high turnover rate and less requirement of power.

The two ESDs are designed to digest 7% to 8% solids with flow 125 to 300 gpm. The design hydraulic retention time is 17 days and operating temperature is 95° F. The digester gas, with a heating value of 600 BTU/cu. ft., contains 60% of methane and 40% carbon dioxide (65:35 more typical). Table 4-18 summarizes ESDs performance, according to the Back River monthly operations report. From 1998-2003, the volatile solids destruction averaged 56% with SRT (solids retention time) also increased from 15 days to 28 days. Retention time improvements were due primarily to a thicker sludge being produced by the GBT facilities.

Recirculating Sludge Pumps

Each digester has three centrifugal type recirculation pumps, located in each digester mechanical room that removes sludge (3 to 6% solids) from the digester bottom and return it to the top. Untreated sludge is added downstream of the pumps, then steam is injected into the mixture before it is discharged into the digester near the top. The pumps can also be used to aid in dewatering the tank. One pump from each digester is used to transfer sludge between digesters.

TABLE 4-18

BACK RIVER WASTEWATER TREATMENT PLANT

PERFORMANCE OF EGG SHAPED DIGESTERS

Parameter	1998	1999	2000	2001	2002	2003
Feed Flow (MGD)	0.42	0.43	0.36	0.34	0.28	0.24
% Feed Volatile Solids	76	77	76	79	76	76
Feed Solid (kips/day)	150	159	155	173	156	123
% Solids in Digested Sludge	2.4	2.4	2.4	2.8	3.6	3.6
% VS in Digested Sludge	64	65	64	66	63	63
VS Destroyed (kips/day)	60	68	63	81	70	50
SRT (days)	15	15	16	19	23	28

For calendar years.

As per City's operations data, before March 14, 2003 the digesters' feed included thickened sludge from GSTs and/or GBTs .

From March 14, 2003 to December 2003 the digesters' feed included a blend of thickened sludge from Thickened Sludge Holding Tank No. 2.

Booster Pumps

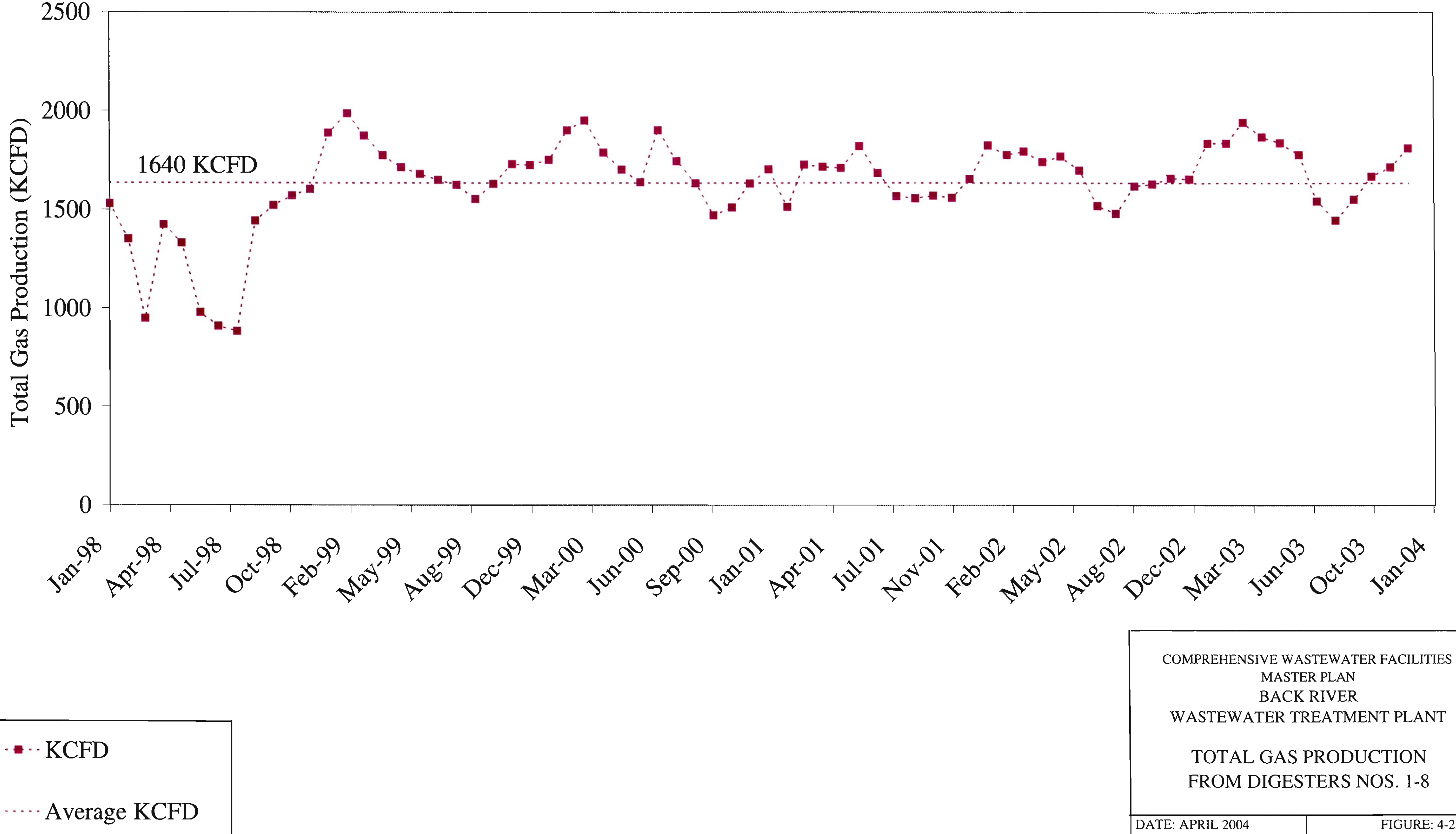
Three booster pumps located in the Digester Control Building pump gravity thickened raw sludge, DAF thickened waste activated sludge, and digested sludge to the ESDs. They are two-stage progressing cavity types. The ESD facilities are in good condition based on 1998 inspections (Appendix XIV).

4.4.1.3.6.3. Digester Gas Production

Gas produced from the digesters is used as a fuel source to supply heat to the digestion process and seasonal heat for plant building. Figure 4-23 shows total gas production from January 1998 to December 2003. The average digester gas production has increased from 1345 KCFD in Fiscal Year 1998 to 1724 KCFD in Fiscal Year 2003. The City is currently negotiating a privatization contract for beneficial use of excess digester gas.

4.4.1.3.6.4. Sludge Dewatering

Based on the recommendations in the 1988 Sludge Management Plan, the City developed three options for handling and disposal of anaerobically digested sludge. Under the first, about half of the digested sludge is dewatered and heat dried at onsite privately owned facility (Pelletizing Facility) operated under contract with the City. For the second and third options, the digested sludge is dewatered and stored at facilities owned and operated by the City. The stored sludge is disposed of offsite under two contracts. One contract provides for hauling sludge and composting at an off-site facility located at Hawkins Point, and the other contract provides for hauling and land application. Under SC 8511R, the City has expanded the capacity of their dewatering facility.



COMPREHENSIVE WASTEWATER FACILITIES
MASTER PLAN
BACK RIVER
WASTEWATER TREATMENT PLANT

TOTAL GAS PRODUCTION
FROM DIGESTERS NOS. 1-8

DATE: APRIL 2004 | FIGURE: 4-23

City Dewatering

The City dewatering facilities, under SC 8511R, include the Vacuum Filter Building (not in service), Centrifuge Building, Sludge Storage Building, and Centrate Storage and Mixing Tank Area. Digested sludge flows by gravity to Digesters Nos. 7, 8, and 9 for storage. Sludge is withdrawn from Digesters Nos. 7, 8, and 9 and pumped by progressing cavity pumps to two centrifuges. Sludge grinders installed ahead of each pump provide homogeneous feed sludge to centrifuges. Belt conveyors transfer the sludge cake from the centrifuge to eight silos for storage. The centrate is discharged by gravity and blended with elutriating water in mixing tanks. Three parallel pumps recycle centrate to the primary clarifiers. The Vacuum Filter Building houses the sludge feed pumps, grinders and centrate tank effluent pumps.

The Sludge Storage Building stores sludge cake from centrifuges in eight silos. Contractors haul the sludge from this facility to a composting facility, to a land application, or landfill site. Each belt conveyor passes sludge cake from two centrifuges to the silos.

Under SC 8511R, new sludge dewatering facilities were constructed, including, a Centrifuge Building, modifications of existing buildings, tanks, pumps and piping, odor control facilities, and other work. The Centrifuge Building has four solid bowl centrifuges and polymer feed system (two tanks and eight polymer feed units). The centrifuges concentrate the influent liquid sludge of 2 to 5% solids to a cake of 20 to 25% solids. Two polymer feed units (one standby) for each centrifuge inject polymer in the sludge line at the centrifuge inlet as a dewatering aid to optmize dewatered solids concentration and capture. Eight metering pumps, two associated with each centrifuge, deliver polymer to the centrifuges.

Table 4-19 shows the annual average performance of the City Dewatering Facility. Since the four new centrifuges commenced operation at the time this plan was written, the data does not represent accurately the performance of these centrifuges. However, the dewatered sludge production for last six years (1998-2003) has average 37 DTPD.

TABLE 4-19
BACK RIVER WASTEWATER TREATMENT PLANT
PERFORMANCE OF CITY DEWATERING FACILITY

Parameter	1998	1999	2000	2001	2002	2003
Average Solids Feed to Centrifuges (kips/day)	115	108	90	74	84	62
Wet Cake Produced (Tons)	193	213	171	176	198	183
Total Solids Concentration %	20	20	21	20	20	21
Polymer Dosage (lb/ton)	15	15	19	16	15	24
Sludge From Heat Drying (DTPD)	57	57	55	53	46	55
Sludge from Centrifuge (DTPD)	38	42	35	34	39	35
Total Sludge Production (DTPD)	95	99	89	87	85	90
Sludge Production (DTPD/MGD)	0.62	0.67	0.59	0.62	0.62	0.50

For calendar years

Heat Drying (Pelletizing) Facility

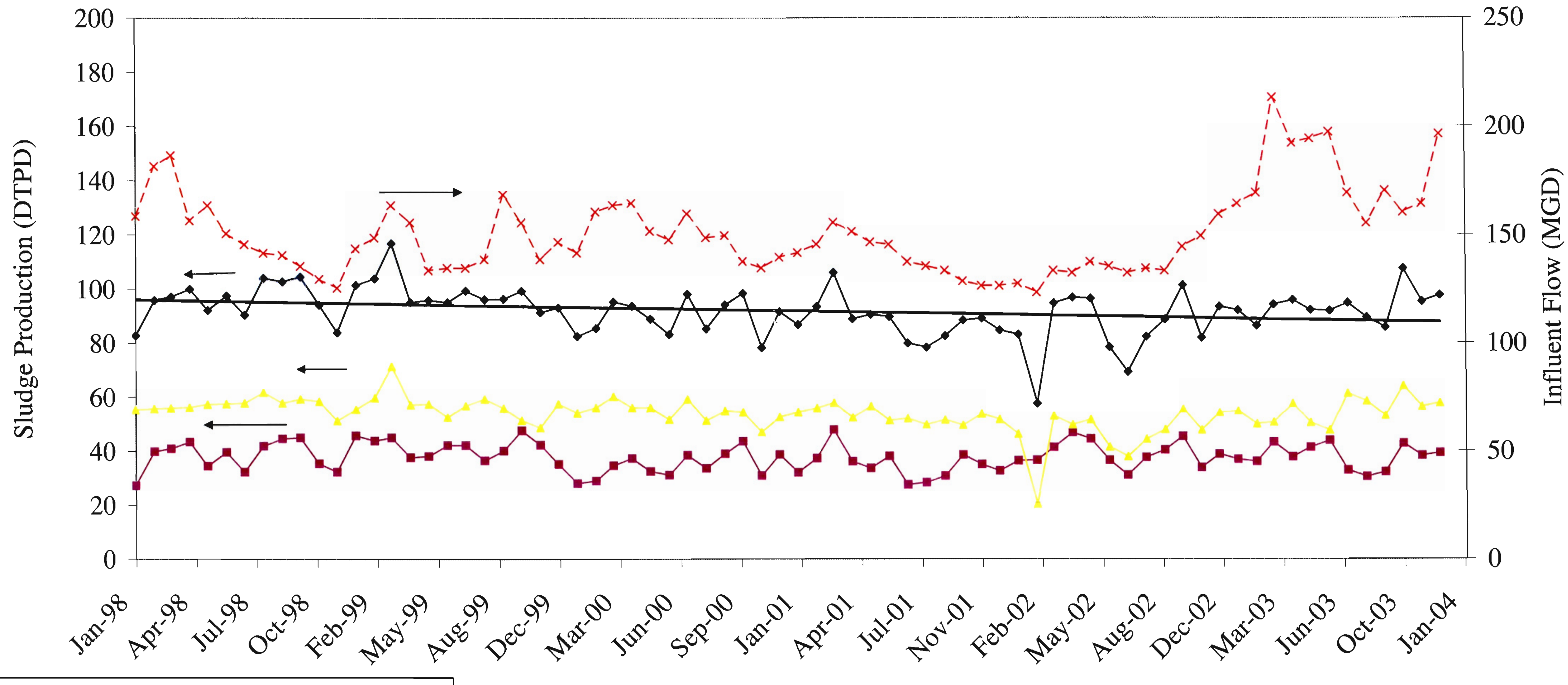
The Heat Drying Facility has been in operation since December 1994 and dewaters and processes approximately half of the sludge generated at the Back River WWTP. The facility receives approximately 0.5 mgd of digested sludge with an average solids concentration of 2.5 %. Solid -bowl centrifuges are used, with the addition of polymer to dewater the sludge. The design feed rate and speed of centrifuges are 200-gpm and 2500 rpm, respectively. They are designed to produce a sludge cake with 24% solids. The facility has storage capacity for 18,000 gallons of digested sludge. Two silos have the capacity to store the quantity of pellets produced in eight days.

Table 4-19 summarizes the annual sludge production from the Heat Drying Facility. For the six year period (1998-2003) the annual average dewatered sludge production remained relatively constant, averaging 54 DTPD.

4.4.1.3.6.5. Sludge Production and Disposal

From 1998 to 2003, the six year average total solids production from City's Dewatering Facility and the Heat Drying Facility is 0.6 dry tons for every million gallons of wastewater treated. Figure 4-24 illustrates the relationship between total sludge produced from both dewatering facilities and influent flow. The linear regression shows that the total sludge production from both dewatering facilities declined insignificantly, with a six year average of 91 DTPD.

Sludge from the City's Dewatering Facility is stored in silos and truck disposed for composting and land application. According to the monthly operation report, before October 2000, centrifuge cake was also disposed of in landfills. In calendar year 2003 based on 7 days per week disposal, an annual average of 25 dry tons/day and 10 dry tons/day of centrifuge cake were composted and land applied, respectively.



Total Sludge Production
Centrifuge Cake
Pelletizer Pellets
Influent Flow
Linear (Total Sludge Production)

COMPREHENSIVE WASTEWATER FACILITIES
MASTER PLAN
BACK RIVER
WASTEWATER TREATMENT PLANT

DEWATERED SLUDGE PRODUCTION VS
PLANT INFLUENT FLOW

DATE: APRIL 2004	FIGURE: 4-24

Figure 4-25 summarizes the performance of the Back River Solids Handling Facility. The histograms illustrate the annual average solids production from the primary and secondary treatment, sludge thickening facilities, digesters and both dewatering facilities (City and Pelletech). The thickened sludge production declined insignificantly compare to the solids loading to the plant. The reason being is that the thickener overflows were contributing to additional solids to primaries. Lower polymer dosage to DAFs resulted in higher solids in the overflow. In summary, for past six years (1998-2003) with the decline of solids BOD, TKN, and TP loadings to plant, the total dewatered sludge production declined insignificantly.

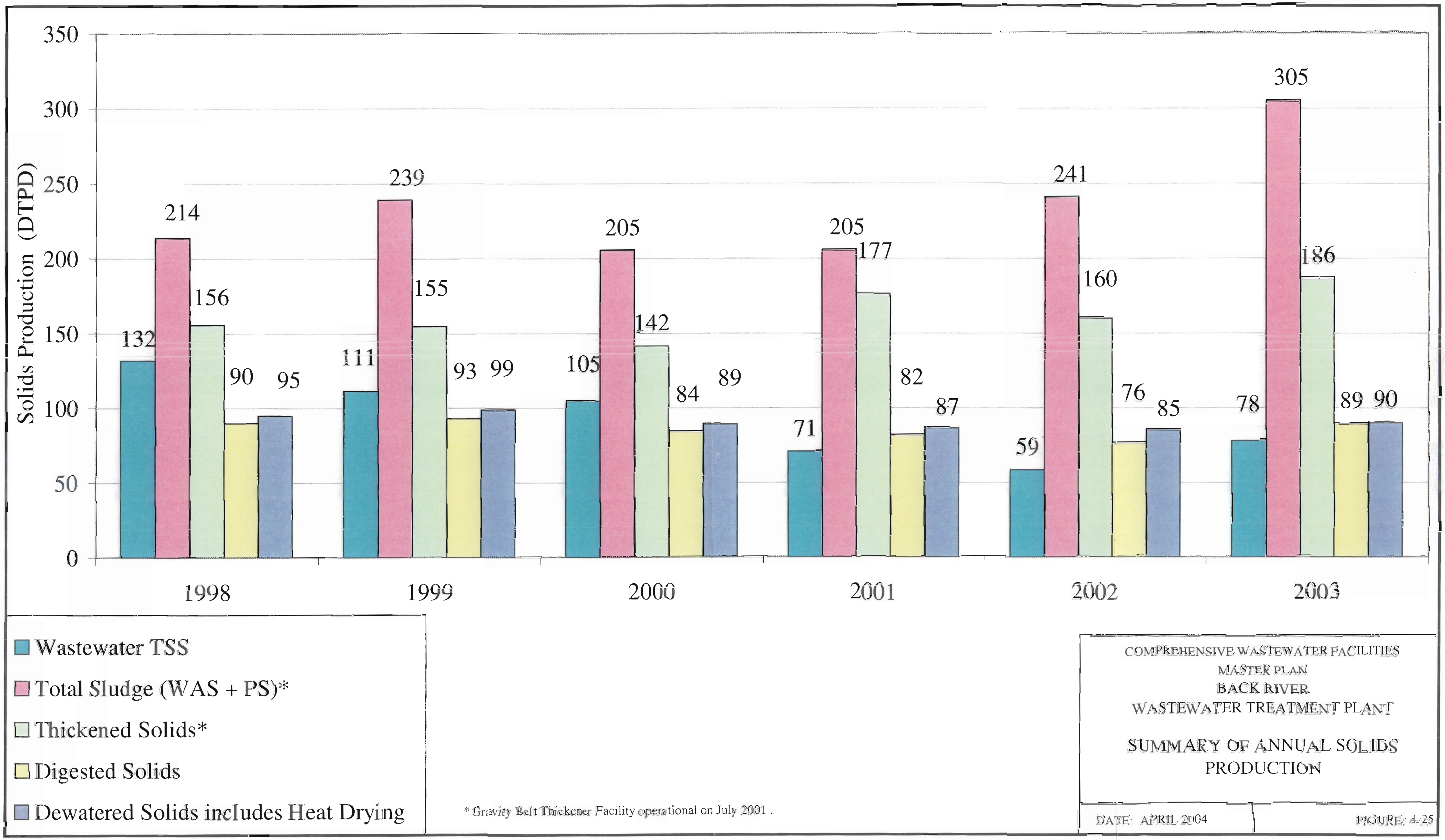
4.4.1.4. Summary of Plant Conditions

A detailed inspection was conducted on the facilities at Back River Wastewater Treatment Plant. The findings of this inspection are located in Appendix XIV. Table 4-20 summarizes the findings of this inspection report and subsequent inspections. The summary table identifies all unit processes at the Back River WWTP and their status based upon the inspections. The summary table also includes the sanitary contract or project number assigned for those facilities undergoing rehabilitation.

4.4.1.5. Detailed Evaluations of Designated Plant Facilities

4.4.1.5.1. Scope of Evaluations

At the request of the City, below are specific facilities that were evaluated, as part of the Comprehensive Plan studies, to determine requirements for rehabilitation and/or improvements. Findings and recommendations are also discussed.



Whitman, Requardt and Associates, LLP
Figure 4-25/Chart2

TABLE 4-20

BACK RIVER WASTEWATER TREATMENT PLANT

SUMMARY OF TREATMENT PLANT EVALUATIONS

Unit Process	Improvments Required	Improvments in Progress	Sanitary Contract No. / Project No.	Remarks
PRIMARY TREATMENT				
Metering Chamber	N	N		
Flushing Tower	Y	Y	SC 796	In progress
Mechanical Screen	Y	N		Improvements necessary
Septage Receiving Station	N	N		
Grit Container Buildings	Y	Y	SC 9535	Currently Under Rehabilitation
Grit Tanks	Y	Y		Currently Under Rehabilitation
Grit Control Building	Y	Y		Currently Under Rehabilitation
Sludge Control Station	Y	N		Improvements not immediately necessary
Raw Sewage Pumping Stations (A-D)	N	N		
Primary Clarifiers	Y	Y	SC 6503	In progress
Dewatering and Sludge Pumping Stn	N	N		
Odor Control Facilities (Clarifiers)	N	N		
Odor Control Facilities (Screen Bldg)	N	N		
Odor Control Facilities (Head Chamber)	N	N		
SECONDARY TREATMENT				
Activated Sludge Plant No. 1	Y	N		not in service,BNR Upgrade, City to optimize the plant
Internal Recycle P.S. (1-4)	Y	N		not in service
Pipe Galleries (N+S)	Y	N		not in service
Blower Building No. 1	Y	Y	SC 798	Currently in Progress

TABLE 4-20

BACK RIVER WASTEWATER TREATMENT PLANT

SUMMARY OF TREATMENT PLANT EVALUATIONS

Unit Process	Improvments Required	Improvments in Progress	Sanitary Contract No. / Project No.	Remarks
Lime Silos	N	N		not in service
Clarifiers (1-4)	Y	N		not in service
Reactors (1-4)	Y	N		not in service
Activated Sludge Plant No. 2	Y	N		BNR Upgrade, City to optimize the plant
Head Chamber	Y	N		Improvement not immediately necessary
Operations Building	Y	N		Improvement not immediately necessary
Internal Recycle P.S. (5-10)	Y	N		Improvement not immediately necessary
Pumping Station (1-2)	Y	N		Improvement necessary
Reactor Dewatering P.S.	N	N		
Clarifier Distribution Box	N	N		
Influent Metering Vaults (N and S)	Y	N		Improvement necessary
Blower Building No. 2	Y	Y	SC 798	Currently in Progress
Diffuser Cleaning Building	N	N		
Clarifiers (5-10 A&B)	Y	Y	SC 802	Renovation evaluation in progress
Reactors (5-10)	Y	N		Improvement not immediately necessary
Activated Sludge Plant No. 3	Y	N		BNR Upgrade, City to optimize the plant
Diffuser Cleaning Building	N	N		
Lime Silos	N	N		
Secondary Clarifier (11A -16B)	N	N		
Reactors (11-16)	Y	N		Improvement not immediately necessary
Internal Recycle P.S. (11-16)	Y	N		Improvement not immediately necessary

TABLE 4-20

BACK RIVER WASTEWATER TREATMENT PLANT

SUMMARY OF TREATMENT PLANT EVALUATIONS

Unit Process	Improvments Required	Improvments in Progress	Sanitary Contract No. / Project No.	Remarks
Pumping Station (3-4)	Y	N		Improvement necessary
Reactor Dewatering P.S.	N	N		
Clarifier Influent Boxes	N	N		
Influent Metering Vaults (N and S)	N	N		
Blower Building No. 3	N	N		
Chemical Building (next to Plant #2)	Y	N		Improvement not immediately necessary
FINAL TREATMENT				
Filtration Beds	Y	N		Improvement necessary
Sand Filter Backwash Return P.S.	Y	N		Improvement necessary
Control Building/Sample Pump Rm.	N	N		
Filtration Diversion Chamber	N	N		
Chlorination/Dechlorination	N	Y	SC 778	Pilot studies in progress
Chlorine Contact Tanks	N	Y	SC 778	
Mixing Bay	N	Y	SC 778	
Backwash Return P.S.	N	Y	SC 778	
Bethlehem Steel P.S.and Influent Chambers	Y	N		Improvement not immediately necessary
OUTFALL	N	N		
SOLIDS HANDLING				
Raw Sludge Pumping				See Pumping Stations A-D
Sludge Degritting	Y	Y	SC 9535	Currently in progress

TABLE 4-20

BACK RIVER WASTEWATER TREATMENT PLANT

SUMMARY OF TREATMENT PLANT EVALUATIONS

Unit Process	Improvments Required	Improvments in Progress	Sanitary Contract No. / Project No.	Remarks
			Proj. No. 897	Evaluation of odor control under progress
Scum Pumping	N	N		
Dilute Water Pumping	N	N		
GSTs (tanks, sludge pumps, scum pumps, electrical)	Y	Y	Proj. No. 897	Currently under evaluation
GSTs Odor Control Facility	N	N		
Thickened Sludge Holding Tanks	N	N		
DAFs (tanks, sludge pumps, scum pumps)	Y	N		Improvement not immediately necessary
DAFs Odor Control Facility	N	N		
WAS Surge Tanks	N	N		
Gravity Belt Thickeners (GBTs, sludge pumps, scum pumps)	N	N		
Sludge Conditioning System	N	N		
GBT Odor Control Facility	N	N		
High Rate Digesters	Y	Y	Proj. No. 8526	PEF under construction for Two Phase Digestion
Recirculating Sludge Pumps	Y	Y	Proj. No. 8526	
Sludge Heating	Y	Y	Proj. No. 8526	
Digested Sludge Pumping	Y	Y	Proj. No. 8526	
Hot Flush Process	Y	Y	Proj. No. 8526	
Egg-Shaped Digesters	N	Y	Proj. No. 8526	

TABLE 4-20

BACK RIVER WASTEWATER TREATMENT PLANT

SUMMARY OF TREATMENT PLANT EVALUATIONS

Unit Process	Improvments Required	Improvments in Progress	Sanitary Contract No. / Project No.	Remarks
Recirculating Sludge Pumps	N	Y	Proj. No. 8526	
Sludge Heating	N	Y	Proj. No. 8526	
Hot Flush Process	N	Y	Proj. No. 8526	
Booster Pumps	N	Y	Proj. No. 8526	
City Dewatering Facility	Y	Y	Proj. No. 8526	Under renovation
Sludge Storage	Y	Y	SC 8511R	
Heat Drying Facilities	N	N		

4.4.1.5.2. Primary Effluent Channel

The Primary Effluent Channel receives effluent from eleven primary settling tanks (PST) and conveys that flow for subsequent distribution to Activated Sludge Plants Nos. 1, 2 and 3. The structure consists of a rectangular shaped reinforced concrete open channel, approximately 1,500 feet in overall length, oriented on a north-south axis, east of the primary clarifiers. Flows from the primaries discharge into the channel. The south portion of the channel, which services PSTs Nos. 1 though 7, is 8 feet wide by about 13 feet deep. The channel crosses Willis Avenue, configured as a dual box conduit inverted siphon, about 240 feet in length (included in the overall length of 1,500 feet). Each box section is 7 feet high x 10 feet wide. The north portion of the channel, which services PSTs Nos. 8 though 11, is 12 feet wide and about 18 feet deep. The north portion of the channel is over 90 years old. The south portion and the inverted siphon are about 70 years old.

Plant Operations has identified limited leakage at a location along the exposed wall of the channel. This finding prompted the request to evaluate the entire channel. Examination of the normally exposed surfaces, including walkways and channel walls, indicates the need for repairs to the concrete, railings, etc. The visible exterior surface of the channel walls appears sound, although the majority of construction joints show evidence of previous leakage. None appear serious at this time.

Examination by diver was conducted to determine the condition of the channel below the water level and in the inverted siphon. The findings and recommendations have been summarized in a report.

The Primary Effluent Channel is a single link, conveying flow from the primary treatment facilities to the activated sludge/BNR plants, and subsequently to the filters and disinfection facilities. Lack of a redundant channel reduces the reliability of the plant. The City may want to consider providing a second Primary Effluent Channel to improve this situation.

Plant Operations has reported difficulty in balancing the distribution of flow to Activated Sludge Plant Nos. 2 and 3. This condition reportedly impacts BNR performance, and will likely have an even greater impact on the ability to optimize future ENR performance. Construction of a second Primary Effluent Channel would afford the opportunity to incorporate flow distribution facilities and additional distribution piping, to improve the balancing capabilities. Additional investigations will be conducted to develop a feasible concept.

4.4.1.5.3. Plant Effluent Outfall to Back River

The plant outfall is constructed of two parallel rows of sheet piling which form a 1,200-foot long open channel outfall into the river. Contract documents indicated the sheet piling conforms to ASTM Designation A-328 and is epoxy coated. The top is covered with a precast concrete deck, provided with railing to create a walkway along the entire length of the outfall. The invert is constructed of stone and gravel. Plant effluent is discharged through a series of diffuser ports located on either side of the outfall, and beginning about 700 feet from shore, and continuing to the end.

Plant Operations reports that the surface of the sheet piling shows evidence of "peeling". The outfall has been inspected and a report with recommendations has been submitted.

4.4.1.5.4. Plant Exterior Lighting

Plant Operations reports that areas of the plant lack adequate lighting. Deficient areas have been identified and recommended improvements have been submitted.

4.4.2. Patapsco Wastewater Treatment Plant

4.4.2.1. Introduction

The Patapsco Wastewater Treatment Plant is located at Wagners Point in the predominately industrial South Baltimore area of East Brooklyn. The plant site fronts the harbor portion of the Patapsco River, into which it discharges treated effluent. Delta Chemical, Shell Eastern Petroleum Products Corporation and the B&O Railroad are located to the south, north and west, respectively. The Patapsco River forms the eastern boundary. The industrial use of the surroundings is not expected to change in the futures. No historical or unique features are within or near the plant site.

The planning for a treatment plant at the existing site originally was begun in the 1920's, and the initial primary treatment plant, rated at 5 mgd, eventually was placed in service in 1940. In 1956 the plant was enlarged to 10 mgd, and in 1964 additional sludge digestion facilities were constructed. In 1969, the primary treatment plant was further enlarged to 15 mgd. Beginning in 1973, a major enlargement and upgrading of the plant was started which increased the treatment capacity to 70 mgd with secondary treatment completed in 1983. The expansion to 70 mgd also included enlarging the site to 65 acres through land reclamation and construction of a bulkhead in to the Patapsco River.

This expansion to 70 mgd provided secondary treatment using the covered pure oxygen activated sludge process. The selection of this process has offered a distinct advantage to the City, particularly in terms of minimizing the land area required for treatment, the ability to handle shock loads, and the degree of treatment provided.

After the upgrading and expansion of the plant was begun in the early 1970's, more stringent wastewater discharge requirements were established by the State of Maryland which limited the discharge of total phosphorus in the effluent to a concentration of 2 milligrams per liter (mg/L).

Several upgrades and expansions have taken place since the last comprehensive plan was published in 1984. The plant design capacity is 87.5 mgd. These include:

- addition of three new primary settling tanks,

- addition of two covered pure oxygen activated sludge trains and four (4) associated clarifiers,

- replacement of the screens in the screening building to four (4) sets of two (2) screens,

- addition of one gravity sludge thickening tank,

- and a heat drying facility was built for the pelletization of the gravity thickened and primary sludge. The heat drying and pelletization facility is a contracted facility currently run by Synagro Technologies, Inc.

4.4.2.2. Description of Existing Liquid Treatment Facilities

The Patapsco Wastewater Treatment Plant is divided into five functional treatment areas as presented below:

- Preliminary Treatment (head works, coarse grit removal, screening)
- Primary Treatment (settling)
- Secondary Treatment (pure oxygen activated sludge and secondary clarification)
- Disinfection and effluent discharge to the Patapsco River
- Sludge processing and disposal

In addition to the five functional areas, the plant has a number of utility systems, which are essential to the treatment process. These include wastewater and sludge pumping, flow monitoring, the electrical systems, chemical delivery systems and non-potable water systems. Figure 4-26 is a site plan of the Patapsco Plant that shows the existing facility. The plant is rated for a capacity of 87.5 mgd according to the draft MDE permit dated 2002.

Figure 4-27 is a schematic process diagram of the existing facilities for Patapsco Wastewater Treatment Plant. This figure shows the general relationships among unit operations, which are delineated, according to functional areas. Major internal recycle streams also are shown as well as sludge process flows and sludge process return flows.

The National Pollutant Discharge Elimination System (NPDES) permit sets monthly average loads to Patapsco River. Table 4-21 summarizes the annual average loading over a six-year period (1998-2003) and permit limitations.

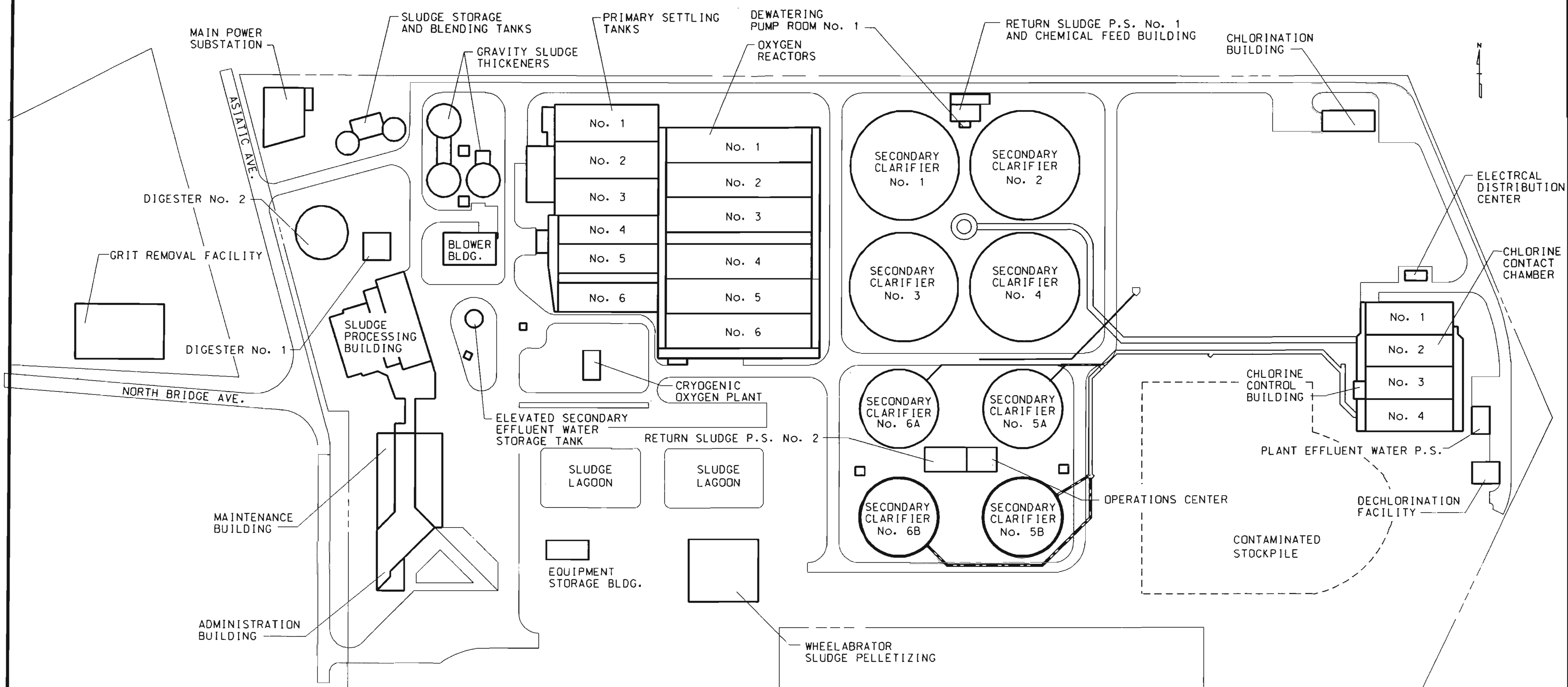
Raw wastewater enters the treatment plant through two influent sewers, a 54-inch gravity box sewer with a hydraulic capacity of 56 mgd termed the Low Level Interceptor, and a 96-inch diameter Southwest Diversion pressure sewer that carries the majority of the flow with a design capacity of 420 mgd.

4.4.2.2.1. Preliminary Treatment

The wastewater from the Southwest diversion passes through the grit removal tanks and is sent through fine screens prior to discharge into the primary sedimentation basins. The low-level wastewater flows via gravity to a wet well, at which point it is pumped into the fine screen building joining the wastewater from the Southwest Diversion tanks with the option of being bypassed to the primary settling tanks. The combined wastewater then flows through the fine screens and into the primary sedimentation tank influent channel.

4.4.2.2.1.1. The 96-inch Southwest Diversion Pressure Sewer

The Southwest Diversion is the principal influent sewer to the wastewater treatment plant. It is designed to flow full under the influence of an upstream



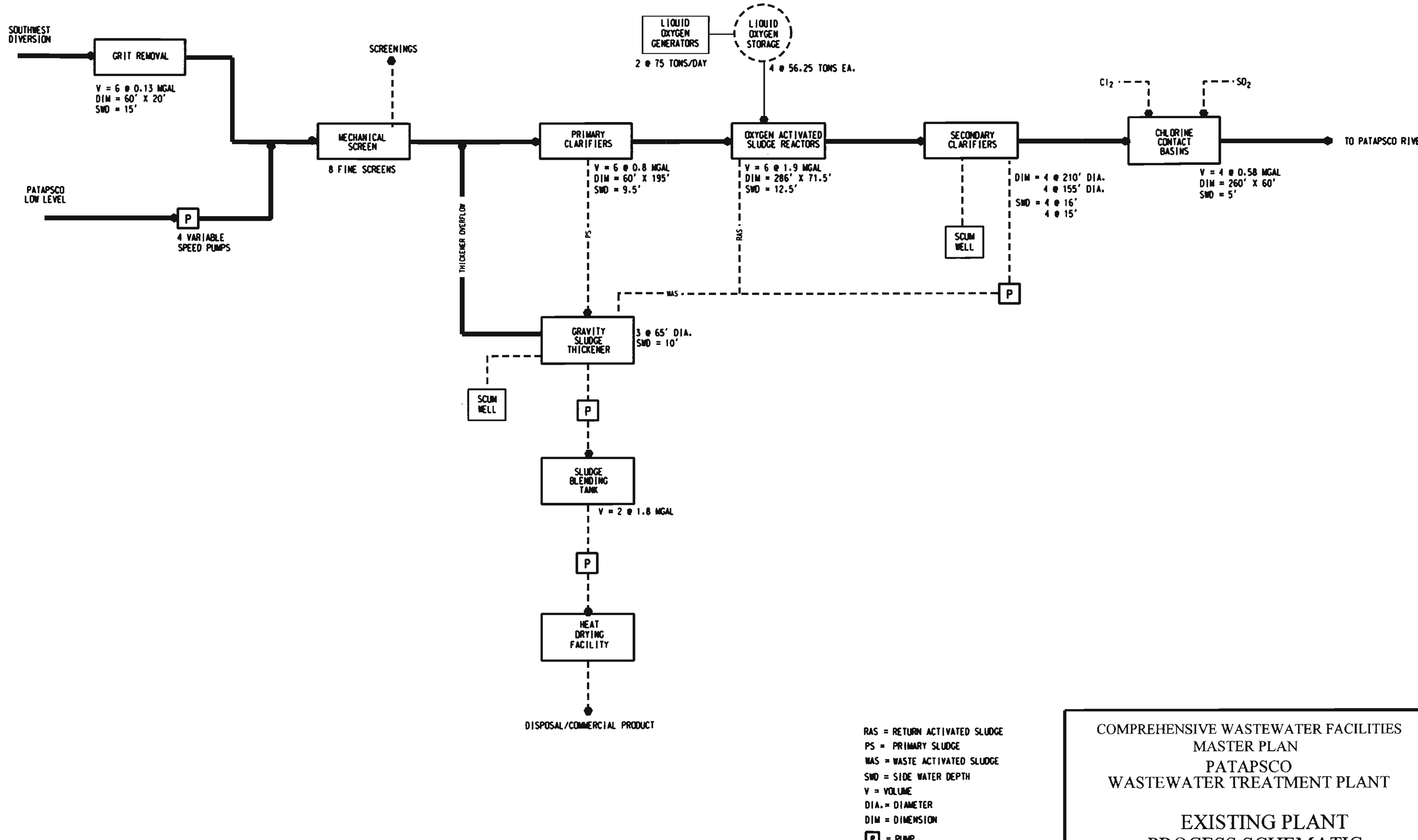
WHITMAN, REQUARDT AND ASSOCIATES, LLP

COMPREHENSIVE WASTEWATER FACILITIES MASTER PLAN

PATAPSCO WASTEWATER TREATMENT PLANT

SITE PLAN

DATE: APRIL 2004 | SCALE: 1"= 200' | FIGURE: 4-26



WHITMAN, REQUARDT AND ASSOCIATES, LLP

COMPREHENSIVE WASTEWATER FACILITIES MASTER PLAN

PATAPSCO WASTEWATER TREATMENT PLANT

EXISTING PLANT PROCESS SCHEMATIC

DATE: APRIL 2004 | SCALE: NONE | FIGURE: 4-27

TABLE 4-21

PATAPSCO WASTEWATER TREATMENT PLANT

PERMIT REQUIREMENTS AND PLANT PERFORMANCE

Parameters	Permit*	Annual Average Performance					
		1998	1999	2000	2001	2002	2003
Effluent Flow (MGD)	87.5	70	60	66	64	54	62
BOD_5 (lbs/day)	22000	3112	3153	3798	6779	4954	4809
TSS (lbs/day)	22000	4554	4053	6055	7473	4504	3258
TP (lbs/day)	1500	385	280	440	480	441	279
BOD_5 (mg/l)	30	5.3	6.3	6.9	12.7	11.0	9.3
TSS (mg/l)	30	7.8	8.1	11.0	14.0	10.0	6.3
TP (mg/l)	2.0	0.66	0.56	0.80	0.90	0.98	0.54

* Monthly Average Values for Permit expiring July 31, 1998

head capable of discharging the influent wastewater through the head works and through the remainder of the plant. The sewer within the plant site was constructed under SC 573 and placed in service in 1979.

4.4.2.2.1.2. Grit Removal Facility

Wastewater entering from the Southwest Diversion passes through the grit tanks prior to flowing into the meter chamber. There are six grit removal tanks each capable of handling a peak flow of 46 mgd. The tank dimensions are 60' x 20' x 15' deep. The facility was designed for the average flow of 70 mgd, however the maximum hydraulic capacity is 305 mgd. Two clamshells are provided to remove the grit in the tanks as it accumulates. The facility is ventilated for odor control purposes. The foul air is blown through an on-site biofilter. The grit is collected and disposed of in a sanitary landfill.

The facility was designed in 1992 under SC 713. Based on inspections, the facility is good shape and requires no improvements. The monthly quantities of grit removed are listed in Table 4-22 along with the annual average for the years between 1998 – 2003.

It is reported that H_2S (hydrogen sulfide) levels are excessive. This condition should be investigated to determine the need for improved ventilation, or measures to reduce H_2S generation.

4.4.2.2.1.3. Meter Chamber

Influent flow in the Southwest Diversion is measured by a Venturi meter located in the meter chamber building to the east of the sludge processing building. The measuring range of the existing flow recorder extends to 275 mgd. Once the wastewater has passed through the grit tanks it passes through the meter chamber.

TABLE 4-22
PATAPSCO WASTEWATER TREATMENT PLANT
GRIT CHAMBER SOLIDS PRODUCTION

	Average Daily Solids Production (wet tons/day, WTPD)					
Year	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**
January	0.6	0.0	0.0	1.6	0.0	1.2
February	0.4	0.0	0.0	0.0	6.0	0.8
March	0.0	0.3	0.0	2.1	2.3	0.6
April	0.0	0.0	0.9	4.3	11.5	2.8
May	0.9	0.4	4.5	0.3	1.4	1.9
June	0.0	0.0	0.5	16.5	3.2	1.3
July	0.0	1.2	0.0	1.7	0.9	2.7
August	0.0	0.3	1.1	0.8	0.3	1.2
September	0.0	0.0	1.8	0.7	1.8	1.3
October	0.0	0.0	1.9	18.7	0.0	4.7
November	0.0	1.2	0.0	1.7	0.5	0.0
December	0.0	1.2	0.9	15.0	0.5	0.0
Average	0.2	0.4	1.0	5.3	2.4	1.5
Max	0.9	1.2	4.5	18.7	11.5	4.7
WTPD/MGD wastewater	0.002	0.006	0.014	0.083	0.037	0.021

The meter chamber was found to be in fair condition, however, some poor conditions existed within the building. Inspections found the roof to the meter chamber to be leaking. Also, one of the two sump pumps was missing.

4.4.2.2.1.4. Junction Chamber

Wastewater exiting the meter chamber passes through a square junction chamber that once served as a means for grit removal and chemical addition.

The junction chamber is in poor condition; however, it is no longer used as mentioned. The clam shell bucket used to remove grit is no longer in place. The chlorine injection pumps and diffusers are not working, but are no longer used. The monorail, trolley and hoist are in fair condition, but are no longer required.

4.4.2.2.1.5. Low Level Pumping Station

Wastewater reaching the plant through the 54-inch gravity box sewer arrives at the original headworks of the plant located at the Pump and Blower Building. The flow passes over a depression designed to entrap coarse grit for periodic removal by a clam shell bucket. This wastewater then passes through one of two screens that are currently out of service. All screenings and grit are ultimately disposed of in a landfill. The wastewater then enters a horizontal wet well, which is actually a continuation of the box sewer. The wastewater is then pumped by one of four variable speed raw sewage pumps. Only one of the four lift pumps is placed in service during normal conditions. The variable speed pump is adequate for handling the Low Level wastewater flow rates. This wet well within the Low Level pumping station is designed to double as a grit removal tank and is checked weekly for solids build up. A clamshell scoop is located locally to remove any build up of solids. The pumped wastewater can then be directed to either the primary settling tank influent channel or the forebay of the screen house. The current practice is to pump the wastewater into the screen house for fine screening prior to entry to the primary settling tanks.

The inspection of the Pump and Blower Building revealed many shortcomings. Architecturally, there were several broken windows, a leaking roof, and the sky lights require maintenance. It is also suggested that a dedicated locker and shower facility be constructed rather than using space next to the motor control center. Neither of the two screens was in service. It is recommended that these be replaced. Also found in poor condition were the clam shell dredging buckets and motors, 36-inch primary gate valve, gas detection system, chart recorders, both Venturi flow meters, hydrogen sulfide meters, combustible gas meters, toxic gas detector and the exhaust fans.

4.4.2.2.1.6. Mechanical Fine Screens

Wastewater from the 96-inch Southwest Diversion flows into the forebay of the screen house. Additionally the Low Level wastewater is pumped into this forebay. A total of eight mechanically cleaned fine screens exist and are capable of handling up to 42.5 mgd per screen for a total of 340 mgd. Four channels with two screens per channel exist. Following the fine screens, the wastewater flows via gravity into the common primary influent channel. Average daily totals of wet screenings removed by the mechanical fine screens are listed in Table 4-23. Also listed are the annual averages for the years between 1998 – 2003. For the years shown, the quantity of screenings per plant flow has stayed relatively constant.

Inspection of the mechanical fine screens indicates that they are in poor condition and should be replaced. Many of the motors are in poor condition and should be replaced when possible. Several of the effluent screen gates appear to be in disrepair or haphazardly rigged to stay in the open position.

TABLE 4-23
PATAPSCO WASTEWATER TREATMENT PLANT
SCREEN PRODUCTION

	Mechanical Screenings (wet tons/day, WTPD)					
Year	1998	1999	2000	2001	2002	2003
January	2.8	2.5	0.9	0.0	2.6	1.1
February	0.6	1.0	4.6	2.1	0.8	1.9
March	1.1	1.4	2.8	0.5	2.7	1.7
April	1.0	2.3	2.9	0.8	2.1	0.8
May	0.8	0.9	0.6	1.0	6.2	1.2
June	0.6	0.9	1.1	2.2	1.5	4.3
July	1.6	1.2	1.7	2.2	1.5	1.2
August	0.2	0.9	0.7	4.4	1.4	3.5
September	2.0	0.2	1.7	2.2	3.4	1.3
October	1.8	2.5	2.7	2.5	1.4	3.0
November	3.3	0.8	4.7	0.1	1.3	2.8
December	2.5	2.5	0.5	2.4	3.0	0.6
Avg	1.5	1.4	2.1	1.7	2.3	2.0
Max	3.3	2.5	4.7	4.4	6.2	4.3
WTPD/MGD wastewater	0.022	0.024	0.031	0.026	0.037	0.027

4.4.2.2.2. Primary Treatment

Primary treatment is accomplished through physical removal of suspended solids in the six primary settling tanks (PSTs). Also included in the primary treatment equipment are the primary sludge pumps. Twelve pumps provide for the transfer of sludge from the settling tanks to the gravity sludge thickeners (GSTs). The wastewater entering the PSTs has undergone preliminary grit removal and mechanical screening to eliminate larger/ heavier materials. The PSTs provide a quiescent zone that allows a portion of the remaining suspended material to settle.

4.4.2.2.2.1. Primary Settling Tanks

Of the six existing PSTs, three were constructed under SC 556 while the remaining three were constructed under SC 686. All six were designed for a 17.5 mgd. The dimensions of the rectangular PSTs are approximately 60'x 195' with a sidewall depth of 9.5 feet. At the design weir loading approximately 50-70% of the suspended solids are removed. Additionally, the BOD_5 removal rate is between 25% and 40%.

Each of the three PSTs constructed under SC 556 has recently been upgraded with new chain and flight mechanisms. The flights scrape sludge continually from the effluent end of the tank toward the influent end. When the flights reach the influent end, they return at the surface to the effluent end of the tank. On the return they skim the scum to a trough located at the effluent end of the tank. The collected sludge accumulates at the influent end of the tank and a helical screw cross collector conveys the primary sludge into the sludge hopper from where it is pumped to the GSTs.

The remaining three PSTs, constructed under SC 686, were originally and still are equipped with chain and flight mechanisms to remove both sludge and scum from the tanks and operate in a manner similar to the other PSTs.

Twelve pumps exist to transfer the collected sludge to the sludge handling facilities. The newer PSTs constructed under SC 686 incorporate eight vortex type pumps. Six of the pumps are used at any given time leaving the remaining two pumps as spares. The older PSTs constructed under SC 556 incorporate 4 pumps. Three of the pumps are used, leaving one as a spare.

The primary settling tanks and associated pumping station were found to be in fair condition. The inspection report shown in Appendix XV goes into more detail on the specific components of the facility. Specifically, the electrical gear for the original primary sludge pumping station will probably need to be replaced in less than 10 years. Additionally, the influent and effluent slide gates and motors, cross collector screw conveyors and instrumentation may require replacement/rehabilitation within the next 10 to 20 years. While the inspection report in the appendix notes that the scum collection and disposal system is in disrepair, this system is being rehabilitated and/or replaced under Sanitary Contract 7515 and is therefore not mentioned under this report.

4.4.2.2.3. Secondary Treatment

Secondary treatment consists of six covered pure oxygen activated sludge reactors and eight secondary clarifiers. Pure oxygen activated sludge systems are designed for the removal of biochemical oxygen demand measured as BOD_5 and total suspended solids (TSS). In addition to these design considerations all six reactors have either been built or modified to provide biological phosphorous removal using the anaerobic / oxic (AO) process. Ancillary equipment involved in the secondary treatment of the wastewater include: the return sludge (RAS) and waste activated sludge (WAS) pumping stations, various chemical feed pumps for enhanced settling, instrumentation and controls.

4.4.2.2.3.1. Oxygen Activated Sludge Reactors

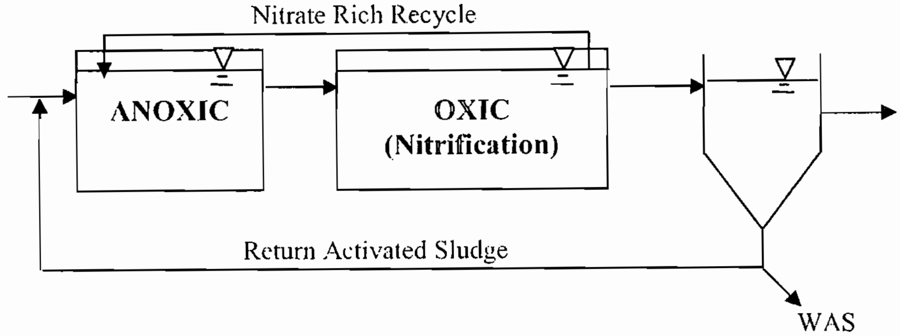
The covered pure oxygen activated sludge system consists of two main components, (1) the biological reactors and (2) the cryogenic oxygen plant. The initial four oxygen activated sludge reactors were built under SC 582. These reactors were sized to provide a 2 hour hydraulic retention time at the average plant flow rate of 70 mgd plus 25% return sludge. Two additional reactors were constructed under SC 690 to increase the capacity to 87.5 mgd, with one reactor out of service. Each reactor is capable of treating at a peak capacity of 25 mgd or a total of 150 mgd. All six reactors measure approximately 286' (71.5' per 4 stages) in length, 71.5' wide with 12.5' sidewall depth. The oxygen activated sludge reactors are covered concrete tanks. The high purity oxygen air is pumped into the reactors and makes up the atmosphere in the gas space above the water surface. The atmosphere is kept slightly above atmospheric pressure to facilitate the flow of oxygen through the entire length of the reactors. Oxygen is transferred into the mixed liquor by a series of surface aerators ranging in size from 75 HP to 150 HP.

Wastewater leaving the primary settling tanks enters the common influent channel of the six oxygen activated sludge reactors. Each reactor is split into 4 stages. The first stage of each reactor operates as an anaerobic zone and is further divided into four cells that provide plug flow and minimize wastewater short-circuiting. As stated earlier the primary purpose of the secondary reactors is to remove BOD_5 and TSS with an upgrade to remove phosphorous biologically. The process used to accomplish the phosphorous removal is termed the anaerobic / oxic (AO) process. Wastewater entering the reactors from the primary settling tanks along with return sludge from the secondary clarifiers is introduced into the first of four stages within the reactor. The first stage, which is split into 4 cells is merely mixed and has no supplemental oxygen present. This encourages an anaerobic environment or one in which is devoid of oxygen. The following stages are all oxic, or aerobic. These stages are also mixed and contain pure oxygen in the atmosphere above the liquid level.

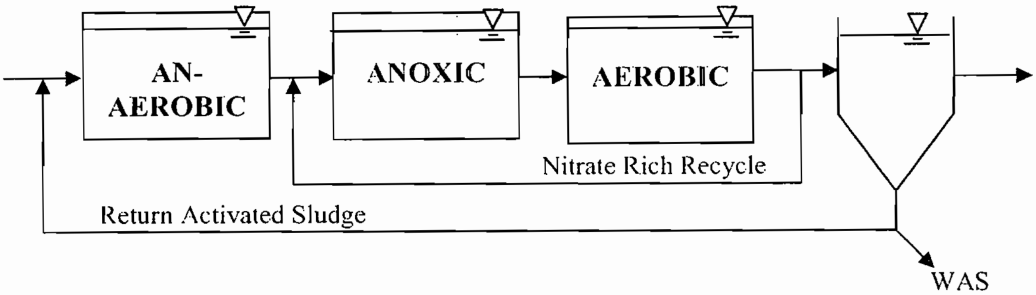
The biological process, which removes the phosphorous from the wastewater, is called luxury uptake. By depriving the bacteria in the first stage of oxygen, the bacteria actually release their internal phosphorous in order to transport organics in through their cell wall. Upon entering the aerobic or oxic stages the bacteria, starved of phosphorous, take up more phosphorous than they once held, thereby producing a net removal of phosphorous, and reducing the overall phosphorous content in the wastewater. Phosphorous is removed continuously from the process by wasting activated sludge.

Reactor No. 6 was constructed with the additional capability of recycling internally from stage 4 of the reactor back to either the first or second stage of the reactor. This capability allows this reactor to operate in two different modes. These modes are termed the Modified Ludzack-Ettinger (MLE) and A^2O processes. Both modes promote denitrification in the reactor. By enabling denitrification, the overall nitrogen content of the wastewater can be reduced. The Modified Ludzack-Ettinger process, depicted below, is designed to use the nitrate produced in the oxic zone as an electron acceptor for the facultative bacteria in the anoxic basin. The first stage in the treatment train is the anoxic zone where influent wastewater, return sludge from the clarifier, and nitrate-rich mixed liquor pumped from the effluent end of the aeration tanks are mixed together. The influent wastewater serves as the carbon source for denitrifying bacteria, return activated sludge from the clarifier provides microorganisms, and the internal recycle pumps provide a nitrate-rich wastewater to be used as an electron acceptor by the facultative bacteria.

The A^2O process, depicted below, is similar to the MLE process, but with the addition of the anaerobic stage prior to the anoxic stage that receives the nitrate rich recycles from the aerobic stage.



MODIFIED LUDZACK-ETTINGER PROCESS



A^2O PROCESS

Each of the six reactors has a purge blower located above the first cell that is automatically controlled to blow air into the reactor to displace the gas volume in the event that a combustible gas mixture of oxygen and volatile hydrocarbons form. If the lower explosion limit (LEL) reaches 25%, the blowers automatically turn on. If the LEL reaches 50%, the entire reactor is automatically shut down. Discharge air through the blowers is controlled by butterfly type purge air valves. All valves operate in conjunction with their related purge air blower.

Renovations to the secondary reactors are in progress under SC 7522. The modifications recommended in the inspection survey in Appendix XV will be made under this Contract. The scope of SC 7522 includes aerator deck plate modifications, replacement of the effluent weir boxes in Reactors Nos. 1-4, influent slide gate rehabilitation, upgrading the scum removal system, aerator gear box upgrades, new instrumentation and control for the influent flow, RAS flow and A/O control panel integration with the plants existing Bailey Fisher-Porter distributive control system (DCS).

4.4.2.2.3.2. Oxygen Generators

The cryogenic oxygen plant produces the pure oxygen for treatment through the liquefaction of the air followed by fractional distillation to separate the oxygen from the other components of the liquefied air. The designs for Reactors Nos. 1- 4 indicate that in order to maintain the desired dissolved oxygen in the mixed liquor at 70 mgd, approximately 75.9 tons per day of oxygen are required. Two modular cryogenic oxygen plants exist, each with capacity of 75 tons per day. In addition, four liquid oxygen storage tanks are provided with a total storage capacity of 225 tons. This arrangement gives the plant the required standby capacity and has taken advantage of the economies of scale in selecting larger sized modular units. Therefore, the Patapsco plant has excess oxygen capacity, which increases its reliability. No additional oxygen generating capacity was provided when Reactors Nos. 5 and 6 were constructed. The oxygen generators are currently operated and maintained through a City Contract with Lotepro Environmental Systems and Services Company. It is recommended that this contract be extended through the planning period.

4.4.2.2.3.3. Secondary Clarifiers

Mixed liquor from Reactors Nos. 1-4 flows into a common mixed liquor flume to the circular distribution chamber which splits the flow into the four secondary clarifiers. The mixed liquor flume is an open, rectangular channel. The flume serves a dual purpose of conveying the wastewater to the secondary clarifiers and acting as a mixing chamber for chemical addition of cationic polyelectrolytes and liquid ferric chloride, which can be added as flocculent to aid in gravity settling in the secondary clarifiers. Chemical addition is only intended for use during periods of excessive solids carry-over from the reactors and then only as long as it takes to complete corrective action. Mixing is accomplished in the mixed liquor flume and by diffused air that is injected through a series of headers and diffusers located in the bottom of the flume. The diffused air also helps to maintain the dissolved oxygen level in the mixed liquor as it enters the secondary clarifiers. Reactors Nos. 5 and 6 each discharge mixed liquor into one of two 66-inch mixed liquor effluent pipelines. The 66-inch pipes terminate at one of two distribution boxes. Once in the distribution box, the mixed liquor is directed to the four secondary clarifiers dedicated to these reactors.

Secondary Reactors Nos. 5 and 6 built under S.C. 690 have four (4)-dedicated clarifiers, which under normal conditions are all operational provided their reactors are online. For Reactors Nos. 1 through 4 built under S.C. 582, only one clarifier per reactor is placed in service. Due to the common mixed liquor flume, distribution box, and return sludge system, however, the clarifiers are not specific to the reactors. To avoid an extended detention time in the clarifiers, which has shown deleterious effects on TSS removal; a minimum of 17 mgd is placed through the each clarifier at any given time. Clarifiers Nos. 1 – 4 were designed for an average overflow rate of 600 gpd/ft^2 and a peak overflow rate of 1200 gpd/ft^2. The result was four clarifiers 210 feet in diameter with 16 feet side wall depth. Clarifiers Nos. 5A, 5B, 6A, and 6B were designed for an average overflow rate of 539 gpd/ft^2 and a peak overflow rate of 757 gpd/ft^2. The result of this design was four clarifiers 155' in diameter with a sidewall depth of 15 feet.

Mixed liquor enters the clarifiers through a center feed well and flows radially outward to the peripheral weirs where the clarified secondary effluent is discharged. For Clarifiers Nos. 1 – 4, the settled sludge is collected by a four rake-arm mechanism having a piping system which provides rapid sludge draw off by siphon for gravity return to the sludge wet well in the Return Sludge Pumping Station No. 1. From the pumping station, the sludge is either returned to the head of the reactors as return activated sludge (RAS) or it pumped to the GST as waste activated sludge (WAS). Skimming blades are provided to move scum floating on the water surface of the clarifiers to scum troughs within the inboard and peripheral launders of Clarifiers Nos. 1-4. The scum then flows through piping into scum pits. For Clarifiers Nos. 1-4 there are two such scum manholes per clarifier. Each pit has a mixer and a pump used to pump the scum to the sludge processing building. Under SC 7515, this procedure will be changed such that a vac-truck will periodically clear all scum from these pits.

For Clarifiers Nos. 5A, 5B, 6A and 6B; the settled sludge is collected by a two rake arm mechanisms having a piping system which provides rapid sludge draw off by siphon for gravity return to RAS Pumping Station No. 2. Additionally, scraper blades on the rake arm mechanisms move the settled sludge toward the center well of the clarifier. A 12-inch suction line from this sump takes bottom sludge to the waste activated sludge pumps in RAS Pumping Station No. 2. Skimming blades are provided to move scum floating on the water surface of the clarifiers to scum pit within the inboard launder of the clarifier. The scum then flows via gravity to a scum well. Each clarifier has one scum pit with its associated sump. Each sump has a mixer, pump and make up water to help with the flow of the scum. The scum is pumped into a scum well located in the return sludge pump station. From the scum well the scum is pumped into the existing 6-inch scum line and onto the sludge processing building. Under SC 758, this practice will be replaced by the periodic removal of scum from these sumps and wells by a vac-truck.

The secondary clarifiers were found to be in fair condition. The scum pumps are all relatively new however the scum lines required cleaning out to provide unimpeded flow for the scum pumps. This may not be necessary however if the new practice of using a vac-truck is successful.

4.4.2.2.3.4. <u>Return Activated Sludge (RAS)</u>

Clarifiers Nos. 1 – 4 have their own RAS Pumping Station, RSPS No. 1. There are five RAS pumps in this pumping station. Under normal conditions only three are in use at any given time leaving two pumps as back up. These pumps are the centrifugal type with variable speed drives to allow for changes in water quality and flow rates. The pumps convey RAS through a common return line to the head of the reactors. RAS is distributed amongst oxygen Reactors Nos. 1 – 4. RAS is discharged into the first cell of each reactor.

Clarifiers' Nos. 5A, 5B, 6A and 6B collectively have there own RAS Pumping Station, RSPS No. 2. This pumping station houses eight RAS pumps used for these four clarifiers. Four of the pumps are standby pumps to the primary four pumps. Each pump is the centrifugal type with a variable speed drive. Each of the four primary RAS pumps has a separate return line entering into the first cell of the first stage of their associated oxygen reactors. This enables Reactors Nos. 5 and 6 to be operated at different RAS rates and therefore different SRT's.
Under SC 7522, the RAS discharge piping was all cross-connected in the West Gallery. This affords the plant flexibility in returning sludge into any of the six oxygen activated sludge reactors.

4.4.2.2.3.5. <u>Waste Activated Sludge (WAS)</u>

The practice of wasting sludge is highly variable and is impacted by many conditions including seasonal changes and loading conditions. Return Sludge Pumping Station No. 1, which services clarifiers and reactors Nos. 1-4, has three WAS pumps. The WAS is pumped into the gravity sludge thickeners. RSPS No. 2, which services clarifiers and reactors Nos. 5-6, has six WAS pumps. Each clarifier (Nos. 5A, 5B, 6A and 6B) has a dedicated WAS pump, the other two pumps serve as backup pumps for the primary WAS pump for any of the four clarifiers. The WAS is in turn pumped into the gravity sludge thickeners.

Under SC 7522, three inactive pumps in the West gallery have been refurbished and connected to the RAS header. These pumps will have the capability of pumping RAS to one of the old digesters to store RAS if this operational scenario is necessary.

The RSPS No. 1 (original pumping station), was found to be in poor condition, while RSPS No. 2 was in fair condition. Some of the issues found in RSPS No. 1 include but are not limited to: older electrical gear, temporary WAS pumps, RAS pumps that all leak sealing water and instrumentation that is not working or not working well. The detailed report can be seen in Appendix XV. Another issue that was found was the disrepair of the West Gallery. This area was reported to be in poor condition due in large part to the failing booster pumps, strainers and instrumentation.

4.4.2.2.4. Chlorination

Two different locations exist for the single point chlorination of the secondary effluent. On the SC 582 side of the plant, chlorine is added in the effluent distribution box. Chlorination on the SC 690 side takes place where the two reactor effluent flumes are joined en route to the chlorine contact tanks. Single point chlorination is the normal practice, however the option is available for multi-point chlorination. The dosage rate of chlorine is based upon meeting a residual between 0.5 and 1.0 part per million (ppm) of chlorine. The dosage range is manually set based upon flow rates of secondary effluent and is adjusted manually in the event of increased or decreased effluent flow. Mixers are also available within the chlorine contact chambers, however under normal conditions are not utilized.

There are four three-pass chlorine contact chambers. The length of the contact chamber is approximately 260 feet by 60 feet wide per chamber and a side water depth of 15 feet. The resultant volume provides a hydraulic residence time of approximately 45 minutes at an average flow rate of 70 mgd.

Liquid chlorine passes through one of the four 6.000 lbs/day evaporators. The evaporator converts the liquid chlorine to gas that is diffused into the secondary effluent prior to the chlorine contact chambers. Chlorine eductors controls the rate of chlorine gas feed and creates a chlorine solution.

The HPEW Pumping Station was inspected and found to be in fair condition. The major issue in this area is the disrepair of the HVAC system. Another potential issue is the chlorine injectors which appear somewhat worn and will require replacement within the planning period. Other problems found in this facility were the maintenance problems with the many analyzers, including the chlorine and dissolved oxygen. At the time of the inspection this analysis was being conducted manually.

The HPEW Pumping Station was found to be in poor condition. The existing chlorinators and evaporator are old and will require replacement within the planning period.

4.4.2.2.5. Dechlorination

After the chlorinated effluent goes over the chlorine contact chamber weir, sulfur dioxide is added to de-chlorinate the water prior to discharge into the Patapsco River. The dosage of sulfur dioxide is typically set at 90% of the chlorine dosage. Liquid sulfur dioxide is fed to one of two 2,000-lb/day sulfurators to create a gaseous mixture which is diffused into the plant effluent. The reaction time to reduce the residual chlorine is less than 2 minutes. Once dechlorinated, the effluent is fed via gravity into the plant outfall.

The dechlorination facility was found to be in fair condition. Some of the instrumentation needed replacing and the storage of sulfur dioxide cylinders was found to be very labor intensive.

4.4.2.2.6. Plant Effluent Recycle

A portion of the chlorinated plant effluent is retained for use in the various processes including spray water for foam control and dilution water for the gravity sludge thickening and others. The plant effluent recycle system consists of the effluent water pumping station and the elevated storage tank. The pumping station is broken into two demands, low service and high service. Low service water is used for low-pressure services such as spray water control for foaming and other places where potable water is not required, while the high service water is used for high-pressure spray, hydrants and flushing water. The high-pressure service is pumped into the elevated storage tank. The elevated storage tank has a 300,000-gallon capacity.

The inspection of this facility indicated that many of the mechanical components were in disrepair. The pumps were in fair condition, gate valves were in poor condition, all of the sampling and analyzers were out of service and sealing water pumps and motors were in poor condition. It is our recommendation that this facility be rehabilitated within the planning period.

4.4.2.3. Description of Existing Solids Handling

As previously shown in Figure 4-27, solids are produced in the liquid treatment facilities. Primary and waste activated sludge are collected and pumped into the gravity sludge thickeners (GST's). The thickened sludge is then pumped to the sludge blending tanks where it is metered to a heat drying pelletizing facility for final disposal. Scum handling facilities at the clarifiers are inoperative. According to plant operators scum builds up until it is vacuumed out or until the tank is taken out of service. When the tank is drained the scum is washed back to the head of the plant.

4.4.2.3.1. Raw Sludge Pumping

Raw primary sludge (PS) is pumped from the primary settling tanks to the GSTs. Primary Sludge is scraped from the bottom of the primary settling tanks and is then conveyed through screw conveyors to the suction of the PS pumps. Twelve PS pumps are provided. PS pumps Nos. 1-4 are dedicated to PST's Nos. 1- 3. PS pumps 5-12 are dedicated to PST's Nos. 4-6. WAS pumps are provided in the return activated sludge pumping stations (No. 1 and No. 2). A total of six WAS pumps are provided for Clarifiers Nos. 5A, 5B, 6A and 6B. Three WAS pumps are provided for the original four secondary clarifiers, Nos. 1, 2, 3 and 4.

4.4.2.3.2. Scum Pumping

Several unit treatment processes produce scum and therefore have scum pumps associated with them. All of the scum pumps currently discharge into the GST's. The following is a list of the scum pumps along with their associated process.

Process	Number	Type	Flow Capacity	TDH
PST's 1-3	2	Horizontal vortex	200 gpm	15'
PST's 1-3	2	Horizontal vortex	150 gpm	27'
PST's 3-6	2	Horizontal vortex	200 gpm	18.5'
Secondary Clarifiers 1-4	8	Submersible	100 gpm	50'
Secondary Clarifiers 5 – 6	4	Submersible	150 gpm	22'
RSPS No. 2 – Transfer Pumps	2	Centrifugal	150 gpm	50'
Chlorine Contact Basins	1	Submersible	100 gpm	50'

The scum pumping, mixing and transfer system is in disrepair across the entire plant. Under several ongoing Sanitary Contracts, a new operational plan has been developed for scum disposal. The existing scum transfer pumps will become obsolete. Instead, a vac-truck will periodically draw scum from the various scum wells around the plant and deliver this to a proposed treatment facility to be designed under SC 578 currently in the preliminary design phase. The treatment facility will remove the water from the scum. Ultimate disposal of this dewatered scum is still undecided. Plans of land filling as well as burning for fuel have been discussed.

4.4.2.3.3. Gravity Sludge Thickeners (GST)

Two existing gravity thickeners are provided and a third was under construction during the writing of this plan as a part of SC 7515. The two existing GST's are designed for a solids loading of 20 $lbs/ft^2/day$ and a hydraulic loading of 800 gpd/ft^2. The dimensions of the gravity thickeners are 65' diameter with a 10' sidewall depth. The current and future use of the GST's involves using one to thicken PS and the other to thicken WAS. The third GST will serve as a back up for the other two.

Upon inspection of the GST facility in 1997 it was found to be in poor condition. This facility has since been under rehabilitation and deficiencies have been addressed (SC 7515).

4.4.2.3.4. Thickened Sludge Pumping

Six thickened sludge pumps are provided for pumping the thickened sludge from the three GST's. Each GST has two sludge pumps dedicated for its service. These pumps send the thickened sludge to one of two sludge blending tanks.

4.4.2.3.5. Sludge Blending Tanks and Transfer Pumps

Two sludge blending tanks are provided for blending and storing the thickened sludge prior to being discharged to the heat drying facility. These blending tanks are in the process of being rehabilitated under Sanitary Contract 7515. Each storage tank has a volume of approximately 244,000 cubic feet (1.8 million gallons). The tanks are aerated using compressed air and diffusers. Additionally, under SC 7515 a new recirculation system is being installed to better mix the sludge. Three recirculation pumps are provided for both tanks. The blended sludge is pumped from the tanks into the heat drying facility by way of one of three progressing cavity type positive displacement pump.

The overall condition of the sludge blending and storage tanks and pumps was poor at the time of inspection. However, the facility is currently being renovated under SC 7515 and the issues identified in the inspection report are being addressed.

4.4.2.3.6. Heat Drying Facility

A sludge heat drying pelletization facility is provided to handle all sludge produced on site. The facility is operated through a City contract with Synagro Technologies, Inc. The contract facility has two units with the capacity to handle the solids generated from flows up to 137 mgd. The facility is contracted to take all solids generated at the Patapsco WWTP. The pelletization facility is currently required to take in sludge up to the guaranteed daily peak processing capacity of 54.8 dry tons. The City can send additional quantities if 24-hour notice is provided. Solids content must meet or exceed approximately 1.5% according to the contract documents. Synagro dries the solids in large rotating kilns and produces pellets that are then commercially packaged for sale. The City also has back up in case Synagro is unable to heat dry the solids, the City has the capability to dewater the solids using a centrifuge and then land apply the solids. Under the agreement with

Synagro, they can then deliver these dewatered solids to have Synagro dispose of them through the various land application contracts that they have.

It is recommended for the planning period that the heat drying be continued for solids dewatering and disposal.

4.4.2.3.7. Sludge Production

Table 4-24 lists the total daily average solids generated by the plant and pumped to the sludge blending tanks (SBTs) for a six year period. The quantity of solids pumped to the SBTs, is in turn pumped to the Heat Drying Facility. Figure 4-28 graphically depicts these solids as well as the incoming total suspended solids in the wastewater influent. As shown on this graph there is no trend of solids loss as seen in the Back River Wastewater Treatment Plant. The incoming TSS as well as the solids generated are relatively similar over the five-year (1997 – 2003) period shown.

4.4.2.4. Summary of Plant Conditions

A detailed inspection was conducted on the facilities at Patapsco Wastewater Treatment Plant. The findings of this inspection are located in Appendix XV. Table 4-25 summarizes the findings of this inspection report and subsequent inspections. The summary table identifies all unit processes at Patapsco WWTP and their status based upon the inspections. The summary table also includes the sanitary contract or project number assigned for those facilities undergoing rehabilitation.

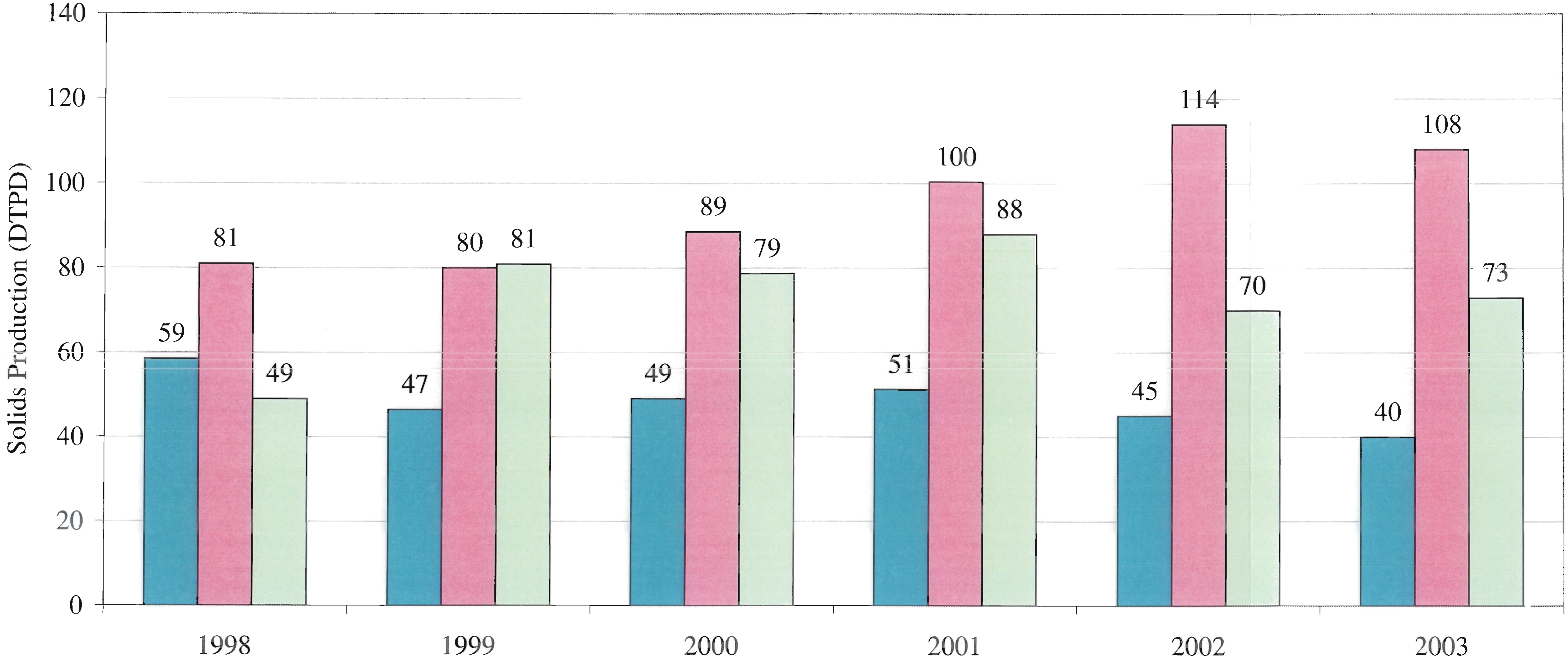
TABLE 4-24

PATAPSCO WASTEWATER TREATMENT PLANT

FEED SLUDGE TO SLUDGE BLENDING TANKS

	Average Daily Sludge Production (GST, WAS, PS) (dry tons/ day, DTPD)*					
Month	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**
January	40	83	78	112	58	77
February	50	69	92	103	64	70
March	56	75	83	105	54	72
April	70	86	78	95	73	60
May	69	82	75	84	57	67
June	68	81	77	109	71	74
July	43	81	75	75	66	68
August	37	74	84	87	67	82
September	41	87	71	75	70	66
October	44	87	74	70	87	82
November	40	82	82	71	82	81
December	33	81	75	70	87	72
Annual Average Sludge	49	81	79	88	70	73
Annual Maximum Sludge	70	87	92	112	87	82
Annual Average Sludge / Annual Average Flow (DTPD/MGD)	0.70	1.35	1.19	1.38	1.10	1.02
Annual Maximum Sludge / Annual Average Sludge	1.43	1.08	1.17	1.27	1.25	1.13

* Not all sludge is thickened prior to being pumped into sludge blending tanks (SBT's)



COMPREHENSIVE WASTEWATER FACILITIES
MASTER PLAN
PATAPSCO
WASTEWATER TREATMENT PLANT

SUMMARY OF ANNUAL SOLIDS PRODUCTION

DATE: APRIL 2004	FIGURE 4-28

TABLE 4-25

PATAPSCO WASTEWATER TREATMENT PLANT

SUMMARY OF TREATMENT PLANT EVALUATIONS

Unit Process	Improvements Required	Improvements in Progress	Sanitary Contract No. / Project No.	Remarks
PRELIMINARY TREATMENT				
Grit Chambers	Y	Y	SC 767	Odor Control Improvements in design phase
Meter Chamber	Y	N		Improvements not immediately necessary
Low Level Pumping Station	Y	Y	SC 578	Currently In Design Phase
Mechanical Fine Screen	Y	N		Improvements not immediately necessary
PRIMARY TREATMENT				
Primary Clarifiers	N			Improvements not immediately necessary
SECONDARY TREATMENT				
Oxygen Activated Sludge 582	Y	Y	SC 7522	Currently Under Construction
Secondary Clarifiers 582	N			
Oxygen Activated Sludge 690	N			
Secondary Clarifiers 690	N			
RSPS No. 1	Y	Y	Proj. No. 929	City evaluating Statement of Qualifications
RSPS No. 2	N			

TABLE 4-25

PATAPSCO WASTEWATER TREATMENT PLANT

SUMMARY OF TREATMENT PLANT EVALUATIONS

Unit Process	Improvements Required	Improvements in Progress	Sanitary Contract No. / Project No.	Remarks
DISINFECTION				
Chlorination	Y	N		
Dechlorination	Y	N		Improvements not immediately necessary
SOLIDS HANDLING				
GST's	Y	Y	SC 758	Currently Under Construction
Sludge Blending Tanks	Y	Y	SC 758	Currently Under Construction

CITY OF BALTIMORE
DEPARTMENT OF PUBLIC WORKS
Water and Wastewater Engineering Division

COMPREHENSIVE WASTEWATER FACILITIES MASTER PLAN

VOLUME 2 OF 2

APRIL 2004

WHITMAN, REQUARDT AND ASSOCIATES, LLP
Baltimore, Maryland

WR&A

CITY OF BALTIMORE
DEPARTMENT OF PUBLIC WORKS
Water and Wastewater Engineering Division

COMPREHENSIVE WASTEWATER FACILITIES MASTER PLAN

VOLUME 1

VOLUME 2

APRIL 2004

PREPARED BY

WHITMAN, REQUARDT AND ASSOCIATES, LLP

COMPREHENSIVE WASTEWATER FACILITIES MASTER PLAN

VOLUME 2

Tables

Figures

CHAPTER 5

FUTURE SITUATION

5.1. SERVICE AREA

The service areas for Back River and Patapsco Wastewater Treatment Plants are shown on Figures 2-1 and 2-2 (included in a plastic pocket in the back of Volume 1 of the Plan). The population projection densities for 2000 and 2020 were developed by sewersheds based on Baltimore Metropolitan Council of Government Transportation Zone Populations (Round 5-D Small Area Forecast), Maryland State Office of Planning Land Use (1996), and Baltimore County Office of Planning Land Use (1993).

5.2. DEMOGRAPHIC PROJECTIONS

Population forecasts for the Back River and Patapsco Planning Areas were obtained from the Baltimore Metropolitan Council of Government using Census 2000 data. The breakdown of population for 2000 and 2020 per treatment plant is as follows:

Back River Wastewater Treatment Plant

	201 Facility Plan 1984	2000	2020
Baltimore City	654,000	548,320	560,274
Baltimore County	390,476	395,241	413,925
Total	1,044,476	943,561	974,199

Patapsco Wastewater Treatment Plant

	201 Facility Plan 1985	2000	2020
Baltimore City	131,394	102,842	97,802
Howard County*	20,934	52,330	68,510
Anne Arundel County*	23,320	27,891	34,999
Baltimore County	192,186	248,876	265,605
Total	367,834	431,939	466,916

* Population Values provided by respective counties.

As shown, the population forecast for 2020 will be 974,199 for Back River and 466,916 for Patapsco. The population total for both treatment plants is 1,441,115. That is an increase of 4.8% from 2000. This shows that there is very little change of population in the service area for both treatment plants.

5.3. PROJECTED WASTEWATER FLOWS

5.3.1. Total Service Area

Since the population in the total service area (Back River and Patapsco service areas) for the year 2020 is predicted to increase by only about 4.8% from year 2000, the projected total flow is expected to change approximately in proportion. Therefore, the change in flow will not be significant. More importantly, the adjustments at the Southwest Diversion to balance flows between the Back River and Patapsco Plants, and the effects of CSO/SSO and I/I improvements, may have a more significant impact on flows. Also, the effects of extremely dry and wet years have caused wide fluctuations in plant annual average flows.

The averages of the average annual flows for the plants for the years 1995 – 2003 are considered in this study. However, the wide range in annual flows at each plant is expected to create an impact on the ability of the plants to meet more stringent total nitrogen and phosphorus limits that are anticipated during the planning period. Therefore, the flow projections for each plant that are developed hereinafter consider these variations.

5.3.2. Back River Service Area

As discussed in Chapter 4, wastewater flows to the Back River Plant for 1995 – 2003 average 159 mgd, and range from 137 to 189 mgd. For three of the nine years flows were 173, 180 and 189 mgd; however, rainfall during the two years with the higher flows was extreme. Therefore, 173 mgd is selected as the baseline flow for the year 2000. The planning year 2020 flow, and year 2030 flow are developed as follows:

Back River Wastewater Treatment Plant

Projected Flows

Source	Flows (MGD) 2000	2020	2030
City/Baltimore County			
2000-2020 Pop. Increase – 3.2%		173.0	
173 X 0.032		5.5	
2020-2030 Pop. Increase – 1.5%			178.5
178.5 X 0.015			2.7
Total Plant	173.0	178.5	181.2

As shown, population forecasts by transportation zone to 2020 result in a 2020 flow of 178.5 mgd. The population and flow projections for 2030 result in a total flow of 181.2 mgd. Therefore, due to the relative closeness of the estimates, 180 mgd is adopted for planning as the year 2020 flow.

5.3.3. Patapsco Service Area

As discussed in Chapter 4, wastewater flows to the Patapsco Plant for 1995 – 2003 average 63 mgd, but range from 53 to 71 mgd. For reasons discussed in 5.3.1., and based on discussions with the City, 70 mgd is selected as the baseline flow for year 2000. This determination considers the uncertainties of the effects of extreme wet and dry weather, and the diversion at Baltimore Street (Southwest Diversion). The planning year 2020 flow, and year 2030 flow are developed as follows:

Patapsco Wastewater Treatment Plant

Projected Flows

	Flows (MGD)		
Source	2000	2020	2030
City/Baltimore County			
2000 – 2020 Pop. Increase – 3.5%	61.4	61.4	
61.4 x 0.035		2.1	
2020 – 2030 Pop. Increase – 1.5%		63.5	63.5
63.5 x 0.015			0.9
			64.4
Howard/ Anne Arundel Counties (1)	8.6	8.6	
2000 – 2020 Flow Increase		7.2	
2020 – 2030 Flow Increase		15.8	15.8
			2.1
			17.9
Total Plant	70.0	79.3	82.3

(1) Data Provided by Counties

As shown, population forecasts by transportation zone to 2020, plus flow increases projected by Howard and Anne Arundel Counties; result in a total 2020 flow of 79.3 mgd. The population and flow projections for 2030 indicate a total flow of 82.3 mgd. Therefore, due to the relative closeness of the flow estimates, 81 mgd is adopted for planning as the year 2020 flow.

5.4. FLOW VARIATIONS

Section 4.2 identified the average flow conditions for both plants, as well as the ratio of the highest 5-day average flow to annual average flow for each facility. This ratio is used to determine the effects of weekly flow on the ability to meet permit. For Back River WWTP, this ratio was 1.37 as compared with 1.43 calculated in the 201 Facility Plan dated 1984. This ratio is anticipated to stay the same over the planning period. The Patapsco WWTP was found to have an existing maximum five-day to average daily flow ratio of 1.7. This ratio was not calculated in the 1985 201 Facility Plan. It is apparent in the evaluation that this ratio is very dependent upon rainfall. It is likely that the ratio will lower as the conveyance system is replaced, repaired, or separation of the combined sewers is completed.

5.5. ADEQUACY OF TREATMENT PLANTS TO HANDLE FUTURE FLOWS, LOADS AND EFFLUENT LIMITATIONS

5.5.1. General

The existing facilities have been evaluated from the standpoint of their process capacity, as well as their physical condition. Process capacity was examined with regard to ability to handle the anticipated wastewater flow considering diurnal, seasonal and wet weather effects, treatment loads (e.g., BOD, TSS, TKN, TP, etc.) and effluent limits based on anticipated future receiving water requirements. The physical condition of each plant was inspected to ascertain their capability to be able to continue operating efficiently for extended service. Reports summarizing the findings of these plant inspections, as well as inspections of designated conveyance system pumping stations, are included in the Appendix.

5.5.2. Back River Wastewater Treatment Plant

The existing wastewater facilities at Back River have the capacity to handle the flow, which is estimated to remain essentially unchanged for the planning period. The existing wastewater unit processes are capable of handling the estimated treatment load and anticipated effluent limits related to BOD_5, TSS and TP. Reduction of total nitrogen (TN) in the effluent is the key issue. The existing Activated Sludge Plants Nos. 1, 2 and 3 do not have the capacity to reduce TN below approximately 6 mg/l. If lower levels, below 6 mg/l to as low as 3 mg/l, are required, additional facilities and modification of existing facilities are needed to provide complete nitrification and denitrification. Alternatives that can achieve these lower TN levels are evaluated in Chapter 6.

The existing solids handling facilities have the capacity to convey, thicken, digest and dewater, as well as provide disposal, for the estimated quantity of solids produced by the anticipated wastewater treatment processes. No appreciable change in solids production is expected.

5.5.3. Patapsco Wastewater Treatment Plant

The existing wastewater facilities at Patapsco have the capacity to handle the flow, which is estimated to remain unchanged over the planning period. The existing wastewater unit processes are capable of handling the estimated load under anticipated effluent limits related to BOD_5, TSS, and TP. Reduction of total nitrogen (TN) in the effluent is the key issue. In the event that restrictions are placed upon Patapsco with regards to TN levels, modifications as well as additional facilities will be required. Alternatives that can achieve several different levels of TN removal are evaluated in Chapter 6.

The existing solids handling facilities have the capacity to convey, thicken, store, blend and dewater, as well as provide disposal for the anticipated quantity of solids produced by processes that may be implemented to reduce nitrogen levels. Based on the projections for the planning period there should be no appreciable increase in the quantity of solids generated.

5.6. ALTERNATE POINT OF DISCHARGE FOR BACK RIVER PLANT

Certain issues related to the NPDES discharge permit suggest that the City consider alternate points of discharge for a portion of the flow from the Back River Plant. The issues revolve around the ability of the plant to meet current and future pound loading limits and TMDL requirements. The design average daily flow for the Back River Plant is 180 mgd.

The current permit is based on an effluent discharge to Back River of 130 mgd. The balance, 50 mgd, is assumed to be discharged under an expired agreement with Bethlehem Steel Corporation (now International Steel Group Sparrows Point, Inc., or ISG), to the steel mill for use as industrial water (IW). The permit, which is undergoing the renewal process at MDE, contains pounds per day discharge limits for BOD_5, Suspended Solids, Ammonia, and Total Phosphorus (TP), and goals for Total Nitrogen (TN). Pound loadings are dependent upon concentration for each parameter and flow, which is now set at 130 mgd for the Back River discharge. Assuming the concentrations are met, the ability to meet permit is based on flow. Currently, TP is the limit impacted during periods of high plant flow, when the discharge to Back River exceeds 130 mgd.

In the future, TMDL pound loadings, especially for TN and TP, may also be impacted by plant flow. TMDLs are currently under review by MDE. Therefore, due to the significance of flow, the City is exploring the possibility of increasing discharge of plant effluent to ISG.

The primary benefit to the City would be the reduction in discharge to Back River of 50 mgd, resulting in an average flow of 80 mgd. This reduction would directly enhance the City's ability to comply with future TMDL requirements.

5.7. SLUDGE MANAGEMENT

5.7.1. Purpose

The intention of the sludge management plan for Back River and Patapsco is two-fold: (1) enable both plants to provide for cost-effective remove of sludge from on-site facilities, and

(2) utilize methods that will allow beneficial reuse of sludge as a resource to the fullest extent possible.

Both plants have successful contracts in place that utilize a combination of on-site and off-site private firms to dry and palletize, compost, or land apply biosolids. Further discussion of the various methods is included hereinafter for each plant. Description of the current sludge management is included in this section, since the Plan recommends continuing with the current sludge disposal methods in the future.

5.7.2. Back River Wastewater Treatment Plant

Based on City and regulatory monitoring, Back River digested sludge is suitable for various end uses. Sludge is currently utilized through: (1) heat drying (pelletization) privatization contract, (2) composting privatization contract, and (3) sludge hauling contract for land application.

5.7.2.1. Heat Drying (Pelletization) Privatization Contract

The heat drying facility, Baltimore Pelletech, was constructed and is operated by Synagro under a 20-year contract which began in 1994. Synagro receives liquid digested sludge from the City, dewaters it and then produces a dry pellet fertilizer supplement utilizing an indirect heat drying process. They market this product nationally in bulk to various customers.

5.7.2.2. City Dewatering

The City dewaters all digested sludge which is not committed to heat drying. The City operated centrifuge dewatering facilities produce a cake solids content of approximately 19 to 21%. The cake is conveyed to the Rapid Sludge Loading Facility where it is stored in hoppers for subsequent loading into trucks for hauling to composting or land application.

5.7.2.3. Composting Privatization Contract

Composting operations began at the Hawkins Point site in 1987. The facility is operated by Northeast Maryland Waste Disposal Authority under a 20-year contract. By agreement between the City and the Authority, the facility is required to accept the guaranteed sludge quantity of 210 wet tons (@ 23% solids) per delivery day (Monday through Friday, each week). During calendar year 2001, composting processed on average of 182 wet tons/day, 5 days/week. The process is operating satisfactorily.

5.7.2.4. Hauling (Land Application) Contract

The City periodically awards a contract for the purpose of hauling and land applying sludge. The basic contract is for one year, with the option to extend for one year. Contracts normally last for two years. The contract is intended to remove sludge that is not committed to heat drying and composting. During calendar year 2001, approximately 114 wet tons/day were contract hauled and applied primarily to agricultural land in Virginia.

5.7.3. Patapsco Wastewater Treatment Plant

The City is currently providing all sludge to an on-site privatization heat drying contractor.

5.7.3.1. Heat Drying (Pelletization) Privatization Contract

The heat drying facility was constructed and is operated by Synagro under a 20-year contract, which began in 1998. Synagro receives liquid raw sludge from the City, dewaters it and then produces a dry pellet fertilizer product which they market in bulk nationally.

5.7.4. Estimated Allocation of Sludge for Disposal

The following tabulation summarizes the current allocation of sludge to each of the three methods of disposal. The summary shows that the combined capacity of the methods exceeds the estimated future required capacity. For each plant, heat drying insures reliability for disposal. Each heat drying facility has a redundant process train to enable processing 110 dry tons/day, if necessary, to handle peak sludge conditions, or reduced capacity in other methods in the case of Back River.

	Average Quantities (dry tons/day)[1]	
Process	Back River	Patapsco
Heat Drying [2]	55[4]	55[4]
Composting [3]	35	--
Land Application	20	--
Estimated Future Required Capacity	110	60

(1) Based on 7 days/week

(2) Guaranteed minimum to privatization contractor = 55 dry tons/day, 7days/week

(3) Guaranteed minimum to privatization contractor = 210 wet tons/day (23% solids), 5 days/week

(4) Heat drying has double capacity, 110 dry tons/day, with all process trains operating.

5.7.5. Current Costs for Sludge Disposal Contracts

The current unit costs per dry ton for the methods of disposal are summarized below. The costs for heat drying and composting are much higher than land application, but those methods are necessary since land application sites do not offer sufficient capacity. Also, land application is subject to seasonal, weather and agricultural interruptions. Therefore, to prevent excessive accumulation of stored sludge on the plant site, as the City experienced frequently in the past, use of heat drying and composting is essential.

	Cost Per Dry Ton	
Process	Back River[1]	Patapsco
Heat Drying[2]	$ 462	$469
Composting[3]	$ 526	--
Land Application	$ 163	----

(1) Based on July 2002

(2) Adjusted based on unit cost for natural gas

(3) Adjusted based on operating costs

5.7.6. Continuation with the Current Sludge Management Plan

Based on the current successful sludge management plan for Back River and Patapsco, and previous evaluations of alternative methods of disposal, continuation of the plan appears appropriate. The combination of the three methods offers the City the insurance of flexibility, reliability and redundancy in not relying on a sole method. The existing methods and capacities are anticipated to be adequate for the planning period since no increase in plant flows or loadings is expected. Only a minimal increase in sludge production is estimated for the possible upgrades in BNR treatment.

The current plan provides flexibility and reliability through the privatization contracts and economical disposal to the extent possible through land application of Back River sludge. The summary of current costs show composting to be the most expensive method; however, the expiration date for the current contract is 2007, and the portion of the cost associated with the initial capital expenditure for the facilities will be complete. Costs for future improvements to composting are expected to result in a lower unit cost for disposal. Also the diversification of disposal offered with composting further enhances flexibility, reliability and redundancy in the event of short-term interruption or reduced capacity of heat drying or land application.

CHAPTER 6

ALTERNATIVES

6.1. BACK RIVER WASTEWATER TREATMENT PLANT -- OPTIMUM OPERATION OF EXISTING BNR FACILITIES

The City has engaged the services of two consultants to independently investigate the performance of the existing BNR process at the Back River Plant to determine whether: (1) the facilities are being operated to their full capability to remove nitrogen, and (2) the facilities can be modified to enhance their capability and increase nitrogen removal.

The investigations were performed by Biochem Technology, Inc. (BTI) (Report dated September 2000) and Rummel, Klepper and Kahl, LLP (RK&K) (Report dated October 19, 2001). Relative to total nitrogen (TN) reduction, the BTI report concluded that: (1) the treatment trains of Plant No. 3 cannot meet an effluent discharge limit of 8 mg/l TN year round under the current physical configuration and operational limitations of the plant, (2) adjustment to the anoxic and oxic volumes and configuration will result in reduction in TN to less than 8 mg/l, and (3) full scale pilot studies should be conducted to confirm process modifications. The RK&K report concluded that, based on full scale pilot testing: warm weather effluent TN levels can be reduced from the current average of 8.3 mg/l to about 6.5 mg/l by increasing the anoxic detention time and creating a second anoxic zone in the second pass of the reactor.

Preliminary calculations developed as part of the Plan by WR&A, indicate that TN as low as 6 mg/l may be achieved during warmer months with supplemental carbon addition in the form of methanol. Further testing incorporating methanol addition are needed to confirm the actual improvement.

6.2. BACK RIVER AND PATAPSCO PLANT FLOWS

6.2.1. Allocation of Flows Between Back River and Patapsco Plants

Population projections for the service area indicate that no significant change is anticipated for the planning period. Therefore, the predicted average daily flows for the Back River and Patapsco plants remain as 180 mgd and 81 mgd, respectively, for 20 year plan. However, based on the need for improved water quality in the Bay and tributaries, treatment for total nitrogen reduction must be improved at Back River and added to Patapsco.

The City has already initiated the detailed planning for BNR treatment at Patapsco with Project No. 877. Therefore, it is assumed that the allocation of flows to each plant will remain as previously planned, i.e., part of the flow to Patapsco will not be diverted to Back River.

6.2.2. Location of Back River Plant Discharges

Effluent from the Back River Plant is discharged to Back River as well as the International Steel Group (ISG) Sparrows Point, Inc. (previously Bethlehem Steel Corporation). The current NPDES permit is based on a discharge of 130 mgd to Back River. The balance of the flow, nominally 50 mgd, is conveyed to ISG for industrial water use, and subsequent treatment and discharge to the Patapsco River. Therefore, in the evaluation of treatment alternatives in the Plan, this split in discharge is considered. It is anticipated that, based on water quality requirements, treatment levels for discharges to the Patapsco River will continue to be less stringent. For the purposes of evaluation, the total nitrogen for Patapsco is assumed to be 8 mg/l. Effluent from the Patapsco Plant discharges to the outer harbor portion of the Patapsco estuary.

6.3. CONCEPTS FOR BNR UPGRADES

6.3.1. Achievable Levels of Total Nitrogen

In order to achieve low total nitrogen levels, e.g., 3 mg/l, it is necessary to insure nearly complete nitrification and then denitrification. Experience at Back River indicates that a TKN level of about 3 mg/l is the best that can be achieved during warmer months, with a range of 3 to 4 mg/l. Therefore, assuming a nitrate-nitrogen concentration of 1 mg/l is achievable; the best seasonal total nitrogen level may be about 4 to 5 mg/l. Refractory organic nitrogen (non-biodegradable) is possibly limiting the TKN to 3 mg/l. Some type of pilot testing is necessary to determine the critical factor, the lowest achievable level of TKN. Therefore, the assumed achievable annual range for TN is 3 to 6 mg/l.

Experience with nitrification and total nitrogen reduction at Patapsco is very limited. Due to plant operational constraints and process interference, apparently from collection system source(s), plant scale testing is not conclusive as to the ability of the plant to nitrify or denitrify, or to quantify the limits that are achievable. Again, testing is necessary to determine the limits of treatment technology for Patapsco. The assumed achievable annual range for TN is 3 to 6 mg/l.

6.3.2. Back River Wastewater Treatment Plant

The suggested concept and basic assumptions for BNR upgrades at Back River are presented in the Plan. Since MDE has not yet provided requirements for BNR at Back River, the approach contained in the Plan is intended to give the City alternatives and associated costs for a range of TN goals to assist in planning discussions with MDE. The alternatives consider that the discharges for permitting purposes, to Back River and ISG, will continue at 130 mgd and 50 mgd, respectively. Also, the discharge limits for Back River will be water quality based and for ISG will be effluent based. Limits for both plants will be based on loadings and concentrations. Implementation of the upgrades for Back River is based on a three-level approach. Level 1 considers that the existing MLE process will be optimized to improve TN to about 6 mg/l for Back River (130 mgd) and 6 to 8 mg/l for ISG (50 mgd). Level 2 is the first stage of improvements to achieve TN in the range of 3 to 6 mg/l for both Back River and ISG. Under Level 2, facilities would be provided to allow treatment to a TN level of 3 mg/l for Back River (130 mgd) and continue with 6 mg/l to 8 mg/l for ISG (50 mgd). Level 3 alternatives provide treatment to a TN level of 3 to 6 mg/l for the entire plant flow (180 mgd). The design and operation and maintenance assumptions are based on 3 mg/l; however, that concentration may not be achievable. Therefore, the range of 3 to 6 mg/l is assumed.

6.3.3. Patapsco Wastewater Treatment Plant

This Plan provides general discussion of several BNR alternatives and costs for those that appear most feasible for Patapsco. MDE has not provided requirements for BNR at Patapsco. The understanding is that Project No. 877 is intended to address BNR at Patapsco in detail and provide: (1) design of a facility at Wagners Point to treat Low Level wastewater, and (2) detailed recommendations for implementing BNR at the Patapsco main plant.

In the Plan, for the purpose of providing preliminary insight into the types of processes that might be considered, and their associated space requirements, costs, etc., several BNR alternatives were developed. The focus was on alternatives that could achieve effluent TN levels in the range of 3 to 6 mg/l. Treatment units for the alternatives could be sized for lesser degrees of TN reduction, with associated reductions in capital and operation and maintenance costs.

6.4. BASIS FOR COMPARISON OF BNR SYSTEMS

6.4.1. General Considerations

Alternatives are compared based on 20-year planning period extending from 2000 to 2020. All expenditures are compared on a present worth basis using an interest (discount rate) of 7%. All costs are based on January 2002 price levels. These price levels have not been escalated to reflect inflation.

The alternatives are also compared based on treating the annual average plant influent flow, plus plant recycles. Peak 5-day flow is based 1.5 times average daily flow plus recycles for Back River and Patapsco Wastewater Treatment Plant. The operating and maintenance costs are based on the average annual plant capacity for the flow-fixed costs (maintenance and labor) and for flow-variable costs (energy and chemicals). The annual O&M costs were assumed to be constant during the 20-year planning period. This assumption is appropriate since the difference in the present worth of the O&M between using variable annual amounts and using a constant average value for the planning period is less than 1%.

The salvage value accounts for the life remaining at the end of the planning period. Salvage values were determined using straight line depreciation, based on the value of capital investment. Generally, structures and pipelines were assumed to have a 50-year life and electrical and mechanical components a 20-year life.

All economic comparisons were made on a present worth basis. This process allows the comparison of different expenditures of money at different periods of time to determine the least costly option. It is equivalent to the amount of money that would be required to be invested at the prescribed interest rate, at the base date of the economic comparison in order to have the sums of money available in the future to pay the capital and the annual operating and maintenance costs. It should be noted the total investment required to build the alternative ultimately selected will be greater than that listed, since the comparisons of the alternatives only include those components which vary, and also because inflation will increase the project cost at the time the construction of the facilities is actually undertaken.

6.4.2. Design and Operation and Maintenance Assumptions

For each alternative, assumptions are shown that are used for sizing unit processes, equipment, etc. and for estimating O&M requirements, which in turn form the basis for cost estimates. Deep bed filters (downflow and upflow), and fluidized bed reactors are primarily proprietary types of denitrification processes. Assumptions shown in the tables for each such alternative are based on manufacturers' recommendations. However, technical information provided in Water Environment Federation (WEF) and Environmental Protection Agency (EPA) literature suggests that some of the manufacturers' criteria (particularly hydraulic and nitrate loadings) may be somewhat optimistic. For this reason, and others, it is advisable to conduct on-site pilot/ demonstration testing of those processes that are seriously considered for use at Back River or Patapsco.

6.5. DESCRIPTION OF AVAILABLE BNR TECHNOLOGY

6.5.1. General

Nitrogen removal can be achieved through physical/chemical, biological, and combination of the two processes. Today physical chemical processes have been abandoned for municipal wastewater treatment except for polishing applications, where further nitrogen control may be a particular design objective.

6.5.2. Physical/Chemical Nitrogen Removal

Several physical/chemical nitrogen control technologies have been tried in municipal wastewater treatment which include ammonia stripping, breakpoint chlorination, selective ion exchange, and reverse osmosis.

Ammonia stripping works well with wastewater that has ammonia contents between 10 to 100 mg/L; for higher ammonia content (>100 mg/L), other technologies, such as biological methods, are more economical[1]. Air stripping involves the volatilization of aqueous ammonia to gaseous ammonia at pH of 10.5-11.5. Following the ammonia removal, effluent pH is reduced by recarbonation or acid addition. Air stripping towers are designed for hydraulic loadings of 1-3 gpm/ft^2, and air to water ratio of 2200:1 to 3800:1. Packing consists of wood slats, plastic pipes or a propylene grid. The tower cannot operate below 0 ^{0}C due to freezing. Scaling on the tower can be troublesome due to carbon dioxide from air forming calcium carbonate at high pH. Because of high operation and maintenance costs with air stripping, the practical application is limited to need of high pH in the influent stream as in lime treatment for phosphorous removal. As of 1998, no municipal ammonia stripping facilities are known to be in use in U.S.

Breakpoint chlorination involves the addition of chlorine to wastewater to oxidize the ammonia in solution to nitrogen gas and other stable compounds. The most important

[1] U.S. EPA: *Wastewater Technology Fact Sheet Ammonia Stripping*, EPA/832/F-00/019, Washington, DC., September 2000.

advantage of this process is that with proper control all ammonia can be oxidized. Breakpoint chlorination can be used either alone or in combination with other processes. To avoid high dosages of chlorine the process can be used following a biological nitrification. Because of the potential toxicity problem that may develop if chlorinated compounds are discharged to environment, it is usually necessary to dechlorinate the effluent. As of 1993, the only known operating facility with breakpoint chlorination in Sugarbush, Vermont, reduced influent ammonium levels of 14.3 mg/l to 0.1 mg/l.

Ion exchange technology involves passing a liquid through a column or bed of specific natural or synthetic zeolite resin with the exchange of one ion for another. The column is run until unacceptable breakthrough of the ion concerned is achieved. A highly concentrated regenerant is then passed through the column to displace the removed ion from the exchange sites. The regenerant is processed further for recovery and reuse or passed as waste. For ammonium-nitrogen removal, clinoptilolite is the natural zeolite of choice. The North Tahoe-Truckee facility historically achieved 2.5 mg/l of ammonium nitrogen in its ion exchange effluent, which was further reduced to 0.3 mg/l by breakpoint chlorination. Most recently with relaxation of its treatment needs, North Tahoe-Truckee has discontinued breakpoint chlorination and averages ammonium nitrogen release of 5 to 6 mg/l.

Reverse osmosis was selected in the late seventies for macrocontaminant removal such as sulfate, COD, TOC, sodium, ammonium-nitrogen, and nitrate at Orange County's Water Factory in California. Present findings suggest reverse osmosis ammonium nitrogen removals on the order of 85%.

After reviewing the physical-chemical type processes, the conclusion was that the only way to achieve low-level ammonium or total nitrogen is with a biological process.

6.5.3. Biological Nitrogen Removal

Biological nitrogen removal is achieved through series of biochemical reactions that transform nitrogen from one form to another. The key transformations are nitrification and denitrification. Nitrification is the oxidation of ammonium to nitrite and finally to nitrate. Denitrification is the reduction of nitrate to nitrogen gas and is accomplished by heterotrophic organisms in absence of dissolved oxygen. Energy for this reaction is provided by carbon addition, usually methanol, when insufficient carbon is available in the wastewater.

Biological nitrogen removal processes are divided into suspended growth, and attached growth. Suspended growth processes consist of single sludge, dual sludge and triple sludge processes. Single sludge processes include Wuhrman, Ludzak-Ettinger, Modified Ludzak-Ettinger (MLE), Bardenpho, sequencing batch reactors, oxidation ditches, and phased isolation processes. Dual sludge processes segregate nitrification-carbonation and denitrification as separate stages in physically separated tanks, each with its own clarifiers and return sludge systems. Triple sludge systems use one set of reactors and clarifiers each for carbonation and nitrification and a separate denitrification process requiring supplemental carbon addition. It suffers from the disadvantages of adding exogenous carbon source and high capital costs for separate tanks and clarifiers needed for each process. Attached growth denitrification processes include deep bed filters, fluidized bed reactors, submerged rotating contactors and moving bed biofilm reactors.

The Wuhrman process is sometimes called a post-denitrification process and consists of aerobic and anoxic stages. The design relies on residual organic matter passing through the first stage or on the endogenous respiration of biomass to provide the energy source for denitrification. Nitrogen removal of 29% to 89% has been achieved in bench and pilot-scale studies.

The Ludzak-Ettinger design reverses anoxic and aerobic stages in the Wuhrman design. The advantage of this design is the provision of influent BOD to the anoxic stage to act as an exogenous carbon source. An 88% reduction in total nitrogen from influent of 130 mg/l has been reported when using a return activated sludge (RAS) recycle ratio of 8:1.

The Modified Ludzak-Ettinger (MLE) process incorporates an internal recycle of mixed liquor from the aeration stage to the anoxic stage. This increases both denitrification and overall nitrogen removal efficiency. The MLE process provides for control over the fraction of nitrate removed through variation of the internal recycle ratio. In addition, higher denitrification rates are attained because the anoxic reactor receives a source of readily biodegradable carbon as COD.

The Bardenpho process consists of a series of four anoxic and aerobic zones with recycling of mixed liquor from the first aerobic zone to the first anoxic zone at a rate as high as four to six times the influent flow rate. This process is intended to achieve more complete nitrogen removal than is possible with a two or three-stage process. The Bardenpho process reliably achieves effluent TN levels of 2 to 4 mg/l depends on the ratio of oxidizable nitrogen to carbon in the influent. For complete denitrification the reported TKN:COD ratio must be less than 0.08.

Sequencing Batch Reactor (SBR) achieves nitrogen removal by the proper combinations of aerobic and anoxic condition in time sequence. They appear well suited for small systems with highly variable wastewater flow and strength. Successful operation depends on efficient clarification. To obtain nitrogen removal, fill and reaction phases are subdivided into static fill, mixed fill, and mixed react. Nitrification and carbon oxidation will occur in the aerobic reaction phase and denitrification in the anoxic fill reaction phase

In the oxidation ditch processes used for nitrogen removal, rates of both nitrification and denitrification will be low because of long solids retention time (SRT) required for nitrification, the low concentration of readily biodegradable COD, and marginal DO (dissolved oxygen) concentrations for either nitrification or denitrification. The Orbal concentric oxidation ditch provides nitrogen removals as high as 95%. It is typically operated with near zero DO in the outermost loop with increasing DO concentrations in inner loops. Recycle of mixed liquor from the inner loop to outer loop allows for denitrification of nitrates.

The phase isolation ditch process extends and adapts the oxidation ditch technology for nutrient removal. It resembles an SBR because both processes create sequential aerobic, anoxic, and anaerobic conditions with one tank or series of tanks. However phase isolation differs from SBR system by having continuous inflow and overflow. Published data have indicated that phased isolation ditch plants in Denmark achieve effluent TN levels less than 8 mg/l.

Denitrification filters, both upflow and downflow have been used successfully in the U.S. since the early 70's. Denitrification filters normally follow nitrification and serve the dual functions of filtration and denitrification. Typically methanol is used as the carbon to provide sufficient energy for denitrification. Some plants use brewery waste as a carbon source for denitrification. Operation and physical design of these filters resembles that of deep bed or dual-media filters except for the necessary nitrogen release cycles, required in downflow type filters. This requirement results from the trapping of nitrogen gas produced in the process that causes increased headloss across the filters. The maximum tolerable nitrogen release cycle is typically once every hour.

Fluidized bed reactors achieve attached growth by another means. Wastewater enters the bottom of the reactor with sufficient velocity to expand the bed. The biomass in these reactors grows on the reactor media. The reactor can achieve a biomass concentration ranging from 25,000 to 30,000 mg/l. This allows for smaller reactor volumes for equal loadings compare to suspended growth processes. Solids are wasted through a small inverted conical-shaped reactor that is installed in the larger reactor. A circulation pump (growth control pump) is used to produce sufficient turbulence for separation of biomass from the media. The pump operates when the bed expands to the height of the cone. Clean sand falls to bottom of reactor while the now suspended solids overflow a weir within the cone. The wastewater facility in Reno-Sparks, Nevada utilizes fluidized bed reactors, and has been performing well. The reactors, with methanol addition, achieve effluent nitrate-nitrogen of 1 mg/l with influent concentrations of 13 mg/l.

Submerged rotating biological contactors (SRBC) have been used with methanol addition for denitrification at an advanced wastewater treatment facility in central Florida. The full-scale facility was modified extensively, to place the SRBCs between nitrifying RBCs and the final clarifiers. In the warm Florida environment, this configuration allowed the plant to achieve TN levels of 3 mg/l.

Integrated fixed film activated sludge process, provides a greater biomass concentration in the aeration basin than suspended growth, resulting in a reduction of basin size. The media on which biomass grows can be suspended in the mixed liquor or a fixed module placed in the basin. In the case of suspended media, the media is free floating and retained by an effluent screen. For both fixed module and suspended media, solids are removed in a secondary clarifier and wasting is from the return line as in a conventional activated sludge process.

There are more than half a dozen different variations of processes in which fixed film material is placed in the aeration basin[2]. Depending on the type of media, they are placed where optimal rates are achievable for ammonia oxidation. Optimal rates are difficult to achieve as variations in BOD loading can vary biofilm growth on the media and competition between heterotrophic and autotrophic bacteria for surface area.

Now there more than ten different variations of processes in which media of various types are suspended in the aeration basins[2]. Foam pads and plastic wheel-shaped media are two of the many types. For aerobic conditions, processes that use foam pads require mixing and diffused aeration to prevent the media from accumulating at the effluent end and floating at the surface. Whereas processes using plastic wheel shaped media, such as moving bed biofilm reactors (MBBR), circulation of media occurs through aeration (aerobic conditions) or mixing (anoxic conditions). The biofilm grows on the inside surface of the plastic media, providing a large specific surface area and having a density less than water. The free-floating media follows the water circulation in the reactor. Aeration in aerobic reactors and mechanical mixing in anoxic reactors creates the necessary circulation. The biofilm surface

[2] Metcalf & Eddy, Inc.: *Wastewater Engineering Treatment and Reuse*, McGraw Hill, MA, 2003.

area in each reactor is controlled by the quantity of plastic media added. The active, specific biofilm surface area can be regulated from between 0 to 400 m^2/m^3. Pumping the plastic media into an empty reactor or storage space is necessary to access the diffusers in an aerobic reactor. There are 69 municipal plants worldwide incorporating the MBBR for reduction of BOD and total nitrogen (TN). This technology has been shown to achieve effluent TN levels between 4-5 mg/l.

6.6. BNR TECHNOLOGIES SELECTED FOR EVALUATION

Based on the type and capacity of existing treatment facilities and availability of site space for upgrades at Back River and Patapsco, certain alternatives were selected for further evaluation. Space on the Patapsco site is significantly limited, especially due to the presence of the chromium contaminated soil storage area which occupies the southeast corner. The processes selected for evaluation are:

<u>Back River Wastewater Treatment Plant</u>
Modified Ludzak-Ettinger (MLE) with Methanol Addition
Two-Sludge Suspended Growth
Carbon Oxidation/Nitrification Suspended Growth plus
- Deep Bed Denitrification Filter (Downflow)
- Deep Bed Denitrification Filter (Upflow)
- Fluidized Bed Denitrification Reactor

<u>Patapsco Wastewater Treatment Plant</u>
Carbon Oxidation/Nitrification Suspended Growth plus
- Deep Bed Denitrification Filter (Downflow)
- Deep Bed Denitrification Filter (Upflow)
- Fluidized Bed Denitrification Reactor

A telephone survey was conducted to ascertain information regarding facilities employing these various process technologies for similar applications. A summary of the results of the survey is shown in Table 6-A. As indicated in the survey, most facilities are considerably smaller than the Back River and Patapsco Plants. Additionally, in most US installations, the technologies are predominantly employed for nitrification, rather than denitrification. All technologies shown have facilities overseas, (predominantly Europe) of comparable size to Back River and Patapsco, that employ the technology to both nitrify and denitrify. Survey forms used in the generation of Table 6-A are compiled in Appendix XVII and contain more detailed information regarding the facilities.

Further evaluation of alternatives, through pilot testing, needed to confirm design and operating parameters and performance, may be desirable in the future in order to select the best processes for use at Back River and Patapsco. Verification of the achievable level of TN removal is essential. Tests should be conducted on site using plant wastewater that will be under the influence of such conditions as temperature, recycles and variations in plant influent characteristics.

Details regarding pilot testing were investigated for each process technology evaluated. Table 6-B summarizes pilot testing information including the type of pilot system, costs, special requirements and services etc. Every process technology contacted was able to provide a pilot test unit. Pilot units will need to operate over a sufficient time period, approximately three to six months, to properly demonstrate performance. All process technologies shown are biological and will require an acclimation period in which the biological population is developed.

TABLE 6-A
PROCESS TECHNOLOGY PHONE SURVEY SUMMARY

Technology	Manufacturer	Plant Name and Location	Size	Contact Name and Phone	Equipment Service	Success Rate	Remarks / Comments
Downflow Filter	Tetra Tech, Severn Trent	Dunedin WWTP Dunedin, FL	6 MGD	Mike Hannos (727) 298-3256	Denitrification of municipal wastewater	TN levels ≅ 0 mg/L	Over 10 years of service and are just now starting to replace misc. parts and valves
Downflow Filter	Tetra Tech, Severn Trent	Howard Curran Plant, Tampa, FL	96 MGD	John Drapp (813) 247-3451 x205	Denitrification of municipal wastewater	TN legvels < 3 mg/L	Performing well, Increased the number of filters recently
Upflow Bioreactor	BIOFOR / Ondeo Degremont	Brecken Ridge, CO, WWTP	1.5 MGD	Andy Carlberg (970) 453-2723	Nitrification Only, Municipal WW	Near Complete NH_4-N reduction	Very satisfied, little operator intervention necessary
Upflow Bioreactor	BIOFOR / Ondeo Degremont	Roanoke, VA	14 MGD	Scott Shirley (540) 853-2393	Nitrification Only, Municipal WW	80% TKN reduction	Some problems with solids and floatable due to nature of influent (primary effluent)
Upflow Bioreactor	BIOFOR / Ondeo Degremont	Irvine Ranch, CA	1.4 MGD	Mr. Shinhi Nu (949) 581-3222	Denitrification of Groundwater	67% reduction in Nitrate level	Minimal operation involvement (is checked only once daily by operations personnel)
Upflow Bioreactor	Biostyr / Kruger	Freeport, IL	6.75 MGD	Kim Reese (815) 235-7672	Ammonia Removal of Municipal WW	96% reduction in Ammonia levels	New installation (less than one year old)
Fluidized Bed Reactor	USFILTER	Syvab WWTP Syvab, Sweden	30 MGD	Anders Ostermann 011-468-530-272-40	Denitrification of Municipal and Industrial WW	Effluent TN Levels of 1 – 9 mg/L	Cost Effective with a small footprint
Fluidized Bed Reactor	USFILTER	Truckee Meadows WRF, Reno, NV	42 MGD	Randall Gray (775) 861-4102	Denitrification of municipal wastewater	TN levels < 3 mg/L	Major costs associated with methanol
Moving Bed Biofilm Reactor	Kaldness North America	Corby England	5 MGD	Mr. Peter Staufert 011-44-1733-414100	Carbonaceous BOD and Nitrification of Municipal and Food Processing Wastewater	Effluent ammonia levels of 0.5 mg/L	Very robust system but absolutely requires post clarification or solids removal

TABLE 6-B
PILOTS FOR BNR ALTERNATIVES AT BACK RIVER WWTP

Process	Manufacturer	Pilot	Field Technician, Process Engineers	Length of Operation	Utility/Connection	Point of Contact	Cost		City Requirements
							Item	Cost Basis	
Deep Bed	US Filter, Krueger	Biostyr	2-day training, Monthly trips	4-6 months including	480 VAC, single phase	David Lounsbury (TLC Environme	Pilot Tower rental (4-6 months)		Support Equipment, improvements
DN Filters		Peak Flow: 50 gpm		2 months for start-up,	100 amp	717-299-3596	Loading and shipment		and labor
Upflow		Three Pieces on drop-deck trailer		and biological seeding	Phone Service		Field oversight for equipment offloading		Influent/ Effluent feed transfer pump and tank
		Tower: 3' dia on 8'x8' platform			Inlet: 2-1/2" dia		Setup and connections		Crane and crew for loading and
		Assembled Height: 29 ft			Outlet: 2-1/2" dia		Startup and shakedown		unloading
		Backwash Storage Tank: 6.5'Dia X					Onsite training		Freeze Protection
		8' tall					Remote technical support		Pilot plant operator
		Control Shed: 7.5'x10.5'x9' (LxWxH)					Monthly site visits		Analytical Work (composite sampler,
							Replacement equipment and instruments		analysis)
							Total cost (4-6 months)	$160,000-$195,000	Carbon source (methanol)
									Carbon Source dosing/storage equipment
									Maintanance and repair equipment
									Solids Disposal Equipment
									Decontamination and decommission
									Spill containment
FB/DN	Envirogen	Fluid Bed Reactor	10-day Installation and Startup	4-5 months	240 volt, single phase	Ray Jasienski	10-day Installation and Startup		Support Equipment, improvements
Reactor		13' X 6' (LxW), 0-10 gpm	Three site visits		30 amps	609-936-9300	Three site visits		and labor
		1' dia reactor vessel, 14 ft high	Phone Support		Inlet: 1" FNPT		Assist shut down and shipping		Influent/ Effluent feed transfer pump and tank
		Overflow feed tank			Treated Effluent: 2" 150#		Envirogen Engineer		Solids Disposal Equipment
		Solids Recovery Tank			ANSI flange		four months rental		Analytical Work (composite sampler,
		Carbon Filter					round trip frieght		analysis)
		Computer Data Logger					Prepare a report		Carbon source (methanol)
		Three chemical feed tanks					Total Cost (4-5 months)	$50,000	Carbon Source storage system
		Automatic Temperature Control							Pilot plant operator
		Control Panel							Crane and crew for loading and
									unloading
									Decontamination and decommission
									Maintanance and repair equipment
									Potable water at discharge pressures of
									40 to 100 psig (mixing chemicals)
									Spill containment
MBBR	Kaldness	40-ft Pilot Plant			480 VAC, 60 HZ	Chandler Johnson	Pilot Plant for three month study	$22,000	Support Equipment, improvements
C/N or DN		48' X 12' (L X W), 0-10 gpm		3 months	3 phase 100 Amps	401-270-3898	with pilot plant operator for 10-		and labor
		Six bioreactors (170 gallons each)			Inlet: 2" Fernco Fitting		days of start up and training of		Influent/ Effluent feed transfer pump and tank
		Media			Sludge Discharge: 1.5" PVC		staff for handover, and round trip		Solids Disposal Equipment
		Influent Tank			Ball Valve		freight included		Analytical Work (composite sampler,
		Settling Tank			Effluent, Overflow Drain:				analysis)
		Two-side Channel Blowers			4" Balck Flexi Pipe				Carbon source (methanol)
		Two Feed Pumps			Floor Drain: 1" Black Hose				Carbon Source storage system
					Potable Water Hookup: 3/8"				Pilot plant operator
					female fitting				Crane and crew for loading and
									unloading
									Decontamination and decommission
									Maintanance and repair equipment
									Potable water
									Spill containment

TABLE 6-B
PILOTS FOR BNR ALTERNATIVES AT BACK RIVER WWTP

Process	Manufacturer	Pilot	Field Technician, Process Engineers	Length of Operation	Utility/Connection	Point of Contact	Cost		City Requirements
							item	Cost Basis	
		Submerged Aerated Filter (SAFTM) &							
Deep Bed	Severn Trent	DeniteÒ skid-mounted	Two Trips:	4 wks for setup,startur	480V, 3-phase	Ken Wineberg	Equipment Rental:	$6500/month	Influent Holding Tank
Nitri/DN		filter system	(2-day set-up, 1-day start-up/	60-days performance	Service water	412-494-4093	not incl. Taxes		Solids disposal equipment
Filters		19'x9'x20' (LXWXH) skid	training, 2-days shipping)	2 wk demobolization	1" influent connection	Ed Kuchtjak (Contract Manager)	Mobilization & Demobilization	$1,000.00	Analytical Work
DownFlow		0-7 gpm		Total: 90 days	1-1/2" effluent connection	412-494-4086	Gravel (0.35 cu.ft.) and Silica Sand (21 cu.	$2,000.00	Ladder
		dual 16" dia, 16-20' high			Both at elevation 4' 3/4"	Paul Miller (Process Engineer)	Transportation to and from job site	$1,600.00	Carbon Source (Methanol)
		columns				412-494-4071	Field Technicians and Process Engineers	$3,000.00	Carbon Source storage system
		Includes clearwell, mudwell					Travel and Living Expenses	$1,500.00	Crane and crew for loading and
		Feed pumps					Total Cost for 90 days:	$28,600.00	unloading
		Chemical tank							Support Equipment, improvements
		backwash pumps, air blowers							and labor
		Electric control panel							Maintanance and repair equipment
		Influent/Effluent Flow meters							Pilot plant operator
		Gravel and Sand							1000-gal service water
									Decontamination of skid and column
									Spill containment
Deep Bed	Ondeo-Degremont	Biofor Aerobic and "DN"	20-day onsite for start-up and traini	2.5 months	480V, 3-phase, 25 amp	Chris Tabor (Project Engineer)	Equipment Rental:		Crane and crew for loading and
Nitrification/		2- 7'X10'X22' (LXWXH) skid			2-Raw Water Pump: 3.0 HP	804-756-7400	Field Technicians and Process Engineers		unloading
DN Filters		Max: 12.26 gpm/ft2			2-Backwash Pump: 1.5 HP		Travel and Living Expenses		Plumber and electrician
Upflow		2-8' dia X 5'8" clearwell			Air Scour Blower: 2 HP		Biolite		Carbon Source (methanol)
		Aerobic: 2' Dia column			Process Air Blowers: 2 HP				Carbon Source storage system
		DN: 1' Dia column			All Pumps 460/3/60				5-gal wastewater for ODI testing prior to pilot
		Biolite			Influent: 2-2" half coupling		Total Cost (not incl. Frieght)	$49,000	Analytical Work
		2-raw water pump			Effluent: 2-4" male NPT		Additional days for ODI operator	$950/day	Maintanance and repair equipment
		2-backwash pump			Service water: 2-3/4" female				Pilot plant operator
		Aerobic: Air Scour Blower							Influent/ Effluent feed transfer pump and tank
		Aerobic: Process Air Blower							Solids disposal equipment
									Spill Containment
FB/DN	US Filter, Envirex	Anoxic Model 30	5-day start-up and instruction	80 days	460VAC, 3-phase, 30 amp	Casey Whittier (Product-Manager)	Option #1: Cost includes:	$10,000 first month	Influent/ Effluent feed transfer pump and tank
Reactors		Fluidized Bed Reactor			Ground connection	262-521-8506	Equipment Rental	$6,700/month	Solids disposal equipment
		7'-3"X13'-6", 15' hieght			influent: 1-1/2" 4 hole flange		Sand		Analytical Work (composite sampler,
		skid with walkway.			effluent: 2" 4 hole flange		Field Technicians and Process Engineers		analysis)
		Reactor: 20'dia X 15' tall					for training and startup.		Carbon Source (methanol)
		25-30 GPM					Travel and Living Expenses		Carbon Source storage system
		Sand or Granular Activated Carbon					Freight Charges	$2000-$3000 (one-way)	Freeze Protection
		Biomass Control System					Total Cost for 80 days	$27,000	Decontamination of skid and column
		Nutrient Feed System							Crane and crew for loading and
		Carbon Source Feed Pump							unloading
		Strainer							Support Equipment, improvements
		Instrumentation and Controls							and labor
		including effluent pH and DO meter							Pilot plant operator
		Lighting							Crane and crew for loading and
		O&M Manuals							unloading
									Spill Containment
							Option #2: US filter runs pilot	$82,000	
							(80 days, incl. Report)		

6.7. BACK RIVER WASTEWATER TREATMENT PLANT

6.7.1. Basis for Comparison

6.7.1.1. General Considerations

Evaluation of Fiscal Year 2000 and 2001 reports revealed that the highest average TKN concentration in secondary influent occurred in the winter of 2000 (November 2000 to March 2001). Hence, all alternatives were evaluated and compared based on these wastewater characteristics that occurred during that period. The following are the associated average plant influent characteristics:

BOD_5 (mg/l)	220
Suspended Solids mg/l	180
Total Phosphorous (TP, mg/l)	4
TKN (mg/l)	28

The alternatives were evaluated based on treating an annual plant flow rate of 180 mgd, plus a plant recycle of 23 mgd for a total BNR influent of 203 mgd. Peak dry weather flow to secondary plant of 292 mgd is based on approximately 1.5 times average daily flow plus plant recycles. The secondary influent characteristics are:

Average Flow (mgd)[3]	203
Peak Dry Weather Flow (mgd)[4]	292
BOD_5 (mg/l)	132
COD (mg/l)	357
TSS (mg/l)	95
TP (mg/l)	3.5
TKN (mg/l)	31.8

[3] Based on 180 mgd Plant Capacity and Plant Recycle of 23 mgd
[4] Based on Peak 5-day factor of 1.5.

TN (mg/l)	32
NO_x-N (mg/l)	0.2
NO_3-N (mg/l)	0.1
NO_2-N (mg/l)	0.1
NH_3-N (mg/l)	22
Alkalinity (mg/l $CaCO_3$)[5]	128
Temperature (^0C)	14

Since only total nitrogen removal is addressed in the BNR alternatives, it is presumed waste pickle liquor is continuously added to the primary effluent for phosphorous removal.

6.7.1.2. Effects on Solids Handling

The effect of each BNR alternative on solids handling includes an evaluation of the quantity of solids wasted to the solids handling facilities and the cost to treat these solids and dispose of them by land application.

The anticipated quantity of waste activated solids produced by each alternative is the sum of biological and chemical (methanol and lime) solids wasted. The solids production ratio for methanol addition is 0.18 lb. VSS produced/ lb. COD removed where 1.5 mg/l of COD is equivalent to 1 mg/l of methanol[6]. For every milligram per liter of lime added, lime solids produced is approximately 0.1% by weight of wasted biological solids[7]. The waste biological solids production is calculated using the design SRT and MLSS (mixed liquor suspended solids) concentrations for Activated Sludge Plant Nos. 1, 2 and 3 (SC 709, 728, and 749) considering separate stage nitrification and denitrification.

[5] Lowest monthly average reported from Jan 1998 to Dec 2000
[6] U.S. EPA: *Manual Nitrogen Control*, EPA/625/R-93/010, Cincinnati, OH., September 1993.
[7] Whitman, Requardt and Assoc., L.L.P.: *Sludge Thickening Facilities Expansion Sanitary Contract No. 736*, November 1992.

	Overall SRT (days)	MLSS (mg/l)
Plant No. 1 (BNR)	16.0 days	3750 mg/l
Plant No. 2 (BNR)	15.1 days	3500 mg/l
Plant No. 3 (BNR)	14.0 days	3500 mg/1
Nitrification[8]	14.3 days	3500 mg/l
Denitrification[7]	20.0 days	3500 mg/l

Solids treatment and disposal costs for each alternative were calculated based on the anticipated waste activated solids treated in the Solids Handling Facility and plant's operating cost. The operating costs include the variable parameters, energy, chemical and disposal. Specifically, energy cost includes waste activated sludge pumping, thickened sludge pumping, and dewatering energy. Chemical costs include polymer cost for gravity belt thickening and centrifuge dewatering and disposal cost for land application. The cost of labor and maintenance is considered fixed and the same for each alternative.

Section 6.7.15.5 summarizes the solids production from each BNR alternative. The tables entitled Summary of Estimated Costs for each alternative list the anticipated costs for solids treatment and disposal.

6.7.1.3. Potential Impact of Two-Phase Digestion

As of 2002, the City is piloting a two-phase mesophilic anaerobic digestion process under SC 776 (Chapter 4). The two-phase process is planned for use in conjunction with the addition of two egg-shaped digesters. This two-phase process is expected to increase the nitrogen loading to the activated sludge plants, improve volatile solids destruction in the digestion process, and reduce solids production for dewatering and disposal.

[8] U.S. EPA: *Manual Nitrogen Control*, EPA/625/R-93/010, Cincinnati, OH., September 1993.

At DuPage County, Illinois, studies of the two-phase mesophilic anaerobic digestion revealed that ammonia-nitrogen concentrations in digested sludge increased by 67% compare to convential high rate digestion[9]. Hence, at the Back River Plant, the nitrogen concentration in digested sludge is expected to increase significantly which in turn would increase the nitrogen concentration in centrate recycles leading to higher nitrogen loading to the activated plants.

The DuPage County study and a design memorandum prepared by Earth Tech[10] for the City estimated that the volatile solids destruction would increase by 20% from two-phase digestion process compared to high rate. This would in turn reduce solids production for dewatering and disposal. Based on an annual average sludge feed of 217 dry tons/day to anaerobic digesters, two-phase digestion, with a 65% volatile solids destruction yields approximately 15.5 dry tons/day less solids for disposal than high rate digestion with 55% volatile solids destruction .

The implementation of the two phase digestion process may require an increased capacity for total nitrogen reduction in BNR treatment. Further evaluation of the alternatives discussed in next sections, especially related to the nitrogen loading returned from dewatering process, is recommended once the two phase digestion process is implemented, and the actual increase in loading can be quantified. Higher strength recycles may increase the benefits of sidestream treatment.

6.7.1.4. Estimated Costs for Levels 1, 2, and 3

The estimated cost of each alternative considers modifying and/or improving the existing treatment facilities to the respective level of treatment. Therefore, the estimated costs for treatment in Levels 1, 2, and 3 are not additive.

[9] Ghosh, S.: "Pilot-Scale Demonstrations of Two-Phase Anaerobic Digestion of Activated Sludge", *Wat. Sci. Tech.*, vol. 23, 1179-1188, 1991.
[10] Earth Tech: *Digester Renovation Final Design Memorandum*, May 1999.

6.7.2. Alternative 1-1 (Level 1): Addition of Methanol to Activated Sludge Plants Nos. 1, 2, and 3

Process Description

This alternative consists of adding a carbon source in the existing BNR basins for denitrification enhancement. As wastewater passes through anoxic/oxic zones in the existing BNR basins at Back River WWTP, lowering of BOD from oxic zones results in depletion of the carbon source for denitrification. Addition of methanol, as an external carbon source, at single or multiple points in the anoxic zones, will enhance denitrification. Besides methanol, other possible external carbon sources are raw sewage (primary sludge), ethanol, methane, acetate, molasses and sugars, and brewery waste. With the City implementing the two-phase mesophilic anaerobic digestion process, liquid from the acid stage (first stage) which contains short chain volatile fatty acids could be supplied to the anoxic zones as an external carbon source for denitrification enhancement.

At the Back River Plant, the BNR effluent nitrate-nitrogen accounted for more than half of the total nitrogen level in the plant effluent. Addition of a carbon source, such as methanol to the anoxic zones will reduce the nitrate-nitrogen to 1 mg/l, resulting in decrease in total nitrogen to 6 mg/l or less.

This process incorporates the addition of methanol, through the use of methanol storage tanks, pumping stations, and piping for each activated sludge plant. If this alternative were implemented, a consolidated methanol facility could be considered. Figures 6-1-1A and 6-1-1B illustrate the concept diagram and the site plan indicating the locations of the methanol facilities, respectively.

Design Assumptions

Methanol facilities are sized based on continuous operation. The facilities are sited along a road for easy accessibility and consist of outdoor storage tanks and pumping station. A dike will be built around the storage tanks for any spillage. The three pumping stations (one for each activated sludge plant) will have metering pumps, safety room, rest room, and containment wall. Activated Sludge Plant No.1 has total of six chemical metering pumps (two standby), whereas Plants Nos. 2 and 3 have nine pumps (three standby) in each pumping station. The design assumptions for methanol addition are presented in Table 6-1-1A. Methanol facility schematic and capacities are shown in Fig.6-1-C and Fig.6-1-D.

Total solids wasted for thickening, 168,000 lbs./day, include chemical (methanol) and biological solids. A breakdown of sludge wasted from each plant is in the design assumption table.

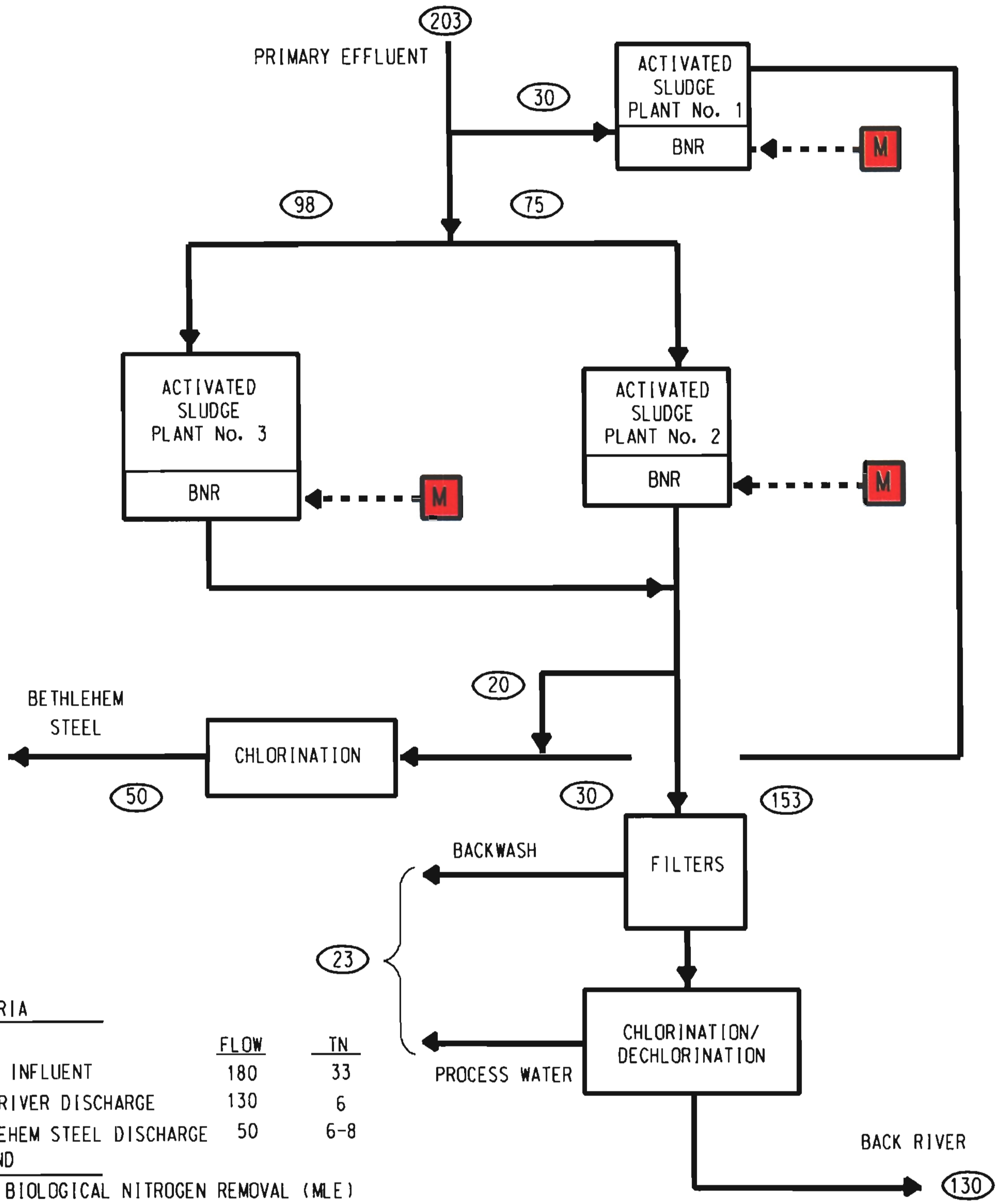
Operation and Maintenance Assumptions

Labor and maintenance costs are based on both existing and new equipment operating at average flow of 203 mgd. Chemical (methanol) and energy (aeration, mixing and pumping) costs are established on continuous operation at an average flow of 30 mgd to Plant No. 1, 75 mgd to Plant No. 2 and 98 mgd to Plant No. 3. Methanol dosage is dependent on the quantity of nitrates consumed in the anoxic zones to produce secondary nitrate-nitrogen levels of 1 mg/l. For every pound of nitrates denitrified, 3 pounds of methanol is dosed. Blue Plains Wastewater Treatment Plant, Washington, D.C, is currently using this ratio.

Operation and maintenance costs are based on the assumptions shown in Table 6-1-1B.

Cost Estimates

A breakdown of capital, salvage, and operation and maintenance costs is shown in Table 6-1-1C.



CRITERIA

	FLOW	TN
PLANT INFLUENT	180	33
BACK RIVER DISCHARGE	130	6
BETHLEHEM STEEL DISCHARGE	50	6-8

LEGEND

- BNR BIOLOGICAL NITROGEN REMOVAL (MLE)
- C/N CARBONACEOUS/NITRIFICATION
- DN DENITRIFICATION
- FB FLUIDIZED BED
- M METHANOL
- P PUMPING STATION
- TN TOTAL NITROGEN
- (oval) FLOW, MGD

NOTE

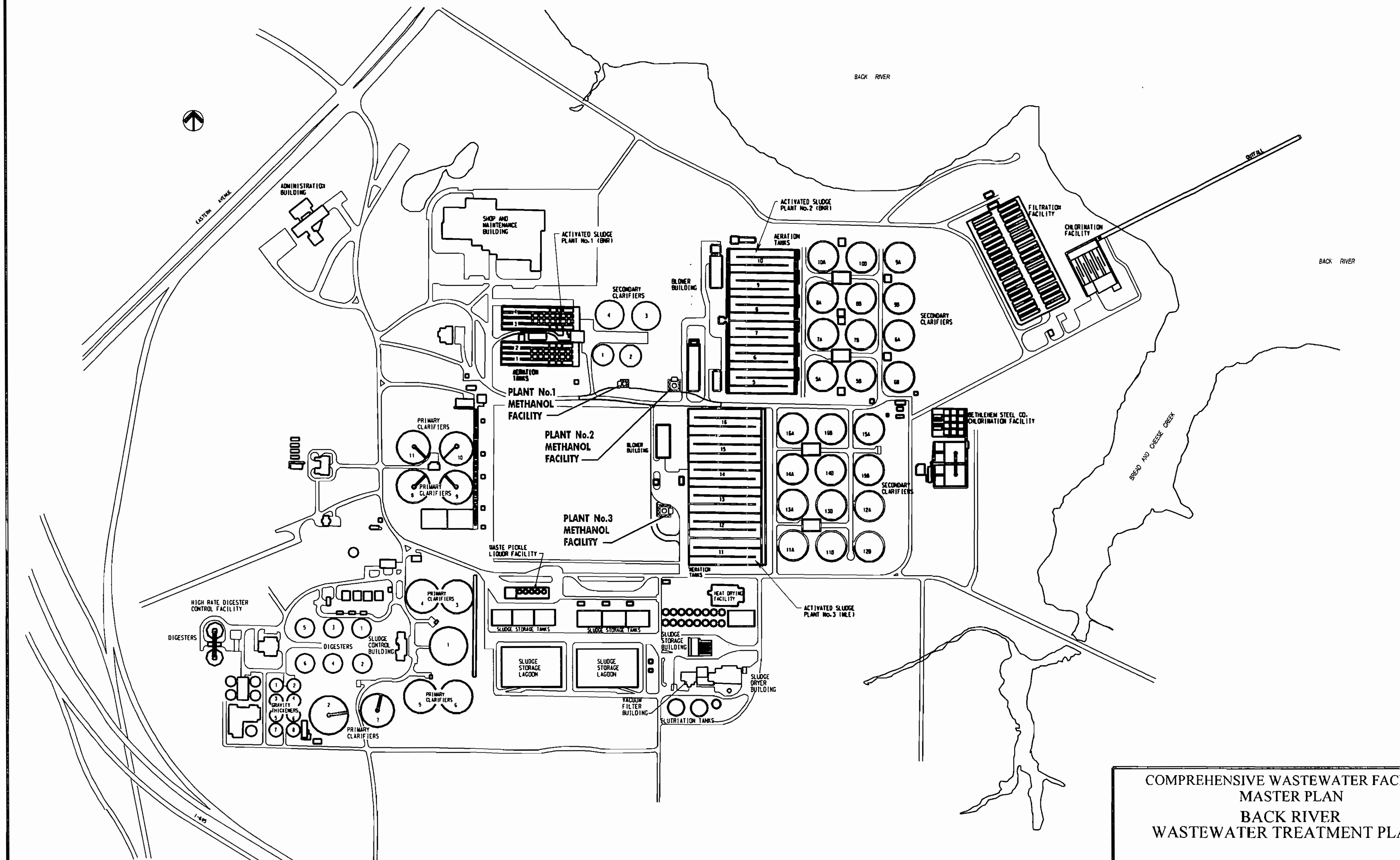
PLANT FLOW=180 MGD, WITH RECYCLES=203 MGD

COMPREHENSIVE WASTEWATER FACILITIES MASTER PLAN

BACK RIVER WASTEWATER TREATMENT PLANT

CONCEPTUAL DIAGRAM ALTERNATIVE 1-1

WHITMAN, REQUARDT AND ASSOCIATES, LLP	DATE: APRIL 2004	SCALE: NONE	FIGURE: 6-1-1A



WHITMAN, REQUARDT AND ASSOCIATES, LLP

COMPREHENSIVE WASTEWATER FACILITIES MASTER PLAN

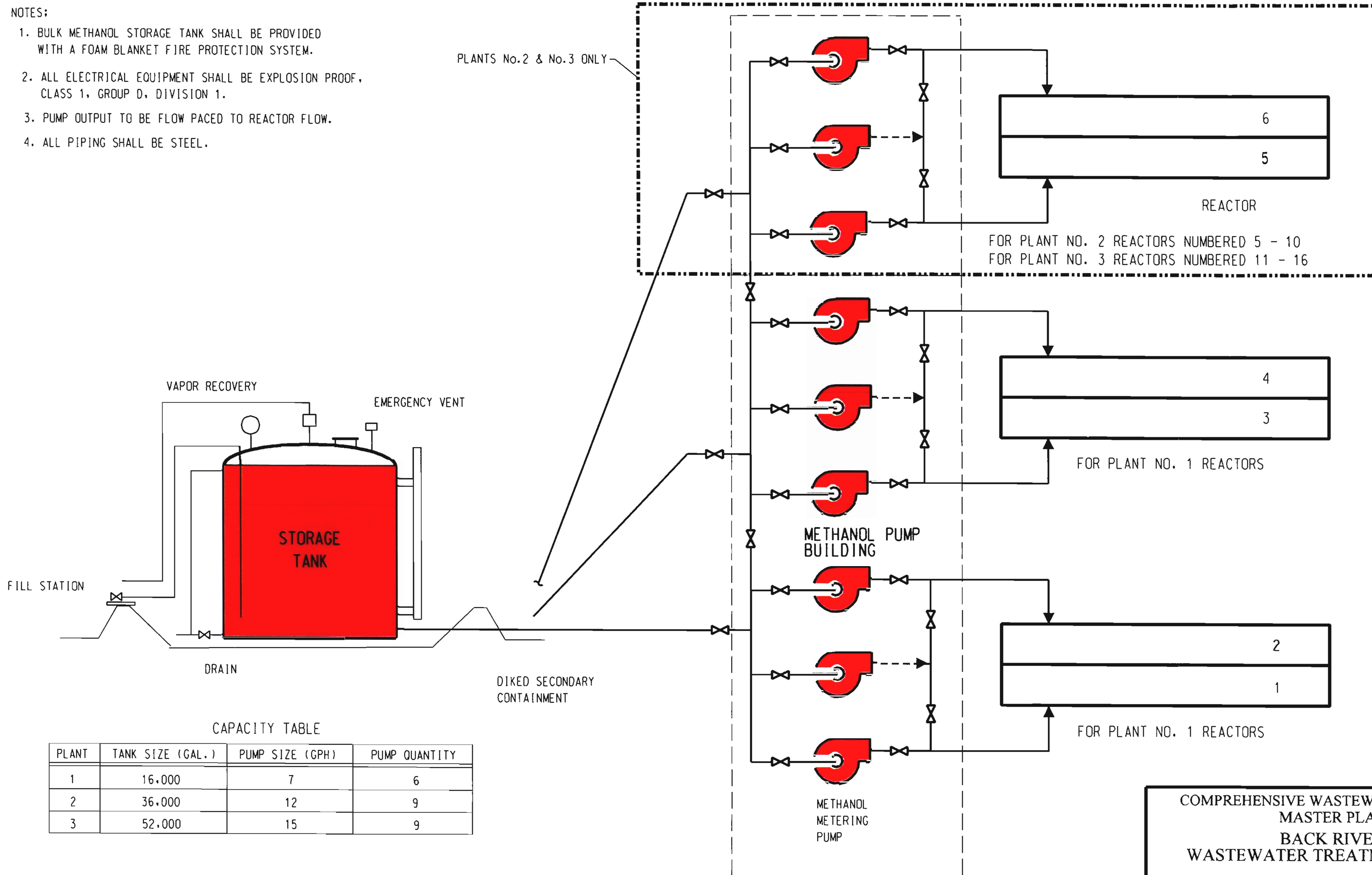
BACK RIVER WASTEWATER TREATMENT PLANT

SITE PLAN ALTERNATIVE 1-1

DATE: APRIL 2004	SCALE: 1'= 500'	FIGURE: 6-1-1B

NOTES:

1. BULK METHANOL STORAGE TANK SHALL BE PROVIDED WITH A FOAM BLANKET FIRE PROTECTION SYSTEM.
2. ALL ELECTRICAL EQUIPMENT SHALL BE EXPLOSION PROOF, CLASS 1, GROUP D, DIVISION 1.
3. PUMP OUTPUT TO BE FLOW PACED TO REACTOR FLOW.
4. ALL PIPING SHALL BE STEEL.



CAPACITY TABLE

PLANT	TANK SIZE (GAL.)	PUMP SIZE (GPH)	PUMP QUANTITY
1	16,000	7	6
2	36,000	12	9
3	52,000	15	9

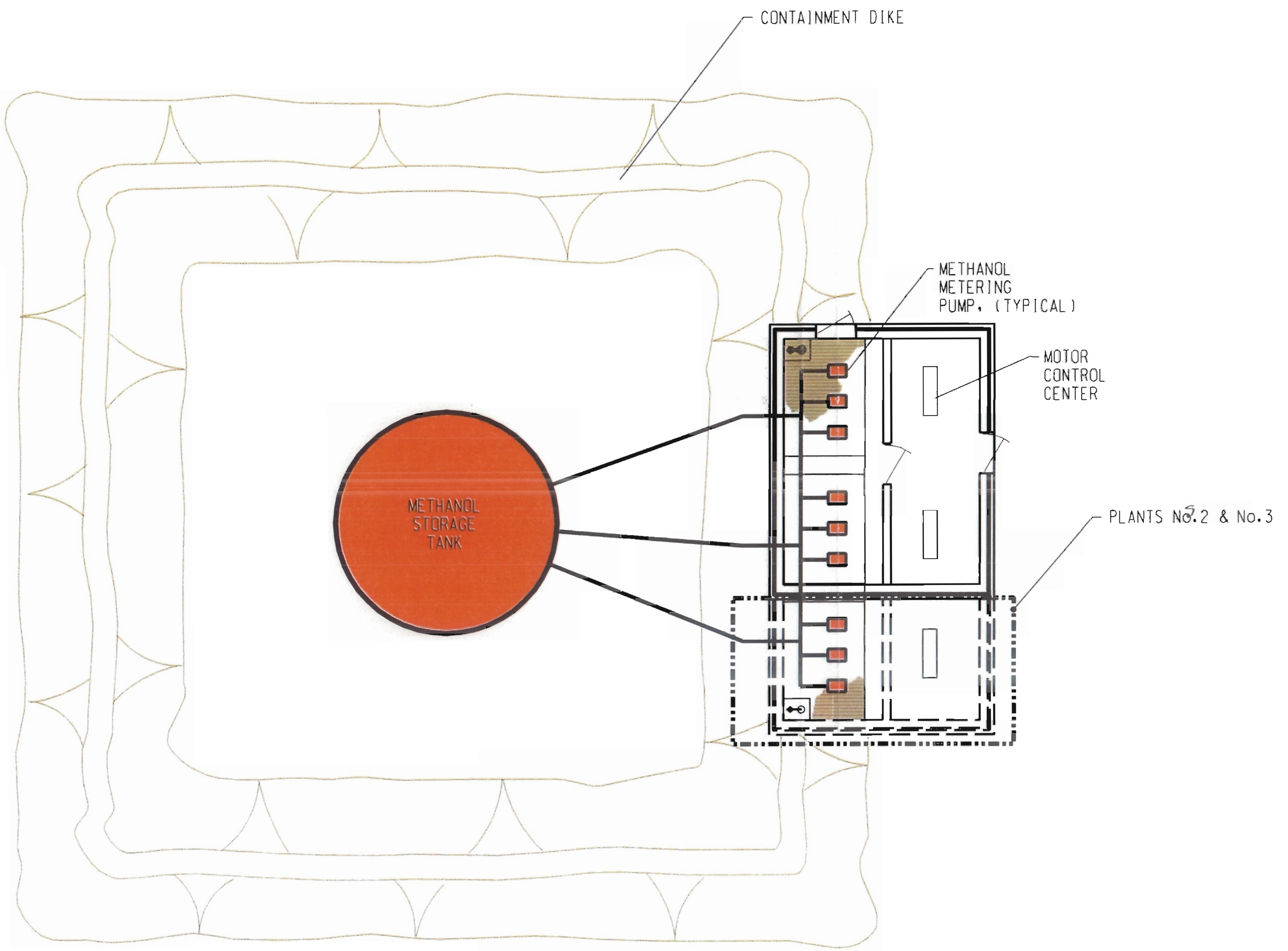
COMPREHENSIVE WASTEWATER FACILITIES MASTER PLAN

BACK RIVER WASTEWATER TREATMENT PLANT

METHANOL FACILITIES SCHEMATIC ALTERNATIVE 1-1

WHITMAN, REQUARDT AND ASSOCIATES, LLP

DATE: APRIL 2004 | SCALE: NONE | FIGURE: 6-1-1C



TYPICAL PLAN

COMPREHENSIVE WASTEWATER FACILITIES MASTER PLAN

BACK RIVER WASTEWATER TREATMENT PLANT

METHANOL FACILITIES PLAN ALTERNATIVE 1-1

DATE: APRIL 2004	SCALE: 1"= 10'	FIGURE: 6-1-1D

WHITMAN, REQUARDT AND ASSOCIATES, LLP

TABLE 6-1-1A

BACK RIVER WASTEWATER TREATMENT PLANT

ALTERNATIVE 1-1; DESIGN ASSUMPTIONS

Unit Process	Parameters	Criteria
Activated Sludge Plant No. 1	Average Daily Flow	30 MGD
BNR	Peak Dry Weather Flow	44 MGD
Chemicals	Methanol Dosage	TN of 8 mg/L: 6.3 mg/L
		TN of 6 mg/L: 12.3 mg/L
	Sludge Production from Methanol Addition	TN of 8 mg/L:567 lb/day
	(0.18 VSS produced/COD removed)	TN of 6 mg/L: 1108 lb/day
	(75% TSS is VSS)	
	Sludge Waste Production	21,032 lbs/day
Performance	Effluent	TN of 8 mg/L: TKN=4.9 mg/L, NOx-N=3.1 mg/L
		TN of 6 mg/L: TKN=4.9 mg/L, NOx-N=1 mg/L
Activated Sludge Plant No. 2	Average Daily Flow	75 MGD
BNR	Peak Dry Weather Flow	108 MGD
Chemicals	Methanol Dosage	TN of 8 mg/L: 6.3 mg/L
		TN of 6 mg/L: 12.3 mg/L
	Sludge Production from Methanol Addition	TN of 8 mg/L: 1419 lb/day
	(0.18 VSS produced/COD removed)	TN of 6 mg/L: 2770 lb/day
	(75% TSS is VSS)	
	Performance	TN of 8 mg/L: TKN=4.9 mg/L, NOx-N=3.1 mg/L
		TN of 6 mg/L: TKN=4.9 mg/L, NOx-N=1 mg/L
	Sludge Waste Production	57,993 lbs/day
Performance	Effluent	TN of 8 mg/L: TKN=4.9 mg/L, NOx-N=3.1 mg/L
		TN of 6 mg/L: TKN=4.9 mg/L, NOx-N=1 mg/L

TABLE 6-1-1A (CONTINUED)

Unit Process	Parameters	Criteria
Activated Sludge Plant No. 3	Average Daily Flow	98 MGD
BNR	Peak Dry Weather Flow	140 MGD
Chemicals	Methanol Dosage	TN of 8 mg/L: 6.3 mg/L
		TN of 6 mg/L: 12.3 mg/L
	Sludge Production from Methanol Addition	TN of 8 mg/L: 1854 lbs/day
	(0.18 VSS produced/COD removed)	TN of 6 mg/L: 3619 lb/day
	(75% TSS is VSS)	
	Sludge Waste Production	81,315 lbs/day
Performance	Effluent	TN of 8 mg/L: TKN=4.9 mg/L, NOx-N=3.1 mg/L
		TN of 6 mg/L: TKN=4.9 mg/L, NOx-N=1 mg/L

TABLE 6-1-1B

BACK RIVER WASTEWATER TREATMENT PLANT

ALTERNATIVE 1-1: OPERATION AND MAINTENANCE ASSUMPTIONS

Unit Process	Assumptions
Activated Sludge Plant No. 1 (BNR)	
Aeration and Mixing	[1.5 (Lbs BOD removed) + 4.6 (lbs of TKN nitrified) – 2.86 (lbs of Nitrates denitrified)]*1.5
	12% O2 transfer efficiency
	346 mg/L of O_2 , $0.045/HP-hr
Mixing Power	27.5 HP/reactor, $0.045/HP-hr
Methanol	TN 6-8 mg/L: 6.3-12.3 mg/L Density: 6.58 lbs/gal, $1.00/gal
Activated Sludge Plant No. 2 (BNR)	
Aeration and Mixing	[1.5 (Lbs BOD removed) + 4.6 (lbs of TKN nitrified) – 2.86 (lbs of Nitrates denitrified)]*1.5
	12% O2 transfer efficiency
	346 mg/L of O_2 , $0.045/HP-hr
Mixing Power	197.5 HP/reactor, $0.045/HP-hr
Methanol	TN 6-8 mg/L: 6.3-12.3 mg/L Density: 6.58 lbs/gal, $1.00/gal
Activated Sludge Plant No. 3 (BNR)	
Aeration and Mixing	[1.5 (Lbs BOD removed) + 4.6 (lbs of TKN nitrified) – 2.86 (lbs of Nitrates denitrified)]*1.5
	12% O2 transfer efficiency
	400 mg/L of O_2, $0.045/HP-hr
Mixing Power	160 HP/reactor, $0.045/HP-hr
Methanol	TN 6-8 mg/L: 6.3-12.3 mg/L Density: 6.58 lbs/gal, $1.00/gal

	PROCESS	CAPITAL ($M)	SALVAGE ($M)	ANNUAL COSTS ($M)				
				OPERATING			MAINT.	TOTAL
				LABOR	ENERGY	CHEMICAL		
1	Ex. Activated Sludge Plant No. 1 (BNR)	8.00	6.96	0.14	0.66		0.46	1.26
2	Ex. Activated Sludge Plant No. 2 (BNR)		33.15	0.36	2.00		2.21	4.57
3	Ex. Activated Sludge Plant No. 3 (BNR)		43.10	0.47	2.38		2.87	5.72
4	Methanol Facilities (3)	3.09	0.93	0.09		1.16	0.06	1.31
5	WAS Treatment[1]				0.08	0.51		0.59
6	Disposal (Land Application)[2]							1.80
7								
8								
9								
10								
11								
12								
13								
14								
15								
16								
17								
18								
19								
20								
21								
22								
	TOTALS	T1= 11.09	T2= 84.14	1.06	5.12	1.67	5.60	T3= 15.25

$M - Millions of Dollars

[1]Based on thickening, pumping, digestion, and dewatering of waste activated sludge (WAS). WAS produced is estimated to be 84.0 dry tons/day (DTPD).

BRWWTP Operations Report for 2001: 80% volatile solids in feed and 80% volatile solids destruction from ESDs.

[2] Sludge cake for disposal is 30.2 DTPD.

PRESENT WORTH COST DETERMINATION

1. PRESENT WORTH FACTORS

F1 = SINGLE PAYMENT, 20 YEARS, 7% = 0.25842

F2 = UNIFORM SERIES, 20 YEARS, 7% = 10.59401

2. PRESENT WORTH BASIS

A. CAPITAL COST: (T1) $11.09

B. SALVAGE COST: (-) (F1 X T2) -$21.74

C. ANNUAL O&M COST: (F2 X T3) $161.56

TOTAL PRESENT WORTH = $150.91

NOTES:
ENR INDEX = 6300
DN = Denitrification
C/N = Carbonaceous / Nitrification

COMPREHENSIVE WASTEWATER FACILITIES
MASTER PLAN

BACK RIVER
WASTEWATER TREATMENT PLANT

SUMMARY OF ESTIMATED COSTS
ALTERNATIVE 1-1

WHITMAN, REQUARDT AND ASSOCIATES, LLP | SEPTEMBER 2002 | TABLE 6 -1-1C

6.7.3. Alternative 1-2 (Level 1): Sidestream BNR Treatment in Activated Sludge Plant No. 1

Process Description

Another alternative is to segregate and treat the centrate from the Pelletizing and Back River dewatering facilities, which contains high contents of TKN, in Activated Sludge Plant No. 1 (MLE process).

Plant operating reports indicate that the centrate TKN monitoring commenced in April 2001. From April 2001 to October 2001 approximately 11% of the TKN loading in primary effluent was contributed by the centrate from the two facilities. Hence separate treatment of centrate in Activated Sludge Plant No. 1 will decrease TKN loading to Activated Sludge Plants Nos. 2 and 3.

This alternative provides sidestream treatment (Plant No. 1), which treats 5 mgd of centrate and 10 mgd of primary effluent. The sidestream is treated to TN of 6 to 8 mg/l in Activated Sludge Plant No. 1 and then blended with rest of the primary effluent before entering Plants Nos. 2 and 3. Plants Nos. 2 and 3 have methanol addition in the anoxic zones for enhanced denitrification. The flow discharged to Back River and ISG (Bethlehem Steel) is treated to a TN of 6 mg/l. Since the flow that is discharged to ISG currently is filtered, the TN levels will be the same as for Back River discharge. A conceptual diagram is presented Figure 6-1-2.

Design Assumptions

Based on Back River operations report, from April 2001 to October 2001, centrate from Pelletizing and City's Dewatering facilities averaged a daily TKN of 222 mg/l, TSS of 196 mg/l and TP of 5.56 mg/l. For the same time period, the average daily flow was 2.27 mgd.

According to SC 709, Plant No. 1 is designed to treat TKN loading of 8737 lbs/day. If 5 mgd of centrate recycle plus 10 mgd of primary effluent were treated in Plant No. 1, the TKN loading would total to 8390 lbs/day, which is less than the plant design loading. Therefore, with 15 mgd of this sidestream treated in Plant No.1 to TN of 6 to 8 mg/l, Plant Nos. 2 and 3 will treat a TKN of approximately 27 mg/l.

The following summarizes average daily flows and characteristics of the sidestream discharge to Plant No. 1.

Average Daily Flow	15 mgd
Peak Dry Weather Flow	22 mgd
BOD_5[11]	127 mg/l
TKN	67 mg/l
TSS	71 mg/l
TP	3.56 mg/l

Total sludge production to thickening, 168,000 lbs/day, includes chemical (methanol) and biological wasted solids. A breakdown of solids wasted from each plant is located in the design assumption table.

The design assumptions are presented in Table 6-1-2A.

Operation and Maintenance Assumptions

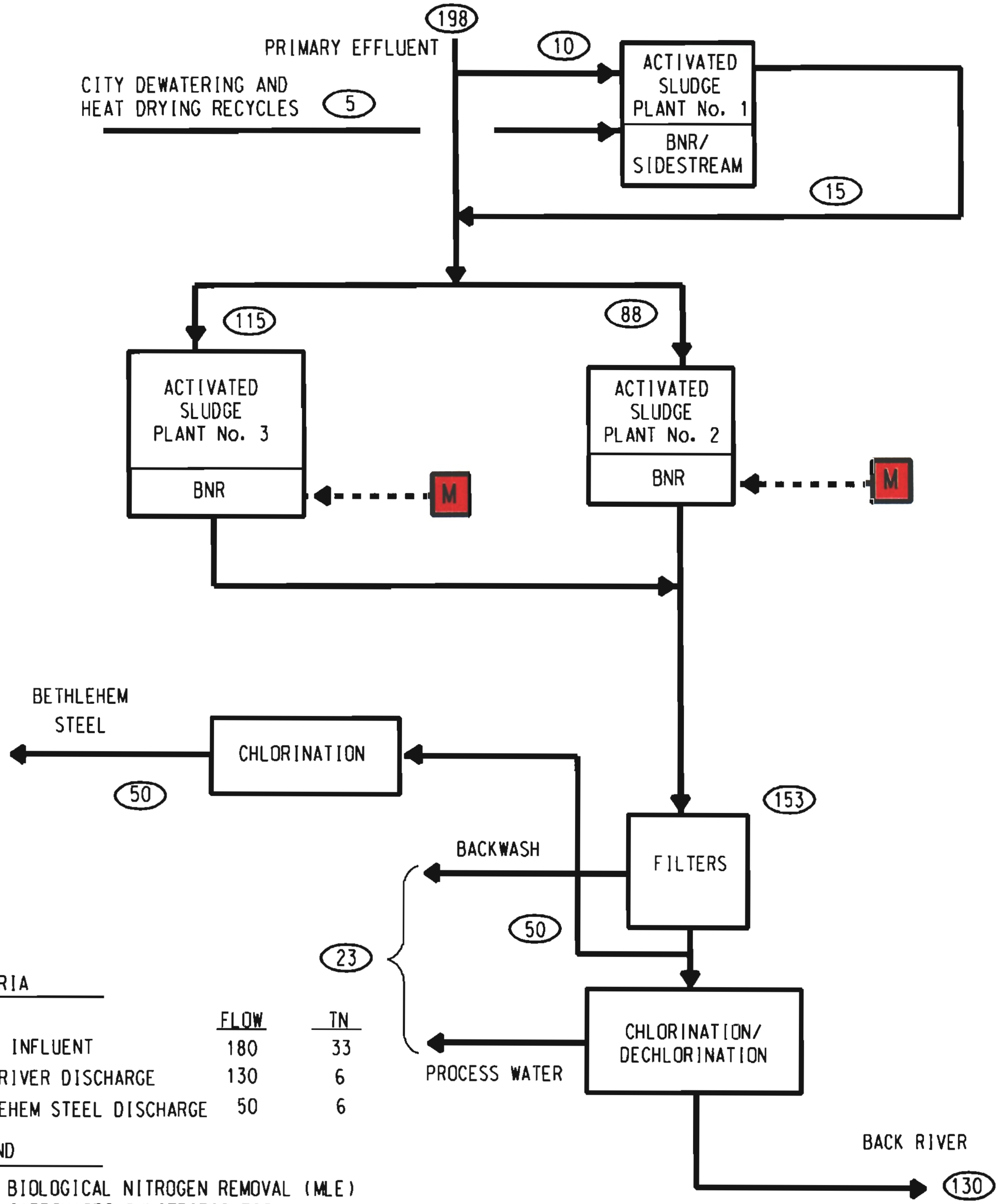
Labor and maintenance costs are based on both existing and new equipment operating at average flow of 203 mgd. Chemical (methanol) and energy (aeration, mixing, and pumping) costs are established from continuous operation at an average influent flow of 15 mgd to Plant No.1, 88 mgd to Plant No. 2 and 115 mgd to Plant No.3. Methanol dosage is computed using the same methanol-nitrate nitrogen ratio as discussed in Alternative 1-1.

Operation and maintenance assumptions for estimating costs are presented in Table 6-1-2B.

[11] BOD for centrate assumed 115 mg/l: Daigger, G.T.: "Recycle Streams", *WE&T*, 47-52, October 1998.

Cost Estimates

A breakdown of capital, salvage, and operation and maintenance costs is shown in Table 6-1-2C. To further determine the cost effectiveness of this alternative, BOD_5 and alkalinity testing of the centrate is recommended.



CRITERIA

	FLOW	TN
PLANT INFLUENT	180	33
BACK RIVER DISCHARGE	130	6
BETHLEHEM STEEL DISCHARGE	50	6

LEGEND

BNR BIOLOGICAL NITROGEN REMOVAL (MLE)
C/N CARBONACEOUS/NITRIFICATION
DN DENITRIFICATION
FB FLUIDIZED BED
M METHANOL
P PUMPING STATION
TN TOTAL NITROGEN
(oval) FLOW, MGD

NOTE

PLANT FLOW=180 MGD, WITH RECYCLES=203 MGD

COMPREHENSIVE WASTEWATER FACILITIES
MASTER PLAN

BACK RIVER
WASTEWATER TREATMENT PLANT

CONCEPTUAL DIAGRAM
ALTERNATIVE 1-2

WHITMAN, REQUARDT AND ASSOCIATES, LLP | DATE: APRIL 2004 | SCALE: NONE | FIGURE: 6-1-2

TABLE 6-1-2A

BACK RIVER WASTEWATER TREATMENT PLANT

ALTERNATIVE 1-2: DESIGN ASSUMPTIONS

Unit Process	Parameters	Criteria
Activated Sludge Plant No. 1	Average Daily Flow	15 MGD: 5 MGD Centrate and 10 MGD Primary Effluent
BNR/SIDESTREAM	Peak Dry Weather Flow	22 MGD
Reactors	Number of Reactors	all four
	Design Hydraulic Detention Time	17 hours
	Design Solids Retention Time	10 days
	Overall Solids Retention Time	16 days
Aeration	O_2 Requirement	60,310 lbs/day
	Blower Capacity	20,060 cfm, 985 HP @ 15.5 ft Head
	Fine Bubble Diffusers	13,370@ 1.5 cfm per diffuser
	Oxygen Transfer Efficiency	12%
Clarifier	Clarifier	all four
	Clarifier Overflow Rate	200 gpd/ft^2
	Solids Flux Loading Rate	6.2 lbs/ft^2
	Design MLSS	3750 mg/L
	Sludge Waste Production	21,032 lbs/day
Performance	Effluent	TN=8-6 mg/L, TKN=4.9,
Activated Sludge Plant No. 2	Average Daily Flow	88 MGD
BNR	Peak Dry Weather Flow	127 MGD
Reactors	Number of Reactors	6
	Design Hydraulic Detention Time	11.2 hours
	Design Solids Retention Time	10.9 days
Air includes mixing	Installed Blower Capacity	71,400 cfm
	Installed Fine Bubble Diffusers	7916/ reactor @ 1.5 SCFM/diffuser
	Oxygen Transfer Efficiency	12%

TABLE 6-1-2A (CONTINUED)

Unit Process	Parameters	Criteria
Clarifier	Clarifier	12
	Clarifier Overflow Rate	Average: 389 gpd/ft^2, Peak: 561 gpd/ft^2
	Solids Flux Loading Rate	11.3 lbs/sq.ft./day
	Design MLSS	3500 mg/L
	Sludge Waste Production	57,993 lbs/day
Chemicals	Methanol	TN 8-6 mg/L: 6.3-12.3 mg/L
	Sludge Production from Methanol Addition	TN of 8 mg/L: 1665 lbs/day
	(0.18 VSS produced/COD removed)	TN of 6 mg/L: 3250 lb/day
	(75% TSS is VSS)	
Performance	Effluent	TN of 8 mg/L: TKN=4.9 mg/L, NOx-N=3.1 mg/L
		TN of 6 mg/L: TKN=4.9 mg/L, NOx-N=1 mg/L
Activated Sludge Plant No. 3	Average Daily Flow	115 MGD
BNR	Peak Dry Weather Flow	165 MGD
Reactors	Number of Reactors	6
	Design Hydraulic Detention Time	11.2 hours
	Design Solids Retention Time	9.4 days
Air includes mixing	Installed Blower Capacity	93,100 cfm
	Installed Fine Bubble Diffusers	10,344/ reactor @ 1.5 SCFM/diffuser
	Oxygen Transfer Efficiency	12%
Clarifier	Clarifier	12
	Clarifier Overflow Rate	Average: 477 gpd/ft^2, Peak: 684 gpd/ft^2
	Solids Flux Loading Rate	13.9 lbs/sq.ft./day
	Design MLSS	3500 mg/L
	Sludge Waste Production	81,315 lbs/day
Chemicals	Methanol	TN 8-6 mg/L: 6.3-12.3 mg/L

TABLE 6-1-2A (CONTINUED)

Unit Process	Parameters	Criteria
	Sludge Production from Methanol Addition	TN of 8 mg/L: 2175 lbs/day
	(0.18 VSS produced/COD removed)	TN of 6 mg/L: 4247 lb/day
	(75% TSS is VSS)	
Performance	Effluent	TN of 8 mg/L: TKN=4.9 mg/L, NOx-N=3.1 mg/L
		TN of 6 mg/L: TKN=4.9 mg/L, NOx-N=1 mg/L

TABLE 6-1-2B

BACK RIVER WASTEWATER TREATMENT PLANT

ALTERNATIVE 1-2: OPERATION AND MAINTENANCE ASSUMPTIONS

Unit Process	Assumptions
Activated Sludge Plant No. 1 (BNR/SIDESTREAM)	
Aeration and Mixing	[1.5 (Lbs BOD removed) + 4.6 (lbs of TKN nitrified) – 2.86 (lbs of Nitrates denitrified)]*1.5
	108,600 lbs/day in all aerobic zones, $0.045/HP-hr
	12% O2 transfer efficiency
Mixing Power	27.5 HP/reactor, $0.045/HP-hour
Activated Sludge Plant No. 2 (BNR)	
Aeration and Mixing	[1.5 (Lbs BOD removed) + 4.6 (lbs of TKN nitrified) – 2.86 (lbs of Nitrates denitrified)]*1.5
	12% O2 transfer efficiency
	356 mg/L of O2 , $0.045/HP-hr
Mixing Power	197.5 HP/reactor, $0.045/HP-hr
Activated Sludge Plant No. 3 (BNR)	
Aeration and Mixing	[1.5 (Lbs BOD removed) + 4.6 (lbs of TKN nitrified) – 2.86 (lbs of Nitrates denitrified)]*1.5
	12% O2 transfer efficiency
	400 mg/L of O2
Mixing Power	160 HP/reactor, $0.045/HP-hr
Methanol (Plant No. 2 and No. 3)	TN 8-6 mg/L: 6.3-12.3 mg/L Density: 6.58 lbs/gal, $1.00/gal

	PROCESS	CAPITAL ($M)	SALVAGE ($M)	ANNUAL COSTS ($M)				
				OPERATING			MAINT.	TOTAL
				LABOR	ENERGY	CHEMICAL		
1	Ex. Activated Sludge Plant No. 1	8.00	6.96	0.14	0.44		0.46	1.04
	(BNR/Sidestream)							
2	Ex. Activated Sludge Plant No. 2 (BNR)		33.15	0.36	2.14		2.21	4.71
3	Ex. Activated Sludge Plant No. 3 (BNR)		43.10	0.47	2.56		2.87	5.90
4	Methanol Facilities (3)	2.33	0.70	0.06		1.16	0.05	1.27
5	WAS Treatment[1]				0.08	0.51		0.59
6	Disposal (Land Application) [2]							1.80
7								
8								
9								
10								
11								
12								
13								
14								
15								
16								
17								
18								
19								
20								
21								
22								
	TOTALS	T1= 10.33	T2= 83.91	1.03	5.22	1.67	5.59	T3= 15.31

$M - Millions of Dollars

[1]Based on thickening, pumping, digestion, and dewatering waste activated sludge (WAS). WAS produced is estimated to be 84.0 dry tons/day (DTPD).
BRWWTP Operations Report for 2001: 80% volatile solids in feed and 80% volatile solids destruction from ESDs.

[2]Sludge cake for disposal is 30.2 DTPD.

PRESENT WORTH COST DETERMINATION

1. PRESENT WORTH FACTORS

F1 = SINGLE PAYMENT, 20 YEARS, 7% = 0.25842
F2 = UNIFORM SERIES, 20 YEARS, 7% = 10.59401

2. PRESENT WORTH BASIS

A. CAPITAL COST: (T1) $10.33

B. SALVAGE COST: (-) (F1 X T2) -$21.68

C. ANNUAL O&M COST: (F2 X T3) $162.19

TOTAL PRESENT WORTH = $150.84

NOTES:
ENR INDEX = 6300
DN = Denitrification
C/N = Carbonaceous / Nitrification

COMPREHENSIVE WASTEWATER FACILITIES
MASTER PLAN

BACK RIVER
WASTEWATER TREATMENT PLANT

SUMMARY OF ESTIMATED COSTS
ALTERNATIVE 1-2

WHITMAN, REQUARDT AND ASSOCIATES, LLP | SEPTEMBER 2002 | TABLE 6-1-2C

6.7.4. Alternative 2-1 (Level 2): Two Sludge Suspended Growth System

Process Description

Separate stage suspended growth nitrification and denitrification takes advantage of optimizing both nitrification and denitrification step in separate reactors. The bacteria responsible for nitrification and denitrification do not thrive in exactly the same environments in single-sludge process (i.e. MLE). Hence, separating the steps allows operations to fine-tune both processes for maximum treatment efficiency.

This process consists of a carbonation/nitrification stage followed by a separate denitrification stage with supplemental methanol addition, sand filtration, and chlorination/dechlorination. The flow to Back River is treated to a TN of 3 to 6 mg/l and flow to ISG (previously Bethlehem Steel) to TN of 6 to 8 mg/l.

The existing Activated Sludge Plant No. 3 and new Activated Sludge Plant No. 4 (four reactors) will provide the carbon oxidation and nitrification process. Nitrified effluent is pumped to Activated Sludge Plant Nos. 1 and 2 for denitrification. The denitrified effluent from Activated Sludge Plant No. 1 has TN of 6 to 8 mg/l, whereas, the denitrified effluent from Activated Sludge Plant No. 2 is treated to TN of 3 mg/l. Due to hydraulic limitations of Plant No. 2 existing secondary clarifiers, additional six new clarifiers will be required. New Activated Sludge Plant No. 4 will include four three-pass reactors, four rectangular clarifiers, and four lime feed systems. A conceptual diagram is presented in Figure 6-2-1. The site plan and process schematic are similar to those shown in Figures 6-3-1B and 6-3-1C.

Design Assumptions

Primary effluent gravity flows to the new influent splitter box for distribution of 122 mgd and 81 mgd to Plants Nos. 3 and 4 for nitrification, respectively. Plant No. 4 consists of four new reactors (same size as Plant No. 3), and four rectangular clarifiers. Four lime silos and slakers are installed for Plant No. 4 and existing slakers are upgraded for Plant No. 3. Two pumping stations pump the nitrified effluent from Plant Nos. 3 and 4 to Plant Nos. 1 and 2 for denitrification. The two methanol pumping stations (Plant Nos. 1 and 2) are similar to Alternative 1-1. Six new clarifiers (Nos. 5C to 10C) and a sludge pumping station are added to Plant No. 2. Existing distribution boxes for Clarifiers Nos. 5A and 5B to 10A and 10B serve new clarifier Nos. 5C to 10C. The detention time for complete nitrification is 6.5 hours and denitrification in Level 2 is 3 hours at peak dry weather flows. Site plan shows the location of the pumping stations, splitter box, and new clarifiers.

In nitrification process, 7.14 mg/1of alkalinity is destroyed per mg/1 of nitrate-nitrogen removed. To maintain neutral pH and residual alkalinity of 50 mg/1, additional chemical is recommended, such as lime or caustic soda. In this case, quick lime was included in the nitrification process. Quick Lime contains 1.8 mg/1 of alkalinity, which implies that 55.7 mg/l of quick lime is required for 100 mg/1 of alkalinity recovery.

Total sludge production to thickening facility, 225,000 lbs/day, includes chemical (lime and methanol) and biological wasted solids. A breakdown of solids wasted from each plant is located in the design assumption, Table 6-2-1A.

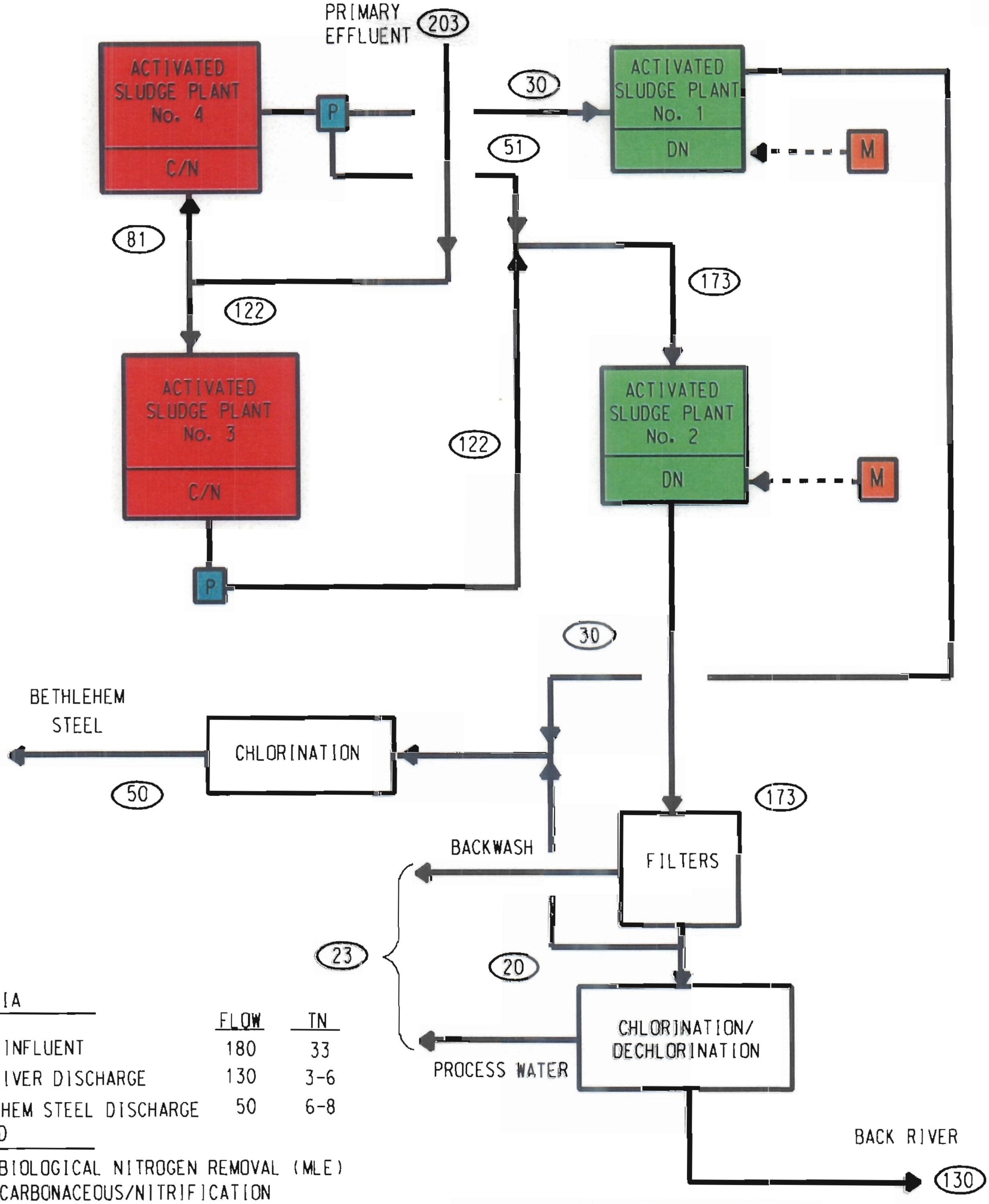
Operation and Maintenance Assumptions

Labor and maintenance costs are based on both existing and new equipment operating at average flow of 203 mgd. Chemical and energy (aeration, mixing and pumping) costs are established on a continuous operation at an average flow of 30 mgd to Plant No.1, 173 mgd to Plant No. 2, 122 mgd to Plant No.3, and 81 mgd to Plant No.4. Methanol dosage is computed using the same ratio as in Alternative 1-1. Cost of quick lime is based on supplier's estimate at the time of writing.

Operation and maintenance assumptions are presented in Table 6-2-1B.

Cost Estimates

A breakdown of capital, salvage, and operation and maintenance costs is shown in Table 6-2-1C.



CRITERIA

	FLOW	TN
PLANT INFLUENT	180	33
BACK RIVER DISCHARGE	130	3-6
BETHLEHEM STEEL DISCHARGE	50	6-8

LEGEND

BNR BIOLOGICAL NITROGEN REMOVAL (MLE)
C/N CARBONACEOUS/NITRIFICATION
DN DENITRIFICATION
FB FLUIDIZED BED
M METHANOL
P PUMPING STATION
TN TOTAL NITROGEN
(oval) FLOW, MGD

NOTE

PLANT FLOW=180 MGD, WITH RECYCLES=203 MGD

COMPREHENSIVE WASTEWATER FACILITIES MASTER PLAN

BACK RIVER WASTEWATER TREATMENT PLANT

CONCEPTUAL DIAGRAM ALTERNATIVE 2-1

WHITMAN, REQUARDT AND ASSOCIATES, LLP	DATE: APRIL 2004	SCALE: NONE	FIGURE: 6-2-1

TABLE 6-2-1A
BACK RIVER WASTEWATER TREATMENT PLANT
ALTERNATIVE 2-1: DESIGN ASSUMPTIONS

Unit Process	Parameters	Criteria
Activated Sludge Plant No. 1	Average Daily Flow	30 MGD
DN	Peak Dry Weather Flow	44 MGD
Reactors	Total Reactor Volume	2.69 Mgal
	Number of Reactors	4 (two standby)
	Design Hydraulic Detention Time	4.3 hours
	Design Solids Retention Time	20 days
Air includes mixing	Installed Blower Capacity	882 SCFM
	Installed Coarse Bubble Diffusers	294 diffuser/reactor
	Installed Mixing Capacity	74.5 HP/reactor mixing (.36 hp/1000 cu.ft)
Clarifiers	Clarifiers	All four existing under SC 709
	Clarifier Overflow Rate	Average: 394 gpd/ft^2, Peak: 577 gpd/ft^2
	Solids Flux Loading Rate	11.5 lbs/sq. ft./day
	Design MLSS	3500 mg/L
	Sludge Waste Production	7852 lbs/day
Chemicals	Methanol Dosage	78 mg/L
For TN average of 7 mg/L		
	Sludge Production from Methanol Addition	
	(0.18 VSS produced/COD removed,)	TN of 6 mg/L: 7026 lb/day
	(75% TSS is VSS)	

TABLE 6-2-1A (CONTINUED)

Unit Process	Parameters	Criteria
Performance	Effluent	TN of 6mg/L: TKN=2 mg/L, NOx-N= 4 mg/L
Activated Sludge Plant No. 2	Average Daily Flow	173 MGD
DN	Peak Dry Weather Flow	248 MGD
Reactor	Number of Reactors	6 (one standby)
	Design Hydraulic Detention Time	3.5 hours
	Design Solids Retention Time	20 days
Air includes Mixing	Blower Capacity Required	4010/reactor cfm
	Coarse Bubble Diffusers Required	2674 diffusers/reactor in rearation zone
	Installed Mixing Capacity	201 HP/reactor in anoxic zone
Clarifiers	Clarifiers	Install 6 new (one standby), 155 ft dia, 5C, 6C, 7C, 8C, 9C,10C
	Clarifier Overflow Rate	Average: 551 gpd/ft^2, Peak: 790 gpd/ft^2
	Solids Flux Loading Rate	14.9 lbs/sq. ft./day
	Design MLSS	3500 mg/L
	Sludge Waste Production	34,490 lbs/day
Chemicals	Methanol Dosage	90 mg/L
	Sludge Production from Methanol Addition	TN of 3 mg/L: 46,747 lbs/day
	(0.18 VSS produced/COD removed)	
	(75% TSS is VSS)	
Performance	Effluent	TN of 3mg/L: TKN=2 mg/L, NOx-N= 1 mg/L

TABLE 6-2-1A (CONTINUED)

Unit Process	Parameters	Criteria
Activated Sludge Plant No. 3	Average Daily Flow	122 MGD
C/N	Peak Dry Weather Flow	175 MGD
Reactors	Number of Reactors	6
	Design Hydraulic Detention Time	7.67 hours
	Design Solids Retention Time	14.3 days
Air includes mixing	Oxygen Consumption for Nitrification	510 mg/L, 4253 Lbs/MGD
	Installed Blower Capacity	26,156 cfm/reactor
	Installed Fine Bubble Diffusers	17,440/ reactor @ 1.5 SCFM/diffuser
	Oxygen Transfer Efficiency	12%
Clarifier	Clarifier	12 existing
	Clarifier Overflow Rate	Average: 526 gpd/ft^2, Peak: 756 gpd/ft^2
	Solids Flux Loading Rate	14.8 lbs/sq.ft./day
	Design MLSS	3500 mg/L
	Sludge Waste Production	79,610 lbs/day
Chemicals	Quick Lime Dosage	76 mg/L
	Lime Solids	6050 lbs/day
	7.6%of Waste Activated Sludge	
Performance	Effluent	TN of 3mg/L: TKN=2 mg/L, NOx-N= 30 mg/L
Activated Sludge Plant No. 4	Average Daily Flow	81 MGD
C/N	Peak Dry Weather Flow	117 MGD
Reactor	Number of Reactors	4 (one standby)

TABLE 6-2-1A (CONTINUED)

Unit Process	Parameters	Criteria
	Design Hydraulic Detention Time	6 hours
	Design Solids Retention Time	14.3 days
Air includes mixing	Oxygen Consumption for Nitrification	510 mg/L, 4253 lbs/MGD
	Installed Blower Capacity	26,156 cfm/reactor
	Installed Fine Bubble Diffusers	17,440 per reactor @ 1.5 scfm/diffuser
	Oxygen Transfer Efficiency	12%
Clarifier	Clarifier	4 new (415'x45'x15.5' (SWD)) 3-pass each (one standby)
	Clarifier Overflow Rate	Average: 482 gpd/ft2, Peak: 696 gpd/ft2
	Solids Flux Loading Rate	10.6 lbs/sq.ft./day
	Design MLSS	3500 mg/L
	Sludge Waste Production	39,805 lbs/day
Chemicals	Quick Lime Dosage	76 mg/L
	Lime Solids	3025 lbs/day
	7.6% of Waste Activated Sludge	
Performance	Effluent	TN of 3mg/L: TKN=2 mg/L, NOx-N= 30 mg/L

TABLE 6-2-1B

BACK RIVER WASTEWATER TREATMENT PLANT

ALTERNATIVE 2-1: OPERATION AND MAINTENANCE ASSUMPTIONS

Unit Process	Assumptions
Activated Sludge Plant No. 3 and Plant No. 4 (C/N)	
Pumping to Plant No.1 and No. 2	122 MGD from Plant No. 3 to Plant No. 2 @ 17 ft Head
	51 MGD from Plant No. 4 to Plant No. 2 @ 17 ft Head
	30 MGD from Plant No. 4 to Plant No. 1 @ 17 ft Head
	0.3132 HP/MGD/ft of Head, $0.06/KWh.
Aeration includes mixing	lbs/day of O2 consumption = ((1.5 X lbs BOD influent) + (4.6 TKN influent) + (1.5 DO)) 1.5
	12% O2 transfer efficiency
	510 mg/L of O_2, $0.045/HP-hr
Lime	76 mg/L Quick Lime, $50/ton
Activated Sludge Plant No. 1 (DN)	
Mixing Power	74.5 HP/ reactor. $0.045/HP-hr.
Methanol	78 mg/L Density: 6.58 lbs/gal, $1.00/gal
Rearation	441 cfm/reactor, 30 cfm/1000 cu. ft.
Activated Sludge Plant No. 2 (DN)	
Mixing Power	201 HP/ reactor. $0.045/HP-hr.
Methanol	90 mg/L Density: 6.58 lbs/gal, $1.00/gal
Rearation	4001cfm/reactor, 30 cfm/1000 cu. ft.

	PROCESS	CAPITAL ($M)	SALVAGE ($M)	ANNUAL COSTS ($M)				
				OPERATING			MAINT.	TOTAL
				LABOR	ENERGY	CHEMICAL		
1	Ex. Activated Sludge Plant No. 1 (DN)	4.89	6.96	0.10	0.08		0.46	0.64
2	Ex. Activated Sludge Plant No. 2 (DN)	8.67	33.15	0.27	0.91		2.21	3.39
3	Ex. Activated Sludge Plant No. 3 (C/N)	23.77	43.10	0.36	3.53		2.87	6.76
4	Activated Sludge Plant No. 4 (C/N)	112.88	33.86	0.24	2.35		1.78	4.37
5	Dentrification Pumping Stations (2)	59.85	17.96	0.04	0.42		0.96	1.42
6	Methanol Facilities (2)	2.33	0.70	0.06		8.29	0.05	8.40
7	Lime Facilities (1 Existing and 1 New)	0.86	0.50			1.64	0.03	1.67
8	WAS Treatment[1]				0.10	0.69		0.79
9	Disposal (Land Application)[2]							2.41
10								
11								
12								
13								
14								
15								
16								
17								
18								
19								
20								
21								
22								
	TOTALS	T1= 213.25	T2= 136.23	1.07	7.39	10.62	8.36	T3= 29.85

$M - Millions of Dollars

[1]Based on thickening, pumping, digestion, and dewatering of waste activated sludge (WAS). WAS produced is estimated to be 112.5 dry tons/day (DTPD).
BRWWTP Operations Report for 2001: 80% volatile solids in feed and 80% volatile solids destruction from ESDs.

[2]Sludge cake for disposal is 40.5 DTPD.

PRESENT WORTH COST DETERMINATION

1. PRESENT WORTH FACTORS
   - F1 = SINGLE PAYMENT, 20 YEARS, 7% = 0.25842
   - F2 = UNIFORM SERIES, 20 YEARS, 7% = 10.59401

2. PRESENT WORTH BASIS
   - A. CAPITAL COST: (T1) $213.25
   - B. SALVAGE COST: (-) (F1 X T2) -$35.20
   - C. ANNUAL O&M COST: (F2 X T3) $316.24

TOTAL PRESENT WORTH = $494.29

NOTES:
ENR INDEX = 6300
DN = Denitrification
C/N = Carbonaceous / Nitrification

COMPREHENSIVE WASTEWATER FACILITIES MASTER PLAN

BACK RIVER WASTEWATER TREATMENT PLANT

SUMMARY OF ESTIMATED COSTS ALTERNATIVE 2-1

WHITMAN, REQUARDT AND ASSOCIATES, LLP	SEPTEMBER 2002	TABLE 6-2-1C

6.7.5. Alternative 2-2 (Level 2): Carbon Oxidation/Nitrification Suspended Growth Plus Deep Bed Denitrification Filter (Downflow)

Process Description

This design concept incorporates one existing activated sludge plant, converts one existing activated sludge plant to carbon oxidation-nitrification process, another plant to denitrification process, and adds downflow deep bed denitrification filters before sand filtration. The flow going to ISG (formerly Bethlehem Steel) is effluent from existing Plant No. 2 (methanol addition) treated to TN of 6 to 8 mg/l. The flow to Back River is a blend of effluent from denitrification in Plant No. 1, and downflow deep bed filters treated to expected TN concentrations of 3 to 6 mg/l.

Downflow deep bed denitrification filter is an attached growth process identical to deep bed sand filters. The wastewater flows from top of the filter through the media, which serves as a support system for the denitrifying microorganisms. Air-water and water backwash sloughs off the excess biomass. Frequent nitrogen gas bumping minimizes headloss through the filter. Part of the backwash maybe returned to filters for reseeding usually backwash waste is recycled through the primaries.

Some of the advantages of the downflow denitrification filters include the additional removal of suspended solids producing a very clean effluent with turbidities in the range of 0.5 NTU. Another advantage is a very small footprint as compared with a suspended growth system that requires further clarification. Lastly, the deep bed downflow denitrification filter has proven successful in producing an effluent with TN ≤ 3 mg/l.

The disadvantages of the downflow filters are that compared with other attached growth technologies, it requires large amount of space due to the low loading rates (1-2 gpm/ft2) allowable. The backwash pump and blower increase the operation and maintenance costs in addition to adding to the overall recycle volume. Lastly this process is proprietary.

The conceptual diagram is presented in Figure 6-2-2. Site plan is similar to Figure 6-3-2B for Alternative 3-2. The third methanol facility for Plant No.2 is in close proximity to Chemical Building.

Design Assumptions

The primary effluent gravity flows to influent splitter box for distribution of 88 mgd and 115 mgd to Plants Nos. 2 and 3, respectively. Plant No. 2 remains as existing MLE and Plant No. 3 is converted to a nitrification process. Lime is added in the nitrification basins of Plant No. 3 to maintain alkalinity of 50 mg/l as $CaCO_3$ and a pH of 7. The two denitrification pumping stations, one for Plant No. 3 and another for Plant No. 2, pump 30 mgd of the nitrified effluent to Plant No. 1 and 123 mgd to deep bed filters for denitrification. This 123 mgd is a blend of nitrified effluent from Plant No. 3 and MLE effluent from Plant No. 2. The rest of the MLE effluent (50 mgd) from Plant No. 2 flows to Bethlehem Steel. Three methanol facilities (two for Plant Nos. 1 and 2 and another for deep bed denitrification filters) are similar to Alternative 1-1. The detention time for complete nitrification is 6.5 hours and denitrification is 4.3 hours.

Downflow deep bed denitrification filters are designed to treat peak flow of 176 mgd of a blend of nitrified and MLE effluent to nitrate-nitrogen levels of less than 1 mg/l. These 36 filters filled with 10 feet deep of sand occupy 1100 ft^2 of surface area per filter. Average design hydraulic loading is 2.1 gpm/ft^2 and nitrate-nitrogen loading is 0.55 lbs/ft^2-day. Approximately 2,233 gpm of backwash water is collected in mudwell and pumped to the primaries.

Total sludge production, 163,000 lbs/day, to thickening facility includes chemical (methanol and lime) and biological wasted solids. A breakdown of solids wasted from each plant is located in the design assumption, Table 6-2-2A.

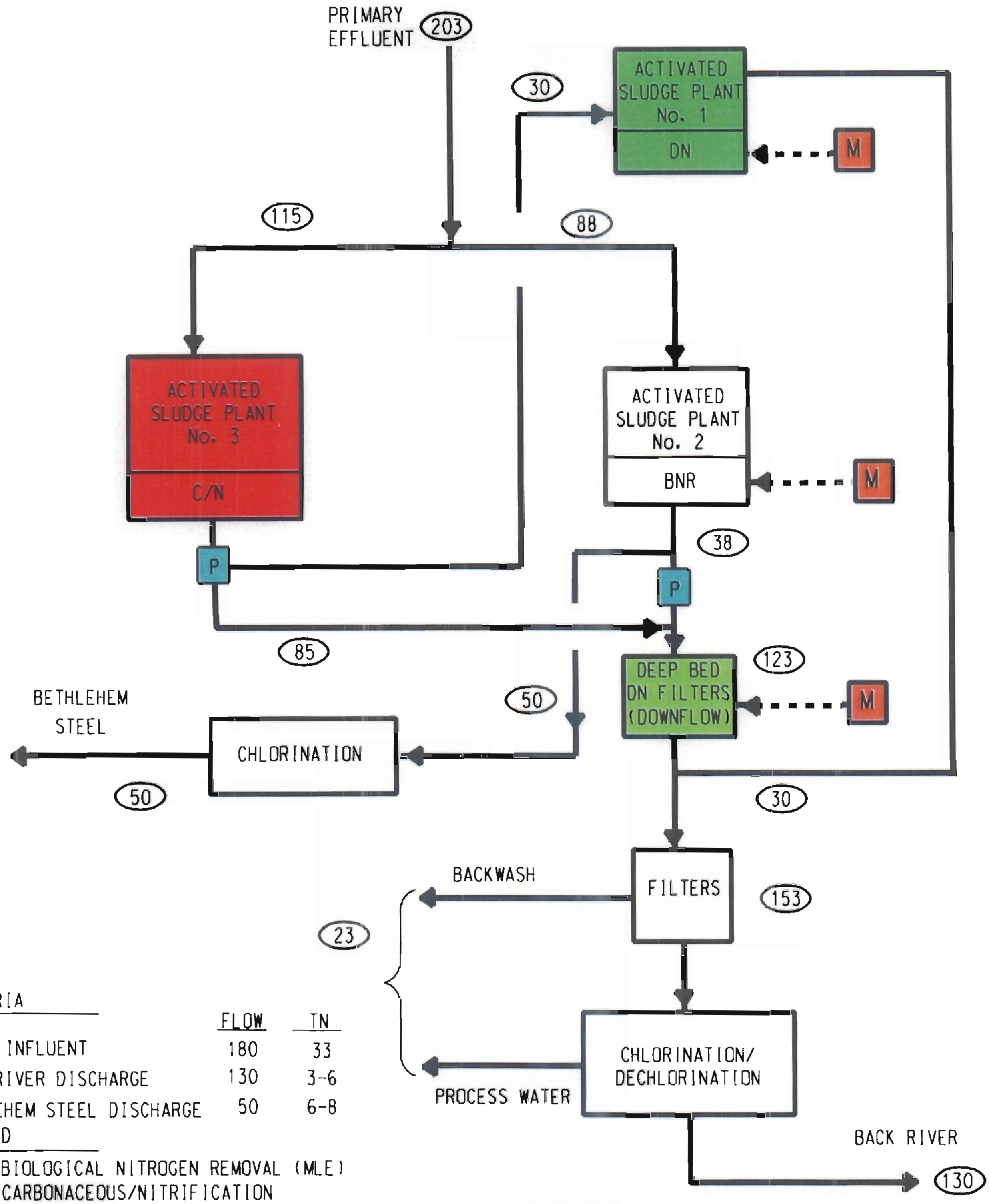
Operation and Maintenance Assumptions

Labor and maintenance costs are based on both existing and new equipment operating at average flow of 203 mgd. Chemical and energy (aeration, mixing and pumping) costs are based on a continuous operation with average flow of 30 mgd to Plant No.1, 88 mgd to Plant No. 2, 115 mgd to Plant No. 3 and 123 mgd to downflow deep bed filters. Methanol dosage is computed using the same methanol to nitrate-nitrogen removal ratio as in Alternative 1-1. Cost of quick lime is based on supplier's estimate at the time of writing.

Operation and Maintenance costs were estimated using assumptions shown in Table 6-2-2B.

Cost Estimates

A breakdown of capital, salvage, and operation and maintenance costs is shown in Table 6-2-2C.



CRITERIA

	FLOW	TN
PLANT INFLUENT	180	33
BACK RIVER DISCHARGE	130	3-6
BETHLEHEM STEEL DISCHARGE	50	6-8

LEGEND

BNR BIOLOGICAL NITROGEN REMOVAL (MLE)
C/N CARBONACEOUS/NITRIFICATION
DN DENITRIFICATION
FB FLUIDIZED BED
M METHANOL
P PUMPING STATION
TN TOTAL NITROGEN
⬭ FLOW, MGD

NOTE

PLANT FLOW=180 MGD, WITH RECYCLES=203 MGD

COMPREHENSIVE WASTEWATER FACILITIES MASTER PLAN

BACK RIVER WASTEWATER TREATMENT PLANT

CONCEPTUAL DIAGRAM ALTERNATIVE 2-2

WHITMAN, REQUARDT AND ASSOCIATES, LLP | DATE: APRIL 2004 | SCALE: NONE | FIGURE: 6-2-2

TABLE 6-2-2A

BACK RIVER WASTEWATER TREATMENT PLANT

ALTERNATIVE 2-2: DESIGN ASSUMPTIONS

Unit Process	Parameters	Criteria
Activated Sludge Plant No. 1	Average Daily Flow	30 MGD
DN	Peak Dry Weather Flow	44 MGD
Reactors	Number of Reactors	4 (two standby)
	Design Hydraulic Detention Time	4.3 hours
	Design Solids Retention Time	20 days
Air includes mixing	Installed Blower Capacity for Reareation	441 SCFM / reactor
	Installed Mixing Capacity for Anoxic Zone	74.5 HP mixing
Clarifiers	Clarifiers	All four existing under SC 709
	Clarifier Overflow Rate	Average: 394 gpd/ft^2, Peak: 577 gpd/ft^2
	Solids Flux Loading Rate	11.5 lbs/sq. ft./day
	Design MLSS	3500 mg/L
	Sludge Waste Production	7850 lbs/day
Chemicals	Methanol	TN of 3 mg/L: 90 mg/L
	Sludge Production from Methanol Addition	
	(0.18 VSS produced/COD removed)	TN of 3 mg/L: 8106 lb/day
	(75% TSS is VSS)	
Performance	Effluent	TKN = 2 mg/L, NOx-N =1mg/L
Activated Sludge Plant No. 2	Average Daily Flow	88 MGD
BNR	Peak Dry Weather Flow	127 MGD

TABLE 6-2-2A (CONTINUED)

Unit Process	Parameters	Criteria
Chemical	Methanol Dosage	
		TN of 6 mg/L: 12.3 mg/L
	Sludge Production from Methanol Addition	
	(0.18 VSS produced/COD removed)	TN of 6 mg/L: 3252 lb/day
	(75% TSS is VSS)	
	Sludge Waste Production	57,993 lbs/day
Performance	Effluent	TKN=4.9 mg/L, NOx-N=1.1 mg/L
Activated Sludge Plant No. 3	Average Daily Flow	115 MGD
C/N	Peak Dry Weather Flow	165 MGD
Reactors	Nitrification Capacity	32.5 Mgal
	Number of Reactors	6 (one standby)
	Design Hydraulic Detention Time	6.78 hours
	Design Solids Retention Time	14.3 days
Air includes mixing	Installed Blower Capacity	23,542 cfm/reactor
	Installed Fine Bubble Diffusers	15,694/ reactor @ 1.5 SCFM/diffuser
	Oxygen Transfer Efficiency	12%
Clarifier	Clarifier	12 (two standby)
	Clarifier Overflow Rate	Average: 572 gpd/ft^2, Peak: 820gpd/ft^2
	Solids Flux Loading Rate	17.8 lbs/sq.ft./day
	Design MLSS	3500 mg/L
	Sludge Waste Production	66,340 lbs/day

TABLE 6-2-2A (CONTINUED)

Unit Process	Parameters	Criteria
Chemicals	Quick Lime Dosage	76 mg/L
	Lime Solids	5040 lbs/day
	7.6% of Waste Activated Sludge	
Performance	Effluent	TKN = 2 mg/L, NOx-N = 30 mg/L
Deep Bed DN Filters	Average Daily Flow	123 MGD
	Peak Dry Weather Flow	176 MGD
	Hydraulic Loading	Average: 2.08 gpm/ft^2, Peak: 2.98 gpm/ft^2
	Nitrates Loading	Average: 0.55 lbs/ft^2-day, Peak: 0.79 lbs/ft^2-day
Filters	Dimensions	36 - 11.7ft X 100 ft X 19 ft (LXWXH) (one standby)
	Media Depth	10 ft.
	Media	Sand
Backwash	Backwash	6 gpm/ft^2, every 15 min and 5 min
	Air Backwash	5 cfm/ft^2, with backwash water for 15 min
	Bumping	29.74 bumps between backwash volume
Backwash Waste	Flow Rate to Primary	2,334 gpm
Chemicals	Methanol	66 mg/L
Performance	Effluent	TKN= 2 mg/L, Nox-N= 2 mg/L, TSS=5 mg/L

TABLE 6-2-2B

BACK RIVER WASTEWATER TREATMENT PLANT

ALTERNATIVE 2-2: OPERATION AND MAINTENANCE ASSUMPTIONS

Unit Process	Assumptions
Activated Sludge Plant No. 1 (DN)	
Pumping to Activated Sludge Plant No. 1	30-MGD from Plant #3 @ 17 ft Head, 0.3132/HP/MGD/ft of Head, $0.06/KWh.
Mixing Power	441 HP/ reactor. $0.045/HP-hr.
Methanol	90 mg/L Density: 6.58 lbs/gal, $1.00/gal
Rearation	30 cfm/1000 cu. ft.
Activated Sludge Plant No. 2 (BNR)	
Aeration and Mixing	[1.5 (Lbs BOD removed) + 4.6 (lbs of TKN nitrified) – 2.86 (lbs of Nitrates denitrified)]*1.5
	12% O2 transfer efficiency
	401 mg/L of O_2 or 80,242 cfm of air
Mixing Power	197.5 HP/reactor, $0.045/HP-hr
Methanol	TN 6 mg/L: 12.3 mg/L Density: 6.58 lbs/gal, $1.00/gal
Activated Sludge Plant No. 3 (C/N)	
Aeration and Mixing	lbs/day of O2 consumption = ((1.5 X lbs BOD influent) + (4.6 TKN influent) + (1.5 DO)) 1.5
	12% O2 transfer efficiency
	510 mg/L of O2
Lime	76 mg/L Quick Lime, $50/ton

TABLE 6-2-2B (CONTINUED)

Unit Process	Assumptions
Deep Bed DN Filters	
Pumping to Filters	123-MGD @ 23 ft Head
	0.3132/HP/MGD/ft of Head, $0.06/KWh.
Back Wash Water and Bumping Power	70,200 gpd @ 10 psig
	Bumping 5500 gpm @ 10 psig per reactor
	0.3132 HP/MGD/ft of Head, $0.06/KWh.
Air Back Wash Blower Power	5835cfm of air @ 10 psig, 420 HP/ reactor
	0.3132 HP/MGD/ft of Head, $0.06/KWh.
Mudwell Pump Power	1.72 MGD @ 65 ft Head
	0.3132 HP/MGD/ft of Head, $0.06/KWh.
Methanol Feed	66 mg/L, $1.00/gal

	PROCESS	CAPITAL ($M)	SALVAGE ($M)	ANNUAL COSTS ($M)				
				OPERATING			MAINT.	TOTAL
				LABOR	ENERGY	CHEMICAL		
1	Ex. Activated Sludge Plant No. 1 (DN)	4.89	6.96	0.14	0.04		0.46	0.64
2	Ex. Activated Sludge Plant No. 2 (BNR)		33.15	0.36	1.57		2.21	4.14
3	Ex. Activated Sludge Plant No. 3 (C/N)	23.77	43.10	0.47	3.33		2.87	6.67
4	Deep Bed DN Filters (Downflow)	44.61	13.38	0.12	0.06		0.89	1.07
5	DN Pumping Stations (2)	59.85	17.96	0.04	0.35		0.96	1.35
6	Methanol Facilities (3)	3.09	0.93	0.09		5.00	0.06	5.15
7	Lime Facilities (2 Existing and 1 New)		0.50			0.93	0.06	0.99
8	WAS Treatment[1]				0.07	0.50		0.57
9	Disposal (Land Application)[2]							1.75
10								
11								
12								
13								
14								
15								
16								
17								
18								
19								
20								
21								
22								
	TOTALS	T1= 136.21	T2= 115.98	1.22	5.42	6.43	7.51	T3= 22.33

$M - Millions of Dollars

[1]Based on thickening, pumping, digestion, and dewatering of waste activated sludge (WAS). WAS produced is estimated to be 81.5 dry tons/day (DTPD).

BRWWTP Operations Report for 2001: 80% volatile solids in feed and 80% volatile solids destruction from ESDs.

[2]Sludge cake for disposal is 29.3 DTPD.

PRESENT WORTH COST DETERMINATION

1. PRESENT WORTH FACTORS

F1 = SINGLE PAYMENT, 20 YEARS, 7% = 0.25842

F2 = UNIFORM SERIES, 20 YEARS, 7% = 10.59401

2. PRESENT WORTH BASIS

A. CAPITAL COST: (T1) $136.21

B. SALVAGE COST: (-) (F1 X T2) -$29.97

C. ANNUAL O&M COST: (F2 X T3) $236.56

TOTAL PRESENT WORTH = $342.80

NOTES:
ENR INDEX = 6300
DN = Denitrification
C/N = Carbonaceous / Nitrification

COMPREHENSIVE WASTEWATER FACILITIES
MASTER PLAN

BACK RIVER
WASTEWATER TREATMENT PLANT

SUMMARY OF ESTIMATED COSTS
ALTERNATIVE 2-2

WHITMAN, REQUARDT AND ASSOCIATES, LLP	SEPTEMBER 2002	TABLE 6-2-2C

6.7.6. Alternative 2-3 (Level 2) Carbon Oxidation/Nitrification Suspended Growth Plus Deep-Bed Denitrification Filter (Upflow):

Process Description

This design concept is similar to Alternative 2-2 where one existing activated sludge plant is converted to carbon oxidation/nitrification process and another plant to denitrification process. The downflow deep bed filters are replaced with upflow deep bed denitrification filters to treat down to TN of 3 to 6 mg/l to Back River. The flow going to ISG (formerly Bethlehem Steel) is treated to TN of 6 to 8 mg/l.

The upflow deep bed denitrification filter is a fixed bed biological filter with the wastewater flow being pumped up through the filter rather than flowing via gravity through the filter. The media is either packed tight enough or made of dense material as to not allow the bed to expand into a fluidized bed. Just as in the other fixed growth reactors as the wastewater passes through the reactor, the bacteria affix themselves to the media and begins to proliferate. The bacteria (biomass) can become very concentrated and allow for high throughput of wastewater per square foot of reactor. Retained wastewater solids and excess biomass are removed from the media through periodic multi-sequence air/water backwashes in the upflow direction. The backwash water is collected in a mudwell then returned to the primary settling tanks for the removal of solids.

Some of the advantages of the upflow denitrification filters include the additional removal of suspended solids producing a very clean effluent. Another advantage is a very small footprint as compared with a suspended growth system that requires further clarification. The upflow filters can take a loading of 6 to 8 gpm/ft^2; hence, less surface area is required. This would considerably reduce the number of filters compare to downflow filters. One other advantage is that nitrogen gas (byproduct of denitrification) is constantly purged with the flow of wastewater, where in downflow filters it becomes trapped within the media and requires frequent bumping. Lastly, the upflow denitrification filter has proven successful in producing an effluent with TN $\leq$ 3 mg/l.

A disadvantage of the upflow deep bed filter is that the backwash pump and blower increase the operation and maintenance costs in addition to adding to the overall recycle volume. Another disadvantage is that this process is proprietary.

The conceptual diagram for upflow filters is presented in Figure 6-2-3.

Design Assumptions

Design assumptions for Plant Nos. 1, 2 and 3 are same as Alternative 2-2. Upflow deep bed denitrification filters are designed to treat peak flow of 176 mgd of a blend of nitrified and MLE effluent to nitrate-nitrogen levels of less than 1 mg/l. These 10 filters are filled 9.5 feet deep with biolite and occupy 1881 ft^2 of surface area per filter. Average design hydraulic loading is 5.7 gpm/ft^2 and nitrate-nitrogen loading 1.5 lbs/ft^2-day. Approximately, 799 gpm of backwash water per filter is expected to flow to the primaries.

Sludge production from chemicals (lime and methanol) and biomass (163,000 lbs./day) is same as Alternative 2-2. A breakdown of solids production from each plant is located in the design assumptions, Table 6-2-3A

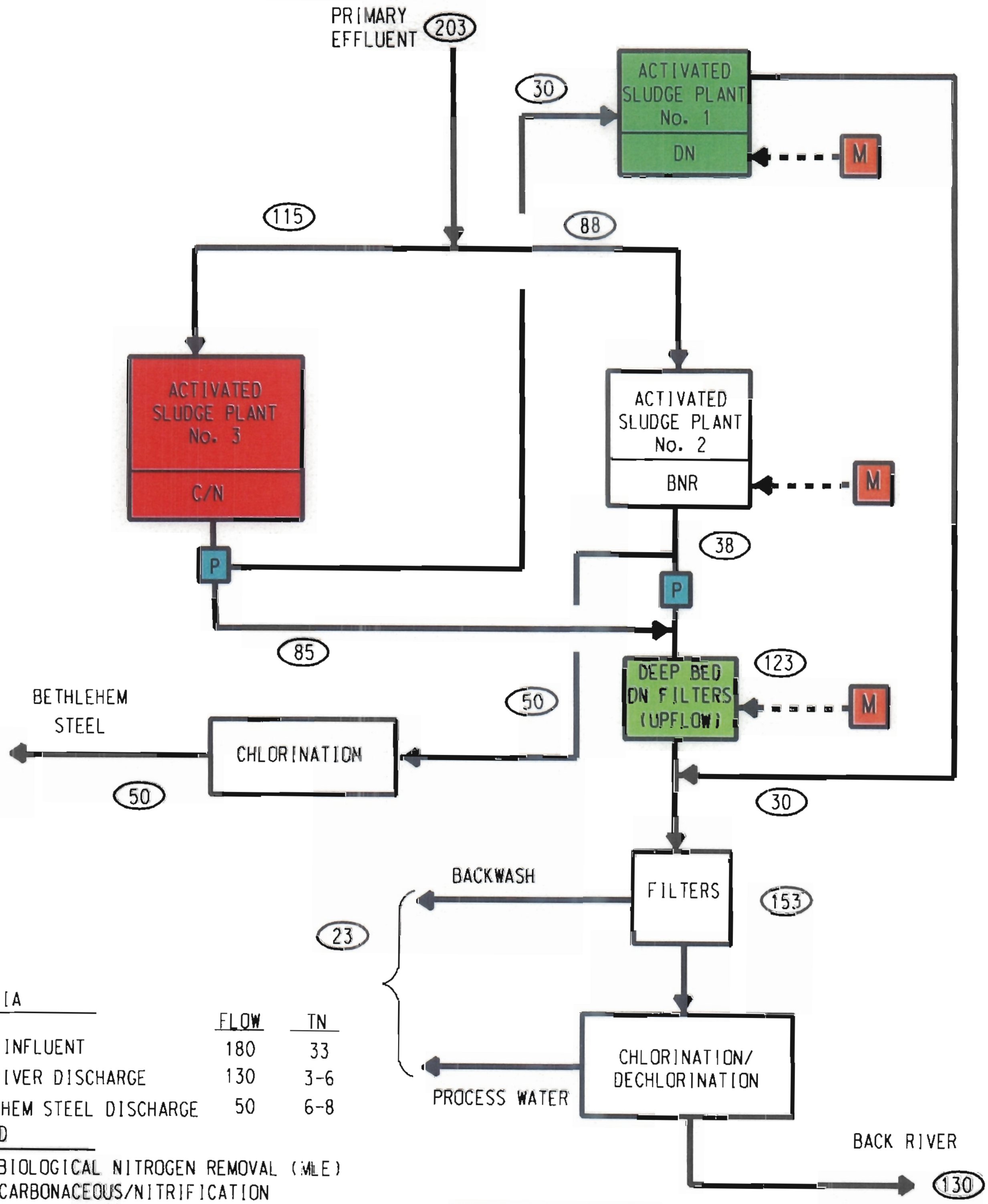
Operation and Maintenance Assumptions

Labor and maintenance costs are based on both existing and new equipment operating at average flow of 203 mgd. Chemical and energy (aeration, mixing and pumping) costs are based on continuous operation with 30 mgd to Plant No.1, 88 mgd to Plant No. 2, 115 mgd to Plant No. 3, and 123 mgd to upflow deep bed filters. Methanol dosage is computed using the same methanol to nitrate-nitrogen removal ratio as in Alternative 1-1. Cost of quick lime is based on supplier's estimate at the time of writing.

Operation and Maintenance costs were estimated based on the assumptions in Table 6-2-3B.

Cost Estimates

A breakdown of capital, salvage, and operation and maintenance costs is shown in Table 6-2-3C.



CRITERIA

	FLOW	TN
PLANT INFLUENT	180	33
BACK RIVER DISCHARGE	130	3-6
BETHLEHEM STEEL DISCHARGE	50	6-8

LEGEND

- BNR BIOLOGICAL NITROGEN REMOVAL (MLE)
- C/N CARBONACEOUS/NITRIFICATION
- DN DENITRIFICATION
- FB FLUIDIZED BED
- M METHANOL
- P PUMPING STATION
- TN TOTAL NITROGEN
- ⬭ FLOW, MGD

NOTE

PLANT FLOW=180 MGD, WITH RECYCLES=203 MGD

COMPREHENSIVE WASTEWATER FACILITIES MASTER PLAN

BACK RIVER WASTEWATER TREATMENT PLANT

CONCEPTUAL DIAGRAM ALTERNATIVE 2-3

WHITMAN, REQUARDT AND ASSOCIATES, LLP | DATE: APRIL 2004 | SCALE: NONE | FIGURE: 6-2-3

TABLE 6-2-3A

BACK RIVER WASTEWATER TREATMENT PLANT

ALTERNATIVE 2-3: DESIGN ASSUMPTIONS

Unit Process	Parameters	Criteria
Activated Sludge Plant No. 1	Average Daily Flow	30 MGD
DN	Peak Dry Weather Flow	44 MGD
Reactors	Number of Reactors	4 (two standby)
	Design Hydraulic Detention Time	4.3 hours
	Design Solids Retention Time	20 days
Air includes mixing	Installed Blower Capacity for Reareation	441SCFM / reactor
	Installed Mixing Capacity for Anoxic Zone	74.5 HP mixing
Clarifiers	Clarifiers	All four existing under SC 709
	Clarifier Overflow Rate	Average: 394 gpd/ft^2, Peak: 577 gpd/ft^2
	Solids Flux Loading Rate	11.5 lbs/sq. ft./day
	Design MLSS	3500 mg/L
	Sludge Waste Production	7850 lbs/day
Chemicals	Methanol	TN of 3 mg/L:69 mg/L, TN of 3 mg/L: 90 mg/L
	Sludge Production from Methanol Addition	
	(0.18 VSS produced/COD removed)	TN of 3 mg/L: 8106 lb/day
	(75% TSS is VSS)	
Performance	Effluent	TKN = 2 mg/L, NOx-N =1 mg/L

TABLE 6-2-3A (CONTINUED)

Unit Process	Parameters	Criteria
Activated Sludge Plant No. 2	Average Daily Flow	88 MGD
BNR	Peak Dry Weather Flow	127 MGD
Chemicals	Methanol Dosage	
		TN of 6 mg/L: 12.3 mg/L
Chemical Sludge	Sludge Production from Methanol Addition	
	(0.18 VSS produced/COD removed)	TN of 6 mg/L: 3252 lb/day
	(75% TSS is VSS)	
	Sludge Waste Production	57,993 lbs/day
Performance	Effluent	TKN=4.9 mg/L, NOx-N=1.1 mg/L
Activated Sludge Plant No. 3	Average Daily Flow	115 MGD
C/N	Peak Dry Weather Flow	165 MGD
Reactors	Nitrification Capacity	32.5 Mgal
	Number of Reactors	6 (one standby)
	Design Hydraulic Detention Time	6.78 hours
	Design Solids Retention Time	14.3 days
Air includes mixing	Installed Blower Capacity	23,542 cfm/reactor
	Installed Fine Bubble Diffusers	15,694/ reactor @ 1.5 SCFM/diffuser
	Oxygen Transfer Efficiency	12%
Clarifier	Clarifier	12 (2 standby)
	Clarifier Overflow Rate	Average: 572 gpd/ft^2, Peak: 820 gpd/ft^2

TABLE 6-2-3A (CONTINUED)

Unit Process	Parameters	Criteria
	Solids Flux Loading Rate	17.8 lbs/sq.ft./day
	Design MLSS	3500 mg/L
	Sludge Waste Production	66,340 lbs/day
Chemicals	Quick Lime Dosage	76 mg/L
	Lime Solids	5040 lbs/day
	7.6% of Waste Activated Sludge	
Performance	Effluent	TKN = 2 mg/L, NOx-N = 30 mg/L
Upflow Deep Bed DN Filters	Average Daily Flow	123 MGD
	Peak Dry Weather Flow	176 MGD
	Hydraulic Loading (average flow)	Average: 5.7 gpm/ft^2 Peak: 7.2 gpm/ft^2
	Nitrates Loading	Average: 1.5 lbs/ft^2-day Peak: 1.9 lbs/ft2-day
Filters	Dimensions (Peak Flow)	10 - 40.2 ft X 46.8 ft X 19 ft (LXWXH) (1 standby))
	Media Depth	9.5 ft.
	Media	Biolite, clay
Backwash	Backwash	12.2 gpm/ft^2, 50 min/day
	Air Backwash	4.8 cfm/ft^2, with backwash water for 50 min/day
Backwash Waste	Flow Rate to Primary	799 gpm for one filter
Chemicals	Methanol	66 mg/L
Performance	Effluent	TKN= 2 mg/L, Nox-N= 2 mg/L, TSS=5 mg/L

TABLE 6-2-3B

BACK RIVER WASTEWATER TREATMENT PLANT

ALTERNATIVE 2-3: OPERATION AND MAINTENANCE ASSUMPTIONS

Unit Process	Assumptions
Activated Sludge Plant No. 1 (DN)	
Mixing Power	441 HP/ reactor. $0.045/HP-hr.
Methanol Feed	90 mg/L Density: 6.58 lbs/gal, $1.00/gal
Rearation	30 cfm/1000 cu. ft.
Activated Sludge Plant No. 2 (BNR)	
Aeration and Mixing	[1.5 (Lbs BOD removed) + 4.6 (lbs of TKN nitrified) – 2.86 (lbs of Nitrates denitrified)]*1.5
	401 mg/L of O_2
Mixing	197.5 HP/reactor, $0.045/HP-hr
Methanol	TN 8-6 mg/L: 6.3-12.3 mg/L Density: 6.58 lbs/gal, $1.00/gal
Activated Sludge Plant No. 3 (C/N)	
Pumping to Activated Sludge Plant #1	30-MGD from Plant No. 3 @ 17 ft Head, 0.3132/HP/MGD/ft of Head, $0.06/KWh.
Aeration and Mixing	lbs/day of O2 consumption = ((1.5 X lbs BOD influent) + (4.6 TKN influent) + (1.5 DO)) 1.5
	510 mg/L of O2
Lime Feed	76 mg/L Quick Lime, $50/ton
Upflow DN Reactors	
Pumping to Filters	123-MGD @ 50 ft Head
	0.3132 HP/MGD/ft of Head, $0.06/KWh.

TABLE 6-2-3B (CONTINUED)

Unit Process	Assumptions
Back Wash Water Pumping Power	3-11,280 gpm @ 50 ft Head (one standby)
	0.3132 HP/MGD/ft of Head, $0.06/KWh.
Air Back Wash Blower Power	5131 cfm of air @ 10.4 psig,
	0.3132 HP/MGD/ft of Head, $0.06/KWh.
Mudwell Pump Power	527 gpm @ 65 ft per filter
	0.3132 HP/MGD/ft of Head, $0.06/KWh.
Methanol Feed	66 mg/L, $1.00/gal

	PROCESS	CAPITAL ($M)	SALVAGE ($M)	ANNUAL COSTS ($M)				
				OPERATING			MAINT.	TOTAL
				LABOR	ENERGY	CHEMICAL		
1	Ex. Activated Sludge Plant No. 1 (DN)	4.89	6.96	0.14	0.18		0.46	0.78
2	Ex. Activated Sludge Plant No. 2 (BNR)		33.15	0.36	1.57		2.21	4.14
3	Ex. Activated Sludge Plant No. 3 (C/N)	23.77	43.10	0.47	3.33		2.87	6.67
4	Deep Bed DN Filters (Upflow)	35.29	10.59	0.17	0.13		0.71	1.01
5	DN Pumping Stations (2)	59.85	17.96	0.04	0.82		0.96	1.82
6	Methanol Facilities (3)	3.09	0.93	0.09		5.00	0.06	5.15
7	Lime Facilities (1 Existing)		0.50			0.93	0.03	0.96
8	WAS Treatment[1]				0.07	0.50		0.57
9	Disposal (Land Application)[2]							1.75
10								
11								
12								
13								
14								
15								
16								
17								
18								
19								
20								
21								
22								
	TOTALS	T1= 126.89	T2= 113.19	1.27	6.10	6.43	7.30	T3= 22.85

$M - Millions of Dollars

[1]Based on thickening, pumping, digestion, and dewatering of waste activated sludge (WAS). WAS produced is estimated to be 81.5 dry tons/day (DTPD).
BRWWTP Operations Report for 2001: 80% volatile solids in feed and 80% volatile solids destruction from ESDs.

[2] Sludge cake for disposal is 29.3 DTPD.

PRESENT WORTH COST DETERMINATION

1. PRESENT WORTH FACTORS — F1 = SINGLE PAYMENT, 20 YEARS, 7% = 0.25842
F2 = UNIFORM SERIES, 20 YEARS, 7% = 10.59401

2. PRESENT WORTH BASIS
A. CAPITAL COST: (T1) $126.89
B. SALVAGE COST: (-) (F1 X T2) -$29.25
C. ANNUAL O&M COST: (F2 X T3) $242.07

TOTAL PRESENT WORTH = $339.71

NOTES:
ENR INDEX = 6300
DN = Denitrification
C/N = Carbonaceous / Nitrification

COMPREHENSIVE WASTEWATER FACILITIES MASTER PLAN

BACK RIVER WASTEWATER TREATMENT PLANT

SUMMARY OF ESTIMATED COSTS ALTERNATIVE 2-3

WHITMAN, REQUARDT AND ASSOCIATES, LLP | SEPTEMBER 2002 | TABLE 6-2-3C

6.7.7. Alternative 2-4 (Level 2) Carbon Oxidation/Nitrification Suspended Growth Plus Fluidized Bed Denitrification Reactor:

Process Description

This design concept is similar to Alternative 2-2 where one existing activated sludge plant is converted to carbon oxidation/nitrification process and another plant to denitrification process. The downflow deep bed filters are replaced with fluidized bed denitrification reactors to treat down to TN of 3 to 6 mg/l to Back River. The flow going to ISG (formerly Bethlehem Steel) is treated to TN of 6 to 8 mg/l.

Fluidized bed denitrification is an attached growth biological treatment process in which process wastewater is passed through a bed of media at a rate sufficient to fluidize the bed. The fluidized bed (FBR) denitrification process has had success in achieving TN levels of 3 mg/l. The FBR is packed with media that holds the biomass in the system and provides for good contact between the biomass and the wastewater. As wastewater is introduced into the fluidized bed, microorganisms begin to attach themselves to the media and form a film. As the film grows in thickness, it causes that particle to become lighter in overall density and the bed to expand even further. Since the lightest density particles always go to the top of the fluidized bed, those particles with the thickest biomass film always go to the top of the bed. A growth control mechanism is used to remove this biomass that has risen to the surface before it is discharged as effluent. The growth control mechanism is typically a pump and a separation mechanism. The media is pumped and through the pumping action the biomass is sheared from the media. The media is returned to the reactor, while the biomass is wasted from the system.

The advantage of FBR over a traditional fixed film filter is that the reactor does not require frequent backwashes to prevent the plugging, as experienced in fixed film. Additionally, due to the nature of the FBR, more area of the media is exposed to the wastewater lending itself to being more active or efficient than a fixed film. The disadvantage is that the FBR will increase the effluent suspended solids, which in turn will increase the backwash rate for the existing sand filters.

The conceptual diagram is presented in Figure 6-2-4. The site plan is similar to Figure 6-3-4B. The third methanol facility for Plant No.2 will be in close proximity to Chemical Building.

Design Assumptions

The design assumptions for Plant Nos. 1, 2 and 3 are same as Alternative 2-2. FBRs are designed to treat a blend of peak flow of 176 mgd of a blend of nitrified and MLE effluent to nitrate-nitrogen levels of less than 1 mg/l. Each filter occupies 1881 ft^2 of surface area with 20 feet side water depth. Average design hydraulic loading is 16.5 gpm/ ft^2 and nitrate-nitrogen loading 3.98 lbs/ ft^2-day.

These 12 reactors are filled with 7 feet deep of sand, fluidized to 14 feet depth. The growth control mechanism maintains the fluidized depth and recycles some of the biomass back to the reactors. The biomass that is not recycled (wasted biomass) is sent to the solids handling facility.

Sludge production from chemicals (lime and methanol) and biomass (163,000 lbs/day) is same as Alternative 2-2. A breakdown of solids production from each plant is located in the design assumptions, Table 6-2-4A

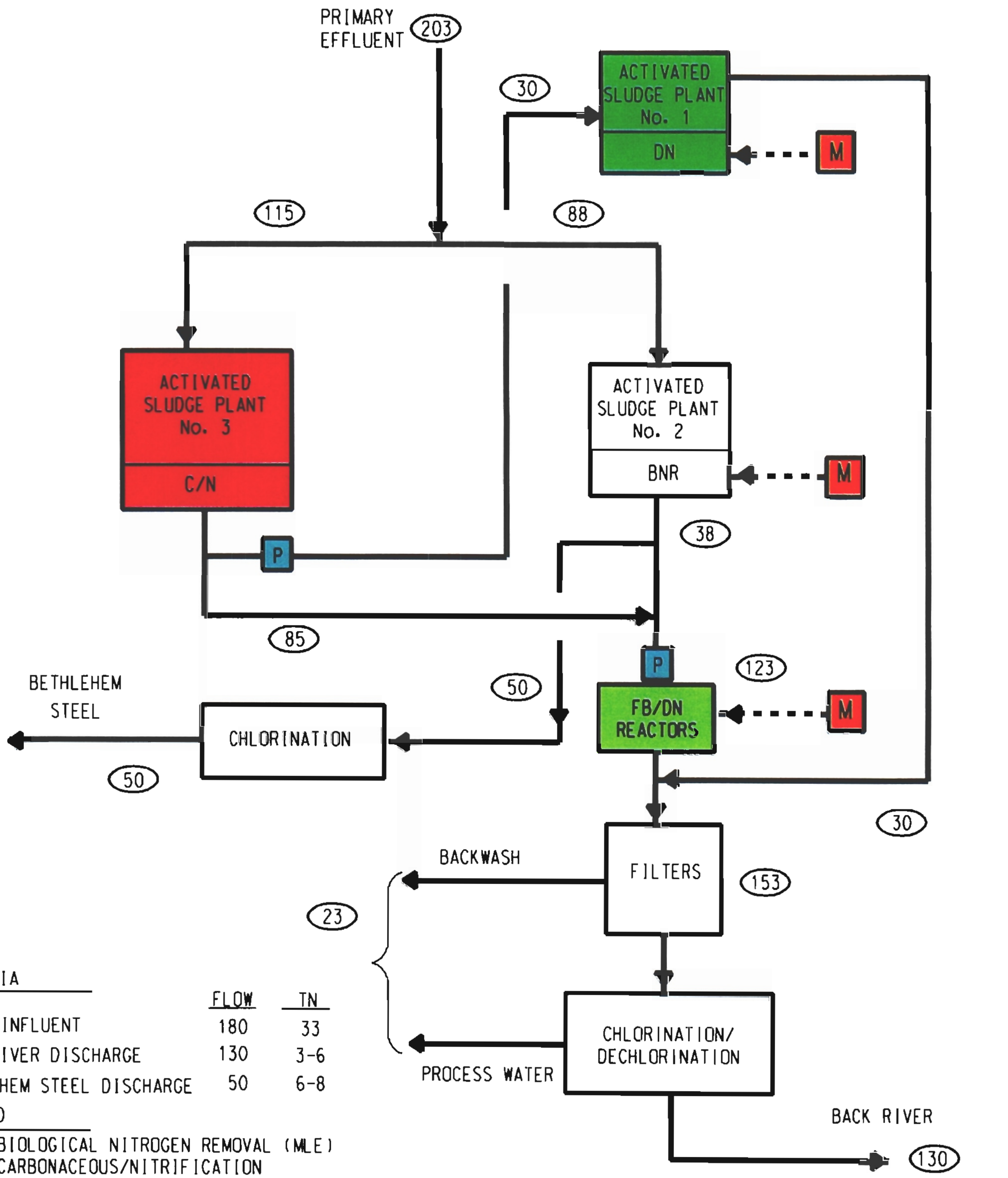
Operation and Maintenance Assumptions

Labor and maintenance costs are based on both existing and new equipment operating at average flow of 203 mgd. Chemical and energy (aeration, mixing and pumping) costs are established based on a continuous operation at an average flow of 30 mgd to Plant No.1, 88 mgd to Plant No. 2, 115 mgd to Plant No. 3 and 123 mgd to fluidized bed reactors. Methanol dosage is computed using the same methanol to nitrate-nitrogen removal ratio as in Alternative 1-1. Cost of quick lime is based on supplier's estimate at the time of writing.

Operation and Maintenance costs are estimated using the assumptions shown in Table 6-2-4B.

Cost Estimates

A breakdown of capital, salvage, and operation and maintenance costs is shown in Table 6-2-4C.



CRITERIA

	FLOW	TN
PLANT INFLUENT	180	33
BACK RIVER DISCHARGE	130	3-6
BETHLEHEM STEEL DISCHARGE	50	6-8

LEGEND

BNR	BIOLOGICAL NITROGEN REMOVAL (MLE)
C/N	CARBONACEOUS/NITRIFICATION
DN	DENITRIFICATION
FB	FLUIDIZED BED
M	METHANOL
P	PUMPING STATION
TN	TOTAL NITROGEN
(oval)	FLOW, MGD

NOTE

PLANT FLOW=180 MGD, WITH RECYCLES=203 MGD

COMPREHENSIVE WASTEWATER FACILITIES MASTER PLAN

BACK RIVER WASTEWATER TREATMENT PLANT

CONCEPTUAL DIAGRAM ALTERNATIVE 2-4

WHITMAN, REQUARDT AND ASSOCIATES, LLP

DATE: APRIL 2004	SCALE: NONE	FIGURE: 6-2-4

TABLE 6-2-4A

BACK RIVER WASTEWATER TREATMENT PLANT

ALTERNATIVE 2-4: DESIGN ASSUMPTIONS

Unit Process	Parameters	Criteria
Activated Sludge Plant No. 1	Average Daily Flow	30 MGD
DN	Peak Dry Weather Flow	44 MGD
Reactors	Number of Reactors	4 (two standby)
	Design Hydraulic Detention Time	4.3 hours
	Design Solids Retention Time	20 days
Air includes mixing	Installed Blower Capacity for Reareation	441 SCFM /reactor
	Installed Mixing Capacity for Anoxic Zone	74.5 HP mixing
Clarifiers	Clarifiers	All four existing under SC 709
	Clarifier Overflow Rate	Average: 394 gpd/ft^2, Peak: 577 gpd/ft^2
	Solids Flux Loading Rate	11.3 lbs/sq. ft./day
	Design MLSS	3500 mg/L
	Sludge Waste Production	7850 lbs/day
Chemicals	Methanol	69 mg/L
	Sludge Production from Methanol Addition	
	(0.18 VSS produced/COD removed)	TN of 6 mg/L: 6215 lb/day
	(75% TSS is VSS)	
Performance		TKN = 2mg/L, NOx-N = 4 mg/L

TABLE 6-2-4A (CONTINUED)

Unit Process	Parameters	Criteria
Activated Sludge Plant No. 2	Average Daily Flow	88 MGD
BNR	Peak Dry Weather Flow	127 MGD
Chemicals	Methanol Dosage	TN of 6 mg/L: 12.3 mg/L
Chemical Sludge	Sludge Production from Methanol Addition	
	(0.18 VSS produced/COD removed)	TN of 6 mg/L: 3252 lb/day
	(75% TSS is VSS)	
Performance	Effluent	TN of 6 mg/L: TKN=2 mg/L, NOx-N=1 mg/L
	Sludge Waste Production	57,993 lbs/day
Activated Sludge Plant No. 3	Average Daily Flow	115 MGD
C/N	Peak Dry Weather Flow	165 MGD
Reactors	Nitrification Capacity	32.5 Mgal
	Number of Reactors	6 (one standby)
	Design Hydraulic Detention Time	6.78 hours
	Design Solids Retention Time	14.3 days
Air includes mixing	Installed Blower Capacity	23,542 cfm/reactor
	Installed Fine Bubble Diffusers	15,694/ reactor @ 1.5 SCFM/diffuser
	Oxygen Transfer Efficiency	12%
Clarifier	Clarifier	12 (2 standby)
	Clarifier Overflow Rate	Average: 572 gpd/ft^2, Peak: 820 gpd/ft^2

TABLE 6-2-4A (CONTINUED)

Unit Process	Parameters	Criteria
	Solids Flux Loading Rate	17.8 lbs/sq.ft./day
	Design MLSS	3500 mg/L
	Sludge Waste Production	66,340 lbs/day
Chemicals	Quick Lime Dosage	76 mg/L
	Lime Solids	5040 lbs/day
	7.6% of Waste Activated Sludge	
Performance	Effluent	TKN = 2 mg/L, NOx-N = 30 mg/L
FB/DN Reactors	Average Daily Flow	123 MGD
	Peak Dry Weather Flow	176 MGD
	Hydraulic Loading	Average: 15 gpm/ft^2, Peak: 15.2 gpm/ft^2
	Nitrates Loading	3.98 lbs/ft^2 , Peak: 4.03 lbs/ft^2
	Fluidization Rate	16.5 gpm/ft^2
Filters	Dimensions (Peak Flow)	12 - 20 ft X 40 ft X 20 ft (SWD) (2 standby)
	Media Depth (settled)	7 ft
	Fluidized Depth	14 ft
	Media	Sand
Waste biomass	Flow Rate to Thickener Facility	800 gpm, MLSS=2000 mg/L
Chemicals	Methanol	66 mg/L
Performance	Effluent	TKN= 2 mg/L, NOx-N= 1 mg/L, TSS=10-20 mg/L

TABLE 6-2-4B

BACK RIVER WASTEWATER TREATMENT PLANT

ALTERNATIVE 2-4: OPERATION AND MAINTENANCE ASSUMPTIONS

Unit Process	Assumptions
Activated Sludge Plant No, 1 (DN)	
Pumping to Activated Sludge Plant #1	30-MGD from Plant No, 3 @ 17 ft Head, 0.3132 HP/MGD/ft of Head, $0.06/KWh.
Mixing Power	441 HP/ reactor. $0.045/HP-hr.
Methanol Feed	90 mg/L Density: 6.58 lbs/gal, $1.00/gal
Rearation	30 cfm/1000 cu. ft.
Activated Sludge Plant No, 2 (BNR)	
Aeration and Mixing	[1.5 (Lbs BOD removed) + 4.6 (lbs of TKN nitrified) – 2.86 (lbs of Nitrates denitrified)]*1.5
	401 mg/L of O_2 or 80,242 cfm of air
Mixing	197.5 HP/reactor, $0.045/HP-hr
Methanol	TN 8-6 mg/L: 6.3-12.3 mg/L Density: 6.58 lbs/gal, $1.00/gal
Activated Sludge Plant No, 3 (C/N)	
Aeration includes mixing	lbs/day of O2 consumption = ((1.5 X lbs BOD influent) + (4.6 TKN influent) + (1.5 DO)) 1.5
	12% O2 transfer efficiency
	510 mg/L of O2
Lime Feed	76 mg/L Quick Lime, $50/ton

TABLE 6-2-4B (CONTINUED)

Unit Process	Assumptions
FB/DN Reactor	
Fluidized Pumping Power	13,194 gpm @ 50 ft Head per reactor
	0.3132 HP/MGD/ft of Head, $0.06/KWh.
Growth Control Pump Power	2 - 3 HP, $0.045/HP-hr per reactor
Mudwell Pump Power	800 gpm @ 65 ft
	0.3132 HP/MGD/ft of Head, $0.06/KWh.
Methanol Feed	66 mg/L, $1.00/gal

	PROCESS	CAPITAL ($M)	SALVAGE ($M)	ANNUAL COSTS ($M)				
				OPERATING			MAINT.	TOTAL
				LABOR	ENERGY	CHEMICAL		
1	Ex. Activated Sludge Plant No. 1 (DN)	4.89	6.96	0.14	0.18		0.46	0.78
2	Ex. Activated Sludge Plant No. 2 (BNR)		33.15	0.36	1.57		2.21	4.14
3	Ex. Activated Sludge Plant No. 3 (C/N)	23.77	43.10	0.47	3.33		2.87	6.67
4	Fluidized Bed DN Reactors	53.08	15.92	0.12	0.95		1.06	2.13
5	DN Pumping Stations (2)	59.85	17.96	0.04	0.06		0.96	1.06
6	Methanol Facilities (3)	3.09	0.93	0.09		5.00	0.06	5.15
7	Lime Facilities (1 Existing)		0.50			0.93	0.03	0.96
8	Existing Filters				0.01			0.01
9	WAS Treatment[1]				0.07	0.50		0.57
10	Disposal (Land Application)[2]							1.75
11								
12								
13								
14								
15								
16								
17								
18								
19								
20								
21								
22								
	TOTALS	T1= 144.68	T2= 118.52	1.22	6.17	6.43	7.65	T3= 23.22

$M - Millions of Dollars

[1] Based on thickening, pumping, digestion, and dewatering of waste activated sludge (WAS). WAS produced is estimated to be 81.5 dry tons/day (DTPD).
BRWWTP Operations Report for 2001: 80% volatile solids in feed and 80% volatile solids destruction from ESDs.

[2] Sludge cake for disposal is 29.3 DTPD.

PRESENT WORTH COST DETERMINATION

1. PRESENT WORTH FACTORS
   - F1 = SINGLE PAYMENT, 20 YEARS, 7% = 0.25842
   - F2 = UNIFORM SERIES, 20 YEARS, 7% = 10.59401

2. PRESENT WORTH BASIS
   - A. CAPITAL COST: (T1) $144.68
   - B. SALVAGE COST: (-) (F1 X T2) -$30.63
   - C. ANNUAL O&M COST: (F2 X T3) $245.99

TOTAL PRESENT WORTH = $360.04

NOTES:
ENR INDEX = 6300
DN = Denitrification
C/N = Carbonaceous / Nitrification

COMPREHENSIVE WASTEWATER FACILITIES MASTER PLAN

BACK RIVER WASTEWATER TREATMENT PLANT

SUMMARY OF ESTIMATED COSTS ALTERNATIVE 2-4

WHITMAN, REQUARDT AND ASSOCIATES, LLP | SEPTEMBER 2002 | TABLE 6-2-4C

6.7.8. Alternative 2-5 (Level 2): Carbon Oxidation/Nitrification Suspended Growth and Deep Bed Denitrification Filter (Upflow) Plus Sidestream BNR Treatment

Process Description

When comparing Alternative 2-2, 2-3, and 2-4, Alternative 2-3 with upflow deep bed denitrification filters is the most cost effective. Hence, in the evaluation of sidestream BNR treatment, upflow deep bed denitrification was incorporate. Based on TKN treatment capacity, Plant No. 1 (MLE) can treat a sidestream consisting of 5 mgd centrate recycle from City Dewatering and Heat Drying Facility plus 10 mgd of primary effluent. Sidestream constituents' concentrations are same as Alternative 1-2. Plant No.1 will treat wastewater to TN of 8 mg/l with methanol addition. ISG (previously Bethlehem Steel) effluent is treated down to TN of 6 to 8 mg/l, whereas, Back River effluent is treated to TN of 3 to 6 mg/l.

The conceptual diagram is presented in Figure 6-2-5.

Design Assumptions

Primary effluent gravity flows to influent splitter box for distribution of 88 mgd and 115 mgd to Plant Nos. 2 and 3. In existing Plant No. 1, 10 mgd of the primary effluent along with 5 mgd of centrate is treated and then blends with primary effluent that enters Plant Nos. 2 and 3. Plant No. 2 remains as a MLE process whereas Plant No. 3 is converted to a nitrification process. The 50 mgd of effluent from Plant No. 2 flows to Bethlehem Steel and 38 mgd to upflow deep bed denitrification filters. The nitrified effluent from Plant No. 3 (115 mgd) also flows to upflow deep bed denitrification filters. Lime is added in the nitrification basins of Plant No. 3 to maintain alkalinity of 50 mg/l as $CaCO_3$ and pH of 7. The two methanol facilities, (Plant No. 2 and upflow deep bed denitrification filters) are similar to Alternative 1-1. The detention time for Plant No. 3 is 6.8 hours for complete nitrification. Detention time for Plant Nos. 1 and 2 is 17 hours and 9.6 hours, respectively.

Upflow deep bed denitrification filters are designed to treat peak flow of 220 mgd to nitrate-nitrogen levels of less than 1 mg/l. These 12 filters are filled 9.5 feet deep with biolite and occupy 1881 ft^2 of surface area per filter. Average design hydraulic loading is 5.7 gpm/ft^2 and nitrate-nitrogen loading 1.5 lbs/ft^2-day. Approximately 799-gpm of backwash water from each filter is expected to flow to the primaries.

The total solids to thickening facility (180,000 lbs/day) include chemical (methanol) and biological wasted solids. A breakdown of solids production from each plant is located in the design assumptions, Table 6-2-5A

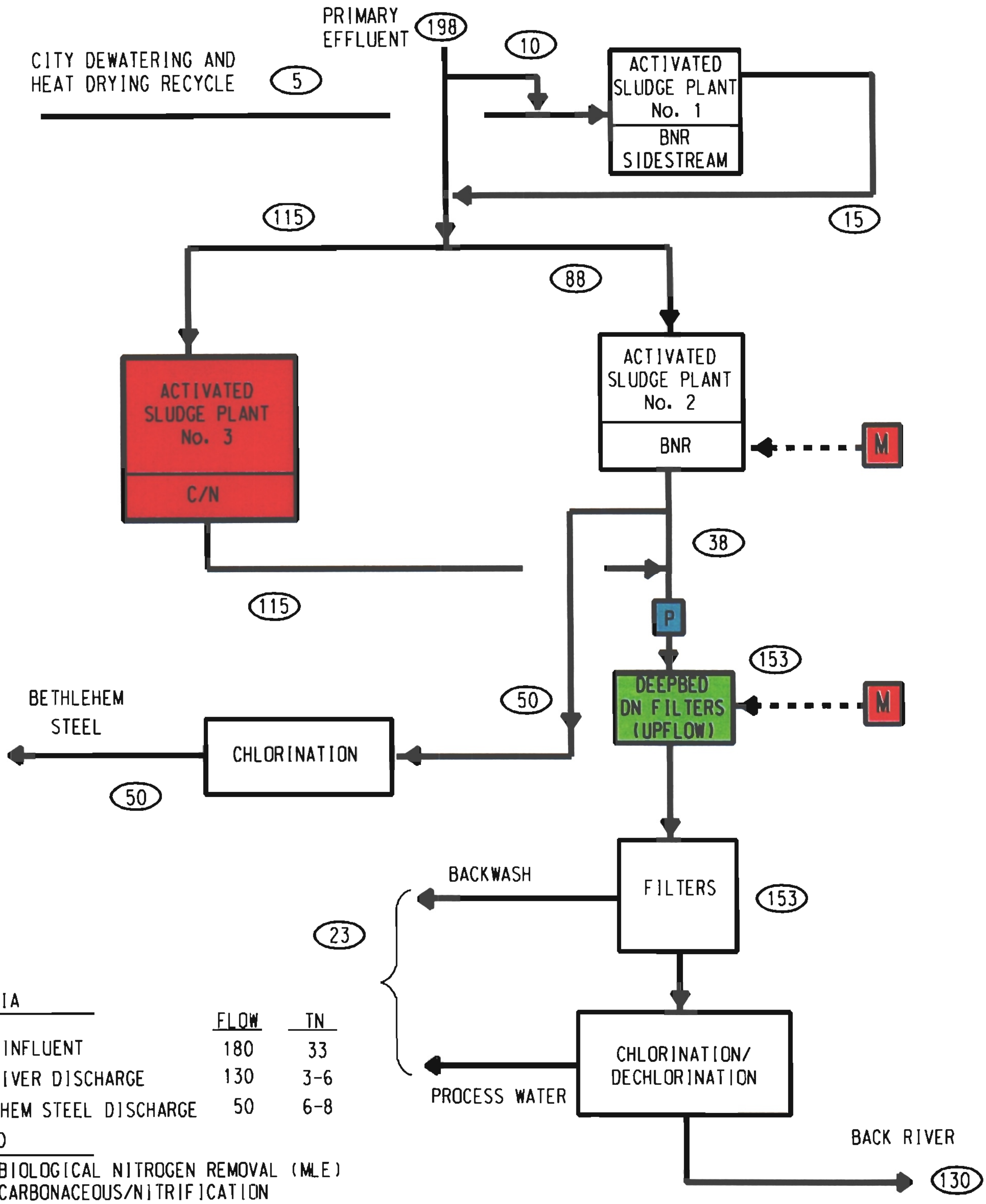
Operation and Maintenance Assumptions

Labor and maintenance costs are based on both existing and new equipment operating at average flow of 203 mgd. Chemical and energy (aeration, mixing, and pumping) costs are established on a continuous operation at an average flow of 15 mgd to Plant No.1, 88 mgd to Plant No. 2, 115 mgd to Plant No. 3 and 153 mgd to upflow deep bed filters. Aeration and mixing power are also based on manufacturer's recommendation. Methanol dosage is computed using the same methanol to nitrate-nitrogen removal ratio as in Alternative 1-1. Cost of quick lime is based on supplier's estimate at the time of writing.

Operation and Maintenance costs were estimated using Table 6-2-5B.

Cost Estimates

A breakdown of capital, salvage, and operation and maintenance costs is shown in Table 6-2-5C.



CRITERIA

	FLOW	TN
PLANT INFLUENT	180	33
BACK RIVER DISCHARGE	130	3-6
BETHLEHEM STEEL DISCHARGE	50	6-8

LEGEND

- BNR BIOLOGICAL NITROGEN REMOVAL (MLE)
- C/N CARBONACEOUS/NITRIFICATION
- DN DENITRIFICATION
- FB FLUIDIZED BED
- M METHANOL
- P PUMPING STATION
- TN TOTAL NITROGEN
- ⬭ FLOW, MGD

NOTE

PLANT FLOW=180 MGD, WITH RECYCLES=203 MGD

COMPREHENSIVE WASTEWATER FACILITIES MASTER PLAN

BACK RIVER WASTEWATER TREATMENT PLANT

CONCEPTUAL DIAGRAM ALTERNATIVE 2-5

WHITMAN, REQUARDT AND ASSOCIATES, LLP	DATE: APRIL 2004	SCALE: NONE	FIGURE: 6-2-5

TABLE 6-2-5A

BACK RIVER WASTEWATER TREATMENT PLANT

ALTERNATIVE 2-5: DESIGN ASSUMPTIONS

Unit Process	Parameters	Criteria
Activated Sludge Plant No. 1	Average Daily Flow	15 MGD: 5 MGD Centrate and 10 MGD Primary Effluent
BNR/SIDESTREAM	Peak Dry Weather Flow	22 MGD
Reactors	Number of Reactors	all four
	Design Hydraulic Detention Time	17 hours
	Design Solids Retention Time	10 days
	Overall Solids Retention Time	16 days
Air includes mixing	O_2 Requirement	60,310 lbs/day
	Blower Capacity	20,060 cfm, 985 HP @ 15.5 ft Head
	Fine Bubble Diffusers	13,370@ 1.5 cfm per diffuser
	Oxygen Transfer Efficiency	12%
Clarifier	Clarifier	all four
	Clarifier Overflow Rate	200 gpd/ft^2
	Design MLSS	3750 mg/L
	Solids Flux Loading Rate	6.2 lbs/ft^2
	Sludge Waste Production	21,032 lbs/day
Performance	Effluent	TN=8 mg/L, TKN=4.9 mg/L
Activated Sludge Plant No. 2	Average Daily Flow	88 MGD
BNR	Peak Dry Weather Flow	127 MGD

TABLE 6-2-5A (CONTINUED)

Unit Process	Parameters	Criteria
Chemicals	Methanol Dosage	TN of 8 mg/L: 6.3 mg/L
		TN of 6 mg/L: 12.3 mg/L
Chemical Sludge	Sludge Production from Methanol Addition	
	(0.18 VSS produced/COD removed)	TN of 6 mg/L: 3252 lb/day
	(75% TSS is VSS)	
	Performance	TN of 6 mg/L: TKN=2 mg/L, NOx-N=4 mg/L
	Sludge Waste Production	57,993 lbs/day
Activated Sludge Plant No. 3	Average Daily Flow	115 MGD
C/N	Peak Dry Weather Flow	165 MGD
Reactors	Nitrification Capacity	32.5 Mgal
	Number of Reactors	6 (one standby)
	Design Hydraulic Detention Time	6.78 hours
	Design Solids Retention Time	14.3 days
Air includes mixing	Installed Blower Capacity	95,000 cfm
	Installed Fine Bubble Diffusers	19000/ reactor @ 1.5 SCFM/diffuser
	Oxygen Transfer Efficiency	12%
Clarifier	Clarifier	12 (two standby)
	Clarifier Overflow Rate	Average: 572 gpd/ft^2, Peak: 820 gpd/ft^2
	Solids Flux Loading Rate	17.8 lbs/sq.ft./day
	Design MLSS	3500 mg/L
	Sludge Waste Production	66,340 lbs/day
Chemicals	Quick Lime Dosage	61 mg/L
	Lime Solids	4047 lbs/day
	6.1 % of Waste Activated Sludge	

TABLE 6-2-5A (CONTINUED)

Unit Process	Parameters	Criteria
Performance	Effluent	TKN = 2 mg/L, NOx-N = 26 mg/L
Upflow Deep Bed DN Filters	Average Daily Flow	153 MGD
	Peak Dry Weather Flow	220 MGD
	Hydraulic Loading (average flow)	Average: 5.7 gpm/ft^2 Peak: 7.4 gpm/ft^2
	Nitrates Loading	Average: 1.5 lbs/ft^2-day Peak: 1.9 lbs/ft2-day
Filters	Dimensions (Peak Flow)	12 - 40.2 ft X 46.8 ft X 19 ft (LXWXH) (1 standby))
	Media Depth	9.5 ft.
	Media	Biolite, clay
Backwash	Backwash	12.2 gpm/ft^2, 50 min/day
	Air Backwash	4.8 cfm/ft^2, with backwash water for 50 min/day
Backwash Waste	Flow Rate to Primary	799 gpm for one filter
Chemicals	Methanol	60 mg/L
Performance	Effluent	TKN= 2 mg/L, NO_x-N= 1mg/L, TSS=5 mg/L

TABLE 6-2-5B

BACK RIVER WASTEWATER TREATMENT PLANT

ALTERNATIVE 2-5: OPERATION AND MAINTENANCE ASSUMPTIONS

Unit Process	Assumptions
Activated Sludge Plant No. 1 (BNR/SIDESTREAM)	
Pumping Centrate	5 MGD of Centrate to Plant #1, 0.3132/HP/MGD/ft of Head, $0.06/KWh.
Aeration and Mixing	[1.5 (Lbs BOD removed) + 4.6 (lbs of TKN nitrified) – 2.86 (lbs of Nitrates denitrified)]*1.5
	12% O2 transfer efficiency
	108,600 lbs/day in all aerobic zones.
Mixing Power	27.5 HP/reactor, $0.045/HP-hour
Activated Sludge Plant No. 2 (BNR)	
Aeration and Mixing	[1.5 (Lbs BOD removed) + 4.6 (lbs of TKN nitrified) – 2.86 (lbs of Nitrates denitrified)]*1.5
	12% O2 transfer efficiency
	354 mg/L O_2 or 71,000 cfm
Mixing	197.4 HP/reactor,
Methanol Feed	6.3 mg/L to 12.3 mg/L, 6.58 lbs/gal, $1.00/gal
Activated Sludge Plant No. 3 (C/N)	
Aeration includes mixing	lbs/day of O_2 consumption = ((1.5 X lbs BOD influent) + (4.6 TKN influent) + (1.5 DO)) 1.5
	12% O2 transfer efficiency
	477 mg/L of O_2
Lime Feed	76 mg/L Quick Lime, $50/ton

TABLE 6-2-5B (CONTINUED)

Unit Process	Assumptions
Upflow DN Reactors	
Pumping to Filters	153-MGD @ 50 ft Head
	0.3132 HP/MGD/ft of Head, $0.06/KWh.
Back Wash Water Pumping Power	3-11,280 gpm @ 50 ft Head (one standby) each filter
	0.3132 HP/MGD/ft of Head, $0.06/KWh.
Air Back Wash Blower Power	5131 cfm of air @ 10.4 psig, each filter
	0.3132 HP/MGD/ft of Head, $0.06/KWh.
Mudwell Pump Power	527 gpm @ 65 ft per filter
	0.3132 HP/MGD/ft of Head, $0.06/KWh.
Methanol Feed	60 mg/L, 6.58 lbs/gal, $1.00/gal

	PROCESS	CAPITAL ($M)	SALVAGE ($M)	ANNUAL COSTS ($M)				
				OPERATING			MAINT.	TOTAL
				LABOR	ENERGY	CHEMICAL		
1	Ex. Activated Sludge Plant No. 1 (BNR/Sidestream)	8.00	6.96	0.14	0.44		0.46	1.04
2	Ex. Activated Sludge Plant No. 2 (BNR)		33.15	0.36	2.26		2.21	4.83
3	Ex. Activated Sludge Plant No. 3 (C/N)	23.77	43.10	0.47	3.15		2.87	6.49
4	Deep Bed DN Filters (Upflow)	42.35	12.71	0.21	0.17		0.85	1.23
5	DN Pumping Stations	59.85	17.96	0.04	0.94		0.96	1.94
6	Methanol Facilities (2)	2.33	0.70	0.06		4.75	0.05	4.86
7	Lime Facilities (2 Existing and 1 New)					0.93		0.93
8	Existing Filters							0.00
9	WAS Treatment[1]				0.08	0.55		0.63
10	Disposal (Land Application)[2]							1.93
11								
12								
13								
14								
15								
16								
17								
18								
19								
20								
21								
22								
	TOTALS	T1= 136.30	T2= 114.58	1.28	7.04	6.23	7.40	T3= 23.88

$M - Millions of Dollars

[1] Based on thickening, pumping, digestion, and dewatering of waste activated sludge (WAS). WAS produced is estimated to be 90.0 dry tons/day (DTPD).
BRWWTP Operations Report for 2001: 80% volatile solids in feed and 80% volatile solids destruction from ESDs.

[2] Sludge cake for disposal is 32.4 DTPD.

PRESENT WORTH COST DETERMINATION

1. PRESENT WORTH FACTORS
   F1 = SINGLE PAYMENT, 20 YEARS, 7% = 0.25842
   F2 = UNIFORM SERIES, 20 YEARS, 7% = 10.59401

2. PRESENT WORTH BASIS
   A. CAPITAL COST: (T1) $136.30
   B. SALVAGE COST: (-) (F1 X T2) -$29.61
   C. ANNUAL O&M COST: (F2 X T3) $252.98

TOTAL PRESENT WORTH = $359.68

NOTES:
ENR INDEX = 6300
DN = Denitrification
C/N = Carbonaceous / Nitrification

COMPREHENSIVE WASTEWATER FACILITIES
MASTER PLAN

BACK RIVER
WASTEWATER TREATMENT PLANT

SUMMARY OF ESTIMATED COSTS
ALTERNATIVE 2-5

WHITMAN, REQUARDT AND ASSOCIATES, LLP | SEPTEMBER 2002 | TABLE 6-2-5C

6.7.9. Alternative 3-1 (Level 3) : Two Sludge Suspended Growth System

Process Description

This alternative is similar to Alternative 2-1, where a separate carbonation/nitrification stage is followed by a separate denitrification stage with supplemental methanol addition, sand filtration, and chlorination/dechlorination. The existing Activated Sludge Plant Nos. 3 and 4 are retrofitted to carbon oxidation/nitrification process. The existing Plant No. 1 and Plant No. 2 are the denitrification process with methanol feed. This alternative will produce a discharge to Back River and ISG (previously Bethlehem Steel) with TN of 3 to 6 mg/l.

The conceptual diagram is shown in Figure 6-3-1A. The process schematic and site plan is shown in Figures 6-3-1B and 6-3-1C, respectively.

Design Assumptions

Primary effluent gravity flows to the new influent splitter box and distributes 122 mgd and 81 mgd to Plant Nos. 3 and 4 for nitrification, respectively. Plant No. 4 consists of four reactors, and four rectangular clarifiers. Four new lime silos and slakers are installed for Plant No. 4 and existing slakers in Plant No. 3 are upgraded. Two pumping stations pump the nitrified effluent from Plant Nos. 3 and 4 to Plant Nos. 1 and 2 for denitrification. The two methanol pumping stations (Plant Nos. 1 and 2) are similar to Alternative 1-1. Six new clarifiers (Nos. 5C to 10C) and a sludge pumping station are added to Plant No. 2. Existing distribution boxes for Clarifiers Nos. 5A and 5B to 10A and B serve new clarifier Nos. 5C to 10C. The detention time for complete nitrification is 6.5 hours and denitrification is 3 hours.

Total sludge production to thickening facility, 226,000 lbs/day, includes chemical (lime and methanol) and biological wasted solids. A breakdown of solids wasted from each plant is located in the design assumption, Table 6-3-1A

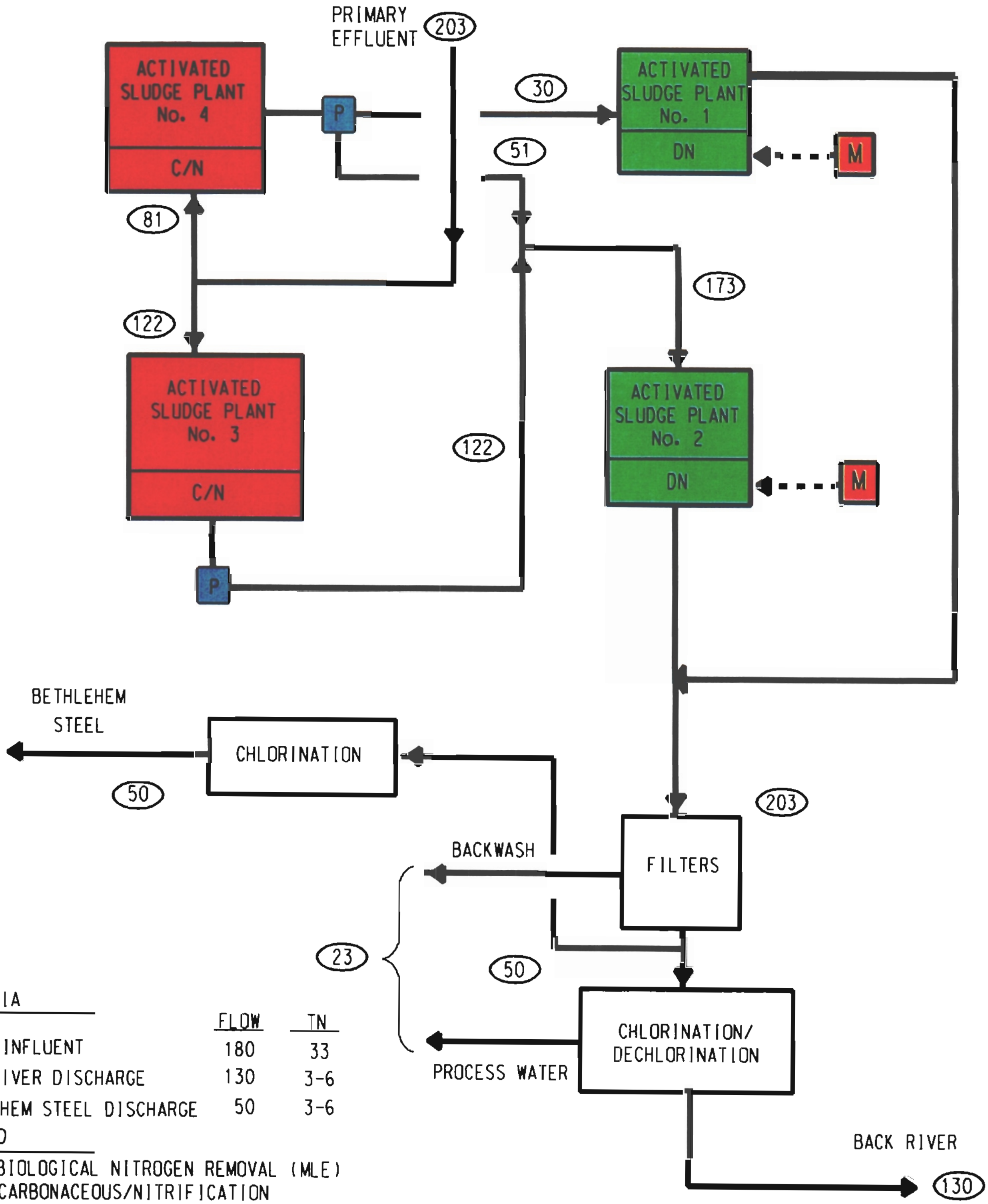
Operation and Maintenance Assumptions

Labor and maintenance costs are based on both existing and new equipment operating at average flow of 203 mgd. Chemical and energy (aeration, mixing and pumping) costs are established on a continuous operation at an average flow of 30 mgd to Plant No.1, 173 mgd to Plant No. 2, 122 mgd to Plant No.3 and 81 mgd to Plant No.4. Methanol dosage is computed using the same methanol to nitrate-nitrogen removal ratio as in Alternative 1-1. Cost of quick lime is based on supplier's estimate at the time of writing.

Operation and Maintenance costs are estimated using Table 6-3-1B.

Cost Estimates

A breakdown of capital, salvage, and operation and maintenance costs is shown in Table 6-3-1C.



CRITERIA

	FLOW	TN
PLANT INFLUENT	180	33
BACK RIVER DISCHARGE	130	3-6
BETHLEHEM STEEL DISCHARGE	50	3-6

LEGEND

BNR BIOLOGICAL NITROGEN REMOVAL (MLE)
C/N CARBONACEOUS/NITRIFICATION
DN DENITRIFICATION
FB FLUIDIZED BED
M METHANOL
P PUMPING STATION
TN TOTAL NITROGEN
(oval) FLOW, MGD

NOTE

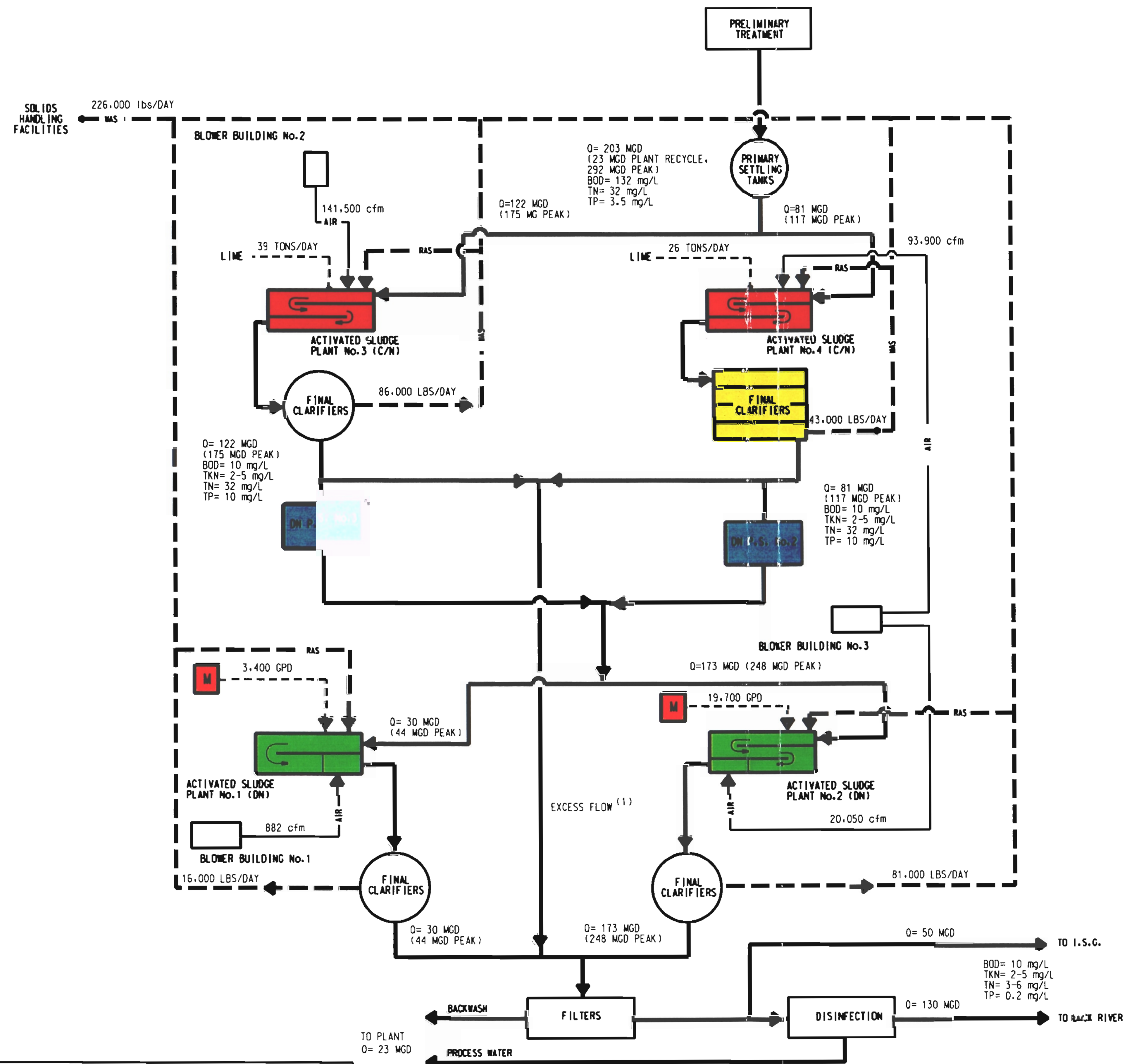
PLANT FLOW=180 MGD, WITH RECYCLES=203 MGD

COMPREHENSIVE WASTEWATER FACILITIES MASTER PLAN

BACK RIVER WASTEWATER TREATMENT PLANT

CONCEPTUAL DIAGRAM ALTERNATIVE 3-1

WHITMAN, REQUARDT AND ASSOCIATES, LLP	DATE: APRIL 2004	SCALE: NONE	FIGURE: 6-3-1A



LEGEND

- WASTEWATER
- SLUDGE
- AIR
- CHEMICAL

ABBREVIATIONS

CARBONACEOUS BOD REMOVAL	C
NITRIFICATION	N
DENITRIFICATION	DN
PUMPING STATION	PS
BIOCHEMICAL OXYGEN DEMAND	BOD
TOTAL KJELDAHL NITROGEN	TKN
TOTAL NITROGEN	TN
TOTAL PHOSPHORUS	TP
METHANOL	M
WASTE ACTIVATED SLUDGE	WAS
RETURN ACTIVATED SLUDGE	RAS

NOTES:

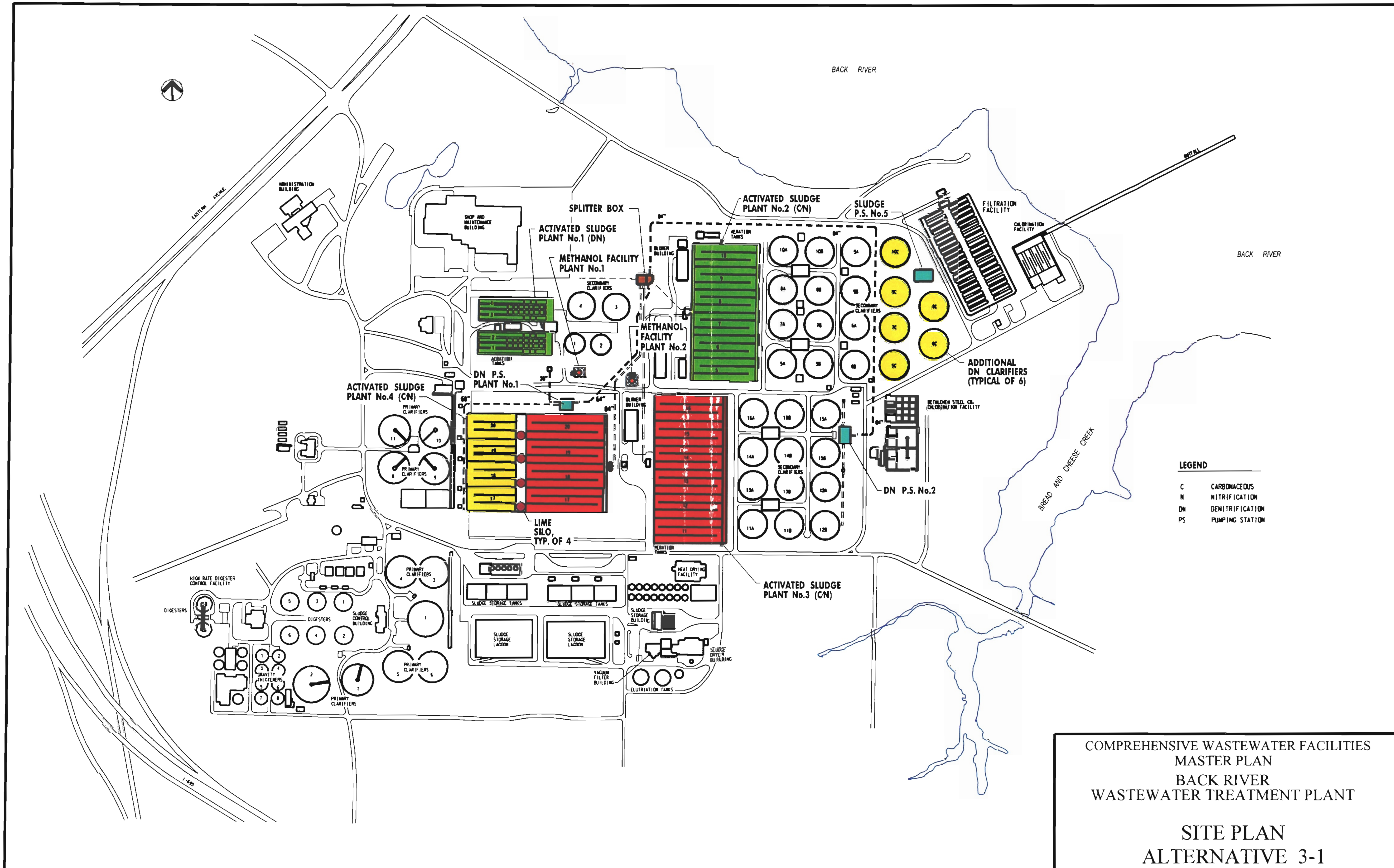
(1) EXCESS FLOW IS FLOW THAT EXCEEDS PEAK DRY WEATHER FLOW.

COMPREHENSIVE WASTEWATER FACILITIES MASTER PLAN
BACK RIVER WASTEWATER TREATMENT PLANT

PROCESS SCHEMATIC ALTERNATIVE 3-1

DATE: APRIL 2004 | SCALE: NONE | FIGURE: 6-3-1B

WHITMAN, REQUARDT AND ASSOCIATES, LLP



WHITMAN, REQUARDT AND ASSOCIATES, LLP

COMPREHENSIVE WASTEWATER FACILITIES MASTER PLAN

BACK RIVER WASTEWATER TREATMENT PLANT

SITE PLAN

ALTERNATIVE 3-1

DATE: APRIL 2004	SCALE: 1'= 500'	FIGURE: 6-3-1C

TABLE 6-3-1A

BACK RIVER WASTEWATER TREATMENT PLANT

ALTERNATIVE 3-1: DESIGN ASSUMPTIONS

Unit Process	Parameters	Criteria
Activated Sludge Plant No. 1	Average Daily Flow	30 MGD
DN	Peak Dry Weather Flow	44 MGD
Reactors	Total Reactor Volume	2.69 Mgal
	Number of Reactors	4 (two standby)
	Design Hydraulic Detention Time	4.3 hours
	Design Solids Retention Time	20 days
Air includes mixing	Installed Blower Capacity	441 SCFM/ reactor
	Installed Coarse Bubble Diffusers	294 diffuser/reactor
	Installed Mixing Capacity	74.5 HP mixing (.36 hp/1000 cu.ft)
Clarifiers	Clarifiers	All four existing under SC 709
	Clarifier Overflow Rate	Average: 394 gpd/ft^2, Peak: 577 gpd/ft^2
	Solids Flux Loading Rate	11.5 lbs/sq. ft./day
	Design MLSS	3500 mg/L
	Sludge Waste Production	7852 lbs/day
Chemicals	Methanol Dosage	90 mg/L
	Sludge Production from Methanol Addition	TN of 3 mg/L: 8106 lb/day
	(0.18 VSS produced/COD removed)	
	(75% TSS is VSS)	
Performance	Effluent	TN of 3mg/L: TKN=2 mg/L, NOx-N= 1 mg/L
Activated Sludge Plant No. 2	Average Daily Flow	173 MGD
DN	Peak Dry Weather Flow	248 MGD

TABLE 6-3-1A (CONTINUED)

Unit Process	Parameters	Criteria
Reactor	Number of Reactors	6 (one standby)
	Design Hydraulic Detention Time	3.5 hours
	Design Solids Retention Time	20 days
Air includes Mixing	Blower Capacity Required	4010/reactor cfm
	Coarse Bubble Diffusers Required	2674 diffusers/reactor in rearation zone
	Installed Mixing Capacity	201 HP/reactor in anoxic zone
Clarifiers	Clarifiers	Install 6 new (one standby), 155 ft dia, 5C, 6C, 7C, 8C, 9C,10C
	Clarifier Overflow Rate	Average: 551 gpd/ft^2, Peak: 790 gpd/ft^2
	Solids Flux Loading Rate	14.9 lbs/sq. ft./day
	Design MLSS	3500 mg/L
	Sludge Waste Production	34,490 lbs/day
Chemicals	Methanol Dosage	90 mg/L
	Sludge Production from Methanol Addition	
	(0.18 VSS produced/COD removed)	TN of 3 mg/L: 46,747 lb/day
	(75% TSS is VSS)	
Performance	Effluent	TN of 3mg/L: TKN=2 mg/L, NOx-N= 1 mg/L
Activated Sludge Plant No. 3	Average Daily Flow	122 MGD
C/N	Peak Dry Weather Flow	175 MGD
Reactors	Number of Reactors	6
	Design Hydraulic Detention Time	7.67 hours
	Design Solids Retention Time	14.3 days
Air includes mixing	Oxygen Consumption for Nitrification	510 mg/L, 4253 Lbs/MGD

TABLE 6-3-1A (CONTINUED)

Unit Process	Parameters	Criteria
	Installed Blower Capacity	26,156 cfm/reactor
	Installed Fine Bubble Diffusers	17,440/ reactor @ 1.5 SCFM/diffuser
	Oxygen Transfer Efficiency	12%
Clarifier	Clarifier	12 existing
	Clarifier Overflow Rate	Average: 526 gpd/ft^2, Peak: 756 gpd/ft^2
	Solids Flux Loading Rate	14.8 lbs/sq.ft./day
	Design MLSS	3500 mg/L
	Sludge Waste Production	79,610 lbs/day
Chemicals	Quick Lime Dosage	76 mg/L
	Lime Solids	6050 lbs/day
	7.6% of Waste Activated Sludge	
Performance	Effluent	TN of 3mg/L: TKN=2 mg/L, NOx-N= 30 mg/L
Activated Sludge Plant No. 4	Average Daily Flow	81 MGD
C/N	Peak Dry Weather Flow	117 MGD
Reactor	Number of Reactors	4 (one standby)
	Design Hydraulic Detention Time	6 hours
	Design Solids Retention Time	14.3 days
Air includes mixing	Oxygen Consumption for Nitrification	510 mg/L, 4253 lbs/MGD
	Installed Blower Capacity	26,156 cfm/reactor
	Installed Fine Bubble Diffusers	17,440 per reactor @ 1.5 scfm/diffuser
	Oxygen Transfer Efficiency	12%
Clarifier	Clarifier	4 new (415'x45'x15.5' (SWD)) 3-pass each (one standby)
	Clarifier Overflow Rate	Average: 482 gpd/ft2, Peak: 696 gpd/ft2
	Solids Flux Loading Rate	10.6 lbs/sq.ft./day

TABLE 6-3-1A (CONTINUED)

Unit Process	Parameters	Criteria
	Design MLSS	3500 mg/L
	Sludge Waste Production	39,805 lbs/day
Chemical	Quick Lime Dosage	76 mg/L
	Lime Solids	3025 lbs/day
	7.6% of Waste Activated Sludge	
Performance	Effluent	TN of 3mg/L: TKN=2 mg/L, NOx-N= 30 mg/L

TABLE 6-3-1B

BACK RIVER WASTEWATER TREATMENT PLANT

ALTERNATIVE 3-1: OPERATION AND MAINTENANCE ASSUMPTIONS

Unit Process	Assumptions
Activated Sludge Plant No. 1 (DN)	
Mixing Power	74.5 HP/ reactor. $0.045/HP-hr.
Methanol Feed	69 mg/L Density: 6.58 lbs/gal, $1.00/gal
Rearation	441 cfm/reactor, 30 cfm/1000 cu. ft.
Activated Sludge Plant No. 2 (DN)	
Mixing Power	201 HP/ reactor. $0.045/HP-hr.
Methanol Feed	69 mg/L Density: 6.58 lbs/gal, $1.00/gal
Rearation	4001cfm/reactor, 30 cfm/1000 cu. ft.
Activated Sludge Plant No. 3 and Plant No. 4 (C/N)	
Pumping to Plant No. 1 and Plant No. 2	122 MGD and 51 MGD from Plant No. 3 and Plant No. 4 to Plant No. 2
	30 MGD from Plant No. 4 to Plant No. 1.
	0.3132 HP/MGD/ft of Head, $0.06/KWh.
Aeration and mixing	lbs/day of O2 consumption = ((1.5 X lbs BOD influent) +
	(4.6 TKN influent) + (1.5 DO)) 1.5
	12% O2 transfer efficiency
Quick Lime	76 mg/L, $50.00/dry ton

	PROCESS	CAPITAL ($M)	SALVAGE ($M)	ANNUAL COSTS ($M)				
				OPERATING			MAINT.	TOTAL
				LABOR	ENERGY	CHEMICAL		
1	Ex. Activated Sludge Plant No. 1 (DN)	4.89	6.96	0.10	0.08		0.46	0.64
2	Ex. Activated Sludge Plant No. 2 (DN)	8.67	33.15	0.27	0.91		2.21	3.39
3	Ex. Activated Sludge Plant No. 3 (C/N)	23.77	43.10	0.36	3.53		2.87	6.76
4	Activated Sludge Plant No. 4 (C/N)	112.88	33.86	0.24	2.35		1.78	4.37
5	Denitrification Pumping Stations (2)	59.85	17.96	0.04	0.42		0.96	1.42
6	Methanol Facilities (2)	2.33	0.70	0.06		8.45	0.05	8.56
7	Lime Facilities (1 Existing and 1 New)	0.86	0.50			1.64	0.03	1.67
8	WAS Treatment[1]				0.10	0.70		0.80
9	Disposal (Land Application)[2]							2.42
10								
11								
12								
13								
14								
15								
16								
17								
18								
19								
20								
21								
22								
	TOTALS	T1= 213.25	T2= 136.23	1.07	7.39	10.79	8.36	T3= 30.03

$M - Millions of Dollars

[1] Based on thickening, pumping, digestion, and dewatering of waste activated sludge (WAS). WAS produced is estimated to be 113.0 dry tons/day (DTPD).
BRWWTP Operations Report for 2001: 80% volatile solids in feed and 80% volatile solids destruction from ESDs.

[2] Sludge cake for disposal is 40.7 DTPD.

PRESENT WORTH COST DETERMINATION

1. PRESENT WORTH FACTORS

F1 = SINGLE PAYMENT, 20 YEARS, 7% = 0.25842
F2 = UNIFORM SERIES, 20 YEARS, 7% = 10.59401

2. PRESENT WORTH BASIS

A. CAPITAL COST: (T1) $213.25

B. SALVAGE COST: (-) (F1 X T2) -$35.20

C. ANNUAL O&M COST: (F2 X T3) $318.14

TOTAL PRESENT WORTH = $496.18

NOTES:
ENR INDEX = 6300
DN = Denitrification
C/N = Carbonaceous / Nitrification

COMPREHENSIVE WASTEWATER FACILITIES MASTER PLAN

BACK RIVER WASTEWATER TREATMENT PLANT

SUMMARY OF ESTIMATED COSTS ALTERNATIVE 3-1

WHITMAN, REQUARDT AND ASSOCIATES, LLP	SEPTEMBER 2002	TABLE 6-3-1C

6.7.10. Alternative 3-2 (Level 3): Carbon Oxidation/Nitrification Suspended Growth Plus Deep Bed Denitrification Filter (Downflow)

Process Description

Secondary treatment for this alternative is same as Alternative 3-1 where Plant No. 2 and Plant No. 3 is converted to combined carbon oxidation/nitrification plants and Plant No. 1 to denitrification. An advanced treatment would consist of downflow deep bed denitrification filters followed by sand filtration, and chlorination/dechlorination. This alternative would produce discharge to Back River and ISG (previously Bethlehem Steel) with TN of 3 to 6 mg/l, annually.

Figure 6-3-2A shows the conceptual diagram. Figures 6-3-2B and 6-3-2C illustrate the site plan and process schematic, respectively.

Design Assumptions

The primary effluent gravity flows to the existing influent splitter box and distributes 115 mgd and 88 mgd to Plant No. 2 and Plant No. 3 for nitrification, respectively. Lime is added in the nitrification basins to maintain alkalinity of 50 mg/l as CaCO3 and pH of 7. Six lime silos and slakers are installed for Plant No. 2 and the slakers for Plant No. 3 are upgraded. The two denitrification pumping stations (Plant No. 2 and Plant No. 3) pump 30-mgd to Plant No. 1 and 173-mgd to deep bed filters for denitrification. Two methanol facilities installed (Plant No.1 and downflow deep bed denitrification filters) are similar to Alternative 1-1. The detention time for complete nitrification is 6.5 hours and for denitrification is 3 hours.

Downflow deep bed filters were designed to treat peak flow of 248 mgd nitrified effluent to nitrate- nitrogen levels of less than 1 mg/l. These 48 filters filled with 10 feet deep of sand occupy 1100 ft^2 of surface area per filter. Average design hydraulic loading is 2.1 gpm/ ft^2 and nitrate-nitrogen loading 0.77 lbs/ft^2-day. Backwash water is collected in mudwell and pumped to the primaries.

Total sludge production to thickening facility includes chemical (lime and methanol) and biological wasted solids. Total solids production wasted is anticipated to be 189,000 lbs./day. A breakdown of solids wasted from each plant is located in the design assumption table.

Design assumptions for the carbon oxidation/nitrification and denitrification are shown in Table 6-3-2A.

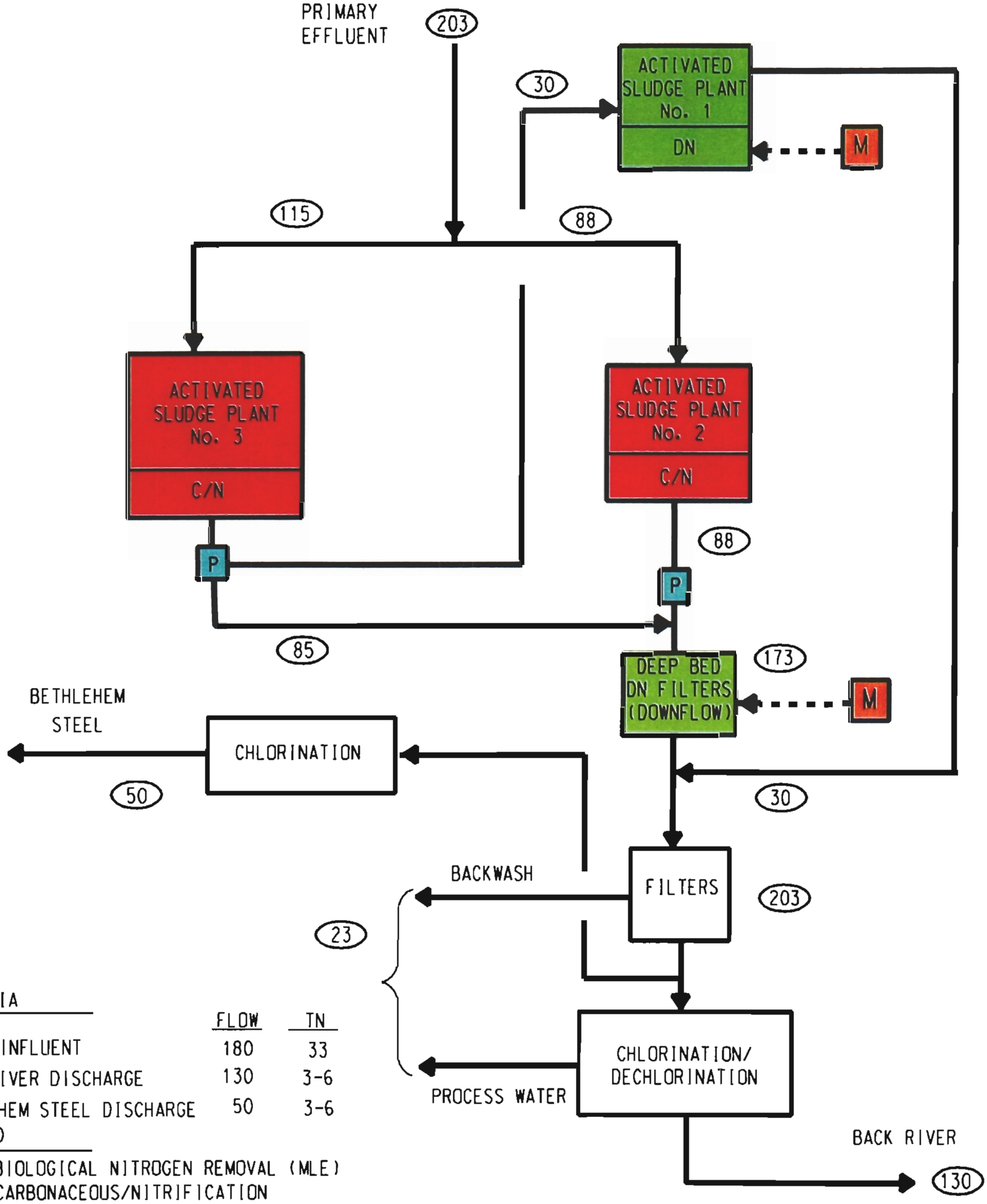
Operation and Maintenance Assumptions

Labor and maintenance costs are based on both existing and new equipment operating at average flow of 203 mgd. Chemical and energy (aeration, mixing and pumping) costs are established on a continuous operation at an average flow of 30 mgd to Plant No. 1, 88 mgd to Plant No. 2, 115 mgd to Plant No. 3 and 173 mgd to deep bed denitrification filters. Methanol dosage is based on same methanol to nitrate-nitrogen removal ratio as Alternative 1-1. Cost of quick lime is based on supplier's estimate at the time of writing.

A summary of assumptions and references used in developing operation and maintenance costs are presented Table 6-3-2B.

Cost Estimates

A breakdown of capital, salvage, and operation and maintenance costs is shown in Table 6-3-2C.



CRITERIA

	FLOW	TN
PLANT INFLUENT	180	33
BACK RIVER DISCHARGE	130	3-6
BETHLEHEM STEEL DISCHARGE	50	3-6

LEGEND

- BNR BIOLOGICAL NITROGEN REMOVAL (MLE)
- C/N CARBONACEOUS/NITRIFICATION
- DN DENITRIFICATION
- FB FLUIDIZED BED
- M METHANOL
- P PUMPING STATION
- TN TOTAL NITROGEN
- (oval) FLOW, MGD

NOTE

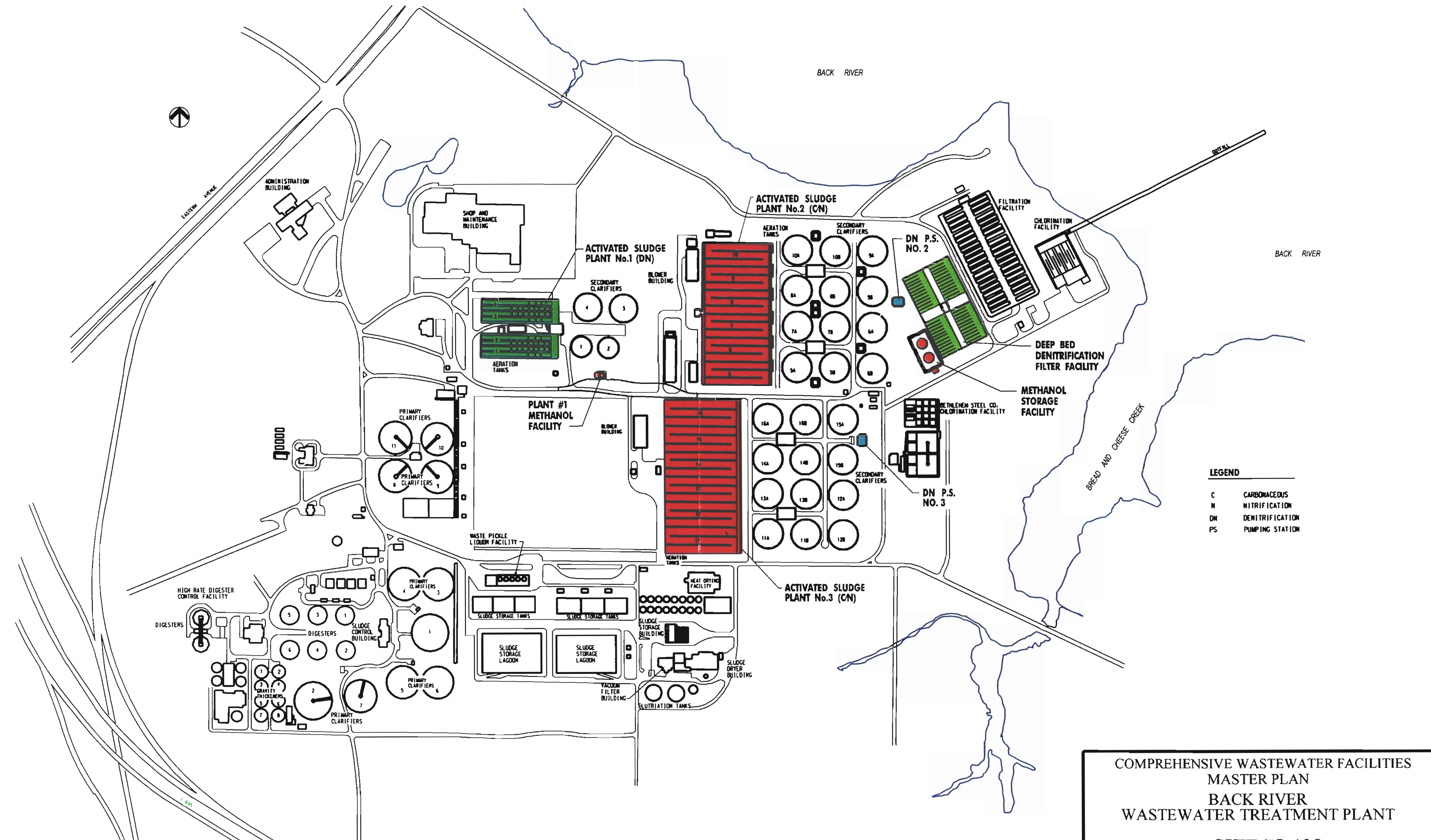
PLANT FLOW=180 MGD, WITH RECYCLES=203 MGD

COMPREHENSIVE WASTEWATER FACILITIES MASTER PLAN

BACK RIVER WASTEWATER TREATMENT PLANT

CONCEPTUAL DIAGRAM ALTERNATIVE 3-2

WHITMAN, REQUARDT AND ASSOCIATES, LLP	DATE: APRIL 2004	SCALE: NONE	FIGURE: 6-3-2A



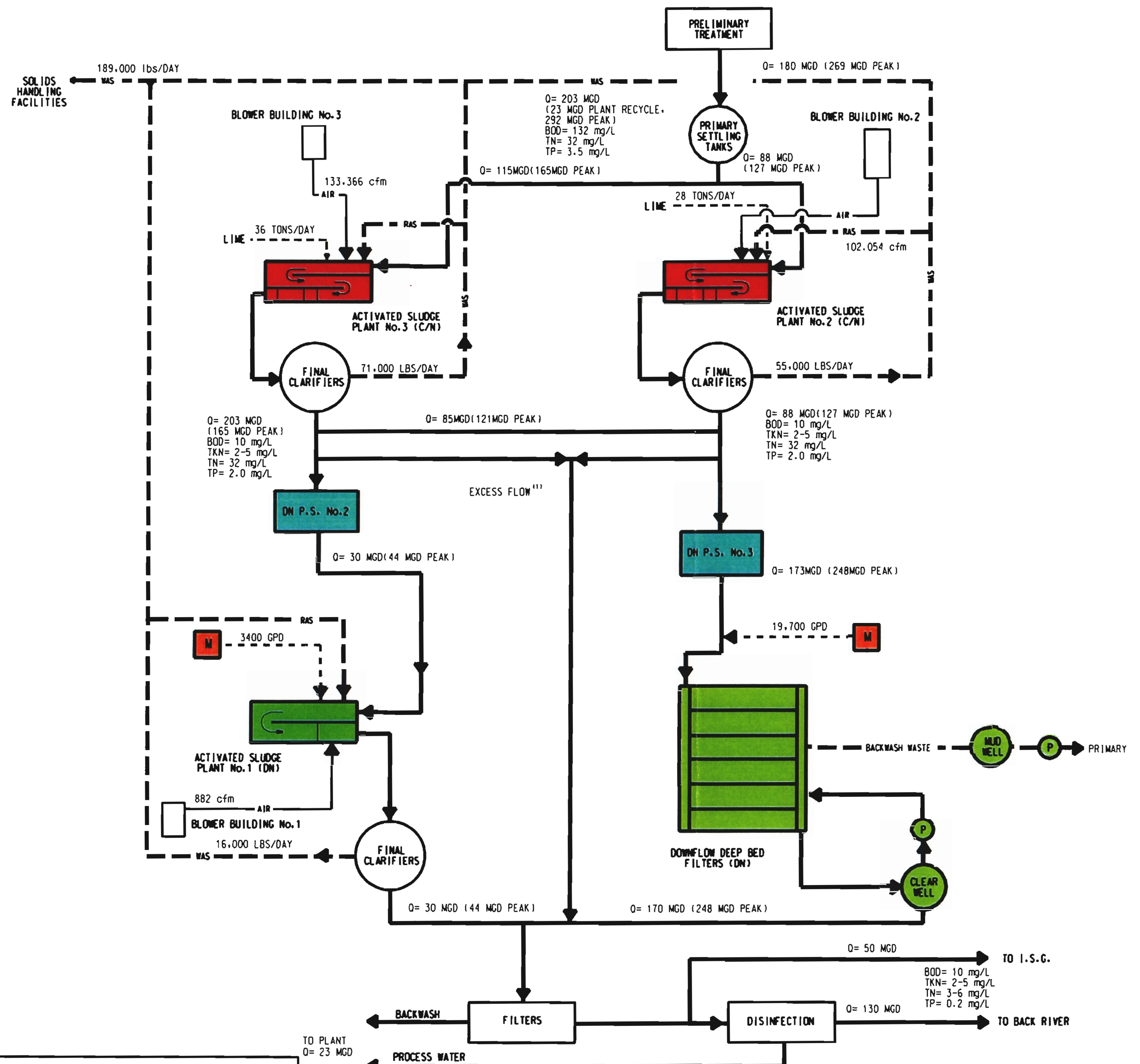
COMPREHENSIVE WASTEWATER FACILITIES
MASTER PLAN

BACK RIVER
WASTEWATER TREATMENT PLANT

SITE PLAN
ALTERNATIVE 3-2

DATE: APRIL 2004	SCALE: 1"= 500'	FIGURE: 6-3-2B

WHITMAN, REQUARDT AND ASSOCIATES, LLP



LEGEND

WASTEWATER
SLUDGE
AIR
CHEMICAL

ABBREVIATIONS

CARBONACEOUS BOD REMOVAL	C
NITRIFICATION	N
DENITRIFICATION	DN
PUMPING STATION	PS
METHANOL	M
BIOCHEMICAL OXYGEN DEMAND	BOD
TOTAL KJELDAHL NITROGEN	TKN
TOTAL NITROGEN	TN
TOTAL SOLIDS	TS
TOTAL PHOSPHORUS	TP
WASTE ACTIVATED SLUDGE	WAS
RETURN ACTIVATED SLUDGE	RAS

NOTES:
(1) EXCESS FLOW IS FLOW THAT EXCEEDS PEAK DRY WEATHER FLOW.

WHITMAN, REQUARDT AND ASSOCIATES, LLP

COMPREHENSIVE WASTEWATER FACILITIES MASTER PLAN
BACK RIVER WASTEWATER TREATMENT PLANT

PROCESS SCHEMATIC ALTERNATIVE 3-2

DATE: APRIL 2004 | SCALE: NONE | FIGURE: 6-3-2C

TABLE 6-3-2A
BACK RIVER WASTEWATER TREATMENT PLANT
ALTERNATIVE 3-2: DESIGN ASSUMPTIONS

Unit Process	Parameters	Criteria
Activated Sludge Plant No. 1	Average Daily Flow	30 MGD
DN	Peak Dry Weather Flow	44 MGD
Reactors	Number of Reactors	4 (two standby)
	Design Hydraulic Detention Time	4.3 hours
	Design Solids Retention Time	20 days
Air includes mixing	Installed Blower Capacity for Reareation	441 SCFM
	Installed Mixing Capacity for Anoxic Zone	74.5 HP mixing (.36 hp/1000 cu.ft)
Clarifiers	Clarifiers	All four existing under SC 709
	Clarifier Overflow Rate	Average: 394 gpd/ft^2, Peak: 577 gpd/ft^2
	Solids Flux Loading Rate	11.5 lbs/sq. ft./day
	Design MLSS	3500 mg/L
	Sludge Waste Production	7852 lbs/day
Chemicals	Methanol Dosage	90 mg/L
	Sludge Production from Methanol Addition	8106 lbs/day
	(0.18 VSS produced/COD removed)	
	(75% TSS is VSS)	
Performance	Effluent	TN of 3mg/L: TKN=2 mg/L, NOx-N= 1 mg/L
Activated Sludge Plant No. 2	Average Daily Flow	88 MGD
C/N	Peak Dry Weather Flow	127 MGD

TABLE 6-3-2A (CONTINUED)

Unit Process	Parameters	Criteria
Reactors	Number of Reactors	6 (one standby)
	Design Hydraulic Detention Time	6.84 hours
	Design Solids Retention Time	14.3 days
Air includes mixing	Installed Blower Capacity	23,542 cfm/reactor
	Installed Fine Bubble Diffusers	15,694/ reactor @ 1.5 SCFM/diffuser
	Oxygen Transfer Efficiency	12%
Clarifier	Clarifier	12 existing (two standby)
	Clarifier Overflow Rate	Average: 466 gpd/ft^2, Peak: 673 gpd/ft^2
	Solids Flux Loading Rate	11.3 lbs/sq.ft./day
	Design MLSS	3500 mg/L
	Sludge Waste Production	51,031 lbs/day
Chemicals	Lime Dosage	76 mg/L
	Lime Solids	3878 lbs/day
	7.6% of Waste Activated Sludge	
Performance	Effluent	TN of 32mg/L: TKN=2 mg/L, NOx-N= 30 mg/L
Activated Sludge Plant No. 3	Average Daily Flow	115 MGD
C/N	Peak Dry Weather Flow	165 MGD
Reactors	Nitrification Capacity	32.5 Mgal
	Number of Reactors	6 (one standby)
	Design Hydraulic Detention Time	6.78 hours
	Design Solids Retention Time	14.3 days

TABLE 6-3-2A (CONTINUED)

Unit Process	Parameters	Criteria
Air includes mixing	Installed Blower Capacity	23,542 cfm/reactor
	Installed Fine Bubble Diffusers	15,694/ reactor @ 1.5 SCFM/diffuser
	Oxygen Transfer Efficiency	12%
Clarifier	Clarifier	12 (2 standby)
	Clarifier Overflow Rate	Average: 572 gpd/ft^2, Peak: 820 gpd/ft^2
	Solids Flux Loading Rate	17.8 lbs/sq.ft./day
	Design MLSS	3500 mg/L
	Sludge Waste Production	66,341 lbs/day
Chemicals	Quick Lime Dosage	76 mg/L
	Lime Solids	5042 lbs/day
	7.6% of Waste Activated Sludge	
Performance	Effluent	TN of 32mg/L: TKN=2 mg/L, NOx-N= 30 mg/L
Deep Bed DN Filters	Average Daily Flow	173 MGD
	Peak Dry Weather Flow	248 MGD
	Hydraulic Loading	Average: 2.14 gpm/ft^2, Peak: 3.07 gpm/ft^2
	Avg. Nitrates Loading	Average: 0.77 lbs/ft^2, Peak: 1.1 lbs/ft^2
Filters	Dimensions	48 - 11.7ft X 100 ft X 19 ft (LXWXH)
	Media Depth	10 ft.
	Media	Sand
Backwash	Backwash	6 gpm/ft^2, every 15 min and 5 min
	Air Backwash	5 cfm/ft^2, with backwash water for 15 min
	Bumping	29.74 bumps/backwash volume
Backwash Waste	Flow Rate to Primary	2,334 gpm
Chemicals	Methanol	90 mg/L
Performance		TKN= 2 mg/L, Nox-N= 1 mg/L, TSS=5 mg/L

TABLE 6-3-2B

BACK RIVER WASTEWATER TREATMENT PLANT

ALTERNATIVE 3-2: OPERATION AND MAINTENANCE ASSUMPTIONS

Unit Process	Assumptions
Activated Sludge Plant No. 1 (DN)	
Mixing Power	74.5 HP/ reactor. $0.045/HP-hr.
Methanol Feed	69 mg/L Density: 6.58 lbs/gal, $1.00/gal
Rearation	441 cfm/reactor, 30 cfm/1000 cu. ft.
Activated Sludge Plant No. 2 and No. 3 (C/N)	
Pumping to Plant No. 1	30-MGD @ 17 ft Head
	0.3132 HP/MGD/ft of Head, $0.06/KWh.
Aeration and mixing	lbs/day of O2 consumption = ((1.5 X lbs BOD influent) + (4.6 TKN influent) + (1.5 DO)) 1.5
	12% O2 transfer efficiency, 510 mg/L of O2
Lime Feed	106 mg/L Quick Lime, $50/ton
Deep Bed DN Filters	
Pumping to Filters	173 MGD @ 15 ft Head
	0.3132 HP/MGD/ft of Head, $0.06/KWh.
Back Wash Water and Bumping Power	70,200 gpd @ 10 psig
	Bumping 5500 gpm @ 10 psig per reactor
	0.3132 HP/MGD/ft of Head, $0.06/KWh.
Air Back Wash Blower Power	5,835 cfm of air @ 10 psig, 420 HP
	0.3132 HP/MGD/ft of Head, $0.06/KWh.
Mudwell Pump Power	3.3 MGD @ 65 ft Head
	0.3132 HP/MGD/ft of Head, $0.06/KWh.
Methanol Feed	90 mg/L, $1.00/gal

	PROCESS	CAPITAL ($M)	SALVAGE ($M)	ANNUAL COSTS ($M)				
				OPERATING			MAINT.	TOTAL
				LABOR	ENERGY	CHEMICAL		
1	Ex. Activated Sludge Plant No. 1 (DN)	4.89	6.96	0.14	0.08		0.46	0.68
2	Ex. Activated Sludge Plant No. 2 (C/N)	18.28	33.15	0.36	2.55		2.21	5.12
3	Ex. Activated Sludge Plant No. 3 (C/N)	23.77	43.10	0.47	3.33		2.87	6.67
4	Deep Bed DN Filters (Downflow)	62.74	18.82	0.17	0.09		1.27	1.53
5	Denitrification Pumping Stations (2)	59.85	17.96	0.04	0.42		0.96	1.42
6	Methanol Facilities (3)	3.09	0.93	0.09		8.45	0.06	8.60
7	Lime Facilities (2 Existing and 1 New)	0.86	0.50			1.64	0.03	1.67
8	WAS Treatment[1]				0.08	0.58		0.66
9	Disposal (Land Application)[2]							2.02
10								
11								
12								
13								
14								
15								
16								
17								
18								
19								
20								
21								
22								
	TOTALS	T1= 173.48	T2= 121.42	1.27	6.55	10.67	7.86	T3= 28.37

$M - Millions of Dollars

[1] Based on thickening, pumping, digestion, and dewatering of waste activated sludge (WAS). WAS produced is estimated to be 94.5 dry tons/day (DTPD).
BRWWTP Operations Report for 2001: 80% volatile solids in feed and 80% volatile solids destruction from ESDs.

[2] Sludge cake for disposal is 34.0 DTPD.

PRESENT WORTH COST DETERMINATION

1. PRESENT WORTH FACTORS
   F1 = SINGLE PAYMENT, 20 YEARS = 0.25842
   F2 = UNIFORM SERIES, 20 YEARS = 10.59401

2. PRESENT WORTH BASIS
   A. CAPITAL COST: (T1) $173.48
   B. SALVAGE COST: (-) (F1 X T2) -$31.38
   C. ANNUAL O&M COST: (F2 X T3) $300.55

TOTAL PRESENT WORTH = $442.65

NOTES:
ENR INDEX = 6300
DN = Denitrification
C/N = Carbonaceous / Nitrification

COMPREHENSIVE WASTEWATER FACILITIES MASTER PLAN

BACK RIVER WASTEWATER TREATMENT PLANT

SUMMARY OF ESTIMATED COSTS ALTERNATIVE 3-2

WHITMAN, REQUARDT AND ASSOCIATES, LLP	SEPTEMBER 2002	TABLE 6-3-2C

6.7.11. Alternative 3-3 (Level 3): Carbon Oxidation/Nitrification Suspended Growth Plus Deep Bed Denitrification (Upflow)

Process Description

The secondary treatment for this alternative is the same as Alternative 3-2. The advanced treatment will consist of upflow deep bed denitrification filters, instead of downflow deep bed denitrification filters, followed by sand filtration, and chlorination/dechlorination. This alternative would produce discharge to Back River and ISG (previously Bethlehem Steel) with TN of 3 to 6 mg/l, annually. The conceptual diagram is shown in Figure 6-3-3A. The site plan and process schematic are similar to Figures 6-3-2B and 6-3-2C, respectively. In the site plan and procees schematics the upflow filters will take the place of downflow filters

Design Assumptions

The treatment process is same as Alternative 3-2, but downflow deep bed denitrification filters is replaced with upflow deep bed denitrification filters. Upflow deep bed denitrification filters are designed to treat peak flow of 248 mgd of nitrified effluent to nitrate-nitrogen levels of less than 1 mg/l. These 14 filters are filled 9.5 feet deep with biolite and occupy 1881 ft^2 of surface area per filter. Average design hydraulic loading is 5.7 gpm/ ft^2 and nitrate-nitrogen loading 1.4 lbs/ft^2-day. Approximately 799 gpm of backwash water from each filter flows to the primaries.

Sludge production to thickening facility, 189,000 lbs/day, from chemicals (lime and methanol) and biomass is same as Alternative 3-2. A breakdown of solids production from each plant is located in the design assumptions.

Design assumptions for the carbon oxidation/nitrification suspended growth system and upflow deep bed denitrification filters are shown in Table 6-3-3A.

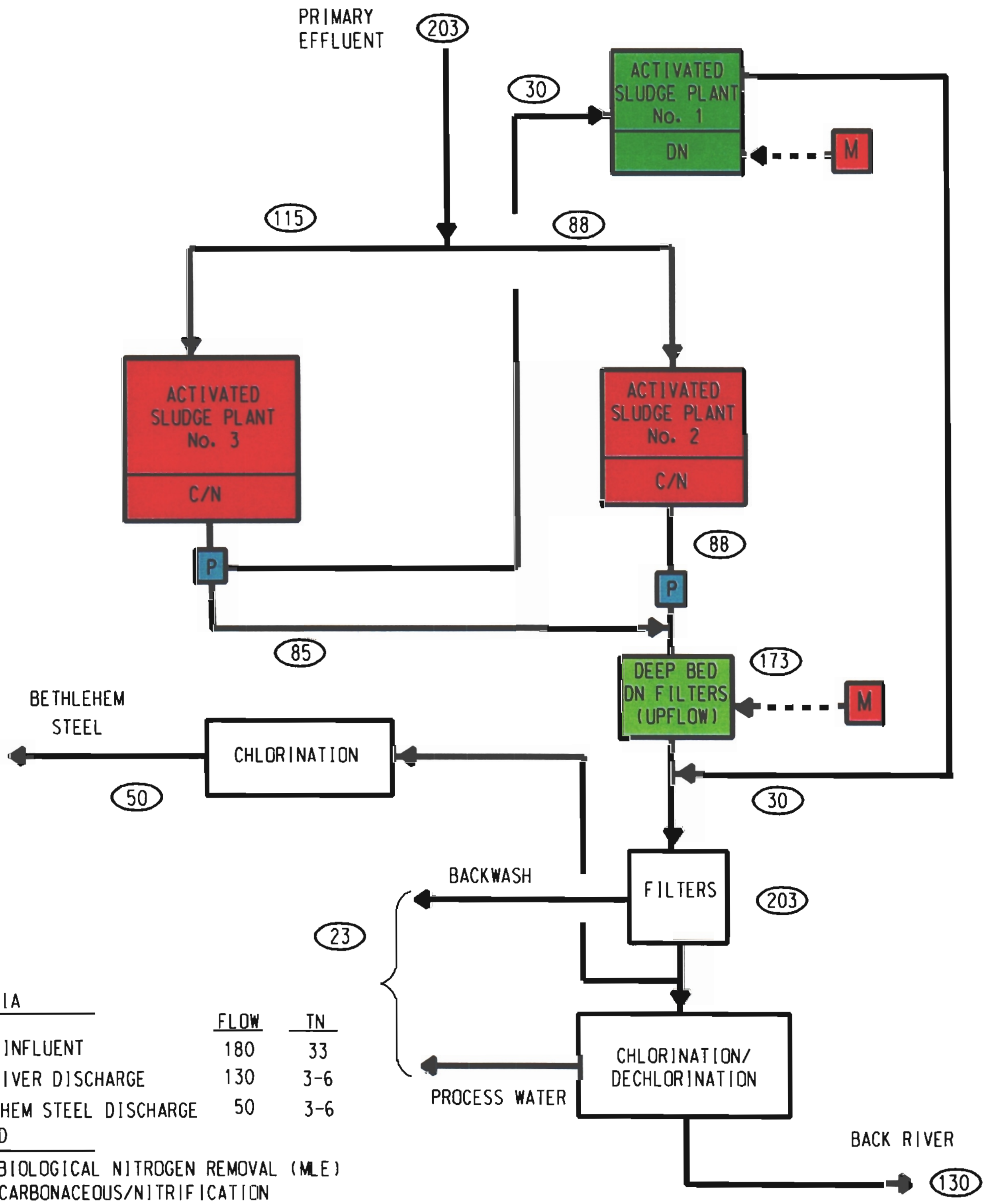
Operation and Maintenance Assumptions

Labor and maintenance costs are based on both existing and new equipment operating at average flow of 203 mgd. Chemical and energy (aeration, mixing and pumping) costs are established on a continuous operation at an average flow of 30 mgd to Plant No. 1, 88 mgd to Plant No. 2, 115 mgd to Plant No.3 and 173 mgd to upflow deep bed denitrification filters. Methanol dosage is based on same methanol to nitrate-nitrogen removal ratio as Alternative 1-1. Cost of quick lime id based on supplier's estimate at the time of writing.

A summary of assumptions and references used in developing operation and maintenance costs are presented Table 6-3-3B.

Cost Estimates

A breakdown of capital, salvage, and operation and maintenance costs is shown Table 6-3-3C.



CRITERIA

	FLOW	TN
PLANT INFLUENT	180	33
BACK RIVER DISCHARGE	130	3-6
BETHLEHEM STEEL DISCHARGE	50	3-6

LEGEND

- BNR BIOLOGICAL NITROGEN REMOVAL (MLE)
- C/N CARBONACEOUS/NITRIFICATION
- DN DENITRIFICATION
- FB FLUIDIZED BED
- M METHANOL
- P PUMPING STATION
- TN TOTAL NITROGEN
- (oval) FLOW, MGD

NOTE

PLANT FLOW=180 MGD, WITH RECYCLES=203 MGD

COMPREHENSIVE WASTEWATER FACILITIES MASTER PLAN

BACK RIVER WASTEWATER TREATMENT PLANT

CONCEPTUAL DIAGRAM ALTERNATIVE 3-3

WHITMAN, REQUARDT AND ASSOCIATES, LLP	DATE: APRIL 2004	SCALE: NONE	FIGURE: 6-3-3A

TABLE 6-3-3A

BACK RIVER WASTEWATER TREATMENT PLANT

ALTERNATIVE 3-3: DESIGN ASSUMPTIONS

Unit Process	Parameters	Criteria
Activated Sludge Plant No. 1	Average Daily Flow	30 MGD
DN	Peak Dry Weather Flow	44 MGD
Reactors	Number of Reactors	4 (two standby)
	Design Hydraulic Detention Time	4.3 hours
	Design Solids Retention Time	20 days
Air includes mixing	Installed Blower Capacity for Reareation	441 SCFM
	Installed Mixing Capacity for Anoxic Zone	74.5 HP mixing (.36 hp/1000 cu.ft)
Clarifiers	Clarifiers	All four existing under SC 709
	Clarifier Overflow Rate	Average: 394 gpd/ft^2, Peak: 577 gpd/ft^2
	Solids Flux Loading Rate	11.5 lbs/sq. ft./day
	Design MLSS	3500 mg/L
	Sludge Waste Production	7852 lbs/day
Chemical	Methanol Dosage	90 mg/L, 3400 gpd
	Sludge Production from Methanol Addition	8106 lbs/day
	(0.18 VSS produced/COD removed)	
	(75% TSS is VSS)	
Performance	Effluent	TN of 3mg/L: TKN=2 mg/L, NOx-N= 1 mg/L
Activated Sludge Plant No. 2	Average Daily Flow	88 MGD
C/N	Peak Dry Weather Flow	127 MGD
Reactors	Number of Reactors	6 (one standby)
	Design Hydraulic Detention Time	6.84 hours

TABLE 6-3-3A (CONTINUED)

Unit Process	Parameters	Criteria
	Design Solids Retention Time	14.3 days
Air includes mixing	Installed Blower Capacity	23,542 cfm/reactor
	Installed Fine Bubble Diffusers	15,694/ reactor @ 1.5 SCFM/diffuser
	Oxygen Transfer Efficiency	12%
Clarifier	Clarifier	12 existing (two standby)
	Clarifier Overflow Rate	Average: 466 gpd/ft^2, Peak: 673 gpd/ft^2
	Solids Flux Loading Rate	11.3 lbs/sq.ft./day
	Design MLSS	3500 mg/L
	Sludge Waste Production	51,031 lbs/day
Chemical	Lime Dosage	76 mg/L
	Lime Solids	3878 lbs/day
	7.6% of Waste Activated Sludge	
Performance	Effluent	TN of 32mg/L: TKN=2 mg/L, NOx-N= 30 mg/L
Activated Sludge Plant No. 3	Average Daily Flow	115 MGD
C/N	Peak Dry Weather Flow	165 MGD
Reactors	Nitrification Capacity	32.5 Mgal
	Number of Reactors	6 (one standby)
	Design Hydraulic Detention Time	6.78 hours
	Design Solids Retention Time	14.3 days
Air includes mixing	Installed Blower Capacity	23,542 cfm/reactor
	Installed Fine Bubble Diffusers	15,694/ reactor @ 1.5 SCFM/diffuser

TABLE 6-3-3A (CONTINUED)

Unit Process	Parameters	Criteria
	Oxygen Transfer Efficiency	12%
Clarifier	Clarifier	12 (2 standby)
	Clarifier Overflow Rate	Average: 572 gpd/ft^2, Peak: 820 gpd/ft^2
	Solids Flux Loading Rate	17.8 lbs/sq.ft./day
	Design MLSS	3500 mg/L
	Sludge Waste Production	66,341 lbs/day
Chemical	Quick Lime Dosage	76 mg/L
	Lime Solids	5042 lbs/day
	7.6% of Waste Activated Sludge	
Performance	Effluent	TN of 32mg/L: TKN=2 mg/L, NOx-N= 30 mg/L
Upflow Deep Bed DN Filters	Average Daily Flow	173 MGD
	Peak Dry Weather Flow	248 MGD
	Hydraulic Loading	Average: 5.7 gpm/ft^2 , Peak: 7.4 gpm/ft^2
	Nitrates Loading	Average: 1.5 lbs/ft^2-day Peak: 1.9 lbs/ft2-day
Filters	Dimensions (Peak Flow)	14 - 40.2 ft X 46.8 ft X 19 ft (LXWXH) (1-standby)
	Media Depth	9.5 ft.
	Media	Biolite, clay
Backwash	Backwash	12.2 gpm/ft^2, 50 min/day
	Air Backwash	4.8 cfm/ft^2, with backwash water for 50 min/day
Backwash Waste	Flow Rate to Primary	799 gpm for one filter
Chemicals	Methanol	90 mg/L
Performance		TKN= 2 mg/L, NOx-N= 1 mg/L, TSS=5 mg/L

TABLE 6-3-3B

BACK RIVER WASTEWATER TREATMENT PLANT

ALTERNATIVE 3-3: OPERATION AND MAINTENANCE ASSUMPTIONS

Unit Process	Assumptions
Activated Sludge Plant No. 1 (DN)	
Mixing Power	74.5 HP/ reactor. $0.045/HP-hr.
Methanol Feed	69 mg/L Density: 6.58 lbs/gal, $1.00/gal
Rearation	441 cfm/reactor, 30 cfm/1000 cu. ft.
Activated Sludge Plant No. 2 and No. 3 (C/N)	
Pumping to Plant #1	30-MGD @ 17 ft Head
	0.3132/HP/MGD/ft of Head, $0.06/KWh.
Aeration and Mixing	lbs/day of O_2 consumption = ((1.5 X lbs BOD influent) + (4.6 TKN influent) + (1.5 DO)) 1.5
	12% O_2 transfer efficiency, 510 mg/L of O2
Lime Feed	106 mg/L Quick Lime, $50/ton
Upflow Deep Bed Filters	
Pumping to Filters	173 MGD @ 50 ft Head
	0.3132 HP/MGD/ft of Head, $0.06/KWh.
Back Wash Water Pumping Power	3-11,280 gpm @ 50 ft Head (one standby)
	0.3132 HP/MGD/ft of Head, $0.06/KWh.
Air Back Wash Blower Power	5131 cfm of air @ 10.4 psig,
	0.3132 HP/MGD/ft of Head, $0.06/KWh.
Mudwell Pump Power	800 gpm @ 65 ft
	0.3132 HP/MGD/ft of Head, $0.06/KWh.
Methanol Feed	90 mg/L, $1.00/gal

	PROCESS	CAPITAL ($M)	SALVAGE ($M)	ANNUAL COSTS ($M)				
				OPERATING			MAINT.	TOTAL
				LABOR	ENERGY	CHEMICAL		
1	Ex. Activated Sludge Plant No. 1 (DN)	4.89	6.96	0.14	0.08		0.46	0.68
2	Ex. Activated Sludge Plant No. 2 (C/N)	18.28	33.15	0.36	2.55		2.21	5.12
3	Ex. Activated Sludge Plant No. 3 (C/N)	23.77	43.10	0.47	3.33		2.87	6.67
4	Deep Bed DN Filters (Upflow)	49.41	14.82	0.25	0.18		0.99	1.42
5	Denitrification Pumping Stations (2)	59.85	17.96	0.04	1.12		0.96	2.12
6	Methanol Facilities (3)	3.09	0.93	0.09		8.45	0.06	8.60
7	Lime Facilities (1 Existing and 1 New)	0.86	0.50			1.64	0.03	1.67
8	WAS Treatment[1]				0.08	0.58		0.66
9	Disposal (Land Application)[2]							2.02
10								
11								
12								
13								
14								
15								
16								
17								
18								
19								
20								
21								
22								
	TOTALS	T1= 160.15	T2= 117.42	1.35	7.34	10.67	7.58	T3= 28.96

$M - Millions of Dollars

[1] Based on thickening, pumping, digestion, and dewatering of waste activated sludge (WAS). WAS produced is estimated to be 94.5 dry tons/day (DTPD).
BRWWTP Operations Report for 2001: 80% volatile solids in feed and 80% volatile solids destruction from ESDs.

[2] Sludge cake for disposal is 34.0 DTPD.

PRESENT WORTH COST DETERMINATION

1. PRESENT WORTH FACTORS
F1 = SINGLE PAYMENT, 20 YEARS, 7% = 0.25842
F2 = UNIFORM SERIES, 20 YEARS, 7% = 10.59401

2. PRESENT WORTH BASIS
A. CAPITAL COST: (T1) $160.15
B. SALVAGE COST: (-) (F1 X T2) -$30.34
C. ANNUAL O&M COST: (F2 X T3) $306.80

TOTAL PRESENT WORTH = $436.61

NOTES:
ENR INDEX = 6300
DN = Denitrification
C/N = Carbonaceous / Nitrification

COMPREHENSIVE WASTEWATER FACILITIES
MASTER PLAN

BACK RIVER
WASTEWATER TREATMENT PLANT

SUMMARY OF ESTIMATED COSTS
ALTERNATIVE 3-3

WHITMAN, REQUARDT AND ASSOCIATES, LLP | SEPTEMBER 2002 | TABLE 6-3-3C

6.7.12. Alternative 3-4 (Level 3): Carbon Oxidation/Nitrification Suspended grpwth Plus Fluidized Bed Denitrification Reactor

Process Description

The design concept is similar to Alternative 3-2, where the activated sludge plants are converted to separate stages of carbon oxidation/nitrification and denitrification. The advance treatment consists of fluidized bed denitrification reactors, instead of downflow deep bed denitrification filters, followed by sand filters, and chlorination/dechlorination. This alternative will produce discharge to Back River and ISG (previously Bethlehem Steel) with TN of 3 to 6 mg/l, annually.

The conceptual diagram is shown in Figure 6-3-4A. Figure 6-3-4B presents the site plan. The process schematic is shown in Figure 6-3-4C.

Design Assumptions

The treatment process is similar to Alternative 3-2, but downflow deep bed denitrification filters were replaced with fluidized bed denitrification reactors.

Fluidized bed denitrification reactors are designed to treat peak 248 mgd of nitrified effluent to nitrate-nitrogen levels of less than 1 mg/l. Each filter occupies 1881 ft^2 of surface area with 20 feet side water depth. Average design hydraulic loading is 16.5 gpm/ft^2 and nitrate-nitrogen loading 4.16 lbs/ft^2-day.

These 20 reactors, filled with 7 feet deep of sand, are fluidize to 14 feet depth. The growth control mechanism maintains the fluidized depth and recycles some of the biomass back to the reactors. The biomass that is not recycled (wasted biomass) is sent to the solids handling facility.

Sludge production to thickening facility, 189,000 lbs/day, from chemicals (lime and methanol) and biomass is same as Alternative 3-2. A breakdown of solids production from each plant is located in the design assumptions, Table 6-3-4A.

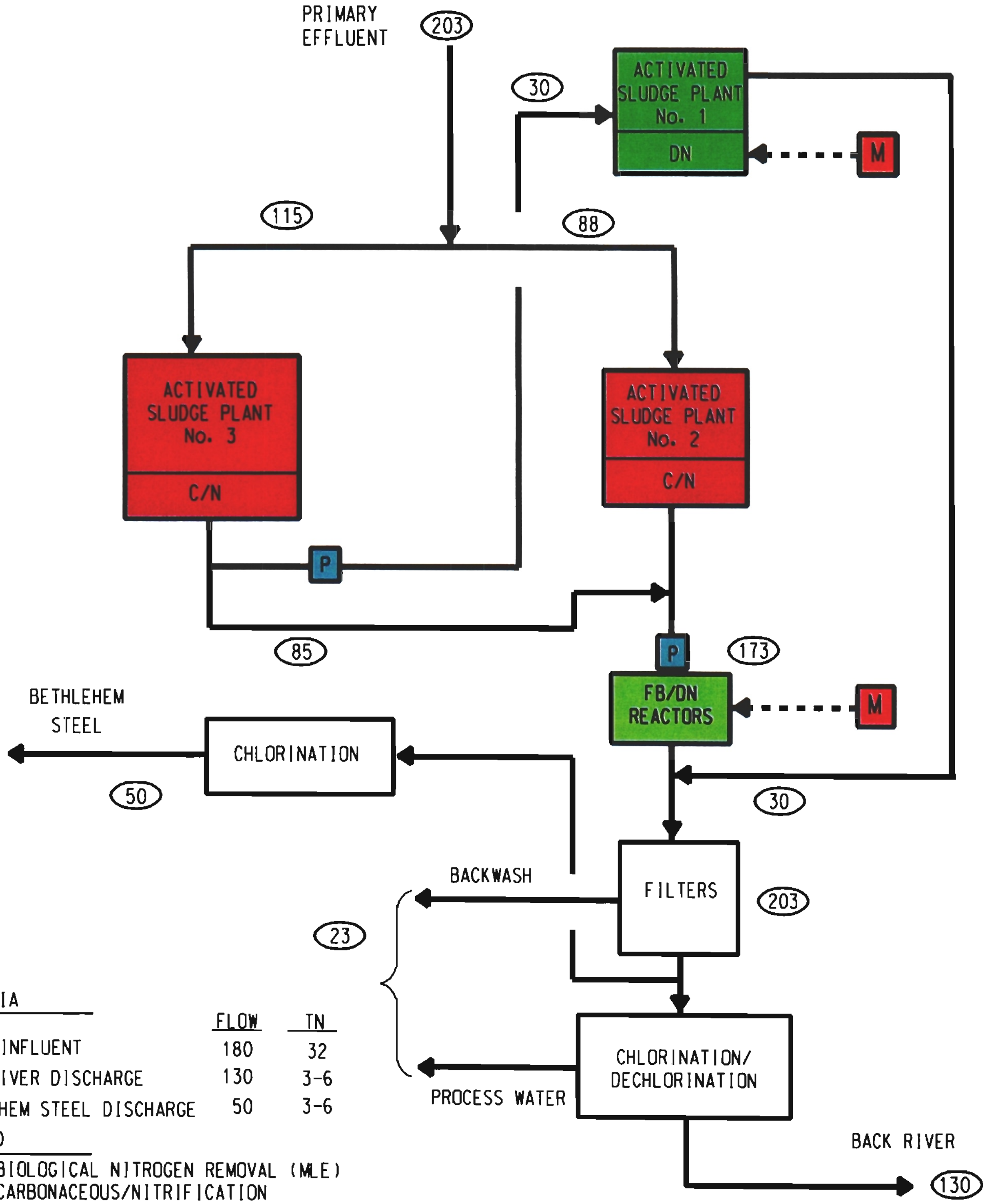
Operation and Maintenance Assumptions

Labor and maintenance costs are based on both existing and new equipment operating at average flow of 203 mgd. Chemical and energy (aeration, mixing, and pumping) costs are established on a continuous operation at an average flow of 30 mgd to Plant No.1, 88 mgd to Plant No. 2, 115 mgd to Plant No.3 and 173 mgd to fluidized bed denitrification reactors. Methanol dosage is based on same methanol to nitrate-nitrogen removal ratio as Alternative 1-1. Cost of quick lime is based on supplier's estimate at the time of writing.

A summary of assumptions and references used in developing operation and maintenance costs are presented Table 6-3-4B.

Cost Estimates

A breakdown of capital, salvage, and operation and maintenance costs for this alternative is shown in Table 6-3-4C.



CRITERIA

	FLOW	TN
PLANT INFLUENT	180	32
BACK RIVER DISCHARGE	130	3-6
BETHLEHEM STEEL DISCHARGE	50	3-6

LEGEND

BNR BIOLOGICAL NITROGEN REMOVAL (MLE)
C/N CARBONACEOUS/NITRIFICATION
DN DENITRIFICATION
FB FLUIDIZED BED
M METHANOL
P PUMPING STATION
TN TOTAL NITROGEN
(oval) FLOW, MGD

NOTE

PLANT FLOW=180 MGD, WITH RECYCLES=203 MGD

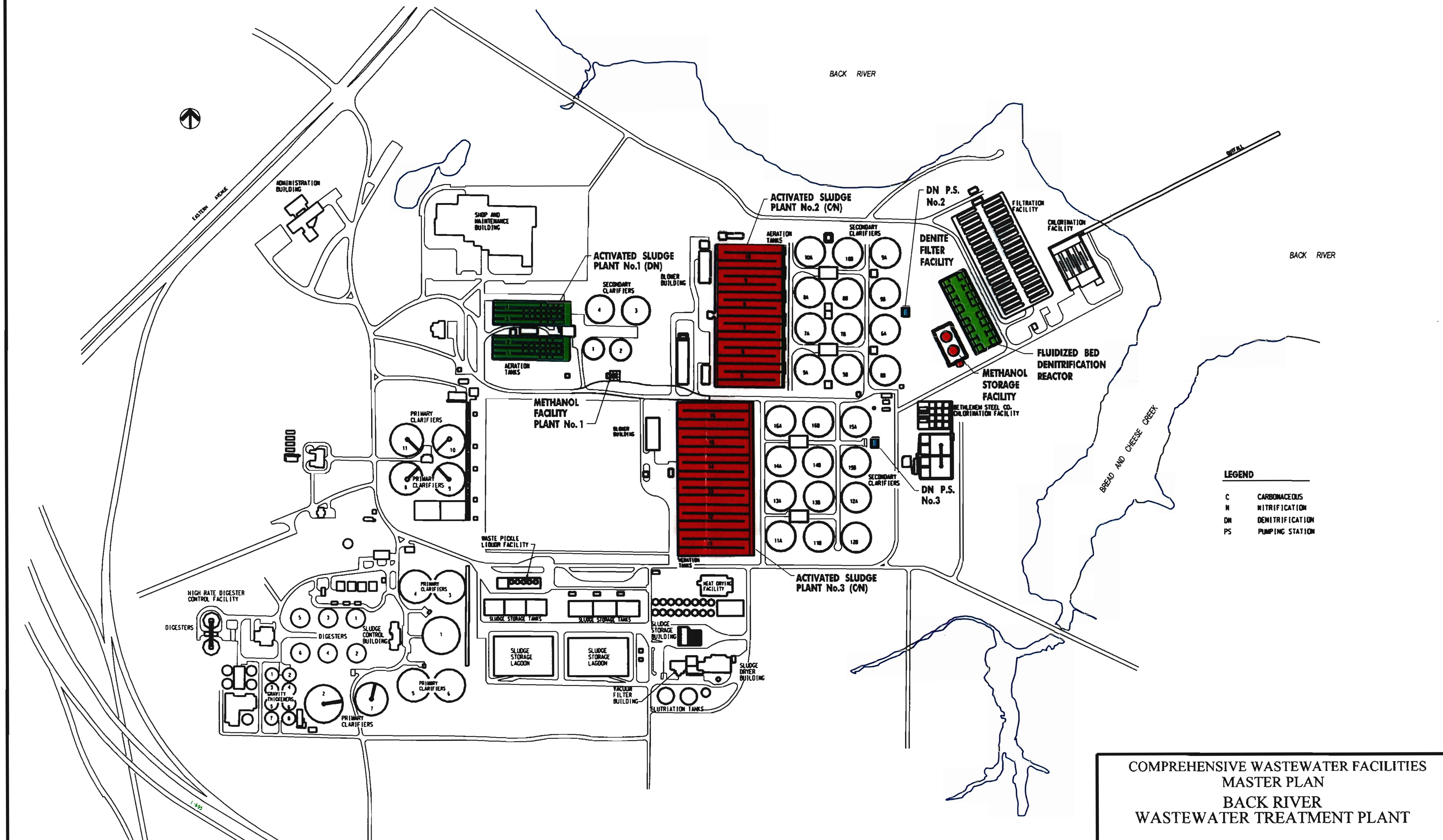
COMPREHENSIVE WASTEWATER FACILITIES MASTER PLAN

BACK RIVER WASTEWATER TREATMENT PLANT

CONCEPTUAL DIAGRAM ALTERNATIVE 3-4

WHITMAN, REQUARDT AND ASSOCIATES, LLP

DATE: APRIL 2004 | SCALE: NONE | FIGURE: 6-3-4A



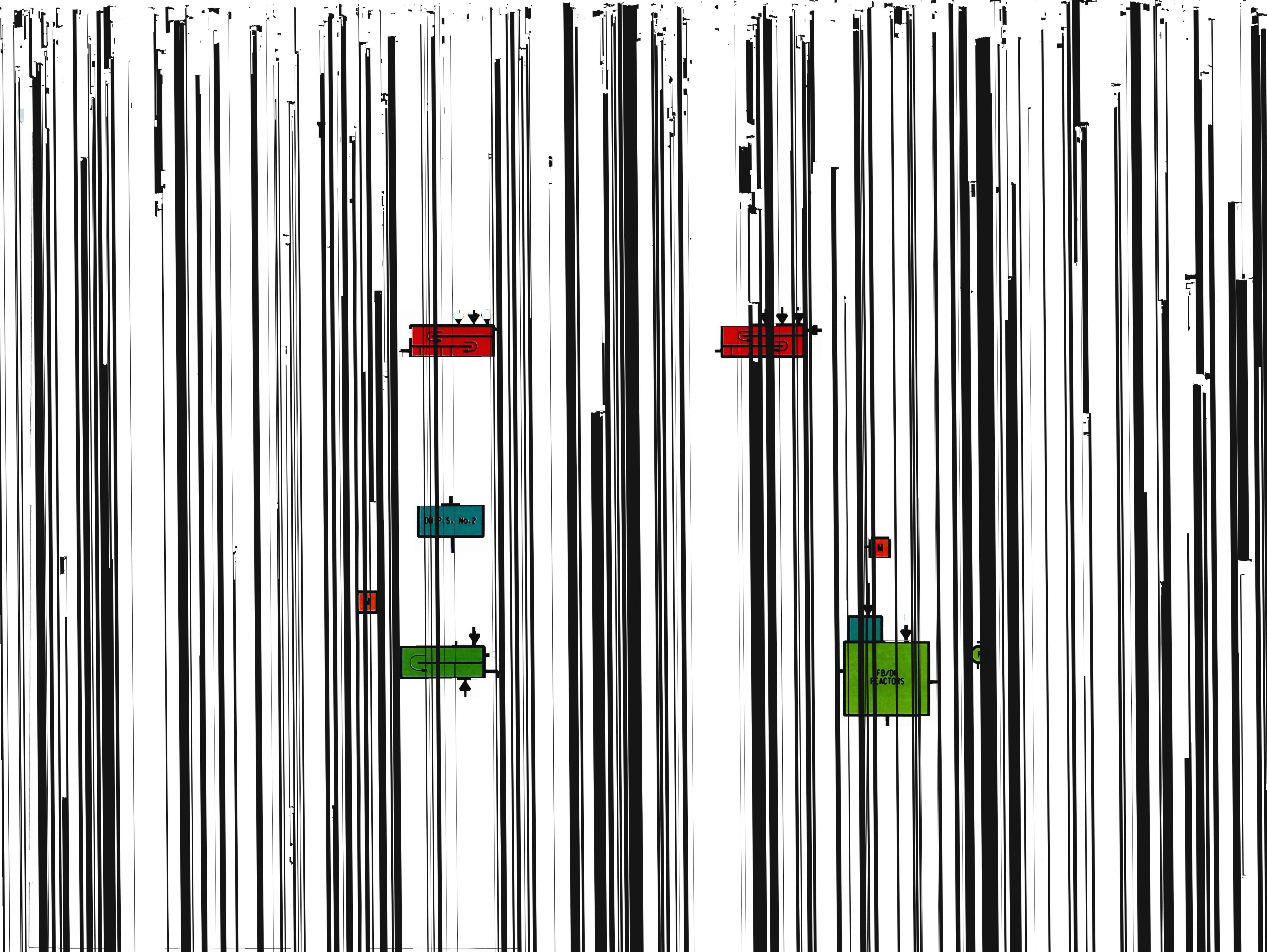
COMPREHENSIVE WASTEWATER FACILITIES MASTER PLAN

BACK RIVER WASTEWATER TREATMENT PLANT

SITE PLAN ALTERNATIVE 3-4

DATE: APRIL 2004	SCALE: 1"= 500'	FIGURE: 6-3-4B

WHITMAN, REQUARDT AND ASSOCIATES, LLP



C
N
DN
PS
M
BOD
TKN
TN
TP
WAS
RAS

EXCEEDS

ATER FACILITIES
AN
ER
MENT PLANT

HEMATIC
IVE 3-4

ONE

FIGURE: 6-3-4C

TABLE 6-3-4A

BACK RIVER WASTEWATER TREATMENT PLANT

ALTERNATIVE 3-4: DESIGN ASSUMPTIONS

Unit Process	Parameters	Criteria
Activated Sludge Plant No. 1	Average Daily Flow	30 MGD
DN	Peak Dry Weather Flow	44 MGD
Reactors	Number of Reactors	4 (two standby)
	Design Hydraulic Detention Time	4.3 hours
	Design Solids Retention Time	20 days
Air includes mixing	Installed Blower Capacity for Reareation	441 SCFM
	Installed Mixing Capacity for Anoxic Zone	74.5 HP mixing (.36 hp/1000 cu.ft)
Clarifiers	Clarifiers	All four existing under SC 709
	Clarifier Overflow Rate	Average: 394 gpd/ft^2, Peak: 577 gpd/ft^2
	Solids Flux Loading Rate	11.5 lbs/sq. ft./day
	Design MLSS	3500 mg/L
	Sludge Waste Production	7852 lbs/day
Chemical	Methanol Dosage	90 mg/L
	Sludge Production from Methanol Addition	8106 lbs/day
	(0.18 VSS produced/COD removed)	
	(75% TSS is VSS)	
Performance	Effluent	TN of 3mg/L: TKN=2 mg/L, NOx-N= 1 mg/L
Activated Sludge Plant No. 2	Average Daily Flow	88 MGD
C/N	Peak Dry Weather Flow	127 MGD
Reactors	Number of Reactors	6 (one standby)

TABLE 6-3-4A (CONTINUED)

Unit Process	Parameters	Criteria
	Design Hydraulic Detention Time	6.84 hours
	Design Solids Retention Time	14.3 days
Air includes mixing	Installed Blower Capacity	23,542 cfm/reactor
	Installed Fine Bubble Diffusers	15,694/ reactor @ 1.5 SCFM/diffuser
	Oxygen Transfer Efficiency	12%
Clarifier	Clarifier	12 existing (two standby)
	Clarifier Overflow Rate	Average: 466 gpd/ft^2, Peak: 673 gpd/ft^2
	Solids Flux Loading Rate	11.3 lbs/sq.ft./day
	Design MLSS	3500 mg/L
	Sludge Waste Production	51,031 lbs/day
Chemical	Lime Dosage	76 mg/L
	Lime Solids	3878 lbs/day
	7.6% of Waste Activated Sludge	
Performance	Effluent	TN of 32mg/L: TKN=2 mg/L, NOx-N= 30 mg/L
Activated Sludge Plant No. 3	Average Daily Flow	115 MGD
C/N	Peak Dry Weather Flow	165 MGD
Reactors	Nitrification Capacity	32.5 Mgal
	Number of Reactors	6 (one standby)
	Design Hydraulic Detention Time	6.78 hours
	Design Solids Retention Time	14.3 days
Air includes mixing	Installed Blower Capacity	23,542 cfm/reactor

TABLE 6-3-4A (CONTINUED)

Unit Process	Parameters	Criteria
	Installed Fine Bubble Diffusers	15,694/ reactor @ 1.5 SCFM/diffuser
	Oxygen Transfer Efficiency	12%
Clarifier	Clarifier	12 (2 standby)
	Clarifier Overflow Rate	Average: 572 gpd/ft^2, Peak: 820 gpd/ft^2
	Solids Flux Loading Rate	17.8 lbs/sq.ft./day
	Design MLSS	3500 mg/L
	Sludge Waste Production	66,341 lbs/day
Chemical	Quick Lime Dosage	76 mg/L
	Lime Solids	5042 lbs/day
	7.6% of Waste Activated Sludge	
Performance	Effluent	TN of 32mg/L: TKN=2 mg/L, NOx-N= 30 mg/L
FB/DN Reactors	Average Daily Flow	173 MGD
	Peak Dry Weather Flow	248 MGD
	Hydraulic Loading	Average: 11.6 gpm/ft^2,Peak: 12 gpm/ft^2
	Avg. Nitrates Loading	Average: 4.16 lbs/ft^2, Peak: 4.3 lbs/ft^2
	Fluidization Rate	16.5 gpm/ft^2
Filters	Dimensions (Peak Flow)	20 - 20 ft X 40 ft X 20 ft (SWD) (2 standby)
	Media Depth (settled)	7 ft
	Fluidized Depth	14 ft
	Media	Sand
Waste biomass	Flow Rate to Thickener Facility	1300 gpm, MLSS=2000 mg/L
Chemicals	Methanol	90 mg/L
Performance		TKN= 2 mg/L, NOx-N= 1mg/L, TSS=10-20 mg/L

TABLE 6-3-4B

BACK RIVER WASTEWATER TREATMENT PLANT

ALTERNATIVE 3-4: OPERATION AND MAINTENANCE ASSUMPTIONS

Unit Process	Assumptions
Activated Sludge Plant No. 1 (DN)	
Mixing Power	74.5 HP/ reactor. $0.045/HP-hr.
Methanol Feed	69 mg/L Density: 6.58 lbs/gal, $1.00/gal
Rearation	441 cfm/reactor, 30 cfm/1000 cu. ft.

Activated Sludge Plant No. 2 and No. 3 (C/N)	
Pumping to Plant #1	30-MGD @ 17 ft Head
	0.3132 HP/MGD/ft of Head, $0.06/KWh.
Aeration and Mixing	lbs/day of O2 consumption = ((1.5 X lbs BOD influent) + (4.6 TKN influent) + (1.5 DO)) 1.5
	12% O2 transfer efficiency
	510 mg/L of O2
Lime Feed	106 mg/L Quick Lime, $50/ton
FB/DN Reactor	
Fluidized Pumping Power	13,194 gpm @ 50 ft Head per reactor
	0.3132 HP/MGD/ft of Head, $0.06/KWh.
Growth Control Pump Power	2 - 3 HP, $0.045/HP-hr per reactor
Mudwell Pump Power	1300 gpm @ 65 ft
	0.3132 HP/MGD/ft of Head, $0.06/KWh.
Methanol Feed	90 mg/L, $1.00/gal

	PROCESS	CAPITAL ($M)	SALVAGE ($M)	ANNUAL COSTS ($M)				
				OPERATING			MAINT.	TOTAL
				LABOR	ENERGY	CHEMICAL		
1	Ex. Activated Sludge Plant No. 1 (DN)	4.89	6.96	0.14	0.08		0.46	0.68
2	Ex. Activated Sludge Plant No. 2 (C/N)	18.28	33.15	0.36	2.55		2.21	5.12
3	Ex. Activated Sludge Plant No. 3 (C/N)	23.77	43.10	0.47	3.33		2.87	6.67
4	Fluidized Bed DN Reactors	73.50	22.05	0.17	1.55		1.47	3.19
5	Denitrification Pumping Stations (2)	59.85	17.96	0.04	0.06		0.96	1.06
6	Methanol Facilities (2)	3.09	0.93	0.09		8.45	0.06	8.60
7	Lime Facilities (1 Existing and 1 New)	0.86	0.50			1.64	0.03	1.67
8	Existing Filters				0.01			0.01
9	WAS Treatment[1]				0.08	0.58		0.66
10	Disposal (Land Application)[2]							2.02
11								
12								
13								
14								
15								
16								
17								
18								
19								
20								
21								
22								
	TOTALS	T1= 184.24	T2= 124.65	1.27	7.66	10.67	8.06	T3= 29.68

$M - Millions of Dollars

[1] Based on thickening, pumping, digestion, and dewatering waste activated sludge (WAS). WAS produced is estimated to be 94.5 dry tons/day (DTPD).
BRWWTP Operations Report for 2001: 80% volatile solids in feed and 80% volatile solids destruction from ESDs.

[2] Sludge cake for disposal is 34.0 DTPD.

PRESENT WORTH COST DETERMINATION

1. PRESENT WORTH FACTORS
   - F1 = SINGLE PAYMENT, 20 YEARS, 7% = 0.25842
   - F2 = UNIFORM SERIES, 20 YEARS, 7% = 10.59401

2. PRESENT WORTH BASIS
   - A. CAPITAL COST: (T1) $184.24
   - B. SALVAGE COST: (-) (F1 X T2) -$32.21
   - C. ANNUAL O&M COST: (F2 X T3) $314.43

TOTAL PRESENT WORTH = $466.46

NOTES:
ENR INDEX = 6300
DN = Denitrification
C/N = Carbonaceous / Nitrification

COMPREHENSIVE WASTEWATER FACILITIES
MASTER PLAN

BACK RIVER
WASTEWATER TREATMENT PLANT

SUMMARY OF ESTIMATED COSTS
ALTERNATIVE 3-4

WHITMAN, REQUARDT AND ASSOCIATES, LLP | SEPTEMBER 2002 | TABLE 6-3-4C

6.7.13. Alternative 3-5 (Level 3): Carbon Oxidation/Nitrification Suspended Growth and Deep Bed Denitrification (Upflow) Plus Sidestream BNR Treatment

Process Description

When comparing Alternative 3-2, 3-3, and 3-4, Alternative 3-3 with upflow deep bed denitrification filters is the most cost effective. Hence, to evaluate sidestream BNR treatment, upflow deep bed denitrification was incorporated. Based on TKN treatment capacity, Plant No. 1 can treat a sidestream consisting of 5 mgd of centrate recycle from City Dewatering and Heat Drying Facility plus 10 mgd of primary effluent. Influent wastewater constituents to Plant No. 1 are shown in Alternative 1-2. Plant No.1 will treat the sidestream to TN levels of 8 mg/l with methanol addition. The flow discharged to ISG (previously Bethlehem Steel) and Back River is treated to TN of 3 to 6 mg/l, annually. The conceptual diagram and the process schematic are presented in Figure 6-3-5A and Figure 6-3-5B, respectively.

Design Assumptions

Primary effluent gravity flows to influent splitter box for distribution of 88 mgd and 115 mgd to Plant Nos. 2 and 3. From existing Plant No. 1, 10 mgd of the primary along with 5 mgd of centrate is treated and then blended with primary effluent to enter Plant Nos. 2 and 3. Plant Nos. 2 and 3 are converted to a nitrification process. Six new lime silos and slakers are installed for Plant No. 2 and the slakers for Plant No. 3 are upgraded. The nitrified effluent is pumped to the upflow deep bed denitrification filters. One methanol facility is installed for upflow deep bed denitrification filters similar to Alternative 1-1. The detention time for complete nitrification is 6.8 hours for Plant Nos. 2 and 3. Detention time for sidestream BNR treatment is 17 hours.

Upflow deep bed denitrification filters are designed to treat peak flow of 292 mgd to nitrate-nitrogen of less than 1 mg/l. These 16 filters are filled 9.5 feet deep with biolite and occupy 1881 ft^2 of surface area per filter. Average design hydraulic loading is 5.8 gpm/ft^2 and nitrate-nitrogen loading 1.8 lbs/ft^2-day. Approximately, 799 gpm of backwash water from each filter is expected to flow to the primaries.

The total solids to thickening facility (193,000 lbs/day) include chemical (methanol) and biological wasted solids. A breakdown of solids production from each plant is located in the design assumptions, Table 6-3-5A.

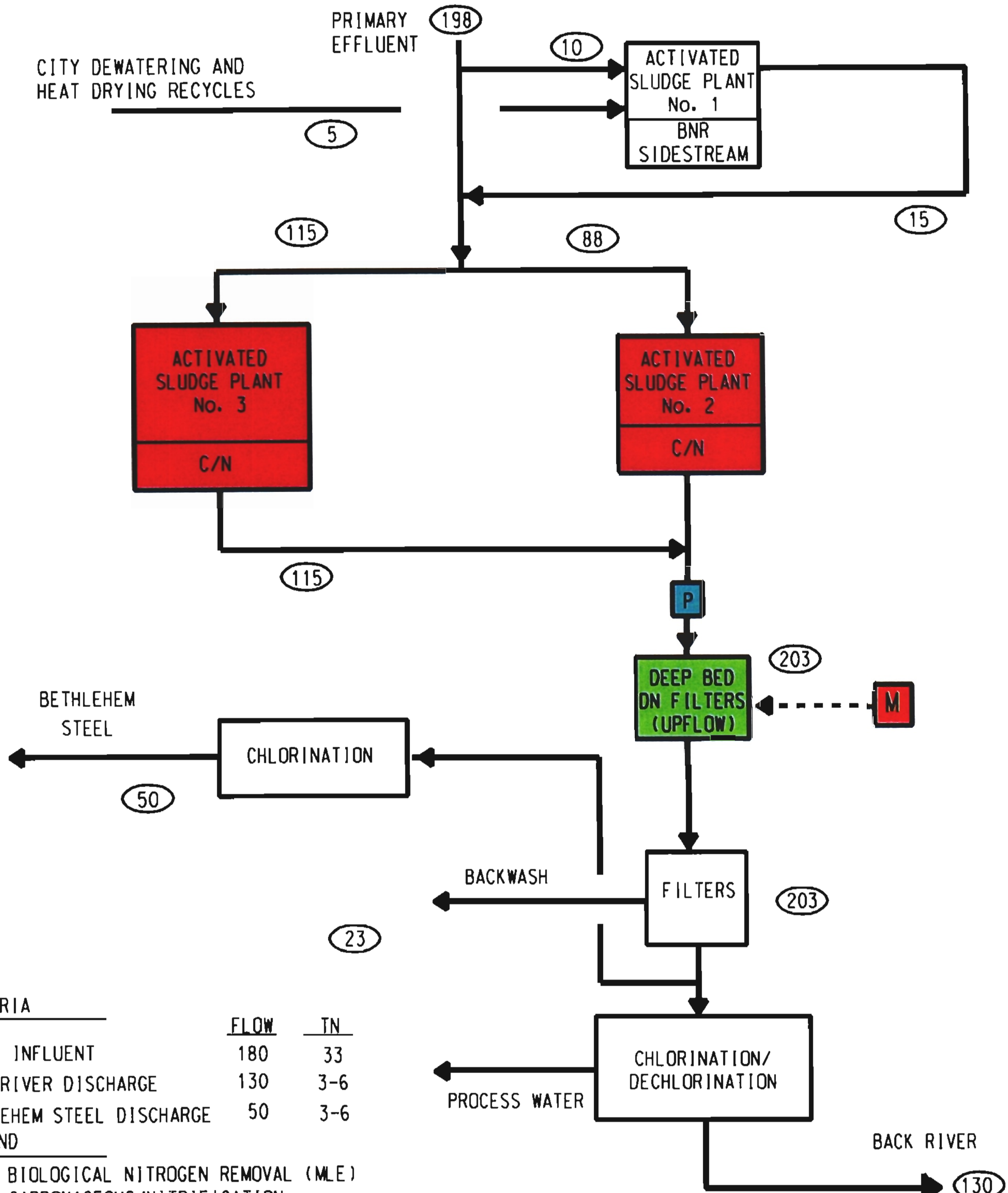
Operation and Maintenance Assumptions

Labor and maintenance costs are based on both existing and new equipment operating at average flow of 203 mgd. Chemical and energy (aeration, mixing and pumping) costs are established on a continuous operation at an average flow of 15-mgd to Plant No.1, 88 mgd to Plant No. 2, 115 mgd to Plant No 3 and 203 mgd to upflow deep bed denitrification filters. Methanol dosage is computed using the same methanol to nitrate-nitrogen removal ratio as in Alternative 1-1. Cost of quick lime is based on supplier's estimate at the time of writing.

Operation and Maintenance costs were estimated using Table 6-3-5B.

Cost Estimates

A breakdown of capital, salvage, and operation and maintenance costs for this alternative is shown in Table 6-3-5C.



CRITERIA

	FLOW	TN
PLANT INFLUENT	180	33
BACK RIVER DISCHARGE	130	3-6
BETHLEHEM STEEL DISCHARGE	50	3-6

LEGEND

- BNR BIOLOGICAL NITROGEN REMOVAL (MLE)
- C/N CARBONACEOUS/NITRIFICATION
- DN DENITRIFICATION
- FB FLUIDIZED BED
- M METHANOL
- P PUMPING STATION
- TN TOTAL NITROGEN
- (oval) FLOW, MGD

NOTE

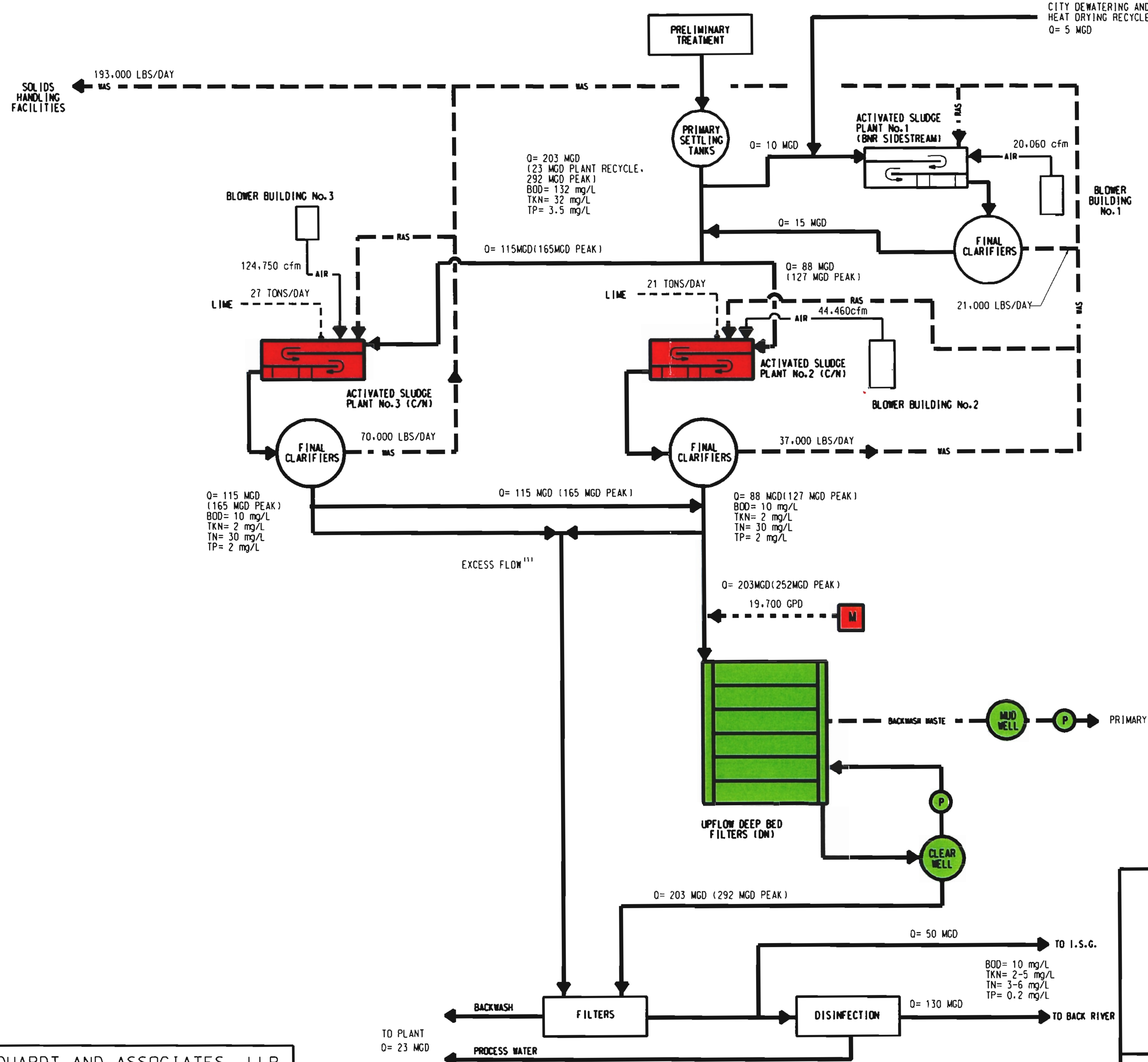
PLANT FLOW=180 MGD, WITH RECYCLES=203 MGD

COMPREHENSIVE WASTEWATER FACILITIES MASTER PLAN

BACK RIVER WASTEWATER TREATMENT PLANT

CONCEPTUAL DIAGRAM ALTERNATIVE 3-5

WHITMAN, REQUARDT AND ASSOCIATES, LLP	DATE: APRIL 2004	SCALE: NONE	FIGURE: 6-3-5A



LEGEND

WASTEWATER	solid line
SLUDGE	long dashed line
AIR	thin line
CHEMICAL	short dashed line

ABBREVIATIONS

CARBONACEOUS BOD REMOVAL	C
NITRIFICATION	N
DENITRIFICATION	DN
PUMPING STATION	PS
METHANOL	M
BIOCHEMICAL OXYGEN DEMAND	BOD
TOTAL KJELDAHL NITROGEN	TKN
TOTAL NITROGEN	TN
TOTAL SOLIDS	TS
TOTAL PHOSPHORUS	TP
WASTE ACTIVATED SLUDGE	WAS
RETURN ACTIVATED SLUDGE	RAS
BIOLOGICAL NUTRIENT REMOVAL	BNR

NOTES:

(1) EXCESS FLOW IS FLOW THAT EXCEEDS PEAK DRY WEATHER FLOW.

COMPREHENSIVE WASTEWATER FACILITIES MASTER PLAN

BACK RIVER WASTEWATER TREATMENT PLANT

PROCESS SCHEMATIC ALTERNATIVE 3-5

DATE: APRIL 2004 | SCALE: NONE | FIGURE: 6-3-5B

WHITMAN, REQUARDT AND ASSOCIATES, LLP

TABLE 6-3-5A

BACK RIVER WASTEWATER TREATMENT PLANT

ALTERNATIVE 3-5: DESIGN ASSUMPTIONS

Unit Process	Parameters	Criteria
Activated Sludge Plant No.1	Average Daily Flow	15 MGD: 5 MGD Centrate and 10 MGD Primary Effluent
(BNR/SIDESTREAM)	Peak Dry Weather Flow	22 MGD
Reactors	Number of Reactors	all four
	Design Hydraulic Detention Time	17 hours
	Design Solids Retention Time	10 days
	Overall Solids Retention Time	16 days
Air includes mixing	O_2 Requirement	60,310 lbs/day
	Blower Capacity	20,060 cfm, 985 HP @ 15.5 ft Head
	Fine Bubble Diffusers	13,370@ 1.5 cfm per diffuser
	Oxygen Transfer Efficiency	12%
Clarifier	Clarifier	all four
	Clarifier Overflow Rate	200 gpd/ft^2
	Design MLSS	3750 mg/L
	Solids Flux Loading Rate	6.2 lbs/ft^2
	Sludge Waste Production	21,032 lbs/day
Performance	Effluent	TN=8-6 mg/L, TKN=4.9, BOD=8 mg/L, TP=0.2 mg/L
Activated Sludge Plant No. 2	Average Daily Flow	88 MGD
(C/N)	Peak Dry Weather Flow	127 MGD

TABLE 6-3-5A (CONTINUED)

Unit Process	Parameters	Criteria
Reactors	Number of Reactors	6 (one standby)
	Design Hydraulic Detention Time	6.84 hours
	Design Solids Retention Time	14.3 days
Air	Installed Blower Capacity	94,460 cfm
	Installed Fine Bubble Diffusers	10867/ reactor @ 1.5 SCFM/diffuser
	Oxygen Transfer Efficiency	12%
Clarifier	Clarifier	12 existing (two standby)
	Clarifier Overflow Rate	Average: 466 gpd/ft^2, Peak: 673 gpd/ft^2
	Solids Flux Loading Rate	11.3 lbs/sq.ft./day
	Design MLSS	3500 mg/L
	Sludge Waste Production	34,490 lbs/day
Chemical	Lime Dosage	56 mg/L
	Lime Solids	2858 lbs/day
	5.6% of Waste Activated Sludge	
Performance	Effluent	NO_3-N =26 mg/L, TKN=2mg/L
Activated Sludge Plant No. 3	Average Daily Flow	115 MGD
(C/N)	Peak Dry Weather Flow	165 MGD
Reactors	Nitrification Capacity	32.5 Mgal
	Number of Reactors	6 (one standby)
	Design Hydraulic Detention Time	6.78 hours
	Design Solids Retention Time	14.3 days
Air includes mixing	Installed Blower Capacity	124,750 cfm
	Installed Fine Bubble Diffusers	10867/ reactor @ 1.5 SCFM/diffuser

TABLE 6-3-5A (CONTINUED)

Unit Process	Parameters	Criteria
	Oxygen Transfer Efficiency	12%
Clarifier	Clarifier	12 (2 standby)
	Clarifier Overflow Rate	Average: 572 gpd/ft^2, Peak: 820 gpd/ft^2
	Solids Flux Loading Rate	17.8 lbs/sq.ft./day
	Design MLSS	3500 mg/L
	Sludge Waste Production	66,341 lbs/day
Chemical	Quick Lime Dosage	56 mg/L
	Lime Solids	3715 lbs/day
	5.6% of Waste Activated Sludge	
Performance	Effluent	NO_3-N=26 mg/L, TKN=2mg/L
Upflow Deep Bed DN Filters	Average Daily Flow	203 MGD
	Peak Dry Weather Flow	292 MGD
	Hydraulic Loading	Average: 5.8 gpm/ft^2 Peak: 7.7 gpm/ft^2
	Avg. Nitrates Loading	Average: 1.8 lbs/ft^2-day Peak: 2.4 lbs/ft^2-day
Filters	Dimensions (Peak Flow)	16- 40.2 ft X 46.8 ft X 19 ft (LXWXH) (2 standby))
	Media Depth	9.5 ft.
	Media	Biolite, clay
Backwash	Backwash	12.2 gpm/ft^2, 50 min/day
	Air Backwash	4.8 cfm/ft^2, with backwash water for 50 min/day
Backwash Waste	Flow Rate to Primary	799 gpm for one filter
Chemicals	Methanol	78 mg/L
Performance	Effluent	TKN= 2 mg/L, NO_x-N= 1mg/L, TSS=5 mg/L

TABLE 6-3-5B

BACK RIVER WASTEWATER TREATMENT PLANT

ALTERNATIVE 3-5: OPERATION AND MAINTENANCE ASSUMPTIONS

Unit Process	Assumptions
Activated Sludge Plant No. 1 (BNR/SIDESTREAM)	
Aeration and mixing	[1.5 (Lbs BOD removed) + 4.6 (lbs of TKN nitrified) – 2.86 (lbs of Nitrates denitrified)]*1.5
	12% O2 transfer efficiency
	108,600 lbs/day in all aerobic zones.
Mixing Power	27.5 HP/reactor, $0.045/HP-hour
Activated Sludge Plant No. 2 and No. 3 (C/N)	
Aeration and mixing	lbs/day of O2 consumption = ((1.5 X lbs BOD influent) + (4.6 TKN influent) + (1.5 DO)) 1.5
	12% O2 transfer efficiency
	477 mg/L of O2
Lime Feed	78 mg/L Quick Lime, $50/ton
Upflow DN Reactors	
Pumping to Filters	203-MGD @ 50 ft Head
	0.3132 HP/MGD/ft of Head, $0.06/KWh.
Back Wash Water Pumping Power	3-11,280 gpm @ 50 ft Head (one standby)
	0.3132 HP/MGD/ft of Head, $0.06/KWh.
Air Back Wash Blower Power	5131 cfm of air @ 10.4 psig,
	0.3132 HP/MGD/ft of Head, $0.06/KWh.
Mudwell Pump Power	527 gpm @ 65 ft per filter
	0.3132 HP/MGD/ft of Head, $0.06/KWh.
Methanol Feed	78 mg/L, $1.00/gal

	PROCESS	CAPITAL ($M)	SALVAGE ($M)	ANNUAL COSTS ($M)				
				OPERATING			MAINT.	TOTAL
				LABOR	ENERGY	CHEMICAL		
1	Ex. Activated Sludge Plant No. 1	8.00	6.96	0.14	0.44		0.46	1.04
	(BNR/Sidestream)							
2	Ex. Activated Sludge Plant No. 2 (C/N)	18.28	33.15	0.36	2.40		2.21	4.97
3	Ex. Activated Sludge Plant No. 3 (C/N)	23.77	43.10	0.47	3.13		2.87	6.47
4	Deep Bed DN Filters (Upflow)	56.46	16.94	0.28	0.22		1.13	1.63
5	Denitrification Pumping Station	59.85	17.96	0.04	1.25		0.96	2.25
6	Methanol Facilities (1)	3.09	0.93	0.09		7.33	0.06	7.48
7	Lime Facilities (1 Existing and 1 New)	0.86	0.50			1.20	0.03	1.23
8	WAS Treatment[1]				0.09	0.59		0.68
9	Disposal (Land Application)[2]							2.07
10								
11								
12								
13								
14								
15								
16								
17								
18								
19								
20								
21								
22								
	TOTALS	T1= 170.31	T2= 119.54	1.38	7.53	9.12	7.72	T3= 27.82

$M - Millions of Dollars

[1] Based on thickening, pumping, digestion, and dewatering of waste activated sludge (WAS). WAS produced is estimated to be 96.5 dry tons/day (DTPD).

BRWWTP Operations Report for 2001: 80% volatile solids in feed and 80% volatile solids destruction from ESDs.

[2] Sludge cake for disposal is 34.7 DTPD.

PRESENT WORTH COST DETERMINATION

1. PRESENT WORTH FACTORS
   - F1 = SINGLE PAYMENT, 20 YEARS, 7% = 0.25842
   - F2 = UNIFORM SERIES, 20 YEARS, 7% = 10.59401

2. PRESENT WORTH BASIS
   - A. CAPITAL COST: (T1) $170.31
   - B. SALVAGE COST: (-) (F1 X T2) -$30.89
   - C. ANNUAL O&M COST: (F2 X T3) $294.73

TOTAL PRESENT WORTH = $434.14

NOTES:
ENR INDEX = 6300
DN = Denitrification
C/N = Carbonaceous / Nitrification

COMPREHENSIVE WASTEWATER FACILITIES
MASTER PLAN

BACK RIVER
WASTEWATER TREATMENT PLANT

SUMMARY OF ESTIMATED COSTS
ALTERNATIVE 3-5

WHITMAN, REQUARDT AND ASSOCIATES, LLP	SEPTEMBER 2002	TABLE 6-3-5C

6.7.14. Other Alternative

6.7.14.1. Integrated Fixed Film Activated Sludge Process

In achieving the Level 3 goal of TN in the range of 3 to 6 mg/l, annually, retrofitting the existing BNR plants to a combined attached and suspended growth process also requires consideration. This process called an integrated fixed film activated sludge process provides a greater biomass concentration in the aeration basin, resulting in a reduction of basin size. The media on which biomass grows can be suspended in the mixed liquor or a fixed module placed in the basin. In the case of suspended media, the media is free floating and retained by an effluent screen. For both suspended media and fixed module, solids are removed in a secondary clarifier and wasting is from the return line as in a conventional activated sludge process.

The advantage of the integrated fixed film activated sludge process is the ability to increase the loading on the existing plant without increasing solids loading onto the secondary clarifier. The SRTs are lower than those in activated sludge process without media. The process has also been used to improve volumetric nitrification rates and accomplish denitrification in aeration basins by having anoxic zones within the biofilm depth. This is based on limited full-scale studies[12].

Some of the disadvantages of this process are as follows. In the suspended media, the presence media discourages the use of more efficient fine bubble systems, which would require periodic drainage of the aeration basin and removal of the media for diffuser cleaning. In the fixed modules, achieving optimal rates can be difficult due to variation of BOD loading. Location of the fixed modules is critical.

The design concept for Back River WWTP includes retrofitting the BNR basins with integrated fixed film activated sludge process followed by post denitrification and post aeration. Primary effluent enters Plant Nos. 2 and 3. The flow scheme of each plant

[12] Metcalf & Eddy, Inc.. *Wastewater Engineering Treatment and Reuse*, McGraw Hill, MA, 2003.

consists of converting existing six three-pass MLE trains into eighteen trains. Each train is comprised of carbonation/nitrification, post denitrification with methanol addition and post aeration zones. Carbonation/nitrification zones include the suspended media (i.e. MBBR) or fixed modules for biomass growth to achieve carbonation and nitrification. Post denitrification zones do not include any suspended media or fixed modules. The mixed liquor from the post aeration zone flows to existing clarifiers for solids separation. Return activated sludge is pumped back to the carbonation/nitrification zones to maintain MLSS of 3500 mg/L. Fixed growth modules are placed where the BOD is high for biomass growth but low enough for ammonia oxidation so optimal nitrification is achieved. This is expected to provide an effluent with TN of 3 to 6 mg/L.

Both suspended media and fixed modules require further research and evaluation before they can be considered. It is also advisable to conduct on-site pilot/ demonstration testing.

6.7.15. Comparison of Alternatives

6.7.15.1. General

The evaluation of the treatment alternatives is summarized on Figure 6-A. The matrix shows the comparison of the alternatives regarding the environmental, implementation and operational impacts. It also summarizes the costs.

The evaluation of each impact is discussed in the following sections. The evaluation rating is shown in the matrix by letter designation. A grading system of A to E was used. The ratings were arrived at using best engineering judgment and indicate the advantages or disadvantages of the alternatives with respect to each other. The rankings are objective in nature and, while an alternative rated A may be the best choice available, its selection may still result in impacts.

6.7.15.2. Environmental Impacts

These evaluations relate to the impacts on the land or air associated with each alternative. Consideration was given to changes occurring at the Back River Plant and impacts on public activities adjacent to the plant. Since the phasing of BNR improvements is dependent upon yet undetermined treatment requirements, all alternatives do not achieve the same degree of treatment. However, all alternatives within a given phase are considered to have the same impact on water quality.

Odors (Item 1)

Under this criterion, consideration was given to impacts on the public outside the plant boundary lines from noxious odors originating within the plant.

Odor is one of the most important considerations in the selection of future treatment processes at Back River. The plant site, which when first selected in 1911 was isolated from major population areas, is today surrounded by commercial and residential development. Odors originate from four major sources: preliminary treatment, primary treatment, BNR (activated sludge) treatment, and sludge processing. Only the odor-producing potential of the BNR treatment processes was considered in this evaluation. These odor problems occur where plants have industrial loads or inorganic constituents (nitrogen and sulfur) that tend to be odor producing[13].

Public Health (Item 2)

Consideration was given under this criterion to the impact on the public outside the plant boundary lines resulting from the transmitting of viruses or bacteria by means of aerosols, insects or bird migrations. Since each alternative assumes that the existing disinfection process complies with the MDE fecal coliform limitation of 200 mpn/100 ml, the evaluations do not include this concern.

Site Development (Item 3)

Consideration was given under this item to the impacts of locating the required facilities on the plant site. The impacts include overall utilization of plant space, grading requirements which affect the buffer zones or the Back River shoreline, area required, and truck traffic required to deliver chemicals.

6.7.15.3. Other Non-Monetary Impacts

Implementation (Item 4)

Consideration was given under this evaluation to the ability to proceed with the design and construction of the treatment process with respect to the need for

[13] WEF Manual of Practice No. 8: *Design of Municipal Wastewater Treatment Plants*, WEF and ASCE, VA, 1998

additional treatability studies. Also included in the evaluation was the adaptability of the process to the existing facilities.

Reliability (Item 5)

Consideration was given under this evaluation to the demonstrated performance of the treatment process and periods of continuous operation without O&M difficulties. Also included, is the effect of equipment malfunctions on the process, and the consistency of performance under different temperature conditions.

Flexibility (Item 6)

This item reflects the ability of the process to be adjusted to accommodate variations in wastewater characteristics, operational conditions, and continue to meet treatment requirements. Consideration was given under this evaluation to the ability of the treatment process to be modified in the future, or new units to be added, if effluent standards are changed as a result of new policies regarding the water quality of the receiving bodies.

Flow Variations (Item 7)

Consideration was given under this evaluation to the ability of the process to accept peak hydraulic loadings without upsetting the plant performance.

Shock Loads (Item 8)

Consideration was given under this evaluation to the ability of the process to accept changes in the wastewater characteristics without upsetting the treatment process.

Staging (Item 9)

Consideration was given under this evaluation to the ability of the treatment process to be constructed while maintaining the performance of the existing units. Consideration was also given to the ability of the process to be constructed in phases to match the projected increase in treatment requirements to reduce TN, as opposed to requiring all the capital investment initially.

Chemical Dependency (Item 10)

Consideration was given under this evaluation of the treatment process requirements to perform satisfactorily if a chemical became limited due to strikes or other delivery difficulties. Also evaluated was the availability of different manufacturers of the chemical.

Simplicity of Operations (Item 11)

Consideration was given to the degree of ease or difficulty anticipated to operate the process.

6.7.15.4. Costs

Figure 6-A summarizes the estimated cost for each alternative as present worth values, capital investment and annual operating and maintenance costs.

6.7.15.5. Impact on Solids Handling Facilities

Waste activated solids production from each alternative is shown in the Table 6-C. Separate stage nitrification and denitrification (Alternative 3-1) is anticipated to produce the maximum waste activated solids of 226,000 lbs/day for total nitrogen level of 3-mg/l, resulting in highest solids treatment and disposal for land application costs.

Under SC 736, the four gravity belt thickeners (GBTs) are designed to treat 299,000 lbs/day of waste activated sludge and gravity thickened primary sludge. Therefore, if only waste activated solids are thickened in the GBTs, the alternatives will have no significant impact on solids loading to the GBT facility. Further evaluation is required with the addition of primary sludge. Solids handling costs are included in the operation and maintenance cost in Figure 6-A.

EVALUATION OF IMPACTS			BNR ALTERNATIVE											
			Level 1		Level 2					Level 3				
			ALTERNATIVE 1-1	ALTERNATIVE 1-2	ALTERNATIVE 2-1	ALTERNATIVE 2-2	ALTERNATIVE 2-3	ALTERNATIVE 2-4	ALTERNATIVE 2-5	ALTERNATIVE 3-1	ALTERNATIVE 3-2	ALTERNATIVE 3-3	ALTERNATIVE 3-4	ALTERNATIVE 3-5
ENVIRONMENTAL (PRIMARY EFFECTS)	Odors	1	B	B	B	C	C	C	C	B	C	C	C	C
	Public Health	2	B	B	B	C	C	C	C	B	C	C	C	C
	Site Development	3	A	A	D	C	B	B	C	D	C	B	B	C
NON-MONETARY EFFECTS	Implementation	4	A	A	C	B	B	B	C	C	B	B	B	C
	Reliability	5	A	B	A	C	C	C	B	A	C	C	C	B
	Flexibility	6	A	A	C	B	B	B	B	C	B	B	B	B
	Flow Variations	7	A	A	B	C	C	C	A	B	C	C	C	A
	Shock Loads	8	C	A	B	B	B	C	A	B	B	B	C	A
	Staging	9	A	A	C	B	B	B	A	C	B	B	B	A
	Chemical Dependency	10	A	A	D	C	C	C	C	D	D	D	D	C
	Simplicity of Operations	11	A	B	B	D	D	D	C	B	D	D	D	C
COSTS (1)	Present Worth		150.91	150.84	494.29	342.80	339.71	360.04	359.68	496.18	442.65	436.61	466.46	434.14
	Capital		11.09	10.33	213.25	136.21	126.89	144.68	136.30	213.25	173.48	160.15	184.24	170.31
	Annual O&M		15.25	15.31	29.85	22.33	22.85	23.22	23.88	30.03	28.37	28.96	29.68	27.83

LEGEND

A = BEST
B = GOOD
C = FAIR
D = POOR
E = UNDESIRABLE

NOTES

(1) IN MILLIONS OF DOLLARS

COMPREHENSIVE WASTEWATER FACILITIES
MASTER PLAN

BACK RIVER
WASTEWATER TREATMENT PLANT

COST-EFFECTIVE MATRIX
BNR ALTERNATIVES

WHITMAN, REQUARDT AND ASSOCIATES, LLP | DATE: APRIL 2004 | FIGURE 6-A

TABLE 6-C

BACK RIVER WASTEWATER TREATMENT PLANT

SOLIDS LOADING ASSUMPTIONS TO SOLIDS HANDLING FACILITIES

	Solids Loading (dry lbs/day)					
	Methanol Solids		Lime Solids	Wasted Biological	Total	
	TN=6	TN=3		Solids	TN=6	TN=3
Alternative 1-1	7,500			160,000	168,000	
Alternative 1-2	7,500			160,000	168,000	
Alternative 2-1		54,000	9,100	161,800		225,000
Alternative 2-2		33,000	5,000	125,000		163,000
Alternative 2-3		33,000	5,000	125,000		163,000
Alternative 2-4		33,000	5,000	125,000		163,000
Alternative 2-5		31,000	4,000	145,000		180,000
Alternative 3-1		55,000	9,100	161,800		226,000
Alternative 3-2		55,000	8,900	125,000		189,000
Alternative 3-3		55,000	8,900	125,000		189,000
Alternative 3-4		55,000	8,900	125,000		189,000
Alternative 3-5		48,000	6,600	138,000		193,000

6.7.16. Apparent Best BNR Alternative

6.7.16.1. Discussion

Several significant factors affect the selection of the best BNR alternative. Some are under the control of the City and some are not, or at least not totally. Although these appear to be the most important, others must be considered also, and have been discussed previously in this chapter.

- Effluent requirements (undetermined)
- Timing of implementation of effluent requirements (undetermined)
- Plant operational considerations and preferences
- Costs

The evaluations in this chapter have considered three possible levels of BNR implementation, organized in a logical progression toward improving total nitrogen (TN) discharge to the local receiving waters (Back River and Patapsco River) and Chesapeake Bay. Evaluation of the alternatives in each level considers which alternative is judged to be the best for a logical progression to Level 3. For this Plan, the use of any of the Level 3 alternatives is expected to result in a reliably achievable effluent TN concentration as low as 3 mg/, but in the annual range of 3 to 6 mg/l. The Level 3 alternatives are thought to represent the best practical treatment technology which is applicable to the Back River Plant. As discussed hereinbefore, the achievable seasonal range may be 4 to 5 mg/l depending on the impact of refactory organic nitrogen on the ability to nitrify.

As indicated, the estimated cost for each alternative considers modifying and/or improving the existing treatment facilities to the respective level of treatment. Therefore, the estimated costs for treatment in Levels 1, 2 and 3 are not additive.

An important consideration in Level 1 is the future use of Activated Sludge Plant No. 1. In order to maintain the existing plant capacity at 180 mgd, Plant No. 1 needs to be restored to operational condition, primarily with regard to renovation of Blower Building No. 1 under Project No. 898, aeration basin and system repairs and other associated work. However, for all alternatives in Levels 2 and 3, except those involving the use of Plant No. 1 for sidestream BNR treatment of high ammonia dewatering recycles, Plant No. 1 is reconfigured as a suspended growth denitrification plant. This choice eliminates the need for the costly blower building renovations, and results in a process that will enable TN levels to 3 mg/l (3 to 6 mg/l on an annual basis). Even though the planning capacity for Back River is 180 mgd, actual plant flows are lower, and conversion of Plant No. 1 to denitrification may be a beneficial consideration in improving the TN level for the Back River discharge. Plant No. 1 could be operated as a 50 to 60 mgd constant flow denitrification plant and reduce the TN level to Back River to 5 mg/l by blending the Plant No.1 effluent with the effluent from Plants Nos. 2 and 3. This use of Plant No. 1 has benefits, but reduces the overall plant capacity to about 150 – 160 mgd (under Level 1, only).

Level 2 is an intermediate step to reach Level 3, so the real decisions lie in the Level 3 alternatives. Level 3 alternatives consider two fundamental approaches to the basic BNR process. One approach employs two separate suspended growth (activated sludge) systems, one to achieve carbon oxidation (BOD reduction) and complete nitrification, followed by the second to denitrify with supplemental methanol addition. The other approach utilizes a suspended growth system to achieve carbon oxidation/ nitrification, and then a fixed growth system for denitrification. The fixed growth system can be implemented in a deep bed filter or a fluidized bed reactor.

6.7.16.2. Selection of Apparent Best BNR Alternative

Based on the evaluations presented in this chapter, use of either deep bed filters or fluidized bed reactors appears to be more economical than a separate suspended growth system for denitrification. However, the evaluation of environmental and other non-monetary effects may indicate suspended growth denitrification offers other important advantages that could justify that selection.

In any case, final selection of the best alternative should include consideration of pilot/demonstration testing performance. This will indicate which processes provide the best treatment, and allow appropriate adjustments to the cost-effectiveness analysis.

6.8. PATAPSCO WASTEWATER TREATMENT PLANT

6.8.1. Basis for Evaluation

The alternatives are compared based on upgrading to the projected 20-year capacity for the plant of 81 mgd and the following annual average water quality characteristics.

BOD_5	230 mg/l
Suspended Solids	190 mg/l
Phosphorous (P)	4.0 mg/l
TKN	27 mg/l

The evaluation considers that the Low Level 1 influent, assumed to be 9 mgd, will be treated separately at a new plant to be designed under Project No. 877. The flow from the Southwest Diversion, 72 mgd, will be treated at the existing main plant. Therefore, the alternatives for the Patapsco Plant will be evaluated based on 81 mgd (72 + 9 mgd recycles = 81 mgd).

BNR alternatives were compared on secondary influent characteristics shown below. Except for average and peak flow, values were determined based on Patapsco Wastewater Treatment Plant Operation Reports for 1998 to 2001.

Average Flow (mgd)[14]	81
Peak Dry Weather Flow (mgd)[15]	121.5
Primary Effluent BOD_5 (mg/l)	137
Primary Effluent TSS (mg/l)	83
Primary Effluent TP (mg/l)	2.54
TKN (mg/l)	26.9
TN (mg/l)	27.1
NO3-N (mg/l)	0.139

[14] Average flow was based upon nominals Southwest Diversion flow plus recycle flows (72 + 9 = 81 mgd).
[15] Peak dry weather flow was estimated at 1.5 times average flow.

NO2-N (mg/l)	0.052
NH3-N (mg/l)	15.9
Alkalinity (mg/l $CaCO_3$)[3]	121
Temperature (^0C)	10

This section of the report focuses on biological nitrogen reduction alternatives specific to the Patapsco Wastewater Treatment Plant. The alternatives highlighted in this section of report are representative and based solely on representative kinetics. The alternatives have been selected based on their known ability to reduce nitrogen levels in municipal wastewater. The alternatives have generally accepted efficiencies in the reduction of nitrogen and have been categorized as such. One alternative capable of reducing total nitrogen to levels ≤ 8 mg/l, two alternatives capable of reducing total nitrogen to levels ≤ 6 mg/l, and three alternatives capable of reducing total nitrogen to levels ≤ 3 mg/l have been selected. These alternatives have been sized and are shown as representative alternatives for the Patapsco Wastewater Treatment Plant.

The first two alternatives (MLE and separate stage denitrification) as shown in the site plans require a large parcel of property. Due to the space constraints faced at Patapsco the construction of these alternatives would require the use of property currently being used for stockpiling contaminated soil. This use of property would assuredly necessitate the removal of this stockpiled soil. The financial and environmental implications of this venture were perceived to be far too expensive to warrant the alternatives as valid, and these two alternatives were therefore shown only as representative. These alternatives were not considered when comparing alternatives on a cost basis.

6.8.2. Alternative 1: Modified Ludzack Ettinger (MLE) Process

Process Description

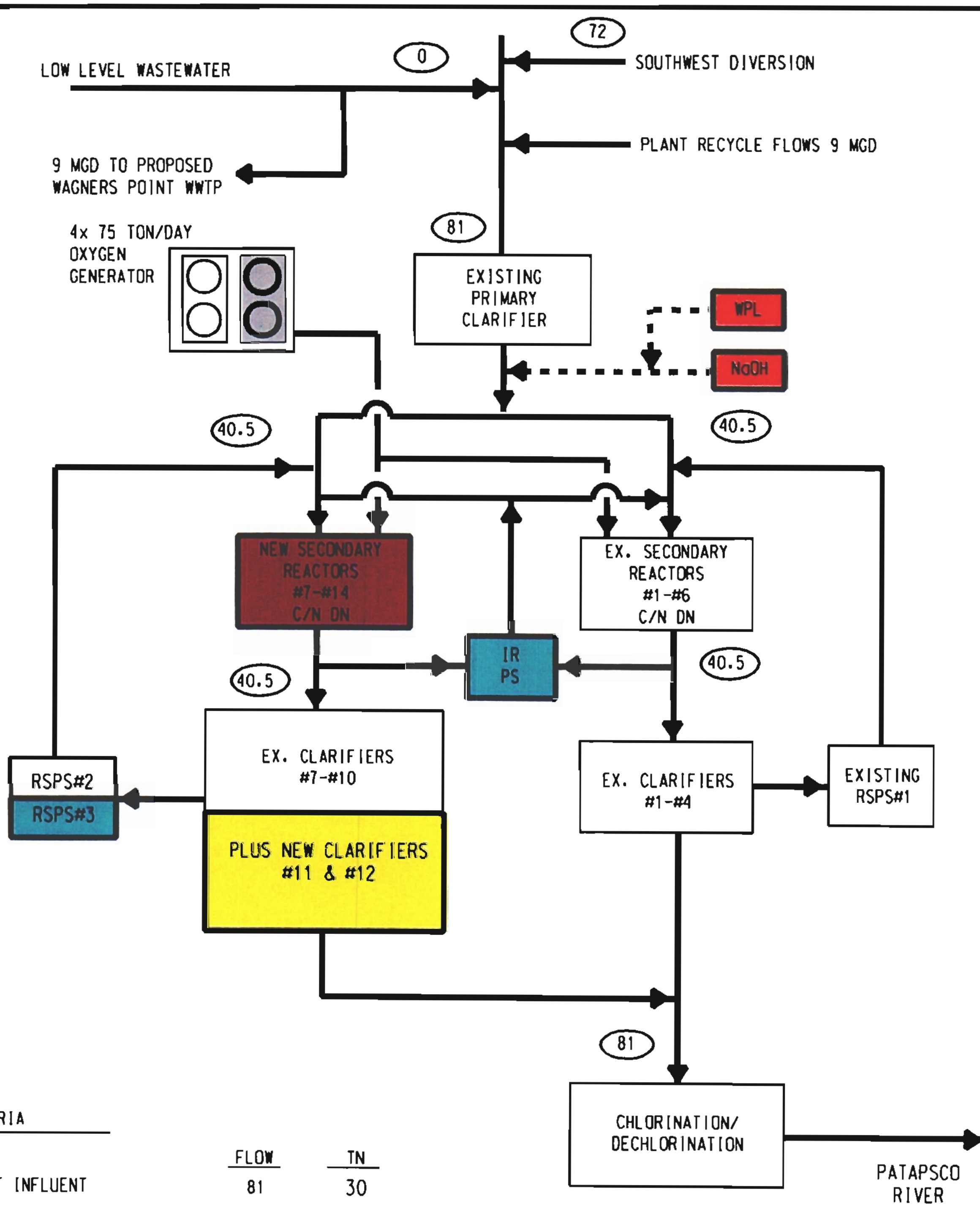
The Modified Ludzack Ettinger (MLE) process is a single–sludge biological nitrogen reduction process in which both nitrification and denitrification take place in the same reactor. The MLE process has had success in producing effluents with a total nitrogen ≤ 8 mg/l. This feat is accomplished by using both an anoxic zone followed by an oxic (aerobic) zone with internal recycle back to the anoxic zone.

The process consists of incoming wastewater combined with return activated sludge from clarification and recycled portion of the wastewater from inside the reactor. The internal recycle (IR) is what differentiates this process from traditional activated sludge. The IR, originating at the end of the aerated portion of the reacto, is rich in nitrate due to the oxidation of nitrogen. The nitrate rich wastewater is then reduced in the anoxic portion of the reactor releasing nitrogen gas and thereby reducing the TN of the wastewater. The anoxic zone is absent of oxygen but rather relies on the nitrate as the electron acceptor for bacterial synthesis. Following the anoxic zone the wastewater enters three successive oxic (aerobic) zones. In the case of the Patapsco Wastewater Treatment Plant, these zones will use pure oxygen in a slightly pressurized tank to provide the necessary oxygen to reduce both carbonaceous BOD and oxidize nitrogen. In the final oxic zone of the reactor, the IR is pumped to the head of the reactor.

The MLE process has proven successful in the reduction of nitrogen. Back River Wastewater Treatment plant is currently employing this process with reasonable success in achieving effluent TN levels between 8 to10 mg/l. The modifications necessary to convert the existing oxygen activated sludge plants at Patapsco to apply the MLE process are shown in Figures 6-1A and 6-1B, the conceptual diagram and site plan, respectively. Essentially, the modification would incorporate the existing preliminary and primary treatment processes. The combined wastewater would be chemically pretreated with sodium hydroxide to ensure sufficient alkalinity and proper pH to maximize nitrification. The modifications would also incorporate the existing six (6) oxygen activated sludge reactors while adding eight (8) more. The additional reactors would be needed in order to increase the overall hydraulic retention time (HRT) in each reactor such that both nitrification and denitrification have ample time to take place. The increase in the number of reactors also precipitated the need for two additional clarifiers. The two new clarifiers would have their own return and waste sludge pumping station. As previously stated, the key to the MLE process is the internal recycle of the nitrate rich mixed liquor back to the front of the anoxic zone. To accommodate this, Two IR pumps would be installed and dedicated to each of the 14 reactors. These IR pumps would be sized such that when both are operational a total of 400% of the influent flow could be recycled.

Design Assumptions

Design assumptions for Alternative 1 are shown in Table 6-1A.



CRITERIA

	FLOW	TN
PLANT INFLUENT	81	30
PATAPSCO RIVER DISCHARGE	81	6-8

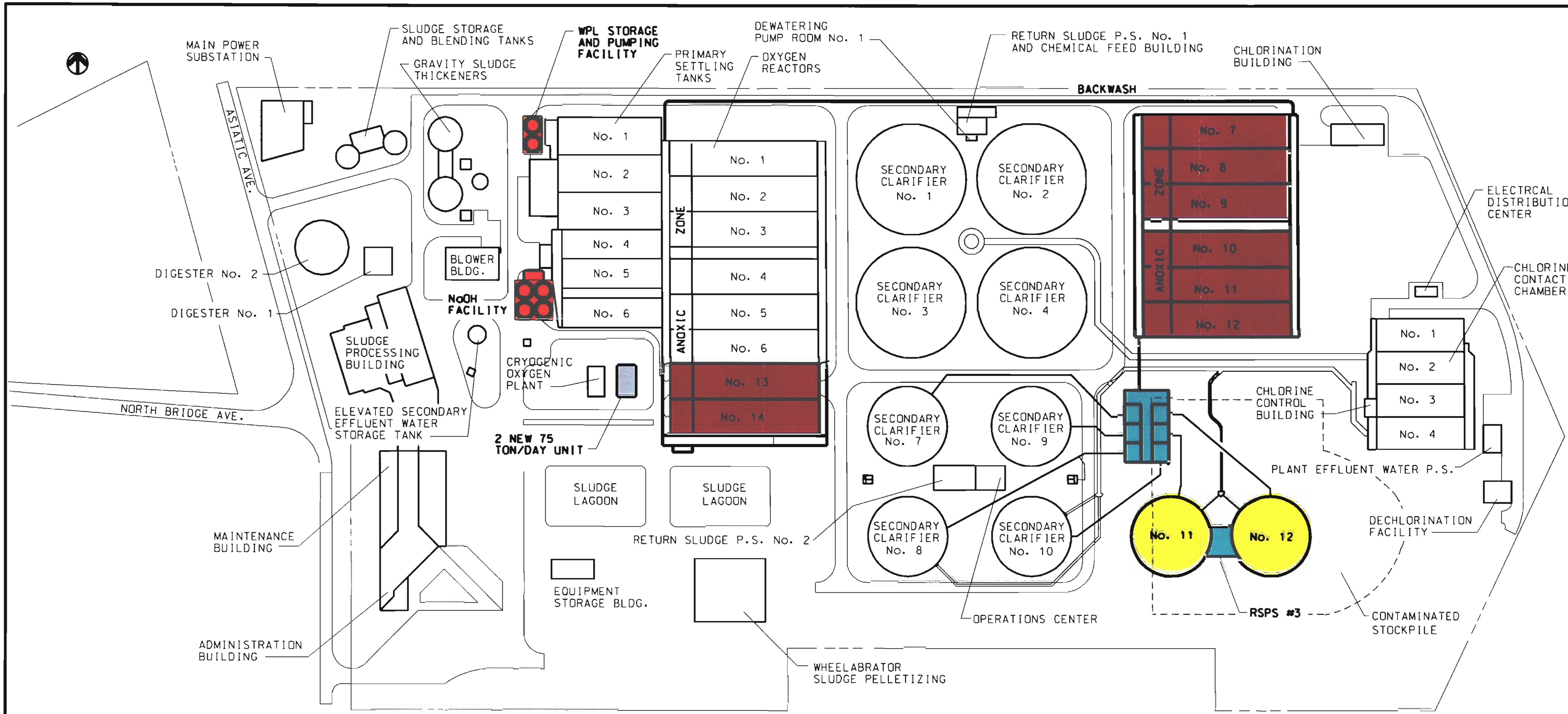
LEGEND

- C/N CARBONACEOUS/NITRIFICATION
- DN DENITRIFICATION
- WPL WASTE PICKLE LIQUER
- NaOH SODIUM HYDROXIDE
- TN TOTAL NITROGEN
- (oval) FLOW, MGD

COMPREHENSIVE WASTEWATER FACILITIES
MASTER PLAN
PATAPSCO
WASTEWATER TREATMENT PLANT

CONCEPTUAL DIAGRAM
ALTERNATIVE 1

WHITMAN, REQUARDT AND ASSOCIATES, LLP | DATE: APRIL 2004 | SCALE: NONE | FIGURE: 6-1A



COMPREHENSIVE WASTEWATER FACILITIES
MASTER PLAN
PATAPSCO
WASTEWATER TREATMENT PLANT

SITE PLAN
ALTERNATIVE 1

DATE: APRIL 2004	SCALE: 1"= 200'	FIGURE: 6-1B

WHITMAN, REQUARDT AND ASSOCIATES, LLP

TABLE 6-1A

PATAPSCO WASTEWATER TREATMETN PLANT

ALTERNATIVE 1: DESIGN ASSUMPTIONS

Unit Process	Parameters	Criteria
NaOH Metering	NaOH Dose	14,400 gpd
	Storage	4 – 33' diameter x 20' height ~500,000 gallons of storage
	Metering Pump Size	10 gpm fractional horsepower metering pump
Waste Pickle Liquor Metering	WPL Dose	5620 gpd
	Storage	2- 30' diameter x 20' height ~200,000 gallons of storage
	Metering Pump Size	3.9 gpm fractional horsepower metering pump
Existing Secondary Reactors 1-6	Average Daily Flow	35 MGD
	Peak Dry Weather Flow	52.5 MGD
	Denitrification Zone	3.1 MG
	Nitrification Zone	8.36 MG
	Total Reactor Volume	11.46 MG
	Number of Reactors	6
	Design HRT	5.7 hours
	Design SRT	28 days
	Installed Mixing Capacity	3 x 125 HP mixers in each aerated zone of each reactor, 4 x 5 HP mixers in each anoxic zone of each reactor
	Clarifiers	Four existing 210' diameter clarifiers from SC 582
	Clarifier Overflow Rate	600 gpd/sf
	Solids Flux Loading Rate	301 lbs /sf/day
	MLSS Design	4000 mg/L
	Sludge Waste Production	Additional 5000 lbs / day
	Underflow Solids Concentrati	10,000 mg/L
	RAS Flow (% Avg. Flow)	Up to 100%
	IR Pumping Rate (% Avg. Flo	Up to 400%
	Oxygen Required	64 tons / day

TABLE 6-1A (CONTINUED)

Unit Process	Parameters	Criteria
New Secondary Reactors 7 - 14	Average Daily Flow	46 MGD
	Peak Dry Weather Flow	69 MGD
	Denitrification Zone	3.8 MG
	Nitrification Zone	11.5 MG
	Total Reactor Volume	15.3 MG
	Number of Reactors	8
	Design HRT	5.7 hrs
	Design SRT	28 days
	Installed Mixing Capacity	3 x 125 HP mixers in each aerated zone of each reactor, 4 x 5 HP mixers in each anoxic zone of each reactor
	Clarifiers	Four existing 155' diameter clarifiers from SC 690 plus two new 155' diameter
	Clarifier Overflow Rate	600 gpd/square foot (sf)
	Solids Flux Loading Rate	301 lbs /sf/day
	MLSS Design	4000 mg/L
	Sludge Waste Production	Additional 12000 lbs / day
	Underflow Solids Concentrati	10,000 mg/L
	RAS Flow (% Avg. Flow)	Up to 100%
	IR Pumping Rate (% Avg. Flo	Up to 400%
	Oxygen Required	64 tons / day

6.8.3. Alternative 2: Two Sludge Suspended Growth System

Process Description

Separate stage suspended growth nitrification and denitrification takes advantage of optimizing both the nitrification and denitrification step in separate reactors. The bacteria responsible for nitrification and denitrification have different optimal environments in which they thrive. Therefore, separating the steps allows both environments to be optimized for maximum treatment efficiency. This process has had success in achieving effluent TN levels of $\leq$ 6 mg/l.

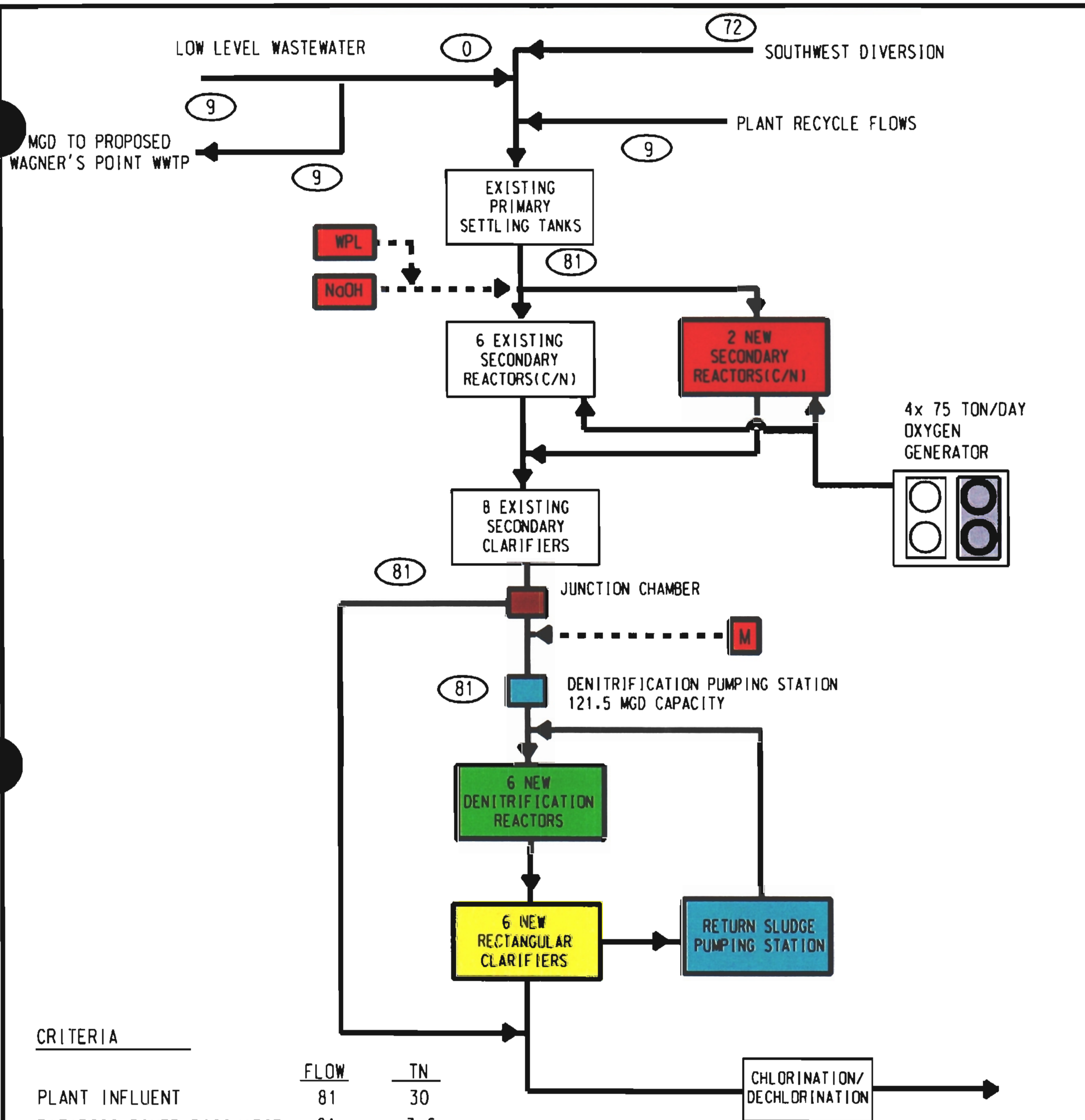
The process, as it would apply to Patapsco, incorporates the use of the existing six pure oxygen activated sludge reactors with the addition of two more reactors of the same dimensions to provide the necessary time for nitrification. These reactors would serve to both reduce carbonaceous BOD and nitrify incoming wastewater. The existing eight clarifiers would provide adequate clarification to the nitrified wastewater. Following the secondary clarifiers the nitrified wastewater would enter the wet well of a pumping station. The pumping station is necessary to provide the necessary hydraulic gradient to remain above the high tide level in the Patapsco River outfall. The pumping station would pump the nitrified wastewater into one of the six anoxic reactors. The anoxic reactors would be approximately 1.4 million gallons (MG) each with a total anoxic volume of 8.4 MG. The dimensions of the reactors would be 136' x 100' x 15' deep (side water depth is 14'). The anoxic reactors would have three 15 HP mixers in each reactor for a total of 18 mixers. The denitrified wastewater would then be clarified in one of six rectangular clarifiers. The sizing of the denitrification clarifiers was limited by the hydraulic overflow rate. The resulting dimensions of the clarifiers would be 355' x 76' x 15' deep (side water depth of 12'). Each clarifier would be segmented into four 19' sections to allow for a chain and flight mechanism to manage sludge collection.

Due to the lack of readily biodegradable material in the secondary effluent, a supplemental source of nitrogen free carbon would be necessary for the denitrification reaction in the anoxic reactors. Methanol is typically used to provide a readily biodegradable nitrogen free organic source of carbon in applications such as these. Alternative sources include brewery waste, ethanol, acetic acid, ketones, molasses, sugars and methane (i.e. digester off gas). While many alternate carbon sources exist, for ease of process alternative comparisons, methanol has been chosen. Upon developing a denitrifying system at Patapsco a more detailed study should be conducted to find the most cost-effective method of supplying the denitrifying process a nitrogen free carbon.

Approximately 5,400 gallons of methanol per day would be necessary for complete denitrification of the secondary effluent. This methanol would be pumped from storage tank into the influent trough. A 30-day supply would be provided and stored in two (2) 100,000-gallon methanol storage tanks. Each anoxic reactor would require a return sludge feed of approximately 300 gpm to maintain the recommended sludge retention time (SRT) for denitrification. Twelve 300-gpm RAS pumps would be provided, with each pump dedicated to one reactor with one spare per reactor. The clarified effluent from the denitrification clarifiers would then flow via gravity into a junction chamber that connects with the original secondary effluent flume and into the chlorination facility. Figures 6-2A and 6-2B show the conceptual diagram and site plan, respectively, for this alternative.

Design Assumptions

Table 6-2A presents the design assumptions.



CRITERIA

	FLOW	TN
PLANT INFLUENT	81	30
PATAPSCO RIVER DISCHARGE	81	3-6

LEGEND

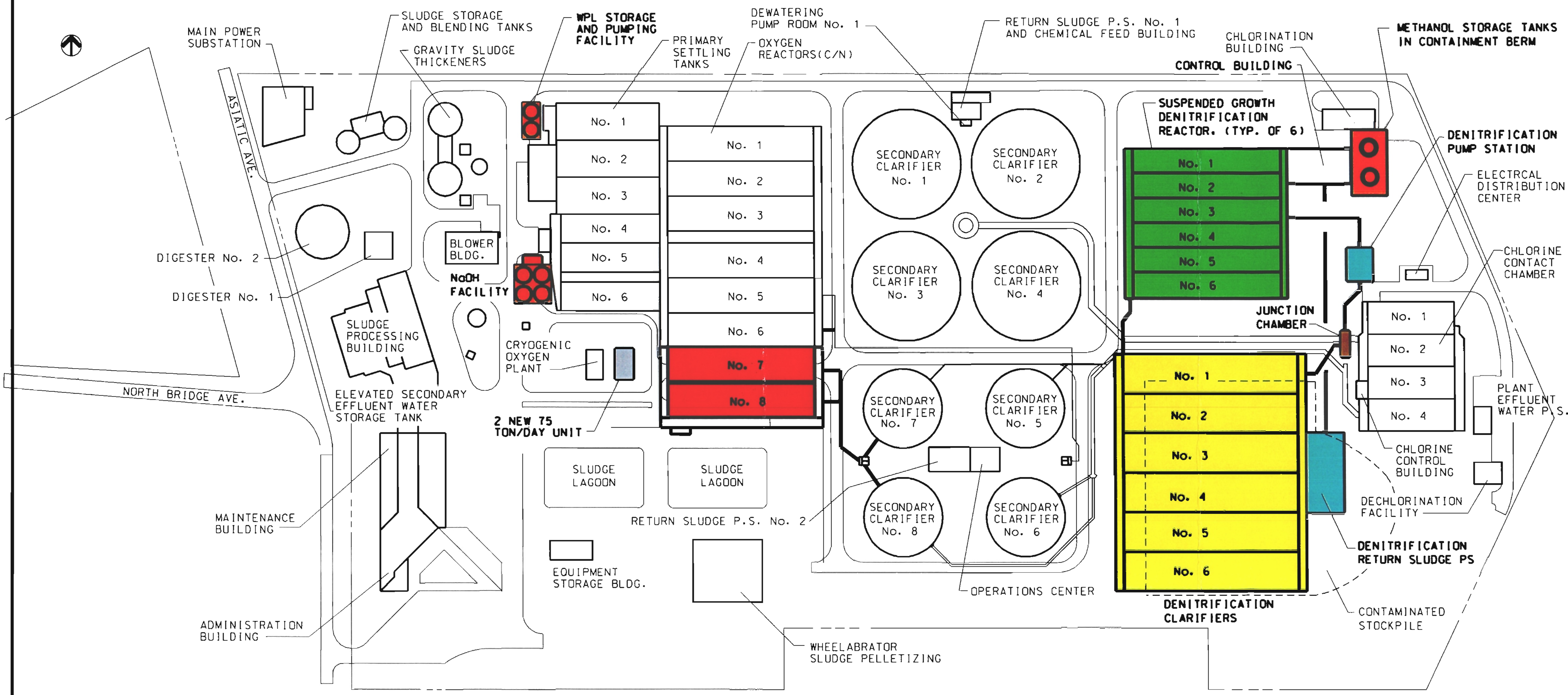
C/N CARBONACEOUS/NITRIFICATION
DN DENITRIFICATION
WPL WASTE PICKLE LIQUOR
M METHANOL
NaOH SODIUM HYDROXITIE
TN TOTAL NITROGEN
(oval) FLOW, MGD

COMPREHENSIVE WASTEWATER FACILITIES
MASTER PLAN
PATAPSCO
WASTEWATER TREATMENT PLANT

CONCEPTUAL DIAGRAM
ALTERNATIVE 2

WHITMAN, REQUARDT AND ASSOCIATES, LLP

DATE: APRIL 2004 | SCALE: NONE | FIGURE: 6-2A



WHITMAN, REQUARDT AND ASSOCIATES, LLP

COMPREHENSIVE WASTEWATER FACILITIES MASTER PLAN

PATAPSCO WASTEWATER TREATMENT PLANT

SITE PLAN ALTERNATIVE 2

DATE: APRIL 2004	SCALE: 1"= 200'	FIGURE: 6-2B

TABLE 6-2A

PATAPSCO WASTEWATER TREATMETN PLANT

ALTERNATIVE 2: DESIGN ASSUMPTIONS

Unit Process	Parameters	Criteria
NaOH Metering	NaOH Dose	14,400 gpd
	Storage	4 – 33' diameter x 20' height ~500,000 gallons of storage
	Metering Pump Size	10 gpm fractional horsepower metering pump
Waste Pickle Liquor Metering	WPL Dose	5620 gpd
	Storage	2- 30' diameter x 20' height ~200,000 gallons of storage
	Metering Pump Size	3.9 gpm fractional horsepower metering pump
Existing Secondary Reactors 1-6	Average Daily Flow	61 MGD
	Peak Dry Weather Flow	91.5 MGD
	Nitrification Zone	11.46 MG
	Total Reactor Volume	11.46 MG
	Number of Reactors	6
	Design HRT	4 hours
	Design SRT	9 days
	Installed Mixing Capacity	3 x 125 HP mixers in each aerated zone of each reactor, 4 x 5 HP mixers in the first zone of each reactor
	Clarifiers	Four existing 210' diameter clarifiers from SC 582 and two of the 155' diameter clarifiers from SC 690
	Clarifier Overflow Rate	600 gpd/sf
	Solids Flux Loading Rate	301 lbs /sf/day
	MLSS Design	4000 mg/l
	Sludge Waste Production	No additional production[1]
	Underflow Solids Concentration	10,000 mg/l
	RAS Flow (% Avg. Flow)	Up to 100%
	Oxygen required	96 tons / day

TABLE 6-2A

Unit Process	Parameters	Criteria
New Secondary Reactors 7 - 8	Average Daily Flow	20 MGD
	Peak Dry Weather Flow	30 MGD
	Nitrification Zone	3.82 MG
	Total Reactor Volume	3.82 MG
	Number of Reactors	2
	Design HRT	4 hours
	Design SRT	9 days
	Installed Mixing Capacity	4 x 125 HP mixers in each of the four aerated zones of each reactor
	Clarifiers	Two existing 155' diameter clarifiers from SC 690
	Clarifier Overflow Rate	600 gpd/square foot (sf)
	Solids Flux Loading Rate	301 lbs /sf/day
	MLSS Design	4000 mg/l
	Sludge Waste Production	No additional production
	Underflow Solids Concentration	10,000 mg/l
	RAS Flow (% Avg. Flow)	Up to 100%
	Oxygen Required	32 tons / day
Oxygen Generation	Existing Capacity	Two 75-ton O_2 generators
	New Capacity	Two 75-ton O_2 generators
Denitrification Pumping Station	New Pumps	81 MGD @ 10' TDH – 3 x 100 HP 121.5 MGD (peak) @ 10' TDH – 4 x 100 HP
Methanol Feed	Methanol Dose	5,338 gpd
	Storage	2- 30' diameter x 20' height ~200,000 gallons of storage
	Metering Pump Size	3.7 gpm fractional horsepower metering pump
New Denitrification Reactors 1-6	Average Daily Flow	81 MGD
	Peak Dry Weather Flow	121.5 MGD
	Denitrification Zone	6.12 MG
	Reaeration Zone	3.30 MG
	Total Reactor Volume	9.42 MG

TABLE 6-2A

Unit Process	Parameters	Criteria
New Denitrification Reactors 1-6	Number of Reactors	6 (300' x 50' x 15') – 14' SWD
	Design HRT	2.5 hours
	Design SRT	19 days
	Installed Mixing Capacity	3 x 15 HP mixers per reactor
	Clarifiers	6 new rectangular (76' x 355' x 12' SWD)
	Clarifier Overflow Rate	500 gal/ day-ft^2
	Solids Flux Loading Rate	25 lbs / day-ft^2
	MLSS Design	3000 mg/l
	Sludge Waste Production	16,500 lbs / day
	Underflow Solids Concentration	8,000 mg/l
	RAS Flow (% Avg. Flow)	3%

[1] The extended sludge retention time necessary for Nitrification results in a slight net loss in solids production as compared with the current process of carbonaceous BOD removal.

6.8.4. Alternative 3: Carbon Oxidation/Nitrification and Fluidized Bed Reactor Denitrification

Process Description

Fluidized bed denitrification is an attached growth biological treatment process in which process wastewater is passed upward through a bed of media at a rate sufficient to fluidize the bed. The fluidized bed reactor (FBR) denitrification process has had success in achieving TN levels ≤ 3 mg/l. The FBR is packed with media that holds the biomass in the system and provides for good contact between the biomass and the wastewater. As wastewater is introduced into the fluidized bed, microorganisms begin to attach themselves to the media and form a film. As the film grows in thickness, it causes that particle to become lighter in overall density and the bed to expand even further. Since the lightest density particles always go to the top of the fluidized bed, those particles with the thickest biomass film always go to the top of the bed. A growth control mechanism would be used to remove this biomass that has risen to the surface before it was discharged as effluent. The growth control mechanism is typically as simple as a pump and a separation mechanism. The media is pumped and through this pumping action the biomass is sheared from the media. The media is returned to the reactor, while the biomass is wasted from the system.

The fluidized bed offers advantages over a traditional fixed film filter in that the reactor does not require frequent backwashes to prevent the plugging experienced in traditional sand filters. Additionally, due to the nature of the fluidized bed reactor, more area of the media is exposed to the wastewater, lending itself to being more active or efficient than a traditional downflow filter.

The design concept for Patapsco Wastewater Treatment Plant is similar to that of the separate stage denitrification reactors, where the existing oxygen activated sludge reactors would be converted to conduct both carbonaceous BOD removal as well as complete nitrification (C/N). The nitrified effluent from the secondary clarifiers would then be diverted into a separate denitrification step.

Due to the renovations of the existing oxygen activated sludge reactors, the existing AO process would be eliminated, therefore necessitating an alternative method of phosphorous removal. A chemical method of phosphorous removal using metal salts, as the precipitant is a known method and is successfully being employed by Back River Wastewater Treatment Plant. A variety of metal salts can reliably precipitate phosphorous from the wastewater including alum, aluminate, ferric chloride, ferrous chloride and ferrous sulfate. Back River currently uses Ferrous Chloride (FeCl2) in the form of waste pickle liquor. This form of phosphorous removal has been incorporated into the design concept for this alternative.

Figures 6-3A and 6-3B show a conceptual diagram and site plan, respectively. Figure 6-3C presents a process schematic.

Design Assumptions

Table 6-3A lists the design assumptions for the fluidized bed denitrification alternative. As shown, the existing oxygen activated sludge reactors would be converted into combined carbonaceous oxidation - nitrification (C/N) reactors. The additional two reactors, of the same dimension, would be required to provide complete nitrification. Additionally, more oxygen is required for the combined C/N reactors. Approximately 128 tons O_2 / day are required. This will require additional oxygen generation capability. The current O_2 capacity is 150 tons / day. To provide the existing redundancy, this capacity should be doubled to 300 tons / day. The existing clarifiers would be sufficient in size to handle the flows however; the distribution of MLSS would require modification such that each clarifier serviced one of the eight reactors. Following clarification the secondary effluent would be diverted through a distribution structure to the denitrification reactors.

The fluidized bed denitrification reactors would consist of a building that would house all ten reactors with a common pipe gallery and control room. The nitrified wastewater would enter the pipe gallery and be pumped into one of ten fluidized bed reactors (FBR's). The pump discharge would be fed with the necessary methanol and distributed to each of the FBR's.

The FBR effluent would either be recycled to maintain the fluid bed or discharged into the effluent trough which would flow via gravity into the existing chlorination / dechlorination facility.

Operation and Maintenance Assumptions

Table 6-3B summarizes the operation and maintenance assumptions.

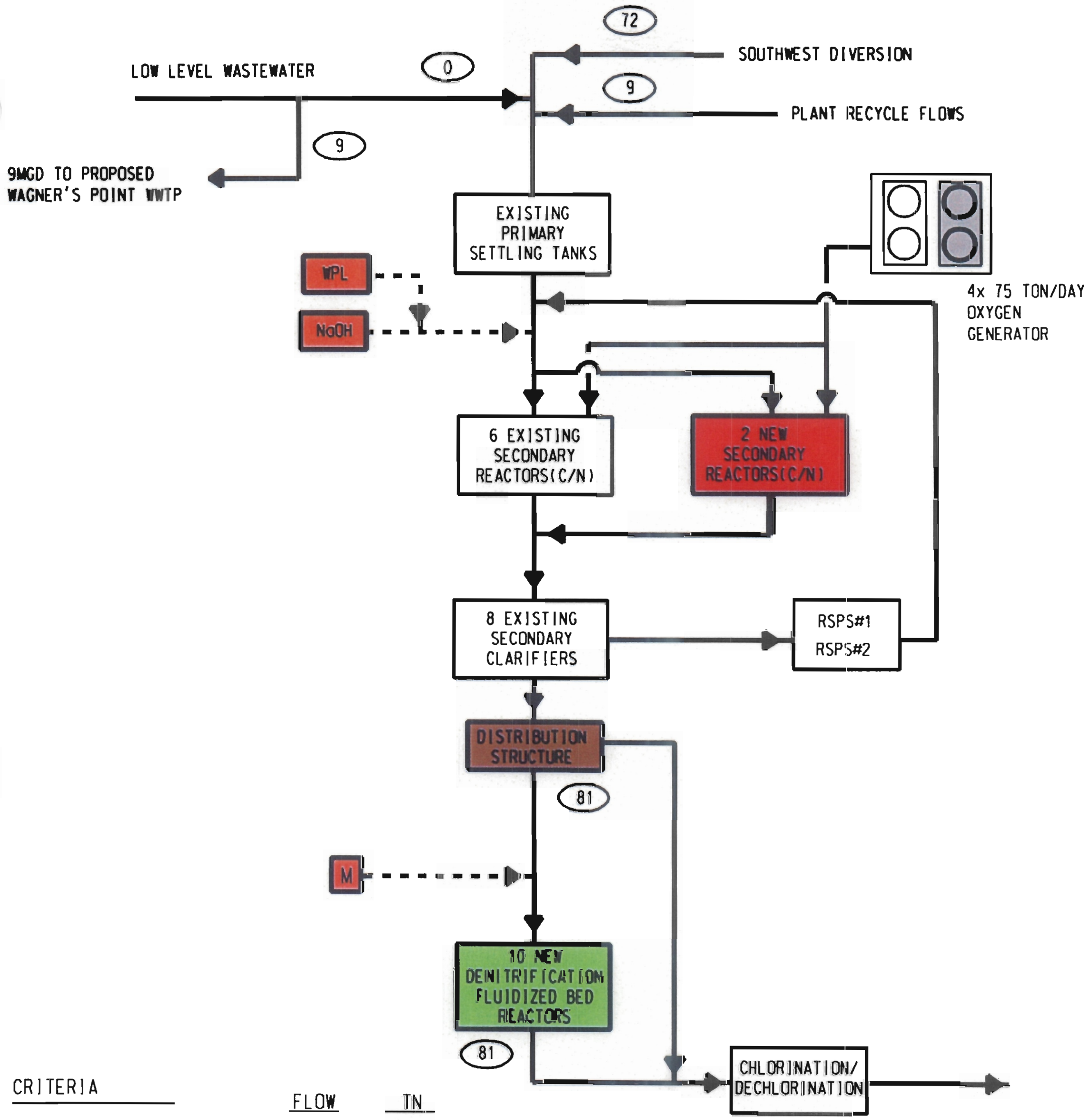
Labor and maintenance costs are based on both existing and new equipment operating at the average flow of 81 mgd. Energy and chemical costs are based on 24-hour operation at the average flow of 81 mgd. Motor sizing for the various mixers and pumps were based on these criteria as well. It was assumed that the low-level waste water (approximately 9 mgd) would be treated separately at the proposed Wagners Point WWTP (Project No. 877) and the effluent from this plant will recombine with the Patapsco effluent prior to discharge. The remaining 72 mgd plus plant recycles (9 mgd) would then be treated at the existing facility. Phosphorous removal would be through chemical addition of waste pickle liquor (WPL) or Ferrous Chloride $FeCl_2$. The dose of the WPL was based on its successful use at the Back River Wastewater Treatment Plant. Approximately 22 lbs. WPL / lb of phosphorous removed is the current feed rate at Back River WWTP. Sodium Hydroxide (NaOH) would be added to both adjust the pH and provide the necessary alkalinity for complete nitrification. The NaOH dose was based on providing 7.4 lb of alkalinity per lb of ammonia oxidized in the nitrification step. Based on the inherent alkalinity of the wastewater, it was determined that approximately 136 mg/l of NaOH was necessary to make up the difference necessary for nitrification and pH adjustment. Methanol addition was base upon 2.5 parts per million of methanol per mg/l of nitrate removed plus 0.9 part per million methanol for every part per million of dissolved oxygen remaining plus 3 parts per million as a safety factor in the wastewater. This totaled 52 parts per million or approximately 5,338 lbs. methanol per day for an influent rate of 81 mgd.

Operation and maintenance costs are based on current labor costs at Patapsco WWTP. Energy costs are based on horsepower estimates for various items of equipment.

Maintenance costs are based on 2% per year of the estimated mechanical equipment cost. Chemical costs for sodium hydroxide and methanol were based on suppliers' estimates. Waste pickle liquor costs are based upon current costs at Back River Wastewater Treatment Plant.

Cost Estimates

Cost estimates are summarized in Table 6-3C.



CRITERIA

	FLOW	TN
PLANT INFLUENT	81	30
PATAPSCO RIVER DISCHARGE	81	3-6

LEGEND

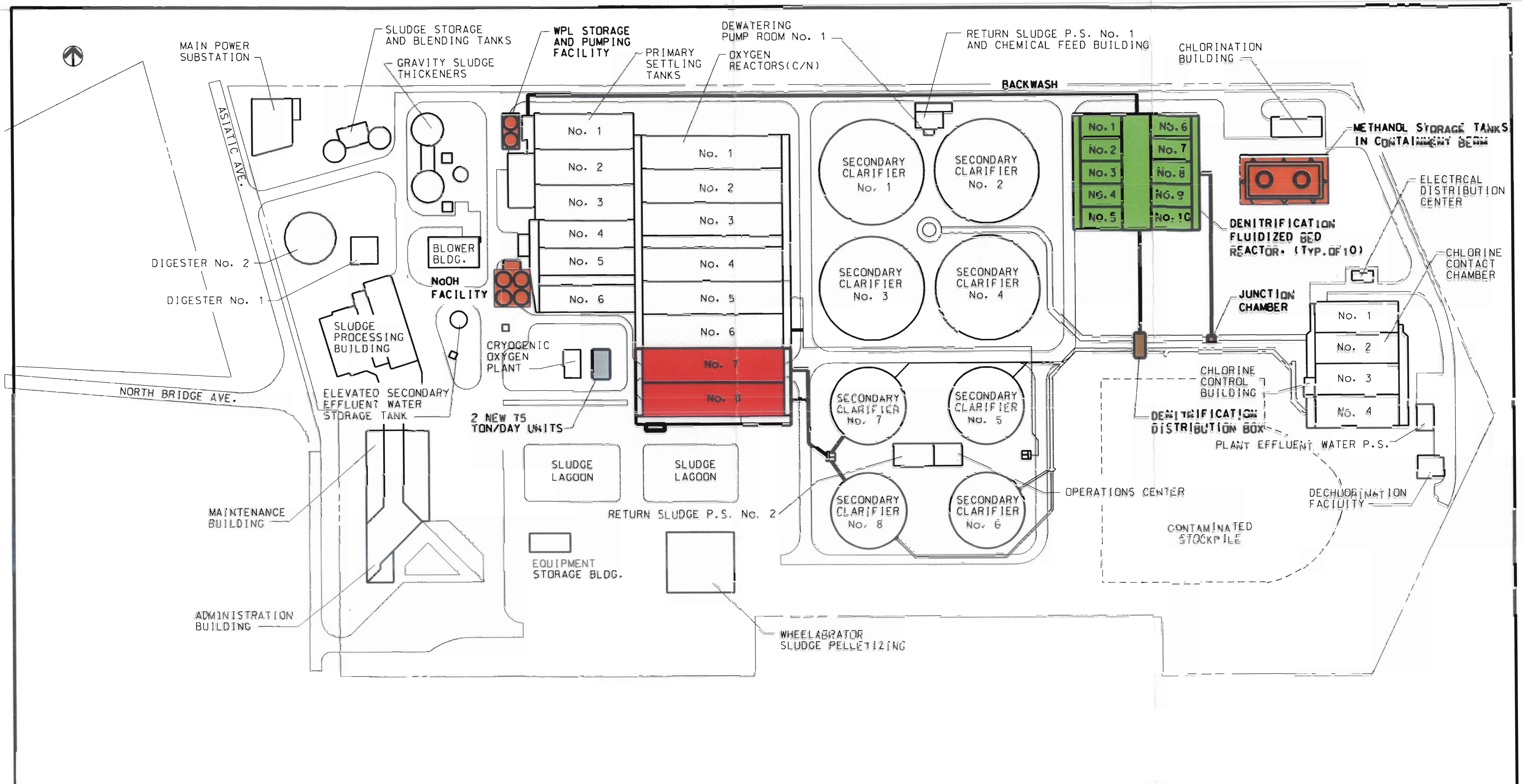
C/N CARBONACEOUS/NITRIFICATION
M METHANOL
NaOH SODIUM HYDROXITE
WPL WASTE PICKLE LIQUOR
TN TOTAL NITROGEN
⬭ FLOW, MGD

COMPREHENSIVE WASTEWATER FACILITIES
MASTER PLAN
PATAPSCO
WASTEWATER TREATMENT PLANT

CONCEPTUAL DIAGRAM
ALTERNATIVE 3

WHITMAN, REQUARDT AND ASSOCIATES, LLP

DATE: APRIL 2004 | SCALE: NONE | FIGURE: 6-3A

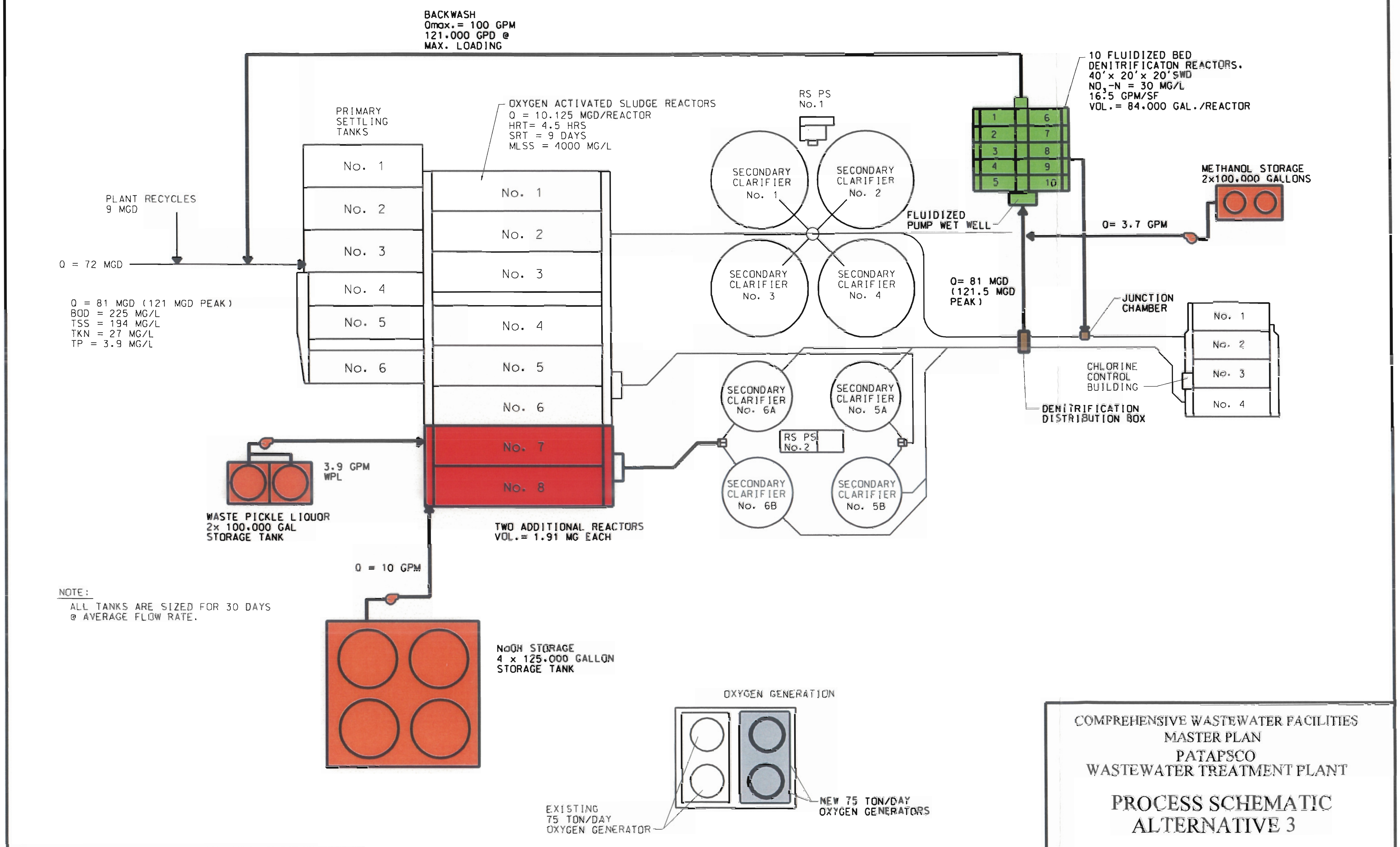


COMPREHENSIVE WASTEWATER FACILITIES
MASTER PLAN
PATAPSCO
WASTEWATER TREATMENT PLANT

SITE PLAN
ALTERNATIVE 3

DATE: APRIL 2004 | SCALE: 1"= 200' | FIGURE: 6-3B

WHITMAN, REQUARDT AND ASSOCIATES, LLP



COMPREHENSIVE WASTEWATER FACILITIES
MASTER PLAN
PATAPSCO
WASTEWATER TREATMENT PLANT

PROCESS SCHEMATIC
ALTERNATIVE 3

DATE: APRIL 2004	SCALE: 1"= 200'	FIGURE: 6-3C

WHITMAN, REQUARDT AND ASSOCIATES, LLP

TABLE 6-3A
PATAPSCO WASTEWATER TREATMETN PLANT
ALTERNATIVE 3: DESIGN ASSUMPTIONS

Unit Process	Parameters	Criteria
NaOH Metering	NaOH Dose	14,400 gpd
	Storage	4 – 33' diameter x 20' height ~500,000 gallons of storage
	Metering Pump Size	10 gpm fractional horsepower metering pump
Waste Pickle Liquor (WPL) Metering	WPL Dose	5620 gpd
	Storage	2- 30' diameter x 20' height ~200,000 gallons of storage
	Metering Pump Size	3.9 gpm fractional horsepower metering pump
Existing Secondary Reactors 1-6	Average Daily Flow	61 MGD
	Peak Dry Weather Flow	91.5 MGD
	Nitrification Zone	11.46 MG
	Total Reactor Volume	11.46 MG
	Number of Reactors	6
	Design HRT	4 hours
	Design SRT	9 days
	Installed Mixing Capacity	3 x 125 HP mixers in each aerated zone of each reactor, 4 x 5 HP mixers in
	Clarifiers	Four existing 210' diameter clarifiers from SC 582 and two of the 155'
	Clarifier Overflow Rate	600 gpd/sf
	Solids Flux Loading Rate	301 lbs /sf/day
	MLSS Design	4000 mg/l
	Sludge Waste Production	No additional production[1]
	Underflow Solids	10,000 mg/l
	RAS Flow (% Avg. Flow)	Up to 100%
	Oxygen Required	96 tons/day
New Secondary Reactors 7 - 8	Average Daily Flow	20 MGD
	Peak Dry Weather Flow	30 MGD
	Nitrification Zone	3.82 MG
	Total Reactor Volume	3.82 MG
	Number of Reactors	2
	Design HRT	4 hours
	Design SRT	9 days
	Installed Mixing Capacity	4 x 125 HP mixers in each of the four aerated zones of each reactor
	Clarifiers	Two existing 155' diameter clarifiers from SC 690

TABLE 6-3A (CONTINUED)

Unit Process	Parameters	Criteria
New Secondary Reactors 7 - 8	Clarifier Overflow Rate	600 gpd/square foot (sf)
	Solids Flux Loading Rate	301 lbs /sf/day
	MLSS Design	4000 mg/l
	Sludge Waste Production	No additional production
	Underflow Solids Concentration	10,000 mg/l
	RAS Flow (% Avg. Flow)	Up to 100%
	Oxygen Required	32 tons/day
Oxygen Generation	Existing Capacity	Two 75-ton O_2 generators
	New Capacity	Two 75-ton O_2 generators
Methanol Metering	Methanol Dose	5,338 gpd
	Storage	2- 30' diameter x 20' height ~200,000 gallons of storage
	Metering Pump Size	3.7 gpm fractional horsepower metering pump
Fluidized Bed Denitrification Reactors 1 -10	Average Daily Flow	81 MGD
	Peak Dry Weather Flow	121.5 MGD
	Number of Reactors	10
	Reactor Dimensions	20' x 40' x 20' SWD
	Fluidized Bed Depth	14'
	Settled Bed Depth	7'
	Fluidization Pumps	230 BHP @50'TDH per reactor
	Reactor Flux	16.5 gpm / ft^2
	Nominal fluidization flow	13,200 gpm (19 MGD)
	Growth Control Pumps	5 pumps – 3HP each
	Mud Well Pumps	2 pumps – 1000 gpm @ 20' TDH (max)
	Estimated Biomass Yield	0.6 lb VSS / lb NO_3-N removed
	Waste Biomass Volume	121,500 gpd / reactor (max load); 72,900 gpd / reactor (average load)
	Waste Biomass	2000 mg/l
	Solids Production	20,300 lbs / day (max load); 12,200 lbs / day (average load)
	Maximum instantaneous	100 gpd / reactor

[1] The extended sludge retention time necessary for Nitrification results in a slight net loss in solids production as compared with the current process of carbonaceous BOD removal.

TABLE 6-3B

PATAPSCO WASTEWATER TREATMENT PLANT

ALTERNATIVE 3: OPERATION AND MAINTENANCE ASSUMPTIONS

Unit Process	Assumptions
New Oxygen Activated Sludge Reactors	125 HP mixers x 4 zones x 2 reactors = 1000 HP of total mixing capacity
New Denitrification FBR feed pumps	10 x 230 HP total of 2300 HP @ 100% duty
FBR growth pumps	5 x 3HP; total of 15 HP @ 100% duty
Denitrification Mud Well Pumps	1 x 10 HP total of 20 HP @ 75% duty cycle
Methanol dose / feed rate	52 mg CH3OH / L; 5,338 gpd
Sodium Hydroxide dose / feed rate	137mg NaOH/L; 14,500 gpd @ 50% strength
Waste Pickle Liquor (WPL) dose / feed rate	84 mg WPL / L wastewater; 5621 gpd

	PROCESS	CAPITAL ($M)	SALVAGE ($M)	ANNUAL COSTS ($M)				
				OPERATING			MAINT.	TOTAL
				LABOR	ENERGY	CHEMICAL		
1	Existing Oxygen Activated Sludge Reactors 1-6	0.00	46.90	0.92	1.10		2.46	4.48
2	Oxygen Activated Sludge Reactors 7-8	23.08	6.92		0.46		0.46	0.92
3	Liquid Oxygen Generators (Existing)	0.00	0.00	0.17	0.84		1.72	2.73
4	Liquid Oxygen Generators (New)	30.74	9.22		0.84		1.72	2.56
5	NaOH Storage and Feed Facility	1.78	0.53	0.05		10.10	0.04	10.19
6	Methanol Storage and Feed Facility	0.66	0.20	0.05		2.70	0.01	2.76
7	Waste Pickle Liquor Facility	0.66	0.20	0.05		0.05	0.01	0.11
8	Fluidized Bed DN Reactors	62.61	18.78	0.17	0.90		1.25	2.32
9								
10								
11								
12								
13								
14								
15								
16								
17								
18								
19								
	TOTALS	T1= 119.53	T2= 82.75	1.41	4.14	12.85	7.67	T3= 26.07

$M - Millions of Dollars

PRESENT WORTH COST DETERMINATION

1. PRESENT WORTH FACTORS
   - F1 = SINGLE PAYMENT, 20 YEARS, 7% = 0.25842
   - F2 = UNIFORM SERIES, 20 YEARS, 7% = 10.59401

2. PRESENT WORTH BASIS
   - A. CAPITAL COST: (T1) $119.53
   - B. SALVAGE COST: (-) (F1 X T2) -$21.39
   - C. ANNUAL O&M COST: (F2 X T3) $276.21

TOTAL PRESENT WORTH = $374.35

NOTES:
ENR INDEX = 6300
DN = Denitrification
C/N = Carbonaceous / Nitrification

COMPREHENSIVE WASTEWATER FACILITIES MASTER PLAN

PATAPSCO WASTEWATER TREATMENT PLANT

SUMMARY OF ESTIMATED COSTS ALTERNATIVE 3

HITMAN, REQUARDT AND ASSOCIATES, LLP | SEPTEMBER 2002 | TABLE 6-3C

6.8.5. Alternative 4: Carbon Oxidation/Nitrification and Deep Bed Denitrification Filter (Downflow)

Process Description

The downflow denitrification filter is one of the most commonly used attached growth denitrification methods. The largest plant using this technology to date is the 96-mgd Hookers Point Plant in Tampa Bay, Florida. The downflow filter is very similar to a tertiary deep bed sand filter with the exception of making the necessary modifications to foster the growth of denitrifying biomass. Under the right conditions, denitrifying biomass becomes fixed to the media in the filter and as wastewater passes through the filter, nitrified wastewater is denitrified producing nitrogen gas, carbon dioxide and more biomass. As the biomass growth and quantity of nitrogen gas increases, the flow rate through the filter decreases or the head loss through the filter increases. Therefore the filters require back washing. Backwashing of the filters includes the reverse flow of effluent as well as an air scour to aid in the removal of excess biomass from the media. A portion of the backwash is returned to filters for reseeding however the majority of the backwash waste would be recycled through the primary clarifier. A practice known as bumping the filter is also used to decrease the head loss through the filter and maximize its throughput. As denitrification occurs, nitrogen gas accumulates among the packed media. These nitrogen gas bubbles need to be periodically released from the media by taking the filter off line and applying backwash water for a few seconds. This bumping process has also been termed nitrogen release cycle (NRC).

Some of the advantages of the downflow denitrification filters include, the additional removal of suspended solids producing a very clean effluent with turbidities in the range of 0.5 NTU's. Another advantage is a very small footprint as compared with a suspended growth system that requires further clarification. Lastly, the deep bed downflow denitrification filter has proven successful in producing effluents with TN $\leq$ 3 mg/l.

The disadvantages of the downflow filters are that compared with other attached growth technologies, it requires a large area of land. This is in part due to the low loading rates (1-2 gpm/ft2) allowable. Additional disadvantages include increased operation and maintenance costs incurred by using the backwash pump and blower and an increase to the overall recycle volume due to the numerous backwashes required. Lastly this process is proprietary and would require additional costs for licensing.

The design concept would be similar to that of the fluidized bed reactor design, where the existing oxygen activated sludge reactors would be converted to conduct both carbonaceous BOD removal as well as complete nitrification (C/N). The nitrified effluent from the secondary clarifiers would then be diverted into a separate denitrification step.

Figures 6-4A, 6-4B and 6-4C show the concept diagram, site plan and process schematic, respectively for the application of a downflow denitrification filter at Patapsco Wastewater Treatment Plant.

Due to the modifications of the existing oxygen activated sludge reactors in this alternative, the existing AO process would be eliminated. This modification would necessitate an alternative method of phosphorous removal. A chemical method of phosphorous removal using metal salts, as the precipitant is a known method and is successfully being employed by Back River Wastewater Treatment Plant. A variety of metal salts can reliably precipitate phosphorous from the wastewater including alum, aluminate, ferric chloride, ferrous chloride and ferrous sulfate. Back River currently uses Ferrous Chloride ($FeCl_2$) in the form of waste pickle liquor. This form of phosphorous removal has been incorporated into the design concept for this alternative.

Design Assumptions

Table 6-4A lists the design assumptions for the downflow denitrification filter alternative. As shown, the existing oxygen activated sludge reactors would be converted into combined carbonaceous oxidation - nitrification (C/N) reactors. The additional two reactors, of the same dimension, would be required to provide complete nitrification. Additionally, more oxygen would be required for the combined C/N reactors. Approximately 128 tons O_2 / day would be required. This quantity of oxygen necessitates additional oxygen generation capacity. The current O_2 capacity at Patapsco Wastewater Treatment Plant is 150 tons / day. To provide the existing redundancy, this capacity should be doubled to 300 tons / day. The existing clarifiers would be sufficient in size to handle the flows however; the distribution of MLSS would require modification such that each clarifier serviced one of the eight reactors. Following clarification, the secondary effluent would be diverted through a distribution structure to the denitrification reactors.

The nitrified wastewater would enter a lift station to provide the necessary head for gravity flow through the filters. Methanol would be pumped into the discharge of the lift pumps with the discharge ending in the filter distribution piping. The downflow denitrification filters would consist of a building that would house all twenty filters with a common pipe gallery and control room. A portion of the filter effluent would be held in a clearwell for use as backwash while the rest would flow via gravity into the existing chlorination / dechlorination facility.

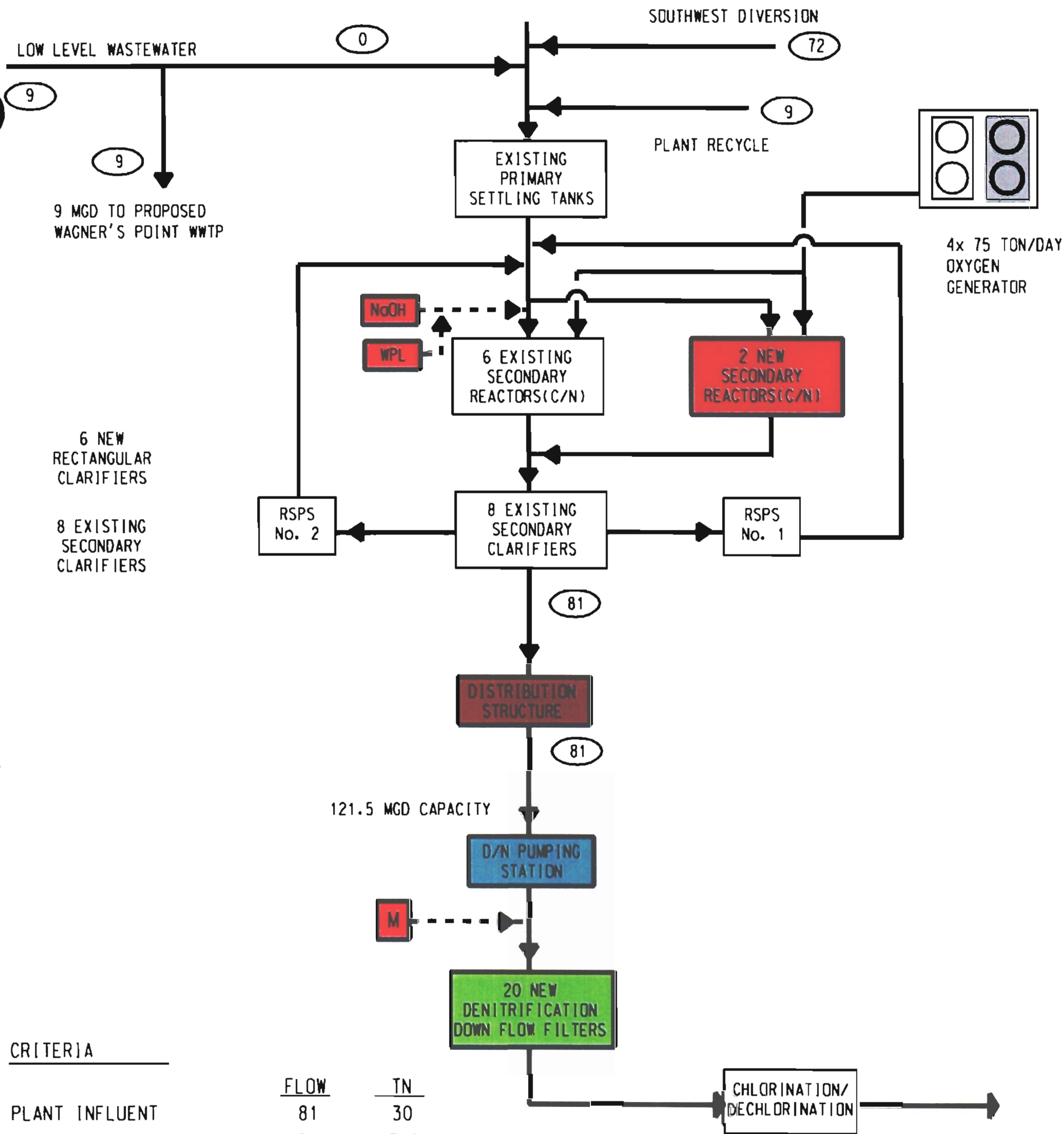
Operation and Maintenance Assumptions

Operation and maintenance assumptions are shown in Table 6-4B. Labor and maintenance costs are based on both existing and new equipment operating at the average flow of 81 mgd. Energy and chemical costs are based on 24-hour operation at the average flow of 81 mgd. Motor sizing for the various mixers and pumps were based on these criteria as well. It was assumed that the low-level waste waster (approximately 9 mgd) would be treated separately at the proposed Wagners Point WWTP and the effluent from this will recombine with the Patapsco effluent prior to discharge (Project No. 877). The remaining 72 mgd plus plant recycles ($\approx$ 9-mgd) would then be treated at the existing facility. Phosphorous removal would be through chemical addition of waste pickle liquor (WPL) or Ferrous Chloride $FeCl_2$. The dose of the WPL was based on its successful use at the Back River Wastewater Treatment Plant. Approximately 22 lbs. WPL / lb of phosphorous removed is the current feed rate at Back River WWTP. Sodium Hydroxide (NaOH) would be added to both adjust the pH and provide the necessary alkalinity for complete nitrification. The NaOH dose was based on providing 7.4 lb of alkalinity per lb of ammonia oxidized in the nitrification step. Based on the inherent alkalinity of the wastewater, it was determined that approximately 136 mg/l of NaOH was necessary to make up the difference necessary for nitrification and pH adjustment. Methanol addition was base upon 2.5 parts per million of methanol per mg/l of nitrate removed plus 0.9 part per million methanol for every part per million of dissolved oxygen remaining plus 3 parts per million as a safety factor in the wastewater. This totaled 52 parts per million or approximately 5,338 lbs. methanol per day for an influent rate of 81 mgd.

Operating and maintenance costs are based on current labor costs at Patapsco WWTP. Energy costs are based on horsepower estimates for various items of equipment. Maintenance costs are based on 2% per year of the estimated mechanical equipment cost. Chemical costs for sodium hydroxide and methanol were based on suppliers' estimates. Waste pickle liquor costs are based upon current costs at Back River Wastewater Treatment Plant.

Cost Estimates

Cost estimates are summarized in Table 6-4C.



CRITERIA

	FLOW	TN
PLANT INFLUENT	81	30
PATAPSCO RIVER DISCHARGE	81	3-6

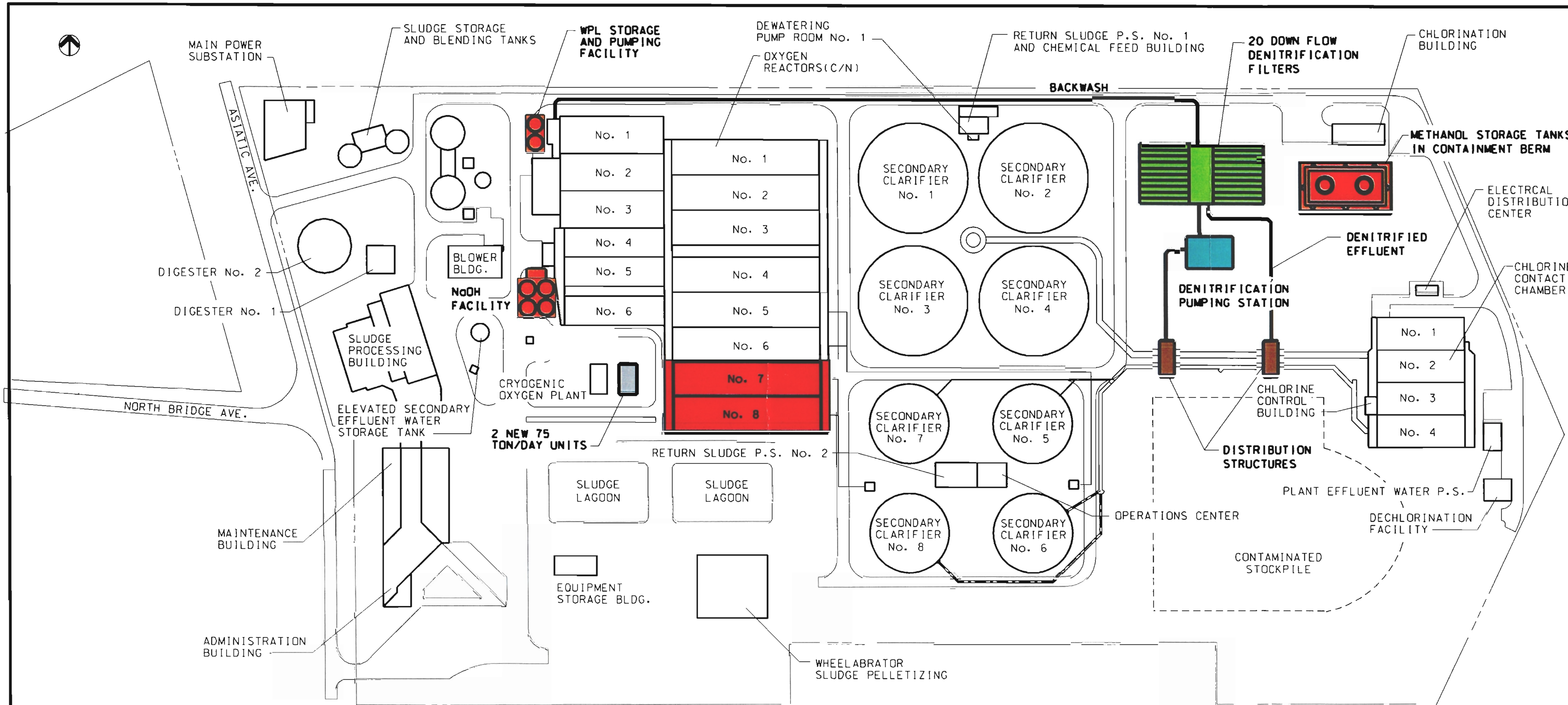
LEGEND

- C/N CARBONACEOUS/NITRIFICATION
- DN DENITRIFICATION
- WPL WASTE PICKLE LIQUOR
- M METHANOL
- NaOH SODIUM HYDROXITIE
- TN TOTAL NITROGEN
- (oval) FLOW, MGD

COMPREHENSIVE WASTEWATER FACILITIES
MASTER PLAN
PATAPSCO
WASTEWATER TREATMENT PLANT

CONCEPTUAL DIAGRAM
ALTERNATIVE 4

WHITMAN, REQUARDT AND ASSOCIATES, LLP	DATE: APRIL 2004	SCALE: NONE	FIGURE: 6-4A

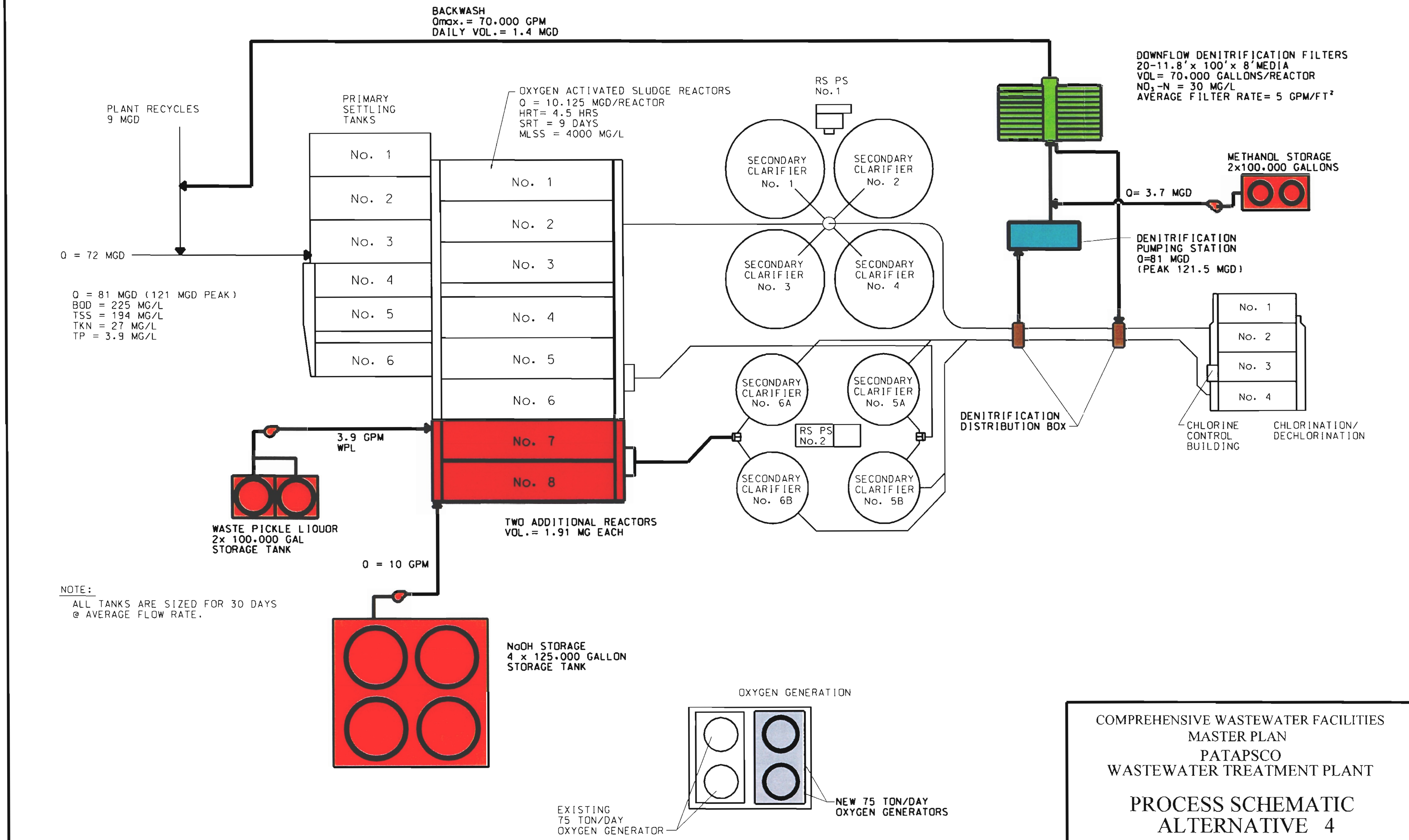


COMPREHENSIVE WASTEWATER FACILITIES
MASTER PLAN
PATAPSCO
WASTEWATER TREATMENT PLANT

SITE PLAN
ALTERNATIVE 4

DATE: APRIL 2004	SCALE: 1"= 200'	FIGURE: 6-4B

WHITMAN, REQUARDT AND ASSOCIATES, LLP



COMPREHENSIVE WASTEWATER FACILITIES
MASTER PLAN
PATAPSCO
WASTEWATER TREATMENT PLANT

PROCESS SCHEMATIC
ALTERNATIVE 4

DATE: APRIL 2004	SCALE: 1"= 200'	FIGURE: 6-4C

WHITMAN, REQUARDT AND ASSOCIATES, LLP

TABLE 6-4A

PATAPSCO WASTEWATER TREATMETN PLANT

ALTERNATIVE 4: DESIGN ASSUMPTIONS

Unit Process	Parameters	Criteria
NaOH Metering	NaOH Dose	14,400 gpd
	Storage	4 – 33' diameter x 20' height ~500,000 gallons of storage
	Metering Pump Size	10 gpm fractional horsepower metering pump
Waste Pickle Liquor (WPL) Metering	WPL Dose	5620 gpd
	Storage	2- 30' diameter x 20' height ~200,000 gallons of storage
	Metering Pump Size	3.9 gpm fractional horsepower metering pump
Existing Secondary Reactors 1-6	Average Daily Flow	61 MGD
	Peak Dry Weather Flow	91.5 MGD
	Nitrification Zone	11.46 MG
	Total Reactor Volume	11.46 MG
	Number of Reactors	6
	Design HRT	4 hours
	Design SRT	9 days
	Installed Mixing Capacity	3 x 125 HP mixers in each aerated zone of each reactor, 4 x 5 HP mixers in the first zone of each reactor
	Clarifiers	Four existing 210' diameter clarifiers from SC 582 and two of the 155' diameter clarifiers from SC 690
	Clarifier Overflow Rate	600 gpd/sf
	Solids Flux Loading Rate	301 lbs /sf/day
	MLSS Design	4000 mg/l
	Sludge Waste Production	No additional production[1]
	Underflow Solids Concentration	10,000 mg/l
	RAS Flow (% Avg. Flow)	Up to 100%
	Oxygen Required	96 tons/day
New Secondary Reactors 7 - 8	Average Daily Flow	20 MGD
	Peak Dry Weather Flow	30 MGD
	Nitrification Zone	3.82 MG

TABLE 6-4A (CONTINUED)

Unit Process	Parameters	Criteria
New Secondary Reactors 7 - 8	Total Reactor Volume	3.82 MG
	Number of Reactors	2
	Design HRT	4 hours
	Design SRT	9 days
	Installed Mixing Capacity	4 x 125 HP mixers in each of the four aerated zones of each reactor
	Clarifiers	Two existing 155' diameter clarifiers from SC 690
	Clarifier Overflow Rate	600 gpd/square foot (sf)
	Solids Flux Loading Rate	301 lbs /sf/day
	MLSS Design	4000 mg/l
	Sludge Waste Production	No additional production
	Underflow Solids Concentration	10,000 mg/l
	RAS Flow (% Avg. Flow)	Up to 100%
	Oxygen Required	32 tons/day
Denitrification Pumping Station	New Pumps	81 MGD @ 25' TDH – 7 x 100 HP 121.5 MGD (Peak) @ 25 TDH – 10 x 100 HP
Oxygen Generation Methanol Metering	Existing Capacity	Two 75-ton O_2 generators
	New Capacity	Two 75-ton O_2 generators
	Methanol Dose	5,338 gpd
Down Flow Denitrification Filters 1 -20	Storage	2- 30' diameter x 20' height ~200,000 gallons of storage
	Metering Pump Size	3.7 gpm fractional horsepower metering pump
	Average Daily Flow	81 MGD
	Peak Dry Weather Flow	121.5 MGD
	Number of Filters	20
	Reactor Filters	11'8" x 100' x 10' SWD
	Media Bed Depth	8' deep
	Back Wash Pumps	2 x 100 HP @ 23 feet
	Back Wash	2 x 350 HP @ 10 psig
	Back Wash Frequency	2.05 days / reactor
	Bump (NRC) Frequency	3.7 hrs / reactor
	Mud Well Pumps	2 x 15 HP @ 20 feet
	Estimated Biomass Yield	0.5 lb VSS / lb NO_x-N reduced

TABLE 6-4A (CONTINUED)

Unit Process	Parameters	Criteria
Down Flow Denitrification Filters 1 -20	Effective MLSS	20,000 mg/l
	Waste Biomass	1,300 mg/l
	Solids Production	5,000 lbs / day
	Maximum instantaneous	7000 gallons / minute
	Daily Backwash Volume	1.4 MGD

[1] The extended sludge retention time necessary for nitrification results in a slight net loss in solids production as compared with the current process of carbonaceous BOD removal.

TABLE 6-4B

PATAPSCO WASTEWATER TREATMENT PLANT

ALTERNATIVE 4: OPERATION AND MAINTENANCE ASSUMPTIONS

Unit Process	Assumptions
New Oxygen Activated Sludge Reactors	125 HP mixers x 4 zones x 2 reactors = 1000 HP of total mixing capacity
Lift Pumps	7 x 100 HP
Back Wash Pumps	2 x 70 HP @ 40% duty
Back Wash Blower	2 x 327 HP @ 40% duty
Mud Well Pumps	2 x 15 HP @ 75% duty cycle
Methanol dose / feed rate	52 mg CH3OH / L; 5,338 gpd
Sodium Hydroxide dose / feed rate	137mg NaOH/L; 14,500 gpd @ 50% strength
Waste Pickle Liquor (WPL) dose / feed rate	84 mg WPL / L wastewater; 5621 gpd

	PROCESS	CAPITAL ($M)	SALVAGE ($M)	ANNUAL COSTS ($M)				
				OPERATING			MAINT.	TOTAL
				LABOR	ENERGY	CHEMICAL		
1	Existing Oxygen Activated Sludge Reactors 1-6	0.00	46.90	0.92	1.10		2.46	4.48
2	Oxygen Activated Sludge Reactors 7-8	23.08	6.92		0.46		0.46	0.92
3	Liquid Oxygen Generators (Existing)	0.00	0.00	0.17	0.84		1.72	2.73
4	Liquid Oxygen Generators (New)	30.74	9.22		0.84		1.72	2.56
5	NaOH Storage and Feed Facility	1.78	0.53	0.05		10.10	0.04	10.19
6	Methanol Storage and Feed Facility	0.66	0.20	0.05		2.70	0.01	2.76
7	Waste Pickle Liquor Facility	0.66	0.20	0.05		0.05	0.01	0.11
8	Denitrification Pumping Station	23.80	7.14	0.04	0.27		0.48	0.79
9	Deep Bed DN Filters (Downflow)	41.02	12.31	0.17	0.13		0.82	1.12
10								
11								
12								
13								
14								
15								
16								
17								
18								
19								
20								
21								
22								
	TOTALS	T1= 121.74	T2= 83.42	1.45	3.64	12.85	7.72	T3= 25.66

$M - Millions of Dollars

PRESENT WORTH COST DETERMINATION

1. PRESENT WORTH FACTORS
   F1 = SINGLE PAYMENT, 20 YEARS, 7% = 0.25842
   F2 = UNIFORM SERIES, 20 YEARS, 7% = 10.59401

2. PRESENT WORTH BASIS
   A. CAPITAL COST: (T1) $121.74
   B. SALVAGE COST: (-) (F1 X T2) -$21.56
   C. ANNUAL O&M COST: (F2 X T3) $271.80

TOTAL PRESENT WORTH = $371.99

NOTES:
ENR INDEX = 6300
DN = Denitrification
C/N = Carbonaceous / Nitrification

COMPREHENSIVE WASTEWATER FACILITIES MASTER PLAN

PATAPSCO WASTEWATER TREATMENT PLANT

SUMMARY OF ESTIMATED COSTS ALTERNATIVE 4

WHITMAN, REQUARDT AND ASSOCIATES, LLP | SEPTEMBER 2002 | TABLE 6-4C

6.8.6. Alternative 5: Carbon Oxidation/Nitrification and Deep Bed Denitrification Filter (Upflow)

Process Description

The upflow denitrification filter is a fixed bed biological filter with the wastewater flow being pumped upward through the filter. The tightly packed media does not allow for expansion but rather acts as a fixed media bed for bacteria to affix and proliferate. The bacteria (biomass) can become very concentrated and active which allows for high throughput of waste while attaining clean effluent. Retained wastewater solids and excess biomass are removed from the media through periodic multi-sequence air/water backwashes in the upflow direction. The backwash water would then be returned to the primary settling tanks for the removal of solids.

Some of the advantages of upflow denitrification filters include the additional removal of suspended solids producing a very clean effluent. Another advantage is a very small footprint as compared with a suspended growth system that requires further clarification. One other advantage is that nitrogen gas (byproduct of denitrification) is constantly purged with the flow of wastewater, where in downflow filters it becomes trapped within the media and requires frequent bumping (see Alternative 3). Lastly, the upflow denitrification filter has proven successful in producing effluents with TN levels ≤ 3 mg/l.

A disadvantage of the upflow filters is that the backwash pump and blower increase the operation and maintenance costs in addition to adding to the overall recycle volume. Another disadvantage, this process is proprietary, and would require additional costs for licensing.

The design concept is similar to that of the downflow filters, where the existing oxygen activated sludge reactors would be converted to conduct both carbonaceous BOD removal as well as complete nitrification (C/N). The nitrified effluent from the secondary clarifiers would then be diverted into a separate denitrification step requiring a denitrification pumping station to produce the head necessary to discharge the final effluent into the Patapsco River.

Figure 6-5A, 6-5B and 6-5C show a concept diagram, site plan and process schematic, respectively for Alternative 5.

Due to the modifications of the existing oxygen activated sludge reactors in this alternative, the existing AO process would be eliminated. This modification would necessitate an alternative method of phosphorous removal. A chemical method of phosphorous removal using metal salts, as the precipitant is a known method and is successfully being employed by Back River Wastewater Treatment Plant. A variety of metal salts can reliably precipitate phosphorous from the wastewater including alum, aluminate, ferric chloride, ferrous chloride and ferrous sulfate. Back River currently uses Ferrous Chloride ($FeCl_2$) in the form of waste pickle liquor. This form of phosphorous removal has been incorporated into the design concept for this alternative.

Design Assumptions

Table 6-5A lists the design criteria for the upflow denitrification filter alternative. As shown, the existing oxygen activated sludge reactors would be converted into combined carbonaceous oxidation - nitrification (C/N) reactors. The additional two- (2) reactors, of the same dimension, would be required to provide complete nitrification. Additionally, more oxygen would be required for the combined C/N reactors. Approximately 128 tons O_2 / day would be required for the average daily flow. The current O_2 capacity is 150 tons / day and to provide the existing level of redundancy, this capacity should be doubled to 300 tons / day. The existing clarifiers would be sufficient in size to handle the flows however; the distribution of MLSS would require modification such that each clarifier serviced one of the eight reactors. Following clarification the secondary effluent would be diverted through a distribution structure to the denitrification facilities.

Within the denitrification facilities, the nitrified wastewater would enter a pumping station to provide the necessary head to flow upward through the filters. Methanol, or an alternate source of nitrogen free, readily biodegradable material, would be pumped into the discharge of the pumps. The discharged wastewater would flow into the filter distribution piping. The upflow denitrification filters would consist of a building that would house all six filters with a common pipe gallery and control room. A portion of the filter effluent would be held in a clearwell for use as backwash while the rest would flow via gravity into the existing chlorination / dechlorination facility.

Operation and Maintenance Assumptions

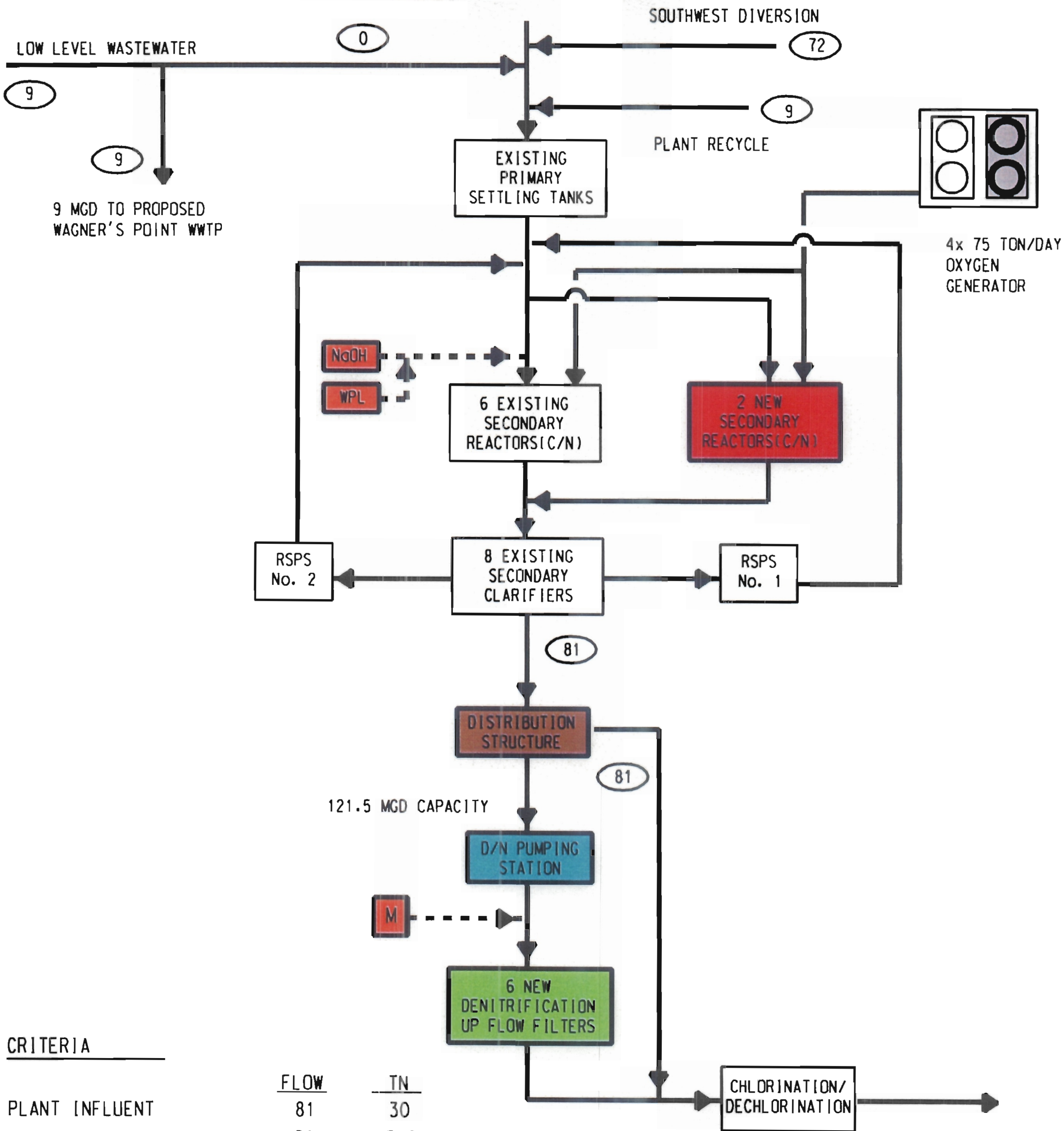
Operation and maintenance assumptions are listed on Table 6-5B.

Labor and maintenance costs are based on both existing and new equipment operating at the average flow of 81 mgd. Energy and chemical costs are based on 24-hour operation at the average flow of 81 mgd. Motor sizing for the various mixers and pumps were based on these criteria as well. It was assumed that the low-level waste waster (approximately 9 mgd) would be treated separately at the proposed Wagners Point WWTP and the effluent from this will recombine with Patapsco effluent prior to discharge. (Project No. 877). The remaining 72 mgd plus plant recycles (≈ 9-mgd) would then be treated at the existing facility. Phosphorous removal would be through chemical addition of waste pickle liquor (WPL) or Ferrous Chloride $FeCl_2$. The dose of the WPL was based on its successful use at the Back River Wastewater Treatment Plant. Approximately 22 lbs. WPL / lb of phosphorous removed is the current feed rate at Back River WWTP. Sodium Hydroxide (NaOH) would be added to both adjust the pH and provide the necessary alkalinity for complete nitrification. The NaOH dose was based on providing 7.4 lb of alkalinity per lb of ammonia oxidized in the nitrification step. Based on the inherent alkalinity of the wastewater, it was determined that approximately 136 mg/l of NaOH was necessary to make up the difference necessary for nitrification and pH adjustment. Methanol addition was base upon 2.5 parts per million of methanol per mg/l of nitrate removed plus 0.9 part per million methanol for every part per million of dissolved oxygen remaining plus 3 parts per million as a safety. This totaled 52 parts per million or approximately 5,338 lbs. methanol per day for an influent rate of 81 mgd.

Operating and maintenance costs are based on current labor costs at Patapsco WWTP. Energy costs are based on horsepower estimates for various items of equipment. Maintenance costs are based on 2% per year of the estimated mechanical equipment cost. Chemical costs for sodium hydroxide and methanol were based on suppliers' estimates. Waste pickle liquor costs are based upon current costs at Back River Wastewater Treatment Plant.

Cost Estimates

Cost estimates are summarized in Table 6-5C.



CRITERIA

	FLOW	TN
PLANT INFLUENT	81	30
PATAPSCO RIVER DISCHARGE	81	3-6

LEGEND

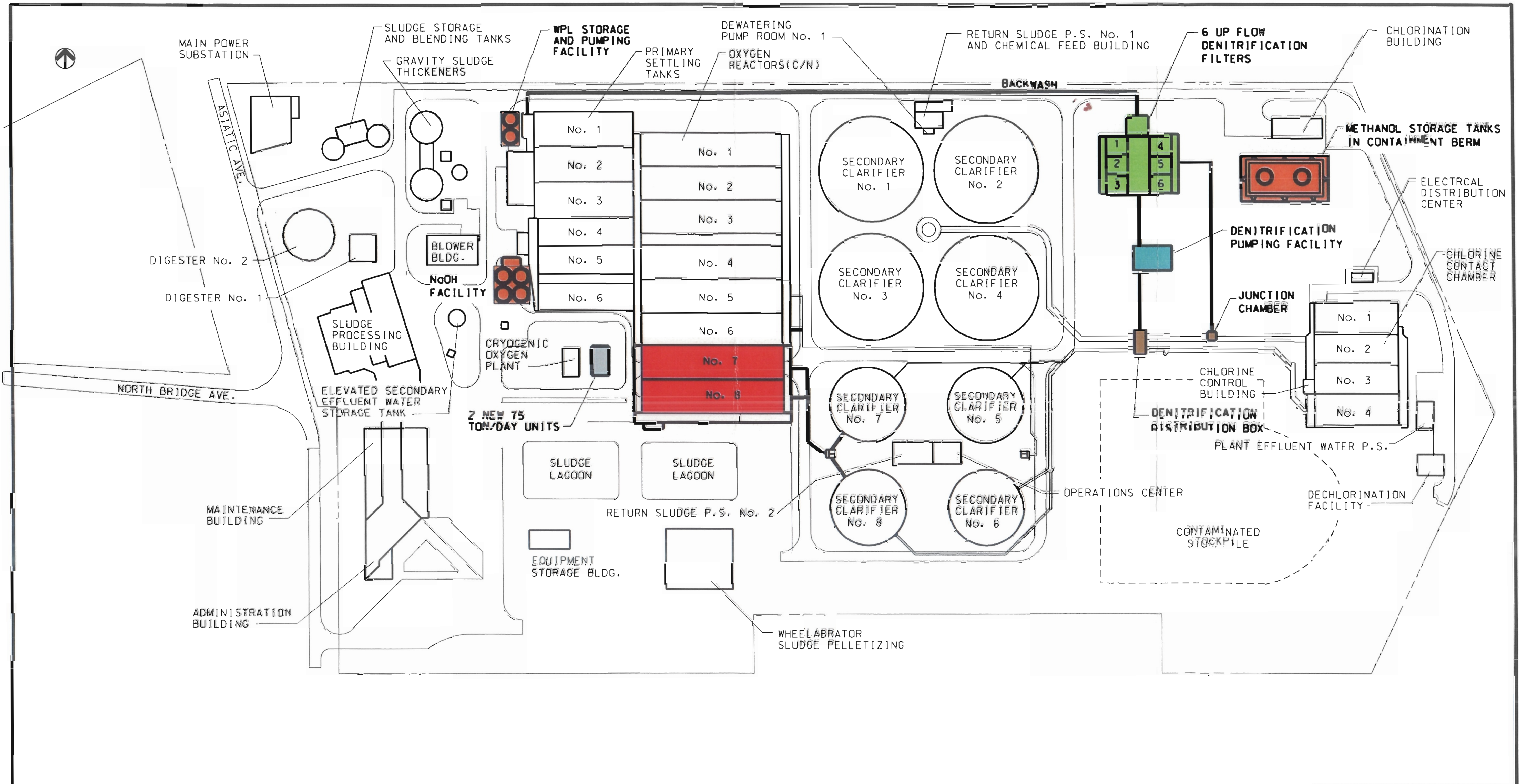
- C/N CARBONACEOUS/NITRIFICATION
- DN DENITRIFICATION
- WPL WASTE PICKLE LIQUOR
- M METHANOL
- NaOH SODIUM HYDROXITIE
- TN TOTAL NITROGEN
- ⬭ FLOW, MGD

COMPREHENSIVE WASTEWATER FACILITIES
MASTER PLAN
PATAPSCO
WASTEWATER TREATMENT PLANT

CONCEPTUAL DIAGRAM ALTERNATIVE 5

WHITMAN, REQUARDT AND ASSOCIATES, LLP

DATE: APRIL 2004	SCALE: NONE	FIGURE: 6-5A



COMPREHENSIVE WASTEWATER FACILITIES MASTER PLAN

PATAPSCO WASTEWATER TREATMENT PLANT

SITE PLAN ALTERNATIVE 5

DATE: APRIL 2004 | SCALE: 1"=200' | FIGURE: 6-5B

WHITMAN, REQUARDT AND ASSOCIATES, LLP

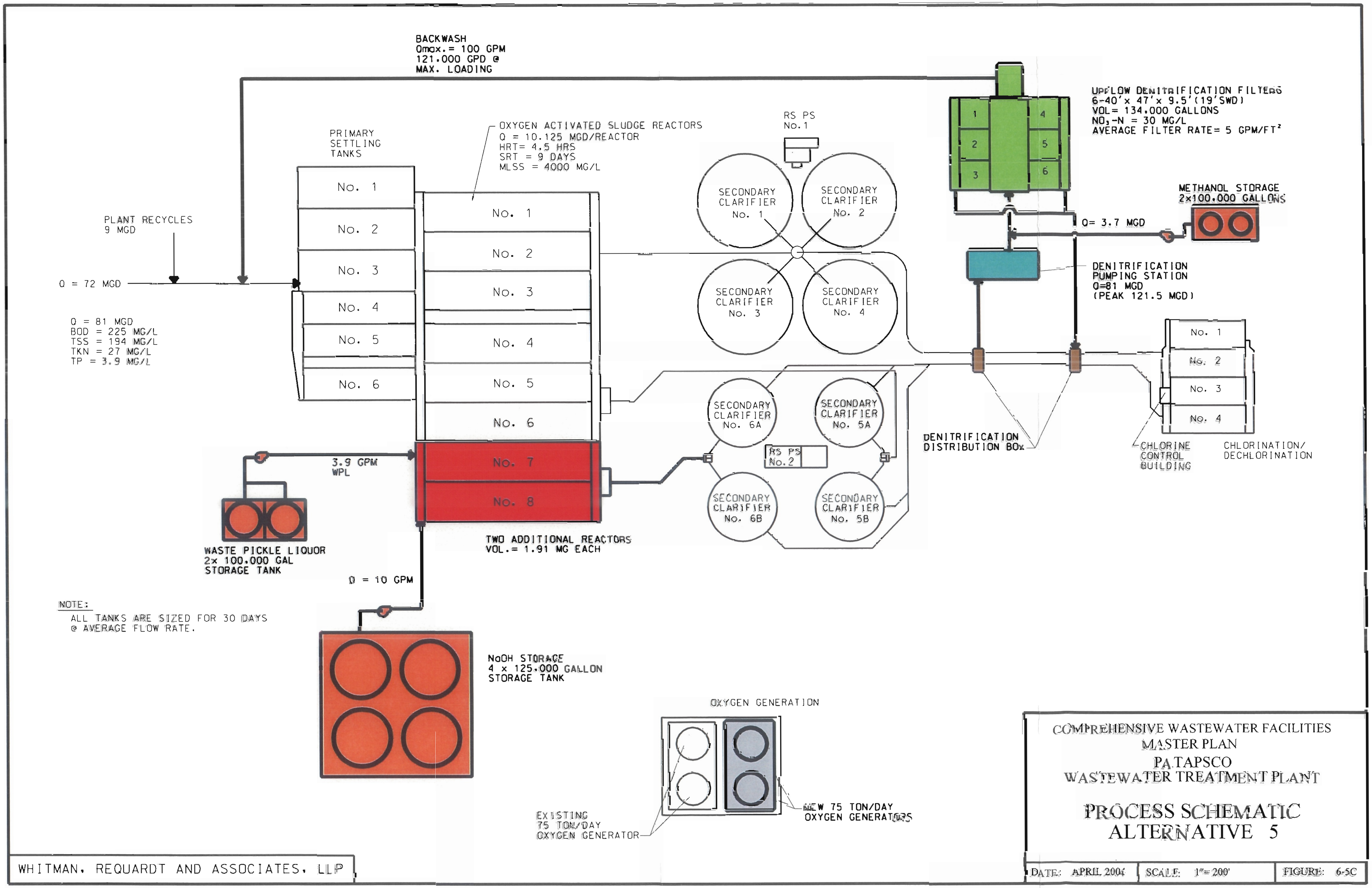

BACKWASH
Qmax.= 100 GPM
121,000 GPD @
MAX. LOADING
UPFLOW DENITRIFICATION FILTERS
6-40' x 47' x 9.5' (19' SWD)
VOL= 134,000 GALLONS
NO3-N = 30 MG/L
AVERAGE FILTER RATE= 5 GPM/FT²
PRIMARY SETTLING TANKS
OXYGEN ACTIVATED SLUDGE REACTORS
Q = 10.125 MGD/REACTOR
HRT= 4.5 HRS
SRT = 9 DAYS
MLSS = 4000 MG/L
RS PS No. 1
SECONDARY CLARIFIER No. 1
SECONDARY CLARIFIER No. 2
SECONDARY CLARIFIER No. 3
SECONDARY CLARIFIER No. 4
METHANOL STORAGE
2x100,000 GALLONS
Q= 3.7 MGD
PLANT RECYCLES
9 MGD
Q = 72 MGD
DENITRIFICATION PUMPING STATION
Q=81 MGD
(PEAK 121.5 MGD)
Q = 81 MGD
BOD = 225 MG/L
TSS = 194 MG/L
TKN = 27 MG/L
TP = 3.9 MG/L
No. 1
No. 2
No. 3
No. 4
No. 5
No. 6
No. 7
No. 8
SECONDARY CLARIFIER No. 6A
SECONDARY CLARIFIER No. 5A
SECONDARY CLARIFIER No. 6B
SECONDARY CLARIFIER No. 5B
RS PS No. 2
DENITRIFICATION DISTRIBUTION BOX
CHLORINE CONTROL BUILDING
CHLORINATION/ DECHLORINATION
3.9 GPM WPL
WASTE PICKLE LIQUOR
2x 100,000 GAL
STORAGE TANK
TWO ADDITIONAL REACTORS
VOL.= 1.91 MG EACH
Q = 10 GPM
NOTE:
ALL TANKS ARE SIZED FOR 30 DAYS @ AVERAGE FLOW RATE.
NaOH STORAGE
4 x 125,000 GALLON
STORAGE TANK
OXYGEN GENERATION
EXISTING 75 TON/DAY OXYGEN GENERATOR
NEW 75 TON/DAY OXYGEN GENERATORS
COMPREHENSIVE WASTEWATER FACILITIES
MASTER PLAN
PATAPSCO
WASTEWATER TREATMENT PLANT
PROCESS SCHEMATIC
ALTERNATIVE 5
DATE: APRIL 2004
SCALE: 1"= 200'
FIGURE: 6-5C
WHITMAN, REQUARDT AND ASSOCIATES, LLP

TABLE 6-5A

PATAPSCO WASTEWATER TREATMETN PLANT

ALTERNATIVE 5: DESIGN ASSUMPTIONS

Unit Process	Parameters	Criteria
NaOH Metering	NaOH Dose	14,400 gpd
	Storage	4 – 33' diameter x 20' height ~500,000 gallons of storage
	Metering Pump Size	10 gpm fractional horsepower metering pump
Waste Pickle Liquor (WPL) Metering	WPL Dose	5620 gpd
	Storage	2- 30' diameter x 20' height ~200,000 gallons of storage
	Metering Pump Size	3.9 gpm fractional horsepower metering pump
Existing Secondary Reactors 1-6	Average Daily Flow	61 MGD
	Peak Dry Weather Flow	91.5 MGD
	Nitrification Zone	11.46 MG
	Total Reactor Volume	11.46 MG
	Number of Reactors	6
	Design HRT	4 hours
	Design SRT	9 days
	Installed Mixing Capacity	3 x 125 HP mixers in each aerated zone of each reactor, 4 x 5 HP mixers in the first zone of each reactor
	Clarifiers	Four existing 210' diameter clarifiers from SC 582 and two of the 155' diameter clarifiers from SC 690
	Clarifier Overflow Rate	600 gpd/sf
	Solids Flux Loading Rate	301 lbs /sf/day
	MLSS Design	4000 mg/l
	Sludge Waste Production	No additional production
	Underflow Solids	10,000 mg/l
	RAS Flow (% Avg. Flow)	Up to 100%
	Oxygen Required	96 tons/day
New Secondary Reactors 7 - 8	Average Daily Flow	20 MGD
	Peak Dry Weather Flow	30 MGD
	Nitrification Zone	3.82 MG
	Total Reactor Volume	3.82 MG
	Number of Reactors	2
	Design HRT	4 hours

TABLE 6-5A (CONTINUED)

Unit Process	Parameters	Criteria
New Secondary Reactors 7 - 8	Design SRT	9 days
	Installed Mixing Capacity	4 x 125 HP mixers in each of the four aerated zones of each reactor
	Clarifiers	Two existing 155' diameter clarifiers from SC 690
	Clarifier Overflow Rate	600 gpd/square foot (sf)
	Solids Flux Loading Rate	301 lbs /sf/day
	MLSS Design	4000 mg/l
	Sludge Waste Production	No additional production
	Underflow Solids Concentration	10,000 mg/l
	RAS Flow (% Avg. Flow)	Up to 100%
	Oxygen Required	32 tons/day
Denitrification Pumping Station	New Pumps	81 MGD @ 25' TDH – 7 x 100 HP 121.5 MGD (Peak) @ 25' TDH – 10 x 100 HP
Oxygen Generation	Existing Capacity	Two 75-ton O_2 generators
	New Capacity	Two 75-ton O_2 generators
Methanol Metering	Methanol Dose	5,338 gpd
	Storage	2- 30' diameter x 20' height ~200,000 gallons of storage
	Metering Pump Size	3.7 gpm fractional horsepower metering pump
Upflow Denitrification Filters 1 -6	Average Daily Flow	81 MGD
	Peak Dry Weather Flow	121.5 MGD
	Number of Filters	6
	Filters Dimensions	40' x 47' x 19' SWD
	Media Bed Depth	9,5' deep
	Back Wash Pumps	3@ 11,500 gpm @ 50 feet
	Back Wash Blowers	3, 5000 scfm @ 10.5 psig
	Back Wash Frequency	1.5 days
	Back Wash Duration	50 minutes
	Mud Well Pumps	2 x 15 HP @ 20 feet

TABLE 6-5A (CONTINUED)

Unit Process	Parameters	Criteria
Upflow Denitrification Filters 1 -6	Maximum instantaneous waste flow rate	12,000 gallons / minute
	Daily Backwash Volume	2.3 MGD

TABLE 6-5B

PATAPSCO WASTEWATER TREATMENT PLANT

ALTERNATIVE 5: OPERATION AND MAINTENANCE ASSUMPTIONS

Unit Process	Assumptions
New Oxygen Activated Sludge Reactors	125 HP mixers x 4 zones x 2 reactors = 1000 HP of total mixing capacity
Lift Pumps	7 x 100 HP
Back Wash Pumps	3 @ 200 HP @ 50% duty
Back Wash Blower	3 x 325 HP @ 50% duty
Mud Well Pumps	2 x 15 HP @ 75% duty cycle
Methanol dose / feed rate	52 mg CH3OH / L; 5,338 gpd
Sodium Hydroxide dose / feed rate	137mg NaOH/L; 14,500 gpd @ 50% strength
Waste Pickle Liquor (WPL) dose / feed rate	84 mg WPL / L wastewater; 5621 gpd

	PROCESS	CAPITAL ($M)	SALVAGE ($M)	ANNUAL COSTS ($M)				
				OPERATING			MAINT.	TOTAL
				LABOR	ENERGY	CHEMICAL		
1	Existing Oxygen Activated Sludge Reactors 1-6	0.00	46.90	0.92	1.10		2.46	4.48
2	Oxygen Activated Sludge Reactors 7-8	23.08	6.92		0.46		0.46	0.92
3	Liquid Oxygen Generators (Existing)	0.00	0.00	0.17	0.84		1.72	2.73
4	Liquid Oxygen Generators (New)	30.74	9.22		0.84		1.72	2.56
5	NaOH Storage and Feed Facility	1.78	0.53	0.05		10.10	0.04	10.19
6	Methanol Storage and Feed Facility	0.66	0.20	0.05		2.70	0.01	2.76
7	Waste Pickle Liquor Facility	0.66	0.20	0.05		0.05	0.01	0.11
8	Denitrification Pumping Station	23.80	7.14	0.04	0.27		0.48	0.79
9	DN Filters (Upflow)	20.52	6.16	0.17	0.25		0.41	0.83
10								
11								
12								
13								
14								
15								
16								
17								
18								
19								
20								
21								
22								
	TOTALS	T1= 101.24	T2= 77.27	1.45	3.76	12.85	7.31	T3= 25.37

$M - Millions of Dollars

PRESENT WORTH COST DETERMINATION

1. PRESENT WORTH FACTORS

F1 = SINGLE PAYMENT, 20 YEARS, 7% = 0.25842
F2 = UNIFORM SERIES, 20 YEARS, 7% = 10.59401

2. PRESENT WORTH BASIS

A. CAPITAL COST: (T1) $101.24

B. SALVAGE COST: (-) (F1 X T2) -$19.97

C. ANNUAL O&M COST: (F2 X T3) $268.73

TOTAL PRESENT WORTH = $350.00

NOTES:
ENR INDEX = 6300
DN = Denitrification
C/N = Carbonaceous / Nitrification

COMPREHENSIVE WASTEWATER FACILITIES
MASTER PLAN

PATAPSCO
WASTEWATER TREATMENT PLANT

SUMMARY OF ESTIMATED COSTS
ALTERNATIVE 5

WHITMAN, REQUARDT AND ASSOCIATES, LLP | SEPTEMBER 2002 | TABLE 6-5C

6.8.7. Other Alternatives

6.8.7.1. Integrated Fixed Film Activated Sludge Process

In achieving TN of 3-mg/l, addition of combined attached and suspended growth process also requires consideration. This process called integrated fixed film activated sludge process provides a greater biomass concentration in aeration basin, resulting in reduction of basin size. The packing material on which biomass grows can be suspended in the mixed liquor or a fixed module placed in the basin. In case of suspended media, the media is free floating and retained by an effluent screen. For both suspended and fixed module, solids are removed in a conventional secondary clarifier and wasting is from the return line as in an activated sludge process.

The advantage of the integrated fixed film activated sludge process is the ability to increase the loading on the existing plant without increasing solids loading onto the secondary clarifier. The SRTs are lower than those in activated sludge process without media. The process has also been used to improve volumetric nitrification rates and accomplish denitrification in aeration basins by having anoxic zones within the biofilm depth. This is based on limited full-scale studies[16].

Some of the disadvantages of this process are as follows. In the suspended media, the presence of packing material discourages the use of more efficient fine bubble systems, which would require periodic drainage of the aeration basin and removal of the packing for diffuser cleaning. In the fixed modules, achieving optimal rates can be difficult due to variation of BOD loading. Location of the fixed module is critical. Lastly these processes are proprietary and would require additional costs for licensing.

The design concept for Patapsco WWTP includes addition of integrated fixed film suspended growth process for nitrification and denitrification. The existing A/O process will reduce the carbonaceous BOD and phosphorous levels in the wastewater.

[16] Metcalf & Eddy, Inc.: *Wastewater Engineering Treatment and Reuse*, McGraw Hill, MA, 2003.

The mixed liquor from the A/O process flows to the suspended media reactors (i.e. MBBR) or the fixed modules for nitrification then denitrification. The mixed liquor from denitrification is then pumped to the existing clarifiers for solids separation. Methanol is added to the new denitrification reactors.

Both suspended media and fixed modules require further research and evaluation before they can be considered. It is also advisable to conduct on-site pilot/ demonstration testing.

6.8.7.2. Separate Carbonaceous BOD Removal, Nitrification and Denitrification

Depending upon the results of pilot/demonstration testing conducted under Project No. 877, and the apparent nitrification inhabitation characteristics of the Patapsco system wastewater, separate treatment for carbonaceous BOD removal and associated reduction in inhibitors may be necessary. Therefore, alternatives for nitrification and denitrification may be similar to Alternatives 1 through 5, but altered to suit different parameters, based on the results of testing.

6.8.8. Impact of BNR on Solids Handling Facilities

Solids production from each BNR alternative is shown in Table 6-D. Alternatives 3, 4 and 5 all produce the highest quantity of solids, at 109,600 lbs/day. This is due largely to the solids generated as a result of both methanol addition and waste pickle liquor.

6.8.9. Discussion of Alternatives

As stated earlier in this chapter, BNR alternatives were evaluated only for the purpose of establishing several feasible BNR processes, planning level space requirements and budgetary costs for the Patapsco Wastewater Treatment Plant. Detailed evaluations and process selections are anticipated to be made under Project No. 877.

Preliminary evaluations in this Plan indicate that use of deep bed filters, upflow filters, fluidized bed reactors or the moving bed biofilm reactor appear to be more economical than a MLE or separate stage suspended growth denitrification system. Space constraints at the Patapsco WWTP were a driving reason for these recommendations. The site currently occupied by the stockpiled contaminated material would be needed to accommodate either a MLE or separate sludge suspended growth system. In either case, the associated clarifiers would require siting in the stockpile area. Removal of the waste is very costly and therefore rendered those alternatives not cost-effective.

TABLE 6-D

PATAPSCO WASTEWATER TREATMENT PLANT

SOLIDS LOADING ASSUMPTIONS TO SOLIDS HANDLING FACILITIES

	Solids Loading (dry lbs/day)			
	Additional due to Methanol	**Additional due to WPL**	**Biological Process (WAS)**	**Total**
Alternative 1	N/A	27,000	42,500	67,500
Alternative 2	12,200	27,000	42,500	79,200
Alternative 3	12,200	27,000	43,400	109,600
Alternative 4	12,200	27,000	43,400	109,600
Alternative 5	12,200	27,000	43,400	109,600

WPL - Waste Pickle Liquor

N/A - Not Applicable

6.9. ESTIMATION OF MONEY AVAILABLE TO REDUCE INFLOW RATHER THAN CONVEY AND TREAT

6.9.1. Background

Various sources of inflow collectively contribute substantial amounts of extraneous water into the wastewater conveyance system and, eventually, to the Back River and Patapsco Plants. Flows that enter the system must be conveyed and treated to meet NPDES permit limits. However, to the extent practical, extraneous flows should be prevented from entering the system. The decision to reduce the amount contributed at each source of inflow should be based on comparing the cost to correct the cause of the inflow with the cost to convey, and either store the excess volume or provide additional treatment capacity for that amount of inflow. Establishing the planning level cost of treatment and storage (construction cost for the additional process units and/or temporary storage on-site) on a unit volume basis allows estimating the amount of equivalent money which could be spent to locate and correct the inflow source(s). This approach results in the most effective use of available funds.

The peak instantaneous rate of inflow contribution can also significantly impact the hydraulic capacity of the conveyance system. Another benefit from controlling inflow contributions results when it avoids the need to construct a parallel main outfall relief sewer. This evaluation is independent of the potential cost savings at the treatment plant.

6.9.2. Back River Service Area

6.9.2.1. Methodology for Estimating Allowable Expenditure to Reduce Inflow

The methodology presented hereinafter is used to estimate the allowable expenditure to locate and correct inflow sources in the conveyance system to remove one million gallons (MG) of inflow arriving at the plant within 24 hours. The Back River WWTP

201 Facility Plan, dated 1984 provides information regarding the amount of inflow, plant influent flow factors, and patterns of flow arriving at the plant. Although this data was developed in the early 1980's, it is still representative and valid for evaluating the cost of reducing inflow sources. Following are the assumptions used in developing the methodology for inflow reduction.

Assumptions

- The flow factors and patterns of the plant influent flows including the inflow component, which were developed in the Back River WWTP 201 Facility Plan dated 1984, are valid today.

- Plant treatment capacity is based on meeting BNR permit limits of total nitrogen (TN) = 3 – 5 mg/l during the greatest observed 5-day average flow determined in the 201 Facility Plan (1.43 x average daily flow = 1.43 x 180 MGD = 257 MGD).

- Projected influent flow at the plant can be developed by combining dry weather and observed wet-weather (i.e. inflow) flow patterns.

- Dry weather flow component is based on an annual average rate of 169 MGD.

- Pattern of dry weather flow is the same for all 5 days and based on max. day.

- System overflows prevented all inflow from arriving at the plant.

- For analysis purposes, the inflow arriving at the plant is assumed to be twice the observed inflow to allow for the overflow volume which the system could not convey to the plant.

- Space is available at the plant for constructing limited ground level storage, assumed to be 30 MG.

- Space is available at the plant for constructing two additional process trains.

- Costs shown are planning level estimates of construction costs and do not include an allowance for engineering or O&M costs.

Methodology

1. Prepare a composite hydrograph combining the estimated inflow pattern (i.e. observed inflow from 201 Facility Plan plus 100% allowance for additional inflow that the system could not convey) and the corresponding flow pattern expected on a maximum day in dry weather. (See Figure 6-B)

2. Assume the plant has been upgraded to achieve a maximum sustained treatment rate of 257 MGD.

3. Prepare a mass diagram based on steps 1 and 2 above which identifies the storage required (i.e. flow equalization) to limit the flow rate through the plant to the maximum sustained treatment rate. Figure 6-C shows the required storage volume to equalize the flow arriving at the plant during a storm event is 325 MG, for the existing plant with BNR upgrades to meet TN=3-5 mg/l. The projected flow rates reduce after the first two days of the peak 5-day period which will allow starting to release the stored volume in a controlled mode of operation.

4. The estimated cost to provide additional treatment including BNR is $\$3.20 \times 10^6$ per MGD. Two trains each can treat 20 MGD on the annual average daily flow basis or a total of 60 MGD sustained flow during a maximum 5-day period to the plant. Figure 6-C shows that constructing this additional treatment capacity reduces the required storage volume to 205 MG (i.e. 120 MG reduction).

5. The estimated cost to construct on-site above-ground storage with a capacity of 30 MG is $\$1.00 \times 10^6$ per MG.

6. The estimated cost to provide underground equalization / storage is \$6.00 x 10^6 per MG. (Based on tunneling cost experience at various municipal locations throughout the U.S.)

7. With two additional BNR process trains and 30 MG of on-site ground level storage, underground storage will still be required (205-30 = 175 MG net storage volume required). Therefore, the first money spent in the collection system to eliminate inflow will reduce the need for underground storage @ \$6.00 x 10^6 per MG of inflow.

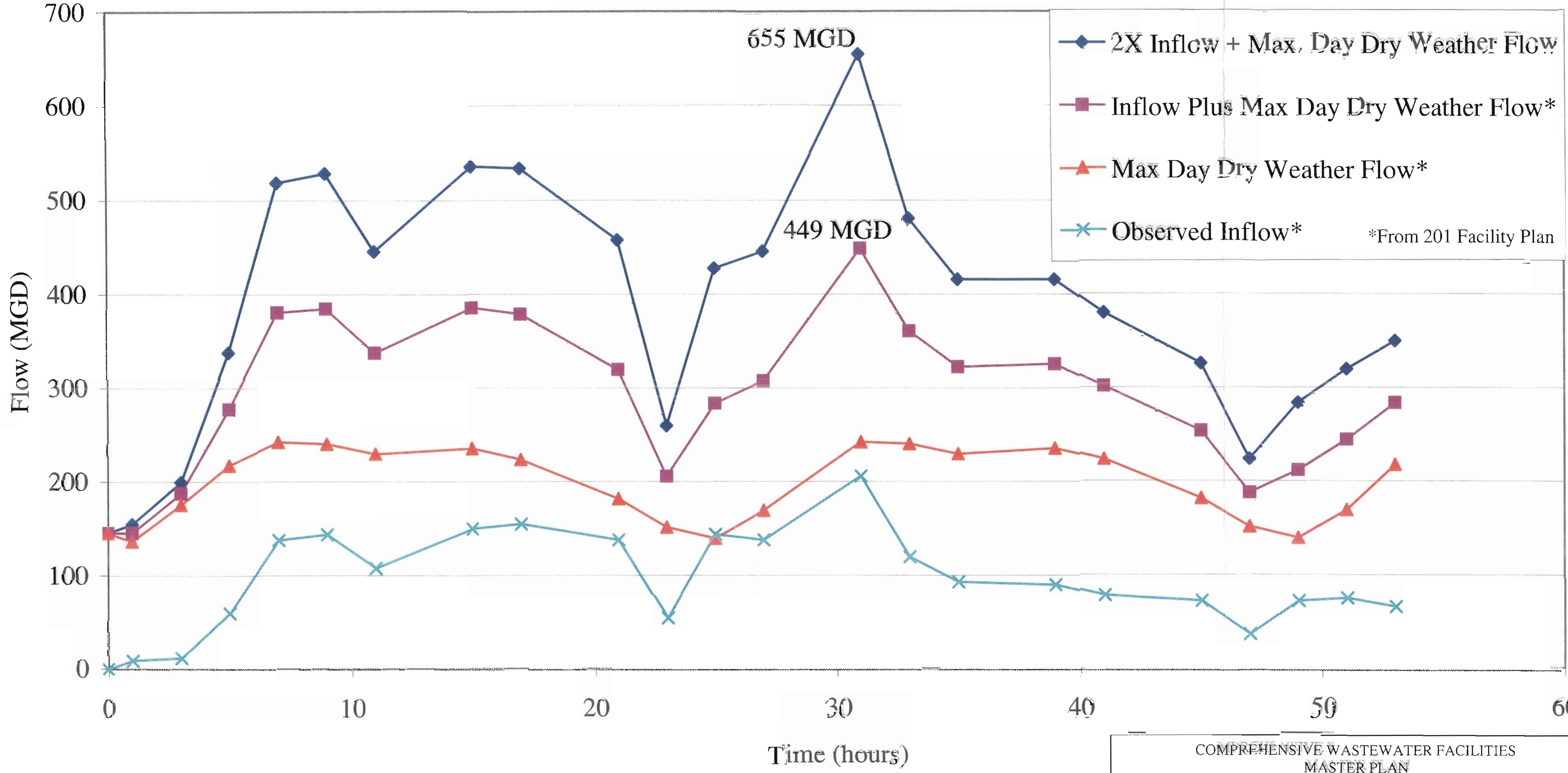
8. Estimated cost to convey the additional 206 MGD of inflow (Figure 6-B) at the time of peak flow rates (100% allowance above the observed inflow of 206 MGD) to BRWWTP (parallel relief for 5.7 miles of Main Outfall to BRWWTP plus half of the length of the sewer from Gwynns Falls to the Main Outfall, 2.5 miles) is \$110 x 10^6, or \$0.53 x 10^6 per MGD. Currently, 449 MGD is the estimated maximum flow that can be conveyed to the BRWWTP based on the Back River Facility Plan.

9. Eliminating an inflow source contributing 1 MG in 24 hours in any sewershed reduces the storage requirement at the treatment plant by 1 MG.

10. Apply an adjustment factor to account for the long-term effectiveness of inflow reduction. Using a 50% allowance, the money available to locate and reduce inflow is \$3.00 per gallon (\$3,000,000 per MG of inflow that otherwise would be contributed in 24 hours).

11. Possible conveyance system improvements should be prioritized based on observed inflow in order to maximize the benefits resulting from the expenditures.

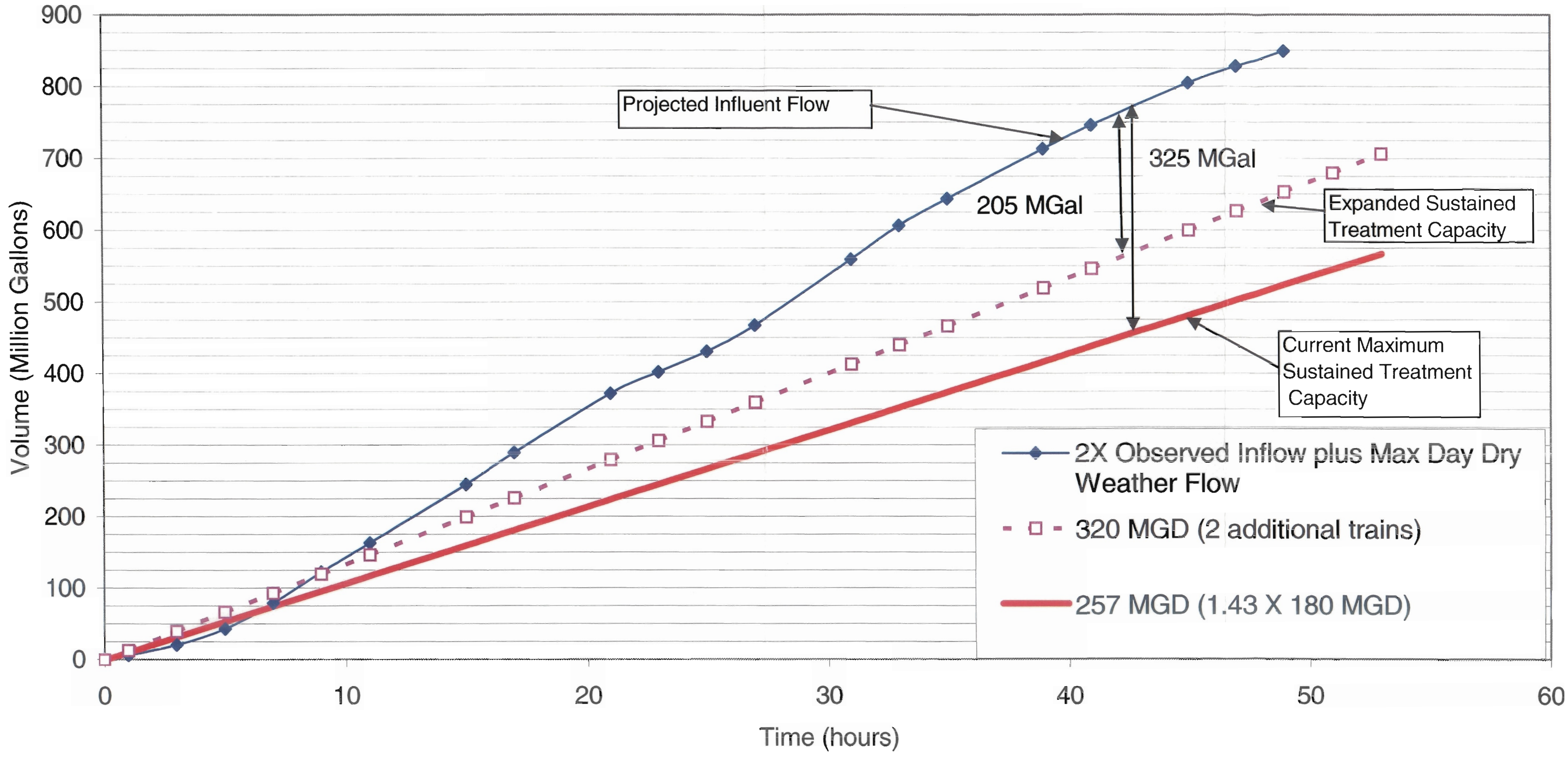
12. After the first phase of the inflow reduction program is complete, re-evaluate the inflow situation to determine how to proceed further.



COMPREHENSIVE WASTEWATER FACILITIES
MASTER PLAN
BACK RIVER
WASTEWATER TREATMENT PLANT

INFLUENT FLOW RATES
PEAK 5-DAY PERIOD

DATE: APRIL 2004 | FIGURE: 6-B



COMPREHENSIVE WASTEWATER FACILITIES
MASTER PLAN
BACK RIVER
WASTEWATER TREATMENT PLANT

INFLUENT MASS DIAGRAM
PEAK 5-DAY PERIOD

DATE: APRIL 2004	FIGURE 6-C

6.9.3. Patapsco Service Area

6.9.3.1. Methodology for Estimating Allowable Expenditure to Reduce Inflow

The methodology presented hereinafter is used to estimate the allowable expenditure to remove one million gallons of inflow contributed within 24 hours. Plant records for the period of 1996 to 2001 provide the source of information regarding plant influent flow.

Assumptions

- Plant treatment capacity is based on meeting BNR permit limits of total nitrogen (TN) = 3-5 mg/L during the peak 5-day average flow (1.7 X average daily flow = 1.7 X 70 MGD = 119 MGD).
- Dry weather flow component is based on an average rate of 70 MGD.
- Upgrades to plant which are required to meet BNR permit do not provide the plant with any excess treatment capacity.
- Space is not available at the plant for constructing ground level storage.
- Space is available at the plant for constructing denitrification facilities to achieve BNR permit limits, but not for additional treatment capacity to handle inflow.
- Costs shown are planning level construction costs and do not include engineering or O&M costs.

Methodology

1. Assume the upgraded plant sustained (5-day) treatment rate is 119 MGD.

2. Identify the peak five-day period during which significant plant inflow occurred, in excess of the average five-day treatment capacity of 119 MGD. (See Figure 6-D).

3. Develop mass diagram based on steps 1 and 2 above which identifies the storage required (i.e. flow equalization) to achieve the sustained treatment rate. Figure 6-E shows the required storage volume is 54.7 million gallons (MG).

4. Since no space is available for constructing additional treatment units or on-site ground level storage, underground storage (55MG) is the most feasible option.

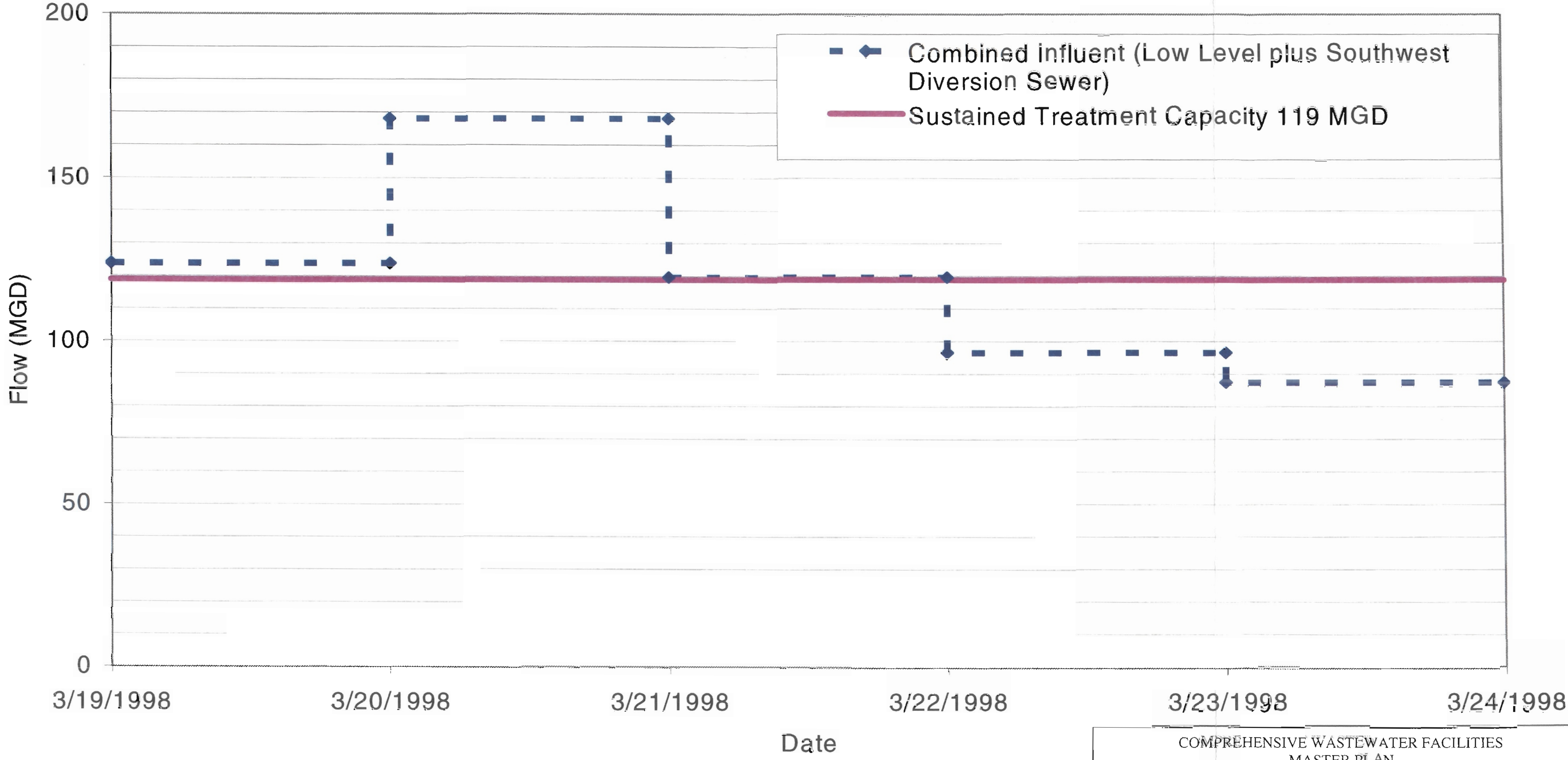
5. The estimated cost to provide underground equalization / storage is \$6.00 x 10^6 per MG.

6. Eliminating an inflow source contributing by 1 MG in 24 hours in any sewer shed will reduce the storage requirement at the treatment plant by 1 MG.

7. Apply an adjustment factor to account for the long-term effectiveness of inflow reduction. Using a 50% allowance, the money available to locate and reduce inflow is \$3.00 per gallon (\$3,000,000 per MG of inflow that otherwise would be contributed in 24 hours).

8. The possible conveyance system improvements should be prioritized based on observed inflow in order to maximize the benefits resulting from the expenditures.

9. After the first phase of the inflow reduction program is complete, re-evaluate the inflow situation to determine how to proceed further.

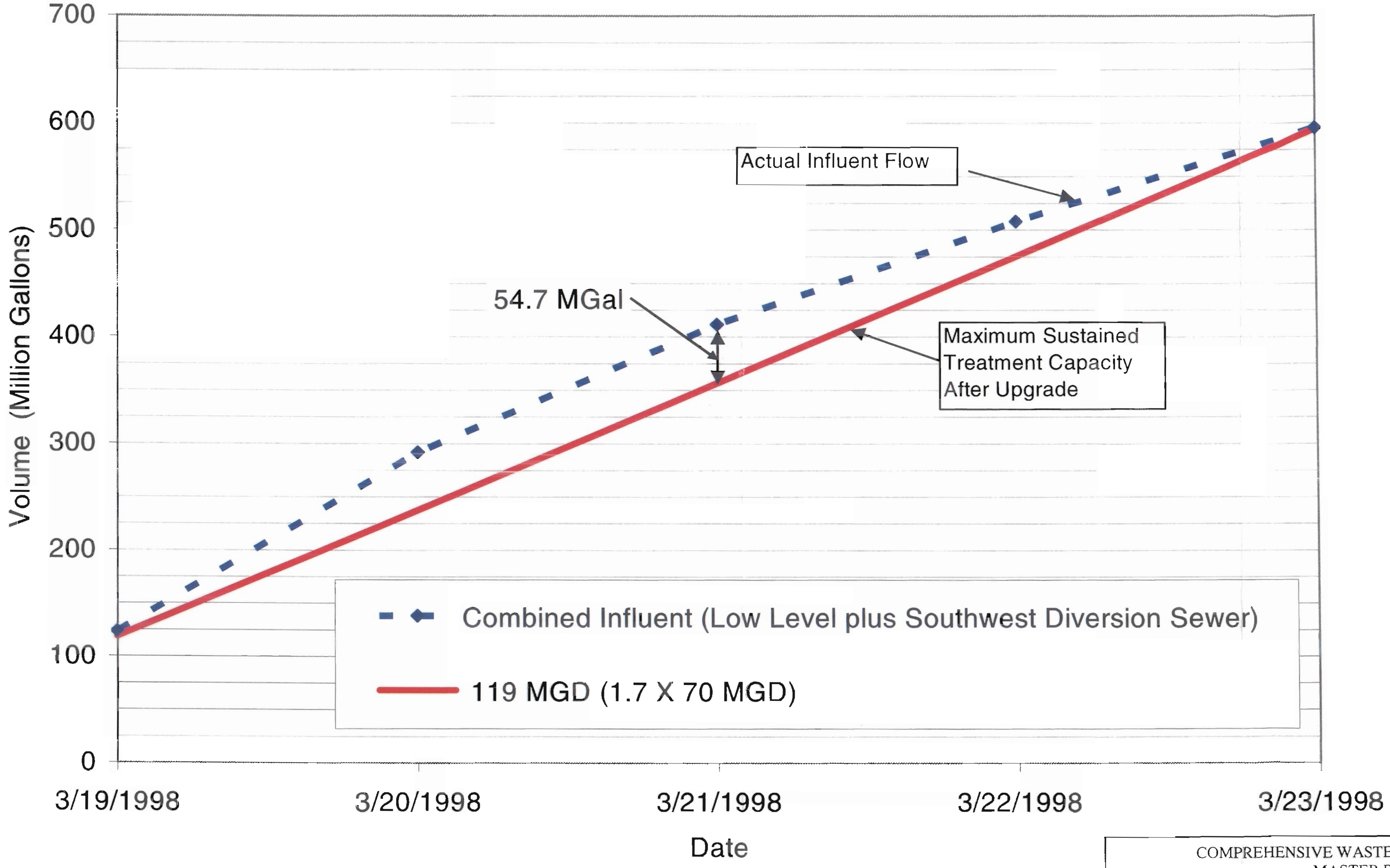


COMPREHENSIVE WASTEWATER FACILITIES
MASTER PLAN
PATAPSCO
WASTEWATER TREATMENT PLANT

INFLUENT DAILY FLOWS
PEAK 5-DAY PERIOD

DATE: APRIL 2004

FIGURE 6-D



COMPREHENSIVE WASTEWATER FACILITIES
MASTER PLAN
PATAPSCO
WASTEWATER TREATMENT PLANT

INFLUENT MASS DIAGRAM
PEAK 5-DAY PERIOD

DATE: APRIL 2004	FIGURE 6-E

CHAPTER 7

FINDINGS AND RECOMMENDATIONS

7.1. FINDINGS

Based on the various investigations and evaluations that were performed and then described in the previous chapters the following findings have been reached:

- Current service area populations, wastewater flows and sludge production for Back River and Patapsco systems are predicted to remain relatively constant throughout the planning period.

- For TN reduction to levels of 3 to 5 mg/l at Back River, carbon oxidation/nitrification suspended growth plus deep bed denitrification filter is most cost effective.

- Use of Back River Activated Sludge Plant No. 1 for sidestream treatment (Alternative 3-5) to reduce the nitrogen loads in dewatering process recycle is cost-effective based on current recycle nitrogen loads. Increased recycle nitrogen loads produced by two-phase digestion will likely improve the cost-effectiveness.

- Back River wastewater may contain sufficient non-biodegradable organic nitrogen to limit achievable effluent TN to 4 to 5 mg/l.

- Continued discharge of 50 mgd (±) of Back River Plant effluent to ISG (alternate point of discharge) will enable the City to implement Level 2 BNR upgrades (i.e., discharge to Back River at TN 3-6 mg/l, and Patapsco River through ISG at TN 6-8 mg/l).

- Increasing the discharge to ISG will potentially offer the City flexibility to meet the NPDES permit pound loading limits.

- Due to the extent of recently completed and current improvement and rehabilitation contracts at both plants, in general, they are in good condition to perform through the planning period.

- Construction of a second Primary Effluent Channel will offer reliability and the opportunity to add flow distribution facilities to enhance the balancing of flows between Activated Sludge Plants Nos. 2 and 3.

- In general, the level of pollutants being released from sediments in Back River and Patapsco River exceeds the levels in the effluent discharge from the respective plants.

- The current sludge management plan for Back River and Patapsco is successful, provides flexibility, reliability and redundancy and has adequate capacity to continue beneficial reuse of all sludge throughout the planning period. (Privatization contracts will require renewal when they expire).

- An estimated $6,000,000 is justified for measures to improve the wastewater collection and conveyance system to reduce influent peak flow by 1 mgd (i.e. inflow contributions), and prevent the need to provide the corresponding capacity to treat that high rate of flow arriving at either plant.

7.2. RECOMMENDATIONS

Based on the investigations and evaluations and the aforementioned findings, the following recommendations are presented:

- Conduct pilot and demonstration testing to determine the achievable effluent TN level for Back River and Patapsco Plants, confirm/modify design and O&M assumptions and cost estimates, and confirm estimated performance of alternatives.

- Visit representative plants for each alternative.

- Pursue discussions with ISG to insure continuation and possible increase of discharge of Back River Plant effluent to the Patapsco River.

- After treatment goals and limits are finalized with MDE, determine apparent best BNR treatment alternative for Back River Plant.

- Implement remaining necessary improvements and rehabilitation contracts at Back River and Patapsco.

- Construct a second Primary Effluent Channel, Flow Distribution Structure and other related piping and appurtenances at the Back River Plant.

- Pursue improvements to the collection and conveyance systems to reduce peak flows arriving at each treatment plant.

- Continue current sludge management plan for both plants.

- Design of projects should incorporate energy conservation measures.

CITY OF BALTIMORE
DEPARTMENT OF PUBLIC WORKS
Water and Wastewater Engineering Division

COMPREHENSIVE WASTEWATER FACILITIES MASTER PLAN

APPENDIX

VOLUME 1 OF 2

APRIL 2004

WHITMAN, REQUARDT AND ASSOCIATES, LLP
Baltimore, Maryland

WR&A

COMPREHENSIVE WASTEWATER FACILITIES MASTER PLAN

APPENDIX
TABLE OF CONTENTS

VOLUME 1

MARYLAND DEPARTMENT OF THE ENVIRONMENT
2500 Broening Highway • Baltimore, Maryland 21224
(410) 631-3000

Parris N. Glendening
Governor

Jane T. Nish
Secreta

DISCHARGE PERMIT

State Discharge Permit Number: 89-DP-0581	Effective Date: October 1, 1996
NPDES Permit Number: MD0021555	Expiration Date: September 30, 2001

Pursuant to the provisions of Title 9 of the Environment Article, Annotated Code of Maryland, and regulations promulgated thereunder, and the provisions of the Clean Water Act 33 U.S.C. Section 1251 et seq., and implementing regulations 40 CFR Parts 122, 123, 124 and 125, the Department of the Environment hereby establishes conditions and requirements pertinent to the wastewater treatment plant and collection system and authorizes:

Mayor and City Council of Baltimore
100 North Holliday Street, City Hall
Baltimore, Maryland 21202

TO DISCHARGE FROM: Back River Wastewater Treatment Plant

LOCATED AT: 8201 Eastern Boulevard, Baltimore County
Baltimore, Maryland 21224

THROUGH OUTFALL: 001- Plant Effluent to Back River
002- Plant Effluent to Bethlehem Steel Corporation

TO: Back River and Baltimore Harbor which is protected for water contact recreation and aquatic life; in accordance with the following special and general conditions and a map incorporated herein and made a part hereof.

I. DEFINITIONS

A. "Bypass" means the intentional diversion of pollutants from any portion of a treatment or collection facility.

B. "BOD_5" (Biochemical Oxygen Demand) means the amount of oxygen consumed in a standard BOD_5 test without the use of a nitrification inhibitor at 20 degree centigrade on an unfiltered sample.

C. "Clean Water Act" means the Federal Water Pollution Control Act, as amended, 33 U.S.C. Section 1251 etseq.

D. "CFR" means the Code of Federal Regulations.

E. "COMAR" means the Code of Maryland Regulations.

F. "Composite sample" means a combination of individual samples obtained at hourly or smaller intervals over a time period. Either the volume of each individual sample is proportional to discharge flow rates or the sampling interval (for constant volume samples) is proportional to the flow rates over the time period used to produce the composite.

G. "Grab sample" means an individual sample collected in less than 15 minutes.

H. "Department" means the Maryland Department of the Environment.

I. "Measured flow" means any method of liquid volume measurement, the accuracy of which has been previously demonstrated in engineering practice, or for which a relationship to absolute volume has been obtained.

J. "Minimum or maximum value" means the lowest or highest value measured.

K. "Monthly average discharge" means the total mass (and concentration, if appropriate) of all daily discharges sampled and/or measured during a calendar month divided by the number of daily discharges sampled and/or measured during such month.

L. "Monthly log" mean (monthly geometric mean) means the logarithmic or geometric mean of all samples taken in the calendar month.

M. "Nondetectable level for total residual chlorine, due to limitations in measurement technology" means a residual concentration of less than 0.10 mg/l.

N. "Outfall XXX" means a sampling location in outfall line XXX downstream from the last addition point or as otherwise specified.

O. "POTW" means a publicly owned treatment works.

I. DEFINITIONS, Continued

P. "Significant Industrial User (SIU)" is defined as any industrial user (IU) that:

1. is subject to national categorical standards; and

2. any other IU that:

a. discharges an average of 25,000 gallons per day or more of process wastewater (excluding sanitary, non-contact cooling and boiler blowdown wastewater); or

b. contributes a process wastestream that makes up 5% or more of the average dry weather hydraulic or organic capacity of the POTW; or

c. is designated as such by the POTW on the basis that the IU has a reasonable potential for adversely affecting the POTW's operation or for violating any pretreatment standard or requirement; or

d. is found by the POTW, the Department, or the Environmental Protection Agency (EPA) to have significant impact either individually or in combination with other contributing industries to the POTW, on the quality of the sludge, the POTW's effluent quality, or air emissions generated by the system.

Q. "TSS" (Total Suspended Solids) means the residue retained on the filter by an analysis done in accordance with Standard Methods or other approved methods.

R. "Weekly average" means the highest weekly average of the month, calculated by dividing the total mass (and concentration, if appropriate) for each week by the number of samples collected and measured that week.

S. "NPDES" (National Pollutant Discharge Elimination System) means the national system for issuing permits as designated by the Clean Water Act.

II. SPECIAL CONDITIONS

A1. Effluent Limitations, Outfall 001 (1)

The quality of the effluent discharged by the facility shall be limited at all times as shown below. (2)

Effluent Characteristics	Monthly Loading Rate kg/d	Monthly Loading Rate (lbs/d)	Weekly Loading Rate kg/d	Weekly Loading Rate (lbs/d)	Monthly Average mg/l	Weekly Average mg/l
BOD_5	4900	(11,000)	7400	(16,000)	10	15
TSS	4900	(11,000)	7400	(16,000)	10	15
Ammonia Nitrogen as N (5/1 to 10/31)	990	(2200)	1500	(3300)	2.0	3.0
Total Nitrogen as N (3)	----------N/A----------					
Total Phosphorus as P	99	(220)	150	(330)	0.2	0.3

Effluent Characteristics	Maximum	Minimum
Fecal Coliforms	200 MPN/100 ml monthly log mean	N/A
Total Residual Chlorine	Dechlorination is required to reduce the total residual chlorine to nondetectable level (See Definition I.M)	
Dissolved Oxygen	N/A	5.0 mg/l at any time
pH	8.5	6.5

(1) When this permit is renewed or replaced, the new limitations may not be equal to the above limitations. The discharge of pollutants not shown shall be illegal.

(2) There shall be no discharge of floating solids or visible foam other than trace amount.

(3) Biological Nitrogen Removal(BNR) facilities are designed to meet a seasonal (May through October) average concentration of total nitrogen of 10 mg/l. Upon the completion of the BNR upgrade in 1998, the permittee shall make every effort to meet a total nitrogen goal of 8 mg/l, whenever possible, as an annual average by operating the BNR processes at the facility on a year round basis. Total nitrogen is the sum of organic-N, ammonia-N, and (nitrate+nitrite)-N.

A flow of 130.0 mgd was used in waste allocation calculations. Notification to be provided to the Department at least 180 days before the flow is expected to exceed this flow.

II. SPECIAL CONDITIONS

A2. Additional Effluent Limitations, Outfall 001 (1)(3)

The quality of the effluent discharged by the facility shall be limited at all times as shown below.

Effluent Characteristics	Monthly Loading Rate kg/d	Monthly Loading Rate (lbs/d)	Weekly Loading Rate kg/d	Weekly Loading Rate (lbs/d)	Monthly Average micro.g/l	Weekly Average micro.g/l
Lead (Total)	6.4	(14)	6.4	(14)	13	13
Mercury ((Total)(2)	0.010	(0.022)	0.010	(0.022)	0.020	0.020
Selenium (Total)	4.1	(9.0)	4.1	(9.0)	8.3	8.3

---

(1) The above limitations for lead, mercury, and selenium become effective 3 years after the issue date of the permit, unless the limitation is modified pursuant to Special Conditions IIC.2. The effective date shall be extended if necessary to accommodate the completion of the Administrative Procedure process associated with the change in the limitation. Monitoring of these substances without limits is required until the effective date. Above parameters shall be analyzed in accordance with the Maryland Department of the Environment, Water Management Administration, Toxic Substance Analytical Protocol (Copy enclosed). In addition to data submitted on the Discharge Monitoring Report, the permittee shall submit a copy of the laboratory report for these parameters in accordance with General Conditions III.A.2.c of this permit.

(2) Results for mercury below 0.5 ppb (i.e below the "Minimum Practical Detection Level" (ML)) found in previously mentioned toxic substance analytical protocol are to be considered in compliance with the monthly and weekly average effluent limitation concentration found on this page. For purposes of reporting on the discharge monitoring report, all analytical values below the ML shall be reported by the permittee as BML (below minimum level) and shall be considered equal to "0". All analytical values at or above the ML shall be reported as the measured values.If proper methodology is used, as specified above, and interference decreases sensivity, documentation must be provided to establish an appropriate ML.

(3) There shall be no discharge of floating solids or visible foam other than trace amount.

A flow of 130.0 mgd was used in waste allocation calculations. Notification to be provided to the Department at least 180 days before the flow is expected to exceed this flow.

II. SPECIAL CONDITIONS, Continued

A3. Monitoring Requirements, Outfall 001

The effluent characteristics established in Special Conditions II. A1 and A2 shall be monitored as follows:

	Effluent Characteristics	Measurement Frequency	Sample Type
	BOD_5	One/day	24 hr Composite
	Total Suspended Solids	One/day	24 hr Composite
	Ammonia Nitrogen as N (5/1 to 10/31)	One/day	24 hr Composite
1,2	(11/1 to 4/30)	Two/week	24 hr Composite
1,2	Organic Nitrogen as N	Two/week	24 hr Composite
1,2	(Nitrate + Nitrite) as N	Two/week	24 hr Composite
1,2	Total Nitrogen as N	Two/week	24 hr Composite
1,2	Orthophosphorus as P	Two/week	24 hr Composite
2	Total Phosphorus as P	One/day	24 hr Composite
1,3,4	Cyanide(Total)	Two/week	4 Grabs(1/6 hours)
1,3	Copper (Total)	Two/week	24 hr Composite
3	Selenium (Total)	Two/week	24 hr Composite
3	Mercury (Total)	Two/week	24 hr Composite
1,3	Nickel (Total)	Two/week	24 hr Composite
3	Lead (Total)	Two/week	24 hr Composite
1,3	Zinc (Total)	Two/week	24 hr Composite
1,3	Silver (Total)	Two/week	24 hr Composite
	Fecal Coliform	One/day	Grab
	Total Residual Chlorine	Three/day	Grab
	Dissolved Oxygen	Three/day	Grab
	pH	Three/day	Grab
	Flow	Continuous	Recorded

1 Monitor only-parameters shall be reported on the monthly operating report as individual results and on the Discharge Monitoring Report (EPA Form 3320-1) as a monthly average concentration and monthly average loading value.

2 All nitrogen and phosphorus parameters shall be measured on the same daily sample and tests for all these parameters should be run on the same 24 hour composite samples. Samples should be taken at least seven days apart. Total Nitrogen is sum of Organic-N, Ammonia-N, Nitrite and Nitrate-N.

3 Parameters shall be analyzed in accordance with the MDE Water Management Administration Toxic Substance Protocol. In addition to data submitted on the Discharge Monitoring Report, the permittee shall submit a copy of the laboratory report for these parameters in accordance with General Condition III.A.2.c of this permit. Frequency of sampling may be adjusted by the Department after a period of one year based on the results of the tests and in consultation with the City of Baltimore.

4 In the event that "Cyanide,Total" is detected, the sample shall be further analyzed for "Cyanide, Amenable to Chlorination" in accordance with footnote 3 above.

II. SPECIAL CONDITIONS

B1. Effluent Limitations, Outfall 002 (1)

The quality of the effluent discharged by the facility shall be limited at all times as shown below. (2)

Effluent Characteristics	Monthly Loading Rate kg/d (lbs/d)	Weekly Loading Rate kg/d (lbs/d)	Monthly Average mg/l	Weekly Average mg/l
BOD_5 (5/1 to 10/31)	7600 (17000)	11000 (25000)	20	30
(11/1 to 4/30)	11000 (25000)	17000 (38000)	30	45
TSS	11000 (25000)	17000 (38000)	30	45
Ammonia Nitrogen as N (5/1 to 10/31)	760 (1700)	1100 (2500)	2.0	3.0
Total Nitrogen as N(3)	---N/A---			
Total Phosphorus as P(4)	760 (1700)	1100 (2500)	2.0	3.0

Effluent Characteristics	Maximum	Minimum
Fecal Coliforms	200 MPN/100 ml monthly log mean	N/A
Total Residual Chlorine	---N/A---	
Dissolved Oxygen	N/A	5.0 mg/l at any time
pH	9.0	6.0

(1) When this permit is renewed or replaced, the new limitations may not be equal to the above limitations. The discharge of pollutants not shown shall be illegal.

(2) There shall be no discharge of floating solids or visible foam other than trace amount.

(3) See Footnote No. 3 on Page 4 of 27 of this permit

(4) Phosphorus removal at outfall 002 will be optimized by providing the same level of treatment as for outfall 001. Flow from outfall 002 is used by Bethlehem Steel Corp. as process water and then treated and discharged through their outfalls 001, 012, 014 and 017 (see Permit No. 79-DP-00648).

A flow of 100.0 mgd was used in waste allocation calculations. Notification to be provided to the Department at least 180 days before the flow is expected to exceed this flow or when the sum of flows from outfall 001 and 002 is expected to exceed 180.0 mgd.

II. SPECIAL CONDITIONS, Continued

B2. Monitoring Requirements, Outfall 002

The effluent characteristics established in Special Conditions II.B1 shall be monitored as follows:

	Effluent Characteristics	Measurement Frequency	Sample Type
	BOD_5	One/day	24 hr Composite
	Total Suspended Solids	One/day	24 hr Composite
	Ammonia Nitrogen as N (5/1 to 10/31)	One/day	24 hr Composite
1,2	(11/1 to 4/30)	Two/week	24 hr Composite
1,2	Organic Nitrogen as N	Two/week	24 hr Composite
1,2	(Nitrate + Nitrite) as N	Two/week	24 hr Composite
1,2	Total Nitrogen as N	Two/week	24 hr Composite
1,2	Orthophosphorus as P	Two/week	24 hr Composite
2	Total Phosphorus as P	One/day	24 hr Composite
1,3,4	Cyanide(Total)	Two/week	4 Grabs(1/6 hours)
1,3	Copper (Total)	Two/week	24 hr Composite
1,3	Selenium (Total)	Two/week	24 hr Composite
1,3	Mercury (Total)	Two/week	24 hr Composite
1,3	Nickel (Total)	Two/week	24 hr Composite
1,3	Lead (Total)	Two/week	24 hr Composite
1,3	Zinc (Total)	Two/week	24 hr Composite
1,3	Chromium (Total)	Two/week	24 hr Composite
1,3	Chromium (Hexavalent)	One/Quarter	24 hr Composite
1,3	Naphthalene	One/Quarter	4 Grabs(1/6 hours)
1,3	Tetrachloroethylene	One/Quarter	4 Grabs(1/6 hours)
	Fecal Coliform	One/day	Grab
	Dissolved Oxygen	Three/day	Grab
	pH	Three/day	Grab
	Flow	Continuous	Recorded

1 Monitor only-parameters shall be reported on the monthly operating report as individual results and on the Discharge Monitoring Report (EPA Form 3320-1) as a monthly average concentration and monthly average loading value.

2 All nitrogen and phosphorus parameters shall be measured on the same daily sample and tests for all these parameters should be run on the same 24 hour composite samples. Samples should be taken at least seven days apart. Total Nitrogen is sum of Organic-N, Ammonia-N, Nitrite and Nitrate-N.

3 Parameters shall be analyzed in accordance with the MDE Water Management Administration Toxic Substance Protocol. In addition to data submitted on the Discharge Monitoring Report, the permittee shall submit a copy of the laboratory report for these parameters in accordance with General Condition III.A.2.c of this permit. Frequency of sampling may be adjusted by the Department after a period of one year based on the results of the tests and in consultation with the City of Baltimore.

4 In the event that "Cyanide,Total" is detected, the sample shall be further analyzed for "Cyanide,Amenable to Chlorination" in accordance with footnote 3 above.

II. SPECIAL CONDITIONS, Continued

C. SCHEDULE OF COMPLIANCE

1. The permittee shall achieve compliance with the preceding discharge limitations found on pages 4 and 7 of this permit by June 30, 1998, in accordance with the following schedule:

Refer to the Amended Consent Judgement and Order signed on August 17, 1994 (copy attached with this permit) for schedule of compliance for the preceding effluent limitations.

2. For the toxic pollutants shown on page 5 of this permit, the following schedule shall apply:

The permittee shall comply with the metal limits within 3 years from the effective date of this permit as described in Special Conditions II.A2 on page 5.

a. Every six months the permittee shall submit to the Department a status report detailing current plans for meeting the lead, mercury and selenium limits in Special Conditions II.A.2 This report is due six months after the issuance of the permit and every six months thereafter until the effective date of the permit limits. The report will cover the investigation of sources of lead, mercury and selenium and the implementation of BMPs or other remedial measures to control these pollutants.

b. No later than 24 months after the effective date of the permit, the permittee may apply for a permit modification to revise the permit limit(s) based on any combination of the following options allowed under COMAR 26.08:

1. Site-Specific Criterion: The permittee shall submit to the Department complete documentation of the proposed site-specific criterion as part of the application for a permit modification.

2. Chemical or Biological Translator: The permittee shall complete all studies supporting use of the translator under COMAR 26.08.04.02-3C, paragraphs (1), (3), and (4) for biological translators or under COMAR 26.08.04.02-4C, paragraphs (1), (3), and (4) for chemical translators and submit the results to the Department as part of the application for a permit modification.

3. Mixing Zone Study: As part of the application for a permit modification, the permittee shall include the proposed dilution calculation and appropriate demonstration, using dye studies or simulation models, that the dilution calculation is applicable during periods of ambient stream conditions, flow rates, and distances specified in COMAR 26.08.02.05.

II. SPECIAL CONDITIONS, Continued

D. MONITORING BACK RIVER

To confirm that the increased discharge to Back River does not adversely impact water quality, the City of Baltimore will conduct a 2-phase water quality and sediment monitoring program. The first phase will be conducted during June-October 1997, and the second phase will be conducted at a later date, most likely in calendar year 1998. The second phase may include some modifications based on the results of the data collected during 1997 and will be conducted on a time frame established by MDE after reviewing the results of the first phase. The first phase work will consist of three parts as follows. For the details of methodologies, sampling schedules, sampling locations and reporting schedule,refer to the enclosed "Work Statement for Monitoring Back River(Work Statement)":

1. A series of flux measurements will be conducted at three stations during the months of June, July and August in 1997. These measurements would include the net sediment-water exchanges of oxygen and nutrients (phosphorus, nitrogen and silica), characterization of surface sediments, and measurements of water quality conditions in near-bottom waters.

2. In-situ high frequency (continuous) measurements of water column temperature, salinity and dissolved oxygen by deploying buoys in the Back River during the months of June, July and August in 1997.

3. Traditional water quality measurements at five water quality stations during June-October in 1997. The parameters will include in situ vertical profile measurements of pH, water temperature, conductivity, secchi depth, light attenuation and dissolved oxygen. The remainder of the parameters shown in Part III. Table 4. in the Work Statement will be determined in the laboratory.

E. COMBINED SEWER OVERFLOWS (CSOs)

There are no known combined sewer overflows in the Baltimore City , Back River wastewater collection system service areas at the time of issuance of this permit. However, since parts of the Baltimore City's collection system are old and the system serves an urban area, there may be secluded or hidden CSOs, which are not known at this time. In order to address this potential, the following CSO reopener clause will apply to any CSO that subsequently comes to the knowledge of the Department.

> If a CSO is identified in the collection system contributing to this facility, this permit may be reopened to incorporate the CSO requirements developed in accordance with the National Combined Sewer Overflow Control Strategy promulgated in April 1994 by the EPA.

II. SPECIAL CONDITIONS, Continued

F. PRETREATMENT PROGRAM

The permittee shall operate and maintain the pretreatment program approved on August 7, 1985 by MDE. The program must be updated, if needed, to comply with COMAR 26.08.08 and the State of Maryland Publicly Owned Treatment Works (POTW) Pretreatment Delegation Agreement signed on September 14, 1994, the terms of which are expressly incorporated herein as if set forth in full.

G. BIOMONITORING PROGRAM

1. Within three months of the effective date of this permit, the permittee shall submit to the Department, for approval, a study plan to evaluate wastewater toxicity at outfall- 001 using biomonitoring. (Flow from outfall-002 is used by Bethlehem Steel Corporation as process water and then discharged via their outfalls-001,012,014 and 017(see fact sheet for details). Since Bethlehem Steel Corporation is required to biomonitor at these outfalls and since wastewater at outfall-002 has received same treatment as outfall-001 at Back River WWTP, no biomonitoring requirements are set for outfall-002 at the Back River WWTP.) The study plan should require that the testing begin before the end of 1996 and should include a discussion of:

a. wastewater and production variability
b. sampling & sample handling
c. source & age of test organisms
d. source of dilution water
e. testing procedures/experimental design
f. data analysis
g. quality control/quality assurance
h. report preparation
i. testing schedule

2. The testing program shall consist of <u>definitive</u> quarterly chronic testing for one year. This testing shall be initiated no later than three months following the Department's acceptance of the study plan.

a. Each quarterly testing shall include the <u>Ceriodaphnia</u> survival and reproduction test and the fathead minnow larval survival and growth test.

b. If the receiving water is estuarine, the permittee shall substitute estuarine species for those species specified above. Approved estuarine species for chronic testing are sheepshead minnow, inland silversides, and mysid shrimp. In all cases, testing must include one vertebrate species and one invertebrate species.

II. SPECIAL CONDITIONS, Continued

G. BIOMONITORING PROGRAM, Continued

3. The samples used for biomonitoring shall be collected at the same time and location as the samples analyzed for the effluent limitations and monitoring requirements for this outfall. For chlorinated effluents, samples shall be collected after dechlorination.

4. The following EPA documents discuss the appropriate methods:

   a. Short-Term Methods for Estimating the Chronic Toxicity of Effluents and Receiving Waters to Marine and Estuarine Organisms, July 1994, EPA/600/4-91/003.

   b. Short-Term Methods for Estimating the Chronic Toxicity of Effluents and Receiving Waters to Freshwater Organisms, July 1994, EPA/600/4-91/002.

5. Test results shall be submitted to the Department within one month of completion of each set of tests.

6. Test results shall be reported in accordance with the Department's "Reporting Requirements for Effluent Biomonitoring Data".

7. As a minimum, the reported chronic results shall be expressed as NOEC, LOEC, ChV, and IC_{25}.

8. If significant mortality occurs, 48-hour LC50s shall be calculated and reported along with the chronic results.

9. If testing is not performed in accordance with the Department-approved study plan, additional testing may be required by the Department.

10. If the test results indicate that the effluent is toxic, additional biomonitoring or a toxicity reduction evaluation will be required by the Department.

11. If plant processes or operations change so that there is a significant change in the nature of the wastewater, the Department may require the permittee to conduct a new set of tests.

12. If a SIU locates within the service area so that significant change in the nature of the wastewater might be anticipated, the Department may require the permittee to conduct a new set of tests.

II. SPECIAL CONDITIONS, Continued

G. 13. Submit all biomonitoring related materials to:

Maryland Department of the Environment
Water Management Administration
Wastewater Discharge Permit Program
Municipal NPDES Permits Division
2500 Broening Highway
Baltimore, Maryland 21224

H. TOXIC CHEMICAL TESTING

1. Concurrent with the biomonitoring study plan, the permittee shall submit to the Department for approval, a study plan to perform analytical testing for toxic chemicals.

2. The toxic chemical testing study plan shall include a description of:

a. sampling methods;
b. analytical methods;
c. practical detection levels; and
d. quality control procedures.

3. Concurrently with the first toxicity test, the permittee shall perform analytical testing for the toxic chemicals identified in the Department's "Toxic Substance Analytical Protocol".

4. Toxic chemical testing shall be performed in accordance with 40 CFR Part 136 and the Department-approved toxic chemical testing plan.

5. Substances other than those identified in paragraph 3 above may be detected in the effluent. If so, the permittee shall identify and quantify the ten present in highest concentration.

6. Testing results shall be submitted to the Department with the results of the first toxicity test.

7. Toxic chemical testing results shall be reported in accordance with the Department's "Reporting Requirements for Priority Pollutant Analytical Data".

8. If testing is not performed in accordance with the Department's approved study plan, additional testing may be required by the Department.

9. Submit all toxic chemical testing related materials to:

Maryland Department of the Environment
Water Management Administration
Wastewater Discharge Permit Program
Municipal NPDES Permits Division
2500 Broening Highway
Baltimore, Maryland 21224

II. SPECIAL CONDITIONS, Continued

I. TOXICITY REDUCTION EVALUATION (TRE)

The permittee shall conduct a Toxicity Reduction Evaluation (TRE) when a review of toxicity test data by the Department indicates unacceptable acute or chronic effluent toxicity. A TRE is an investigation conducted to identify the causative agents of effluent toxicity, isolate the source(s), determine the effectiveness of control options, implement the necessary control measures and then confirm the reduction in toxicity.

1. Within 90 days of notification by the Department that a TRE is required, the permittee shall submit a plan of study and schedule for conducting a TRE. The permittee shall conduct the TRE study consistent with the submitted plan and schedule.

2. This plan should follow the framework presented in Toxicity Reduction Evaluation Protocol for Municipal Wastewater Treatment Plants (EPA/600/2-88/062).

3. Beginning 60 days from the date of the Department's acceptance of the TRE study plan and every 60 days thereafter, the permittee shall submit progress reports including all relevant test data to the Department. This shall continue until completion of the toxicity reduction confirmation.

4. Within 60 days of completion of the toxicity identification, or the source identification phase of the TRE, the permittee shall submit to the Department a plan and schedule for implementing those measures necessary to eliminate acute toxicity and/or reduce chronic toxicity to acceptable levels. The implementation of these measures shall begin immediately upon submission of this plan.

5. Within 60 days of completing the implementation of the control measures to eliminate or reduce toxicity, the permittee shall submit to the Department, for approval, a study plan to confirm the elimination or reduction of toxicity using biomonitoring.

6. If, for any reason, the implemented measures do not result in compliance with the Department's toxicity limitations, the permittee shall continue the TRE.

7. Submit all TRE-related materials to:

   Maryland Department of the Environment
   Technical and Regulatory Services Administration
   Environmental Risk Assessment Program
   2500 Broening Highway
   Baltimore, Maryland 21224

III. GENERAL CONDITIONS

A. Monitoring and Reporting

1. Representative Sampling

Samples and measurements shall be taken at times that are representative of the quantity and quality of the discharge, and at evenly spaced intervals.

2. Monthly Monitoring Results

a. Discharge Monitoring Reports

Monitoring results obtained each month shall be summarized on a Discharge Monitoring Report form (EPA No. 3320-1). Reports shall be submitted to the Department postmarked no later than the 28th of the month following the reporting month. Duplicate signed copies of these reports shall be submitted to:

Inspection and Compliance Program
Water Management Administration
Department of the Environment
2500 Broening Highway
Baltimore, Maryland 21224

and to:

U.S. Environmental Protection Agency
Region III
Permits Enforcement Branch
General Enforcement Section (3WM52)
841 Chestnut Building
Philadelphia, Pennsylvania 19107

b. Monthly Operating Reports

The permittee shall submit monthly operating reports on a form supplied or approved by the Inspection and Compliance Program. Reports shall be submitted to the Inspection and Compliance Program postmarked no later than the 28th day of the month following the reporting month.

c. The permittee shall submit monthly copies of the laboratory reports for cyanide(total), copper, selenium, mercury, nickel, lead, zinc, silver, chromium, naphthalene and tetrachloroethylene. At a minimum, these reports shall include: the date,times(s) and place of sample collection; the sample type; the preservation method; the person performing the sampling; the analytical method; the analytical method detection limit; the date of analysis; the

III. GENERAL CONDITIONS, Continued

e. the analytical techniques or methods used; and

f. the results of such analyses.

6. Additional Monitoring by Permittee

If the permittee monitors any pollutant at the location(s) designated herein more frequently than required by this permit, using approved analytical methods as specified above, the results of such monitoring shall be included in the calculation and reporting of the values required in the Discharge Monitoring Report form (EPA No. 3320-1). The increased frequency shall also be reported. The results of any other monitoring performed by the permittee shall be made available to the Department upon request.

7. Record Retention

All data used to complete the permit application and all records and information resulting from the monitoring activities required by this permit, including all records of sampling and analyses performed, calibration and maintenance of instrumentation, and recordings from continuous monitoring instruments, shall be retained for a minimum of three years. This period shall be extended automatically during the course of litigation or when requested by the Department.

B. General Requirements

1. Permit Noncompliance - Notification Requirements

All discharges authorized herein shall be consistent with the terms and conditions of this permit. The discharge of any pollutant not identified in this permit, or of any pollutant identified in this permit at a level in excess of that authorized shall constitute a violation of this permit. If, for any reason, the permittee does not comply with or will be unable to comply with any permit condition, the permittee shall, within 24 hours, notify the Department by telephone at (410) 631-3510 during work hours or at (410) 631-3937 during evenings, weekends, and holidays. The permittee shall provide the Department with the following information in writing within five days of such oral notification.

a. a description of the noncomplying discharge including its impact upon the receiving waters;

b. cause of noncompliance;

III. GENERAL CONDITIONS, Continued

c. the duration of the period of noncompliance and the anticipated time the condition of noncompliance is expected to continue;

d. steps taken by the permittee to reduce and eliminate the noncomplying discharge;

e. steps to be taken by the permittee to prevent recurrence of the condition of noncompliance;

f. a description of the accelerated or additional monitoring to determine the nature and impact of the noncomplying discharge; and

g. the results of the monitoring described in f. above.

2. Change in Discharge

The permittee shall report any anticipated facility expansions, production increases, or process modifications which will result in new, different or an increased discharge of pollutants by submitting a new application at least 180 days prior to the commencement of the changed discharge or, if such changes will not violate the effluent limitations specified in this permit, by providing prior written notice to the Department. Following such notice, the permit may be modified by the Department to specify and limit any pollutants not previously limited.

3. Facility Operation and Quality Control

All waste collection, control, treatment and disposal facilities shall be operated in a manner consistent with the following:

a. Facilities shall be operated efficiently to minimize upsets and discharges of excessive pollutants.

b. The permittee shall provide an adequate operating staff qualified to carry out operation, maintenance and testing functions required to ensure compliance with this permit. Superintendents and operators must be certified by the Board of Waterworks and Waste Systems Operators located at 2500 Broening Highway, Baltimore, Maryland 21224 in accordance with Title 12 of Environmental Article, Annotated Code of Maryland.

III. GENERAL CONDITIONS, Continued

c. Facility maintenance work which adversely affects or may adversely affect the discharge quality shall be scheduled during non-critical water quality periods. The permittee shall follow the reporting procedures listed in General Condition III.B.1 of this permit, Noncompliance Notification.

4. Adverse Impact

The permittee shall take all reasonable steps to minimize any adverse impact to waters of this State, human health or the environment resulting from noncompliance with any effluent limitations specified in this permit, and must perform accelerated or additional monitoring as necessary to determine the nature and impact of the noncomplying discharge.

5. Bypassing

Any bypass of treatment facilities is prohibited unless the bypass does not cause any violations of the effluent limitations specified in Special Condition II.A. and is for essential maintenance to assure efficient operation. Or unless the permittee can prove that:

a. the bypass is unavoidable to prevent loss of life, personal injury, or substantial physical damage to property, damage to the treatment facilities which would cause them to become inoperable, or substantial and permanent loss of natural resources; and

b. there are no feasible alternatives to the bypass; and

c. the Department receives notification pursuant to General Condition III.B.I. above. Where the need for a bypass is known (or should have been known) in advance, this notification shall be submitted to the Department for approval at least ten days before the date of the bypass or at the earliest possible date if the period of advance knowledge is less than ten days; and

d. the bypass is allowed under conditions determined by the Department to be necessary to minimize adverse effects.

III. GENERAL CONDITIONS, Continued

6. Sewage Sludge Requirements

The permittee shall comply with all existing State and federal laws and regulations that apply to sewage sludge monitoring requirements and utilization practices, and with any regulations promulgated pursuant to Environment Article, Section 9-230 et seq. or to the Clean Water Act, Section 405 (d). The permittee is responsible for ensuring that its sewage sludge is utilized in accordance with a valid sewage sludge utilization permit issued by the Department.

7. Power Failure

The permittee shall maintain compliance with the effluent limitations and all other terms and conditions of this permit in the event of a reduction, loss or failure of the primary source of power to the wastewater collection and treatment facilities.

8. Right of Entry

The permittee shall allow the Secretary of the Department, the Regional Administrator of the Environmental Protection Agency, and their authorized representatives, upon the presentation of credentials to enter upon the permittee's premises and:

a. to have access to and to copy any records required to be kept under the terms and conditions of this permit;

b. to inspect any monitoring equipment or monitoring method required in this permit;

c. to inspect any collection, treatment, pollution management, or discharge facilities required under this permit; or

d. to sample any discharge of pollutants.

9. Property Rights/Compliance With Other Requirements

The issuance of this permit does not convey any property rights in either real or personal property, or any exclusive privileges, nor does it authorize any injury to private property, invasion of personal rights, or any infringement of federal, State or local laws or regulations.

III. GENERAL CONDITIONS, Continued

10. Reports and Information

a. Upon request, the permittee shall provide to the Department, within a reasonable time, copies of records required to be kept by this permit. The permittee shall also furnish to the Department, within a reasonable time, any information which the Department may request to determine whether cause exists for modifying, revoking and reissuing, or terminating this permit; or to determine compliance with this permit.

b. All applications, reports or information submitted to the Department shall be signed and certified as required by COMAR 26.08.04.01 and 40 CFR 122.22.

c. Except for data determined to be confidential under COMAR 26.08.04.01, all data shall be available for public inspection at the Department and the Office of the Regional Administrator of the Environmental Protection Agency. Effluent data shall not be considered confidential.

d. Environment Article, Section 9-343 provides that any person who knowingly makes any false statement, representation, or certification in any record or other document submitted or required to be maintained under this permit, including monitoring reports or reports of compliance or noncompliance, shall upon conviction be punished by a fine of not more than $10,000 or by imprisonment for not more than six months or by both.

11. Transfer of Ownership or Control

In the event of any change in ownership or control of facilities from which the authorized discharge emanates, the permit may be transferred automatically to another person only if:

a. the current permittee notifies the Department, in writing, of the proposed transfer at least 30 days prior to the proposed transfer date;

b. the notice includes a written agreement between the existing and new permittees containing the specific date of proposed transfer of permit coverage, and of responsibilities and liabilities under the permit; and

III. GENERAL CONDITIONS, Continued

c. neither the current permittee nor the new permittee receive notification from the Department, within 30 days of the Department's receipt of the agreement, of its intent to modify, revoke, reissue or terminate the existing permit. If this notice is not received, the transfer is effective on the date specified in the agreement mentioned in paragraph 4(b) above.

12. New Effluent Standards

This permit shall be revoked and reissued or modified to meet any effluent standard, water quality standard or prohibition established under the Environment Article, the Clean Water Act, or regulations promulgated thereto, and the permittees shall be so notified.

13. Industrial Users

The permittee shall require all industrial users of the wastewater treatment facility to comply with user charges as established by the permittee, pursuant to Section 9-325(a)(i) of the Environment Article.

14. Noncompliance

Nothing in this permit shall be construed to preclude the institution of any legal action for noncompliance with State, federal or local laws and regulations.

15. Oil and Hazardous Substance Liability

Nothing in this permit shall be construed to preclude the institution of any legal action against the permittee or to relieve the permittee from any responsibilities, liabilities, or penalties to which the permittee is or may be subject under Section 311 of the Clean Water Act or under the Environment Article.

16. Waterway Construction and Obstruction

The permit does not authorize the construction or placing of physical structures, facilities, debris, or the undertaking of related activities in any waters of this State including the 100 year flood plain.

III. GENERAL CONDITIONS, Continued

17. Construction Permit

This permit is not a permit to construct. For a new facility, in order to make this permit valid, a construction permit shall be obtained to meet the requirements of COMAR 26.03.12.03(A) and Environment Article, Section 9-204(d).

18. Severability

If any provision of this permit shall be held invalid for any reason, the remaining provisions shall remain in full force and effect, and such invalid provisions shall be considered severed and deleted from this permit.

C. Wastewater Collection System

1. Operation

a. All wastewater collection system facilities shall be operated in a manner which will minimize upsets and overflows from the wastewater collection system.

b. The permittee shall take all reasonable steps to prevent or minimize overflows from the wastewater collection system.

c. The permittee shall provide adequate operating and maintenance staff for the wastewater collection system as set forth in Section III, General Condition B.3., Facility Operation and Quality Control.

d. The permittee shall comply with Section III General Condition B.7., Power Failure as it applies to the wastewater collection system facilities.

2. Best Management Practices

The permittee may develop and implement a Best Management Practices Plan/Program (BMP) to help prevent, eliminate, minimize, or otherwise control wastewater collection system discharges.

a. The BMP program must be in written form and available for review.

b. The permittee shall revise, change, modify or enhance the BMP program if it is deficient in helping to prevent, eliminate,

III. GENERAL CONDITIONS, Continued

2. b. minimize or otherwise control discharges or upon notification from the Department that revision is necessary.

c. The BMP program provisions in this permit may be modified in accordance with the procedures set forth in COMAR 26.08.04.10.

d. The permittee must notify the Department at least 14 days before:

i) the BMP program is placed into effect or

ii) the BMP program is modified or discontinued by the permittee

e. The implementation of a BMP program:

i) can be used to comply with General Condition C.1. Operation above, provided the BMP program is in accordance with the terms, conditions, requirements and/or provisions as set forth in paragraphs C.1. above, C.3. and C.4. below.

ii) does not nullify, change, alter, modify or in any way affect the specific terms, conditions, requirements or provisions as set forth under paragraphs C.I. above and C.3. below.

3. Wastewater Collection System Overflows

a. All overflows from the wastewater collection system are prohibited.

b. In the event of an unauthorized overflow of wastewater from the collection system, the permittee may assert a defense if the permittee can affirmatively demonstrate:

i) The collection system or component of the collection system from where the wastewater overflowed:

I) was properly designed and;

II) had adequate back-up equipment installed in the exercise of reasonable engineering judgement and;

III) was properly maintained and;

IV) was being properly operated at the time of the overflow and;

III. GENERAL CONDITIONS, Continued

ii) The overflow was caused by factors beyond the permittee' reasonable control and;

iii) The permittee took all reasonable steps to minimize or control and eventually stop the overflow and;

iv) The permittee gave notice of the unauthorized overflow i accordance with paragraph C.4. below.

c. An adequate and properly implemented BMP program may constitut one or more of the conditions necessary to assert a defense to an unauthorized overflow pursuant to paragraph 3.b. above, to the extent determined by the Department.

4. Reporting Wastewater Collection System Overflows

The permittee shall report all wastewater collection system overflows in accordance with the Notification Requirements set forth in Section III. General Condition B.1.. However, the written reports on the overflows shall be submitted monthly unless the Department specifically requests the report to be submitted within 5 days after the permittee becomes aware of the overflow.

City of Baltimore shall be responsible for the operation and maintenance o the collection system within its jurisdiction only.

D. Permit Expiration, Modification, or Revocation

1. Expiration of Permit

This permit and the authorization to discharge shall expire at midnight on the expiration date of the permit unless permittee has submitted a timely and complete reapplication pursuant to Section III.C.2 below.

2. Reapplication for a Permit

At least 180 days before the expiration date of this permit, unless permission for a later date has been granted by the Department, the permittee shall submit a new application for a permit or notify the Department of the intent to cease discharging by the expiration date. In the event that a timely and complete reapplication has been submitted and the Department is unable, through no fault of the permittee, to issue a new permit before the expiration date of this permit, the terms and conditions of this permit continue and remain fully effective and enforceable.

III. GENERAL CONDITIONS, Continued

D. 3. Permit Modification - Request of Permittee

A permit may be modified by the Department upon the written request of the permittee and after notice and opportunity for a public hearing in accordance with the provisions set forth in COMAR 26.08.04.10.

4. Permit Modification, Suspension, Revocation - Violation of Laws

A permit may also be modified, suspended or revoked by the Department, in the event of a violation of the terms or conditions of the permit, or of State or federal laws and regulations and in accordance with the provisions set forth in COMAR.

IV. CIVIL AND CRIMINAL PENALTIES

1. Civil Penalties for Violations of Permit Conditions

In addition to civil penalties for violations of State water pollution control laws set forth in Section 9-342 of the Environment Article, Annotated Code of Maryland, the Clean Water Act provides that any person who violates Section 301, 302, 306, 307, 308, 318 or 405 of the Act, or any permit condition or limitation implementing any of such sections in a permit issued under Section 402 of the Act or in a permit issued under Section 404 of the Act, is subject to a civil penalty not to exceed $25,000 per day for each violation.

2. Criminal Penalties for Violations of Permit Conditions

In addition to criminal penalties for violations of State water pollution control laws set forth in Section 9-343 of the Environment Article, Annotated Code of Maryland, the Clean Water Act provides that:

a. any person who negligently violates Section 301, 302, 306, 307, 308, 318, or 405 of the Act, or any permit condition or limitation implementing any of such sections in a permit issued under Section 402 of the Act, or in a permit issued under Section 404 of the Act, is subject to a fine of not less than $2,500 nor more than $25,000 per day of violation, or by imprisonment for not more than one (1) year, or by both.

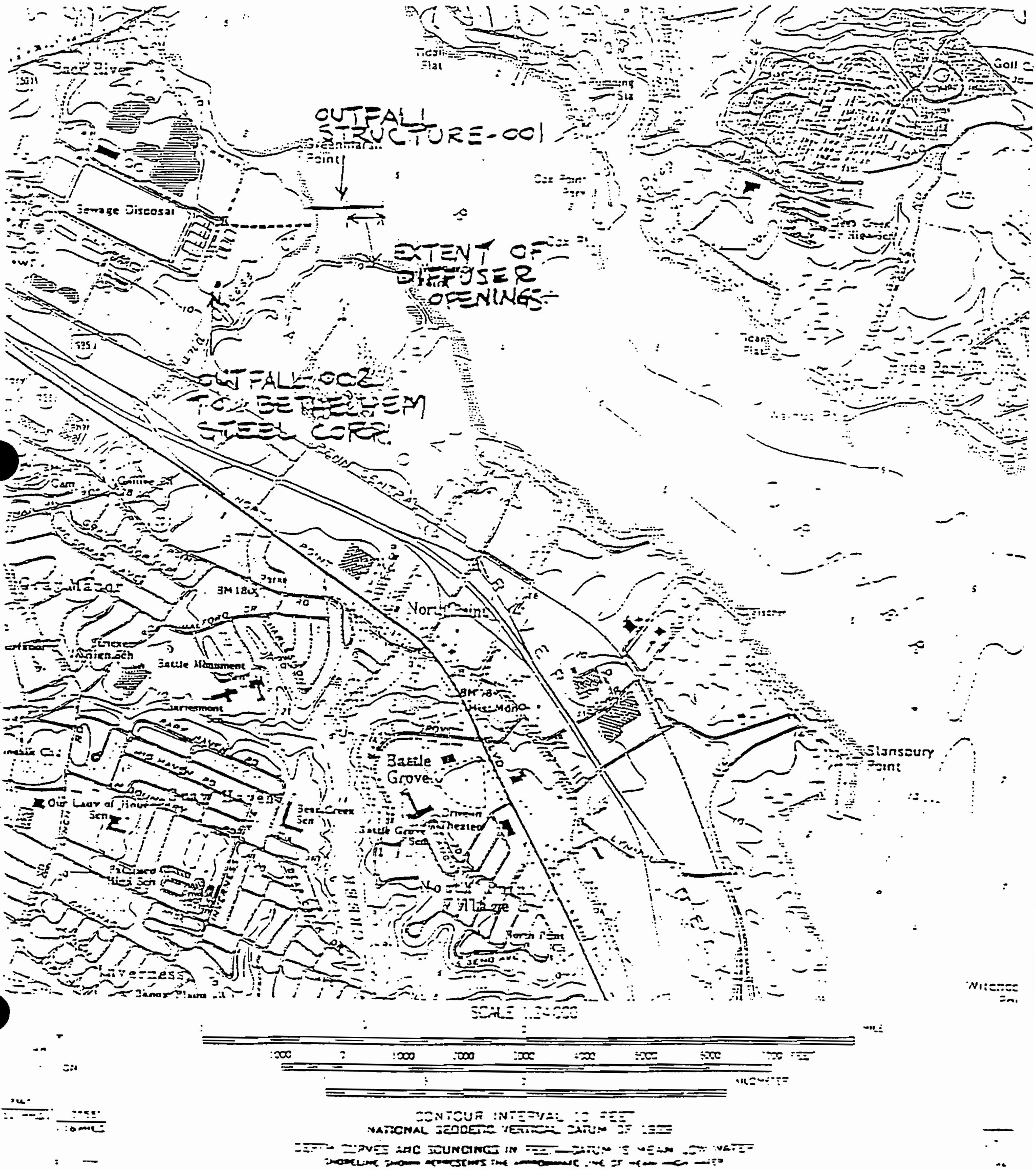
b. any person who knowingly violates Section 301, 302, 306, 307, 308, 318 or 405 of the Act, or any permit condition or limitation implementing any of such sections in a permit issued under Section 402 of the Act, or in a permit issued under Section 404 of the Act, is subject to a fine of not less than $5,000 nor more than $50,000 per day of violation, or by imprisonment for not more than three (3) years, or by both.

IV. CIVIL AND CRIMINAL PENALTIES, Continued

c. any person who knowingly violates Section 301, 302, 306, 307, 318 or 405 of the Act, or any permit condition or limitation implementing any of such sections in a permit issued under Section 402 of the Act, or in a permit issued under Section 404 of the Act, and who knows at that time that he thereby places another person in imminent danger of death or serious bodily injury, is subject to a fine of not more than $250,000 or imprisonment of not more than 15 years, or both.

d. any person who knowingly makes any false material statement, representation, or certification in any application, record, report, plan, or other document filed or required to be maintained under the Act or who knowingly falsifies, tampers with or renders inaccurate any monitoring device or method required to be maintained under the Act, is subject to a fine of not more than $10,000 or by imprisonment for not more than two (2) years, or by both.

V. MAP SHOWING DISCHARGE POINT LOCATION



VI. NPDES PROGRAM

On September 5, 1974, the Administrator of the U.S. Environmental Protection Agency approved the proposal submitted by the State of Maryland for the operation of a permit program for wastewater discharges pursuant to Section 402 of the Clean Water Act.

Pursuant to the aforementioned approval, this discharge permit is both a State of Maryland discharge permit and an NPDES permit.

J. L. Hearn

J. L. Hearn, Director
Water Management Administration

MARYLAND DEPARTMENT OF THE ENVIRONMENT
2500 Broening Highway • Baltimore, Maryland 21224
(410) 631-3000

William Donald Schaefer
Governor

Robert Perciasepe
Secretary

DISCHARGE PERMIT

State Discharge Permit Number: 93-DP-0580	Effective Date: August 1, 1993
NPDES Permit Number: MD0021601	Expiration Date: July 31, 1998

Pursuant to the provisions of Title 9 of the Environment Article, Annotated Code of Maryland, and implementing regulation COMAR 26.08.01 et seq. and the provisions of the Clean Water Act (33 U.S.C. Sections 1251, et seq.) and implementing regulations 40 C. F. R. Parts 122, 123, 124, and 125, the Department of the Environment, hereby authorizes

Mayor and City Council of Baltimore
600 Abel Wolman Municipal Building
Baltimore, Maryland 21202

TO DISCHARGE FROM: The Patapsco Wastewater Treatment Plant

LOCATED AT: 3501 Asiatic Avenue
Baltimore, Maryland 21226

THROUGH OUTFALL: 001- Facility Effluent

TO: The Patapsco River which is protected for water contact recreation and aquatic life; in accordance with the following special and general conditions and a map incorporated herein and made a part hereof.

I. DEFINITIONS

A. Bypass means the intentional diversion of pollutants from any portion of a treatment facility.

B. BOD_5 (Biochemical Oxygen Demand) means the amount of oxygen consumed in standard BOD_5 test without the use of a nitrification inhibitor at 20 degree centigrade on an unfiltered sample.

C. The Clean Water Act means the Federal Water Pollution Control Act, as amended, 33 U.S.C. Sections 1251 et seq.

D. CFR means the Code of Federal Regulations.

E. COMAR means the Code of Maryland Regulations.

F. Composite Sample means a combination of individual samples obtained at hourly or smaller intervals over a time period. Either the volume of each individual sample is proportional to discharge flow rates or the sampling interval (for constant volume samples) is proportional to the flow rates over the time period used to produce the composite.

G. Environment Code means Environment Article, Annotated Code of Maryland.

H. Grab samples means an individual sample collected in less than 15 minutes.

I. MDE means the Maryland Department of the Environment.

J. Measured Flow means any method of liquid volume measurement, the accuracy of which has been previously demonstrated in engineering practice, or for which a relationship to absolute volume has been obtained.

K. Minimum or maximum value means the lowest or highest value measured.

L. Monthly average discharge means the total mass (and concentration, if appropriate) of all daily discharges sampled and/or measured during a calendar month divided by the number of daily discharges sampled and/or measured during such month.

M. Monthly log mean (monthly geometric mean) means the logarithmic or geometric mean of all samples taken in the calendar month.

I. DEFINITIONS, Continued

N. Nondetectable level for Total Residual Chlorine, due to limitations in measurement technology, means a residual concentration of less than 0.10 mg/l.

O. Outfall XXX means a sampling location in outfall line XXX downstream from the last addition point or as otherwise specified.

P. POTW means a publicly owned treatment works.

Q. Significant Industrial User (SIU) is defined as any industrial user that:

1. All users subject to categorical pretreatment standards under 40 CFR 403.6 and 40 CFR Chapter 1, Subchapter N; and

2. Any other user that:

(a) discharges an average of 25,000 gallons per day or more or process wastewater to the POTW (excluding sanitary, noncontact cooling and boiler blowdown wastewater);

(b) contributes a process wastestream which makes up five percent or more of the average dry weather hydraulic or organic capacity of the POTW treatment ; or

(c) is designated as such by the POTW on the basis that the user has a reasonable potential for adversely affecting the POTW's operation or for violating any pretreatment standard or requirement {in accordance with 40 CFR 403.8(f)(6)}; or

(d) is found by the POTW, the Department or the Environmental Protection Agency (EPA) to have significant impact, either individually or in combination with other contributing industries to the POTW, to the quality of the sludge, the POTW's effluent quality, or air emissions generated by the system.

R. Suspended Solids means the residue retained on the filter by an analysis done in accordance with Standard Methods or other approved methods.

S. Weekly average means the highest weekly average of the month, calculated by dividing the total mass (and concentration, if appropriate) for each week by the number of samples collected and measured that week.

T. NPDES (National Pollutant Discharge Elimination System) means the national system for issuing permits as designated by the Clean Water Act.

II. SPECIAL CONDITIONS

A1. EFFLUENT LIMITATIONS, POINT SOURCE - 001*

Effective August 1, 1993, and lasting until July 31, 1998, the quality of the effluent discharge shall be limited at all times as follows:**

Effluent Characteristic	Monthly Loading Rate Kg/D (lbs/D)	Weekly Loading Rate Kg/D (lbs/D)	Monthly Average mg/l	Weekly Average mg/l
BOD_5	6,800 (15,000)	10,000 (22,000)	30	45
Suspended Solids	6,800 (15,000)	10,000 (22,000)	30	45
Total P	450 (1,000)	680 (1,500)	2.0	3.0

Effluent Characteristic	Maximum	Minimum
Fecal Coliforms	200 MPN/100 ml monthly log mean value	N/A
Total Residual Chlorine	Dechlorination is required to reduce the total residual chlorine to a nondetectable level (See Definition I.N.)	
Dissolved Oxygen	N/A	5.0 mg/l at any time
pH	8.5	6.0
Flow***	60.0 mgd	

---

* Renewal permit limitations may or may not be equal to the above limitation; discharge of pollutants not shown shall be illegal.

** There shall be no discharge of floating solids or visible foam other than trace amount.

***Flow used in waste allocation calculations. Notification to be provided to MDE at least 180 days before the flow is expected to exceed the permit flow.

II. SPECIAL CONDITIONS

A2. EFFLUENT LIMITATIONS, POINT SOURCE - 001*

Effective August 1, 1993, and lasting until July 31, 1998, the quality of the effluent discharge shall be limited at all times as follows:**

Effluent Characteristic	Monthly Loading Rate Kg/D (lbs/D)	Weekly Loading Rate Kg/D (lbs/D)	Monthly Average mg/l	Weekly Average mg/l
BOD_5	8,000 (17,000)	12,000 (26,000)	30	45
Suspended Solids	8,000 (17,000)	12,000 (26,000)	30	45
Total P	530 (1,200)	800 (1,700)	2.0	3.0

Effluent Characteristic	Maximum	Minimum
Fecal Coliforms	200 MPN/100 ml monthly log mean value	N/A
Total Residual Chlorine	Dechlorination is required to reduce the total residual chlorine to a nondetectable level (See Definition-I.N.)	
Dissolved Oxygen	N/A	5.0 mg/l at any time
pH	8.5	6.0
Flow***	70.0 mgd	

* Renewal permit limitations may or may not be equal to the above limitation; discharge of pollutants not shown shall be illegal.

** There shall be no discharge of floating solids or visible foam other than trace amount.

***Flow used in waste allocation calculations. Notification to be provided to MDE at least 180 days before the flow is expected to exceed the permit flow.

NOTE: Above limits shall be effective upon the determination by MDE that 70 MGD is the appropriate capacity rating.

II. SPECIAL CONDITIONS

A3. EFFLUENT LIMITATIONS, POINT SOURCE - 001*

Effective August 1, 1993, and lasting until July 31, 1998, the quality of the effluent discharge shall be limited at all times as follows:**

Effluent Characteristic	Monthly Loading Rate Kg/D (lbs/D)	Weekly Loading Rate Kg/D (lbs/D)	Monthly Average mg/l	Weekly Average mg/l
BOD_5	9,900 (22,000)	15,000 (33,000)	30	45
Suspended Solids	9,900 (22,000)	15,000 (33,000)	30	45
Total P	660 (1,500)	1,000 (2,200)	2.0	3.0

Effluent Characteristic	Maximum	Minimum
Fecal Coliforms	200 MPN/100 ml monthly log mean value	N/A
Total Residual Chlorine	Dechlorination is required to reduce the total residual chlorine to a nondetectable level (See Definition-I.N.)	
Dissolved Oxygen	N/A	5.0 mg/l at any time
pH	8.5	6.0
Flow***	87.5 mgd	

---

* Renewal permit limitations may or may not be equal to the above limitation; discharge of pollutants not shown shall be illegal.

** There shall be no discharge of floating solids or visible foam other than trace amount.

***Flow used in waste allocation calculations. Notification to be provided to MDE at least 180 days before the flow is expected to exceed the permit flow.

NOTE: Above limits shall be effective when the average sewage flow for any one quarter exceeds 70.0 mgd and MDE determines that the plant has been expanded to accommodate at least 87.5 mgd flow.

II. SPECIAL CONDITIONS, Continued

B. MONITORING REQUIREMENTS, POINT SOURCE 001*

The effluent characteristics prescribed in IIA1,A2 and A3 shall be monitored as follows:

Effluent Characteristic	Measurement Frequency	Sample Type
BOD_5	One/Day	24 hr. composite
Suspended Solids	One/Day	24 hr. composite
Mercury +**	One/Month	24 hr. composite
Total P	One/ Day	24 hr. composite
Copper +**	One/Month	24 hr. composite
Ortho-P+	Two/Month	24 hr. composite
Ammonia-N+*	Two/Month	24 hr. composite
Organic-N+*	Two/Month	24 hr. composite
$(NO_3 + NO_2)$ -N+*	Two/Month	24 hr. composite
Fecal Coliforms	One/Day	Grab
Total Residual Chlorine	Three/Day	Grab
Dissolved Oxygen	Three/Day	Grab
pH	Three/Day	Grab
Flow	Continuous	Recorded

\+ Monitor only parameters shall be reported on the Monthly Operating Report as individual results and the Discharge Monitoring Report (EPA Form 3320-1) as a monthly average concentration and monthly average loading value.

* Tests for all these parameters should be run on the same 24 hour composite sample.

** Numerical limits may be imposed based on the results of the additional monitoring.

II. SPECIAL CONDITIONS, Cont.

C. SCHEDULE OF COMPLIANCE

The permittee shall achieve compliance with the preceding discharge limitations in accordance with the following schedule:

On the effective date of this permit. For Compliance with Section II.G refer to the forthcoming Administrative Order.

D. PRETREATMENT PROGRAM

The permittee shall operate and maintain the pretreatment program approved on August 7, 1985 by MDE. The program must be updated if needed to comply with COMAR 26.08.08 and the State of Maryland Treatment Works (POTW) Pretreatment Delegation Agreement signed on May 19, 1986, the terms of which are expressly incorporated herein as if set forth in full.

E. TOXICITY REDUCTION EVALUATION (TRE)

1. A TRE is a step-wise process which combines toxicity testing and analysis of the physical and chemical characteristics of causative toxicants to zero in on the toxicants causing effluent toxicity and/or treatment methods which will reduce the effluent toxicity.

   The TRE plan includes appropriate measures to characterize effluent variability with respect to toxicity, to identify the causative toxicants and/or evaluate toxicity treatability and a schedule for completing the study.

2. A TRE study is currently being performed by the US Environmental Protection Agency.

3. Within 90 days of notification by MDE, the permittee shall submit to MDE a schedule for completing the implementation of those measures identified as necessary to eliminate the acute toxicity.

4. The permittee shall implement the measures identified as necessary to eliminate the acute toxicity in accordance with the schedule established in Section E. 3 of this permit.

5. Within 90 days of completing the implementation of the control measures to eliminate or reduce toxicity, the permittee shall submit to the MDE for approval a study plan to confirm elimination of toxicity by using biomonitoring, as specified in Section F of this permit.

II. SPECIAL CONDITIONS, Cont.

6. MDE may reopen and modify this permit to include a change in the biomonitoring requirements or any other conditions related to the elimination of acute toxicity.

7. Submit all TRE related materials to:

Maryland Department of the Environment
Water Management Administration
Pretreatment and Enforcement Division
2500 Broening Highway
Baltimore, Maryland 21224

F. BIOMONITORING PROGRAM

1. Within 90 days of the completing the implementation of the control measures to eliminate or reduce toxicity as specified in Section E.5. of this permit, the permittee shall submit to MDE for approval a Study Plan to evaluate, using biomonitoring, wastewater toxicity at outfall 001.

2. The study plan, at a minimum, shall include:

a. A discussion of the wastewater characteristics and production variability;

b. The species selected for testing and the rationale for the selection;

c. A description of sample collection procedures, testing protocols and quality control procedures for both acute and chronic toxicity testing.

d. A schedule that defines the dates of the four quarters and the type of corresponding tests to be performed in each quarter as required in F.4. and 7.

e. This schedule shall enable the testing to be initiated no later than three months after the due date of the study plan.

3. Unless shown to be impractical, the permittee shall use daily composite samples for chronic testing. A rationale for the type of sample taken for acute testing shall also be provided in each report.

4. Testing shall be performed for a period of one year as follows:

a. During the first and second quarters after the date that MDE's comments are incorporated in the study plan: Short term chronic testing using Ceriodaphnia and fathead minnows. In estuarine waters the permittee may substitute sheepshead minnows, inland silversides, and mysid shrimp. In all cases, tests must include one vertebrate and one invertebrate species.

II. SPECIAL CONDITIONS, Cont.

4. b. At least once per quarter for the subsequent two quarters:

1) 48-hour static renewal acute test using the fathead minnow or an MDE approved locally important fish species; and

2) 48-hour static renewal acute test using Daphnia magna, Daphnia pulex, Ceriodaphnia dubio, or an MDE approved locally important insect species or other invertebrate species.

Quarterly tests shall be performed at least one month apart.

5. The permittee shall employ methods for toxicity testing consistent with:

a. Methods for Measuring the Acute toxicity of Effluents to Freshwater and Marine Organisms. March 1985, EPA/600/4-85/013.

b. Short-Term methods for Estimating the Chronic Toxicity of Effluents and Receiving Waters to Freshwater Organisms, Second Edition, March 1989, EPA/600/4-89/001.

c. Short-Term Methods for Estimating the Chronic Toxicity of Effluents and Receiving Waters to Marine and Estuarine Organisms, May 1988, EPA/600/4-87/028.

6. The permittee shall schedule the required testing within each quarter as defined in the study plan. The permittee shall submit test results to MDE no later than the end of each quarter as defined in the study plan. The permittee shall notify MDE in writing of the reason for any delay in performing the test and/or reporting the results of the required testing. The test results shall include, at a minimum, the following:

a. Documentation of the effluent collection procedures (including effluent source, sampling date, time, location, and custody forms.

b. Documentation of the test conditions (including test starting date and time, raw and summarized physical and chemical data, summary of test methods and the source of dilution water and test organisms).

c. Documentation of the test results (including raw and summarized biological data, the appropriate test endpoints and statistics, reference toxicant test results, the 48-hour LC_{50}, and any test method deviations).

II. SPECIAL CONDITIONS, Cont.

F. 7. The Permittee shall perform chemical testing for those pollutants identified in the MDE Toxic Substance Analytical Protocal concurrently with the first chronic toxicity test. A chemical testing plan shall be submitted with the biomonitoring plan of study.

a. The priority pollutant testing plan shall, at a minimum, identify the analytical methods and their practical limits of detection. The analytical methods as specified in "MDE Priority Pollutant analytical Protocol" for pollutants with established water quality criterion shall be used. All testing shall be done in accordance with 40 CFR Part 136. Quality assurance/quality control procedures shall also be described.

b. The ten highest peaks other than the priority pollutants shall be identified and quantified as part of the testing procedures.

c. Twenty-four hour composite samples shall be collected for the analyses unless otherwise required by 40 CFR Part 136.

8. The permittee shall perform the priority pollutant testing in accordance with the plan submitted per section F.7., above, and as approved and amended by MDE. The permittee shall submit the priority pollutant test results along with the first chronic toxicity test results to MDE. The permittee shall notify MDE in writing of the reason for any delay in performing the test and/or reporting the results of the priority pollutant testing. The report of the results shall include all items specified in "Reporting Requirements for Priority Pollutant Analytical Data" (MDE-WMA).

9. MDE may require additional testing if testing was not properly performed or if the presence of toxicity is detected.

10. If plant processes or operation changes or if a significant industrial user locates within the service area, so that significant change in the nature of the wastewater might be anticipated, MDE may require that the permittee repeat the tests required by section F4. and 7.

11. Submit all Biomonitoring related materials to:

Maryland Department of the Environment
Water Management Administration
Pretreatment and Enforcement Division
2500 Broening Highway
Baltimore, Maryland 21224

II. SPECIAL CONDITIONS, Cont.

G. BYPASSES, OVERFLOWS AND COMBINED SEWER OVERFLOWS

1. Point sources 003P, 012P, 016P, 017P, 023P, 024P, 025P, 028P, 029P, and 030P listed below, as well as any pump station or sewer overflow structure not listed below, represent potential overflows discharging untreated wastewater into the waters of the State. Pursuant to General Conditions III. B.5 the bypass of treatment facilities is prohibited unless the conditions of III.B.5 are satisfied. Each point source shall be monitored for cause, frequency, duration and quantity of flow. These monitoring results are to be reported quarterly as an attachment to the Discharge Monitoring Report Forms which are submitted in compliance with the requirements of III.A.2.

2. Point sources 020P and 027P listed below have been identified by the Department as a health hazard and are to be eliminated in accordance with the Schedule of Compliance listed in IIC1.

3.

Point Source		Diameter of Point Source Pipe	Receiving Stream
003P	Brooklyn Pumping Station	-	Middle Branch
012P	Rear 2900 Hillsdale Rd.	18"	Gwynns Falls
016P	NW Corner Stanford Rd.	15"	Gwynns Falls
017P	NW Corner Brianclift Rd.	18"	Gwynns Falls
020P	Garrison Blvd/Windsor Mill Rd.	-	Gwynns Falls
022P	Ghesholm Rd-Siphon	-	Gwynns Falls
023P	Rear 5612 Edmondson Ave.	12"	Maidens Choice Run
024P	NE Corner Mallow Hill Rd.	15"	Maidens Choice Run
025P	Howard Park & Brightwood	15"	Gwynns Falls
026P	Howard Park & California Blvd.	15"	Gwynns Falls
027P	Mohawk Path-Liberty Hts. & Kathland Ave.	-	Gwynns Falls
028P	Elderon and Leredo Ave.	15"	Gwynns Falls
029P	Elderon Ave. & Hillsdale Rd.	24"	Gwynns Falls
030P	Rear A313 Elderon Ave.	8"	Gwynns Falls

4. a. Point sources listed below in (C) have been identified as combined sewer overflows (dry weather interceptor flows). Discharges from any of these point sources is permitted only when the hydraulic capacity of the related conveyance system is exceeded due to the introduction of storm water during wet weather periods. Discharges during dry weather are prohibited.

b. PLAN OF ACTION

1. The permittee shall provide, within six months after the issue date of this permit, a plan of action for developing and establishing a CSO control program. This program shall minimize the quantity of discharges from all CSOs.

II. SPECIAL CONDITIONS, Cont.

2. The plan of action must set forth a description and schedule of actions City of Baltimore will take to establish a CSO control program. The program must consider the items set forth in the CSO Program Guidance as provided by the Department.

3. The permittee shall implement the plan of action as approved by Maryland Department of the Environment.

c.

Point Source		Receiving Stream
010P	Front of 4508 Wentworth Rd.	Gwynns Falls
011P	W. Hillsdale Rd. at California Blvd	Gwynns Falls
013P	NE Corner of Purnell Dr. & Forest Park	Gwynns Falls
018P	Rear of 4017 Liberty Hgts Ave.	Gwynns Falls
019P	Grenada Ave. alley S. of Main Ave.	Gwynns Falls
021P	N of Winterborne Ave. E of Chelsco Terr.	Gwynns Falls
031P	Alley in rear of 4309 Springdale Ave.	Gwynns Falls

III. GENERAL CONDITIONS

A. MONITORING AND REPORTING

1. Representative Sampling
Samples and measurements shall be taken at times that are representative of the quantity and quality of the discharge, and at evenly spaced intervals.

2. Monthly Monitoring Results

a. Discharge Monitoring Reports
Monitoring results obtained each month shall be summarized on a Discharge Monitoring Report form (EPA No. 3320-1). Reports shall be submitted to MDE postmarked no later than the 28th day of the month following the reporting month. Duplicate signed copies of these reports shall be submitted to:

Wastewater Inspection Division
Water Management Administration
Maryland Department of the Environment
2500 Broening Highway
Baltimore, Maryland 21224

b. Monthly Operating Reports
The permittee shall submit monthly operating reports on a form supplied or approved by the STP Inspection Division. Reports shall be submitted to the STP Inspection Division postmarked no later than the 28th day of the month following the reporting month.

III. GENERAL CONDITIONS, Continued

A. 3. Sampling and Analysis Methods
Analytical and sampling methods shall conform to test procedures for the analysis of pollutants as identified in 40 CFR, 136 - "Guidelines Establishing Test Procedures for the Analysis of Pollutants."

4. Monitoring Equipment Maintenance

a. The permittee shall calibrate and maintain all monitoring and analytical instrumentation to ensure accuracy of measurements.

b. Environment Code, Section 9-343 provides that any person who falsifies, tampers with, or knowingly renders inaccurate, any monitoring device or method required to be maintained under this permit shall, upon conviction, be punished by a fine of not more than $10,000 per violation, or by imprisonment for not more than 6 months per violation, or by both.

5. Recording of Results
For each measurement or sample taken pursuant to the requirements of this permit, the permittee shall record the following information:

a. The date, exact place and time of sampling or measurement;

b. The person(s) who performed the sampling or measurement;

c. The dates analyses were performed;

d. The person(s) who performed each analysis;

e. The analytical techniques or methods used; and

f. The results of such analyses.

6. Additional Monitoring by Permittee
If the permittee monitors any pollutant at the location(s) designated herein more frequently than required by this permit, using approved analytical methods as specified above, the results of such monitoring shall be included

III. GENERAL CONDITIONS, Continued

A. 6. in the calculation and reporting of the values required in the Discharge Monitoring Report form (EPA No. 3320-1). The increased frequency shall also be reported. The results of any other monitoring performed by the permittee shall be made available to MDE upon request.

7. Records Retention
All data used to complete the permit application and all records and information resulting from the monitoring activities required by this permit, including all records of sampling and analyses performed, calibration and maintenance of instrumentation, and recordings from continuous monitoring instrumentation shall be retained for a minimum of three (3) years. This period shall be extended automatically during the course of litigation or when requested by MDE.

B. General Requirements

1. Permit Noncompliance - Notification Requirements
All discharges authorized herein shall be consistent with the terms and conditions of this permit. The discharge of any pollutant not identified in this permit, or of any pollutant identified in this permit at a level in excess of that authorized shall constitute a violation of this permit. If for any reason the permittee does not comply with or will be unable to comply with any permit condition, the permittee shall, within twenty four hours, notify MDE by telephone at (410) 631-3635 during work hours and at (410) 243-8700 during evenings, weekends, and holidays. The permittee shall provide MDE with the following information in writing within five days of such oral notification.

a. A description of the noncomplying discharge including its impact upon the receiving waters;

b. Cause of noncompliance;

c. The duration of the period of noncompliance and the anticipated time the condition of noncompliance is expected to continue;

d. Steps taken by the permittee to reduce and eliminate the noncomplying discharge;

e. Steps to be taken by the permittee to prevent recurrence of the condition of noncompliance;

III. GENERAL CONDITIONS, Continued

B. 1. f. A description of the accelerated or additional monitoring to determine the nature and impact of the noncomplying discharge; and

g. the results of the monitoring described in f. above.

2. Change in Discharge
The permittee shall report any anticipated facility expansions, production increases, or process modifications which will result in new, different or an increased discharge of pollutants by submitting a new application at least 180 days prior to the commencement of the changed discharge or, if such changes will not violate the effluent limitations specified in this permit, by providing prior written notice to MDE. Following such notice, the permit may be modified by MDE to specify and limit any pollutants not previously limited.

3. Facility Operation and Quality Control
All waste collection, control, treatment and disposal facilities shall be operated in a manner consistent with the following:

a. Facilities shall be operated efficiently to minimize upsets and discharges of excessive pollutants;

b. The permittee shall provide an adequate operating staff qualified to carry out operation, maintenance and testing functions required to ensure compliance with this permit. Superintendents and operators must be certified by the Board of Waterworks and Waste Systems Operators, located at 2500 Broening Highway, Baltimore, Maryland 21224 in accordance with Title 12 of the Environmental Article, Annotated Code of Maryland.

c. Facility maintenance work which adversely affects or may adversely affect the discharge quality shall be scheduled during noncritical water quality periods. The permittee shall follow the reporting procedures listed in this permit for III.B.1, Noncompliance Notification.

III. GENERAL CONDITIONS, Continued

B. 4. Adverse Impact
The permittee shall take all reasonable steps to minimize any adverse impact to waters of the State, human health or the environment resulting from noncompliance with any effluent limitations specified in this permit, and must perform accelerated or additional monitoring as necessary to determine the nature and impact of the noncomplying discharge.

5. Bypassing
Any bypass of treatment facilities is prohibited unless the bypass does not cause any violations of the effluent limitations specified in II.A. and is for essential maintenance to assure efficient operation.
Or unless the permittee can prove that:

a. The bypass is unavoidable to prevent loss of life, personal injury, or substantial physical damage to property, damage to the treatment facilities which would cause them to become inoperable, or substantial and permanent loss of natural resources; and

b. There are no feasible alternatives to the bypass; and

c. MDE receives notification pursuant to Section III.B.1. above. Where the need for a bypass is known (or should have been known) in advance, this notification shall be submitted to MDE for approval at least ten (10) days before the date of the bypass or at the earliest possible date if the period of advance knowledge is less than ten days; and

d. The bypass is allowed under conditions determined by MDE to be necessary to minimize adverse effects.

6. Sewage Sludge Requirements
The permittee shall comply with all existing State and Federal laws and regulations that apply to sewage sludge monitoring requirements and utilization practices, and with any regulations promulgated pursuant to Environment Code Sections 9-230 et seq. Or to the Clean Water Act Section 405 (d). The permittee is responsible for ensuring that its sewage sludge is utilized in accordance with a valid Sewage Sludge Utilization Permit issued by MDE, if is disposed of in the State of Maryland.

7. Power Failure
Permittee shall maintain compliance with the effluent

III. GENERAL CONDITIONS, Continued

B. 7. limitations and all other terms and conditions of this permit in the event oo a reduction, loss or failure of the primary source of power to the wastewater collection and treatment facilities.

8. Right of Entry
The permittee shall allow the Secretary of MDE, the Regional Administrator of the Environmental Protection Agency, and their authorized representatives, upon the presentation of credentials to enter upon the permittee's premises and:

a. To have access to and to copy any records required to be kept under the terms and conditions of this permit;

b. To inspect any monitoring equipment or monitoring method required in this permit;

c. To inspect any collection, treatment, pollution management, or discharge facilities required under this permit; or

d. To sample any discharge of pollutants.

9. Property Rights/Compliance With Other Requirements
The issuance of this permit does not convey any property rights in either real or personal property, or any exclusive privileges, nor does it authorize any injury to private property, invasion of personal rights, or any infringement of Federal, State or local laws or regulations.

10. Reports and Information

a. The permittee shall provide to MDE, within a reasonable time, upon request, copies of records required to be kept by this permit. The permittee shall also furnish to MDE, within a reasonable time, any information which MDE may request to determine whether cause exists for modifying, revoking and reissuing, or terminating this permit; or to determine compliance with this permit.

b. All applications, reports or information submitted to MDE shall be signed and certified as required by COMAR 26.08.04.01.

III. GENERAL CONDITIONS, Continued

B. 10. c. Except for data determined to be confidential under COMAR 26.08.04.01, all data shall be available for public inspection at MDE and the office of the Regional Administrator of the Environmental Protection Agency. Effluent data shall not be considered confidential.

d. Environment Code 9-343 provides that any person who knowingly makes any false statement, representation, or certification in any record or other document submitted or required to be maintained under this permit, including monitoring reports or reports of compliance or noncompliance shall, upon conviction, be punished by a fine of not more than $10,000 or by imprisonment for not more than 6 months or by both.

11. Transfer of Ownership or Control
In the event of any change in ownership or control of facilities from which the authorized discharge emanates, the permit may be tdansferred automatically to another person only if:

a. The current permittee notifies MDE, in writing of the proposed transfer at least 30 days prior to the proposed transfer date;

b. The notice includes a written agreement between the existing and new permittees containing the specific date of proposed transfer of permit coverage, and of responsibilities and liabilities under the permit; and

c. Neither the current permittee nor the new permittee receive notification from MDE, within 30 days of MDE's receipt of the agreement, of its intent to modify, revoke, reissue or terminate the existing permit. If this notice is not received, the transfer is effective on the date specified in the agreement mentioned in paragraph (b) above.

12. New Effluent Standards
This permit shall be revoked and reissued or modified to meet any effluent standard, water quality standard or prohibition established under the Environment Code, under the Clean Water Act, or under regulations promulgated thereto, and the permittees shall be so notified.

III. GENERAL CONDITIONS, Continued

B. 13. Industrial Users
The permittee shall require all industrial users of the wastewater treatment facility to comply with user charges as established by the permittee, pursuant to Section 9-326(a)(i) of the Environment Code.

14. Noncompliance
Nothing in this permit shall be construed to preclude the institution of any legal action for noncompliance with Maryland, federal or local laws and regulations.

15. Oil and Hazardous Substances Liability
Nothing in this permit shall be construed to preclude the institution of any legal action against the permittee or to relieve the permittee from any responsibilities, liabilities, or penalties to which the permittee is or may be subject under Section 311 of the Clean Water Act or under the Maryland Annotated Code.

16. Waterway Construction and Obstruction
This permit does not authorize the construction or placing of physical structures, facilities, debris, or the undertaking of related activities in any waters of the State including the 100 year flood plain.

17. Construction Permit
This permit is notta permit to construct. For a new facility, in order to make this permit valid, a construction permit shall be obtained to meet the requirements of COMAR 26.08.04.01B(3) and Annotated Code of Maryland 9-204(d).

18. Severability
If any provision of this permit shall be held invalid for any reason, the remaining provisions shall remain in full force and effect, and such invalid provisions shall be considered severed and deleted from this permit.

III. GENERAL CONDITIONS, Continued

C. Permit Expiration, Modification, or Revocation

1. Expiration of Permit
This permit and the authorization to discharge shall expire at midnight on the expiration date of the permit unless permittee has submitted a timely and complete reapplication pursuant to Section III.C.2. below.

2. Reapplication for a Permit
At least 180 days before the expiration date of this permit, unless permission for a later date has been granted by MDE, the permittee shall submit a new application for a permit or notify MDE of the intent to cease discharging by the expiration date. In the event that a timely and complete reapplication has been submitted and MDE is unable, through no fault of the permittee, to issue a new permit before the expiration date of this permit, the terms and conditions of this permit continue and remain fully effective and enforceable.

3. Permit Modification - Request of Permittee
A permit may be modified by MDE upon the written request of the permittee and after notice and opportunity for a public hearing in accordance with the provisions set forth in COMAR 26.08.04.10

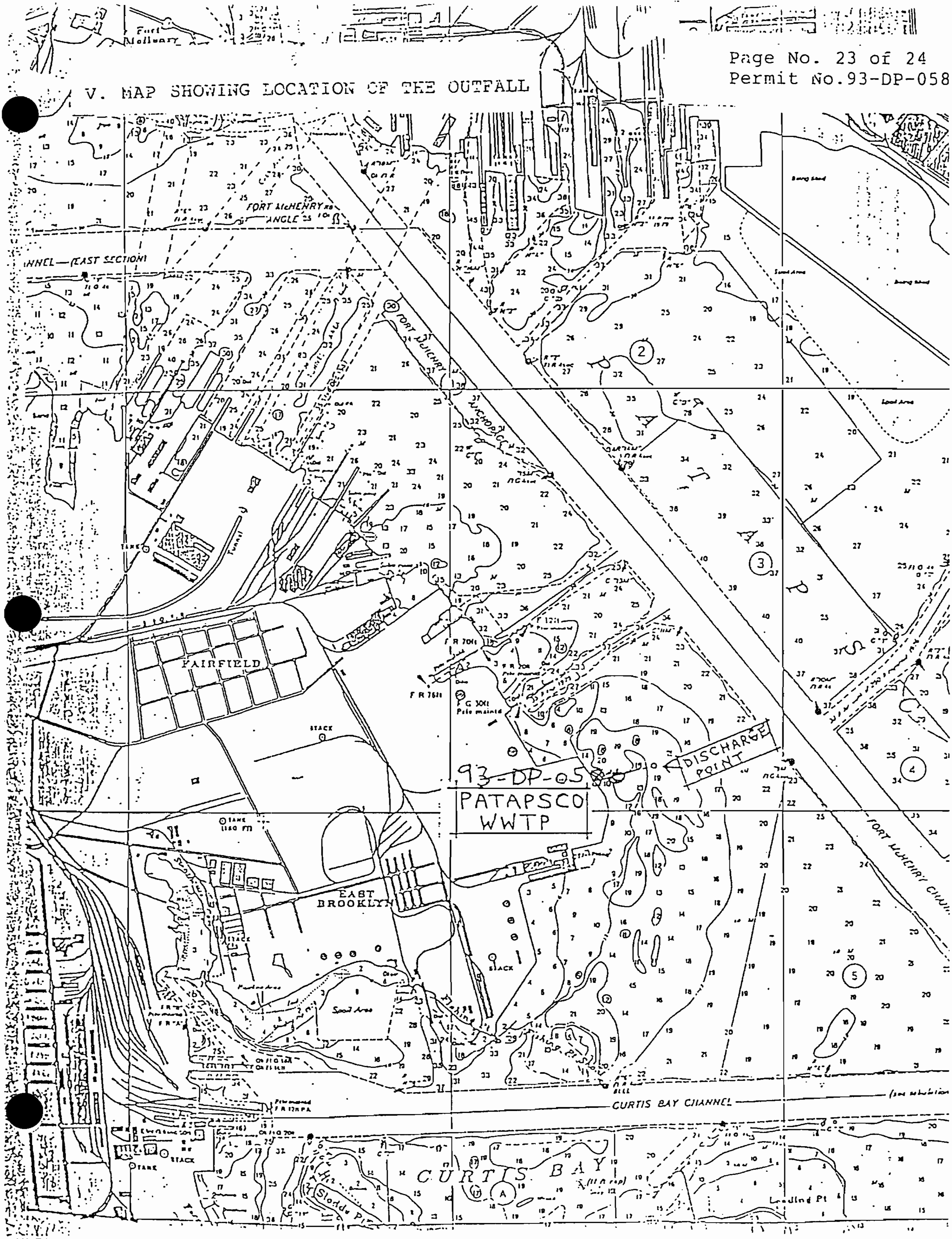
4. Permit Modification, Suspension, Revocation - Violation of Laws
A permit may also be modified, suspended or revoked by MDE, in the event of a violation of the terms or conditions of the permit, or of State or Federal Laws and Regulations and in accordance with the provisions set forth in COMAR 26.08.04.10

IV. CIVIL AND CRIMINAL PENALTIES

A. Violations of Maryland Law
Environment Code, Section 9-342 and 9-343 provide that any person who violates a permit condition implementing Environment Code Section 9-322 et seq. is subject to a civil penalty in an amount not to exceed $1.000 per day for such violation; and to criminal penalties of a $25,000 fine or imprisonment not2 exceeding one year or both for a first offense, and a $50,000 fine or imprisonment not exceeding two years or both for subsequent offenses.

B. Violations of Federal Law
The Clean Water Act provides that any person who violates a permit condition implementing the Clean Water Act Sections 301, 302, 306, 307, 308, 318, or 405 [33 USCS Sections 1311, 1312, 1316, 1317, 1318, 1328, 1345] is subject to a civil penalty not to exceed $10,000 per day for such violation. Any person who willfully or negligently violates permit conditions implementing Section 301, 302, 306, 307, or 308 of the Clean Water Act [33 USCS Sections 1311, 1312, 1316, 1317, 1318] is subject to a fine of not less than $2,500 nor more than $25,000 per day of violation, or by imprisonment for not more than one year, or both.

V. MAP SHOWING LOCATION OF THE OUTFALL



VI. NPDES PROGRAM

On September 5, 1974 the Administrator of the U. S. Environmental Protection Agency approved the proposal submitted by the State of Maryland Department of Natural Resources for the operation of a permit program for wastewater discharges pursuant to Section 402 of the Clean Water Act. Responsibility for enfuccing that program was subsequently transferred to MDE.

Pursuant to the aforementioned approval, this Discharge Permit is both a State of Maryland Discharge Permit and an NPDES Permit.

J. L. Hearn, Director
Water Management Administration

CITY OF BALTIMORE
Kurt L. Schmoke
Mayor

DEPARTMENT OF PUBLIC WORKS
George G. Balog, Director

BUREAU OF WATER AND WASTEWATER
Leonard H. Addison, Acting Bureau Head

PROJECT NO. 613

DATABASE REPORT FOR WATER QUALITY TASKS, COMPREHENSIVE WASTEWATER FACILITIES MASTER PLAN

May, 1999

ENVIRONMENTAL RESOURCES MANAGEMENT
for
WHITMAN, REQUARDT AND ASSOCIATES
Prime Consultant

Baltimore®
THE CITY THAT READS
Kurt L. Schmoke, Mayor

Serving all the people
dpw
everyday

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

1.0 *INTRODUCTION*

The Patapsco/Back River watershed is a 634-square mile urban watershed that receives nutrient inputs from agricultural and urban runoff, atmospheric loadings, wastewater treatment plants and industries. The City of Baltimore is performing an extensive planning effort for its wastewater conveyance and treatment facilities (*Comprehensive Wastewater Facilities Master Plan*) within this watershed in order to ensure adequate capacity to meet the needs of growth through the year 2020. A major component of the planning effort is the need to estimate the assimilative capacities of the receiving waters for the effluents from its wastewater treatment plants. Proper estimation of assimilative capacities would be needed to assure the Maryland Department of the Environment (MDE, which issues discharge permits for the City's two wastewater treatment plants) that any upgrades of the plants to provide for future needs would not exceed assimilative capacities in the receiving waters. At the same time, MDE in its discharge permit for the Back River Wastewater Treatment Plant, specified that the City undertake the monitoring of certain parameters in Back River, which receives the effluent from Outfall 001 of the Plant. Finally, MDE expressed a need for data on the Patapsco-Back River watersheds as part of its development of a Chesapeake Bay Tributary Strategy, and a Total Maximum Daily Load (TMDL) analysis for the combined watershed. MDE plans to use existing modeling and monitoring data, but also needs additional water and sediment quality, stream loading, and sediment flux data for Baltimore Harbor and Back River to augment these data.

To fill this need for additional data, the City of Baltimore initiated a comprehensive monitoring program of Baltimore Harbor, Back River, and their associated tributaries. Under the terms of the Special Conditions of the State Discharge Permit for the Back River wastewater treatment plant, and in conjunction with voluntary monitoring efforts, the City of Baltimore retained a team headed by Whitman, Requardt, and Associates, Inc. (WRA) to implement monitoring activities in 1997. Other members of the team responsible for the collection of water quality data included:

- The University of Maryland (U of MD), responsible for the collection of sediment flux data, and high frequency oxygen monitoring in Back River;

- Environmental Technologies Associates, Inc. (ETA), responsible for monitoring flow and chemical loadings at the fall lines of four streams in the watershed, and at other upstream locations; and

- Environmental Resources Management (ERM), responsible for water and sediment quality sampling in the Harbor and Back River.

1.1 PURPOSE

The purpose of this report is to summarize the sampling plan and electronic format of the monitoring data for the City of Baltimore water quality monitoring effort that was initiated in June 1997 and completed in the Spring 1998. The monitoring data resulting from this water quality monitoring effort is contained on a CD-ROM accompanying this report.

Whitman Requardt and Associates, Inc. will use the water quality monitoring data to assist the City of Baltimore with preparation of its Comprehensive Wastewater Facilities Master Plan. The goal of this plan is to develop alternative management strategies for continued operations of the Back River and Patapsco wastewater treatment plants through the year 2020. As part of this planning effort, the data will support the calibration of a three-dimensional, time-variable water quality model of Baltimore Harbor, Back River, and associated tributaries. This model will evaluate the impact of increased flows from the Back River and Patapsco wastewater treatment plants on these receiving waters during the planning period.

1.2 REPORT ORGANIZATION

The remainder of this report is organized into the following sections.

- Section 2.0—*Methods*. This section discusses the dates of sampling and field conditions, and describes the setup of the database.
- Section 3.0—*Database*. This describes the setup of the database for all aspects of the water quality studies.
- Appendices—The appendices include ERM's Baltimore Harbor/Back River Sampling Plan, Health and Safety Plan and a CD-ROM with MS ACCESS and MS Excel data files for all portions of the water and sediment quality studies. Reports for ETA and the University of Maryland are incorporated by reference. No hard copies of the data are included in this report.

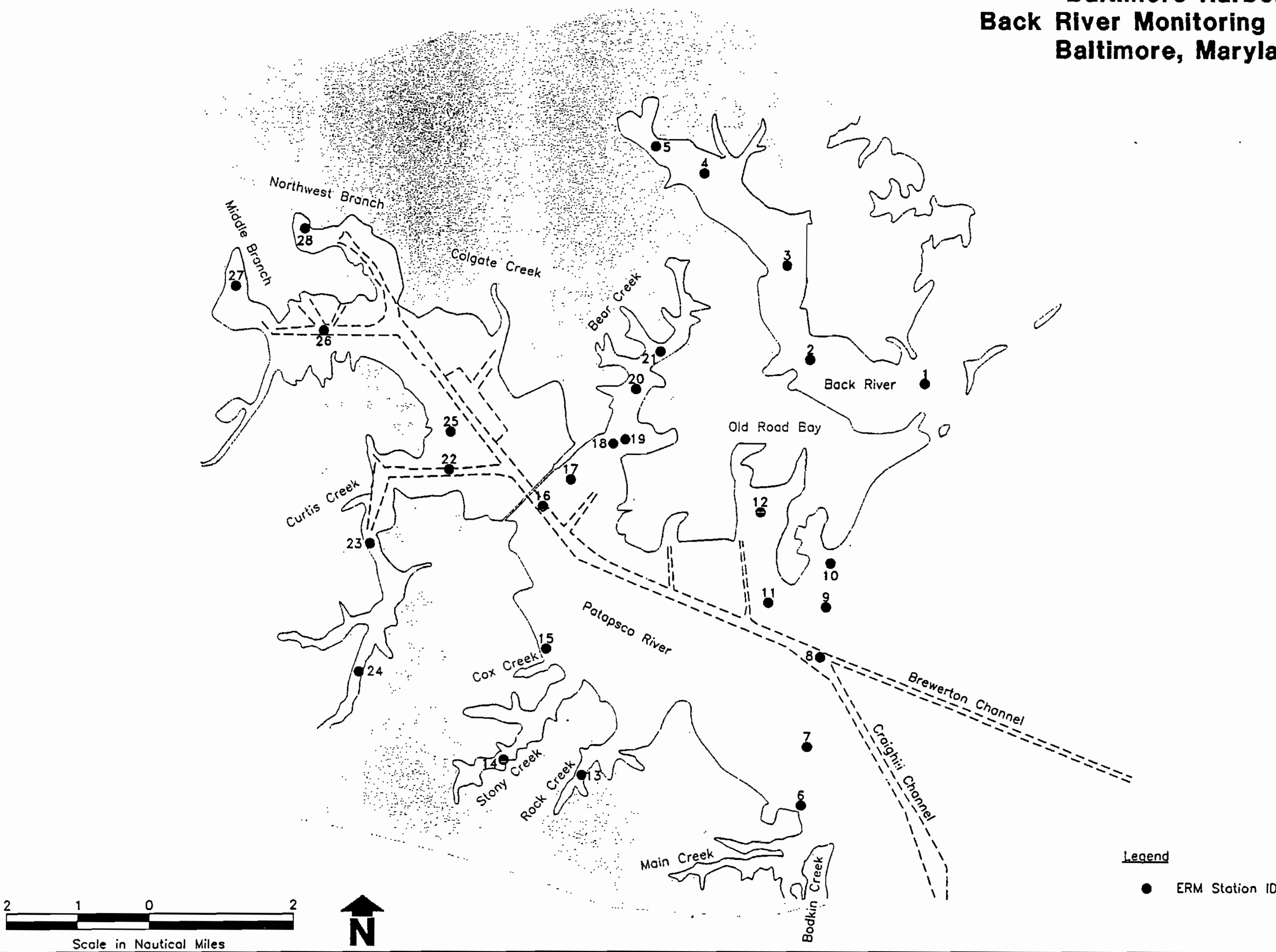
2.0 *METHODS*

2.1 *OVERVIEW OF THE MONITORING PROGRAM*

Three separate monitoring programs were performed to characterize water quality in Baltimore Harbor and its tributaries. Environmental Technologies Associates, Inc. (ETA) performed a stream sampling program designed to quantify pollutant loadings from Patapsco River, Gwynns Falls, Jones Falls and Herring Run (measured at the fall line, and at other upstream locations) into Baltimore Harbor and the Back River estuary. Environmental Resources Management (ERM) performed water column sampling in Baltimore Harbor, Back River and the Patapsco River, while the University of Maryland performed sediment flux studies in both Back River and Baltimore Harbor, and high-frequency oxygen monitoring in Back River. Sampling methods and analytical results of the ETA and University of Maryland sampling programs are contained in separate report documents (ETA, 1998; Boynton *et al.*, 1998; Cornwell *et al.*, 1999); however, all of the analytical data are also presented on the CD-ROM contained in Appendix D of this report.

The monitoring program presented in the field sampling plan contained in Appendix A consisted of water and sediment quality sampling at 28 stations throughout Baltimore Harbor and Back River (Figure 2-1). Table 2-1 describes the location of the sampling stations. The network of monitoring stations and the depths of sampling were established originally to meet the needs of MDE's water quality modeling framework. The total depth of each station determined how many samples were collected at each location. One sample was collected from stations with total depth of 1.8 meters (i.e., those stations inside the 6 ft. depth contour on NOAA charts) and less, at 0.15 meters, just below the surface. Two samples were collected from stations with total depths greater than 1.8 meters but less than 6.1 meters, at 0.15 meters from the surface and approximately 0.9 meters above the bottom of the water column. Stations 6.1 meters and greater in depth were sampled at three intervals, 0.15 meters, the approximate mid-point of the water column, and 0.9 meters above the sediment substrate. Table 2-2 presents the sampling depth ranges for each station.

Figure 2-1
Sampling Locations
Baltimore Harbor/ Back River Monitoring Program Baltimore, Maryland



F7103.00.01/05.06.99-MKB/A103-1F

Table 2-1 Location of ERM Sampling Stations

ERM Station Number	Description	Depth (m) (Approx. MLW based on NOAA Charts)
	Back River Transect	
1	300 yds NE of Cuckhold Point	4.8
2	Midriver between Porter Pt. & Lynch Pt.	2.5
3	(MWT4.1) 600 yds ENE Stansbury Pt. 300 yds WSW of R"12"	1.7
4	Midriver between Bread and Cheese Cr. & Whittaker's Marina	1.6
5	Midriver just before Eastern Ave Bridge (Md. Rte. 150)	0.8
	Alpine Beach Transect	
6	Alpine Beach 600 yds off house with single white brick retaining wall	3
7	On transect from Alpine Beach halfway between Craighill Channel marker and shore	5.4
8	Brewerton Channel at junction with Craighill Channel 300 yds off R"2B"	16
9	SE of white water tower, 0.7 nm offshore	4.5
10	Due east of white water tower and 300 yds SW of long narrow point at 6 ft contour line	1.2
	Old Road Bay Transect	
11	1,100 yds NNE of R"6". 1,000 yds SW North Pt, off hospital	4.5
12	Middle of Old Road Bay, midway between water tower and White Square Tower	3.0
	Patapsco Tributaries	
13	Rock Creek, 300 yds from Water Oak Point on heading 240, Rockview Beach area	3.5
14	Stony Creek, 1.7 nm from mouth, just upriver from Big Burley Cove	3.5

Table 2-1 Location of ERM Sampling Stations (Continued)

ERM Station Number	Description	Depth (m) (Approx. MLW based on NOAA Charts)
21	Bear Creek, Mid Channel off mouth of Lynch Cove in Bear Creek, 400 yds above railroad bridge	3.6
23	Curtis Creek, Pennington Ave Bridge, upriver 50 yds	4.7
24	Marley Creek, 0.8 nm above mouth, 200 yds downstream of overhead power cables	3.3
26	Patapsco River, Head of Ferry Bar Channel between R"6" & FL "7", 0.7 nm east of Ferry Bar, 0.75 nm SW of Ft. McHenry	12.5
27	Middle Branch Spring Garden Channel downstream Western Maryland railroad bridge, where channel forks at Red Daybeacon	2.2
	Curtis Creek	
22	Mouth of Curtis Bay in Curtis Bay Channel, midway on transect from Leading Pt. To Fishing Pt.	15.6
	Key Bridge Transect	
16	At Buoy "3" Hawkins Point	9.5
17	500 yds south of Sollers Pt. & 500 yds north of Fort Carroll	3.3
18	On transect from Coffin Point to tank on east shore, 260 yds from West Bank, on west side of marker #3	1.8
	Inner Harbor	
28	Mid-Basin opposite Constellation Pier	7.3
	Other	
15	Cox Creek Wastewater Treatment Plant	1.4

Table 2-1 Location of ERM Sampling Stations (Continued)

ERM Station Number	Description	Depth (m) (Approx. MLW based on NOAA Charts)
19	Bethlehem Steel Outfall 014, Humphreys Creek	3.2
20	Upper Bear Creek, off of Long Point	4.1
25	Patapsco Wastewater Treatment Plant, Fairfield Outfall	5.6

Table 2-2 *Range of sampling depths for each monitoring station, Baltimore Harbor/Back River Monitoring Program*

Station	Sampling Depth Range (meters)
1	0.15, 2.4-4.4
2	0.15, 1.5-2.0
3	0.15
4	0.15
5	0.15
6	0.15, 1.0-2.2
7	0.15, 4.3-4.7
8	0.15, 6.0-6.1, 14.1-15.2
9	0.15, 3.2-3.6
10	0.15
11	0.15, 3.4-3.9
12	0.15, 1.9-2.5
13	0.15
14	0.15, 2.5-3.0
15	0.15
16	0.15, 5.0-7.0, 8.5-15.1
17	0.15, 2.1-2.6
18	0.15
19	0.15, 1.9-2.8
20	0.15, 2.9-3.3
21	0.15, 2.4-3.0
22	0.15, 6.0-8.0, 12.0-15.3
23	0.15, 3.5-5.1
24	0.15, 2.0-2.9
25	0.15, 4.4-5.0
26	0.15, 6.0-6.1, 10.3-11.6
27	0.15, 1.2
28	0.15, 2.6-3.8, 5.6-6.9

Water quality samples were collected at each of the 28 stations from June 1997 to December 1997 in ten sampling events or cruises. Table 2-3 presents the start and end dates for each sampling event. The Baltimore Harbor stations (Stations 6 through 28) were sampled seven times (three in wet months and four in dry months), and the Back River stations (Stations 1 through 5) were sampled 10 times, as required by a Special

Condition of the discharge permit for the Back River Plant. Sediment quality sampling, described in Appendix A, has not yet been done in order to avoid redundancy with ongoing MDE sampling of sediment quality.

Table 2-3 *Date and Duration of Sampling Events, Baltimore Harbor/Back River Monitoring Program*

Sampling Event	Start Date	End Date
Cruise No. 1	6/23/97	6/30/97
Cruise No. 2 (Back River only)	6/30/97	6/30/97
Cruise No. 3	7/8/97	7/11/97
Cruise No. 4 (Back River only)	7/22/97	7/22/97
Cruise No. 5	8/5/97	8/8/97
Cruise No. 6 (Back River only)	8/19/98	8/19/98
Cruise No. 7	9/22/97	9/26/97*
Cruise No. 8	10/27/97	10/30/97
Cruise No. 9	11/17/97	11/20/97
Cruise No. 10	12/15/97	12/17/97

*Weather conditions precluded sampling on 9/25/97.

Environmental Resources Management (ERM) and Gascoyne Laboratories (GL) collected the water and sediment samples. Prior to collecting the samples, the sampling team recorded field parameters at various depths throughout the water column. Samples collected for conventional constituents (such as nutrients and related parameters) were field-filtered in a dedicated clean laboratory established at GL (in Dundalk, MD) and then transported to the Chesapeake Biological Laboratory (CBL) in Solomons, Maryland, for analysis. Environmental Resources Management (ERM) collected toxic constituent samples (such as metals, volatile organic compounds, cyanide, and biological parameters) and transported them to GL's Baltimore laboratory for analysis. All field and laboratory analytical data were tabulated into a database.

Engineering Technologies Associates, Inc. (ETA) collected water quality samples from the following streams in order to quantify pollutant loading to the Baltimore Harbor and Back River:

- Patapsco River;
- Gwynns Falls;
- Jones Falls;
- and Herring Run.

Stream samples were collected from a total of eight locations as shown on Figure 2-2. Stream flow measurements were made and water quality samples were collected during both dry and wet weather conditions using automatic sampling devices. The samples were submitted to both GL's Baltimore laboratory and CBL for analysis. GL performed analysis of fecal coliform and total metals (copper, nickel, zinc, silver, lead, selenium, chromium and mercury), while CBL analyzed the following parameters: particulate carbon, dissolved organic carbon, total suspended solids, total dissolved nitrogen, particulate nitrogen, particulate phosphorus, and total dissolved phosphorus. A detailed description of the methodology used in the stream sampling and presentation of the analytical results is contained in ETA's report entitled *Baltimore City Comprehensive Wastewater Facilities Master Planning Project Task 202 Stream Sampling Data*, dated December 1998.

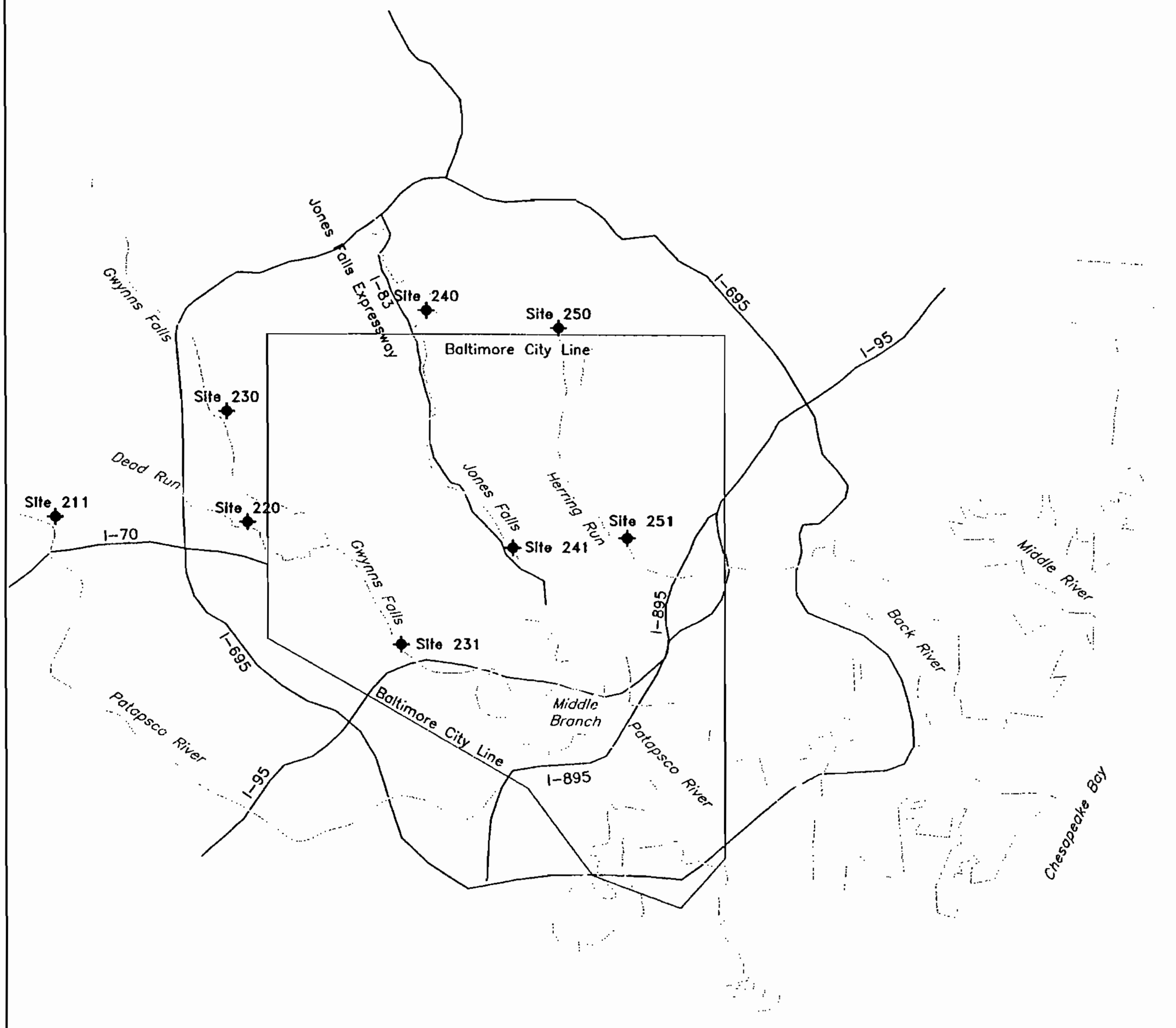
Two laboratories of the University of Maryland's Center for Environmental Science conducted specialized investigations of sediment and oxygen metabolism in Back River and the Harbor. A team from the Chesapeake Biological Laboratory (CBL) conducted two investigations of sediment and water metabolism (Boynton et al., 1998):

- **Sediment-water exchanges of nutrients and oxygen**: Replicate sediment core samples were collected monthly in June, July, and August, 1997 from three stations in Back River and two in Baltimore Harbor (Figure 2-3). Samples were incubated aboard ship and the fluxes to the water column of nitrogen, phosphorus and silica, as well as the consumption of oxygen, were measured.

- **High-frequency monitoring of dissolved oxygen in Back River:** DO, temperature and salinity were measured at 15-minute intervals at two stations in Back River (Figure 2-3, locations 1 and 2) from 20 June through 24 September 1997. The records were virtually continuous over that interval.

Another University of Maryland team, from both the Horn Point Laboratory and CBL, collected a set of cores from the three Back River and

Figure 2-2
Stream Sampling Locations Sampled by ETA During 1997
Baltimore Harbor/Back River Monitoring Program
Baltimore, Maryland



Legend

✦ ETA Stream Sampling Locations

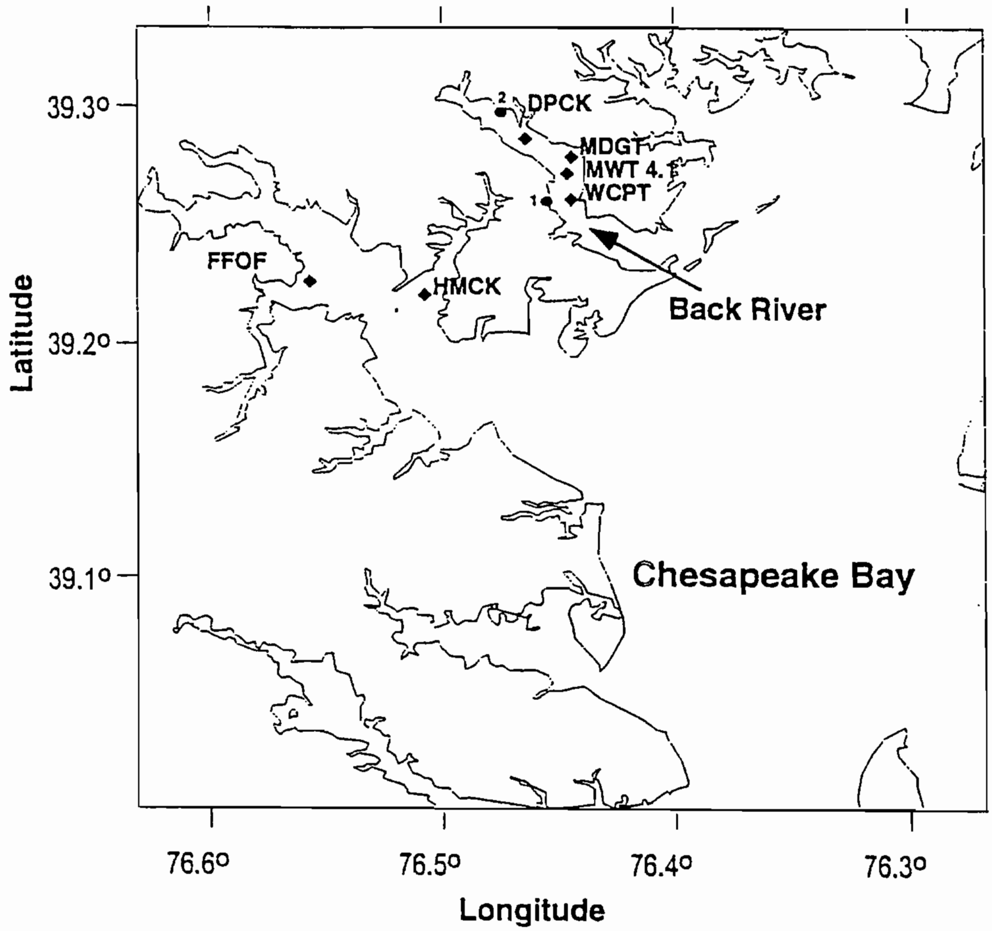
Site 211 Patapsco River
Site 240 Jones Falls Upstream (Lake Roland)
Site 251 Herring Run "Fall Line" (Brehms Ave)
Site 250 Herring Run Tributary (Register Avenue)
Site 241 Jones Falls "Fall Line" (Tunnel Entrance)
Site 231 Gwynns Falls "Fall Line" (Wilkens Ave.)
Site 230 Gwynns Falls Upstream (Essex Road)
Site 220 Dead Run

N

Not to Scale

Source:
"Figure 1, Baltimore City Stream Sites,
Task 202," Engineering Technologies Associates, Inc.
Ellicott City, Maryland, June 1997.

Figure 2-3
High Frequency Monitoring and Sediment-Water Flux Stations
Sampled by CBL During 1997



1 = Rudy's Marina
2 = Riverside Marina

two Baltimore Harbor stations on 18 September 1997 (Cornwell *et al.*, 1999). This team estimated the sediment-water exchanges of manganese, copper, nickel, zinc, arsenic, mercury (total and methyl-) selenium, chromium, lead and cadmium.

The following sections provide a brief description of the water quality monitoring efforts conducted as part of this study. A thorough description of the water quality monitoring effort is presented in Appendix A, *Baltimore Harbor/Back River Monitoring Program, Field Sampling Program, Baltimore, Maryland, 1997.*

2.2 *WATER QUALITY MONITORING*

2.2.1 *Field Parameters*

Environmental Resources Management (ERM) recorded field parameters, weather, and sea conditions before sampling the water column. Then ERM verified the field location of each sampling station using a Global Positional System (GPS). Once the station location was confirmed, ERM profiled the water column recording depth, pH, specific conductivity , temperature, salinity, and dissolved oxygen (DO) with an in-situ probe, and water transparency with a Secchi disk. Field parameters were taken at 2-meter intervals, unless the station was in a shallow area, or appreciable changes occurred in specific conductivity or DO (i.e., the pycnocline). In shallow stations and at the pycnocline, field parameters were collected at intervals of one meter or less. Refer to *Appendix A, Field Sampling Program* for additional information on recording field parameters.

2.2.2 *Conventional Water Quality Constituents*

Table 2-4 presents the list of conventional water quality constituents sampled as part of the monitoring program. The Special Conditions of the Back River wastewater treatment plant NPDES Permit 89-DP-0581, and current work being conducted by CBL to determine sediment fluxes in Back River dictated the parameters that were monitored. Appendix A provides information on sample analyses for these conventional water quality constituents. Sampling and analytical laboratory methods, and quality assurance/quality control (QA/QC) procedures were consistent with those described in Appendix A.

Table 2-4 *Conventional Water Quality Constituents Sampled During the Monitoring Program*

Constituent	Abbreviation
Total dissolved nitrogen as N	TDN
Total dissolved phosphorus as P	TDP
Ammonium as N	NH_4
Nitrate and nitrite as N	NO_{2+3}
Nitrite as N	NO_2
Ortho-phosphorus as P	PO_4
Dissolved organic carbon as C	DOC
Particulate carbon as C	PC
Particulate nitrogen as N	PN
Total suspended solids	TSS
Particulate phosphorus as P	PP
Chlorophyll-a	
Phaeophytin	

2.2.3 *Toxic Constituents*

Toxic constituents include metals, total cyanide, volatile organic compounds (VOCs), and biological parameters. Table 2-5 lists the toxic constituents included in this monitoring program. The sample stations for toxic constituent analysis were the same as those for conventional constituents. Appendix A provides information on sample analyses for these toxic constituents. Sampling and analytical laboratory methods, and QA/QC procedures were consistent with those described in Appendix A.

Table 2-5 Toxic Constituents Sampled During the Monitoring Program

Dissolved Metals	Volatile Organic Compounds	Other
Chromium	Tetrachloroethene	Total Cyanide
Copper		Biological Oxygen Demand
Nickel		Fecal Coliform
Selenium		Total Residual Chlorine
Lead		Naphthalene
Silver		
Mercury		
Zinc		

3.0 *DATABASE*

All data collected during implementation of the sampling program are presented on a CD-ROM contained in Appendix C. The data are organized as shown on Figure 3-1, and have the following structure:

Sediment Flux Data

- Metals fluxes
- Nutrient and Oxygen Fluxes

Stream Data

- Conventional Constituent Data
- Field-measured Data
- MS Access Database - containing the stream flow and water quality database
- Stream Flow
- Toxic Metals Data

Water Column Data

- Conventional Constituent Data - consisting of BOD, coliform bacteria, carbon, chlorophyll, nitrogen, phosphorus, and solids
- Field Measured Data
- MS Access database - containing the water column database
- Toxic Constituent Data - including metals and organics.

In addition to a comprehensive MS ACCESS database for the two major components of the study (i.e., water column, stream data), each parameter (except for field-measured parameters like salinity) is also presented as a separate Excel 97 workbook. Within this workbook, the data are arranged in worksheets, one for each sampling station (e.g., 28 worksheets in the case of water column data), with the data presented chronologically for each depth sampled. Figure 3-2 presents an example of a work sheet for field-measured data, while Figure 3-3 presents an example work sheet for orthophosphate, a conventional constituent, and Figure 3-4 presents an example worksheet for copper, a toxic constituent.

Figure 3-1
CD-ROM Data Organization
Baltimore Harbor/Back River Monitoring Program

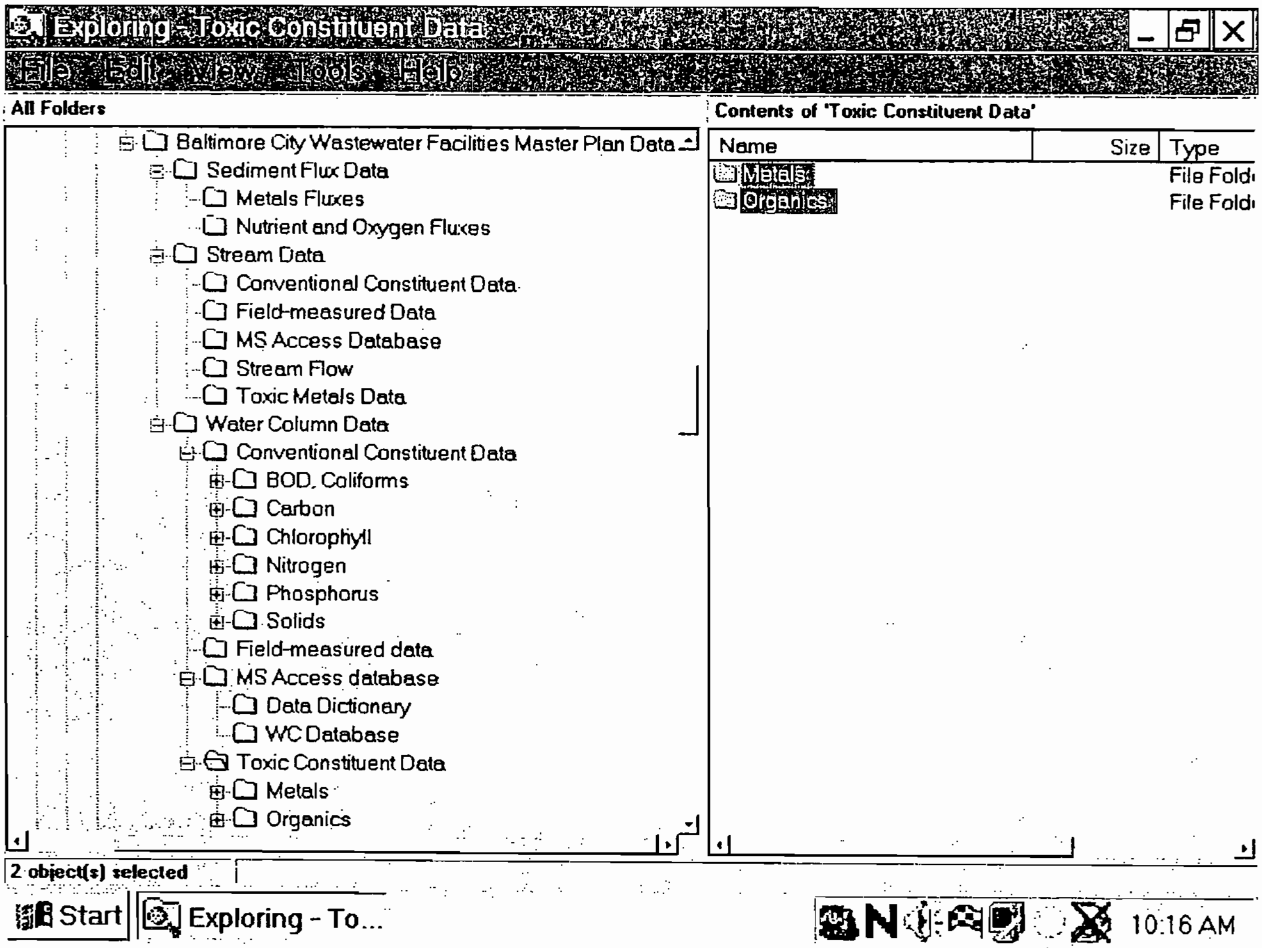
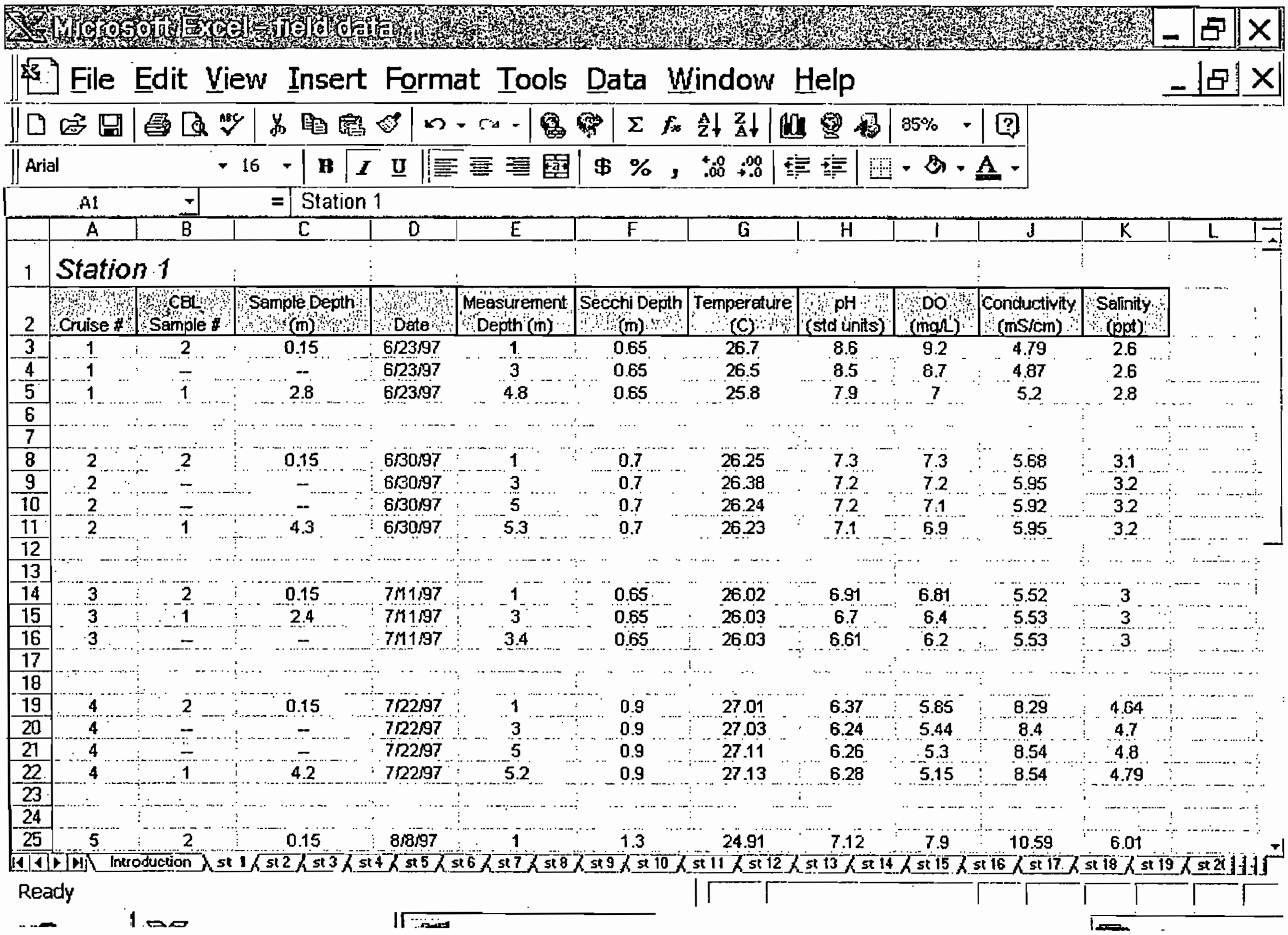


Figure 3-2
Sample Field-Measured Data Worksheet
Baltimore Harbor/Back River Monitoring Program



	A	B	C	D	E	F	G	H	I	J	K	L
1	*Station 1*											
2	Cruise #	CBL Sample #	Sample Depth (m)	Date	Measurement Depth (m)	Secchi Depth (m)	Temperature (C)	pH (std units)	DO (mg/L)	Conductivity (mS/cm)	Salinity (ppt)	
3	1	2	0.15	6/23/97	1	0.65	26.7	8.6	9.2	4.79	2.6	
4	1	--	--	6/23/97	3	0.65	26.5	8.5	8.7	4.87	2.6	
5	1	1	2.8	6/23/97	4.8	0.65	25.8	7.9	7	5.2	2.8	
6												
7												
8	2	2	0.15	6/30/97	1	0.7	26.25	7.3	7.3	5.68	3.1	
9	2	--	--	6/30/97	3	0.7	26.38	7.2	7.2	5.95	3.2	
10	2	--	--	6/30/97	5	0.7	26.24	7.2	7.1	5.92	3.2	
11	2	1	4.3	6/30/97	5.3	0.7	26.23	7.1	6.9	5.95	3.2	
12												
13												
14	3	2	0.15	7/11/97	1	0.65	26.02	6.91	6.81	5.52	3	
15	3	1	2.4	7/11/97	3	0.65	26.03	6.7	6.4	5.53	3	
16	3	--	--	7/11/97	3.4	0.65	26.03	6.61	6.2	5.53	3	
17												
18												
19	4	2	0.15	7/22/97	1	0.9	27.01	6.37	5.85	8.29	4.64	
20	4	--	--	7/22/97	3	0.9	27.03	6.24	5.44	8.4	4.7	
21	4	--	--	7/22/97	5	0.9	27.11	6.26	5.3	8.54	4.8	
22	4	1	4.2	7/22/97	5.2	0.9	27.13	6.28	5.15	8.54	4.79	
23												
24												
25	5	2	0.15	8/8/97	1	1.3	24.91	7.12	7.9	10.59	6.01	

Figure 3-3
Sample Worksheet for Orthophosphate
Baltimore Harbor/Back River Monitoring Program

Microsoft Excel - Po4

File Edit View Insert Format Tools Data Window Help

	A	B	C	D	E	F	G
1	*Station 1*						
2	Sample #	Sample Depth (m)	Date	Year Sample Collected	Month Sample Collected	Day Sample Collected	Orthophosphate (mg/L)
3							
4	Sample 1						
5	1	2.8	23-Jun-97	97	6	23	0.0102
6	1	0.15	30-Jun-97	97	6	30	0.0028
7	1	2.4	11-Jul-97	97	7	11	0.0192
8	1	4.2	22-Jul-97	97	7	22	0.0283
9	1	4.4	8-Aug-97	97	8	8	0.0293
10	1	3.3	19-Aug-97	97	8	19	0.045
11	1	4.1	24-Sep-97	97	9	24	0.0214
12	1	4.18	30-Oct-97	97	10	30	0.0205
13	1	4.07	20-Nov-97	97	11	20	0.0274
14	1	3.86	15-Dec-97	97	12	15	0.012
15							
16	Sample 2						
17	2	0.15	23-Jun-97	97	6	23	0.01

st 1 / st 2 / st 3 / st 4 / st 5 / st 6 / st 7 / st 8 / st 9 / st 10 / st 11 / st 12 / st 13 / st 14 / st 15 / st 16 / st 17 / st 18 / st 19 / st 20

Ready

Figure 3-4
Sample Worksheet for Copper
Baltimore Harbor/Back River Monitoring Program

Microsoft Excel - Copper

File Edit View Insert Format Tools Data Window Help

Station 1

Sample #	Sample Depth (m)	Date	Year Sample Collected	Month Sample Collected	Day Sample Collected	Copper, Dissolved, mg/L	Reporting Limit mg/L
Sample 1							
1	2.8	23-Jun-97	97	6	23	<0.001	0.001
1	2.8	23-Jun-97	97	6	23	<0.005	0.005
1	2.4	11-Jul-97	97	7	11	0.0110	0.001
1	4.4	08-Aug-97	97	8	8	0.0040	0.001
1	4.1	26-Sep-97	97	9	26	0.0050	0.001
1	4.18	30-Oct-97	97	10	30	0.0050	0.001
1	4.07	20-Nov-97	97	11	20	0.0050	0.001
1	3.86	15-Dec-97	97	12	15	0.0060	0.001
Sample 2							
2	0.15	23-Jun-97	97	6	6	<0.001	0.001
2	0.15	23-Jun-97	97	6	6	<0.005	0.005
2	0.15	11-Jul-97	97	7	11	0.0120	0.001
2	0.15	08-Aug-97	97	8	8	0.0030	0.001
2	0.15	26-Sep-97	97	9	26	0.0050	0.001
2	0.15	30-Oct-97	97	10	30	0.0040	0.001
2	0.15	20-Nov-97	97	11	20	0.0040	0.001
2	0.15	15-Dec-97	97	12	15	0.0040	0.001

st 1 | st 2 | st 3 | st 4 | st 5 | st 6 | st 7 | st 8 | st 9 | st 10 | st 11 | st 12 | st 13 | st 14 | st 15 | st 16 | st 17 | st 18 | st 19

Ready

Each station has its own worksheet—each worksheet contains the concentration data by depth and sample date, followed by a graph of the data.

4.0 *LITERATURE CITED*

Boynton, W.R., N.H. Burger, R.M. Stankelis, F.M. Rohland, J.D. Hagy III, J.M. Frank, L.L. Matteson, and M.M. Weir. 1998. An environmental evaluation of Back River with selected data from Patapsco River. Prepared for Baltimore City Department of Public Works for Project 613, Comprehensive Wastewater Facilities Master Plan.University of Maryland Center for Environmental Science, October, 1998.

Cornwell, Jeffrey C., Michael Owens, and Robert Mason. 1999. Metal fluxes from sediments in the Back and Patapsco River estuaries. Prepared for Baltimore City Department of Public Works for Project 613, Comprehensive Wastewater Facilities Master Plan. University of Maryland Center for Environmental Science, January, 1999.

Environmental Technologies Associates, Inc. 1998. Baltimore City Comprehensive Wastewater Facilities Master Planning Project, Task 202, Stream sampling data. Prepared for Baltimore City Department of Public Works. December, 1998.

Appendix A
Baltimore Harbor/Back River
Sampling Plan

FIELD SAMPLING PLAN

ENVIRONMENTAL RESOURCES MANAGEMENT

Baltimore Harbor/Back River Monitoring Program
Field Sampling Plan
Baltimore, Maryland

3 July 1997

W.O. No. F7103

Environmental Resources Management
2666 Riva Road, Suite 200
Annapolis, Maryland 21401

ERM®

TABLE OF CONTENTS *PAGE*

LIST OF FIGURES | *PAGE*

LIST OF TABLES

1.0 INTRODUCTION

The State of Maryland must implement tributary-specific nutrient reduction strategies as required by the 1992 amendments to the 1987 Chesapeake Bay Agreement. The Maryland Department of the Environment (MDE) has already begun to prepare an appropriate tributary strategy using existing modeling and monitoring data. However, further water and sediment quality, stream loading, and sediment flux data for Baltimore Harbor and Back River (Figure 1-1) are needed to assist MDE with their evaluation of these surface water bodies.

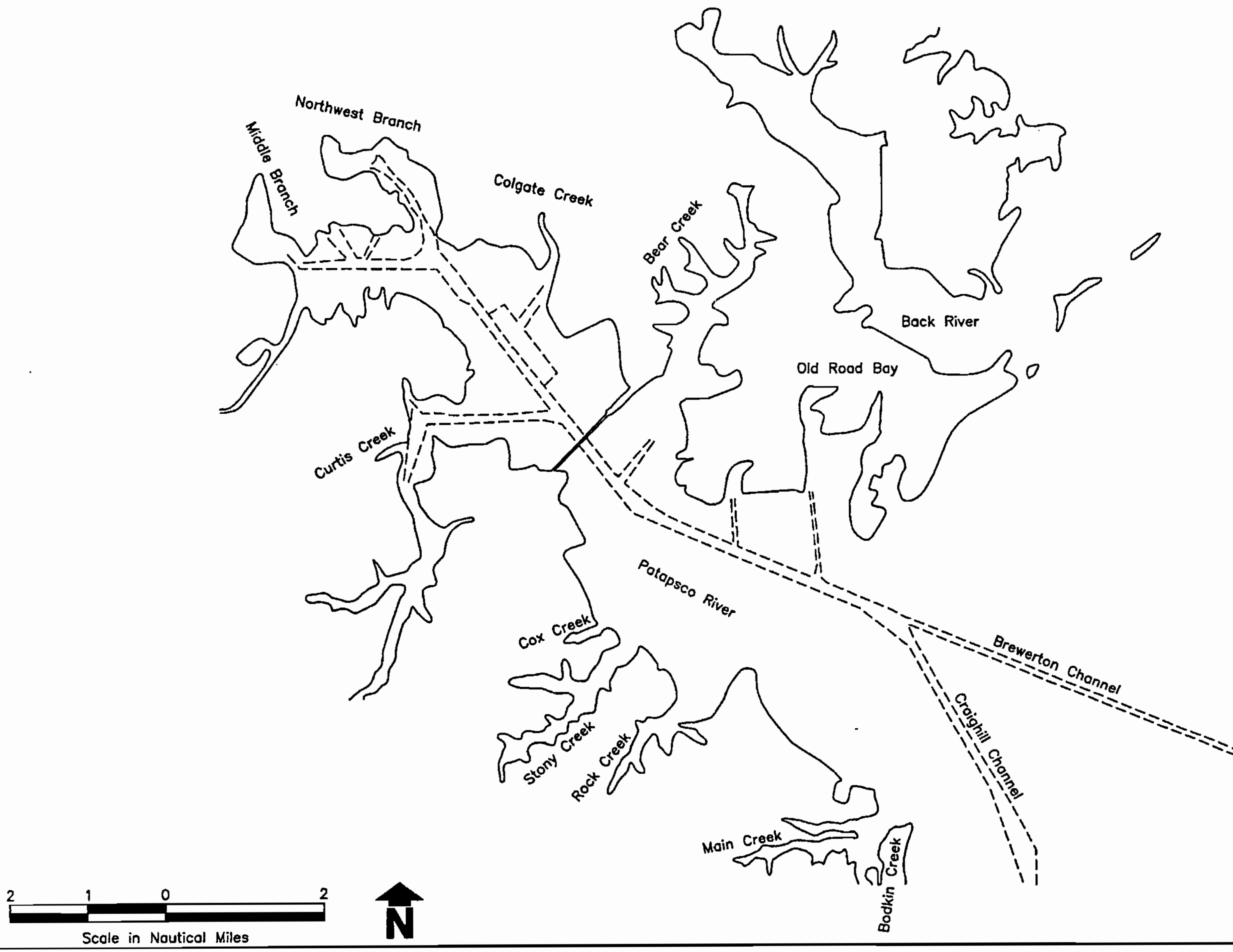
Consequently, Baltimore Harbor, Back River, and their associated tributaries are the subject of a comprehensive monitoring program to be implemented under direction of MDE and the City of Baltimore. Under the terms of the Special Conditions of the State Discharge Permit for the Back River wastewater treatment plant, and as part of voluntary monitoring efforts, the City of Baltimore has retained a team led by Whitman, Requardt, and Associates, Inc. (WRA) to implement monitoring activities beginning in 1997. Various entities will be involved in the collection of data for this monitoring program, including the University of Maryland (U of MD), Environmental Technologies Associates, Inc. (ETA), and Environmental Resources Management (ERM). ERM is responsible for conducting water and sediment quality sampling in the Harbor and Back River. Accordingly, ERM has prepared this field sampling plan (FSP) to document the appropriate sample collection, handling, and laboratory protocols to implement these monitoring activities.

1.1 PURPOSE

The purpose of this FSP is to provide detailed guidance for water and sediment quality monitoring activities to be completed in Baltimore Harbor and Back River by ERM. The FSP will be implemented in June 1997 and extend through the Spring 1998.

Monitoring data generated from these sampling activities will be used by WRA to assist the City of Baltimore with preparation of its Comprehensive Wastewater Facilities Master Plan, the goal of which is to develop alternative management strategies for continued operations of the Back River and Patapsco wastewater treatment plants through the year 2025. Specifically, the monitoring data will be used to support the

Figure 1-1
Site Location Map
Baltimore Harbor/
Back River Monitoring Program
Baltimore, Maryland



calibration of a three-dimensional, time-variable water quality model of Baltimore Harbor, Back River, and associated tributaries. The calibrated model will then evaluate the impact of increased flows from the Back River and Patapsco wastewater treatment plants on these receiving waters during the planning period.

1.2 *OVERVIEW OF MONITORING PROGRAM*

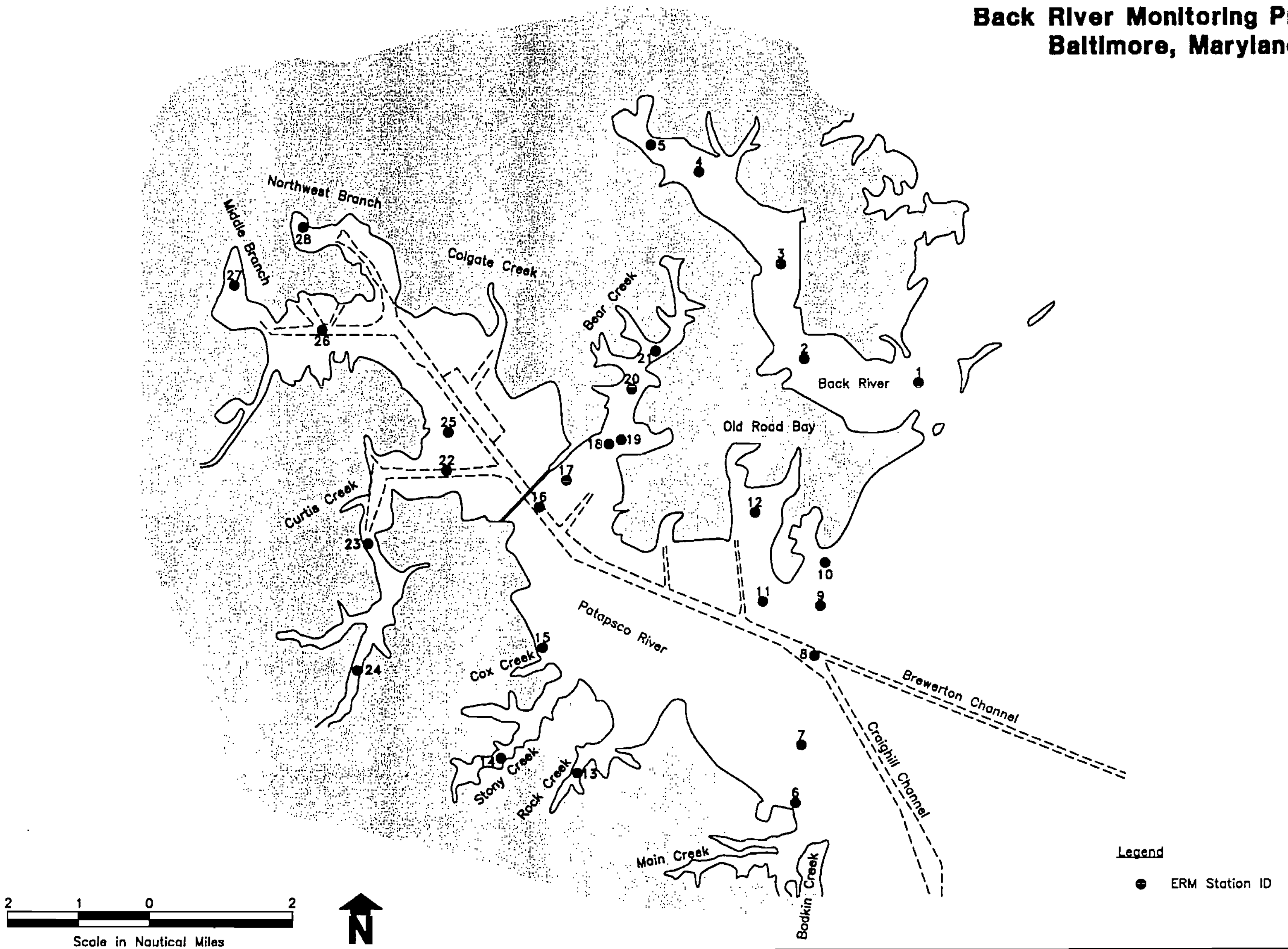
The monitoring program detailed in this FSP consists of water and sediment quality sampling at 28 stations throughout Baltimore Harbor and Back River (Figure 1-2). The monitoring network was sited based on the needs of MDE's water quality modeling framework. Each station will be sampled at various water column depths depending upon the total depth of the sampling location. For example, sampling stations six feet or less will be sampled at a single depth, while stations deeper than 20 feet will be sampled at three depths.

Water quality samples will be collected at each of the 28 stations during a series of monitoring events between June 1997 and the Spring 1998. The Harbor stations will be sampled a total of seven times (three during wet months, and four during dry months), and the Back River stations will be sampled ten times. During the same time period, sediment quality will be sampled during a single monitoring event at each of the 28 stations.

ERM and Gascoyne Laboratories (GL) will cruise the water bodies to collect water and sediment quality samples. Field parameters will be taken at various depths throughout the water column at each station prior to sample collection. Samples collected for conventional constituents (i.e., nutrients and related parameters) will be field-filtered at a filtration station to be established at GL, and then transported to the Chesapeake Bay Laboratory (CBL) in Solomons, Maryland, for analysis. Toxic constituent samples (i.e., metals, volatile organic compounds, cyanide, and biological parameters) will be collected by ERM and transported to GL in Baltimore, Maryland, for analysis. The metals aliquot will be field-filtered and acidified at the GL filtration station by an ERM technician. Metals samples will be collected and analyzed using "clean" techniques to the extent possible.

All field and laboratory analytical data will be tabulated into a database compatible with those of MDE and the Chesapeake Bay Program. ERM will assist with analysis of this data, as necessary.

Figure 1-2
Sampling Locations
Baltimore Harbor/
Back River Monitoring Program
Baltimore, Maryland



1.3 *PROJECT ORGANIZATION*

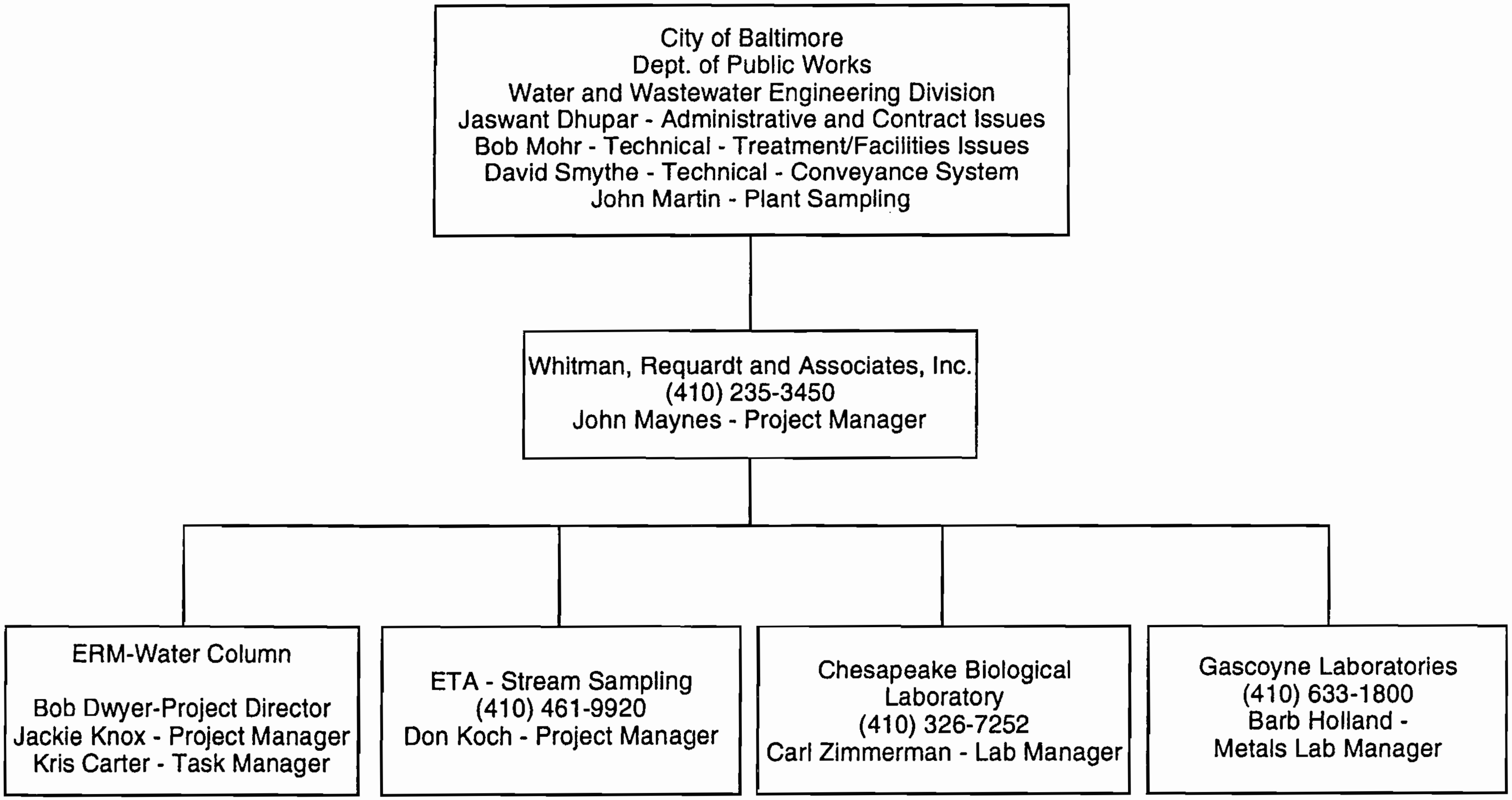
The project organization for the monitoring program is summarized in Figure 1-3. As shown in this figure, ERM is one of four contractors providing support to WRA to assist the City of Baltimore with its Wastewater Facilities Master Plan.

1.4 *SAMPLING PLAN ORGANIZATION*

The remainder of this document is organized as follows:

- *Section 2.0 - Water Quality Monitoring*: This section presents the stations, methodologies, and schedule for the collection of water column samples to be analyzed for conventional and toxic constituents. Field parameter measurements are also discussed in this section.
- *Section 3.0 - Sediment Quality Monitoring*: This section describes the stations, methodologies, and schedule for the collection of sediment samples, which will be analyzed for conventional and toxic constituents.
- *Section 4.0 - Sample Documentation and Handling*: This section provides a detailed review of environmental site sample labeling, documentation, packaging, and transport requirements.
- *Section 5.0 - Quality Assurance/Quality Control Procedures:* This section presents the quality assurance/quality control procedures to be implemented by field and laboratory personnel throughout the monitoring program.
- *Section 6.0 - Health and Safety:* This section presents health and safety issues that are integral to the implementation of the monitoring program. Specifically, boat safety, laboratory safety, and communications are discussed.

Figure 1-3. City of Baltimore Comprehensive Wastewater Facilities Master Plan Organization Chart



2.0 WATER QUALITY MONITORING

The purpose of this section is to specify the sample stations, methods, and schedule for conventional and toxic constituent monitoring activities in Baltimore Harbor and Back River. Protocols for field parameters, conventional water quality constituents, and toxic constituents are presented in Sections 2.1, 2.2, and 2.3, respectively. Section 2.4 presents the project schedule for conducting the monitoring activities.

2.1 FIELD PARAMETERS

Field parameters, weather, and sea conditions will be recorded at each station prior to water column sample collection. The first field measurement will be that of station location; the latitude and longitude in degrees, minutes and seconds will be verified using a Global Positional System (GPS) instrument. Then, the water column will be profiled for depth, pH, specific conductivity, temperature, salinity, and dissolved oxygen (DO) with an in-situ probe which provides a digital readout. These field data will be recorded on field data sheets. Profiling will generally be conducted at two-meter intervals; however, intervals of one meter or less may be sampled in shallow areas or areas of the water column where appreciable changes in specific conductivity or dissolved oxygen are observed to occur (i.e., the pycnocline). In addition, water transparency will be measured using a Secchi disk. Table 2-1 summarizes the methods and instrumentation that will be used to record these field parameters.

Table 2-1 In-Situ Measurement of Field Parameters

Field Parameter	Range (Lower-Upper Limits)	Methods/References
Depth (m)	0 - 20	Pressure transducer
pH (Standard Units)	0 - 14	Glass electrode; Ag/AgCl reference electrode pair; Hydrolab System Water Quality Instrumentation Manual (HSWQIM), 1984
Specific Conductivity (mS/cm)	0 - 200	Temperature compensated six electrode cell; HSWQIM
Temperature (°C)	-5 - 45	Linear thermistor network; HSWQIM
Dissolved Oxygen (mg/L)	0 - 20	Au/Ag polarographic cell (Clark); HSWQIM
Salinity (ppt)	0 - 30	Direct conversion from specific conductivity
Secchi Depth (m)	0.1 - 50	20 cm diameter disk, Welch, P.S., 1948; Chapter 11 in Limnological Methods, Blakiston, Philadelphia

A Hydrolab unit will be lowered through the water column to measure the depth, pH, specific conductivity, temperature, DO, and salinity at each station. All measurements will be manually recorded on field data sheets.

The sampling team will perform periodic maintenance and calibration of the Hydrolab unit, and record these activities in a project field book dedicated for this purpose. Maintenance requirements specific to the Hydrolab unit include the following:

1) The conductivity sensor will be calibrated against a reference solution according to manufacturer's specifications. At a minimum, the specific conductivity will be calibrated before each cruise, and verified against the reference solution daily.

2) The pH sensor will be calibrated against two buffer solutions (pH 7 and 10) according to manufacturer's specifications before each cruise, and verified against the buffer solutions daily. When not in use, the pH probe will be immersed in tap solution. If the probe drifts more than ±0.1 pH units, the pH sensor must be recalibrated using the pH 7 and 10 buffers.

3) The dissolved oxygen meter will be calibrated each day using air-saturated water and the current barometric pressure reading for the Baltimore area.

4) The thermometer will be calibrated by the manufacturer once a year against a National Institute of Standards and Technologies (NIST) certified thermometer over a range of temperatures.

5) The depth sensor will be calibrated before each cruise to the 0.0 meter depth. The depth sensor will undergo a more thorough calibration by the manufacturer once a year.

Calibration of the Hydrolab unit for specific conductivity, pH, and depth will be completed by the sampling team prior to each cruise, and the DO meter will be calibrated every morning using current barometric pressure data. Calibration of the unit for temperature and depth will be completed annually by the manufacturer.

Water transparency will be measured at each sampling station using a Secchi disk and line graduated to ±0.1 meter. This measurement must be determined on the shady side of the vessel during daylight hours, and the sampling personnel should not wear sunglasses while performing the measurement. The disk will be slowly lowered into the water column until it is no longer visible, and the corresponding depth will be recorded. The disk will then be raised until it just becomes visible; this depth will also be noted. These steps should be repeated twice, noting both readings during each step, so that an average Secchi depth can be calculated using six total measurements. If the range of Secchi disk measurements is greater than 0.5 meters, the entire process should be performed again to determine a more precise reading.

Field parameters will be logged on field data sheets so that the project team is aware of the ambient conditions under which the water quality samples were collected.

2.2 *CONVENTIONAL WATER QUALITY CONSTITUENTS*

For the purposes of this monitoring program, a list of conventional water quality constituents was derived from the Special Conditions of the Back River wastewater treatment plant NPDES Permit 89-DP-0581, and current work being conducted by CBL to determine sediment fluxes in Back River. Table 2-2 lists each of the constituents required for the monitoring program.

Table 2-2 Conventional Water Quality Constituents

Constituent	Abbreviation	Sample Matrix	Detection Limits (mg/L)	Method/Reference	Holding Times/ Conditions
Total dissolved nitrogen as N	TDN	aqueous	0.02	D'Elia *et al.*, 1977; Vladerrama, 1981; EPA, 1979 (Method 353.2)	to be filtered; 28 days at -20°C
Total dissolved phosphorus as P	TDP	aqueous	0.001	EPA, 1979 (Method 365.4; colorimetric; automated ascorbic acid)	to be filtered; 28 days at -20°C
Ammonium as N	NH_4	aqueous	0.003	EPA, 1979 (Method 350.1; colorimetric, automated phenate)	to be filtered; 28 days at -20°C
Nitrate and nitrite as N	NO_{2+3}	aqueous	0.0002	EPA, 1979 (Method 350.1; colorimetric, automated cadmium reduction; diazotation)	to be filtered; 28 days at -20°C
Nitrite as N	NO_2	aqueous	0.0002	EPA, 1979 (Method 353.2; colorimetric; automated diazotation)	to be filtered; 28 days at -20°C
Ortho-phosphorus as P	PO_4	aqueous	0.0006	EPA, 1979 (Method 365.1)	to be filtered; 28 days at -20°C
Dissolved organic carbon as C	DOC	aqueous	0.24	Sugimura and Suzuki, 1988	to be filtered; 28 days at -20°C
Particulate carbon as C	PC	2 filter pads	0.063	EPA Method 440.0	28 days at -20°C
Particulate nitrogen as N	PN	2 filter pads	0.0105	EPA Method 440.0	28 days at -20°C
Total suspended solids	TSS	2 filter pads	1.5	APHA, 1975 and EPA, 1979	28 days at -20°C
Particulate phosphorus as P	PP	2 filter pads	0.0012	Aspila *et al.*, 1976	28 days at -20°C
Chlorophyll-a		2 filter pads	0.002	Strickland and Parsons, 1972; Parsons *et al.*, 1984; Welschmeyer, 1994	28 days at -20°C
Phaeophytin		2 filter pads	to be determined	Strickland and Parsons, 1972; Parsons *et al.*, 1984; Welschmeyer, 1994	28 days at -20°C

2.2.1 *Sample Stations*

The 28 sampling stations for Baltimore Harbor and Back River are summarized in tabular format in Table 2-3 and shown graphically on Figure 1-2. Table 2-3 assigns a station ID consisting of an "ERM" prefix

Table 2-3 Location of Sampling Stations

Description	ERM Station ID	Latitude/ Longitude	Depth (m)	No. of Samples Anticipated
<u>Alpine Beach Transect</u>				
Alpine Beach 600 yds off house with single white brick retaining wall	ERM6	39 08.80 76 26.80	3	2
On transect from Alpine Beach halfway between Craighill Channel marker and shore	ERM7	39 09.57 76 26.40	5.4	2
Brewerton Channel at junction with Craighill Channel 300 yards off R"2B"	ERM8	39 10.43 76 26.07	16	3
SE of white water tower, 0.7 nm offshore	ERM9	39 11.53 76 25.47	4.5	2
Due east of white water tower and 300 yds SW of long narrow point at 6 ft contour line	ERM10	39 12.07 76 25.45	1.2	1
<u>Old Road Bay Transect</u>				
1,100 yds NNE of R"6", 1,000 yds SW North Pt, off hospital	ERM11	39 11.55 76 27.19	4.5	2
Middle of Old Road Bay, midway between water tower and White Square Tower	ERM12	39 12.59 76 27.26	3.0	2
<u>Key Bridge Transect</u>				
At Bouy "3" Hawkins Point	ERM16	39 12.72 76 31.49	9.5	3
On Transect from Coffin Point to tank on east shore, 260 yds from West Bank, on west side of marker #3	ERM18	39 13.87 76 30.02	1.8	1
500 yds south of Sollers Pt. & 500 yds north of Fort Carroll	ERM17	39 13.20 76 31.05	3.3	2
<u>Curtis Creek</u>				
Mouth of Curtis Bay in Curtis Bay Channel. Midway on transect from Leading Pt. to Fishing Pt.	ERM22	39 13.30 76 33.20	15.6	3
<u>Inner Harbor</u>				
Mid-Basin opposite Constellation Pier	ERM28	39 17.01 76 36.63	7.3	2

Table 2-3. Location of Sampling Stations (continued)

Description	Map ID	Latitude/ Longitude	Depth (m)	No. of Samples Anticipated
Back River Transect				
300 yds NE of Cuckhold Point	ERM1	39 14.57 76 23.97	4.8	2
Midriver between Porter Pt. & Lynch Pt.	ERM2	39 14.98 76 26.27	2.5	2
Midriver between Bread and Cheese Cr. & Whittaker's Marina	ERM4	39 17.67 76 28.52	1.6	1
Midriver just before Eastern Avenue Bridge (Md. Rte. 150)	ERM5	39 18.08 76 29.35	0.8	1
(MWT4.1) 600 yds ENE Stansbury Pt. 300 yds WSW of R"12"	ERM3	39 16.31 76 26.45	1.7	1
Patapsco Tributaries				
Rock Creek, 300 yds from Water Oak Point on heading 240, Rockview Beach area	ERM13	39 08.86 76 30.89	3.5	2
Stony Creek, 1.7 nm from mouth, just upriver from Big Burley Cove	ERM14	39 09.10 76 32.23	3.5	2
Bear Creek, Mid Channel off mouth of Lynch Cove in Bear Creek, 400 yds above railroad bridge	ERM21	39 15.00 76 29.13	3.6	2
Curtis Creek, Pennington Avenue Bridge, Upriver 50 yds	ERM23	39 12.40 76 34.92	4.7	2
Marley Creek, 0.8 nm above mouth, 200 yds downstream of overhead power cables	ERM24	30 10.40 76 35.08	3.3	2
Patapsco River, Head of Ferry Bar Channel between R"6" & FL "7", 0.7 nm east of Ferry Bar, 0.75 nm SW of Ft. McHenry	ERM26	39 15.32 76 35.77	12.5	3
Middle Branch, Spring Garden Channel downstream Western Maryland railroad bridge, where channel forks at Red Daybeacon	ERM27	39 15.78 76 37.47	2.2	2
Other				
Upper Bear Creek, off of Long Point	ERM20	39 14.67 76 29.50	4.1	2
Bethlehem Steel Outfall 014, Humphreys Creek	ERM19	39 13.95 76 29.79	3.2	2
Patapsco Wastewater Treatment Plant, Fairfield Outfall	ERM25	39 14.03 76 33.26	5.6	2
Cox Creek Wastewater Treatment Plant	ERM15	39 10.7 76 31.3	1.4	1

followed by a number. The numbers represent the anticipated sampling order for the project. This table also summarizes the anticipated number of samples to be collected at each station based on the average reported water depth.

Stations with depths of ≤6 feet (1.8 meters) will be sampled at a single depth (i.e., approximately six inches below the water surface). Stations with depths of >6 feet but ≤20 feet (6.1 meters) will be sampled at two depths (i.e., six inches below the water surface and approximately three feet above the bottom of the water column). Finally, stations ≥20 feet in depth will be sampled at three depths (i.e., six inches below the water surface, three feet above the bottom of the water column, and in the approximate mid-point of the water column).

Table 2-4 below cross references ERM's station IDs with those used by MDE.

Table 2-4 Comparison of Sampling Station ID Numbers

ERM Station ID	MDE Station ID
ERM1	XIF4462
ERM2	XIF5037
ERM3	XIF6633
ERM4	XIF7714
ERM5	XIF8107
ERM6	XHF8831
ERM7	XHF9636
ERM8	XIF0540
ERM9	XIF1644
ERM10	XIF2145
ERM11	XIF1629
ERM12	XIF2628
ERM13	XHE9093
ERM14	XHE9277
ERM15	---
ERM16	XIE2885
ERM17	XIE3190
ERM18	XIF3903
ERM19	---
ERM20	---
ERM21	XIF5008
ERM22	XIE3168
ERM23	CUR0007
ERM24	XIE0449
ERM25	---
ERM26	XIE5343
ERM27	XIE5925
ERM28	XIE7133

2.2.2 *Sampling and Analytical Laboratory Methods*

Conventional constituent samples will be collected for the parameters listed in Table 2-2 using a peristaltic pump with Teflon tubing at the required sampling depths for each station. Decontamination between sampling depths will consist of pumping at least three times the tubing volume through the pump prior to sample collection.

The samples will be collected and prepared in two stages. First, a one-gallon polyethylene bottle will be pre-rinsed with sample water and filled on the boat for each location (i.e., water column depth). The bottles will be labeled with the appropriate sample numbers, and placed on ice in an insulated cooler. Every two to three hours, batches of samples will be transported to shore for pickup and transport to GL for field filtration, the second stage of sample preparation. Figure 2-1 illustrates the location of some of these sample pickup locations.

A filtration station will be established at GL to accommodate both conventional and dissolved metals samples. The filtration station for conventional constituents will consist of four, 300-milliliter (mL) capacity magnetic filter funnels and two, 200-mL capacity screw-on filter funnels. The 300-mL capacity filtration units require Whatman GF/F 47-mm diameter filter pads with 0.70 μm pores, while the 200-mL capacity filtration units require Whatman GF/F 25-mm diameter filter pads with 0.70 μm pores.

Figure 2-2 is a flow chart representation of sample collection, preparation, and laboratory analysis protocols to be implemented under the monitoring program. In particular, note that both filter pad and filtrate samples are required to analyze each water column sample for the suite of parameters listed in Table 2-2. The remainder of this section discusses preparation and handling requirements specific to each kind of sample.

2.2.2.1 *Filter Pad Samples*

Filter pad samples will be collected for Chlorophyll-a and Phaeophytin, particulate carbon (PC), particulate nitrogen (PN), particulate phosphorus (PP), and total suspended solids (TSS) analysis according to the methods provided in Table 2-2. Chlorophyll-a/Phaeophytin samples will be collected on 47-mm filter pads, PC/PN samples will be collected on 25-mm filter pads, and TSS/PP samples will be collected on pre-weighed 47-mm filter pads. Two filter pads are needed for each group of analyses per sample (Figure 2-2). Note that the TSS/PP filter pads must be rinsed with

Figure 2-1
Sample Pickup Locations
Baltimore Harbor/
Back River Monitoring Program
Baltimore, Maryland

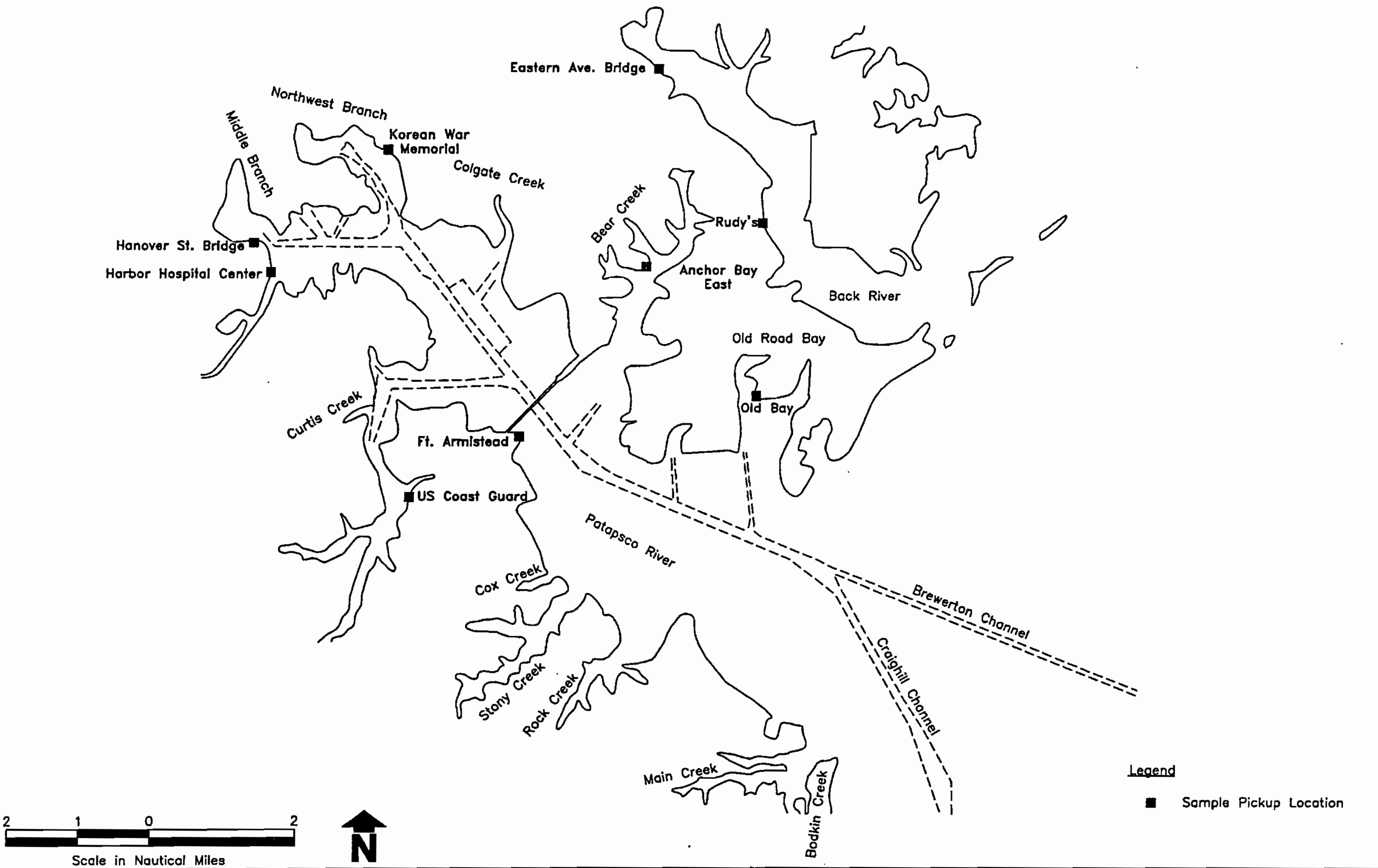
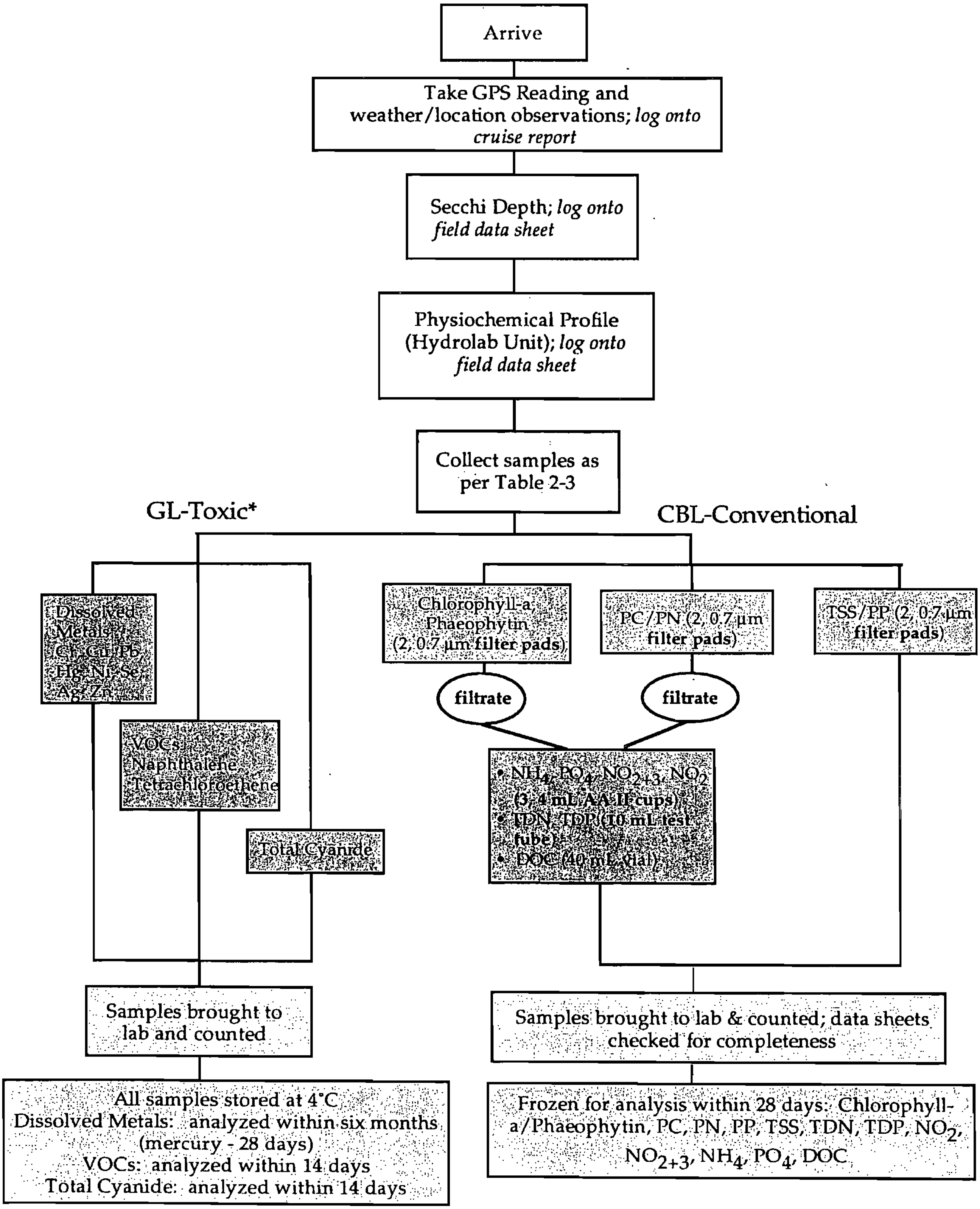


Figure 2-2
ERM Sample Collection and Processing



*GL will analyze selected samples for fecal coliform, total residual carbon, and biological oxygen demand during the first one or two events only approximately 10 mL of deionized water prior to removal from the filter funnel. This precludes filtrate from the TSS/PP ports from being used as filtrate samples (Section 2.2.2.2).

Once collected, each pair of filter pads is folded in half, sealed in individual foil squares, and labeled with a sample label. Filter pad samples must be transported on dry ice, and can be frozen for up to 28 days prior to analysis.

2.2.2.2 *Filtrate Samples*

Aqueous filtrate samples will be collected for ammonia (NH_4), nitrate + nitrite (NO_{2+3}), nitrite (NO_2), ortho-phosphorus (PO_4), dissolved organic carbon (DOC), total dissolved nitrogen (TDN), and total dissolved phosphorus (TDP) according to the methods provided in Table 2-2.

Each aqueous sample will be filtered through 0.7 μm pore size filter pads and placed in autoanalyzer (AA) cups, vials, or test tubes, as appropriate (Figure 2-2). Each sample will be color-coded and labeled with a sample number. These filtrate samples must be transported on dry ice, and can be frozen for up to 28 days prior to analysis.

2.2.2.3 *Decontamination*

Prior to each monitoring event, all glassware, filter funnels, and graduated cylinders required for the filtration process will be thoroughly decontaminated. The decontamination procedure is summarized in bulleted format below:

- 10 percent HCl rinse;
- triple deionized water rinse; and
- air dry.

A deionized water rinse will be required between samples collected from different stations.

Finally, all bottleware and equipment must be pre-rinsed with sample water prior to collection of a sample. The pre-rinse frequencies are summarized below:

- Erlenmeyer flasks and filter funnels will be pre-rinsed once using approximately 50 mL of sample water;

- Sample jugs, buckets, and graduated cylinders will be pre-rinsed using 10 to 100 mL of sample water, depending upon the size of the container or cylinder; and
- Sample test tubes, vials, and AA cups will be rinsed to capacity three times.

All pre-rinse water will be discarded prior to the collection of aqueous filtrate samples. It is imperative that the sample containers have been thoroughly rinsed prior to filling so that a representative sample can be collected.

2.3 *TOXIC CONSTITUENTS*

Toxic constituents include metals, total cyanide, volatile organic compounds (VOCs), and biological parameters. Table 2-5 lists each of these constituents along with the appropriate laboratory analytical methods and detection limits.

Table 2-5 Toxic Constituents

Constituent	Detection Limits (mg/L)	Method/ Reference	Bottleware Requirements	Holding Times/ Conditions
Dissolved Metals				
Chromium, Copper, Nickel, Selenium	0.001	EPA 200.8	1000-mL plastic	six-month holding time at 4°C; field-filtered; preserved to pH<2 with HNO_3
Lead, Silver	0.0005	EPA 200.8	1000-mL plastic	six-month holding time at 4°C; field-filtered; preserved to pH<2 with HNO_3
Mercury	0.0002 - 0.0005	EPA 245.1	1000-mL plastic	28-day holding time at 4°C; field-filtered; preserved to pH<2 with HNO_3
Zinc	0.02	EPA 200.8	1000-mL plastic	six-month holding time at 4°C; field-filtered; preserved to pH<2 with HNO_3
Volatile Organic Compounds				
Naphthalene	0.010	GC/MS; EPA 8270	2, 40-mL glass	14-day holding time at 4°C; preserved to pH<2 with HCl
Tetrachloroethene	0.005	GC/MS; EPA 8260	2, 40-mL glass	14-day holding time at 4°C; preserved to pH<2 with HCl
Other				
Total Cyanide	0.010	EPA 335.2 or 335.3	1000-mL plastic	14-day holding time at 4°C; preserved to pH>12 using NaOH
Biological Oxygen Demand	2.0	EPA 405.1	1000-mL plastic	48-hr holding time at 4°C
Fecal Coliform	1 org	SM 9221 E(MPN)	4 oz plastic	6-hr holding time at 4°C; preserved with sodium thiosulfate
Total Residual Chlorine	0.03	SM 4500 Cl G	1000-mL plastic	test within 15 minutes; store at 4°C

2.3.1 *Sample Stations*

The toxic constituent sample stations are identical to those for conventional constituents (see Table 2-3).

2.3.2 *Sampling and Analytical Laboratory Methods*

Toxic constituent samples will be collected for the parameters listed in Table 2-4 using a peristaltic pump with Teflon tubing at the required sampling depths for each station. Decontamination between sampling depths will consist of pumping at least three times the tubing volume through the pump prior to sample collection.

Toxic constituent samples will be collected in bottleware to be provided by GL. The VOC, total cyanide, biological oxygen demand (BOD), and fecal coliform samples will be collected directly into laboratory bottles according to the guidelines in Table 2-4. The total residual chlorine (TRC) samples will be collected and analyzed on the boat as soon as each one is collected. The metals aliquots will be collected into temporary, pre-cleaned, 1,000-mL polyethylene bottles for transport to GL for field filtration. The fifth magnetic filter funnel of each filtration station (see Section 2.2.2) will be used with 47-mm diameter, 0.45 μm pore size, membrane filters to prepare these dissolved metals samples. Whatman GF/F 47-mm diameter filter pads with 0.70 μm pores may be used as pre-filters for particularly turbid metals grab samples. As indicated in Table 2-4, the filtered metals aliquot will be transferred to pre-cleaned GL bottleware that has been acidified to a pH of less than 2.0 using nitric acid (HNO_3) prior to analysis.

The limitations of the depth from which the peristaltic pump will operate (i.e., approximately 25 feet) will require that an alternate sampling device be used for those stations greater than 25 feet in depth. A stainless steel Kemmerer sample bottle has been chosen as the alternate sampling device. This precludes the collection of dissolved metals samples at these deeper water column depths, as the clean metals methodologies prohibit the use of metal sampling devices (see Section 2.3.3).

With the exception of VOCs and fecal coliform, 1,000-mL plastic bottles will be used to collect the toxic constituents listed above. The VOC samples will require two, 40-mL glass vials, and fecal coliform samples will require 4 oz plastic bottles. All samples must be cooled to 4°C.

Preservation and sample holding times vary among the toxic constituents (Table 2-4). Consequently, the sampling team must remain aware of sample collection times and plan sample drop-offs accordingly.

2.3.3 *Practical First Steps to Approach EPA/MDE Clean Metals Procedures*

The purpose of this section is to outline those procedures which can practicably be implemented by ERM sampling personnel and GL to approach the recommended sample preparation and analyses set forth in EPA's April 1995 documents entitled *Method 1669: Sampling Ambient Water for Trace Metals at EPA Water Quality Criteria Levels* and *Guidance on the Documentation and Evaluation of Trace Metals Data Collected for Clean Water Act Compliance Monitoring.*

The procedures summarized in this section by no means represent compliance with Method 1669; however, these procedures will be followed to reduce as much metals sample contamination as possible given the resources available to ERM and GL.

The clean metals procedures to be implemented are grouped by organization and are listed in bulleted format below.

ERM

- use and change of gloves when potential sources of contamination are touched; only powder-free gloves (recommended by Batelle) will be used for sampling purposes;
- use of a recommended, metal-free Masterflex® peristaltic pump for purging and sampling purposes; the pump tubing is purged with at least three tubing volumes in between sample locations prior to sample collection;
- designation of "clean" and "dirty" hands personnel during sampling; the "dirty" hands person handles the Hydrolab unit, peristaltic pump, and sample bags, while the "clean" hands person only touches the metals sample bottle;
- pre-rinsing of metals bottleware three times with sample water before the bottle is filled to capacity;
- double bagging of metals samples (the metals sample bottle will be placed in its own bag, and then placed in a larger bag which will also be used to hold the other toxic constituent bottleware);

- use of 10 percent Instra-analyzed HCl and deionized water for daily filtration apparatus and peristaltic pump decontamination;
- collection of one pump blank per day to evaluate the possible contribution of potentially accumulated metals in the pump tubing;
- collection of one filter apparatus blank and one pre-filter apparatus blank per event to evaluate the possible contribution of metals from filter paper used in the apparatus;
- collection of matrix spike and duplicate samples at frequencies of one per day and one per 20 samples, respectively.

Gascoyne Laboratories

- provision of 10 percent Instra-analyzed HCl to ERM for filtration apparatus and peristaltic pump decontamination;
- provision of deionized water to ERM for filtration apparatus and peristaltic pump decontamination;
- provision of pre-cleaned bottles for raw and filtered metals samples; filtered samples will be preserved with Instra-analyzed HNO_3;
- analysis of standards at the concentration reported as the quantitation limit;
- use and change of gloves when potential sources of contamination are touched
- analysis of a bottle blank during the first event to evaluate the cleanliness of pre-cleaned bottleware;
- decontamination of sampling vessel between events with potable water;
- analysis and review of all relevant blank, duplicate, and matrix spike samples as per the GL QA/QC Manual dated December 1995; and
- preparation of a detailed analytical data package for each sample.

2.4 *SAMPLING SCHEDULE*

Baltimore Harbor and Back River monitoring activities will commence in June 1997 and extend through the Spring 1998. The sampling schedule will take into account both wet and dry months, and will be arranged so that approximately half of the monitoring events will be completed by August 1997.

The sampling schedule consists of Back River and Baltimore Harbor/Back River cruises for water and sediment quality monitoring. Table 2-6 provides the overall sampling schedule between June and August 1997.

Table 2-6 Sampling Schedule (June - August 1997)

Sampling Dates	Back River	Baltimore Harbor/Back River	
	(conventional)	(conventional and toxics)	(sediment)
23-27 June		x	
30 June	x		
8-11 July		x	
22 July	x		
5-8 August		x	
19 August	x		
20-22 August			x

3.0 SEDIMENT QUALITY MONITORING

The purpose of this section is to specify the sample stations, methods, and schedule for sediment quality monitoring activities in Baltimore Harbor and Back River.

3.1 SAMPLE STATIONS

The sediment quality sample stations are identical to those for water quality samples. One sediment sample will be collected per station (Table 2-3).

3.2 SAMPLING AND ANALYTICAL LABORATORY METHODS

Sediment quality sampling will be conducted using either stainless steel Ekman or Ponar dredges. Dredges will be decontaminated between sample locations using 10 percent HCl and three deionized water rinses.

Sediment samples will be analyzed for eight metals and total cyanide, as in the water quality monitoring program. A list of these parameters and their respective analytical methods are included in Table 2-5. In addition, sediment quality samples will be analyzed for acid-volatile sulfides by the EPA ABS & SEM procedures dated 18 October 1991.

Due to the contaminated nature of bottom sediments, personnel must take extreme precaution when collecting and handling sediment quality samples. Sampling personnel will wear latex gloves while collecting these samples. In addition, prior to initiating the sediment quality sampling event, ERM personnel will be briefed on sampling methodologies and health and safety issues unique to this task.

3.3 SAMPLING SCHEDULE

A single sediment quality monitoring event will be conducted during the Summer 1997. As indicated in Table 2-6, this sampling event will be conducted at the 28 Baltimore Harbor/Back River stations in August 1997 during a three-day field effort.

4.0 SAMPLE DOCUMENTATION AND HANDLING

This section describes the necessary sample identification, packaging, transport, and chain-of-custody procedures that must be followed throughout the monitoring program.

4.1 SAMPLE IDENTIFICATION

Water quality samples will be assigned sample identification numbers and labeled with self-adhesive labels. At a minimum, each sample label will contain the sample identification number. For example, test tubes, vials, and AA cups provided by CBL for filtrate analyses will be labeled with the sample number only. Filter pad samples will be wrapped in foil and labeled with the station ID, sample number, depth of sample (m), date collected, analysis to be performed, and volume of water filtered through each sample pad. GL samples will be labeled with the ERM work order number, sample identification, collection date, and required analyses.

Every sample from each of the 28 stations will be assigned a sample number. The sample number designations will be maintained throughout the monitoring program on master sample reference sheets, which will be used to cross reference sample numbers with the appropriate field parameters and cruise-specific information (i.e., sampling team, weather, and laboratory testing and preservation requirements).

4.2 SAMPLE PACKAGING AND TRANSPORT

Immediately after collection, each one-gallon sample bottle will be labeled and placed into a strong metal or plastic insulated cooler with sufficient ice for transport to GL for field filtration. Due to differences in the sample and laboratory locations, sample packaging and transport requirements for CBL samples will vary slightly from those of GL samples. Accordingly, the following subsections discuss the packaging requirements for each group of samples.

4.2.1 CBL Packaging Requirements

CBL samples will consist of two sample matrices: 1) filter pads (wrapped in aluminum foil squares), and 2) aqueous filtrate (collected in laboratory-provided test tubes, vials, and AA cups). These samples must be packaged according to the following procedures prior to transport to CBL.

- Line the bottom of the cooler with a layer of plastic bubble wrap.
- Check screw caps on filtrate sample bottles for tightness, verify that each bottle has been labeled with a sample number, and place each in the appropriate color-coded bottle tray. Each bottle tray should be wrapped in bubble wrap for additional protection.
- Each filter pad sample will be wrapped in an individual foil square and labeled with adhesive labels. Groups of filter pads (i.e., TSS/PP, PC/PN, and Chlorophyll-a/Phaeophytin) will be bagged in individual ziplock bags.
- For all containers, plastic wrap must be used to keep containers in place and to prevent breakage. When the cooler is picked up or shaken, no movement or "clanging" of bottles should be heard.
- Dry ice wrapped in newspaper should be placed in the top of the cooler in order to freeze the samples during transport.
- Chain-of-custody and master sample reference sheets should accompany the samples and be sealed in a ziplock plastic bag prior to placement inside the cooler on top of the samples.
- The lid of the cooler must be closed and fastened. Shipping tape should be used to seal the space between the lid and the cooler. The tape should be wrapped around the cooler several times to ensure that the lid does not open if the latch becomes unfastened.
- The outside of each cooler must be labeled with the name and address of the receiving laboratory, the ERM return address, and arrows indicating "This End Up" on the sides of the cooler.

4.2.2 GL Packaging Requirements

GL samples will consist of aqueous metals, VOC, naphthalene, total cyanide, and biological parameter aliquots collected in plastic and glass bottleware according to the guidelines in Section 2.3. Each sample will be sealed in a ziplock plastic bag prior to placement in an insulated cooler cooled to 4°C with ice, with the exception of the metals samples, which must be sealed inside two ziplock plastic bags. In addition, chain-of-custody forms will accompany these samples at all times. The lid of the cooler will be closed for transport from the filtration room to GL's sample receiving department.

4.2.3 *Sample Transport*

Toxic constituent samples will be transported directly to GL by ERM field sampling personnel for filtration of the metals aliquots and analysis of the samples. The conventional constituent sample coolers will either be delivered directly to CBL by ERM personnel, or by an overnight courier service. In any case, the transactions of these samples must be recorded on the appropriate chain-of-custody forms.

Upon receipt of the samples, each laboratory will inspect the condition of the samples, compare the information on the sample labels against the field chain-of-custody records, assign a laboratory control number, and log the control number into a computer sample inventory system. Laboratory personnel will note any damaged sample containers or discrepancies between sample labels and information on the chain-of-custody record when logging the sample. This information will also be communicated to ERM so that proper action can be taken, as necessary.

4.3 *CHAIN-OF-CUSTODY PROCEDURES*

Chain-of-custody records will accompany the samples at all times, and each sample transaction will be documented on the chain-of-custody form to ensure the proper handling and possession of the samples. The primary objective of these procedures is to create an accurate, written record which can be used to trace the possession and handling of the sample from the moment of its collection through analysis and its introduction as evidence.

A sample is defined as being in someone's custody if:

- it is in one's actual possession;
- it is in one's view, after being in one's physical possession;
- it is in one's physical possession and then stored in a secure facility or location so that no one can tamper with it; or
- it is kept in a secured area, restricted to authorized personnel only.

To eliminate potential problems in the chain-of-custody protocol, the task manager will be appointed Field Custodian for each monitoring event. As such, the Field Custodian will inspect each of the sample containers after sample collection, ensure that the samples are handled appropriately, and document each sample transaction using the chain-of-custody forms. The samples will remain in the custody of the Field Custodian until they are transported to the appropriate laboratory.

5.0 QUALITY ASSURANCE/QUALITY CONTROL PROCEDURES

Analytical data cannot be properly assessed for accuracy and precision unless it is accompanied by a quality assurance/quality control (QA/QC) program. Therefore, this field sampling plan requires that both field and laboratory QA/QC procedures be followed according to the guidelines discussed in this section. Conventional water quality samples will be evaluated using QA/QC procedures in the Chesapeake Bay Program (CBP) Manual dated August 1996. Toxic water and sediment quality samples will be evaluated using QA/QC procedures in the December 1995 GL QA/QC Manual.

This section focuses on QA/QC procedures to be followed by ERM personnel in the field. The reader should refer to the CBP Manual and the GL QA/QC Program Manual for detailed information on CBL's and GL's laboratory-specific QA/QC procedures.

5.1 ANNUAL CALIBRATION

An annual calibration is an extensive and thorough calibration using standards or instruments relating to certified NIST instruments or standards to ensure parameter precision. For example, the temperature sensor in the Hydrolab unit must be calibrated against NIST standards once a year (Section 2.1).

5.2 CALIBRATION CHECK

A calibration check is a verification performed before and after each cruise to ensure that the instrument response is comparable to that which existed at the annual calibration. Calibration by standard operating procedures should include measurements against a reference standard or meter. The calibration of pH, DO, and specific conductivity sensors in the Hydrolab unit (Section 2.1) is an example of just such a calibration check. When the calibration check indicates a significant change during a cruise, the instrument should be recalibrated as soon as possible.

5.3 *CHECK SAMPLE*

A check sample is a water sample that is collected simultaneously with an in-situ measurement and returned to the laboratory for analysis. If these measurements differ by 20 percent or more, the Hydrolab unit will be recalibrated as soon as possible according to manufacturer specifications. One check sample will be collected per monitoring event.

5.4 *EQUIPMENT BLANKS*

Equipment blanks, consisting of pump and filter blanks, will be collected for analysis of dissolved metals at a frequency of one per day and one per event, respectively. The peristaltic pump blanks will be collected on the sampling vessel by pumping 1,000 mL of deionized water through the tubing and pump head immediately after the apparatus has been decontaminated with approximately one liter of 10 percent HCl and four liters of deionized water.

Two kinds of filter blanks will be collected for this monitoring program: one through the metals filtration apparatus installed with a 0.70 µm pore size pre-filter, and a second through the identical filtration apparatus installed with a 0.45 µm pore size filter. Prior to the collection of filter blank samples, the metals filtration apparatus will be decontaminated with 10 percent HCl and three deionized water rinses. Each filter blank will be collected by filtering 1,000 mL of deionized water through the metals filtration apparatus loaded with the appropriate filter pad.

5.5 *TRIP BLANKS*

Trip blanks will be collected for analysis of the VOC tetrachloroethene at a frequency of one per field sample cooler per day. Each blank sample will consist of two, 40-mL vials preserved with HCl and filled to capacity with deionized water. The trip blanks will accompany the collected samples in the field/boat coolers. It is anticipated that two to three trip blanks will be submitted to GL on a daily basis.

5.6 *FIELD DUPLICATES*

The sampling frequency for field duplicate samples to be collected for both CBL and GL is one per twenty environmental samples. Each field duplicate sample will be collected as a duplicate volume of the original sample.

GL field duplicate samples will be collected by filling duplicate bottleware for VOC, naphthalene, dissolved metals, and total cyanide analysis. CBL requires that their field duplicate samples be collected by pre-rinsing and filling a five-gallon bucket with sample water, and then transferring the sample water to two, one-gallon sample jugs directly from the bucket. For the purposes of this monitoring program, the nineteenth of every 20 samples will be designated as the field duplicate sample.

5.7 *MATRIX SPIKES*

The sampling frequency for matrix spike samples to be collected for CBL and GL is one per twenty environmental samples and one per day, respectively. Each matrix spike sample will be collected as a duplicate volume of the original sample.

GL matrix spike samples will be collected by filling duplicate bottleware for VOC, naphthalene, dissolved metals, and total cyanide analysis. CBL requires that their matrix spike duplicate volume be collected by pre-rinsing and filling a five-gallon bucket with sample, and then transferring the sample water to two, one-gallon sample jugs directly from the bucket. For the purposes of this monitoring program, the twentieth of every 20 samples will be designated as the matrix spike.

6.0 HEALTH AND SAFETY

Health and safety affects every aspect of a field monitoring program. Therefore, ERM has prepared this section to highlight key health and safety issues related to field tasks to be conducted under the monitoring program. The reader is referred to ERM's comprehensive health and safety plan (dated 20 June 1997) for more information on this subject.

61 BOAT SAFETY

While working on the sampling vessel, all personnel must protect themselves from excessive contact with sample water, weather conditions, and laboratory preservatives in sample bottleware. To this end, the following PPE is required:

- life vests;
- long pants or shorts, depending on the weather;
- enclosed shoes (either tennis shoes or work boots are acceptable);
- safety glasses;
- work gloves or latex sampling gloves, as appropriate for the task at hand;
- sunscreen lotion and hats, as necessary during sunny conditions; and
- raingear, as necessary during wet conditions.

Towels will be kept on board the vessel so that if sampling personnel are splashed with sample water, they can immediately dry their skin and clothing.

6.2 ACID HANDLING

When using 10 percent HCl for acid washing or decontamination purposes, the following procedures must be followed:

- Personnel will wear heavy rubber gloves, a rubber apron, and safety glasses when acid washing GL bottleware; and

- Personnel will wear latex gloves, a lab coat or apron, and safety glasses when using 10 percent HCl wash bottles for decontamination of the filter apparatus. HCl wash bottles must be labeled at all times.

6.3 *FILTRATION ROOM*

Safety glasses, latex gloves, long pants, enclosed shoes, and either a lab coat or apron must be worn at all times while working in the filtration room. All activities in the filtration room will be conducted using the buddy system. A buddy is another worker fully dressed in the appropriate PPE, who can perform the following activities:

- Provide his/her partner with assistance;
- Periodically check the integrity of his/her partner's PPE; and
- Notify other is emergency help is needed.

An emergency eye wash station is built into the sink, and an acid neutralization kit is mounted on the wall in the GL filtration room. These resources should be utilized if any personnel comes into contact with 10 percent HCl, or if an acid spill occurs.

6.4 *COMMUNICATIONS*

Cellular phones will be present during field activities for emergency response and office communications. The following table summarizes the appropriate project management, laboratory, and emergency response contacts to be utilized for the monitoring program.

Table 6-1 Emergency Response Telephone Numbers

ERM Contacts	Telephone Number
ERM Project Director Robert Dwyer	(410) 247-1119
ERM Project Manager Jackie Knox	(410) 266-0006
ERM Health and Safety Coordinator Jackie Knox	(410) 266-0006
ERM Task Manager Kristin Carter	(410) 266-0006
ERM Health and Safety Officer Kristin Carter	(410) 266-0006
Gascoyne Laboratory Barb Holland	(410) 633-1800
ETA Don Koch	(410) 461-9920
Emergency Response Agency	**Telephone Number**
Baltimore City Police Department	911 or (410) 396-2310
Fire Department	911
Ambulance	911
Harbor Hospital Center	Information - (410) 347-3200 Emergency Room - (410) 347-3510
MDE Emergency Response Program	Normal work hours - (410) 333-2950 After hours - (410) 974-3551
Coast Guard Baltimore Search and Rescue Activities	(410) 576-2525
DNR Police - Gwynbrook	(410) 356-7060

Appendix B
Water Column Health and Safety Plan

ENVIRONMENTAL RESOURCES MANAGEMENT GROUP

City of Baltimore Wastewater Master Facilities Plan

Baltimore Harbor/Back River Water Column Sampling Health and Safety Plan

Baltimore, Maryland

WO# F7103.00.01

20 June 1997

Environmental Resources Management
2666 Riva Road, Suite 200
Annapolis, Maryland 21401

ERM®

TABLE OF CONTENTS

LIST OF FIGURES *PAGE*

LIST OF TABLES

1.0 INTRODUCTION

1.1 PURPOSE

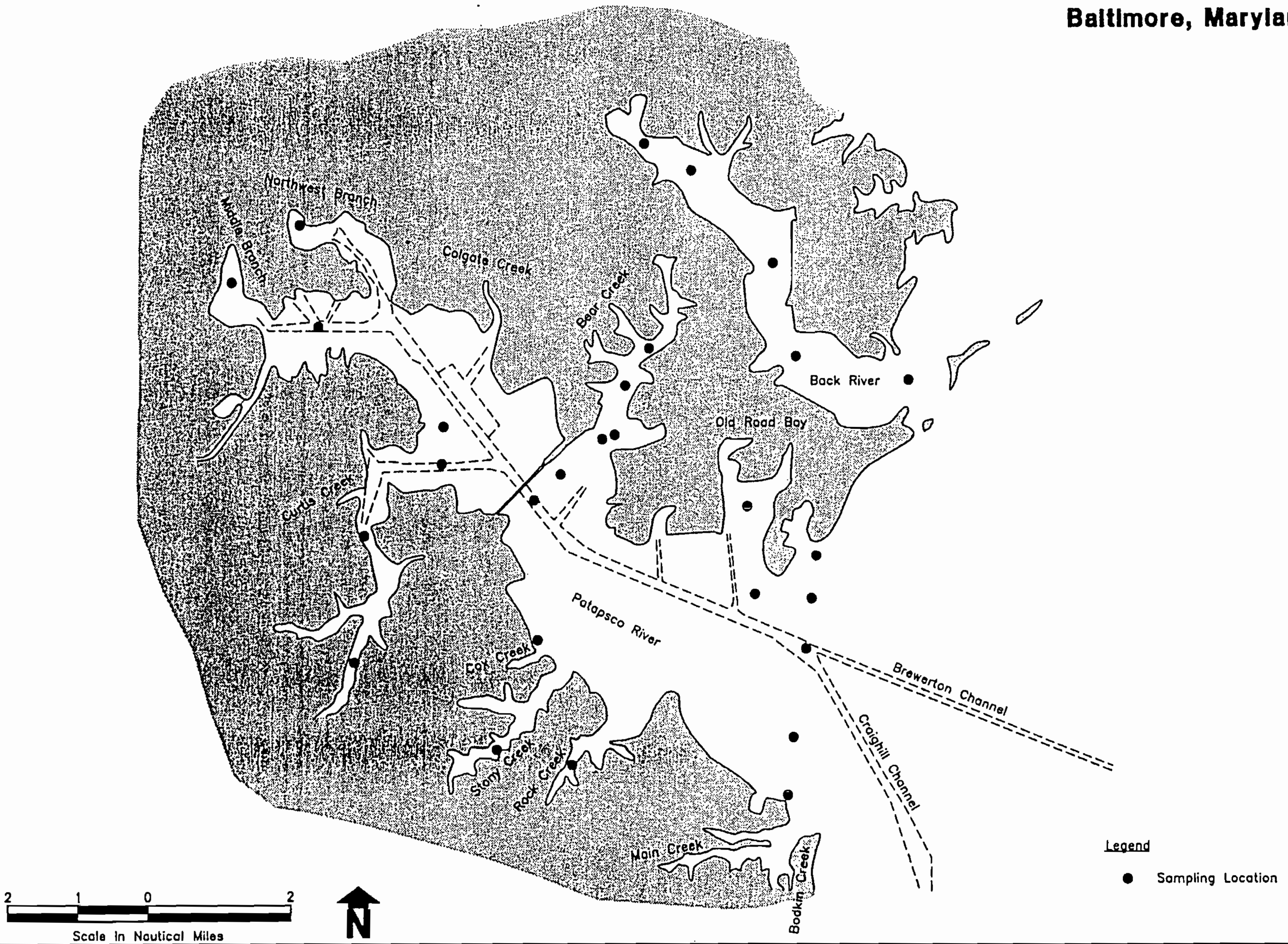
This Health and Safety Plan (HASP) has been developed for the Baltimore Harbor/Back River monitoring program to be conducted by Environmental Resources Management (ERM) on behalf of Whitman, Requardt, and Associates, Inc. (WRA) and the City of Baltimore. This HASP provides recommended health and safety procedures for those ERM employees and subcontractors participating in the associated field operations which are defined in the Baltimore Harbor/Back River Field Sampling Plan dated 20 June 1997.

The monitoring program consists of water quality sampling at 28 locations throughout Baltimore Harbor and Back River (Figure 1-1). The locations were selected based on the needs of MDE's water quality modeling program. ERM and Gascoyne Laboratories (GL) will cruise the water bodies to collect water quality samples during a series of monitoring events between June 1997 and the Spring 1998. The first event will take place the week of 23 June 1997. Each station will be sampled at various water column depths depending upon the total depth of the station.

The procedures set forth in this HASP are designed to reduce the risk of exposure to chemical substances that may be present in the water, and to other hazards associated with any of the activities conducted by ERM cited in this plan. The procedures contained herein are developed in accordance with the provisions of 29 CFR 1910.120 (Hazardous Waste Operations and Emergency Response) and in accordance with ERM's experience for similar field operations. ERM shall be responsible solely for compliance with the provisions of the HASP by ERM employees, subcontractors of ERM where applicable, and designated personnel other than ERM employees and subcontractors. Any other personnel are required to prepare and administer their own health and safety plan. The recommended health and safety guidelines set forth within this document may be modified as further information is obtained from sample analyses.

ERM and other personnel as designated are required to adhere to the procedures specified in this HASP. Failure to do so will result in immediate dismissal from participation in sampling activities. This includes the use of the required personal protective equipment and adherence to the safe work practices specified in this HASP.

Figure 1-1
Sampling Locations
Baltimore Harbor
Baltimore, Maryland



This HASP may be updated to reflect any scope of activities not yet defined, or changes in scope and personnel. Updates, if any, will be reviewed by ERM prior to distribution. The most current HASP will be maintained by the Site Safety Officer. This HASP is dated in the lower right hand corner of each page to assure that the most current version of the HASP is implemented.

2.0 *PROJECT PERSONNEL AND RESPONSIBILITIES*

The following responsibilities and authorities have been assigned to designated ERM personnel for this project.

ERM Project Director

Dr. Robert Dwyer is the Project Director (PD) for the project. He will have overall responsibility for project quality and completion. Dr. Dwyer is also responsible for maintaining communications between ERM, other subcontractors, and WRA.

ERM Project Manager

Ms. Jackie Knox is the Project Manager (PM) for the project. Ms. Knox will have day-to-day responsibility for completion of the project, and will meet regularly with key project personnel to discuss project status, correct potential difficulties, and anticipate potential problems so that timely solutions can be applied.

ERM Task Manager

Ms. Kristin Carter is the Task Manager for the project. Ms. Carter is appointed by the PM to coordinate daily activities during the monitoring program and ensure that health and safety responsibilities are met.

ERM Health and Safety Coordinator

Ms. Knox is the ERM Health and Safety Coordinator for all aspects of the project. The Health and Safety Coordinator is the person duly appointed to act in a supervisory capacity over all aspects of the monitoring program.

ERM Health and Safety Officer

Ms. Carter is the ERM Health and Safety Officer for all aspects of the project. The Health and Safety Officer's responsibilities include:

- creating and updating the HASP;
- initiating the health and safety procedures during sampling; and
- resolving any health and safety questions that may arise.

3.0 HEALTH AND SAFETY HAZARDS

The sampling activities pose potential exposure risks to both chemical and physical hazards. The chemical risks are explained in detail below. The potential for chemical exposure to hazardous substances is significantly reduced through the use of personal protective clothing, engineering controls, and implementation of safe work practices.

Other potential hazards that are associated with the sampling activities include heat stress or cold exposure (depending on the time of year) and insects. Precautionary measures have been established to reduce these risks to a minimum during sampling activities.

3.1 CHEMICAL HAZARDS

Dilute (i.e., 10 percent) Hydrochloric acid (HCl) will be used to clean laboratory glassware and containers, and decontaminate sampling equipment. In addition, much of the GL laboratory bottleware will be pre-preserved with nitric acid (HNO_3), sodium hydroxide (NaOH), or other chemicals. The use of these chemicals poses a limited health and safety risk. Section 4.0 details the personal protective equipment (PPE) that is necessary to reduce the risk associated with 10 percent HCl and laboratory preservatives.

Emergency eye wash stations are built into the sinks at GL, and an acid neutralization solution is mounted on the wall in the GL filtration room. In addition, a portable eye wash station will be on board the sampling vessel during all scheduled sampling activities.

3.2 WATER SAFETY

The sampling vessel will be operated by a qualified captain trained in appropriate safety and rescue procedures. Life vests must be worn at all times, and no horseplay will be tolerated.

Contact with land-based sampling personnel is expected every two to three hours. However, the boat is also equipped with a cellular phone for emergency communications.

3.3 HEAT STRESS/COLD EXPOSURE

It is not anticipated that heat stress will be a significant factor in the health and safety of the workers. However, if heat stress does become a significant factor, work/rest regimens will be employed as necessary so that personnel do not suffer adverse effects from heat stress. Special clothing and an appropriate diet and fluid intake will be recommended to all site personnel to further reduce these temperature-related hazards. If necessary, the work/rest regimens will be developed following the guidelines in the ACGIH Threshold Limit Values and Biological Exposure Indices for 1993-1994 and other practices developed and used by experienced industrial hygienists.

Effects of heat stress can occur as either heat exhaustion, or the more dangerous condition of heat stroke. Signs of heat exhaustion are summarized below:

- pale, clammy skin;
- profuse perspiration;
- extreme fatigue;
- headache; or
- vomiting.

Even with these symptoms, however, the body temperature will appear normal. Effects of heat stroke include the following:

- hot, flushed or red, dry skin;
- extremely high body temperature (up to 106°F);
- dizziness;
- nausea;
- headache;
- rapid pulse; or
- unconsciousness.

The effects of cold exposure can be less apparent to the victim. It is extremely important that partners use the buddy system and visually inspect their fellow workers often. Redness of the skin indicates the onset of cold exposure. A white or pale skin color, especially on extremities such as the nose, cheeks, chin, ears, fingers, and toes are indications that frostbite is setting in. Individuals should dress in layers, peeling off each layer as they get warmer from exertion. The Site Safety Officer should keep informed of the wind-chill factor and inspect workers during cold exposure conditions.

3.4 *BIOLOGICAL HAZARDS*

All sampling personnel should be aware of hazards presented by bees, mosquitoes, and other insects. Accordingly, personnel should consider the use of an insect repellent. To prevent possible insect contact, wear light colored shirts, pants, and socks.

In the case of a bee sting, remove the stinger with tweezers and spray the affected area with an antiseptic or rubbing alcohol. For mosquito bites spray the affected area with antiseptic or rubbing alcohol. A first aid kit will be kept on the boat for just such incidents. However, if the sting or bite is severe, personnel should seek medical attention.

3.5 *ADDITIONAL SAFETY PRACTICES*

The following are important safety precautions which will be enforced during all field activities.

- Eating, drinking, chewing gum or tobacco, smoking, or any practice that increases the probability of hand-to-mouth transfer and ingestion of contaminants is prohibited (i.e., during sample collection and handling activities).
- Personnel should wash their hands and face thoroughly upon leaving their work area, and before eating or drinking.

4.0 PERSONAL PROTECTIVE EQUIPMENT

All personnel must be provided with appropriate personal safety equipment and protective clothing. Each individual should be properly trained in the use of this safety equipment before the start of field activities. Safety equipment and protective clothing shall be used as directed by the Site Safety Officer.

Personal protective equipment must be worn at all times, as designated by this HASP. Protective clothing and equipment requirements have been assigned to specific tasks, as discussed below.

4.1 BOAT SAFETY

While working on the sampling vessel, all personnel must protect themselves from excessive contact with sample water, weather conditions, and laboratory preservatives in sample bottleware. To this end, the following PPE is required:

- life vests;
- long pants or shorts, depending on the weather;
- enclosed shoes (either tennis shoes or work boots are acceptable);
- safety glasses;
- work gloves or latex sampling gloves, as appropriate for the task at hand;
- sunscreen lotion and hats, as necessary during sunny conditions; and
- raingear, as necessary during wet conditions.

Towels will be kept on board the vessel so that if sampling personnel are splashed with sample water, they can immediately dry their skin and clothing.

4.2 ACID HANDLING

When using 10 percent HCl for acid washing or decontamination purposes, the following procedures must be followed:

- Personnel will wear heavy rubber gloves, a rubber apron, and safety glasses when acid washing GL bottleware; and

- Personnel will wear latex gloves, a lab coat or apron, and safety glasses when using 10 percent HCl wash bottles for decontamination of the filter apparatus. HCl wash bottles must be labeled at all times.

4.3 *FILTRATION ROOM*

Safety glasses, latex gloves, long pants, enclosed shoes, and either a lab coat or apron must be worn at all times while working in the filtration room. All activities in the filtration room will be conducted using the buddy system. A buddy is another worker fully dressed in the appropriate PPE, who can perform the following activities:

- Provide his/her partner with assistance;
- Periodically check the integrity of his/her partner's PPE; and
- Notify other is emergency help is needed.

An emergency eye wash station is built into the sink, and an acid neutralization kit is mounted on the wall in the GL filtration room. These resources should be utilized if any personnel comes into contact with 10 percent HCl, or if an acid spill occurs.

5.0 *EMERGENCY RESPONSE/CONTINGENCY PLAN*

Table 5-1 contains emergency response telephone numbers. This table will be maintained on both the sampling vessel and in the filtration room for use in case of an emergency.

5.1 *RESPONSIBILITIES*

The Site Safety Officer or her designee will be responsible for responding to all emergencies. The Site Safety Officer or her designee will:

- Notify appropriate individuals, authorities and/or health care facilities of the activities and hazards of the investigation;
- Ensure that the following safety equipment is available to personnel: eyewash station, first aid supplies, and fire extinguishers;
- Have working knowledge of all safety equipment;
- Ensure that emergency telephone numbers are prominently posted; and
- Ensure that a map which details the most direct route to the nearest hospital is prominently posted.

5.2 *ACCIDENTS AND INJURIES*

In the event of a safety or health emergency, appropriate emergency measures will immediately be taken to assist those who have been injured or exposed and to protect others from hazards. The Site Safety Officer or her designee will be immediately notified and will respond according to the seriousness of the injury. The ERM Project Manager will be immediately informed of any serious injuries.

Table 5-1 *Emergency Response Telephone Numbers*
City of Baltimore Wastewater Master Facilities Plan, Baltimore, Maryland

ERM Contacts	Telephone Number
ERM Project Director Robert Dwyer	(410) 247-1119
ERM Project Manager Jackie Knox	(410) 266-0006
ERM Health and Safety Coordinator Jackie Knox	(410) 266-0006
ERM Task Manager Kristin Carter	(410) 266-0006
ERM Health and Safety Officer Kristin Carter	(410) 266-0006
Gascoyne Laboratory Barb Holland	(410) 633-1800
ETA Don Koch	(410) 461-9920

Emergency Response Agency	Telephone Number
Baltimore City Police Department	911 or (410) 396-2310
Fire Department	911
Ambulance	911
Harbor Hospital Center	Information - (410) 347-3200 Emergency Room - (410) 347-3510
MDE Emergency Response Program	Normal work hours - (410) 333-2950 After hours - (410) 974-3551
Coast Guard Baltimore Search and Rescue Activities	410 576-2525
DNR Police - Gwynbrook	410 356-7060

5.3 *COMMUNICATIONS*

Cellular phones will be present during field activities for emergency response and office communications.

5.4 *HOSPITAL DIRECTIONS*

In the event of a serious injury to site personnel, an ambulance shall be used for transportation to the nearest hospital. In the event of minor injuries or illness, the Site Safety Officer or her designee may elect to have the injured transported to the nearest hospital by company vehicle. If there is any doubt about the severity of the injury, an ambulance shall be used. A Hospital Route Map is referenced in Figure 5-1.

Directions to Harbor Hospital Center, Baltimore, Maryland

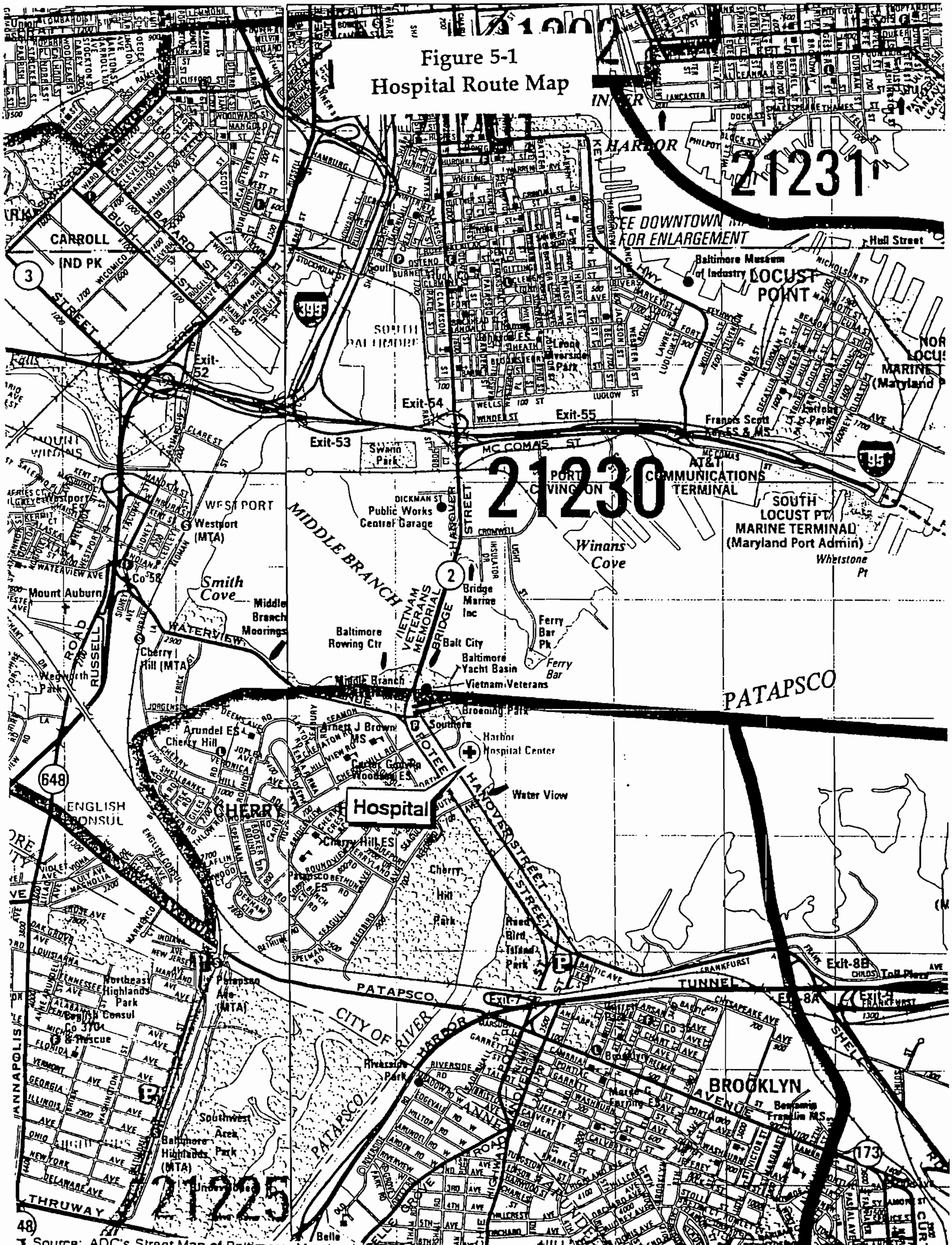
Directions by water: Harbor Hospital Center is located on the south side of Middle Branch just prior to the Hanover Street Bridge. The hospital has a boat ramp accessible from Middle Branch.

Directions by land: From I-95 take Exit 55 (Key Highway) to Hanover Street and turn left. Proceed to Hanover Street (Rt. 2) and turn right (i.e., south). Proceed over the Vietnam Veterans Memorial Bridge. After crossing the bridge, southbound traffic is directed onto Potee Street because Hanover Street becomes one-way northbound. Proceed south on Potee Street and turn left on 10th Street. Proceed to Hanover Street and turn left (one way northbound). Proceed north on Hanover Street - Harbor Hospital Center will be on the right. Follow signs to the Emergency Room.

5.4 *INCIDENT REPORTING PROCEDURES*

Adherence to this site-specific HASP and any additional facility safety rules and regulations will significantly reduce the likelihood of personnel being exposed to toxic substances above permissible exposure limits and to physical hazards. However, in the event an incident does occur, it is imperative that specific reporting procedures be followed so that appropriate corrective action can be taken by the Health and Safety Coordinator/Project Manager. Upon notification of an incident, the Health and Safety Coordinator will contact the appropriate technical personnel for recommended medical diagnosis and treatment, as necessary. The Project Manager/Health and Safety Coordinator will

Figure 5-1
Hospital Route Map



Source: ADC's Street Map of Baltimore, Maryland investigate site conditions to determine: (1) the severity of the incident, (2) the cause of the incident, and (3) the means to prevent the incident from recurring.

An incident reporting form (Table 5-2) has been developed so that consistent and appropriate information is obtained regarding employee exposures or accidents. This form will be completed by the ERM Health and Safety Coordinator and the exposed individual. The form will be filed at ERM with the employee's medical and safety records to serve as documentation of the incident and the actions taken.

Table 5-2 Incident Report Form

CLIENT NAME:
LOCATION OF INCIDENT:
TYPE OF INCIDENT:
DATE:
EMPLOYEE NAME:
EMPLOYEE JOB TITLE:
SPECIFIC JOB AT TIME OF INCIDENT:
LEVEL OF PROTECTION WORN AT TIME OF EXPOSURE/ACCIDENT:
INCIDENT SUMMARY:
CORRECTIVE ACTIONS:
EMPLOYEE SIGNATURE:
SITE SAFETY OFFICER:
ERM HEALTH AND SAFETY COORDINATOR:
TIME & DATE OF REPORT:

Appendix C
CD-ROM and Data Organization

COMPACT DISC RAW DATA
TABLE OF CONTENTS

The following is a listing of the folders and files found on the Baltimore City Wastewater Facilities Master Plan Data Compact Disc. To conserve the volume of paper necessary, this data was included in a compact disc rather than printed. The primary format for the data is found in the Microsoft Excel form while other forms of data are found in both Microsoft Access and the Word formats. The data found in this Compact Disc was provided for Tasks 101, 202, 203, 204, 205, 206 and 210.

iv) Montebello Water Filtration Plant.xls
v) Mount Pleasant Golf course.xls
vi) Robert E. Lee Park.xls
vii) Summary of All Precipitation

c) MS Access Database

i) FLOWBALT.db
ii) SAMPBALT.db

d) Stream Flow

i) Site-211.xls
ii) Site-220.xls
iii) Site-230.xls
iv) Site-231.xls
v) Site-240.xls
vi) Site-241.xls
vii) Site-250.xls
viii) Site-251.xls

e) Toxic Metals Data

i) Gascoyne Chemical Data

f) Stream Data Dictionary.doc

3) WATER COLUMN DATA BASE

a) Conventional Constituent Data

i) BOD, Coliforms

(1) BOD.xls
(2) Fecal Coliforms.xls

ii) Carbon

(1) DOC.xls
(2) PC.xls

iii) Chlorophyll

(1) ACT.xls
(2) CHL.xls

iv) Nitrogen

(1) NH4.xls
(2) NITROGEN.xls
(3) NO2.xls
(4) NO2+NO3.xls
(5) NO3.xls
(6) PN.xls
(7) TDN.xls

v) Phosphorus

(1) PHOS.xls
(2) PO4.xls
(3) PP.xls
(4) TDP.xls

vi) Solids

(1) TSS.xls

b) Field-measured data

i) Field Data.xls

c) MS Access database

i) Data Dictionary
ii) WC Database
(1) Data.db

d) Toxic Constituent Data

i) Metals

(1) Chromium.xls
(2) Copper.xls
(3) Lead.xls
(4) Mercury.xls
(5) Nickel.xls
(6) Selenium.xls
(7) Silver.xls
(8) Zinc.xls

ii) Organics

(1) Napthalene.xls
(2) Tetrachlorethene.xls
(3) Total Cyanide.xls

Baltimore City
Comprehensive Wastewater Facilities Master Planning Project

City Project 613

Task 202
Stream Sampling Data

submitted to
Baltimore Department of Public Works

submitted by
Engineering Technologies Associates, Inc.
3458 Ellicott Center Drive
Ellicott City, Maryland, 21043

March 17, 1998

TABLE OF CONTENTS

SECTION I

Wet Weather Stream Sampling Summary

Station Locations

Patapsco River- Hollifield Area of Patapsco State Park at site of USGS stream gage
Dead Run- Baltimore County at site of USGS stream gage.
Gwynns Falls- Baltimore County at site of USGS stream Gage
Gwynns Falls- close to fall line at Wilkens Avenue
Jones Falls- below Lake Roland Dam
Jones Falls- at Maryland Avenue (old USGS gage site)
Herring Run- Baltimore County at site of USGS stream gage
Herring Run- close to fall line at Brehms Ave.

A map of these site locations is shown on Figure 1.

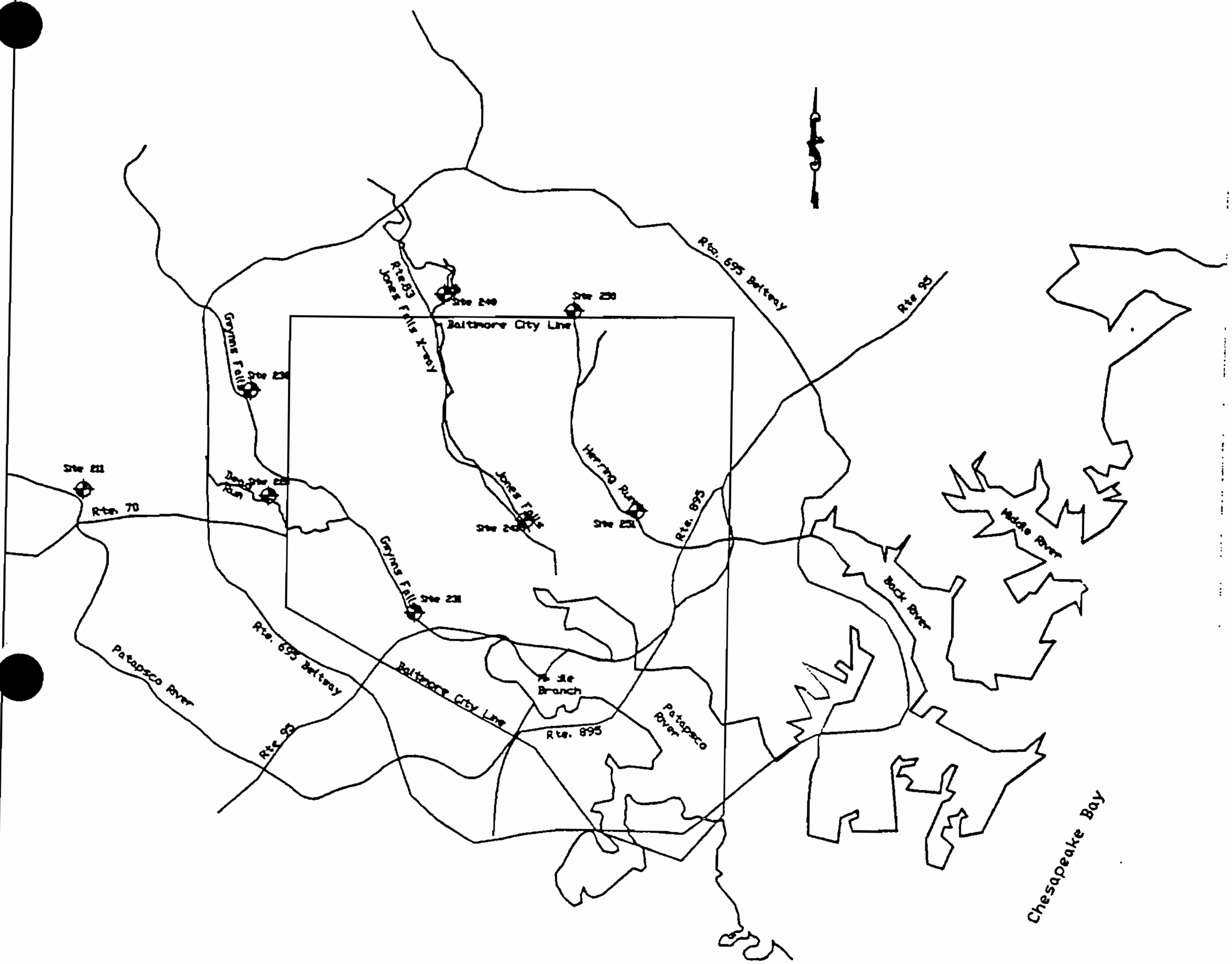
Objective

The objectives of the stream sampling task were:

to collect high quality, water quality data from the Patapsco River, Gwynns Falls, Jones Falls, and Herring Run during both dry and wet weather to be used to quantify the total loading of pollutants to the Baltimore Harbor and Back River estuaries; and

to collect high quality, water quality data at the City/County line on the Gwynns Falls, Jones Falls, and Herring Run during both dry and wet weather to be used to quantify the loading of pollutants at these locations.

Collected stream stage data continuously and calculated flows. A total of 304 samples were collected during 15 rain events from June 16 to December 22, 1997.



Site 211

ETA Stream Sampling Locations

Site 211 - Patapsco River
Site 220 - Dead Run
Site 230 - Gwynns Falls Upstream (Essex Road)
Site 231 - Gwynns Falls 'Fall Line' (Wilkens Ave.)
Site 240 - Jones Falls Upstream (Lake Roland)
Site 241 - Jones Falls 'Fall Line' (Tunnel Entrance)
Site 250 - Herring Run Tributary (Regester Avenue)
Site 251 - Herring Run 'Fall Line' (Brehms Ave)

DESIGNED	AJH	7/97
DRAWN	AJH	7/97
CHECKED	DHK	7/97
APPROVED	DHK	7/97

ENGINEERING TECHNOLOGIES ASSOCIATES, INC.

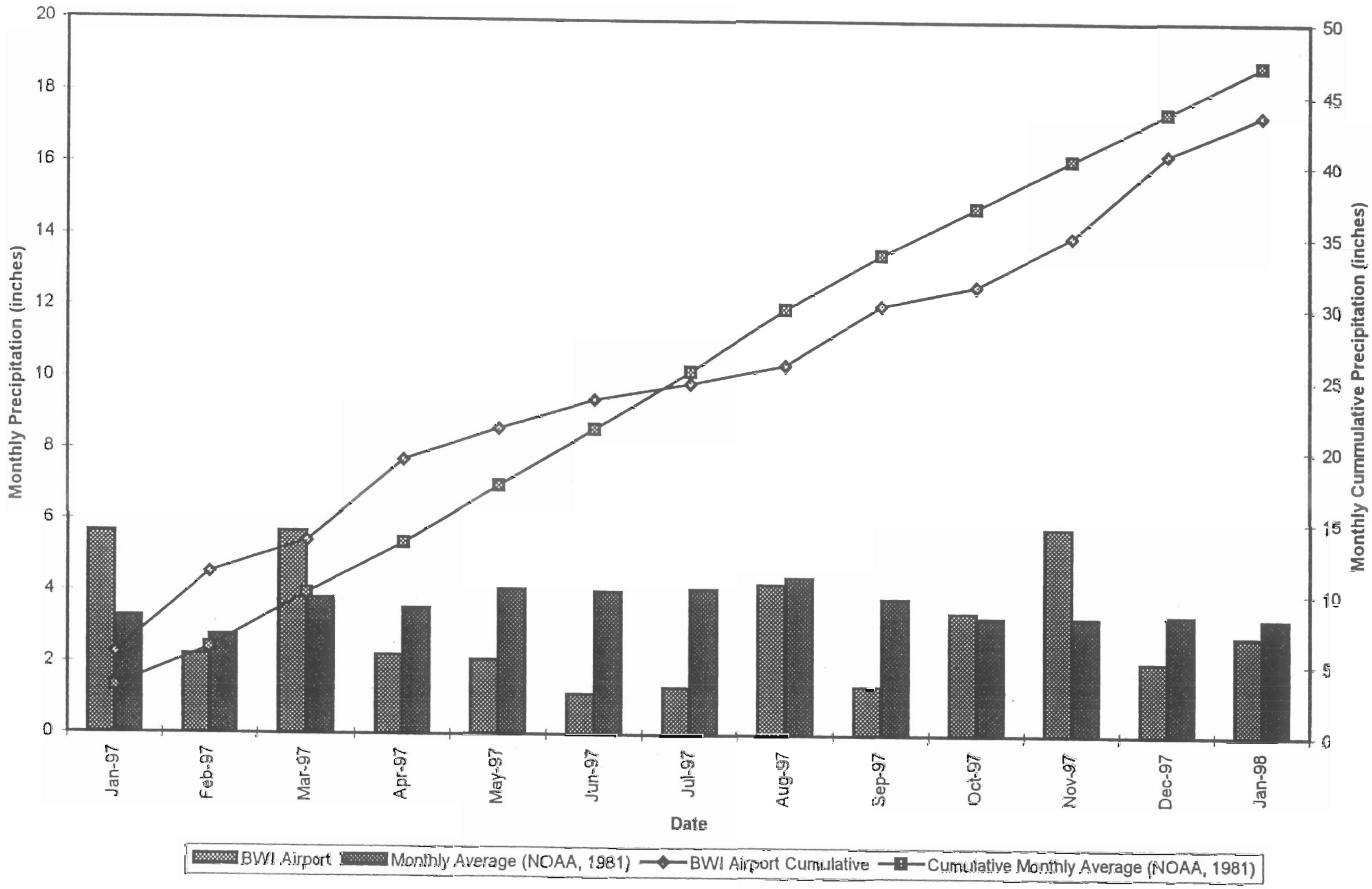
ENGINEERS • PLANNERS • SURVEYORS

3400 ELLICOTT CENTER DRIVE SUITE 101
ELLICOTT CITY, MARYLAND 21043

Figure 1
Baltimore City Stream Sites
Task 202

SCALE	CONTRACT NO.	DATE	SHEET

Figure 2
Monthly Precipitation for Central Maryland
1997

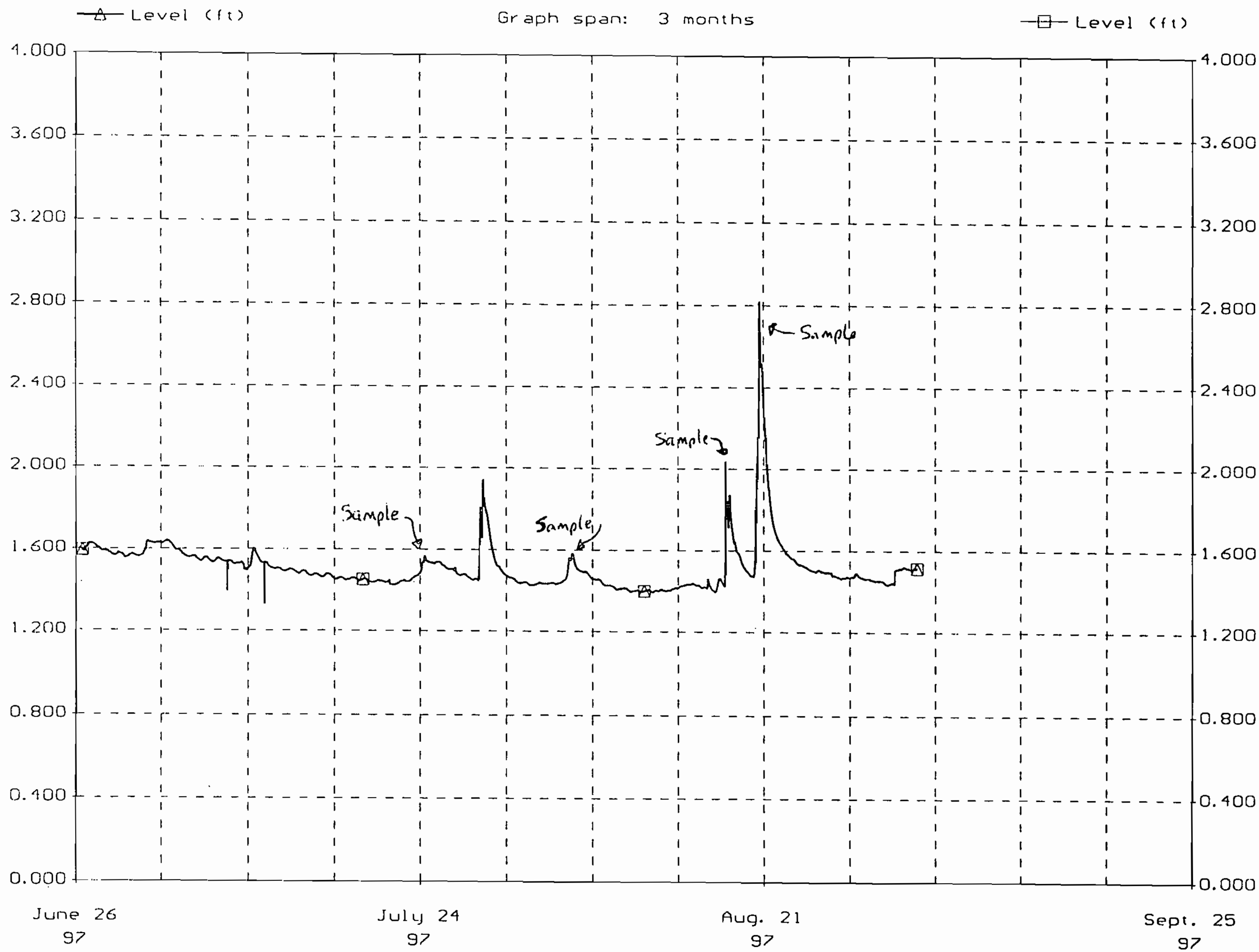


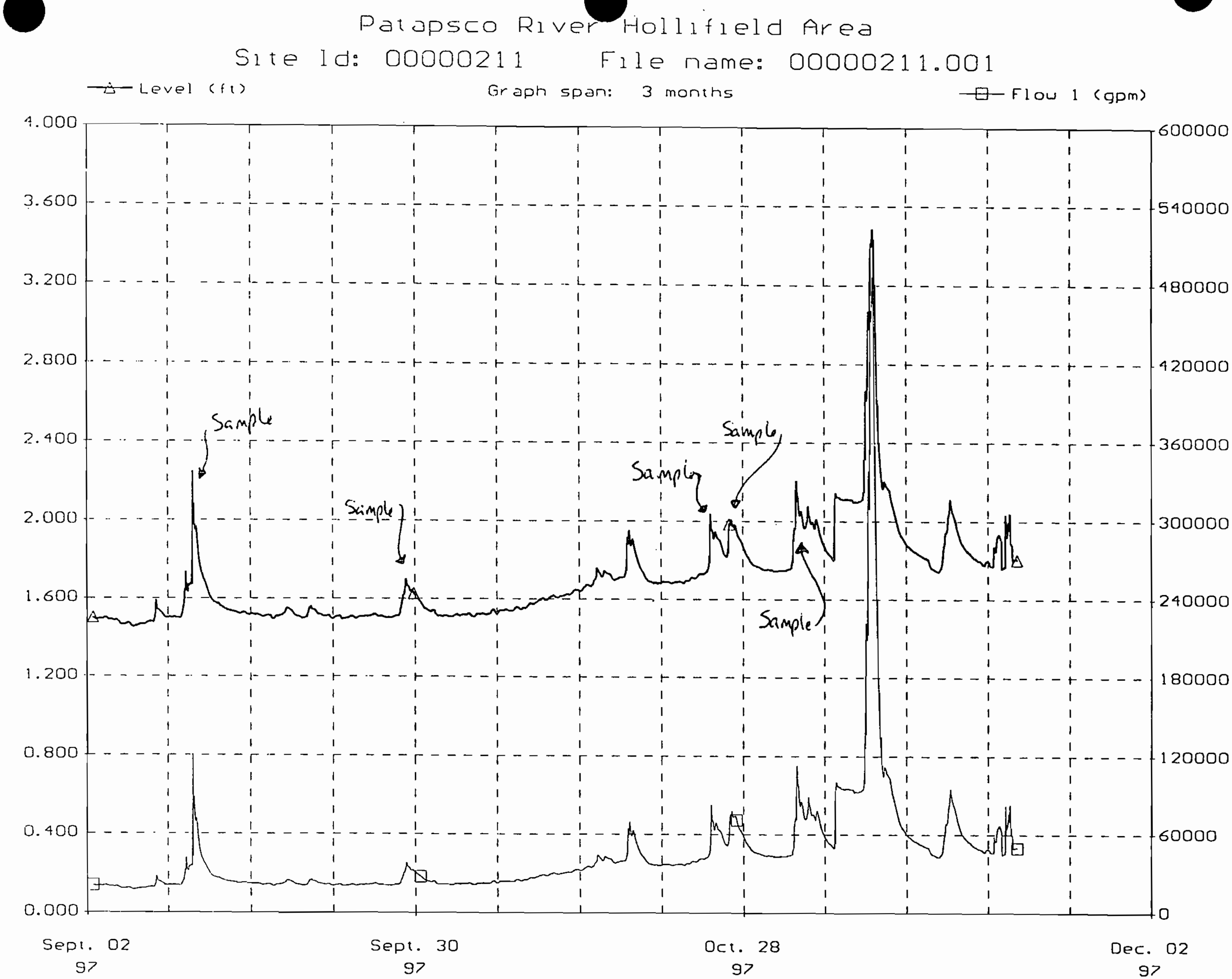
SECTION II

HYDROGRAPHS

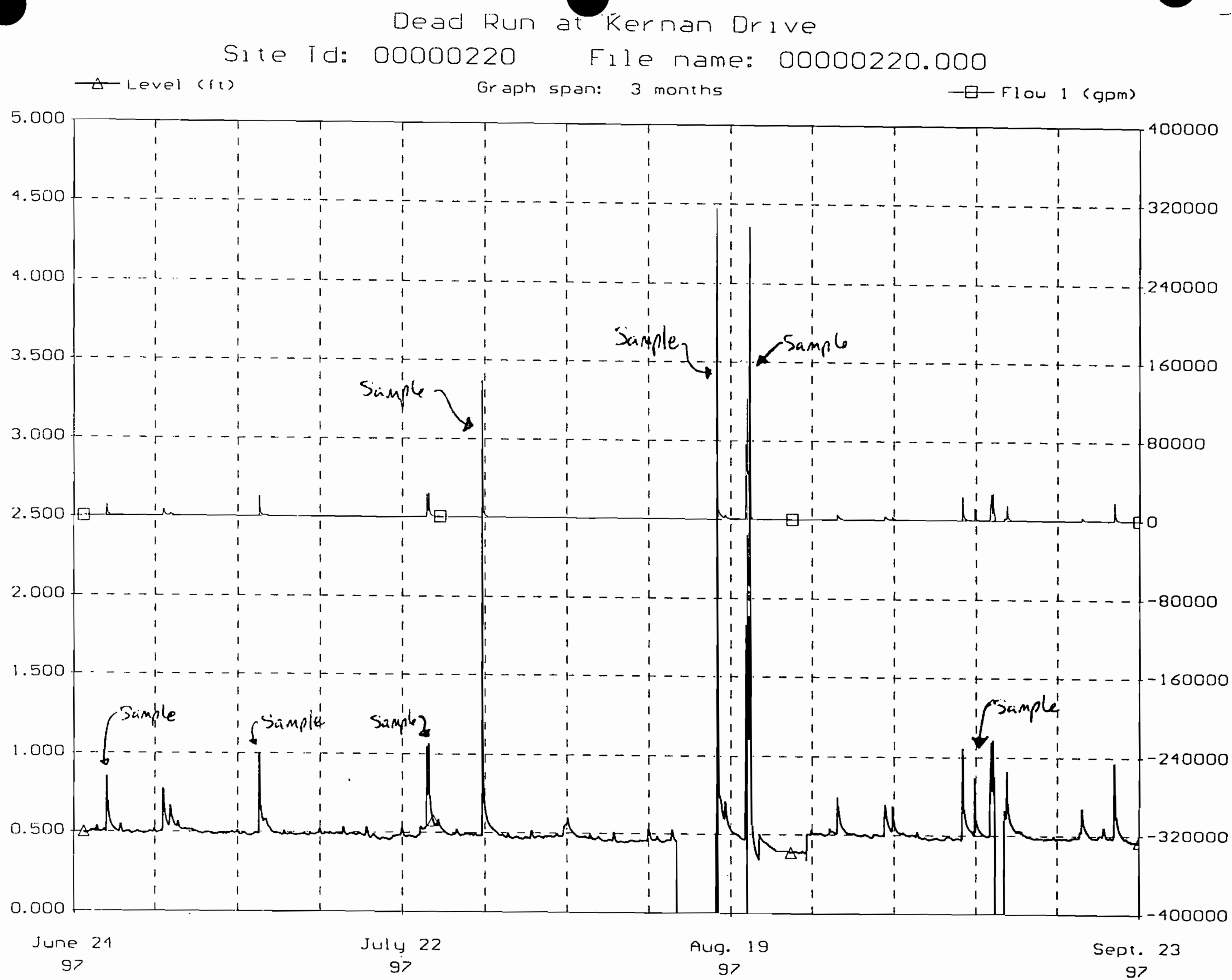
Palapsco River Hollifield Area

Site Id: 00000211 File name: 00000211.000





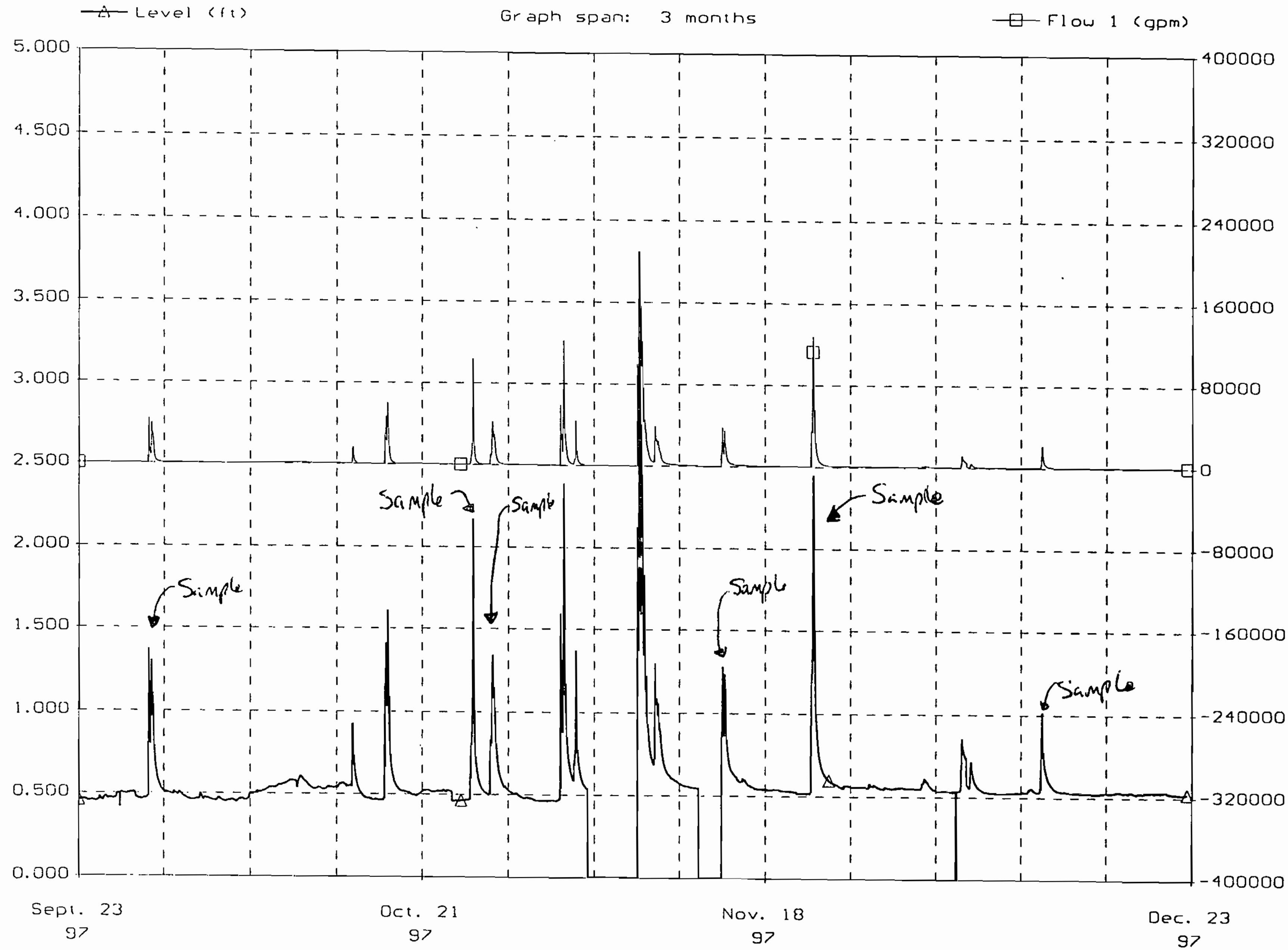
Patapsco River Hollifield Area
Site Id: 00000211 File name: 00000211.001
Level (ft)
Graph span: 3 months
Flow 1 (gpm)
4.000
3.600
3.200
2.800
2.400
2.000
1.600
1.200
0.800
0.400
0.000
600000
540000
480000
420000
360000
300000
240000
180000
120000
60000
0
Sept. 02 97
Sept. 30 97
Oct. 28 97
Dec. 02 97
Sample
Sample
Sample
Sample
Sample

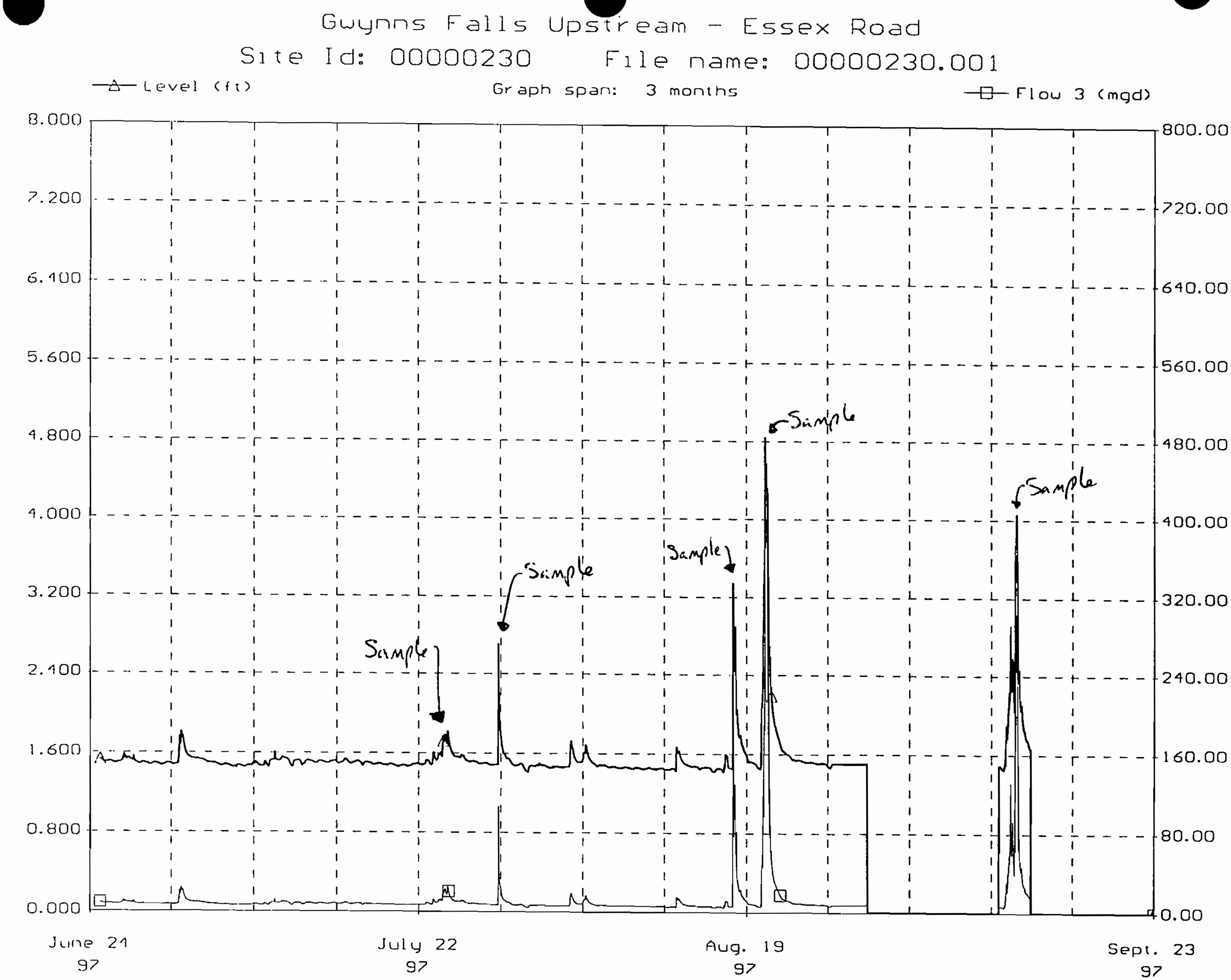


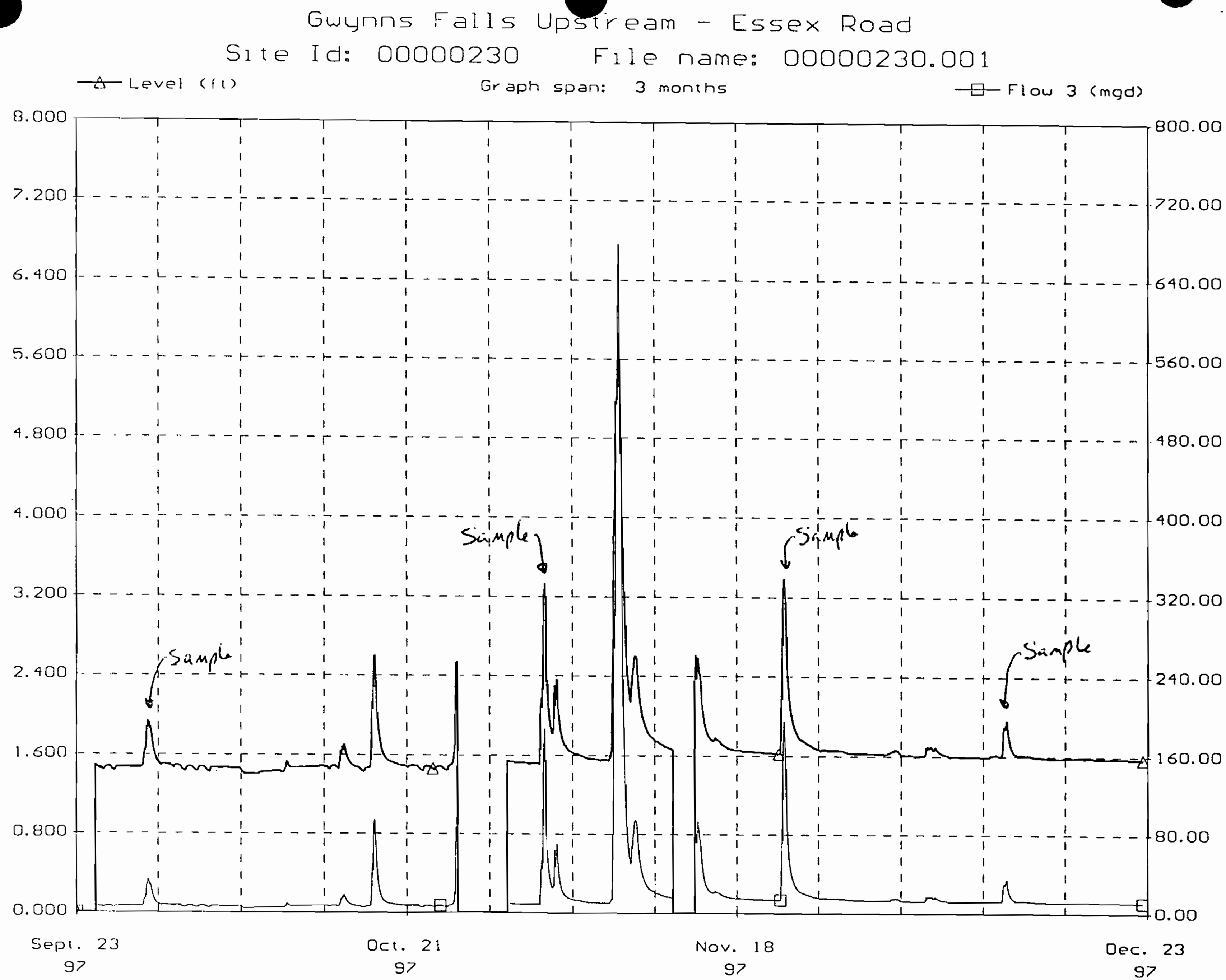
Dead Run at Kernan Drive
Site Id: 00000220 File name: 00000220.000
Level (ft)
Graph span: 3 months
Flow 1 (gpm)
5.000
4.500
4.000
3.500
3.000
2.500
2.000
1.500
1.000
0.500
0.000
400000
320000
240000
160000
80000
0
-80000
-160000
-240000
-320000
-400000
June 24
97
July 22
97
Aug. 19
97
Sept. 23
97
Sample
Sample
Sample
Sample
Sample
Sample
Sample
Sample

Dead Run at Kernan Drive

Site Id: 00000220   File name: 00000220.000



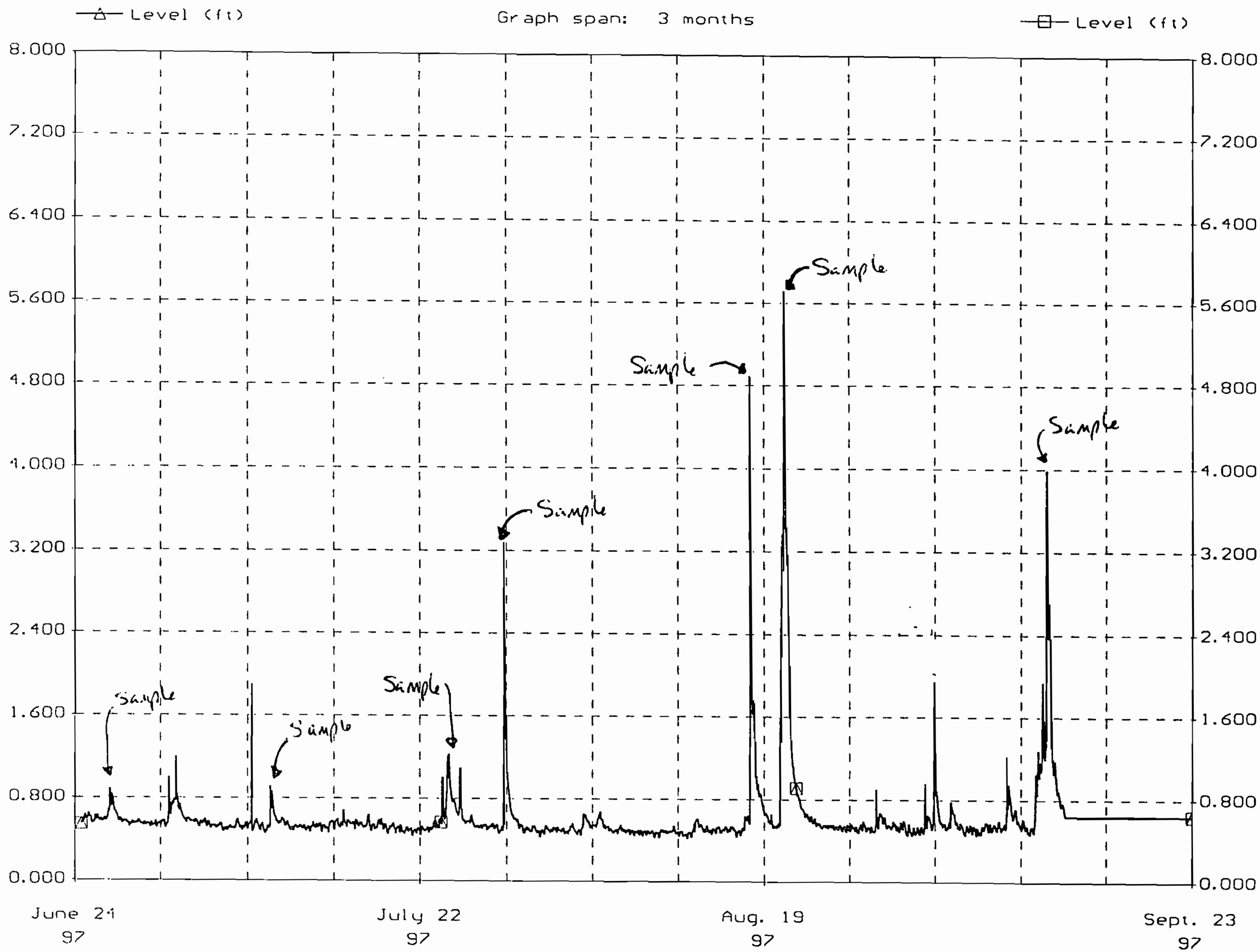

Gwynns Falls Upstream - Essex Road
Site Id: 00000230 File name: 00000230.001
Level (ft)
Graph span: 3 months
Flow 3 (mgd)
8.000
7.200
6.400
5.600
4.800
4.000
3.200
2.400
1.600
0.800
0.000
800.00
720.00
640.00
560.00
480.00
400.00
320.00
240.00
160.00
80.00
0.00
June 21 97
July 22 97
Aug. 19 97
Sept. 23 97
Sample
Sample
Sample
Sample
Sample



Gwynns Falls Upstream - Essex Road
Site Id: 00000230 File name: 00000230.001
Level (ft)
Graph span: 3 months
Flow 3 (mgd)
8.000
7.200
6.400
5.600
4.800
4.000
3.200
2.400
1.600
0.800
0.000
800.00
720.00
640.00
560.00
480.00
400.00
320.00
240.00
160.00
80.00
0.00
Sample
Sample
Sample
Sample
Sept. 23 97
Oct. 21 97
Nov. 18 97
Dec. 23 97

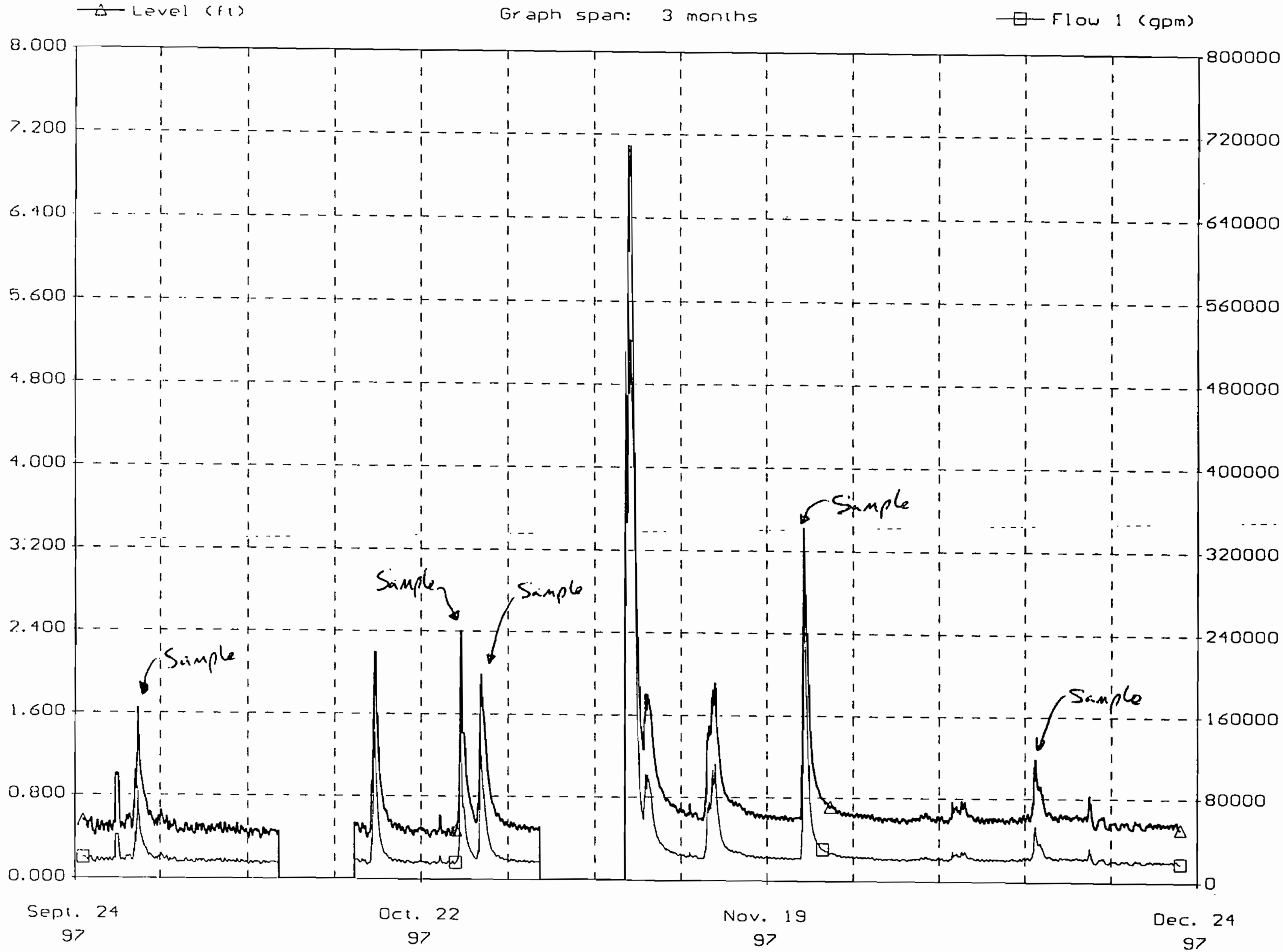
Gwynns Falls Downstream Wilkens Ave.

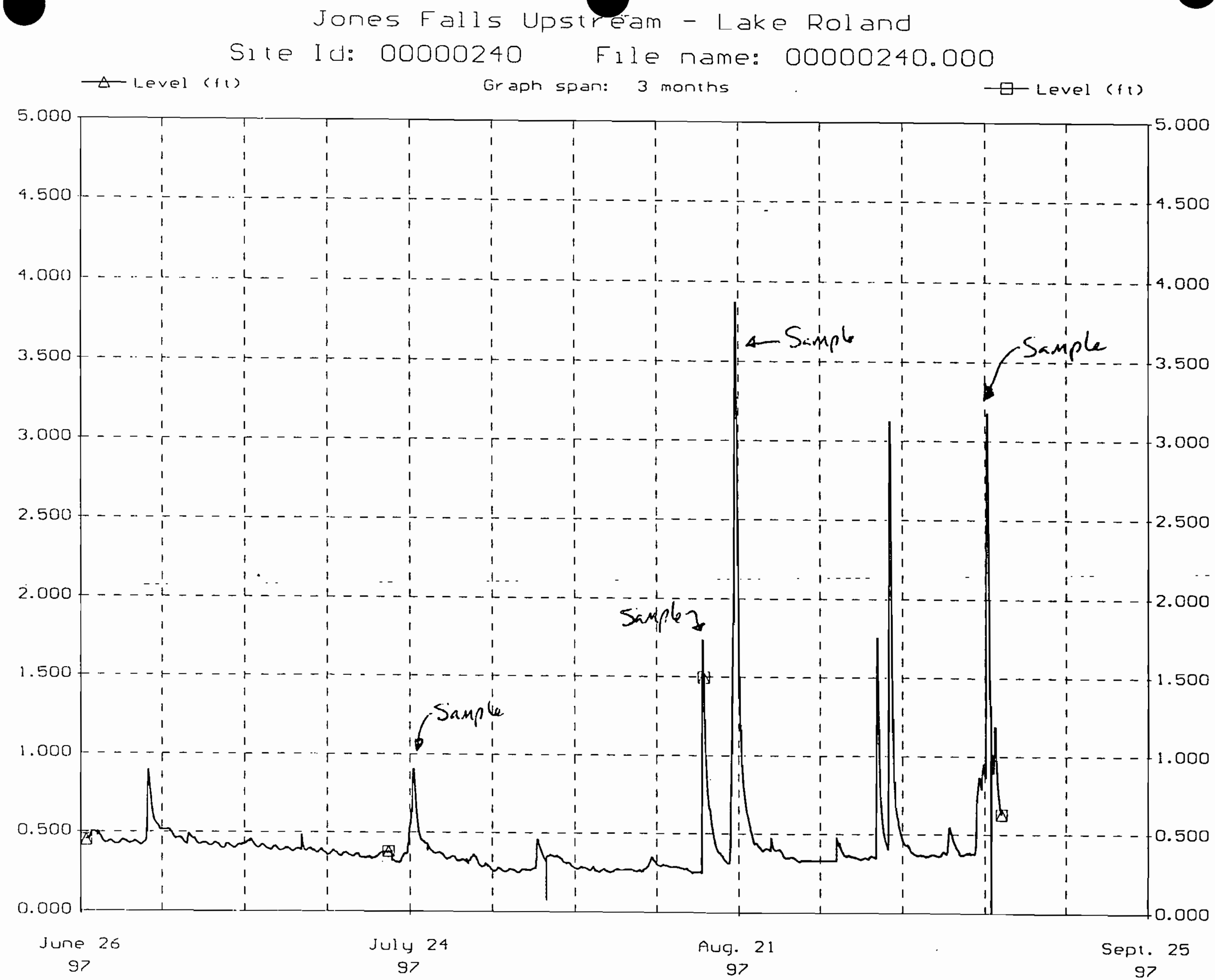
Site Id: 00000231 File name: 00000231.000

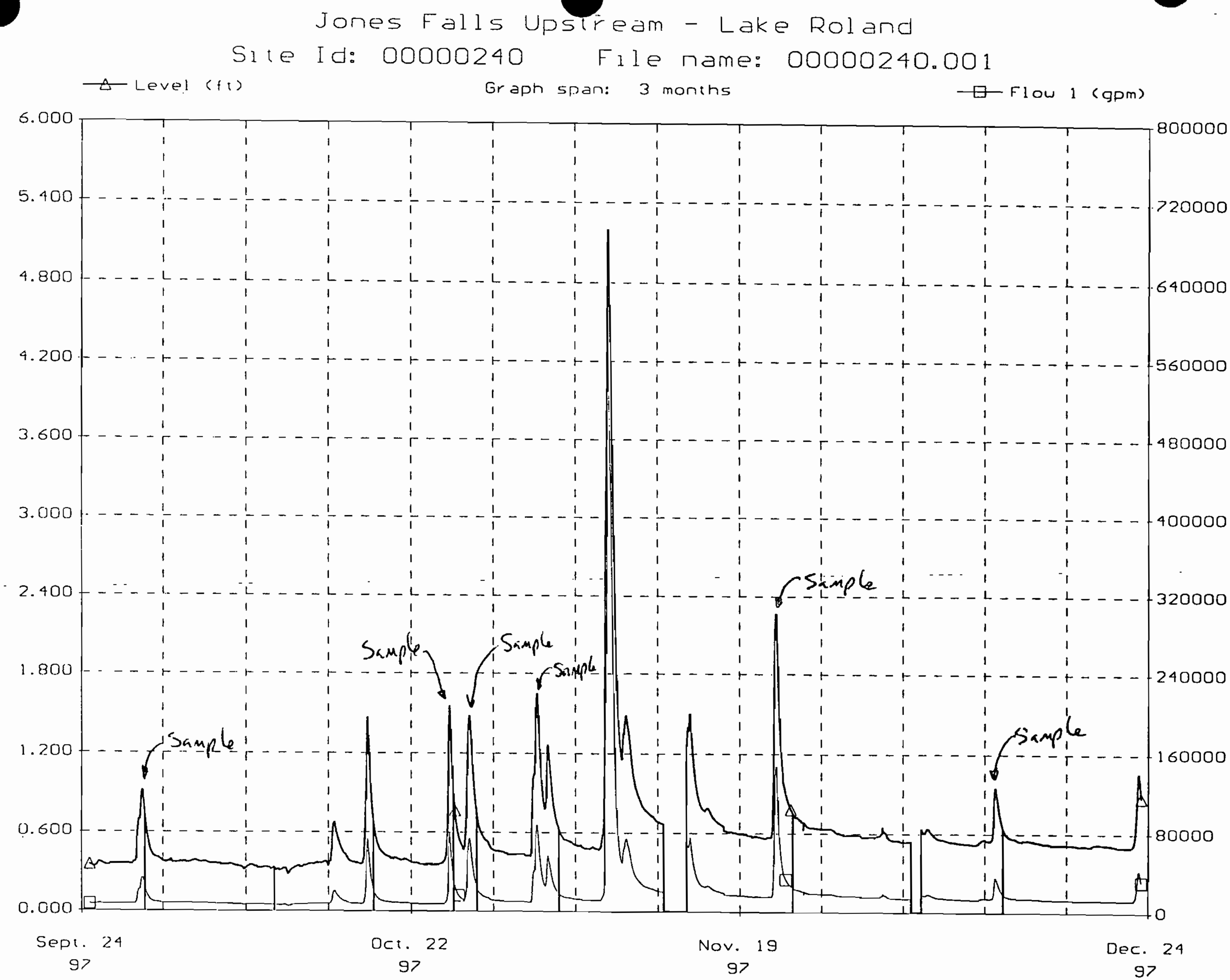


Gwynns Falls Downstream Wilkens Ave.

Site Id: 00000231 File name: 00000231.001

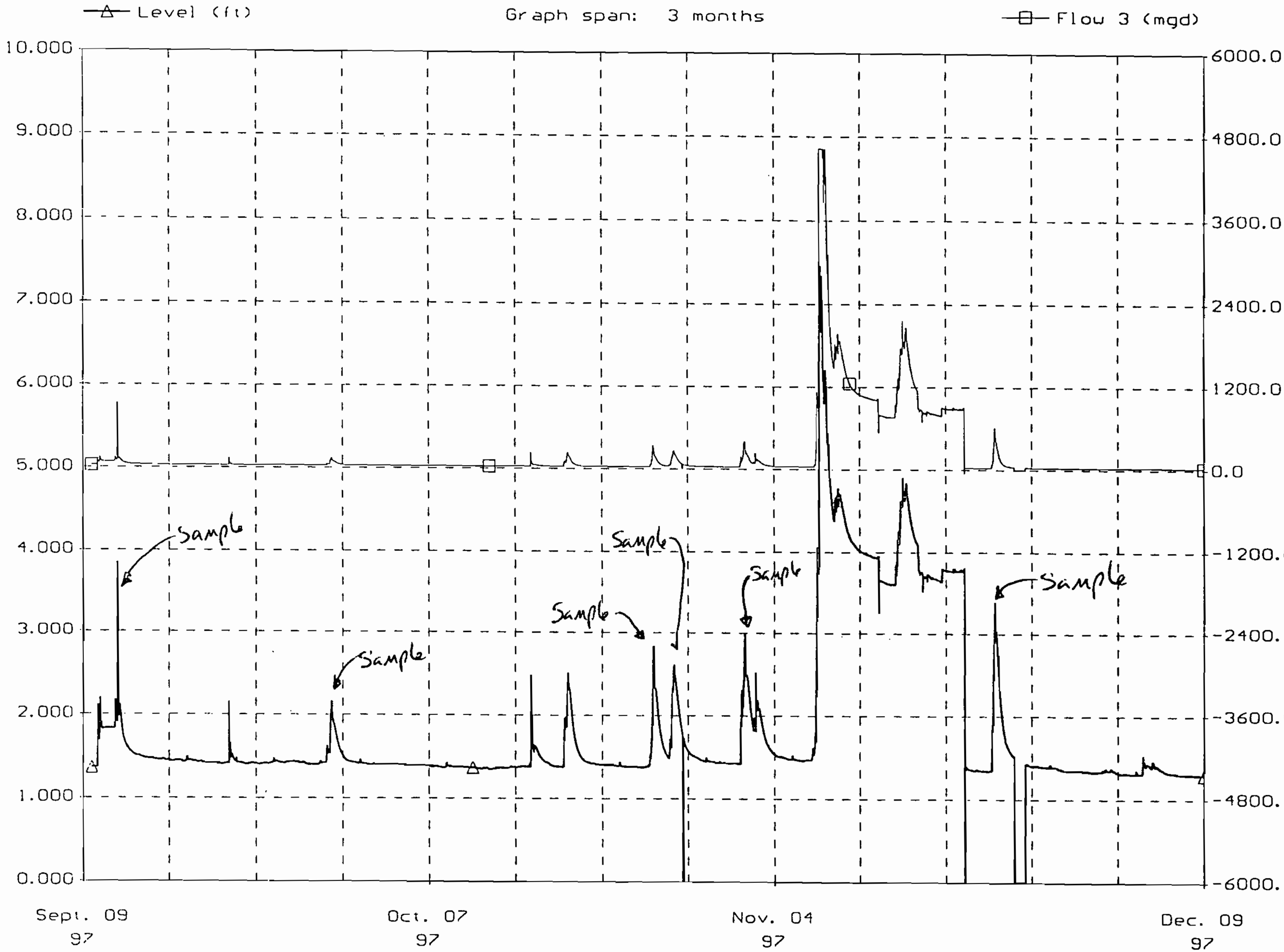


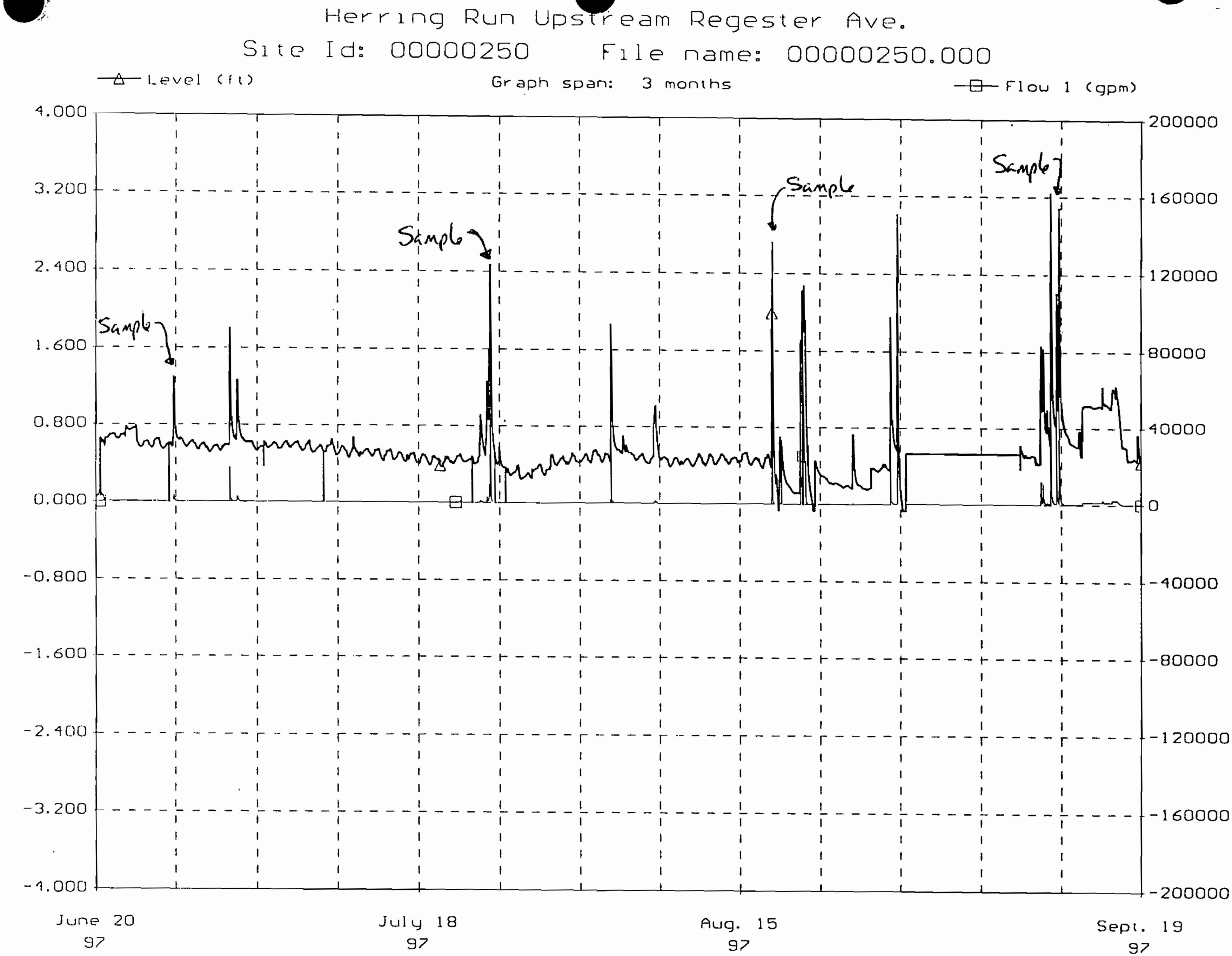

Jones Falls Upstream - Lake Roland
Site Id: 00000240 File name: 00000240.000
Level (ft)
Graph span: 3 months
Level (ft)
5.000
4.500
4.000
3.500
3.000
2.500
2.000
1.500
1.000
0.500
0.000
Sample
Sample
Sample
Sample
Sample
June 26 97
July 24 97
Aug. 21 97
Sept. 25 97

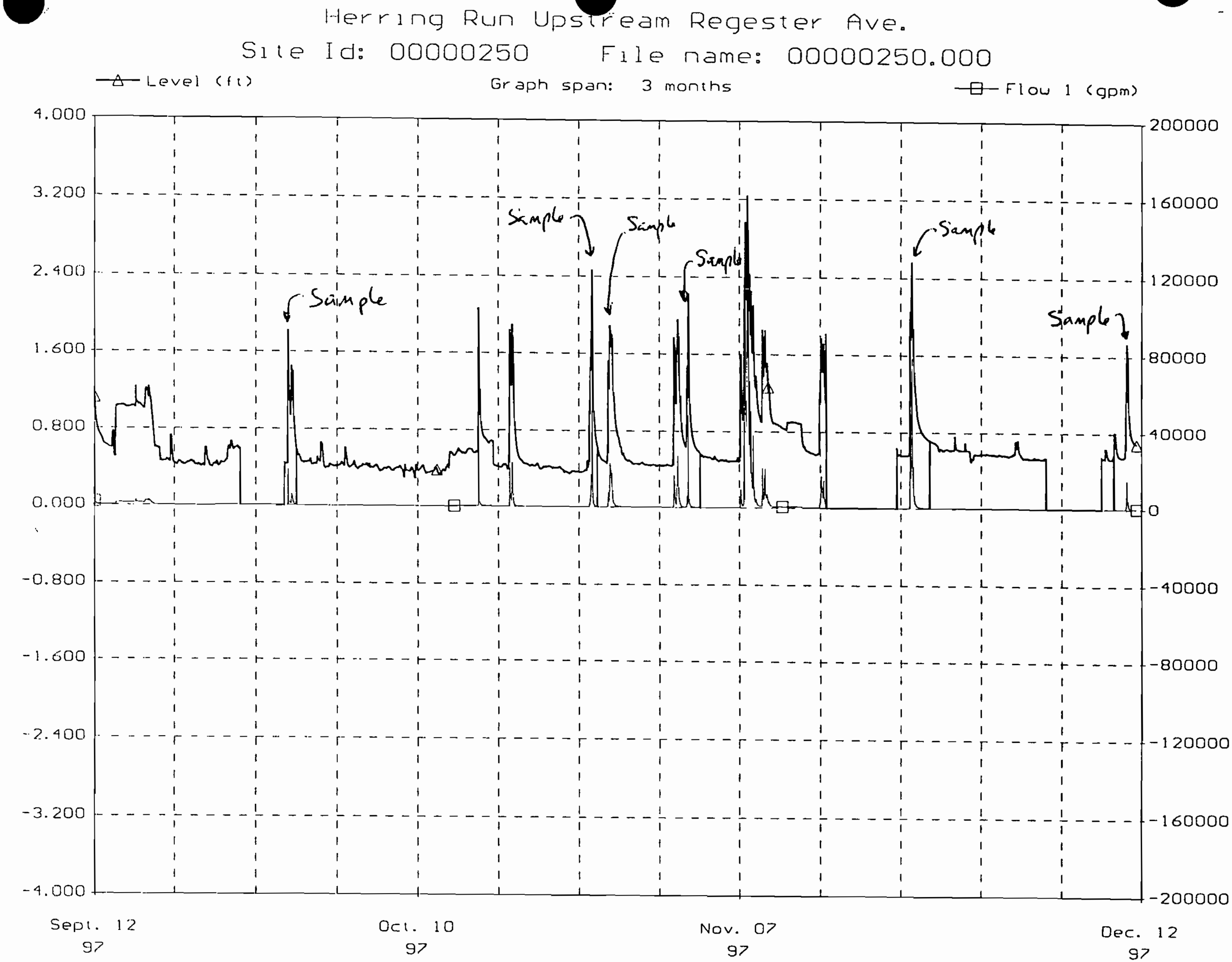

Jones Falls Upstream - Lake Roland
Site Id: 00000240
File name: 00000240.001
Level (ft)
Graph span: 3 months
Flow 1 (gpm)
6.000
5.400
4.800
4.200
3.600
3.000
2.400
1.800
1.200
0.600
0.000
800000
720000
640000
560000
480000
400000
320000
240000
160000
80000
0
Sept. 24 97
Oct. 22 97
Nov. 19 97
Dec. 24 97
Sample
Sample
Sample
Sample
Sample
Sample

Jones Falls Downstream Maryland Ave.

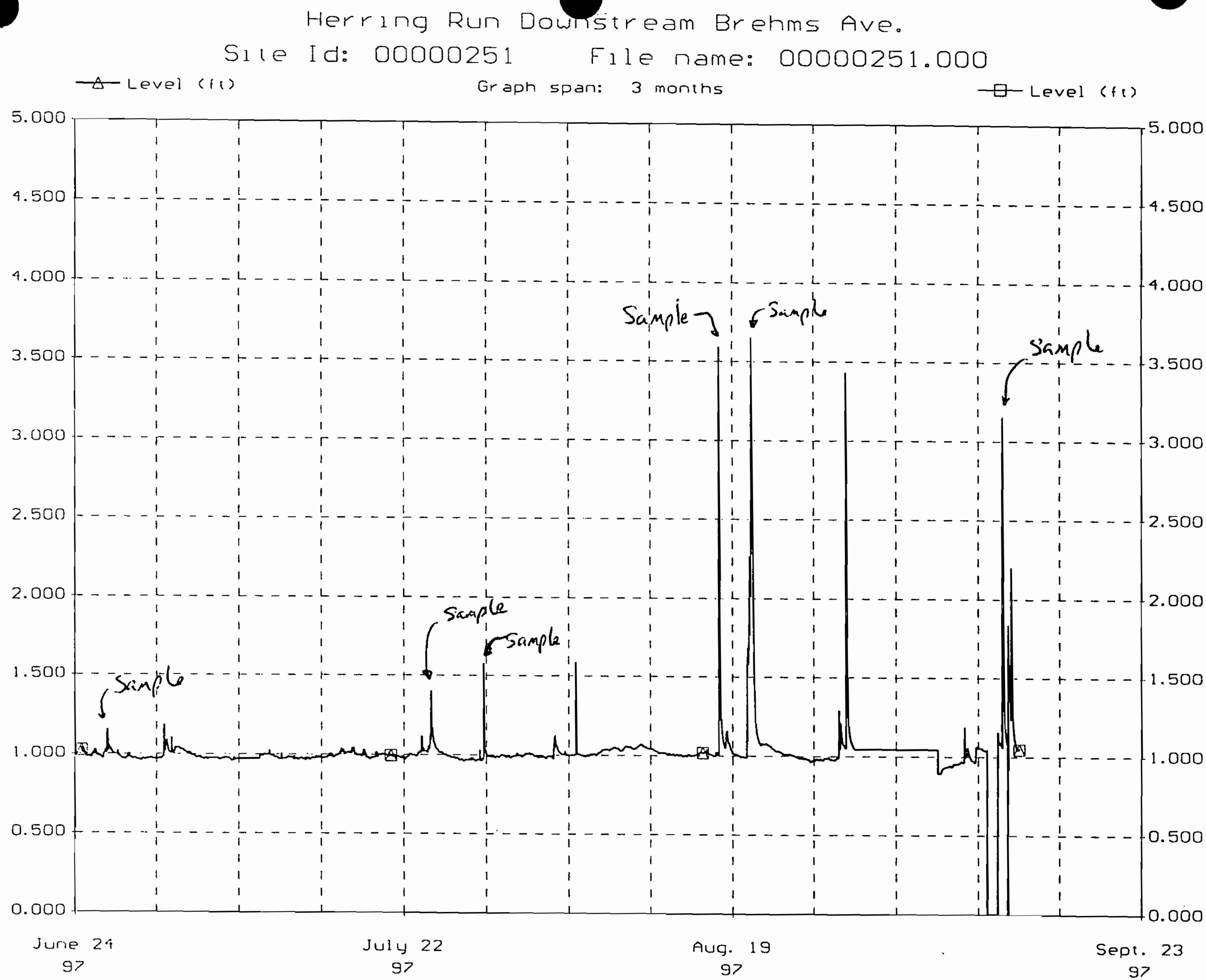
Site Id: 00000241 File name: 00000241.001




Herring Run Upstream Regester Ave.
Site Id: 00000250 File name: 00000250.000
Level (ft)
Graph span: 3 months
Flow 1 (gpm)
4.000
3.200
2.400
1.600
0.800
0.000
-0.800
-1.600
-2.400
-3.200
-4.000
200000
160000
120000
80000
40000
0
-40000
-80000
-120000
-160000
-200000
June 20
97
July 18
97
Aug. 15
97
Sept. 19
97
Sample
Sample
Sample
Sample



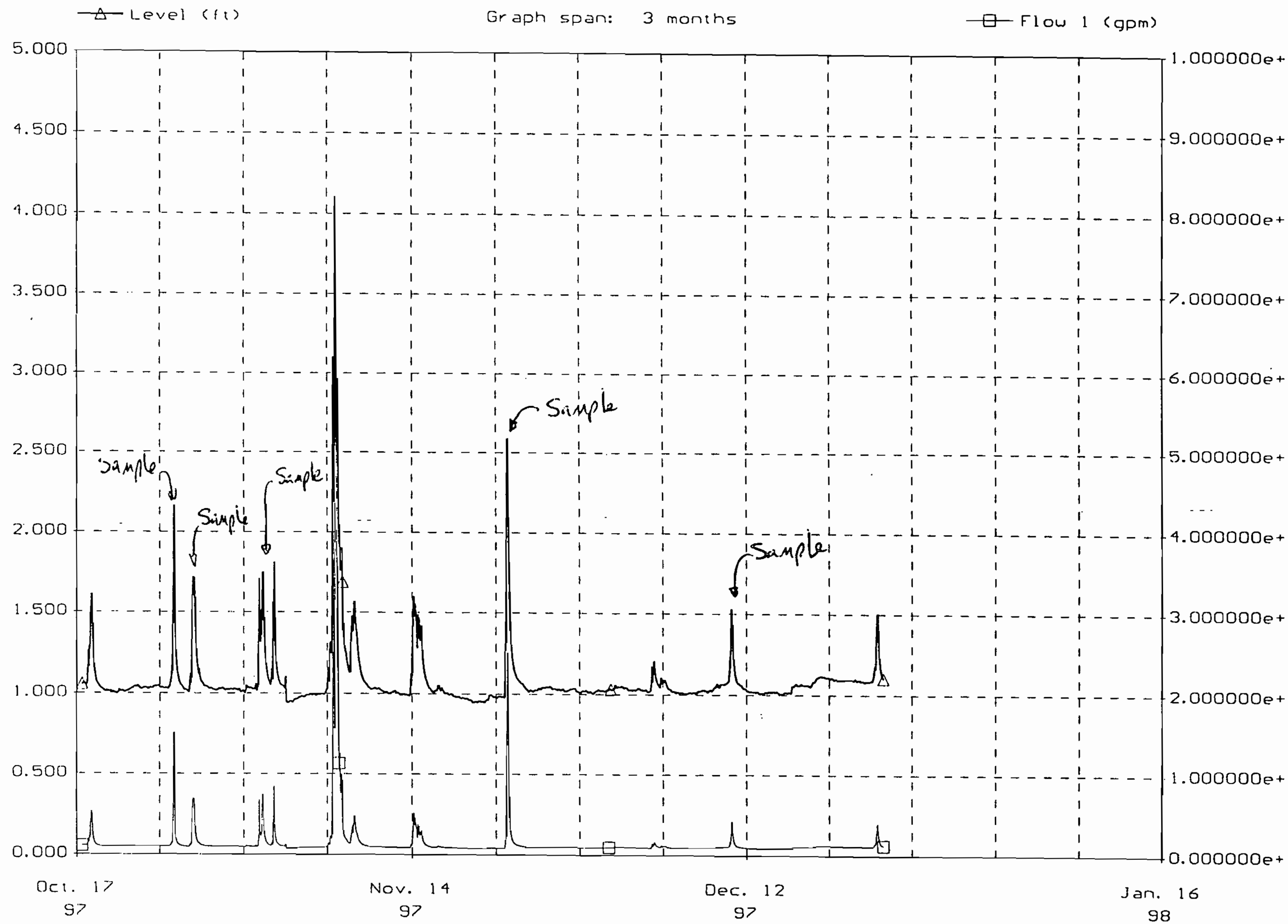
Herring Run Upstream Regester Ave.
Site Id: 00000250 File name: 00000250.000
Level (ft)
Graph span: 3 months
Flow 1 (gpm)
4.000
3.200
2.400
1.600
0.800
0.000
-0.800
-1.600
-2.400
-3.200
-4.000
200000
160000
120000
80000
40000
0
-40000
-80000
-120000
-160000
-200000
Sept. 12 97
Oct. 10 97
Nov. 07 97
Dec. 12 97
Sample
Sample
Sample
Sample
Sample
Sample



Herring Run Downstream Brehms Ave.
Site Id: 00000251
File name: 00000251.000
Level (ft)
Graph span: 3 months
Level (ft)
5.000
4.500
4.000
3.500
3.000
2.500
2.000
1.500
1.000
0.500
0.000
Sample
June 24 97
July 22 97
Aug. 19 97
Sept. 23 97

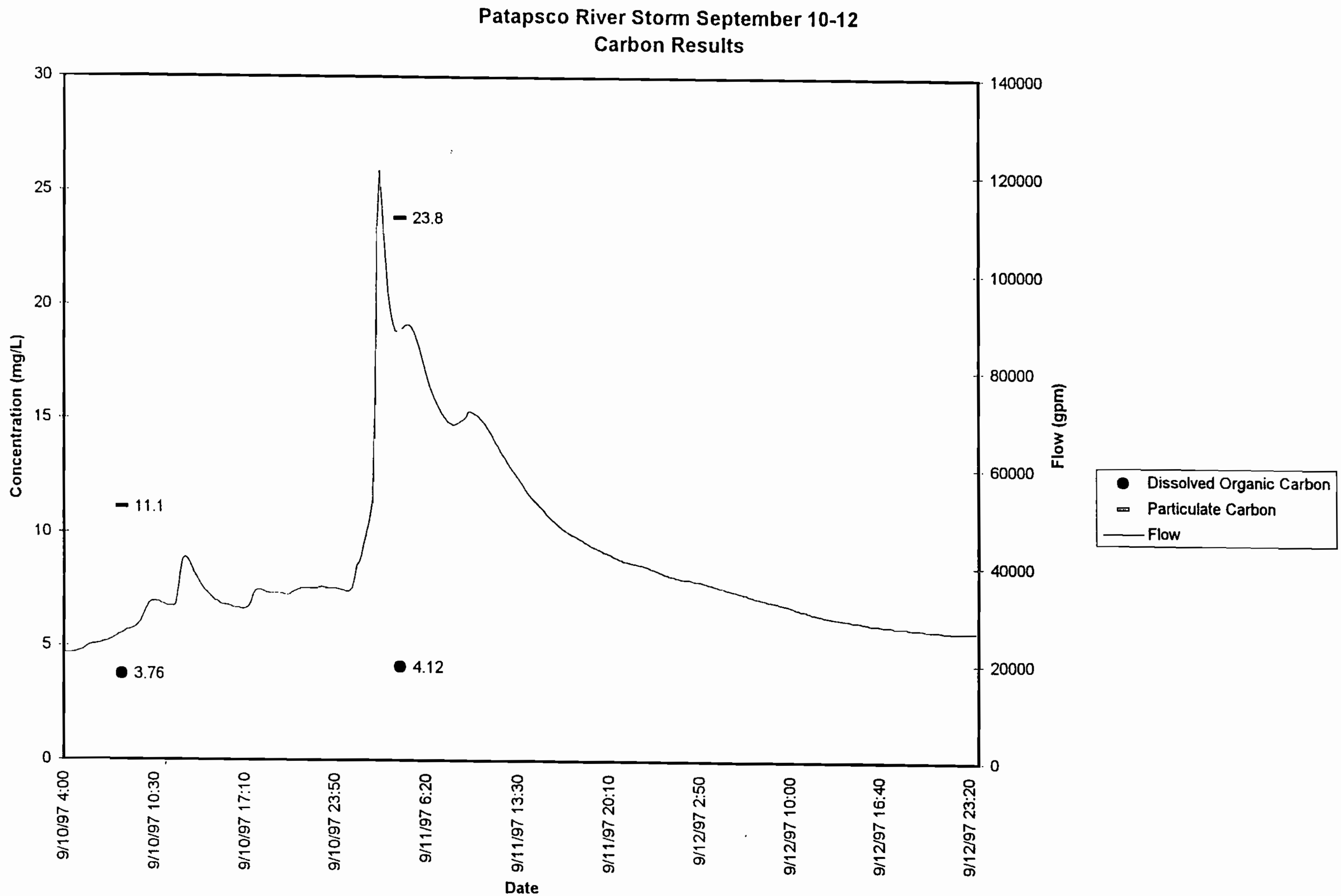
Herring Run Downstream Brehms Ave.

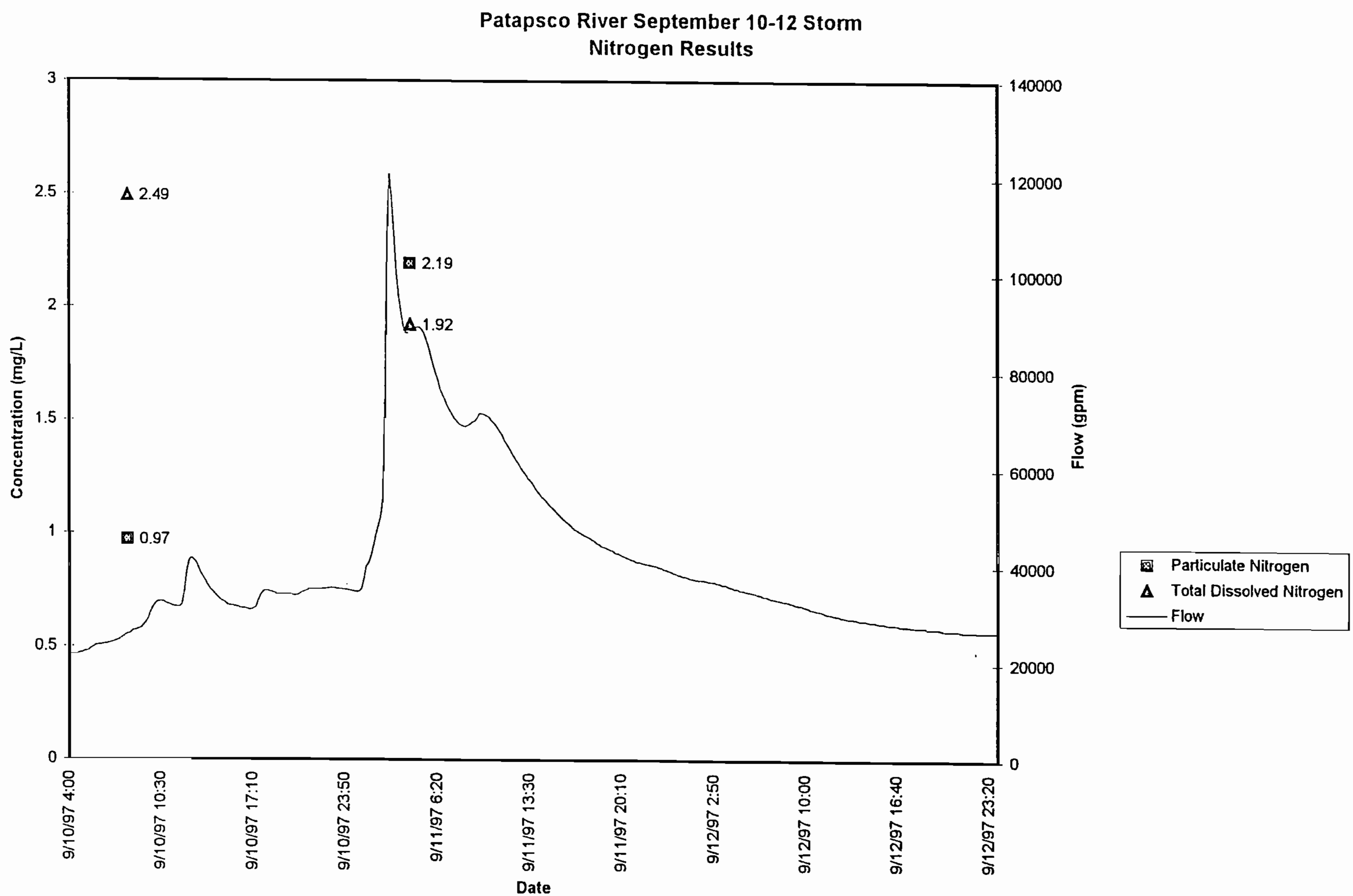
Site Id: 00000251 File name: 00000251.001



SECTION III

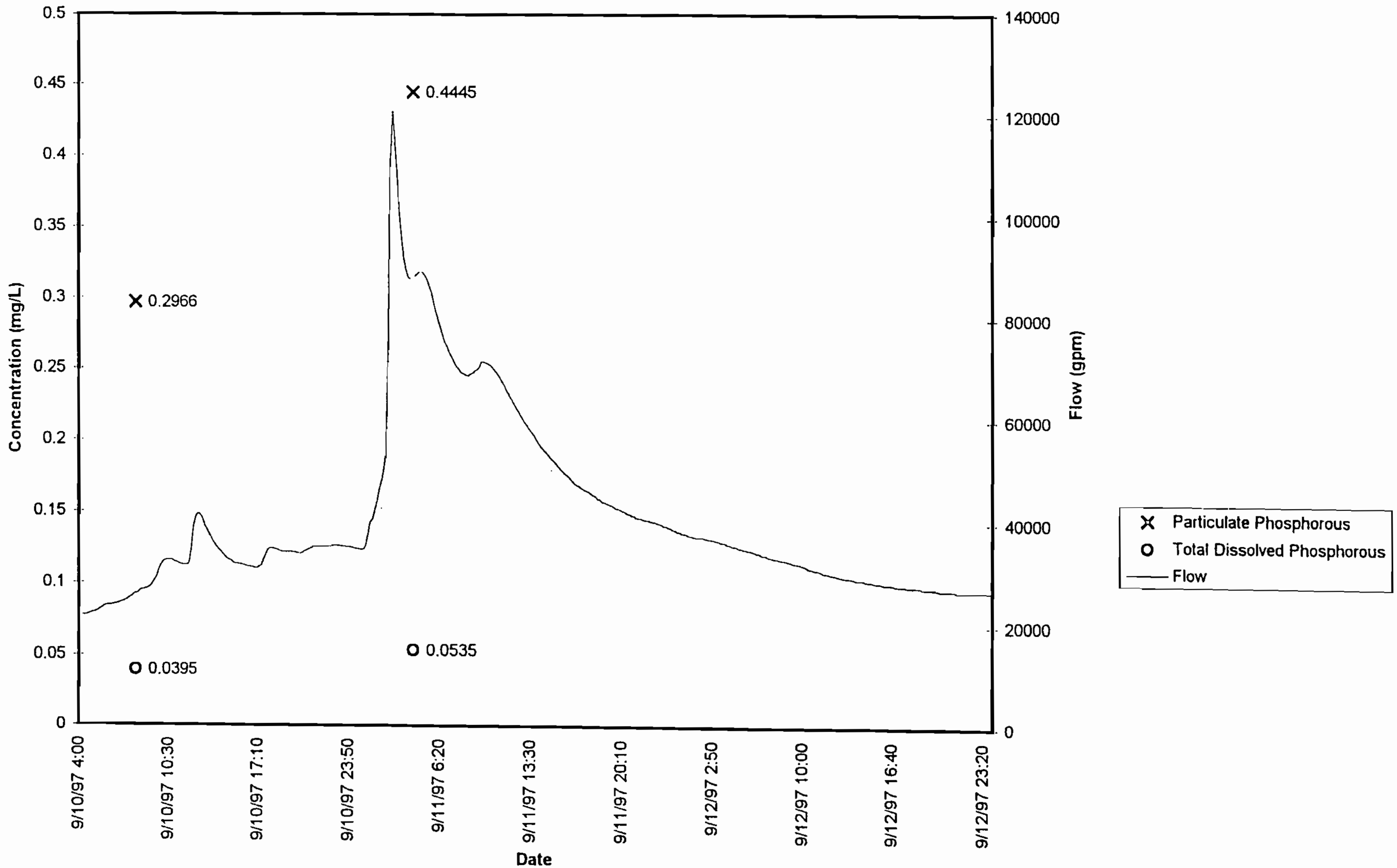
NUTRIENT ANALYSIS RESULTS

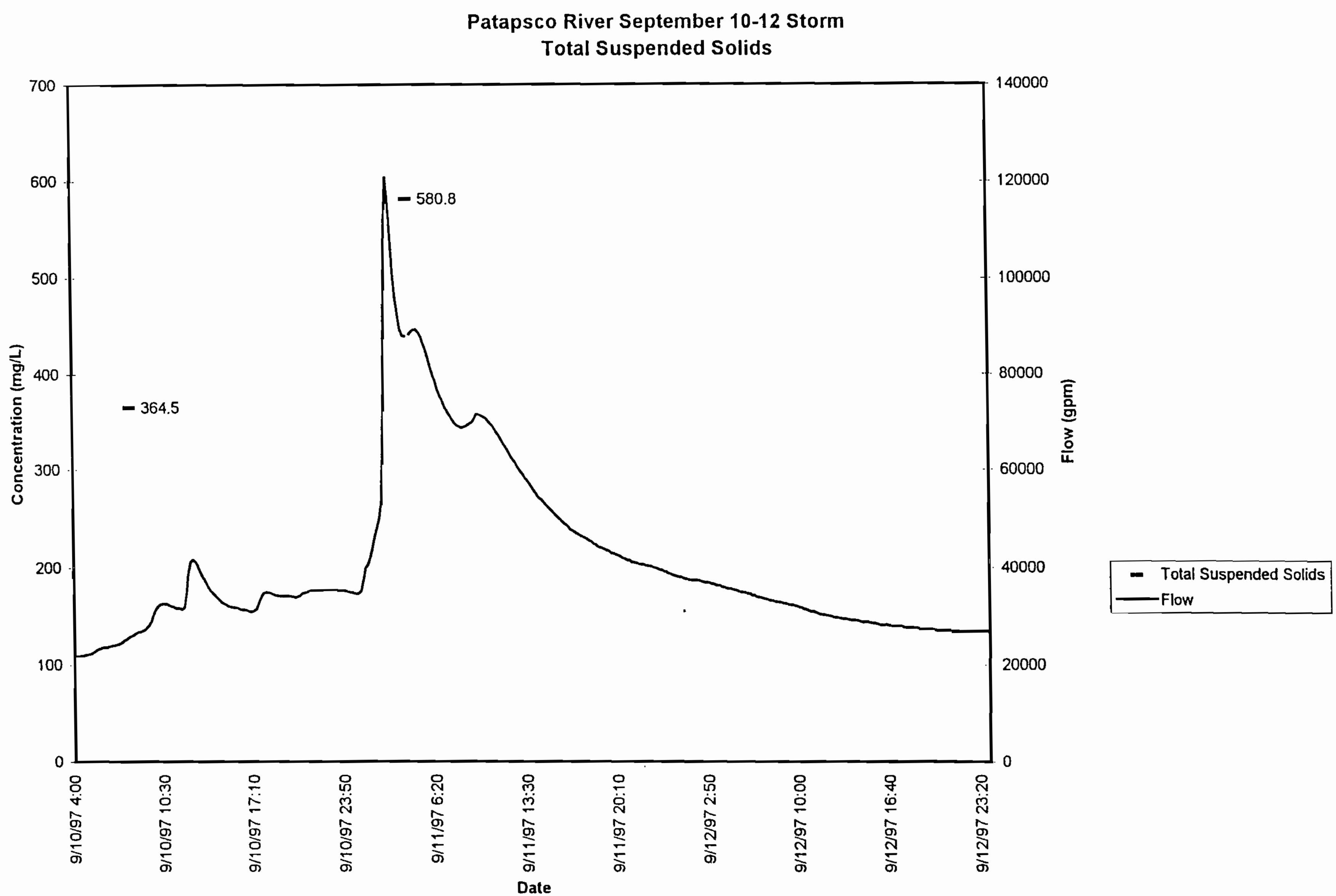

Patapsco River Storm September 10-12
Carbon Results
Concentration (mg/L)
Flow (gpm)
Date
30
25
20
15
10
5
0
140000
120000
100000
80000
60000
40000
20000
0
11.1
23.8
3.76
4.12
9/10/97 4:00
9/10/97 10:30
9/10/97 17:10
9/10/97 23:50
9/11/97 6:20
9/11/97 13:30
9/11/97 20:10
9/12/97 2:50
9/12/97 10:00
9/12/97 16:40
9/12/97 23:20
Dissolved Organic Carbon
Particulate Carbon
Flow



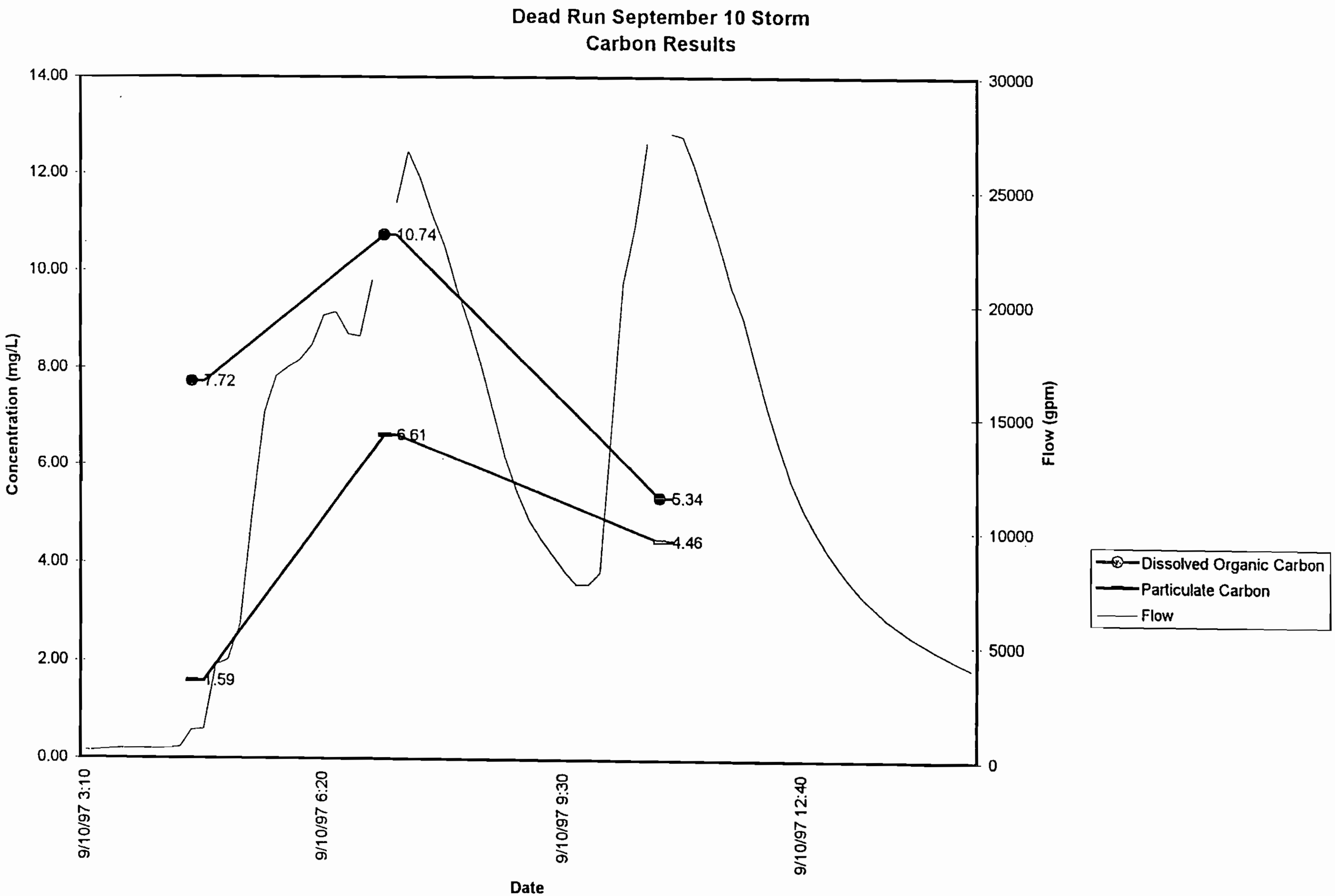
Patapsco River September 10-12 Storm
Nitrogen Results
Concentration (mg/L)
Flow (gpm)
Date
3
2.5
2
1.5
1
0.5
0
140000
120000
100000
80000
60000
40000
20000
0
2.49
2.19
1.92
0.97
9/10/97 4:00
9/10/97 10:30
9/10/97 17:10
9/10/97 23:50
9/11/97 6:20
9/11/97 13:30
9/11/97 20:10
9/12/97 2:50
9/12/97 10:00
9/12/97 16:40
9/12/97 23:20
Particulate Nitrogen
Total Dissolved Nitrogen
Flow

Patapsco River September 10-12 Storm Phosphorous Results

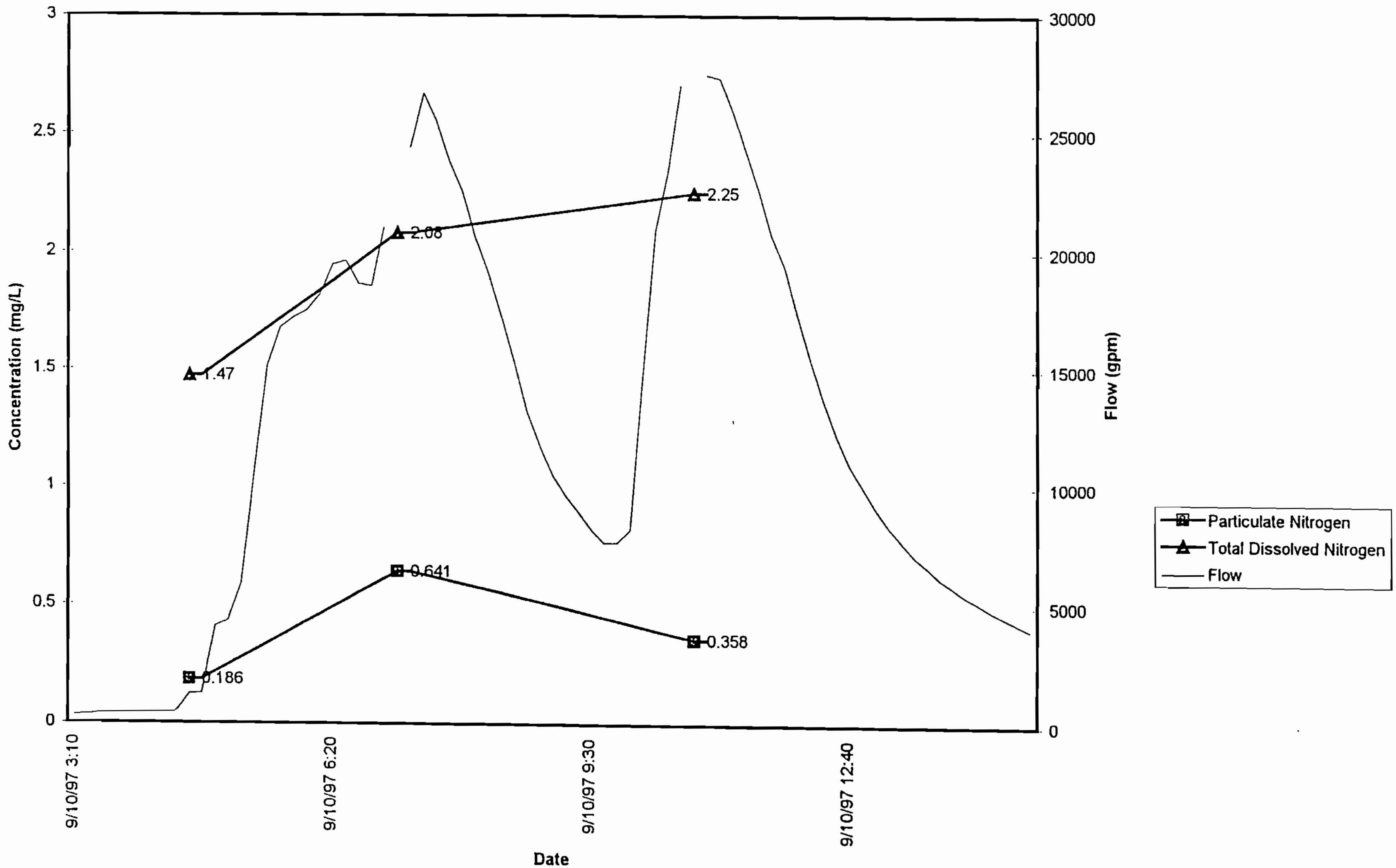


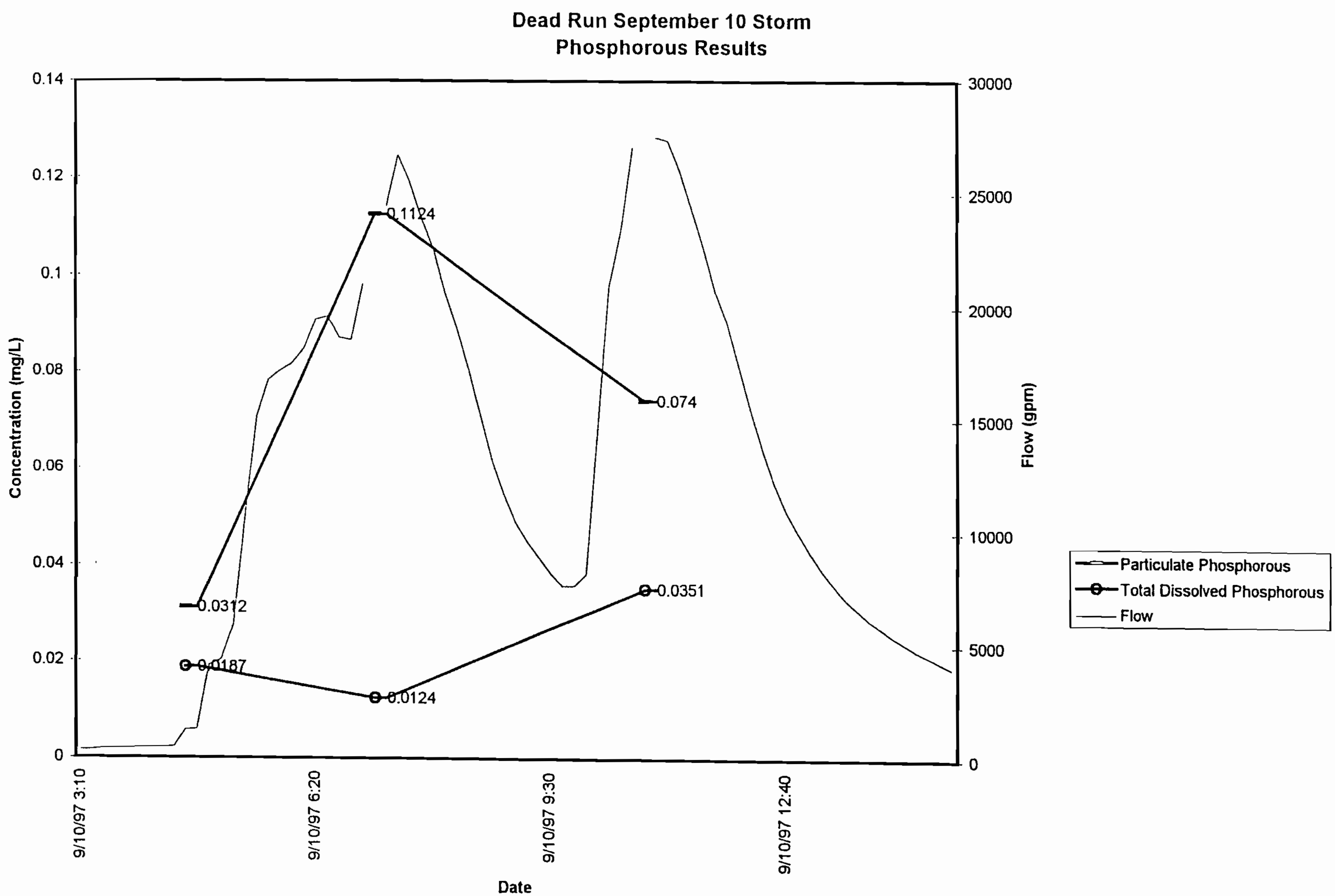


Patapsco River September 10-12 Storm
Total Suspended Solids
Concentration (mg/L)
700
600
500
400
300
200
100
0
Flow (gpm)
140000
120000
100000
80000
60000
40000
20000
0
580.8
364.5
9/10/97 4:00
9/10/97 10:30
9/10/97 17:10
9/10/97 23:50
9/11/97 6:20
9/11/97 13:30
9/11/97 20:10
9/12/97 2:50
9/12/97 10:00
9/12/97 16:40
9/12/97 23:20
Date
Total Suspended Solids
Flow

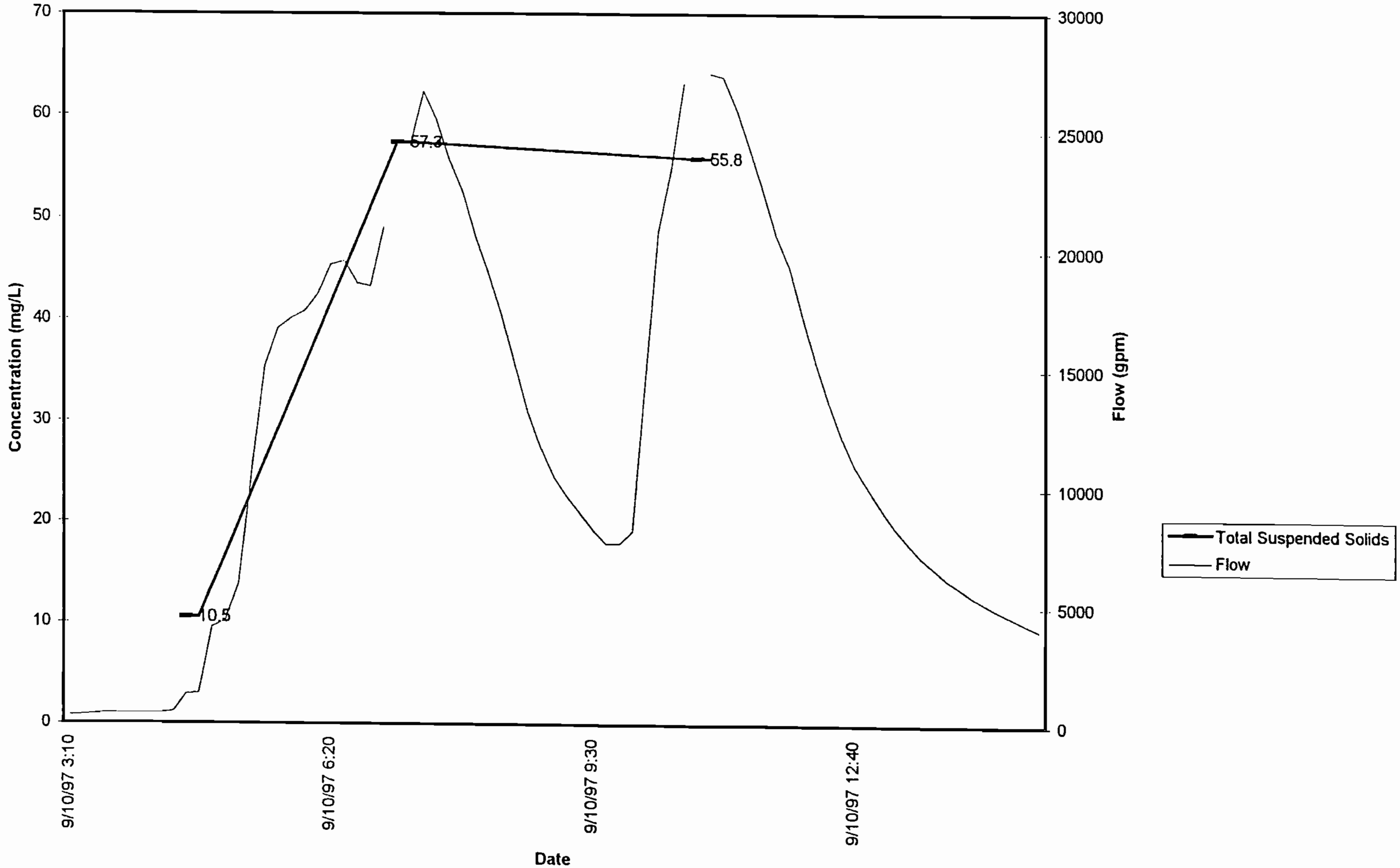

Dead Run September 10 Storm
Carbon Results
14.00
12.00
10.00
8.00
6.00
4.00
2.00
0.00
Concentration (mg/L)
30000
25000
20000
15000
10000
5000
0
Flow (gpm)
10.74
7.72
6.61
5.34
4.46
1.59
9/10/97 3:10
9/10/97 6:20
9/10/97 9:30
9/10/97 12:40
Date
Dissolved Organic Carbon
Particulate Carbon
Flow

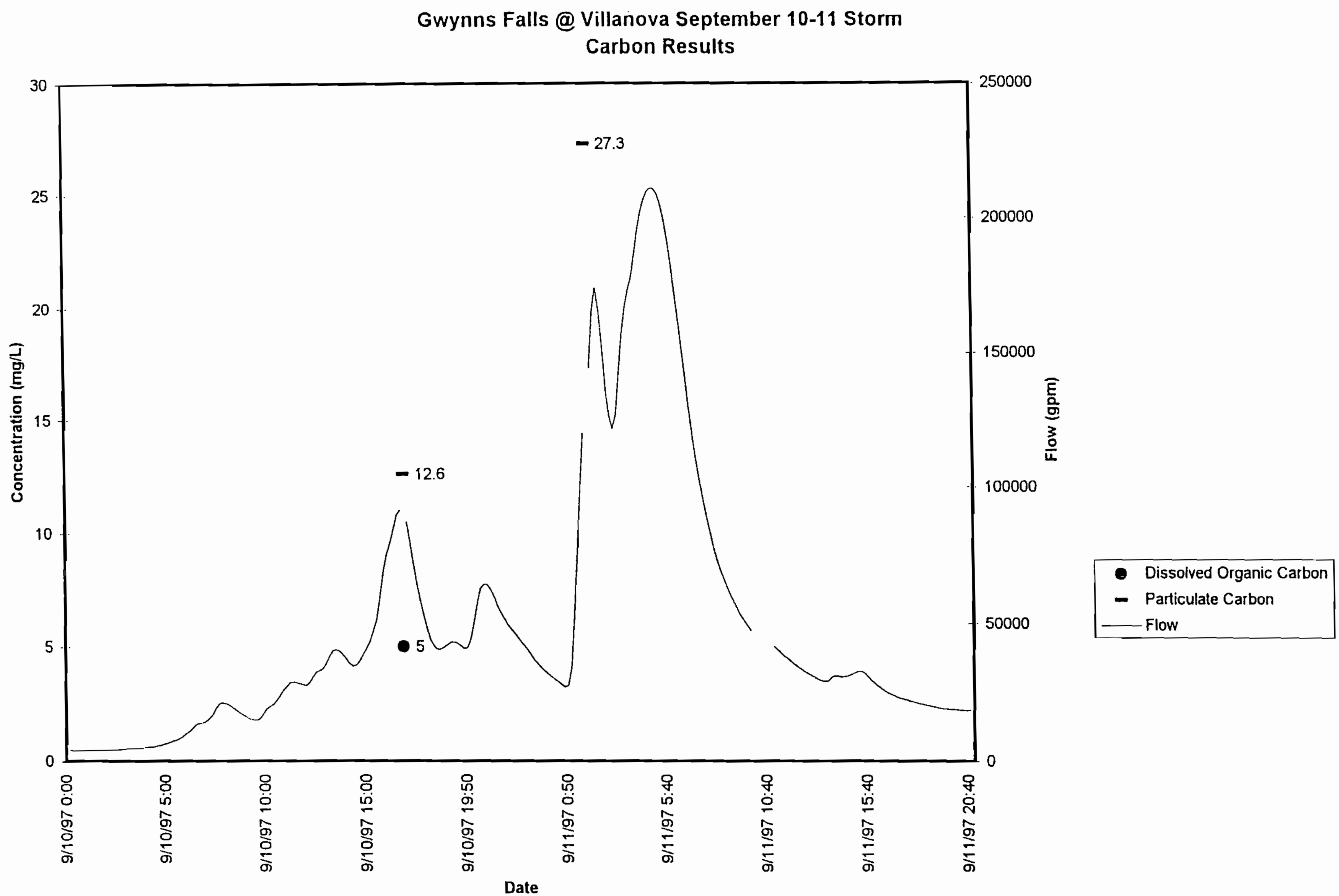
Dead Run September 10 Storm
Nitrogen Results



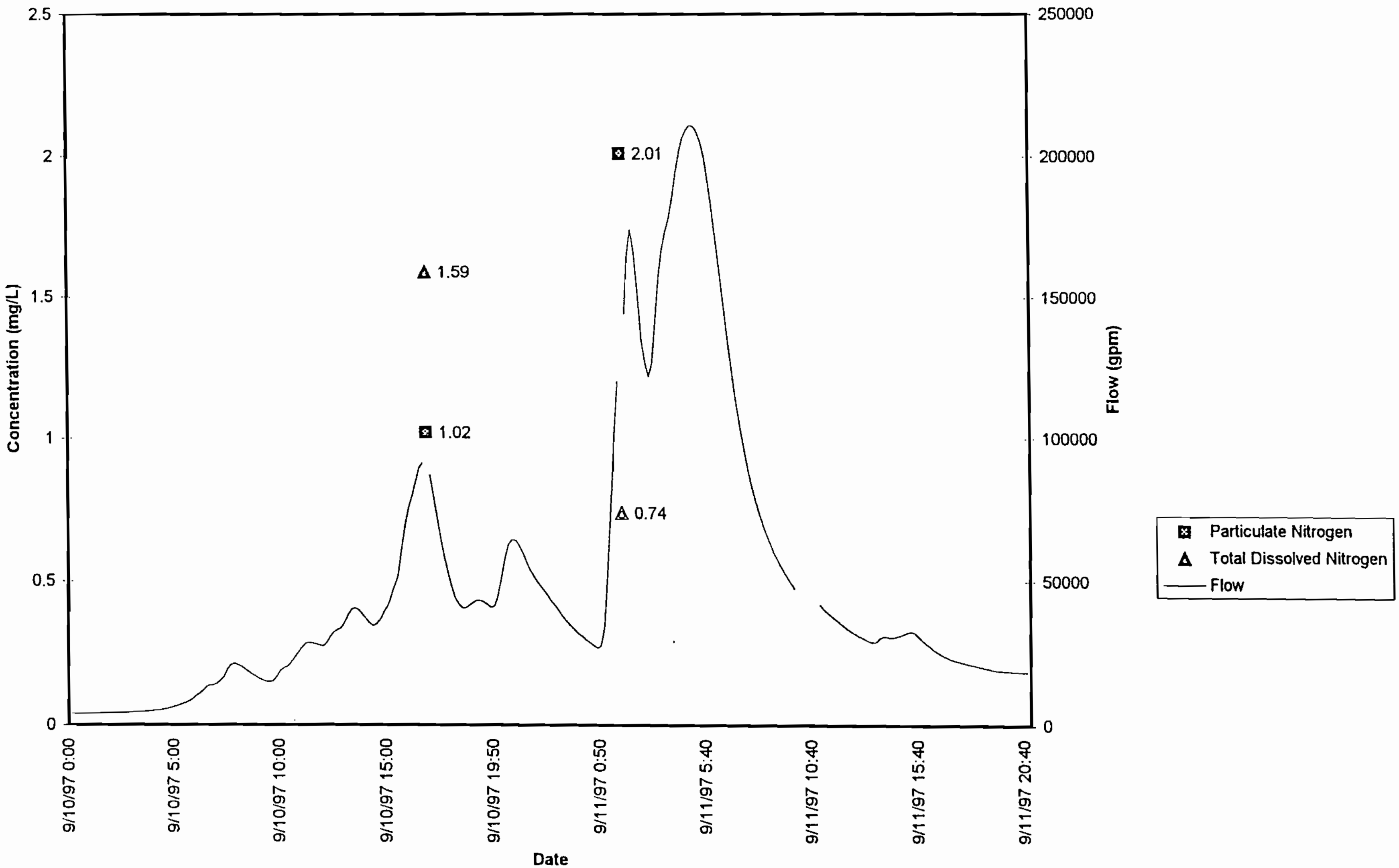

Dead Run September 10 Storm
Phosphorous Results
0.14
0.12
0.1
0.08
0.06
0.04
0.02
0
Concentration (mg/L)
30000
25000
20000
15000
10000
5000
0
Flow (gpm)
0.1124
0.074
0.0312
0.0351
0.0187
0.0124
9/10/97 3:10
9/10/97 6:20
9/10/97 9:30
9/10/97 12:40
Date
Particulate Phosphorous
Total Dissolved Phosphorous
Flow

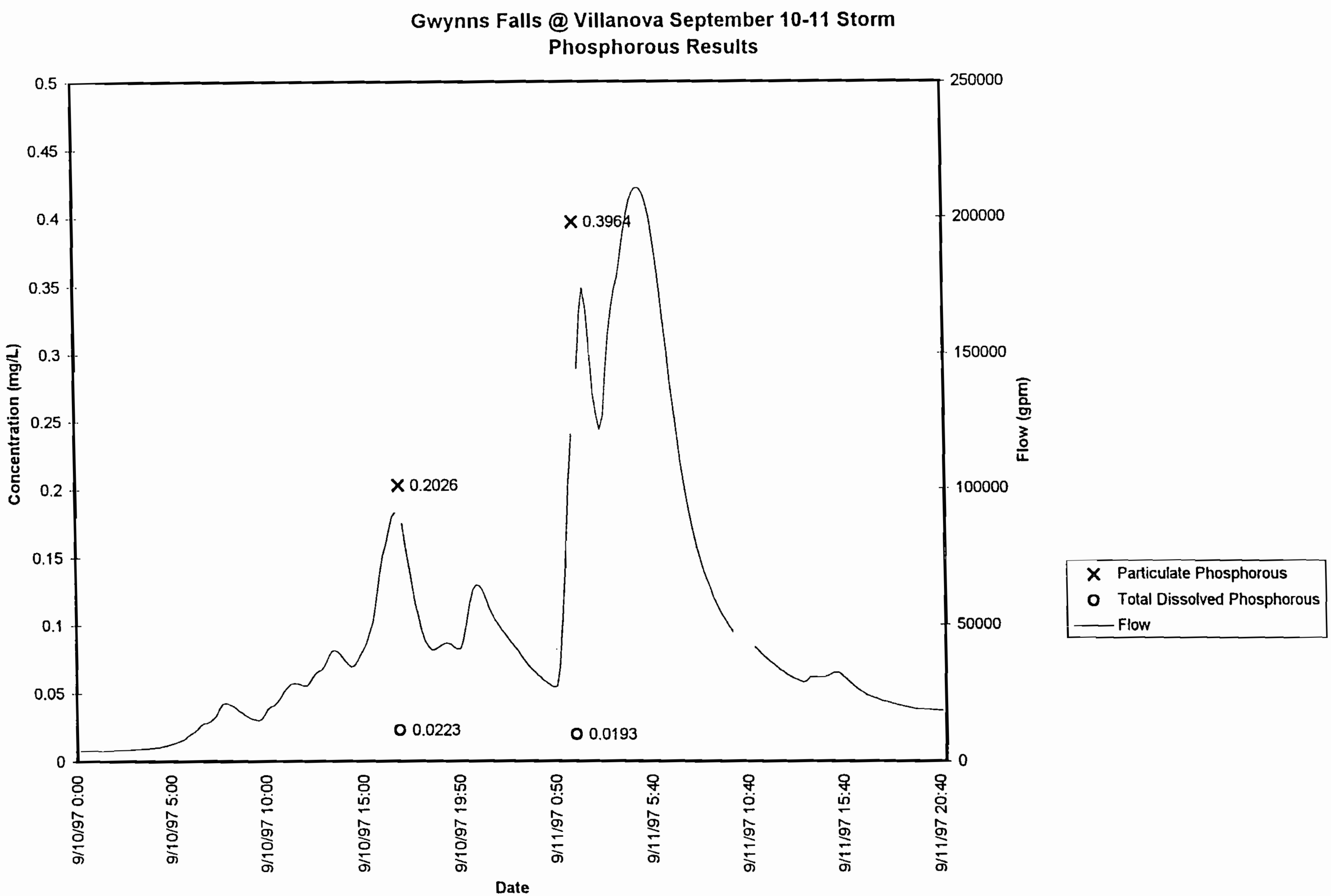
Dead Run September 10 Storm
Total Suspended Solids



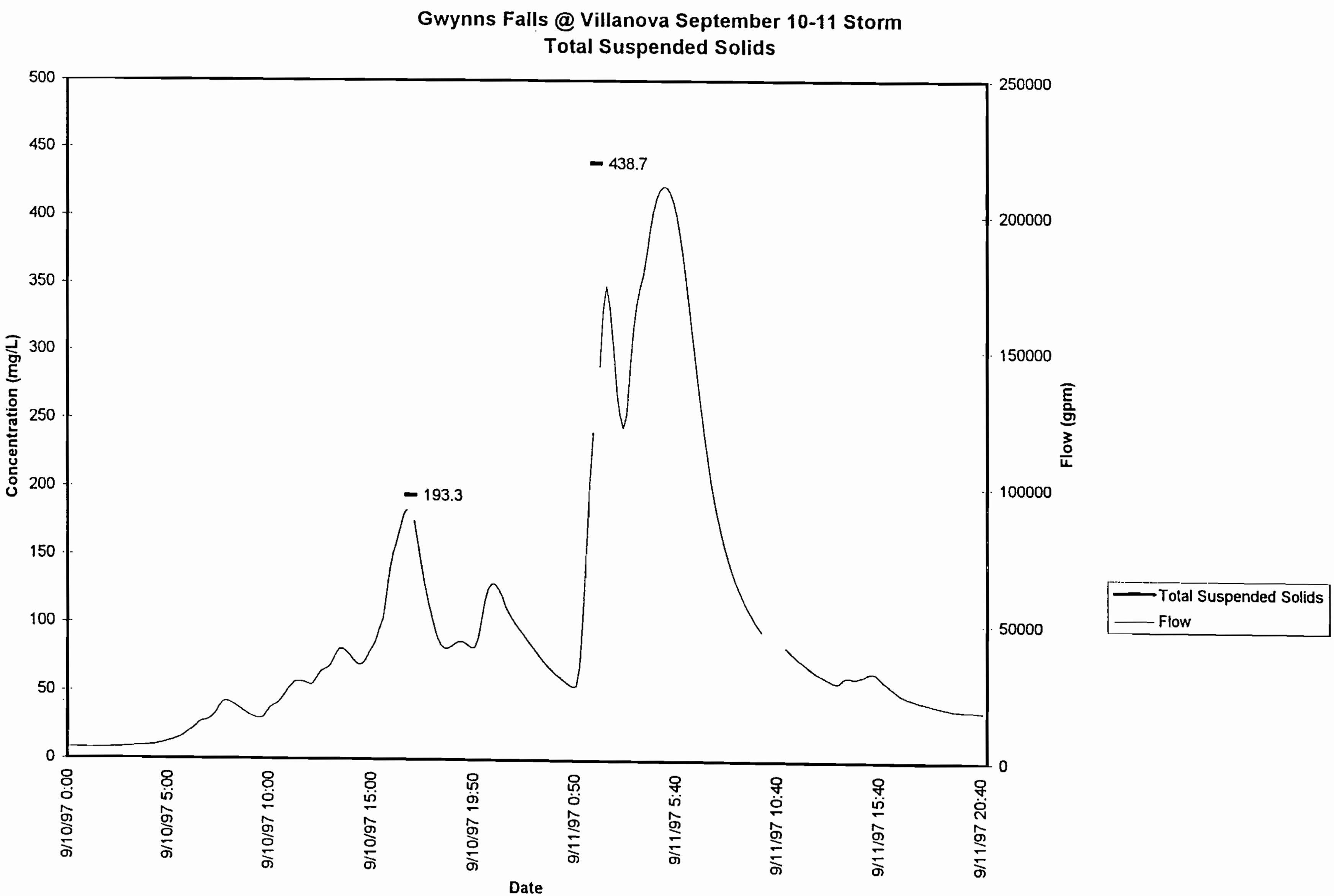

Gwynns Falls @ Villanova September 10-11 Storm
Carbon Results
Concentration (mg/L)
30
25
20
15
10
5
0
Flow (gpm)
250000
200000
150000
100000
50000
0
27.3
12.6
5
9/10/97 0:00
9/10/97 5:00
9/10/97 10:00
9/10/97 15:00
9/10/97 19:50
9/11/97 0:50
9/11/97 5:40
9/11/97 10:40
9/11/97 15:40
9/11/97 20:40
Date
Dissolved Organic Carbon
Particulate Carbon
Flow

Gwynns Falls @ Villanova September 10-11 Storm Nitrogen Results



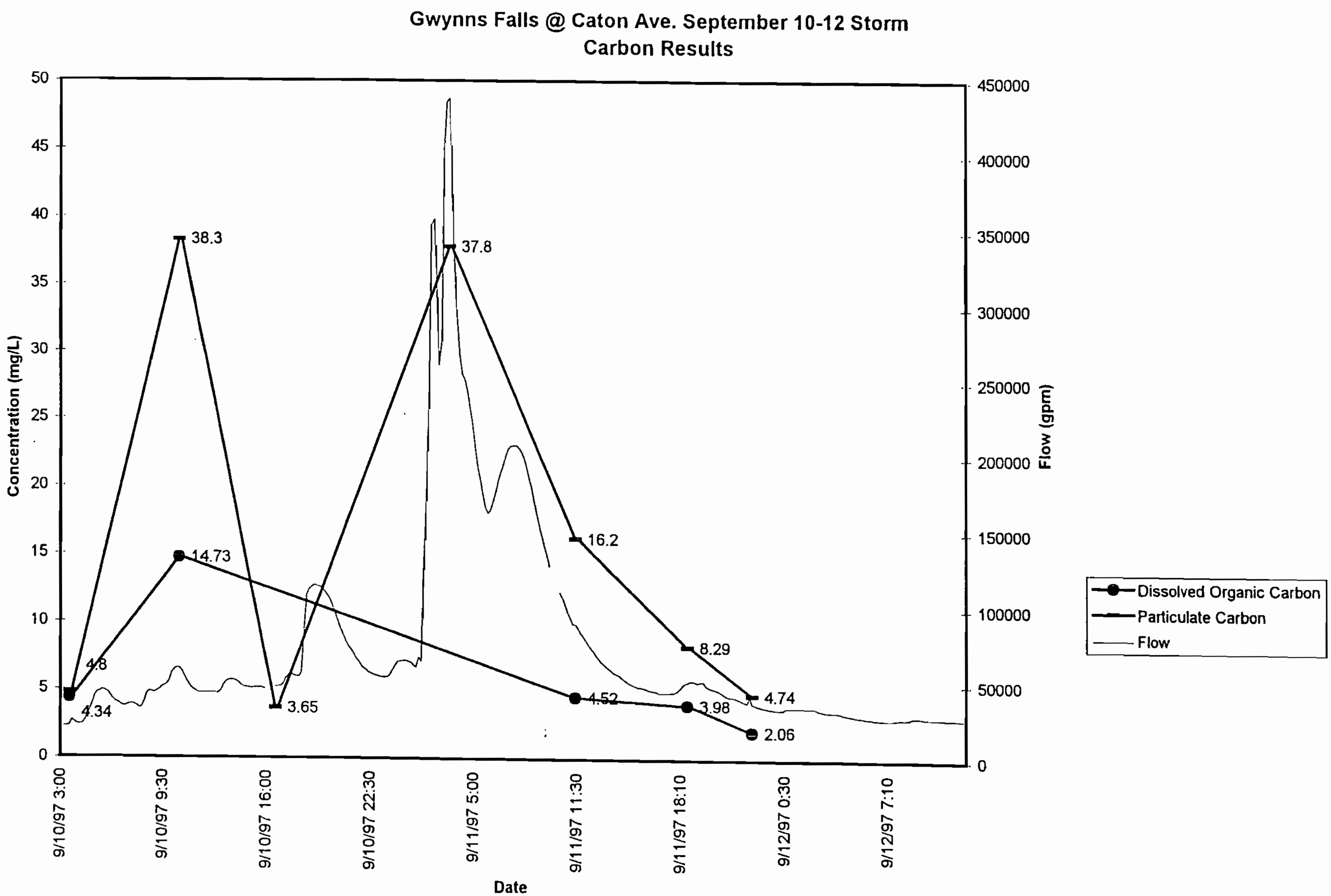


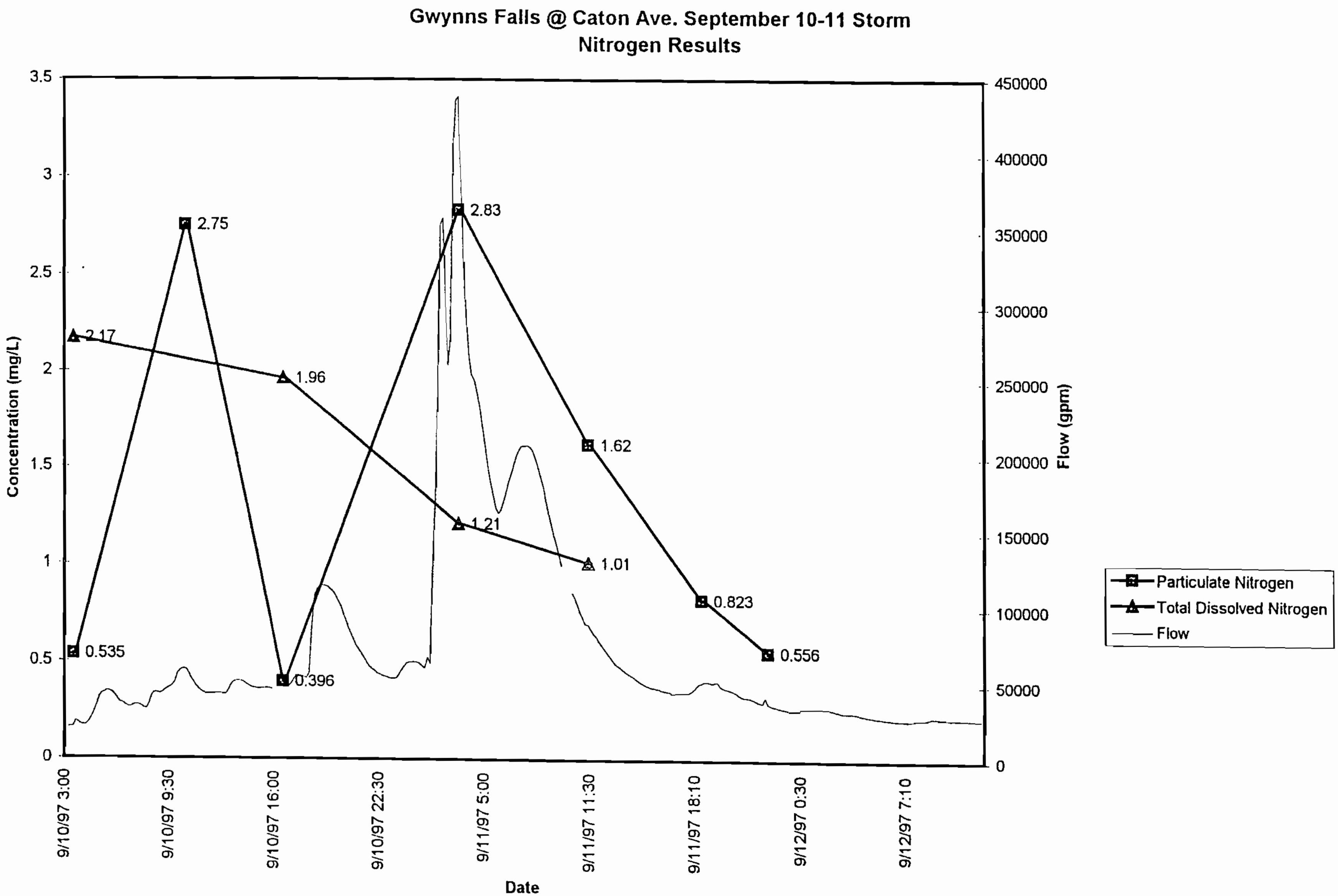
Gwynns Falls @ Villanova September 10-11 Storm
Phosphorous Results
Concentration (mg/L)
0.5
0.45
0.4
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
Flow (gpm)
250000
200000
150000
100000
50000
0
0.2026
0.3964
0.0223
0.0193
9/10/97 0:00
9/10/97 5:00
9/10/97 10:00
9/10/97 15:00
9/10/97 19:50
9/11/97 0:50
9/11/97 5:40
9/11/97 10:40
9/11/97 15:40
9/11/97 20:40
Date
Particulate Phosphorous
Total Dissolved Phosphorous
Flow



Gwynns Falls @ Villanova September 10-11 Storm
Total Suspended Solids
Concentration (mg/L)
Flow (gpm)
Date
500
450
400
350
300
250
200
150
100
50
0
250000
200000
150000
100000
50000
0
438.7
193.3
9/10/97 0:00
9/10/97 5:00
9/10/97 10:00
9/10/97 15:00
9/10/97 19:50
9/11/97 0:50
9/11/97 5:40
9/11/97 10:40
9/11/97 15:40
9/11/97 20:40
Total Suspended Solids
Flow

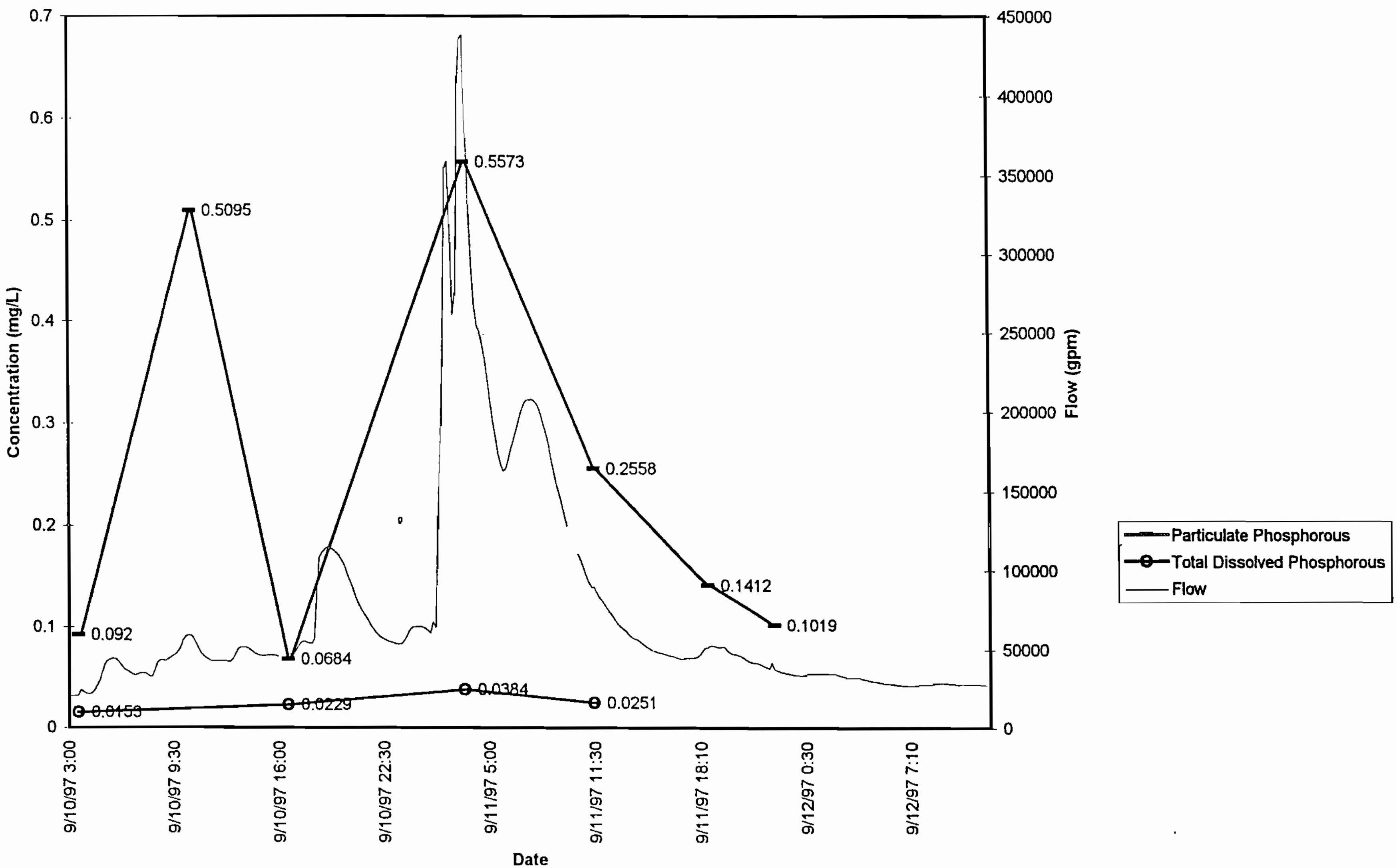
Gwynns Falls @ Caton Ave. September 10-12 Storm Carbon Results

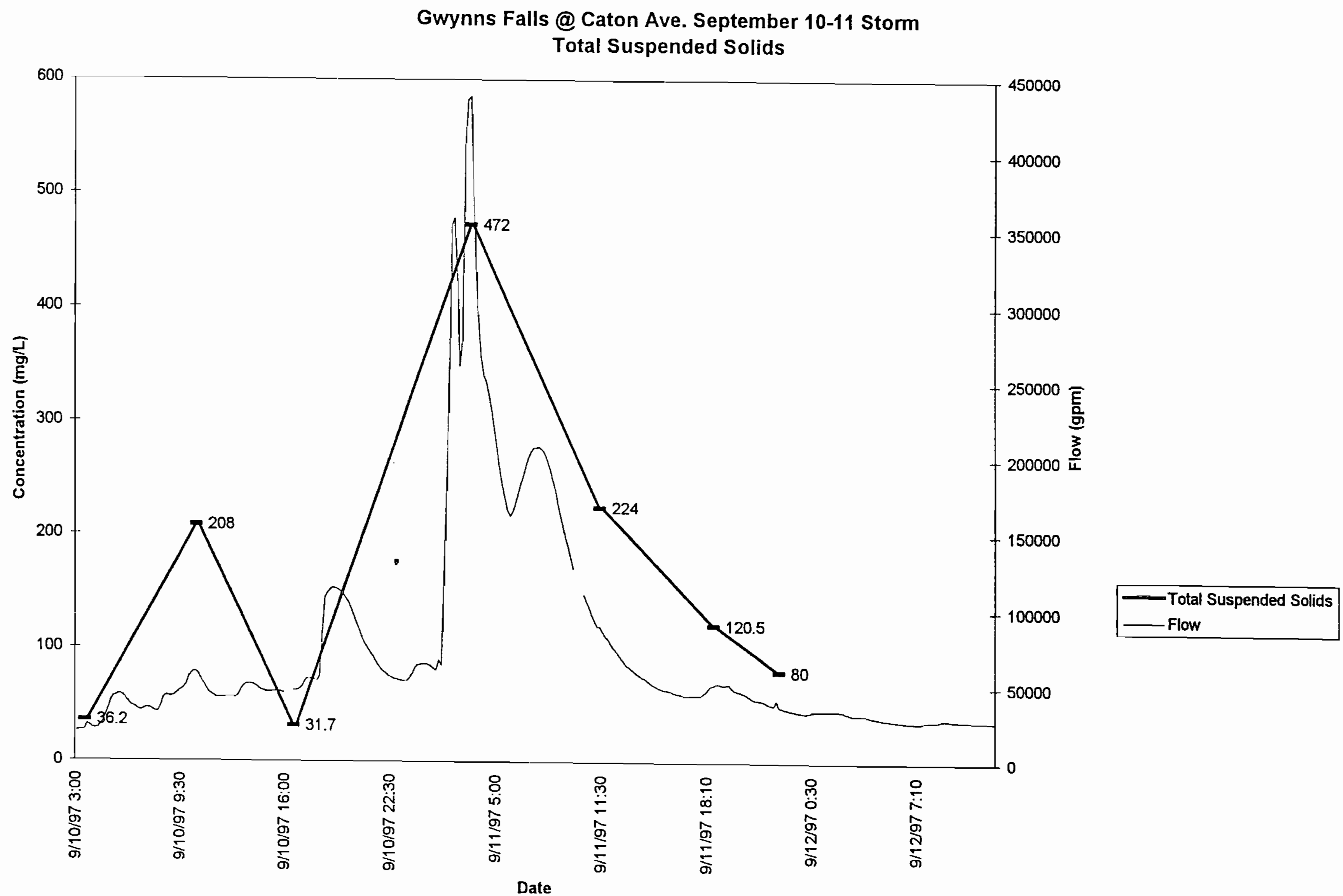


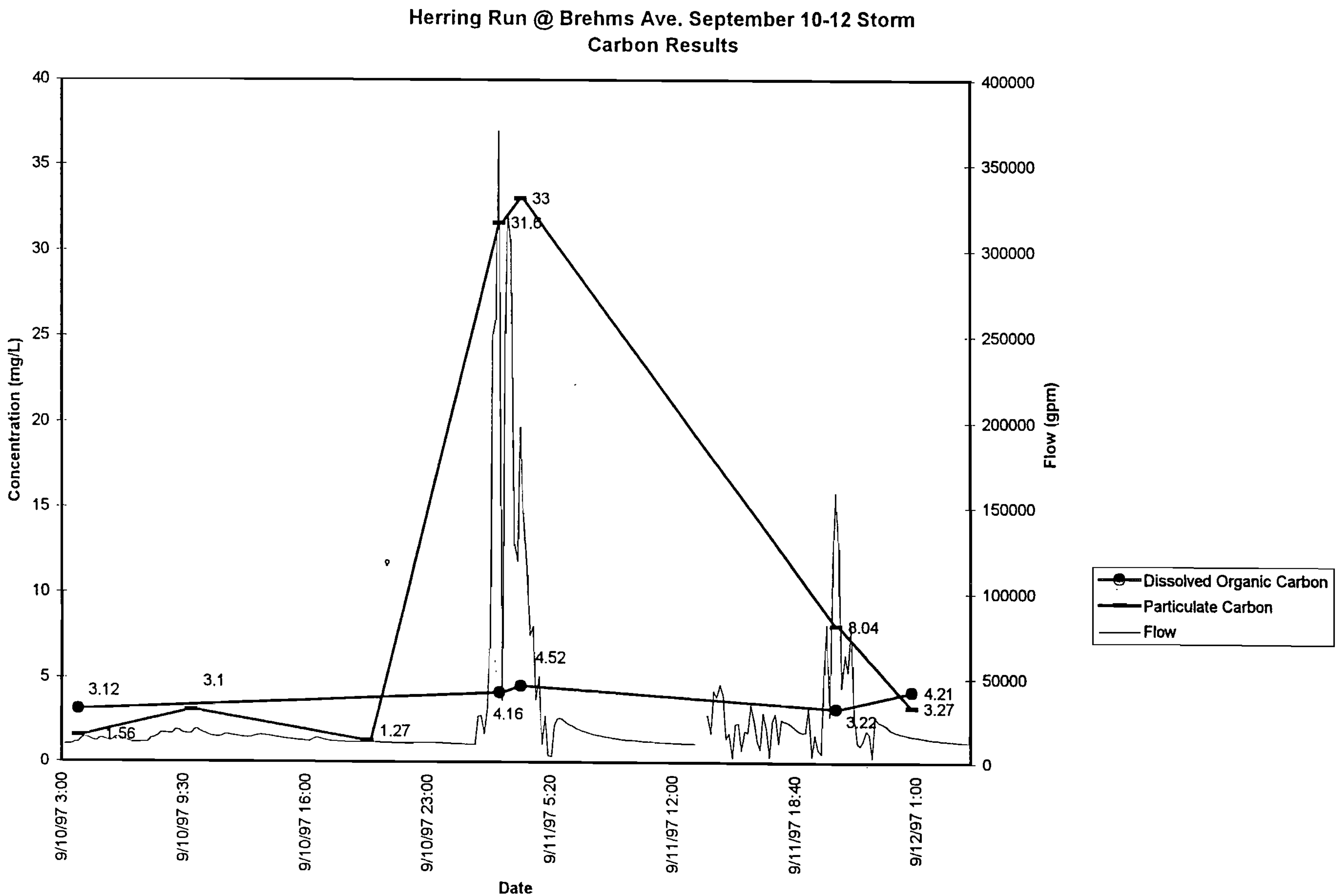


Gwynns Falls @ Caton Ave. September 10-11 Storm
Nitrogen Results
Concentration (mg/L)
Flow (gpm)
Date
0
0.5
1
1.5
2
2.5
3
3.5
0
50000
100000
150000
200000
250000
300000
350000
400000
450000
9/10/97 3:00
9/10/97 9:30
9/10/97 16:00
9/10/97 22:30
9/11/97 5:00
9/11/97 11:30
9/11/97 18:10
9/12/97 0:30
9/12/97 7:10
0.535
2.75
0.396
2.83
1.62
0.823
0.556
2.17
1.96
1.21
1.01
Particulate Nitrogen
Total Dissolved Nitrogen
Flow

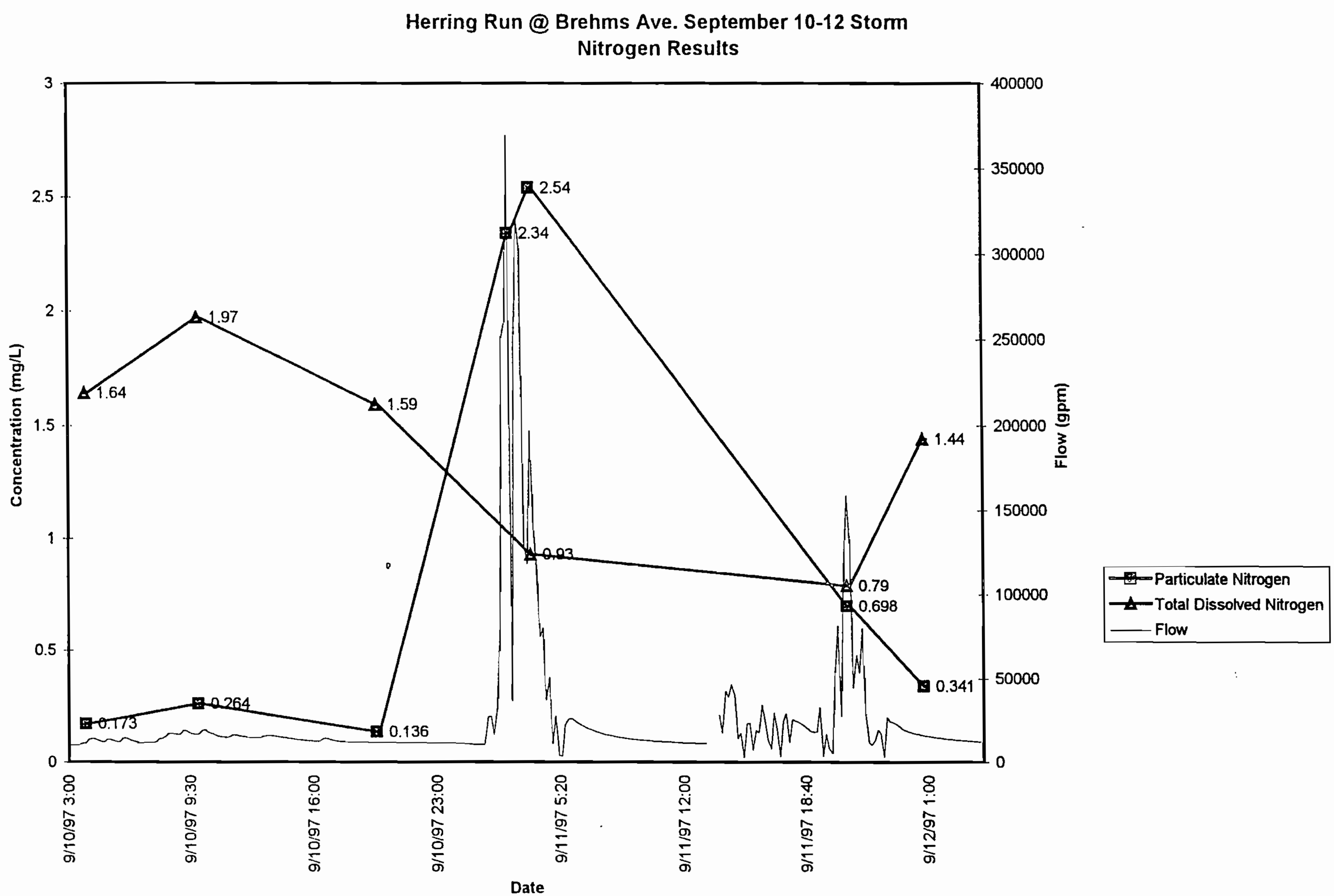
Gwynns Falls @ Caton Ave. September 10-11 Storm
Phosphorous Results




Gwynns Falls @ Caton Ave. September 10-11 Storm
Total Suspended Solids
Concentration (mg/L)
Flow (gpm)
Date
0
100
200
300
400
500
600
0
50000
100000
150000
200000
250000
300000
350000
400000
450000
36.2
208
31.7
472
224
120.5
80
9/10/97 3:00
9/10/97 9:30
9/10/97 16:00
9/10/97 22:30
9/11/97 5:00
9/11/97 11:30
9/11/97 18:10
9/12/97 0:30
9/12/97 7:10
Total Suspended Solids
Flow

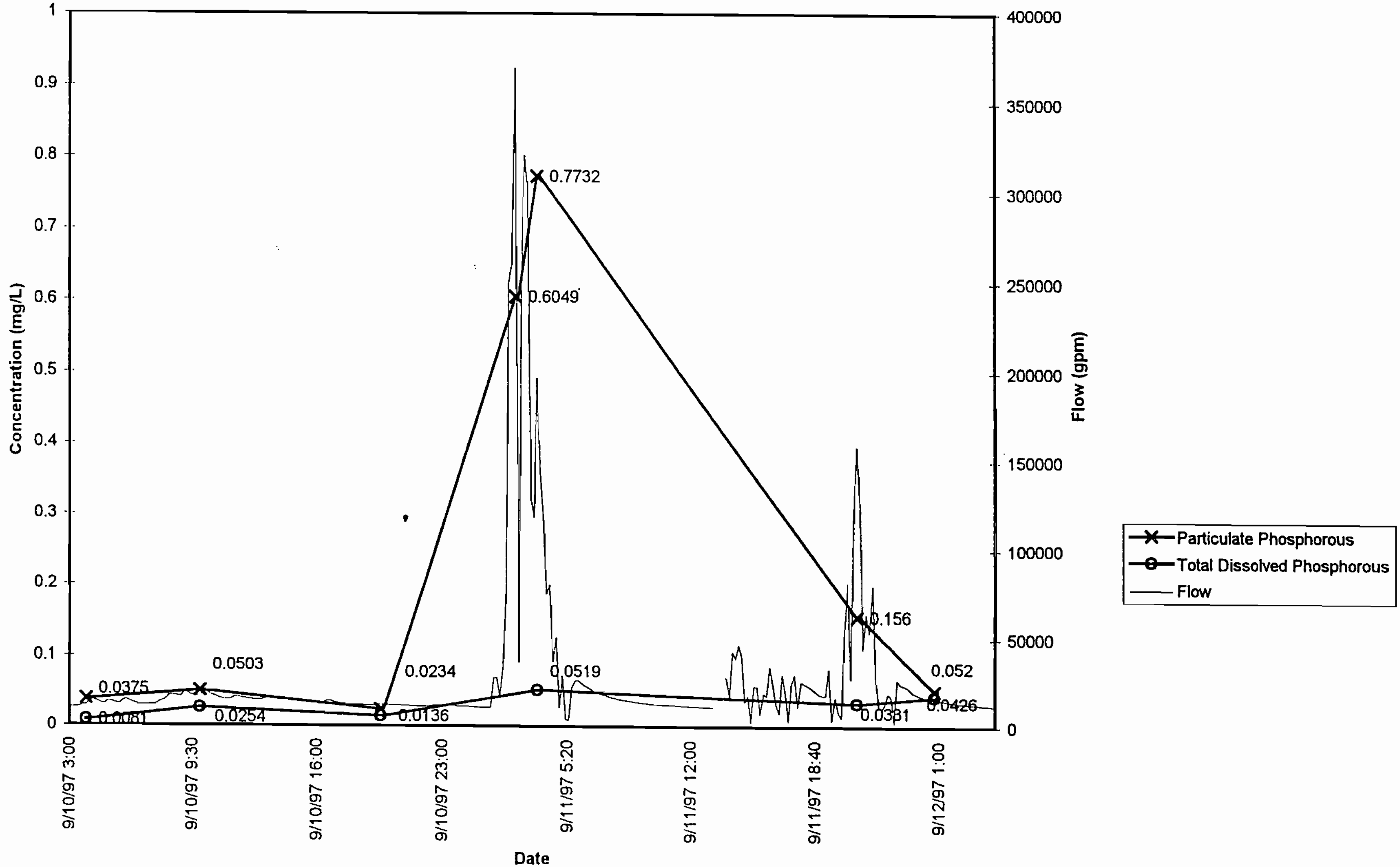


Herring Run @ Brehms Ave. September 10-12 Storm
Carbon Results
Concentration (mg/L)
Flow (gpm)
Date
0
5
10
15
20
25
30
35
40
0
50000
100000
150000
200000
250000
300000
350000
400000
9/10/97 3:00
9/10/97 9:30
9/10/97 16:00
9/10/97 23:00
9/11/97 5:20
9/11/97 12:00
9/11/97 18:40
9/12/97 1:00
3.12
3.1
1.56
1.27
31.6
33
4.16
4.52
8.04
3.22
4.21
3.27
Dissolved Organic Carbon
Particulate Carbon
Flow

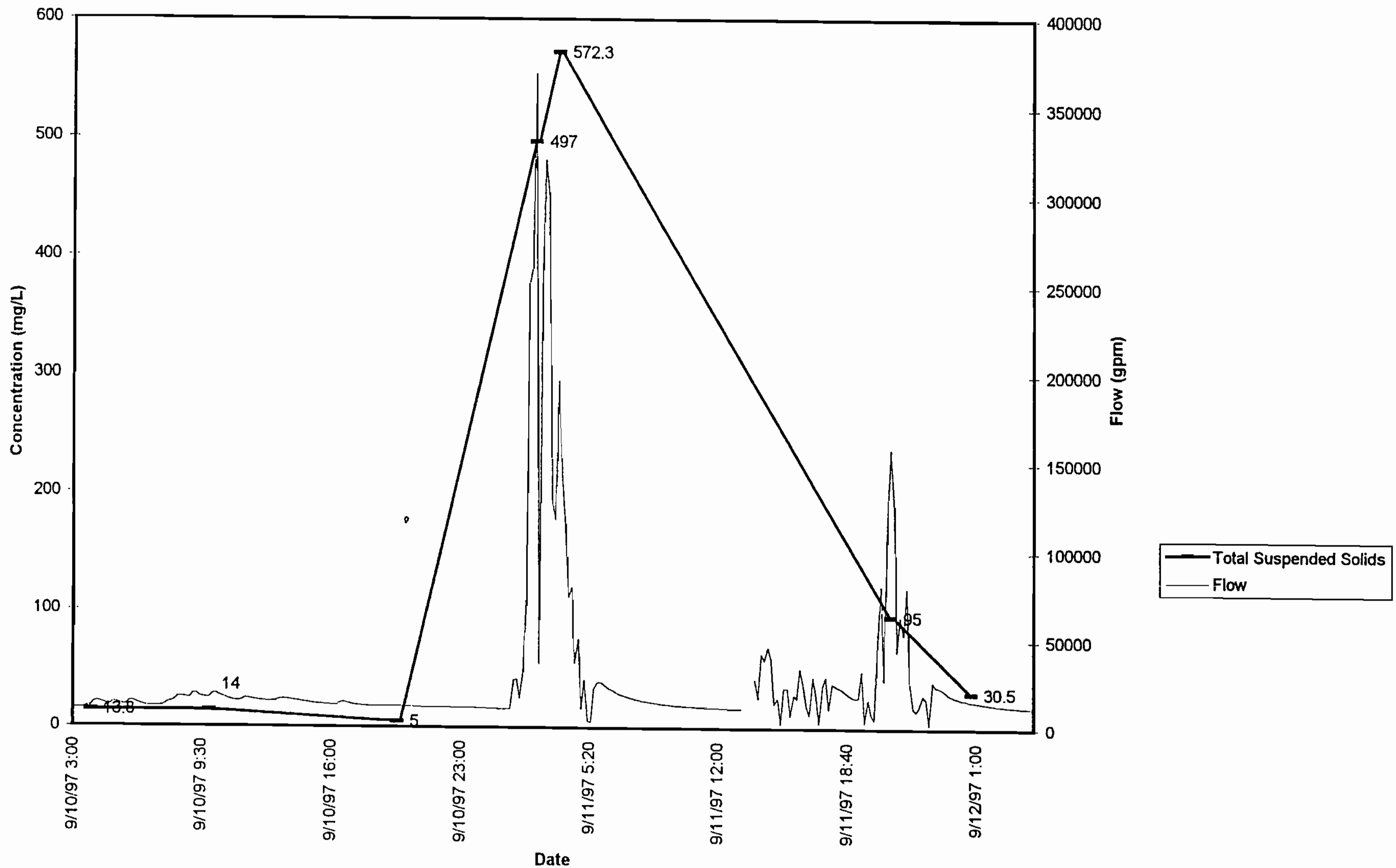


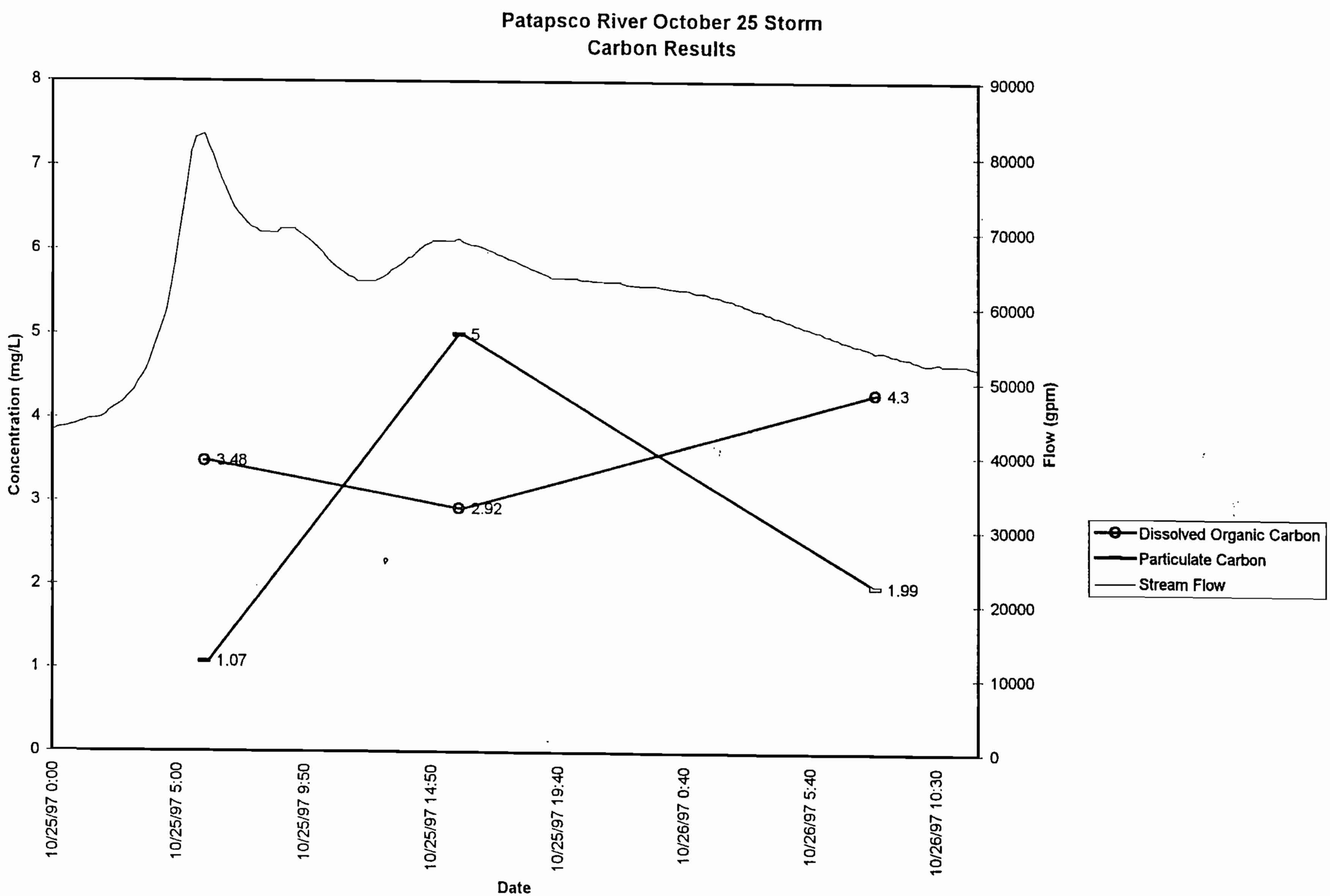
Herring Run @ Brehms Ave. September 10-12 Storm
Nitrogen Results
Concentration (mg/L)
Flow (gpm)
Date
0
0.5
1
1.5
2
2.5
3
0
50000
100000
150000
200000
250000
300000
350000
400000
9/10/97 3:00
9/10/97 9:30
9/10/97 16:00
9/10/97 23:00
9/11/97 5:20
9/11/97 12:00
9/11/97 18:40
9/12/97 1:00
1.64
1.97
1.59
0.93
0.79
1.44
0.173
0.264
0.136
2.34
2.54
0.698
0.341
Particulate Nitrogen
Total Dissolved Nitrogen
Flow

Herring Run @ Brehms Ave. September 10-12 Storm Phosphorous Results



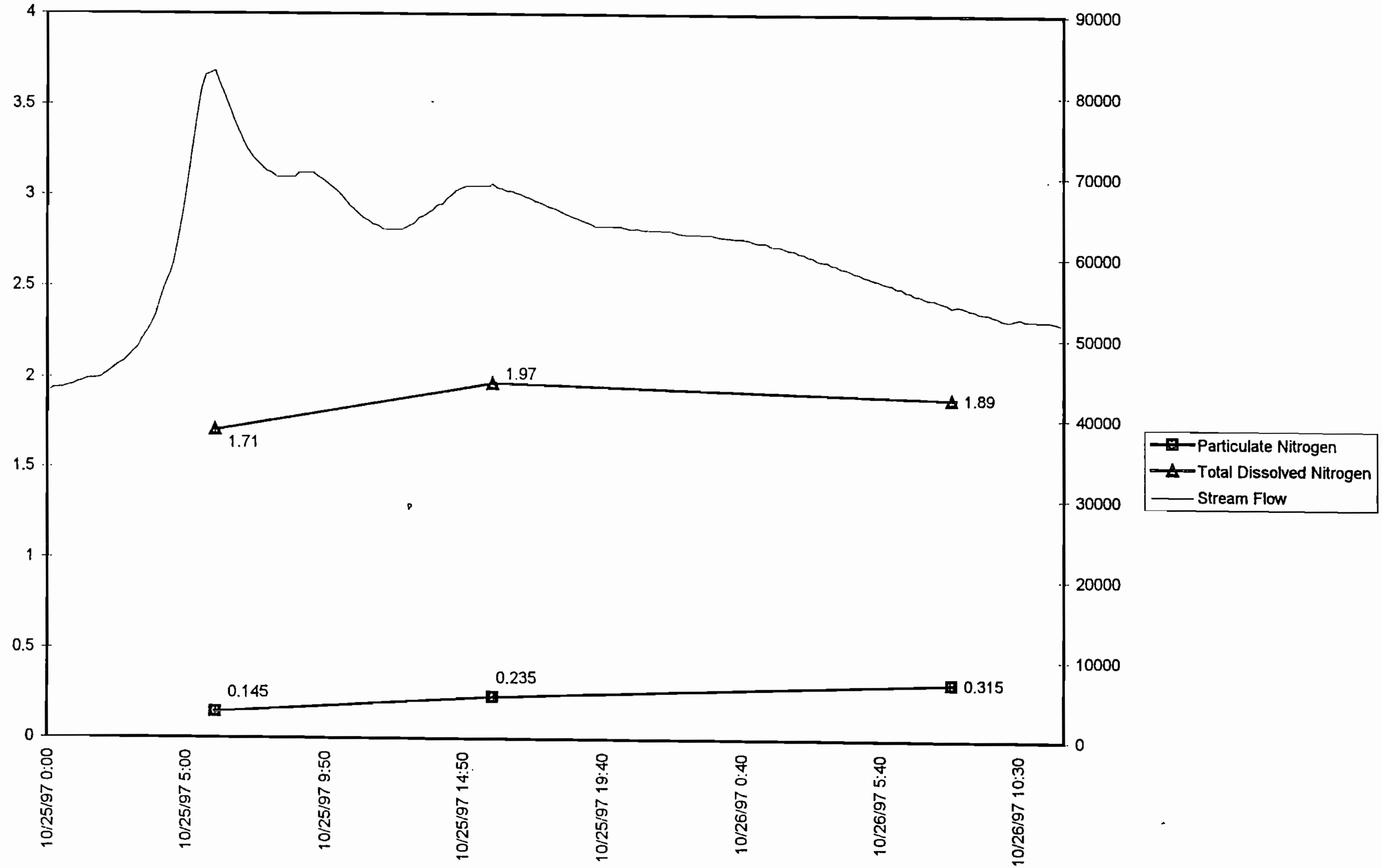
Herring Run @ Brehms Ave September 10-12 Storm
Total Suspended Solids

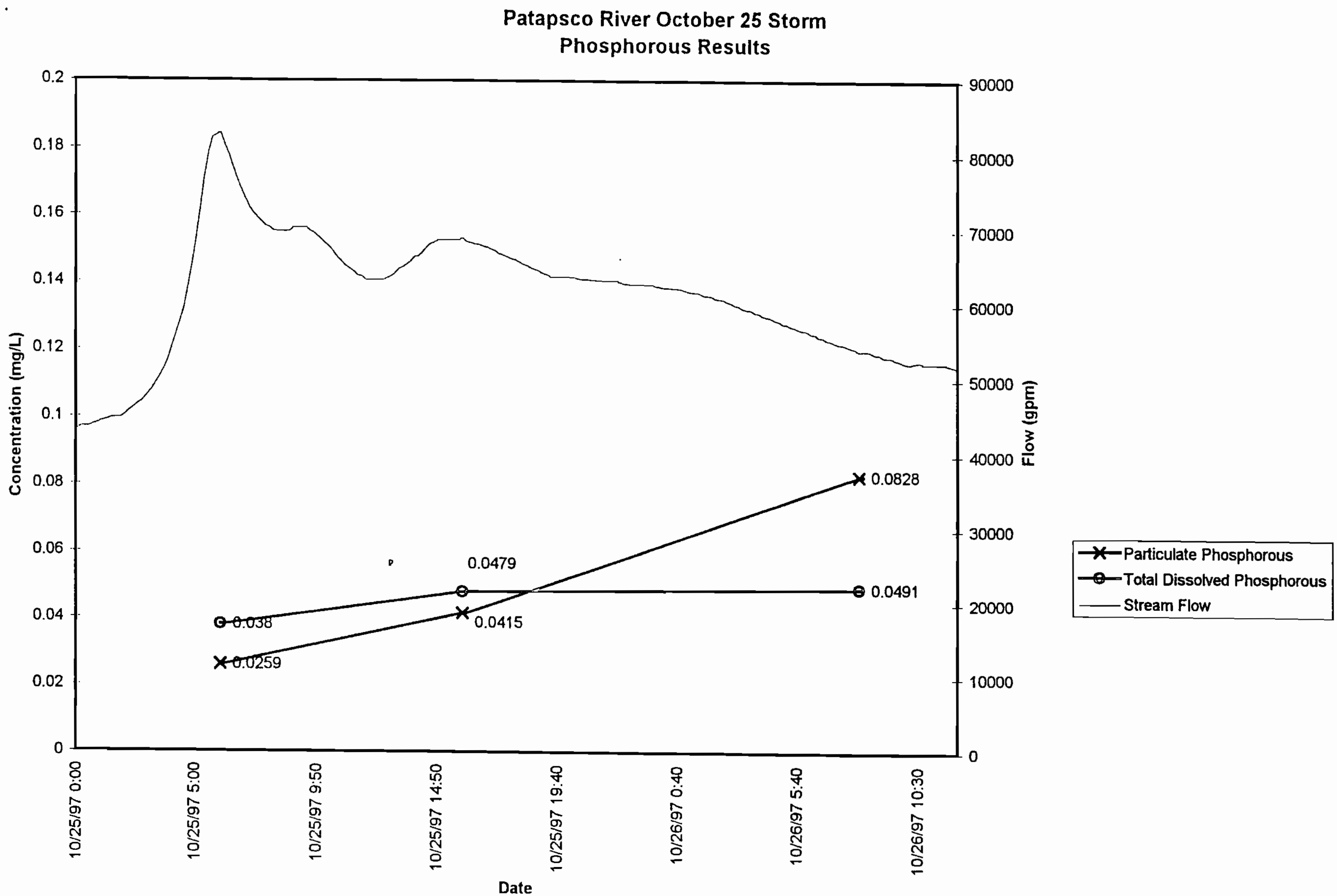




Patapsco River October 25 Storm
Carbon Results
Concentration (mg/L)
8
7
6
5
4
3
2
1
0
Flow (gpm)
90000
80000
70000
60000
50000
40000
30000
20000
10000
0
3.48
2.92
4.3
1.07
5
1.99
10/25/97 0:00
10/25/97 5:00
10/25/97 9:50
10/25/97 14:50
10/25/97 19:40
10/26/97 0:40
10/26/97 5:40
10/26/97 10:30
Date
Dissolved Organic Carbon
Particulate Carbon
Stream Flow

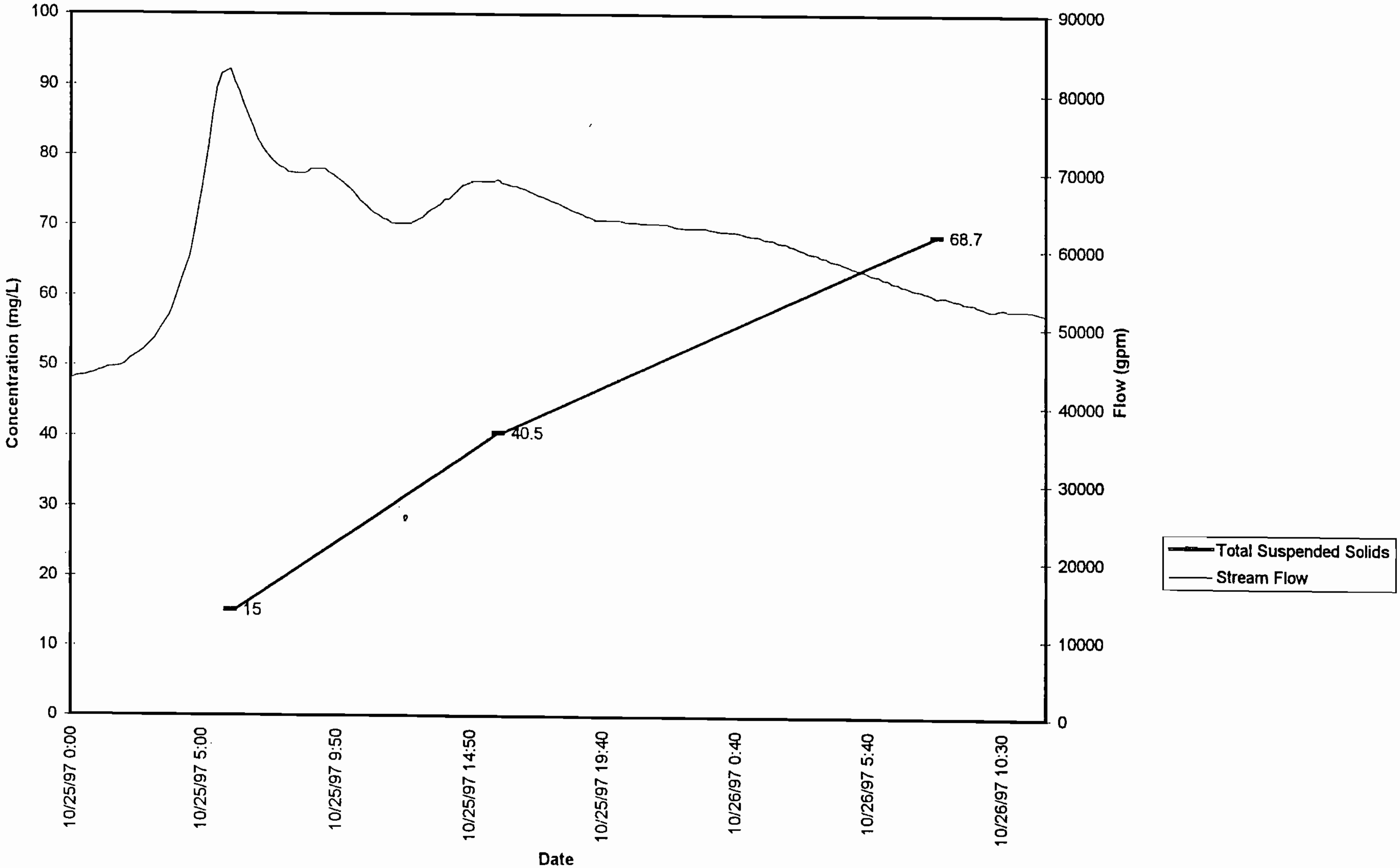
Patapsco River October 25 Storm
Nitrogen Results



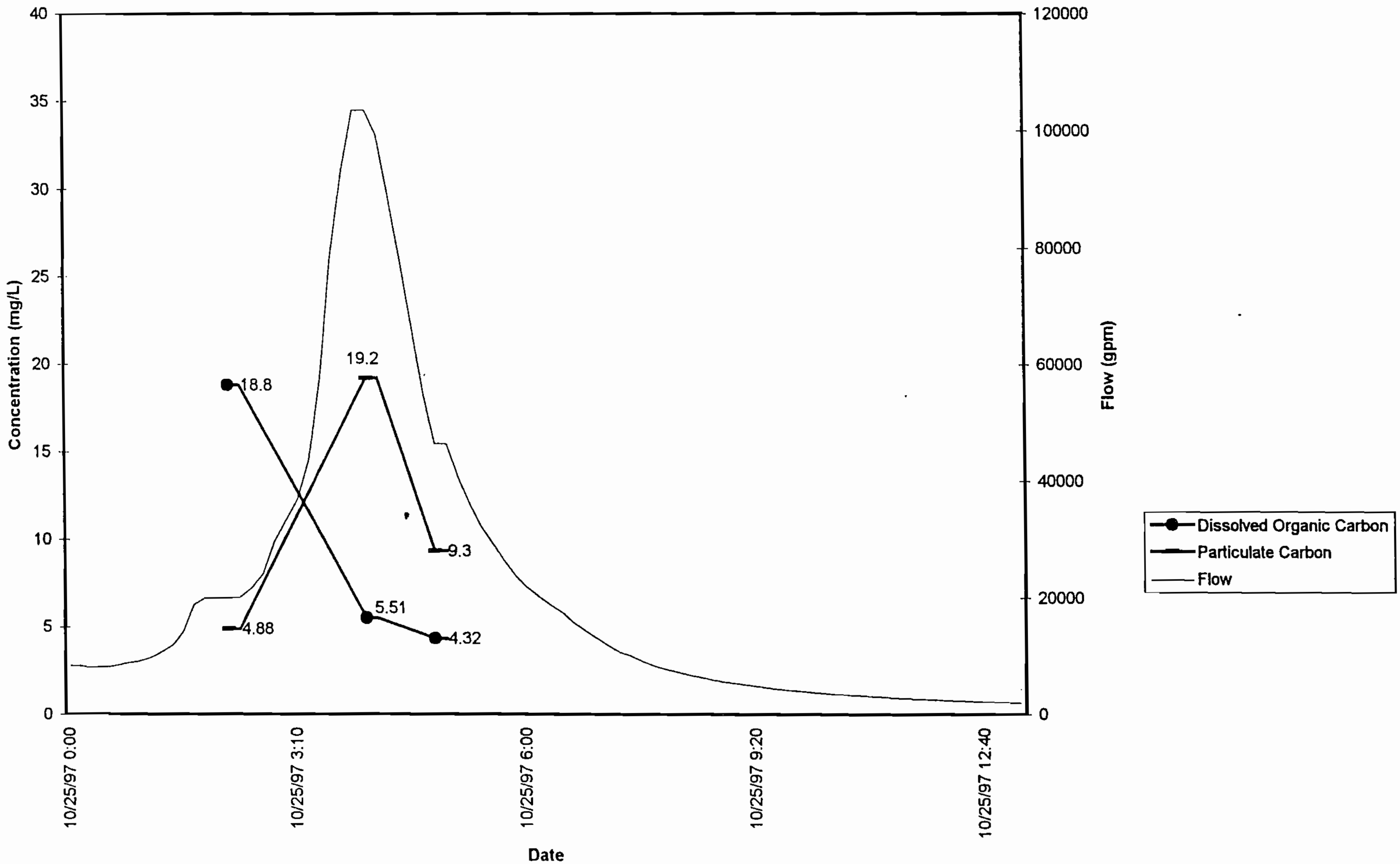


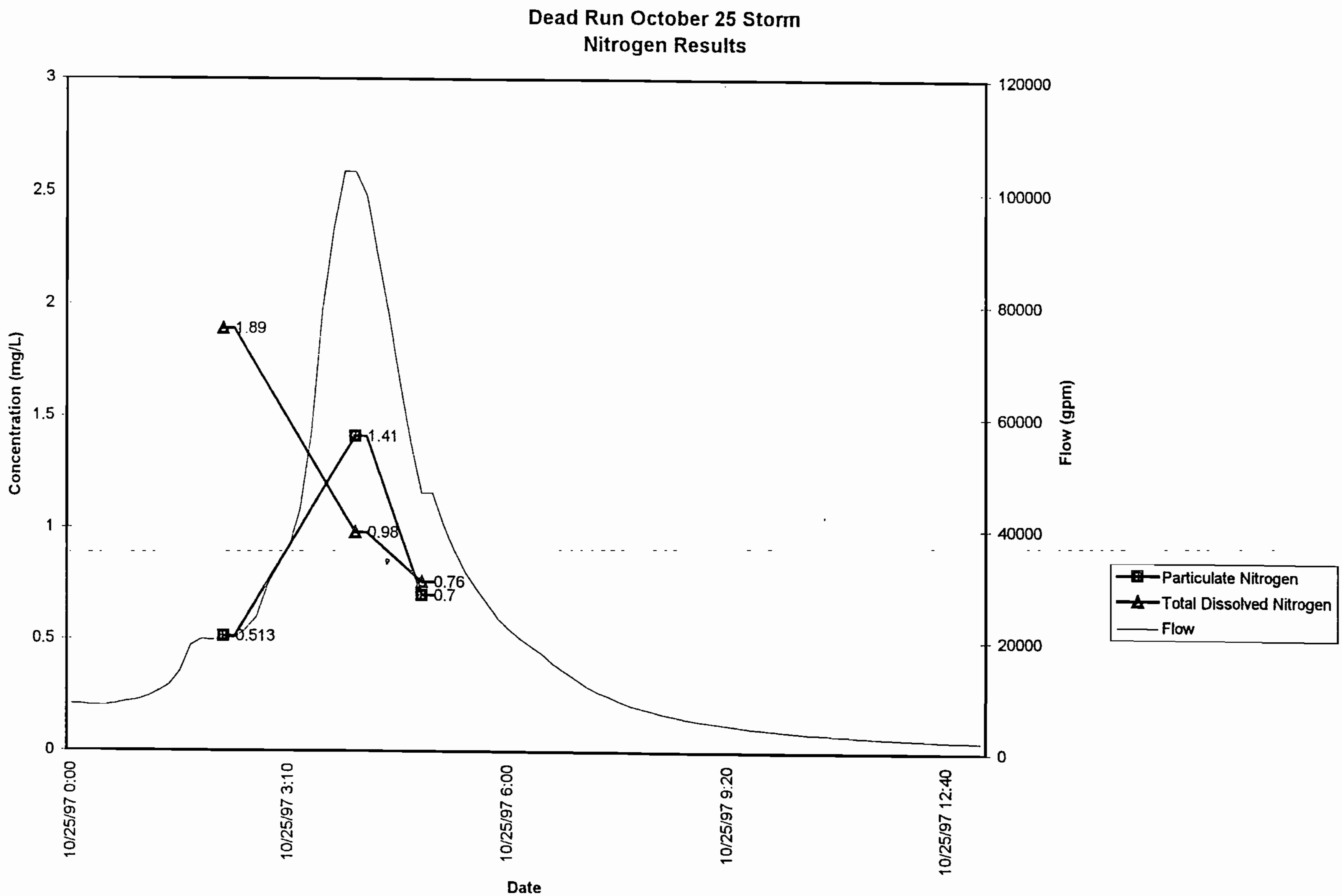
Patapsco River October 25 Storm
Phosphorous Results
Concentration (mg/L)
0.2
0.18
0.16
0.14
0.12
0.1
0.08
0.06
0.04
0.02
0
Flow (gpm)
90000
80000
70000
60000
50000
40000
30000
20000
10000
0
0.0828
0.0479
0.0491
0.038
0.0415
0.0259
10/25/97 0:00
10/25/97 5:00
10/25/97 9:50
10/25/97 14:50
10/25/97 19:40
10/26/97 0:40
10/26/97 5:40
10/26/97 10:30
Date
Particulate Phosphorous
Total Dissolved Phosphorous
Stream Flow

Patapsco River October 25 Storm
Total Suspended Solids

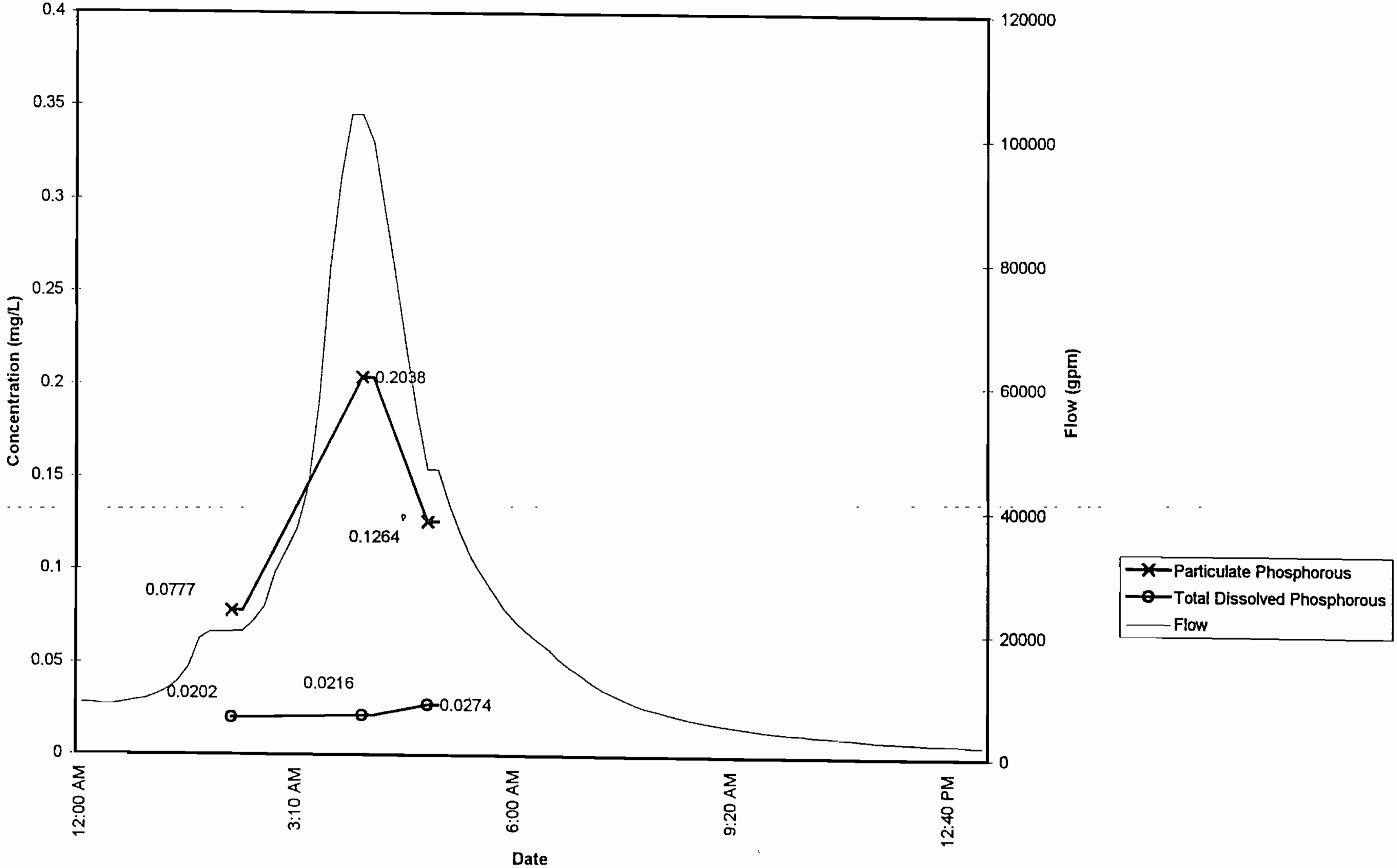


Dead Run October 25 Storm
Carbon Results

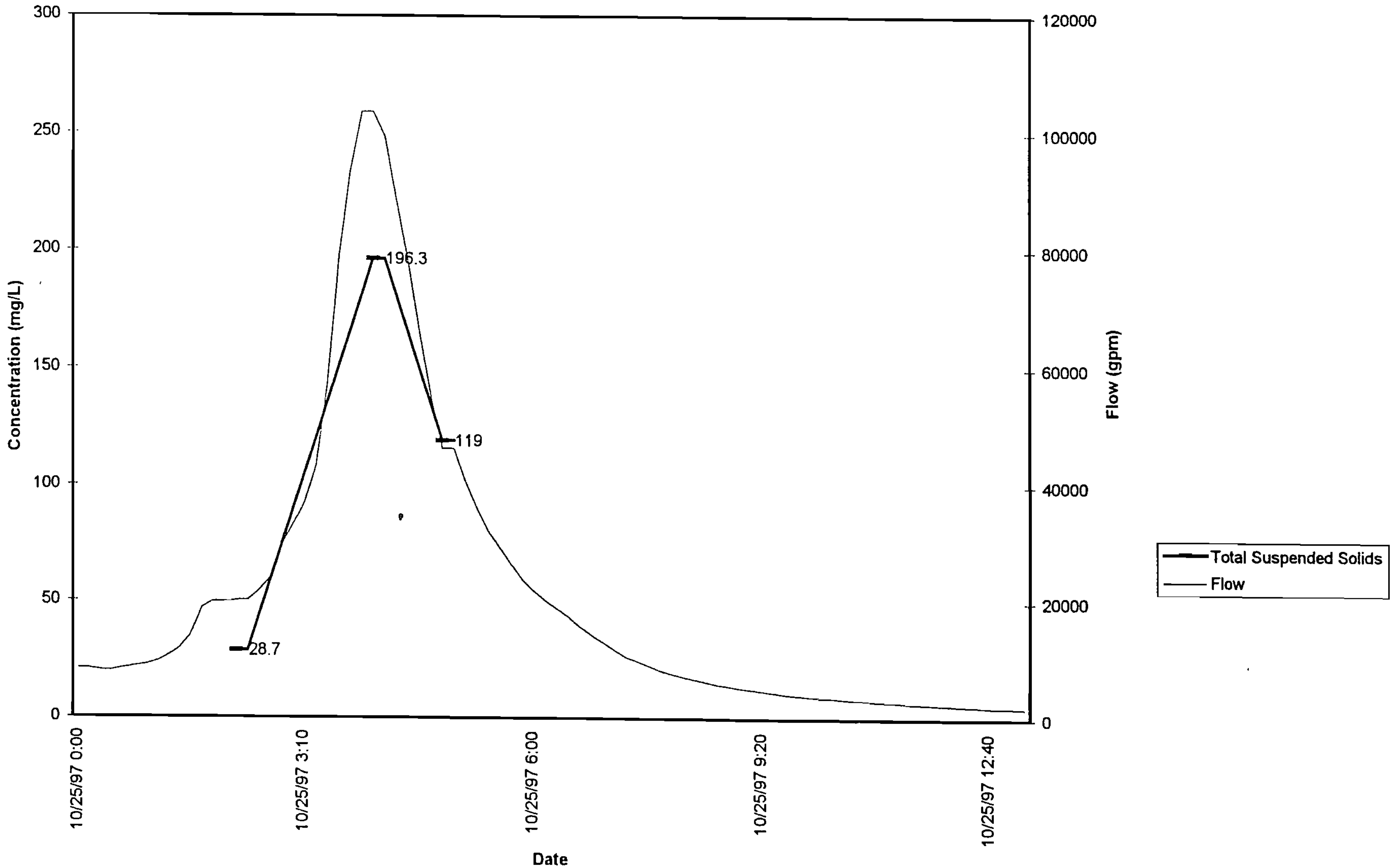



Dead Run October 25 Storm
Nitrogen Results
Concentration (mg/L)
Flow (gpm)
0
0.5
1
1.5
2
2.5
3
0
20000
40000
60000
80000
100000
120000
1.89
1.41
0.98
0.76
0.7
0.513
10/25/97 0:00
10/25/97 3:10
10/25/97 6:00
10/25/97 9:20
10/25/97 12:40
Date
Particulate Nitrogen
Total Dissolved Nitrogen
Flow

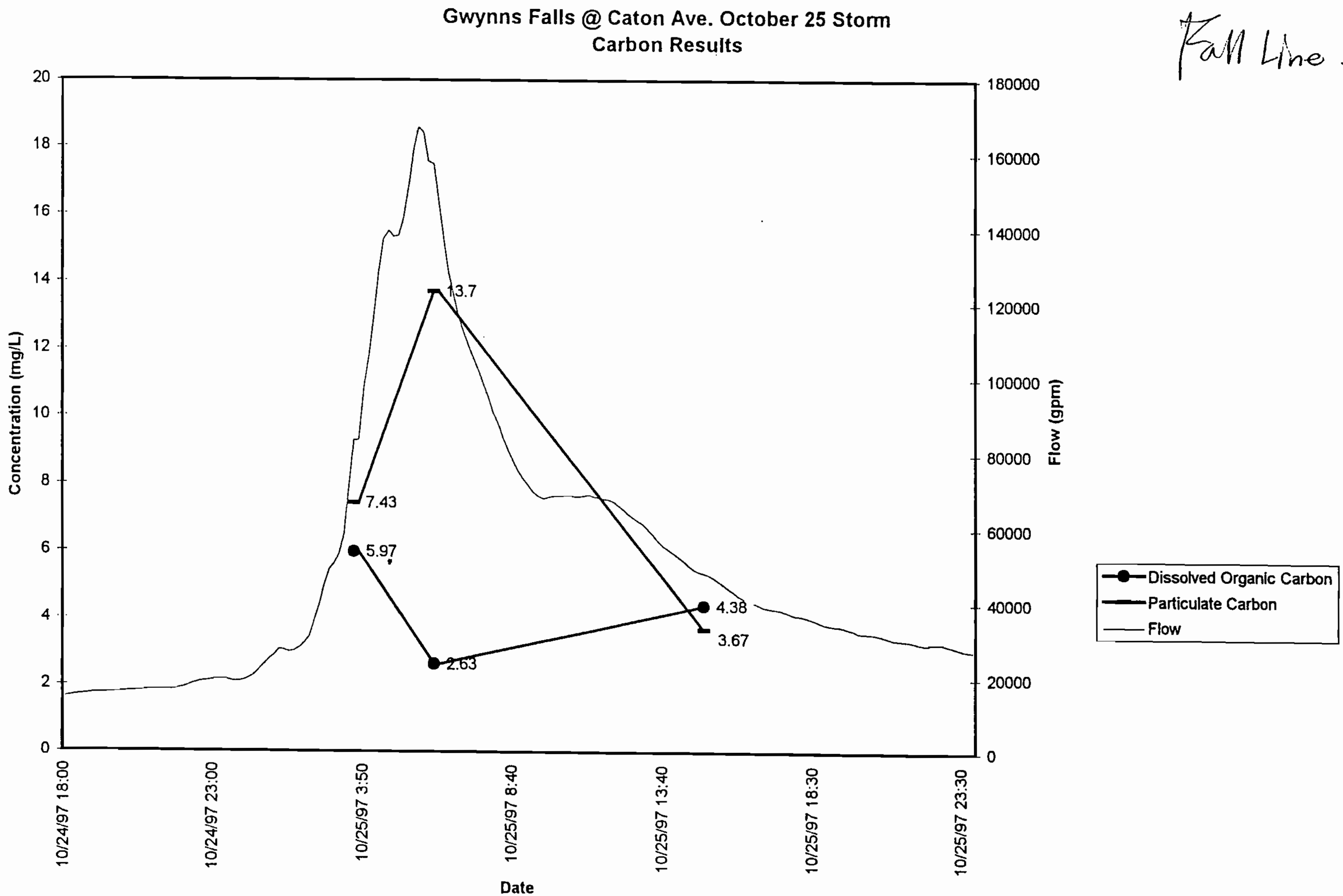
Dead Run October 25 Storm
Phosphorous Results



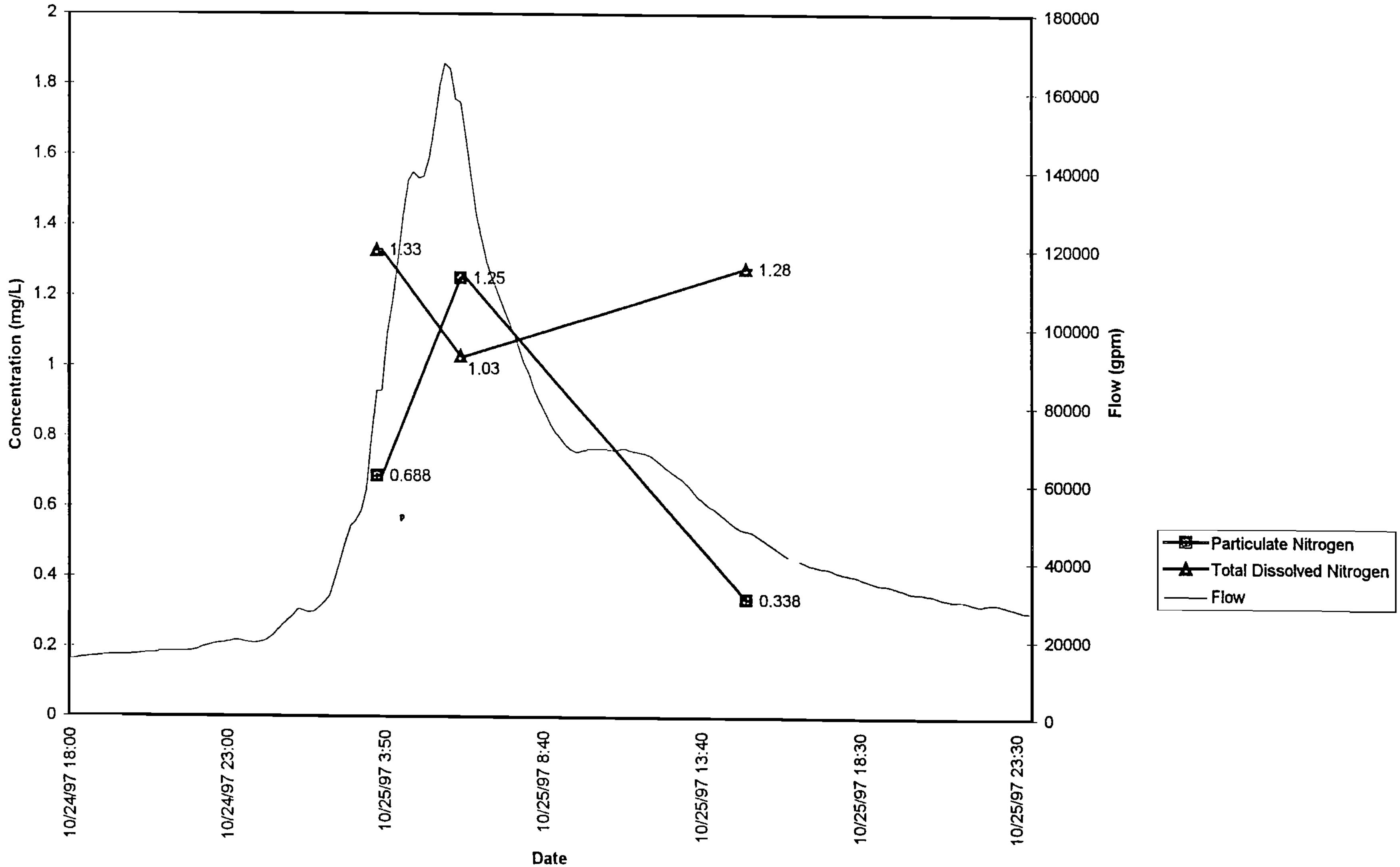
Dead Run October 25 Storm
Total Suspended Solids

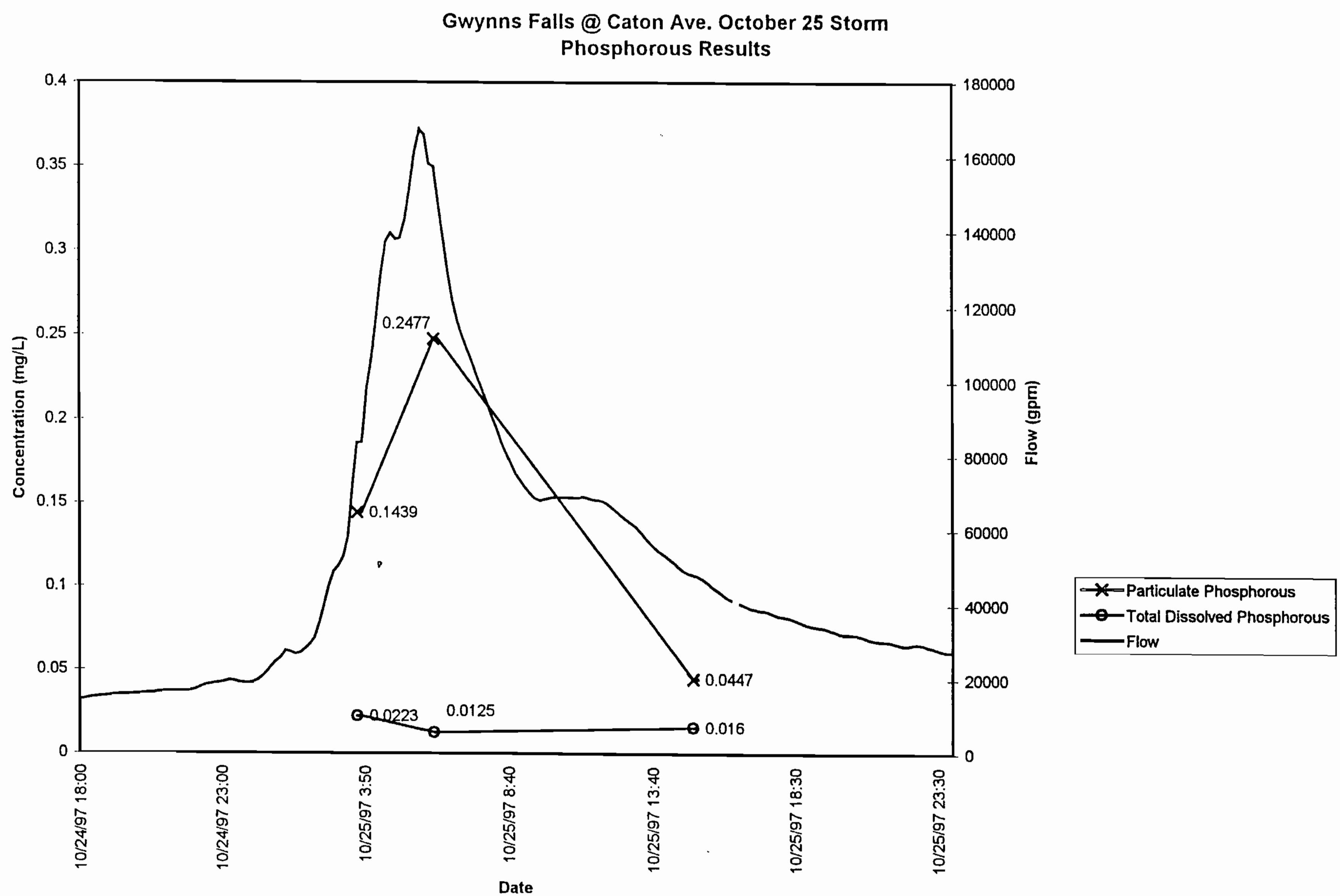


Fall Line Sta.

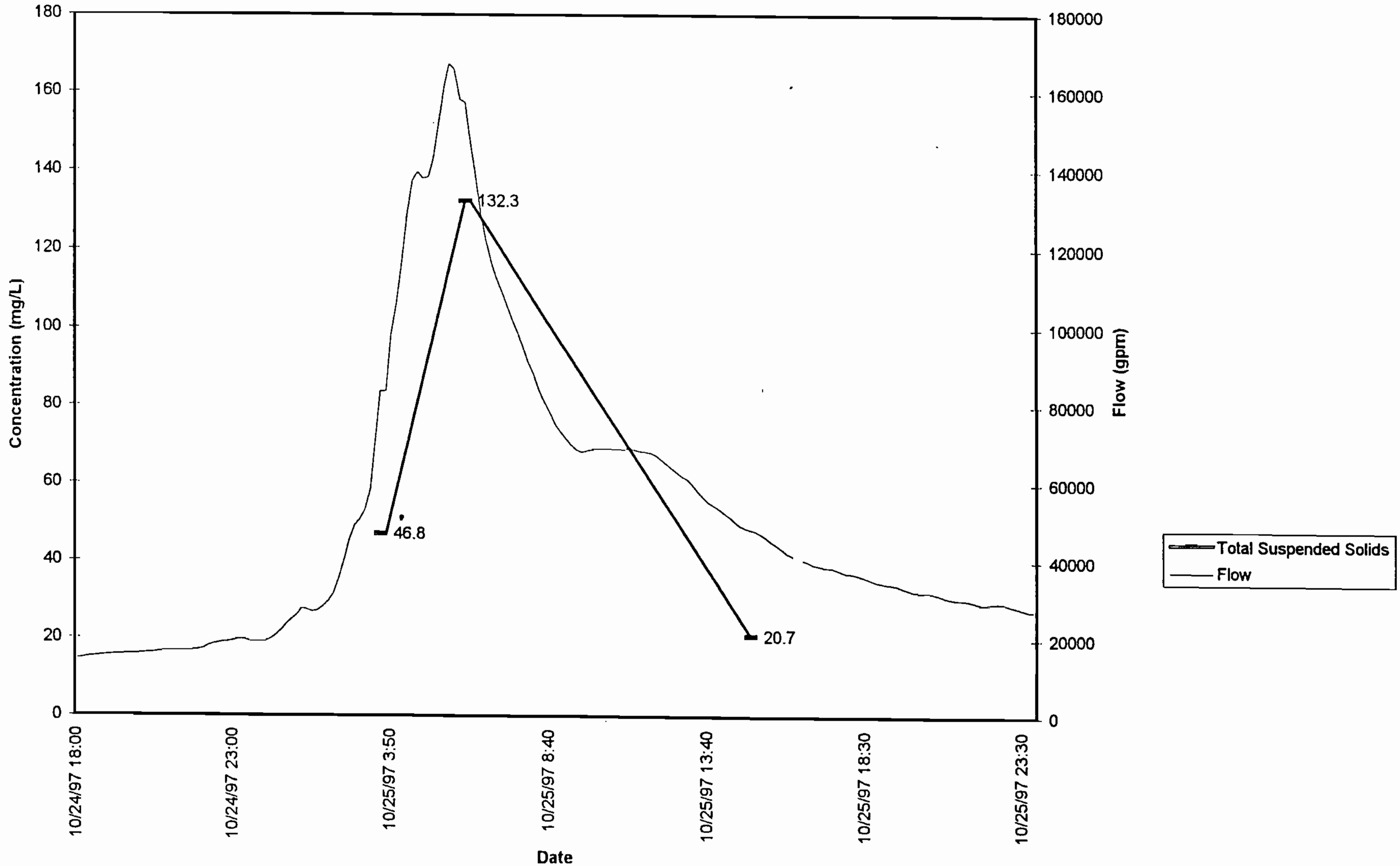


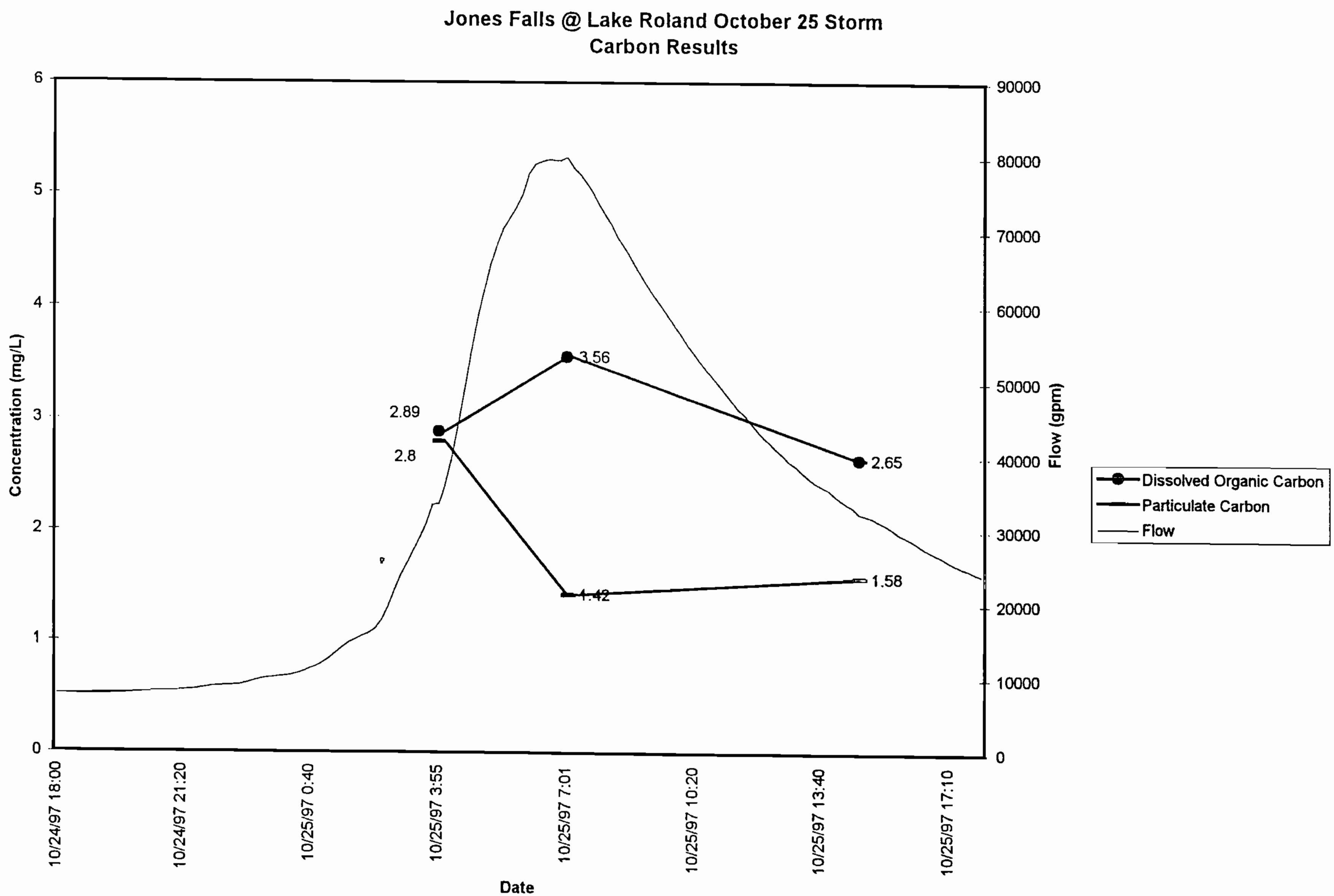
Gwynns Falls @ Caton Ave.
Nitrogen Results

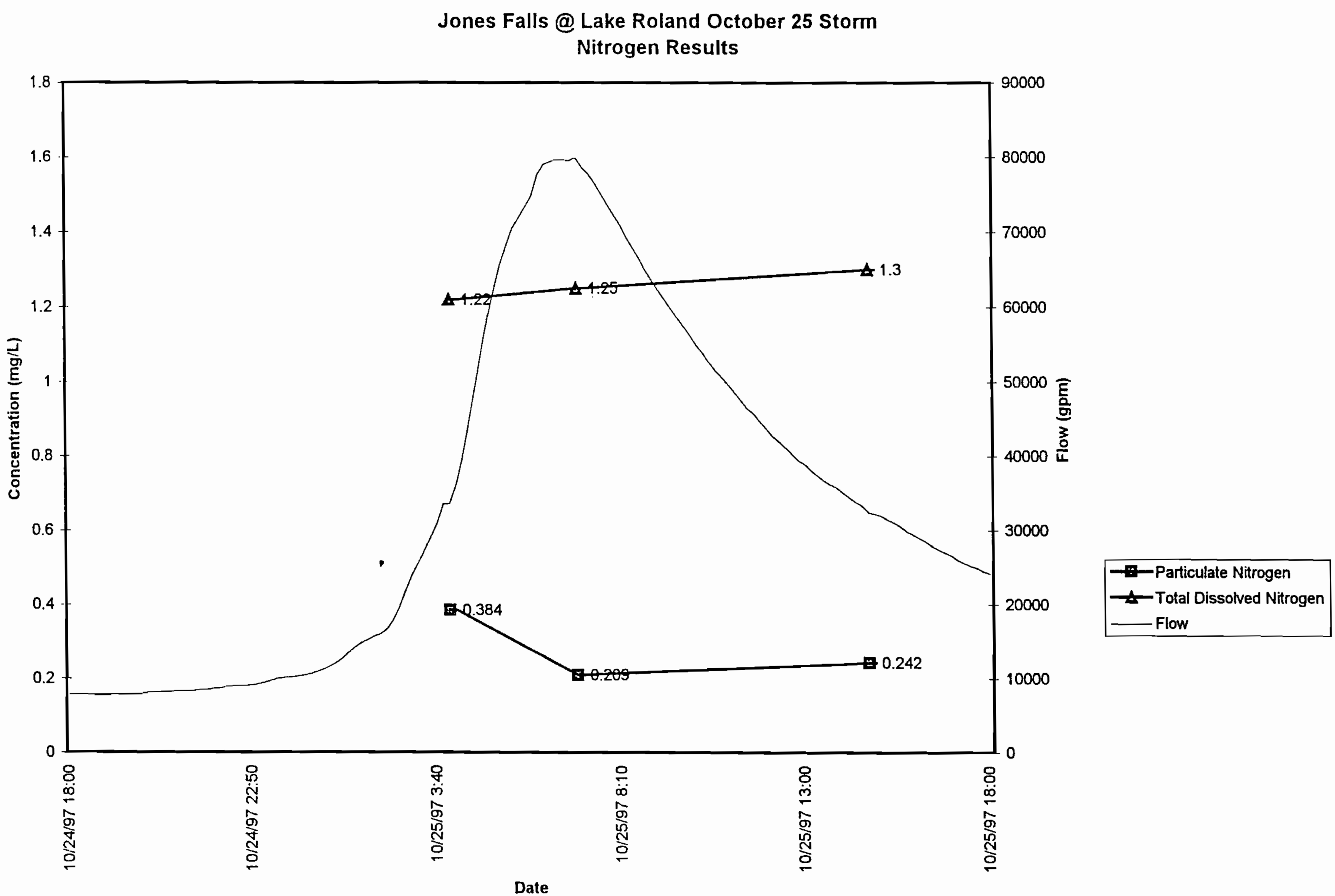


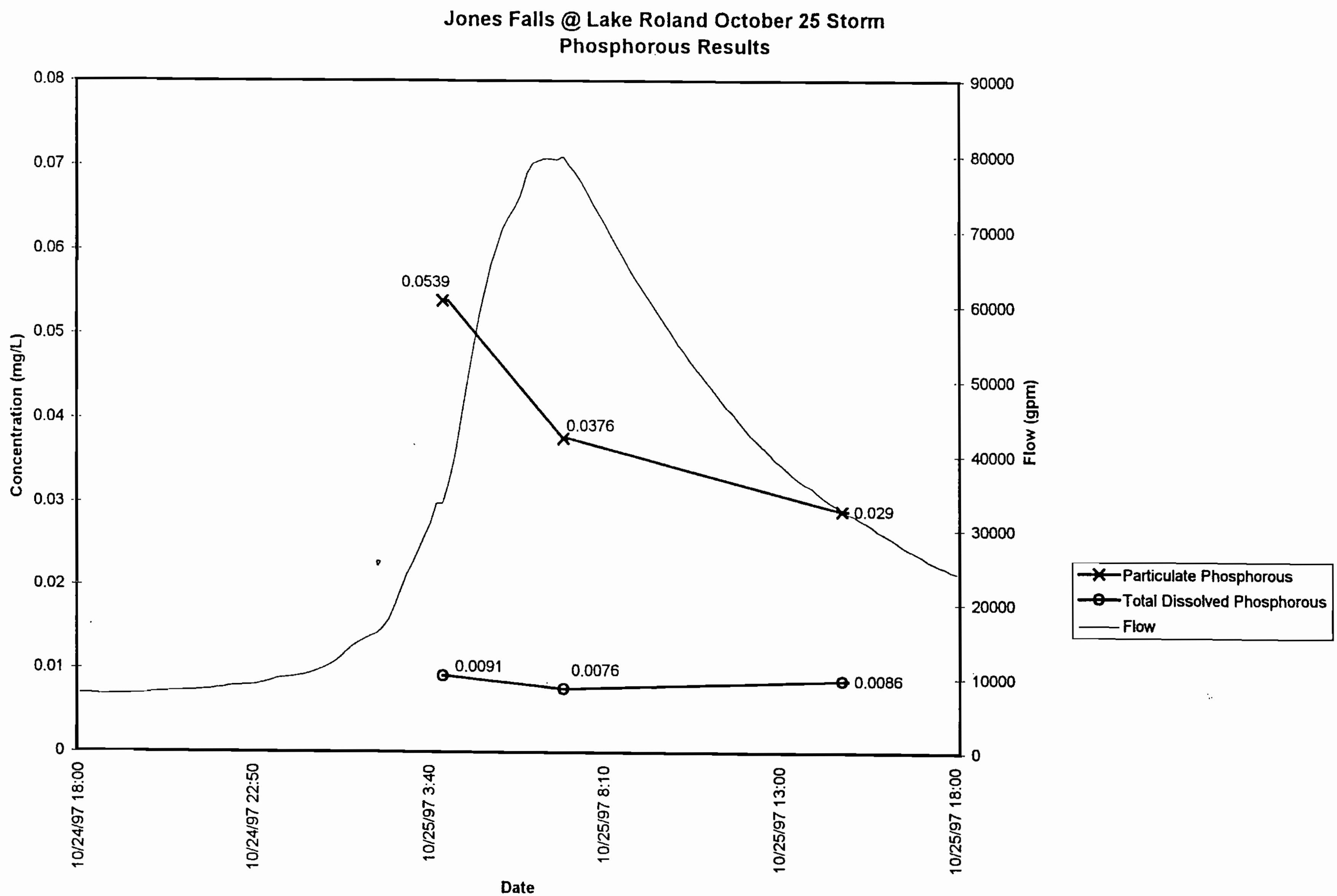

Gwynns Falls @ Caton Ave. October 25 Storm
Phosphorous Results
Concentration (mg/L)
Flow (gpm)
Date
0.4
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
180000
160000
140000
120000
100000
80000
60000
40000
20000
0
0.2477
0.1439
0.0447
0.0223
0.0125
0.016
10/24/97 18:00
10/24/97 23:00
10/25/97 3:50
10/25/97 8:40
10/25/97 13:40
10/25/97 18:30
10/25/97 23:30
Particulate Phosphorous
Total Dissolved Phosphorous
Flow

Gwynns Falls @ Caton Ave. October 25 Storm
Total Suspended Solids



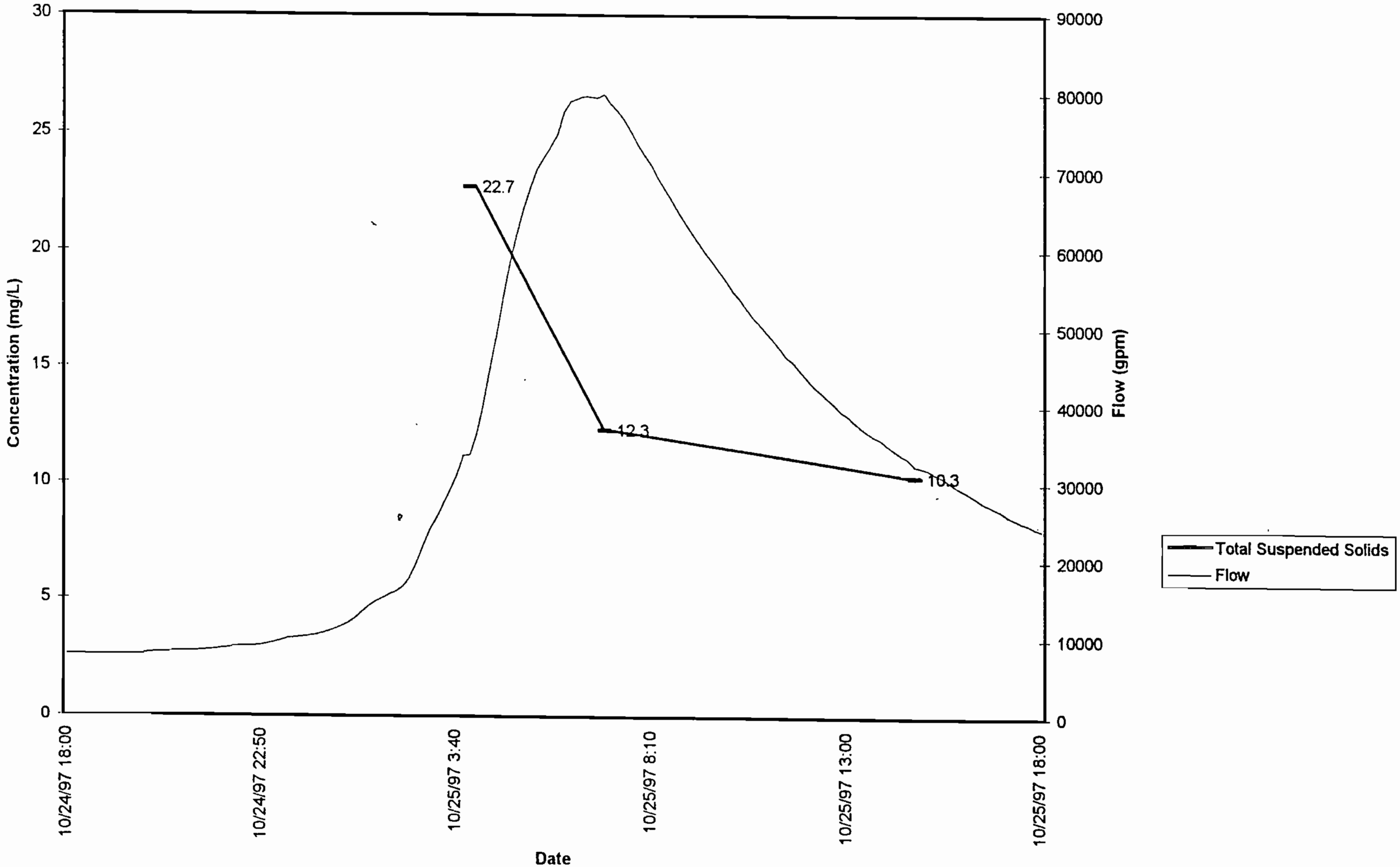

Jones Falls @ Lake Roland October 25 Storm
Carbon Results
Concentration (mg/L)
Flow (gpm)
Date
0
1
2
3
4
5
6
0
10000
20000
30000
40000
50000
60000
70000
80000
90000
10/24/97 18:00
10/24/97 21:20
10/25/97 0:40
10/25/97 3:55
10/25/97 7:01
10/25/97 10:20
10/25/97 13:40
10/25/97 17:10
2.89
2.8
3.56
1.42
2.65
1.58
Dissolved Organic Carbon
Particulate Carbon
Flow


Jones Falls @ Lake Roland October 25 Storm
Nitrogen Results
Concentration (mg/L)
Flow (gpm)
Date
1.8
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
90000
80000
70000
60000
50000
40000
30000
20000
10000
0
1.22
1.25
1.3
0.384
0.209
0.242
10/24/97 18:00
10/24/97 22:50
10/25/97 3:40
10/25/97 8:10
10/25/97 13:00
10/25/97 18:00
Particulate Nitrogen
Total Dissolved Nitrogen
Flow

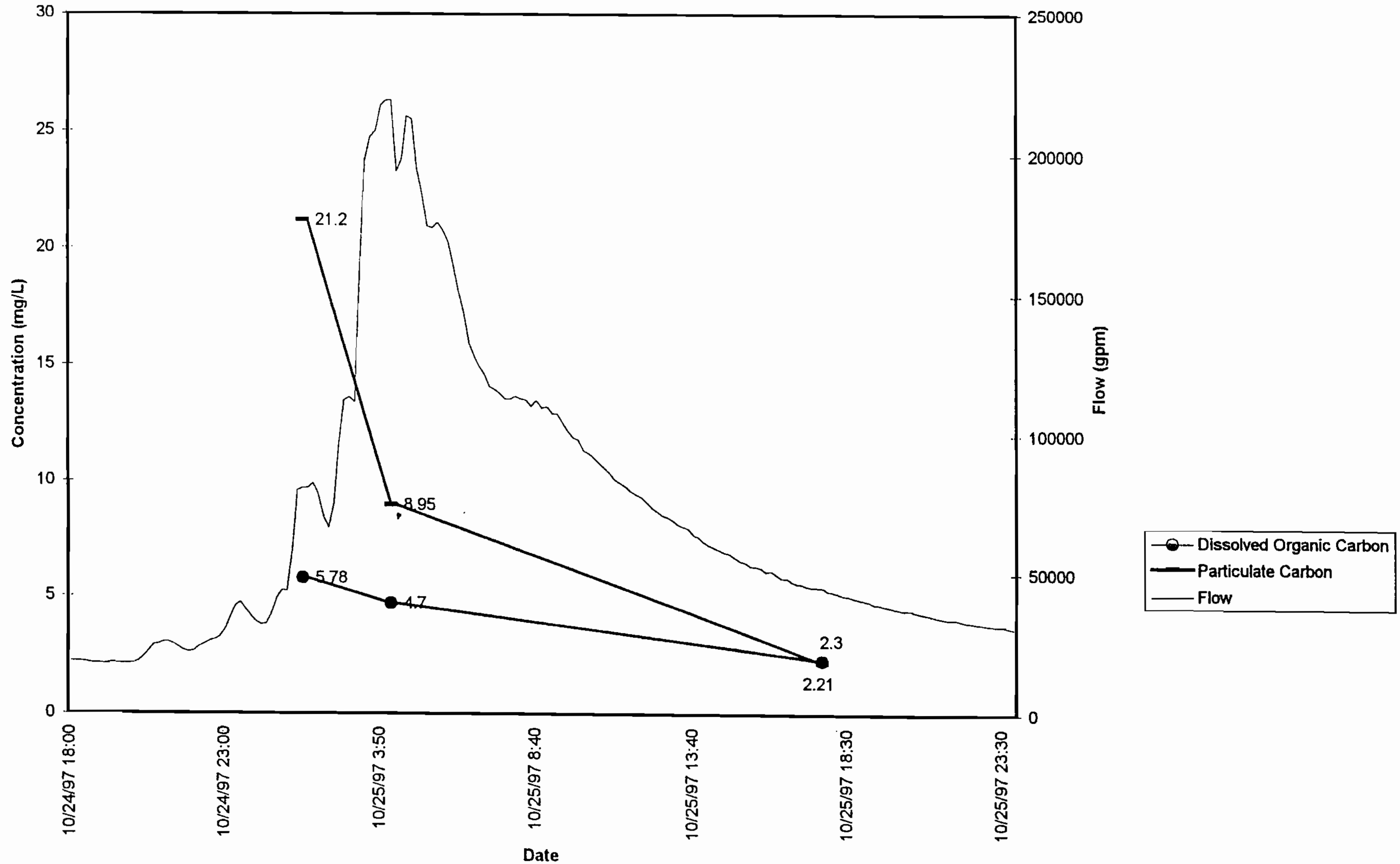


Jones Falls @ Lake Roland October 25 Storm
Phosphorous Results
Concentration (mg/L)
0.08
0.07
0.06
0.05
0.04
0.03
0.02
0.01
0
Flow (gpm)
90000
80000
70000
60000
50000
40000
30000
20000
10000
0
0.0539
0.0376
0.029
0.0091
0.0076
0.0086
10/24/97 18:00
10/24/97 22:50
10/25/97 3:40
10/25/97 8:10
10/25/97 13:00
10/25/97 18:00
Date
Particulate Phosphorous
Total Dissolved Phosphorous
Flow

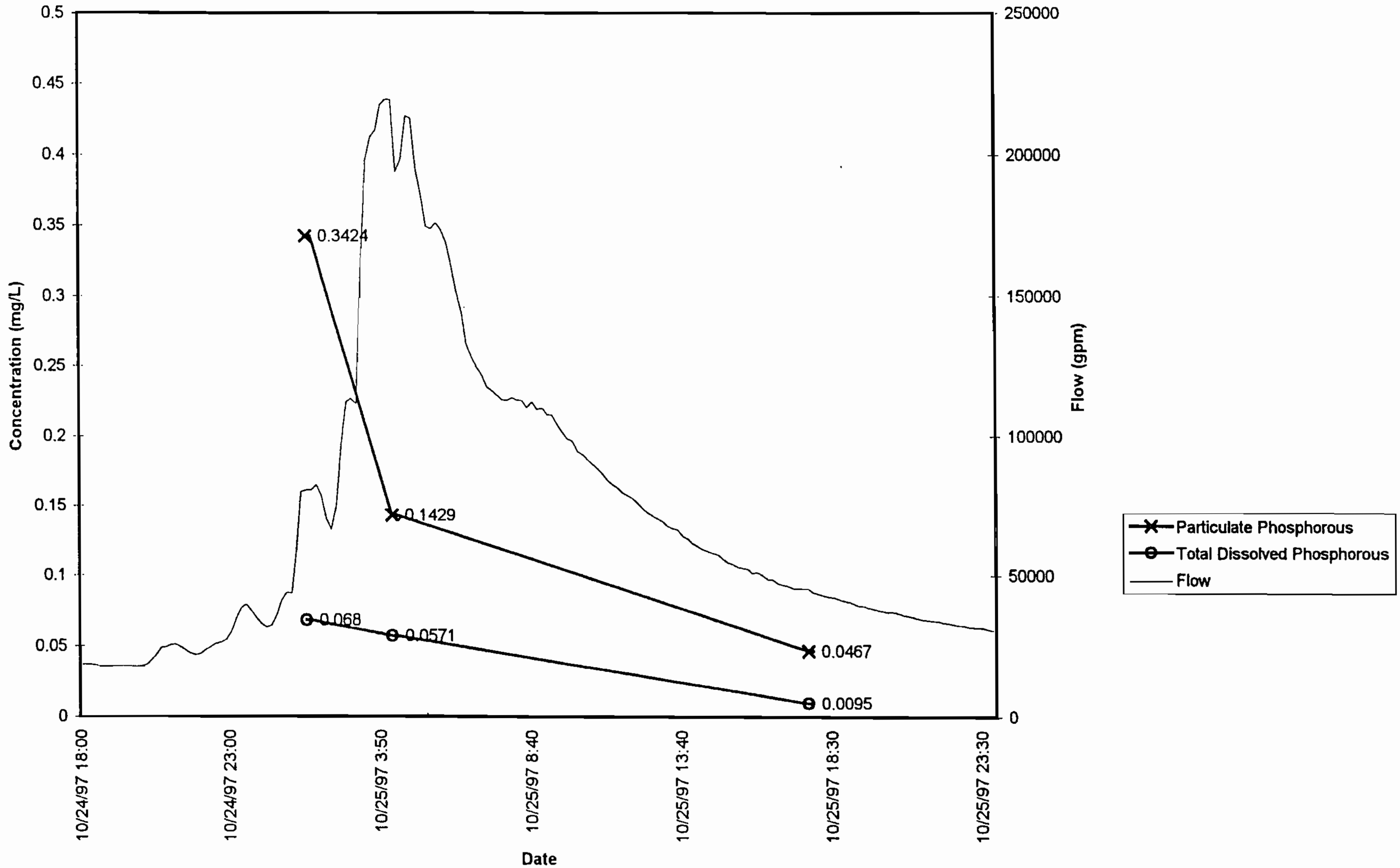
Jones Falls @ Lake Roland October 25 Storm
Total Suspended Solids



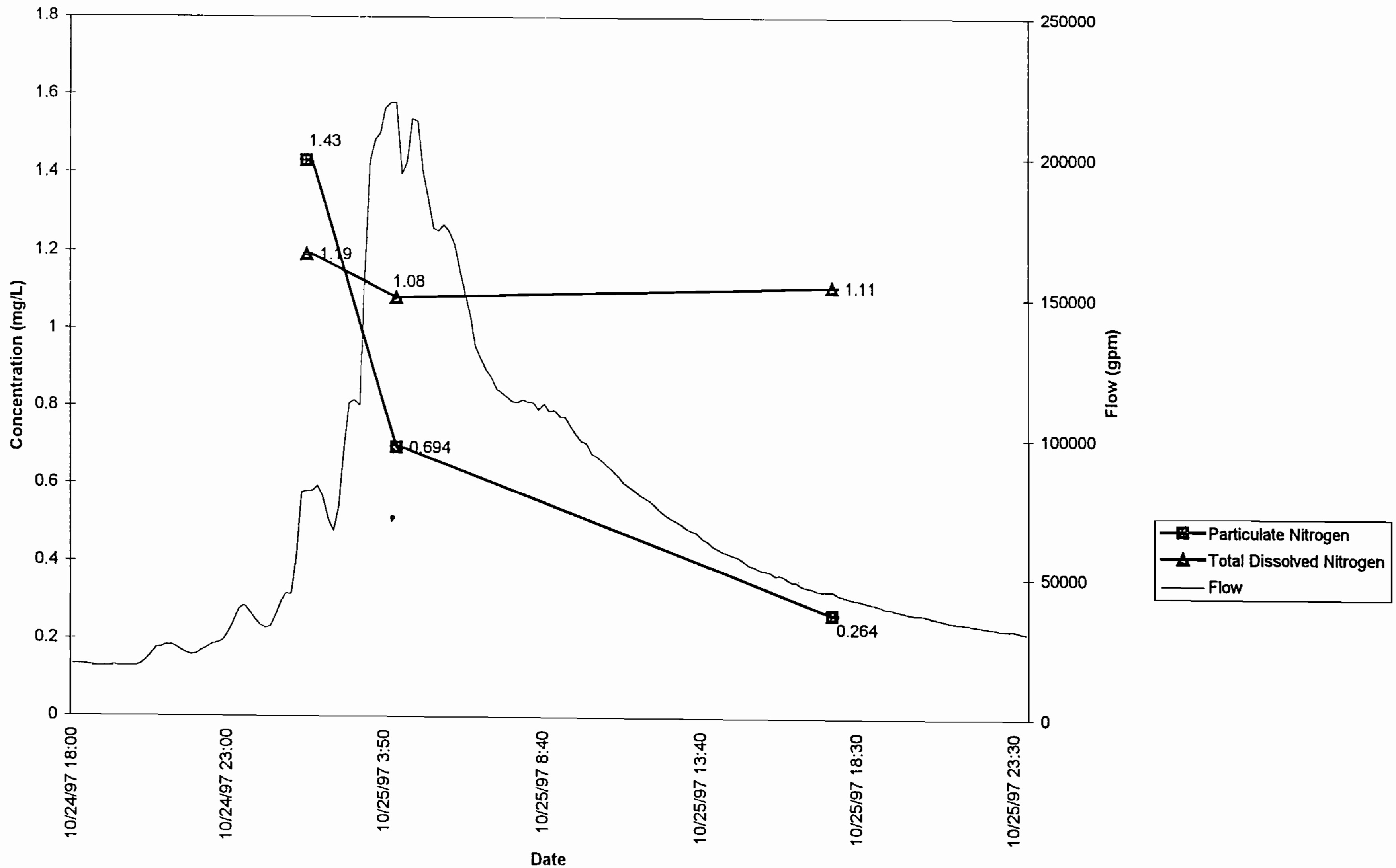
Jones Falls Downstream October 25 Storm
Carbon Results



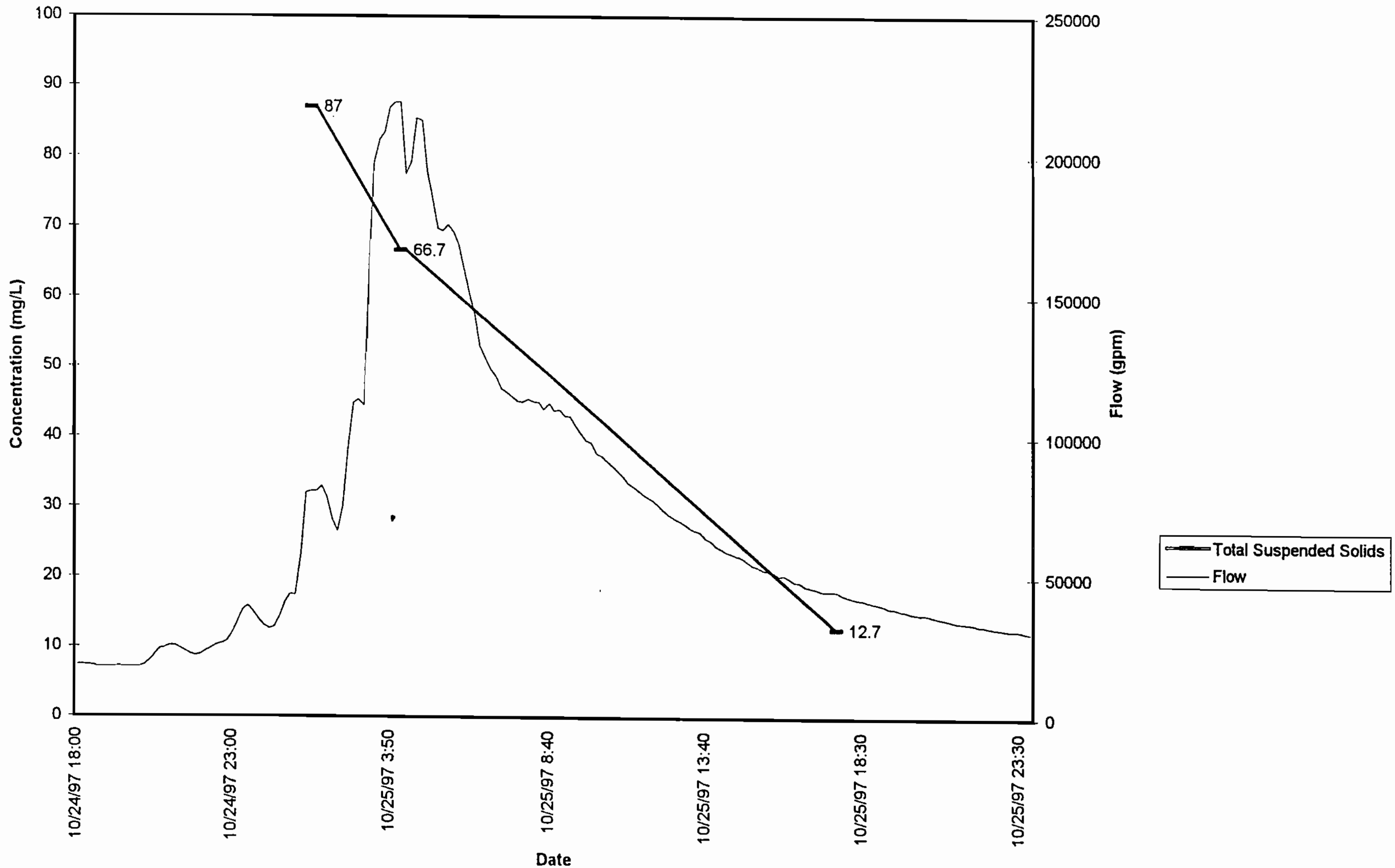
Jones Falls Downstream October 25 Storm Phosphorous Results



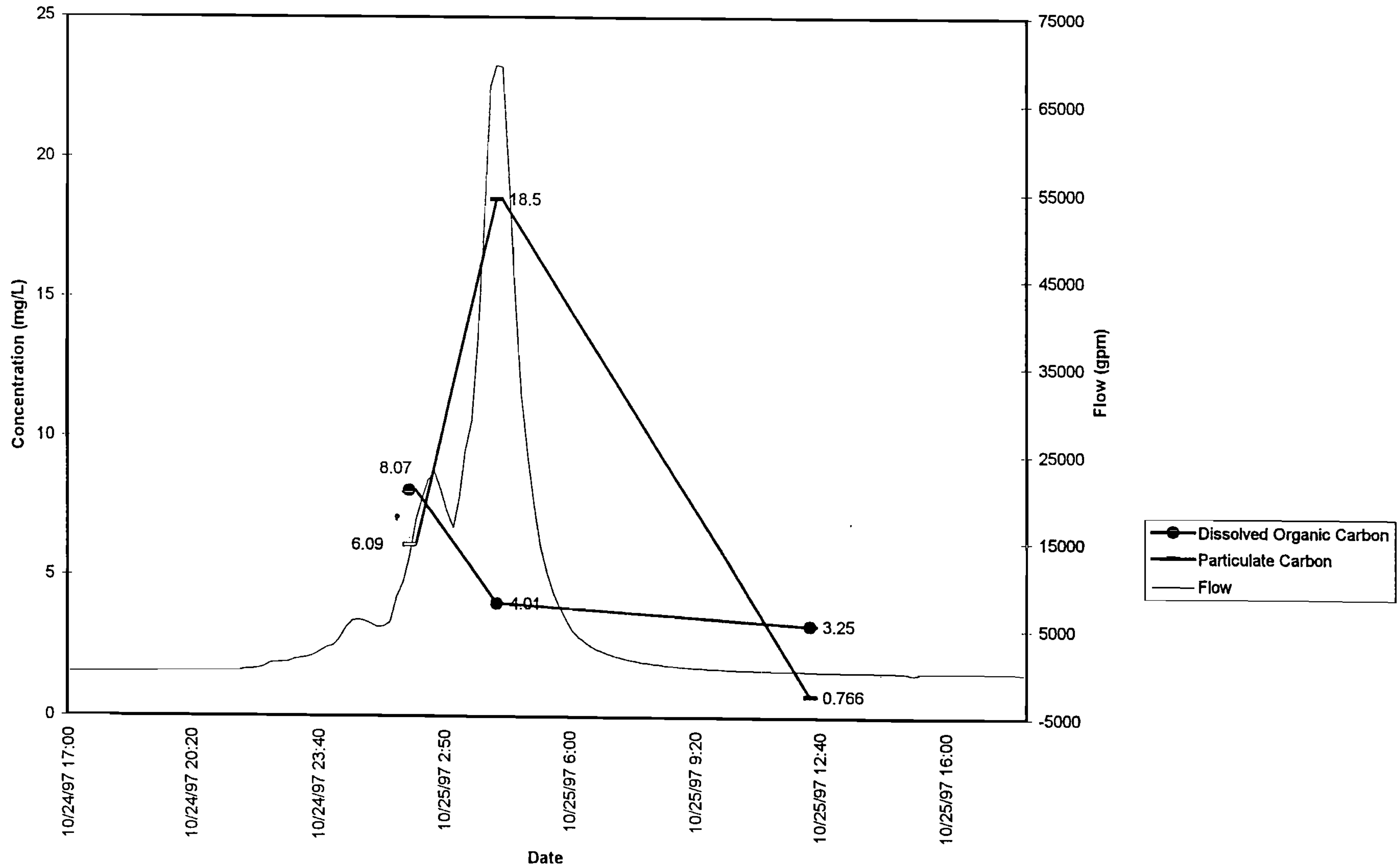
Jones Falls Downstream October 25 Storm
Nitrogen Results

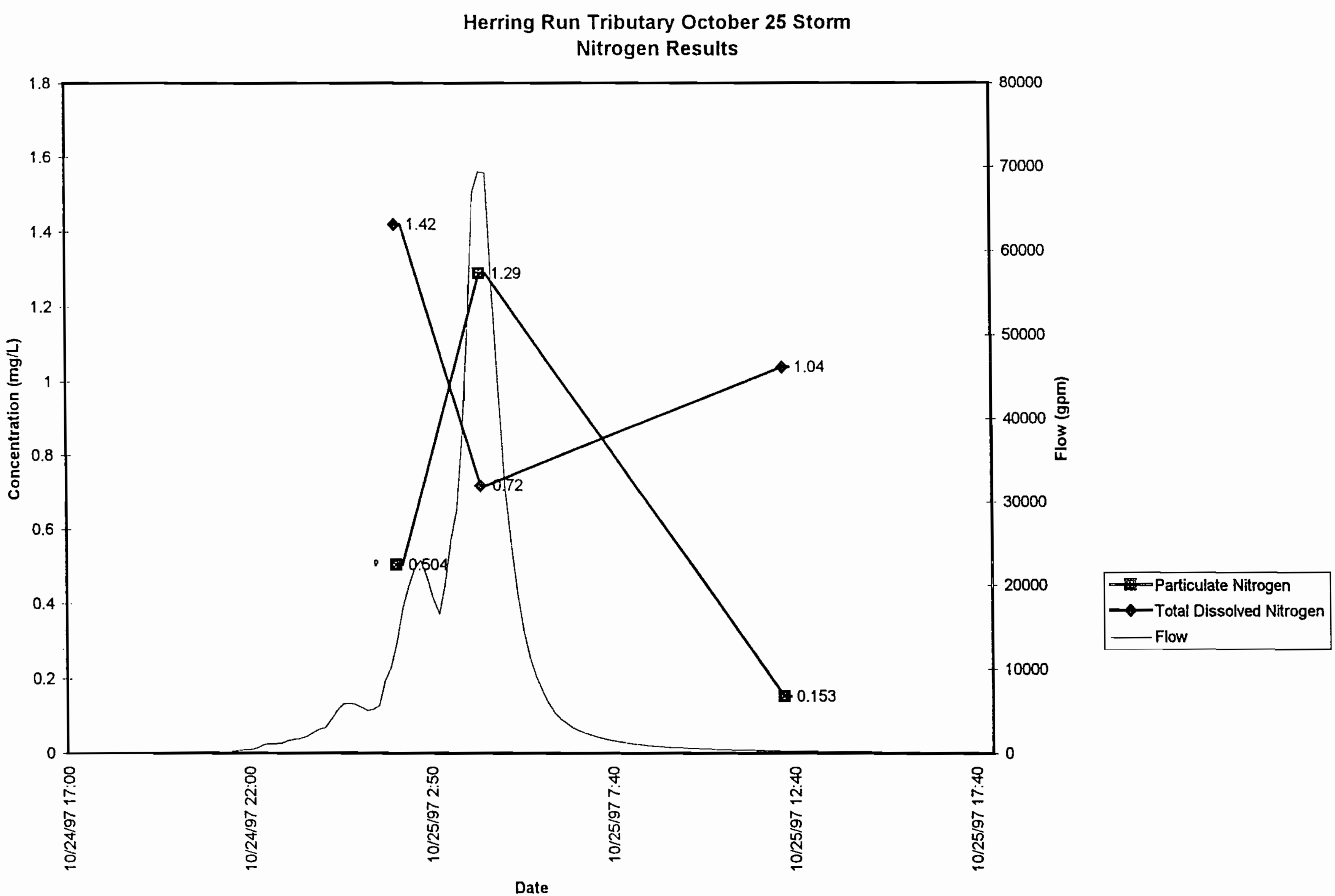


Jones Falls Downstream October 25 Storm
Total Suspended Solids

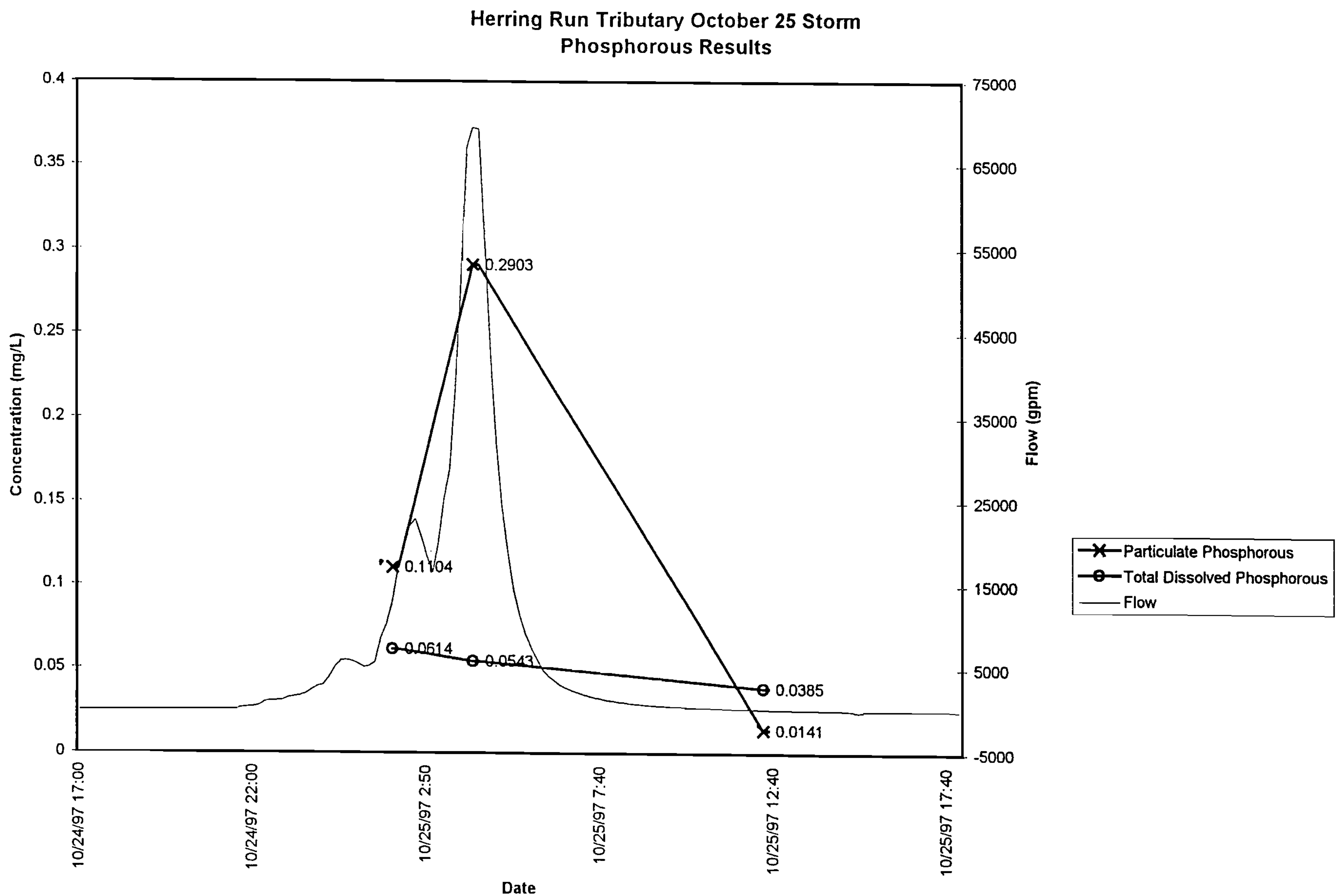


Herring Run Tributary October 25 Storm Carbon Results

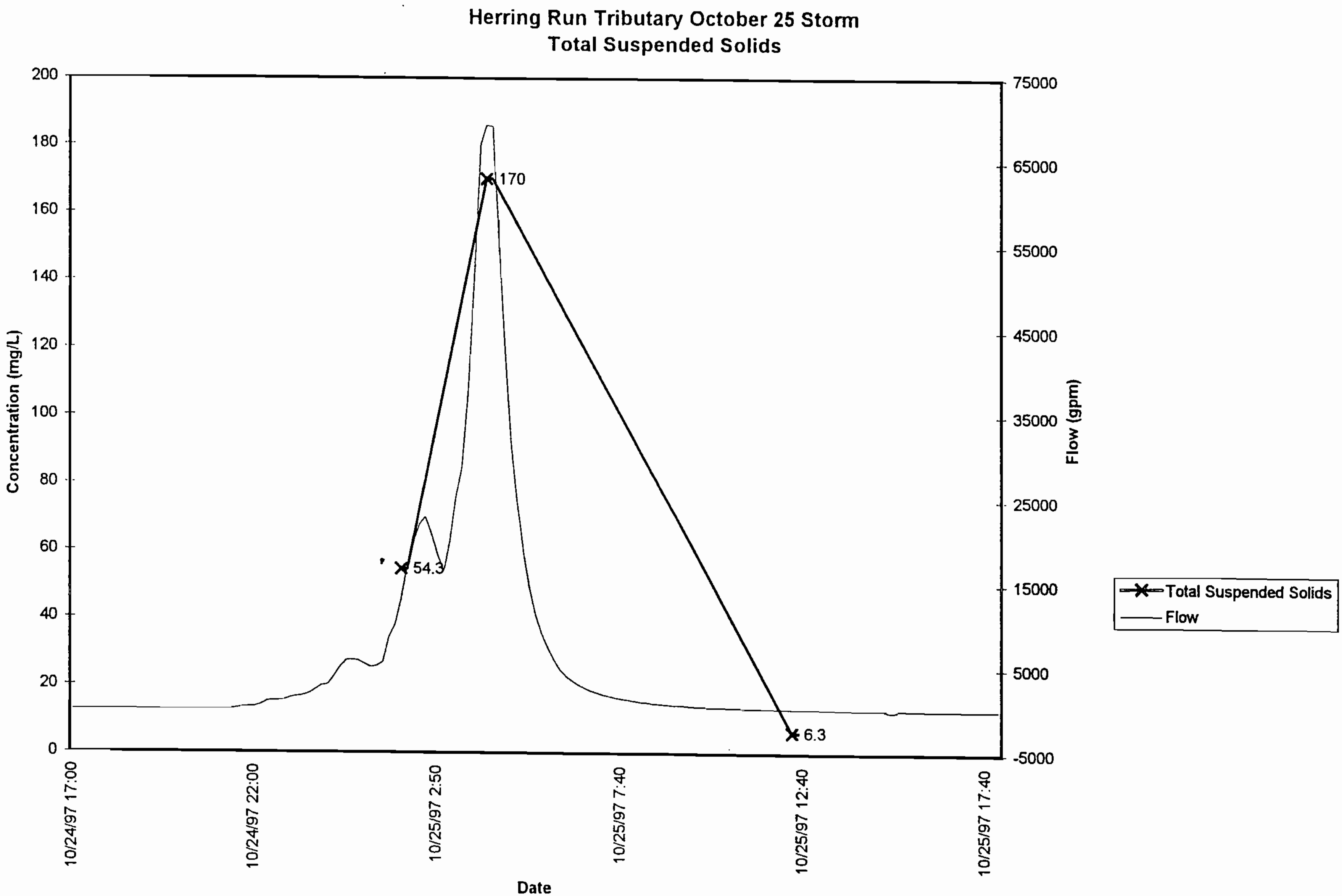




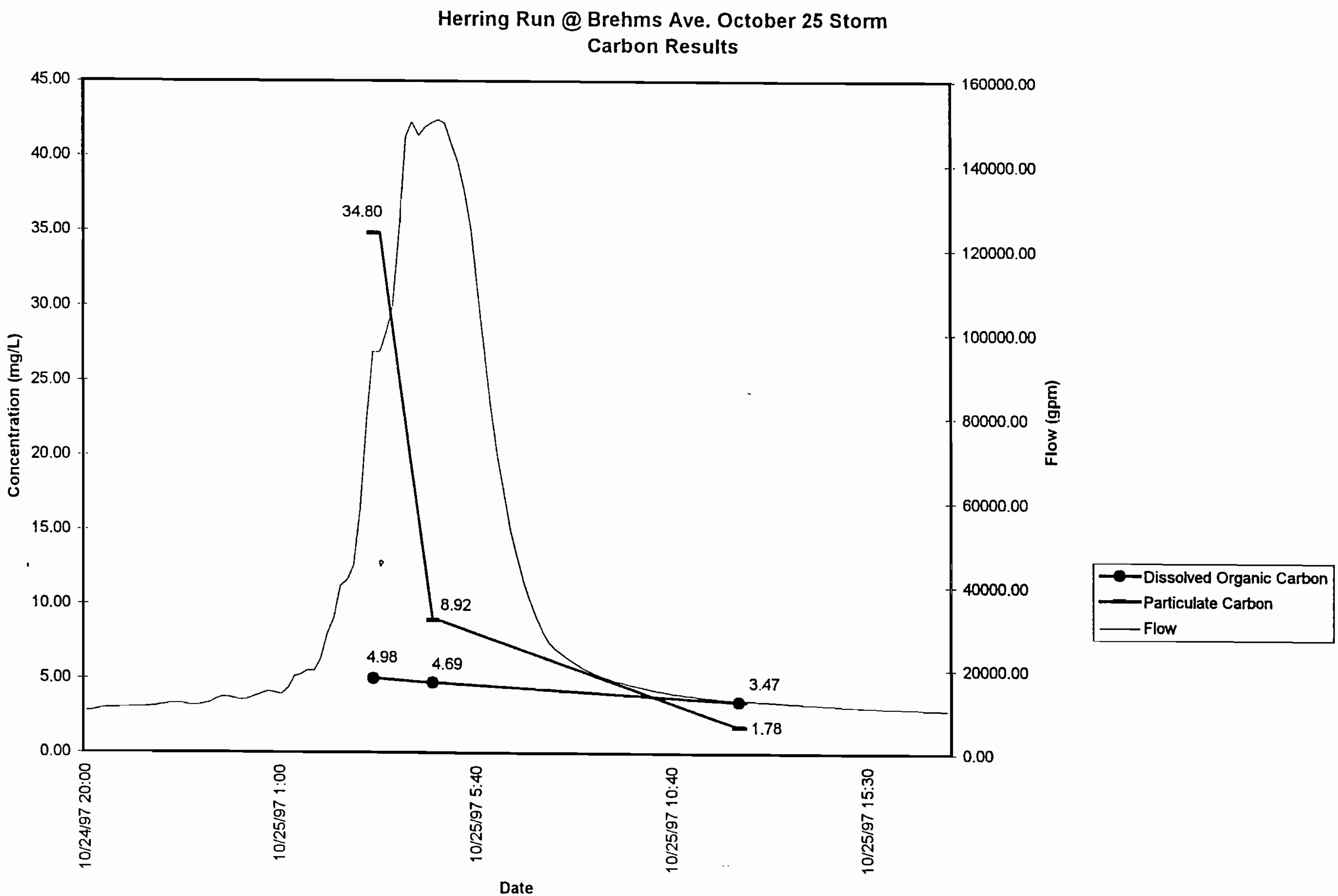
Herring Run Tributary October 25 Storm
Nitrogen Results
1.8
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
Concentration (mg/L)
80000
70000
60000
50000
40000
30000
20000
10000
0
Flow (gpm)
1.42
1.29
1.04
0.72
0.504
0.153
10/24/97 17:00
10/24/97 22:00
10/25/97 2:50
10/25/97 7:40
10/25/97 12:40
10/25/97 17:40
Date
Particulate Nitrogen
Total Dissolved Nitrogen
Flow



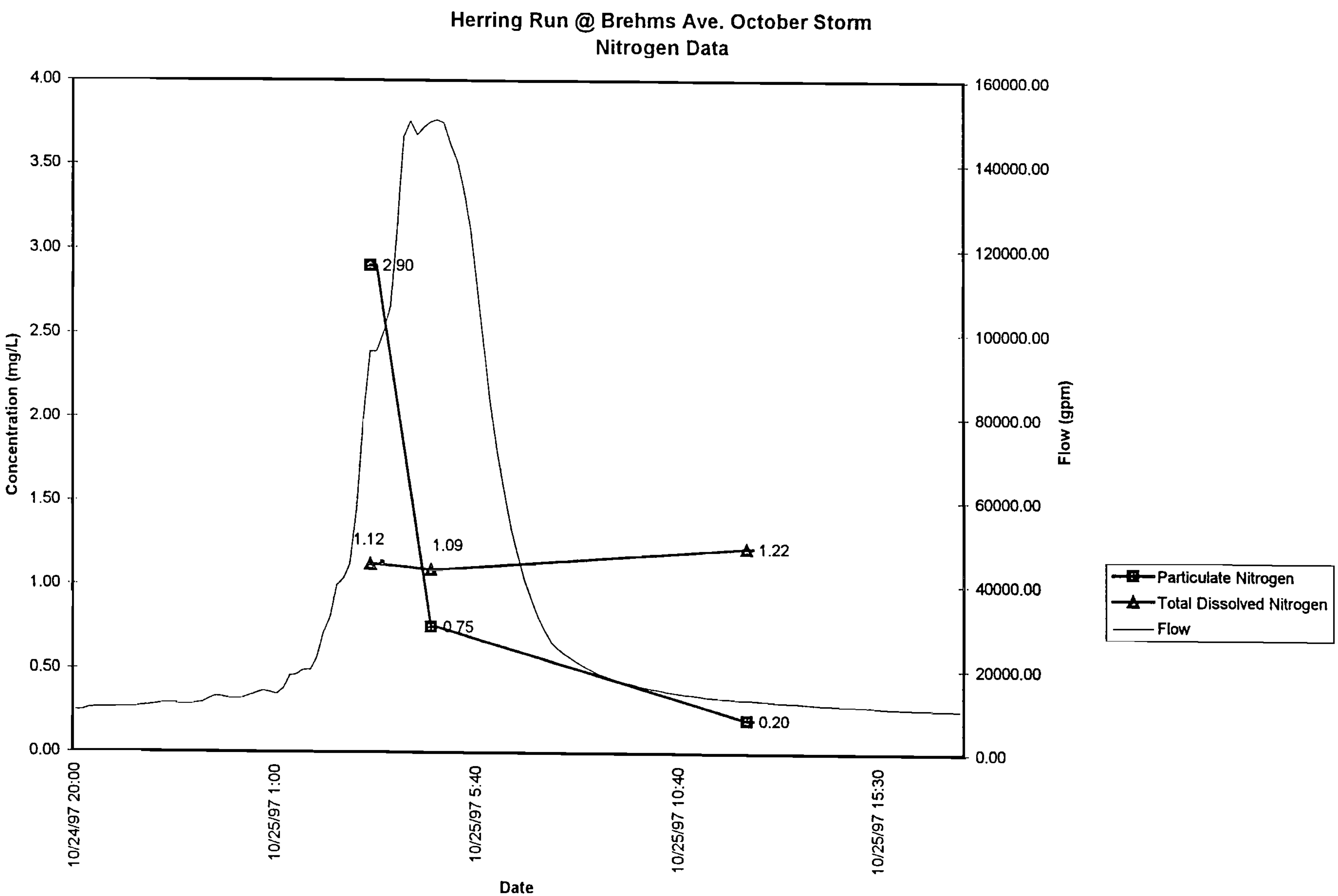
Herring Run Tributary October 25 Storm
Phosphorous Results
Concentration (mg/L)
Flow (gpm)
0.4
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
75000
65000
55000
45000
35000
25000
15000
5000
-5000
0.2903
0.1104
0.0614
0.0543
0.0385
0.0141
10/24/97 17:00
10/24/97 22:00
10/25/97 2:50
10/25/97 7:40
10/25/97 12:40
10/25/97 17:40
Date
Particulate Phosphorous
Total Dissolved Phosphorous
Flow



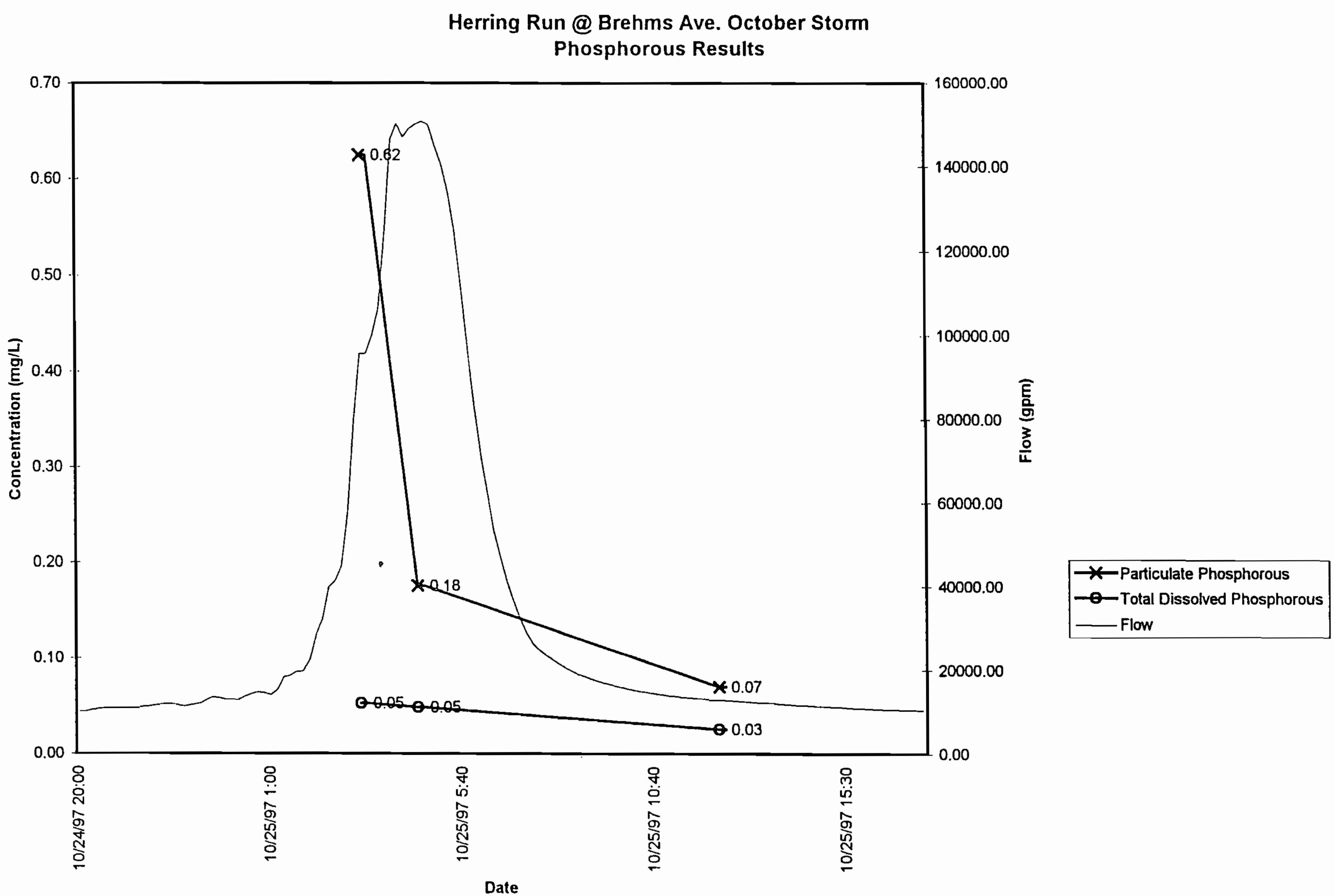
Herring Run Tributary October 25 Storm
Total Suspended Solids
Concentration (mg/L)
Flow (gpm)
Date
200
180
160
140
120
100
80
60
40
20
0
75000
65000
55000
45000
35000
25000
15000
5000
-5000
170
54.3
6.3
10/24/97 17:00
10/24/97 22:00
10/25/97 2:50
10/25/97 7:40
10/25/97 12:40
10/25/97 17:40
Total Suspended Solids
Flow



Herring Run @ Brehms Ave. October 25 Storm
Carbon Results
45.00
40.00
35.00
30.00
25.00
20.00
15.00
10.00
5.00
0.00
Concentration (mg/L)
160000.00
140000.00
120000.00
100000.00
80000.00
60000.00
40000.00
20000.00
0.00
Flow (gpm)
34.80
8.92
4.98
4.69
3.47
1.78
10/24/97 20:00
10/25/97 1:00
10/25/97 5:40
10/25/97 10:40
10/25/97 15:30
Date
Dissolved Organic Carbon
Particulate Carbon
Flow

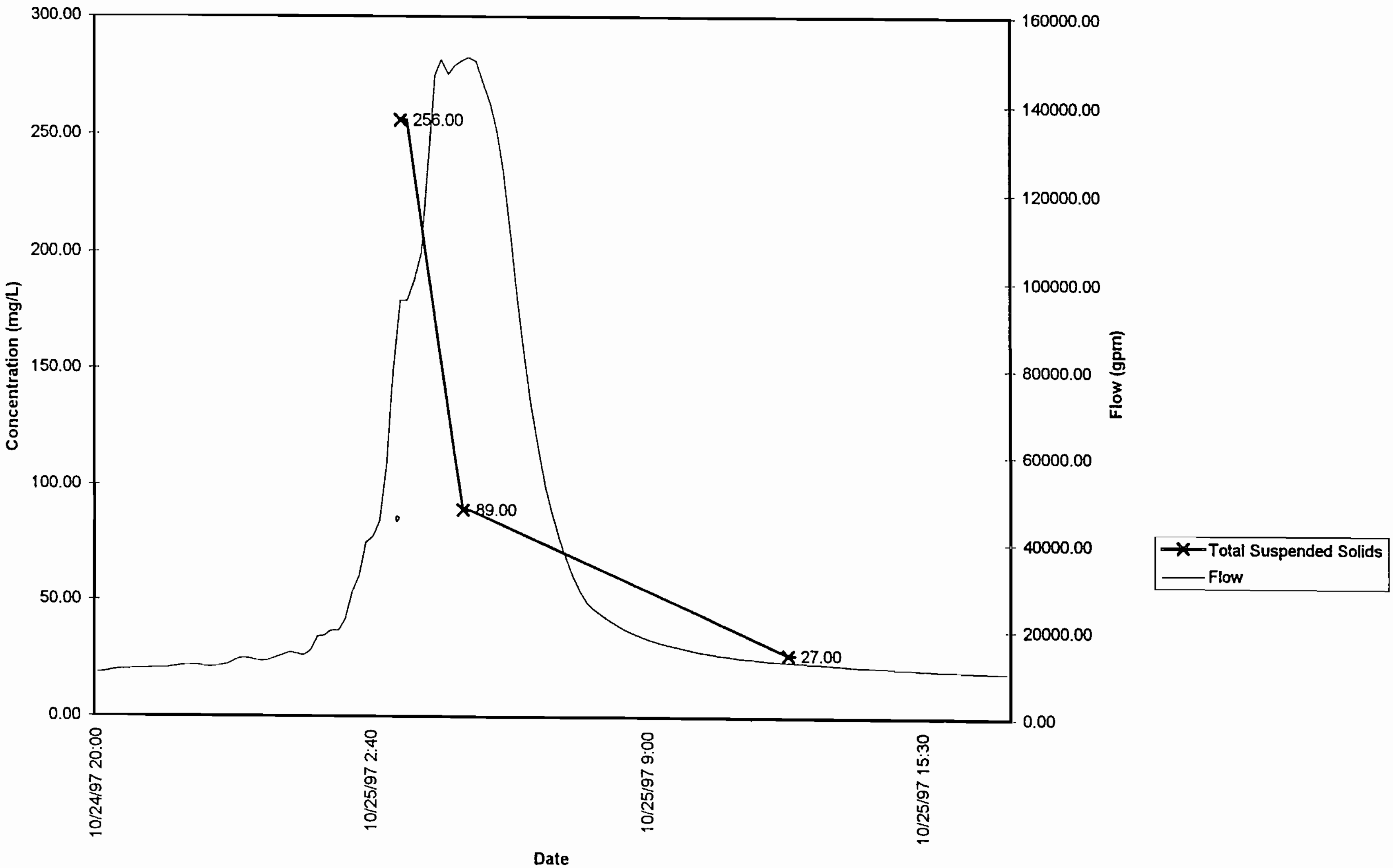


Herring Run @ Brehms Ave. October Storm
Nitrogen Data
Concentration (mg/L)
4.00
3.50
3.00
2.50
2.00
1.50
1.00
0.50
0.00
Flow (gpm)
160000.00
140000.00
120000.00
100000.00
80000.00
60000.00
40000.00
20000.00
0.00
2.90
0.75
0.20
1.12
1.09
1.22
10/24/97 20:00
10/25/97 1:00
10/25/97 5:40
10/25/97 10:40
10/25/97 15:30
Date
Particulate Nitrogen
Total Dissolved Nitrogen
Flow



Herring Run @ Brehms Ave. October Storm
Phosphorous Results
Concentration (mg/L)
0.70
0.60
0.50
0.40
0.30
0.20
0.10
0.00
Flow (gpm)
160000.00
140000.00
120000.00
100000.00
80000.00
60000.00
40000.00
20000.00
0.00
0.62
0.18
0.07
0.05
0.05
0.03
10/24/97 20:00
10/25/97 1:00
10/25/97 5:40
10/25/97 10:40
10/25/97 15:30
Date
Particulate Phosphorous
Total Dissolved Phosphorous
Flow

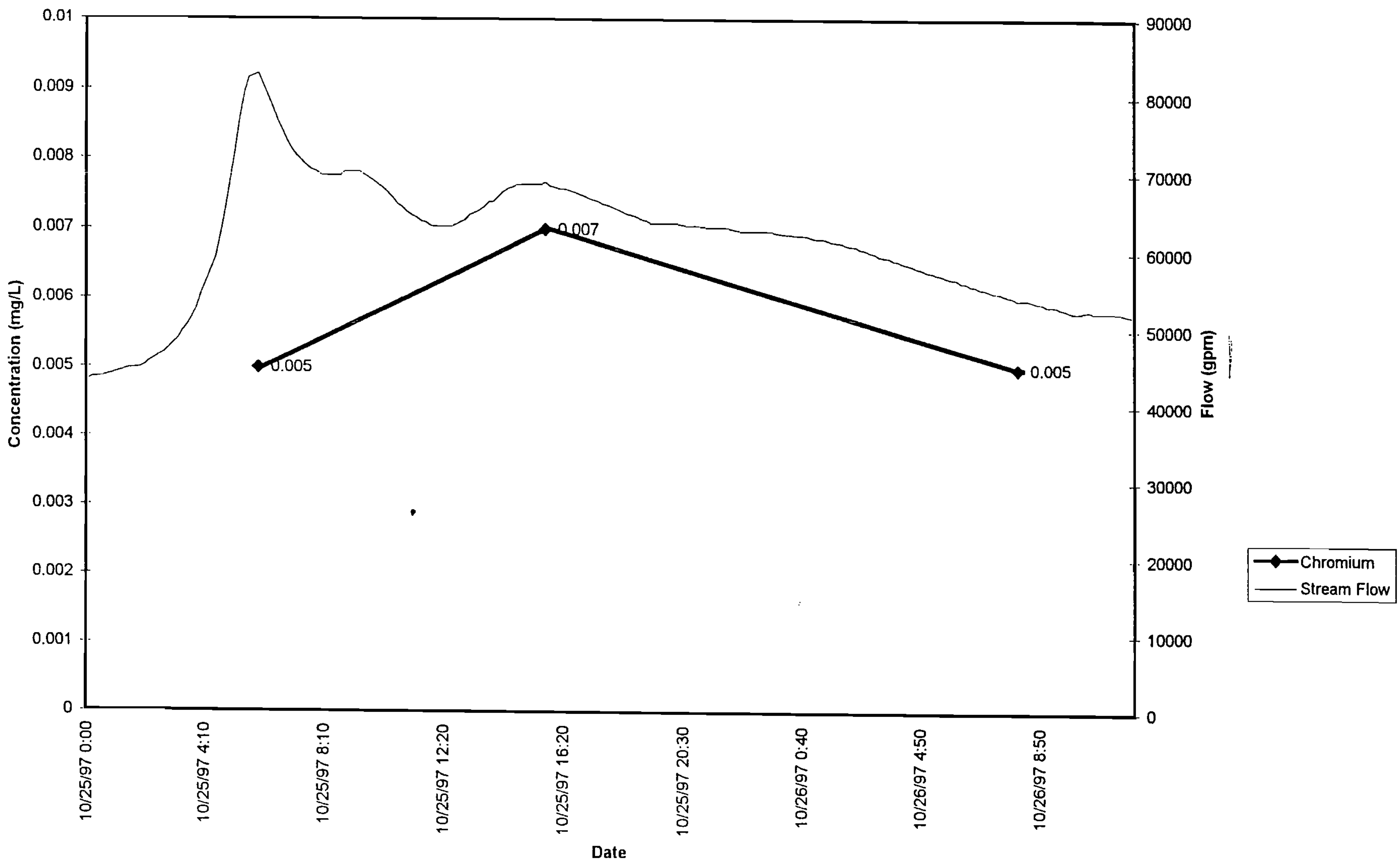
Herring Run @ Brehms Ave. October Storm
Total Suspended Solids

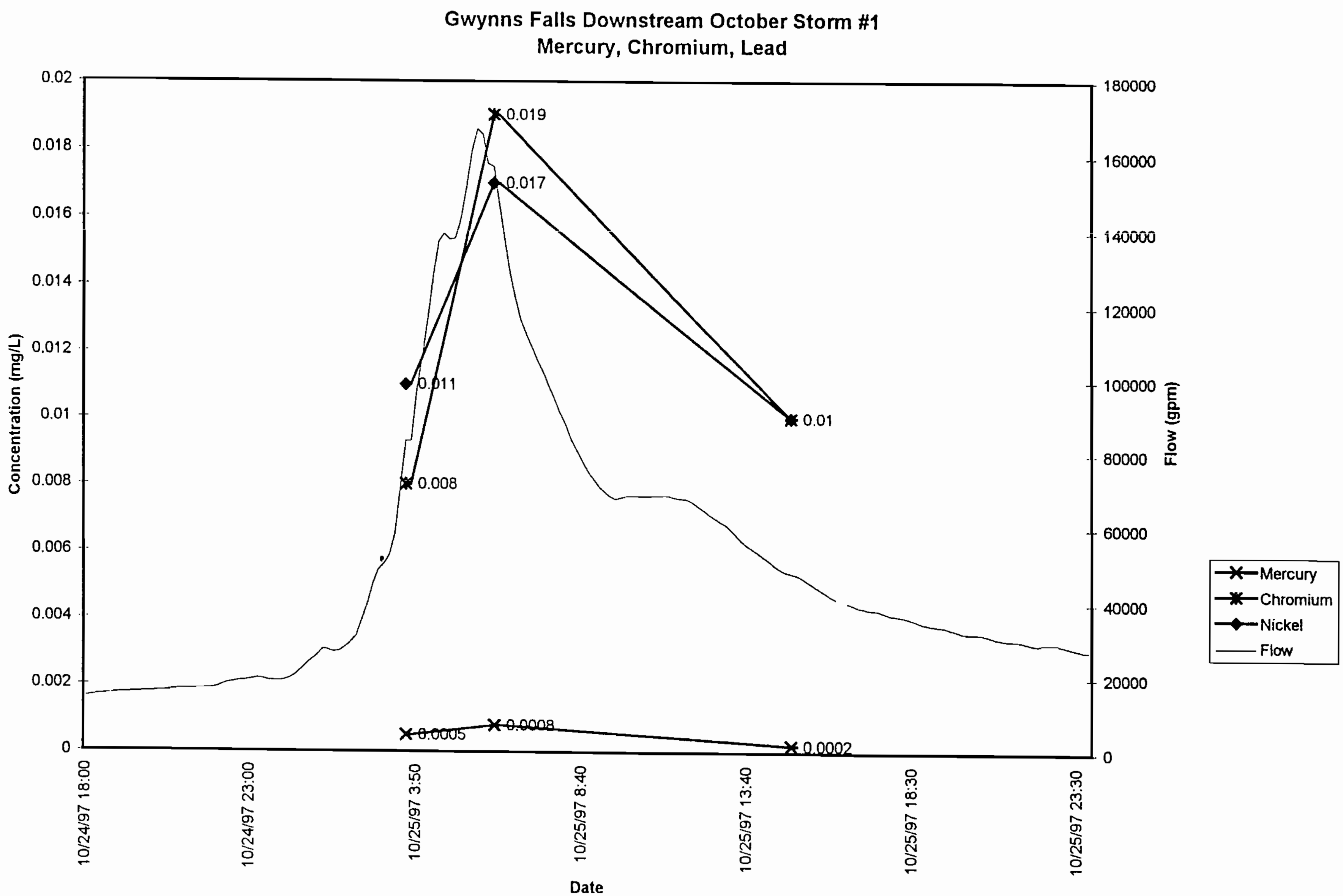


SECTION IV

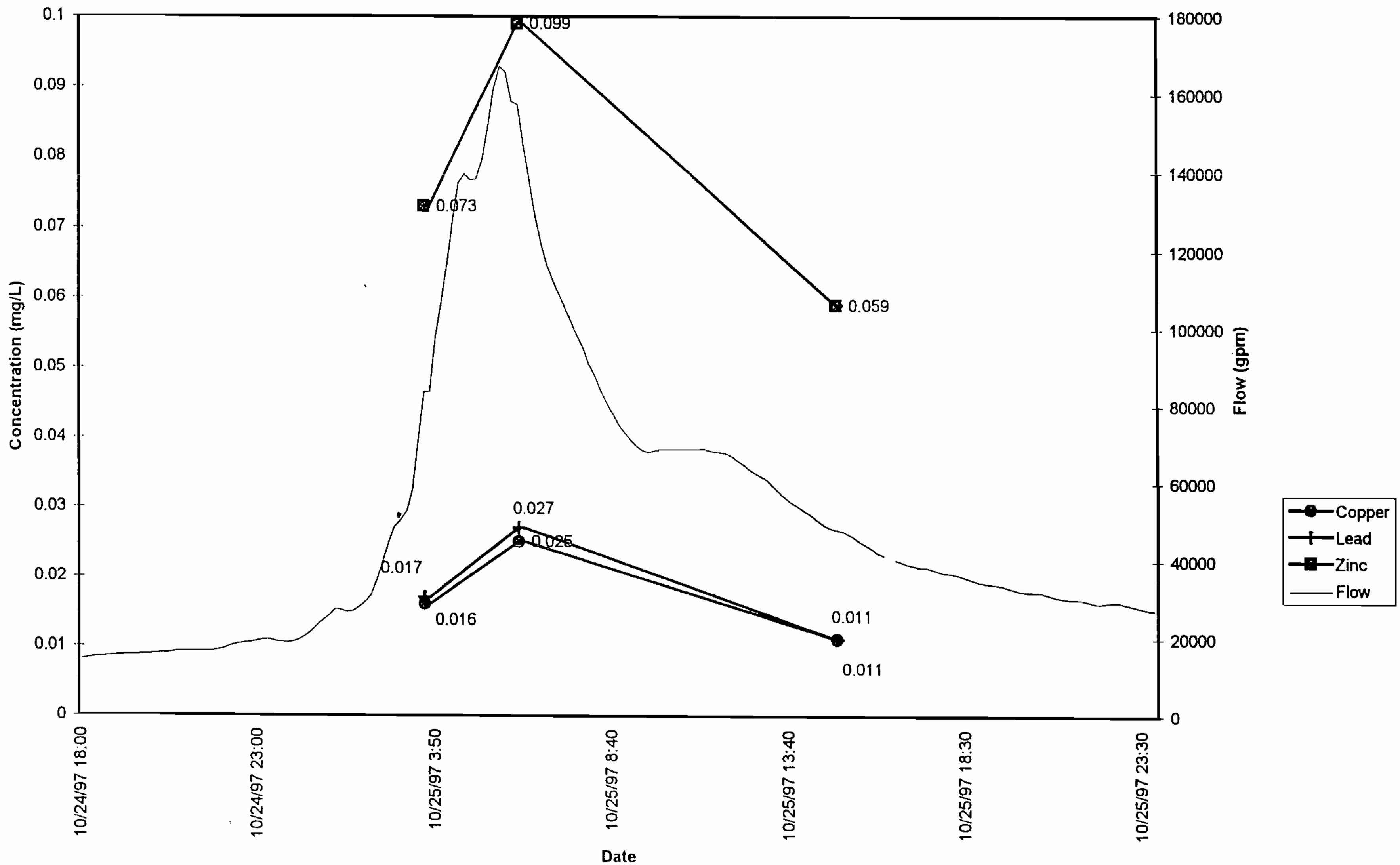
METALS ANALYSIS RESULTS

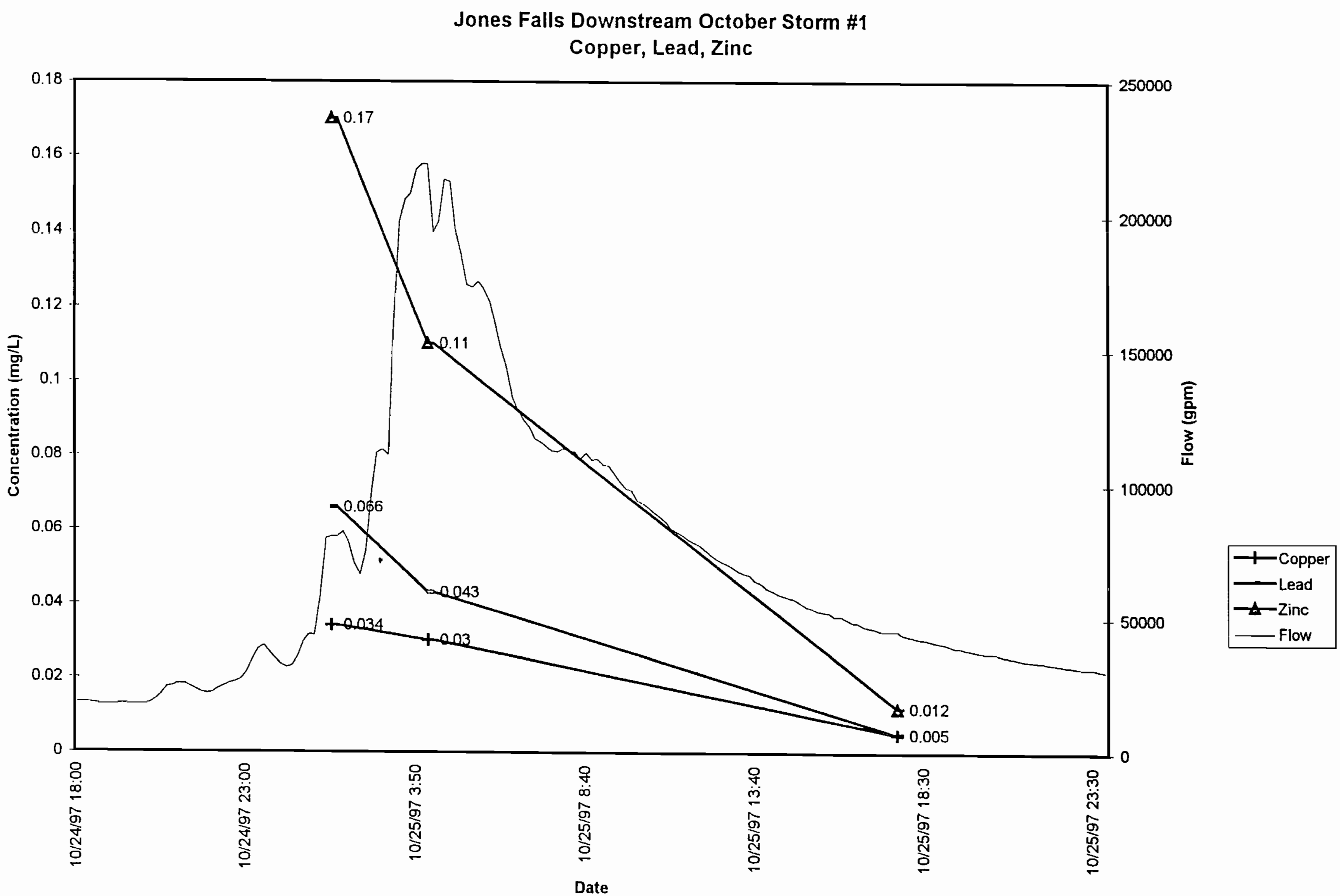
Patapsco River October Storm #1




Gwynns Falls Downstream October Storm #1
Mercury, Chromium, Lead
Concentration (mg/L)
0.02
0.018
0.016
0.014
0.012
0.01
0.008
0.006
0.004
0.002
0
Flow (gpm)
180000
160000
140000
120000
100000
80000
60000
40000
20000
0
0.019
0.017
0.011
0.01
0.008
0.0005
0.0008
0.0002
10/24/97 18:00
10/24/97 23:00
10/25/97 3:50
10/25/97 8:40
10/25/97 13:40
10/25/97 18:30
10/25/97 23:30
Date
Mercury
Chromium
Nickel
Flow

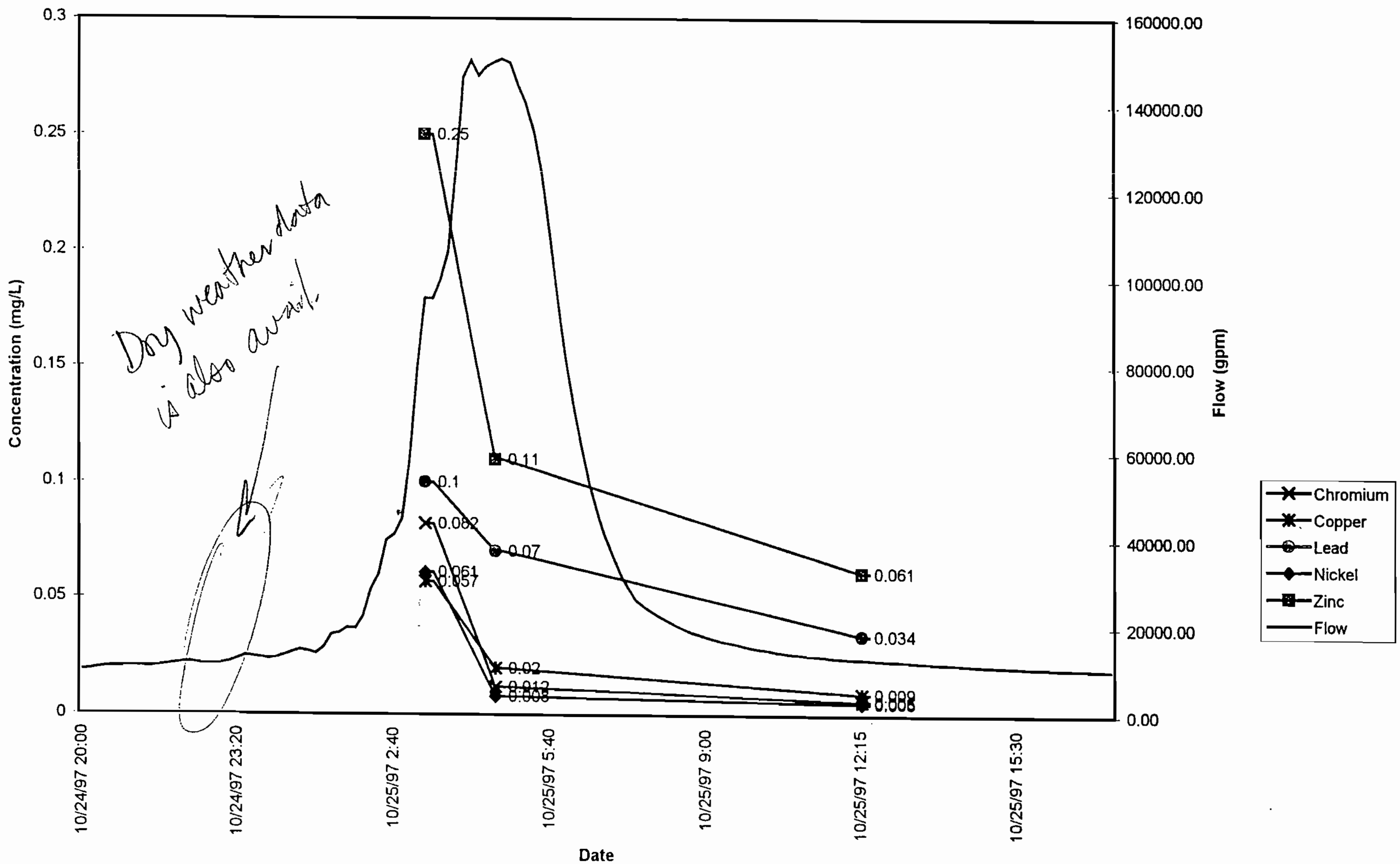
Gwynns Falls Downstream October Storm #1
Copper, Lead, Zinc





Jones Falls Downstream October Storm #1
Copper, Lead, Zinc
Concentration (mg/L)
0.18
0.16
0.14
0.12
0.1
0.08
0.06
0.04
0.02
0
0.17
0.11
0.066
0.043
0.034
0.03
0.012
0.005
Flow (gpm)
250000
200000
150000
100000
50000
0
10/24/97 18:00
10/24/97 23:00
10/25/97 3:50
10/25/97 8:40
10/25/97 13:40
10/25/97 18:30
10/25/97 23:30
Date
Copper
Lead
Zinc
Flow

Herring Run Downstream October Storm #1



AN ENVIRONMENTAL EVALUATION OF BACK RIVER WITH SELECTED DATA FROM PATAPSCO RIVER

(June - September 1997)

PREPARED AT THE REQUEST OF:

Whitman Requardt and Associates, LLP
2315 St. Paul Street
Baltimore, MD 21218

FOR:

The Baltimore City Department of Public Works
Project 613
Master Waste Water Facilities Plan
The Wolman Building, North Holliday Street
Baltimore, MD 21202

PREPARED BY:

W.R. Boynton (Principal Investigator), N.H. Burger, R.M. Stankelis, F.M. Rohland, J.D. Hagy III, J.M. Frank, L.L. Matteson and M.M. Weir

University of Maryland Center for Environmental Science
Chesapeake Biological Laboratory (CBL)
Solomons, MD 20688-0038

Ref. No. [UMCES]CBL 98-112b

AN ENVIRONMENTAL EVALUATION OF BACK RIVER WITH SELECTED DATA FROM PATAPSCO RIVER

(June - September 1997)

PREPARED AT THE REQUEST OF:

Whitman Requardt and Associates, LLP
2315 St. Paul Street
Baltimore, MD 21218

for

The Baltimore City Department of Public Works
Project 613
Master Waste Water Facilities Plan
The Wolman Building, North Holliday Street
Baltimore, MD 21202

October, 1998

W.R. Boynton[1] Principal Investigator
N.H. Burger[1] Sr. FRA, Field Program
R.M. Stankelis[1] Sr. FRA, Field Program Coordinator
F.M. Rohland[1] Ass. Res. Sci., Data Management and Analyst
J.D. Hagy III[1] Graduate Research Assistant
J.M. Frank[1] Physical Scientist, Technician I, Field Program
L.L. Matteson[1] Sr. FRA, Data Entry and Management
M.M. Weir[1] Sr. FRA, Field Program

University of Maryland Center for Environmental Science

[1]Chesapeake Biological Laboratory (CBL)
Solomons, Maryland 20688-0038

TABLE OF CONTENTS

Page No.

TABLE OF CONTENTS (Continued)

TABLE OF CONTENTS (Continued)

Page No.

ACKNOWLEDGEMENTS

Special thanks are expressed to the owners and staff of Rudy's Marina, Inc. of Dundalk, MD and Riverside Marina, Inc. of Essex for use of their facilities and assisstance with the high frequency deployments throughout the summer and fall.

LIST OF FIGURES

LIST OF FIGURES (Continued)

LIST OF TABLES

Page No.

LIST OF TABLES (Continued)

GLOSSARY:

Abbreviation	Explanation
anaerobic	metabolic processes which use substances other than oxygen as a terminal electron acceptor
anoxic	condition where free oxygen (O_2) is not present
BOD	biological oxygen demand
BOD_5	five-day biological oxygen demand
C	Celsius
CBL	Chesapeake Biological Laboratory
cm	centimeters
CO_2	carbon dioxide
CTD	submersible conductivity, temperature and depth instruments
CTBY	Curtis Bay (sampling station)
DO	dissolved oxygen
DIP	alternate abbreviation for dissolved inorganic phosphorus
DNR	Department of Natural Resources
DPCK	Deep Creek (sampling station)
DPW	Department of Public Works
EAI	Exeter Analytical, Inc. CE-440 Elemental Analyzer
Eh	oxidation-reduction potential (redox)
EPA	Environmental Protection Agency
EPC	Ecosystem Processes Component
FFOF	Fairfield Outfall (sampling station)
FYBR	Ferry Bar (sampling station)
g	grams
$g\ m^{-2}\ day^{-1}$	grams per square meter per day
$g\ m^{-3}\ hr^{-1}$	grams per cubic meter per hour
$g\ m^{-2}\ night^{-1}$	grams per square meter per night
$g\ m^{-2}\ yr^{-1}$	grams per square meter per year
GF/F	glass fiber filter
$HgCl_2$	mercuric chloride
HMCK	Humphrey's Creek (sampling station)
HPEL	Horn Point Environmental Laboratory
hypoxic	condition when dissolved oxygen concentration is well below saturation values, generally considered to be less than 3 mg l^{-1}.
INHB	Inner Harbor (sampling station)

GLOSSARY:

Abbreviation	Explanation
$kg\ yr^{-1}$	kilograms per year
km^2	square kilometers
$\mu g\ l^{-1}$	micrograms per liter
$\mu M\ l^{-1}$	micromoles per liter
$\mu M\ m^2\ hr^{-1}$	micromoles per square meter per hour
m	meter
$m\ yr^{-1}$	meters per year
$m^2\ yr^{-1}$	meters squared per year
$m^3\ day^{-1}$	cubic meters per day
$m^3\ hr^{-1}$	cubic meters per hour
MD	Maryland
MDE	Maryland Department of the Environment
MDGT	Muddy Gut (sampling station)
mgd	millions gallons per day
$mg\ l^{-1}$	milligrams per liter
$mg\ l^{-1}\ day^{-1}$	milligrams per liter per day
$mg\ l^{-1}\ hr^{-1}$	milligrams per liter per hour
$mg\ m^{-2}$	milligrams per square meter
$mg\ m^{-3}$	milligrams per cubic meter
ml	milliliters
mV	millivolts
N	nitrogen
na	not available
NASL	Nutrient Analytical Services Laboratory
NH_4^+	ammonium
NOAA	National Oceanographic and Atmospheric Administration
NO_2^-	nitrite
$NO_2^- + NO_3^-$	nitrite plus nitrate
$\#\ l^{-1}$	numbers per liter
P	phosphorus
Pa	net oxygen production ($g\ O_2\ m^{-3}\ day^{-1}$) between sunrise and sunset
Pa *	net oxygen production during periods of net autotrophy ($gO_2\ m^{-3}\ day^{-1}$), which occurs between times or dissolved oxygen minimum (SRm) and maximum (SSm).

GLOSSARY:

Abbreviation	Explanation
PAR	photosynthetically active radiation
PC	particulate organic carbon
Pg	gross oxygen production (g O_2 m^{-3} day^{-1}) between sunrise and sunset, assuming daytime respiration rate is equal to nighttime respiration rate (Rn hr^{-1}) during subsequent night
Pg*	gross oxygen production during period of net autotrophy (g O_2 m^{-3} day^{-1}), assuming daytime respiration rate is equal to nighttime respiration rate (Rn hr^{-1}) during subsequent night
PN	particulate organic nitrogen
PO_4^{-3}	dissolved inorganic phosphate (µM P)
POSAT	percentage oxygen saturation
PP	particulate phosphorus (a large but variable portion of PP is inorganic)
ppt	parts per thousand
Rn	night respiration (gO_2 m^{-3} day^{-1}): oxygen consumption between sunset and sunrise
Rn hr^{-1}	night respiration rate (gO_2 m^{-3} hr^{-1}); mean hourly oxygen consumption rate between sunset and sunrise.
RVBH	Rivera Beach (sampling station)
SAV	submerged aquatic vegetation
Si	silicon
$Si(OH)_4$	silicate
SOC	sediment oxygen consumption
SONE	sediment oxygen and nutrient exchanges
SRm	metabolic Sunrise: time of DO minimum during daylight hours
SSm	metabolic Sunset: time of DO maximum during daylight hours
t	time intervals in hours
TCO_2	total dissolved inorganic carbon
TN	total nitrogen
TP	total phosphorus
TSS	total suspended solids
WCPT	Witch Coat Point (sampling station)
WWTP	wastewater treatment plant
YSI	Yellow Springs Instrument - Model 6920 was used in this study

EXECUTIVE SUMMARY

Purpose of Study

Eutrophication is the enrichment of aquatic systems with nutrients or organic matter and this process is becoming an increasingly important problem in estuaries in many areas of the world, including Chesapeake Bay. Highly fertilized systems often have increased algal blooms, occurrences of hypoxia and anoxia in bottom waters, losses of sea grasses and other commercially and recreationally important species. Many tributary sub-systems of Chesapeake Bay show signs of eutrophication and both Back and Patapsco Rivers have shown clear indications of extreme eutrophication for several decades (Magnien, 1993).

The present monitoring study was composed of three parts: (1) an examination of available information for the Back River basin related to land use and diffuse source nutrient loads, sewage treatment plant discharges and selected water quality conditions during the period 1984 through 1996. The purpose of this component was to provide historical context in which to interpret the results of current monitoring results and to construct total nitrogen (TN) and total phosphorus (TP) input budgets; (2) monitoring of sediment-water exchanges of nutrients, oxygen and carbon at two stations in Patapsco River and three stations in Back River during June, July and August 1997. This portion of the study provided estimates of the magnitude of sediment processes which can have a substantial impact on water quality conditions; (3) high frequency monitoring (15 minute intervals) of dissolved oxygen (DO), temperature and salinity at two locations in Back River during summer, 1997. The goal of this activity was to supplement conventional biweekly water quality monitoring in this targeted tributary with nearly continuous monitoring of several variables known to exhibit fundamental responses to nutrient enrichment.

Data Sources, Monitoring Sites and Schedule

Water quality data (salinity, DO, secchi disk depth and chlorophyll-a) were obtained from the Chesapeake Bay Water Quality Monitoring Program. This program has collected data in the Back River since 1986. Land use data and land use nutrient yield coefficients were obtained from the Maryland Department of Environment (MDE) and sewage treatment plant discharge rates and concentrations were obtained from the Back River Wastewater Treatment Plant (WWTP) and MDE. These data were used to construct TN and TP input budgets.

Five stations in the oligohaline (0.5 - 5.0 ppt) region of Patapsco and Back Rivers were visited three times during 1997 (June, July and August) and measurements of sediment-water exchanges conducted using standard field methods. Stations located in Back River were adjacent to Deep Creek (DPCK), Witch Coat Point (WCPT) and Muddy Gut (MDGT). Stations located in Patapsco River were adjacent to Fairfield Outfall (FFOF) and Humphrey's Creek (HMCK).

Continuous high frequency field measurements of water quality were conducted for 3 months at two sites on Back River (20 June, 1997 through 24 September, 1997). Submersible self-recording monitoring instruments recorded DO, temperature and salinity every 15 minutes at a depth of one meter below the water surface. Water samples were also collected each week and analysed for DO and chlorophyll-a.

Background Water Quality Information

Monthly average values for salinity, secchi disk depth, DO and chlorophyll-a were examined for the period 1986 through 1995. Salinity values ranged from zero to 6 ppt and were similar to those observed during this monitoring project (0.5 - 7.2 ppt). With few exceptions, secchi disc values were less than 0.4 m and frequently 0.2 m. These values equate to light extinction coefficients of 4.3 and 8.5, respectively. Under these conditions 1% of surface radiation only reaches to depths of 1.1 and 0.6 m, respectively, considerably less than the mean depth of Back River estuary (1.8 m). DO concentrations measured between 1986 and 1996 generally ranged between 8 and 12 mg l^{-1}; there were no values that were observed below 2 mg l^{-1} and highest values were about 18 mg l^{-1}. In the present study, DO ranged between 2.5 and 22 mg l^{-1}. Chlorophyll-a concentrations were as high or higher than those observed in the Bay monitoring program; during July and August, 1997 concentrations at the WWTP station were close to or exceeded 300 $\mu g\ l^{-1}$ and concentrations farther down estuary were between 200 and 300 $\mu g\ l^{-1}$. The extremely large diel excursions in DO, low transparency and large chlorophyll-a concentrations are all characteristic of a shallow estuary having relatively long residence times (to allow the build-up of algal stocks) and enrichment via inorganic nutrients. Daily TN and TP loading rates from the Back River WWTP were examined for 1997. Freshwater flows, TN and TP loads were about $0.3 \times 10^6\ m^3\ day^{-1}$, 1.28×10^6 kg yr^{-1} and 1.83×10^4 kg yr^{-1}, respectively. If nutrient loads from all sources to Back River were prorated over the surface area of the estuary, annual areal loads of about 0.0094 kg N $m^{-2}\ yr^{-1}$ and 0.0027 kg P $m^{-2}\ yr^{-1}$ result.

High Frequency Measurements of Dissolved Oxygen

The high frequency DO data collected in Back River were evaluated to assess compliance with living resource habitat criteria for DO. At both sites the frequency of occurrence of low DO values was low; for example, at Riverside Marina DO values of 3 mg l^{-1} occurred about 1% of the time or for about 23 hours during the 97 day monitoring period. At both sites DO concentrations below 5 mg l^{-1} occurred only about 3% of the time or for about 70 hours during the summer.

The magnitude of net autotrophic oxygen production (Pa*) ranged from near zero to about 18 g $O_2\ m^{-3}\ day^{-1}$. Production was variable from day to day but rates tended to be higher in late June and July than in late August and September. Analyses of the temporal pattern in Pa* suggests relationships to sunlight (daily variability due to clear and cloudy days), algal biomass and seasonal changes in water temperature. Community night-time respiration (Rn) ranged from near zero to about 8 g $O_2\ m^{-3}\ day^{-1}$ at both sites; rates of Rn were also variable on a day to day basis. The broad pattern in respiration estimates was an increase in rates from late June through early August, followed by a decrease through early fall.

Sediment-Water Nutrient and Oxygen Exchanges

Data from a variety of coastal and estuarine systems were examined and ammonium (NH_4^+) fluxes from sediments most often ranged from 25 to 250 μM N $m^{-2}\ hr^{-1}$. The fluxes measured in this study were high to very high in comparison with other areas of Chesapeake Bay and world; very large fluxes of NH_4^+ (300 - 700 μM N m^{-2} hr^{-1}) were also observed at all Back/Patapsco River stations during 1997. These extremely high fluxes are characteristic of very eutrophic ecosystems. Sediment fluxes of dissolved inorganic phosphorus (PO_4^{-3}) were related to NH_4^+ fluxes in proportions reflecting expected composition of original organic matter supplies to sediments. In comparison to other areas of the world and Chesapeake Bay, fluxes in the Patapsco River/Back River sub-systems were very large, again indicating very eutrophic conditions.

2. INTRODUCTION

Eutrophication is the enrichment of an aquatic system with nutrients or organic matter. This process is becoming an increasingly important problem in estuaries in many areas of the world, including Chesapeake Bay. Anthropogenic activity directly affects nutrient inputs in estuarine systems (Nixon, 1990) while population growth and associated activities along the East Coast have intensified eutrophic conditions in many areas. Excessive nutrient inputs greatly affect the water quality of a system. Highly fertilized systems often have increased algal blooms, occurrences of hypoxia and anoxia in bottom waters, losses of sea grasses and other commercially and recreationally important species. Many tributary sub-systems of Chesapeake Bay show signs of eutrophication and Back River has shown clear indications over many decades of extreme eutrophication (Robertson, 1977).

Estuarine systems, such as Chesapeake Bay, characteristically have high rates of nutrient inputs compared to other ecological systems. Nutrients enter the system via a variety of terrestrial and atmospheric sources. Point sources derived from sewage treatment facilities and industrial discharges can enhance nutrient inputs to a particular area. Urbanization and farming of previously forested areas also increases the amount of nitrogen (N) and phosphorus (P) reaching the system from land by increasing terrestrial nonpoint sources. Other anthropogenic activity also exacerbates the existing problem of elevated nutrient loading. Air pollution increases the amount of N and P entering the system via wet and dry fall.

The Chesapeake Bay Program and Maryland Department of the Environment (MDE) developed the Tributaries Strategy Initiatives Program in accordance with a 1992 Executive Council decision to re-focus the 1987 Chesapeake Bay agreement from the mainstem of the Bay to its tributaries. The overall goal of the agreement is to reduce nutrient inputs by 40% by the year 2000 in each of the Chesapeake's ten tributary sub-systems. The Patapsco River, Baltimore Harbor and Back River basins constitute several of these targeted systems.

In previous years the Maryland Chesapeake Bay Water Quality Monitoring program recorded anoxic and hypoxic events during summer months in Patapsco River and occasionally low DO values in Back River. Some of the highest chlorophyll-a concentrations observed in the entire Chesapeake system have been routinely recorded in Back River while water transparency in this system is extremely low. Calculated areal total nitrogen (TN) and total phosphorus (TP) loads to the Patapsco and Back River systems are higher than loads to most portions of the bay, including such nutrient stressed areas as Potomac River and the Maryland portion of the mainstem bay (Stammerjohn *et al.*, 1991; Boynton *et al.*, 1995a). All of these systems also suffer from seagrass loss and other changes in trophic structure.

The present monitoring study was composed of three parts:

1. An examination of available information for the Back River basin related to land use and diffuse source nutrient loads, wastewater treatment plant (WWTP) discharges and selected water quality conditions during the period 1984 through 1996. The purpose of this component was to provide relevant historical information against which to interpret the results of the current monitoring

program and to construct TN and TP input budgets for the Back River system;

2. Monitoring of sediment-water exchanges of nutrients, oxygen and carbon at three stations in Back River and at two stations in Patapsco River during June, July and August, 1997. This portion of the study provides estimates of the magnitude of sediment processes, which can have a substantial impact on water quality conditions. Data from monitoring sediment processes during the summer of 1997 is also compared to measurements recorded during 1994 and 1995 in Back and Patapsco Rivers;

3. High frequency monitoring (15-minute intervals for approximately 90 days) of dissolved oxygen (DO), temperature and salinity at two locations in Back River during June through September, 1997. The goal of this activity is to supplement conventional biweekly water quality monitoring in this targeted tributary with nearly continuous monitoring of several variables known to exhibit fundamental responses to nutrient enrichment and environmental factors. High frequency measurements will advance understanding of DO dynamics and provide confidence in interpretation of trends relative to DO goals. The use of these high frequency measurements may also provide a more sensitive tool for monitoring improvements in habitat conditions resulting from further implementation of tributary nutrient reduction programs.

3. DATA ACQUISITION AND DATA MANAGEMENT

3.1 Background Information

Water quality data including salinity, DO concentrations and chlorophyll-a concentrations as well as secchi disk depth were obtained from the Maryland Chesapeake Bay Water Quality Monitoring Program. Since 1996, this program has collected data at a single site in Back River on a bi-weekly or monthly basis. Land use data were taken from a report prepared by MDE (N.N. Panday, *pers. comm.*) and nutrient yield coefficients for different land uses were taken from Domotor *et al.* (1989). Wastewater Treatment Plant discharge rates and TN and TP concentrations were obtained from the staff at the Back River WWTP (J. Martin, *pers. comm.*) and from MDE (N.N. Panday, *pers. comm.*).

3.2 High Frequency Monitoring Study

3.2.1 Location of two stations in Back River: Rudy's Marina and Riverside Marina

Continuous high frequency field measurements of water quality were conducted for three months at two estuarine sites on Back River from 20 June, 1997 through 24 September, 1997. An upriver site was established at a depth of 1.5 meters of water at Riverside Marina, Inc. off Riverside Drive in Essex (39 degrees 17.92 minutes North latitude, 76 degrees 28.25 minutes West longitude; Figure 3-1). A down river site was established in 2.1 meters of water at Rudy's Marina, Inc. in Dundalk off Shore Road (39 degrees 15.58 minutes North latitude, 76 degrees 27.13 minutes West longitude; Figure 3-1).

Submersible conductivity, temperature and depth (CTD) instruments recorded DO, temperature and salinity every 15 minutes at a depth of one meter below the water surface. In addition to high frequency measurement by sensors, water samples were collected each week and analysed for DO using the standard modification of the classical Winkler titration procedure (American Public Health Association, Inc., 1966; Strickland and Parsons, 1972) and for chlorophyll-a using Strickland and Parsons (1972) and Shoaf and Lium (1976) methods. DO analyses were used to supplement sensor air saturation calibration and to compute *in situ* phytoplankton community and respiration rates by the light-dark bottle method (Gaarder and Gran, 1927). Synoptic data from high frequency meteorological instruments, including photosynthetically active radiation (PAR) measured at Solomons, MD were used to analyze community metabolism estimates.

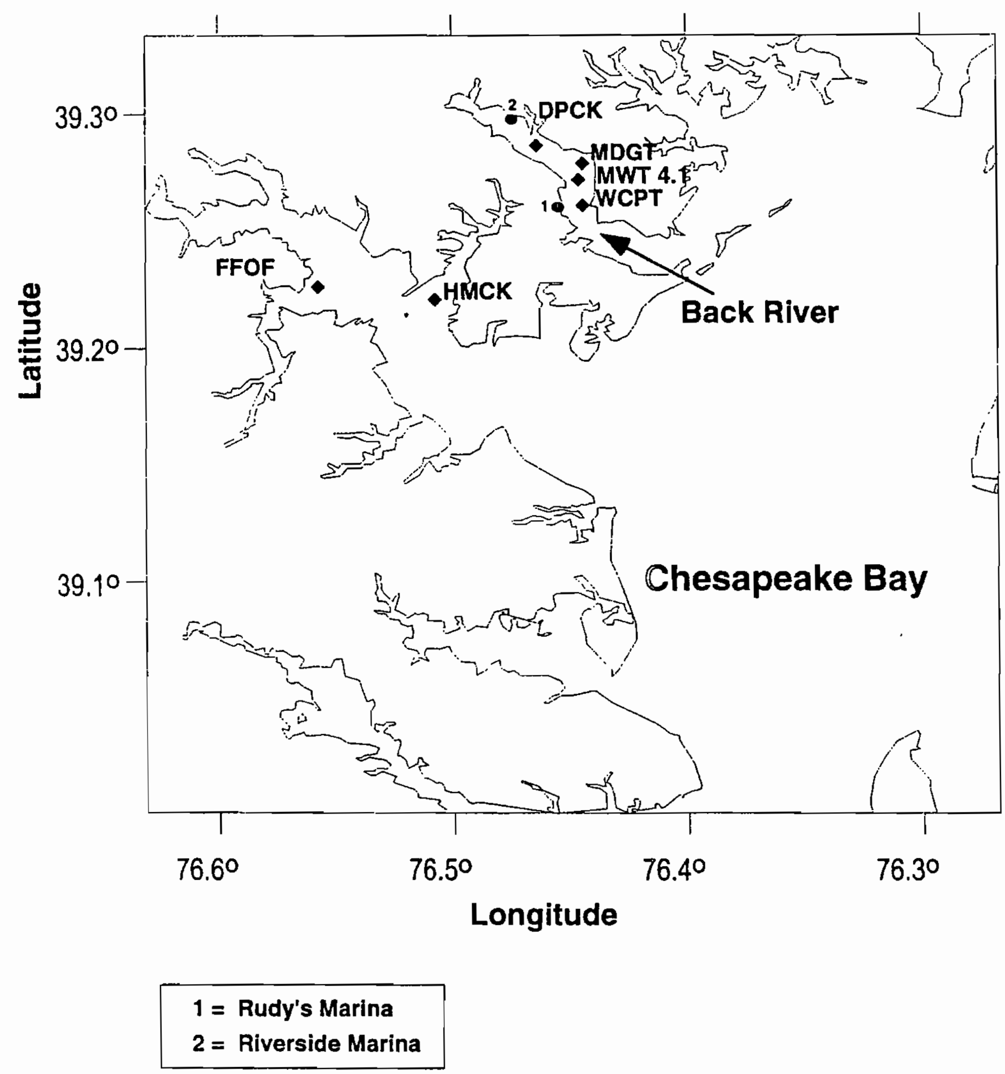


Figure 3-1. Map of Back River and Patapsco River showing high frequency monitoring stations and sediment-water flux stations sampled during 1997.

3.2.2 Field Data Collection Methods

Submersible conductivity, temperature and depth instruments were attached to a surface float array configured to position probe sensors one meter below the water surface. The floating CTD array was enclosed inside a protective standpipe attached to a piling in deep water at the seaward end of the pier at each marina. The stand-pipe enclosures were abundantly perforated with 5.1 cm holes to allow water to circulate freely. This maintained a constant water height *above* the probe and precluded the vertical stratification of components of DO, temperature, salinity and light attenuation effects. Analysis of recurring cycles observed in the high frequency data was thus confined to differentiation of environmental factors due to tidal transport, mixing, gravitational currents and meterological events (storms, strong winds) from those due to phytoplankton and sediment community metabolism.

The instruments were rotated each week to ensure optimum sensor operation and to upload data. The Yellow Springs Instruments (YSI) Model 6920 and Hydrolab DataSonde-3 were programmed to collect the following parameters every 15 minutes: date, time, temperature, specific conductance, salinity, DO saturation, DO concentration and battery voltage. Prior to each weeklong deployment, instruments were disassembled, cleaned, fitted with fresh batteries, sensor electrolyte and DO membrane. Sensors were calibrated before each deployment following manufacturers specifications for conductivity using a 0.1 molar potassium chloride solution; new DO membranes were allowed to 'relax' overnight before the sensor was calibrated for air saturation.

During weekly field visits, the replacement CTD was positioned next to the CTD to be retrieved, while a horizontally positioned 2.5 liter Niskin bottle at probe depth was triggered to collect a water sample. This provided overlapping readings from each CTD and also a discrete water sample that corresponded precisely to both beginning and end-points for respective data records. From the Niskin bottle, one 300-ml BOD bottle was filled and preserved immediately for later completion of the Winkler titration analysis. A second opaque 'dark' BOD bottle was filled and stored in a constant temperature water bath for 12 to 18 hours prior to preservation. A third bottle was filled and kept in the dark on ice for later chlorophyll-a analysis.

When CTD's were retrieved, any visible evidence of biofouling was noted. Biofouling on DO sensor membranes has been found to cause lower readings than clean sensors or water samples analysed by Winkler titration. Beginning and end-point Winkler determinations can also be used to confirm pre-deployment and post-deployment air saturation calibration.

Refrigerated water samples for chlorophyll-a analysis were filtered using 47 mm Whatman glass microfiber (GF/F) 0.1 micron pads, frozen and sent to the Nutrient Analytical Services Laboratory (NASL) for pigment extraction and spectrophotometer measurements.

3.2.3 Preliminary Assessment of Field Data

After the sensor that had been in the water for a week was retrieved, the DO sensor membrane was closely examined and a scaled value was recorded to indicate the degree of biofouling observed. Initial comparisons of *in situ* Winkler determinations to sensor end-point measurements indicated there were lower readings from fouled sensors than from clean sensors. Pre-deployment and post-deployment sensor calibrations in air and *in situ* DO determinations by Winkler methods were retained for later calibration validation and correction if needed. An example of Winkler DO values and sensor values is provided in Figure 3-2 and the plot indicates that in general there is good agreement between measurement methods.

After sensors were retrieved each week, raw data were downloaded and graphics were created which enabled an examination of time series data to ensure that values fell within acceptable limits determined by weekly calibration throughout the deployment phase of the project. By "splicing" plots of time series records from successive weeks together, the coincidence of overlapping temperature, salinity and DO measurements at beginning and end points provided a qualitative assessment of these data, in addition to the pre-deployment and post-deployment sensor calibrations and the *in situ* DO determinations using the Winkler method. A summary of Winkler DO concentration values versus probe DO concentration values is provided in Figure 3-3 and Table 3-1 indicating that in almost all cases there was excellent agreement between the two techniques. Two of the points in Figure 3-3 that strongly diverge from the general pattern (open circles) did so because of faulty Winkler titrations and it is likely that the other pair of points were divergent for the same reason. The complete high frequency data record comprises 8,928 observations of water temperature, salinity and DO at each of the two Back River stations. A summary list of variables measured during this portion of the study can be found in Appendix A.

3.3 Sediment-water Flux Study

3.3.1 Location of Sediment-water Flux Monitoring Stations in Back River and Patapsco River

Five stations in the tidal oligohaline (0.5 - 5.0 ppt) region of the Back and Patapsco River basins were sampled three times during 1997 (June, July and August; Figure 3-1 and Table 3-4). Three stations were located in Back River. Deep Creek (DPCK) and Witch Coat Point (WCPT) previously sampled in 1994 and 1995 were sampled in 1997 and a third station adjacent to Muddy Gut (MDGT) was added in 1997. Two new stations, Fairfield Outfall (FFOF) and Humphrey's Creek (HMCK), were added in Patapsco River. Inner Harbor (INHB), Ferry Bar (FYBR) and Curtis Bay (CTBY) were not sampled in 1997, although the Curtis Bay (CTBY) station is close to the new Fairfield Outfall (FFOF) station.

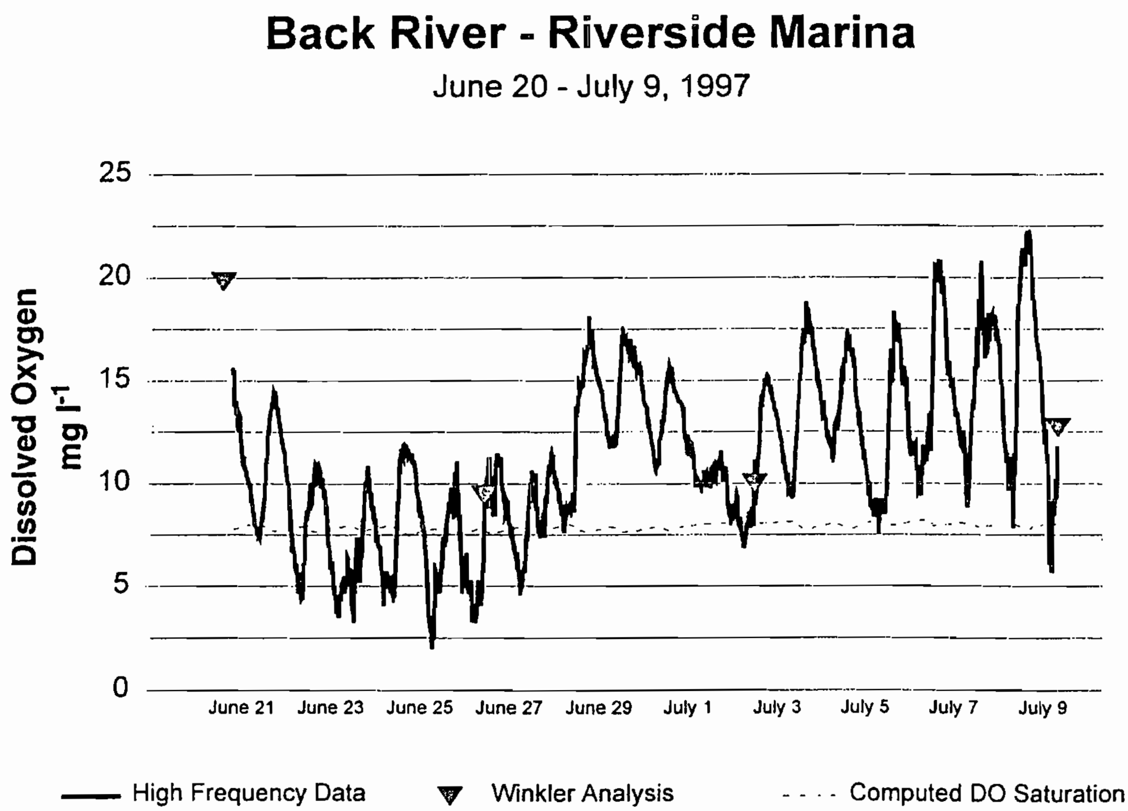


Figure 3-2. An 18-day time series plot of DO concentration recorded every 15 minutes from June 20, 1997 through July 9, 1997.

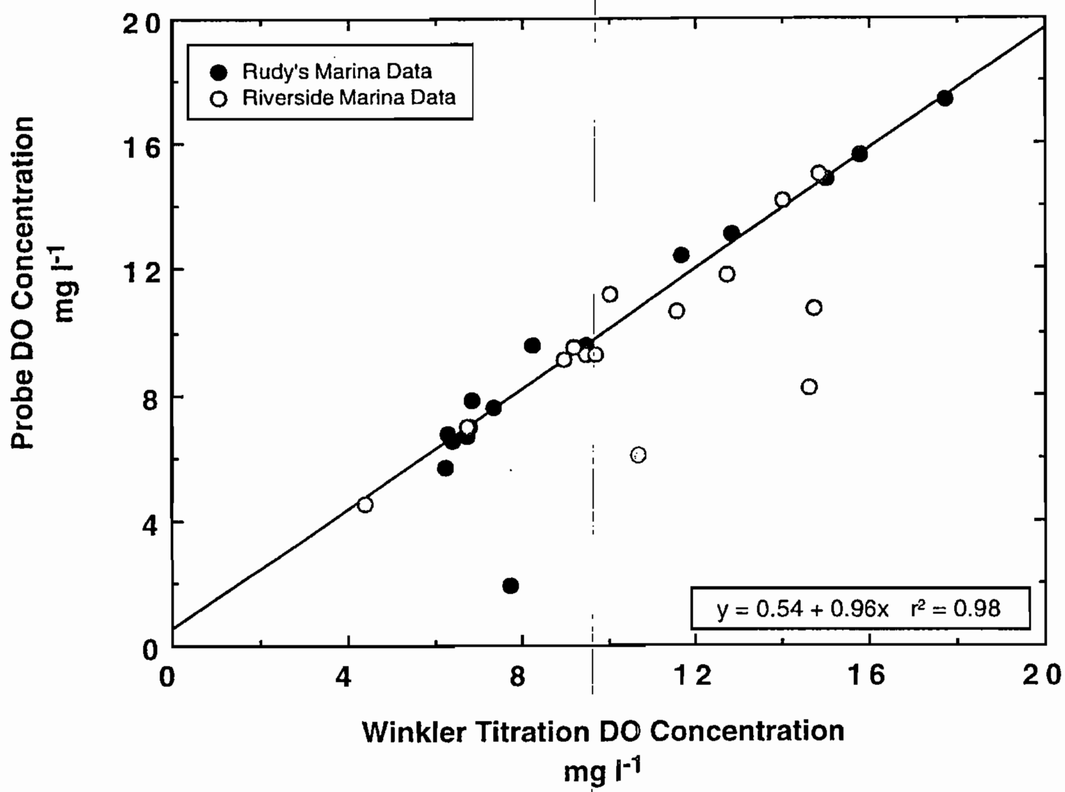


Figure 3-3. A scatter plot of DO concentrations measured with probes (Hydrolab and YSI) and by Winkler titration.

Measurements were made at both stations located in Back River between June and September 1997. The four observations, which plot far from the regression line, were not included in the calculation of that line. All probe measurements of DO were from instruments which had been laboratory calibrated and had just been deployed in the field.

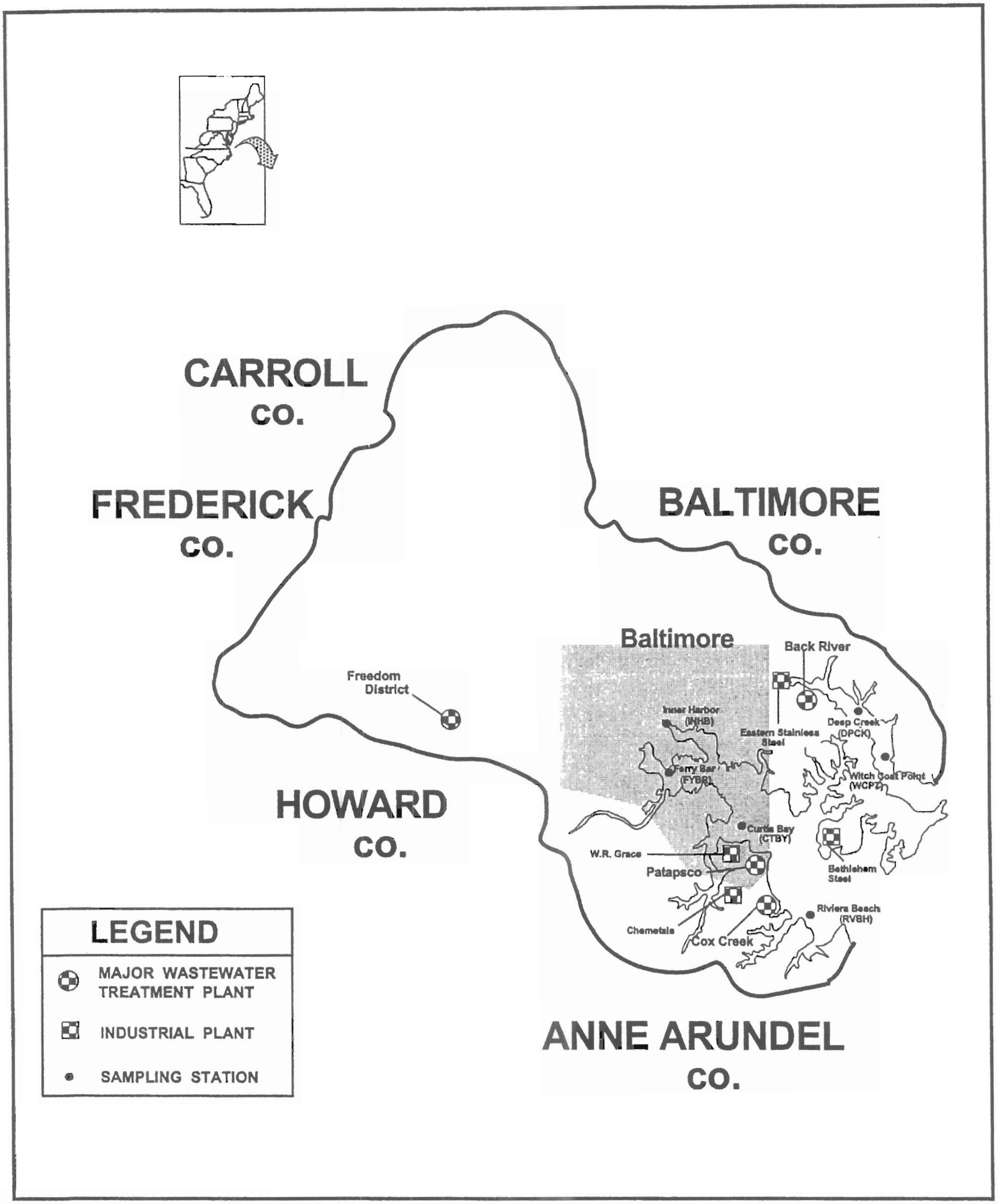


Figure 3-4. Map of Back River and Patapsco River Watershed showing sediment-flux stations monitored in 1994 and 1995.

Table 3-1. A summary of synoptic DO measurements made at Rudy's Marina and Riverside Marina stations on Back River during summer, 1997.
Measurements are comparisons of DO concentrations measured with DO meters and Winkler titrations. Each pair of measurements were made on water samples collected from the same depth (~ 1 meter from the surface) and at the same time. The abbreviation "na" indicates that data were not available.

DATE	RUDY'S MARINA		RIVERSIDE MARINA	
	METER DO CONCENTRATION ($mg\ l^{-1}$)	WINKLER DO CONCENTRATION ($mg\ l^{-1}$)	METER DO CONCENTRATION ($mg\ l^{-1}$)	WINKLER DO CONCENTRATION ($mg\ l^{-1}$)
20-Jun-97	9.55	9.45	na	na
26-Jun-97	6.06	10.65	9.26	9.45
2-Jul-97	12.42	11.65	11.15	10.00
9-Jul-97	9.56	8.20	11.79	12.70
16-Jul-97	17.36	17.70	8.22	14.60
23-Jul-97	1.89	7.70	4.51	4.40
30-Jul-97	15.61	15.75	10.72	14.70
6-Aug-97	14.84	15.00	10.68	11.55
13-Aug-97	5.66	6.20	14.20	14.00
20-Aug-97	6.71	6.30	9.54	9.15
27-Aug-97	13.14	12.85	14.99	14.85
3-Sep-97	7.58	7.35	9.26	9.65
11-Sep-97	7.78	6.85	6.99	6.70
11-Sep-97	6.66	6.70	na	na
11-Sep-97	7.01	6.80	na	na
17-Sep-97	6.51	6.40	9.15	8.95

Table 3-2. Back River and Patapsco River stations, codes and locations.

Region	Station	Code	Latitude	Longitude
Back River	Deep Creek	DPCK	39° 17.173'	76° 27.723'
	Muddy Gut	MDGT	39° 16.257'	76° 26.520'
	Witch Coat Point	WCPT	39° 15.760'	76° 26.643'
Patapsco River	Inner Harbor	INHB	39° 14' 49"	76° 36' 16"
	Ferry Bar	FYBR	39° 15' 24"	76° 36' 16"
	Curtis Bay	CTBY	39° 10' 36"	76° 30' 00"
	Riviera Beach	RVBH	39° 13' 38"	76° 32' 50"
	Fairfield Outfall	FFOF	39° 14.029'	76° 33.256'
	Humphries Creek	HMCK	39° 13.945'	76° 29.788'

Note: Latitude and Longitude for INHB, FYBR, CTBY and RVBH was determined using Loran C with a latitude and longitude conversion while the 1997 station locations were determined using DGPS. Station location values for June 1997 are given in this table; July and August values were within anchorage error.

Table 3-3. Back River and Patpsco River Cruises in 1994, 1995 and 1997.

Region	Station	Code	1994	1995	1997
Back River	Deep Creek	DPCK	June, July, November	June, July, August	June, July, August
	Muddy Gut	MDGT			June, July, August
	Witch Coat Point	WCPT	June, July, November	June, July, August	June, July, August
Patapsco River	Inner Harbor	INHB	June, July, November	June, July, August	
	Ferry Bar	FYBR	June, July, November	June, July, August	
	Curtis Bay	CTBY	June, July, November	June, July, August	
	Rivera Beach	RVBH	June, July, November	June, July, August	
	Fairfield Outfall	FFOF			June, July, August
	Humphries Creek	HMCK			June, July, August

In this report, sediment-water exchange rate measurements made during 1997 are compared to similar measurements made at six stations in the tidal oligohaline (0.5 - 5.0 ppt) portions of the basin during 1994 (June, July and November) and during 1995 (June, July and August; Figure 3-4 and Tables 3-3 and 3-4). For the sake of clarity, locations of these stations are also included here. Two stations were located in Back River; Deep Creek (DPCK) was the shallowest station accessible to the Research Vessel Orion in Back River with a depth of 1.8 meters and Witch Coat Point (WCPT) was a slightly deeper station (depth of 2.1 meters). Both stations had depths characteristic of the area and had fine organic sediments. Three stations were located in Patapsco River. Inner Harbor (INHB) is a station in the Northwest Branch of the estuary. The observed depth was 7.3 meters. The sediments were very loose and oily with observable amounts of methane gas (due to bubble formation in the sediment). Ferry bar (FYBR) is located in the Lower Middle Branch of the estuary. The observed depth at this site was 4.5 meters. The sediments had a silt surface and a clay base. Curtis Bay (CTBY) is located in the Middle Harbor and is influenced by Curtis Bay, Marley and Furnace Creeks. Curtis Bay (CTBY) had an observed depth of 6.4 meters. The sediments had a silt surface and black clay base. An additional station, Riviera Beach (RVBH) is located in the Outer Harbor. RVBH is adjacent to Cox, Stony, and Rock Creeks. The observed depth was 4.8 meters. The sediments had a silt surface and gray clay base.

3.3.2 Field Methods used in the Sediment-water Flux Study

Details concerning field methodologies are described in the Ecosystem Processes Component (EPC) Study Plan (Garber *et al.*, 1987) and fully documented in EPC Data Dictionary (Boynton and Rohland, 1990). Field activities are briefly reviewed in the following sections.

3.3.2.1 Water Column Profiles

Vertical water column profiles of temperature, salinity, and DO were measured at 2 meter intervals (0.5 or 1 meter intervals at shallow stations) from the surface to the bottom. The turbidity of surface waters was measured using a Secchi disk.

3.3.2.2 Water Column Nutrients

Near-bottom (usually 1 meter above sediment surface) water samples were collected using a high volume submersible pump system. A sub-sample was filtered with a Whatman GF/F 2.5 cm diameter, 0.7 μm glass fiber filter and frozen for later analysis of dissolved inorganic N, P and silica.

3.3.2.3 Surficial Sediment Samples

At each station an intact sediment core was used to measure the oxidation-reduction potential, (Eh, in units of mV) of sediments at 1 cm intervals to about 10 cm of sediment depth. A 1 cm deep sample of surface sediments was placed in a centrifuge tube and frozen for later analysis of particulate organic carbon (PC), particulate organic nitrogen (PN) and particulate phosphorus (PP) concentrations and chlorophyll-a.

3.3.2.4 Sediment Cores

Stations were sampled using the standard techniques in which three replicated sediment cores and a blank were used to estimate sediment-water flux. Intact sediment cores constitute a benthic microcosm where changes in oxygen, nutrient and other compound concentrations are determined. An overview of the measurement technique follows and the details of the techniques are provided in Boynton and Rohland (1990).

Sediment cores were collected at each station using a modified Bouma box corer. These cores were then transferred to a Plexiglass cylinder (15 cm diameter x 30 cm length) and inspected for disturbances such as large macrofauna or cracks in the sediment surface. If the sample was satisfactory, the core was fitted with an O-ring sealed top containing various sampling ports, and a gasket sealed bottom (Figure 3-5). The core was then placed in a darkened, temperature controlled holding tank where overlying water in the core was slowly replaced by fresh bottom water to ensure that water quality conditions in the core closely approximate *in situ* conditions. Water was also exchanged in the blank core.

The cores were placed in a darkened water bath to maintain ambient temperature. Gentle circulation of water, with no induction of sediment resuspension, was maintained in the cores during the measurement period via the stirring devices attached to the oxygen probes. Oxygen concentrations and temperature were recorded and overlying water samples (35 ml) were extracted from each core and the blank every 60 minutes over a 4-hour incubation period. During the incubation period, five overlying water samples were extracted from each core. As a nutrient sample was extracted from a core, an equal amount of ambient bottom water was added. Overlying bottom water samples were filtered with a Whatman GF/F 2.5 cm diameter, 0.7 µm glass fiber filter and immediately frozen for later analysis of NH_4^+, nitrite (NO_2^-), nitrite plus nitrate ($NO_2^- + NO_3^-$), PO_4^{-3} and silicate ($Si(OH)_4$) concentrations. Oxygen and nutrient fluxes were estimated by calculating the mean rate of change in concentration over the incubation period and converting the volumetric rate to a flux using the volume:area ratio of each core.

In addition to the samples collected for nutrient analysis, water (75 ml) was also extracted for analysis of total dissolved inorganic carbon (TCO_2). The water sample was transferred to a 75 ml BOD bottle using a syringe fixed with mercuric chloride ($HgCl_2$) to stop metabolism. The addition of $HgCl_2$ was appropriate for either oxic or anoxic conditions. Three samples were collected from each core at each station. Total carbon dioxide fluxes were computed in the same way as nutrient and DO fluxes.

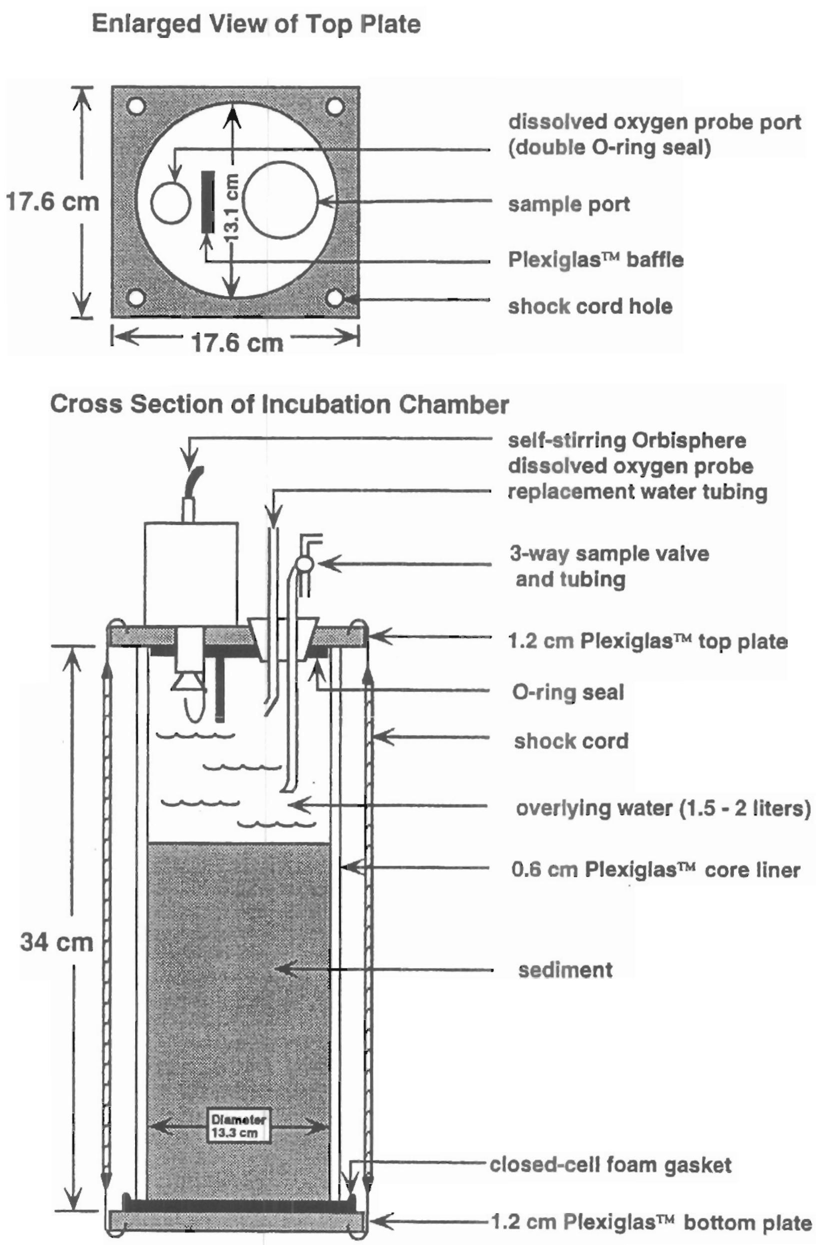


Figure 3-5. Diagram of the Incubation Chamber

3.3.3 Chemical Analysis

Reference material for chemical analyses is summarized in Table 3-4, details of methods are provided in the EPC Data Dictionary (Boynton and Rohland, 1990).

3.3.4 Data Management of Sediment-water Flux Information

Five data sets were created:

Water Column Profiles (Filename: HPPBmmyy, Table B-1) containing temperature, salinity, and DO data measured at two meter intervals (0.5 or 1 m at shallower stations).

Bottom Water Nutrients (Filename: HNPBmmyy, Table B-2) reporting bottom water nutrient concentrations.

Sediment Profiles (Filename: SPPBmmyy, Table B-3) including Eh and selected sediment measurements of PC, PN, PP, total and active chlorophyll-a concentrations.

Core Data (Filename: CDPBmmyy, Table B-4) lists DO, TCO_2 and nutrient concentration measurements in sediment-water flux chambers.

Sediment-Water Flux (Filename: FLPBmmyy, Table B-5) is a summary table providing oxygen, TCO_2 and nutrient flux data.

3.3.4.1 Data Tables Quality Assurance/Quality Control (QA/QC)

Data recorded by instruments in the field were entered directly onto specially prepared data sheets. Data from samples analysed by NASL at CBL were returned in written format. Data were keyed into Lotus 1-2-3® using the standard format. Hard copies of the files were manually checked for errors. Data files were corrected, and a second printout produced which was re-verified by a different staff member.

3.3.4.2 Incorporation of Error Codes in Data Tables

In order to eliminate blank spaces in data tables a one or two-letter alpha code (Table 3-5) was used to describe problems associated with questionable parameter values. Valid entries from the Sediment Data Management Plan (EPA, 1989) and Sediment Oxygen and Nutrient Exchanges (SONE) program were used.

Table 3-4. Variables measured in the laboratory, current detection limits and methods.

Analyte	Method Number	Detection Limit	Reference
Chlorophyll-a	N/A	2.00 µg l^{-1}	Strickland and Parsons, 1972; Shoaf and Lium, 1976
NH_4^+	350.1	0.21µM	EPA, 1979 Colorometric automated phenate
NO_2^-	353.2	0.01µM	EPA, 1979 Colorometric automated diazotation
$NO_2^- + NO_3^-$	353.2	0.01µM	EPA, 1979 Automated cadmiun reduction; diazotation
PO_4^{-3}	N/A	0.02µM	EPA, 1979
PC	N/A	5.28µM	Exeter Analytical, Inc. (EAI) CE-440 Elemental Analyzer High temperature oxidative combustion
PN	N/A	0.75µM	Exeter Analytical, Inc. (EAI) CE-440 Elemental Analyzer High temperature oxidative combustion
PP	N/A	0.04µM	Aspila *et al.*, 1976 Acid digestion of muffled-dry samples
$Si(OH)_4$	811-86T	0.36µM	Technicon Industrial System, 1977
TCO_2	N/A	10µM	Johnson *et al.*, 1987 These analyses were conducted at the Horn Point Environmental Laboratory (HPEL; P. Sampou, *pers. comm.*).

Table 3-4. Analysis Problem Codes

ANALYSIS PROBLEM CODE	DESCRIPTION
A	Laboratory accident
B	Interference
C	Mechanical/materials failure
D	Insufficient sample
N	Sample Lost
P	Lost results
R	Sample contaminated
S	Sample container broken during analysis
V	Sample results rejected due to QA/QC criteria
W	Duplicate results for all parameters
X	Sample not preserved properly
AA	Sample thawed when received
BB	Torn filter paper
CC	Pad unfolded in foil pouch
EE	Foil pouch very wet when received from field, therefore poor replication between pads, mean reported
FF	Poor replication between pads; mean reported
HH	Sample not taken
JJ	Amount filtered not recorded (Calculation could not be done)
LL	Mislabeled
LS	Lost epiphyte strip
NI	Data for this variable are considered to be non-interpretable
NN	Particulates found in filtered sample
NR	No replicate analyzed for epiphyte strip chlorophyll-a concentration
PA	Propagule trap added during cruise on June 5th, 1997
PF	Propagule trap not found in field
PG	Propagules weighed as a group, individual weights not recorded
PP	Assumed sample volume (pouch volume differs from data sheet volume; pouch volume used)
PU	Propagule trap found, but turned upside down
QQ	Although value exceeds a theoretically equivalent or greater value (*e.g.* , PO_4F>TDP), the excess is within precision of analytical techniques and therefore not statistically significant
RR	No sample received
SS	Sample contaminated in field
TF	Dissolved oxygen probe failure
TL	Instrument failure in research laboratory
TS	Dissolved oxygen probe not stabilized
TT	Instrument failure on board research vessel
UU	Analysis discontinued
WW	Station was not sampled due to bad weather conditions, research vessel mechanical failure, or failure of state highway bridges to open or close
XX	Sampling for this variable was not included in the monitoring program at this time or was not monitored during a specific cruise
YY	Data not recorded

4. BACKROUND INFORMATION CONCERNING WATER QUALITY AND NUTRIENT LOADING RATES TO BACK RIVER

4.1 Status and Trends of Selected Water Quality Variables

4.1.1 Purpose of Review and Content

The Maryland Chesapeake Bay Program has conducted water quality measurements in Back River since 1985 and determined that Back River has had serious water quality problems for many years. Robertson (1977) listed some impacts related to WWTP discharges and noted that heavy algal blooms and fish kills were first reported in 1917, some six years after the plant went into operation. Robertson (1977) found records indicating fish kills during 1921-1925, 1928, 1929, 1930 and 1939-1940. A study by Robertson (1977) was initiated in August, 1974 in response to a large fish kill. We have assembled water quality data for purposes of comparing data collected in Back River during the mid-1980's through mid-1990's with data collected in this monitoring study. In addition, because sediment-water oxygen and nutrient exchanges and water column metabolic rates (both of which were the focus of monitoring in this project) are sensitive to nutrient loading rates, available data were assembled to construct a preliminary N and P input budget for Back River and to compare these input rates with those observed from a variety of estuarine systems, including several tributaries of Chesapeake Bay.

4.1.2 Water Quality Variables

Monthly average values for salinity, secchi disk depth, DO and chlorophyll-a are shown in Figure 4-1 for the period 1986-1995. Salinity values ranged from zero to about 6 ppt during the period of record and were generally similar to those observed during the June through September, 1997 period of this monitoring project (0.5 - 7.2 ppt). As expected, salinities in Back River were also similar to salinities in the upper Chesapeake, being higher during drought years (1992, 1995) and lower during years of high freshwater input (1993, 1994).

Secchi disk depth measurements indicated that water in Back River is usually very turbid. With few exceptions, secchi disk values were less than 0.4 m and frequently at 0.2 m. These values equate to light extinction coefficients of 4.3 and 8.5, respectively. Under these conditions 1% of surface radiation only reaches to depths of 1.1 and 0.6 m, respectively, considerably less than the mean depth of Back River estuary (1.8 m). The secchi disk depth measurements made during our monitoring project were similar to those observed in previous years.

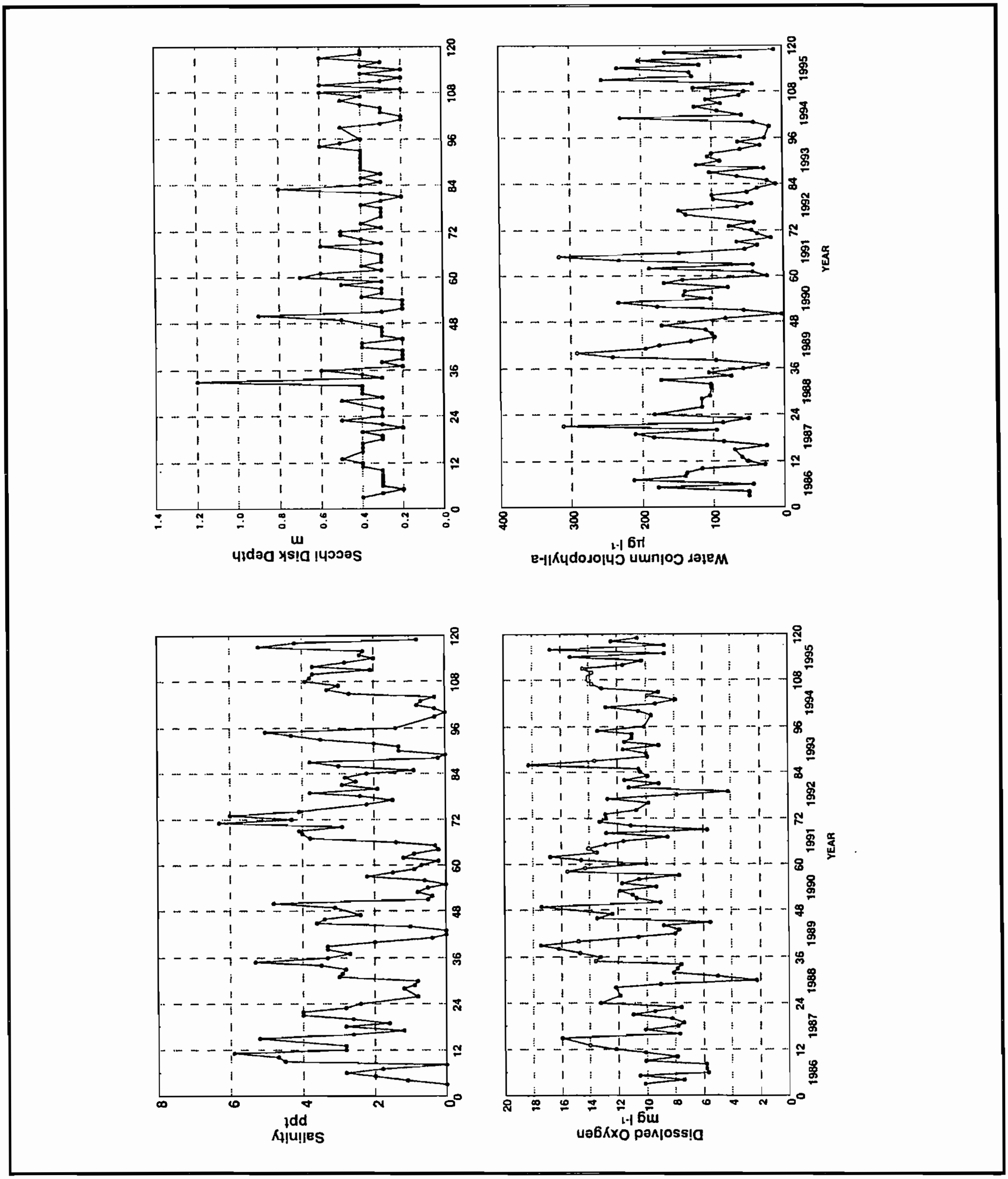


Figure 4-1. A summary of selected water quality conditions observed in Back River from 1986 through 1995.
All data were collected at 0.5 meters below the surface at station MWT 4.1. This station is routinely sampled as part of the Maryland Chesapeake Bay Water Quality Monitoring Program (B.Michaels, pers. comm.). The station MWT 4.1 is located in the channel area east of Stansbury Point.

In Chapter 5, the high frequency monitoring study, water column DO concentrations are shown to vary by as much as 20 mg l^{-1} over the course of a diel period. Hence, it is difficult to make too much of the DO data presented in Figure 4-1. However, it appears that most measurements shown in this figure were collected between mid-morning and mid-afternoon so the potential variability between measurements is not as great as it could be. In general, concentrations for much of the year ranged between 8 and 12 mg l^{-1}; there were no values observed below 2 mg l^{-1} and the highest value was just over 18 mg l^{-1}. In the present study, DO ranged between 2.5 and 22 mg l^{-1} during the June through September, 1997 period. In general, DO concentrations were similar to those observed between 1986 and 1995.

Water column chlorophyll-a concentrations observed in the Maryland Chesapeake Bay Monitoring Program (Figure 4-1) were high to extremely high relative to most other locations in Chesapeake Bay. Between 1986 and 1995 annual average concentrations were about 125 µg l^{-1}, while peak concentrations (generally occurring during spring or summer) reached or slightly exceeded 300 µg l^{-1} on several occasions. During the three month period monitored in this project, chlorophyll-a concentrations were as high or higher than those observed in the Bay monitoring program. During July and August 1997, concentrations at the station proximal to the sewage treatment plant were close to or exceeded 300 µg l^{-1} and concentrations at the station farther down the estuary (Rudy's Marina) were between 200 and 300 µg l^{-1} for the same period.

The large diel excursions in DO, low transparency and large chlorophyll-a concentrations are all characteristic of a shallow estuary having relatively long residence times (to allow the build-up of algal stocks) and enrichment via inorganic nutrients (Boynton *et al.*, 1982, Nixon *et al.*, 1986a and D'Avanzo *et al.*, 1996). If enrichment was via dissolved or particulate organic matter, DO concentrations would be lower, as they were in earlier years when the treatment plant operated at lower levels of treatment. The lack of hypoxic or anoxic conditions in this estuary is likely to be related to the lack of vertical stratification of the water column which allows for atmospheric replenishment of water column DO when concentrations are reduced below saturation levels. However, the general lack of hypoxia is probably also related to rapidly growing algal stocks which produce large amounts of oxygen during the day and consume about the same amount during hours of darkness.

4.2 Back River Wastewater Treatment Plant Discharges

4.2.1 Historical Patterns

Annually averaged WWTP freshwater discharges and TN and TP loads to Back River are summarized for the period 1984 through 1996 in Figure 4-2. For each variable temporal patterns are clear with flow increasing (from about 70 mgd in 1984 to about 110 mgd in 1996), TN load decreasing (from about 7,000 kg day^{-1} in 1984 to about 5,000 kg day^{-1} in 1996) and TP loads decreasing (from about 600 kg day^{-1} in 1984 to less than 100 kg day^{-1} in 1996). During this same period there have been equally substantial reductions in total suspended solids (TSS) and five-day biological oxygen demand (BOD_5).

4.2.2 Loads for 1997

Daily discharge of freshwater, TN and TP loading rates for 1997 from Back River WWTP are shown in Figure 4-3. In addition, the period monitored by this project is indicated in each panel. Freshwater discharges were generally constant from day to day, especially during the warmer portions of the year. On several occasions discharges "spiked", at times to twice average flow rates, during the winter-spring period and again for several days in the fall. Loading rates of TN and TP followed freshwater discharge rates, as expected. Loads were somewhat higher during the cool portions of the year compared to the warmer portions of the year. Spikes in TN and TP loads mirrored spikes in flow. During the monitoring period of this project (20 June, 1997 through 24 September, 1997), freshwater flows, TN and TP loads were quite constant at about 80 mgd, 3,500 kg day^{-1} and 50 kg day^{-1}, respectively.

4.3 Nitrogen and Phosphorus Inputs

4.3.1 Estimated Loads for 1997 from Local and Atmospheric Sources

To place the nutrient loads from the WWTP in some perspective and to estimate total nutrient loading rates (from landsite and atmospheric sources; not including inputs from the mainstem Chesapeake Bay) to this estuarine system, data were assembled to produce such an estimate, generally following the procedure used in Boynton *et al.* (1995a). Results of this exercise are summarized in Table 4-1. The WWTP loads of TN, as expected, represented about 86% of the TN load. WWTP discharges of TP represent about 40% of the total load. Urban sources of TP are also important (55%). If nutrient loads are prorated over the surface area of the estuary, annual areal loads of about 93.5 g N m^{-2} yr^{-1} and 2.7 g P m^{-2} yr^{-2} result.

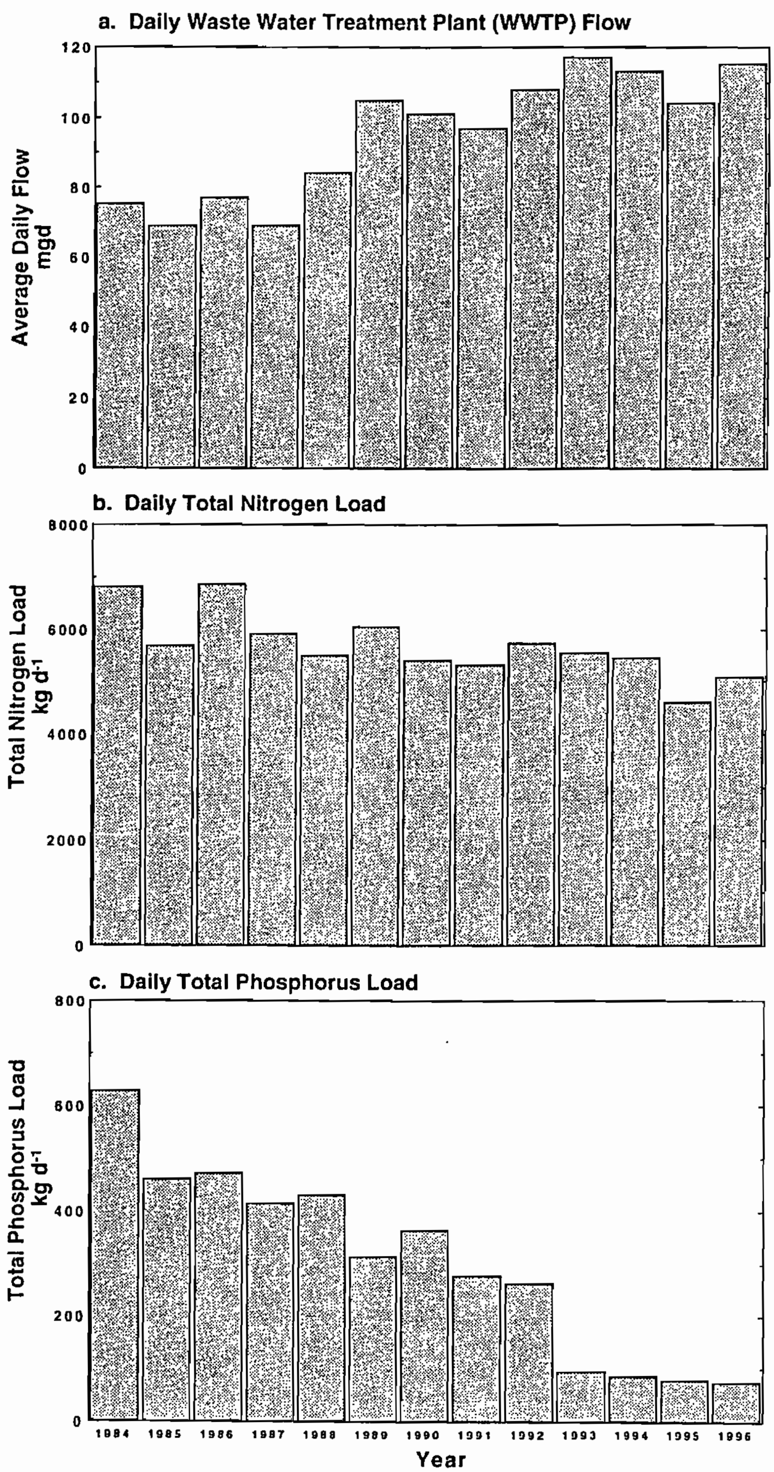


Figure 4-2. Average annual Back River WWTP discharge rates, TN and TP loads for the period 1984 through 1996.
Data were provided by John Martin (DPW Facilities Engineering Division, Baltimore, MD).

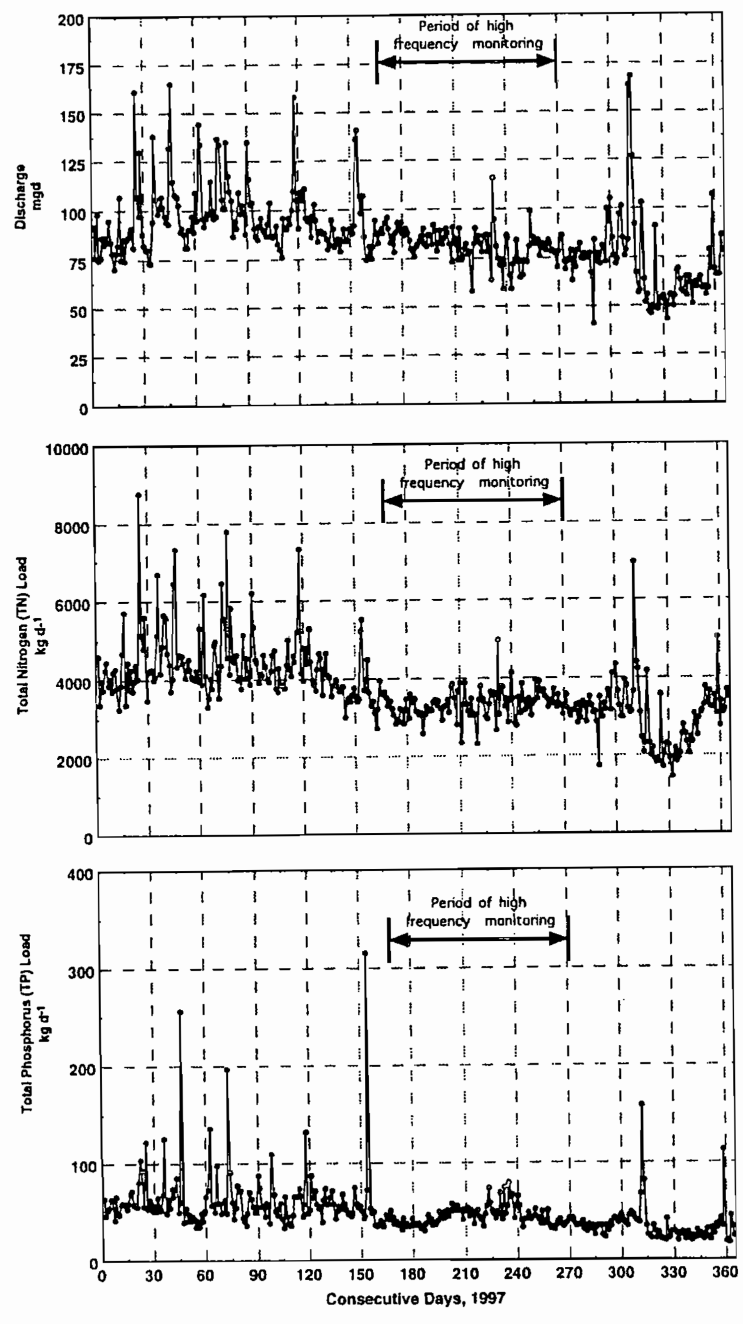


Figure 4-3. Line plots indicating daily discharge (mgd), TN and TP load from WWTP to Back River during 1997.

Data were obtained from John Martin (DPW Facilities Engineering Division, Baltimore, MD).

The period of time during which high frequency water quality measurements were made (20 June, 1997 through 24 September, 1997) is also indicated in each panel.

Table 4-1. Annual estimates of TN and TP loads from various land uses and activities to Back River.
Basin and estuarine areas are from N.N. Panday (MDE, Baltimore, MD), TN and TP yield coefficients are from Domotor *et al.* (1989). TN and TP concentrations in wet atmospheric deposition are reported in Boynton *et al.* (1995a) and WWTP releases (for calendar year 1997) are from John Martin (DPW Facilities Engineering Division, Baltimore, MD). Inputs from urban, forest and agriculture are simple "edge of field" estimates for an average year. Concentrations in rainfall are also for an average year (assuming total rainfall of 1 m yr^{-1}).

We have also recomputed TN and TP load estimates for the Back River Basin using more recent nutrient yield coefficients from the Chesapeake Bay Program Land Use model (Gary Shenk, *pers.comm.*, USEPA Chesapeake Bay Program, Annapolis, MD). Total loads were similar to those contained in Table 4-1. The TN and TP yield coefficients from the Bay Program Water Quality Model include both surface and ground water TN and TP transport.

Land Use or Activity	Area (km^2)	Total Nitrogen Yield Coefficient ($g\ N\ m^{-2}\ yr^{-1}$)	Total Phosphorus Yield Coefficient ($g\ P\ m^{-2}\ yr^{-1}$)	Annual Total Nitrogen Load ($kg\ N\ yr^{-1}$)	Annual Total Phosphorus Load ($kg\ P\ yr^{-1}$)
Urban	107	1.70	0.230	181,900	24,610
Forest	23.0	0.25	0.024	5,750	552
Agriculture	3.6	0.89	0.222	3,204	799
Water Surface (direct atmospheric wet deposition)	16.8	1.59	0.064	26,712	1,075
Sewage Treatment Plant Discharge (calender 1997)	na	na	na	1,353,896	18,070
			TOTAL LOADS ($kg\ yr^{-1}$)	**1,571,462**	**45,106**
			AREAL LOADS TO ESTUARY ($g\ m^{-2}\ yr^{-1}$)	**93.5**	**2.7**

4.3.2 Comparison of Loads with Other Estuarine Environments

During the past few years nutrient loading rates for a diverse mixture of ecosystems have started to appear in the literature. For example, the National Oceanographic and Atmospheric Administration and the Environmental Protection Agency Team on Near Coastal Waters have compiled estimates of loading rates for many coastal systems of the United States (NOAA/EPA 1989). Nixon *et al.* (1986b) has also assembled loading data for both aquatic and terrestrial systems and concluded that coastal systems have become among the most heavily fertilized ecosystems because of increasing anthropogenic additions of TN and TP. Compared to other estuarine systems, loading rates to Chesapeake Bay are moderate to high for TN and low to moderate for TP (Figure 4-4). Nutrient loading rates to Back River are among the highest of the areas examined for TN and substantial for TP.

Responses of estuarine systems to increasing nutrient loads include increases in primary production rates, increases in algal standing stocks (as is evident in Back River), increased rates of nutrient recycling but only slight enhancement in higher food web production. Most additional production appears to be rapidly consumed by microheterotrophs (Nixon *et al.*, 1986a). Recent investigations in the Chesapeake have also reported similar attenuated responses to loading rates. For example, a significant relationship was found between TN loading and primary production rates at one site in the mainstem bay and for sediment releases of ammonium measured at several locations in the bay system (Boynton *et al.*, 1995b). These results suggest a tight coupling between nutrient loading, water column production of organic matter and recycling of nutrients from sediments.

However, it is also clear that comparable nutrient loading rates in different systems do not produce the same responses as those observed locally. For example, N loading rates for Potomac River and Narragansett Bay are similar but water quality conditions in the mesohaline portion of Potomac are poor but quite good in Narragansett Bay (Nixon *et al.*, 1986b). On the other hand, loading rates to Baltic Sea are much lower than those recorded in Chesapeake systems but hypoxic and anoxic conditions are now characteristic of both. Estuarine morphology, circulation and regional climate conditions undoubtedly have strong influences on the relative impact of loading rates (Wulff *et al.*, 1990). In the case of Back River, loading rates are high but severe hypoxia and anoxia were not observed, presumably because the system was not vertically stratified, again indicating the modifying influence of such factors as morphology on water quality conditions.

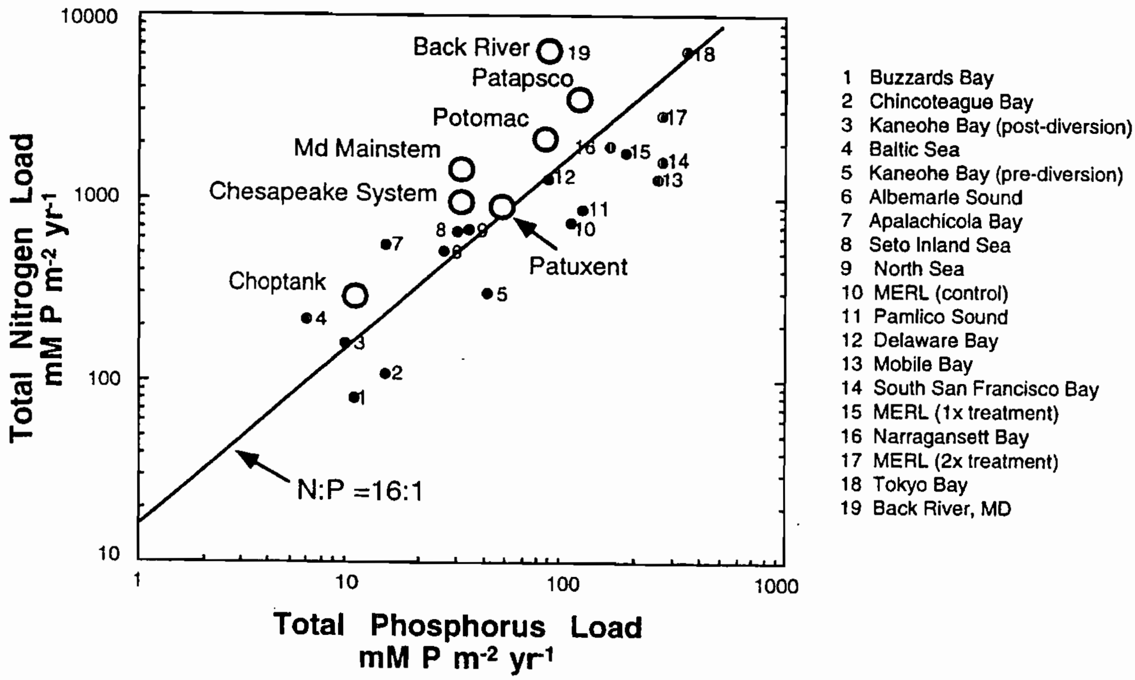


Figure 4-4. A selection of annual TN and TP loading rates plotted as a scatter graph for a variety of estuarine and coastal marine systems.
Figure was adapted from Boynton et al. (1995a). Those systems plotted as large open circles are located in the Chesapeake Bay region.

5. BACK RIVER HIGH FREQUENCY MONITORING

The use of methods such as ^{14}C primary production and fluorescence-based algal stock estimates for monitoring is very common. They are best used to obtain measures of algal performance at a variety of locations; that is as tools to obtain spatial estimates of rates and stocks. Most approaches do not lend themselves to problems involving monitoring of temporal variability at fine scales (*i.e.* days to weeks) simply due to the costs associated with such measurements.

There is at least one method that is relatively inexpensive and can address both fine-scale (*i.e.* hours to days) and coarse (*i.e.* months to years) temporal variability of processes relevant to estuarine system performance. One of these techniques was developed by Odum and Hoskin (1958) and involves estimating community production and community respiration from changes in DO concentrations over diel periods. In its simplest form, production is estimated from the positive rate of change of DO during daylight hours. Any increase in DO concentration can be attributed to net photosynthesis of primary producers. In a similar fashion, decreases in DO concentrations during hours of darkness can be attributed to respiration of primary producers and the assemblage of heterotrophs. In both cases it is assumed that measurements are being made within the same general water mass over the 24 hour period. Net advective additions or deletions of DO are assumed to be small, as would be the case within a generally homogeneous water mass. In heterogeneous systems the utility of the method is diminished because of the violation of this assumption. Finally, both daytime and nighttime rates of change must be corrected for oxygen diffusion across the air-water interface. This leaves an oxygen signal, which is an estimate of biological metabolism.

5.1 High Frequency Monitoring during 1997

Submersible self-recording environmental monitoring instruments were deployed from 20 June, 1997 through 24 September, 1997 at two sites (Rudy's Marina and Riverside Marina; Figure 3-1) in Back River estuary. In addition to continuous water temperature, salinity and DO measurements by sensors, water samples were collected each week throughout the 1997 deployments for several laboratory analyses. One analysis provided DO concentrations for *in-situ* sensor calibration. Another analysis provided total and active chlorophyll-a concentrations, while a third procedure provided plankton respiration rates.

The major objectives of this study are:

1. To examine high frequency DO data to determine if DO habitat criteria are achieved at current loading regimes in Back River,

2. To use high frequency temperature, salinity and DO data to calculate daily community production and respiration for two sites in the Back River estuary and

3. To relate calculated metabolism rates at two sites in the Back River estuary to possible controlling factors including temperature, solar radiation and algal biomass.

5.2 Examination of 1997 Data

5.2.1 Database Compilation

Copies of raw data were formatted for later retrieval as a "meta-file," which included synoptic measurements of water quality sensor data, corresponding results of water sample analyses and meteorological data. Continuous sampling for 12 weeks from June through September yielded a total of 9,220 observations for each water quality variable (water temperature, conductivity, salinity, DO percentage saturation and DO concentration) at 15 minute intervals. Included in the synoptic database compiled for analysis were daily observations for PAR. There also were 16 *in situ* Winkler determinations for instrument calibration, 15 total and active chlorophyll-a concentration measurements and 11 Winkler determinations from dark bottle experiments for independent weekly community respiration estimates. The resulting data set consists of a time series for the 97 days that sensors were deployed. Brief data gaps occurred on several of the days due to temporary instrument failures.

5.2.2 Data Evaluation

Before the high frequency data could be utilized for analysis, it was necessary to verify the accuracy of the observations. The first step in verification was to plot the observations against time. Time series plots of temperature, salinity and DO reveal important features of each series, such as trend, seasonality, discontinuities and outliers.

The temperature portion of the sensor is certified to ± 0.25 degrees Celsius by the manufacturer and requires no calibration or maintenance. Time series plots showed the continuous temperature trace with no perturbations even when sensors were exchanged; therefore, all temperature data were considered acceptable in the raw form.

The conductivity portion of the sensor was calibrated with a conductivity standard each week. The time series plots of salinity measurements that are computed by the sensor internally showed no perturbations associated with exchanging instruments, so these data were also considered to be acceptable for analysis in raw form.

Strong agreement between sensors calibrated in air with *in situ* Winkler determinations is further validated by a strong statistical relationship (r^2 = 0.98; Figure 3-3 and Table 3-1). Over the season, two sets of the Winkler determinations departed significantly from sensor measurements. These large discrepancies were likely the result of measurement error and were removed from the analysis shown in Figure 3-3. In contrast to the accuracy found at the beginning of each deployment, comparisons of sensor concentrations and *in situ* Winkler determinations at the end of each sensor deployment did not initially appear to follow consistent patterns. In order to optimize data for analysis, further action was needed to distinguish acceptable DO time series data from that which needed to be either corrected or eliminated.

5.2.3 Data Compensation

Due to varying rates of biofouling observed on sensors and the inconsistent effect of fouling on DO measurements by sensors, it was necessary to assess DO probe performance using the independent *in situ* calibration measurements available. It seems possible that the inconsistent relationship between observed fouling, sensor readings and Winkler determinations may be due to different effects on sensor performance by different species of fouling organisms. If DO data from sensor measurements at the end of a deployment period differed by 1 mg l^{-1} or less from corresponding Winkler DO determinations, the sensor DO data were accepted without correction

The question of whether to accept, reject or compensate for a portion of deployments which ended with sensor DO data more than 1 mg l^{-1} different than Winkler DO was resolved using linear correction to compensate data based on the following considerations. Conventional use of monitoring sensors for attended overboard measurements (spot sampling) relies, at a minimum, on proper adherence to laboratory procedures specified by the manufacturer for calibration of the DO sensor in air. For long-term unattended deployments, air calibration is recommended prior to and following each deployment. Of the 2 monitors used, one (YSI Model 6920) provides software to compensate the data for any sensor drift which may occur, by a linear correction of data between accepted values from pre-deployment and post-deployment air calibration or from independent measurements. The other type of sensor used (Hydrolab DataSonde 3) does not provide software for drift compensation.

An algorithm was developed to compensate data for sensor drift (probably caused by biofouling of the sensor membranes) as needed using a linear interpolation correction for each DO value between accepted sensor end and beginning values (as done by YSI software) based on the following criteria:

1. All sensor data from deployments with both beginning and end point measurements within ± 1 mg l^{-1} of respective Winkler concentrations are retained unchanged. This condition applied to most deployments.

2. If end point sensor measurements exceeded the Winkler concentration by more than 1 mg l^{-1}, the difference between that and the corresponding beginning point concentration of the replacement sensor was computed, then added to the end point concentration. All preceding measurements were similarly compensated by addition of a linearly decreasing value from end to beginning of that deployment, where correction was zero for the first DO measurement. Then, compensated percent saturation DO was computed from each temperature and salinity observation and compensated DO concentration.

3. Deployments with beginning point sensor measurements that exceeded the acceptable ± 1 mg l^{-1} range of end point sensor data *and* Winkler DO concentrations were also compensated as in criteria 2.

Both unaltered and compensated water quality sensor data were combined with simultaneous meteorological data and archived in a (nearly) continuous time series format suitable for analysis.

5.3 Description of 1997 Back River High Frequency Dissolved Oxygen Data

Time series plots of high frequency DO measurements collected at Back River stations during 1997 generally exhibited diel patterns commonly observed in other Chesapeake Bay tributaries (Boynton *et al.*, 1998), although the magnitude of diel changes was particularly large in this system. One way to characterize the diel pattern of DO concentration is shown in Figure 5-1 based on data collected at Rudy's Marina. In this case the means and standard deviations (error bars in the figure) were calculated by hour on the residuals from a trend line through the DO record (20 June through 24 September, 1997). The standard deviation reflects the expected variability in the daily cycle, not the uncertainty in the estimates of the hourly means, which is far smaller (0.1 - 0.15 mg l^{-1}). A number of useful points emerge from inspection of this graphic. First, the pattern clearly reflects strong influences of biological metabolism on the diel DO pattern. Oxygen concentrations (residuals from the trend line in this presentation) declined from late afternoon until several hours after sunrise the following day, reflecting community respiration during hours of darkness and the dominance of respiration over autotrophic DO production during the periods just before sunset and after sunrise. During daylight periods, DO concentrations rose in response to phytoplanktonic DO production in excess of that used in respiratory processes. In short, this is the diel DO cycle expected if biological metabolism was the major influence on DO conditions. Second, the magnitude of diel change was relatively large, amounting on average to about 4 mg l^{-1} day^{-1}, an indication of a metabolically active system. Finally, there was variability associated with DO concentrations for any hour of the day suggesting sharp changes in metabolic rates during different days during the monitoring period. Such sharp changes were frequently observed and were apparently in response to changes in such controlling variables as sunlight, temperature and algal biomass.

5.4 Compliance with Dissolved Oxygen Habitat Criteria

The 1997 high frequency DO data collected from both stations in Back River were evaluated to assess compliance with living resource habitat criteria for DO as defined in Table 5-1. Two frequency histograms of the DO data collected at Rudy's Marina and at Riverside Marina were constructed using 1 mg l^{-1} intervals. The frequencies were expressed as percentages of the total number of observations (Figure 5-2). At both sites the frequency of occurrence of low DO values was low, at least at 1 m depth below the surface of the water. For example, at Riverside Marina, DO values of 3 mg l^{-1} occurred about 1% of the time or for about 23 hours during the 97-day summer monitoring period. In fact, at both sites DO concentrations below 5 mg l^{-1} occurred only about 3% of the time or for about 70 hours during the summer period. The DO

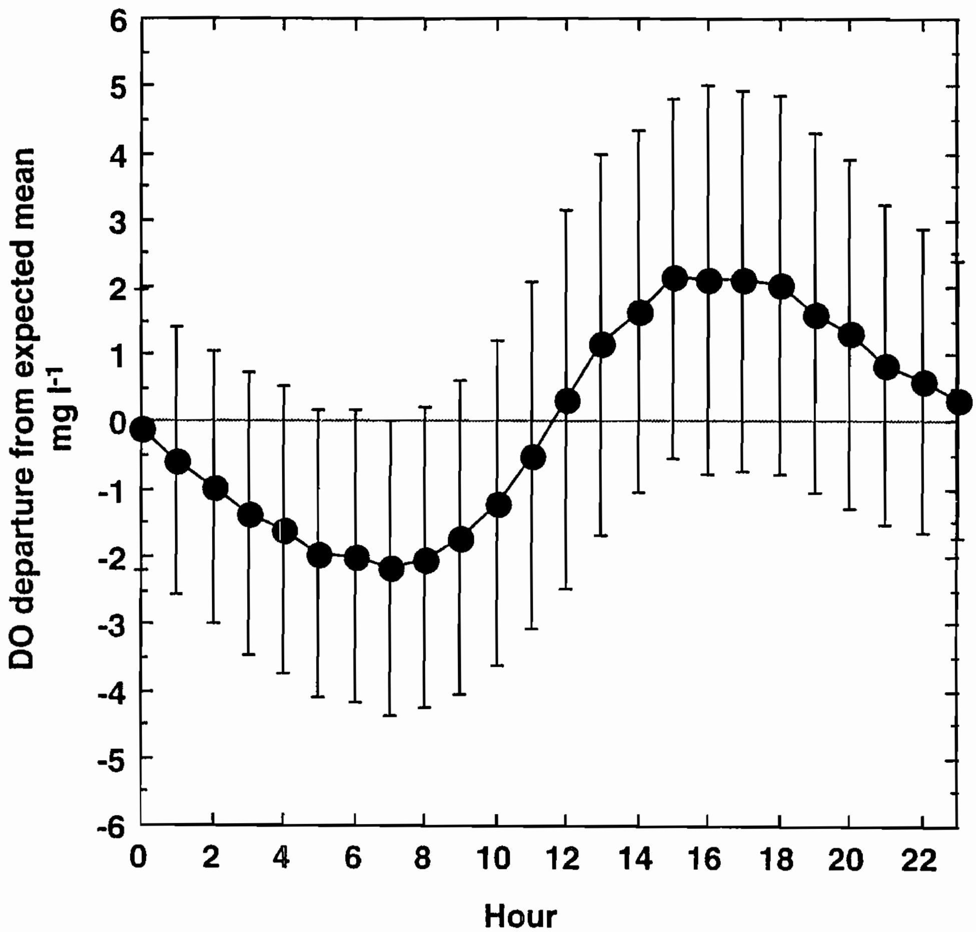


Figure 5-1. The typical diel cycle of DO at Rudy's Marina.
The means and standard deviations (error bars) were calculated by hour on the residuals from the trend line through the period of record. The standard deviation reflects the expected variability in the daily cycle not the uncertainty in the estimates of the hourly means, which is far smaller (0.1 – 1.5 mg l^{-1}).

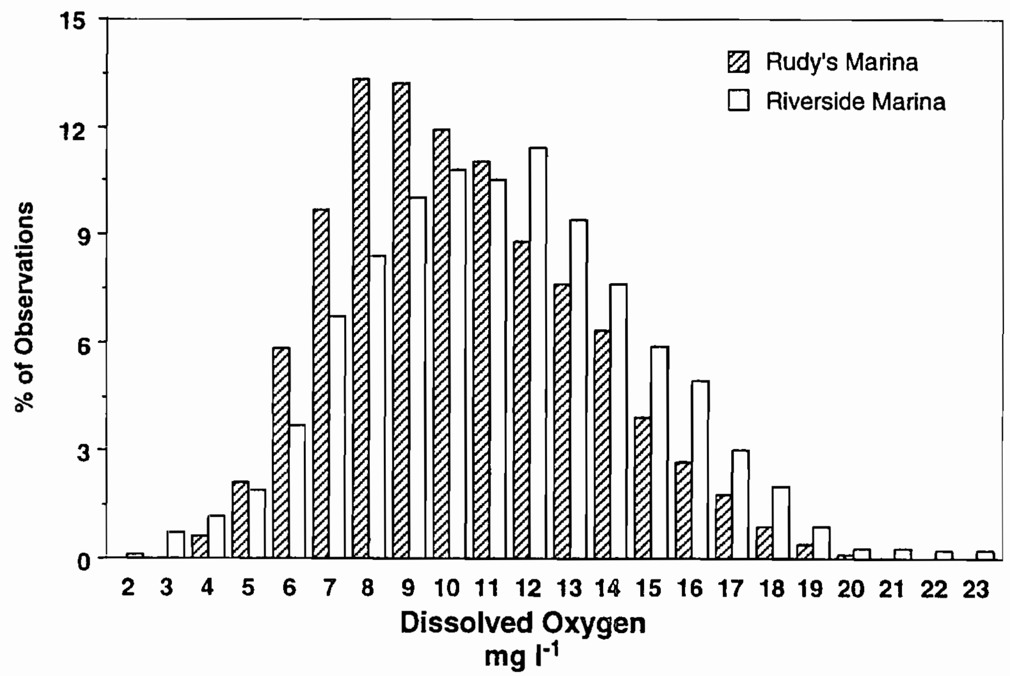


Figure 5-2. The distribution of DO observations at Rudy's Marina and Riverside Marina stations. *The categories are DO concentrations rounded to the nearest integer.*

Table 5-1. The living resource habitat requirements for dissolved oxygen.

a. The DO concentration should be at least 1.0 mg l^{-1} at all times throughout Chesapeake Bay and its tributaries, including subpycnocline waters.

b. DO concentrations between 1.0 and 3.0 mg l^{-1} should not occur for longer than 12 hours and the interval between excursions of DO between 1.0 and 3.0 mg l^{-1} should be at least 48 hours throughout Chesapeake Bay and its tidal tributaries, including subpycnocline waters.

c. Monthly mean DO concentrations should be at least 5.0 mg l^{-1} throughout the above-pycnocline waters of Chesapeake Bay and its tidal tributaries.

d. DO concentrations should be at least 5.0 mg l^{-1} at all times throughout the above pycnocline waters of anadramous fish spawning reaches, spawning rivers and nursery areas of Chesapeake Bay and its tidal tributaries as defined in Habitat Requirements for Chesapeake Bay Living Resources, 1991 revised edition (Funderburk *et al.*, 1991).

e. In addition, where DO conditions presently exceed the requirements, these conditions should be maintained.

conditions of near-surface waters in this system were better than those found in the low salinity portion of Patuxent River during the summer of 1997 (Boynton *et al.*, 1998). At that site in the Patuxent River, DO concentrations in above-pycnocline waters were below or equal to 5 mg l^{-1} for a total of 19% (689 hours) of the 5 month monitoring period. Excursions below 3 mg l^{-1} totaled 11 hours, but were distributed over nine days and were relatively short-lived. The most persistent hypoxia was during a 3-day period when excursions remained below 3 mg l^{-1} on 5 separate occasions, ranging from 15 minutes to two hours.

Any sense that the data collected in Back River represent adequate habitat conditions should be tempered with the awareness that an overly optimistic bias may be contained in these data since concentrations at 1 meter depth (from which depth all measurements were taken) represent the highest DO values in the water column. It is possible that more persistent periods of lower DO occur in deeper waters near the sediment-water interface. In systems that have relatively large diel DO excursions, such as Back River, concentrations in deeper waters may be especially prone to low DO events of short duration (*i.e.* for the several hours before sunrise). In the future, it would be worth testing this idea by deploying one or more recording instruments closer to the sediment surface in deeper waters.

Finally, the frequency histogram of DO concentrations indicates some clear differences between stations in Back River. There is a higher occurrence of lower DO concentrations (6 - 11 mg l^{-1}) at the station nearest the mouth of Back River (Rudy's Marina) and a higher occurrence of especially high DO concentrations (12 - 23 mg l^{-1}) at the station nearest the sewage treatment plant (Riverside Marina). It appears that the most probable explanation for this is that algal stocks (as indicated by chlorophyll-a concentrations) are higher near the WWTP than at the down river site. Dense algal communities are capable of high rates of oxygen production during daylight hours; the increased frequency of high DO concentrations is probably a direct result of this situation.

5.5 Open Water Metabolism Measurements in Back River

5.5.1 Background and Definitions

Measurements of both gross and net metabolism of an ecosystem are useful descriptors of ecosystem function for a number of reasons. Gross and net community production (P) and respiration (R) are an indication of the overall activity of a system. High metabolism (the sum of both P and R) is usually associated with enriched systems, and many of the undesirable effects associated with eutrophication can be associated with high community metabolism rates. In addition, the relative magnitude of organic production to community respiration provides an estimate of the amount of organic matter that must be imported into the system (the case when P/R ratios are less than unity) or the amount of organic matter that is accumulating in the system (the case when P/R ratios are greater than unity; Kemp *et al.*, 1997). Importantly, ecosystem metabolism measurements are rates and as such are particularly useful for understanding ecosystem dynamics.

The high frequency time series of DO from the sites in Back River were used to generate daily estimates of surface water (top 1 meter) metabolism from June through late September, 1997. The open water technique that was used relies on the daily excursions in DO caused by oxygen production during hours of daylight and oxygen consumption during hours of darkness. The diel pattern is also affected by oxygen exchange (diffusion) across the air-sea interface in either direction to maintain equilibrium between water and overlying air. When water is over-saturated, oxygen is diffused from water to air and conversely from air to water when water is under-saturated. The exchange of oxygen is proportional to the degree of over or undersaturation. While certain assumptions are required, as with all techniques, the open water technique is especially useful for characterizing ecosystems because it integrates across ecosystem components, time and space and has no container effects. Open water techniques are particularly well suited to metabolically active systems such as Back River.

The parameters used for community metabolism estimates are defined as follows:

Rn Night Respiration (g O_2 m^{-3} day^{-1}): oxygen consumption between sunset and sunrise.

Rn hr^{-1} Night Respiration Rate (g O_2 m^{-3} hr^{-1}): mean hourly oxygen consumption rate between sunset and sunrise.

SRm Metabolic Sunrise: time of DO minimum during daylight hours.

SSm Metabolic Sunset: time of DO maximum during daylight hours.

Pa Net oxygen production (g O_2 m^{-3} day^{-1}) between sunrise and sunset.

Pa* Net oxygen production during period of net autotrophy (g O_2 m^{-3} day^{-1}), which occurs between the times of DO minimum (SRm) and maximum (SSm). Periods during which there is net DO consumption are not included.

Pg Gross oxygen production (g O_2 m^{-3} day^{-1}) between sunrise and sunset, assuming daytime respiration rate is equal to nighttime respiration rate (Rn hr^{-1}) during subsequent night.

Pg* Gross oxygen production during period of net autotrophy (g O_2 m^{-3} day^{-1}), assuming daytime respiration rate is equal to nighttime respiration rate (Rn hr^{-1}) during subsequent night.

5.5.2 Estimation Algorithms

All of the metabolic parameters can be routinely calculated once several operations are performed on the entire time series. Operations are as follows:

(1) Times of sunset and sunrise were obtained from the US Naval Observatory (http://riemann.usno.navy.mil/AA/) for each day. Supplemental DO concentration and percent oxygen saturation (POSAT) were computed by interpolation for times when sunrise or sunset did not correspond exactly to measured observations. Using times of sunrise and sunset, DAYPART labels were assigned to distinguish each observation measured during either daylight or nighttime.

(2) Change in DO, mean POSAT and time interval in hours (t) were computed between each observation and preceding observation.

(3) Air-sea oxygen exchange (ASEXCH) during each interval was computed, assuming a constant reaeration coefficient of 0.5 g O_2 m^{-2} hr^{-1} at 100% saturation deficit. This equation is:

$$ASEXCH = 0.5 * t * (100-POSAT)/100$$

Resulting units are g O_2 m^{-2}.

(4) Corrected net oxygen production (CNOP) was computed by subtracting ASEXCH from DO. ASEXCH is multiplied by 1 m to obtain identical units, since this metabolism calculation represents processes across the dimensions of the 1 meter near-surface water.

(5) Minimum and maximum DO observations for each day were identified. A METPART label was then assigned to each daytime observation preceding the minimum as "Predawn"; or daytime observations following the maximum as "Predusk". Remaining daytime observations were assigned METPART labels "Day"; and all nighttime observations labeled "Night".

(6) A date variable (METDAY) was assigned to designate observations during each "metabolic day", defined as one daytime period and the entire following night (sunrise to the following sunrise) rather than the usual 24 period. (Note that this "metabolic day" may encompass slightly more or less than 24 hours.)

Once the above operations were completed, daily metabolic parameter values were computed by summation of all values in each METPART group for that METDAY. The parameters Rn hr^{-1}, Pg and Pg* were calculated using the formulas in Table 5-2. Once all of these parameters were calculated, any daily observations for which insufficient data were available were eliminated.

Table 5-2. The formulas for calculating Rn hr^{-1}, Pg and Pa* and resulting units.

Parameter	Method of Calculation	Units
Rn hr^{-1}	Rn $Night^{-1}$	g O_2 m^{-3} hr^{-1}
Pg	Pa + (Rn $Night^{-1}$)*(Pre-Dawn+Day+Pre-Dusk)	g O_2 m^{-3} d^{-1}
Pg*	Pa* + (Rn $Night^{-1}$)*(Pre-Dawn+Day+Pre-Dusk)	g O_2 m^{-3} d^{-1}

5.5.3 Metabolism Estimates

5.5.3.1 Net Production (Pa*), Respiration (Rn) and Gross Production (Pg*) Rates

The magnitude of net autotrophic production (Pa*) ranged from near zero to about 18 g O_2 m^{-3} day^{-1} at Rudy's Marina and was somewhat higher at Riverside Marina (top panels in Figures 5-3 and 5-4, respectively). Pa* was variable from day to day but rates tended to be higher in late June and July than in late August and September, especially at Rudy's Marina. Qualitative inspection of the seasonal pattern in Pa* suggests relationships to possibly sunlight (daily variability due to clear and cloudy days) and seasonal changes in water temperature. Quantitative analyses of these and other possible factors controlling metabolic rates are provided in another section of this report.

Nighttime respiration (Rn) ranged from near zero to about 8 g O_2 m^{-3} day^{-1} over the period of record at both study sites. As was observed for Pa*, rates of Rn were also variable on a day to day basis at both sites. The broad pattern in respiration estimates was an increase in rates from late June through early August, followed by a decrease through early fall (middle panels in Figures 5-3 and 5-4, respectively). This pattern probably reflects the influence of water temperature on estuarine respiration rates, as reported by Smith and Kemp (1995) for adjacent areas of Chesapeake Bay.

Gross production (Pg*) rates ranged from about 2 to 25 g O_2 m^{-3} day^{-1} at Rudy's Marina and from about 1 to 32 g O_2 m^{-3} day^{-1} at Riverside Marina (bottom panels in Figures 5-3 and 5-4, respectively). Seasonal patterns and the degree of daily variability of Pg* estimates were similar to those observed for the other metabolic rate measurements. Further analyses are presented in a later section of this report which examine correlation of Pg* with daily integrated photosynthetically active radiation (PAR), temperature and algal biomass. Overall, estimates of all metabolic rates (*i.e.* Pa*, Rn, Pg*) in Back River were high compared to identical measurements made in other less nutrient stressed environments (Table 5-3).

5.5.3.2 Characterizations of Metabolism Estimates

The entire data set for each metabolic variable is summarized for each sampling site as a set of box and whisker plots (Figure 5-5). In the box and whisker plot format, the 5th and 95th percentiles are indicated as the ends of the vertical lines, the 25th and 75th as the bottom and top of the rectangle, the 50th as the horizontal line within the rectangle and the mean as the small open or darkened square within the rectangle. At both sites, Pg* > Pg >Pa* >Pa as expected (see definitions in section 5-5.1). The estimates of autotrophic rates (Pa, Pa*, Pg and Pg*) were all greater at Riverside Marina (nearer the WWTP) than at Rudy's Marina and this is probably the direct result of higher chlorophyll-a stocks in the immediate vicinity of the WWTP outfall and the ultimate result of higher nutrient loading rates nearer the WWTP outfall. Respiration rates during hours of darkness (Rn) averaged about 2.0 and 2.5 g O_2 m^{-3} day^{-1} at Rudy's and Riverside Marinas, respectively. While values of Rn were smaller than the autotrophic rates, rates were still substantial compared with those observed in other estuarine environments (Boynton *et al.*,

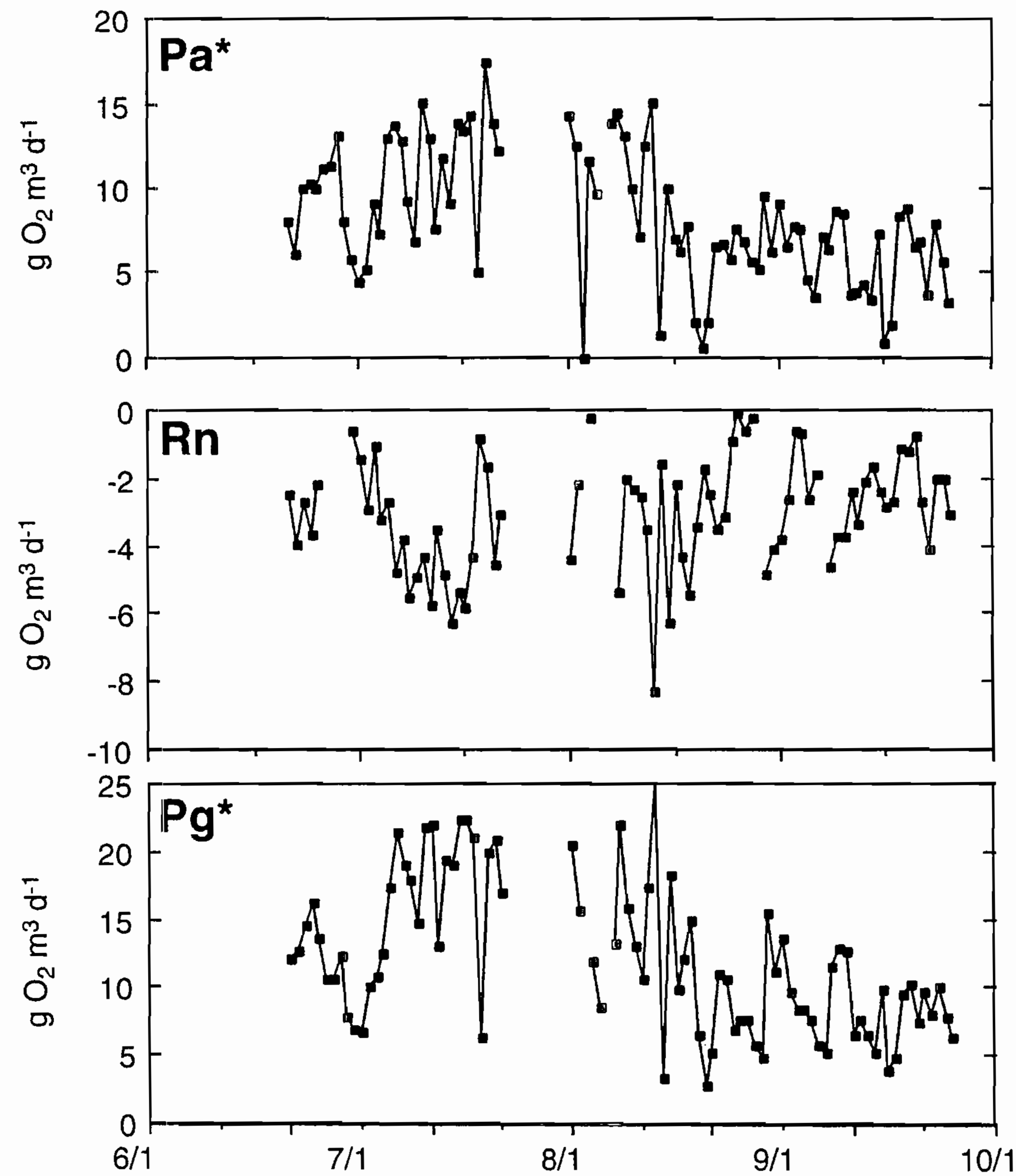


Figure 5-3. The time series of metabolism estimates at Rudy's Marina.
Respiration (Rn) is shown as a negative oxygen flux; therefore, large respiration values are lower on the graph.

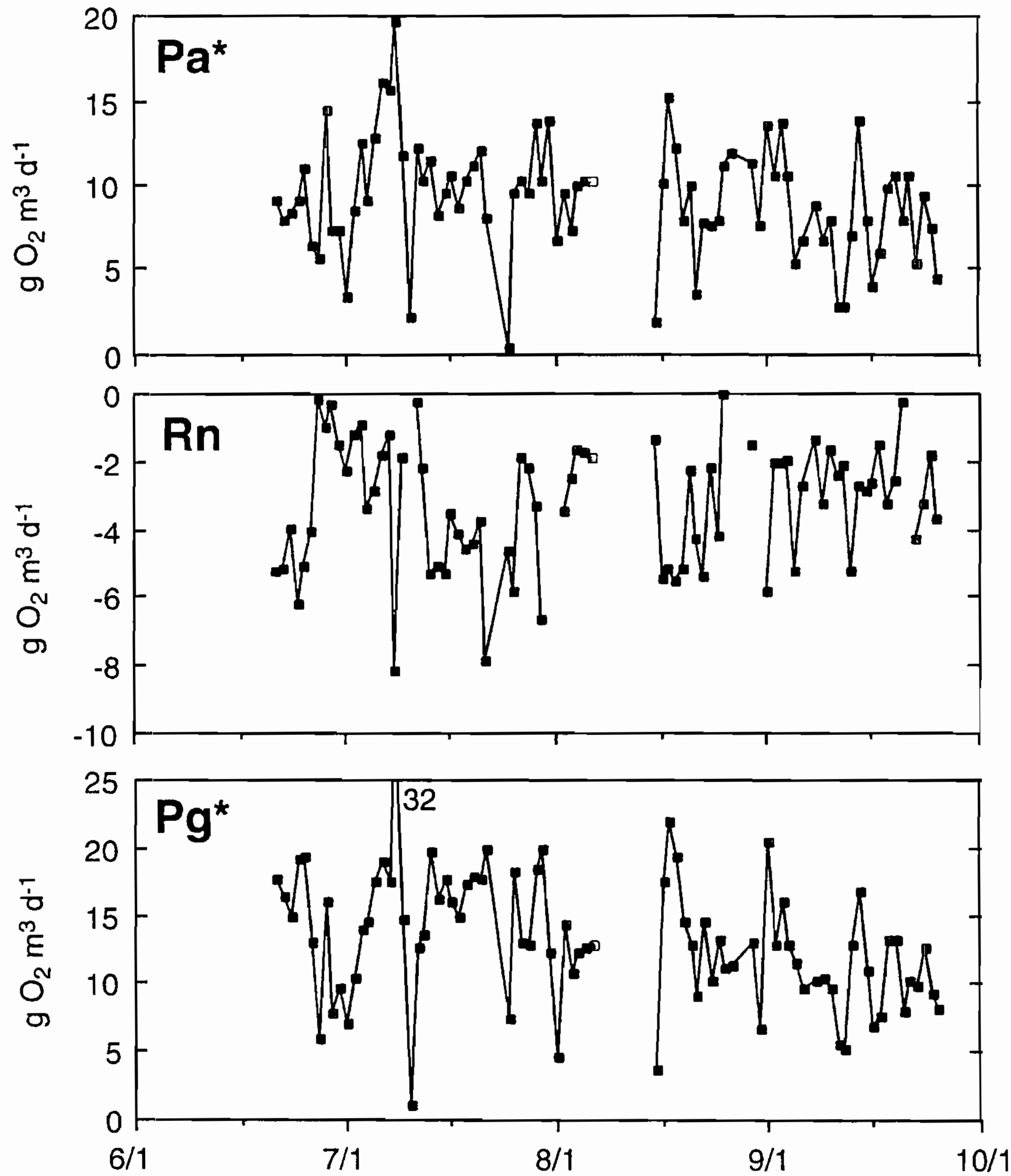


Figure 5-4. The time series of metabolism estimates at Riverside Marina.
Respiration (Rn) is shown as a negative oxygen flux; therefore, large respiration values are lower on the graph.

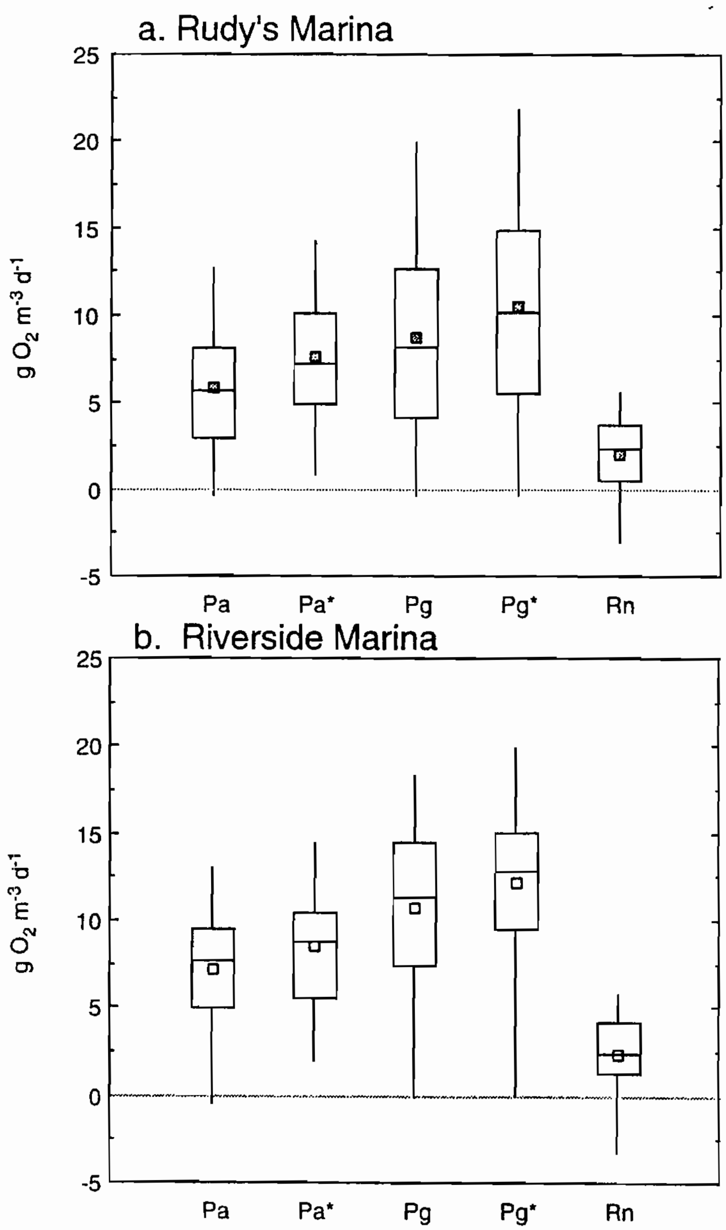


Figure 5-5. Box and whisker plots illustrating the 5, 25, 50, 75 and 95th percentiles plus the means (open and filled squares) of metabolic parameters at Rudy's Marina and Riverside Marina.

Table 5-3. A summary of estimates of Pa* and Rn rates for several estuarine ecosystems, including several from Chesapeake Bay region.

All measurements were made during the summer periods. Sites with submerged aquatic vegetation (SAV) are indicated to differentiate them from sites dominated by other types of primary producers. All measurements were made using the open water technique identical to the technique used in Back River study except Smith and Kemp (1995) who used a light-dark bottle approach.

LOCATION	SYSTEM TYPE	AVERAGE DEPTH (m)	Pa* ($g\ O_2\ m^{-2} day^{-1}$)	Rn ($g\ O_2 m^{-2}\ day^{-1}$)	REFERENCE
Back River					This study
Rudy's Marina	shallow, well-mixed,	1.4	8.00	2.40	
Riverside Marina	large nutrient inputs		9.00	2.60	
Appalachicola Bay	river dominated, shallow	2.5	3.40	3.30	Boynton, 1975
Florida Panhandle					
Upper Chesapeake Bay, MD	well mixed, turbid, plankton measurements	4.5	1.1 - 1.9	0.37 - 0.92	Smith and Kemp, 1996
Chincoteague Bay MD	shallow, turbid and well mixed	2.1	1.90	0.95	Boynton, 1973
Wiquoit Bay, MA					D'Avanzo *et al.*, 1996
Sage Lot Pond	shallow, well mixed	0.9	4.50	4.50	
Childs River	as above with high nutrient inputs	1.1	8.00	7.50	
Patuxent River at Benedict, MD	well mixed, turbid with low nutrient loads in 1964 and higher loads since	4.5			Boynton *et al.*, 1998
1964			1.60	2.60	
1992			4.90	4.10	
1996			3.60	2.90	
1997			2.80	2.80	
Texas Estuaries	shallow, well mixed with high salinities	0.5 - 1.5	1.2 - 8.0	2.1 - 17.6	Odum and Hoskin, 1958
SAV Site					
Eastern Bay, MD	both sites shallow and well mixed,				Kaumeyer *et al.*, 1981
SAV Site	SAV community	1-1.5	4.80	5.60	
Littoral Site	non-vegetated area	1-1.5	2.20	2.30	

1998 and Kemp and Boynton, 1980). Finally, the ratio of Pa to Rn (often referred to as the P/R ratio) at both sites exceeded unity indicating that on average more organic matter was being produced than consumed at these sites. The accumulation of large stocks of phytoplankton in most of Back River is consistent with this prediction. This organic matter is available for deposition to bottom sediments where it can be decomposed by sediment microorganisms or exported via tidal transport to the open waters of upper Chesapeake Bay. The inorganic nitrogen and phosphorus resulting from local decomposition can be readily returned to the water column (because the water column is well mixed) and be again utilized by phytoplanktonic communities. This cycle of high production rates, organic matter sinking to the bottom, remineralization of deposited organic matter, release of inorganic nutrients and re-utilization of nutrients by growing pyhtoplankton is a basic characteristic of a eutrified system; we would expect the magnitude of these processes to decrease rapidly as nitrogen loads decrease.

5.5.3.3. Effect of Tidal Advection on Metabolism Estimates

One of the important requirements of the open water metabolism calculation is that there are no horizontal gradients in DO. If such gradients were present, apparent changes in DO concentrations would be generated by tidal action as the oxygen gradient is advected past the measurement point. On average, this will not lead to a bias in the metabolic parameters; however, as the phase of the tidal cycle and diel cycle in DO shifts, an error of periodically varying magnitude will be generated in all of the metabolic parameters.

In Back River, DO concentrations are high, usually well above the saturation concentration. In the upper Chesapeake Bay, the DO concentrations are much lower, often below saturation concentrations. Consequently, as the tide comes in, the DO concentration will decrease if no other factors lead to a change. Similarly, as the tide goes out, DO concentrations will increase. If high tide occurs around sunset and the tide at dawn is not also high, then Rn for that night will be erroneously low (small negative number). In fact, this could lead to an overnight increase in DO, an event that occurred on only a few occasions in the record. In contrast, if low tide occurs at sunset and the tide is not also low at sunrise, the estimate of Rn will be erroneously high (large negative number). The effect of advection can be shown statistically using the high frequency DO and salinity data for Back River. Correcting for time of day, changes in DO concentrations are negatively correlated with changes in salinity. Although not overtly simple, it is likely that the effect of advection can be removed from the time series, leading to more precise estimates of the metabolic parameters and their relationships to environmental factors.

5.6. Comparisons of Back River Metabolic Rates with Other Systems

Estimates of community metabolism rates from a variety of estuarine systems, including several sites in Chesapeake Bay, have been organized for purposes of comparing these with those observed in Back River during the summer of 1997. Most measurements contained in Table 5-3 were made using the same technique as that used in Back River studies and those that were made using a modified technique are indicated. The main point to be made from this summary is that production rates in Back River are as high as those observed in other nutrient stressed environments (*e.g.* Waquoit Bay, MA) and in SAV communities (*e.g.* Texas estuaries with SAV communities) which are among the most metabolically active aquatic environments known.

Community respiration rates in Back River are comparable to those observed in other systems as indicated in Table 5.3. We had expected to see generally higher respiration rates in Back River associated with high production rates. Several explanations of this appear possible. First, the system may often act like a chemostat wherein algal communities grow rapidly (under conditions of high nutrient availability) in Back River but a significant amount of biomass was respired (decomposed via respiratory processes) after being transported out of the river, similar to the losses associated with export of product from a chemostat. A second explanation is that we have underestimated respiration, especially that associated with the sediment-water interface, because continuous DO measurements were collected at only one depth (1 m below the surface). Our computations were based on the surface one-meter of the water column where DO measurements were made. If we were to assume that DO concentrations measured at this depth were representative of those deeper in the water column (not unreasonable in this relatively well-mixed system) during hours of darkness (the time interval when Rn is computed) then estimates of Back River respiration would be larger, by about a factor of 1.5 - 2.0 depending on the depth of the water column (1.5 to 2.0 m). This adjustment would substantially increase estimates of areal respiration rates but would yield P/R ratios still less than one which is important because a ratio greater than unity is required for the development of the large algal stocks which were observed.

Finally, at one of the sites in Table 5-3 (Patuxent River at Benedict, MD), data for a total of 9 years (1964 through 1969; 1992; 1996 and 1997) were available to generate daily community production and respiration rates. The historical range of available data is especially significant for comparative analysis since the record includes years prior to water quality deterioration (mid 1960's), followed by a period during which nutrient enrichment of Patuxent River was high (1990's). Efforts to decrease nutrient loadings were first implemented during the early 1980's with phosphorus load reductions. The pattern for N loadings is similar, with a rapid increase beginning in the 1960's but not beginning a decline until later, in the early 1990's. Both N and P loading rates appear, by 1997, to be approaching the lower levels that existed in the mid 1960's. Comparisons of the range of community production and respiration rates calculated for years of available data suggest a pattern analogous to nutrient loading rates. The lowest production rates were during 1964, when nutrient loading rates were at the lowest level. The average net production rate was exceeded by respiration rate, which indicates that all available organic matter produced within the community ecosystem was effectively metabolized by autotrophic and heteotrophic activities. Among the four years (1964, 1992, 1996 and 1997) presented in Table 5-3, seasonally averaged peak production and respiration rates occurred during 1992, when N loading rates were the highest of those years. Metabolism rates and loading rates were at intermediate levels during 1996. Metabolism rates and nutrient loading rates are relatively low during 1997, with net production and respiration rates approximately in balance. Respiration rates in 1997 and 1964 were approximately equal. The main point here is that these systems respond to nutrient loading rates. When loading rates, especially of N, decrease in Back River, rates of community production and respiration should also decline to levels typical of healthier aquatic ecosystems.

5.7 Statistical Models of Metabolism

5.7.1 Daytime Net Production vs. Chlorophyll-a and Photosynthetically Active Radiation

Daily integrated PAR and phytoplankton biomass are often important predictors of Pa or Pa*. Specifically, since PAR provides the energy needed for photosynthesis, one would expect a positive relationship between PAR and net production. Such a positive relationship was observed at both Rudy's and Riverside stations (Figure 5-6). In these models, the natural log of Pa* is linearly related to PAR. The models have been converted back to a linear scale, yielding an exponential relationship and a log-normal error distribution. The increase in Pa* with PAR is approximately the same at the two stations, although the mean Pa* is slightly higher at Riverside.

Clearly, these models leave considerable variability. Two possible sources include estimation of Pa* and daily integrated PAR. While PAR is measured continuously and with considerable precision, the radiometer is located in Solomons, MD, where cloud cover may be different than in Back River. Other sources of variability include environmental factors besides PAR. These include phytoplankton biomass, light attenuation in the water column, respiration, and others.

A limited number of chlorophyll-a concentrations are available as an indicator of phytoplankton biomass. Since phytoplankton biomass is the abundance of organisms capable of producing oxygen, one may expect a positive relationship between phytoplankton biomass and Pa*. However, at high biomass the phytoplankton could easily limit their own net production through self-shading, leading to an equilibrium net production dependent on incident PAR and export of phytoplankton biomass. In this situation, the direction of causation is that Pa* (over a preceding time interval) determines phytoplankton biomass, not phytoplankton biomass determining the rate of Pa*. The important time-scale may be several days in length, not daily, since biomass integrates net production over a period related to the population turnover time. This was investigated for the Riverside site by constructing a robust moving average of 9 proceeding days (Figure 5-7). The moving average was re-weighted in two iterations to reduce the effect of outliers on the mean. Since there were far fewer observations of chlorophyll-a than Pa, the chlorophyll-a concentration was linearly interpolated in time. A repeated measure regression analysis was used to relate chlorophyll-a to Pa. This type of regression model accounts for both natural correlation of successive observations and the correlation introduced by smoothing and interpolation.

The resulting regression model predicts that that for every 1 g O_2 m^{-3} day^{-1} increase in Pa at Riverside Marina, chlorophyll-a increases 32±4 μg l^{-1}. Using a photosynthetic quotient (C:O molar ratio) of 1.2 and a phytoplankton carbon:chlorophyll-a ratio of 50:1, the regression implies that a 450 mg C m^{-3} day^{-1} increase in net production leads to a 1600 mg C m^{-3} increase in phytoplankton biomass. Therefore, to achieve the change in phytoplankton biomass net production must be sustained at the higher level for at least 3.5 days, or a larger increase net production must occur.

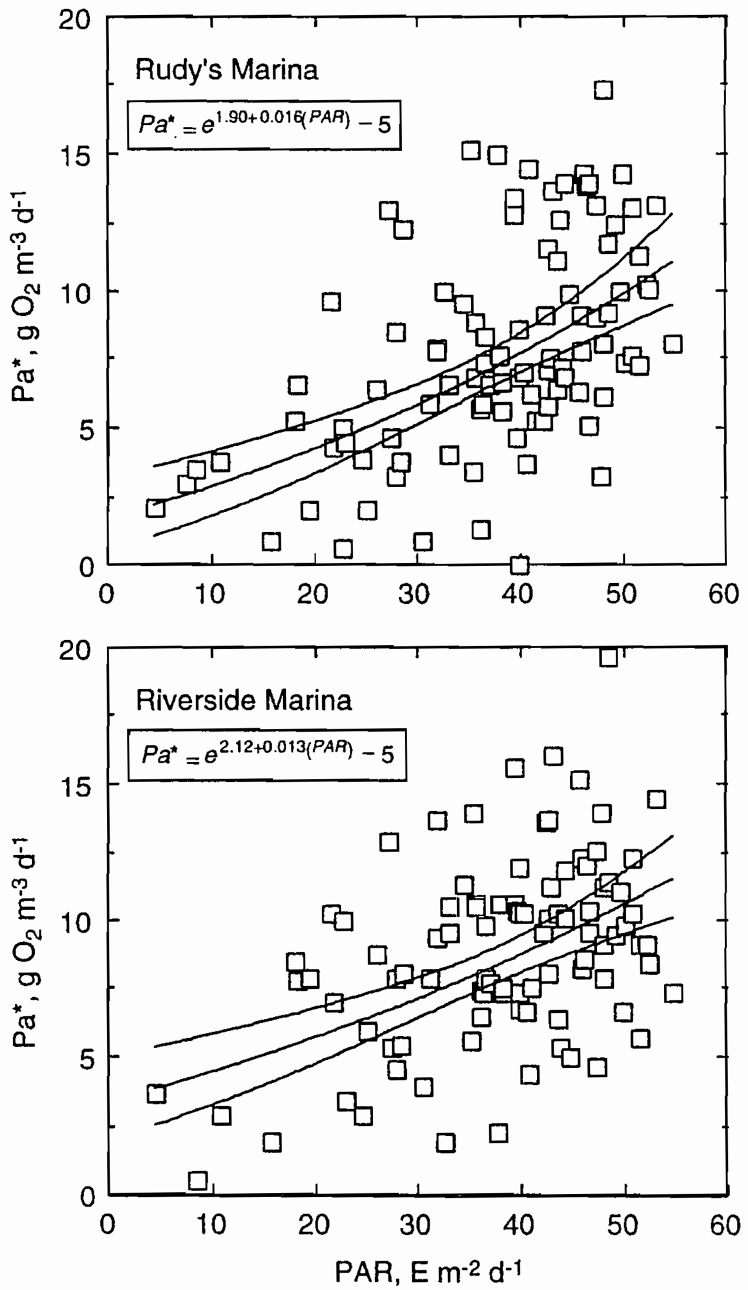


Figure 5-6. The relationship between Pa* at Rudy's Marina and Riverside Marina and daily integrated PAR measured at Solomons, MD.

The confidence bands express the 95% confidence limits for the regression line. Values were transformed by adding 5 prior and log-transforming prior to fitting a model. This promotes normality of residuals. Back transformation of the values resulted in the "-5" constant that appears in the equations.

5.7.2 Nightime Respiration and Dark Bottle Respiration vs. Water Temperature

The comparison of nighttime open water respiration (Rn) measurements to dark bottle measurements (Figure 5-8) shows that the open water respiration estimates tended to be larger than the bottle measurements. This is expected for several reasons. One reason is that including benthic respiration could contribute some respiration to Rn. Another reason is that nighttime respiration, which follows the period of greatest net production, can be higher than respiration in waters collected in the morning following hours of net respiration in the water column. Since the water for the dark bottle incubations was not collected at sunset, the respiration may be expected to be lower than Rn. An additional source for the difference is the tendency for settling of particles in the unmixed water in a dark bottle to lead to lower respiration. However, since there is little reason to expect that a dark bottle respiration measurement would be higher than Rn, some confidence is gained that the Rn estimates are not underestimates. Both the dark bottle measurements and the open water respiration measurements showed an increase in respiration with water temperature (Figure 5-8).

5.8 Water Column Respiration Rates and Measures of Algal Biomass and Composition

On a weekly basis throughout the study period (20 June through 24 September, 1997) measurements of water column respiration and water column algal biomass (as indicated by chlorophyll-a concentrations) were made at both Back River stations. Data from these measurements are presented in Figure 5-10 and Table 5-4. Water column respiration rates ranged from 0.05 to 0.36 g O_2 m^{-3} hr^{-1} and 0.12 to 0.37 g O_2 m^{-3} hr^{-1}, at Rudy's Marina and Riverside Marina, respectively. At both sites, water column respiration rates were higher earlier in the study period than towards the latter half of the study period. Rates were frequently, but not always, similar among the sites with respect to temporal patterns but rates tended to be higher at the Riverside Marina site (average = 0.22 g O_2 m^{-3} hr^{-1}) than at Rudy's Marina (0.16 g O_2 m^{-3} hr^{-1}). If we use 10 hours as an average estimate of the hours of darkness per night for this period of year, these average bottle-based rates amount to rates of 1.6 to 2.2 gO_2 m^{-3} day^{-1} which would be roughly equivalent to the open water technique estimates of Rn. In general, water column respiration rates were smaller than Rn rates and this was expected because the dark bottle technique used for the water column estimates does not include any sediment respiration. In a later section of this report we compare the results of bottle plus sediment oxygen consumption rates with rates measured using the open water technique and construct a preliminary summer season DO budget for this system.

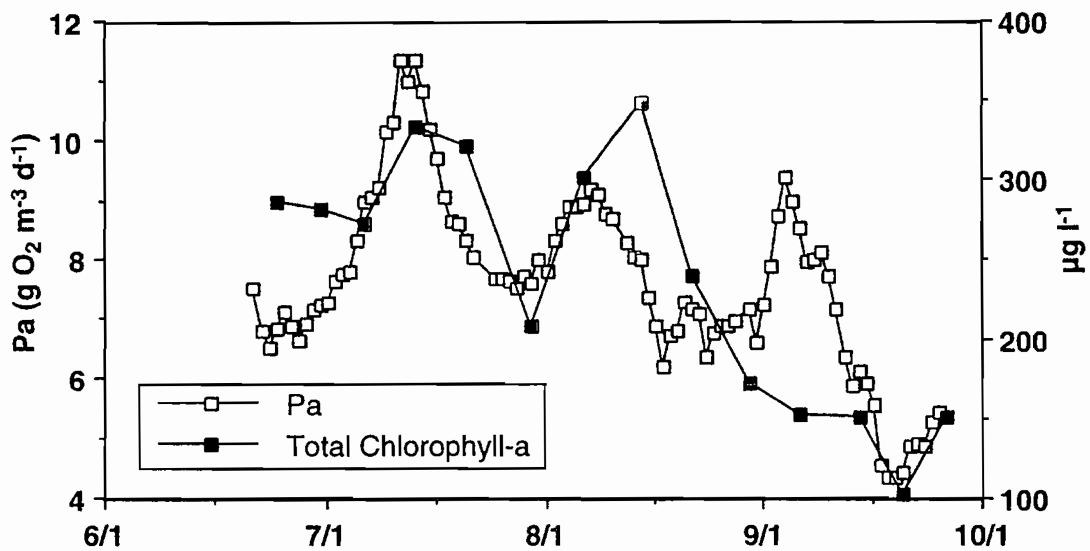


Figure 5-7. A robust 9-day moving average of daytime apparent production preceding the observed total chlorophyll-a concentrations at Riverside Marina.

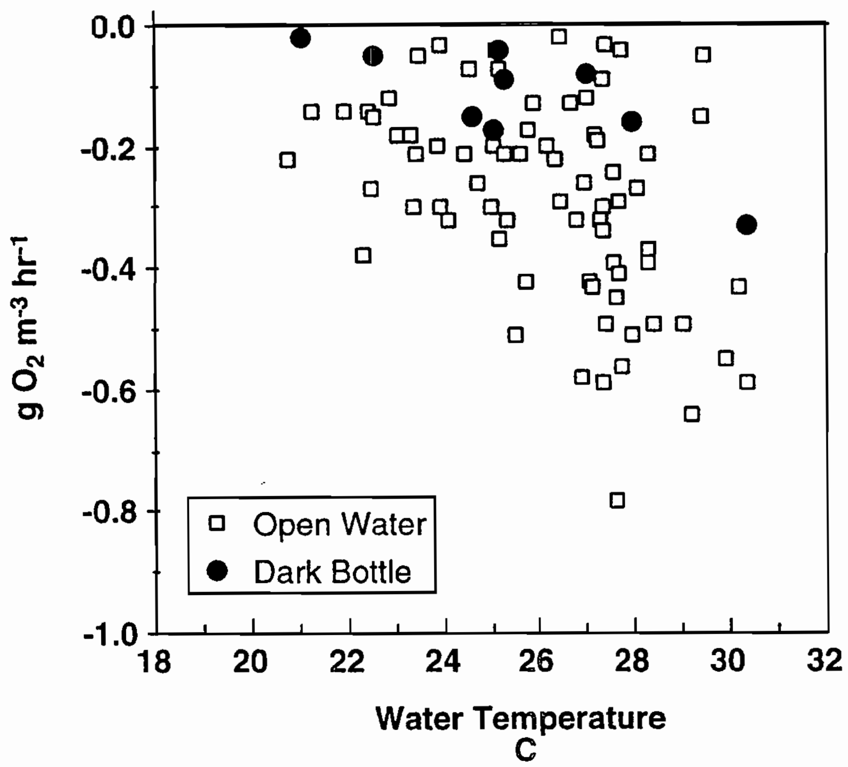


Figure 5-8. Hourly nighttime respiration (Rn hr^{-1}) and dark bottle respiration measurements at Rudy's Marina related to water temperature.

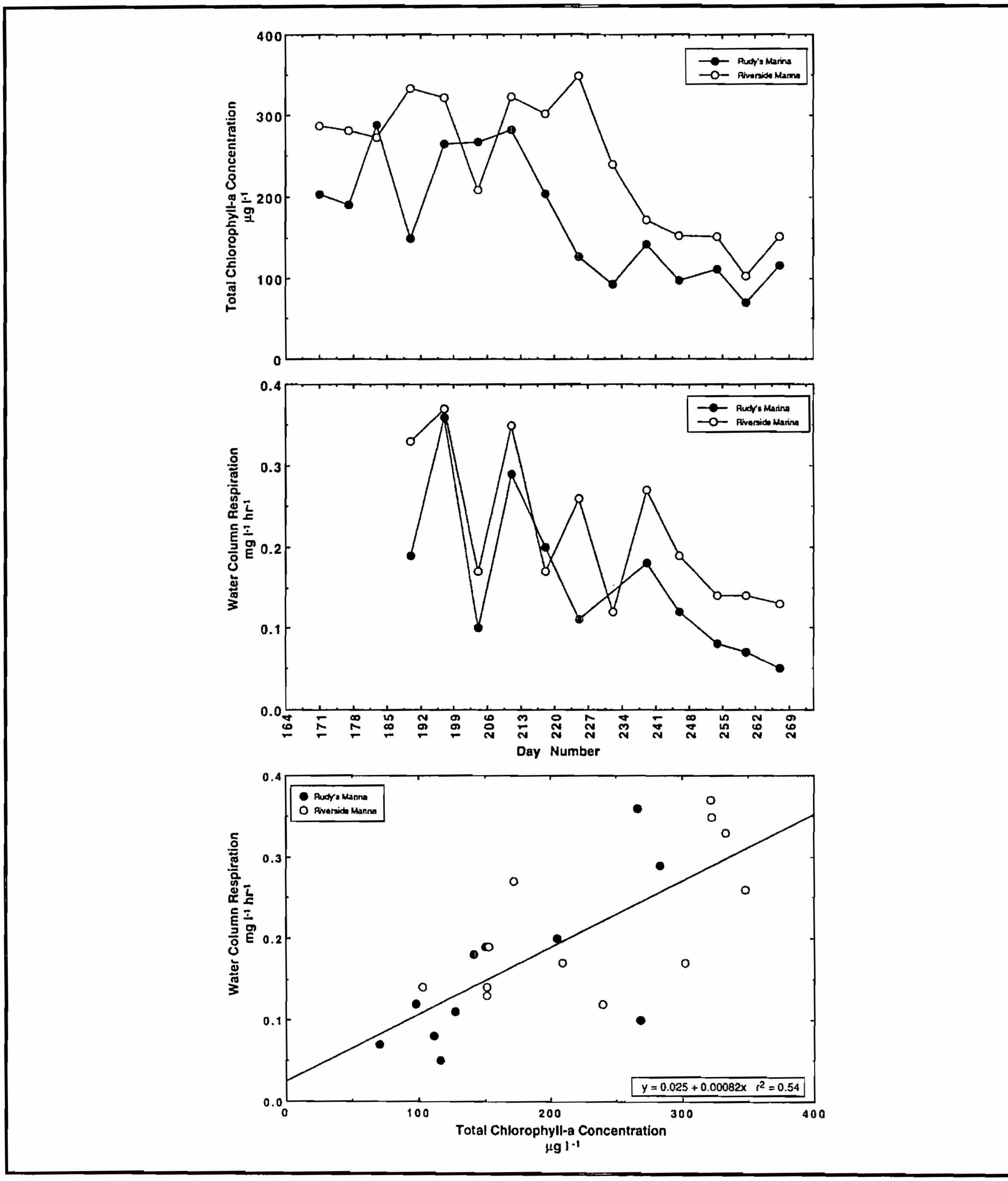


Figure 5-9. Line plots of chlorophyll-a and water column respiration data collected at two stations in Back River during the summer of 1997.

Samples for both measurements were taken at a water depth of approximately 0.5m. Station locations are shown in Figure 3-1. The bottom panel is a scatter plot of total chlorophyll-a concentration versus water column respiration rates and is based on data collected at the same two stations in Back River during the summer of 1997.

Table 5-4. A summary of dark bottle water column respiration rates (mg O_2 l^{-1} hr^{-1}) and water column total (Tchl) and active (Achl) chlorophyll-a concentrations (µg l^{-1}) collected at Rudy's Marina and Riverside Marina in Back River (Figure 3-1) during 1997.
Blank spaces in the table indicate that data were not collected on those days.

	Rudy's Marina Water Column Respiration (mg O_2 l^{-1} hr^{-1})	Rudy's Marina Water Column Tchl Concentration (µg l^{-1})	Rudy's Marina Water Column Achl Concentration (µg l^{-1})	Riverside Marina Water Column Respiration (mg O_2 l^{-1} hr^{-1})	Riverside Marina Water Column Tchl Concentration (µg l^{-1})	Riverside Marina Water Column Achl Concentration (µg l^{-1})
20-Jun-97		203	199		287	270
26-Jun-97		191	194		282	264
2-Jul-97		289	281		273	255
9-Jul-97	0.19	150	141	0.33	333	311
16-Jul-97	0.36	266	225	0.37	322	299
23-Jul-97	0.10	268	236	0.17	209	186
30-Jul-97	0.29	283	247	0.35	323	281
6-Aug-97	0.20	205	202	0.17	302	288
13-Aug-97	0.11	128	124	0.26	348	322
20-Aug-97		93	83	0.12	240	212
27-Aug-97	0.18	142	130	0.27	172	156
3-Sep-97	0.12	98	76	0.19	153	130
11-Sep-97	0.08	111	92	0.14	152	124
17-Sep-97	0.07	70	56	0.14	103	85
24-Sep-97	0.05	116	92	0.13	152	122

Concentrations of chlorophyll-a were extremely high at both sites in Back River during the 1997 study period. Concentrations ranged from 70 to 289 $\mu g\ l^{-1}$ at Rudy's Marina and from 103 to 348 $\mu g\ l^{-1}$ at Riverside Marina (Figure 5-9 and Table 5-4). The temporal pattern of chlorophyll-a concentrations was generally similar among sites (with a few exceptions); concentrations tended to be higher during June and July than during August and September. The chlorophyll-a levels in Back River were the highest observed by Maryland Chesapeake Bay Water Quality Monitoring Program for a number of years (highest of 58 different sampling sites in the Maryland portion of the Bay; R. Karrh, Maryland Department of Natural Resources (DNR), *pers. comm.*). Most other sites have summer chlorophyll-a concentrations in the range of 20 - 40 $\mu g\ l^{-1}$ and several nutrient enriched sites (upper Patuxent and Potomac River estuaries) have concentrations as high as 40 - 60 $\mu g\ l^{-1}$. The concentrations in Back River are extremely high by any local standards and high compared to a more global review of algal biomass in estuarine systems (Boynton *et al.*, 1982). Finally, a reasonable and statistically significant relationship was observed between algal stock size and water column respiration rates, as expected (Figure 5-10). This relationship indicates that water column respiration is associated with the phytoplanktonic stock and/or an ecosystem component (bacteria and other microorganisms) closely associated with phytoplankton.

While not a specific requirement of this study, we took the opportunity to examine algal stock species composition and abundance (number of cells per liter) on one occasion (9 September, 1997) at both Back River sites. These data were kindly developed by Mr. Richard Lacouture and staff of the Philadelphia Academy of Natural Sciences Estuarine Research Center and are summarized in Table 5-5. Cell densities at both sites were extremely high (2.68×10^8 cells l^{-1} at Riverside Marina and 2.62×10^8 cells l^{-1} at Rudy's Marina). At both sites species composition was dominated by blue green algae (*Oscillatoria sp.*, *Spirulina sp.* and *Microcystis sp.*). At both Riverside Marina and Rudy's Marina small centric diatoms were also important but at most represented about 25% of the cells present. To place these cell densities in some perspective, abundance in other portions of the bay range from 1.0×10^7 cells l^{-1} to 2.0×10^7 cells l^{-1}.

Table 5-5. A summary of algal densities from samples collected at Rudy's Marina and Riverside Marina on September 9, 1997

Algal species were identified and quantified by R. Lacouture of the Philadelphia Academy of Natural Sciences Estuarine Research Center. Techniques and codes followed those used in the Maryland Chesapeake Bay Monitoring Program.

Location and Date	Phylum Code	Species Code	Species Name	Raw Counts	# Fields Counted	Cell Densities $(\# l^{-1})$
Rudy's Marina	1	174	UNID. CENTRIC DIATOM DIAM <10 MICRONS	68	5	20,867,840
9-Sep-97	1	41	CYCLOTELLA SP#1 DIAM <10 MICRONS	49	5	15,037,120
	1	186	UNID. CENTRIC DIATOM DIAM 10-30 MICRONS	11	5	3,375,680
	1	100	CYLINDROTHECA CLOSTERIUM	5	5	1,534,400
	1	136	SKELETONEMA COSTATUM	2	5	613,760
	5	170	OSCILLATORIA CELLS #2 DIAM >5UM	292	5	89,608,960
	5	161	OSCILLATORIA CELLS #1 DIAM <5UM	241	5	73,958,080
	5	585	MICROCYSTIS SP.	91	5	27,926,080
	5	169	ANABAENA SP. 1	71	5	21,788,480
	5	382	AGMENELLUM SP.	14	5	4,296,320
	5	769	MICROCYSTIS AERUGINOSA	4	5	1,227,520
	7	872	SCENEDESMUS SP.	4	5	1,227,520
	7	873	SCENEDESMUS QUADRICAUDA	4	5	1,227,520
			Summary			
			Diatoms	41,428,800		
			Dinoflagellates	0		
			Microflagellates	0		
			Blue Greens	218,805,440		
			Greens	2,455,040		
			Unid. Blue Green Single Spheres	0		
			Local Density for entire sample (#/liter)	262,689,280		

Table 5-5. A summary of algal densities from samples collected at Rudy's Marina and Riverside Marina on September 9, 1997 (Continued).
Identification and quantification of algal species was done by R. Lacoutre of the Benedict Estuarine Research Laboratory, Academy of Natural Sciences of Philadelphia. Techniques and codes followed those used in the Maryland Chesapeake Bay Monitoring Program.

Location and Date	Phylum Code	Species Code	Species Name	Raw Counts	# Fields Counted	Cell Densities (# l^{-1})
Riverside	1	174	UNID. CENTRIC DIATOM DIAM <10 MICRONS	114	6	29,153,600
Marina	1	41	CYCLOTELLA SP#1 DIAM <10 MICRONS	53	6	13,553,867
9-Sep-97	1	100	CYLINDROTHECA CLOSTERIUM	7	6	1,790,133
	1	4	CHAETOCEROS SP#1 DIAM <10 MICRONS	2	6	511,467
	2	996	GYMNODINIUM SP.#1 5-20UM W 10-20UM L	1	6	255,733
	6	170	OSCILLATORIA CELLS #2 DIAM >5UM	279	6	71,349,600
	6	161	OSCILLATORIA CELLS #1 DIAM <5UM	151	6	38,615,733
	6	526	SPIRULINA SP.	130	6	33,245,333
	6	585	MICROCYSTIS SP.	121	6	30,943,733
	6	169	ANABAENA SP. 1	53	6	13,553,867
	6	382	AGMENELLUM SP.	8	6	2,045,867
	6	769	MICROCYSTIS AERUGINOSA	8	6	2,045,867
	-	710	UNID. CHLOROPHYTE	29	6	7,416,267
	-	872	SCENEDESMUS SP.	27	6	6,904,800
	-	876	SCENEDESMUS ACUMINATUS	14	6	3,580,267
	-	986	SELENASTRUM SP.	6	6	1,534,400
	-	423	OOCYSTIS SP.	4	6	1,022,933
	-	751	ANKISTRODESMUS SP.	1	6	255,733
	-	741	QUADRIGULA SP.	1	6	255,733
	-	40	CRYPTOMONAS SP#2 LENGTH >10 MICRONS	24	6	6,137,600
	-	31	CRYPTOMONAS SP#1 LENGTH <10 MICRONS	5	6	1,278,667
	13	804	UNID. MICRO-PHYTOFLAG LENGTH <10 MICRONS	7	6	1,790,133
	13	805	UNID. MICRO-PHYTOFLAG LENGTH >10 MICRONS	3	6	767,200
			Summary			
			Diatoms	45,009,067		
			Dinoflagellates	255,733		
			Microflagellates	9,973,600		
			Blue Greens	191,800,000		
			Greens	20,970,133		
			Unid. Blue Green Single Spheres	0		
			Local Density for entire sample (#/liter)	268,008,533		

6. SEDIMENT-WATER EXCHANGES OF OXYGEN, CARBON AND NUTRIENTS

6.1 Physical Characteristics

Environmental *in situ* conditions were examined to gain a better understanding of the factors possibly regulating sediment-water oxygen, carbon and nutrient exchanges in Back River and the tidal Patapsco. Data for June, July and August, 1997 are listed by cruise in Tables B-1 through B-5. A series of bar graphs summarize temperature, salinity, and DO in bottom waters at the sampling locations (Figure 6-1.a -6-1.c; Table 6-1). Table 6-2 summarizes bottom water nutrient concentrations. Table 6-3 summarizes surficial sediment characteristics including PC, PN, PP, active and total chlorophyll-a concentrations and oxidation-reduction potential Eh values (corrected to a hydrogen electrode) in sediments.

6.1.1 Temperature

Bottom water temperatures during 1997 ranged from 22.5 C in June at MDGT to 30.5 C in July at WCPT in Back River; and from 19.5 C in June at FFOF to 28.8 C in July at HMCK in Patapsco River (Figure 6-1.a; Table 6-1). These values are typical of this region of the bay during summer periods (Magnien *et al.*, 1993).

6.1.2 Salinity

Bottom water salinity conditions during 1997 ranged from 0.0 ppt in June at DPCK to 6.3 in August at WCPT in Back River; and from 1.2 ppt in June at HMCK to 8.9 ppt in August at FFOF in Patapsco River (Figure 6-1.b; Table 6-1). Again, these values are typical of this region of the bay during summer periods (Magnien *et al.,* 1993).

6.1.3 Dissolved Oxygen

Bottom water DO conditions during 1997 ranged from 8.19 mg l^{-1} in August at MDGT to 16.60 mg l^{-1} in June at WCPT in Back River; and from 4.64 mg l^{-1} in July at FFOF to 7.27 mg l-1 in August at HMCK in Patapsco River (Figure 6-1.c; Table 6-1). These values are typical of this region of the bay during summer periods (Magnien *et al.*, 1993). These DO concentrations are relatively high for bottom waters during summer periods. However, most of these measurements were made during morning or afternoon hours when DO concentrations were either increasing or at diel maxima; as indicated in the high frequency DO data set there are large diel DO excursions in these areas. It is probable that lower DO concentrations occurred during the hours preceding sunrise on many days during the summer.

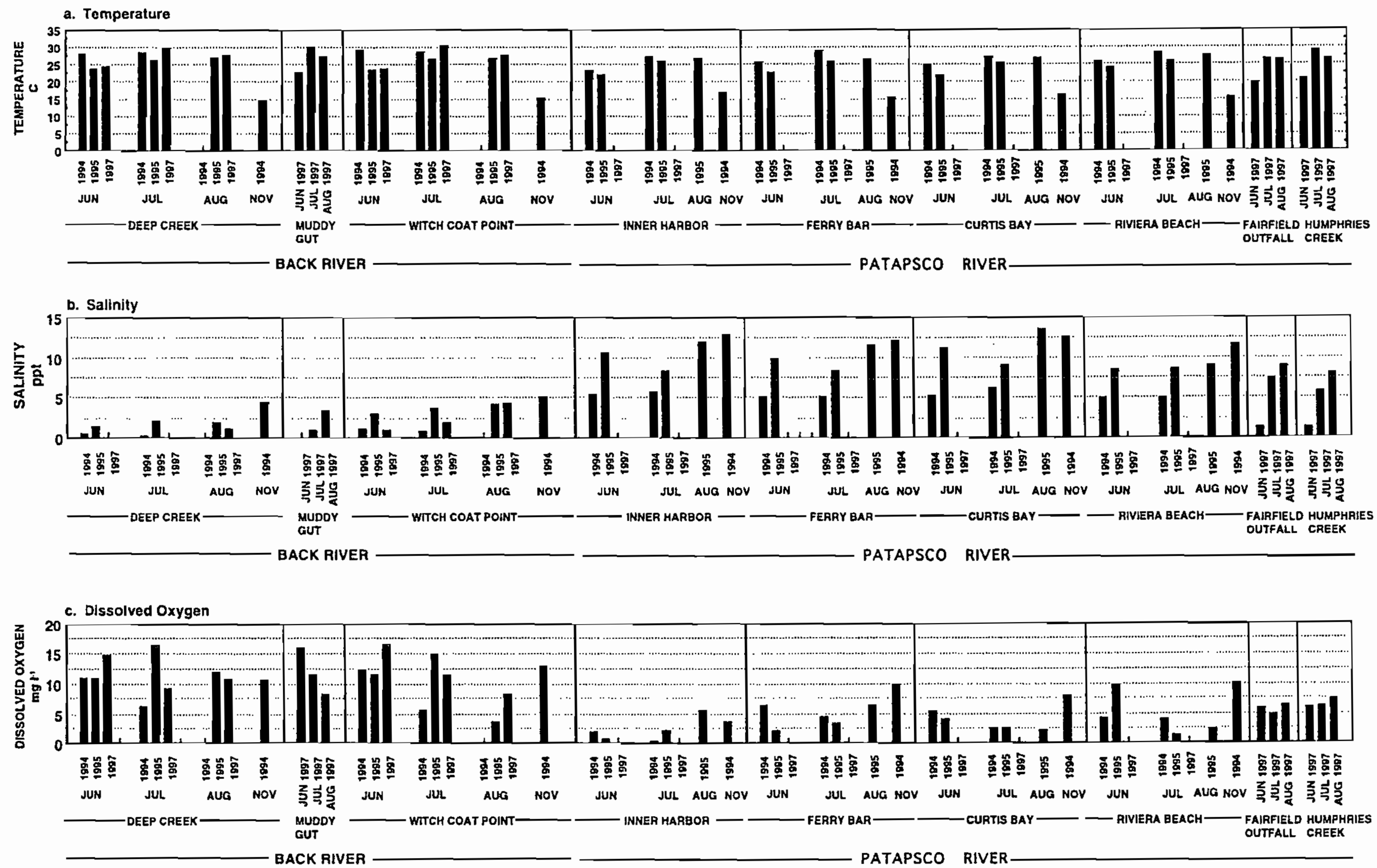


Table 6-1. Monthly bottom water temperature, salinity and DO values in Back River and Patapsco River for 1994, 1995 and 1997.

Table 6-1. Summary of Bottom Water Parameters: temperature, salinity, and dissolved oxygen at Back River and Patapsco River stations, 1994, 1995 and 1997.

STATION	MONTH	DATE	Sample Depth (m)	Temperature (C)	Conductivity (mmho cm^{-1})	Salinity (ppt)	DO (mg l^{-1})	DO SAT (%)
a. BACK RIVER								
DPCK	JUNE	15-Jun-94	1.0	28.0	1.7	0.5	10.86	139.1
		13-Jun-95	1.0	23.6	3.2	1.4	10.90	129.5
		11-Jun-97	1.0	24.2	0.4	0.0	14.74	175.7
	JULY	19-Jul-94	1.0	28.1	0.9	0.1	6.08	77.9
		11-Jul-95	1.5	26.2	4.3	2.0	16.26	203.5
		16-Jul-97	1.0	29.6	1.4	0.5	9.16	120.7
	AUGUST	28-Aug-95	1.0	26.9	4.1	1.9	11.93	151.0
		13-Aug-97	1.0	27.4	2.6	1.1	10.70	136.1
	NOVEMBER	9-Nov-94	1.0	14.4	8.4	4.4	10.62	106.7
MDGT	JUNE	11-Jun-97	1.0	22.5	0.5	0.0	15.90	183.6
	JULY	16-Jul-97	1.0	29.9	3.3	0.9	11.36	151.0
	AUGUST	13-Aug-97	1.0	27.1	6.4	3.3	8.19	105.0
WCPT	JUNE	15-Jun-94	1.0	28.8	2.4	1.0	12.20	158.9
		13-Jun-95	1.0	23.3	5.9	2.9	11.50	137.0
		11-Jun-97	1.5	23.6	2.4	0.9	16.60	196.6
	JULY	19-Jul-94	1.0	28.7	1.9	0.7	5.58	72.5
		11-Jul-95	1.5	26.4	7.1	3.6	14.87	188.5
		16-Jul-97	1.5	30.5	4.1	1.9	11.50	155.2
	AUGUST	28-Aug-95	1.0	26.9	8.0	4.2	3.39	43.5
		13-Aug-97	1.5	27.4	8.2	4.3	8.26	107.0
	NOVEMBER	9-Nov-94	1.5	14.9	9.4	5.0	12.85	130.9

Table 6-1. Summary of Bottom Water Parameters: temperature, salinity, and dissolved oxygen at Back River and Patapsco River stations, 1994, 1995 and 1997 (Continued).

STATION	MONTH	DATE	Sample Depth (m)	Temperature (C)	Conductivity (mmho cm^{-1})	Salinity (ppt)	DO (mg l^{-1})	DO SAT (%)
b. PATAPSCO RIVER								
INHB	JUNE	16-Jun-94	7.0	23.2	9.8	5.3	1.84	22.2
		15-Jun-95	4.5	21.8	18.2	10.6	0.56	6.8
	JULY	20-Jul-94	6.0	27.2	10.3	5.6	0.20	2.6
		12-Jul-95	4.0	26.1	14.6	8.2	1.99	25.8
	AUGUST	29-Aug-95	5.0	26.9	20.2	11.9	5.48	73.4
	NOVEMBER	10-Nov-94	7.0	16.7	21.8	12.9	3.48	38.6
FYBR	JUNE	16-Jun-94	4.0	25.6	9.5	5.1	6.37	80.2
		15-Jun-95	3.5	22.6	17.1	9.8	2.10	25.7
	JULY	20-Jul-94	4.0	28.9	9.3	5.0	4.20	56.1
		12-Jul-95	4.0	25.7	14.7	8.3	3.19	41.0
	AUGUST	30-Aug-95	4.0	26.6	19.7	11.5	6.42	85.4
	NOVEMBER	10-Nov-94	3.0	15.5	20.6	12.1	9.84	106.0
CTBY	JUNE	16-Jun-94	6.0	24.6	9.8	5.2	5.36	66.4
		14-Jun-95	5.5	21.8	19.2	11.2	3.83	46.6
	JULY	20-Jul-94	6.0	27.3	11.1	6.1	2.54	33.2
		12-Jul-95	6.0	25.3	15.8	9.0	2.38	30.5
	AUGUST	30-Aug-95	5.5	26.7	22.6	13.5	2.13	28.7
	NOVEMBER	9-Nov-94	5.5	15.9	21.3	12.6	8.01	87.4
RVBH	JUNE	17-Jun-94	4.0	25.8	9.3	4.9	4.00	50.6
		15-Jun-95	4.0	23.9	14.9	8.4	9.73	121.1
	JULY	19-Jul-94	4.0	28.3	9.2	4.9	3.97	52.4
		13-Jul-95	4.0	25.8	15.1	8.6	1.14	14.7
	AUGUST	21-Aug-95	4.5	27.4	15.8	9.0	2.26	30.0
	NOVEMBER	8-Nov-94	5.0	15.4	20.0	11.7	10.00	107.4
FFOF	JUNE	10-Jun-97	5.0	19.5	3.1	1.3	5.95	65.2
	JULY	15-Jul-97	5.0	26.6	13.3	7.4	4.64	60.3
	AUGUST	12-Aug-97	5.0	26.0	15.6	8.9	6.35	82.3
HMCK	JUNE	10-Jun-97	3.0	20.8	2.9	1.2	5.87	66.1
	JULY	15-Jul-97	3.0	28.8	10.6	5.7	6.03	80.7
	AUGUST	12-Aug-97	2.5	26.5	14.1	7.9	7.27	94.6

6.1.4 Bottom Water Nutrient Concentrations

Bottom water nutrient concentrations are summarized in Table 6-2. Ammonium concentrations in 1997 ranged from 0.4 μM N in July at MDGT to 4.5 μM N in August at MDGT in Back River; and from 3.3 μM N in August at HMCK to 34.0 μM N in July at FFOF in Patapsco River (Table 6-2).

Nitrite plus nitrate concentrations in 1997 ranged from 0.1 μM N in July at WCPT to 8.9 μM N in June at DPCK in Back River; and from 0.4 μM N in August at HMCK to 1.45 μM N in July at FFOF in Patapsco River (Table 6-2).

Dissolved inorganic phosphorus concentrations in 1997 ranged from 0.15 μM P in June at DPCK to 6.87 μM P in July at MDGT in Back River; and from 0.08 μM P in June at FFOF to 0.41 μM P at FFOF in Patapsco River (Table 6-2).

Silicate ($Si(OH)_4$) concentrations in 1997 ranged from 5.6 μM Si in June at WCPT to 151.0 μM Si in July at DPCK in Back River; and from 23.2 μM Si in June at FFOF to 38.4 μM Si in August at HMCK in Patapsco River (Table 6-2).

6.1.5 Surfical Sediment Measurements

Concentrations of particulate carbon (PC) in the sediment surface during 1997 ranged from 4.9% in August at WCPT to 6.6% in August at DPCK in Back River; and from 4.2% in August at FFOF to 11.2% in June at HMCK (Tables B-3.1 – B-3.3).

Concentrations of PN in the sediment surface during 1997 ranged from 0.7% in August at WCPT to 0.8% at DPCK in Back River; and from 0.4% in August to 0.6% in June at HMCK (Table B-3.1 – B-3.3) in Patapsco River.

Concentrations of PP in the sediment surface during 1997 ranged from 0.11% in June at MDGT to 0.43% in August at DPCK in Back River; and from 0.16% in July and August at FFOF to 0.27% in June at HMCK (Table B-3.1 – B-3.3) in Patapsco River.

Concentrations of total chlorophyll-a mass in the sediment surface during 1997 ranged from 219.7 mg m^{-2} in July at DPCK to 411 mg m^{-2} in June at DPCK in Back River; and from 143.9 mg m^{-2} in August at HMCK to 199.9 mg m^{-2} in June at HMCK (Tables B-3.1 – B-3.3).

Sediment Eh values measured at the sediment-water interface (0 cm) during 1997 for each station are summarized in Table 6-3. The values during 1997 ranged from 281 mV in June at MDGT to 325 mV at DPCK in Back river, and from 63 mV at HMCK to 314 mV in July at FFOF (Tables B-3.1 – B-3.3) in Patapsco River.

Table 6-2. **Summary of Bottom Water Nutrient Concentrations: NH_4^+, NO_2^-, NO_2^- + NO_3^-, salinity corrected DIP and $Si(OH)_4$ at Back River and Patapsco River stations, 1994, 1995 and 1997.**

STATION	MONTH	DATE	NH_4^+ (μM)	NO_2^- (μM)	NO_2^- + NO_3^- (μM)	DIP (μM)	$Si(OH)_4$ (μM)
a. BACK RIVER							
DPCK	JUNE	15-Jun-94	5.5	27.30	149.00	3.15	5.9
		13-Jun-95	60.6	16.20	135.00	2.21	2.7
		11-Jun-97	0.9	8.91	66.70	0.15	8.0
	JULY	19-Jul-94	112.4	22.00	177.00	5.24	134.9
		11-Jul-95	0.5	1.30	4.44	3.57	95.9
		16-Jul-97	0.5	5.65	30.80	4.48	151.0
	AUGUST	28-Aug-95	15.8	11.80	58.70	3.66	130.4
		13-Aug-97	3.9	6.33	92.00	1.73	97.9
	NOVEMBER	9-Nov-94	13.6	17.60	207.00	0.21	0.7
MDGT	JUNE	11-Jun-97	0.7	7.95	51.20	0.17	5.7
	JULY	16-Jul-97	0.4	0.17	0.17	6.87	139.1
	AUGUST	13-Aug-97	4.5	0.48	2.30	3.20	100.3
WCPT	JUNE	15-Jun-94	4.6	17.50	96.00	3.75	4.6
		13-Jun-95	1.3	5.36	40.50	4.13	20.9
		11-Jun-97	0.7	0.83	2.69	0.75	5.6
	JULY	19-Jul-94	30.2	12.60	78.10	9.28	127.3
		11-Jul-95	0.5	0.17	0.25	3.35	102.5
		16-Jul-97	0.2	0.10	0.22	0.75	131.4
	AUGUST	28-Aug-95	51.8	3.32	11.40	12.79	134.5
		13-Aug-97	1.0	0.23	0.24	0.75	92.1
	NOVEMBER	9-Nov-94	5.2	11.40	146.00	0.26	5.9

Table 6-2. Summary of Bottom Water Nutrient Concentrations: NH_4^+, NO_2^-, $NO_2^- + NO_3^-$, salinity corrected DIP and $Si(OH)_4$ at Back River and Patapsco River stations, 1994, 1995 and 1997.

STATION	MONTH	DATE	NH_4^+ (μM)	NO_2^- (μM)	$NO_2^- + NO_3^-$ (μM)	DIP (μM)	$Si(OH)_4$ (μM)
b. PATAPSCO RIVER							
INHB	JUNE	16-Jun-94	32.4	1.92	26.50	2.13	46.4
		15-Jun-95	30.9	0.69	4.59	1.58	36.9
	JULY	20-Jul-94	61.5	0.11	0.10	5.99	51.6
		12-Jul-95	69.2	0.08	1.00	5.58	59.1
	AUGUST	29-Aug-95	11.3	1.18	3.99	1.29	59.5
	NOVEMBER	10-Nov-94	27.4	1.02	21.10	1.24	42.2
FYBR	JUNE	16-Jun-94	8.9	1.41	23.00	0.10	32.6
		15-Jun-95	17.0	1.14	7.80	0.17	36.3
	JULY	20-Jul-94	14.6	3.25	11.50	0.82	34.7
		12-Jul-95	23.1	1.60	12.50	0.11	48.8
	AUGUST	30-Aug-95	12.7	1.44	3.83	1.23	35.8
	NOVEMBER	10-Nov-94	1.7	1.07	24.00	0.07	27.2
CTBY	JUNE	16-Jun-94	15.6	1.22	22.30	0.39	33.5
		14-Jun-95	16.1	0.69	8.42	0.23	36.7
	JULY	20-Jul-94	25.9	5.14	10.30	1.48	40.6
		12-Jul-95	29.3	1.33	10.60	0.16	49.7
	AUGUST	30-Aug-95	15.4	1.62	3.75	1.45	56.3
	NOVEMBER	9-Nov-94	10.1	1.33	25.30	0.08	28.2
RVBH	JUNE	17-Jun-94	4.4	0.67	16.60	0.06	34.9
		15-Jun-95	-0.3	0.98	9.01	0.13	36.8
	JULY	19-Jul-94	17.0	2.42	8.90	0.10	37.8
		13-Jul-95	19.1	0.78	6.82	0.13	59.2
	AUGUST	21-Aug-95	18.1	1.23	5.03	0.30	71.7
	NOVEMBER	8-Nov-94	1.2	1.31	25.50	0.12	28.0
FFOF	JUNE	10-Jun-97	14.7	0.92	24.00	0.08	23.2
	JULY	15-Jul-97	34.0	1.45	12.90	0.41	31.1
	AUGUST	12-Aug-97	16.5	1.20	10.60	0.13	38.4
HMCK	JUNE	10-Jun-97	8.1	0.89	16.30	0.12	27.8
	JULY	15-Jul-97	6.0	0.55	6.52	0.12	32.9
	AUGUST	12-Aug-97	3.3	0.42	8.17	0.14	37.7

Table 6-3. Summary of sediment particulates and chlorophyll-a measurements at Back River and Patapsco River stations for 1994, 1995 and 1997: PC, PN, PP, total and active chlorophyll-a.

STATION	MONTH	DATE	Eh (mV)	Sediment PC (%)	Sediment PN (%)	Sediment PP (%)	CHLA Total (mg m^{-2})
a. BACK RIVER							
DPCK	JUNE	15-Jun-94	237.0	6.3	0.6	0.59	107.8
		13-Jun-95	128.0	5.9	0.7	0.44	59.4
		11-Jun-97	288.0	6.0	0.7	0.32	410.5
	JULY	19-Jul-94	240.0	6.5	0.7	0.51	62.6
		11-Jul-95	255.0	5.8	0.7	0.42	48.1
		16-Jul-97	319.0	6.0	0.7	0.36	219.7
	AUGUST	28-Aug-95	325.0	6.6	0.8	0.43	260.9
		13-Aug-97	325.0	6.6	0.8	0.43	260.9
	NOVEMBER	9-Nov-94	329.0	6.4	0.7	0.37	166.4
MDGT	JUNE	11-Jun-97	281.0	5.6	0.7	0.11	398.0
	JULY	16-Jul-97	299.0	5.3	0.6	0.30	249.7
	AUGUST	13-Aug-97	296.0	5.5	0.6	0.28	225.1
WCPT	JUNE	15-Jun-94	138.0	5.1	0.5	0.27	118.6
		13-Jun-95	319.0	4.5	0.5	0.26	42.9
		11-Jun-97	286.0	5.1	0.6	0.26	371.3
	JULY	19-Jul-94	310.0	5.0	0.6	0.26	81.8
		11-Jul-95	319.0	5.0	0.6	0.34	233.0
		16-Jul-97	319.0	5.0	0.6	0.34	233.0
	AUGUST	28-Aug-95	272.0	4.0	0.5	0.35	45.1
		13-Aug-97	319.0	4.9	0.5	0.27	290.9
	NOVEMBER	9-Nov-94	340.0	5.0	0.5	0.32	313.5

Table 6-3. Summary of sediment particulates and chlorophyll-a measurements at Back River and Patapsco River stations for 1994, 1995 and 1997: PC, PN, PP, total and active chlorophyll-a (Continued).

STATION	MONTH	DATE	Eh (mV)	Sediment PC (%)	Sediment PN (%)	Sediment PP (%)	CHLA Total (mg m^{-2})
b. PATAPSCO RIVER							
INHB	JUNE	16-Jun-94	318.0	8.0	0.4	0.10	65.8
		15-Jun-95	233.0	7.6	0.5	0.11	25.8
	JULY	20-Jul-94	228.0	8.5	0.4	0.12	72.4
		12-Jul-95	-92.0	7.9	0.5	0.11	56.0
	AUGUST	29-Aug-95	289.0	7.5	0.5	0.10	26.3
	NOVEMBER	10-Nov-94	303.0	7.0	0.4	0.10	134.5
FYBR	JUNE	16-Jun-94	292.0	3.4	0.2	0.11	79.1
		15-Jun-95	345.0	3.2	0.3	0.16	43.1
	JULY	20-Jul-94	30.0	3.6	0.3	0.14	49.3
		12-Jul-95	148.0	3.6	0.3	0.13	60.4
	AUGUST	30-Aug-95	139.0	3.7	0.4	0.15	66.7
	NOVEMBER	10-Nov-94	334.0	3.2	0.3	0.13	109.9
CTBY	JUNE	16-Jun-94	325.0	4.5	0.4	0.20	81.9
		14-Jun-95	354.0	4.0	0.4	0.16	39.1
	JULY	20-Jul-94	244.0	2.8	0.3	0.15	61.6
		12-Jul-95	250.0	4.2	0.5	0.22	33.5
	AUGUST	30-Aug-95	165.0	5.1	0.5	0.18	37.3
	NOVEMBER	9-Nov-94	363.0	4.5	0.3	0.11	136.4
RVBH	JUNE	17-Jun-94	328.0	4.3	0.4	0.14	73.4
		15-Jun-95	311.0	2.7	0.3	0.11	23.7
	JULY	19-Jul-94	316.0	4.0	0.4	0.13	46.8
		13-Jul-95	328.0	3.9	0.4	0.16	13.2
	AUGUST	21-Aug-95	316.0	4.0	0.4	0.18	33.4
	NOVEMBER	8-Nov-94	368.0	4.0	0.4	0.15	128.3
FFOF	JUNE	10-Jun-97	149.0	4.8	0.5	0.17	183.1
	JULY	15-Jul-97	314.0	4.6	0.5	0.16	146.0
	AUGUST	12-Aug-97	178.0	4.2	0.4	0.16	171.9
HMCK	JUNE	10-Jun-97	90.0	11.2	0.6	0.27	199.9
	JULY	15-Jul-97	257.0	8.5	0.5	0.22	168.4
	AUGUST	12-Aug-97	63.0	9.3	0.5	0.26	143.9

6.2. Characteristics of Sediment-Water Oxygen and Nutrient Exchanges

Mean monthly sediment-water fluxes are summarized in the form of bar graphs (Figure 6-2.a. to 6-2.f) for six variables; sediment oxygen consumption (SOC), NH_4^+, $NO_2^- + NO_3^-$, DIP or PO_4^{-3}, $Si(OH)_4$ and TCO_2. We have included values of sediment-water fluxes measured at these and other adjacent locations during 1994 and 1995 for comparative purposes. Techniques used to make the 1994 and 1995 measurements were the same as those used in the present study.

6.2.1 Sediment Oxygen Consumption

Mean monthly SOC rates for 1997 ranged from -1.46 g O_2 m^{-2} day^{-1} in July at MDGT to -2.99 g O_2 m^{-2} day^{-1} in July at WCPT in Back River and from -1.75 g O_2 m^{-2} day^{-1} in July at FFOF to -2.09 g O_2 m^{-2} day^{-1} in August at FFOF in Patapsco River (Figure 6.2a; Tables B-5.1 – B-5.3). *Note: larger negative SOC flux values indicate larger fluxes of SOC (i.e. larger amounts of DO consumed by sediments).*

Flux values in 1997 followed seasonal patterns observed in other areas of Chesapeake with highest values generally observed during early summer in areas with adequate DO concentrations. In bottom water at the Inner Harbor station, depressed SOC values reflect limiting DO concentrations in deep waters and not low levels of sediment metabolism which remain high but which are mainly anaerobic (Boynton *et al.*, 1997a). Hypoxic conditions in bottom waters were reported for the Inner Harbor station during June and July, 1995 and for the Riviera Beach (RVBH) station during July, 1995 and were probably responsible for depressed SOC fluxes. SOC rates above 1 g O_2 m^{-2} day^{-1} can have a significant impact on DO water quality conditions, especially in relatively shallow estuaries. In a later section of this chapter SOC and other DO sources and sinks are compared for stations in Back River.

6.2.2 Ammonium Fluxes

Mean monthly NH_4^+ flux values for 1997 ranged from 163.0 μM N m^{-2} hr^{-1} in July at MDGT to 796.7 μM N m^{-2} hr^{-1} in July at DPCK in Back River; and from 196 μM N m^{-2} hr^{-1} in June FFOF to 600 μM N m^{-2} hr^{-1} in July at HMCK in Patapsco River (Figure 6-2.b.; Tables B-5.1 – B-5.3).

Flux values in 1994 and 1995 at the Inner Harbor (INHB) station were generally large, being among the highest ever measured in the Chesapeake Bay region and higher even than those measured at other sites in Patapsco and Back Rivers. While lower, NH_4^+ fluxes measured during 1997 in Back and Patapsco Rivers were still high. To put these values in perspective, the median NH_4^+ flux based on data collected at 10 sites in Chesapeake Bay during summer periods from 1985 - 1996 was about 200 μM N m^{-2} hr^{-1}. The NH_4^+ fluxes measured during 1997 in both Back and Patapsco Rivers generally exceeded this by a large margin.

Table 6-4. Summary of Sediment-Water oxygen, nutrient and carbon fluxes:
SOC, NH_4^+, NO_2^-, $NO_2^- + NO_3^-$, DIP, $Si(OH)_4$ and TCO_2
at Back River and Patapsco River stations,1994,1995 and 1997.

STATION	MONTH	DATE	SOC ($g\ O_2\ m^{-2}\ day^{-1}$)	NH_4^+ ($\mu M\ N\ m^{-2}\ hr^{-1}$)	$NO_2^- + NO_3^-$ ($\mu M\ N\ m^{-2}\ hr^{-1}$)	DIP ($\mu M\ P\ m^{-2}\ hr^{-1}$)	$Si(OH)_4$ ($\mu M\ Si\ m^{-2}\ hr^{-1}$)	TCO_2 ($\mu M\ C\ m^{-2}\ hr^{-1}$)
a. BACK RIVER								
DPCK	JUNE	15-Jun-94	-1.75	507.9	-290.84	17.66	214.00	7926
		13-Jun-95	-1.62	134.4	-263.31	20.37	290.00	.
		11-Jun-97	-2.05	322.8	-182.14	5.04	363.67	5451
	JULY	19-Jul-94	-1.19	564.6	-477.13	8.71	NI	3816
		11-Jul-95	-1.89	128.0	101.65	44.42	509.00	.
		16-Jul-97	-2.17	796.7	-54.88	31.24	640.24	6522
	AUGUST	28-Aug-95	-2.78	949.9	-233.45	48.89	293.00	.
		13-Aug-97	-2.24	636.2	-286.98	29.65	314.74	5508
	NOVEMBER	9-Nov-94	-1.12	185.4	-162.43	2.04	38.00	3203
MDGT	JUNE	11-Jun-97	-1.71	207.0	-56.09	21.63	243.54	5394
	JULY	16-Jul-97	-1.46	163.0	13.76	49.17	297.00	6026
	AUGUST	13-Aug-97	-2.66	760.4	3.28	NI	284.76	4800
WCPT	JUNE	15-Jun-94	-2.52	564.5	-290.38	41.65	481.00	6024
		13-Jun-95	-2.86	211.6	-184.88	33.82	428.00	.
		11-Jun-97	-1.82	240.3	81.40	29.49	299.44	6111
	JULY	19-Jul-94	-1.27	417.7	-282.03	102.13	587.00	4898
		11-Jul-95	-2.84	58.9	16.19	115.34	782.00	.
		16-Jul-97	-2.99	532.6	24.38	110.98	502.40	8460
	AUGUST	28-Aug-95	-1.61	550.0	-102.25	171.47	476.00	.
		13-Aug-97	-2.05	541.1	76.91	30.73	166.98	4858
	NOVEMBER	9-Nov-94	-0.82	84.9	-2.49	3.97	114.00	1757

Table 6-4. Summary of Sediment-Water oxygen, nutrient and carbon fluxes:
SOC, NH_4^+, NO_2^-, $NO_2^- + NO_3^-$, DIP, $Si(OH)_4$ and TCO_2
at Back River and Patapsco River stations,1994,1995 and 1997 (Continued).

STATION	MONTH	DATE	SOC ($g\ O_2\ m^{-2}\ day^{-1}$)	NH_4^+ ($\mu M\ N\ m^{-2}\ hr^{-1}$)	$NO_2^- + NO_3^-$ ($\mu M\ N\ m^{-2}\ hr^{-1}$)	DIP ($\mu M\ P\ m^{-2}\ hr^{-1}$)	$Si(OH)_4$ ($\mu M\ Si\ m^{-2}\ hr^{-1}$)	TCO_2 ($\mu M\ C\ m^{-2}\ hr^{-1}$)
b. PATAPSCO RIVER								
INHB	JUNE	16-Jun-94	-0.95	2168.7	-152.01	89.05	371.00	13809
		15-Jun-95	-0.56	1009.1	-56.38	132.06	361.00	.
	JULY	20-Jul-94	-0.38	1762.4	1.21	133.32	382.00	9218
		12-Jul-95	-0.63	1602.3	-65.64	128.54	370.00	.
	AUGUST	29-Aug-95	-1.82	1234.6	-27.90	31.33	452.00	.
	NOVEMBER	10-Nov-94	-0.76	411.2	-97.11	3.15	150.00	5638
FYBR	JUNE	16-Jun-94	-1.09	211.2	-96.52	14.92	373.00	7791
		15-Jun-95	-0.91	207.6	-46.81	28.65	171.00	.
	JULY	20-Jul-94	-1.11	381.6	-43.51	20.40	328.00	8575
		12-Jul-95	-1.17	299.7	-58.38	27.94	333.00	.
	AUGUST	30-Aug-95	-1.63	272.6	-6.91	16.62	374.00	.
	NOVEMBER	10-Nov-94	-0.67	18.1	1.33	0.47	365.00	2780
CTBY	JUNE	16-Jun-94	-3.12	258.9	-139.29	35.37	484.00	8377
		14-Jun-95	-1.48	198.6	-54.27	8.78	200.00	.
	JULY	20-Jul-94	-0.75	179.3	-64.43	-1.74	194.00	2059
		12-Jul-95	-1.00	578.6	-93.58	105.09	534.00	.
	AUGUST	30-Aug-95	-1.02	279.6	-12.10	32.03	276.00	.
	NOVEMBER	9-Nov-94	-0.71	0.0	16.22	-0.44	154.00	1227
RVBH	JUNE	17-Jun-94	-2.92	102.4	-80.66	11.53	488.00	9552
		15-Jun-95	-4.12	82.9	158.25	9.74	397.00	.
	JULY	19-Jul-94	-1.93	304.2	-50.17	12.81	469.00	3466
		13-Jul-95	-0.85	144.7	-62.28	5.59	292.00	.
	AUGUST	21-Aug-95	-1.27	248.6	-43.75	9.91	241.00	.
	NOVEMBER	8-Nov-94	-2.03	22.2	-52.87	0.62	199.00	1764
FFOF	JUNE	10-Jun-97	-1.82	196.1	-232.77	9.51	289.44	2527
	JULY	15-Jul-97	-1.75	560.6	-116.35	51.46	444.02	4925
	AUGUST	12-Aug-97	-2.09	394.2	-58.04	13.02	296.04	4319
HMCK	JUNE	10-Jun-97	-1.82	238.6	-166.24	4.57	297.92	3035
	JULY	15-Jul-97	-1.96	600.3	-27.19	27.54	321.34	5725
	AUGUST	12-Aug-97	-1.76	371.3	-33.90	1.46	141.88	4230

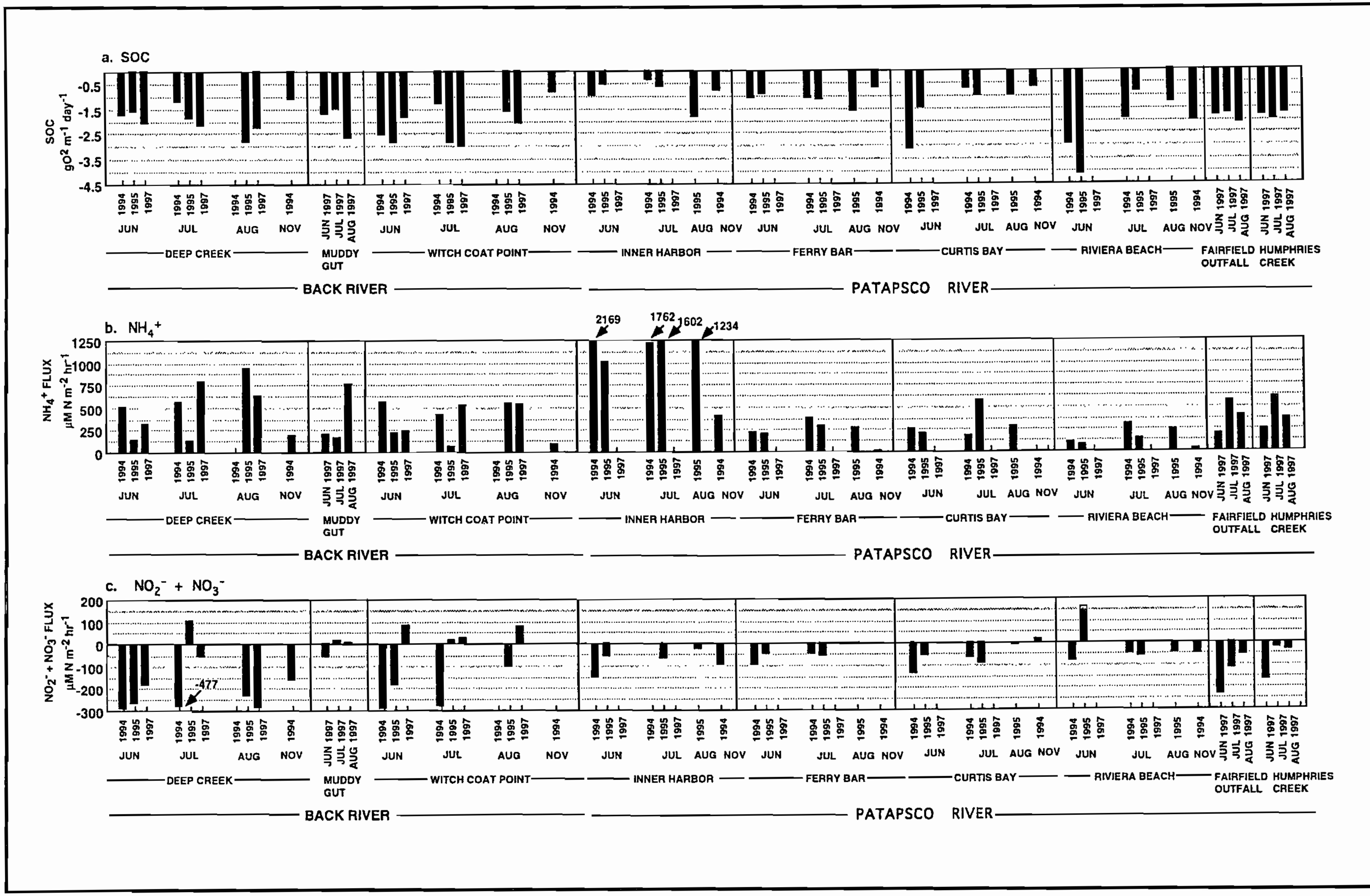


Table 6-2. Monthly sediment-water oxygen, carbon and nutrient exchanges at Back River and Patapsco River stations. *Data were collected between June through August, 1994; June, July and November, 1995; and June through August, 1997. There was one set of triplicate flux values available for each month for estimating means. Positive values indicate fluxes from sediment to water while negative fluxes indicate fluxes from water to sediment.*

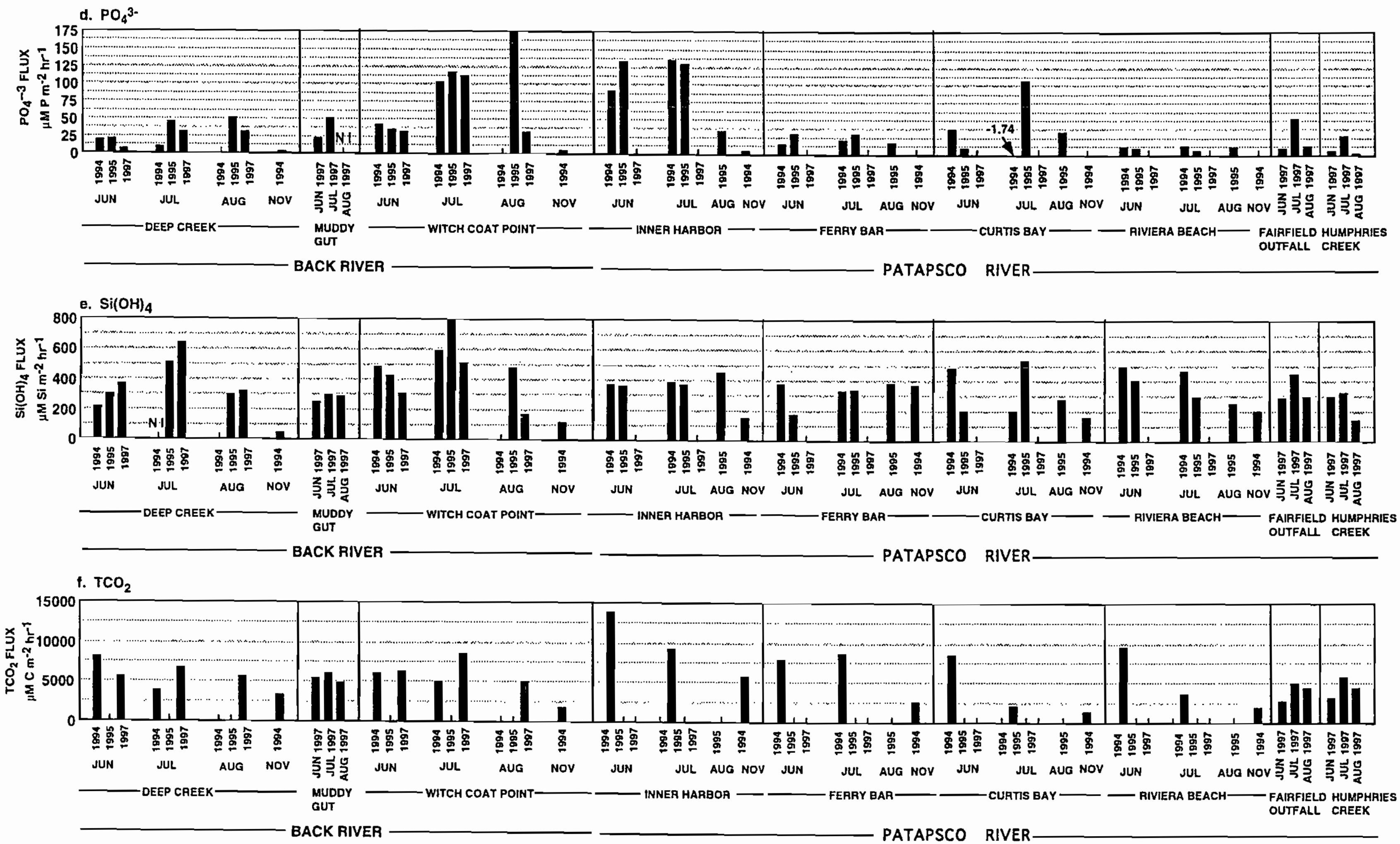


Table 6-2. Monthly sediment-water oxygen, carbon and nutrient exchanges at Back River and Patapsco River stations. *Data were collected between June through August, 1994; June, July and November, 1995; and June through August, 1997. There was one set of triplicate flux values available for each month for estimating means. Positive values indicate fluxes from sediment to water while negative fluxes indicate fluxes from water to sediment.*

6.2.3 Nitrite plus Nitrate Fluxes

Mean monthly $NO_2^- + NO_3^-$ fluxes for 1997 ranged from -287 μM N m^{-2} hr^{-1} in August at DPCK to 81.40 μM N m^{-2} hr^{-1} in June at WCPT in Back River; and from -232.77 μM N m^{-2} hr^{-1} in June at FFOF to 127.19 μM N m^{-2} hr^{-1} in July at HMCK in Patapsco River (Figure 6-2c.; Tables B-5.1-B-5.3). In general, $NO_2^- + NO_3^-$ fluxes were directed from the water column into sediments and as such represents a loss of available nitrogen. The ultimate fate of this nitrogen is not definitely known but it is probable that it is denitrified (Jenkins and Kemp, 1984) and lost from the system as dinitrogen gas. Relative to the sediment-water nitrite plus nitrate flux measurements made at 10 sites in Chesapeake Bay during the last decade (median value = 6 μM N m^{-2} hr^{-1}) those made in Back and Patapsco Rivers during 1997, and in previous years, were large and mainly directed from water to sediments.

6.2.4 Dissolved Inorganic Phosphorus Fluxes

Mean monthly DIP flux values ranged from 5.04 μM P m^{-2} hr^{-1} in June at DPCK to 110.98 μM P m^{-2} hr^{-1} in July at WCPT in Back River ; and from 1.46 μM P m^{-2} hr^{-1} in August at HMCK to 51.46 μM P m^{-2} hr^{-1} in July at FFOF in Patapsco River (Figure 6-1.d.; Tables B-5.1-B-5.3).

During 1994 and 1995 DIP flux values were lowest for all stations in November and generally highest in July with the exception of CTBY in Patapsco River and Deep Creek (DPCK) in Back River. The highest fluxes occurred during months when bottom water DO conditions were hypoxic or lower than average. Iron-sulphur reactions with sediment bound phosphorus are probably the cause for the high fluxes under low DO conditions (Krom and Berner, 1980).

Relative to phosphorus flux measurements made at 10 sites in Chesapeake Bay during the last decade (median value = 11 μM P m^{-2} hr^{-1}) those made in Back and Patapsco Rivers during 1997, and in previous years, were large and are among the highest observed in the Chesapeake region.

6.2.5 Silicate Fluxes

Average monthly values for $Si(OH)_4$ fluxes in 1997, ranged from 166 μM Si m^{-2} hr^{-1} in August at WCPT to 640 μM Si m^{-2} hr^{-1} in July at DPCK in Back River; and from 142 μM Si m^{-2} hr^{-1} in August at HMCK to 444 μM Si m^{-2} hr^{-1} in July at FFOF in the Patapsco River (Figure 6-1.e; Tables B-5.1-B-5.3).

Mean monthly $Si(OH)_4$ fluxes varied from station to station, were always low during the single cold month (November) in which measurements were made and were similar in magnitude to other measurements made in the Chesapeake Bay region (Boynton *et al.*, 1997b).

6.2.6 Total Carbon Dioxide Fluxes

Average monthly fluxes in 1997 for TCO_2 ranged from 4,800 μM TCO_2 m^{-2} hr^{-1} in August at MDGT to 8,460 μM TCO_2 m^{-2} hr^{-1} in July at WCPT in Back River; and from 2,527 μM TCO_2 m^{-2} hr^{-1} in June at FFOF to 5,725 μM TCO_2 m^{-2} hr^{-1} in July at HMCK in Patapsco River (Figure 6-1.f.; Tables B-5.1-B-5.3).

Rates of TCO_2 flux from sediments is a measure of both aerobic and anaerobic metabolism. Such measurements made in less impacted portions of Chesapeake Bay range between 2,000 and 3,000 μM CO_2 m^{-2} hr^{-1}. In Back and Patapsco Rivers, rates measured during 1994 and 1997 were generally higher, often by a large margin (factor of 2 x or more). This indicates that large amounts of organic matter are being decomposed in these sediments, a situation which is not surprising given the large stock of labile organic matter being produced in the water column.

6.3 Comparison of Back River and Patapsco River Sediment-Water Fluxes with those Measured in Other Estuarine Systems

Sediment nutrient releases have been shown to be an important process linking benthic and water column components of shallow estuarine ecosystems. The release of nutrients from sediments can be substantial and, if this is the case, is an important factor affecting the water quality in these systems. Fluxes of NH_4^+ and PO_4^{-3} are of particular importance in the case of Back River because both nutrients are important factors promoting algal growth and both have been or are presently targeted for input reduction via upgrades to the WWTP in Back River.

To place the sediment-water exchanges of nitrogen and phosphorus in some perspective, we have assembled values measured in a variety of coastal and estuarine ecosystems (Table 6-5). Various other coastal estuarine systems release NH_4^+ from sediments during the summer at low to moderate rates, most often ranging from 25 to 250 μM N m^{-2} hr^{-1}. Fluxes are also reported for various Chesapeake mainstem locations and tributaries (Potomac River, Patuxent River and Choptank River) and these are generally higher than those observed in coastal system with lower levels of anthropogenic nutrient additions. The fluxes reported in this study are high to very high in comparison with other areas of the Chesapeake and world. At the Inner Harbor station in the Patapsco River in 1994 and 1995, fluxes were uncommonly high (average = 1,996 μM N m^{-2} hr^{-1}); very large fluxes of NH_4^+ were also observed at all Back River stations during 1997. These extremely high fluxes are characteristic of eutrophic ecosystems.

Fluxes of PO_4^{-3} in all the systems were approximately proportional to NH_4^+ fluxes (Table 6-5), probably reflecting original organic matter supply rates to sediments. Fluxes of PO_4^{-3} were particularly high in the Patapso River/Baltimore Harbor sub-system of Chesapeake Bay. In comparison to other areas of the world and Chesapeake Bay, fluxes in the Patapsco River/Back River sub-systems are large, again indicating eutrophic conditions.

6.4. Sediment-Water Nutrient Flux Ratios

In most of the Maryland portion of the Chesapeake Bay, nutrients released from sediments are able to support significant amounts of phytoplankton primary production and algal biomass (Boynton *et al.*, 1994). Organic matter produced by the phytoplankton is either consumed in the water column by bacteria, protozoans, zooplankton, or herbivorous fish (such as menhaden), sinks to the sediments or is exported to some downstream location. Particulate waste from consumers also sinks to the sediments. At or near the sediment surface, this organic debris is either consumed by microbes and invertebrates or stored in sediments. Decomposition of organic matter and excretions by heterotrophic communities release nutrients back into the overlying waters. The mixing of nutrient-rich bottom waters with surface waters again supplies phytoplankton with nutrients necessary for growth. Deposition of organic matter from the water column accompanied by large nutrient storages in sediments make the benthic-pelagic coupling processes an important characteristic of shallow estuaries such as Chesapeake Bay and its tributary rivers. It is possible to infer which of several microbial processes may be important in sediments by comparing sediment fluxes one to another as is done below.

According to the Redfield model (Redfield, 1934; Alvarez-Borrego *et al.*, 1975), when organic matter from phytoplankton decomposes aerobically, 1 atom of N is generated for every 13.25 atoms of O, if the end product is NH_4^+; or 1 atom of N per 17.25 atoms of O if oxidation goes to NO_3^-. In the mainstem of Chesapeake Bay, Boynton and Kemp (1985) found benthic O:N flux ratios consistent with the Redfield model in late summer; however, anomalously high ratios were found in May. Nixon and his colleagues (Nixon, 1981) believe large deviations from stoichiometric relations predicted from the Redfield model exist in Narragansett Bay due to N removal from the system via high denitrification rates, the same conclusion reached by Boynton and Kemp(1985). Seasonal trends of denitrification rates in Chesapeake Bay reported by Jenkins and Kemp (1984) support the application of Nixon's argument for Chesapeake Bay.

Based on sediment flux data collected during 1997, it appears that sediment denitrification (based on the Redfield arguement provided above) may be an important process at stations in Back River but not at stations in Patapsco River. In Back River O:N flux ratios ranged between 5.5 and 9.0, well below the expected 13.25 or 17.25 for oxidation of nitrogen to NH_4^+ or NO_3^-, respectively. This sort of examination should be considered speculative and not a substitute for direct measurements. It is prudent to confirm this possibility because sediment denitrification represents a terminal removal of nitrogen from a system which, by any standards, is nutrient enriched. Stations in Patapsco River did not have sediment O:N flux ratios suggesting substantial denitrification and the reasons for this are not obvious.

6.5 Water Quality Impacts of Sediment-Water Fluxes

Previous studies have shown the important role sediments play in determining water quality conditions in Chesapeake Bay (Boynton *et al.*, 1994). Ultimately, nutrient and organic matter inputs drive sediment-water fluxes. Larger loading rates are reflected in larger nutrient fluxes. Increased nutrient enrichment also leads to increased sediment metabolism and generally lower DO concentrations in bottom waters. The nutrients released back into overlying waters support

Table 6-5. Comparison of summer season SOC, NH_4^+ and PO_4^{-3} fluxes from various estuarine and coastal marine ecosystems.

	SOC $g\ m^{-2}\ d^{-1}$	NH_4^+ $\mu M\ m^{-2}\ h^{-1}$	DIP $\mu M\ m^{-2}\ h^{-1}$	Station Depth m	Months Sampled	References
COASTAL MARINE SYSTEMS						
Loch Ewe, Scotland	0.6 - 1.2	20 - 80	--	20 - 30	Jun,Jul	1
Buzzard's BAy, MA	1.4	125	-15	17	Jun	1
Eel Pond, MA	1.1	85	16	2	Jul	1
Narragansett Bay, RI	1.8	200	30 - 50	9	Jun, Jul, Aug	1
Long Island Sound, CN	--	50 - 200	5 - 20	--	Jul	1
New York Bight, NY	0.8	25	2	35	Aug	1
Pamlico River Estuary, NC		45	--	--	--	1
South River Estuary, NC	1.6	250	17	--	May	1
Cape Blanc, West Africa	--	235	50	25	--	1
Vostoc Bay, USSR	1.1	150	20	5.7	Aug	1
Maisuru Bay, Japan	--	13 - 32	--	--	Jul	1
Kaneohe Bay, HA	0.5	54	3	8	--	1
La Jolla Bight, CA		40	6	18	Jun,Jul,Aug	1
Yaquina Bay mudflat, OR	-6 to 7	-91 to 204	-5 to19	--	--	2
CHESAPEAKE BAY SYSTEMS						
Upper Patuxent River Estuary	0.9 - 1.8	297 - 423	17	7 - 8	Jun,Jul,Aug	3
Lower Patuxent River Estuary	1.8	123 - 258	7	7 - 16	Jun,Jul,Aug	3
Lower Potomac River Estuary	0.3	251	34	16	Jun,Jul,Aug	3
Lower Choptank River Estuary	1.5	141	8	8	Jun,Jul,Aug	3
Mesohaline Chesapeake Mainstem	0.3	312	38	16	Jun,Jul,Aug	3
Chesapeake Bay Deep Trough	0.01 - 0.05	292 - 720	11 - 69	21 - 42	Aug	4
Upper Chesapeake Mainstem	1.0	108	9	4	Jun,Jul,Aug	5
Baltimore Harbor	0.7 - 1.9	219 - 1966	17 - 111	5 - 8	Jun, Jul	6
Annapolis Deep Trough (site 104)	0.0 - 0.4	134 - 396	32 - 55	18 - 24	Jun,Jul,Aug	5

References:
1. Nixon 1981
2. Collins 1986
3. Boynton *et al.* 1996
4. Boynton and Garber 1989
5. Boynton *et al.* 1997a
6. Boynton *et al.* 1995b

phytoplankton growth, increasing organic matter deposition, decomposition and oxygen consumption in a self-reinforcing cycle. In the following section estimates are made of: (1) the probable influence water column and sediment respiration have on DO conditions in Back River and; (2) the contribution of sediment nitrogen and phosphorus releases to nutrient availability in Back River system.

6.5.1 Respiration Rates and Dissolved Oxygen Conditions

Sediment oxygen consumption rates were appreciable at all stations in Back River during the summer periods. If the average SOC rate of 2.2 g O_2 m^{-2} day^{-1} is assumed to be characteristic of the Back River during summer of 1997, this can be compared to the amount of oxygen present in the water column and a potential DO turnover time can be calculated as follows: using a mean depth of about 1.8 m and an average oxygen saturation concentration of 8 mg l^{-1} during summer periods, a DO turnover time of about 6.5 days is estimated based solely on SOC rates (water column DO stock [8 mg l-1 * 1.8 m = 14.4 g O_2 m^{-2}] divided by SOC rate).

Our estimate of a turn over time of 6.5 days is fairly long. It is not reasonable to expect SOC to be the sole important factor in determining DO dynamics in this system. Using an *in situ* technique, Robertson (1977) estimated SOC to be about 3.2 g O_2 m^{-2} day^{-1} which would yield a DO turn over time of 4.5 days, still not particularly rapid. The point here is, that rapid DO turn over times would be expected to yield erratic (and at times very low) DO conditions. We did not observe such conditions.

Measurements of water column respiration rates for Back River are not extensive, but measurements made at Rudy's Marina and Riverside Marina during the summer of 1997 indicate values of about 0.2 mg l^{-1} hr^{-1} or about 3.6 g O_2 m^{-2} $night^{-1}$ (0.2 g O_2 m^{-3} hr^{-1} * 10 hours of darkness day^{-1} * 1.8 m water column). The inclusion of water column respiration rates during periods of darkness would decrease DO turnover time considerably in this simple example to about 2.5 days.

However, there are two additional sources of oxygen which can compensate for losses due to biological respiration in the water column and sediments. First, phytoplankton produce oxygen during daylight hours as a bi-product of photosynthesis and, in the case of Back River, this oxygen production can be large. In fact, the majority of DO measurements in the near-surface (1 meter depth) waters of Back River were above DO saturation levels. Some of the oxygen losses due to water column respiration at night are compensated for by water column production of oxygen during hours of daylight. This was apparently the case in Back River because P/R ratios based on high frequency DO measurements were greater than unity for the summer period. Second, this shallow tributary is generally vertically mixed due to wind and tidal action. If oxygen concentrations in surface waters decrease below saturation concentrations (about 8 mg l^{-1} during summer periods in Back River), oxygen can diffuse across the air-water interface and be mixed throughout the water column. In vertically mixed areas, air-water diffusion of oxygen provides a buffer against development of low oxygen conditions, at least to a certain level of biological oxygen consumption. During 1997, DO diffusing into Back River waters was a relatively rare occurrence (5% of the time) and occurred at relatively small rates (0.01 - 0.30 g

O_2 m^{-2} hr^{-1}) compared to other DO fluxes. The small rates of reaeration were caused by the large amounts of DO released from the large phytoplanktonic stock which had the effect of keeping surface waters above DO saturation levels.

Several points relative to water quality conditions can be made based on examination of the above calculations. First, there is little oxygen storage in the water column because of high summer temperatures (oxygen solubility is inversely related to water temperature) and a short water column. Thus, there is little DO buffering available in this system based on DO storages alone. Second, the rates of oxygen use are substantial but during 1997 these were not high enough to cause DO depletion to low levels (< 2.0 mg l^{-1}) at least to depths of one meter. However, if photosynthetic DO production were to decrease for several days in a row (*e.g.* due to a stalled frontal system) or if there was a period of calm winds and especially hot weather (which could stratify the water column) it seems possible for DO conditions to deteriorate rapidly, reaching low levels in just several days. In past years (1970's and earlier) when the organic matter load (BOD_5) from the WWTP was larger and general DO concentrations lower (because of bacterial respiration of the organic matter), very low DO events did occur, causing fish kills on several occasions (Robertson, 1977). Finally, the above considerations have been based on the assumption that the Back River water column is mixed in the vertical direction. While there is evidence that this is generally the case, near-bottom water DO measurements have not been made on a high frequency basis as was done in near-surface waters in this study. It is possible that sediments and benthic organisms in Back River are routinely exposed to low DO conditions on a diel basis, especially in the hours just before and after sunrise when DO concentrations in the upper water column are lowest. If future monitoring of DO is to be conducted in Back River, near-bottom measurements should be included in the study design.

6.5.2 Sediment Nutrient Releases and Nutrient Loading Rates

An approach to evaluating the impact of sediment-water nutrient exchanges on overall water quality is to examine the magnitude of nutrient fluxes to or from sediments compared with the magnitude of nutrient inputs from external sources. In the case of Back River most of the TN load comes from the Back River WWTP while most of the TP load comes from urban and WWTP sources. On an annual basis N and P loads to this tributary amount to about 94 g N m^{-2} yr^{-1} and 2.7 g P m^{-2} yr^{-1} (Table 4-1). These are substantial loading rates when compared to other portions of Chesapeake Bay and to most other estuarine areas (Boynton *et al.*, 1995b; Table 4-4). Ammonium fluxes from sediments averaged about 467 μM N m^{-2} hr^{-1} in summer of 1997 and this is equivalent to a loading rate of about 57 g N m^{-2} yr^{-1} or about 60% of the external loading rate. In Back River, sediment releases of NH_4^+ during summer constituted a substantial input relative to external sources of N. It is important to understand that we are not indicating here that nitrogen is ultimately generated from sediments (via such processes as N fixation). Rather, organic matter containing N is produced in the water column, deposited to the sediment surface and then the N is liberated via decomposition processes. So, while sediment N releases are certainly a source of nitrogen available to phytoplankton, this source of N comes originally from external sources and can be thought of as an internal recycling source or a reuse of imported N.

If the same sort of calculation is done for P, sediment releases of P in Back River during 1997 amount to about 10 g P m^{-2} yr^{-1} or about three times the external loads. This high ratio of sediment P recycling to external inputs indicates that whatever P gets into this system is thoroughly used and reused during the course of the summer season. Phosphate fluxes are strongly influenced by DO levels in overlying waters. Fluxes are larger in zones of the bay exposed to anoxic or hypoxic conditions than in areas where bottom water remain oxic during the warm periods of the year. Under anoxic or hypoxic conditions, P bound to sediments and iron oxides dissolve and diffuse upward through the sediment column into the water column. Dissolved inorganic phosphorus fluxes in Back River area are relatively large and are generally comparable to those observed in regions of the bay where bottom waters are hypoxic during the warm months of the year. It may be that in Back River there is sufficient organic matter (which contains phosphorus) so that large fluxes result even if bottom waters are not especially hypoxic. The magnitude of PO_4^{-3} fluxes and the relationship of these fluxes to DO conditions is another reason to consider high frequency monitoring of near-bottom waters in the future.

In the above calculations summer rates have been used as estimates of annual fluxes to make direct comparisons with the N and P loads from external sources in Back River. It is important to note that sediment nutrient releases in the bay, and at these sites, are much reduced during the cooler portion of the year (November through April). As a result, it is reasonable to expect that the percentages provided above are higher than annual values would be if lower sediment fluxes based on cold season values were used. Nevertheless, sediment fluxes are an important source of nutrients during late spring, summer and fall periods of the year.

7. SUMMARY AND CONCLUSIONS

- During the period June through September, 1997 selected water quality conditions (DO, temperature, salinity, turbidity and chlorophyll-a) and sediment-water nutrient and oxygen exchanges were monitored in Back River as well as at several stations in the tidal Patapsco River. Water quality conditions measured during previous and on-going monitoring programs were compared with results developed in this program. Nutrient load (N and P) estimates for Back River were compared to those determined for other Chesapeake Bay sub-systems and selected estuaries around the world.

- Monthly average values for salinity, secchi disk depth and chlorophyll-a measured in the Back River during June through September, 1997 were similar to those observed at MWT 4.1, a sampling station in Back River during the much longer monitoring program conducted by the Maryland Chesapeake Bay Program. Salinity values in both studies were low which is typical of locations in the upper bay. Water column turbidity was high with only 1% of surface radiation reaching depths of 0.6 to 1.1 m. Chlorophyll-a concentrations were among the highest observed in the Chesapeake bay and were often in excess of 200 $\mu g\ l^{-1}$ during the summer of 1997.

- Water column DO concentrations (measured at 1 m below the surface) varied by as much as 20 mg l^{-1} over the course of a diel period. Lowest values recorded were about 2.5 mg l^{-1} and highest values were 22 mg l^{-1} during the summer of 1997. Anoxic conditions were not observed during the monitoring period. The large diel excursions in DO, low transparency and large chlorophyll-a concentrations are all characteristic of a shallow estuary having relatively long residence times (to allow build-up of algal stocks) and enrichment via inorganic nutrients (Boynton *et al.*, 1982, Nixon *et al.*, 1986a and D'Avanzo *et al.*, 1996). If enrichment was via dissolved or particulate organic matter, DO concentrations would be lower, as they were in earlier years when the WWTP in Back River operated at lower levels of treatment. The lack of extreme hypoxic or anoxic conditions in Back River is likely to be related to the lack of vertical stratification of the water column which allows for atmospheric replenishment of water column DO when concentrations are reduced below saturation levels.

- To place the nutrient loads from the WWTP in some perspective, total nutrient loading rate estimates (from landside and atmospheric sources) to Back River were assembled (Boynton *et al.* 1995a). Wastewater Treatment Plant loads of TN represented about 86% of the TN load. Wastewater Treatment Plant discharges of TP represent about 40% of the total load. Urban sources of TP are also important (55%). If nutrient loads are prorated over the surface area of Back River, annual areal loads are about 93.5 g N $m^{-2}\ yr^{-1}$ and 2.7 g P $m^{-2}\ yr^{-1}$.

- Compared to other estuarine systems, loading rates to Chesapeake Bay are moderate to high for TN and low to moderate for TP. Nutrient loading rates to Back River are among the highest of the areas examined for TN and substantial for TP. However, it is also clear that comparable nutrient loading rates in different systems do not produce the same responses as those observed locally. For example, N loading rates for Potomac River and Narragansett Bay are similar, while water quality conditions in the mesohaline portion of Potomac River are poor but quite good in Narragansett Bay (Nixon *et al.*, 1986b). On the other hand, loading rates to Baltic Sea are much lower than those recorded in Chesapeake sub-systems but hypoxic and anoxic conditions are characteristic of both. Estuarine morphology, circulation and regional climate conditions undoubtedly have strong influences on the relative impact of loading rates (Wulff *et al.*, 1990). In the case of Back River, loading rates are high but severe hypoxia and anoxia were not observed, presumably because the river is not vertically stratified, an indication of modifying influences of such factors as morphology on water quality conditions.

- The 1997 high frequency DO data collected at two stations in Back River were evaluated to assess compliance with living resource habitat criteria for DO. At both sites the frequency of occurrence of hypoxic DO values was low. At Riverside Marina, DO values of 3 mg l^{-1} occurred 1% of the time or for 23 hours during the 97-day summer monitoring period. In fact, at both sites DO concentrations below 5 mg l^{-1} occurred only 3% of the time or for 70 hours during the summer period. Any sense that the data collected in Back River represent adequate habitat conditions should be tempered with the awareness that an overly optimistic bias may be contained in these data since concentrations at 1 meter depth (depth all measurements were taken) represent the highest DO values in the water column. It is possible that more persistent periods of lower DO occur in deeper waters near the sediment-water interface. In estuarine ecosystems that have relatively large diel DO excursions, such as Back River, concentrations in deeper waters may be especially prone to low DO events of short duration (*i.e.* for several hours before sunrise). In the future, it would be worth testing this idea by deploying one or more recording instruments closer to the sediment surface in deeper waters.

- Estimates of autotrophic production rates (Pa, Pa*, Pg and Pg*) were all greater at Riverside Marina (nearer the WWTP) than at Rudy's Marina and this is probably the direct result of higher chlorophyll-a stocks in the immediate vicinity of the WWTP outfall and ultimately the result of higher nutrient loading rates nearer the outfall. Respiration rates during hours of darkness (Rn) averaged about 2.0 at Rudy's Marina and 2.5 g O_2 m^{-3} day^{-1} and Riverside Marina. While values of Rn were smaller than the autotrophic rates, rates were still substantial compared with those observed in other estuarine environments (Boynton *et al.*, 1998 and Kemp and Boynton, 1980). Finally, the ratio of Pa to Rn (often referred to as the P/R ratio) at both sites exceeded unity indicating that on average more organic matter was being produced than consumed at these sites. The accumulation of large stocks of phytoplankton in most of Back River is consistent with this prediction. This organic matter is available for deposition to bottom sediments where it can be decomposed by sediment microorganisms or exported via tidal transport to the open waters of upper Chesapeake Bay. The inorganic N and P resulting from local decomposition can readily be returned to the water column (because the water column is well mixed) to be utilized by phytoplanktonic communities. This cycle of high production rates, deposition of organic matter to the bottom sediments, remineralization of deposited organic matter, release of inorganic nutrients and re-utilization of nutrients by growing pyhtoplankton is a basic characteristic of a eutrified system. The magnitude of these processes is expected to decrease rapidly as N loads decrease.

- Estimates of community metabolism rates from a variety of estuarine systems, including several sites in Chesapeake Bay, were compared with those observed in Back River during the summer of 1997. Most measurements were made using the same technique as was used in Back River. The production rates in Back River are as high as those observed in other nutrient stressed environments (*e.g.* Waquoit Bay, MA) and in SAV communities (*e.g.* Texas estuaries with SAV communities) which are among the most metabolically active aquatic environments known.

- Mean monthly SOC rates for 1997 ranged from -1.46 g O_2 m^{-2} day^{-1} to -2.99 g O_2 m^{-2} day^{-1} in Back River and from -1.75 g O_2 m^{-2} day^{-1} to -2.09 g O_2 m^{-2} day^{-1} in Patapsco River. Fluxes in 1997 followed seasonal patterns observed in other areas of Chesapeake Bay with highest values generally observed during early summer in areas with adequate bottom water DO concentrations. The INHB station in the Patapsco River exhibited depressed SOC values reflecting limiting DO concentrations in deep waters (Boynton *et al.*, 1997a). Hypoxic conditions in bottom waters were reported for INHB and RVBH stations and this situation was probably responsible for depressed SOC fluxes. Sediment oxygen consumption rates above 1 g O_2 m^{-2} day^{-1} can have a significant impact on DO water quality conditions, especially in relatively shallow estuaries.

- Mean monthly NH_4^+ fluxes for 1997 ranged from 163 μM N m^{-2} hr^{-1} to 797 μM N m^{-2} hr^{-1} in Back River; and from 196 μM N m^{-2} hr^{-1} to 600 μM N m^{-2} hr^{-1} in Patapsco River. Flux values in 1994 and 1995 at INHB were very large, being among the highest ever measured in Chesapeake Bay and higher even than those measured at other sites in Patapsco and Back Rivers. While lower, NH_4^+ fluxes measured during 1997 in Back and Patapsco Rivers were still high. To put these values in perspective, the median NH_4^+ flux based on data collected at 10 sites in Chesapeake Bay during summer periods from 1985 through 1996 was about 200 μM N m^{-2} hr^{-1}. The NH_4^+ fluxes measured during 1997 in both Back and Patapsco Rivers generally exceeded this by a large margin.

- Mean monthly NO_2^- + NO_3^- fluxes for 1997 ranged from -287 μM N m^{-2} hr^{-1} to 81 μM N m^{-2} hr^{-1} in Back River and from -233 μM N m^{-2} hr^{-1} to 127 μM N m^{-2} hr^{-1} in Patapsco River. In general, NO_2^- + NO_3^- fluxes were directed from the water column into sediments and as such represents a loss of available N. The ultimate fate of this N is not certain but it is probable that it is denitrified (Jenkins and Kemp, 1984) and lost from the system as dinitrogen gas. Relative to the sediment-water NO_2^- + NO_3^- flux measurements made at 10 sites in Chesapeake Bay during the last decade (median value = 6 μM N m^{-2} hr^{-1}) those made in Back and Patapsco Rivers during 1997, and in previous years, were large and mainly directed from water to sediments.

- Mean monthly PO_4^{-3} flux values ranged from 5 μM P m^{-2} hr^{-1} to 111 μM P m^{-2} hr^{-1} in Back River and from 1.5 μM P m^{-2} hr^{-1} to 51 μM P m^{-2} hr^{-1} in July in Patapsco River. During 1994 and 1995 DIP fluxes were lowest for all stations in November and generally highest in July. The highest fluxes from sediment to overlying water occurred during months when hypoxic (less than 1.0 mg l^{-1} DO) bottom water conditions were recorded in Patapsco River and lower than average bottom water conditions were observed in Back River. Iron-sulphur reactions with sediment bound P are probably the cause for the high fluxes under low DO conditions (Krom and Berner, 1980). Relative to the DIP flux measurements made at 10 sites in Chesapeake Bay during the last decade (median value = 11 μM P m^{-2} hr^{-1}) those made in Back and Patapsco Rivers during 1997, and in previous years, were large and are among the highest observed in Chesapeake Bay.

- Average monthly values for $Si(OH)_4$ fluxes in 1997 ranged from 166 μM Si m^{-2} hr^{-1} to 640 μM Si m^{-2} hr^{-1} in Back River; and from 142 μM Si m^{-2} hr^{-1} to 444 μM Si m^{-2} hr^{-1} in the Patapsco River. Mean monthly $Si(OH)_4$ fluxes varied from station to station, but were always low during the single cold month (November) in which measurements were made. Fluxes were similar in magnitude to other $Si(OH)_4$ flux measurements made in Chesapeake Bay (Boynton *et al.*, 1997b).

- Average monthly TCO_2 fluxes in 1997 ranged from 4,800 μM TCO_2 m^{-2} hr^{-1} to 8,460 μM TCO_2 m^{-2} hr^{-1} in Back River; and from 2,530 μM TCO_2 m^{-2} hr^{-1} to 5,730 μM TCO_2 m^{-2} hr^{-1} in Patapsco River. Rates of TCO_2 flux from sediments is a measure of both aerobic and anaerobic metabolism. Such measurements made in less impacted portions of Chesapeake Bay range between 2,000 and 3,000 μM TCO_2 m^{-2} hr^{-1}. In Back and Patapsco Rivers, rates measured during 1994 and 1997 were generally higher, often by a large margin (factor of 2 x or more). This indicates that large amounts of organic matter are being decomposed in these sediments, a situation which is not surprising given the large stock of labile organic matter being produced in the water column.

- Sediment nutrient releases have been shown to be an important process linking benthic and water column components of shallow estuarine ecosystems. The release of nutrients from sediments can be substantial and, if this is the case, is an important factor affecting the water quality in these systems. Fluxes of NH_4^+ and PO_4^{-3} are of particular importance in the case of Back River because both nutrients are important factors promoting algal growth and both have been or are presently targeted for input reduction via upgrades to the WWTP in Back River. To place the sediment-water exchanges of nitrogen and phosphorus in some perspective, we assembled values measured in a variety of coastal and estuarine ecosystems. Various other coastal estuarine systems release NH_4^+ from sediments during the summer at low to moderate rates, most often ranging from 25 to 250 μM N m^{-2} hr^{-1}. Fluxes reported for various Chesapeake mainstem locations and tributaries (Potomac, Patuxent and Choptank Rivers) were generally higher than those observed in coastal system with lower levels of anthropogenic nutrient additions. The fluxes reported in this study are high to very high in comparison with other areas of the Chesapeake and world. At the INHB station in Patapsco River in 1994 and 1995, fluxes were uncommonly high (average = 2,000 μM N m^{-2} hr^{-1}); very large fluxes of NH_4^+ were also observed at all Back River stations during 1997. These extremely high fluxes are characteristic of eutrophic ecosystems. Fluxes of PO_4^{-3} in all the systems reviewed were proportional to NH_4^+ fluxes probably reflecting the composition of the supply of organic matter reaching sediments. Fluxes of PO_4^{-3} were particularly high in the Patapso River and Baltimore Harbor sub-system of Chesapeake Bay. In comparison to other areas of the world and Chesapeake Bay, fluxes in the Patapsco and Back River sub-systems are large, again indicating eutrophic conditions.

- Sediment oxygen consumption rates were appreciable at all stations in Back River during the summer periods. If the average SOC rate of 2.2 g O_2 m^{-2} day^{-1} is assumed to be characteristic of Back River during summer of 1997, this can be compared to the amount of oxygen present in the water column and a potential DO turnover time can be calculated as follows: using a mean depth of about 1.8 m and an average oxygen saturation concentration of 8 mg l^{-1} during summer periods, a DO turnover time of about 6.5 days is estimated based solely on SOC rates (water column DO stock [8 mg l^{-1} * 1.8 m = 14.4 g O_2 m^{-2}] divided by SOC rate). This estimate of a turn over time of 6.5 days is fairly long. It is not reasonable to expect SOC to be the sole important factor in determining DO dynamics in this system. Using an *in situ* technique, Robertson (1977) estimated SOC to be about 3.2 g O_2 m^{-2} day^{-1} which would yield a DO turn over time of 4.5 days, still not particularly rapid. The point here is that rapid DO turn over times would be expected to yield erratic (and at times very low) DO conditions. We did not observe such conditions. Measurements of water column respiration rates for Back River are not extensive, but measurements made at Rudy's Marina and Riverside Marina during the summer of 1997 indicate values of about 0.2 mg l^{-1} hr^{-1} or about 3.6 g O_2 m^{-2} $night^{-1}$ (0.2 g O_2 m^{-3} hr^{-1} * 10 hours of darkness day^{-1} * 1.8 m water column). The inclusion of water column respiration rates during periods of darkness would decrease DO turnover time considerably (in this simple example to about 2.5 days). However, there are two additional sources of oxygen which can compensate for losses due to biological respiration in the water column and sediments. First, phytoplankton produce oxygen during daylight hours as a bi-product of photosynthesis and, in the case of Back River, this oxygen production can be large. In fact, the majority of DO measurements in the near-surface (1 m depth) waters of Back River were above DO saturation levels. Some of the oxygen losses due to water column respiration at night are compensated for by water column production of oxygen during hours of daylight. This was apparently the case in Back River because P/R ratios based on high frequency DO measurements were greater than unity for the summer period. Second, this shallow tributary is generally vertically mixed due to wind and tidal action. If oxygen concentrations in surface waters decrease below saturation concentrations (about 8 mg l^{-1} during summer periods in Back River), oxygen can diffuse across the air-water interface and be mixed throughout the water column. In vertically mixed areas, air-water diffusion of oxygen provides a buffer against development of low oxygen conditions, at least to a certain level of biological oxygen consumption. During 1997, DO diffusing into Back River waters was a relatively rare occurrence (5% of the time) and occurred at relatively small rates (0.01 - 0.30 g O_2 m^{-2} hr^{-1}) compared to other DO fluxes. The small rates of reaeration were caused by the large amounts of DO released from the phytoplanktonic stock which had the effect of keeping surface waters above DO saturation levels.

- Several points relative to water quality conditions can be made based on examination of the above calculations. First, there is little oxygen storage in the water column because of high summer temperatures (oxygen solubility is inversely related to water temperature) and a short water column. Thus, there is little DO buffering available in this system based on DO storages alone. Second, the rates of oxygen use are substantial but during 1997 these were not high enough to cause DO depletion to low levels (< 2.0 mg l^{-1}) at least to depths of one meter. However, if photosynthetic DO production were to decrease for several days in a row (*e.g.* due to a stalled frontal system) or if there was a period of calm winds and especially hot weather (which could stratify the water column) it seems possible for DO conditions to deteriorate rapidly, reaching low levels in just several days. In past years (1970's and earlier) when the organic matter load (BOD_5) from the WWTP was larger and general DO concentrations lower (because of bacterial respiration of the organic matter), very low DO events did occur, causing fish kills on several occasions (Robertson, 1977). Finally, the above considerations have been based on the assumption that Back River water column is mixed in the vertical direction. While there is evidence that this is generally the case, near-bottom water DO measurements have not been made on a high frequency basis as was done in near-surface waters in this study. It is possible that sediments and benthic organisms in Back River are routinely exposed to low DO conditions on a diel basis, especially in the hours just before and after sunrise when DO concentrations in the upper water column are lowest. If future monitoring of DO is to be conducted in Back River, near-bottom measurements should be included in the study design.

- An approach to evaluating the impact of sediment-water nutrient exchanges on overall water quality involves examining the magnitude of nutrient fluxes to or from sediments compared with the magnitude of nutrient inputs from external sources. In the case of Back River most of the TN load comes from the Back River WWTP while most of the TP load comes from urban and WWTP sources. On an annual basis N and P loads to this tributary amount to about 94 g N m^{-2} yr^{-1} and 2.7 g P m^{-2} yr^{-1}. These are substantial loading rates when compared to other portions of Chesapeake Bay and to most other estuarine areas (Boynton *et al.*, 1995b). Ammonium fluxes from sediments averaged about 467 μM N m^{-2} hr^{-1} in summer of 1997 and this is equivalent to a loading rate of about 57 g N m^{-2} yr^{-1} or about 60% of the external loading rate. In Back River, sediment releases of NH_4^+ during summer constituted a substantial input relative to external sources of N. It is important to understand that we are not indicating here that nitrogen is ultimately generated from sediments (via such processes as N fixation). Rather, organic matter containing N is produced in the water column, deposited to the sediment surface and then the N is liberated via decomposition processes. So, while sediment N releases are certainly a source of nitrogen available to phytoplankton, this source of N comes originally from external sources and can be thought of as an internal recycling source or a reuse of imported N. If the same sort of calculation is done for P, sediment releases of P in Back River during 1997 amount to about 10 g P m^{-2} yr^{-1} or about three times the external loads. This high ratio of sediment P recycling to external inputs indicates that whatever P gets into this system is thoroughly used and reused during the course of the summer season. Phosphate fluxes are strongly influenced by DO levels in overlying waters. Fluxes are larger in zones of the bay exposed to anoxic or hypoxic conditions than in areas where bottom water remains oxic during the warm periods of the year. Under anoxic or hypoxic conditions, P bound to sediments and iron oxides dissolves and diffuses upward through the sediment column into the water column. Dissolved inorganic phosphorus fluxes in Back River are relatively large and are generally comparable to those observed in regions of the bay where bottom waters are hypoxic during the warm months of the year. It may be that in Back River there is sufficient organic matter (which contains P) so that large fluxes result even if bottom waters are not especially hypoxic. The magnitude of PO_4^{-3} fluxes and the relationship of these fluxes to DO conditions is another reason to consider high frequency monitoring of near-bottom waters in the future. In the above calculations summer rates have been used as estimates of annual fluxes to make direct comparisons with the N and P loads from external sources in Back River. It is important to note that sediment nutrient releases in the bay, and at these sites, are much reduced during the cooler portion of the year (November through April). As a result, it is reasonable to expect that the percentages provided above are higher than annual values would be if lower sediment fluxes based on cold season values were used. Nevertheless, sediment fluxes are an important source of nutrients during late spring, summer and fall periods of the year.

References

American Public Health Association, Inc. 1966. Standard Methods for the Examination of Water and Wastewater including Bottom Sediments and Sludges. Twelfth Edition. New York.

Alvarez-Borrego, S., D. Guthrie, C.H. Culberson and P.K. Park. 1975. Test of Redfield's model for oxygen relationships using regression analysis. *Limnol. Oceanogr.* 20(5):795-805.

Aspila, I., H. Agemian, and A.S.Y. Chau. 1976. A semi-automated method for the determination of inorganic, organic and total phosphate in sediments. Analyst 101:187-197.

Boynton, W.R. 1973. Phytoplankton production in Chincoteague Bay. Maryland-Virginia. M.S. Thesis, Curriculum in Marine Sciences, Univ. N. Carolina, Chapel Hill, NC.

Boynton, W.R. 1975. Energy basis of a coastal region: Franklin County and Appalachicola Bay, Florida. PH.D. Dissertation. Department Environmental Engineering, Univ. Florida, Gainesville, FL.

Boynton, W.R., J.M. Barnes, F.M. Rohland, L.L. Matteson, J.M. Frank and M.M. Weier. 1996. G-East and Site 92 Subaqueous Placement Baseline Study, Final Report. Chesapeake Biological Laboratory (CBL), University of Maryland System, Solomons, MD 20688-0038. Ref No. [UMCEES]CBL 96-149.

Boynton, W.R., J.M. Barnes, F.M. Rohland, L.L. Matteson, J.M. Frank and M.M. Weier. 1997a. G-West Hydraulic Placement Monitoring Study: Final Report , Sampling Period June, July and August, 1996. Chesapeake Biological Laboratory (CBL), University of Maryland System, Solomons, MD 20688-0038. Ref No. [UMCEES]CBL 96-167.

Boynton, W. R. and J. H. Garber. 1989. Sediment-water Oxygen and Nutrient Exchanges in Chesapeake Bay: Deep Trough Dredge Disposal Areas, Summer 1989. Final Report for Versar Inc., 9200 Rumsey Rd, Columbia, MD.

Boynton, W. R., J. H. Garber, R. M. Summers and W. M. Kemp. 1995a. Inputs, transformations and transport of nitrogen and phosphorus in Chesapeake Bay and selected tributaries. Estuaries 18 (1B): 285-314.

Boynton, W.R. and W.M. Kemp. 1985. Nutrient regeneration and oxygen consumption by sediments along an estuarine salinity gradient. Mar. Ecol. Prog. Ser. 23:45-55.

Boynton, W.R., W.M. Kemp and C.W. Keefe. 1982. A comparative analysis of nutrients and other factors influencing estuarine phytoplankton production, p. 69-90. In: V.S. Kennedy, [Ed.], Estuarine Comparisons, Academic Press, NY.

Boynton, W.R., W.M. Kemp, J.M. Barnes, L.L. Matteson, F.M. Rohland, D.A. Jasinski and H.L. Kimble. 1994. Ecosystem Processes Component Level 1 Interpretive Report No. 11. Chesapeake Biological Laboratory (CBL), University of Maryland System, Solomons, MD 20688-0038. Ref No. [UMCEES]CBL 94-031a.

Boynton, W.R., W.M. Kemp, J.M. Barnes, L.L. Matteson, F.M. Rohland, L.L. Madgeburger and B.J. Weaver. 1995b. Ecosystem Processes Component Level 1 Interpretive Report No. 15. Chesapeake Biological Laboratory (CBL), University of Maryland System, Solomons, MD 20688-0038. Ref No. [UMCEES]CBL 95-039.

Boynton, W.R., R.M Stankelis, F.M. Rohland, L.L. Matteson, J. Frank, N.H. Burger and M.M. Weir. 1997b. Ecosystems Processes Component (EPC) Level One Report #15, Data and Progress Report. January - June 1996. University of Maryland System Center for Environmental Science, Chesapeake Biological Laboratory (CBL), Solomons, MD 20688-0038. Ref. No. [UMCES]CBL 97-096.

Boynton, W.R., R.M Stankelis, N.H. Burger, F.M. Rohland, J.D. Hagy III, J.M. Frank, L.L. Matteson and M.M. Weir. 1998. Ecosystems Processes Component (EPC) Level 1 Interpretive Report No.15. University of Maryland System Center for Environmental Science, Chesapeake Biological Laboratory (CBL), Solomons, MD 20688-0038. Ref. No. [UMCES]CBL 98-073.

Boynton, W.R. and F.M. Rohland. 1990. Ecosystem Processes Component (EPC) Data Dictionary. Chesapeake Biological Laboratory (CBL), University of Maryland System, Solomons, MD 20688-0038. Ref. No. [UMCEES]CBL 90-029.

Collins, J. 1986. The influence if intertidal microalgae on exchange of nutrients and oxygen in a Pacific Northwest Estuary. M.Sc. Thesis. Oregon State University.

D'Avanzo, C., J.N. Kremer and S.C. Wainright. 1996. Ecosystem production and respiration in response to eutrophication in shallow temperate estuaries. Mar. Ecol. Prog. Series 141:263-274.

Domotor, D. K., M. S. Haire, N. N. Panday and R. M. Summers. 1989. Patuxent Estuary Water Quality Assessment: Special Emphasis 1983-1987. Technical Report No. 104. MD Dept Environment, Water Management Administration, Chesapeake Bay and Special Projects Program, Baltimore, MD.

Environmental Protection Agency (EPA). 1979. Methods for Chemical Analysis of Water and Wastes. USEPA-6000/4-79-020. Environmental Monitoring and Support Laboratory, Cincinnati, OH.

Environmental Protection Agency (EPA). 1989. Sediment data management plan. Chesapeake Bay Program. CBP/TRS 29/89.

Funderburk, S.L., S.J. Jordan, J.A. Mihursky and D.R. Riley (eds.). 1991. Habitat Requirements for Chesapeake Bay Living Resources, 1991 Revised Edition. Living Resources Subcommittee, Chesapeake Bay Program. Annapolis, Maryland.

Gaader, T. and H.H. Gran. 1927. Investigations of the Production of Plankton in the Oslo Fiord. *J.du Conseil.* Vol II. No. 1:373-374.

Garber, J.H., W.R. Boynton and W.M. Kemp. 1987. Ecosystem processes component-study plan and budget for FY88. Maryland Office of Environmental Programs. Maryland Chesapeake Bay Water Quality Monitoring Program. Chesapeake Biological Laboratory (CBL), University of Maryland System, Solomons, MD 20688-0038. Ref. No.[UMCEES]CBL 87-50.

Jenkins, M.C. and W.M. Kemp. 1984. The coupling of nitrification and denitrification in two estuarine sediments. *Limnology and Oceanography* 29:609-619.

Jordan, S.L., C. Stenger, M. Olson, R. Batiuk and K. Mountford. 1992. Chesapeake Bay Dissolved Oxygen Goal for Restoration of Living Resource Habitats. Living Resources Subcommittee, Chesapeake Bay Program. Annapolis, Maryland.

Johnson, K.M., Sieburth, J.M., Williams, P.J. leB, and L. Brandstrom. 1987. Coulorimetric total carbon dioxide analysis for marine studies: Automation and calibration. Mar. Chem. 21:117-133.

Kaumeyer, K., W.R. Boynton, L. Lubbers, K. Staver., S. Bunker, W.M. Kemp and J.C. Means. 1981. Metabolism and biomass of submerged macrophyte communities in Northern Chesapeake Bay. Chapter 13 in Submerged Aquatic Vegetation (SAV) Studies. Chesapeake Biological Laboratory, Box 38, Solomons, MD.

Kemp, W.M. and W.R. Boynton. 1980. Influence of biological and physical factors on dissolved oxygen dynamics in an estuarine system: implications for measurement of community metabolism. Estuar. Coast. Mar. Sci. 11:407-431.

Kemp, W.M., E.M. Smith, M. M. DiPasquale and W.R. Boynton. 1997. Organic carbon balance and net ecosystem metabolism in Chesapeake Bay. Mar. Ecol. Prog. Ser. In Press.

Krom, M.D. and R.A. Berner. 1980. The diffusion coefficients of sulfate, ammonium and phosphate ions in anoxic marine sediments. *Limnol. Oceanogr.* 25:327-337.

Magnien R.E., D.K. Austina and B.D. Michael. 1993. Chemical/Physical Properties Component. Level 1 Data Report (1984-1991). Maryland Department of the Environment, Baltimore, MD.

National Oceanographic and Atmospheric Administration/Environmental Protection Agency. 1989. Strategic Assessment of Near Coastal Waters, Susceptibility of East Coast Estuaries to Nutrient Discharges: Passamaquoddy Bay to Chesapeake Bay. Strategic Assessment Branch, NOS/NOAA, Rockville, MD.

Nixon, S.W. 1981. Remineralization and nutrient cycling in coastal marine ecosystem. In: Nielson, B.J., L.E. Cronin (ed.) Estuaries and nutrients, p. 111- 138. Humana Press, Clifton, NJ.

Nixon, S.W., C.D. Hunt and B.L. Nowicki. 1986b. The retention of nutrients (C,N,P), heavy metals (Mn, Cd, Pb, Cu), and petroleum hydrocarbons in Narragansett Bay, p.99-122. In: P. Lasserre and J.M. Martin (eds.). Biogeochemical Processes at the Land-Sea Boundary. Elsevier Oceanography Series, 43. New York.

Nixon, S.W., C.A. Oviatt, J. Frithsen and B. Sullivan. 1986a. Nutrients and the productivity of estuarine and coastal marine systems. J. Limnol. Soc. Sth. Afr. 12(1/2): 43-71.

Nixon, S.W. 1990. Marine eutrophication: A growing international problem. *Ambio* 19:101.

Odum, H.T. and C.M. Hoskin. 1958. Comparative studies on the metabolism of marine waters. Publ. Inst. Mar. Sci., Univ. Texas, 5:16-46.

Redfield, A.C. 1934. On the proportions of organic derivatives in seawater and their relation to the composition of plankton. In: James Johnstone Memorial Volume, p. 176-192. University Press, Liverpool.

Robertson, P. G. 1977. Back River An Assessment of Water Quality and Related Fish Mortalities. MD Dept Nat Res, Water Resources Administration, Water Quality Services, Annapolis, MD. pp. 133.

Shoaf, W.T. and B.W. Lium. 1976. Improved extraction of chlorophyll a and b from algae using dimethyl sulfoxide. *Limnol. Oceanogr.* 21:926-928.

Strickland, J.D.H. and T.R. Parsons. 1972. A practical handbook of seawater analysis. Fish. Res. Bd. Can. Bull. 167 (second edition).

Stammerjohn, S., E.S. Smith, W.R. Boynton and W.M. Kemp. 1991. Potential impacts from marinas and boats in Baltimore Harbor. Prepared for the Baltimore Regional Council of Governments. CRC Publication No. 139.

Smith, E.M. and W.M. Kemp. 1995. Seasonal and regional variations in plankton community production and respiration for Chesapeake Bay. Mar. Ecol. Prog. Ser. 116:217-231.

Technicon Industrial Systems. 1977. Silicates in water and seawater. Industrial Method No. 186-72W/B. Technicon Industrial Systems, Terrytown, NY.

Wulff, F., A. Stigebrandt and L. Rahm. 1990. Nutrient dynamics of the Baltic. *Ambio* 14 (3): 126-133.

APPENDIX A

HIGH FREQUENCY WATER COLUMN MEASUREMENTS: RUDY'S MARINA AND RIVERSIDE MARINA

BACK RIVER WATER QUALITY MONITORING PROGRAM
ECOSYSTEMS PROCESSES COMPONENT

BACK RIVER ESTUARY

Mid-River and Upriver High Frequency Water Column Measurements

Date, time and value for each 15-minute Conductivity, Temperature and Depth (CTD) record at Rudy's Marina and Riverside Marina showing temperature, conductivity, salinity, dissolved oxygen percent saturation and dissolved oxygen concentration.
Also listed are respective weekly values for dissolved oxygen concentration from Winkler analysis, total and active chlorophyll-a concentrations

PARAMETERS:

DATE:	MMDDYY, Month, Day, Year
TIME:	HHMMSS, Hours, Minutes, Seconds
TEMPERATURE:	Degrees Celsius (C)
SPECIFIC CONDUCTANCE:	Milliseimens per centimeter
SALINITY:	Parts per thousand (ppt)
DISSOLVED OXYGEN	Percent saturation at incident temperature and salinity
DISSOLVED OXYGEN	Milligrams per liter
TOTAL CHLOROPHYLL-a	Micrograms per liter
ACTIVE CHLOROPHYLL-a	Micrograms per liter

DATES COLLECTED: 20th June, 1997 through 24th September, 1997

BACK RIVER WATER QUALITY MONITORING PROGRAM
ECOSYSTEMS PROCESSES COMPONENT
BACK RIVER ESTUARY
Mid-River and Upriver High Frequency Water Column Measurements

Date, time and value for each 15-minute Conductivity, Temperature and Depth (CTD) record at Rudy's Marina and Riverside Marina showing temperature, conductivity, salinity, dissolved oxygen percent saturation and dissolved oxygen concentration.
Also listed are respective weekly values for dissolved oxygen concentration from Winkler analysis, total and active chlorophyll-a concentrations

PARAMETERS:

DATE:	MMDDYY, Month, Day, Year
TIME:	HHMMSS, Hours, Minutes, Seconds
TEMPERATURE:	Degrees Celsius (C)
SPECIFIC CONDUCTANCE:	Milliseimens per centimeter
SALINITY:	Parts per thousand (ppt)
DISSOLVED OXYGEN	Percent saturation at incident temperature and salinity
DISSOLVED OXYGEN	Milligrams per liter
TOTAL CHLOROPHYLL-a	Micrograms per liter
ACTIVE CHLOROPHYLL-a	Micrograms per liter

DATES COLLECTED: 20th June, 1997 through 24th September, 1997

BACK RIVER AND PATAPSCO RIVER EVALUATION DATA SET:

Page No.

TABLE B-1.1 BACK RIVER AND PATAPSCO RIVER EVALUATION - 1997
WATER COLUMN PROFILES: Vertical profiles of temperature, salinity, dissolved oxygen and other characteristics at Back River and Patapsco River stations

FILENAME : HPPBJN97
REVISED : 28APR98

STATION	DATE	TIME	TOTAL DEPTH (m)	SECCHI DEPTH (m)	GEAR CODE	SAMPLE DEPTH (m)	TEMP (C)	COND (mmho/cm)	SALIN (ppt)	DO (mg/l)	DO SAT (%)
DPCK	11JUN97	1130	1.5	0.5	WP05	0.5	24.5	0.4	0.0	18.30	219.3
						1.0	24.2	0.4	0.0	14.74	175.7
MDGT	11JUN97	840	1.5	0.3	WP05	0.5	22.6	0.5	0.0	16.28	188.0
						1.0	22.5	0.5	0.0	15.90	183.6
WCPT	11JUN97	1440	2.0	0.4	WP05	0.5	25.4	2.3	0.9	19.20	235.3
						1.5	23.6	2.4	0.9	16.60	196.6
FFOF	10JUN97	1125	6.0	1.0	WP05	0.5	21.7	2.4	1.0	11.40	130.4
						1.0	21.0	2.5	1.0	11.78	132.8
						2.0	20.7	2.5	1.0	10.68	119.8
						3.0	20.3	2.6	1.1	9.86	109.7
						4.0	19.8	2.7	1.1	7.84	86.5
						5.0	19.5	3.1	1.3	5.95	65.2
HMCK	10JUN97	1425	4.0	0.9	WP05	0.5	23.7	2.4	0.9	12.64	150.2
						1.0	23.4	2.4	0.9	12.73	150.3
						2.0	22.3	2.4	1.0	12.88	148.9
						3.0	20.8	2.9	1.2	5.87	66.1

TABLE B-1.2. BACK AND PATAPSCO RIVER EVALUATION - 1997
WATER COLUMN PROFILES: Vertical profiles of temperature, salinity, dissolved oxygen and other characteristics at Back River and Patapsco River stations

FILENAME : HPPBJL97
REVISED : 15MAY98

STATION	DATE	TIME	TOTAL DEPTH (m)	SECCHI DEPTH (m)	GEAR CODE	SAMPLE DEPTH (m)	TEMP (C)	COND (mmho/cm)	SALIN (ppt)	DO (mg/l)	DO SAT (%)
DPCK	16JUL97	830	2.0	0.2	WP05	0.5	29.8	1.5	0.5	9.75	128.9
						1.0	29.6	1.4	0.4	9.16	120.7
MDGT	16JUL97	1055	1.8	0.3	WP05	0.5	30.3	2.3	0.9	14.92	199.4
						1.0	29.9	3.3	1.5	11.36	151.4
WCPT	16JUL97	1510	1.8	0.3	WP05	0.5	31.3	3.9	1.8	15.02	205.4
						1.5	30.5	4.1	1.9	11.50	155.2
FFOF	15JUL97	1326	6.0	1.0	WP05	0.5	28.4	11.9	6.6	8.96	119.6
						1.0	28.4	11.9	6.6	8.98	119.9
						2.0	28.4	11.9	6.6	8.95	119.5
						3.0	28.2	11.9	6.6	8.51	113.2
						4.0	27.4	12.1	6.7	5.83	76.6
						5.0	26.6	13.3	7.4	4.64	60.3
HMCK	15JUL97	1250	3.6	0.8	WP05	0.5	29.9	V	V	6.74	89.1
						1.0	29.4	10.2	5.5	8.38	113.2
						2.0	29.0	10.5	5.7	5.99	80.4
						3.0	28.8	10.6	5.7	6.03	80.7

TABLE B-1.3. BACK RIVER AND PATAPSCO RIVER EVALUATION - 1997

WATER COLUMN PROFILES: Vertical profiles of temperature, salinity, dissolved oxygen and other characteristics at Back River and Patapsco River stations

FILENAME : HPPBAG97

REVISED : 22NOV97

STATION	DATE	TIME	TOTAL DEPTH (m)	SECCHI DEPTH (m)	GEAR CODE	SAMPLE DEPTH (m)	TEMP (C)	COND (mmho/cm)	SALIN (ppt)	DO (mg/l)	DO SAT (%)
DPCK	13AUG97	818	1.8	0.3	WP05	0.5	27.4	2.3	0.9	11.81	150.0
						1.0	27.4	2.6	1.1	10.70	136.1
MDGT	13AUG97	935	1.8	0.4	WP05	0.5	27.1	5.9	2.9	9.22	117.9
						1.0	27.1	6.4	3.3	8.19	105.0
WCPT	13AUG97	1400	2.1	0.4	WP05	0.5	27.9	7.6	3.9	12.01	156.8
						1.5	27.4	8.2	4.3	8.26	107.0
FFOF	12AUG97	1045	5.7	1.3	WP05	0.5	26.7	15.0	8.5	8.83	115.6
						1.0	26.5	15.2	8.6	8.45	110.4
						2.0	26.3	15.4	8.8	7.61	99.1
						3.0	26.1	15.5	8.8	7.18	93.2
						4.0	26.0	15.5	8.8	6.97	90.4
						5.0	26.0	15.6	8.9	6.35	82.3
HMCK	12AUG97	925	3.6	0.7	WP05	0.5	26.8	13.6	7.6	6.99	91.2
						1.0	26.7	13.6	7.6	6.98	90.9
						2.5	26.5	14.1	7.9	7.27	94.6

BACK RIVER AND PATAPSCO RIVER EVALUATION DATA SET:

Page No.

TABLE B-2.1. BACK RIVER AND PATAPSCO RIVER EVALUATION - 1977
WATER COLUMN NUTRIENTS: Dissolved and particulate nutrient concentrations in surface and bottom waters at Back River and Patapsco River stations

FILENAME : HNPBJN97
REVISED : 20NOV97

STATION	DATE	TOTAL DEPTH (m)	SAMPLE DEPTH (m)	DISSOLVED NUTRIENTS NH4 (uM)	NO2 (uM)	NO2+NO3 (uM)	CORR DIP (uM)	SI(OH)4 (uM)
DPCK	11JUN97	1.5	1.0	0.9	8.91	66.70	0.15	8.0
MDGT	11JUN97	1.5	1.0	0.7	7.95	51.20	0.17	5.7
WCPT	11JUN97	2.0	1.5	0.7	0.83	2.69	0.75	5.6
FFOF	10JUN97	6.0	5.0	14.7	0.92	24.00	0.08	23.2
HMCK	10JUN97	4.0	3.0	8.1	0.89	16.30	0.12	27.8

TABLE B-2.2. BACK RIVER AND PATAPSCPO RIVER EVALUATION - 1997
WATER COLUMN NUTRIENTS: Dissolved and particulate nutrient concentrations in surface and bottom waters at Back River and Patapsco River stations

FILENAME : HNPBJL97
REVISED : 28APR97

STATION	DATE	TOTAL DEPTH (m)	SAMPLE DEPTH (m)	DISSOLVED NUTRIENTS NH4 (uM)		NO2 (uM)	NO2+NO3 (uM)	CORR DIP (uM)	SI(OH)4 (uM)
DPCK	16JUL97	2.0	1.0	0.5		5.65	30.80	4.48	151.0
MDGT	16JUL97	1.8	1.0	0.4		0.17	0.17	6.87	139.1
WCPT	16JUL97	1.8	1.5	0.2	<	0.10	0.22	0.75	131.4
FFOF	15JUL97	6.0	5.0	34.0		1.45	12.90	0.41	31.1
HMCK	15JUL97	3.6	3.0	6.0		0.55	6.52	0.12	32.9

TABLE B-2.3. BACK RIVER AND PATAPSCO RIVER EVALUATION- 1997
WATER COLUMN NUTRIENTS: Dissolved and particulate nutrient concentrations in surface and bottom waters at Back River and Patapsco River stations

FILENAME : HNPBAG97
REVISED : 15MAY98

				DISSOLVED NUTRIENTS				
STATION	DATE	TOTAL DEPTH (m)	SAMPLE DEPTH (m)	NH4 (uM)	NO2 (uM)	NO2+NO3 (uM)	CORR DIP (uM)	SI(OH)4 (uM)
DPCK	13AUG97	1.8	1.0	3.9	6.33	92.00	1.73	87.9
MDGT	13AUG97	1.8	1.0	4.5	0.48	2.30	3.20	100.3
WCPT	13AUG97	2.1	1.5	1.0	0.23	0.24	0.75	92.1
FFOF	12AUG97	5.7	5.0	16.5	1.20	10.60	0.13	38.4
HMCK	12AUG97	3.6	2.5	3.3	0.42	8.17	0.14	37.7

BACK RIVER AND PATAPSCO RIVER EVALUATION DATA SET:

TABLE B-3.1. BACK RIVER AND PATAPSCO RIVER EVALUATION - 1977

SEDIMENT PROFILES: Vertical sediment profiles of Eh and surficial sediment characteristics at Back River and Patapsco River stations

FILENAME : SPPBJN97

REVISED : 20NOV97

STATION	DATE	TIME	CORE DEPTH (cm)	Eh MEAS (mV)	Eh CORR (mV)	SURFICIAL SEDIMENT PARTICULATES SED PC %(wt)	SED PN %(wt)	SED PP %(wt)	SED CHLa TOTAL (mg/m2)	SED CHLa ACTIVE (mg/m2)
DPCK	11JUN97	1108	1.0	34	278					
			0.0	44	288					
			-1.0	-224	20	6.03	0.730	0.320	410.5	308.4 (1 cm)
			-2.0	-175	69					
			-3.0	-187	57					
			-4.0	-190	54					
			-5.0	-182	62					
			-6.0	-175	69					
			-7.0	-161	83					
			-8.0	-162	82					
			-9.0	-168	76					
			-10.0	-190	54					
MDGT	11JUN97	812	1.0	25	269					
			0.0	37	281					
			-1.0	-140	104	5.59	0.660	0.110	398.0	245.5 (1 cm)
			-2.0	-226	18					
			-3.0	-204	40					
			-4.0	-184	60					
			-5.0	-170	74					
			-6.0	-161	83					
			-7.0	-173	71					
			-8.0	-177	67					
			-9.0	-187	57					
			-10.0	-199	45					

TABLE B-3.1. BACK RIVER AND PATAPSCO RIVER EVALUATION - 1977

SEDIMENT PROFILES: Vertical sediment profiles of Eh and surficial sediment characteristics at Back River and Patapsco River stations

FILENAME : SPPBJN97
REVISED : 20NOV97

STATION	DATE	TIME	CORE DEPTH (cm)	Eh MEAS (mV)	Eh CORR (mV)	SURFICIAL SEDIMENT PARTICULATES: SED PC %(wt)	SED PN %(wt)	SED PP %(wt)	SED CHLa TOTAL (mg/m2)	SED CHLa ACTIVE (mg/m2)
WCPT	11JUN97	1413	1.0	38	282					
			0.0	42	286					
			-1.0	-151	93	5.05	0.580	0.260	371.3	243.3 (1 cm)
			-2.0	-228	16					
			-3.0	-236	8					
			-4.0	-221	23					
			-5.0	-215	29					
			-6.0	-197	47					
			-7.0	-188	56					
			-8.0	-174	70					
			-9.0	-168	76					
			-10.0	-167	77					

TABLE B-3.1. BACK RIVER AND PATAPSCO RIVER EVALUATION - 1977
SEDIMENT PROFILES: Vertical sediment profiles of Eh and surficial sediment characteristics at Back River and Patapsco River stations

FILENAME : SPPBJN97
REVISED : 20NOV97

STATION	DATE	TIME	CORE DEPTH (cm)	Eh MEAS (mV)	Eh CORR (mV)	SURFICIAL SEDIMENT PARTICULATES SED PC %(wt)	SED PN %(wt)	SED PP %(wt)	SED CHLa TOTAL (mg/m2)	SED CHLa ACTIVE (mg/m2)
FFOF	10JUN97	1054	1.0	74	318					
			0.0	-95	149					
			-1.0	-153	91	4.84	0.520	0.170	183.1	89.7 (1 cm)
			-2.0	-247	-3					
			-3.0	-300	-56					
			-4.0	-223	21					
			-5.0	-273	-29					
			-6.0	-301	-57					
			-7.0	-356	-112					
			-8.0	-427	-183					
			-9.0	-395	-151					
			-10.0	-407	-163					
HMCK	10JUN97	1413	1.0	36	280					
			0.0	-154	90					
			-1.0	-272	-28	11.20	0.620	0.270	199.9	112.1 (1 cm)
			-2.0	-275	-31					
			-3.0	-288	-44					
			-4.0	-253	-9					
			-5.0	-443	-199					
			-6.0	-428	-184					
			-7.0	-476	-232					
			-8.0	-487	-243					
			-9.0	-496	-252					
			-10.0	-497	-253					

TABLE B-3.2. BACK RIVER AND PATAPSCO RIVER EVALUATION - 1997

SEDIMENT PROFILES: Vertical sediment profiles of Eh and surficial sediment characteristics at Back River and Patpasco River stations

FILENAME : SPPBJL97

REVISED : 28NOV97

						SURFICIAL SEDIMENT PARTICULATES				
STATION	DATE	TIME	CORE DEPTH (cm)	Eh MEAS (mV)	Eh CORR (mV)	SED PC %(wt)	SED PN %(wt)	SED PP %(wt)	SED CHLa TOTAL (mg/m2)	SED CHLa ACTIVE (mg/m2)
DPCK	16JUL97	810	1.0	84	328					
			0.0	75	319					
			-1.0	-214	30	6.04	0.650	0.360	219.7	96.4 (1 cm)
			-2.0	-197	47					
			-3.0	-193	51					
			-4.0	-168	76					
			-5.0	-162	82					
			-6.0	-137	107					
			-7.0	-110	134					
			-8.0	-124	120					
			-9.0	-24	220					
			-10.0	-11	233					
MDGT	16JUL97	952	1.0	73	317					
			0.0	55	299					
			-1.0	-34	210	5.30	0.600	0.300	249.7	144.7 (1 cm)
			-2.0	-135	109					
			-3.0	-111	133					
			-4.0	-154	90					
			-5.0	-34	210					
			-6.0	-63	181					
			-7.0	-126	118					
			-8.0	-20	224					
			-9.0	-82	162					
			-10.0	-10	234					

TABLE B-3.2. BACK RIVER AND PATAPSCO RIVER EVALUATION - 1997
SEDIMENT PROFILES: Vertical sediment profiles of Eh and surficial sediment characteristics at Back River and Patpasco River stations

FILENAME : SPPBJL97
REVISED : 28NOV97

STATION	DATE	TIME	CORE DEPTH (cm)	Eh MEAS (mV)	Eh CORR (mV)	SURFICIAL SEDIMENT PARTICULATES: SED PC %(wt)	SED PN %(wt)	SED PP %(wt)	SED CHLa TOTAL (mg/m2)	SED CHLa ACTIVE (mg/m2)
WCPT	16JUL97	1527	1.0	81	325					
			0.0	75	319					
			-1.0	46	290	4.99	0.580	0.340	233.0	122.2 (1 cm)
			-2.0	-12	232					
			-3.0	-163	81					
			-4.0	-168	76					
			-5.0	-143	101					
			-6.0	-128	116					
			-7.0	-151	93					
			-8.0	-102	142					
			-9.0	-114	130					
			-10.0	-95	149					

TABLE B-3.2. BACK RIVER AND PATAPSCO RIVER EVALUATION - 1997
SEDIMENT PROFILES: Vertical sediment profiles of Eh and surficial sediment characteristics at Back River and Patpasco River stations

FILENAME : SPPBJL97
REVISED : 28NOV97

STATION	DATE	TIME	CORE DEPTH (cm)	Eh MEAS (mV)	Eh CORR (mV)	SURFICIAL SEDIMENT PARTICULATES SED PC %(wt)	SED PN %(wt)	SED PP %(wt)	SED CHLa TOTAL (mg/m2)	SED CHLa ACTIVE (mg/m2)
FFOF	15JUL97	1417	1.0	77	321					
			0.0	70	314					
			-1.0	-186	58	4.63	0.460	0.160	146.0	59.4 (1 cm)
			-2.0	-129	115					
			-3.0	-159	85					
			-4.0	-143	101					
			-5.0	-198	46					
			-6.0	-249	-5					
			-7.0	-261	-17					
			-8.0	-271	-27					
			-9.0	-299	-55					
			-10.0	-299	-55					
HMCK	15JUL97	1215	1.0	82	326					
			0.0	13	257					
			-1.0	-258	-14	8.54	0.520	0.220	168.4	76.3 (1 cm)
			-2.0	-281	-37					
			-3.0	-274	-30					
			-4.0	-253	-9					
			-5.0	-326	-82					
			-6.0	-433	-189					
			-7.0	-414	-170					
			-8.0	-433	-189					
			-9.0	-467	-223					
			-10.0	-496	-252					

TABLE B-3.3. BACK RIVER AND PATPSCO RIVER EVALUATION -1997

SEDIMENT PROFILES: Vertical sediment profiles of Eh and surficial sediment characteristics at Back River and Patapsco River stations

FILENAME : SPPBAG97

REVISED : 20NOV97

STATION	DATE	TIME	CORE DEPTH (cm)	Eh MEAS (mV)	Eh CORR (mV)	SURFICIAL SEDIMENT PARTICULATES: SED PC %(wt)	SED PN %(wt)	SED PP %(wt)	SED CHLa TOTAL (mg/m2)	SED CHLa ACTIVE (mg/m2)
DPCK	13AUG97	800	1.0	84	328					
			0.0	81	325					
			-1.0	13	257	6.55	0.750	0.429	260.9	155.9 (1 cm)
			-2.0	-11	233					
			-3.0	-153	91					
			-4.0	-166	78					
			-5.0	-156	88					
			-6.0	-188	56					
			-7.0	-57	187					
			-8.0	-113	131					
			-9.0	-93	151					
			-10.0	-36	208					
MDGT	13AUG97	952	1.0	64	308					
			0.0	52	296					
			-1.0	-10	234	5.46	0.620	0.275	225.1	137.1 (1 cm)
			-2.0	-82	162					
			-3.0	-38	206					
			-4.0	-133	111					
			-5.0	-29	215					
			-6.0	-47	197					
			-7.0	-17	227					
			-8.0	-120	124					
			-9.0	-55	189					
			-10.0	-60	184					

TABLE B-3.3. BACK RIVER AND PATPSCO RIVER EVALUATION -1997
SEDIMENT PROFILES: Vertical sediment profiles of Eh and surficial sediment characteristics at Back River and Patapsco River stations

FILENAME : SPPBAG97
REVISED : 20NOV97

STATION	DATE	TIME	CORE DEPTH (cm)	Eh MEAS (mV)	Eh CORR (mV)	SURFICIAL SEDIMENT PARTICULATES SED PC %(wt)	SED PN %(wt)	SED PP %(wt)	SED CHLa TOTAL (mg/m2)	SED CHLa ACTIVE (mg/m2)
WCPT	13AUG97	1352	1.0	70	314					
			0.0	75	319					
			-1.0	43	287	4.89	0.520	0.273	290.9	172.7 (1 cm)
			-2.0	-7	237					
			-3.0	-20	224					
			-4.0	-108	136					
			-5.0	-136	108					
			-6.0	-65	179					
			-7.0	-113	131					
			-8.0	-83	161					
			-9.0	HH	HH					
			-10.0	-79	165					

TABLE B-3.3. BACK RIVER AND PATPSCO RIVER EVALUATION -1997

SEDIMENT PROFILES: Vertical sediment profiles of Eh and surficial sediment characteristics at Back River and Patapsco River stations

FILENAME : SPPBAG97

REVISED : 20NOV97

STATION	DATE	TIME	CORE DEPTH (cm)	Eh MEAS (mV)	Eh CORR (mV)	SURFICIAL SEDIMENT PARTICULATES: SED PC %(wt)	SED PN %(wt)	SED PP %(wt)	SED CHLa TOTAL (mg/m2)	SED CHLa ACTIVE (mg/m2)
FFOF	12AUG97	1024	1.0	113	357					
			0.0	-66	178					
			-1.0	-213	31	4.24	0.410	0.163	171.9	89.7 (1 cm)
			-2.0	-193	51					
			-3.0	-159	85					
			-4.0	-166	78					
			-5.0	-76	168					
			-6.0	-77	167					
			-7.0	-132	112					
			-8.0	-256	-12					
			-9.0	-313	-69					
			-10.0	-292	-48					
HMCK	12AUG97	855	1.0	125	369					
			0.0	-181	63					
			-1.0	-260	-16	9.28	0.540	0.258	143.9	66.2 (1 cm)
			-2.0	-263	-19					
			-3.0	-249	-5					
			-4.0	-270	-26					
			-5.0	-411	-167					
			-6.0	-456	-212					
			-7.0	-471	-227					
			-8.0	-475	-231					
			-9.0	-482	-238					
			-10.0	-515	-271					

BACK RIVER AND PATAPSCO RIVER EVALUATION DATA SET:

Page No.

TABLE B-4.1. BACK RIVER AND PATAPSCO RIVER EVALUATION -1997
CORE DATA: Dissolved nutrient and oxygen concentrations in Back River and Patapsco River sediment-water flux chambers

FILENAME : CDPBJN97
REVISED : 15MAY98

STATION	DATE	CORE NO	TIME OF SAMPLE (hr min)	TIME DELTA (min)	TIME SUM (min)	DO (mg/l)	AA VIAL NO	NH4 (uM)	NO2 (uM)	NO2+NO3 (uM)	DIP (uM)	SI(OH)4 (uM)	BOTTLE NO	TCO2 (uM)
DPCK	11JUN97	B	13 55	0	0	16.86	61	0.8	9.57	75.80	0.07	9.4	B28	754
			14 55	60	60	TF	69	0.7	9.56	76.30	0.30	9.3	HH	HH
			15 55	60	120	15.88	74	0.7	9.56	75.10	0.08	8.6	HH	HH
			16 55	60	180	15.17	78	0.8	9.60	75.40	0.07	8.0	HH	HH
			17 55	60	240	14.72	90	4.8	9.57	75.30	0.12	9.0	HH	HH
		1	13 55	0	0	16.49	62	2.6	9.44	74.80	0.11	10.6	B29	757
			14 55	60	60	14.21	70	6.1	9.66	74.00	0.15	15.6	HH	HH
			15 55	60	120	12.94	75	7.4	9.64	72.10	0.15	19.8	B35	844
			16 55	60	180	12.12	79	9.6	9.83	70.60	0.15	22.4	HH	HH
			17 55	60	240	11.38	91	12.9	9.83	68.50	0.18	30.1	B42	926
		2	13 55	0	0	15.70	63	2.8	9.51	73.70	0.21	8.8	B30	792
			14 55	60	60	13.81	71	5.3	9.79	73.40	0.32	10.9	HH	HH
			15 55	60	120	12.76	76	7.7	10.00	70.90	0.27	12.1	B36	877
			16 55	60	180	11.94	80	9.7	10.34	70.40	0.35	14.1	HH	HH
			17 55	60	240	11.20	92	12.6	10.68	69.30	0.40	15.2	B43	944
		3	13 55	0	0	15.63	64	2.6	9.63	74.80	0.18	8.8	B31	788
			14 55	60	60	13.36	72	4.7	9.85	73.70	0.20	11.4	HH	HH
			15 55	60	120	12.22	77	7.4	10.18	72.30	0.27	12.4	B37	866
			16 55	60	180	11.43	81	9.3	10.44	71.60	0.30	13.9	HH	HH
			17 55	60	240	10.75	93	11.2	10.80	70.00	0.35	15.7	B44	938

TABLE B-4.1. BACK RIVER AND PATAPSCO RIVER EVALUATION -1997

CORE DATA: Dissolved nutrient and oxygen concentrations in Back River and Patapsco River sediment-water flux chambers

FILENAME : CDPBJN97

REVISED : 15MAY98

STATION	DATE	CORE NO	TIME OF SAMPLE (hr	min)	TIME DELTA (min)	TIME SUM (min)	DO (mg/l)	AA VIAL NO	NH4 (uM)	NO2 (uM)	NO2+NO3 (uM)	DIP (uM)	SI(OH)4 (uM)	BOTTLE NO	TCO2 (uM)
MDGT	11JUN97	8	9	55	0	0	16.70	44	0.5	8.27	53.50	0.11	5.6	B21	751
			10	55	60	60	15.71	48	0.4	8.14	53.30	0.10	5.9	HH	HH
			11	55	60	120	15.08	52	1.0	8.22	52.60	0.08	5.5	HH	HH
			12	55	60	180	14.77	57	0.6	8.04	53.30	0.10	6.7	HH	HH
			13	55	60	240	14.28	65	0.5	8.18	53.40	0.14	5.7	HH	HH
		1	9	55	0	0	16.59	45	1.0	7.99	51.60	0.30	6.7	B22	748
			10	55	60	60	14.68	49	1.8	8.16	51.20	0.42	7.8	HH	HH
			11	55	60	120	13.63	53	3.7	8.19	50.80	0.60	9.5	B25	823
			12	55	60	180	12.98	58	4.3	8.54	50.30	0.76	12.1	HH	HH
			13	55	60	240	12.29	66	5.6	8.80	50.80	0.88	13.7	B32	888
		2	9	55	0	0	16.51	46	1.2	7.92	50.60	0.47	6.9	B23	747
			10	55	60	60	14.60	50	2.7	8.13	50.80	0.64	8.7	HH	HH
			11	55	60	120	13.66	54	4.4	8.32	50.20	0.78	9.7	B26	827
			12	55	60	180	13.03	59	6.6	8.64	49.90	0.89	11.1	HH	HH
			13	55	60	240	12.17	67	7.9	8.88	50.20	1.07	12.6	B33	888
		3	9	55	0	0	16.63	47	0.9	8.04	49.30	0.32	7.1	B24	747
			10	55	60	60	14.77	51	1.4	8.17	50.50	0.45	8.7	HH	HH
			11	55	60	120	13.78	55	3.2	8.47	50.90	0.56	10.4	B27	821
			12	55	60	180	12.98	60	4.0	8.61	50.40	0.67	12.4	HH	HH
			13	55	60	240	12.19	68	5.2	8.95	50.60	0.83	12.8	B34	886

TABLE B-4.1. BACK RIVER AND PATAPSCO RIVER EVALUATION -1997
CORE DATA: Dissolved nutrient and oxygen concentrations in Back River and Patapsco River sediment-water flux chambers

FILENAME : CDPBJN97
REVISED : 15MAY98

STATION	DATE	CORE NO	TIME OF SAMPLE (hr min)		TIME DELTA (min)	TIME SUM (min)	DO (mg/l)	AA VIAL NO	NH4 (uM)	NO2 (uM)	NO2+NO3 (uM)	DIP (uM)	SI(OH)4 (uM)	BOTTLE NO	TCO2 (uM)
WCPT	11JUN97	B	15	45	0	0	15.41	82	0.9	0.32	0.58	0.43	5.4	B38	703
			16	45	60	60	14.46	86	R	R	0.67	0.54	6.6	HH	HH
			17	45	60	120	14.04	94	0.4	0.21	0.87	0.42	5.5	HH	HH
			18	45	60	180	13.68	98	0.7	0.18	0.33	0.39	6.5	HH	HH
			19	45	60	240	13.43	102	R	R	0.64	0.66	6.1	HH	HH
		1	15	45	0	0	15.22	83	1.0	0.41	0.87	0.56	6.8	B39	705
			16	45	60	60	13.21	87	2.8	0.64	1.33	0.69	10.2	HH	HH
			17	45	60	120	12.10	95	4.3	0.91	2.01	0.85	12.6	B45	807
			18	45	60	180	11.33	99	6.5	1.16	2.48	0.94	14.3	HH	HH
			19	45	60	240	10.65	103	7.3	1.35	3.14	1.10	16.5	B48	891
		2	15	45	0	0	14.01	84	1.7	0.64	1.46	0.70	6.6	B40	752
			16	45	60	60	12.46	88	4.5	0.96	1.96	0.90	8.8	HH	HH
			17	45	60	120	11.60	96	7.0	1.22	3.04	1.31	10.3	B46	845
			18	45	60	180	10.90	100	8.9	1.40	3.14	1.47	12.5	HH	HH
			19	45	60	240	10.29	104	11.1	1.61	3.65	1.69	14.5	B49	929
		3	15	45	0	0	15.21	85	0.6	0.47	1.02	0.64	6.2	B41	718
			16	45	60	60	13.64	89	2.3	0.79	1.78	0.85	9.2	HH	HH
			17	45	60	120	12.56	97	3.2	1.02	2.44	1.10	11.3	B47	805
			18	45	60	180	11.69	101	3.9	1.14	3.00	1.32	13.6	HH	HH
			19	45	60	240	10.86	105	5.8	1.39	3.58	1.63	14.9	B50	883

TABLE B-4.1. BACK RIVER AND PATAPSCO RIVER EVALUATION -1997
CORE DATA: Dissolved nutrient and oxygen concentrations in Back River and Patapsco River sediment-water flux chambers

FILENAME : CDPBJN97
REVISED : 15MAY98

STATION	DATE	CORE NO	TIME OF SAMPLE (hr min)	TIME DELTA (min)	TIME SUM (min)	DO (mg/l)	AA VIAL NO	NH4 (uM)	NO2 (uM)	NO2+NO3 (uM)	DIP (uM)	SI(OH)4 (uM)	BOTTLE NO	TCO2 (uM)
FFOF	10JUN97	B	12 55	0	0	6.31	2	15.0	0.96	24.10	0.07	23.9	B1	1186
			13 55	60	60	6.20	6	14.7	0.97	23.70	0.08	24.1	HH	HH
			14 55	60	120	6.15	10	15.3	1.11	23.90	0.07	24.2	HH	HH
			15 55	60	180	6.13	15	14.5	1.05	23.50	0.06	24.1	HH	HH
			16 55	60	240	6.10	23	7.5	0.94	17.30	0.08	30.6	HH	HH
		1	12 55	0	0	5.98	3	16.7	0.96	23.00	0.15	28.0	B2	1207
			13 55	60	60	5.28	7	19.2	1.13	21.80	0.22	29.4	HH	HH
			14 55	60	120	4.71	11	20.2	0.99	22.20	0.28	33.6	B5	1248
			15 55	60	180	4.30	16	20.9	1.11	20.80	0.31	34.4	HH	HH
			16 55	60	240	3.86	24	11.7	1.25	16.50	0.13	32.3	B12	1286
		2	12 55	0	0	5.49	4	17.3	1.01	23.00	0.36	25.9	B3	1220
			13 55	60	60	4.70	8	19.7	0.99	21.60	0.41	24.0	HH	HH
			14 55	60	120	4.03	12	22.0	1.19	20.30	0.46	29.6	B6	1259
			15 55	60	180	3.55	17	21.1	1.00	19.60	0.54	29.8	HH	HH
			16 55	60	240	3.02	25	12.8	1.14	16.30	0.15	32.7	B13	1283
		3	12 55	0	0	5.85	5	17.5	0.96	23.40	0.22	25.8	B4	1202
			13 55	60	60	5.20	9	16.4	1.56	21.80	0.28	26.0	HH	HH
			14 55	60	120	4.61	13	16.7	1.02	21.00	0.38	29.6	B7	1239
			15 55	60	180	4.17	18	22.0	1.02	19.90	0.46	30.3	HH	HH
			16 55	60	240	3.71	26	11.9	0.87	16.10	0.11	33.6	B14	1266

TABLE B-4.1. BACK RIVER AND PATAPSCO RIVER EVALUATION -1997
CORE DATA: Dissolved nutrient and oxygen concentrations in Back River and Patapsco River sediment-water flux chambers

FILENAME : CDPBJN97
REVISED : 15MAY98

STATION	DATE	CORE NO	TIME OF SAMPLE (hr	min)	TIME DELTA (min)	TIME SUM (min)	DO (mg/l)	AA VIAL NO	NH4 (uM)	NO2 (uM)	NO2+NO3 (uM)	DIP (uM)	SI(OH)4 (uM)	BOTTLE NO	TCO2 (uM)
HMCK	10JUN97	B	16	10	0	0	7.25	19	9.8	0.96	16.20	0.10	30.0	B8	1205
			17	10	60	60	7.14	27	15.5	0.93	23.80	0.09	24.3	HH	HH
			18	10	60	120	7.07	31	8.1	1.01	16.30	0.08	28.7	HH	HH
			19	10	60	180	7.01	35	7.6	0.97	16.10	0.14	28.1	HH	HH
			20	10	60	240	6.90	39	11.9	1.00	13.70	0.14	28.9	HH	HH
		1	16	10	0	0	6.87	20	9.9	0.88	16.70	0.15	29.6	B9	1214
			17	10	60	60	6.04	28	22.6	1.07	19.80	0.37	38.1	HH	HH
			18	10	60	120	5.41	32	12.7	0.72	14.70	0.14	34.8	B15	1267
			19	10	60	180	4.87	36	13.6	0.99	14.20	0.26	34.9	HH	HH
			20	10	60	240	4.36	40	14.2	0.57	11.10	0.23	38.1	B18	1303
		2	16	10	0	0	6.47	21	9.5	0.89	17.40	0.26	30.1	B10	1217
			17	10	60	60	5.80	29	24.4	1.02	18.20	0.63	33.9	HH	HH
			18	10	60	120	5.24	33	13.9	0.87	14.70	0.20	33.7	B16	1262
			19	10	60	180	4.77	37	15.4	0.86	14.60	0.25	36.5	HH	HH
			20	10	60	240	4.31	41	16.1	1.09	13.80	0.22	37.9	B19	1295
		3	16	10	0	0	6.61	22	9.7	0.89	16.40	0.12	30.8	B11	1221
			17	10	60	60	5.80	30	24.9	1.08	19.10	0.59	33.2	HH	HH
			18	10	60	120	5.16	34	13.2	0.88	14.50	0.14	35.2	B17	1261
			19	10	60	180	4.66	38	17.1	0.88	14.00	0.18	38.2	HH	HH
			20	10	60	240	4.12	42	16.9	0.93	14.30	0.26	39.0	B20	1295

TABLE B-4.2. BACK RIVER AND PATAPSCO RIVER EVALUATION - 1997
CORE DATA: Dissolved nutrient and oxygen concentrations in Back River and Patapsco River sediment-water flux chambers

FILENAME : CDPBJL97
REVISED : 15MAY98

STATION	DATE	CORE NO	TIME OF SAMPLE (hr min)		TIME DELTA (min)	TIME SUM (min)	DO (mg/l)	AA VIAL NO	NH4 (uM)	NO2 (uM)	NO2+NO3 (uM)	DIP (uM)	SI(OH)4 (uM)	BOTTLE NO	TCO2 (uM)
DPCK	16JUL97	B	10	20	0	0	11.98	44	0.2	4.20	15.80	4.44	151.0	B21	924
			11	20	60	60	11.03	49	0.2	4.19	16.10	4.37	152.4	HH	HH
			12	20	60	120	10.49	53	0.2	4.19	15.80	4.28	147.7	HH	HH
			13	20	60	180	10.18	65	0.2	4.21	15.90	4.26	154.6	HH	HH
			14	22	62	242	9.85	69	0.2	4.17	15.70	4.50	151.0	HH	HH
		1	10	20	0	0	10.50	45	5.7	4.24	17.60	4.78	150.0	B22	1005
			11	20	60	60	8.62	50	13.7	4.30	17.00	4.92	162.9	HH	HH
			12	20	60	120	7.41	54	20.0	4.33	16.40	5.12	166.6	B29	1124
			13	20	60	180	6.66	66	26.1	4.44	15.90	5.17	170.8	HH	HH
			14	22	62	242	5.56	70	31.2	4.51	15.40	5.52	176.5	R25	1225
		2	10	20	0	0	10.25	46	4.3	4.23	16.80	5.10	154.3	B23	979
			11	20	60	60	8.68	51	9.0	4.29	16.50	5.27	157.2	HH	HH
			12	20	60	120	7.70	55	14.8	4.40	16.20	5.34	160.4	B30	1064
			13	20	60	180	6.79	67	19.8	4.51	15.70	5.92	163.2	HH	HH
			14	22	62	242	5.92	71	24.7	4.62	15.20	6.32	163.7	R26	1141
		3	10	20	0	0	11.35	47	6.4	4.19	16.50	4.79	155.5	B24	951
			11	20	60	60	9.62	52	12.2	4.33	15.60	4.78	151.1	HH	HH
			12	20	60	120	8.54	56	16.8	4.53	16.00	4.79	157.5	B31	1033
			13	20	60	180	7.58	68	21.9	4.74	15.80	4.98	160.3	HH	HH
			14	22	62	242	6.66	72	26.0	4.95	15.70	5.22	165.9	R27	1104

TABLE B-4.2. BACK RIVER AND PATAPSCO RIVER EVALUATION - 1997
CORE DATA: Dissolved nutrient and oxygen concentrations in Back River and Patapsco River sediment-water flux chambers

FILENAME : CDPBJL97
REVISED : 15MAY98

STATION	DATE	CORE NO	TIME OF SAMPLE (hr	min)	TIME DELTA (min)	TIME SUM (min)	DO (mg/l)	AA VIAL NO	NH4 (uM)	NO2 (uM)	NO2+NO3 (uM)	DIP (uM)	SI(OH)4 (uM)	BOTTLE NO	TCO2 (uM)
MDGT	16JUL97	B	12	15	0	0	14.01	57	0.6	0.13	0.40	7.00	137.8	B25	730
			13	15	60	60	12.95	61	0.9	0.21	0.15	6.53	140.5	HH	HH
			14	15	60	120	12.15	73	0.8	0.14	0.31	6.30	132.3	HH	HH
			15	15	60	180	11.60	77	0.4	0.13	0.14	6.70	141.9	HH	HH
			16	15	60	240	11.05	82	0.4	0.13	0.20	6.27	139.9	HH	HH
		1	12	15	0	0	10.97	58	0.4	0.14	0.07	7.13	141.6	B26	795
			13	15	60	60	9.46	62	0.6	0.20	0.15	7.58	141.2	HH	HH
			14	15	60	120	8.35	74	0.9	0.30	0.24	7.12	139.2	R31	860
			15	15	60	180	7.51	78	1.9	0.33	0.28	7.70	146.6	HH	HH
			16	15	60	240	6.68	83	4.0	0.42	0.42	8.50	146.8	B32	931
		2	12	15	0	0	10.28	59	0.6	0.14	0.18	6.83	142.5	B27	786
			13	15	60	60	8.54	63	0.6	0.28	0.71	7.48	143.7	HH	HH
			14	15	60	120	7.37	75	1.2	0.51	0.29	7.40	136.2	R32	881
			15	15	60	180	6.58	79	2.4	0.38	0.32	7.40	145.8	HH	HH
			16	15	60	240	5.78	84	4.8	0.43	0.48	7.84	150.3	B33	956
		3	12	15	0	0	11.58	60	1.0	0.17	0.09	7.21	139.4	B28	751
			13	15	60	60	9.52	64	0.6	0.20	0.10	7.54	142.9	HH	HH
			14	15	60	120	8.18	76	0.6	0.23	0.18	7.51	143.1	R33	851
			15	15	60	180	7.30	80	1.4	0.28	0.29	8.40	148.1	HH	HH
			16	15	60	240	6.29	85	4.2	0.39	0.50	9.23	150.6	B34	942

TABLE B-4.2. BACK RIVER AND PATAPSCO RIVER EVALUATION - 1997
CORE DATA: Dissolved nutrient and oxygen concentrations in Back River and Patapsco River sediment-water flux chambers

FILENAME : CDPBJL97
REVISED : 15MAY98

STATION	DATE	CORE NO	TIME OF SAMPLE (hr	min)	TIME DELTA (min)	TIME SUM (min)	DO (mg/l)	AA VIAL NO	NH4 (uM)	NO2 (uM)	NO2+NO3 (uM)	DIP (uM)	SI(OH)4 (uM)	BOTTLE NO	TCO2 (uM)
WCPT	16JUL97	B	16	30	0	0	12.35	86	0.2	0.10	0.15	6.98	130.4	B35	676
			17	30	60	60	11.55	90	0.2	0.09	0.13	6.80	129.7	HH	HH
			18	30	60	120	11.04	94	0.2	0.09	0.31	6.86	132.8	HH	HH
			19	30	60	180	10.72	98	0.2	0.18	0.23	6.93	132.2	HH	HH
			20	30	60	240	10.45	102	0.2	0.09	1.10	7.13	130.8	HH	HH
		1	16	30	0	0	12.19	87	0.2	0.20	0.27	6.78	132.0	B36	703
			17	30	60	60	9.90	91	0.2	0.21	0.31	6.78	134.3	HH	HH
			18	30	60	120	8.63	95	2.7	0.31	0.42	7.95	140.5	B39	822
			19	30	60	180	7.58	99	7.2	0.43	0.96	7.71	142.9	HH	HH
			20	30	60	240	6.47	103	10.4	0.50	0.70	9.56	143.9	B42	938
		2	16	30	0	0	11.14	88	1.3	0.20	0.31	7.30	131.7	B37	735
			17	30	60	60	9.22	92	1.5	0.26	0.36	7.46	137.5	HH	HH
			18	30	60	120	8.04	96	5.6	0.42	0.53	7.97	142.5	B40	838
			19	30	60	180	7.09	100	9.0	0.51	0.74	8.67	145.2	HH	HH
			20	30	60	240	6.01	104	14.5	0.89	1.24	10.08	148.1	B43	958
		3	16	30	0	0	11.52	89	3.2	0.16	0.50	7.59	132.5	B38	735
			17	30	60	60	9.42	93	7.4	0.32	0.41	7.36	139.9	HH	HH
			18	30	60	120	7.88	97	13.9	0.50	0.69	7.99	142.0	B41	888
			19	30	60	180	6.60	101	19.6	0.66	1.05	8.70	146.3	HH	HH
			20	30	60	240	5.44	105	24.9	0.81	1.22	9.84	147.6	B44	1015

TABLE B-4.2. BACK RIVER AND PATAPSCO RIVER EVALUATION - 1997
CORE DATA: Dissolved nutrient and oxygen concentrations in Back River and Patapsco River sediment-water flux chambers

FILENAME : CDPBJL97
REVISED : 15MAY98

STATION	DATE	CORE NO	TIME OF SAMPLE (hr	min)	TIME DELTA (min)	TIME SUM (min)	DO (mg/l)	AA VIAL NO	NH4 (uM)	NO2 (uM)	NO2+NO3 (uM)	DIP (uM)	SI(OH)4 (uM)	BOTTLE NO	TCO2 (uM)
FFOF	15JUL97	B	16	5	0	0	4.30	15	33.5	1.31	11.90	0.47	29.4	B8	1383
			17	5	60	60	4.65	23	34.9	1.45	11.90	0.52	30.6	HH	HH
			18	5	60	120	4.52	31	34.1	1.32	11.70	0.42	32.1	HH	HH
			19	5	60	180	4.45	35	34.1	1.27	8.46	0.37	29.5	HH	HH
			20	5	60	240	4.44	39	34.5	1.29	12.80	0.58	29.2	HH	HH
		1	16	5	0	0	3.66	16	38.9	1.35	12.40	0.72	36.8	B9	1433
			17	5	60	60	3.02	24	41.9	1.30	11.80	0.80	41.8	HH	HH
			18	5	60	120	2.46	32	44.3	1.26	11.40	1.06	42.7	B15	1497
			19	5	60	180	2.01	36	47.6	1.33	10.60	1.17	43.4	HH	HH
			20	5	60	240	1.54	40	52.5	1.25	10.20	1.54	46.7	B18	1557
		2	16	5	0	0	3.71	17	40.4	1.40	13.20	0.76	33.5	B10	1446
			17	5	60	60	2.92	25	45.5	1.51	12.90	1.28	36.4	HH	HH
			18	5	60	120	2.27	33	49.6	1.30	11.40	1.58	39.0	B16	1510
			19	5	60	180	1.93	37	52.1	1.24	10.60	1.82	44.2	HH	HH
			20	5	60	240	1.45	41	55.5	1.18	9.90	2.22	46.4	B19	1575
		3	16	5	0	0	3.84	18	42.8	1.47	13.90	0.90	33.2	B11	1454
			17	5	60	60	3.12	26	46.1	1.41	13.30	1.20	35.6	HH	HH
			18	5	60	120	2.49	34	50.5	1.35	12.60	1.85	39.9	B17	1520
			19	5	60	180	2.02	38	57.0	1.34	11.30	2.10	42.2	HH	HH
			20	5	60	240	1.54	42	57.5	1.22	10.70	2.72	45.0	B20	1588

TABLE B-4.2. BACK RIVER AND PATAPSCO RIVER EVALUATION - 1997
CORE DATA: Dissolved nutrient and oxygen concentrations in Back River and Patapsco River sediment-water flux chambers

FILENAME : CDPBJL97
REVISED : 15MAY98

STATION	DATE	CORE NO	TIME OF SAMPLE (hr min)		TIME DELTA (min)	TIME SUM (min)	DO (mg/l)	AA VIAL NO	NH4 (uM)	NO2 (uM)	NO2+NO3 (uM)	DIP (uM)	SI(OH)4 (uM)	BOTTLE NO	TCO2 (uM)
HMCK	15JUL97	B	13	55	0	0	6.56	2	5.6	0.57	6.06	0.14	33.3	B1	900
			14	55	60	60	6.29	7	5.3	0.57	5.86	0.12	33.7	HH	HH
			15	55	60	120	6.24	11	5.4	0.52	6.07	0.10	34.0	HH	HH
			16	55	60	180	6.14	19	9.9	0.60	6.41	0.18	36.3	HH	HH
			17	55	60	240	6.09	27	5.6	0.54	5.83	0.13	31.9	HH	HH
		1	13	55	0	0	5.89	3	9.8	0.52	6.15	0.14	34.9	B2	941
			14	55	60	60	4.95	8	13.8	0.53	5.57	0.16	38.1	HH	HH
			15	55	60	120	4.29	12	18.7	0.55	5.35	0.18	41.1	B5	1026
			16	55	60	180	3.77	20	23.2	0.66	5.44	0.24	41.0	HH	HH
			17	55	60	240	3.27	28	25.5	0.61	5.03	0.36	44.1	B12	1092
		2	13	55	0	0	5.88	4	10.0	0.52	5.82	0.16	36.3	B3	947
			14	55	60	60	4.96	9	14.6	0.54	5.52	0.16	38.9	HH	HH
			15	55	60	120	4.35	13	20.3	0.54	5.53	0.21	42.0	B6	1053
			16	55	60	180	3.87	21	24.3	0.56	5.33	0.23	47.9	HH	HH
			17	55	60	240	3.40	29	29.0	0.73	5.41	0.32	46.1	B13	1127
		3	13	55	0	0	5.98	5	9.8	0.58	5.81	0.19	36.6	B4	949
			14	55	60	60	5.01	10	14.0	0.56	5.70	0.17	39.4	HH	HH
			15	55	60	120	4.32	14	18.6	0.56	5.63	0.21	41.8	B7	1033
			16	55	60	180	3.79	22	21.6	0.58	5.68	0.24	43.6	HH	HH
			17	55	60	240	3.24	30	24.4	0.90	5.16	0.27	45.1	B14	1096

TABLE B-4.3. BACK RIVER AND PATAPSCO RIVER EVALUATION - 1997
CORE DATA: Dissolved nutrient and oxygen concentrations in BAck River and Patapsco River sediment-water flux chambers

FILENAME : CDPBAG97
REVISED : 15MAY98

STATION	DATE	CORE NO	TIME OF SAMPLE (hr	min)	TIME DELTA (min)	TIME SUM (min)	DO (mg/l)	AA VIAL NO	NH4 (uM)	NO2 (uM)	NO2+NO3 (uM)	DIP (uM)	SI(OH)4 (uM)	BOTTLE NO	TCO2 (uM)
DPCK	13AUG97	B	9	35	0	0	11.25	85	3.8	5.92	85.50	1.85	88.8	B21	814
			10	35	60	60	10.47	89	4.4	6.09	83.60	1.74	91.2	HH	HH
			11	35	60	120	10.11	97	5.0	6.19	98.40	1.82	91.2	HH	HH
			12	35	60	180	9.90	105	5.7	6.01	86.80	1.86	90.1	HH	HH
			13	35	60	240	9.70	113	6.2	6.02	87.50	1.83	91.2	HH	HH
		1	9	35	0	0	10.97	86	6.4	6.48	89.20	1.79	89.4	B22	837
			10	35	60	60	9.46	90	11.8	6.77	86.50	1.99	92.3	HH	HH
			11	35	60	120	8.57	98	18.7	7.18	85.50	2.30	93.0	B29	922
			12	35	60	180	7.90	106	22.9	7.42	83.60	2.47	97.0	HH	HH
			13	35	60	240	7.26	114	27.2	8.00	80.90	2.91	97.8	B35	944
		2	9	35	0	0	10.79	87	5.5	6.52	87.50	1.62	90.4	B23	829
			10	35	60	60	9.51	91	10.7	6.87	81.70	1.63	89.6	HH	HH
			11	35	60	120	8.57	99	16.2	6.94	84.10	1.94	93.6	B30	918
			12	35	60	180	7.84	107	21.6	7.77	82.10	2.14	93.3	HH	HH
			13	35	60	240	7.15	115	26.3	8.25	80.70	2.19	98.8	B36	784
		3	9	35	0	0	11.23	88	3.7	6.40	85.20	1.91	90.8	B24	817
			10	35	60	60	9.69	92	9.1	6.70	84.30	2.04	92.6	HH	HH
			11	35	60	120	8.65	100	15.1	7.12	82.20	2.21	96.0	B31	903
			12	35	60	180	7.84	108	19.0	7.48	79.70	2.44	97.4	HH	HH
			13	35	60	240	7.09	116	25.1	7.81	74.30	2.78	100.6	B37	988

TABLE B-4.3. BACK RIVER AND PATAPSCO RIVER EVALUATION - 1997
CORE DATA: Dissolved nutrient and oxygen concentrations in BAck River and Patapsco River sediment-water flux chambers

FILENAME : CDPBAG97
REVISED : 15MAY98

STATION	DATE	CORE NO	TIME OF SAMPLE (hr min)		TIME DELTA (min)	TIME SUM (min)	DO (mg/l)	AA VIAL NO	NH4 (uM)	NO2 (uM)	NO2+NO3 (uM)	DIP (uM)	SI(OH)4 (uM)	BOTTLE NO	TCO2 (uM)
MDGT	13AUG97	B	10	40	0	0	9.05	93	3.7	0.48	1.99	3.17	103.7	B25	653
			11	40	60	60	8.68	101	4.2	0.46	1.80	3.05	102.9	HH	HH
			12	40	60	120	8.50	109	3.8	0.45	1.96	2.89	102.2	HH	HH
			13	40	60	180	8.32	117	5.1	0.58	1.94	2.96	102.2	HH	HH
			14	40	60	240	8.24	122	5.2	0.44	2.41	3.01	102.3	HH	HH
		1	10	40	0	0	9.02	94	6.1	0.54	2.14	3.20	104.7	B26	671
			11	40	60	60	7.88	102	12.2	0.59	2.35	3.23	109.6	HH	HH
			12	40	60	120	6.97	110	17.2	0.58	2.26	3.06	108.3	B32	744
			13	40	60	180	6.15	118	23.1	0.73	2.06	3.22	109.5	HH	HH
			14	40	60	240	5.38	123	29.7	0.78	2.16	3.55	109.5	B38	817
		2	10	40	0	0	9.99	95	5.8	0.57	2.10	3.33	105.2	B27	701
			11	40	60	60	8.68	103	11.2	0.53	2.23	3.14	107.4	HH	HH
			12	40	60	120	7.64	111	16.0	0.65	2.22	2.93	107.8	B33	768
			13	40	60	180	6.65	119	20.8	0.65	2.11	3.09	109.6	HH	HH
			14	40	60	240	5.84	124	27.4	0.68	2.17	3.42	112.4	B39	808
		3	10	40	0	0	9.21	96	6.8	0.69	2.08	3.18	106.4	B28	661
			11	40	60	60	7.96	104	13.2	0.58	2.17	3.03	108.2	HH	HH
			12	40	60	120	7.04	112	21.2	0.80	2.12	2.95	110.2	B34	747
			13	40	60	180	6.22	120	23.5	0.69	2.29	2.77	110.4	HH	HH
			14	40	60	240	5.47	125	31.7	0.88	2.38	3.02	115.7	B40	812

TABLE B-4.3. BACK RIVER AND PATAPSCO RIVER EVALUATION - 1997
CORE DATA: Dissolved nutrient and oxygen concentrations in BAck River and Patapsco River sediment-water flux chambers

FILENAME : CDPBAG97
REVISED : 15MAY98

STATION	DATE	CORE NO	TIME OF SAMPLE (hr	min)	TIME DELTA (min)	TIME SUM (min)	DO (mg/l)	AA VIAL NO	NH4 (uM)	NO2 (uM)	NO2+NO3 (uM)	DIP (uM)	SI(OH)4 (uM)	BOTTLE NO	TCO2 (uM)
WCPT	13AUG97	B	15	25	0	0	9.09	126	0.3	0.10	1.17	2.36	93.8	B41	584
			16	25	60	60	8.67	130	0.9	0.15	0.22	2.32	92.2	HH	HH
			17	25	60	120	8.55	134	0.8	0.23	0.24	2.29	92.7	HH	HH
			18	25	60	180	8.41	138	0.4	0.18	0.27	2.32	94.5	HH	HH
			19	25	60	240	8.27	142	0.8	0.12	0.13	2.36	93.5	HH	HH
		1	15	25	0	0	8.46	127	2.8	0.13	0.78	2.43	97.5	B42	617
			16	25	60	60	7.44	131	7.8	0.33	0.30	2.32	98.9	HH	HH
			17	25	60	120	6.70	135	10.9	0.47	0.35	2.57	99.3	B45	689
			18	25	60	180	6.14	139	14.6	0.30	1.05	2.77	103.5	HH	HH
			19	25	60	240	5.56	143	18.5	0.53	1.10	3.36	102.4	B48	746
		2	15	25	0	0	8.15	128	4.0	0.14	0.22	2.52	85.5	B43	626
			16	25	60	60	7.10	132	9.0	0.20	1.06	2.59	100.8	HH	HH
			17	25	60	120	6.25	136	13.3	0.30	0.38	2.39	101.9	B46	717
			18	25	60	180	5.72	140	19.1	0.31	0.46	3.03	104.4	HH	HH
			19	25	60	240	5.19	144	20.8	0.35	1.11	3.17	103.8	B49	782
		3	15	25	0	0	8.75	129	3.2	0.17	0.25	2.63	98.2	B44	603
			16	25	60	60	7.58	133	5.9	0.40	0.22	2.64	97.8	HH	HH
			17	25	60	120	6.86	137	9.3	0.53	0.50	2.83	98.1	B47	673
			18	25	60	180	6.29	141	14.2	0.34	0.38	3.01	103.8	HH	HH
			19	25	60	240	5.73	145	14.5	1.11	0.43	3.68	102.9	B50	722

TABLE B-4.3. BACK RIVER AND PATAPSCO RIVER EVALUATION - 1997
CORE DATA: Dissolved nutrient and oxygen concentrations in BAck River and Patapsco River sediment-water flux chambers

FILENAME : CDPBAG97
REVISED : 15MAY98

STATION	DATE	CORE NO	TIME OF SAMPLE (hr	min)	TIME DELTA (min)	TIME SUM (min)	DO (mg/l)	AA VIAL NO	NH4 (uM)	NO2 (uM)	NO2+NO3 (uM)	DIP (uM)	SI(OH)4 (uM)	BOTTLE NO	TCO2 (uM)
FFOF	12AUG97	B	12	10	0	0	5.60	36	15.3	1.06	10.40	0.24	37.6	B5	1134
			13	10	60	60	5.52	44	15.3	1.20	9.37	0.24	37.0	HH	HH
			14	10	60	120	5.50	52	15.6	1.37	10.00	0.23	38.6	HH	HH
			15	10	60	180	5.48	60	14.3	1.02	10.10	0.23	38.1	HH	HH
			16	10	60	240	5.42	65	14.6	1.04	10.30	0.27	38.6	HH	HH
		1	12	10	0	0	6.12	37	18.1	1.18	10.20	0.35	38.6	B6	1159
			13	10	60	60	5.33	45	20.2	1.00	9.47	0.50	40.6	HH	HH
			14	10	60	120	4.64	53	24.0	1.43	8.83	0.60	43.5	B12	1216
			15	10	60	180	4.12	61	26.1	1.02	8.66	0.76	45.8	HH	HH
			16	10	60	240	3.55	66	29.3	0.98	8.28	0.95	49.2	B18	1291
		2	12	10	0	0	6.93	38	18.4	1.23	10.10	0.34	38.3	B7	1155
			13	10	60	60	5.89	46	20.0	1.02	9.57	0.36	40.3	HH	HH
			14	10	60	120	5.12	54	24.8	1.16	9.64	0.44	41.3	B13	1227
			15	10	60	180	4.59	62	23.6	1.08	9.69	0.46	42.9	HH	HH
			16	10	60	240	4.05	67	28.9	1.08	8.88	0.49	44.9	B19	1275
		3	12	10	0	0	6.09	39	19.4	1.06	10.10	0.46	40.0	B8	1169
			13	10	60	60	5.44	47	22.2	1.21	9.80	0.60	40.6	HH	HH
			14	10	60	120	4.87	55	24.4	1.00	9.11	0.57	43.9	B14	1236
			15	10	60	180	4.44	63	26.8	1.07	8.81	0.70	45.5	HH	HH
			16	10	60	240	3.98	68	29.0	1.00	8.56	0.78	46.2	B20	1267

TABLE B-4.3. BACK RIVER AND PATAPSCO RIVER EVALUATION - 1997
CORE DATA: Dissolved nutrient and oxygen concentrations in BAck River and Patapsco River sediment-water flux chambers

FILENAME : CDPBAG97
REVISED : 15MAY98

STATION	DATE	CORE NO	TIME OF SAMPLE (hr	min)	TIME DELTA (min)	TIME SUM (min)	DO (mg/l)	AA VIAL NO	NH4 (uM)	NO2 (uM)	NO2+NO3 (uM)	DIP (uM)	SI(OH)4 (uM)	BOTTLE NO	TCO2 (uM)
HMCK	12AUG97	B	10	40	0	0	7.36	28	3.9	0.49	9.01	0.17	39.1	B1	807
			11	40	60	60	7.10	32	3.7	0.40	9.26	0.14	39.4	HH	HH
			12	40	60	120	7.02	40	4.9	0.96	9.13	0.15	38.7	HH	HH
			13	40	60	180	7.00	48	3.9	0.47	9.47	0.20	39.7	HH	HH
			14	40	60	240	6.96	56	4.1	0.54	9.04	0.14	40.9	HH	HH
		1	10	40	0	0	6.79	29	6.5	0.49	8.76	0.18	41.3	B2	842
			11	40	60	60	5.91	33	9.1	0.45	8.40	0.18	42.0	HH	HH
			12	40	60	120	5.28	41	11.9	0.52	8.26	0.23	43.9	B9	906
			13	40	60	180	4.85	49	14.7	0.85	8.36	0.28	44.9	HH	HH
			14	40	60	240	4.42	57	16.3	0.53	7.85	0.18	46.7	B15	956
		2	10	40	0	0	6.97	30	6.7	0.47	8.63	0.14	41.6	B3	842
			11	40	60	60	6.03	34	9.8	0.46	8.46	0.17	42.2	HH	HH
			12	40	60	120	5.39	42	13.7	0.59	8.07	0.20	43.8	B10	917
			13	40	60	180	4.92	50	16.3	0.49	7.82	0.20	46.2	HH	HH
			14	40	60	240	4.45	58	19.6	0.49	7.57	0.27	48.6	B16	989
		3	10	40	0	0	7.11	31	6.4	0.45	8.68	0.12	40.9	B4	841
			11	40	60	60	6.23	35	8.3	0.45	8.43	0.13	42.8	HH	HH
			12	40	60	120	5.65	43	11.1	0.43	8.26	0.17	43.1	B11	909
			13	40	60	180	5.25	51	13.2	0.59	7.97	0.18	40.8	HH	HH
			14	40	60	240	4.84	59	16.2	0.69	7.65	0.14	45.8	B17	955

BACK RIVER AND PATAPSCO RIVER EVALUATION DATA SET:

Page No.

TABLE B-5.1. BACK RIVER AND PATAPSCO RIVER EVALUATION - 1997

SEDIMENT-WATER FLUX: Net sediment-water exchange rates of dissolved oxygen [gO2/(m2.day)] and nutrients [uMN, P, Si and S/(m2.hr)] and total carbon dixide [uMCO2/(m2.hr)]

FILENAME : FLPBJN97
REVISED : 15MAY98

			CORE		DO			NH4		
			H2O				FLUX			FLUX
STATION	DATE	NO	VOL (ml)	DEPTH (m)	SLOPE [mg/(l.min)]	FLUX [gO2/(m2.day)]	MEAN [gO2/(m2.day)]	SLOPE (uMN/min)	FLUX [uMN/(m2.hr)]	MEAN [uMN/(m2.hr)]
DPCK	11JUN97	1	1889	0.136	-0.020517	-2.24	-2.05	0.040167	327.6	322.8
		2	1931	0.139	-0.018117	-1.81		0.040000	333.4	
		3	1960	0.141	-0.019483	-2.11		0.036333	307.4	
MDGT	11JUN97	1	2270	0.163	-0.017167	-1.77	-1.71	0.019500	191.1	207.0
		2	2160	0.155	-0.017083	-1.67		0.028833	268.8	
		3	2001	0.144	-0.017783	-1.69		0.018667	161.2	
WCPT	11JUN97	1	1876	0.135	-0.018367	-2.03	-1.82	0.027167	219.9	240.3
		2	2017	0.145	-0.015000	-1.48		0.038667	336.7	
		3	1902	0.137	-0.017750	-1.94		0.020000	164.2	
FFOF	10JUN97	1	2084	0.150	-0.008700	-1.76	-1.82	0.022667	203.9	196.1
		2	1910	0.137	-0.010150	-1.90		0.022833	188.2	
		3	2090	0.150	-0.008850	-1.80		NI	NI	
HMCK	10JUN97	1	2070	0.149	-0.010317	-1.92	-1.82	0.018286	163.4	238.6
		2	2240	0.161	-0.008917	-1.75		0.028333	274.0	
		3	1960	0.141	-0.010200	-1.79		0.032905	278.4	

TABLE B-5.1. BACK RIVER AND PATAPSCO RIVER EVALUATION - 1997
SEDIMENT-WATER FLUX: Net sediment-water exchange rates of dissolved oxygen [gO2/(m2.day)] and nutrients [uMN, P, Si and S/(m2.hr)] and total carbon dixide [uMCO2/(m2.hr)]

FILENAME : FLPBJN97
REVISED : 15MAY98 Part 2 of 5

		CORE			NO2			NO2 + NO3		
			H2O				FLUX			FLUX
STATION	DATE	NO	VOL	DEPTH	SLOPE	FLUX	MEAN	SLOPE	FLUX	MEAN
			(ml)	(m)	[uMN/(l.min)]	[uMN/(m2.hr)]		[uMN/(l.min)]	[uMN/(m2.hr)]	
DPCK	11JUN97	1	1889	0.136	0.001762	14.37	31.95	-0.026667	-217.49	-182.14
		2	1931	0.139	0.004817	40.15		-0.019667	-163.94	
		3	1960	0.141	0.004883	41.31		-0.019500	-164.98	
MDGT	11JUN97	1	2270	0.163	0.003333	32.66	34.32	-0.007167	-70.23	-56.09
		2	2160	0.155	0.004050	37.76		-0.004500	-41.96	
		3	2001	0.144	0.003767	32.53		NI	NI	
WCPT	11JUN97	1	1876	0.135	0.004000	38.84	38.95	0.009483	76.77	81.40
		2	2017	0.145	0.003967	41.49		0.009267	80.68	
		3	1902	0.137	0.003650	36.52		0.010567	86.76	
FFOF	10JUN97	1	2084	0.150	0.001167	10.50	10.50	-0.026524	-238.59	-232.77
		2	1910	0.137	NI	NI		-0.025667	-211.61	
		3	2090	0.150	NI	NI		-0.027500	-248.09	
HMCK	10JUN97	1	2070	0.149	NI	NI	NI	-0.021286	-190.20	-166.24
		2	2240	0.161	NI	NI		-0.014714	-142.27	
		3	1960	0.141	NI	NI		NI	NI	

TABLE B-5.1. BACK RIVER AND PATAPSCO RIVER EVALUATION - 1997

SEDIMENT-WATER FLUX: Net sediment-water exchange rates of dissolved oxygen [gO2/(m2.day)] and nutrients [uMN, P, Si and S/(m2.hr)] and total carbon dixide [uMCO2/(m2.hr)]

FILENAME : FLPBJN97

REVISED : 15MAY98 Part 3 of 5

STATION	DATE	CORE NO	CORE H2O VOL (ml)	CORE DEPTH (m)	DIP SLOPE [uMP/(l.min)]	DIP FLUX [uMP/(m2.hr)]	DIP FLUX MEAN [uMP/(m2.hr)]	SILICATE SLOPE [uMSi/(l.min)]	SILICATE FLUX [uMSi/(m2.hr)]	SILICATE FLUX MEAN [uMSi/(m2.hr)]
DPCK	11JUN97	1	1889	0.136	0.000271	2.21	5.04	0.078333	638.87	363.67
		2	1931	0.139	0.000805	6.71		0.026667	222.29	
		3	1960	0.141	0.000733	6.20		0.027167	229.84	
MDGT	11JUN97	1	2270	0.163	0.002500	24.50	21.63	0.030500	298.86	243.54
		2	2160	0.155	0.002417	22.54		0.023000	214.45	
		3	2001	0.144	0.002067	17.85		0.025167	217.33	
WCPT	11JUN97	1	1876	0.135	0.002217	17.95	29.49	0.039167	317.09	299.44
		2	2017	0.145	0.004250	37.00		0.032500	282.96	
		3	1902	0.137	0.004083	33.52		0.036330	298.27	
FFOF	10JUN97	1	2084	0.150	0.000900	8.10	9.51	0.039000	350.82	289.44
		2	1910	0.137	0.000983	8.10		0.026476	218.28	
		3	2090	0.150	0.001367	12.33		0.033167	299.22	
HMCK	10JUN97	1	2070	0.149	NI	NI	4.57	0.033429	298.70	297.92
		2	2240	0.161	NI	NI		0.030333	293.29	
		3	1960	0.141	0.000540	4.57		0.035667	301.76	

TABLE B-5.1. BACK RIVER AND PATAPSCO RIVER EVALUATION - 1997

SEDIMENT-WATER FLUX: Net sediment-water exchange rates of dissolved oxygen [gO2/(m2.day)] and nutrients [uMN, P, Si and S/(m2.hr)] and total carbon dixide [uMCO2/(m2.hr)]

FILENAME : FLPBJN97

REVISED : 15MAY98 Part 4 of 5

STATION	DATE	NO	CORE H2O VOL (ml)	CORE DEPTH (m)	TCO2 SLOPE [uMCO2/(l.min)]	TCO2 FLUX [uMCO2S/(m2.hr)]	TCO2 FLUX MEAN [uMCO2S/(m2.hr)]
DPCK	11JUN97	1	1889	0.136	0.705417	5753	5451
		2	1931	0.139	0.634583	5290	
		3	1960	0.141	0.627500	5309	
MDGT	11JUN97	1	2270	0.163	0.584583	5728	5394
		2	2160	0.155	0.585417	5458	
		3	2001	0.144	0.578333	4994	
WCPT	11JUN97	1	1876	0.135	0.774583	6271	6111
		2	2017	0.145	0.736667	6414	
		3	1902	0.137	0.687917	5648	
FFOF	10JUN97	1	2084	0.150	0.332083	2987	2527
		2	1910	0.137	0.265833	2192	
		3	2090	0.150	0.266250	2402	
HMCK	10JUN97	1	2070	0.149	0.373333	3336	3035
		2	2240	0.161	0.325000	3142	
		3	1960	0.141	0.310417	2626	

TABLE B-5.1. BACK RIVER AND PATAPSCO RIVER EVALUATION - 1997
SEDIMENT-WATER FLUX: Net sediment-water exchange rates of dissolved oxygen [gO2/(m2.day)] and nutrients [uMN, P, Si and S/(m2.hr)] and total carbon dixide [uMCO2/(m2.hr)]

FILENAME : FLPBJN97
REVISED : 15MAY98 Part 5 of 5

STATION	DATE	NO	---- CORE H2O VOL (ml)	---- DEPTH (m)	BLANK DO [mg/(l.min)]	BLANK NH4 ------	BLANK NO2 [uMN/(l.min)]	BLANK NO2+NO3 --------	BLANK DIP [uMP/(l.min)]	BLANK Si(OH)4 [uMSi/(l.min)]
DPCK	11JUN97	1	1889	0.136	-0.009081	0.000000	0.000000	0.000000	0.000000	0.000000
		2	1931	0.139	-0.009081	0.000000	0.000000	0.000000	0.000000	0.000000
		3	1960	0.141	-0.009081	0.000000	0.000000	0.000000	0.000000	0.000000
MDGT	11JUN97	1	2270	0.163	-0.009633	0.000000	0.000000	0.000000	0.000000	0.000000
		2	2160	0.155	-0.009633	0.000000	0.000000	0.000000	0.000000	0.000000
		3	2001	0.144	-0.009633	0.000000	0.000000	0.000000	0.000000	0.000000
WCPT	11JUN97	1	1876	0.135	-0.007900	0.000000	-0.000798	0.000000	0.000000	0.000000
		2	2017	0.145	-0.007900	0.000000	-0.000798	0.000000	0.000000	0.000000
		3	1902	0.137	-0.007900	0.000000	-0.000798	0.000000	0.000000	0.000000
FFOF	10JUN97	1	2084	0.150	-0.000533	0.000000	0.000000	0.000000	0.000000	0.000000
		2	1910	0.137	-0.000533	0.000000	0.000000	0.000000	0.000000	0.000000
		3	2090	0.150	-0.000533	0.000000	0.000000	0.000000	0.000000	0.000000
HMCK	10JUN97	1	2070	0.149	-0.001383	0.000000	0.000000	0.000000	0.000000	0.000000
		2	2240	0.161	-0.001383	0.000000	0.000000	0.000000	0.000000	0.000000
		3	1960	0.141	-0.001383	0.000000	0.000000	0.000000	0.000000	0.000000

TABLE B-5.2. BACK RIVER AND PATAPSCO RIVER EVALUATION - 1997

SEDIMENT-WATER FLUX: Net sediment-water exchange rates of dissolved oxygen [gO2/(m2.day)] and nutrients [uMN, P, Si and S/(m2.hr)] and total carbon dioxide [(uMCO2/(m2.hr)]

FILENAME : FLPBJL97

REVISED : 15MAY98

			CORE		DO			NH4		
			H2O				FLUX			FLUX
STATION	DATE	NO	VOL	DEPTH	SLOPE	FLUX	MEAN	SLOPE	FLUX	MEAN
			(ml)	(m)	[mg/(l.min)]	[gO2/(m2.day)]		(uMN/min)	[uMN/(m2.hr)]	
DPCK	16JUL97	1	1792	0.129	-0.019592	-2.07	-2.17	0.104920	811.6	796.7
		2	2126	0.153	-0.017457	-1.98		0.085419	783.9	
		3	2275	0.164	-0.018896	-2.46		0.080933	794.8	
MDGT	16JUL97	1	2071	0.149	-0.017550	-1.17	-1.46	0.014170	126.7	163.0
		2	2008	0.144	-0.018267	-1.28		0.023000	199.4	
		3	2014	0.145	-0.021333	-1.92		NI	NI	
WCPT	16JUL97	1	1945	0.140	-0.022933	-3.07	-2.99	0.045667	383.4	532.6
		2	1945	0.140	-0.020650	-2.61		0.056500	474.4	
		3	1850	0.133	-0.024967	-3.31		0.092667	740.0	
FFOF	15JUL97	1	2084	0.150	-0.008750	-1.64	-1.75	0.054833	493.2	560.6
		2	1960	0.141	-0.009183	-1.63		0.061333	518.9	
		3	2310	0.166	-0.009500	-1.99		0.067167	669.7	
HMCK	15JUL97	1	1970	0.142	-0.010700	-1.95	-1.96	0.068000	578.2	600.3
		2	2041	0.147	-0.010083	-1.89		0.079500	700.4	
		3	1973	0.142	-0.011167	-2.04		0.061333	522.3	

TABLE B-5.2. BACK RIVER AND PATAPSCO RIVER EVALUATION - 1997
SEDIMENT-WATER FLUX: Net sediment-water exchange rates of dissolved oxygen [gO2/(m2.day)] and nutrients [uMN, P, Si and S/(m2.hr)] and total carbon dioxide [(uMCO2/(m2.hr)]

FILENAME : FLPBJL97
REVISED : 15MAY98 Part 2 of 5

STATION	DATE	CORE NO	CORE H2O VOL (ml)	CORE DEPTH (m)	NO2 SLOPE [uMN/(l.min)]	NO2 FLUX [uMN/(m2.hr)]	NO2 FLUX MEAN [uMN/(m2.hr)]	NO2 + NO3 SLOPE [uMN/(l.min)]	NO2 + NO3 FLUX [uMN/(m2.hr)]	NO2 + NO3 FLUX MEAN [uMN/(m2.hr)]
DPCK	16JUL97	1	1792	0.129	0.001126	8.71	18.46	-0.009103	-70.41	-54.88
		2	2126	0.153	0.001667	15.30		-0.006627	-60.82	
		3	2275	0.164	0.003196	31.39		-0.003402	-33.41	
MDGT	16JUL97	1	2071	0.149	0.001150	10.28	9.21	0.001383	12.36	13.76
		2	2008	0.144	0.001133	9.82		0.001148	9.95	
		3	2014	0.145	0.000867	7.54		0.002183	18.98	
WCPT	16JUL97	1	1945	0.140	0.001367	11.48	16.19	0.001857	15.59	24.38
		2	1945	0.140	0.001817	15.25		0.002433	20.43	
		3	1850	0.133	0.002733	21.82		0.004650	37.13	
FFOF	15JUL97	1	2084	0.150	-0.000400	-3.60	-6.93	-0.009333	-83.96	-116.35
		2	1960	0.141	-0.000914	-7.73		-0.014833	-125.50	
		3	2310	0.166	-0.000950	-9.47		-0.014000	-139.60	
HMCK	15JUL97	1	1970	0.142	0.000386	3.28	1.68	-0.004352	-37.01	-27.19
		2	2041	0.147	0.000200	1.76		-0.002433	-21.43	
		3	1973	0.142	0.000000	0.00		-0.002714	-23.11	

TABLE B-5.2. BACK RIVER AND PATAPSCO RIVER EVALUATION - 1997

SEDIMENT-WATER FLUX: Net sediment-water exchange rates of dissolved oxygen [gO2/(m2.day)] and nutrients [uMN, P, Si and S/(m2.hr)] and total carbon dioxide [(uMCO2/(m2.hr)]

FILENAME : FLPBJL97

REVISED : 15MAY98 Part 3 of 5

		CORE			DIP			SILICATE	
			H2O				FLUX			FLUX
STATION	DATE	NO	VOL (ml)	DEPTH (m)	SLOPE [uMP/(l.min)]	FLUX [uMP/(m2.hr)]	MEAN [uMP/(m2.hr)]	SLOPE [uMSi/(l.min)]	FLUX [uMSi/(m2.hr)]	MEAN [uMSi/(m2.hr)]
DPCK	16JUL97	1	1792	0.129	0.002868	22.18	31.24	0.100770	779.48	640.24
		2	2126	0.153	0.005122	47.00		0.041002	376.27	
		3	2275	0.164	0.002497	24.52		0.077896	764.95	
MDGT	16JUL97	1	2071	0.149	0.004767	42.61	49.17	0.026333	235.41	297.00
		2	2008	0.144	0.003910	33.89		0.029500	255.69	
		3	2014	0.145	0.008167	71.00		0.046000	399.90	
WCPT	16JUL97	1	1945	0.140	0.012471	104.70	110.98	0.054000	453.37	502.40
		2	1945	0.140	0.014267	119.78		0.067500	566.71	
		3	1850	0.133	0.013583	108.47		0.061000	487.12	
FFOF	15JUL97	1	2084	0.150	0.003350	30.13	51.46	0.039619	356.39	444.02
		2	1960	0.141	0.005767	48.79		0.056000	473.78	
		3	2310	0.166	0.007567	75.45		0.050333	501.88	
HMCK	15JUL97	1	1970	0.142	0.000533	4.54	27.54	0.035500	301.88	321.34
		2	2041	0.147	0.008330	73.39		0.041000	361.21	
		3	1973	0.142	0.000550	4.68		0.035333	300.92	

TABLE B-5.2. BACK RIVER AND PATAPSCO RIVER EVALUATION - 1997

SEDIMENT-WATER FLUX: Net sediment-water exchange rates of dissolved oxygen [gO2/(m2.day)] and nutrients [uMN, P, Si and S/(m2.hr)] and total carbon dioxide [(uMCO2/(m2.hr)]

FILENAME : FLPBJL97

REVISED : 15MAY98 Part 4 of 5

STATION	DATE	CORE NO	CORE H2O VOL (ml)	CORE DEPTH (m)	TCO2 SLOPE [uMCO2/(l.min)]	TCO2 FLUX [uMCO2S/(m2.hr)]	TCO2 FLUX MEAN [uMCO2S/(m2.hr)]
DPCK	16JUL97	1	1792	0.129	0.918333	7104	6522
		2	2126	0.153	0.674167	6187	
		3	2275	0.164	0.639167	6277	
MDGT	16JUL97	1	2071	0.149	0.566667	5066	6026
		2	2008	0.144	0.705417	6114	
		3	2014	0.145	0.793333	6897	
WCPT	16JUL97	1	1945	0.140	0.980417	8231	8460
		2	1945	0.140	0.930833	7815	
		3	1850	0.133	1.168750	9333	
FFOF	15JUL97	1	2084	0.150	0.517500	4655	4925
		2	1960	0.141	0.536250	4537	
		3	2310	0.166	0.560000	5584	
HMCK	15JUL97	1	1970	0.142	0.627500	5336	5725
		2	2041	0.147	0.750833	6615	
		3	1973	0.142	0.613333	5223	

TABLE B-5.2. BACK RIVER AND PATAPSCO RIVER EVALUATION - 1997
SEDIMENT-WATER FLUX: Net sediment-water exchange rates of dissolved oxygen [gO2/(m2.day)] and nutrients [uMN, P, Si and S/(m2.hr)] and total carbon dioxide [(uMCO2/(m2.hr)]

FILENAME : FLPBJL97
REVISED : 15MAY98 Part 5 of 5

STATION	DATE	NO	---- CORE H2O VOL (ml)	---- DEPTH (m)	BLANK DO [mg/(l.min)]	BLANK NH4 ------	BLANK NO2 [uMN/(l.min)]	BLANK NO2+NO3 --------	BLANK DIP [uMP/(l.min)]	BLANK Si(OH)4 [uMSi/(l.min)]
DPCK	16JUL97	1	1792	0.129	-0.008451	0.000000	0.000000	0.000000	0.000000	0.000000
		2	2126	0.153	-0.008451	0.000000	0.000000	0.000000	0.000000	0.000000
		3	2275	0.164	-0.008451	0.000000	0.000000	0.000000	0.000000	0.000000
MDGT	16JUL97	1	2071	0.149	-0.012117	0.000000	0.000000	0.000000	0.000000	0.000000
		2	2008	0.144	-0.012117	0.000000	0.000000	0.000000	0.000000	0.000000
		3	2014	0.145	-0.012117	0.000000	0.000000	0.000000	0.000000	0.000000
WCPT	16JUL97	1	1945	0.140	-0.007717	0.000000	0.000000	0.000000	0.000000	0.000000
		2	1945	0.140	-0.007717	0.000000	0.000000	0.000000	0.000000	0.000000
		3	1850	0.133	-0.007717	0.000000	0.000000	0.000000	0.000000	0.000000
FFOF	15JUL97	1	2084	0.150	-0.001167	0.000000	0.000000	0.000000	0.000000	0.000000
		2	1960	0.141	-0.001167	0.000000	0.000000	0.000000	0.000000	0.000000
		3	2310	0.166	-0.001167	0.000000	0.000000	0.000000	0.000000	0.000000
HMCK	15JUL97	1	1970	0.142	-0.001167	0.000000	0.000000	0.000000	0.000000	0.000000
		2	2041	0.147	-0.001167	0.000000	0.000000	0.000000	0.000000	0.000000
		3	1973	0.142	-0.001167	0.000000	0.000000	0.000000	0.000000	0.000000

TABLE B-5.3. BACK RIVER AND PATAPSCO RIVER EVALUATION - 1997
SEDIMENT-WATER FLUX: Net sediment-water exchange rates of dissolved oxygen [gO2/(m2.day)] and nutrients [uMN, P, Si and S/(m2.hr)] and total carbon dioxide [(uMCO2/(m2.hr)]

FILENAME : FLPBAG97
REVISED : 15MAY98

		CORE			DO			NH4		
			H2O				FLUX			FLUX
STATION	DATE	NO	VOL (ml)	DEPTH (m)	SLOPE [mg/(l.min)]	FLUX [gO2/(m2.day)]	MEAN [gO2/(m2.day)]	SLOPE (uMN/min)	FLUX [uMN/(m2.hr)]	MEAN [uMN/(m2.hr)]
DPCK	13AUG97	1	1910	0.137	-0.014967	-2.13	-2.24	0.087833	640.3	636.2
		2	1931	0.139	-0.014917	-2.14		0.087500	644.6	
		3	1860	0.134	-0.016883	-2.44		0.087833	623.6	
MDGT	13AUG97	1	2000	0.144	-0.015017	-2.49	-2.66	0.096833	779.9	760.4
		2	2084	0.150	-0.017217	-3.07		0.088000	733.1	
		3	1900	0.137	-0.015367	-2.43		0.100170	768.2	
WCPT	13AUG97	1	2014	0.145	-0.011833	-2.00	-2.05	0.063667	553.5	541.1
		2	1950	0.140	-0.012167	-2.01		0.072833	613.1	
		3	2055	0.148	-0.012217	-2.13		0.051500	456.8	
FFOF	12AUG97	1	2020	0.145	-0.010583	-2.10	-2.09	0.047167	411.3	394.2
		2	1876	0.135	-0.011767	-2.18		0.045762	370.6	
		3	2340	0.168	-0.008700	-1.98		0.039667	400.7	
HMCK	12AUG97	1	1955	0.141	-0.009667	-1.81	-1.76	0.042000	354.4	371.3
		2	1730	0.124	-0.010250	-1.71		0.053833	402.0	
		3	2028	0.146	-0.009200	-1.78		0.040833	357.5	

TABLE B-5.3. BACK RIVER AND PATAPSCO RIVER EVALUATION - 1997

SEDIMENT-WATER FLUX: Net sediment-water exchange rates of dissolved oxygen [gO2/(m2.day)] and nutrients [uMN, P, Si and S/(m2.hr)] and total carbon dioxide [(uMCO2/(m2.hr)]

FILENAME : FLPBAG97

REVISED : 15MAY98 Part 2 of 5

STATION	DATE	CORE NO	CORE H2O VOL (ml)	CORE DEPTH (m)	NO2 SLOPE [uMN/(l.min)]	NO2 FLUX [uMN/(m2.hr)]	NO2 FLUX MEAN [uMN/(m2.hr)]	NO2 + NO3 SLOPE [uMN/(l.min)]	NO2 + NO3 FLUX [uMN/(m2.hr)]	NO2 + NO3 FLUX MEAN [uMN/(m2.hr)]
DPCK	13AUG97	1	1910	0.137	0.006150	50.70	53.15	-0.032500	-267.95	-286.98
		2	1931	0.139	0.007267	60.57		-0.028762	-239.74	
		3	1860	0.134	0.006000	48.17		-0.044000	-353.27	
MDGT	13AUG97	1	2000	0.144	0.001033	10.27	7.84	0.000000	0.00	3.28
		2	2084	0.150	0.000443	5.40		0.000000	0.00	
		3	1900	0.137	NI	NI		0.001200	9.84	
WCPT	13AUG97	1	2014	0.145	0.001591	13.83	18.53	NI	NI	76.91
		2	1950	0.140	0.000883	7.43		NI	NI	
		3	2055	0.148	0.003871	34.34		0.008670	76.91	
FFOF	12AUG97	1	2020	0.145	NI	NI	NI	-0.007755	-67.62	-58.04
		2	1876	0.135	NI	NI		-0.004691	-37.99	
		3	2340	0.168	NI	NI		-0.006783	-68.51	
HMCK	12AUG97	1	1955	0.141	NI	NI	9.04	-0.003624	-30.58	-33.90
		2	1730	0.124	NI	NI		-0.004600	-34.35	
		3	2028	0.146	0.001033	9.04		-0.004200	-36.77	

TABLE B-5.3. BACK RIVER AND PATAPSCO RIVER EVALUATION - 1997

SEDIMENT-WATER FLUX: Net sediment-water exchange rates of dissolved oxygen [gO2/(m2.day)] and nutrients [uMN, P, Si and S/(m2.hr)] and total carbon dioxide [(uMCO2/(m2.hr)]

FILENAME : FLPBAG97

REVISED : 15MAY98 Part 3 of 5

STATION	DATE	NO	CORE H2O VOL (ml)	DEPTH (m)	DIP SLOPE [uMP/(l.min)]	DIP FLUX [uMP/(m2.hr)]	DIP FLUX MEAN [uMP/(m2.hr)]	SILICATE SLOPE [uMSi/(l.min)]	SILICATE FLUX [uMSi/(m2.hr)]	SILICATE FLUX MEAN [uMSi/(m2.hr)]
DPCK	13AUG97	1	1910	0.137	0.004533	37.38	29.65	0.035833	295.43	314.74
		2	1931	0.139	0.002750	22.92		0.038667	322.30	
		3	1860	0.134	0.003567	28.64		0.040667	326.51	
MDGT	13AUG97	1	2000	0.144	NI	NI	NI	NI	NI	284.76
		2	2084	0.150	NI	NI		0.027667	248.88	
		3	1900	0.137	NI	NI		0.039095	320.64	
WCPT	13AUG97	1	2014	0.145	0.005533	48.10	30.73	0.019857	172.63	166.98
		2	1950	0.140	0.002900	24.41		0.019167	161.33	
		3	2055	0.148	0.002217	19.67		NI	NI	
FFOF	12AUG97	1	2020	0.145	0.002433	21.21	13.02	0.044000	383.65	296.04
		2	1876	0.135	0.000667	5.40		0.026333	213.24	
		3	2340	0.168	0.001233	12.45		0.028833	291.23	
HMCK	12AUG97	1	1955	0.141	0.000583	2.24	1.46	0.022833	137.83	141.88
		2	1730	0.124	0.000543	1.69		0.030000	175.49	
		3	2028	0.146	0.000367	0.44		0.019330	112.31	

TABLE B-5.3. BACK RIVER AND PATAPSCO RIVER EVALUATION - 1997
SEDIMENT-WATER FLUX: Net sediment-water exchange rates of dissolved oxygen [gO2/(m2.day)] and nutrients [uMN, P, Si and S/(m2.hr)] and total carbon dioxide [(uMCO2/(m2.hr)]

FILENAME : FLPBAG97
REVISED : 15MAY98 Part 4 of 5

		---- CORE ----			------------ TCO2 ------------		
			H2O				FLUX
STATION	DATE	NO	VOL	DEPTH	SLOPE	FLUX	MEAN
			(ml)	(m)	[uMCO2/(l.min)]	[uMCO2S/(m2.hr)]	
DPCK	13AUG97	1	1910	0.137	0.657500	5421	5508
		2	1931	0.139	0.648333	5404	
		3	1860	0.134	0.710000	5700	
MDGT	13AUG97	1	2000	0.144	0.605417	5227	4800
		2	2084	0.150	0.445833	4011	
		3	1900	0.137	0.629583	5163	
WCPT	13AUG97	1	2014	0.145	0.537083	4669	4858
		2	1950	0.140	0.651250	5482	
		3	2055	0.148	0.498750	4424	
FFOF	12AUG97	1	2020	0.145	0.549167	4788	4319
		2	1876	0.135	0.501667	4062	
		3	2340	0.168	0.406667	4108	
HMCK	12AUG97	1	1955	0.141	0.473333	3994	4230
		2	1730	0.124	0.609583	4552	
		3	2028	0.146	0.473333	4144	

TABLE B-5.3. BACK RIVER AND PATAPSCO RIVER EVALUATION - 1997

SEDIMENT-WATER FLUX: Net sediment-water exchange rates of dissolved oxygen [gO2/(m2.day)] and nutrients [uMN, P, Si and S/(m2.hr)] and total carbon dioxide [(uMCO2/(m2.hr)]

FILENAME : FLPBAG97

REVISED : 15MAY98 Part 5 of 5

STATION	DATE	NO	CORE H2O VOL (ml)	DEPTH (m)	BLANK DO [mg/(l.min)]	BLANK NH4	BLANK NO2 [uMN/(l.min)]	BLANK NO2+NO3	BLANK DIP [uMP/(l.min)]	BLANK Si(OH)4 [uMSi/(l.min)]
DPCK	13AUG97	1	1910	0.137	-0.004200	0.010167	0.000000	0.000000	0.000000	0.000000
		2	1931	0.139	-0.004200	0.010167	0.000000	0.000000	0.000000	0.000000
		3	1860	0.134	-0.004200	0.010167	0.000000	0.000000	0.000000	0.000000
MDGT	13AUG97	1	2000	0.144	-0.003000	0.006500	-0.000157	0.000000	0.000000	0.000000
		2	2084	0.150	-0.003000	0.006500	-0.000157	0.000000	0.000000	0.000000
		3	1900	0.137	-0.003000	0.006500	-0.000157	0.000000	0.000000	0.000000
WCPT	13AUG97	1	2014	0.145	-0.002233	0.000000	0.000000	0.000000	0.000000	0.000000
		2	1950	0.140	-0.002233	0.000000	0.000000	0.000000	0.000000	0.000000
		3	2055	0.148	-0.002233	0.000000	0.000000	0.000000	0.000000	0.000000
FFOF	12AUG97	1	2020	0.145	-0.000533	0.000000	0.000000	0.000000	0.000000	0.000000
		2	1876	0.135	-0.000533	0.000000	0.000000	0.000000	0.000000	0.000000
		3	2340	0.168	-0.000533	0.000000	0.000000	0.000000	0.000000	0.000000
HMCK	12AUG97	1	1955	0.141	-0.000733	0.000000	0.000000	0.000000	0.000317	0.006500
		2	1730	0.124	-0.000733	0.000000	0.000000	0.000000	0.000317	0.006500
		3	2028	0.146	-0.000733	0.000000	0.000000	0.000000	0.000317	0.006500

Metal Fluxes from Sediments in the Back and Patapsco River Estuaries

Final Report

Prepared at the Request of:

Whitman Requardt and Associates, Inc.
2315 St. Paul St.
Baltimore, MD 21218

for

The Baltimore City Department of Public Works
Project 613
Water Master Facilities Plan

January 1999

Prepared By:

Jeffrey C. Cornwell
Michael Owens
Horn Point Laboratory

and

Robert Mason
Chesapeake Biological Laboratory

University of Maryland Center for Environmental Science

SUMMARY

The sediment-water exchanges of transition metals, arsenic (As), selenium (Se), methylmercury (MMHg) and total Hg were determined from Back River and Baltimore Harbor sediments. Box cores were collected on September 8, 1997 from three sites in Back River, a site adjacent to Sparrows Point, and Fairfield Outfall. Cores were incubated for up to 159 hours to determine the flux of metals. Cores were kept oxygenated during the incubations.

At two sites, we observed moderate to high rates of sediment metabolism (as determined by inorganic carbon flux) and no discernable net flux of dissolved organic carbon. At Fairfield Outfall, net fluxes of manganese (Mn), copper (Cu), nickel (Ni), zinc (Zn) and As were measured, indicating that sediment metals are a source of water column trace metals. Copper fluxes out of sediments were observed at all sites, Ni fluxes were observed at 4 sites, Mn fluxes were observed at 3 sites, Zn fluxes were observed at 1 site, and low fluxes of As to the water column were found in 4 sites.

Time course incubations suggest that rapid increases in metal concentrations in the water column occur on the order of less than 3 days. We observed a plateau in the concentration of many metals after approximately 3 days, indicating that longer time courses were unnecessary. Overall, these results are the first comprehensive examination of sediment-water trace metal exchange in urban harbor setting.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

INTRODUCTION

Recent evidence suggests that there has been a substantial reduction in direct inputs of contaminants to Baltimore Harbor and the Chesapeake Bay (Chesapeake Bay Program's Toxics Subcommittee, 1994). However, the sediments of the harbor contain a significant inventory of pollutants and thus the rate of return of previously-deposited trace metals to the water column represents a potentially important source of contaminants to the harbor. The "permanent" burial of sediment and associated contaminants are thus key elements to developing contaminant and sediment budgets for Baltimore Harbor, a research priority identified in the CBEEC 1997 RFP and in the Toxics Regional Action Plan (TRSW/MDE 1996, p. 7-32). Particle-bound contaminants can be released to sediment pore water or overlying water by such processes as resuspension, redox-driven changes in sediment adsorptive properties, remineralization of organic-bound metals, biological reworking of sediment deposits, and diffusion.

Despite the fact that the contamination of Baltimore Harbor and Back River with organics and trace metals has been recognized for several decades, there have been relatively few detailed studies of contaminants in the Harbor. Trace metals in the harbor tend to be very elevated, with previous studies suggesting that the Harbor is an efficient metal trap, with little export to the mainstem of the bay (Sinex and Helz 1982; Helz and Huggett 1987). The 1970s era data showed that the highest concentrations of some trace metals occurred at depths of 1 m or greater in the sediments. Since these earlier studies of the harbor, most trace element data has been obtained not with a goal of understanding metal cycling within the harbor, but more with a view of how high metal (and organic) levels were in dredged sediment. The latter interest was largely because of the potential environmental impact of dredged sediment disposal. Consequently, much of the more recent contaminant data has been from the dredged channels, a small subset of the 88 km^2 area of the harbor.

New information generated in the last year (Baker et al. 1997) has shown that there is a very high range in metals concentration in Baltimore Harbor and Back River. There are strong local sources of contaminants, and grain size is not the only determinant of trace metal concentration (Trefry and Presley, 1976; Daskalakis and O'Conner, 1995). We have also observed a broad range of AVS (acid volatile sulfide, primarily iron monosulfide, Cornwell and Morse 1987) and total sulfur concentrations, with some total sulfur concentrations approaching 4%. At many sites, the AVS-based toxicity model of DiToro et al. (1990; 1992) would suggest that sequestration of metals such as Cd and Ni as sulfides would result in a toxicity lower than generally predicted from the metal concentrations. Solid-phase speciation data are not available, but previous studies in other systems suggest that incorporation of metals into pyrite would also be likely in this sulfur-rich environment (Huerta-Diaz and Morse 1992); pyrite is the dominant iron sulfide phase in most Chesapeake Bay sediments (Cornwell and Sampou 1995). Apparent high rates of sulfide generation in these sediments are consistent with their high organic carbon (C) concentrations (in silts and clays) and C:N ratios at least crudely suggest that phytoplankton, not terrestrial organic matter, drive sediment metabolism.

The recycling of trace metals from sediment back to the water column may have two primary mechanisms: sediment resuspension and solute flux. Sediment resuspension and its effects on contaminant cycling were a major focus of early CBEEC work in the mainstem of the Chesapeake Bay, and in the southern Chesapeake, it was shown that resuspension mediated by macrofauna was an important transport mechanism for some contaminants (Greer and Terlizzi, 1997). In the Baltimore Harbor area, sediment resuspension does not appear to be a major feature of the system (L. Sanford, pers. comm.), with the possible exception of some sediment transport resulting from physical disturbances from commercial shipping.

The ambient dissolved flux of trace metals into or out of sediments has been measured in relatively few locations (mostly uncontaminated), with most studies showing relatively low rates of overall flux. Incubations lasted from days to many weeks to reliably measure concentration changes (i.e. Westerlund et al. 1986; Sundby et al. 1986). The only published Chesapeake Bay metal flux work is a series of experiments by Riedel et al. (1987; 1989) on As release from Patuxent River sediments; by far the largest fluxes were found at high macrofauna densities. Sediment core incubations or *in-situ* chamber fluxes have been used extensively in the Chesapeake (and many other aquatic systems) for measuring sediment-water exchange of oxygen and nutrients (Boynton and Kemp 1995; Cowan and Boynton 1996). The overlying water in such incubations are generally stirred, but in general, water flow over the sediment does not completely mimic the range of flows found in tidal systems. Boynton et al. (1981) noted that stirring speed had an effect on sediment oxygen demand, but in some devices such effects are minimal (i.e. Booij et al. 1994). Artifacts are most problematic in sandy sediments where lateral pressure gradients result in advective motion of water through sediments (Huettel and Gust 1992). Santschi et al. (1990) examined problems with changing physics and noted that lack of realistic simulation of the diffusive sub-layer, or benthic boundary layer (generally 1-4 mm thick) can result in poor estimation of fluxes. Other approaches such as using pore water gradients to calculate fluxes have their own problems; pore water fluxes assume molecular diffusion (not the case in sediments with methane or macrofauna) or suffer from a lack of resolution at the sediment-water interface where adsorption, desorption, and remineralization may be maximal. We have measured fluxes in Chesapeake mesohaline sediments and found that 1) fluxes are very low, 2) pore water metal gradients are very low, and 3) core to core variability was high (Cornwell and Owens, unpublished). There were well-defined Mn fluxes as expected from Mn accumulation in the water column (Gavis and Grant 1986), but Cu, Zn, Ni, and Co concentrations in overlying and pore water were generally less than 1 ppb (Zn was a little higher). To our knowledge, transition metal flux measurements have not been carried out in heavily contaminated sediments such as those found in Baltimore Harbor.

This study provides data from 5 sites in Baltimore Harbor and Back River analyzed for trace metal fluxes in late summer 1997. The purpose of this study is to determine whether sediments are a potentially important source of metals to the water column. The scope of the work is narrow, with a single time of analysis and minimal time courses for the flux measurements. Thus, these data are best suited to determining whether there are large fluxes of metals from the sediments; more detailed studies, currently funded by Sea Grant, will address the controls of such fluxes.

METHODS

Sample Collection

Sediment cores were collected from 5 sites on September 18, 1997. We used a Soutar-designed acrylic/PVC box corer which was deployed from a fiberglass boat. Undisturbed cores were readily obtained from the soft sediments at these sites. We used differential GPS to locate stations, with sites in Back River (Witch Coat, Deep Creek, Muddy Gut) and Baltimore Harbor (Sparrows Point and Fair Field Outfall). Cores were transported to the Horn Point Laboratory and placed in a temperature-controlled environmental chamber for incubation. Incubation times were 12, 87 and 159 hours after sediment collection. Samples for transition metals were filtered, acidified and stored at room temperature until analysis; samples for Hg species and other metals were frozen.

Table 1. Station Locations.

Station	Latitude N	Longitude W
Back River-Witch Coat	39°15.760	76°26.643
Back River-Deep Creek	39°17.173	76°27.723
Back River-Muddy Gut	39°16.257	76°26.520
Sparrows Point	39°13.945	76°29.788
Fair Field Outfall	39°14.029	76°33.256

For most analytes, we did an initial and final time point for trace metal analysis (as per our contract). For several analyses, we also added a number of intermediate time analyses to provide an idea of the linearity of metal flux. To provide a sense of overall rates of sediment metabolism and the possible increase in ligand concentrations, we measured dissolved inorganic (DIC) and organic C (DOC) for the Sparrows Point and Muddy Gut sites. We used a high precision coulometric analyzer (Johnson et al. 1985) and high temperature DOC analyzer for the analysis of these species.

Analytical Procedures

Low level Hg speciation was determined using cold vapor atomic fluorescence spectroscopy (CVAFS). Total Hg is determined after oxidation of samples with bromine monochloride, pre-reduction with hydroxylamine hydrochloride to remove excess halide reactive species followed by tin chloride reduction and purging onto gold traps. Thermal desorption released the trapped Hg to the CVAFS for quantification (Bloom and Crecelius, 1983; Bloom and Fitzgerald, 1988). The estimated method detection limit (MDL; 3 standard deviations of the blank over a month period) is approximately 0.15 nanograms per liter (ng/L) for water samples of 100 mL or greater. Given the low volumes of sample available in this instance (10 mL), the detection limit was higher, around 2 ng/L. However, blank values (i.e. water at time zero) for the system used in the experiments were substantially higher (10-20 ng/L), possibly reflecting the actual water concentrations at these sites (see below) or because of contamination by the core tube materials. Inorganic Hg (IHg) was be determined as the difference between total Hg and methyl-Hg(MMHg). Methylmercury was determined after acidic chloride distillation to liberate the MMHg from the matrix (Horvat et al. 1993). The distillates were analyzed using aqueous phase ethylation, trapping on Carbotrap, isothermal GC separation and CVAFS detection (Bloom 1989).

Dissolved Mn, Cu, Ni and Zn were determined on a Dionex chelation ion chromatogaph (IC); we have successfully used this instrument for transition metal analysis at the 0.1 ppb level in estuarine waters (Owens, unpublished data). At the levels that occur in Baltimore Harbor, we did not detect Cd or Pb with this technique. Similarly, graphite furnace AAS analysis showed no analytically-detectable concentrations of Ag and only a few detectable measurements of Cr.

Arsenic and Se were determined by hydride generation atomic fluorescence using an automated PSA Excalibur Analyzer. The metalloids are converted to the respective hydrides with sodium borohydride under acidic conditions. The hydrides are purged from the sparger into the flame of the detection system. Low detection limits, typically less than 0.5 ppb are attained with the use of boosted cathode discharge lamps. This method is an automated version of the typical metalloid methodology - see, for example, Aurilio et al., 1994.

We used a high precision coulometric DIC analyzer (Johnson et al. 1985) and high temperature DOC analyzer (Shimadzu 2500) for the analysis of these species.

The calculation of sediment-water exchange fluxes generally involves the regression of the concentration of the analyte versus time. With knowledge of the sediment area and overlying water volume, a mass flux rate on an areal basis may be estimated. For most analytes, we used an initial and final analysis; the main exceptions were the three time-point time courses used for the chelation IC analyses

RESULTS

Analytical Reproducibility

Our chemical analyses generally appeared to be of the highest quality, with transition metals showing excellent reproducibility (Table 2). Total and methyl Hg analyses were similarly well behaved. Selenium and arsenic samples were all run in duplicate, with an average standard deviation of 0.11 and 0.12 $\mu g\ L^{-1}$ respectively. Both Pb and Cd were not detected by our chelation ion chromatograph; Cr was detected infrequently and Ag was not detectable by graphite furnace AAS.

Table 2. Replicates for selected transition metal analyses. Concentrations are ppb or µg L^{-1}. The T=0, T=1 and T=F represent initial, middle and final time points of the incubation.

ID	Fe	Cu	Ni	Zn	Mn
Fairfield Core 3 T=1	11.9 12.8	4.15 4.22	8.5 9.2	67.2 66.8	277 278
Fairfield Blank T=1	27.9 31.6	2.65 2.09	12.3 11.8	26.6 24.4	7.0 8.3
Deep Creek Core 1 T=0	27.9 31.6	2.75 2.60	12.6 13.5	11.5 12.2	650 679
Deep Creek Core 1 T=F	18.5 16.8	3.01 3.01	19.3 19.3	29.8 30.9	2254 2153
Muddy Gut Core 3 T=0	8.6 7.0	2.36 2.28	15.3 15.3	28.3 28.1	679 665

Trace Metal Concentrations in Bottom Water

The trace metal concentrations in bottom water were generally quite low (Table 3), with the highest Cu, Mn, Ni concentrations in Back River and the highest Zn and Fe concentrations at Sparrows Point. The higher Ni concentrations in Back River are consistent with the high sediment Ni concentrations observed there (Baker et al. 1997). Similarly, the high dissolved Zn concentrations in the Sparrows Point and Bear Creek area are reflected in high sediment Zn concentrations. The average concentration of Hg in blanks was 22.3 ng L^{-1} and 0.26 ng L^{-1} for total and methyl-Hg respectively. While there are no recent published water column data for comparison at the collection sites, concentrations of total Hg at sites within Baltimore harbor are typically less than 10 ng L^{-1} for surface waters although higher concentrations were found in the near bottom waters of the inner harbor during sample collection in July 1987 (Mason et al., in press). For methyl-Hg, typical surface water concentrations in Baltimore Harbor were

Table 3. Initial blank values. Concentrations are ppb or µg L^{-1}.

ID	Fe	Cu	Ni	Zn	Mn	As	Se
Fairfield Outfall	5.2	2.23	6.2	19.4	14.2	0.53	0.83
Back River	6.9	3.34	10.8	21.5	109		
Sparrows Point	8.1	2.01	5.0	44.8	22.5	0.58	0.32

0.25 ng L^{-1} or less, with values as high as 1.5 ng L^{-1} in bottom waters during the July 1997 sampling. Thus, the background values found in this study are potentially elevated for total Hg due to contamination via sampling equipment, but a significant flux from the sediment would have been discernible if it had occurred. For methyl-Hg, the blank values are as would be expected for these waters.

Carbon Flux Rates

We examined two sites for dissolved inorganic carbon (DIC) fluxes in order to provide some contemporaneous data on rates of sediment metabolism. Two cores were incubated from Sparrows Point and three from Muddy Gut. There appeared to be some curvature in the DIC time courses, indicating that the fluxes were run an excessively long time. The average values of DIC flux were 634±237 and 1705 ± 603 µmol m^{-2} h^{-1} for Sparrows Point and Muddy Gut respectively. The higher rates in the Back River (Muddy Gut) are consistent with higher nutrient inputs in that system. The metabolic rates at Sparrows Point seem excessively low, perhaps indicating an inhibition of metabolism by the high concentrations of trace metals and anthropogenic organic inputs observed there (Baker et al. 1997). The strong spatial heterogeneity in DIC flux is somewhat surprising, but given the large changes in DIC flux during the experiment, probably not a result of experimental artifacts.

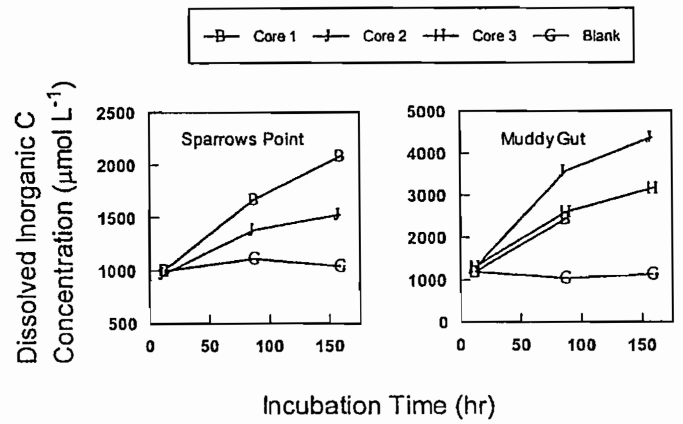


Figure 1. Dissolved inorganic carbon concentrations during fluxes.

We carried out DOC fluxes in these cores to better understand the potential role of ligand flux on the chemistry of trace metals at these sites. The are relatively few published rates of DOC fluxes from sediments, with DOC fluxes studied by Burdige et al. (1994) in the mid and lower Chesapeake area and by Owens and Cornwell (1995) in the tidal Delaware River. The concentrations of DOC were generally high relative to those found in the main stem of the Chesapeake Bay (Fisher et al. in press).

The DOC time courses were not particularly instructive, with modest increases at Sparrows Point and no definite increase (or decrease) at Muddy Gut in the Back River. A high DOC value for Sparrows Point core 1 and the initial Muddy Gut blank core make quantification difficult. These data do not support or refute the possibility that metal-organic complexes may be important in controlling sediment metal fluxes. Because DOC is a complex mixture of organic compounds, small changes in important metal-binding ligands may not be reflected by this relatively general carbon pool.

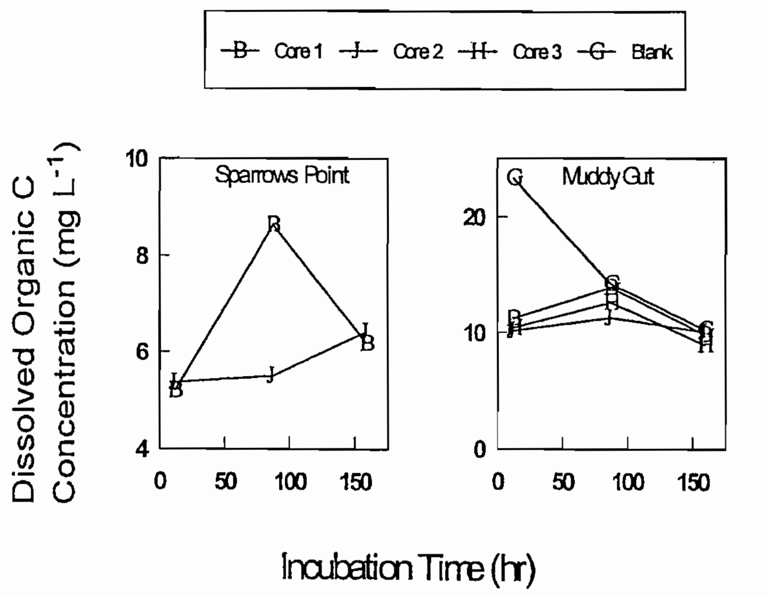


Figure 2. Dissolved organic carbon concentrations during fluxes.

Metal Time Courses

We added a number of intermediate time point transition metal analyses to provide more time courses than originally proposed in this program. At Fairfield Outfall, iron concentrations changed over the course of the incubation (Figure 3), but there was no steady pattern of concentration increase or decrease. Given the rapid oxidation of Fe(II), such variability is not suprising. The blank cores showed no changes in the concentration of Fe.

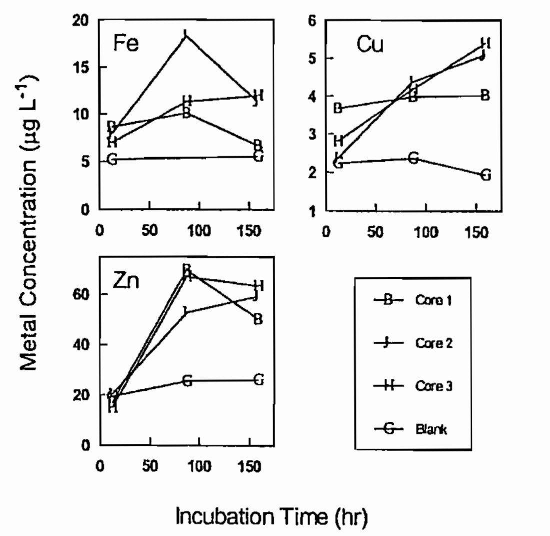


Figure 3. Iron, copper and zinc time courses at Fairfield Outfall.

In contrast, substantial increases in the concentrations of Cu were observed at Fairfield Outfall (Figure 3). The Cu blank had a small amount a variability, but did not increase. Of the three cores, core 1 started out with a higher Cu concentration than the other two, and it had a smaller concentration increase. The other two cores started out at 2-3 ppb (µg L^{-1}) and increased to ~ 5 ppb. The apparent linear increase in Cu concentration suggests that a substantial gradient in Cu concentration exists between the overlying water and surficial pore waters.

An initial rapid increase in Zn concentration at Fairfield outfall was observed (Figure 3), with no increase after the intermediate point. The Zn blanks increase slightly, but considerably less than the core samples. The observed pattern of Zn increase suggests that there is a rapid increase in Zn concentration, but within a short period of time, pore water and overlying water Zn concentrations are similar.

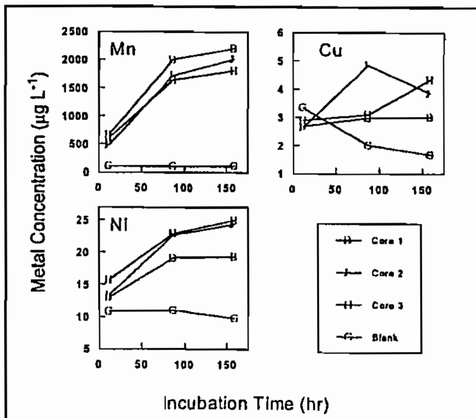


Figure 4. Manganese, copper and nickel time courses for the Deep Creek site.

At the Deep Creek Site on Back River (Figure 4), we observed increases in the concentrations of Cu, Mn, and Ni. The Mn increases were large, increasing about 3-fold from the initial concentration of 500 ppb. In general, Mn fluxes are thought to result primarily from the chemical or microbial reduction of Mn(IV) oxides to aqueous Mn(II) in reducing sediments (Burdige 1993), with the slow oxidation of Mn(II) to Mn(IV) oxides occurring in the water column (Stumm and Morgan 1981). This process occurs in the absence of contamination (Trefry and Presley 1982), with Mn(IV) serving as a terminal electron acceptor. The decrease in slope of the concentration versus time data indicates that the aqueous Mn gradient decreases during the course of the incubation. The flux calculations would provide a lower rate if only initial and final time points were used.

The flux of Cu at Deep Creek is not readily observable, with the blank concentration decreasing and the cores generally showing modest increases. Nickel concentrations, however, showed substantial increases with the highest slope occurring between the first two time points. The blank Ni concentrations changed very little.

The concentrations of arsenic were measured on initial and final time points only. In general, the concentration of As increased during the course of incubation. Clear increases were observed at Witch Coat, Muddy Gut and Deep Creek; a large As concentration increase in the blank core at Fairfield Outfall suggests potential contamination of the As blank core.

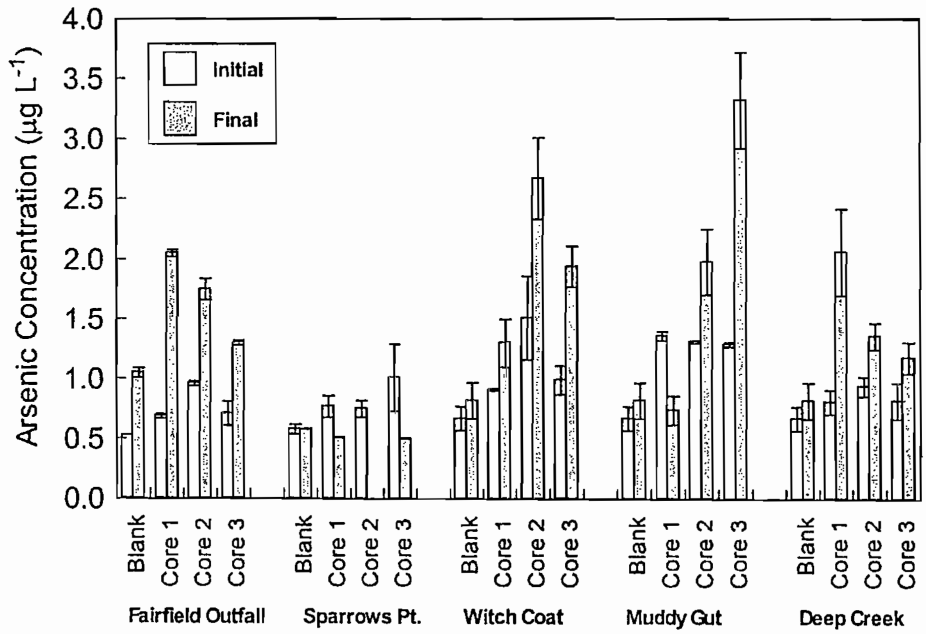


Figure 5. Initial and final arsenic data from flux experiments.

The concentrations of Hg were somewhat variable, but there was clearly no major efflux of total or methyl Hg. Indeed, most cores showed some decrease in both Hg analytes during the course of incubation. Some aberrant concentrations were noted, with concentrations in suspect samples approaching 100 ng L^{-1}.

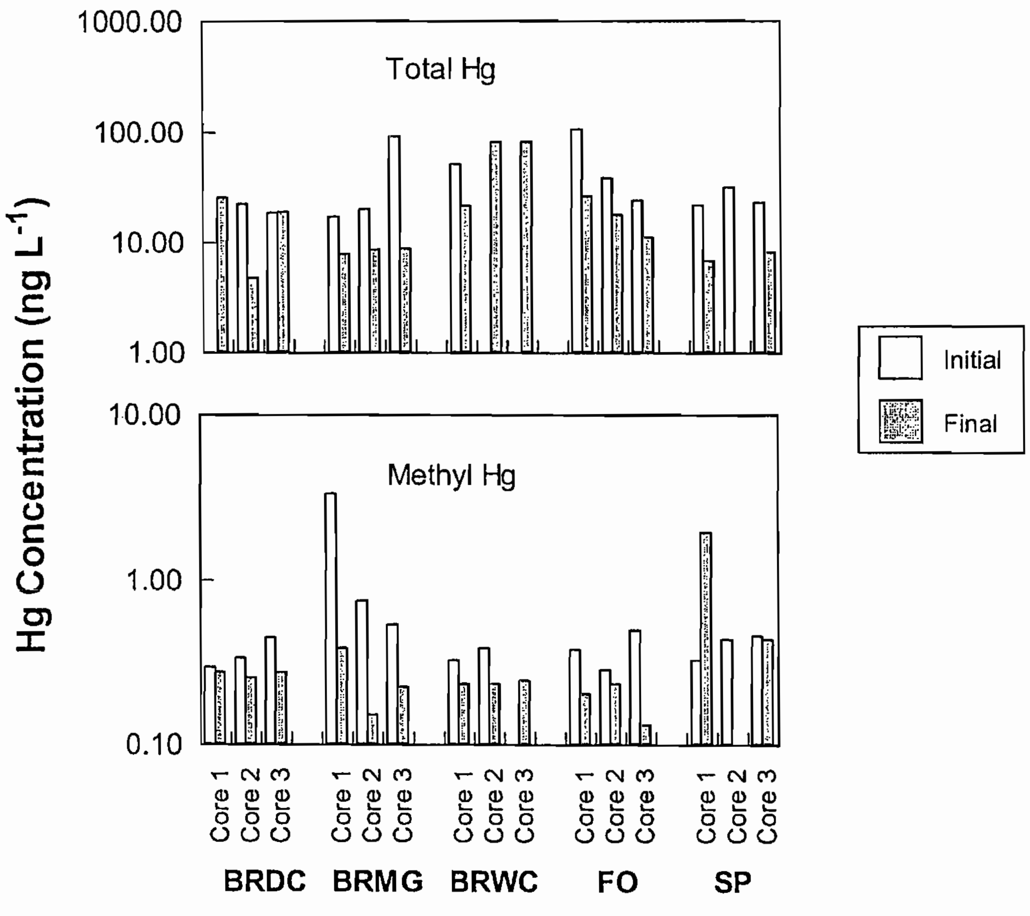


Figure 6. Total and methyl Hg concentrations for the Back River and Baltimore Harbor incubations.

Metal Flux Rates

The summary of the metal fluxes from Baltimore Harbor and Back River are listed in Table 4. We observed significant efflux of Mn, Cu, Ni, Zn and As from these sediments; only at Fairfield Outfall did we observe fluxes of all metals. Because of low concentrations or "noisy" data, fluxes for Hg, Se, Cr, Pb and Cd were not calculated.

Large fluxes of Mn were observed at three sites, with modest levels of core-to-core variability. As described before, the fluxes of Mn occur by dissolution or reduction of Mn(IV) oxides in reducing sediment horizons. Despite these large rates, relatively little carbon oxidation would be represented by these Mn fluxes.

Table 4. Fluxes of transition metals from sediments. Rates are $\mu g\ m^{-2}\ h^{-1}$. Total incubation times were ~147 h. Standard deviations are shown.

ID	Mn	Cu	Ni	Zn	As
Fairfield Outfall	528±321 n=3	2.3±1.5 n=3	5.7±1.6 n=3	75±19 n=3	0.33±0.32
Deep Creek	1980±253 n=3	1.5±1.8 n=3	12.3±2.7 n=3		0.39±0.43
Witch Coat	887±293 n=2	1.0±0.3 n=2	7.7±1.5 n=2		0.58±0.27
Muddy Gut		0.6±0.3 n=2	6.9±1.7 n=3		0.17±0.76
Sparrows Point		0.6±0.2 n=2			-0.48±0.08

The fluxes of Cu from sediments ranged from 0.6 $\mu g\ m^{-2}\ h^{-1}$ to 2.3 $\mu g\ m^{-2}\ h^{-1}$, all directed out of the sediment. High core to core variability in flux rate resulted in a large standard deviation at these sites. Fluxes of Cu were observed at all sites.

Nickel fluxes were found at all sites except Sparrows Point, with rates ranging from 5.7 to 12.3 $\mu g\ m^{-2}\ h^{-1}$. Unlike Cu, the core to core variability was very low, and in all cases, blank cores showed little variability. The flux of Zn was significant only for Fairfield Outfall, averaging 75 $\mu g\ m^{-2}\ h^{-1}$.

Core to core variability was high for As fluxes, with very large standard deviations. For four sites, fluxes were directed out of the sediment; for Sparrows Point, fluxes appear to be directed into the sediment. Overall flux rates were quite low.

DISCUSSION

Comparison to other metal flux studies is difficult because 1) there are few studies and 2) they generally have not been carried out in urban harbors. Recent unpublished Baltimore Harbor core incubation work by Riedel and colleagues have maximum Cu and As flux rate data that are similar to that in this study. Our own unpublished data from the Elizabeth River (VA) shows Cu fluxes into the sediments, while both Ni and Mn fluxes out of the sediment at rates similar to those observed in Baltimore Harbor (Cornwell unpublished). In the mainstem of Chesapeake Bay, our data shows an efflux of Mn out of sediment, but low rates of efflux or moderate rates of influx of most transition metals into the sediment.

These data clearly show that sediments are 1) often a source of water column As, Cu, Mn, and Ni at most sites and 2) not a major source of Ag, Cr, Se or Hg. It must be recognized that this study is limited to one time period and that changes in redox status of the sediment may result in different results. The rapid increase in metal concentrations over the course of several days was unexpected, with most studies looking at fluxes over the time scale of 10's of days. As a consequence, the metal flux rates presented here may be modest underestimates because of rapid changes in the dissolved metal gradient between sediment and overlying water. Our ongoing work in Bear Creek and Fairfield Outfall will examine metals fluxes in considerably more temporal detail.

CONCLUSIONS

This study has provided the first spatially detailed investigation of the rates of trace metal flux from Baltimore Harbor sediments. At one site, Fairfield Outfall, we observed efflux of As, Cu, Mn, Ni and Zn; sediment trace metals are clearly an important source of metals to overlying waters. The Back River sites also had significant Cu and Ni fluxes. At Sparrows Point, sediment appear to be a source of Cu.

REFERENCES

Aurilio, A.C., Mason, R.P., and Hemond, H. (1994). Speciation and fate of arsenic in three lakes of the Aberjona Watershed. Environmental Science and Technology, **28**, 577-585.

Baker, J., R. Mason, J. Cornwell, J. Ashley, J. Halka, and J. Hill. 1997. Spatial Mapping of Sedimentary Contaminants in the Baltimore Harbor/Patapsco River/Back River System. Final Report to Maryland Department of the Environment, Ref. No. UMCES [CBL] 97-142.

Bloom, N.S. Determination of picogram levels of methylmercury by aqueous phase ethylation floowed by cryogenic trapping and cold vapor atomic fluorescence spectroscopy. *Can. J. Fish. Aquat. Sci.* **1989**, 46, 1131.

Bloom, N.S.; Fitzgerald, W.F. Determination of volatile mercury species at the picogram level by low temperature gas chromatography with cold vapor atomic fluorescence detection. *Anal. Chim. Acta* **1988**, 208, 151.

Bloom, N.S.; Crecelius, E.A. Determination of mercury in seawater at sunanogram per liter levels. *Mar. Chem.* **1983**, 14, 49.

Booij, K., B. Sundby, and W. Helder. 1994. Measuring the flux of oxygen to a muddy sediment with a cylindrical microcosm. Netherlands J. Sea Res. 32:1-11.

Boynton, W. R., W. M. Kemp, C. G. Osborne, K. R. Kaumeyer, and M. C. Jenkins. 1981. Influence of water circulation rate on in situ measurements of benthic community respiration. Marine Biology. 65:185-190.

Boynton, W. R., J. H. Garber, R. Summers, and W. M. Kemp. 1995. Inputs, transformations and transport of nitrogen and phosphorus in Chesapeake Bay and selected tributaries. Estuaries. 18:285-314.

Burdige, D. J. 1993. The biogeochemistry of manganese and iron reduction in marine sediments. Earth Sci. Rev. 35:249-284.

Burdige, D. J., and J. Homstead. 1994. Fluxes of dissolved organic carbon from Chesapeake Bay sediments. Geochim. Cosmochim. Acta. 58:3407-3423.

Cornwell, J. C., and J. W. Morse. 1987. The characterization of iron sulfide minerals in anoxic marine sediments. Mar. Chem. 22:193-206.

Cornwell, J. C., and P. A. Sampou. 1995. Environmental controls on iron sulfide mineral formation in a coastal plain estuary. p. 224-242. *In* M. A. Vairavamurthy and M. A. A. Schoonen Geochemical Transformations of Sedimentary Sulfur. American Chemical Society, Washington, DC

Cowan, J. L. W., and W. R. Boynton. 1996. Sediment-water oxygen and nutrient exchanges along the longitudinal axis of Chesapeake Bay: Seasonal patterns, controlling factors and ecological significance. Estuaries. 19:562-580.

Daskalakis, K. D., and T. P. O'Connor. 1995. Normalization and elemental sediment contamination in the coastal United States. Environ. Sci. Technol. 29:470-477.

Di Toro, D. M., J. D. Mahony, D. J. Hansen, K. J. Scott, M. B. Hicks, S. M. Mayr, and M. S. Redmond. 1990. Toxicity of cadmium in sediments, the role of acid volatile sulfide. Environ. Toxicol. Chem. 9:1489-1504.

DiToro, D. M., J. D. Mahony, D. J. Hansen, K. J. Scott, A. R. Carlson, and G. T. Ankley. 1992. Acid volatile sulfide predicts the acute toxicity of cadmium and nickel in sediments. Environ. Sci. Technol. 26:96-101.

Fisher, T.R., J. D. Hagy and E. Rochelle-Newall. *1998*. Dissolved and particulate organic carbon in Chesapeake Bay . Estuaries 21:215-229.

Gavis, J., and V. Grant. 1986. Sulfide, iron, manganese, and phosphate in the deep water of the Chesapeake Bay during anoxia. Est. Coast. Shelf Sci. 23:451-463.

Goldberg, E. D., V. Hodge, M. Koide, J. Griffin, J. Gamble, O. P. Bricker, G. Matisoff, and G. R. Holdren Jr. 1978. A pollution history of Chesapeake Bay. Geochim. Cosmochim. Acta. 42:1413-1425.

Greer, J., and D. Terlizzi. 1997. Chemical Contamination in the Chesapeake Bay: A Synthesis of Research to Date and Future Research Directions. Maryland Sea Grant, College Park, MD. 48 p.

Helz, G. R., and R. J. Huggett. 1987. Contaminants in Chesapeake Bay: the regional perspective. p. 270-297. *In* S. K. Majumdar, L. W. Hall Jr., and H. M. Austin Contaminant Problems and Management of Living Chesapeake Bay Resources. Pennsylvania Academy of Science,

Horvat, M, Liang, L. and Bloom, N.S. Comparison of distillation with other current isolation methods for the determination of methylmercury in low level environmental samples. Anal. Chim. Acta 282 153-168.

Huerta-Diaz, M. A., and J. W. Morse. 1992. Pyritization of trace metals in anoxic marine sediments. Geochim. Cosmochim. Acta. 56:2681-2702.

Huettel, M., and G. Gust. 1992. Solute release mechanisms from confined sediment cores in stirred benthic chambers and flume flows. Mar. Ecol. Prog. Ser. 82:187-197.

Johnson, K. M., A. E. King, and J. M. Sieburth. 1985. Coulometric TCO2 analyses for marine studies; an introduction. Mar. Chem. 16:61-82.

Mason, R.P., N.M. Lawson, J. Leaner, A.L. Lawrence, and J.G. Lee. Mercury in the Chesapeake Bay. Marine Chemistry (in press).

Miller-Way, T., G. S. Boland, G. T. Rowe, and R. R. Twilley. 1994. Sediment oxygen consumption and benthic nutrient fluxes on the Louisiana continental shelf: a methodological comparison. Estuaries. 17:809-815.

Officer, C. B., D. R. Lynch, G. H. Setlock, and G. R. Helz. 1984. Recent sedimentation rates in Chesapeake Bay. p. 131-157. *In* V. S. Kennedy The Estuary as a Filter. Academic Press, New York

Owens, M., and J. C. Cornwell. 1995. Sedimentary evidence for decreased heavy-metal inputs to the Chesapeake Bay. Ambio. 24:24-27

Riedel, G. F., J. G. Sanders, and R. W. Osman. 1987. The effect of biological and physical disturbances on the transport of arsenic from contaminated estuarine sediments. Est. Coast. Shelf Sci. 25:693-706.

Riedel, G. F., J. G. Sanders, and R. W. Osman. 1989. The role of three species of benthic invertebrates in the transport of arsenic from contaminated estuarine sediment. J. Exp. Mar. Biol. Ecol. 134:143-155.

Robbins, J. A. 1978. Geochemical and geophysical applications of radioactive lead. p. 285-405. *In* J. O. Nraigu The Biogeochemistry of Lead in the Environment. Elsevier, New York

Santschi, P., P. Hoehner, G. Benoit, and M. B. Brink. 1990. Chemical processes at the sediment-water interface. Mar. Chem. 30:269-315.

Sinex, S. A., and G. R. Helz. 1982. Entrapment of zinc and other trace elements in a rapidly flushed industrialize harbor. Environ. Sci. Technol. 16:820-825.

Stumm, W. And J.J. Morgan. 1981. Aquatic Chemistry. Wiley-interscience. 780 p.

Sundby, B., L. G. Anderson, P. O. J. Hall, A. Iverfeldt, M. M. R. Van Der Loeff, and S. F. G. Westerlund. 1986. The effect of oxygen on release and uptake of cobalt, manganese, iron and phosphate at the sediment-water interface. Geochim. Cosmochim. Acta. 50:1281-1288.

Trefry, J. H., and B. J. Presley. 1976. Heavy metals in sediments from San Antonio Bay and the Northwest Gulf of Mexico. Environ. Geol. 1:283-294.

Trefry, J.H. and B.J. Presley. 1982. Manganese fluxes from Mississippi Delta sediments. Geochim. Cosmochim. Acta.46:1715-1726.

TRSW/MDE. 1996. Toxics Regional Action Plan for Baltimore Harbor. Toxics RAP Stakeholder Workgroup and Maryland Department of the Environment. Baltimore, MD.

Valette-Silver, N. J. 1993. The use of sediment cores to reconstruct historical trends in contamination of estuarine and coastal sediments. Estuaries. 16:577-588.

Westerlund, S. F. G., L. G. Anderson, P. O. J. Hall, A. Iverfeldt, M. M. R. Van Der Loeff, and B. Sundby. 1986. Bentic fluxes of cadmium, copper, nickel, zinc and lead in the coastal environment. Geochim. Cosmochim. Acta. 50:1289-1296.

APPENDIX I. DATA TABLES

Transition Metal Data

Location	Core #	Time	Replicate	Fe	Cu	Ni	Zn	Mn
				µg L⁻¹				
Fairfield Outfall	1	0		8.6	3.66	5.65	16.66	74.0
	1	1		10.1	3.98	9.40	69.68	360.5
	1	F		6.7	4.03	7.50	50.15	156.5
	2	0		7.9	2.36	6.80	20.18	105.1
	2	1		18.3	4.38	11.15	52.64	638.8
	2	F		11.3	5.09	10.09	59.31	64.1
	3	0		6.9	2.80	6.45	14.80	131.0
	3	1		11.9	4.15	8.48	67.24	276.6
	3	1	X	12.7	4.22	9.24	66.77	278.3
	3	F		11.9	5.40	10.73	63.33	208.6
	Blank	0		5.2	2.23	6.15	19.39	14.2
	Blank	1		27.9	2.65	12.26	26.61	7.0
	Blank	1	X	31.6	2.09	11.84	24.37	8.3
	Blank	F		5.5	1.93	6.01	25.96	2.8
Sparrows Pt.	1	0		33.2	2.16	5.66	14.86	648.9
	1	F		15.7	3.12	6.26	114.87	536.9
	3	0		22.6	2.18	6.18	22.86	217.3
	3	F		10.6	2.68	5.79	54.07	7.7
	Blank	0		8.1	2.01	5.04	44.77	22.5
	Blank	F		4.4	1.91	5.10	104.09	85.4
Back River	Blank	0		6.9	3.34	10.79	21.48	109.0
	Blank	1		1.8	2.01	10.97	41.20	101.8
	Blank	F		1.7	1.68	9.77	55.63	108.1
Deep Creek	1	0		8.8	2.75	12.55	11.50	650.2
	1	0	X	9.6	2.60	13.49	12.20	679.1
	1	1		17.1	2.96	19.09	30.12	2005.0
	1	F		18.5	3.01	19.33	29.75	2254.2
	1	F	X	16.8	3.01	19.26	30.92	2153.2
	2	0		7.5	2.63	13.37	15.87	479.2
	2	1		27.4	4.84	22.64	36.06	1724.4

	2	F		21.4	3.86	24.37	45.61	2012.7
	3	0		13.3	2.89	15.73	17.26	602.6
	3	1		15.4	3.10	22.90	37.67	1641.4
	3	F		12.0	4.34	24.96	54.47	1809.1
Witch Coat	1	0		18.5	3.98	13.80	28.66	660.6
	1	F		20.6	3.08	21.01	32.48	1471.3
	2	0		18.1	3.25	15.08	34.93	577.6
	2	F		13.5	4.09	25.21	41.52	1881.8
	3	0		9.3	2.90	14.10	31.90	701.9
	3	F		12.0	4.50	24.43	41.20	596.9
Muddy Gut	1	0		1.9	1.53	13.15	12.84	687.7
	1	F		17.8	1.90	19.06	17.51	1812.4
	2	0		11.0	2.74	17.50	18.50	560.7
	2	F		19.4	3.86	27.42	20.40	768.9
	3	0		8.6	2.36	15.32	28.29	679.1
	3	0	X	6.9	2.28	15.26	28.06	665.8
	3	F		32.3	2.17	24.20	27.72	2526.5

Dissolved inorganic and organic carbon data

Location	Core #	Time	DIC	DOC
			µmol L^{-1}	mg L^{-1}
Sparrows Point	1	0	1002.4	5.19
	1	1	1670	8.64
	1	F	2079.2	6.17
	3	0	970.7	5.36
	3	1	1381	5.5
	3	F	1529.1	6.42
	Blank	0	997.6	
	Blank	1	1108.4	
	Blank	F	1038.4	
Muddy Gut	1	0	1184.6	11.2
	1	1	2439.7	13.9
	1	F		9.83
	2	0	1268.2	10.14
	2	1	3574	11.25
	2	F	4383	10.02
	3	0	1302.8	10.38
	3	1	2598.5	12.6

	3	F	3169.4	8.92
	Blank	0	1182.7	23.31
	Blank	1	1044.9	14.24
	Blank	F	1139.6	10.23

		Total Hg (ng/L)		MethylHg (ng/L)	
		T=0	T=7	T=0	T=7
BRDC	1	772	25.3	0.29	0.27
	2	21.9	4.7	0.33	0.25
	3	18.3	18.6	0.44	0.27
BRMG	1	16.7	7.8	3.28	0.38
	2	19.9	8.5	0.74	0.15
	3	90.0	8.7	0.53	0.22
BRWC	1	50.8	21.3	0.32	0.23
	2	771	80.3	0.38	0.23
	3	---	80.8	---	0.24
FO	1	104	25.9	0.37	0.20
	2	37.7	17.6	0.28	0.23
	3	23.6	11.0	0.49	0.13
SP	1	21.5	6.7	0.32	1.92
	2	31.2	---	0.43	---
	3	22.6	8.0	0.45	0.43

CITY OF BALTIMORE
DEPARTMENT OF PUBLIC WORKS
Water and Wastewater Engineering Division

COMPREHENSIVE WASTEWATER FACILITIES MASTER PLAN

APPENDIX

VOLUME 2 OF 2

APRIL 2004

WHITMAN, REQUARDT AND ASSOCIATES, LLP
Baltimore, Maryland

WR&A

COMPREHENSIVE WASTEWATER FACILITIES MASTER PLAN

APPENDIX
TABLE OF CONTENTS

VOLUME 2

Baltimore City
Comprehensive Wastewater
Facilities Master Planning Project

City Project 613

Task 207
Sewer Overflow Monitoring Summary

submitted to
Baltimore Department of Public Works

submitted by
Engineering Technologies Associates, Inc.
3458 Ellicott Center Drive
Ellicott City, Maryland, 21043

April 24, 1998

Table of Contents

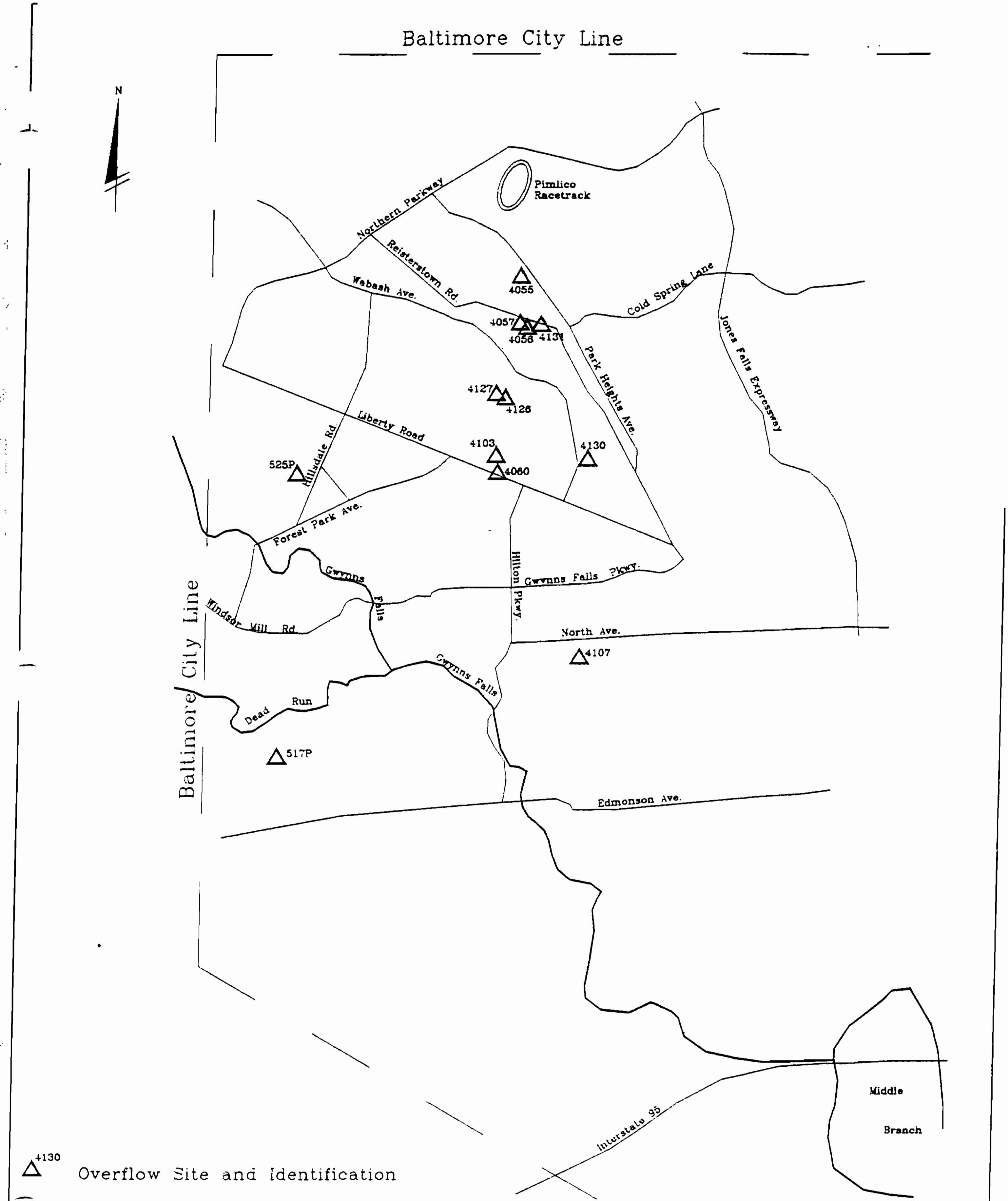
1.0 Background

As a part of the Comprehensive Waste Water Facilities Master Plan (Baltimore City Project 613), Engineering Technologies Associates (ETA) was subcontracted to Whitman Requardt & Associates to perform sewer overflow sampling and monitoring in the Gwynns Falls and Gwynns Run watersheds. The objective of the sewer overflow sampling is to quantify the pollutant loadings to the Gwynns Falls and Gwynns Run watersheds from the overflow of sanitary sewers. Twelve overflow points throughout the two watersheds were designated for monitoring by the City of Baltimore. The site locations and identifications are as follows:

ETA ID	Location	Sewer Size
4055	Front 3300 Woodland Ave. and Homer Ave.	12"
4056	SW corner of Ridgewood Ave. and Umatilla Ave.	12"
4057	Front of 4515 Umatilla Ave., North of Ridgewood	12"
4060	NE corner of Liberty Heights and Edgewood Rd.	8"
4103	Dorchester and Cedardale Ave.	8"
4107	Dukeland St. and Presbury St.	24"
4126	Front of 3825 Copley Rd.	8"
4127	Front of 3820 Copley Rd.	8"
4130	Sequoia and Willowdale Ave.	22"
4131	Towanda Ave. and Ridgewood Ave.	15"
4017	NW corner of Brianclift and Winans Way (017P)	12"
4025	Howard Park Ave. and Brightwood Ave. (025P)	8"

The last three digits of the identification correspond to the DPW overflow pipe identification number. Figure 1 shows the locations of these sites.

ETA personnel performed a preliminary inspection at each site prior to the installation of equipment. During the preliminary inspections, overflow pipes at three of the sites were found to be partially clogged (25 to 50%) with sediment. The sites were the NE corner of Liberty Heights and Edgewood Road (4060); NW corner of Brianclift and Winans Way (4017); and Howard Park Ave. at Brightwood Ave (4025). Installing flow meters at these three sites was impractical due to a restriction of flow through the pipe. The partially clogged pipes would cause flow to be



DESIGNED ______ DATE DRAWN ______ DATE CHECKED ______ DATE APPROVED ______ DATE		ENGINEERING TECHNOLOGIES ASSOCIATES, INC. ENGINEERS - PLANNERS - SURVEYORS 3458 ELLICOTT CENTER DRIVE SUITE 101 ELLICOTT CITY, MARYLAND 21043	BALTIMORE CITY PROJECT 613 FIGURE 1 SEWER OVERFLOW SITE MAP TASK 207 SCALE: 1" = 4,000' | CONTRACT NO.: 97302.10 | DATE: 03/98 | SHEET:

calculated incorrectly during periods of overflow. The City of Baltimore Department of Public Works (DPW) was notified of this problem when it was discovered, and several additional times during the project. The overflow pipes at these three locations were never "cleaned out" by the DPW. Consequently, flow meters were only installed in nine of the overflow pipes.

2.0 Installation and Data Collection

The Sigma 950 Area Velocity Submerged Sensor utilizes a pressure transducer in conjunction with the Doppler method of velocity measurement to calculate flow in open channels. A small probe containing both a transducer and velocity sensor is mounted in the overflow pipe by using a metal band sized for the diameter of the overflow pipe. ETA personnel installed the Sigma flow meters between August 25 and September 3, 1997. The confined space entry procedures outlined in the workplan were followed. The bands, with sensors attached, were placed three to four feet into the overflow pipe from the sanitary sewer manhole. The area-velocity sensors were installed facing downstream to maximize the length of pipe used, and minimize the potential fouling of the sensor. When the wastewater stream flows over the velocity sensor, the flow meter readings are opposite to actual flow (negative), however the Sigma meters were programmed to reverse the flow readings to the "real" flow direction when recording data. At each site, the flow meters were programmed with the site identification and overflow pipe diameter.

Each meter recorded level and velocity at five minute intervals. Flow was then calculated internally. Data was collected at each site with American Sigma data transfer units and downloaded to the office PC every two weeks. The nine overflows were monitored from September 3, 1997 through January 26, 1998. American Sigma Insight Software allows the level and velocity data to be plotted graphically. Appendix A contains charts of the recorded overflows during this project as well as calculations of total flow during each event. Figure 2 shows the precipitation recorded at BWI from January 1997 to January 1998. Figures 3 and 4 show the daily precipitation for the months where overflows occurred.

3.0 Sample Collection

3.1 Automatic Samplers

Overflow sampling was also conducted during this phase of the project. Flow composited samples were to be collected using automatic sampling equipment in conjunction with the flow meters. Three American Sigma samplers with compact bases were rented from September to December of 1997. The samplers were installed at sites 4131, 4126, and 4107. The site selection of locations with samplers was based on data collected by the DPW in 1995-1996 and ETA observations during the first month of data collection. When rainfall was anticipated, the samplers were loaded with clean bottles and ice; and programmed to collect samples at fifteen minute intervals. However, no overflow samples were collected with automatic samplers.

Figure 2
Monthly Precipitation for Central Maryland
1997

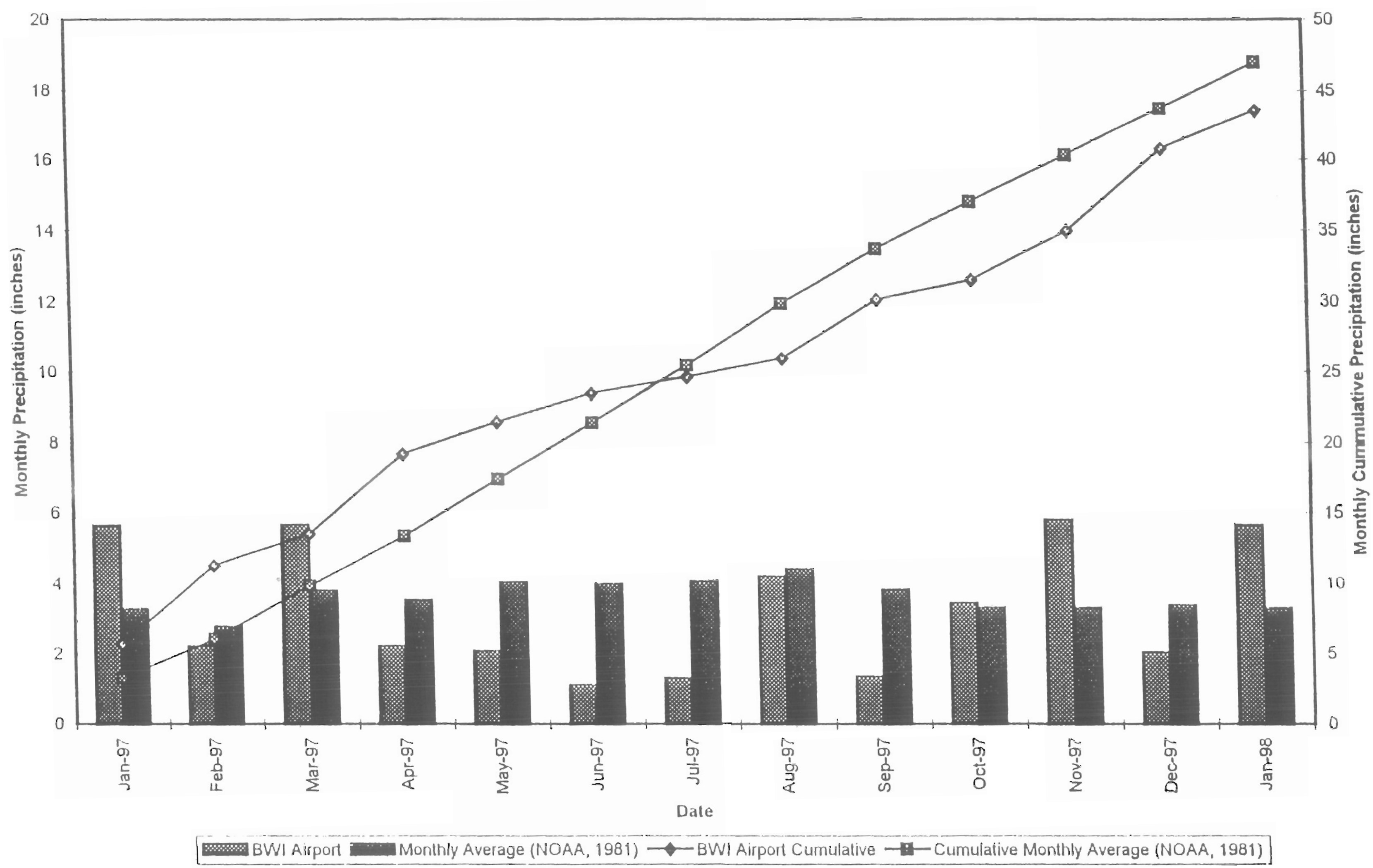


Figure 3
Daily Precipitation for November 1997
BWI Airport

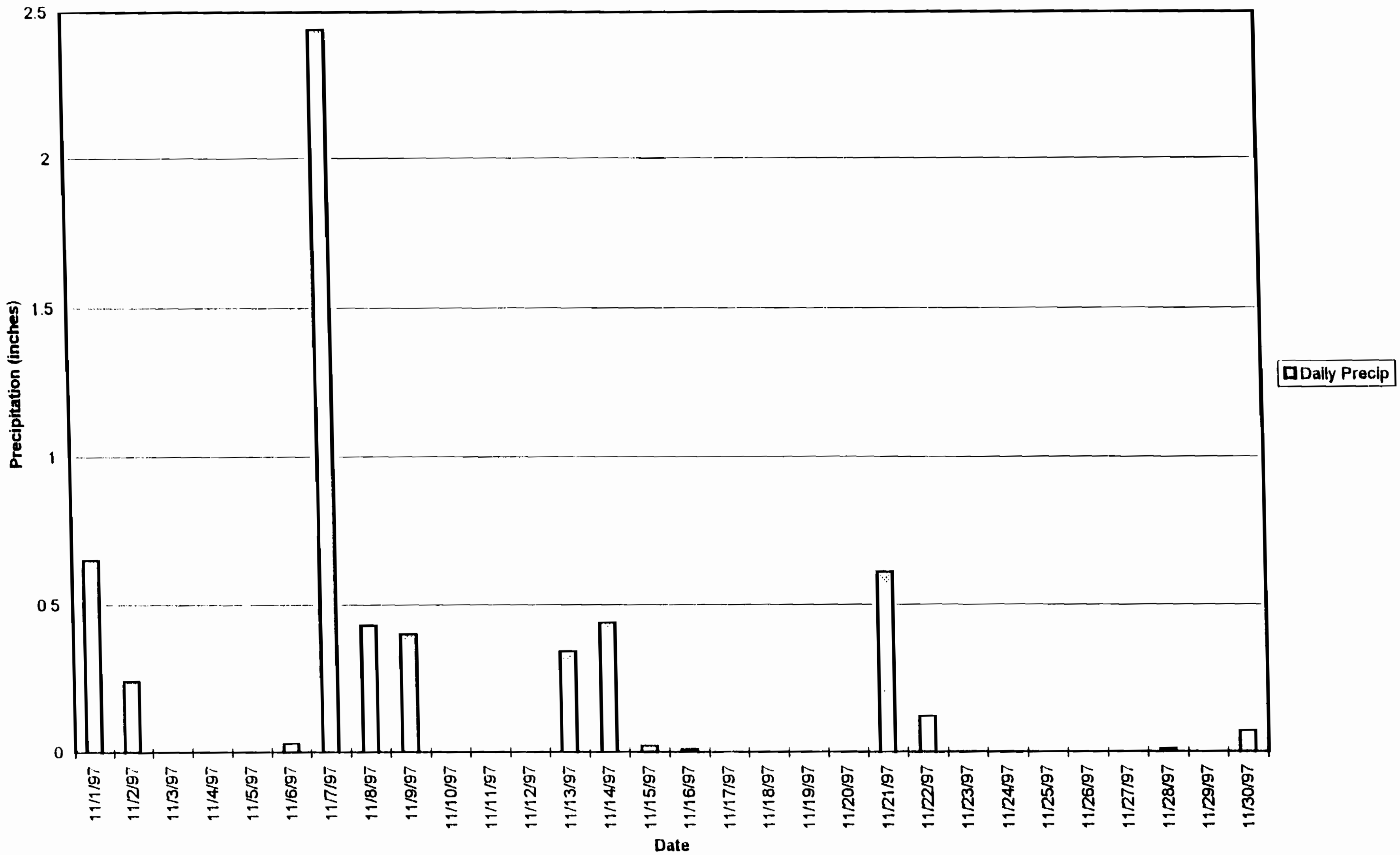
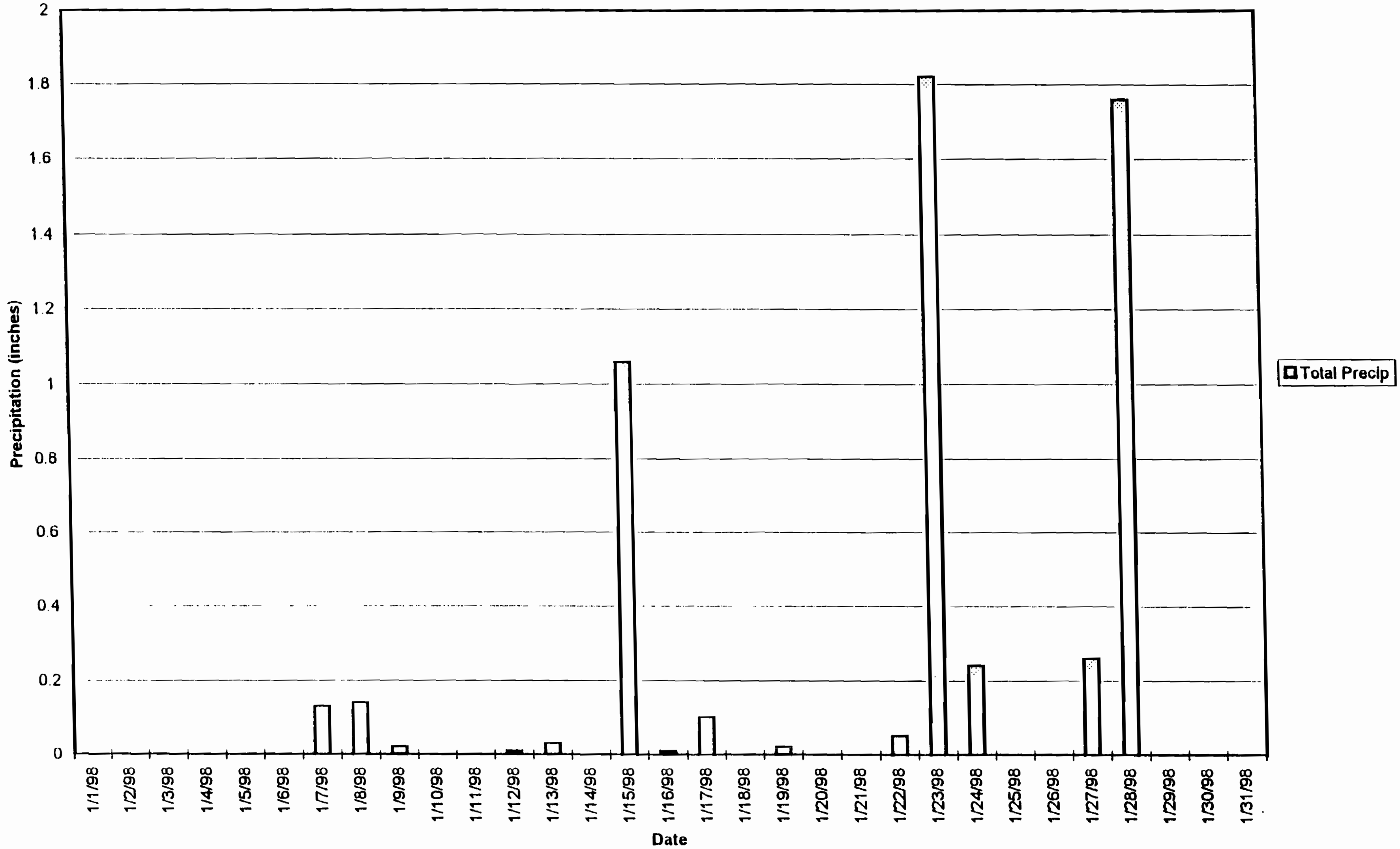


Figure 4
Daily Precipitation for January 1998
BWI Airport



3.2 Grab Sampling

ETA personnel visited the nine overflow locations during heavy rain events to observe any sewer overflows, and collect samples should there be any overflow. Overflow samples were manually collected on January 28, 1998 by ETA personnel. The nine sites which had previously contained flow meters were visited the afternoon of January 28. Based on BWI precipitation data, Baltimore City had received over two inches of rainfall during the previous twenty-four hour period. ETA personnel observed two sewer manholes overflowing: 3300 Woodland Avenue and Homer Avenue (4055); and the SW corner of Ridgewood Avenue and Umatilla Avenue (4056). While the levels of the remaining seven manholes were elevated, no overflow was occurring. Fieldnote sheets of the sampling event are included in Appendix B. A plastic "dipper" with a ten foot extension was used to collect a sample from the sanitary sewer manhole. The sampling device was decontaminated with distilled water between locations. The samples were delivered to Gascoyne Laboratory for analysis of the parameters specified in the Task 207 Workplan.

4.0 Results

Between September 3, 1997 and January 26, 1998, three overflows from the nine stations were recorded. The recorded overflows and their volumes are shown in the following table.

Site	Number	Date	Overflow Volume (gal)
3300 Woodland Ave and Homer Ave	4055	11/07/97	171959
3300 Woodland Ave and Homer Ave	4055	01/23/98	313642
SW corner of Ridgewood and Umatilla	4056	01/23/98	18519

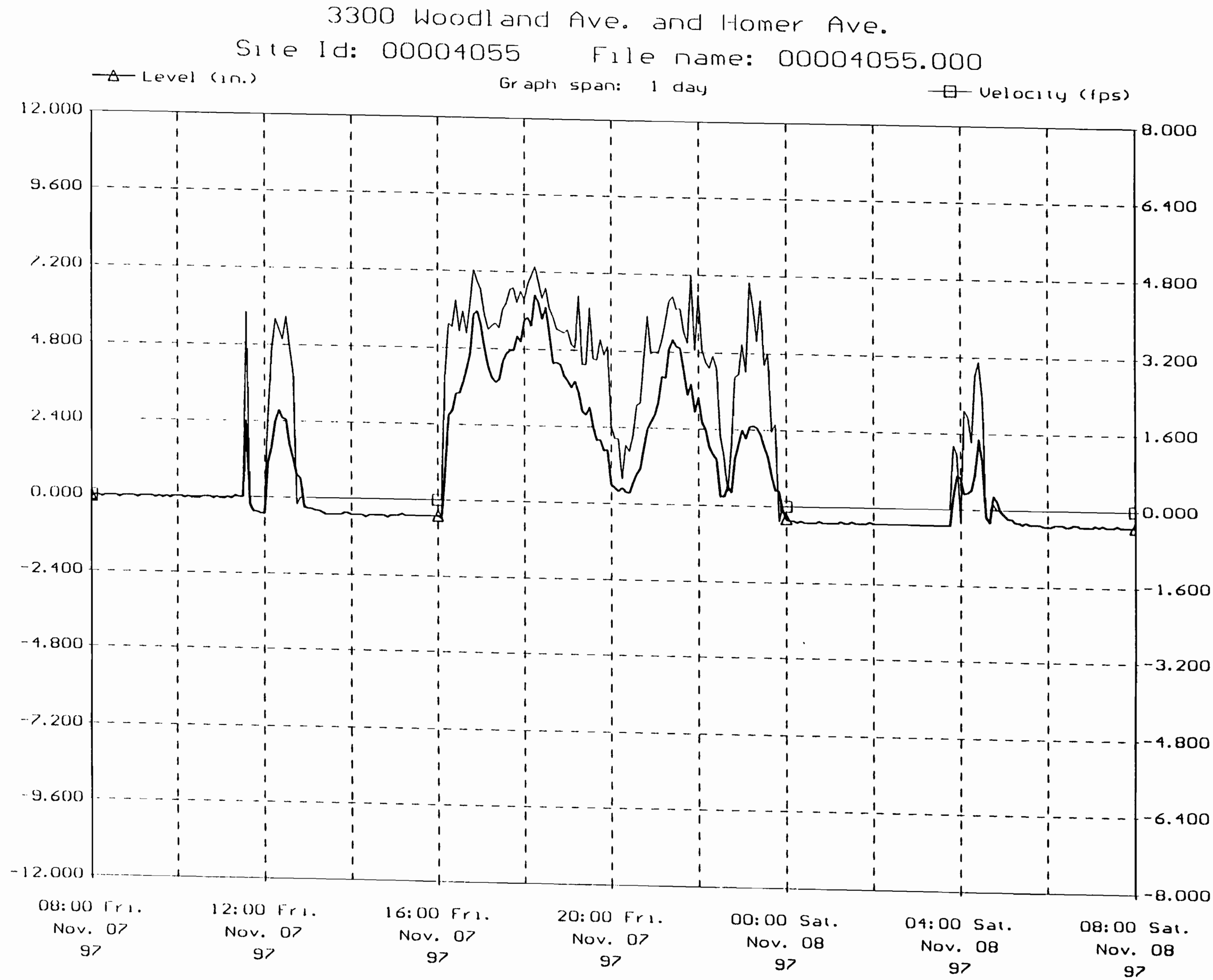
The overflow event on November 7 may not have been entirely due to infiltration and inflow. When this site was visited the following week, an abnormally high water level was observed in the sewer indicating that the sewer may have been partially clogged.

Because of the lack of overflows, only two samples of an overflow were collected for analysis and these were collected outside of the monitoring period during a large event. The average concentrations from the two samples were as follows:

Biological oxygen demand (5 days)	42 ppm
Surfactants (MBAS)	2.4 ppm
Nitrite as N	0.043 ppm
Nitrate as N	2.9 ppm
Total Kjedahl nitrogen as N	5 ppm
Total organic carbon	14 ppm
Total phosphorus	0.61 ppm
Total suspended solids	40 ppm
Fecal coliforms	>16000/100 ml

Appendix C shows the laboratory results for the two samples. Almost identical results were obtained from the two samples. These results are consistent with what would be expected from diluted domestic sewage. Assuming a BOD_5 concentration of 200 ppm in domestic sewage, the sampled overflows have been diluted by a factor of five. Assuming a total nitrogen concentration in domestic sewage of 40 ppm, the sampled overflows have again been diluted by a factor of five.

Appendix A
Overflow Charts and Flow Calculations


3300 Woodland Ave. and Homer Ave.
Site Id: 00004055 File name: 00004055.000
Level (in.)
Graph span: 1 day
Velocity (fps)
12.000
9.600
7.200
4.800
2.400
0.000
-2.400
-4.800
-7.200
-9.600
-12.000
8.000
6.400
4.800
3.200
1.600
0.000
-1.600
-3.200
-4.800
-6.400
-8.000
08:00 Fri. Nov. 07 97
12:00 Fri. Nov. 07 97
16:00 Fri. Nov. 07 97
20:00 Fri. Nov. 07 97
00:00 Sat. Nov. 08 97
04:00 Sat. Nov. 08 97
08:00 Sat. Nov. 08 97

==

Week Report - 07/NOV/97 - 08/NOV/97

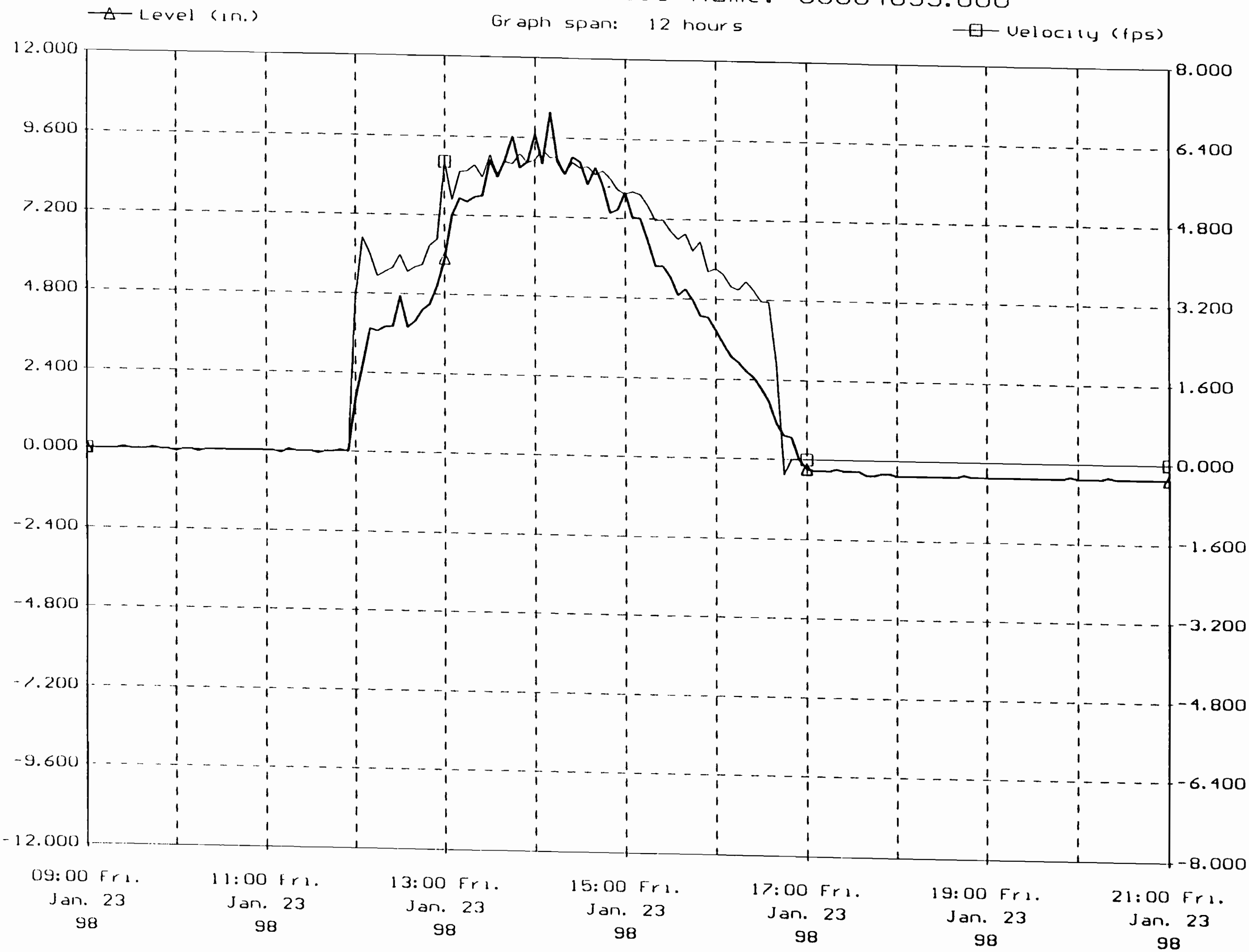
Site Id: 00004055

D cription:

		Level in.	Vel. fps	Flow mgd
Friday 07/NOV/97	Min.	-0.562	-0.30	0.00
		14:20	23:50	23:50
	Max.	6.482	4.91	1.61
		18:15	18:15	18:15
	Avg.	0.987	1.17	0.17
	Total Flow:		170244.56	(gal)
Saturday 08/NOV/97	Min.	-0.618	-0.27	-0.01
		11:00	04:00	04:00
	Max.	2.240	3.11	0.23
		04:25	04:25	04:25
	Avg.	-0.399	0.11	0.00
	Total Flow:		1714.69	(gal)
Week Summary				
	Min.	-0.618	-0.30	-0.01
		Sat	Fri	Sat
	Max.	6.482	4.91	1.61
		Fri	Fri	Fri
	Avg.	0.294	0.64	0.09
	Total Flow:		171959.25	(gal)

3300 Woodland Ave. and Homer Ave.

Site Id: 00004055 File name: 00004055.000

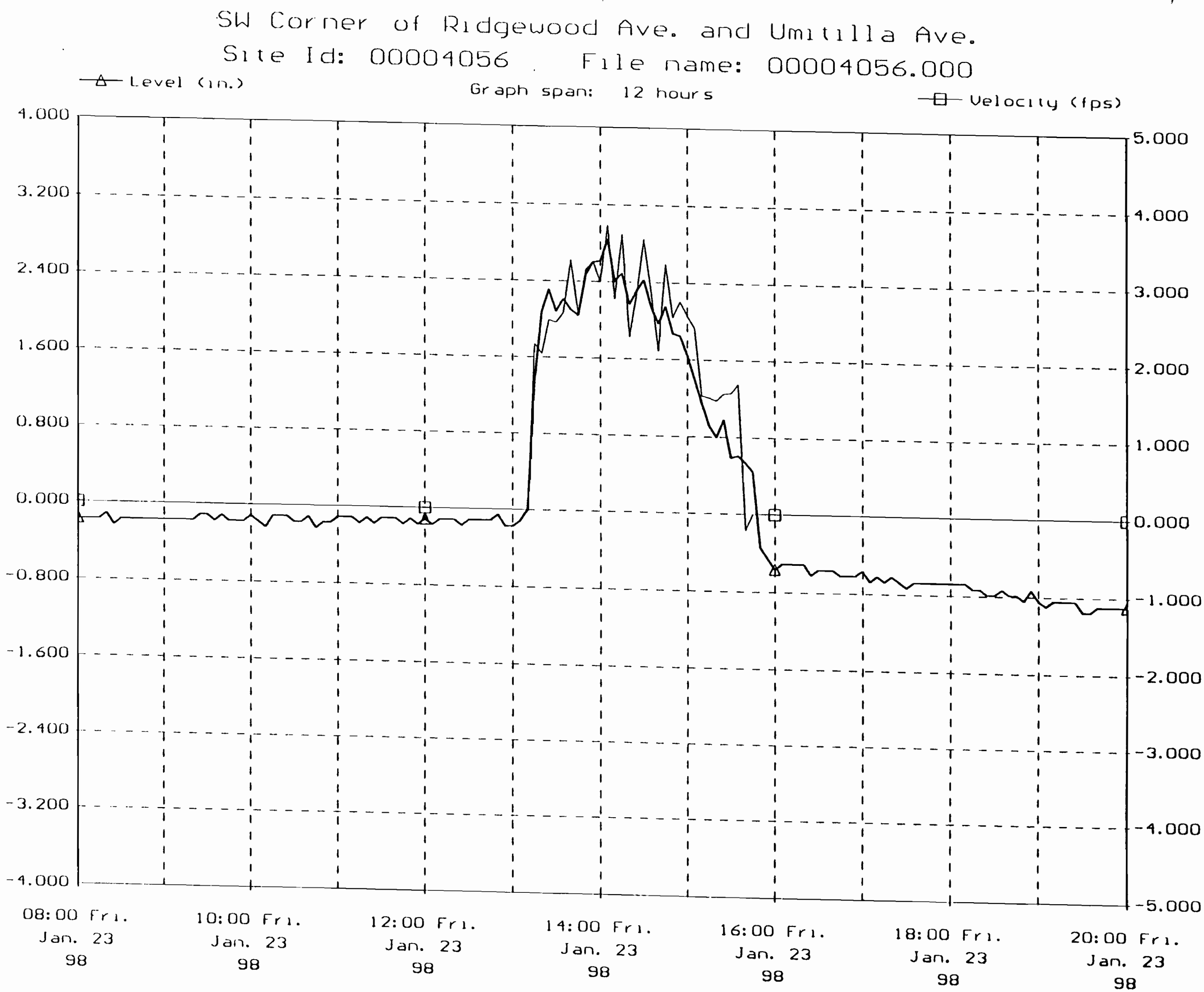


Week Report - 23/JAN/98 - 23/JAN/98

Site Id: 00004055

D cription:

		Level in.	Vel. fps	Flow mgd
Friday	Min.	-0.505	-0.30	0.00
23/JAN/98		21:20	16:45	16:45
	Max.	10.401	6.16	3.52
		14:10	14:05	14:10
	Avg.	1.057	0.94	0.31
	Total Flow:		313641.69	(gal)
Week Summary				
	Min.	-0.505	-0.30	0.00
		Fri	Fri	Fri
	Max.	10.401	6.16	3.52
		Fri	Fri	Fri
	Avg.	1.057	0.94	0.31
	Total Flow:		313641.69	(gal)


SW Corner of Ridgewood Ave. and Umitilla Ave.
Site Id: 00004056 File name: 00004056.000
Level (in.)
Graph span: 12 hours
Velocity (fps)
4.000
3.200
2.400
1.600
0.800
0.000
-0.800
-1.600
-2.400
-3.200
-4.000
5.000
4.000
3.000
2.000
1.000
0.000
-1.000
-2.000
-3.000
-4.000
-5.000
08:00 Fri. Jan. 23 98
10:00 Fri. Jan. 23 98
12:00 Fri. Jan. 23 98
14:00 Fri. Jan. 23 98
16:00 Fri. Jan. 23 98
18:00 Fri. Jan. 23 98
20:00 Fri. Jan. 23 98

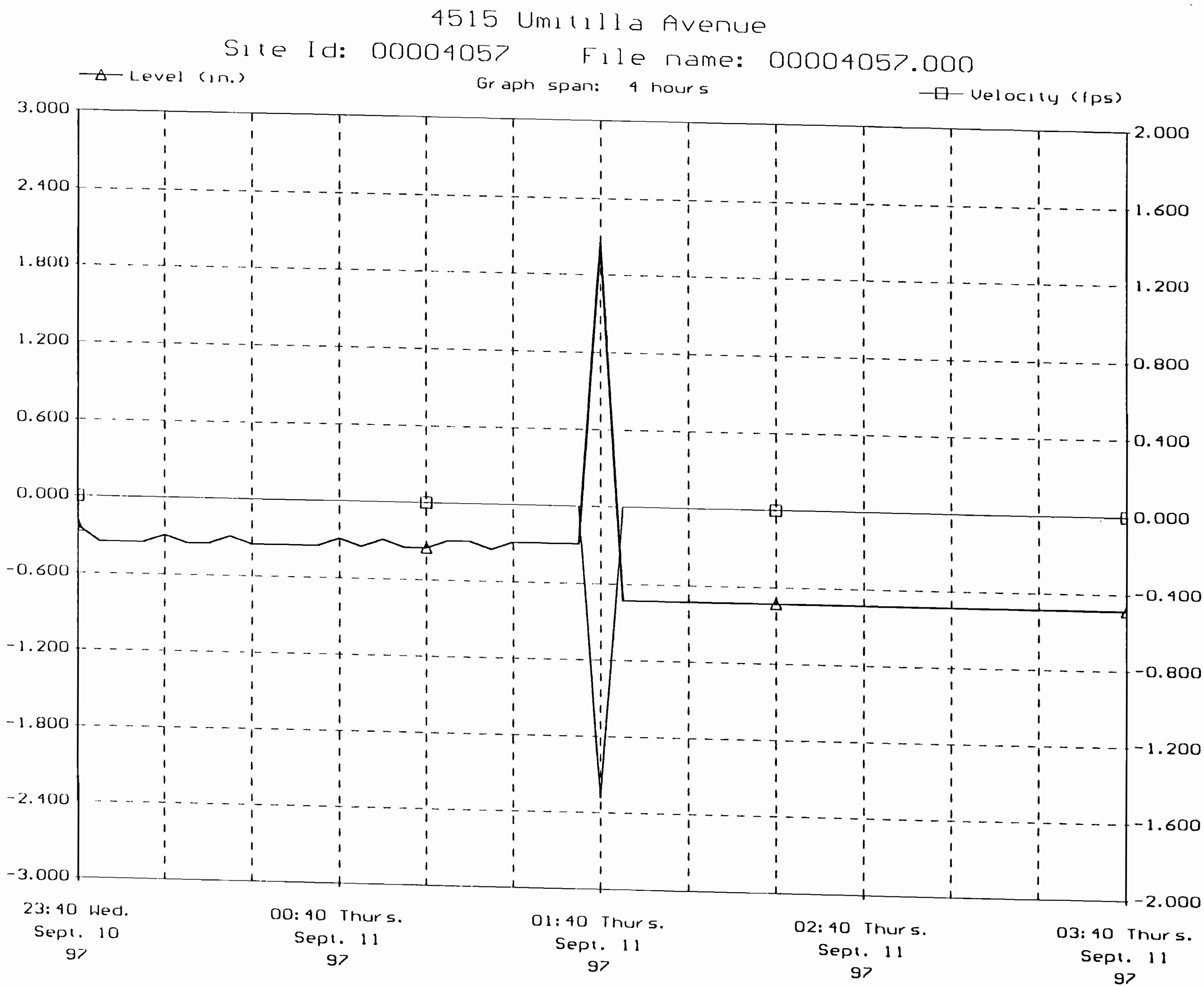
==

Week Report - 23/JAN/98 - 23/JAN/98

Site Id: 00004056

D 'cription:

		Level in.	Vel. fps	Flow mgd
Friday	Min.	-0.618	-0.20	0.00
23/JAN/98		16:25	15:40	15:40
	Max.	2.845	3.73	0.43
		14:05	14:05	14:05
	Avg.	0.749	1.20	0.09
	Total Flow:		18518.58	(gal)
Week Summary				
	Min.	-0.618	-0.20	0.00
		Fri	Fri	Fri
	Max.	2.845	3.73	0.43
		Fri	Fri	Fri
	Avg.	0.749	1.20	0.09
	Total Flow:		18518.58	(gal)



4515 Umitilla Avenue
Site Id: 00004057 File name: 00004057.000
Level (in.)
Graph span: 4 hours
Velocity (fps)
3.000
2.400
1.800
1.200
0.600
0.000
-0.600
-1.200
-1.800
-2.400
-3.000
2.000
1.600
1.200
0.800
0.400
0.000
-0.400
-0.800
-1.200
-1.600
-2.000
23:40 Wed. Sept. 10 97
00:40 Thurs. Sept. 11 97
01:40 Thurs. Sept. 11 97
02:40 Thurs. Sept. 11 97
03:40 Thurs. Sept. 11 97

Week Report - 11/SEP/97 - 11/SEP/97

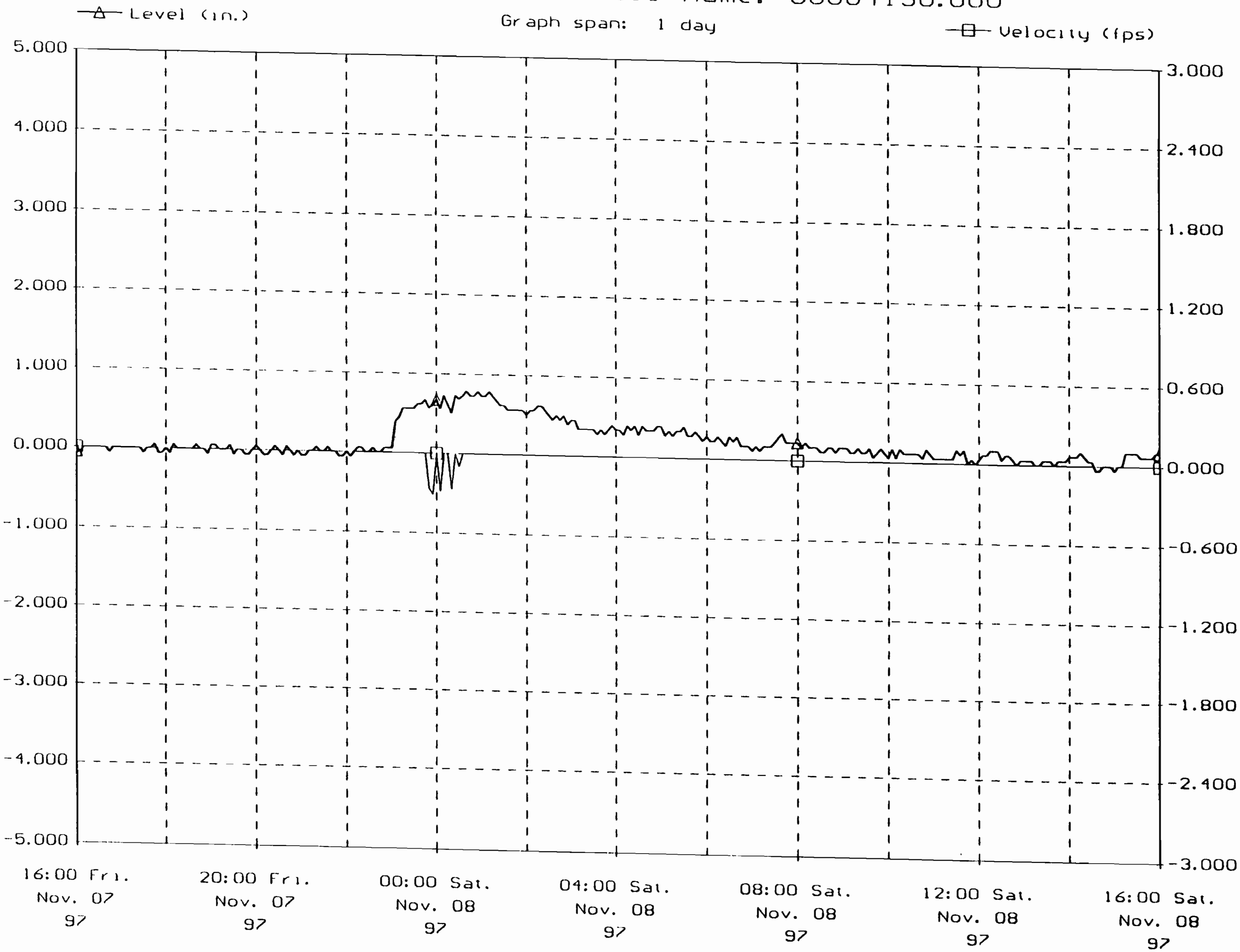
Site Id: 00004057

D :ription:

		Level in.	Vel. fps	Flow mgd
Thursday	Min.	-0.730	-1.52	-0.11
11/SEP/97		01:45	01:40	01:40
	Max.	2.053	0.00	0.00
		01:40	01:00	01:00
	Avg.	-0.482	-0.06	0.00
	Total Flow:		-380.63	(gal)
Week Summary				
	Min.	-0.730	-1.52	-0.11
		Thu	Thu	Thu
	Max.	2.053	0.00	0.00
		Thu	Thu	Thu
	Avg.	-0.482	-0.06	0.00
	Total Flow:		-380.63	(gal)

Sequoia and Willowdale Ave.

Site Id: 00004130 File name: 00004130.000



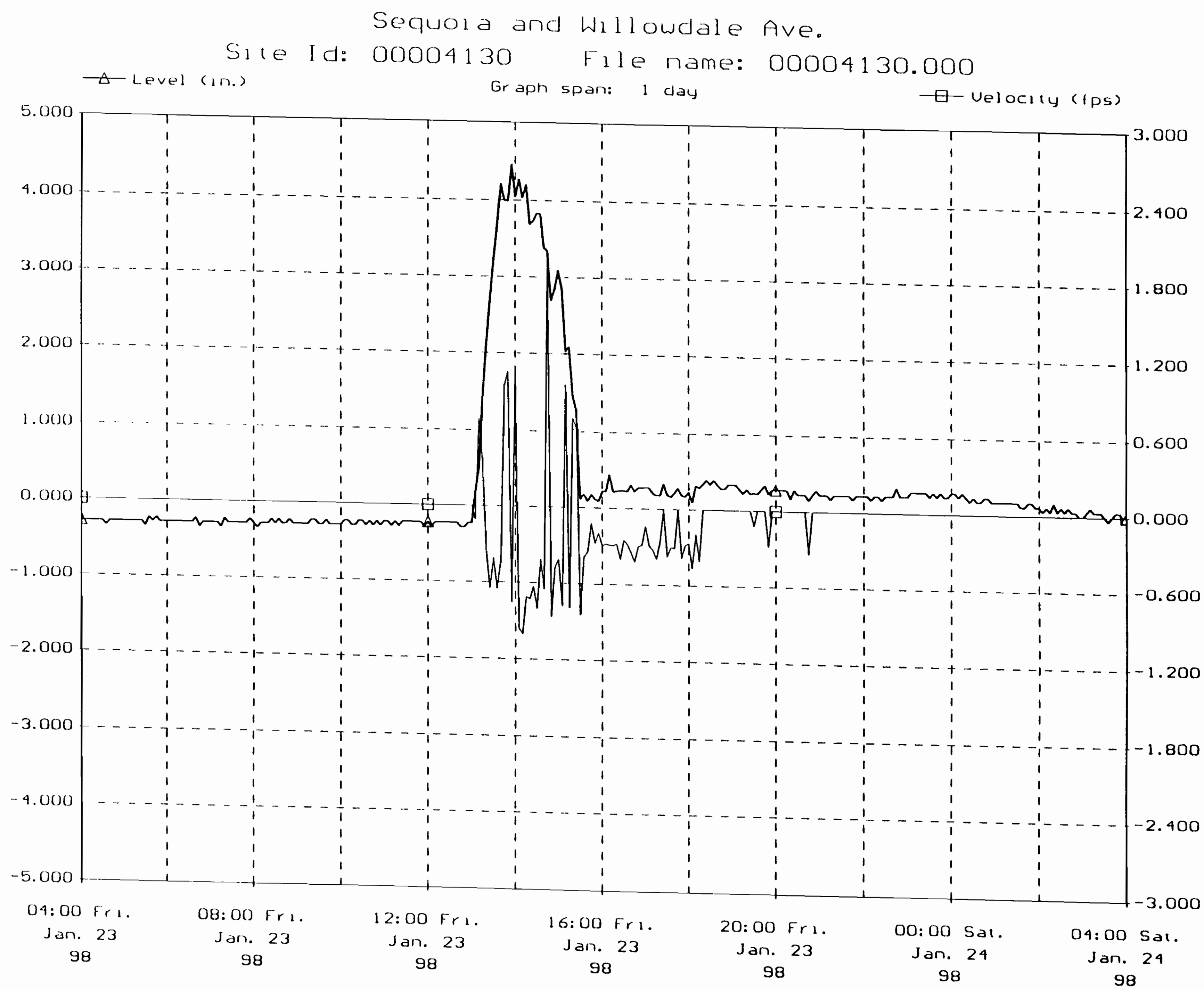
==

Week Report - 07/NOV/97 - 08/NOV/97

Site Id: 00004130

D cription:

		Level in.	Vel. fps	Flow mgd
Friday 07/NOV/97	Min.	-0.056	-0.31	0.00
		20:10	23:55	23:55
	Max.	0.674	0.00	0.00
		23:45	20:00	20:00
	Avg.	0.131	-0.01	0.00
	Total Flow:		-20.62 (gal)	
Saturday 08/NOV/97	Min.	0.112	-0.28	0.00
		07:00	00:05	00:05
	Max.	0.786	0.00	0.00
		00:40	00:00	00:00
	Avg.	0.409	-0.01	0.00
	Total Flow:		-21.58 (gal)	
Week Summary				
	Min.	-0.056	-0.31	0.00
		Fri	Fri	Fri
	Max.	0.786	0.00	0.00
		Sat	Fri	Fri
	Avg.	0.270	-0.01	0.00
	Total Flow:		-42.20 (gal)	



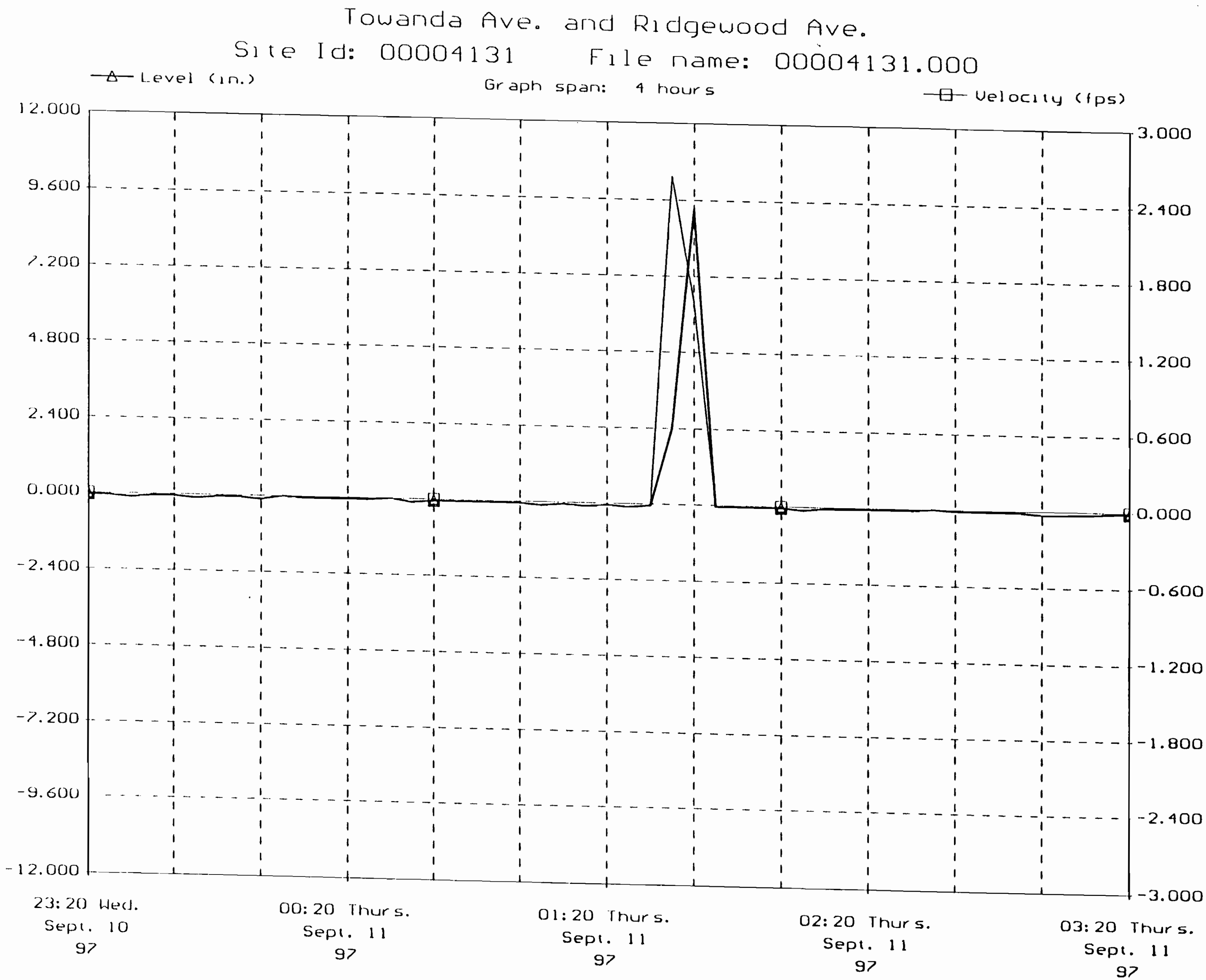
Sequoia and Willowdale Ave.
Site Id: 00004130 File name: 00004130.000
Level (in.)
Graph span: 1 day
Velocity (fps)
5.000
4.000
3.000
2.000
1.000
0.000
-1.000
-2.000
-3.000
-4.000
-5.000
3.000
2.400
1.800
1.200
0.600
0.000
-0.600
-1.200
-1.800
-2.400
-3.000
04:00 Fri. Jan. 23 98
08:00 Fri. Jan. 23 98
12:00 Fri. Jan. 23 98
16:00 Fri. Jan. 23 98
20:00 Fri. Jan. 23 98
00:00 Sat. Jan. 24 98
04:00 Sat. Jan. 24 98

Week Report - 23/JAN/98 - 24/JAN/98

Site Id: 00004130

Description:

		Level in.	Vel. fps	Flow mgd
Friday	Min.	-0.281	-1.00	-0.18
23/JAN/98		12:05	14:10	14:05
	Max.	4.470	1.95	0.26
		13:55	14:45	14:45
	Avg.	0.755	-0.10	-0.01
	Total Flow:		-2973.44	(gal)
Saturday	Min.	0.281	0.00	0.00
24/JAN/98		00:00	00:00	00:00
	Max.	0.281	0.00	0.00
		00:00	00:00	00:00
	Avg.	0.281	0.00	0.00
	Total Flow:		0.00	(gal)
Week Summary				
	Min.	-0.281	-1.00	-0.18
		Fri	Fri	Fri
	Max.	4.470	1.95	0.26
		Fri	Fri	Fri
	Avg.	0.518	-0.05	0.00
	Total Flow:		-2973.44	(gal)


Towanda Ave. and Ridgewood Ave.
Site Id: 00004131 File name: 00004131.000
Level (in.)
Graph span: 4 hours
Velocity (fps)
12.000
9.600
7.200
4.800
2.400
0.000
-2.400
-4.800
-7.200
-9.600
-12.000
3.000
2.400
1.800
1.200
0.600
0.000
-0.600
-1.200
-1.800
-2.400
-3.000
23:20 Wed. Sept. 10 97
00:20 Thurs. Sept. 11 97
01:20 Thurs. Sept. 11 97
02:20 Thurs. Sept. 11 97
03:20 Thurs. Sept. 11 97

===

Week Report - 11/SEP/97 - 11/SEP/97

Site Id: 00004131

I cription:

		Level in.	Vel. fps	Flow mgd
Thursday	Min.	-0.116	0.00	0.00
11/SEP/97		00:00	00:00	00:00
	Max.	9.348	2.59	0.83
		01:40	01:35	01:40
	Avg.	0.257	0.11	0.03
	Total Flow:		3626.39 (gal)	

Week Summary

		Level in.	Vel. fps	Flow mgd
	Min.	-0.116	0.00	0.00
		Thu	Thu	Thu
	Max.	9.348	2.59	0.83
		Thu	Thu	Thu
	Avg.	0.257	0.11	0.03
	Total Flow:		3626.39 (gal)	

Appendix B
Overflow Site Fieldnotes

Task 207 Wastewater Overflows

Site ID 4055 Location 3700 Woodland + Homer Ave.

Date 1/28/98 Time 14:00

Temp 40 °F Weather Rain ~3" last 24 hrs

Personnel AH SP OT

Is the unit functioning properly? N/A unit removed 1/26 If not, describe problem in comments

Has there been an overflow since the last visit? Y

Is the manhole overflowing now? Y

Is this site equipped with an automatic sampler? NO If so, complete the composite sheet.

Are there any noticeable problems with the manhole or overflow pipe? —

If so, call the city of Baltimore DPW and report site, use road address and overflow serial #.

Comments: Overflow in progress at site. 2 pictures taken. Approximately 2 - 3" of flow going into overflow pipe. Sample collected for analysis of parameters in 207 workplan. High water marks on side of manhole indicate water may have been 1-2" higher at some point.

4055OJANXX

Task 207 Wastewater Overflows

Site ID 4056 Location SW Corner of Ridgewood Ave - Uniondale Ave

Date 1/28/98 Time 15:00

Temp 40 °F Weather Rain ~3" last 24 hours

Personnel AH SP DJ

Is the unit functioning properly? N/A (removed 1/26) If not, describe problem in comments

Has there been an overflow since the last visit? Y

Is the manhole overflowing now? Yes

Is this site equipped with an automatic sampler? NO If so, complete the composite sheet.

Are there any noticeable problems with the manhole or overflow pipe? No

If so, call the city of Baltimore DPW and report site, use road address and overflow serial #.

Comments: Sewer overflowing while on-site. Water is just at the bottom of the overflow pipe <1". Sample taken for list in 207 workplan. 2 pictures taken

4056 6 JANXX

Task 207 Wastewater Overflows

Site ID 4057 Location 4515 Umi hills

Date 1/28 Time 15:00

Temp 40 °F Weather Rain ~3" last 24 hours

Personnel AH SP DJ

Is the unit functioning properly? NA Removed 1/26 If not, describe problem in comments

Has there been an overflow since the last visit? ?

Is the manhole overflowing now? NO

Is this site equipped with an automatic sampler? NO If so, complete the composite sheet.

Are there any noticeable problems with the manhole or overflow pipe? NO

If so, call the city of Baltimore DPW and report site, use road address and overflow serial #.

Comments: Sewer line is elevated, but not overflowing

No Sample taken.

Task 207 Wastewater Overflows

Site ID 4107 Location Dukeland + Presbury

Date 1/28 Time 15:15

Temp 40 °F Weather Rain ~.3" last 24hrs.

Personnel AbT SP DJ

Is the unit functioning properly? N/A removed 12/26 If not, describe problem in comments

Has there been an overflow since the last visit? ?

Is the manhole overflowing now? NO

Is this site equipped with an automatic sampler? NA If so, complete the composite sheet.

Are there any noticeable problems with the manhole or overflow pipe? NO

If so, call the city of Baltimore DPW and report site, use road address and overflow serial #.

Comments: No overflow. No samples taken

Task 207 Wastewater Overflows

Site ID 4126 + 4127 + 4103 Location Cr?by Rd.

Date 1/28 Time 14:40

Temp 40 °F Weather Rain 3" last 24 hrs

Personnel AH JP DT

Is the unit functioning properly? N/A removed 12/26 If not, describe problem in comments

Has there been an overflow since the last visit? [illegible] ?

Is the manhole overflowing now? No

Is this site equipped with an automatic sampler? No If so, complete the composite sheet.

Are there any noticeable problems with the manhole or overflow pipe? No

If so, call the city of Baltimore DPW and report site, use road address and overflow serial #.

Comments: Sanitary Sewer is higher than usual, but not overflowing into Storm Sewer. No Samples taken

Task 207 Wastewater Overflows

Site ID 41131 Location Towanda + Ridgewood

Date 1/28 Time 15:20

Temp 40 °F Weather Rain 2" last 24 hrs

Personnel AH SP DJ

Is the unit functioning properly? N/A removed 1/26 If not, describe problem in comments

Has there been an overflow since the last visit? ~~No~~ ?

Is the manhole overflowing now? NO

Is this site equipped with an automatic sampler? NO If so, complete the composite sheet.

Are there any noticeable problems with the manhole or overflow pipe? NO

If so, call the city of Baltimore DPW and report site, use road address and overflow serial #.

Comments: Car parked on manhole lid. No entry

Appendix C
Analytical Results

Gascoyne Laboratories, Inc.

YOUR ON-TIME QUALITY LAB...

Baltimore, MD 21224

(410) 633-1800
(800) GAS-COYN
FAX NO.
(410) 633-5443
www.gascoyne.com

REPORT OF ANALYSIS

Report No: 9800480

Engineering Technologies Assoc
3458 Ellicott Center Drive
Suite 101
Ellicott City, MD 21043
Attn: Don Koch

This report of analysis contains test results for the following samples submitted to Gascoyne Laboratories, Inc. for project BALTO. CITY/207:

Client Sample I.D.,	Sample Type	Lab Sample No.	Received by Gascoyne
SEWER-4055; GRAB, 28-Jan-1998(1400)	Wastewater	980001643	28-Jan-1998

Gascoyne Laboratories, Inc.

YOUR ON-TIME QUALITY LAB...

Baltimore, MD 21224

(410) 633-1800
(800) GAS-COYN
FAX NO.
(410) 633-5443
www.gascoyne.com

REPORT OF ANALYSIS

Report No: 9800480

Engineering Technologies Assoc
3458 Ellicott Center Drive
Suite 101
Ellicott City, MD 21043
Attn: Don Koch

Client Sample I.D.,	Sample Type	Lab Sample No.	Received by Gascoyne
SEWER-4056; GRAB, 28-Jan-1998(1500)	Wastewater	980001644	28-Jan-1998

This Report contains the following:

A) Cover Letter
B) Test Results
C) Chain-of-Custody

All samples were analyzed following EPA protocols and other recognized methodologies as specified in the report. All laboratory Quality Control(QC) data associated with this report are within established control limits unless otherwise noted in this report.

Gascoyne Laboratories, Inc. laboratory identification numbers:

Maryland :109; Delaware: MD015; Virginia: 00152; New Jersey: 60637; Pennsylvania: 68-339
West Virginia: 9901(C) and 054; New York: 11158; A2LA: 410.01; AIHA:8885; US Army Corps of Engineers; and EPA ICR: ICRMD003.

The analyses specified in this report may or may not be included in the scopes of the above listed certifications.

This cover page is an integral part of this report and must be included with all copies of this report.

Final report reviewed by: James H. Newman, Laboratory Manager — 2/10/98 Report issue date

Please see reverse side for explanation of terms and other information.

Gascoyne Laboratories, Inc.

YOUR ON-TIME QUALITY LAB...

Baltimore, MD 21224

(410) 633-1800
(800) GAS-COYN
FAX NO.
(410) 633-5443
www.gascoyne.com

REPORT OF ANALYSIS

Report no: 9800480

Client: Engineering Technologies Assoc

Sample Id: Submitted samples: SEWER-4055; GRAB collected on 28-Jan-98(14:00)
Laboratory Sample Number: 980001643

Parameter	Test Results	Reporting Limit	Method	Analyst	Date of Analysis
BOD(5 days)	39 ppm	3 ppm	EPA-405.1	AVE	29-Jan-98(14:15)
Fe_ Coliforms	>160000 org/100ml	200 org/100ml	SM-9221E	TMV	28-Jan-98(17:10)
Detergents(MBAS)	2.9 ppm	0.20 ppm	EPA-425.1	RED	29-Jan-98(16:50)
Nitrite(as N)	0.043 ppm	0.005 ppm	SM-4500 NO2-B	AVE	29-Jan-98(15:30)
Nitrate(as N)	2.9 ppm	0.1 ppm	EPA-353.2	TTM	30-Jan-98(14:26)
TKN(as N)	5 ppm	1 ppm	EPA-351.3	TTM	02-Feb-98(13:40)
Total Organic Carbon	13 ppm	1.0 ppm	EPA-415.1	TTM	04-Feb-98(08:30)
Total Phosphorus(P)	0.60 ppm	0.02 ppm	SM-4500 P E	JMT	04-Feb-98(13:30)

Gascoyne Laboratories, Inc.

YOUR ON-TIME QUALITY LAB...

Baltimore, MD 21224

(410) 633-1800
(800) GAS-COYN
FAX NO.
(410) 633-5443
www.gascoyne.com

REPORT OF ANALYSIS

Report no: **9800480**

Client: **Engineering Technologies Assoc**

Sample Id: **Submitted samples: SEWER-4055; GRAB collected on 28-Jan-98(14:00)**
Laboratory Sample Number: 980001643

Parameter	Test Results	Reporting Limit	Method	Analyst	Date of Analysis
Total Suspended Solids	41 ppm	5 ppm	EPA-160.2	DMW	29-Jan-98(10:47)

Gascoyne Laboratories, Inc.

YOUR ON-TIME QUALITY LAB...

Baltimore, MD 21224

(410) 633-1800
(800) GAS-COYN
FAX NO.
(410) 633-5443
www.gascoyne.com

REPORT OF ANALYSIS

Report no: 9800480

Client: Engineering Technologies Assoc

Sample Id: Submitted samples: SEWER-4056; GRAB collected on 28-Jan-98(15:00)
Laboratory Sample Number: 980001644

Parameter	Test Results	Reporting Limit	Method	Analyst	Date of Analysis
BOD(5 days)	44 ppm	3 ppm	EPA-405.1	AVE	29-Jan-98(14:17)
Fecal Coliforms	>160000 org/100ml	200 org/100ml	SM-9221E	TMV	28-Jan-98(17:10)

Sample/Test Notes:
Bacteria samples were positive for sodium thiosulfate.

Parameter	Test Results	Reporting Limit	Method	Analyst	Date of Analysis
Detergents(MBAS)	1.9 ppm	0.20 ppm	EPA-425.1	RED	29-Jan-98(16:50)
Nitrite(as N)	0.043 ppm	0.005 ppm	SM-4500 NO2-B	AVE	29-Jan-98(15:30)
Nitrate(as N)	2.9 ppm	0.1 ppm	EPA-353.2	TTM	30-Jan-98(14:26)
TKN(as N)	5 ppm	1 ppm	EPA-351.3	TTM	02-Feb-98(13:40)
Total Organic Carbon	14 ppm	1.0 ppm	EPA-415.1	TTM	04-Feb-98(08:30)
Total Phosphorus(P)	0.62 ppm	0.02 ppm	SM-4500 P E	JMT	04-Feb-98(13:30)

Gascoyne Laboratories, Inc.

YOUR **ON-TIME** QUALITY LAB...

Baltimore, MD 21224

(410) 633-1800

(800) GAS-COYN

FAX NO.
(410) 633-5443

www.gascoyne.com

REPORT OF ANALYSIS

Report no: 9800480

Client: Engineering Technologies Assoc

Sample Id: Submitted samples: SEWER-4056; GRAB collected on 28-Jan-98(15:00)
Laboratory Sample Number: 980001644

Parameter	Test Results	Reporting Limit	Method	Analyst	Date of Analysis
Total Suspended Solids	39 ppm	5 ppm	EPA-160.2	DMW	29-Jan-98(16:00)

SAMPLE SUBMITTAL — CHAIN-OF-CUSTODY

Page ___ of ___

Sample Type Codes:					
Air - Airbag	AB	Sludge	SL	Water - Drinking	WD
Air Filter	AF	Soil	SO	Groundwater	WG
Sorbent Tubes	AT	Trip Blank	TB	Surface	WS
Field Blank	FB	Waste - Liquid	LW	Wastewater	WW
Oil(s)	OI	- Solid	SW	Wipes	WP
Paint Chips	PC				

GASCOYNE LABORATORIES, INC.

YOUR **ON-TIME** QUALITY LAB...

2101 Van Deman Street • Baltimore, MD 21224
410 633 1800 • FAX 410 633 5443

LAB USE ONLY
Report # 98004805
Temp. Blk. ________
Cooler # ________

Test Results to:

Company: ETA
Contact: ANDY HUBER
Phone No. 410-461-9760
FAX No.

Sample Site/Project: BALT. City / 002 sewers
Sampler/MDOE #
Gascoyne Quote #
Client's P.O. #

RESULTS NEEDED BY: ☐ ROUTINE (10-15 DAYS) ☐ PRIORITY* BY: ____/____/____

TESTS REQUIRED: BOD; TOC; TOTAL P; TKN; NITRITE NO2; NITRATE NO3; TSS; MBAS; FECAL COLIFORM

LIMS NO. LAB USE ONLY	SAMPLE TYPE (USE CODES ABOVE if applicable)	SAMPLE IDENTIFICATION (Keep brief and assign sample numbers if possible)	DATE COLLECTED	TIME COLLECTED	COMPOSITE	GRAB	NPDES	NUMBER OF CONTAINERS	BOD	TOC	TOTAL P	TKN	NITRITE NO2	NITRATE NO3	TSS	MBAS	FECAL COLIFORM	COMMENTS (i.e. Data Package, methods, detection limits, etc.)
1643	WW	SEWER-4055	1/28	14:00		X		6	X	X	X	X	X	X	X	X	X	
1644	WW	SEWER-4056	1/28	15:00		X		6	X	X	X	X	X	X	X	X	X	

2 unpres. 'B' per # ; 2 'S' in 50

Total Number of Containers: 12

Relinquished By (signature)	Printed Name/Affiliation	Date/Time	Received By (signature)	Printed Name/Affiliation	Date/Time
[signature]	DAVE DACOSTA	1/28 16:42	[signature]	M. MASON / GLI	1-28-98 16:42

*May Require Surcharge

WHITE COPY - LAB   YELLOW - REPORT COPY   PINK - CLIENT SAMPLE SUBMITTAL RECEIPT

CITY OF BALTIMORE
DEPARTMENT OF PUBLIC WORKS

FLOW MONITORING AND HYDRAULIC MODELING REPORT
JONES FALLS SEWERSHED

ENGINEERING AND PROJECT MANAGEMENT SERVICES
BALTIMORE CITY PROJECT No. 639

December 1998
Revised February 1999

Table of Contents

List of Figures

List of Tables

List of Appendices

EXECUTIVE SUMMARY

As a part of Baltimore City Project No. 639, Rummel, Klepper and Kahl, LLP performed flow monitoring and hydraulic modeling in the Jones Falls Sewershed. Flowmeters and rain gauges were installed and monitored from April through November 1997 at various locations throughout the sewage conveyance system. Following the flow monitoring, a two-year storm event inflow and infiltration analysis was performed using the hydraulic model XP-SWMM32.

The Jones Falls Sewershed encompasses approximately 39 square miles; roughly half of which is located within the City of Baltimore and half in Baltimore County. The sewer system is comprised of three basic sections: the Upper Jones Falls or Pumped Section (pumped from the Jones Falls Pumping Station to the High Level Outfall), Baltimore County (which drains into the Pumped Section) and the Lower Jones Falls or Gravity Section (which is discharged directly into the High Level Outfall). Over 330,000 linear feet of 12-inch and larger gravity sewers were monitored by 21 meters installed in the Jones Falls Sewershed, six were located in Baltimore County. Three rain gauges were installed during the flow monitoring period to collect concurrent rain event data.

Flow monitoring serves to separate and quantify the three primary components that comprise flow in sanitary sewers: base flow, infiltration, and inflow. A spreadsheet was used to calculate the infiltration and inflow values using 1997 winter quarter water consumption data provided by the City and the two week dry weather flow obtained from flowmeter data. Daily and hourly factors were determined using the spreadsheet in order to calculate a model flow which was imported into XP-SWMM32. Flow values for the model data, as well as infiltration, were divided according to Sewer Service Area (SSA) and imported into the furthest upstream manhole of each SSA.

Calibration of the model was performed by comparing dry weather flow from the meter and the output from running the model data. Various problems arose during calibration that required a complete and detailed investigation of the flowmeter data and the calculated parameters. Certain characteristics of the model, such as overflows and siphons, required specialized set-up within the model.

After the model was calibrated, inflow data was imported to simulate a two-year storm event, corresponding to 3.19 inches of rainfall within a 24-hour period. The peak of the calculated inflow hydrograph was matched to the peak of the day for each meter site to simulate the worst case, highest rate of flow scenario.

The following table shows the current peak flowrates for the Pumped and Gravity Sections of the Jones Falls Sewershed during dry-weather and wet-weather flows. It should be noted that the peak wet weather flow of 45.7 million gallons per day (mgd) exceeds the maximum capacity of the Jones Falls Pumping Station (34 mgd). The excess flow that would have overflowed into the Gravity Section was accounted for in the conservative input values used for the Gravity Section model. Therefore, the total flow contribution to the Back River WWTP from the Jones Falls Sewershed, under the peak wet weather flow conditions, would be 107.7 mgd (34 mgd from the pumping station in the Pumped Section and 73.7 mgd from the Gravity Section)

SUMMARY OF HYDRAULIC MODEL RESULTS			
	Avg. Dry Weather Flow + Infiltration	Avg. Wet Weather Flow	Peak Wet Weather Flow
Pumped Section @ JP73	15.4 mgd	28.4 mgd	45.7 mgd
Gravity Section @ JG082	23.4 mgd	42.6 mgd	73.7 mgd

The volume of flows exfiltrating from manholes and overflows in the sewer system totaled over 8 million gallons. There were three active overflows in the Pumped Section and one in the Gravity Section contributing to this volume. Over 33% of all manholes within the Pumped Section were surcharged, and over 37% in the Gravity Section. The majority of the mainline interceptor for both sections was shown having deficient capacity. Over 30% of the total length of the entire conveyance system was shown as deficient. Several branches in the Gravity Section were shown as deficient along their entire lengths as well.

A future flow analysis was performed using the 2020 population projections obtained from the City's on-going Wastewater Comprehensive Plan study. The same inflow and infiltration values were used as the two-year storm event analysis, except the infiltration values were increased 10%. The future flow results were similar to the current flow results. Deficient capacity was shown to occur in the same locations as found for the current two-year storm event analysis. The major difference was the future flow analysis showed almost one million gallons more flow leaving the system through surcharged manholes and active overflows than under current conditions.

In comparing the Jones Falls hydraulic modeling results to the *201 Facility Plan*, similar findings were made for portions of the sewer system. The major differences were found in the Gravity Section where the XP-SWMM32 results showed deficient capacity in the JGB and JGC branches and not in the JGD branch, whereas the *201 Facility Plan* showed the opposite results.

Based on the results of flow monitoring and hydraulic modeling described in this report, Phase II flow monitoring will be performed in order to verify modeling results and clarify the boundaries of the deficient areas. This will lead to the development of design projects to eliminate sewer overflows, alleviate inflow and infiltration problems and address deficient sewer capacities.

8.0 CONCLUSIONS AND RECOMMENDATIONS

As a result of the flow monitoring and subsequent hydraulic modeling of the Jones Falls Sewershed, a dependable and thorough analysis of the current conditions of the sewer system has been completed. An I/I analysis has been performed on flowmeter data and the hydraulic model XP-SWMM32 has been run for a two-year storm event.

The data analysis and hydraulic model showed that the resulting two-year, 24-hour storm would produce a peak flow of 107.7 mgd to the Back River Wastewater Treatment Plant from the Jones Falls Sewershed. The average daily dry weather flows consist of 38.8 mgd of that flow, leaving 68.9 mgd of additional flow due to rain-induced inflow. The Pumped Section of the Jones Falls contributed 15.4 mgd to the average daily dry weather flow value and 18.3 mgd to the rain induced inflow. The Gravity section provided the other half of the total flow, 23.4 mgd as average daily flow during dry weather flow and 50.6 mgd as inflow during wet weather.

Table 17
SUMMARY OF CURRENT 2-YEAR STORM HYDRAULIC MODEL RESULTS

	Avg. Daily Flow (mgd)	Peak Flow (mgd)	Time of Day Peak Flow Occurred	Min Flow (mgd)	Time of Day Min. Flow Occurred	Volume Exfiltrated (million gallons)	Overflow Volume (million gallons)
Pumped Section @ JP73	28.4	45.7	1:15 pm	18.4	5:00 am	0.1	4.066
Gravity Section @ JG082	42.6	73.7	11:45 am	28.2	4:15 am	3.5	0.37

The results of the hydraulic model are shown in Table 17. Note that the peak flow for the Pumped Section exceeds the pumping station maximum capacity of 34 mgd. The excess flow in this section overflows into the Gravity Section and is accounted for in the already conservative values entered in the model for the Gravity Section.

Minimum flows occurred during the early hours of the morning (between 2:00 a.m. and 5:00 a.m.), as expected, when the flow is usually comprised of only constant infiltration. The Jones Falls Sewershed generated a total minimum flow of only 28 mgd entering the High Level Outfall. The Pumped section contributed approximately 12 mgd of flow during this time, which was primarily accounted for by the constant infiltration amount from all the meters in this section. A total of 16 mgd was produced by the Gravity section and again was primarily comprised of the constant infiltration at all meters in this section.

In comparing the XP-SWMM32 hydraulic modeling results to the *201 Facility Plan*, similar findings were made for some portions of the sewer system and differing results in others. The major similarity between the XP-SWMM32 results and the *201 Facility Plan* was that large portions of the mainline interceptor in the Pumped and Gravity sections were shown as deficient. Other areas where similarities were found were along the majority of the Western Run section, the lower portion of Stony Run, the JGE branch in the Gravity section, and the lower portion of the JGAA branch in the Gravity section. There were, however, some discrepancies in the results, particularly in the Gravity section. The XP-SWMM32 results showed serious deficient capacity problems in the JGB and JGC branches, whereas this problem did not appear in the *201 Facility Plan*. Conversely, the XP-SWMM32 results showed no problems in the JGD branch, whereas the *201 Facility Plan* showed this branch as deficient. However, there was a good overall correlation between the *201 Facility Plan* and the XP-SWMM32 model results.

Based on the results of flow monitoring and modeling described in this report, Phase II flow monitoring will be performed to verify the modeling results and clarify the boundaries of the deficient areas. Meters may be placed on previously un-metered branches to verify the high inflow and infiltration values, such as the JGB and JGC branches in the Gravity section. The mainline interceptor in both the Pumped and Gravity sections may be metered at a midpoint location to determine if upper or lower portions of those sections are more problematic than others. Results of Phase II metering will be used to further refine the development of design projects and establishment of project scopes of work.

CITY OF BALTIMORE
DEPARTMENT OF PUBLIC WORKS

PHASE 2
FLOW MONITORING AND HYDRAULIC MODELING REPORT
JONES FALLS SEWERSHED

ENGINEERING AND PROJECT MANAGEMENT SERVICES
BALTIMORE CITY PROJECT No. 639

May 2000
Revised July 2000

<u>Table of Contents</u>

Final revisions to report made in July 2000 are indicated in italic text.

Final revisions to report made in July 2000 are indicated in italic text.

List of Figures

List of Tables

Final revisions to report made in July 2000 are indicated in italic text.

List of Appendices

Final revisions to report made in July 2000 are indicated in italic text.

DRAFT

List of Appendices

EXECUTIVE SUMMARY

This *Flow Monitoring and Hydraulic Modeling Phase 2 Report* presents a comprehensive summary of the Phase 2 flow monitoring and hydraulic modeling program established and performed by Rummel, Klepper and Kahl, LLP (RK&K) within the Jones Falls Sewershed, as a part of Baltimore City Project No. 639. During Phase 2, flowmeters were installed and monitored for a period between April 13 and September 27, 1999 at various locations throughout the Jones Falls sewage conveyance system. Following flow monitoring, a two-year storm event inflow and infiltration analysis was performed using the hydraulic model XP-SWMM32. These results were compared with the Phase 1 flow monitoring/modeling program results, previously completed by RK&K, as contained in the *Flow Monitoring and Hydraulic Modeling Report, December 1998.*

Over 330,000 linear feet of 12-inch and larger gravity sewers were monitored by 13 meters installed in the Jones Falls Sewershed. One rain gage was installed during the flow monitoring period to collect concurrent rain event data. Several Phase 1 metering locations were once again monitored to verify Phase 1 flow data or collect additional wet weather flow data. Updated flows from the Phase 2 data analysis were entered into the hydraulic model and the results evaluated.

The following table contains the updated peak flows for the Pumped Section (Upper Jones Falls) and Gravity Section (Lower Jones Falls) of the sewershed during dry-weather and wet-weather periods using a combination of Phase 1 and Phase 2 data. It should be noted that the peak wet-weather flow of 47 million gallons per day (mgd) exceeds the maximum capacity of the Jones Falls Pumping Station (JFPS) of 34 mgd. The total flow contribution to the Back River WWTP from the Jones Falls Sewershed, under the peak wet weather flow conditions, is calculated to be 95 mgd (34 mgd from the JFPS in the Pumped Section, and 61 mgd from the Gravity Section).

SUMMARY OF HYDRAULIC MODEL RESULTS			
	Avg. Dry Weather Flow + Infiltration	Avg. Wet Weather Flow	Peak Wet Weather Flow
Pumped Section @ JP76	15 mgd	32 mgd	47 mgd
Gravity Section @ JG082	18 mgd	43 mgd	61 mgd

The total volume of flow exfiltrating from manholes and sanitary sewer overflows (SSO's) in the sewershed is estimated to be over two million gallons. There were four active SSO's in the Pumped Section and two in the Gravity Section contributing to this volume. Over 36% of all manholes within the sewershed were surcharged. The majority of the main trunk sewers for both the Pumped and Gravity Sections are shown to have deficient hydraulic capacity. Approximately 40% of the total length of sewer for the entire conveyance system is shown as having deficient capacity. Furthermore, several branch interceptors in the Gravity Section are shown having deficient capacity along their entire lengths as well.

6.0 SUMMARY OF RESULTS

As presented in this report, a thorough analysis of the current conditions of the Jones Falls Sewershed sewer system, based on Phase 1 and Phase 2 flow monitoring and hydraulic modeling, has been completed. An I/I analysis has been performed using the flow meter data collected, and the hydraulic model XP-SWMM32 has been run for a two-year storm event. The results are shown in Table 11.

The data analysis and hydraulic model of the Jones Falls Sewershed show that the resulting two-year, 24-hour storm would produce a peak flow of 108 mgd that would be conveyed to the Back River Wastewater Treatment Plant, depending upon the future pumping capacity of the JFPS and carrying capacity of the discharge pressure sewer. The JFPS and pressure sewer can currently handle 34 mgd, which translates to a conveyance of 95 mgd of flow from the Jones Falls Sewershed to Back River at its peak wet-weather flows.

Of the potential total peak flow of 108 mgd, 33 mgd comprises the average daily dry-weather flows, leaving 75 mgd of additional flow contributed by rain-induced inflow and infiltration. The Upper Jones Falls (Pumped Section) of the sewershed contributes 47 mgd of peak wet-weather flow, and the Lower Jones Falls (Gravity Section) contributed 61 mgd.

Table 11
SUMMARY OF CURRENT 2-YEAR STORM HYDRAULIC MODEL RESULTS

	Avg. Daily Flow (mgd)	Peak Flow (mgd)	Time of Day Peak Flow Occurred	Min. Flow (mgd)	Time of Day Min. Flow Occurred	Volume Exfiltrated (million gallons)	Overflow Volume (million gallons)
Pumped Section @ JP76	15	47	1 p.m.	17	4 a.m.	0.31	0.55
Gravity Section @ JG082	18	61	12 p.m.	24	4 a.m.	0.90	0.30

City of Baltimore

Martin O'Malley
Mayor

Department of Public Works
Bureau of Water and Wastewater
Water and Wastewater Engineering Division

Phase I - Study and Investigation
Jones Falls Force Main and Pressure Sewer Study
Baltimore City Sanitary Contract No: 8510

Volume I - Final Report

October 2000

George L. Winfield
Director of Public Works

Amar Sokhey
Bureau Head
Bureau of Water and Wastewater

Prepared By
PURDUM AND JESCHKE, LLC
The Professional Engineering Center
8005 Harford Road
Baltimore, Maryland 21234

PURDUM and JESCHKE, LLC

The Professional Engineering Center
8005 Harford Road
Baltimore, Maryland 21234

Consulting Engineers and Land Surveyors
Civil • Structural • Environmental

Phone: 410-668-8800
Fax: 410-668-8801

November 22, 2000

Mr. Wasir Qadri
Baltimore City Department of Public Works
Bureau of Water and Wastewater
Room 305 Abel Wolman Building
Baltimore, MD 21202

RE: Jones Falls Force Main and Pressure Sewer Rehabilitation
Baltimore City Project No. 8510 - Final Report

Dear Mr. Qadri:

We are pleased to transmit ten copies of the Final Report of our findings on the Jones Falls Pressure Sewer. This report documents the findings of our investigation. Based on the current peak design flow of 47 MGD , we find that the existing pipe can not be rehabilitated using lining techniques available today and meet this capacity of flow.

We recommend that a phased replacement pipe be programmed and constructed in order to meet the flow requirement. We have included detailed budget cost estimates for these improvements.

The continued uninterrupted operation of the pipe line has proven to be difficult since there is no period of time for inspection and maintenance. We therefore recommend that after the new parallel replacement system is installed and operational that the existing pipe be inspected and upgraded for use as an alternate back-up pipe.

We trust that you will contact us for any additional information required or questions regarding the recommendations presented in this report. Please call if we can further assist you in the preparation of improvements to this important Baltimore City project.

Very truly yours,
PURDUM AND JESCHKE, LLC

John R. Tabak, P.E.
Project Manager

*** Table of Contents ***

CHAPTER VI

CHAPTER VII

*** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** ***

*** Table of Contents ***

APPENDIX VOLUME 2

*** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** ***

*** Table of Exhibits ***

*** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** ***

EXECUTIVE SUMMARY

1. The Jones Falls Pressure Sewer is a four mile long concrete pressure pipe built in the early 1950's. The pipe has suffered deterioration from hydrogen sulfide gas resulting in pipe failures and spills.

2. As a single pipe sewer system without a back-up, the pipe must remain in continuous operation. In the event of a pipe failure, it is necessary to repair the pipe using emergency by-pass pumping or other diversion means. Today, spills and overflows into the Jones Falls are not permitted and may result in fines to the City under the Clean Water Act.

3. Due to the continuing corrosion, the structural integrity of the existing pipe is uncertain. Breaks can be expected to occur, resulting in surface collapse and spills. This worst condition occurs at high points and negative pipe grades where partial flow allows hydrogen sulfide gas to collect. A complete inspection and lining repair of these locations is recommended.

4. Immediate repairs to the existing system are recommended. Inspection and repair or replacement of existing pipe, valves and vaults is required for continued operation.

5. Immediate chemical treatment is recommended to halt the pipe corrosion problem. A Hydrogen peroxide demonstration trial as offered by U.S. Peroxide is recommended for Spring 2001 to evaluate chemical treatment rates, costs and performance results.

6. The area with the greatest potential for failure along Broadway will be lined this year. This will reduce the immediate threat of pipe failure. Additional repairs may be required and pipe lining performed at areas along the existing pipe which are found to be structurally weakened.

7. Continued chemical treatment using hydrogen peroxide to be verified by demonstration contract is recommended. This will reduce the probability of pipe failure while a new pipe is constructed. The new sewer pipe is estimated to take seven years to be completed.

8. The present peak design flow for the system, 47 MGD, exceeds the capacity of the existing pipe and Jones Falls Pumping Station. This study recommends a new pipe system to carry future design sewer flows. A 42" minimum size pipe is required. The new pipe will be corrosion resistant. The final pipe size will depend on the route alignment and the pumps selected at the Jones Falls Pumping Station. See Exhibit 9-2. Phased construction is planned.

9. The recommended first phase of work is for a new 42" outfall sewer at Broadway from Oliver St. to E. Chase St. This will correct deficiencies to the pipe and existing terminal vault.

10. The retention of the existing pressure pipe is recommended to provide a back-up pipe and to act as a by-pass system for continued inspection and maintenance.

CHAPTER IX

FINDINGS AND RECOMMENDATIONS

A. FORCE MAIN

1. Two force mains, North and South, operate in parallel on a normal operating basis. Operation on a single main is not possible due to high pressure head requirements for peak flows.

2. The condition found at the North and South force mains is better than the partial flow sections of the system. Both mains are in fair to good condition with a long projected useful life.

3. The replacement of the 30" South Main is recommended to meet future projected peak flows. This pipe was constructed in the 1950's and has the smallest capacity of the two mains. A new alignment is recommended.

4. The 36" Main exhibits some scour and deterioration. It is recommended that this pipe be lined to extend its operating life, maintain the parallel pipe configuration and improve the flow characteristics.

5. There are serious maintenance problems which were found along both force mains. It is recommended that the following items be corrected immediately:

   a. Replace the existing defective gate valves on the 30" and 36" mains.

   b. Replace air release valves on both mains.

   c. Provide new blow-off connections.

   d. Provide a maintenance contract to service all valves on an annual basis.

6. Provide for meeting future peak flows by replacement of impellers, pumps, and improvement of friction head losses in the pumping system.

Summary

- **Perform immediate maintenance. Replace Existing Gate Valves on 30" and 36" Force Main**
- **Condition of both Force Mains is fair to good**
- **Provide for future replacement of 30" South Force Main**
- **Provide for lining of 36" North Force Main to keep operational**
- **Operation of Both Mains is required to meet peak flows**

B. PRESSURE SEWER

1. The overall condition of the pressure sewer is found to be, at best, fair. This rating combines the ratings of known poor sections of pipe and areas that have been repaired and are considered good.

2. The pipe is a single 36" concrete pipe (PCCP) and carries pressurized sewer flow on a continuous basis. There are no relief sewers available to carry the flow in the event of pipe failure. The pipe flows mostly full at all times except during the late night and early morning hours (1 AM to 8 AM).

3. There are sections of this pressure sewer that exhibit all parameters associated with pipe that is in danger of immediate failure. This determination is based on one section of pipe which was found to be leaking during testing performed under this study. As a result of sections of pipe found in poor condition, repair or replacement is required. This work may be completed on a phased construction schedule.

Summary

- **The condition of the Pressure Sewer is considered poor in sections and can fail under higher flows or pressures**
- **The existing pipe will not meet future flow requirements**
- **The Phased construction of a new pressure sewer pipe is recommended**

4. The available capacity will be reduced in this 36" pipe if it is lined. The diameter of the pipe could be reduced from 1.5" to 6" by the liner selected. The capacity will be reduced to a level below the required future peak flow of 47 MGD. and will not meet the future needs of the City. Also, the cost of installing a pipe liner while in operation requires performing by-pass operations. This increases the costs of a liner to a level that is a large portion of the cost of a new replacement pipe.

5. The addition of a new pressure sewer is recommended. The installation of a new sewer will allow the work to proceed independently of the existing sewer operation, under normal no-flow conditions. This will prove beneficial to construction methods and costs. A larger size pipe can be installed to increase pipe capacity and meet future demands. The pressure sewer pipe can be selected to meet project requirements, resist the corrosive conditions present within the sewer system and be sized for future peak flows. A dual parallel pipe system is the optimum operating condition.

6. Phased construction is recommended. See **Exhibit 9-2** for the sequence of phased work. The proposed alignment is not yet determined. The parallel alignment shown is for cost estimating purposes only. The present alignment is pictorially shown in Chapter 7 and numerous difficulties exist that can be improved with a new alignment. Further study of a new alignment is recommended as part of the design for a new pressure sewer pipe.

7. Immediate maintenance will require the servicing and possible replacement of air release valves and vault equipment. Some Blow-off valves will require the addition of pipe fittings for pump-out to a tanker truck where a nearby sewer outfall is not available. Corrosion protection of all surfaces is recommended. The use of non-corrosive materials such as stainless steel is recommended.

C. GRAVITY SEWER

1. The pressure sewer changes to a gravity sewer at the Vent Vault located at Broadway west of Harford Road. From that point the sewer has experienced numerous failures and collapses as a result of severe corrosion to the pipe. The original 27" gravity sewer was abandoned and replaced with a 36" pipe. The condition of this section of sewer is rated poor due to its history of corrosion.

2. At present an emergency repair contract is being performed to repair and line the existing 36" gravity sewer. The lining is not considered to be a total structural repair but will extend the total life of the existing sewer pipe.

3. A portion of the pipe is 30" ductile iron pipe south of Oliver Street. This section of pipe transitions from gravity to pressure sewer which operates under a surcharge at high flows. The section of 30" pipe is inadequate in size to meet peak flow requirements.

Summary

- **The portion of gravity sewer is exposed to the highest levels of hydrogen sulfide corrosion and has a past history of repeated pipe failures**
- **The existing sewer and liner will not meet future peak flows demands**
- **A new parallel sewer is recommended**

4. It is recommended that the existing gravity sewer be supplemented with a new parallel sewer pipe. This will allow the new pipe to be sized for future flows, be more corrosion resistant and be structurally sound under anticipated pressures and loadings.

5. The existing pipe should be retained to allow a back-up capability for future maintenance and repairs.

6. This section of sewer may flow under a pressure surcharge during peak flows. The recommended new outfall pipe will reduce this pressure gradient. However, a calculation of the gradient must be performed for all operating conditions particularly for the existing 30" pipe with liner and valve controls. It may be necessary to consider the design as a pressure pipe system and not a gravity system as the computed gradient dictates.

D. CONNECTION TO OUTFALL SEWER

1. The condition of the 30" connection sewer is not known. Based on its age, it is rated as fair condition. The pipe operates in a surcharge condition due to its relatively flat grade.

2. The existing pipe will not meet the future peak flows due to limitations of size and grade.

3. The existing terminal vault is in need of major rehabilitation. The design configuration causes continued flow back-ups and its location adjacent to residential properties is a source of repeated odor complaints.

4. This report recommends supplementing the existing sewer connection with a new outfall along Broadway and a new connection to the High Level Outfall Sewer. The existing pipe and Terminal vault may be used as a secondary connection in addition to new Broadway Outfall. **See Chapter 8 for more specific plans and details.**

Summary

- **Replacement of the outfall sewer is recommended**
- **Construct a new sewer outfall along Broadway**
- **Restore the capacity of the existing Main Outfall by removal of silt deposits**
- **Provide City Maintenance Capability in Live Sewers**

5. The Main Outfall Sewer was found to contain large amounts of silt deposits. The reduction in capacity within the Main Outfall Pipe impacts on the performance of the pressure sewer connection and will increase the levels of sewer surcharge upstream. This condition is shown on Exhibit 3-6. It is recommended that the silt be removed under contract to restore the capacity within the Outfall Pipe lost to high levels of siltation which have accumulated over the past century of use.

6. The normal cleaning of live sewers such as the Terminal Vault is not available by City maintenance staff. All work including the work performed under this study must be contracted out side of the City. It is recommended that the City workers be trained and equipped to safely perform normal maintenance functions in live (flowing) sewers, including manual and power cleaning as part of their required services. This requirement will be needed for cleaning of the pressure sewer system in the future in order to keep it flowing at all times.

7. Rehabilitation of the existing 30" pipe, terminal vault and 20" pipes is recommended to be performed after the new outfall is constructed. At that time the pipes and vault will require inspection, repairs and the application of a corrosion resistant lining. The cost of rehabilitation will be significantly reduced without the high flows to be by-passed around the work site.

8. Immediate maintenance is recommended to keep this connection operational. Normal inspection, repair and periodic cleaning is required. The addition of a bar screen will permit the collection and removal of debris from the terminal vault.

E. ODOR CONTROL/CHEMICAL TREATMENT

1. The pressure sewer exhibits all traits of extreme high levels of hydrogen sulfide.

2. The reoccurring problem of corrosion may be directly attributed to hydrogen sulfide.

3. Chemical treatment is recommended to be added to the pressure sewer at the Pumping Station. Chemical treatment can neutralize the effects of hydrogen sulfide, reduce odors and reduce corrosion. Several methods are available to the City. Hydrogen peroxide has widely replaced chlorine as a treatment method due to its cost, handling and safety characteristics.

4. Immediate measures to provide treatment to neutralize hydrogen sulfide in the sewage are recommended. Treatment will slow the rate of pipe corrosion and extend the life of the sewer. It is known that the existing pipe is seriously weakened by corrosion and can fail at any time. Immediate treatment will reduce the probability of a spill from occurring due to a pipe failure.

Summary

- **Chemical treatment is recommended**
- **Treatment should be applied at the Pumping Station**
- **Hydrogen peroxide treatment appears most cost effective**
- **A Demonstration trial has been offered by U.S. Peroxide for early Spring 2001**
- **Treatment will extend the life of the pipe and reduce the probability of a sewage spill**

5. U.S. Peroxide has submitted a proposal to the City to provide a temporary trial demonstration to evaluate the effects and results of treatment using hydrogen peroxide. The cost compares favorably for using hydrogen peroxide if the desired results can be obtained. The hydrogen peroxide trial should be scheduled for the next warm weather period in order to evaluate its performance during peak hydrogen sulfide production periods.

6. Hydrogen peroxide treatment is recommended to be continued until a new pipe system is installed. Its use would be subject to the successful completion of the hydrogen peroxide trial.

7. All materials including the pipe, valves, vaults and other structures should be constructed from materials resistant to hydrogen sulfide generated acids and be designed for complete corrosion resistance. This will require the use of special materials which, although more costly, will prove more cost effective by the increase to the useful life.

8. The odors created by the emission of sewer gases may be considered serious environmental concerns within the City. The methods used for the treatment of odors are the same as for the reduction of corrosion. Both methods require the reduction or removal of hydrogen sulfide. Methods that are designed to mask the smell at specific locations using point treatment are <u>not</u> recommended since they do not treat the problem but only conceal it.

F. IMMEDIATE PRIORITY REQUIREMENT FOR REHABILITATION AND MAINTENANCE OF ENTIRE SYSTEM

Summary

- **Immediate pipe repair and lining is a priority**
- **Provide 30" and 36" gate valve replacement**
- **Provide air release valve replacement and vault corrosion protection**
- **Provide environmental blow-off fittings for removal of sewage by trucks**
- **Provide cleaning and rehabilitation of the existing Terminal Vault**
- **Provide bar screen to prevent clogging of 20" pipes**

1. There were immediate maintenance issues found during the performance of this study that need to be corrected. Provide pipe repairs and lining for weakened sections of the existing 36" pipe. These are necessary to continue normal operations and prevent a sewage spill.

2. The 30" gate valve located on 33rd Street can not be operated. This could be a serious problem in an emergency and require the complete shut-down of the sewer. It is recommended that this valve be replaced. Isolation of the North Force Main requires the operation of the 36" valve. The condition of this valve is not known due to its submergence. Replacement of this valve is also included in the budget. The valve maintenance/replacement will require the isolation of each force main using line stops. Access to the valves within each valve vault will require excavation and the removal of the top slab. Valve operation may be improved with the use of actuators.

3. The air release valves were found to be seriously corroded. Valves, piping and mechanical systems located within the air release vaults must be serviced and damaged equipment replaced. The continued daily operation of air and vacuum release is necessary for the normal pumped operation of flow. Failure of these air controls could shut down the pumping or result in a collapsed pipe as a result of excessive negative pressures. Corrosion protective linings are recommended for the vault surfaces and for equipment located within the vault. The use of stainless steel valves should be considered for all work within the air release vaults.

4. The blow-off valves were in relatively good condition, however, the discharge of sewage is not permitted into or onto waterways, storm drains or ground surfaces. The installation of pipe fittings to eliminate illegal discharges and allow a pumped discharge to a tanker truck is recommended.

5. The Terminal Vault requires cleaning and rehabilitation. Surfaces are deteriorated and require water blasting and surface coating. A bar screen is recommended to prevent clogging of 20" pipes and facilitate cleaning within the Terminal Vault. Equip and train City maintenance personnel to perform live cleaning within the Terminal Vault.

G. PHASED CONSTRUCTION OF A NEW PARALLEL PIPE AND BACK-UP SYSTEM

1. The replacement of the pressure sewer system is recommended to improve system reliability and to plan for future system demands. The conditions found during this study show that system reliability is low due to the deteriorated condition of sections of the sewer. Future pipe failures can be expected until system reliability is improved.

2. Replacement of the system is recommended to be performed independently of the existing pipe. The new parallel system in conjunction with the existing pipe system will create two independent pipe systems - a primary and a back-up system. Cross connections with valves are recommended for shutting down and diversion of flow from one pipe to another.

Summary

- **A new parallel pipe is recommended**
- **Phased construction based on cost and condition is possible**
- **Retention of the existing pipe as a back-up system is recommended**
- **An alignment study is required**

3. Since the existing pipe system cannot meet existing or projected peak flows a new adequately sized pressure sewer is required. This new system may be constructed in phases as shown in Exhibit 9-2 with the corresponding budget costs shown in Chapter 10.
The new pipe system must be sized and designed for the most effective alignment to avoid difficult construction and yet provide for interconnections between the two systems to achieve a parallel capability. The selection of the phased order of construction should be based on the pipe condition, age, probability of failure and cost. Contract lengths and sections should be flexible and based on the current conditions at the time of design. A detailed alignment study is required for the entire new parallel pipe system.

4. The selection of pipe materials used should be based on performance. A matrix ranking was performed as part of this study and Ductile Iron Pipe with a corrosion resistant interior lining was ranked highest.

5. The existing pipe will be able to by-pass average daily flows for routine or emergency maintenance. The lining and repair of the existing pressure pipe is recommended once the new phased sewer is completed.

H. FUTURE REQUIREMENTS

1. Forecasts for the future needs and requirements are always difficult. This study has revealed that the Jones Falls Pressure Sewer is one part of a totally integrated wastewater system. This pressure pipe conveys sewage around other systems that do not have sufficient capacity. Future flows are projected to change based on land development and pipe condition.

2. Present studies are being performed by the City to identify future peak flows. The peak design flow number has changed during the course of this study from 36 MGD to 47 MGD as a result of these studies. It is recommended that the Jones Falls Pressure Sewer be sized to meet the projected future flow. An allowance for future increases should be also be provided.

Summary

- **Future forecasts for change must be considered**
- **Pumping requirements will be exceeded in the future**
- **Downstream conveyance Outfall Sewer must be cleaned**
- **Changes to sewersheds are major changes not considered**

3. The Pumping Station will not be able meet the projected future flows without major upgrades. The pumps form a crucial part of operating a reliable and energy efficient system. The present design capacity is 36 MGD with two pumps operating, and with one in reserve. **See Picture 9-1.**

4. There are studies being considered to connect other entire sewersheds into this pipe system. This study could not include these issues which are under separate study.

5. The final conveyance system to the treatment plant displays serious problems of siltation with depositions of solids caused by low velocities and flat grades. These have occurred slowly over a long period of time. The time will approach when the mechanics of sediment movement will cause choking within a section of the outfall resulting in uncontrolled overflows.

6. This report is based on present conditions. This report offers recommendations to improve the operation and reliability of the Jones Falls Pressure Sewer System. These recommendations are included in this Chapter and are described in Exhibit 9-2. Budget cost estimates are included for planning purposes in Chapter 10 for each recommended Phase of construction.

CITY OF BALTIMORE
DEPARTMENT OF PUBLIC WORKS

DRAFT

PHASE I & II METERING
Final Flow Monitoring Report
Gwynns Run Portion of High Level Sewershed
Project No. 721

September 25, 2000

Prepared by
Hyder Consulting, Inc.

Hyder

Table of Contents

Page

Executive Summary

This final flow monitoring report is being submitted to the City of Baltimore in accordance with the Scope of Services for the Gwynns Run portion of the High Level sewershed.

Included within this report is a site map of the Phase I and Phase II flow monitoring locations, graphs and tabulations of flow data including peak, average, and dry weather flows, and rain data showing daily tabulations of rainfall amounts. Additionally, this report incorporates all information contained in the previously submitted interim flow monitoring reports dated August, 1999 and January, 2000.

Phase I metering was intended to assist in the identification of the hydraulic capacity analysis of the sewer system, the existing base sewage flows in the system, existing infiltration levels, and storm inflow levels. The purpose of Phase II metering was to obtain additional flow monitoring to further define specific sub-areas contributing excessive I/I and to refine the flow estimates generated by the hydraulic model.

7.0 TECHNICAL SUMMARY

The information presented within this flow monitoring report is intended to provide hydraulic information relative to the Gwynns Run portion of the High Level sewershed. The primary objective of the Phase I metering investigation was to gain a better perspective on flow through the conveyance system under various dry and wet weather conditions. This included an understanding of flow characteristics as well as variation in flow rates on an hourly and daily basis. Historical records, flow meters, and rain gauges were collectively used to help determine the hydraulic capacity of the sewer system, the existing base sewage flows in the system, existing infiltration levels, and storm inflow levels. Phase II metering was conducted to obtain additional flow monitoring data to further define specific sub-areas contributing excessive I/I and to refine the flow estimates generated by the hydraulic model. These data were evaluated to determine a representative dry weather metered flow which was utilized to help determine infiltration and inflow rates to the Gwynns Run collection system.

CITY OF BALTIMORE
DEPARTMENT OF PUBLIC WORKS

FLOW MONITORING REPORT
HERRING RUN SEWERSHED

ENGINEERING AND PROJECT MANAGEMENT SERVICES
BALTIMORE CITY PROJECT No. 635

Table of Contents

APPENDICES

REFERENCES

SEWER SYSTEM INFRASTRUCTURE ANALYSIS AND REHABILITATION, UNITED STATES ENVIRONMENTAL PROTECTION AGENCY, OCTOBER 1991, pp .27.

EXISTING SEWER EVALUATION AND REHABILITATION, WATER ENVIRONMENT FEDERATION, 1994, pp.74, 75.

DESIGN OF WASTEWATER AND STORMWATER PUMPING STATIONS, WATER ENVIRONMENT FEDERATION, 1993, pp. 27-29.

FLOW MONITORING REPORT
HERRING RUN SEWERSHED

1.0 PROJECT DESCRIPTION

The City of Baltimore has ranked and identified certain priority projects in the City's ten (10) major sewersheds that comprise the Back River Sewer System Service Area (total area covering 213 square miles). These were pursuant to the *Final Submission of Facility Plan for Back River Conveyance System - Phase 2, 201 Facility Plan, (EPA Project No. C-240621-01)* prepared with the assistance of Whitman, Requardt and Associates, LLP (updated in March 1992). This *201 Facility Plan* developed various alternatives for the sewersheds for overcoming various deficiencies of the gravity sewers, pumping stations and force mains which make up the conveyance system transporting wastewater to the Back River Wastewater Treatment Plant (WWTP). These alternatives included the provision of supplemental relief sewer systems in sections identified to be hydraulically deficient, elimination of excessive inflow/infiltration, and correction at locations experiencing discharges (overflows) of untreated wastewater.

A number of priority projects identified by the City are related to rehabilitation of portions of the conveyance system and require engineering design and construction services to be provided to the City. The City awarded a contract to George, Miles & Buhr, LLP (GMB) for the Herring Run Sewershed (City Project No: 635). The primary goal of this sewershed project is the elimination of wet-weather sewage overflows into the environment. A secondary goal is to conduct a pilot study within the sewershed to determine the effectiveness of an inflow reduction program. The overall goal is to address current problems with the sanitary sewer and to prepare for future flows.

1.1 HERRING RUN SEWERSHED

The Herring Run Sewershed, encompassing approximately 25 sq. miles, (mostly within the City of Baltimore), has a population of about 190,000 (194,526 in 1995 and 185,924 projected in 2020) and is more than 97% developed. This drainage basin is served by more than 270,000 linear feet of gravity sewers. They range in size and configurations from 6 to 12-inch diameter circular collection sewer pipes to larger branch interceptors. The major interceptors include non-circular conduits, such as 72-inch horseshoe-shaped sewers in the lowermost reaches of the Herring Run Sewershed. Just downstream of the sewershed, wastewater is conveyed by the 12-foot by 11-foot semi-elliptical Outfall to the Back River WWTP.

Eleven (11) sub-sewershed areas within the Herring Run Sewershed were previously delineated in the 201 Facility Plan and they will remain the same for this report. Much of the wastewater flow is conveyed by two primary parallel gravity sewer lines, the Herring Run Main and the Herring Run Relief Interceptors. These two parallel interceptors join together near Lake Montebello to form the Herring Run Interceptor that exits the sewershed as a 72-inch horseshoe-shaped gravity sewer. The seven (7) sub-sewersheds tributary to the Herring Run Interceptor are the East Branch Herring Run, West Branch Herring Run, Chinquapin Run, Tiffany Run, Herring Run (Central), Moores Run, and Moores-Herring Run Low. The remaining four sub-sewersheds (Herring Run Low Level, Moores Run Low Level, Garden Village and Summit Farms) convey wastewater to the Quad Avenue Pump Station. Wastewater from the Quad Avenue Pump Station is pumped via a 36-inch force main to the Outfall leading to the Back River WWTP.

1.2 METER LOCATIONS

The Herring Run Sewershed was divided into eighteen (18) drainage areas for the initial Phase 1 flow analysis. Through the Phase 1 metering program, specific areas within the entire sewershed were identified as problem areas and then further analyzed and inspected for infiltration and inflow. The Phase 1 flow meters were installed and metering began in April of 1997. The installation, maintenance, and

5.7 CONCLUSIONS AND RECOMMENDATIONS

In conclusion, the flow monitoring program and XP-SWMM analysis determined that the Herring Run Sewershed does not have as many problems as was shown in the 201 Facility Plan, however; various problem areas do overlap between the 201 Facility Plan and the XP-SWMM analysis. The XP-SWMM analysis showed that the majority of the capacity problems as well as most of the overflow and flooding occurred in the Moores Run Drainage Area. This is the case in both the Year 2000 and 2020 conditions. The XP-SWMM analysis also showed that there was not a significant change in the hydraulic adequacy of the Herring Run Sewershed between the current (Year 2000) flows and projected (Year 2020) future flows.

CITY OF BALTIMORE, MARYLAND
DEPARTMENT OF PUBLIC WORKS
BUREAU OF WATER AND WASTEWATER
WATER AND WASTEWATER ENGINEERING DIVISION

Infiltration/Inflow (I/I) Report
Gwynn's Falls Sewershed I/I Study
Sanitary Contract No. 8509

June 2000

DRAFT

URS

Morgan Millworks Building
1801 Falls Road, Suite 3B
Baltimore, Maryland 21201

Gwynns Falls Sewershed Study
Inflow & Infiltration (I/I) Report

Table of Contents

List of Tables

List of Figures

Executive Summary

The Gwynns Falls Sewershed Study has five objectives to complete within a five year time frame beginning August 5, 1998 (contract signature date). These goals are listed as follows, and are presented in their projected sequence of occurrence.

1. Identify general areas within the Patapsco WWTP service area that may be contributing excessive inflow to the plant.
2. Identify areas within the City portion of Gwynns Falls Sewershed where capacity deficiencies are resulting in back-ups or overflows.
3. Develop long-term projections for the entire Gwynns Falls Sewershed.
4. Develop a comprehensive conveyance system rehabilitation program for the Gwynns Falls Sewershed to meet current and future needs while addressing State or Federal mandated water quality objectives.
5. Oversee the design and construction of new facilities to rehabilitate the Gwynns Falls Sewershed.

These objectives have been grouped together in three distinct stages of work progression for this study.

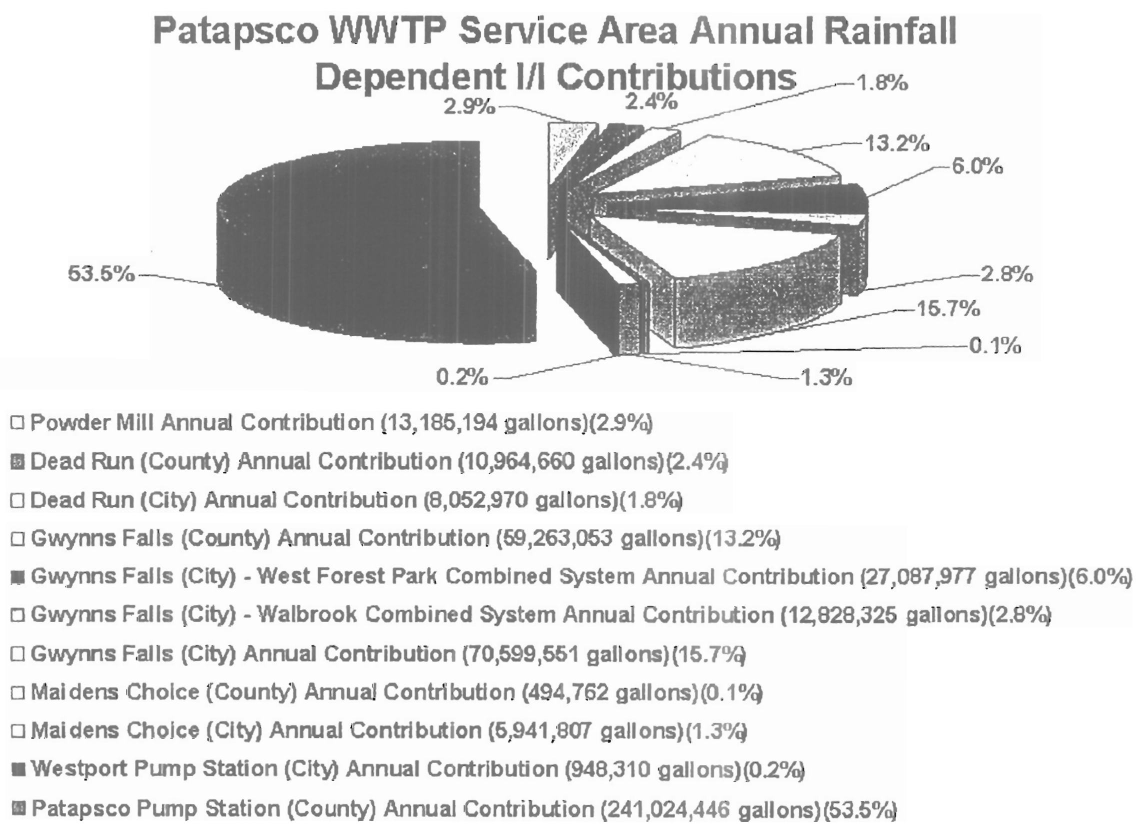
- Analysis – Will satisfy goals 1 & 2 and the results will be presented in the Infiltration & Inflow (I/I) Report (under this cover)
- Design – Will satisfy goals 3 & 4 and the results will be presented in the SSES Report (scheduled for completion on 12/30/02)
- Oversight – Will satisfy the last goal, and will begin after competition of the first four goals

This report being presented today represents the completion of the Analysis Stage and the associated project objectives 1 & 2. Although the term "Analysis Stage" sounds simplistic in nature, it was the most complicated and involved multiple labor intensive tasks. The tasks performed during this stage of the project included the following and each of which will be described in detail in the Report.

- Historical Records Research
- Flow Monitoring
- Rainfall Gauging
- Flow Data Analysis
- Structural Inspections
- Wet Weather Investigations
- Hydraulic Flow Simulations

The results of these investigations presented in this Report were used to identify areas of the City's portion of the Gwynns Falls Sewershed where the remaining investigations will be focused. The completed I/I analysis established predicted annual Infiltration and Inflow rates, which clearly identified the inflow volume as the most significant source of extraneous water volumes with the following respective annual volumetric contributions of 8 million and 450 million gallons. Based on this observation, the investigations were focused on the contributing inflow areas. The results of the investigation to identify the general areas contributing inflow are presented in Figure E.1 (noting the percent contribution to the PWWTP and associated volume are representative of the annual inflow contribution only (excludes average daily dry-weather flows)).

Figure E.1



These results were used to make recommendations for performance of investigative tasks to identify the specific I/I sources located within the general areas with notable I/I rates. These supplemental investigations will be in the form of smoke testing, dye testing and CCTV inspections, and will be performed in the Gwynns Falls, Powder Mill and Dead Run mini-basins.

Additionally, limitations in system capacities were identified via computer assisted hydraulic simulations incorporating "real time" observations during calibration. The conclusions drawn by these simulations identified "bottlenecking" in the Maidens Choice Interceptor, a portion of the Dead Run Interceptor and various sections of the Gwynns Falls (City) system including the GF, GFA, GFB, GFD, GFE, GFG and GFH. These areas will be evaluated further during the design stage to identify and recommend cost-effective solutions that will increase capacities thereby reducing the occurrence of overflows.

Delivery of this I/I Report on or before July 31, 2000 represents partial fulfillment of paragraph 28 of the Consent Decree dated November 17, 1999 between the City of Baltimore and Environmental Protection Agency (EPA) and Maryland Department of Environment (MDE). This schedule also requires the Sanitary Sewer Evaluation Study (SSES) Report to be submitted to EPA and MDE no later than December 31, 2002.

The information contained in this report will detail the approach, methodology, equipment analysis protocols as well as the results of each task used to identify inflow volumes and capacity restrictions. As previously mentioned, the results of those tasks were compiled in this report and used solely to recommend areas requiring additional investigation. The findings from those investigations will be evaluated to determine viable repair solutions and will also be compiled and presented in the Sanitary Sewer Evaluation Study (SSES) Report scheduled to be delivered on 12/31/02.

6.0 Conclusions & Recommendations

The results of the first phases of work for the Gwynns Falls Sewershed Study have been collected, sorted, analyzed and presented in this I/I Report. The purpose of investigations performed in relation to this Report was associated with two goals. With these goals in mind, all resulting conclusions and recommendations will be presented in this section of this report.

1. To identify general areas within the Patapsco WWTP service area which may be contributing excessive inflow to the plant.
2. To identify areas within the City portion of the Gwynns Falls Sewershed where capacity deficiencies are resulting in back-ups or overflows.

6.1 Contributing Inflow Areas

General areas that contribute excessive inflow to the PWWTP were determined primarily with the results of the aggressive short-term flow monitoring program and associated data analysis. Wet weather observations from three rainfall events recorded during the flow metering phase have

Table 6.1
Patapsco WWTP Service Area RDII Contributions

[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Baltimore City Annual Rainfall Dependent Infiltration & Inflow (RDII) Volumes				
Powder Mill	GFI	Powder Mill	13,185,194	2.9%
Dead Run	DR & DRR	Interceptor & Relief	8,052,970	1.8%
Gwynns Falls	GF Combined	Combined System	27,087,977	6.0%
Gwynns Falls@	Walbrook	Combined System	12,828,325	2.8%
Maidens Choice*	MC	Maidens Choice	5,941,807	1.3%
Westport* $	Pump Station	Westport	948,310	0.2%
Gwynns Falls	GF & GFR	Interceptor & Relief	70,599,551	15.7%
		City Total	**138,644,133**	**30.8%**
Baltimore County Annual Rainfall Dependent Infiltration & Inflow (RDII) Volumes				
Dead Run	DR County	Baltimore County	10,964,660	2.4%
Maidens Choice*	MC County	Baltimore County	494,762	0.1%
Gwynns Falls	GF County	Baltimore County	59,263,053	13.2%
Patapsco* #	Pump Station	Baltimore County	241,024,446	53.5%
		County Total	**311,746,922**	**69.2%**
		Total Contribution	**450,391,055**	

** Site only contributes to the Patapsco WWTP not Gwynns Falls*
 # Estimated Wet Weather Volume
@ Estimated Annual RDII Volume was based on Phase I Flow Monitoring
$ Estimated Flow Rate based on rated P.S. capacity of 0.08 MGD

URS

August 31, 2001

City of Baltimore
Department of Public Works
Water and Wastewater
900 Abel Wolman Municipal Building
200 Holliday Street
Baltimore, Maryland 21202

Attn: Wazir Qadri, Engineer III
Re: Sanitary Sewer Evaluation Survey for the Gwynns Falls Sewershed

Dear Mr. Qadri,

URS is pleased to submit the Gwynns Falls Sanitary Sewer Evaluation Study (SSES) Report for your review and approval. This report expands upon our previously submitted Inflow/Infiltration Report of July 2000, and presents the results of our field investigations in this sewershed.

The combination of these two Reports satisfies the following criteria in our project scope:

- Identification of general areas in the Patapsco WWTP Service Area that may be contributing to excessive inflow.
- Identification of capacity deficiencies in the City's portion of the Gwynns Falls Sewershed that are resulting in back-ups or overflows.
- Development of a comprehensive conveyance system rehabilitation program.

Please review the content of this Report and contact me should you have any questions or concerns.

Sincerely yours,

URS Corporation

Aaron K. Nelson, PE
Project Office Manager

URS Corporation
The Morgan Millworks Building
1801 Falls Road, Suite 3B
Baltimore, MD 21201
Tel: 410.468.0875
Fax: 410.468.3259

SANITARY SEWER EVALUATION SURVEY REPORT

Gwynns Falls (City) Sewershed

August 2001

This report is for the City of Baltimore Department of Public Works use only, and is not to be distributed to third parties outside the City of Baltimore Department of Public Works organization. This preliminary report is a draft document and is not to be used as the basis for final design, construction, or remedial action, or as a basis for major capital decisions. Please be advised that the preliminary report is still undergoing URS internal reviews. Your comments, together with URS comments, will be incorporated into a final submission of this document.

CITY OF BALTIMORE
DEPARTMENT OF PUBLIC WORKS

SANITARY SEWER EVALUATION SURVEY FOR THE REHABILITATION OF THE GWYNNS FALLS SEWERSHED

Table of Contents

List of Figures

List of Tables

1.0 EXECUTIVE SUMMARY

In August of 1998 URS Corporation received from the City of Baltimore the notice to proceed with work on the Gwynns Falls Sewershed Study (Sanitary Contract Number 8509). This Report, in conjunction with the Inflow/Infiltration Report (July 2000), satisfy the following items listed of areas contributing in the scope of services of this contract.

- **Identification to Inflow and Infiltration (I/I)**
- **Identification of areas with capacity deficiencies**
- **Development of a comprehensive conveyance system rehabilitation program.**

This Report is submitted as the Sanitary Sewer Evaluation Study (SSES) Report of the Gwynns Falls Sewershed by URS Corporation to summarize the findings of investigative work performed in the study area of Gwynns Falls Sewershed.

During the investigative phase of the Gwynns Falls Study, URS conducted 5 activities to examine the condition and characteristics of the sanitary sewer system. The 5 investigations consisted of flow monitoring, structural inspections, smoke testing, CCTV inspections, and dye testing. These activities were not dispersed equally throughout each Sub-area of the Sewershed. Decisions on the appropriate evaluation method for each Sub-area were based upon the results of flow monitoring and input from Baltimore City's Department of Public Works. Areas were prioritized for each investigation also using the three project criteria listed above.

The most significant work efforts were focussed in the Dead Run, Powder Mill, Gwynns Falls and Maidens Choice Sub-Area. Only manhole inspections were performed in the Brooklyn and Patapsco area, due to their exclusion from the I/I investigations as a result of the flow data analyses (eliminating these areas as major I/I contributors). Results from the various I/I investigations performed indicated areas or portions of each system require improvement to either remove existing overflow structures, remove identified sources of I/I, improve the hydraulic capacity or address specific structural defects located during the inspections.

These recommendations vary in nature. Areas that URS conducted sufficient investigative activities were addressed with the appropriate rehabilitation intended to improve or restore the hydraulic capacity of the system. Other regions prompted URS to suggest further evaluation to examine the systems behavior. Recommended evaluations, were basically continuations of those conducted for this project, however they would be performed in areas that could not be included in the current work efforts. Table 1.1 outlines the recommended rehabilitation for the various sub-areas of Gwynns Falls Sewershed.

Table 1.1	Evaluation/Rehabilitation Assignments in Each Sub-Area						
	Rehabilitation Recommendations		Evaluation Recommendations				
Sub-Area	Cured in Place Lining	Pipe Upsizing	Smoke Testing	CCTV Inspections	Hydraulic Modeling	Dye Testing	Overflow Removal
Powder Mill	✔	-	-	-	-	-	✔
Dead Run	✔	✔	-	✔	-	-	✔
Maidens Choice	✔	✔	-	✔	-	-	✔
Gwynns Falls	✔	-	✔	✔	✔	✔	✔
Brooklyn/ Patapsco	-	-	✔	✔	-	✔	-

A recommended system improvements were grouped into projects by Subarea and prioritized based on system specific data including items such as age, condition, existence of overflows and impact of failure to highlight a couple of items. In addition, a preliminary cost opinion was developed for each of the recommended projects to establish the associated capital expenditures required to undertake these tasks. Sections 5 & 6 of this Report discusses the nature of the recommendations, the approach for prioritizing the repairs details each preliminary cost opinion. This information has also been reproduced in the following Table.

Table 1.2	Project Detail Summaries					
			Project Details			Estimated Project Cost (1,000,000's)
			Pipe		# of Manholes	
Sub-Area	Branch	Project Description	Diameter (in)	Length (ft)		
Dead Run	DRA	1,2,3,4,5	8 to 12	11,829	67	$1.51
	DR&DRR	2,3,4,5	12 to 24	19,577	86	$5.10
Powder Mill	GFI & GFIB	1,2,3,4,5	8 to 27	45,668	216	$5.55
Maidens Choice	MC	1,2,3,4,5,6	8 to 24	11,685	103	$3.61
Gwynns Falls	GFA	2,3,4,5,6	8 to 18	41,532	63	$1.72
	GFB	2,3,4,5,6	8 to 15	50,563	36	$1.31
	GFC	1,2,3,4,5,6	8 to 18	31,172	35	$1.03
	GFE	2,3,4,5,6	30 to 54	5,035	30	$5.37
	GFD	2,3,4,5,6	8 to 27	12,812	16	$0.41
	GFF	2,3,4,5,6	8 to 12	12,419	10	$0.37
	GFR	2,3,4,5,6	54 to 66	30,250	55	$2.13
Brooklyn & Patapsco	B & P	6	6 to (54x54)	247,000	1,181	$1.24
Estimated ProgramTotals				519,542	1,898	$29.35

1 = Eliminate existing overflow structure or structures
2 = Eliminate identified sources of I/I
3 = Improve system hydraulics
4 = Repair identified system structural defects
5 = Increase system reliability
6 = Investigate remaining portions of system not previously investigated

The recommendations listed in the table above include removal of overflow structures, removal of I/I sources, improvement to system hydraulics, repair of structural defects and also include additional evaluation services such as smoke testing, manhole inspection, CCTV pipe inspections and dye testing. The estimated total cost is nearly $30 million and the estimated time for completion is 10 to 15 years.

There are some additional considerations that would improve the Gwynns Falls system operation, and this includes the following.

- Initiation of a preventative maintenance program
- Coordination with satellite systems to control contributing I/I volumes.

6.0 REHABILITATION RECOMMENDATIONS

Recommendations for improvements to the Gwynns Falls sewer system are based on the objectives listed in the project scope and include the following.

i. Identify general areas within the Patapsco WWTP service area, which may be contributing excessive inflow to the plant.
ii. Identify areas within the City portion of the Gwynns Falls Sewershed where capacity deficiencies are resulting in backups or overflows.
iii. Develop long-term projections for the Gwynns Falls Sewershed.
iv. Develop a comprehensive conveyance system rehabilitation program for the Gwynns Falls Sewershed to meet the current and future needs while addressing State and Federal mandated water quality objectives.

6.1 IDENTIFY PATAPSCO WWTP I/I CONTRIBUTIONS

Using these guidelines, the data collected during the Sewershed Study was reviewed and organized such that logical decisions could be made regarding the recommendations for all system improvements.

The first objective was identification of areas within the Patapsco WWTP service area that may be contributing inflow to the plant. This goal was satisfied using existing flow data from the WWTP, system attribute information (such as pipe size, lengths and configuration), supplemental flow data and associated analyses. The results of this work effort were presented in the I/I Report for the Gwynns Falls Sewershed submitted in July of 2000, and the pertinent information from that Report has been extracted and summarized in table 6.1.

MDE
MARYLAND DEPARTMENT OF THE ENVIRONMENT
2500 Broening Highway ● Baltimore Maryland 21224
(410) 631- 3000 ● 1- 800 -633-6101 ● http:// www. mde. state. md. us

Parris N. Glendening
Governor

Jane T Nishida
Secretary

April 21, 1999

Mr. John Martin, Engineer
Water & Wastewater Engineering Division
8201 Eastern Avenue
Baltimore, MD 21224

Re: Chronic whole effluent toxicity (WET) test results for State Discharge Permit 86-DP-0581 (NPDES Permit MD0021555)

Dear Mr. Martin:

The Department has received four sets of quarterly tests for chronic WET conducted on the effluent from the Back River wastewater treatment plant. These tests were required by Special Condition II.G of the above permits. All of the test results indicate that the effluent was neither acutely nor chronically toxic to either the *Ceriodaphnia dubia* or the *Pimephales promelas* test species.

This testing satisfies the above testing requirement. If I can ever be of assistance please contact me at 410-631-3605.

Sincerely,

Melvin Knott

Melvin Knott, Chief
Effluent Toxicity & Evaluation Division

mk

cc: Jeff Rein
Dave Lyons

MDE

MARYLAND DEPARTMENT OF THE ENVIRONMENT

2500 Broening Highway • Baltimore Maryland 21224
(410) 631-3000 • 1-800-633-6101 • http:// www. mde. state. md. us

Parris N. Glendening
Governor

Jane T. Nishida
Secretary

May 1, 2000

Mr. Ralph O. Cullison, III, Chief
Environmental Services Division
City of Baltimore
Department of Public Works
300 Abel Wolman Municipal Building
Baltimore, MD 21202

Re: Whole Effluent Toxicity (WET)/Toxicity Reduction Evaluation (TRE) at Patapsco WWTP (State Discharge Permit 93-DP-0580A, NPDES Permit MD0021601)

Dear Mr. Cullison: Ralph

This is in response to your letter of March 28, 2000. Enclosed with your letter was a document that described the history of WET at the Patapsco WWTP and discussed possible reasons for its disappearance.

Since January 1997, as part of its TRE, the City of Baltimore has been conducting monthly WET testing of the effluent at the Patapsco WWTP. For approximately the first two years, the WET testing also included influent testing. The effluent had been exhibiting consistent acute toxicity to the invertebrate test species and, based on earlier work conducted by the U.S. EPA, ammonia and the pesticides Malation and Diazinon were suspected as toxicants. However, after analyzing a number of effluent samples, your testing consultant effectively ruled out ammonia. Additionally, the above pesticides were consistently less than the detection level of 0.10 ug/l.

Your consultant hypothesized that surfactants may instead be responsible for the observed toxicity and prepared to conduct additional experiments to isolate these toxicants in subsequent toxic effluent samples. It was at that time, in May of 1997, that the effluent from the Patapsco WWTP ceased to be acutely toxic to either the fish or the invertebrate test species. Since then, monthly WET testing has shown that the effluent has remained not toxic. Additionally, recent permit-required testing for chronic WET has also shown the effluent to be not chronically toxic.

Consequently, the Department considers the TRE at the Patapsco WWTP closed at this time. The monthly WET testing may be discontinued. The renewal permit, which should soon be issued, will contain requirements to conduct another round of quarterly WET tests for four consecutive quarters. If you have any questions, please contact Melvin Knott at 410-631-3605 or me at 410-631-3512.

Sincerely,

Dane Bauer, Deputy Director
Water Management Administration

mk

cc: Jennifer Wazenski
Melvin Knott
Jack Bowen
Dave Lyons
Jeff Rein

CITY OF BALTIMORE, MARYLAND

COMPREHENSIVE WASTEWATER
FACILITIES MASTER PLAN

TASK 401

INVESTIGATION OF THE CONDITION
OF EXISTING FACILITIES

BACK RIVER WWTP INSPECTIONS SUMMARY OF FINDINGS

DRAFT

DECEMBER 1998

WHITMAN, REQUARDT AND ASSOCIATES, LLP
ENGINEERS AND PLANNERS
BALTIMORE, MARYLAND

WHITMAN, REQUARDT AND ASSOCIATES, LLP

Engineers and Planners

2315 Saint Paul Street
Baltimore, Maryland 21218
(410) 235-3450

Fax: (410) 243-5716
www.wrallp.com

December 31, 1998

Mr. Amarjit S. Sokhey, P.E., Chief
City of Baltimore
Water and Wastewater Engineering Division
900 Abel Wolman Municipal Building
Baltimore, Maryland 21202
Attention: Mr. Jaswant Dhupar, Chief
Facilities Engineering Section

Re: Comprehensive Wastewater Facilities Master Plan
Back River WWTP Inspections

Gentlemen:

Task 401 of the Comprehensive Plan involves the evaluation of the condition of the existing wastewater treatment plants to identify plant improvements which may be required to enable the plant to perform through the end of the planning period, the year 2020. We have completed our inspection of the Back River Plant and enclose five (5) copies of the draft report which summarizes our findings.

Table A summarizes the overall condition of the individual facilities and the general nature of the required improvements. Detailed inspection sheets for each facility on the plant are enclosed and include specific remarks pertaining to individual items of equipment, building components, etc.

We understand that the City intends to review these findings and compare them with the scopes of the various current plant improvement contracts to ensure that the needed improvements are either included or should be incorporated into future capital improvement projects. Based on your comments and our further review, we will revise and submit the final report.

We are available to discuss any findings further at your convenience, if you desire. Please advise.

Very truly yours,

WHITMAN, REQUARDT AND ASSOCIATES, LLP

John D. Emerson

JDE/mp
Enclosures
cc: Johns S. Maynes
William P. Wagner
Brian C. Aylaian

WR&A W.O.: 70317
R:\7031\LTR\DHUPAR5.WPD

TABLE B

INSPECTION OF BACK RIVER WWTP

SUMMARY OF FINDINGS

Plant Area	Facility	Overall Condition	General Nature of Improvements
Preliminary Treatment	Grit Removal	Poor	Complete rehabilitation.
Primary Treatment	Sludge Control Station	Fair	Maintain existing equipment only.
Preliminary Treatment	Screening	Fair	Rehabilitate screens, power panels, building heat, gas detection.
Primary Treatment	Primary Settling Tanks	Fair	Improve flow distribution and grease and scum collection. Rehabilitate influent stoplog structure.
Primary Treatment	Odor Control - Clarifiers	Poor	Provide odor control for all primary clarifiers.
Preliminary Treatment	Odor Control - Screening	Fair	Rehabilitate storage tanks, pumps and appurtenances. Exhaust main outfall to screening odor control facilities. Provide enclosure.
Secondary Treatment	Odor Control -Head Chamber	Fair	Rehabilitate storage tanks, pumps and appurtenances. Provide enclosure.
Primary Treatment	Pumping Stations A-C	Poor	Rehabilitate flow metering, scum pumps and piping MCCs.
Primary Treatment	Pumping Station D	Fair	Rehabilitate scum pumps.
Secondary - Plant #1	Reactors 1-4	Fair	Replace diffuser.
Secondary - Plant #1	Pipe Galleries	Fair	Replace VFDs and flow meters. Rehabilitate Train #3 RAS and WAS pumps.

Plant Area	Facility	Overall Condition	General Nature of Improvements
Secondary - Plant #1	Clarifiers 1-4	Fair	Rehabilitate scum collection and pumping and Clarifier #4 bridge and drive.
Secondary - Plant #1	Activated Sludge Station	Fair	Rehabilitate electrical feeders and drain pump valving.
Secondary - Plant #1	Blower Building	Poor	Repair air line leakage. Rehabilitate blower system with lower capacity.
Secondary - Plant #1	Internal Recycle Pumping Stations 1-4	Fair	Replace VFDs.
Secondary - Plant #2	Reactor Dewatering Pumping Stations	Poor	Rehabilitate Pump #7 discharge valves on RAS pumps, pneumatic system, dewatering pump VFDs, and floor drainage system.
Secondary - Plant #2	Pumping Stations 1-2	Fair	Rehabilitate pneumatic valves on RAS pumps, scum transfer pumps, final clarifier drainage pumps, VFDs, sealing water system, HMI Computer in PS No. 4 and floor drainage system.
Secondary - Plant #2	Internal Recycling Pumping Stations 5-10	Fair	Correct electrical problems related to internal recycle pumps.
Secondary - Plant #2	Blower Building	Good	Evaluate blower capacity requirements and modify accordingly.
Secondary - Plant #2	Reactors 5-10	Fair	Evaluate internal recycle pumps, mixer, and instrumentation problems and replace accordingly. Evaluate and modify flow distribution to Plants #2 and #3.

Plant Area	Facility	Overall Condition	General Nature of Improvements
Secondary - Plant #2	Clarifiers 5A-10B	Fair	Rehabilitate scum collection and pumping. Control of algae buildup. Evaluate and improve sludge blanket instrumentation. Correct short-circuiting in #7A. Replace drive bearings in #9A.
Secondary - Plant #2	Chemical Building	Fair	Rematch chemical feed lines with feed paints. Repair polymer feed pump oil leaks, ferric chloride pump line clogging. Rehabilitate ferric chloride pump drives and compressed air system.
Secondary - Plant #2	Operations Building	Fair	Rehabilitate plant SCADA MMI terminals and HVAC system.
Secondary - Plant #3	Reactor Dewatering Pumping Stations	Fair	Evaluate and correct reactor dewatering pumps and controls problems.
Secondary - Plant #3	Internal Recycle Pumping Stations 11-16	Fair	Evaluate and correct pump and control problems.
Secondary - Plant #3	Pumping Stations 3-4	Good	Repair sealing water system problems.
Secondary - Plant #3	Diffuser Cleaning	Good	-
Secondary - Plant #3	Clarifiers 11A-16B	Good	Investigate scum collection and pumping problem and correct. Control algae buildup. Improve sludge blanket instrumentation.
Secondary - Plant #3	Blower Building	Good	Replace submersible sewage pump.
Secondary - Plant #3	Influent Metering Vaults	Good	Replace #12 gate and #14 magmeter.

Plant Area	Facility	Overall Condition	General Nature of Improvements
Secondary - Plant #3	Reactors 11-16	Good	Replace mixers. Rehabilitate instrumentation. Repair air manifold controls and sump pumps. Flow redistribution.
Sludge Processing	GST Facilities	Poor	Rehabilitate.
Sludge Processing	DAF Facilities	Poor	Extent of rehabilitation to be determined.
Sludge Processing	Conventional Digesters	Poor	Evaluate and rehabilitate/replace digesters.
Sludge Processing	Egg-Shape Digesters	Good	Evaluate and add digester capacity.
Sludge Processing	Dewatering	Fair	Rehabilitate/add capacity.
Final Treatment	Sand Filtration	Fair	Control algae growth. Rehabilitate backwash system. Repair media leakage. Relocate electrical masts. Replace effluent slide gates. Replace effluent gate valve to redirect flows.
Final Treatment	Beth. Steel P.S.	Fair	Repair sluice gate and screen box level indicator.
Final Treatment	Outfall	Fair	Relocate effluent sample pump. Repair spray water piping.
Final Treatment	Control Building	Fair	Replace/repair pumping units.
Final Treatment	Chlorine Contact Chambers	Fair	Repair leaks in gates #1-#3. Repair tank expansion joints.
Final Treatment	Backwash Return Pumping Station	Fair	Replace SO_2 dessicant system. Repair scum pump check valve. Replace evaporators and sulfonators. Replace cone valves and strainers. Replace booster pump #1.

altimore City CWWFMP - Back River WWTP

acility Name: Primary Treatment

Date: 8/31/98

Service: Flushing Water Tower

Inspection Team:

Emerson, Aylaian

Conditions

rchitectural				
N/A				
tructural				
Riser		X		
Ladder		X		
Foundation		X		
Vents		X		
rocess Mechanical				
Tank		X		
Pipes, Valves and Fittings		X		
lectrical				
Power		X		
Lighting		X		
nstrumentation				
I/A				
uilding Mechanical				
Wind Vane		X		
)ther				
Comments				

Recommendations

altimore City CWWFMP - Back River WWTP

acility Name: Primary Treatment

Date: 8/31/98

Service: Mechanical Screen Building

Inspection Team:

Emerson, Aylaian

Condition

rchitectural				
Exterior/Interior Walls	X			
Windows	X			
Louvers		X		
Ceiling	X			
Doors		X		
Roofing	X			
Trim	X			
tructural				
Foundation				
Columns				N/A
Slabs				Not reviewed.
Beams		X		Needs paint in dumpster loading area.
Roof Framing	X			
Equipment Supports	X			
Steel Screen Supports	X			
Railings	X			
Terrazo			X	Needs finishing.
Gate Platform	X			
By-pass Channel				Not reviewed, covered by floor.
Bridge Crane Truss	X			
rocess Mechanical				
Fine Screens		X		
Air Diffusers	X			
Compactors	X			
Conveyors	X			
Hoppers	X			
Influent Gate	X			
Effluent Gate	X			

altimore City CWWFMP - Back River WWTP
acility Name: Primary Treatment

Date: 8/31/98

Service: Mechanical Screen Building
Inspection Team:
Emerson, Aylaian

Condition

Item	Good	Fair	Poor	Remarks
Channel Aeration Blowers	X			
Bar Racks	X			Grease ball buildup. Baffle overflow.
Condensate Receivers and Pumps			X	Heating system.
Electrical				
MCCs		X		Replaced in 1989.
Power		X		Fair but old.
Lighting	X			
Screen Motors	X			
Gate Motors	X			
Duplex Conveyor Motors	X			
Trolley, Hoist and Crane Motors			X	
Winch Motor	X			
Instrumentation				
Bubbler and Control Panel		X		
Weather Recorder	X			
Flow Recorder		X		
Combustible Gas Recorder		X		
H(2)S, O(2) and LEL Monitors and Panel			X	Older system, requires replacement.
Level Sensors		X		
Annunciator			X	PLC collects data, annunciator no longer required.
Building Mechanical				
Hoist w/Cable			X	
Boiler and Control Panel		X		New.
Bridge Crane			X	Undergoing rehabilitation.
HVAC			X	Heating needs to be replaced.
Winch			X	
Washdown Station	X			Flushing water hose.
Other				

altimore City CWWFMP - Back River WWTP
acility Name: Primary Treatment

Date: 8/31/98

Service: Mechanical Screen Building
Inspection Team:
Emerson, Aylaian

Condition

[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
mployee Facilities			X	
omments				

ecommendations

dd odor control drawoff from main outfall chamber.
educe H2S in screen building.

ıltimore City CWWFMP - Back River WWTP
ıcility Name: Primary Treatment

Date: 8/31/98

Service: Septage Receiving Station
Inspection Team:
Emerson, Aylaian

Condition

:chitectural				
J/A				
ructural				
'oundation				See comments.
Columns				See comments.
;labs				See comments.
3eams				See comments.
Roof Framing				See comments.
Equipment Supports				See comments.
Hatches				See comments.
Stairs				See comments.
rocess Mechanical				
Septage Receiving Pumps				See comments.
Septic Collection Tanks				See comments.
Pipes, Valves and Fittings				See comments.
Stop Logs and Lifters				See comments.
lectrical				
Septage Pump Control				See comments.
Power				See comments.
Lighting				See comments.
nstrumentation				
Limit Switch				See comments.
Annunciators				See comments.
Bubbler and Control Panel				See comments.
Dry Well Flood Alarm				See comments.
uilding Mechanical				

altimore City CWWFMP - Back River WWTP

acility Name: Primary Treatment

Date: 8/31/98

Service: Septage Receiving Station

Inspection Team:

Emerson, Aylaian

Condition

HVAC				See comments.
Hot Water Heater				See comments.
Sump Pump				See comments.
Air Compressor System				See comments.
Other				
Comments				
acility is obsoleted and abandoned.				

Recommendations

here will be no need for use of this facility in the foreseeable future.

altimore City CWWFMP - Back River WWTP

acility Name: Primary Treatment

Date:

Service: Grit Container Buildings

Inspection Team:

Criteria

rchitectural				
Exterior/Interior Walls				
Windows				
Ceilings				
Doors				
Roofing				
Trim				
tructural				
Foundation				
Columns				
Slabs				
Beams				
Roof Framing				
Equipment Supports				
Rail Assemblies and Supports				
rocess Mechanical				
Grit Containers (Tilt)				
Belts and Screen Conveyor Interfaces				

altimore City CWWFMP - Back River WWTP

acility Name: Primary Treatment

Date:

Service: Grit Container Buildings

Inspection Team:

Criteria

[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
lectrical				
Power and Control Center				
Lighting/Power				
Screen Conveyor Control Panel				
Belt Conveyor Control Panel				
Remote Annunciators				
(Coll. & Conveyor & Sept. Tks 1 & 2)				
nstrumentation				
uilding Mechanical				
Other				
Comments				

Not reviewed, new contract to rehabilitate facility is in place.

Recommendations

altimore City CWWFMP - Back River WWTP

acility Name: Primary Treatment

Date:

Service: Grit Tanks

Inspection Team:

Criteria

rchitectural				
N/A				
ructural				
Tank Support				
Tank Foundations				
Center Piers				
Influent Channels				
Slabs				
Beams				
Tank Access Bridges				
Influent Grate Hoist Platform				
Infl Chnl Grates & Stop Logs & Cndt Clrs				
Effluent Channels				
Influent Sluice Gate				
Belt Conveyor Channel				
Grit Conveyor Channel				
Influent Diverters				
rocess Mechanical				
Tank Influent Gratings				
Pipes, Valves and Fittings				
Screen Conveyors				
Belt Conveyors				
Influent Gate				
Grit Tanks				
Effluent Weirs				
Plowblades, Rotating Arms, Grit Scoops				
Spray Nozzles				
Organic Return Pumps				
Drive Cages and Ring Gear				

altimore City CWWFMP - Back River WWTP **Service: Grit Tanks**

acility Name: Primary Treatment **Date:** **Inspection Team:**

Criteria

3rit Conveyors				
Collectors				
Effluent Stop Gates				
lectrical				
Power				
Lighting				
TEFC Motors (Rotating Arms)				
nfluent/Effluent Gt Motors & Cntrl Stns				
Screw Conveyor Belt Motors & Controls				
Collector Mtrs & Drv Mech & Cntrl Stn				
nstrumentation				
Conveyor Belt Pressure Gauges				
uilding Mechanical				
ther				
omments				

Not reviewed, new contract to rehabilitate facility is in place.

ecommendations

ltimore City CWWFMP - Back River WWTP

cility Name: Primary Treatment

Date:

Service: Grit Control Building

Inspection Team:

Criteria

chitectural				
ilt Fence/Walkway				
xterior Walls				
nterior Walls				
Vindows				
eiling				
oors/Stairs				
oofing				
rim				
ructural				
oundation				
olumns				
labs				
eams				
oof Framing/Railings				
ridge/Monorail Supports				
onveyor Channel				
rocess Mechanical				
rit Conveyor				
ipes, Valves and Fittings				
onveyor Bucket				
lectrical				
ower Panel				
ontrol Panel				
ower				
ighting				
MCCs				
strumentation				

altimore City CWWFMP - Back River WWTP **Service: Grit Control Building**

acility Name: Primary Treatment **Date:** **Inspection Team:**

Criteria

uilding Mechanical				
HVAC				
3oiler				
Water Heater				
Tilt Containers				
ther				
omments				

ot reviewed, new contract to rehabilitate facility is in place.

ecommendations

altimore City CWWFMP - Back River WWTP
acility Name: Primary Treatment

Date: 8/31/98

Service: Sludge Control Station
Inspection Team:
Emerson, Aylaian

Criteria

rchitectural				
ɜxterior/Interior Walls	X			
ꞁouvers		X		
Ceiling			X	Stains on ceiling indicate leaks.
Doors		X		
Roofing		X		
Trim		X		
Stone Porch		X		
tructural				
Foundation				
Columns				
Slabs				
Beams				
Roof Framing				
Equipment Supports				
Wooden Piles				
Concrete Cradles				
rocess Mechanical				
Sludge Pumps		X		Not used except for cleaning out digesters.
Pipes, Valves and Fittings		X		
Waste Gas Burners		X		Outside building.
lectrical				
Settling Tank Motors				Not used.
Swivel Pipes Lift Motor				Not used.
Power		X		
Mag. Motor Starter		X		
MCC and Control Panel				
Unit Substation		X		

altimore City CWWFMP - Back River WWTP

acility Name: Primary Treatment

Date: 8/31/98

Service: Sludge Control Station

Inspection Team:

Emerson, Aylaian

Criteria

Clarifier Valve Controls		X		Not used.
nstrumentation				
Raw Sewage Flwmtr & Pnl w/Purge Mtr		X		New PLC collects all data, existing panels obsolete.
Venturi Room Flowmeters		X		
Gas Meters		X		
Pressure sensors		X		
Level Sensor & Indicators		X		Some missing on panel.
uilding Mechanical				
HVAC				
Air Compression System				
Sump Pump				
Boiler and Controls		X		
Hot Water Heater		X		
Duplex Condensate Pump				
ther				
Comments				

Recommendations

altimore City CWWFMP - Back River WWTP
acility Name: Primary Treatment

Date: 8/31/98

Service: Raw Sewage Pumping Stations A-D
Inspection Team:
Emerson, Aylaian

Criteria

rchitectural				
N/A				
tructural				See comments.
Foundation				
Columns				
Slabs				
Beams				
Roof Framing				
Equipment Supports				
Manholes (Scum and Sludge)				
rocess Mechanical				
Scum Pumps			X	
Pipes, Valves and Fittings		X		Scum lines clog for Stations A-C.
Sludge Pumps		X		
lectrical				
Power		X		
Lighting		X		
MCCs (Pumps and Slidegates)		X*	X	Stations A-C require replacement, Station D is O.K.
Pushbutton Station		X		
Instrumentation				
Flood Alarm		X		
Flowmeters and Signal Converters		X		Venturis in Stations A-C need to be changed to magmeters.
Low Air Pressure Alarm		X		
Low Scaling Water Pressure Switches		X		
Building Mechanical				
Sump Pumps		X		

Baltimore City CWWFMP - Back River WWTP
Facility Name: Primary Treatment

Date: 8/31/98

Service: Raw Sewage Pumping Stations A-D
Inspection Team:
Emerson, Aylaian

Criteria

Sealing Water System		X		
Other				
Comments				

Recommendations

Rehabilitation required within the next 10-20 years, especially for Stations A-C.

altimore City CWWFMP - Back River WWTP
acility Name: Primary Treatment

Date: 8/31/98

Service: Primary Clarifiers
Inspection Team:
Emerson, Aylaian

Criteria

rchitectural				
N/A				
tructural				
Foundation				
Tank Support Structure				
Influent/Effluent Channels				
rocess Mechanical				
Tanks				
Tank Center Piers				
Weirs				
Pipes, Valves and Fittings				
lectrical				
Clarifier Motors				
nstrumentation				
Float Switches/Tubes			X	Should be rehabilitated along with entire instrumentation system.
Flowmeters			X	Should be rehabilitated along with entire instrumentation system.
Mechanical Overload Indicator			X	Should be rehabilitated along with entire instrumentation system.
uilding Mechanical				
ther				

Baltimore City CWWFMP - Back River WWTP

Facility Name: Primary Treatment

Date: 8/31/98

Service: Primary Clarifiers

Inspection Team:

Emerson, Aylaian

Criteria

Comments				

Primary clarifier #2 recieves the majority of the flow during storms.

Problems with grease in the scum collectors and conveyance system.

Some short-circuiting is ocurring to the new sludge holding tank.

Influent stoplog structure needs structural rehabilitation although it is functional.

Recommendations

altimore City CWWFMP - Back River WWTP

acility Name: Primary Treatment

Date: 12/22/98

Service: Dewatering and Sludge Pumping Stn

Inspection Team:

Emerson, Aylaian

Criteria

rchitectural				
V/A				
tructural				
Foundation	X			
Columns	X			
Slabs	X			
Beams	X			
Equipment Supports	X			
Doors	X			
Roof and Framing		X		Leaks observed on west side of building.
Stairs	X			
Sludge Wet Well		X		Outside only reviewed.
Drainage Wet Well		X		Outside only reviewed.
Railings		X		
rocess Mechanical				
Dewatering Pumps		X		No. 2 pump out of service for repairs.
Pipes, Valves and Fittings		X		
Sludge Transfer Pumps		X		
lectrical				
Control Panel		X		
Lighting		X		Some bulbs missing from fixtures.
Power		X		
Sump Pump Control Panel		X		
MCC		X		
Temp Control Panel		X		Power light burned out.
nstrumentation				
Bubbler System (Well Levels)		X		
8" Flowmeter		X		

altimore City CWWFMP - Back River WWTP
acility Name: Primary Treatment **Date: 12/22/98**
Service: Dewatering and Sludge Pumping Stn
Inspection Team:
Emerson, Aylaian

Criteria

4" Flowmeter		X		
F/P Panel		X		
Gas Detection Panel	X			New Enmet system for %LEL.
PCS Data Highway Panel with UPS	X			
uilding Mechanical				
Sealing Water Tank & Pumps		X		
Air Compressor & Supply System		X		
Monorail and Hoist	X			
HVAC		X		
Sump Pump		X		
Gas Furnace	X			
)ther				
Comments				

Recommendations

altimore City CWWFMP - Back River WWTP
acility Name: Sludge Thickening

Date: 8/31/98

Service: Odor Control Facility (Clarifiers)
Inspection Team:
Emerson, Aylaian

Criteria

rchitectural				
Exterior/Interior Walls		X		Control Building.
Doors		X		Control Building.
Roofing		X		Control Building.
ructural				
Foundation		X		
Slabs		X		
Equipment Supports		X		
rocess Mechanical				
Scrubbers		X		
NaOH Storage Tanks			X	Needs rehabilitation and sizing evaluation.
Blower Fans		X		
NaOCl Storage Tank		X		
Pipes, Valves and Fittings			X	Hardware/line plug, heat tracing required.
Centrifugal Pumps			X	Problems with original pumps.
Chemical Pumps			X	Original pumps replaced.
Recirculation Pumps			X	Liquid seal replacement.
Exhaust Stack		X		
lectrical				
Power		X		
Lighting		X		
MCC		X		
nstrumentation				
Scrubber & Control Panel/Annunciator			X	
NaOH Tank Level			X	Meters give false alarms on occasion.
Sump Level			X	
Demister DPT			X	
Bed Press DPT			X	
Temp (Stages 1 & 2) Trans.			X	

[illegible]

altimore City CWWFMP - Back River WWTP

acility Name: Sludge Thickening

Date: 8/31/98

Service: Odor Control Facility (Clarifiers)

Inspection Team:

Emerson, Aylaian

Criteria

[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
›H Sensors			X	Meters abandoned as they required too much maintenance - manual control.
ÒRP Sensors			X	Meters abandoned as they required too much maintenance - manual control.
›ump/Fan Failure Switches			X	
H(2)S Sensor/Trans			X	
›LC				
uilding Mechanical				
Sumps Pumps		X		
Eyewash/Shower		X		
ther				
omments				

ıstrumentation abandoned due to continuous maintenance problems, false alarms and equipment failures.

ecommendations

/hen new GBT odor control facility is running, route odor-laden air from clarifiers to new facility and shut down this facility.

facility is to be retained, enclose area with building or other shelter to limit outdoor exposure.

altimore City CWWFMP - Back River WWTP
acility Name: Sludge Thickening

Date: 8/31/98

Service: Odor Control Facility (Screen Bldg.)
Inspection Team:
Emerson, Aylaian

Criteria

rchitectural				
Exterior/Interior Walls		X		Control Building.
Doors		X		Control Building.
Roofing		X		Control Building.
tructural				
Foundation		X		
Slabs		X		
Equipment Supports		X		
rocess Mechanical				
Scrubbers		X		
NaOH Storage Tanks			X	Needs rehabilitation.
Blower Fans		X		
NaOCl Storage Tank		X		
Pipes, Valves and Fittings			X	Hardware/line plug, heat tracing required.
Centrifugal Pumps			X	Problems with original pumps.
Chemical Pumps			X	Original pumps replaced.
Recirculation Pumps			X	Liquid seal replacement.
Exhaust Stack		X		
Conduits		X	X	Original conduit needs to bereplaced with PVC.
lectrical				
Power		X		
Lighting		X		
MCC		X		
nstrumentation				
Scrubber & Control Panel/Annunciator			X	
NaOH Tank Level			X	Meters give false alarms on occasion.
Sump Level			X	
Demister DPT			X	
Bed Press DPT			X	

altimore City CWWFMP - Back River WWTP

acility Name: Sludge Thickening

Date: 8/31/98

Service: Odor Control Facility (Screen Bldg.)

Inspection Team:

Emerson, Aylaian

Criteria

Temp (Stages 1 & 2) Trans.			X	
pH Sensors			X	Meters abandoned as they required too much maintenance - manual control.
ORP Sensors			X	Meters abandoned as they required too much maintenance - manual control.
Pump/Fan Failure Switches			X	
H(2)S Sensor/Trans			X	
PLC				
uilding Mechanical				
Sumps Pumps		X		
Eyewash/Shower		X		
ther				
omments				

nstrumentation abandoned due to continuous maintenance problems, false alarms and equipment failures.

ecommendations

nclose area with building or other shelter to reduce outdoor exposure.

acility has excess capacity, so it can process odors from influent channel which is fairly close by.

ltimore City CWWFMP - Back River WWTP
cility Name: Sludge Thickening

Date: 8/31/98

Service: Odor Control Facility (Head Cham.)
Inspection Team:
Emerson, Aylaian

Criteria

chitectural				
xterior/Interior Walls		X		Control Building.
oors		X		Control Building.
oofing		X		Control Building.
ructural				
oundation		X		
labs		X		
quipment Supports		X		
ocess Mechanical				
crubbers		X		
aOH Storage Tanks			X	Needs rehabilitation.
lower Fans		X		
aOCl Storage Tank		X		
ipes, Valves and Fittings			X	Hardware/line plug, heat tracing required.
entrifugal Pumps			X	Problems with original pumps.
hemical Pumps			X	Original pumps replaced.
ecirculation Pumps			X	Liquid seal replacement.
xhaust Stack		X		
onduits		X	X	Original conduit needs to bereplaced with PVC.
lectrical				
Power		X		
Lighting		X		
MCC		X		
nstrumentation				
Scrubber & Control Panel/Annunciator			X	
NaOH Tank Level			X	Meters give false alarms on occasion.
Sump Level			X	
Demister DPT			X	
Bed Press DPT			X	

altimore City CWWFMP - Back River WWTP

acility Name: Sludge Thickening

Date: 8/31/98

Service: Odor Control Facility (Head Cham.)

Inspection Team:

Emerson, Aylaian

Criteria

Temp (Stages 1 & 2) Trans.			X	
H Sensors			X	Meters abandoned as they required too much maintenance - manual control.
ORP Sensors			X	Meters abandoned as they required too much maintenance - manual control.
Pump/Fan Failure Switches			X	
H(2)S Sensor/Trans			X	
PLC				
uilding Mechanical				
Sumps Pumps		X		
Eyewash/Shower		X		
ther				
omments				

strumentation abandoned due to continuous maintenance problems, false alarms and equipment failures.

ecommendations

nclose area with building or other shelter to reduce outdoor exposure.

altimore City CWWFMP - Back River WWTP
acility Name: ASP #1

Date: 9/29/98

Service: Internal Recycle P.S.s 1 - 4
Inspection Team:
Emerson, Wagner, Aylaian

Criteria

rchitectural				
N/A				
ructural				
Foundations		X		
Ladders		X		
Concrete Pipe Supports		X		
Walls/Partitions		X		
Dowels		X		
Gratings		X		
Beams and Supports		X		
rocess Mechanical				
nternal Recycle Pumps	X			
Pipes, Valves and Fittings	X			
lectrical				
Recycle Pump Electric Motor Operators			X	VFD problems - during storms they trip out.
Sump Pump Backboards		X		
Pump Discharge Valve Backboards		X		
Flowmeter Signal Converter Backboards		X		
Station Power and Pullboxes		X		
Internal Recycle Pump Backboards		X		
Recycle Pump and Thermal Switches		X		
Discharge Valve Actuators		X		
Sump Pump Control Panels		X		
MCCs		X		
istrumentation				
Float Switches				Not reviewed.
uilding Mechanical				

altimore City CWWFMP - Back River WWTP
acility Name: ASP #1

Date: 9/29/98

Service: Lime Silos
Inspection Team:
Emerson, Wagner, Aylaian

Criteria

Lightning Protection System				Not reviewed.
Lime System Control Panel				Not reviewed.
Air Louver Motor and Damper				Not reviewed.
Conveyor Drive Units w/Belt Guard				Not reviewed.
nstrumentation				
Low/High Level Bin Switches				Not reviewed.
Ultrasonic Level Sensors				Not reviewed.
uilding Mechanical				
Exhaust Fans and Thermostat				Not reviewed.
Unit Heater				Not reviewed.
Outside Air Louver System				Not reviewed.
Shower and Eyewash				Not reviewed.
ther				
omments				

lthough all lime silos are functional, there is currently no need for lime in any of the three ASPs.

Recommendations

There may be a future requirement for lime addition, thus these facilities should be kept and maintained on standby until and if they are needed.

ıltimore City CWWFMP - Back River WWTP
ıcility Name: ASP #1

Date: 9/29/98

Service: Clarifiers 1-4
Inspection Team:
Emerson, Wagner, Aylaian

Criteria

[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
:chitectural				
I/A				
ructural				
)ewatering Boxes		X		
'oundations and Footings		X		
'russes		X		
3ridges		X		
;cum Battles and Troughs		X		
;kimmer Arm		X		
nboard Launder and Launder Bracket		X		
;cum Boxes		X		
∃ffluent Boxes		X		
Valls and Joints		X		
;upports and Reinforcements		X		
Concrete Piles		X		
rocess Mechanical				
Scum Skimmer and Beach		X		
Algae Cleaning Apparatus and Brush Bdg.		X		
Spray Water Nozzles		X		
Scum Pumps (in Scum Boxes)			X	Not operating properly.
Slide Gates (in Effluent Boxes)		X		
Final Clarifier Dewatering Pumps		X		
Final Clarifier Scum Pumps		X		
Clarifier Slide Gates		X		
Recirculating Nozzles		X		
Pipes, Valves and Fittings		X		
lectrical				
Electric Slide Gate Motor Operator		X		
Scum Pit Scum Pump Motor & Controls		X		

ıltimore City CWWFMP - Back River WWTP

ıcility Name: ASP #1

Date: 9/29/98

Service: Clarifiers 1-4

Inspection Team:

Emerson, Wagner, Aylaian

Criteria

[illegible]	[illegible]	[illegible]	[illegible]	Remarks
Ieat-Trace Thermostats		X		
;pray Water Solenoid Valves		X		
;kimmer Arm Limit Switches		X		
;in. Clar. Scum Trough Spray Wat. Ctl. Pnl.		X		
.ight Fixtures		X		
Clarifier Drive Torque Limit Switches		X		
;inal Clarifier Drive Motors		X		
;inal Clarifier Control Panels		X		
?ower and Pull Boxes (each box)		X		
;luice Gate Operator (Effluent box)		X		
Clar. Scum Pump Act. & Low Lev. Oil Swchs.		X		
;inal Clarifier Dewatering Pump Ctl. Pnls.		X		
Clarifier Scum Pump Control Panels		X		
ıstrumentation				
;ludge Blanket Level Detectors			X	
Clarifier Level Probes		X		
;cum Box Level Transmitters & Probes		X		
Dewatering Box Float Switches (4/box)		X		
uilding Mechanical				
ther				
omments				

larifier #4 bridge and drive removed, all others O.K.

larifier #3 can be used with either reactor #3 or #4 as it has the larger diameter.

cum removal is a problem as there is no dedicated system for this purpose. Must use WAS pump to pump scum.

ecommendations

altimore City CWWFMP - Back River WWTP
acility Name: ASP #1

Date: 9/29/98

Service: Reactors 1 - 4
Inspection Team:
Emerson, Wagner, Aylaian

Criteria

rchitectural				
\/A				
ructural				
.ime Slurry Trough				Not reviewed.
₹eactor Passes				Not reviewed.
:larifier Influent Boxes				Not reviewed.
Aonorail and Support				Not reviewed.
'oundation/Footings				Not reviewed.
Valls/Partitions				Not reviewed.
)rains/Gutters				Not reviewed.
:ontractor/Slab/Longit. Joints				Not reviewed.
Iandrailings/Walkways				Not reviewed.
nfluent Weir Gates				Not reviewed.
Aixed Liquor Chnls and Related Supports				Not reviewed.
3luice Gates and Openings				Not reviewed.
3toplogs				Not reviewed.
nfluent Boxes				Not reviewed.
rocess Mechanical				
?ipes, Valves and Fittings		X		
Air Manifolds		X		
Bubbler Air Diffusers and Grids			X	Diffusersare not secure to tank bottom.
Mixers and Guide Rails and Winch		X		
Spray Water System (Header)		X		
Flushing Water Hydrants		X		
Diffuser Cleaning Systems		X		
Drain gates			X	
Basin Drain Pumps			X	
lectrical				
Sluice Gate Motors				Not reviewed.

altimore City CWWFMP - Back River WWTP
acility Name: ASP #1

Date: 9/29/98

Service: Reactors 1 - 4
Inspection Team:
Emerson, Wagner, Aylaian

Criteria

Motors for Air System Valves				Not reviewed.
Power Lines and Pull Boxes and Conduit				Not reviewed.
Lighting				Not reviewed.
Gas Cleaning Receptacles				Not reviewed.
Mixer Motor/Control				Not reviewed.
Air Valve Control Backboards				Not reviewed.
Sluice Gate Actuators				Not reviewed.
Reactor Panels and Panelboard Enclosures				Not reviewed.
Wier Gate Actuators				Not reviewed.
Mixer Control Stations				Not reviewed.
Instrumentation Backboards				Not reviewed.
nstrumentation				
ORP Probes				Not reviewed.
36" Mag Flowmeters (on Recycle Line)				Not reviewed.
Process Air Flowmeters (DPT)				Not reviewed.
Bubbler - Gas Feed Pressure				Not reviewed.
DO Probes				Not reviewed.
pH Probes				Not reviewed.
uilding Mechanical				
ther				
omments				

eactors 2-4 out of service.
eactor 3 has aeration line leak.

ecommendations

n the short term this facility will be capable of functioning as a test reactor for experimental processes.
n the long term this facility will no longer be necessary as there is no enough flow to justify its use.

altimore City CWWFMP - Back River WWTP

acility Name: ASP #2

Date: 12/22/98

Service: Head Chamber

Inspection Team:

Emerson, Aylaian

Criteria

rchitectural				
N/A				
tructural				
Foundation		X		
Slabs		X		
Weir Plates		X		
Handrails		X		
Ladders		X		
rocess Mechanical				
Pipes, Valves and Fittings		X		
Sluice Gate		X		
lectrical				
Sluice Gate Operators		X		
Power				Not reviewed.
nstrumentation				
uilding Mechanical				
ther				
omments				

ecommendations

altimore City CWWFMP - Back River WWTP
acility Name: ASP #2

Date: 12/22/98

Service: Operations Building
Inspection Team:
Emerson, Aylaian

Criteria

rchitectural				
xterior Walls	X			
Vindows	X			
eiling	X			
Doors	X			
oofing	X			
rim	X			
ructural				
oundation	X			
olumns	X			
labs	X			
oof Framing	X			
eams				Not reviewed.
ocess Mechanical				
ectrical				
ontrol Power Panel		X		
ighting	X			
ower and Power Distribution	X			
MCC-CC3		X		
strumentation				
OPC - Computer	X			
ocal Control Panel		X		F/P control faceplates require replacement.
ewage Pump Control Pad		X		F/P control faceplates require replacement.
ilding Mechanical				
IVAC			X	One AC unit does not operate, waiting for new heat pump.

ltimore City CWWFMP - Back River WWTP
acility Name: ASP #2

Date: 12/22/98

Service: Operations Building
Inspection Team:
Emerson, Aylaian

Criteria

[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
ewage Pumps		X		
Vater Heater		X		Booster pump needed.
ab and Lab Equipment		X		
ire Alarm System & Panel Annunciators		X		
her				
omments				

ant SCADA system has older PCUs which need replacement.

ecommendations

70317\INSPEC\BR\ASP#2.WB2

ltimore City CWWFMP - Back River WWTP
cility Name: ASP #2

Date: 9/29/98

Service: Lime Silos
Inspection Team:
Emerson, Wagner, Aylaian

Criteria

chitectural				
/A				
uctural				
oors				Not reviewed.
lo Toeplates				Not reviewed.
lo Foundations				Not reviewed.
los (Steel) and Walls				Not reviewed.
ipport Pedestals				Not reviewed.
oncrete Piles				Not reviewed.
aming				Not reviewed.
airs				Not reviewed.
andrails/Guardrails				Not reviewed.
atings				Not reviewed.
acing				Not reviewed.
dders				Not reviewed.
anholes				Not reviewed.
ocess Mechanical				
me Silo Screw Conveyor				Not reviewed.
let Turbulence Boxes				Not reviewed.
me Storage Bin				Not reviewed.
me Silo Dumpsters				Not reviewed.
n Vent Filter w/Bag Cleaner				Not reviewed.
n Activator				Not reviewed.
me Slaker				Not reviewed.
n Gate				Not reviewed.
olumetric Feeder				Not reviewed.

ltimore City CWWFMP - Back River WWTP
cility Name: ASP #2

Date: 9/29/98

Service: Reactors 5 - 10
Inspection Team:
Emerson, Wagner, Aylaian

Criteria

chitectural				
/A				
ructural				
ime Slurry Trough		X		
eactor Passes		X		
larifier Influent Boxes		X		
onorail and Support		X		
oundation/Footings		X		
alls/Partitions		X		
rains/Gutters		X		
ontractor/Slab/Longit. Joints		X		
andrailings/Walkways		X		
nfluent Weir Gates		X		
ixed Liquor Chnls and Related Supports		X		
luice Gates and Openings		X		
toplogs		X		
nfluent Boxes		X		
ocess Mechanical				
ipes, Valves and Fittings		X		
ir Manifolds		X		
ubbler Air Diffusers and Grids		X		
ixers and Guide Rails and Winch			X	Mixers pulled and replaced, many remain inoperable on a long term basis.
pray Water System (Header)		X		
lushing Water Hydrants		X		
iffuser Cleaning Systems		X		
ectrical				
luice Gate Motors		X		
otors for Air System Valves		X		

ltimore City CWWFMP - Back River WWTP

cility Name: ASP #2

Date: 9/29/98

Service: Internal Recycle P.S.s 5 - 10

Inspection Team:

Emerson, Wagner, Aylaian

Criteria

chitectural				
'alls				
eiling				
oors				
oofing				
uctural				
oundations				
adders				
oncrete Pipe Supports				
'alls/Partitions				
owels				
ratings				
eams and Supports				
abs				
olumns				
quipment Supports				
ocess Mechanical				
ternal Recycle Pumps (A&B) ea. Station			X	Pumps kick out on OL.
pes, Valves and Fittings				
ctrical				
ecycle Pump Electric Motor Operator				
ımp Pump Backboards				
ımp Discharge Valve Backboards				
owmeter Signal Converter Backboards				
ation Power and Pullboxes				
ernal Recycle Pump Backboards				
cycle Pump Motor Thermal Switches				

altimore City CWWFMP - Back River WWTP
acility Name: ASP #2

Date: 9/29/98

Service: Pumping Stations 1 - 2
Inspection Team:
Emerson, Wagner, Aylaian

Criteria

rchitectural				
Exterior Walls	X			
Windows	X			
Louvers	X			
Ceiling	X			
Doors	X			
Roofing	X			
Trim	X			
ructural				
Foundation	X			
Columns	X			
Slabs	X			
Beams	X			
Roof	X			
Equipment Supports	X			
Bridge/Monorail Supports	X			
Sump Well			X	Improper slope causes drainage problems.
ocess Mechanical				
WAS Pumps		X		
RAS Pumps		X		Pneumatic valves on discharge should be repaired or replaced.
cum Transfer Pumps			X	Pumps not turning on due to signal transmission problems, causes flooding.
cum Pumps			X	
AS Chlorination System	X			
inal Clarifier Drainage Pumps			X	Some electrical motor problems.
AS Modulating Valves		X		
ipes, Valves and Fittings		X		
ectrical				
ower and Lighting	X			

ltimore City CWWFMP - Back River WWTP

cility Name: ASP #2

Date: 9/29/98

Service: Pumping Stations 1 - 2

Inspection Team:

Emerson, Wagner, Aylaian

Criteria

ICC-PS3	X			
ICC-VF3			X	No repair parts avail. Replacing all units, but problems with signal trans. to Ops Bldg.
Iain Control Panel W/PLC	X			
strumentation				
AS Flowmeters	X			
VAS Flowmeters	X			
lowmeter Signal Converters			X	False signals, meters appear O.K.
ilding Mechanical				
IVAC	X			
lumbing	X			
ealing Water System			X	The system has problems from the pneumatic system.
oiler Room Equipment	X			
-Ton Bridge Crane and Trolley	X			
neumatic System			X	Pressure control problems - replace.
ther				
MI Computer			X	Inoperative in PS No. 4.
omments				

ecommendations

ltimore City CWWFMP - Back River WWTP
cility Name: ASP #2

Date: 9/29/98

Service: Reactor Dewatering P.S.s (1/reactor)
Inspection Team:
Emerson, Wagner, Aylaian

Criteria

chitectural	X			
xterior/Interior Walls	X			
oors	X			
eiling	X			
oofing	X			
uctural				
oncrete Walls	X			
oundations	X			
adders	X			
ratings	X			
ump Braces and Guide Rails	X			
owels	X			
tairs	X			
/alkways	X			
labs	X			
eams	X			
olumns	X			
quipment Supports	X			
ocess Mechanical				
ipes, Valves and Fittings		X		
eactor Dewatering Pumps		X		Pump #7 has problems.
efoaming System		X		Not used.
neumatic Valves			X	Problems with discharge valves on return pumps.
neumatic System			X	High and low air pressure limits not triggered.
ectrical				
AS Pump Level Control		X		
eactor Dewatering Pump Control		X		

ltimore City CWWFMP - Back River WWTP
cility Name: ASP #2

Date: 9/29/98

Service: Reactor Dewatering P.S.s (1/reactor)
Inspection Team:
Emerson, Wagner, Aylaian

Criteria

ewatering Pump VFDs			X	Cannot get replacement parts for older Robicon VFDs.
trumentation				
ilding Mechanical				
nch drain system			X	Drainage system not properly sloped.
her				
mments				

commendations

altimore City CWWFMP - Back River WWTP
acility Name: ASP #2

Date: 9/29/98

Service: Clarifier Influent Boxes
Inspection Team:
Emerson, Wagner, Aylaian

Criteria

rchitectural				
V/A				
ructural				
'oundation and Supports		X		
iteel Grating		X		
Valls		X		
itairs		X		
)owels		X		
rocess Mechanical				
'ipes, Valves and Fittings		X		
'erric Chloride Diffusers		X		
'olymer Diffusers		X		
luice Gates		X		
Chemical Metering Enclos. w/Rotameters		X		
ectrical				
'erric Chloride Flow Control Panel		X		
'olymer Flow Control Panel		X		
iff. Sluice Gate Electric Motor Actuator		X		
iffluent Sluice Gate Backboard		X		
strumentation				
iilding Mechanical				
ther				
omments				

oth ferric and polymer are presently in use at this facility.

ltimore City CWWFMP - Back River WWTP
cility Name: ASP #2

Date: 12/22/98

Service: Influent Metering Vaults (N and S)
Inspection Team:
Emerson, Aylaian

Criteria

chitectural				
A				
ructural				
oundations		X		
ccess Hatches		X		
ump Pits		X		
einforcements		X		
adders/Stairs/Handrails		X		
utters		X		
ratings		X		
'ater Proofing		X		
labs,		X		
olumns/Beams		X		
quipment Supports		X		
ocess Mechanical				
pes, Valves and Fittings		X		
ctrical				
uplex Receptacles		X		
ight Fixtures		X		
nit Heaters		X		
MV" Panelboards		X		
st. Pull Boxes		X		
trumentation				
" Dia. Mag Meters (11-16)		X		
owmeter Signal Converters		X		

ltimore City CWWFMP - Back River WWTP

cility Name: ASP #2

Date: 12/22/98

Service: Influent Metering Vaults (N and S)

Inspection Team:

Emerson, Aylaian

Criteria

ilding Mechanical				
xhaust/Ventilation Fans and Ducts		X		
lectric Heaters		X		
ump Pumps		X		
ample Pump			X	Mechanical problems.
her				
mments				

commendations

timore City CWWFMP - Back River WWTP
ility Name: ASP #2

Date: 9/29/98

Service: Blower Building
Inspection Team:
Emerson, Wagner, Aylaian

Criteria

hitectural				
terior/Interior Walls	X			
ndows	X			
iling (Tiles)	X			
ors	X			
ofing	X			
m	X			
ictural				
undation	X			
lumns/Beams	X			
bs	X			
of Framing	X			
uipment Supports	X			
dge/Monorail Supports	X			
etal Gratings	X			
irs	X			
cess Mechanical				
es, Valves and Fittings	X			
owers	X			
et Silencers	X			
ters	X			
ctrical				
'S/DCU	X			
:TV Monitoring System	X			
wer and Lighting	X			
ower Controls (PLC/I(O))	X			
:C - BL1 (B1+2)	X			
:C - R14 (B1+2)	X			

ltimore City CWWFMP - Back River WWTP
cility Name: ASP #3

Date: 12/22/98

Service: Internal Recycle P.S.s 11 - 16
Inspection Team:
Emerson, Aylaian

Criteria

chitectural				
/A				
uctural				
oundations		X		
adders		X		
oncrete Pipe Supports		X		
'alls/Partitions		X		
owels		X		
ratings		X		
eams and Supports		X		
olumns		X		
eams		X		
abs		X		
quipment Supports		X		
ocess Mechanical				
ternal Recycle Pumps (A&B) ea. Station			X	Mechanical and electrical problems.
pes, Valves and Fittings		X		
ctrical				
ecycle Pump Electric Motor Operator		X		
ımp Pump Backboards		X		
ımp Discharge Valve Backboards		X		
owmeter Signal Converter Bäckboards		X		No. 16 has problems.
ation Power and Pullboxes		X		
ternal Recycle Pump Backboards		X		
ecycle Pump Motor Thermal Switches		X		
ischarge Valve Actuators		X		
ımp Pump Control Panels		X		
trumentation				

ltimore City CWWFMP - Back River WWTP
cility Name: ASP #3

Date: 9/29/98

Service: Pumping Stations 3 - 4
Inspection Team:
Emerson, Wagner, Aylaian

Criteria

chitectural	X			
xterior Walls	X			
/indows	X			
ouvers	X			
eiling	X			
oors	X			
oofing	X			
rim	X			
uctural				
oundation	X			
olumns	X			
labs	X			
eams	X			
oof	X			
quipment Supports	X			
ridge/Monorail Supports	X			
ocess Mechanical				
'AS Pumps		X		Pressure regulator problems.
AS Pumps		X		Pressure regulator problems, repair required for Reactor #11.
um Transfer Pumps				
um Pumps				
AS Chlorination System		X		
nal Clarifier Drainage Pumps				
AS Modulating Valves		X		
pes, Valves and Fittings		X		
ctrical		X		
wer and Lighting		X		
CC-PS3		X		
CC-VF3		X		

[redacted]

ltimore City CWWFMP - Back River WWTP

cility Name: ASP #3

Date: 9/29/98

Service: Pumping Stations 3 - 4

Inspection Team:

Emerson, Wagner, Aylaian

Criteria

[redacted]				
lain Control Panel W/PLC		X		
strumentation				
AS Flowmeters	X			
/AS Flowmeters	X			
lowmeter Signal Converters	X			
ilding Mechanical				
VAC				
ealing Water System			X	Pumping Sstation #4 system has pressure-related on/off switching problems.
oiler Room Equipment				
-Ton Bridge Crane and Trolley				
her				
mments				

commendations

altimore City CWWFMP - Back River WWTP

acility Name: ASP #3

Date: 12/22/98

Service: Reactor Dewatering P.S.s (1/reactor)

Inspection Team:

Emerson, Aylaian

Criteria

rchitectural				
N/A				
tructural				
Slabs				
Foundations				
Ladders				
Gratings				
Pump Braces and Guide Rails				
Dowels				
Stairs				
Walkways				
Columns/Beams				
Equipment Supports				
rocess Mechanical				
Pipes, Valves and Fittings		X		
Reactor Dewatering Pumps			X	Electrical and mechanical problems.
ectrical				
RAS Pump Level Control			X	
Reactor Dewatering Pump Control			X	Dewatering pumps kick out when tank is drained but stay off.
strumentation				
uilding Mechanical				
ther				
omments				

ltimore City CWWFMP - Back River WWTP
cility Name: ASP #3

Date: 12/22/98

Service: Reactor Dewatering P.S.s (1/reactor)
Inspection Team:
Emerson, Aylaian

Criteria

commendations

altimore City CWWFMP - Back River WWTP

acility Name: ASP #3

Date: 9/29/98

Service: Clarifier Influent Boxes

Inspection Team:

Emerson, Wagner, Aylaian

Criteria

rchitectural				
Exterior/Interior Walls	X			
Roofing	X			
Doors	X			
Ceiling	X			
	X			
tructural				
Foundation and Supports	X			
Steel Grating	X			
Walls	X			
Stairs	X			
Dowels	X			
Slabs	X			
Beams	X			
Equipment Supports	X			
Columns	X			
rocess Mechanical				
Pipes, Valves and Fittings	X			
Ferric Chloride Diffusers	X			
Polymer Diffusers	X			
Sluice Gates	X			
Chemical Metering Enclos. w/ Rotameters	X			
lectrical				
Ferric Chloride Flow Control Panel	X			
Polymer Flow Control Panel	X			
Eff. Sluice Gate Electric Motor Actuator	X			
Effluent Sluice Gate Backboard	X			
nstrumentation				

ıltimore City CWWFMP - Back River WWTP

ıcility Name: ASP #3

Date: 9/29/98

Service: Clarifier Influent Boxes

Inspection Team:

Emerson, Wagner, Aylaian

Criteria

ıilding Mechanical				
:her				
›mments				

ɛcommendations

altimore City CWWFMP - Back River WWTP

acility Name: ASP #3

Date: 9/29/98

Service: Influent Metering Vaults (N and S)

Inspection Team:

Emerson, Wagner, Aylaian

Criteria

rchitectural				
xterior/Interior Walls				
oofing				
oors				
eilings				
ructural				
oundations				
ccess Hatches				
ump Pits				
labs				
adders/Stairs/Handrails				
utters				
ratings				
eams				
olumns				
quipment Supports				
rocess Mechanical				
nfluent Gates		X		No. 12 gate does not work.
ipes, Valves and Fittings				
lectrical				
Duplex Receptacles				
Light Fixtures				
"SMV" Panelboards				
nstrumentation				
48" Dia. Mag Meters (11-16)			X	No. 14 magmeter does not work.
Flowmeter Signal Converters				

altimore City CWWFMP - Back River WWTP
acility Name: ASP #3

Date: 9/29/98

Service: Influent Metering Vaults (N and S)
Inspection Team:
Emerson, Wagner, Aylaian

Criteria

uilding Mechanical				
Exhaust/Ventilation Fans and Ducts				
Electric Heaters				
Sump Pumps				
ther				
omments				

annot dewater vaults with existing pumping units, requires submersible pump.

ecommendations

altimore City CWWFMP - Back River WWTP
acility Name: ASP #3

Date: 9/29/98

Service: Blower Building
Inspection Team:
Emerson, Wagner, Aylaian

Criteria

rchitectural				
Exterior/Interior Walls	X			
Windows	X			
Ceiling (Tiles)	X			
Doors	X			
Roofing	X			
Trim	X			
tructural				
Foundation	X			
Columns/Beams	X			
Slabs	X			
Roof Framing	X			
Equipment Supports	X			
Bridge/Monorail Supports	X			
Metal Gratings	X			
Stairs	X			
rocess Mechanical				
Pipes, Valves and Fittings	X			
Blowers	X			
nlet Silencers	X			
Filters		X		Alarm problems.
lectrical				
UPS/DCU	X			
CCTV Monitoring System	X			
Power and Lighting	X			
Blower Controls (PLC/I(O))	X			
MCC - BL1 (B1+2)	X			
MCC - R14 (B1+2)	X			

ltimore City CWWFMP - Back River WWTP
cility Name: ASP #3

Date: 9/29/98

Service: Blower Building
Inspection Team:
Emerson, Wagner, Aylaian

Criteria

ICC - R15 (B1+2)	X			
ICC - R16 (B1+2)	X			
witchgear	X			
ilter Banks and Access Switches	X			
anelboards	X			
strumentation				
ılet Temp. Sensors	X			
ypass Temp. Sensors	X			
ilding Mechanical				
VAC	X			
ubmersible Sump Pump	X			
ubmersible Sewage Pump			X	Pump does not have adequate head to operate properly.
rane	X			
CTV Cameras	X			
il Cooling Water System	X			
her				
mments				

commendations

altimore City CWWFMP - Back River WWTP

acility Name: Final Treatment

Date: 10/8/98

Service: Filtration Beds

Inspection Team:

Emerson, Wagner, Aylaian

	Criteria			
rchitectural				
Roofing		X		Heavy snow buildup deflects roof load onto elect. mast, derailing travelling bridge.
Exterior Walls		X		
tructural				
Foundations				Not reviewed.
Filtration Diversion Chamber		X		
Slabs		X		
Effluent Channel		X		
Influent Box and Channel		X		
Backwash Channel		X		
Gratings		X		
Roof Framing		X		
Columns and Piers		X		
Backwash Effluent Trough		X		
rocess Mechanical				
Filter Beds		X		Bed No. 6 out-underdrain sealing problem. 10 beds on standby from low flows.
Pipes, Valves and Fittings		X		
Slide Gates and Frames		X		Too many to maintain.
Stop Logs		X		
Effluent Gates			X	Aluminum construction worn from chlorine exposure, replace.
Parshall Flume		X		
Submersible Washwater Pump		X		
Submersible Backwash Pump		X		
Chlorine Diffusers		X		
Chlorinators & Chlorine Injection Pumps		X		
Ejectors		X		
Travelling Bridges		X		
lectrical				
		X		Lighting over Filters 1-6 not operable.

ltimore City CWWFMP - Back River WWTP
cility Name: Final Treatment

Date: 10/8/98

Service: Filtration Beds
Inspection Team:
Emerson, Wagner, Aylaian

Criteria

ubstation		X		
lectrical Control Panels		X		
ump Drives		X		
ump Pump Controller		X		
strumentation				
LCs		X		
nstrumentation Control Panel		X		
evel Probes		X		Must be cleaned continuously, maintenance problems, new probes to be installed.
onic Flow Element & Flow Mtr Transd.		X		
ubbler System		X		
tranco Cl2 Feed Controller	X			New.
ilding Mechanical				
ump Pump		X		
ir Compressor & System				
her				
mments				

gae growth clogs backwash hoods, tanks and channels, screens plug up within 8 hours of service.
ckwashing appears to be inadequate to prevent solids accumulation.
edia leaks into the clearwell.

commendations
aintain sand level in filters.
locate electrical masts off travelling bridge rails.

altimore City CWWFMP - Back River WWTP
acility Name: Final Treatment

Date: 10/8/98

Service: Sand Filter Backwash Return P. S.
Inspection Team:
Emerson, Wagner, Aylaian

Criteria

rchitectural				
Valls		X		
Vindows		X		
Doors		X		
Roofing		X		
Ceiling		X		
ructural				
Foundation		X		
Columns		X		
Beams		X		
Equipment Supports		X		
ocess Mechanical				
Backwash Return Pumps		X		Problems with kinetic air check valves, balls gets stuck, releasing effluent on deck.
lide Gates		X		Maintenance problems, require lots of lubrication, 2-3 men needed to turn valves.
Effluent gate valve			X	Valve stuck in open position, effluent flow diverted to clarifier No. 10A.
ectrical				
ower		X		
ighting		X		
ICC		X		
ontrol Panels		X		
strumentation				
ubbler (levels)		X		
lume Transducer & Transmitter		X		
ressure Switches		X		
ilding Mechanical				
VAC		X		

ltimore City CWWFMP - Back River WWTP
cility Name: Final Treatment **Date: 10/8/98**

Service: Sand Filter Backwash Return P. S.
Inspection Team:
Emerson, Wagner, Aylaian

Criteria

ir Compressor System		X		
her				
omments				

ilt new valve vault on BW return line to divert flow to Clarifier No. 10A. This prevents buildup of sand in ASPs.

ecommendations

duce media losses in backwash, then discharge BW to head of ASP No. 2 instead of clarifier No. 10A.

altimore City CWWFMP - Back River WWTP

acility Name: Final Treatment

Date: 10/8/98

Service: Control Building/Sample Pump Rm.

Inspection Team:

Emerson, Wagner, Aylaian

Criteria

rchitectural				
Exterior/Interior Walls		X		
Windows		X		
Ceiling		X		
Doors		X		
Roofing		X		
Trim		X		
Louvers		X		
tructural				
Foundation		X		
Columns		X		
Slabs		X		
Beams		X		
Roof Framing		X		
Equipment Supports		X		
Influent Channel		X		
Railings		X		
rocess Mechanical				
Filter Effluent Sample Pumps			X	Not working.
Slide Gates and Framing			X	Too much maintenance, manual operation only.
Duplex Grinder Pumps			X	Manual operation only.
Filter Influent Sample Pumps			X	Manual operation only.
Standby Sample Pumps			X	No sample pumps, manual operation only.
Automatic Samplers		X		
lectrical				
Power		X		
Lighting		X		
Main Substation		X		

altimore City CWWFMP - Back River WWTP
acility Name: Final Treatment

Date: 10/8/98

Service: Control Building/Sample Pump Rm.
Inspection Team:
Emerson, Wagner, Aylaian

Criteria

;witchgear		X		
ACC		X		
3ridge Control Interface Cabinet		X		
ıstrumentation				
'urbidimeters (Influent & Effluent)		X		In repair shop.
›H Meter		X		
)RP Meter		X		Used for Cl2 feed control.
uilding Mechanical				
IVAC		X		
ther				
omments				

ıtomatic operation of sample pumps not required as all sampling is done manually.

ecommendations

altimore City CWWFMP - Back River WWTP
acility Name: Final Treatment

Date: 10/8/98

Service: Filtration Diversion Chamber
Inspection Team:
Emerson, Wagner, Aylaian

Criteria

rchitectural				
N/A				
tructural				
Foundation		X		
Walls		X		
Ladder		X		
Pipe Support Structures		X		
Slabs		X		
Beams		X		
Equipment Supports		X		
rocess Mechanical				
Pipes, Valves and Fittings		X		
Cl2 feed lines	X			Served from Cl2 building - manual.
Gratings		X		
Sluice Gates		X		
Stop Logs		X		
lectrical				
Power		X		
Floor Stand Motors		X		
Lighting		X		
istrumentation				
uilding Mechanical				
ther				

altimore City CWWFMP - Back River WWTP

acility Name: Final Treatment

Date: 10/8/98

Service: Filtration Diversion Chamber

Inspection Team:

Emerson, Wagner, Aylaian

Criteria

omments				

each addition at JB No. 1 (after final clarifier) - adds capability to add Cl2 to all filters evenly.

ecommendations

altimore City CWWFMP - Back River WWTP

acility Name: Final Treatment

Date: 10/8/98

Service: Chlorine Contact Tanks

Inspection Team:

Emerson, Wagner, Aylaian

Criteria

rchitectural				
N/A				
tructural				
Foundation		X		
Concrete Walls		X		Expansion joints need to be caulked.
Cascade Aeration Structure		X		
Effluent Channel		X		
Final Control Building		X		
Slabs		X		
Dowels		X		
Walkways		X		
SO(2) Mixing Bay		X		
Scum Collection Troughs & Boxes		X		
rocess Mechanical				
Sluice Gates		X		
SO2 Diffusers		X		May be additional holes in diffusers as line has low pressure.
Cl2 Diffusers		X		
Flash Mixers		X		
Drain Gates			X	Gates No. 1 - 3 are leaking.
lectrical				
Power	X			
Lighting	X			
nstrumentation				
Chlorine Analyzers & Sample Pumps	X			
Refrigerated Sampler	X			
Chlorine Sump Pump Fluoride Indicators				
Flowmeters - Final Control Building		X		
DO Probe & Transmitter - Outfall Box			X	Removed due to maintenance problems - reading is taken with portable Wyse meter.

altimore City CWWFMP - Back River WWTP
acility Name: Final Treatment

Date: 10/8/98

Service: Chlorine Contact Tanks
Inspection Team:
Emerson, Wagner, Aylaian

Criteria

uilding Mechanical				
Louver Dampers - Final Control Building		X		
ther				
omments				

ecommendations

altimore City CWWFMP - Back River WWTP

acility Name: Final Treatment

Date: 10/8/98

Service: Mixing Bay

Inspection Team:

Emerson, Wagner, Aylaian

Criteria

rchitectural					
N/A					
tructural					
Foundation		X			
Columns		X			
Struts		X			
Walls		X			
Dowels		X			
Gratings		X			
Influent Chamber		X			
Tank Canopy		X			
Weir		X			
rocess Mechanical					
Flash Mixers		X			
Chlorine Diffusers		X			
lectrical					
Power		X			
Lighting		X			
Mixer Motors		X			
nstrumentation					
Level Sensor		X			
uilding Mechanical					
ther					

altimore City CWWFMP - Back River WWTP

acility Name: Final Treatment

Date: 10/8/98

Service: Mixing Bay

Inspection Team:

Emerson, Wagner, Aylaian

Criteria

omments				

acility not needed as the majority of the chlorine is added earlier in the process.

ecommendations

Baltimore City CWWFMP - Back River WWTP
Facility Name: Final Treatment

Date: 10/8/98

Service: Backwash Return Pumping Station
Inspection Team:
Emerson, Wagner, Aylaian

Criteria

Architectural				
Exterior/Interior Walls		X		
Windows		X		
Louvers		X		
Ceiling		X		
Doors		X		
Roofing		X		
Trim		X		
Structural				
Beams		X		
Slabs		X		
Stairs		X		
Foundations		X		
Columns		X		
Equipment Supports		X		
Roof Framing		X		
Monorail Support		X		
Railroad Unloading Area		X		
Gratings		X		
Chlorine Storage Shed		X		
Process Mechanical				
Pipes, Valves and Fittings		X		
SO(2) & Chlorine Tanks (DCB)		X		SO2 lines clog on a regular basis, maintenance problems.
Flushing Water Booster Pumps			X	No.1 is out of service, all are old and need to be replaced.
Cone valves and Strainers			X	Problems with limit switches, other electrical malfunctioning, needs to be replaced.
Scum & Sediment Pumps			X	Scum Pump No. 1 check valve stuck open.
Contact Tank Dewatering Pump				
Evaporators, SO2 and Cl2			X	Only 1 is new, others are old and will need to be replaced.
Cl(2) Ejectors		X		
Sulfonators			X	Old, will need to be replaced.

altimore City CWWFMP - Back River WWTP
acility Name: Final Treatment

Date: 10/8/98

Service: Backwash Return Pumping Station
Inspection Team:
Emerson, Wagner, Aylaian

Criteria

Chlorinators			X	Old, will need to be replaced.
Strainers		X		
Sluice Gates		X		
Motorized Filters		X		
Monorails		X		
Chlorine Tanks (Chlorine Storage Shed)		X		
lectrical				
Power		X		
Lighting		X		
MCCs		X		
Control Panels		X		
Computer		X		
strumentation				
Instrumentation Panel		X		
Chem Tank Pulse Duration Press. Trans.		X		
Low Pressure Cl(2) Switch w/Alarm		X		
Chlorine Analyzers & Sample Pumps		X		
SO(2) Leak Detectors		X		
Cl(2) Leak Detectors		X		
Scum Wet Well Level Sensor		X		
Flushing Water Level Transmitter		X		
Flushing Water 18" Mag Flowmeter		X		
4" Mag. Flowmeter (Chlorine Line)		X		
uilding Mechanical				
Monorail w/Crane		X		
Submersible Sump Pump		X		
Air Compressors & Dryers		X		
HVAC			X	Exhaust discharge on Cl2 and SO2 evaporator rooms are on same side as intake.

Baltimore City CWWFMP - Back River WWTP
Facility Name: Final Treatment

Date: 10/8/98

Service: Backwash Return Pumping Station
Inspection Team:
Emerson, Wagner, Aylaian

Criteria

Other				
Comments				

Area too cluttered, downstairs and up.
SO2 dessicant system needs to be replaced.
SO2 and waste can go back into contact chambers from scum pump check valve problem. Lowers Cl2 residual in contact chambers on occasion.

Recommendations
Repair or replace scum pump and/or check valve.

altimore City CWWFMP - Back River WWTP
acility Name: Final Treatment

Date: 10/8/98

Service: Beth Steel P.S. & Influent Chambers
Inspection Team:
Emerson, Wagner, Aylaian

Criteria

rchitectural				
Louvers		X		
Exterior/Interior Walls		X		
Windows		X		
Ceiling		X		
Doors		X		
Roofing		X		
Trim		X		
Entrance & Side Platforms		X		
tructural				
Roads & Parking Lot		X		
Head Box		X		
Screen Chamber		X		
Effluent Vault		X		
Columns		X		
Slabs		X		
Roof Framing		X		
Railings		X		
Stairs		X		
Equipment Supports		X		
Overflow Scupper		X		
Suction Well		X		
Distribution Channel		X		
Valve Vault		X		
rocess Mechanical				
Beth. Steel Pumps	X			
Chlorine Solution Diffuser	X			
Screens (Screen Chamber)		X		
Sluice Gate (Screen Chamber)			X	Gate controller stuck closed, thus one cannot divert all flow to Beth. Steel when service is required.
Pipes, Valves and Fittings		X		

altimore City CWWFMP - Back River WWTP

acility Name: Final Treatment

Date: 10/8/98

Service: Beth Steel P.S. & Influent Chambers

Inspection Team:

Emerson, Wagner, Aylaian

Criteria

lectrical				
Power		X		
MCC		X		
Oil Lube System Control Panel		X		
Sluice Gate Operator		X		
Pump Motors		X		
Lighting		X		
Screen Motors		X		
ıstrumentation				
Lift Box Level Sensor		X		
Float Switches		X		
Screen box Level Indicator			X	Broken, needs to be replaced.
uilding Mechanical				
Oil Lube System Dist & Pump		X		
ther				

omments

oam problems cause false alarms on ultrasonic level indicator.

ecommendations

altimore City CWWFMP - Back River WWTP
acility Name: Final Treatment

Date: 10/8/98

Service: Outfall
Inspection Team:
Emerson, Wagner, Aylaian

Criteria

rchitectural				
tructural				
Aeration steps		X		One of three trains out of service.
Structural walls		X		
rocess Mechanical				
Pipes, Valves and Fittings			X	Spray water piping broken and unsupported, needs to be removed.
Effluent Sample Pump		X		Needs to be relocated to center of channel to get more representative sample.
lectrical				
istrumentation				
uilding Mechanical				
ther				
omments				

ecommendations

JDE

CITY OF BALTIMORE, MARYLAND

COMPREHENSIVE WASTEWATER
FACILITIES MASTER PLAN

TASK 401
INVESTIGATION OF THE CONDITION
OF EXISTING FACILITIES

PATAPSCO WWTP INSPECTIONS
SUMMARY OF FINDINGS

JULY 1998

WHITMAN, REQUARDT AND ASSOCIATES, LLP
ENGINEERS AND PLANNERS
BALTIMORE, MARYLAND

WR&A

WHITMAN, REQUARDT AND ASSOCIATES, LLP

Engineers and Planners

2315 Saint Paul Street
Baltimore, Maryland 21218
(410) 235-3450

Fax: (410) 243-5716

July 1, 1998

Mr. Amarjit S. Sokhey, P.E., Chief
City of Baltimore
Water and Wastewater Engineering Division
900 Abel Wolman Municipal building
Baltimore, Maryland 21202
Attention: Mr. Jaswant Dhupar, Chief
Facilities Engineering Section

Re: Comprehensive Wastewater Facilities Master Plan
Patapsco WWTP Inspections

Gentlemen:

Task 401 of the Comprehensive Plan involves the evaluation of the condition of the existing wastewater treatment plants. As part of the evaluation, we have completed our inspection of the Patapsco Plant and have met with representatives of WWED and Plant Operations on May 29, 1998, to discuss our findings.

The purpose of the meeting was to identify plant improvements which may be required to enable the plant to perform through the end of the planning period, the year 2020. Table A summarizes the overall condition of the individual facilities and the general nature of the required improvements. Detailed inspection sheets for each facility on the plant are enclosed and include specific remarks pertaining to individual items of equipment, building components, etc.

It was agreed that the City will review these findings and compare them with the scopes of the various current plant improvement contracts to ensure that the needed improvements are either included or should be incorporated into future capital improvement projects.

We are available to discuss these findings further at your convenience, if you desire. Please advise.

Very truly yours,
WHITMAN, REQUARDT AND ASSOCIATES, LLP

John D. Emerson

JDE/mp
Enclosures
cc: William P. Wagner
Brian C. Aylaian

TABLE A

INSPECTION OF PATAPSCO WWTP

SUMMARY OF FINDINGS

Plant Area	Facility	Overall Condition	General Nature of Improvements
Primary Treatment	Grit Removal	Good	Odor and Ventilation Control
Primary Treatment	Pump & Blower Building	Fair	Roofing, Vacuum Priming, Sewer Flow Diversion, Climber Screens, Motorize Valves
Primary Treatment	Screen House	Fair	Conveyor/compactor system, Handling of Peak Flows, Gas Detection, HVAC
Primary Treatment	Primary Settling Tanks	Fair	1, 2 and 3 Traveling Bridges, Scum Collection
Primary Treatment	Primary Sludge Pumping Station #1	Poor	MCC and Power Distribution, Sludge Flowmeter #1, Sump Pumps
Primary Treatment	Primary Sludge Pumping Station #2	Fair	Roofing, MCC, Sump Pumps
Secondary	Reactors	Fair	Instrumentation
Secondary	Clarifiers	Fair	Foam Containment, Scum Collection
Secondary	Return Sludge Pumping Station #1	Poor	Complete Rehabilitation
Secondary	Return Sludge Pumping Station #2	Fair	Polymer System, Ferric Chloride System, Sump Pump, Automatic RAS/WAS Pump Operation
Sludge Processing	Sludge Thickening	Poor	Complete Rehabilitation
Sludge Processing	Sludge Blending	Poor	Complete Rehabilitation
Final Treatment	Chlorine Storage	Poor	Complete Rehabilitation

Plant Area	Facility	Overall Condition	General Nature of Improvements
Final Treatment	Chlorine Contact Chambers	Fair	Automated Sampling
Final Treatment	Chlorine Contact Building	Fair	MCC, Chlorine Injection, Gas Detection System
Final Treatment	Dechlorination Building	Fair	Increase Capacity, Automated SO2 Feed System, Instrumentation
Final Treatment	Plant Effluent Water Pumping Station	Fair/Poor	Complete Rehabilitation

Baltimore City CWWFMP - Patapsco WWTP
Facility Name: Primary Treatment
Date: 11/7/97
Service: 96" Interceptor Meter Chamber
Inspection Team:
Emerson, Wagner, Kirk, Aylaian

Condition

Criteria	Good	Fair	Poor	Remarks
Architectural				
Exterior/Interior walls		X		
Roofing			X	Leaking.
Doors		X		
Windows		X		
Louvers		X		
Ceiling		X		
Structural				Not reviewed.
Foundation				
Slabs				
Columns				
Beams				
Roof framing				
Equipment supports				
Stairs				
Process Mechanical				
Piping, valves and fittings		X		Clean and paint - removable slab joints leaking on piping.
Electrical				
Power		X		
Lighting		X		
Instrumentation				
96" flow meter/transmitter		X		Pressure gauge working, eventually replace with DP transmitter.
Totalizer indicator and recorder	X			Not needed, flow totalized through DCS.
O2 gas detector	X			New.
Building Mechanical				
Sump pump #1	X			
Sump pump #2			X	Missing.
HVAC		X		Heater corroded on the outside.
Other				

JDE

CITY OF BALTIMORE, MARYLAND

COMPREHENSIVE WASTEWATER FACILITIES MASTER PLAN

TASK 401
INVESTIGATION OF THE CONDITION OF EXISTING FACILITIES

PATAPSCO WWTP INSPECTIONS SUMMARY OF FINDINGS

JULY 1998

WHITMAN, REQUARDT AND ASSOCIATES, LLP
ENGINEERS AND PLANNERS
BALTIMORE, MARYLAND

WR&A

WHITMAN, REQUARDT AND ASSOCIATES, LLP

Engineers and Planners

2315 Saint Paul Street
Baltimore, Maryland 21218
(410) 235-3450

Fax: (410) 243-5716

July 1, 1998

Mr. Amarjit S. Sokhey, P.E., Chief
City of Baltimore
Water and Wastewater Engineering Division
900 Abel Wolman Municipal building
Baltimore, Maryland 21202
Attention: Mr. Jaswant Dhupar, Chief
Facilities Engineering Section

Re: Comprehensive Wastewater Facilities Master Plan
Patapsco WWTP Inspections

Gentlemen:

Task 401 of the Comprehensive Plan involves the evaluation of the condition of the existing wastewater treatment plants. As part of the evaluation, we have completed our inspection of the Patapsco Plant and have met with representatives of WWED and Plant Operations on May 29, 1998, to discuss our findings.

The purpose of the meeting was to identify plant improvements which may be required to enable the plant to perform through the end of the planning period, the year 2020. Table A summarizes the overall condition of the individual facilities and the general nature of the required improvements. Detailed inspection sheets for each facility on the plant are enclosed and include specific remarks pertaining to individual items of equipment, building components, etc.

It was agreed that the City will review these findings and compare them with the scopes of the various current plant improvement contracts to ensure that the needed improvements are either included or should be incorporated into future capital improvement projects.

We are available to discuss these findings further at your convenience, if you desire. Please advise.

Very truly yours,
WHITMAN, REQUARDT AND ASSOCIATES, LLP

John D. Emerson

JDE/mp
Enclosures
cc: William P. Wagner
Brian C. Aylaian

TABLE A

INSPECTION OF PATAPSCO WWTP

SUMMARY OF FINDINGS

Plant Area	Facility	Overall Condition	General Nature of Improvements
Primary Treatment	Grit Removal	Good	Odor and Ventilation Control
Primary Treatment	Pump & Blower Building	Fair	Roofing, Vacuum Priming, Sewer Flow Diversion, Climber Screens, Motorize Valves
Primary Treatment	Screen House	Fair	Conveyor/compactor system, Handling of Peak Flows, Gas Detection, HVAC
Primary Treatment	Primary Settling Tanks	Fair	1, 2 and 3 Traveling Bridges, Scum Collection
Primary Treatment	Primary Sludge Pumping Station #1	Poor	MCC and Power Distribution, Sludge Flowmeter #1, Sump Pumps
Primary Treatment	Primary Sludge Pumping Station #2	Fair	Roofing, MCC, Sump Pumps
Secondary	Reactors	Fair	Instrumentation
Secondary	Clarifiers	Fair	Foam Containment, Scum Collection
Secondary	Return Sludge Pumping Station #1	Poor	Complete Rehabilitation
Secondary	Return Sludge Pumping Station #2	Fair	Polymer System, Ferric Chloride System, Sump Pump, Automatic RAS/WAS Pump Operation
Sludge Processing	Sludge Thickening	Poor	Complete Rehabilitation
Sludge Processing	Sludge Blending	Poor	Complete Rehabilitation
Final Treatment	Chlorine Storage	Poor	Complete Rehabilitation

Plant Area	Facility	Overall Condition	General Nature of Improvements
Final Treatment	Chlorine Contact Chambers	Fair	Automated Sampling
Final Treatment	Chlorine Contact Building	Fair	MCC, Chlorine Injection, Gas Detection System
Final Treatment	Dechlorination Building	Fair	Increase Capacity, Automated SO2 Feed System, Instrumentation
Final Treatment	Plant Effluent Water Pumping Station	Fair/Poor	Complete Rehabilitation

Baltimore y CWWFMP - Patapsco WWTP **Service: 96" Interceptor Meter C hber**
Facility Name: Primary Treatment **Date: 11/7/97** **Inspection Team:**
Emerson, Wagner, Kirk, Aylaian

Criteria	Condition: Good	Fair	Poor	Remarks
Architectural				
Exterior/Interior walls		X		
Roofing			X	Leaking.
Doors		X		
Windows		X		
Louvers		X		
Ceiling		X		
Structural				Not reviewed.
Foundation				
Slabs				
Columns				
Beams				
Roof framing				
Equipment supports				
Stairs				
Process Mechanical				
Piping, valves and fittings		X		Clean and paint - removable slab joints leaking on piping.
Electrical				
Power		X		
Lighting		X		
Instrumentation				
96" flow meter/transmitter		X		Pressure gauge working, eventually replace with DP transmitter.
Totalizer indicator and recorder	X			Not needed, flow totalized through DCS.
O2 gas detector	X			New.
Building Mechanical				
Sump pump #1	X			
Sump pump #2			X	Missing.
HVAC		X		Heater corroded on the outside.
Other				

FACILITIES INSPECTION

Baltimore [illegible]y CWWFMP - Patapsco WWTP
Facility Name: Primary Treatment

Date: 11/7/97

Service: Junction Chamber
Inspection Team:
Emerson, Wagner, Kirk, Aylaian

Condition

Criteria	Good	Fair	Poor	Remarks
Architectural				Not reviewed.
Roofing				
Exterior/Interior walls				
Doors				
Windows				
Ceiling				
Trim				
Louvers				
Structural				Not reviewed.
Foundation				
Columns				
Slabs				
Beams				
Equipment supports				
Monorail support				
Stairs				
Gratings				
Railings				
Platforms				
Piles				
Roof framing				
Process Mechanical				
Sluice gates		X		
Chlorine injection pumps			X	Not working, but not currently required for plant operation.
Clamshells		X		
Pipes, valves and fittings		X		
Chlorine Diffusers			X	Not working, but not currently required for plant operation.
Chlorine Injectors			X	

Baltimore City CWWFMP - Patapsco WWTP
Facility Name: Primary Treatment

Date: 11/7/97

Service: Junction Chamber
Inspection Team:
Emerson, Wagner, Kirk, Aylaian

Criteria	Good	Fair	Poor	Remarks
Electrical				Not reviewed.
Trolley motor				
Clamshell motor				
Sluice gate operator				
Hoist motor				
Damper and louver motors				
Crane control				
Power				
Lighting				
Transformers				
Pump motors				
Instrumentation				
Gas detector systems		X		
Building Mechanical				
Monorail and trolley and hoist				
HVAC		X		
Other				

Baltimore CWWFMP - Patapsco WWTP
Facility Name: Primary Treatment

Date: 11/7/97

Service: Pump and Blower Bld
Inspection Team:
Emerson, Wagner, Kirk, Aylaian

Criteria	Good	Fair	Poor	Remarks
Architectural				
Exterior/Interior walls		X		
Roofing			X	Leaking/BUR stove BUR screen.
Doors		X		
Ceiling			X	3 tiles stained in main area.
Trim		X		
Windows			X	1 broken pane.
Louvers		X		
Lockers, showers			X	Need facilities.
Skylights			X	Need maintenance.
Structural				
Foundation				Not reviewed.
Columns				Not reviewed.
Slabs				Not reviewed.
Beams				Not reviewed.
Roof framing		X		Needs painting.
Equipment supports		X		Needs painting.
Stairs		X		Needs painting.
Monorail supports		X		Needs painting.
Ladders		X		Needs painting.
Engine/generator shed		X		Needs painting.
Handrails		X		Needs painting.
Sewage well		X		Needs painting.
Process Mechanical				
Raw sewage lift pump #1	X			
Raw sewage lift pump #2	X			
Raw sewage lift pump #3	X			
Raw sewage lift pump #4	X			
Pipes, valves and fittings	X			
Seal water pumps, tank and system		X		Bare wires to a pumping station.
Air con ssor system #1	X			

Baltimore C..y CWWFMP - Patapsco WWTP
Facility Name: Primary Treatment **Date: 11/7/97**
Service: Pump and Blower Bld
Inspection Team:
Emerson, Wagner, Kirk, Aylaian

Criteria	Condition Good	Fair	Poor	Remarks
Air compressor system #2	X			
Bubbler air compressor system	X			
Vacuum priming system #1	X			Problems with foam, priming valves/clean time/month
Vacuum priming system #2	X			Valves don't fully close. No. 1 broken closed.
Vacuum priming system (old)			X	Replaced.
Vacuum priming system #4	X			
Climber screen #1 (In filco degreement)			X	Needs replacement.
Climber screen #2 (In filco degreement)			X	Needs replacement.
Grit removal system			X	Needs replacement.
Primary sludge pump #1			X	Not in service - remove.
Primary sludge pump #2			X	Not in service - remove.
Primary sludge pump #3			X	Not in service - remove.
Influent/effluent screen gates #1			X	Needs replacement.
Influent/effluent screen gates #2			X	Needs replacement.
Dredge Bucket			X	
36" Primary Gate Valve			X	No. 1 gate gear broken (but works). No. 2 not sure if it opens all around.
Electrical				
Power		X		
Lighting	X			
Sewage lift pump motor #1	X			
Sewage lift pump motor #2	X			
Sewage lift pump motor #3	X			
Sewage lift pump motor #4	X			
Primary sludge pump motor #1			X	Not in service - remove.
Primary sludge pump motor #2			X	Not in service - remove.
Primary sludge pump motor #3			X	Not in service - remove.
Climber screen motor #1			X	Needs replacement.
Climber screen motor #2			X	Needs replacement.
Influent/effluent screen gate motor #1			X	Needs replacement.
Influent/effluent screen gate motor #2			X	Needs replacement.
Hoist m...r			X	Nee..s replacement.

Baltimore City CWWFMP - Patapsco WWTP
Facility Name: Primary Treatment

Date: 11/7/97

Service: Pump and Blower Bld
Inspection Team:
Emerson, Wagner, Kirk, Aylaian

Criteria	Condition: Good	Fair	Poor	Remarks
Clamshell bucket motors			X	Needs replacement.
Roll up door motors		X		
Supply fan motors		X		
Exhaust fan motors		X		
MCCs	X			
Switchboards		X		
Annunciators		X		
750 kW engine/generator &silencer & controls	X			New.
Control panels		X		
Panelboards		X		
Vacuum priming system motor #1	X			
Vacuum priming system motor #2	X			
Vacuum priming system motor (old)	X			
Vacuum priming system motor #4	X			
Transformers	X			New.
Switchgear	X			New.
VFDs	X			New.
Power failure system	X			New.
Air compressor motor #1	X			New.
Air compressor motor #2	X			New.
Bubbler air compressor motor		X		
Instrumentation				
Bubbler system and control panel	X			
Leak detection panel w/liquid sensor	X			
Tank gauging indicator	X			
Gas detection system and control and alarms			X	Needs replacement.
Chart recorders			X	Not needed, import to DCS.
Pump water seal leak detection system	X			
Instrument panel		X		
Distributed process system	X			New.
PLC ar anel	X			Ne

Baltimore City CWWFMP - Patapsco WWTP
Facility Name: Primary Treatment

Date: 11/7/97

Service: Pump and Blower Bldg.
Inspection Team:
Emerson, Wagner, Kirk, Aylaian

Condition

Criteria	Good	Fair	Poor	Remarks
Venturi flowmeter #1			X	Needs to replace with magmeter/Rosemount sealed DP system.
Venturi flowmeter #2			X	Needs to replace with magmeter/Rosemount sealed DP system.
H2S sensors			X	Needs replacement.
Combustible gas detectors			X	Needs replacement.
Toxic gas detectors			X	Needs replacement.
pH meters				Not reviewed.
Biometers				Not reviewed.
Annunciator panels 8, 8A and 8B		X		
Building Mechanical				
Monorail		X		
Exhaust duct		X		
Winches		X		Manually operated.
Supply fans		X		
Exhaust fans			X	One out of service/other missing/domes removed.
Standby Turbine generator	X			New.
Fuel oil tanks		X		
Condensate pumps, tank and system		X		
Deisel tank, pumps and system	X			New.
Diesel fuel storage tank	X			New.
Air compressor suction pumps				Not reviewed.
Air conditioning systems 1-4				Not reviewed.
Sump pump #1		X		
Sump pump #2		X		
Pedestal sump pump		X		
Burner and furnace and blower		X		Under service contract to improve.
Steam heaters		X		Steam leak in Pumping Station room.
Hot water pumps		X		
Intake perthouses			X	

Baltimore City CWWFMP - Patapsco WWTP
Facility Name: Primary Treatment

Date: 11/7/97

Service: Screen House
Inspection Team:
Emerson, Wagner, Kirk, Aylaian

Criteria	Good	Fair	Poor	Remarks
	Condition			
Architectural				
Exterior/Interior walls		X		
Roofing			X	Rehab.
Doors		X		
Ceiling		X		
Trim		X		
Windows		X		
Louvers		X		
Parapet walls			X	Replace.
Structural				Not reviewed.
Foundation				
Columns				
Slabs				
Beams				
Roof framing				
Equipment supports				
Stairs				
Gratings				
Handrails				
Platforms				
Monorail and support				
Screen forebay				
Screen channels				
Overflow channels				

Baltimore City CWWFMP - Patapsco WWTP
Facility Name: Primary Treatment
Date: 11/7/97
Service: Screen House
Inspection Team:
Emerson, Wagner, Kirk, Aylaian

Condition

Criteria	Good	Fair	Poor	Remarks
Process Mechanical				
Mechanical screen #1A			X	Out of service - plastic links wear and tension possibly.
Mechanical screen #1B			X	Out of service - plastic links wear and tension possibly.
Mechanical screen #2A	X			
Mechanical screen #2B	X			
Mechanical screen #3A	X			
Mechanical screen #3B	X			
Mechanical screen #4A	X			
Mechanical screen #4B	X			
Screen winch hoist and cable	X			
Sluice gates	X			
Conveyor/belt/plow		X		Problems with high flows/high volume of screenings.
Screen washdown station		X		
Screen discharge chutes		X		Rotate into conveyor side walls.
Compactor #1		X		Problems with high flows/high volume of screenings.
Compactor #2		X		Problems with high flows/high volume of screenings.
Screenings containers		X		Not adequate to contain screenings - spills over onto the ground.
Dumpster winches			X	Problem - plant installing new cable system.
Hydraulic sluice gate pump				Not reviewed.
Influent/Effluent slide gate #1	X			
Influent/Effluent slide gate #2	X			
Influent/Effluent slide gate #3	X			
Influent/Effluent slide gate #4	X			
Air compressor #1		X		Old.
Air compressor #2		X		Old.
Air compressor #3		X		Old.
Hoists 1-4	X			
Pipes, valves and fittings	X			
Crane		X		Rehabilitated recently.

Baltimore (, CWWFMP - Patapsco WWTP
Facility Name: Primary Treatment

Date: 11/7/97

Service: Screen House
Inspection Team:
Emerson, Wagner, Kirk, Aylaian

Criteria	Good	Fair	Poor	Remarks
Electrical				
Power	X			
Lighting	X			
Annunciators	X			
Panelboards	X			
MCCs	X			
Electrical control panels	X			
Motor operations for sluice gates	X			
Hoist motors	X			
Conveyor motor/drive	X			
Air compressor motor #1		X		Old.
Air compressor motor #2		X		Old.
Fine screen motor #1A	X			New.
Fine screen motor #1B	X			New.
Fine screen motor #2A	X			New.
Fine screen motor #2B	X			New.
Fine screen motor #3A	X			New.
Fine screen motor #3B	X			New.
Fine screen motor #4A	X			New.
Fine screen motor #4B	X			New.
Screens controller	X			New.
Interface terminals blocks and enclosure		X		
Dumpster winch motors and starter			X	Problem to be addressed.
Switchboard		X		
Gauge board		X		
Roll up door motors		X		
Influent/Effluent slide gate motor #1	X			
Influent/Effluent slide gate motor #2	X			
Influent/Effluent slide gate motor #3	X			
Influent/Effluent slide gate motor #4	X			
High pressure washer motor		X		

Baltimore ...y CWWFMP - Patapsco WWTP
Facility Name: Primary Treatment

Date: 11/7/97

Service: Screen House
Inspection Team:
Emerson, Wagner, Kirk, Aylaian

Criteria	Good	Fair	Poor	Remarks
Instrumentation				
Bubbler system, controls and annunciator	X			New, old compressor.
Wastewater samplers		X		
Influent channel level sensors and alarms	X			
Gas detection system and panels			X	Old Enmet - no spares, needs replacement.
Chart recorder			X	Not needed - DCS.
Differential level controls		X		
Building Mechanical				
Monorail		X		
HVAC		X		Access to heating is a problem - difficult to repair.
Traveling crane and rail		X		
Dumpster track heating system		X		
Condensate return pumps		X		
Motor operated dampers			X	Missing/stuck open - repair.
Steam heaters		X		
Roll up doors		X		
Winches		X		
Exhaust fans 1-4			X	Louvers/gravity dampers missing or broken.
Other				

Recommendations
- Solve peak screening and handling capacity problems
- Investigate conveyor and compactor problems
- Replace gas detection system

Baltimore City CWWFMP - Patapsco WWTP

Facility Name: Primary Treatment

Date: 11/7/97

Service: Primary Settling Tanks

Inspection Team:

Emerson, Wagner, Kirk, Aylaian

Condition

Criteria	Good	Fair	Poor	Remarks
Architectural				Not applicable.
Structural				Not reviewed (not possible in general as tanks were in use at time of inspection).
Foundation				
Equipment supports				
Concrete tanks/walls				
Slabs				
Beams/columns				
Piles				
Stairs				
Settled wastewater flume				
Gratings/platforms				
Railings				
Effluent trough				
Pipe tunnels				
Baffles				
Reactor Influent channels				
Effluent launders				
Bypass channel				
Distribution channel				
Process Mechanical				
Pipes, valves and fittings		X		
Traveling bridge #1		X		
Traveling bridge #2			X	Back in service in May 2000 contract.
Traveling bridge #3			X	Old - will need replacement in 1-5 years.
Influent slide gate #1		X		
Influent slide gate #2		X		
Influent slide gate #3		X		
Influent slide gate #4		X		
Influent slide gate #5		X		
Influent slide gate #6		X		

Baltimore City CWWFMP - Patapsco WWTP
Facility Name: Primary Treatment

Date: 11/7/97

Service: Primary Sludge Pumping Station #1
Inspection Team:
Emerson, Wagner, Kirk, Aylaian

Criteria	Condition: Good	Fair	Poor	Remarks
Electrical				
MCC		X		Old - may need replacement, in 5 - 10 years old.
Transformers		X		Old - may need replacement, in 5 - 10 years old.
Panelboards		X		Old - may need replacement, in 5 - 10 years old.
Power		X		Old - may need replacement, in 5 - 10 years old.
Lighting		X		Old - may need replacement, in 5 - 10 years old.
Control panels		X		Old - may need replacement, in 5 - 10 years old.
Switchgear and distribution center		X		Old - may need replacement, in 5 - 10 years old.
Primary sludge pump motor #1	X			
Primary sludge pump motor #2	X			
Primary sludge pump motor #3	X			
Primary sludge pump motor #4	X			
Scum pump motor #1		X		Not in use.
Scum pump motor #2		X		Not in use.
Air compressor motor #1		X		
VFDs #1-#4		X		
Instrumentation				
Leak detection monitoring panel	X			
Sludge flowmeter #1 (pump flow)		X		Needs replacement in 5 - 10 years.
Sludge flowmeter #2 (pump flow)	X			
Sludge flowmeter #3 (pump flow)	X			
Sludge flowmeter #4 (pump flow)	X			
Annunciator panels 1 and 2				Not reviewed.
Recorder, total flow			X	Not needed - totalization by DCS.

FACILITIE INSPECTION

Baltimore City CWWFMP - Patapsco WWTP
Facility Name: Primary Treatment

Date: 11/7/97

Service: Primary Sludge Pumpi.. Station #1
Inspection Team:
Emerson, Wagner, Kirk, Aylaian

Criteria	Good	Fair	Poor	Remarks
Building Mechanical				
HVAC		X		
Fuel oil storage tank		X		
Boiler and feed water pump & tank & controls				Not reviewed.
HW circulator pump #1				Not reviewed.
HW circulator pump #2				Not reviewed.
Sump pump #1			X	Needs replacement - pumps on order.
Sump pump #2			X	Needs replacement - pumps on order.
Sump pump #3			X	Needs replacement - pumps on order.
Sump pump #4			X	Needs replacement - pumps on order.
Air compressor & system				Not reviewed.
Make up water pump #1				Not reviewed.
Make up water pump #2				Not reviewed.
Crane rail				Not reviewed.
Monorail				Not reviewed.
Furnace and related controls and equipment				Not reviewed.
Exhaust fans (2)				Not reviewed.
Hydropneumatic tank		X		Old, but working.
Steam unit heaters #1-#3				Old, but working.
Condensate return pump and motor				Old, but working.
Other				

Baltimore y CWWFMP - Patapsco WWTP **Service: Primary Sludge Pumpi tation #2**
Facility Name: Primary Treatment **Date: 11/7/97** **Inspection Team:**
Emerson, Wagner, Kirk, Aylaian

Condition

Criteria	Good	Fair	Poor	Remarks
Architectural				
Exterior/Interior walls		X		
Roofing			X	Roof leaks over MCC 1-5 and down the walls.
Windows				Not applicable.
Doors		X		
Ceiling		X		
Trim				Not applicable.
Louvers				Not applicable.
Structural				
Foundation		X		
Beams/'columns		X		
Slabs		X		
Equipment supports		X		
Stairs		X		
Scum wells		X		
Piles		X		
Concrete walls		X		
Process Mechanical				
Primary sludge pump #5	X			
Primary sludge pump #6	X			
Primary sludge pump #7	X			
Primary sludge pump #8	X			
Primary sludge pump #9	X			
Primary sludge pump #10	X			
Primary sludge pump #11	X			
Primary sludge pump #12	X			
Scum pump #1			X	Out of service - scum system not operational.
Scum pump #2			X	Out of service - scum system not operational.
Sealing water tanks, pumps & systems 3 - 4	X			
Pipes, valves and fittings	X			

Baltimore City CWWFMP - Patapsco WWTP
Facility Name: Primary Treatment

Date: 11/7/97

Service: Primary Sludge Pumping Station #2
Inspection Team:
Emerson, Wagner, Kirk, Aylaian

Criteria	Good	Fair	Poor	Remarks
	Condition			
Electrical				
MCC		X		Corrosion from leaking roof.
Transformers	X			
Panelboards	X			
Power	X			
Lighting	X			
Control panels	X			
Switchgear and distribution center	X			
Primary sludge pump motor #4	X			
Primary sludge pump motor #5	X			
Primary sludge pump motor #6	X			
Primary sludge pump motor #7	X			
Primary sludge pump motor #8	X			
Primary sludge pump motor #9	X			
Primary sludge pump motor #10	X			
Primary sludge pump motor #11	X			
Primary sludge pump motor #12	X			
Scum pump motor #1			X	Not in service.
Scum pump motor #2			X	Not in service.
Screw conveyor motor #4	X			
Screw conveyor motor #5	X			
Screw conveyor motor #6	X			
Air compressor motor #2	X			
Hoist motor	X			

Baltimore City CWWFMP - Patapsco WWTP
Facility Name: Primary Treatment

Date: 11/7/97

Service: Primary Sludge Pumping Station #2
Inspection Team:
Emerson, Wagner, Kirk, Aylaian

Criteria	Condition: Good	Fair	Poor	Remarks
Instrumentation				
Leak detection monitoring panel	X			
Primary sludge flowmeter #4	X			
Primary sludge flowmeter #5	X			
Primary sludge flowmeter #6	X			
Annunciators	X			
Building Mechanical				
HVAC	X			
HW circulator pump #1	X			
HW circulator pump #2	X			
Sump pump #1			X	Replacements on order.
Sump pump #2			X	Replacements on order.
Sump pump #3			X	Replacements on order.
Sump pump #4			X	Replacements on order.
Air compressor & system #2	X			
Make up water pump #1	X			
Make up water pump #2	X			
Crane rail	X			
Monorail	X			
Exhaust fans (2)	X			
Hydropneumatic tank	X			
Monorail hoist	X			
Electric heaters 1 - 3	X			
Condensate return pumps and motor	X			
Other				

Baltimore CWWFMP - Patapsco WWTP
Facility Name: Primary Treatment
Date: 11/7/97
Service: Water Tower
Inspection Team:
Emerson, Wagner, Kirk, Aylaian

Criteria	Condition: Good	Fair	Poor	Remarks
Architectural				Not applicable.
Structural				
Foundation				
Walls		X		To be painted in the Spring of 1998.
Slabs				Not applicable.
Tank Support		X		
Equipment support		X		
Beams		X		
Process Mechanical				
Water tower		X		
Pumps		X		
Pipes, valves and fittings		X		
Electrical				
Power				Not reviewed.
Lighting				Not reviewed.
Instrumentation				
Pressure Transmitter	X			
Chart Recorder			X	Not needed, impact to DCS.
Building Mechanical				
Ventilation		X		
Other				

Baltimore City CWWFMP - Patapsco WWTP
Facility Name: Primary Treatment
Date: 11/7/97
Service: Water Tower
Inspection Team:
Emerson, Wagner, Kirk, Aylaian

Condition

Criteria	Good	Fair	Poor	Remarks

Baltimore City CWWFMP - Patapsco WWTP
Facility Name: ASP

Date: 12/10/97

Service: Reactors
Inspection Team:
Emerson, Wagner, Bougher, Aylaian

Criteria	Condition: Good	Fair	Poor	Remarks
Architectural				Not applicable.
Structural				
Foundation				Not reviewed.
Concrete walls				Not reviewed.
Columns				Not reviewed.
Slabs			X	Top slab over E-W gallery (N) leaking badly.
Beams				Not reviewed.
Equipment supports				Not reviewed.
Gratings				Not reviewed.
Manholes				Not reviewed.
Railings				Not reviewed.
Mixed liquor flume				Not reviewed.
Effluent channel		X		Spray water nozzles have a chronic clogging problem.
Reactor influent channels				Not reviewed.
Baffles				Not reviewed.
Stairs				Not reviewed.
MCC buildings				Not reviewed.
Process Mechanical				
Reactor #1 aerators and motors (125, 75, and 150 hp)				Not reviewed.
Reactor #2 aerators and motors (125, 75, and 150 hp)				Not reviewed.
Reactor #3 aerators and motors (125, 75, and 150 hp)				Not reviewed.
Reactor #4 aerators and motors (125, 75, and 150 hp)				Not reviewed.
Reactor #5 aerators and motors (125, 75, and 150 hp)				Not reviewed.
Reactor #6 aerators and motors (125, 75, and 150 hp)				Not reviewed.
Reactor #1 mixers and motors 1-4				Not reviewed.
Reactor #2 mixers and motors 1-4				Not reviewed.
Reactor #3 mixers and motors 1-4				Not reviewed.
Reactor [illegible] mixers and motors 1-4				[illegible]t reviewed.

Baltimore City CWWFMP - Patapsco WWTP
Facility Name: ASP

Date: 12/10/97

Service: Reactors
Inspection Team:
Emerson, Wagner, Bougher, Aylaian

Criteria	Condition: Good	Fair	Poor	Remarks
Reactor #5 mixers and motors 1-4				Not reviewed.
Reactor #6 mixers and motors 1-4				Not reviewed.
Reactor #1 motorized slide gates (1A/1B)				Not reviewed.
Reactor #2 motorized slide gates (2A/2B)				Not reviewed.
Reactor #3 motorized slide gates (3A/3B)				Not reviewed.
Reactor #4 motorized slide gates (4A/4B)				Not reviewed.
Reactor #5 butterfly valve (5-1/5-2)				Not reviewed.
Reactor #6 butterfly valve (6-1/6-2)				Not reviewed.
Reactor #1 purge blower and motor				Not reviewed.
Reactor #2 purge blower and motor				Not reviewed.
Reactor #3 purge blower and motor				Not reviewed.
Reactor #4 purge blower and motor				Not reviewed.
Reactor #5 purge blower and motor				Not reviewed.
Reactor #6 purge blower and motor				Not reviewed.
Reactor #1 venturi purge				Not reviewed.
Reactor #2 venturi purge				Not reviewed.
Reactor #3 venturi purge				Not reviewed.
Reactor #4 venturi purge				Not reviewed.
Pipes, valves and fittings				Not reviewed.
Electrical				
MCC #1	X			
MCC #2	X			
MCC #3	X			
MCC #4	X			
VFD control aerator 5-1				Not reviewed.
VFD control aerator 5-3				Not reviewed.
VFD control aerator 6-1				Not reviewed.
VFD control aerator 6-3				Not reviewed.
Bubbl[illegible]ump panels	X			
Power	X			

Baltimore City CWWFMP - Patapsco WWTP
Facility Name: ASP

Date: 12/10/97

Service: Reactors
Inspection Team:
Emerson, Wagner, Bougher, Aylaian

Criteria	Condition: Good	Fair	Poor	Remarks
Lighting and poles	X			
Reactor #6 MCC rmmeter/recorder panel	X			
Reactor #1 relay control panel	X			
Reactor #2 relay control panel	X			
Reactor #3 relay control panel	X			
Reactor #4 relay control panel	X			
Reactor #5 relay control panel	X			New.
Reactor #6 relay control panel	X			New.
MCC 2 annunciator panels (2)				
Instrumentation				
Reactor #1 LEL gas analyzers (2nd, 3rd, and anar)	X			New.
Reactor #2 LEL gas analyzers (2nd, 3rd, and anar)	X			New.
Reactor #3 LEL gas analyzers (2nd, 3rd, and anar)	X			New.
Reactor #4 LEL gas analyzers (2nd, 3rd, and anar)	X			New.
Reactor #5 LEL gas analyzers (2nd, 3rd, and anar)	X			New.
Reactor #6 LEL gas analyzers (2nd, 3rd, and anar)	X			New.
Sigma steamline reactor influent sampler				Not reviewed.
Reactor #1 D.O. probes				Not reviewed.
Reactor #2 D.O. probes				Not reviewed.
Reactor #3 D.O. probes				Not reviewed.
Reactor #4 D.O. probes				Not reviewed.
Reactor #5 D.O. probes				Not reviewed.
Reactor #6 D.O. probe	X			New.
Reactor #1 oxygen flow meter				Not reviewed.
Reactor #2 oxygen flow meter				Not reviewed.
Reactor #3 oxygen flow meter				Not reviewed.
Reactor #4 oxygen flow meter				Not reviewed.
Reactor #5 oxygen flow meter				Not reviewed.
Reactor #6 oxygen flow meter				Not reviewed.
BNR ar[illegible]turned sludge flow meters				[illegible]t reviewed.

Baltimore City CWWFMP - Patapsco WWTP
Facility Name: ASP

Date: 12/10/97

Service: Reactors
Inspection Team:
Emerson, Wagner, Bougher, Aylaian

Criteria	Condition: Good	Fair	Poor	Remarks
Reactor #1 suspended solids meters				Not reviewed.
Reactor #2 suspended solids meters				Not reviewed.
Reactor #3 suspended solids meters				Not reviewed.
Reactor #4 suspended solids meters				Not reviewed.
Reactor #5 suspended solids meters				Not reviewed.
Reactor #6 suspended solids meters (4)	X			New.
Reactor #1 pH meters				Not reviewed.
Reactor #2 pH meters				Not reviewed.
Reactor #3 pH meters				Not reviewed.
Reactor #4 pH meters				Not reviewed.
Reactor #5 pH meters				Not reviewed.
Reactor #6 pH and BNR pH meters (5)	X			New.
Reactor #1 ORP meters				Not reviewed.
Reactor #2 ORP meters				Not reviewed.
Reactor #3 ORP meters				Not reviewed.
Reactor #4 ORP meters				Not reviewed.
Reactor #5 ORP meters				Not reviewed.
Reactor #6 ORP meters (5)	X			New.
Reactor #1 valve positioners				Not reviewed.
Reactor #2 valve positioners				Not reviewed.
Reactor #3 valve positioners				Not reviewed.
Reactor #4 valve positioners				Not reviewed.
Reactor #5 valve positioners				Not reviewed.
Reactor #6 valve positioners				Not reviewed.
RAS flowmeters 5A/B (DP sensors)				Not reviewed.
RAS flowmeter 6A (DP sensor)				Not reviewed.
Reactor #1 (A/B) oxic zone pressure sensors		X		Working.
Reactor #2 (A/B) oxic zone pressure sensors		X		Working.
Reactor #3 (A/B) oxic zone pressure sensors		X		Working.
Reactor #4 (A/B) oxic zone pressure sensors		X		Working.
Reactor #1 oxygen exhaust flow transmitter			X	Confirm not operational.
Reactor . oxygen exhaust flow transmitter			X	ıfirm not operational.

Baltimore City CWWFMP - Patapsco WWTP
Facility Name: ASP

Date: 12/10/97

Service: Reactors
Inspection Team:
Emerson, Wagner, Bougher, Aylaian

Criteria	Condition: Good	Fair	Poor	Remarks
Reactor #3 oxygen exhaust flow transmitter			X	Confirm not operational.
Reactor #4 oxygen exhaust flow transmitter			X	Confirm not operational.
Reactor #1 oxygen vent purity analyzer		X		Confirm operational.
Reactor #2 oxygen vent purity analyzer		X		Confirm operational.
Reactor #3 oxygen vent purity analyzer		X		Confirm operational.
Reactor #4 oxygen vent purity analyzer		X		Confirm operational.
Reactor #5 oxygen vent purity analyzer		X		Confirm operational.
Reactor #6 oxygen vent purity analyzer		X		Confirm operational.
Building Mechanical				
Heating and ventilation equipment	X			
Compressed air system	X			
Aerator/mixer oil heater systems				Not reviewed.
Duplex sump pumps	X			
Water tank and pumps	X			
A/C units 1-4				Not reviewed.
Exhaust fans (west/east galleys and MCC 2-4)		X		
Reactor intake fans (VAX 1-4 - 8 total)		X		
Probe puller hoist				Not required.
Other				

Comments

Facilities in service and therefore not readily available for inspection.

Recom ndations

FACILITIES INSPECTION

Baltimore City CWWFMP - Patapsco WWTP
Facility Name: ASP

Date: 12/10/97

Service: Reactors
Inspection Team:
Emerson, Wagner, Bougher, Aylaian

Criteria	Condition: Good	Fair	Poor	Remarks

FACILITIES INSPECTION

Baltimore City CWWFMP - Patapsco WWTP
Facility Name: ASP

Date: 12/10/97

Service: Secondary Clarifiers
Inspection Team:
Emerson, Wagner, Bougher, Aylaian

Condition

Criteria	Good	Fair	Poor	Remarks
Architectural				
Structural				
Foundations	X			
Concrete walls	X			
Slabs	X			
Mixed liquor and flume	X			
Secondary effluent flume	X			
Railings	X			
Scum manholes	X			
Baffles	X			
Equipment supports	X			
Walkway landings	X			
Clarifier influent walls	X			
Piles	X			
Effluent and scum boxes	X			
Distribution boxes 2 and 3	X			
Foam containment area and mixed liquor flume		X		Foam problem.
Process Mechanical				
Clarifier tank #1	X			
Clarifier tank #2	X			
Clarifier tank #3	X			
Clarifier tank #4	X			
Clarifier tank #5A	X			
Clarifier tank #5B	X			
Clarifier tank #6A	X			
Clarifier tank #6B	X			
Clarifier #1 center drive	X			Algae removal brushes work well.

Baltimore City CWWFMP - Patapsco WWTP
Facility Name: ASP

Date: 12/10/97

Service: Secondary Clarifiers
Inspection Team:
Emerson, Wagner, Bougher, Aylaian

Criteria	Condition Good	 Fair	 Poor	Remarks
Clarifier #2 center drive	X			Algae removal brushes work well.
Clarifier #3 center drive	X			Install algae removal brushes.
Clarifier #4 center drive	X			Install algae removal brushes.
Clarifier #5A center drive	X			Install algae removal brushes.
Clarifier #5B center drive	X			Install algae removal brushes.
Clarifier #6A center drive	X			Install algae removal brushes.
Clarifier #6B center drive	X			Install algae removal brushes.
Scum pumps 1-1/1-2		X		Original pump replaced, scum must be hauled out from line clogs
Scum pumps 2-1/2-2		X		Original pump replaced, scum must be hauled out from line clogs
Scum pumps 3-1/3-2		X		Original pump replaced, scum must be hauled out from line clogs
Scum pumps 4-1/4-2		X		Original pump replaced, scum must be hauled out from line clogs
Scum pumps 5A/5B		X		Original pump replaced, scum must be hauled out from line clogs
Scum pumps 6A/6B		X		Original pump replaced, scum must be hauled out from line clogs
Scum mixers 1-1/1-2		X		
Scum mixers 2-1/2-2		X		
Scum mixers 3-1/3-2		X		
Scum mixers 4-1/4-2		X		
Scum mixers 5A/5B		X		
Scum mixers 6A/6B		X		
Distribution box slide gates 5A/B		X		On/off buttons stick in cold weather.
Distribution box slide gates R5A/B		X		On/off buttons stick in cold weather.
Distribution box slide gates 6A/B		X		On/off buttons stick in cold weather.
Distribution box slide gates R6A/B		X		On/off buttons stick in cold weather.
Clarifier motorized slide gate #1		X		On/off buttons stick in cold weather.
Clarifier motorized slide gate #2		X		On/off buttons stick in cold weather.
Clarifier motorized slide gate #3		X		On/off buttons stick in cold weather.
Clarifier motorized slide gate #4		X		On/off buttons stick in cold weather.
Effluent motorized slide gate 5A/B		X		On/off buttons stick in cold weather.
Effluent motorized slide gate 6A/B		X		On/off buttons stick in cold weather.
Single point chlorine strainer				Not reviewed.
Dewatering pump H9	X			

FACILITIES INSPECTION

Baltimore City CWWFMP - Patapsco WWTP
Facility Name: ASP

Date: 12/10/97

Service: Secondary Clarifiers
Inspection Team:
Emerson, Wagner, Bougher, Aylaian

Criteria	Good	Fair	Poor	Remarks
Dewatering pump H10	X			
Scum scrapers		X		Scrapers freeze and break on cold days.
Pipes, valves and fittings				Not reviewed.
Electrical				
Power		X		
Lighting		X		
MCC 2-5		X		
Instrumentation				
Clarifier #1 torque analyzer		X		Mechanical torque analyzers are O.K., but electrical analyzers were replaced.
Clarifier #2 torque analyzer		X		Mechanical torque analyzers are O.K., but electrical analyzers were replaced.
Clarifier #3 torque analyzer		X		Mechanical torque analyzers are O.K., but electrical analyzers were replaced.
Clarifier #4 torque analyzer		X		Mechanical torque analyzers are O.K., but electrical analyzers were replaced.
Royce sludge blanket level detector #5A		X		Readings drift as algae accumulates, requires periodic maintenance.
Royce sludge blanket level detector #5B		X		Readings drift as algae accumulates, requires periodic maintenance.
Royce sludge blanket level detector #6A		X		Readings drift as algae accumulates, requires periodic maintenance.
Royce sludge blanket level detector #6B		X		Readings drift as algae accumulates, requires periodic maintenance.
Sampler #1		X		
Sampler #2		X		

FACILITIES INSPECTION

Baltimore City CWWFMP - Patapsco WWTP

Facility Name: ASP

Date: 12/10/97

Service: Secondary Clarifiers

Inspection Team:

Emerson, Wagner, Bougher, Aylaian

Criteria	Good	Fair	Poor	Remarks
Building Mechanical				
Other				
Comments				
Recommendations				

FACILITIES INSPECTION

Baltimore City CWWFMP - Patapsco WWTP
Facility Name: ASP

Date: 12/10/97

Service: RSPS #1
Inspection Team:
Emerson, Wagner, Bougher, Aylaian

Criteria	Good	Fair	Poor	Remarks
		Condition		
Architectural				
Exterior/Interior walls		X		
Roofing		X		
Doors		X		
Windows		X		No breakage.
Ceiling		X		Some leaks.
Floor		X		Water covers major portion of floor for extended time periods.
Structural				
Equipment supports		X		Metal support structure for RAS pumps corroded badly.
Slabs		X		
Columns		X		
Beams		X		
Roof framing		X		
Railings		X		
Monorail supports		X		
Stairs		X		
Piles		X		
Wet well		X		
Process Mechanical				
RAS pump #1		X		Coupling disassembled, leaks sealing water.
RAS pump #2		X		Leaks sealing water.
RAS pump #3		X		Leaks sealing water.
RAS pump #4		X		Leaks sealing water.
RAS pump #5		X		Leaks sealing water.
WAS pump #1 (H6)		X		Abandoned in place, replaced by temperary pumps, not currently operating.
WAS pump #2 (H7)		X		Abandoned in place, replaced by temperary pumps, not currently operating.
WAS pump #3 (H8)		X		Abandoned in place, replaced by temperary pumps, not currently operating.
Wet well mixer #1		X		

Baltimore City CWWFMP - Patapsco WWTP

Facility Name: ASP

Date: 12/10/97

Service: RSPS #1

Inspection Team:

Emerson, Wagner, Bougher, Aylaian

Condition

Criteria	Good	Fair	Poor	Remarks
Wet well mixer #2		X		
FeCl3 storage tank #1		X		Tank pressurization for flow leads to maintenance problems, possibly relocate
FeCl3 storage tank #2		X		Tank pressurization for flow leads to maintenance problems, possibly relocate
FeCl3 recovery tank (outside)				Not reviewed.
FeCl3 day tank #1		X		Working.
FeCl3 day tank #2		X		Working.
Bubbler air compressor and tank #1		X		
Bubbler air compressor and tank #2		X		
Lance air compressor and tank		X		
FeCl3 mixer #1		X		Corroded but working.
FeCl3 mixer #2		X		Corroded but working.
FeCl3 feed pump #1		X		
FeCl3 feed pump #2		X		
Polymer feed bin			X	Abandoned in place.
Dust collector			X	Abandoned in place.
Polymer feed hopper #1			X	Abandoned in place.
Polymer feed hopper #2			X	Abandoned in place.
Polymer feeder #1 (Vac U Max)			X	Abandoned in place.
Polymer feeder #2 (Vac U Max)			X	Abandoned in place.
Hopper bin vibrator #1			X	Abandoned in place.
Hopper bin vibrator #2			X	Abandoned in place.
Shaker #1			X	Abandoned in place.
Shaker #2			X	Abandoned in place.
Wetting unit #1			X	Abandoned in place.
Wetting unit #2			X	Abandoned in place.
Wetting box transfer pump #1			X	Abandoned in place.
Wetting box transfer pump #2			X	Abandoned in place.
Polymer mixing tank #1		X		Still in use.
Polymer mixing tank #2			X	Not in service.
Polymer mixing tank mixer #1		X		Still in use.
Polymer mixing tank mixer #2			X	Not in service.
Polymer nsfer pump #1		X		Still in use.

Baltimore City CWWFMP - Patapsco WWTP
Facility Name: ASP

Date: 12/10/97

Service: RSPS #1
Inspection Team:
Emerson, Wagner, Bougher, Aylaian

Condition

Criteria	Good	Fair	Poor	Remarks
Polymer transfer pump #2			X	Not in service.
Polymer day tank #1		X		Used as manich storage tank.
Polymer day tank #2			X	Not in service.
Polymer feed pump #1		X		Still in use.
Polymer feed pump #2			X	Not in service.
Lift station submersible pump #1				Not reviewed.
Lift station submersible pump #2				Not reviewed.
Polyblend pump/motor/mixer/VSD/PS				Not reviewed.
Chlorine injectors		X		
Secondary clarifier sludge valves 1 - 4		X		
Electrical				
Polymer control panel #1 (Polypak)				Not reviewed.
Polymer control panel #2 (Polypak)				Not reviewed.
MCC 2-4		X		Old but working.
Power		X		
Lighting		X		
Variable speed panel and control		X		
Moyno speed controller, #4 WAS pump		X		
Moyno speed controller, #5 WAS pump		X		
Sluice gate controller #1		X		
Sluice gate controller #2		X		
Sluice gate controller #3		X		
Sluice gate controller #4		X		
Butterfly valve #5		X		
Butterfly valve #6		X		
UPS system		X		Improperly located on crating above wet floor, needs permanent location.
Bailey computer terminal and system	X			

Baltimore City CWWFMP - Patapsco WWTP
Facility Name: ASP

Date: 12/10/97

Service: RSPS #1
Inspection Team:
Emerson, Wagner, Bougher, Aylaian

Condition

Criteria	Good	Fair	Poor	Remarks
Instrumentation				
Instrumentation panel		X		
RAS sludge flow element/transmitters/indicator #1	X			New.
RAS sludge flow element/transmitters/indicator #2	X			New.
RAS sludge flow element/transmitters/indicator #3	X			New.
RAS sludge flow element/transmitters/indicator #4	X			New.
RAS sludge flow element/transmitters/indicator #5	X			New.
WAS sludge flow element/transmitters/indicator #6	X			New DP cell and wiring.
FeCl3 storage tank level trans/indicator #1 (Drexelbrook)		X		
FeCl3 storage tank level trans/indicator #2 (Drexelbrook)		X		
FeCl3 dat tank level indicator and display #1		X		KEP display.
FeCl3 dat tank level indicator and display #2		X		KEP display.
FeCl3 level indicator panel		X		
Chloralert Cl2 detector/alarm		X		Working.
Flow transmitter/totalizer/recorder #1			X	Out of service.
Flow transmitter/totalizer/recorder #2			X	Out of service.
Flow transmitter/totalizer/recorder #3		X		
Flow transmitter/totalizer/recorder #4		X		
Wetwell level indicator		X		
Bubbler system and display panel	X			New.
DP cells on each sludge pump (5)	X			New.
Building Mechanical				
Monorail hoist and motor		X		
Submersible sump pump #1		X		
Submersible sump pump #2		X		
Pedestal sump pump #1 (Ferric Room)			X	Ferric chloride exposure quickly destroys any sump pumps in this room.
Pedestal sump pump #2 (Ferric Room)			X	Ferric chloride exposure quickly destroys any sump pumps in this room.

Baltimore City CWWFMP - Patapsco WWTP
Facility Name: ASP

Date: 12/10/97

Service: RSPS #1
Inspection Team:
Emerson, Wagner, Bougher, Aylaian

Criteria	Good	Fair	Poor	Remarks
		Condition		
Air compressor and motor #1		X		
Air compressor and motor #2		X		
Air retention tanks 1-2		X		
Water strainer		X		
Ventilation roof fans 1-6		X		
Exhaust fans, FeCl3 and wet well		X		
Heaters, hot water and electric			X	Space heaters only.
HVAC			X	Not in service.
Sealing water pump/motor #1		X		
Sealing water pump/motor #2		X		
Sealing water tank		X		
Other				

Comments

Recommendations

Salvage working equipment and rehabilitate building.

FACILITIES INSPECTION

Baltimore City CWWFMP - Patapsco WWTP
Facility Name: ASP

Date: 12/10/97

Service: RSPS #2
Inspection Team:
Emerson, Wagner, Bougher, Aylaian

Criteria	Good	Fair	Poor	Remarks
Architectural				
Exterior/Interior walls	X			
Roofing	X			
Doors	X			
Windows	X			
Ceiling	X			
Trim	X			
Louvers	X			
Floor		X		Some tiles coming up off floor.
Structural				
Equipment supports	X			
Slabs	X			
Columns	X			
Beams	X			
Roof framing	X			
Railings	X			
Monorail supports	X			
Stairs	X			
Piles	X			
Wet well	X			
Scum well	X			
Process Mechanical				
RAS pump and motor #5A1	X			Impeller clearance low - makes start-up difficult.
RAS pump and motor #5A2	X			
RAS pump and motor #5B1	X			
RAS pump and motor #5B2	X			
RAS pump and motor #6A1	X			
RAS pump and motor #6A2	X			
RAS pump and motor #6B1	X			

Baltimore C[illegible] CWWFMP - Patapsco WWTP
Facility Name: ASP

Date: 12/10/97

Service: RSPS #2
Inspection Team:
Emerson, Wagner, Bougher, Aylaian

Criteria	Good	Fair	Poor	Remarks
RAS pump and motor #6B2	X			
WAS pump and motor #5A	X			
WAS pump and motor #5B	X			
WAS swing pump and motor #5A/6A	X			
WAS swing pump and motor #5B/6B	X			
WAS pump and motor #6A	X			
WAS pump and motor #6B	X			
Scum transfer pump and motor #SC-1		X		Using scum well to hold scum - line to SPB is clogged - must collect and dispose.
Scum transfer pump and motor #SC-2		X		Using scum well to hold scum - line to SPB is clogged - must collect and dispose.
Scum decanting pump and motor , 6"		X		Using scum well to hold scum - line to SPB is clogged - must collect and dispose.
Clarifier drainage pump and motor (#5A/6A)	X			
Clarifier drainage pump and motor (#5B/6B)	X			
Sealing water pump and motor #1	X			
Sealing water pump and motor #2	X			
Sealing water tank #1 (small)	X			Float hangs up occassionally.
Sealing water tank #2 (large)	X			
Polymer transfer pump and motor #1		X		Pulsafeeders replaced with Moyno pumps, much improved reliability.
Polymer transfer pump and motor #2		X		Pulsafeeders replaced with Moyno pumps, much improved reliability.
Vacuum pump and motor				Not reviewed.
Polymer feed pump and motor #1		X		Replaced pulsafeeders with Moyno pumps - works O.K.
Polymer feed pump and motor #2		X		Replaced pulsafeeders with Moyno pumps - works O.K.
Polymer feed pump and motor #2		X		Replaced pulsafeeders with Moyno pumps - works O.K.
Polymer feed pump and motor #4 (Moyno)				Not yet installed.
Polymer feed pump and motor #5 (Moyno)				Not yet installed.
Polymer feed pump and motor #6 (Moyno)				Not yet installed.
Polymer feed pump and motor #7 (Moyno)				Not yet installed.
Polymer feed pump and motor #8 (Moyno)				Not yet installed.
FeCl3 feed pump and motor #1		X		Replaced.
FeCl3 feed pump and motor #2			X	Out of service.
FeCl3 feed pump and motor #3		X		Replaced.
FeCl3 feed pump and motor #4		X		Replaced.
Polymer storage tank #1		X		Loading in too much polymer - shelf life exceeded - this causes clogging.
Polyme[illegible] storage tank #2		X		Loading in too much polymer - shelf life exceeded - this causes clogging.

Baltimore City CWWFMP - Patapsco WWTP
Facility Name: ASP

Date: 12/10/97

Service: RSPS #2
Inspection Team:
Emerson, Wagner, Bougher, Aylaian

Criteria	Condition: Good	Fair	Poor	Remarks
Polymer batch tank #1		X		
Polymer batch tank #2		X		
Polymer batch tank mixer and motor #3		X		
Polymer batch tank mixer and motor #4		X		
Waste pickle liquor tank		X		Using as ferric chloride storage tank.
Ferric chloride storage tank #1		X		Header valves sometimes stick.
Ferric chloride storage tank #2		X		Header valves sometimes stick.
Ferric chloride storage tank #3		X		Header valves sometimes stick.
Dual basket strainer and motor #1	X			
Dual basket strainer and motor #2	X			
Dual basket strainer and motor #3	X			
Pipes, valves and fittings		X		Galvanized drain lines on RAS replaced with S.S.
Electrical				
WAS pump variable speed drive	X			
FeCl3 feed pump speed controller #1		X		8 years old - high maintanence.
FeCl3 feed pump speed controller #2		X		8 years old - high maintanence.
FeCl3 feed pump speed controller #3		X		8 years old - high maintanence.
FeCl3 feed pump speed controller #4		X		8 years old - high maintanence.
Polymer feed pump speed controller #1		X		Some clogging problems.
Polymer feed pump speed controller #2		X		Some clogging problems.
Polymer feed pump speed controller #3		X		Some clogging problems.
Polymer feed pump speed controller #4		X		Some clogging problems.
Polymer feed pump speed controller #5		X		Some clogging problems.
Polymer feed pump speed controller #6		X		Some clogging problems.
WAS pump speed controller #5A		X		
WAS pump speed controller #5B		X		
WAS s[illegible]g pump speed controller #5A/6A		X		

FACILITIES INSPECTION

Baltimore City CWWFMP - Patapsco WWTP **Service: RSPS #2**
Facility Name: ASP **Date: 12/10/97** **Inspection Team:**
Emerson, Wagner, Bougher, Aylaian

Criteria	Condition: Good	Fair	Poor	Remarks
WAS swing pump speed controller #5B/6B		X		
WAS VSD #5A1	X			Pumps run manually.
WAS VSD #5B1	X			Pumps run manually.
WAS VSD #5A1	X			Pumps run manually.
WAS VSD #6A	X			Pumps run manually.
WAS VSD #6B	X			Pumps run manually.
WAS VSD #5B1	X			Pumps run manually.
WAS VSD #5B2	X			Pumps run manually.
WAS VSD #6A1	X			Pumps run manually.
WAS VSD #6A2	X			Pumps run manually.
WAS VSD #6B1	X			Pumps run manually.
WAS VSD #6B2	X			Pumps run manually.
UPS		X		Problems with batteries.
Process control computer	X			Newly installed, but not fully operational yet, can only change some setpoints.
Control panels		X		Annunciator won't reset.
Power		X		
Lighting		X		
Tranformers T1/T2		X		
MCC		X		
RAS VSD #5A1		X		
RAS VSD #5B1		X		
RAS VSD #5A1		X		
RAS VSD #6A		X		
RAS VSD #6B		X		
RAS VSD #5B1		X		
RAS VSD #5B2		X		
RAS VSD #6A1		X		
RAS VSD #6A2		X		
RAS VSD #6B1		X		
RAS VSD #6B2		X		
Clarifier slide gate MCCs		X		
Clarifier sluice gate MCCs		X		
BNR c[illegible]ol panel (flow, speed, and valves)	X			

FACILITIES I[illegible]PECTION

Baltimore City CWWFMP - Patapsco WWTP
Facility Name: ASP

Date: 12/10/97

Service: RSPS #2
Inspection Team:
Emerson, Wagner, Bougher, Aylaian

Condition

Criteria	Good	Fair	Poor	Remarks
Instrumentation				
RAS magmeter 5A1/5A2		X		High maintenance - clogging and coating problems, needs bypass piping
RAS magmeter 5B1/5B2		X		High maintenance - clogging and coating problems, needs bypass piping
RAS magmeter 6A1/6A2		X		High maintenance - clogging and coating problems, needs bypass piping
RAS magmeter 6B1/6B2		X		High maintenance - clogging and coating problems, needs bypass piping
Allen Bradley PLC-5 controller		X		
FeCl3 tank level sensor #1		X		
FeCl3 tank level sensor #2		X		
FeCl3 tank level sensor #3		X		
Polymer batch tank level sensor #1		X		
Polymer batch tank level sensor #2		X		
Polymer storage tank level sensor #1		X		
Polymer storage tank level sensor #2		X		
RAS flowmeter - flow to reactor (#5A)	X			Some coating problems - regular maintenance required.
RAS flowmeter - flow to reactor (#5B)	X			Some coating problems - regular maintenance required.
RAS flowmeter - flow to reactor (#6A)	X			Some coating problems - regular maintenance required.
RAS flowmeter - flow to reactor (#6B)	X			Some coating problems - regular maintenance required.
WAS flowmeter - flow to AFT (#5A)		X		High maintenance due to clogging
WAS flowmeter - flow to AFT (#5B)		X		
WAS flowmeter - flow to AFT (#6A)		X		
WAS flowmeter - flow to AFT (#6B)		X		
Magmeter, polymer flow (#5A)			X	Clogging - continuous maintenance and piping problems
Magmeter, polymer flow (#5B)			X	Clogging - continuous maintenance and piping problems
Magmeter, polymer flow (#6A)			X	Clogging - continuous maintenance and piping problems
Magmeter, polymer flow (#6B)			X	Clogging - continuous maintenance and piping problems
Magmeter, FeCl3 flow #1	X			
Magme[illegible] FeCl3 flow #2	X			

Baltimore City CWWFMP - Patapsco WWTP
Facility Name: ASP

Date: 12/10/97

Service: RSPS #2
Inspection Team:
Emerson, Wagner, Bougher, Aylaian

Criteria	Condition: Good	Fair	Poor	Remarks
Sigma sampler #1	X			
Sigma sampler #2	X			
Instrumentation panels	X			
Annunciator panel		X		Some bulbs are out.
Building Mechanical				
Sump pump and motor #1, basement			X	Bottleneck if two sump pumps are on simultaneously - pipe diameter too small.
Sump pump and motor #2, basement			X	Bottleneck if two sump pumps are on simultaneously - pipe diameter too small.
Polymer sump pump and motor			X	Out of service.
FeCl3 sump pump and motor #1		X		
FeCl3 sump pump and motor #1			X	Missing.
Air compressor and motor #1		X		For sealing water.
Bridge crane - 5 ton	X			
Bridge travel motors, east and west	X			
Motors, crane trolley and hoist	X			
Exhaust fans	X			
Motor operated dampers		X		Mechanical linkage and motors are high maintenance.
Heaters			X	Space heaters have bad thermostats and fan motors.
Air handling units 1-3		X		
Air conditioning units 1-2		X		Internal pitting causes corroding of coils and compressor burn-out and leaks.
Air filters			X	Inaccessable - difficult to change filters.
Other				

Baltimore City CWWFMP - Patapsco WWTP **Service: RSPS #2**

Facility Name: ASP **Date: 12/10/97** **Inspection Team:**

Emerson, Wagner, Bougher, Aylaian

Criteria	Good	Fair	Poor	Remarks
Comments				
Moyno replacements use more power than Pulsafeeders, thusa power shortage exists. Currently will turn off heaters to run Moynos. Need to fix situation.				
Polymer feed lines clogging due to overfilling of storage tanks, polymer inconsistencies, piping bens, and piping diameter - need to resolve.				
Polymer system could use flushing system.				
HWEW polymer solution water needs strainer.				
Recommendations				

FACILITIES INSPECTION

Baltimore Ci[illegible] CWWFMP - Patapsco WWTP
Facility Name: ASP

Date: 12/10/97

Service: East Gallery
Inspection Team:
Emerson, Wagner, Bougher, Aylaian

Criteria	Condition: Good	Fair	Poor	Remarks
Architectural				Not applicable.
Structural				
Foundation				Not reviewed.
Concrete walls				Not reviewed.
Slabs				Not reviewed.
Equipment supports				Not reviewed.
Stairs		X		
Process Mechanical				
Air blower and motor #1		X		
Air blower and motor #2		X		
Coarse air blower and motor 5-1		X		
Coarse air blower and motor 6-1		X		
Dewatering pump and motor		X		
Automatic strainer and drive #1E			X	
Automatic strainer and drive #2E			X	Not in service.
BNR piping DP cell/flowmeter		X		
BNR pump		X		
Electrical				
Power		X		
Lighting			X	Inadequate, especially on north side of gallery.

FACILITIES INSPECTION

Baltimore City CWWFMP - Patapsco WWTP
Facility Name: ASP

Date: 12/10/97

Service: East Gallery
Inspection Team:
Emerson, Wagner, Bougher, Aylaian

Condition

Criteria	Good	Fair	Poor	Remarks
Instrumentation				
DP cell influent channel venturi flow (2)		X		
BNR pH sampler		X		
Building Mechanical				
Submersible sump pump 3-1		X		
Submersible sump pump 3-2	X			New.
Submersible sump pump 4-1			X	Missing.
Submersible sump pump 4-2			X	Missing.
Submersible sump pump 5-1/5-2			X	Missing.
Submersible sump pump 6-1/6-2			X	Needs replacement.
Electric louvers		X		
Other				

Comments

Recommendations

Baltimore City CWWFMP - Patapsco WWTP
Facility Name: ASP

Date: 12/10/97

Service: West Gallery
Inspection Team:
Emerson, Wagner, Bougher, Aylaian

Criteria	Condition Good	 Fair	 Poor	Remarks
Architectural				Not applicable.
Structural				
Foundation				Not reviewed.
Concrete walls				Not reviewed.
Slabs				Not reviewed.
Equipment supports				Not reviewed.
Scum pits				Not reviewed.
Stairs				Not reviewed.
Process Mechanical				
RAS valve actuator #1		X		
RAS valve actuator #2		X		
RAS valve actuator #3		X		
RAS valve actuator #4		X		
Primary wastewater pump and motor #1			X	Abandoned in place.
Primary wastewater pump and motor #2			X	Abandoned in place.
Primary wastewater pump and motor #3			X	Abandoned in place.
Booster pump and motor #1			X	Abandoned in place.
Booster pump and motor #2			X	Abandoned in place.
Chlorine booster pumps 1 & 2			X	Abandoned in place.
Automatic strainer and drive #1		X		Leaking.
Automatic strainer and drive #2		X		Leaking.
Seal water system			X	Reactors 1 - 4 meter purge.
Pipes, Valves and Fittings		X		
Electrical				
Power				Not reviewed.
Lighting			X	Need more lighting, especially on north end of gallery.

FACILITIES INSPECTION

Baltimore City CWWFMP - Patapsco WWTP
Facility Name: ASP

Date: 12/10/97

Service: West Gallery
Inspection Team:
Emerson, Wagner, Bougher, Aylaian

Criteria	Condition: Good	Fair	Poor	Remarks
Instrumentation				
Influent flowmeter/transmitter, reactor #1A		X		Needs renovation and replacement, especially pipng systems.
Influent flowmeter/transmitter, reactor #2A		X		Needs renovation and replacement, especially pipng systems.
Influent flowmeter/transmitter, reactor #3A		X		Needs renovation and replacement, especially pipng systems.
Influent flowmeter/transmitter, reactor #4A		X		Needs renovation and replacement, especially pipng systems.
Influent flowmeter/transmitter, reactor #5	X			
Influent flowmeter/transmitter, reactor #6	X			
RAS flowmeter #1		X		DP cell and related piping needs rehabilitation.
RAS flowmeter #2		X		DP cell and related piping needs rehabilitation.
RAS flowmeter #3		X		DP cell and related piping needs rehabilitation.
RAS flowmeter #4		X		DP cell and related piping needs rehabilitation.
SS probe			X	Probe present, but instrumentation missing.
Reactor #1 chart recorders			X	Abandoned.
Reactor #2 chart recorders			X	Abandoned.
Reactor #3 chart recorders			X	Abandoned.
Reactor #4 chart recorders			X	Abandoned.
Reactor #5 chart recorders			X	Abandoned.
Reactor #6 chart recorders			X	Abandoned.
Reactor #5 influent flowmeter (DP sensor)	X			
Reactor #6 influent flowmeter (DP sensor)	X			
RAS flowmeters 1A/B (DP sensors)			X	Needs renovation and replacement, especially pipng systems.
RAS flowmeters 2A/B (DP sensors)			X	Needs renovation and replacement, especially pipng systems.
RAS flowmeters 3A/B (DP sensors)			X	Needs renovation and replacement, especially pipng systems.
RAS flowmeters 4A/B (DP sensors)			X	Needs renovation and replacement, especially pipng systems.
Purge water systems and piping with panels (3)			X	1 DP cell missing from each panel, disconnected piping, needs renovation.
Building Mechanical				
Sealing water pumps and motors 1-2		X		
Sealing water tanks 1-3		X		
Submersible sump pumps 1-6		X		Pumps present, low water level implies working systems.
Air compressors/motors/receivers/dryers 1, 2, 6-1		X		
Water softener tank				Not reviewed.

FACILITIES INSPECTION

Baltimore City CWWFMP - Patapsco WWTP
Facility Name: ASP

Date: 12/10/97

Service: West Gallery
Inspection Team:
Emerson, Wagner, Bougher, Aylaian

Criteria	Good	Fair	Poor	Remarks
Water softener pump				Not reviewed.
Electric heater				Not reviewed.
Other				

Comments

Recommendations

FACILITIES INSPECTION

Baltimore City CWWFMP - Patapsco WWTP
Facility Name: Sludge Processing

Date: 12/18/97 and 3/4/98

Service: Sludge Blending Tanks and Building
Inspection Team:
Emerson, Wagner, Aylaian

Criteria	Condition: Good	Fair	Poor	Remarks
Architectural				
Exterior/Interior walls		X		
Windows		X		
Doors			X	
Ceiling			X	
Roofing			X	Insulation floating - needs repair
Trim				Not reviewed.
Coping blocks	X			Need sealant
Structural				
Foundations		X		
Columns		X		
Slabs		X		
Beams		X		
Roof framing				Not reviewed.
Equipment supports		X		
Monorail support		X		
Railings		X		
Process Mechanical				
Sludge storage tank #1		X		
Sludge storage tank #2		X		
Storage tank #1 air mixing system equipment			X	Out of service
Storage tank #2 air mixing system equipment			X	Out of service
Sludge recirculation pump and motor #1			X	At least one recirculation pump should be in service
Sludge recirculation pump and motor #2			X	
Sludge recirculation pump and motor #3			X	
Recirculation gas compressor and motor #1			X	Out of service
Recirculation gas compressor and motor #2			X	Out of service
Recirculation gas compressor and motor #3			X	Out of service

Baltimore City CWWFMP - Patapsco WWTP
Facility Name: Sludge Processing

Date: 12/18/97 and 3/4/98

Service: Sludge Blending Tanks and Building
Inspection Team:
Emerson, Wagner, Aylaian

	Condition			
Blended sludge pump and motor #1 (S11)			X	Out of service
Blended sludge pump and motor #2 (S12)			X	Out of service
Blended sludge pump and motor #3 (S13)			X	Out of service
Blended sludge pump and motor #4 (S14)	X			New
Blended sludge pump and motor #5 (S15)	X			New
Sludge shredder and motor #1 (jaws)			X	Out of service, needs refurbishment
Sludge shredder and motor #2 (jaws)			X	Out of service, needs refurbishment
Sludge shredder and motor #3 (jaws)			X	Out of service, needs refurbishment
Sludge shredder and motor #4	X			New
Sludge shredder and motor #5	X			New
Bubbler system air compressor/receiver/motor #1		X		New system upstairs O.K., system in pit in bad condition
Bubbler system air compressor/receiver/motor #2			X	
Motor operated sampling valve #1 (3 elevations)			X	Only one of two work
Motor operated sampling valve #2 (3 elevations)			X	
Motor operated sampling valve #3 (3 elevations)			X	
NaOCl pump and motor #1		X		3 pumps out of service: 2 - NaOCl, 1 - NaOH
NaOCl pump and motor #2		X		3 pumps in service: 2 - NaOCl, 1 - NaOH
NaOCl pump and motor #3			X	
NaOCl pump and motor #4			X	
NaOH pump and motor #1		X		
NaOH pump and motor #2			X	
Acid pump #1			X	Gone - need to replace
Salt tank #1, softener			X	Scrubber system works, but it is in bad shape
Salt tank #2, large			X	
NaOCl recovery tank, 2500 gallons			X	
Scrubber reaction chamber			X	
Caustic injection pump and motor #1			X	
Caustic injection pump and motor #2			X	
Sampling lines			X	Mostly clogged
Pipes, valves and fittings		X		

Baltimore City CWWFMP - Patapsco WWTP
Facility Name: Sludge Processing

Service: Sludge Blending Tanks a. Building
Date: 12/18/97 and 3/4/98
Inspection Team: Emerson, Wagner, Aylaian

	Condition			
Electrical				
Sludge pump speed controller, S-11			X	Out of service, can run pump in manual if necessary
Sludge pump speed controller, S-12			X	Out of service, can run pump in manual if necessary
Sludge pump speed controller, S-13			X	Out of service, can run pump in manual if necessary
Annunciator panel #9			X	
MCC 1-4A			X	
MCC 1-4B			X	
Power				Not reviewed.
Lighting		X		
MCC	X			For S-14 and S-15 blended sludge pumps
Instrumentation				
pH controller, Odor Scrubber			X	Not operational
Sludge storage tank level meter #1			X	Not operational
Sludge storage tank level meter #2			X	Not operational
Odor scrubber tank level meter #1				Not reviewed.
Odor scrubber tank level meter #2				Not reviewed.
Orifice plate DP sensor			X	
Dilution water flowmeter to blender				Not reviewed.
NaOH ultrasonic tank level meter		X		
NaOCl ultrasonic tank level meter		X		
pH meter, Great Lakes			X	
H2S meter		X		
Combustible gas meter		X		
Sludge blending tank level meter #1			X	
Sludge blending tank level meter #2			X	
Process logic Micro 612 controller, Modicon, #1				Not reviewed.
Process logic Micro 612 controller, Modicon, #2				Not reviewed.
SBT stream pressure sensor/switch #1				Not reviewed.
SBT stream pressure sensor/switch #2				Not reviewed.
Flowmeter from S13 to centrifuge		X		

Baltimore City CWWFMP - Patapsco WWTP
Facility Name: Sludge Processing

Date: 12/18/97 and 3/4/98

Service: Sludge Blending Tanks and Building
Inspection Team:
Emerson, Wagner, Aylaian

Condition

Building Mechanical				
Air compressor, receiver and motor #1			X	In basement - out of service
Air compressor, receiver and motor #2			X	In basement - out of service
Submersible sump pump #1			X	Working
Submersible sump pump #2			X	Working
Monorail hoist and motor		X		
Emergency lights #1 - 4				Not reviewed.
Electric heating units #1 - 6				Not reviewed.
Air compressor and motor, Sullair		X		
Air compressor and motor, Campbell	X			New
Hot water heater			X	
Supply fan		X		
Exhaust fans			X	Out of service
Air compressor and motor, Leroi				
Other				

Comments

Recommendations

Pumping, odor control and instrumentation need rehabilitation

Baltimore C[illegible] CWWFMP - Patapsco WWTP

Facility Name: Sludge Processing

Date: 12/18/97 and 3/4/98

Service: Gravity Sludge Thickeners an[illegible]uilding

Inspection Team: Emerson, Wagner, Kirk, Aylaian

	Condition			
Architectural				
Exterior/Interior walls		X		
Windows			X	
Doors			X	
Ceiling		X		
Roofing				Not reviewed.
Trim		X		
Louvers		X		
Structural				
Foundation				Unable to check
Equipment supports	X			
Columns	X			
Slabs	X			
Roof framing				Not reviewed.
Beams	X			
Stairs	X			
Distribution chamber				Not reviewed.
Baffles				Not reviewed.
Gratings	X			
Walkways	X			
Platforms				Not reviewed.
Scum pit #1				Not reviewed.
Scum pit #2				Not reviewed.
Distribution box				Not reviewed.
Process Mechanical				
Gravity sludge thickener tank #1			X	Rehabilitation under design
Gravity sludge thickener tank #2			X	Rehabilitation under design
GST scraper #1			X	Rehabilitation under design
GST sc[illegible]er #2			X	R[illegible]abilitation under design

Baltimore City CWWFMP - Patapsco WWTP
Facility Name: Sludge Processing

Date: 12/18/97 and 3/4/98

Service: Gravity Sludge Thickeners an[illegible]uilding
Inspection Team:
Emerson, Wagner, Kirk, Aylaian

	Condition			
Gravity thickened sludge pump and motor #1				Not reviewed.
Gravity thickened sludge pump and motor #2				Not reviewed.
Gravity thickened sludge pump and motor #3				Not reviewed.
Gravity thickened sludge pump and motor #4				Not reviewed.
Chlorine injector (basement)				Not used
Cyclone degritter/removal screw #1			X	
Cyclone degritter/removal screw #2			X	
Cyclone degritter/removal screw #3			X	
Cyclone degritter/removal screw #4		X		
Grit classifier/screw/motor #1			X	
Grit classifier/screw/motor #2			X	
Grit classifier/screw/motor #3			X	
Grit classifier/screw/motor #4		X		
Polymer tank (100 gallon)				Not reviewed.
Distribution box mixer and motor				Not reviewed.
Scum pit mixer and motor #1				Not reviewed.
Scum pit mixer and motor #2				Not reviewed.
Conveyors			X	
Electrical				
Annunciator panel				Not reviewed.
MCC #1				Not reviewed.
MCC #2				Not reviewed.
Power				Not reviewed.
Lighting		X		
Instrumentation				
North sludgeline pressure sensor				Not reviewed.
South sludgeline pressure sensor				Not reviewed.
Degritt[illegible]agnetic flowmeter #1	X			N[illegible] magmeter

Baltimore C... CWWFMP - Patapsco WWTP
Facility Name: Sludge Processing

Date: 12/18/97 and 3/4/98

Service: Gravity Sludge Thickeners an... ...uilding
Inspection Team: Emerson, Wagner, Kirk, Aylaian

	Condition			
Degritter magnetic flowmeter #2	X			New magmeter
Degritter magnetic flowmeter #3	X			New magmeter
Degritter magnetic flowmeter #4	X			New magmeter
Degritter flow totalizer recorder				Not reviewed.
GTS mag. meter (north)				Not reviewed.
GTS mag. meter (south)				Not reviewed.
Ultrasonic generator (north)				Not reviewed.
Ultrasonic generator (south)				Not reviewed.
Sludge pump pressure sensor, B1				Not reviewed.
Sludge pump pressure sensor, B2				Not reviewed.
Sludge pump pressure sensor, B3				Not reviewed.
Sludge pump pressure sensor, B4				Not reviewed.
Chloralert Cl2 meter				
Building Mechanical				
Electric unit heaters #1 - 6				Not reviewed.
Monorail hoist				Not reviewed.
Emergency lighting				Not reviewed.
Exhaust fans #1 - 4				Not reviewed.
Wall ventilators #1 - 2				Not reviewed.
Air intake fans #1 - 2				Not reviewed.
Air compressor/receiver/motor (Ingersol-Rand)				Not reviewed.
Air compressor/receiver/motor (Qunicy)				Not reviewed.
Submersible sump pump B5 (north)			X	Only one of two installed.
Submersible sump pump B5A				Not reviewed.
Submersible sump pump B6 (south)		X		Both installed.
Submersible sump pump B6A				Not reviewed.

Baltimore C... CWWFMP - Patapsco WWTP
Facility Name: Sludge Processing

Date: 12/18/97 and 3/4/98

Service: Gravity Sludge Thickeners an... uilding
Inspection Team:
Emerson, Wagner, Kirk, Aylaian

	Condition			
Other				
Comments				
Recommendations				
Facility in poor condition, needs major renovations - contract under design				

FACILITIES INSPECTION

Baltimore City CWWFMP - Patapsco WWTP
Facility Name: Final Treatment

Date: 12/18/97 and 1/15/98

Service: Chlorine Contact Bui g
Inspection Team:
Emerson, Wagner, Aylaian

Criteria	Good	Fair	Poor	Remarks
Architectural				
Exterior/Interior Walls	X			Dirty
Roofing	X			Roof in good shape, no apparent leaks
Doors	X			
Ceiling	X			Coping needs maintenance
Windows	X			
Trim	X			
Louvers	X			
Access shaft				Entrance blocked by construction
Structural				
Concrete Walls		X		
Foundation		X		
Piles				Cannot find
Slabs		X		
Pedestals		X		
Gratings/Plates			X	FRP construction
Equipment Supports		X		
Beams		X		
Baffles		X		
Railings		X		
Monorail Supports		X		
Process Mechanical				
Chlorine injector #1		X		
Chlorine injector #2		X		
Chlorine injector #3		X		
Chlorine injector #4		X		
Chlorine injector #5	X			
Chlorine injector #6	X			
Dewate g pump #1		X		

Baltimore C... CWWFMP - Patapsco WWTP
Facility Name: Final Treatment

Date: 12/18/97
and 1/15/98

Service: Chlorine Contact Buil... g
Inspection Team:
Emerson, Wagner, Aylaian

	Condition			
Criteria	Good	Fair	Poor	Remarks
Dewatering pump #2		X		
Dewatering pump #3		X		
Dual basket strainer		X		
Pipes, Valves and Fittings		X		
Electrical				
Power		X		
Lighting		X		
MCC 3 - 1	X			Need to replace
Emergency lights #1 - 9				Not reviewed.
Instrumentation				
Annunciator panel		X		
Sampling pump and motor #G4				Not used due to high maintenance
Sampling pump and motor #G5				Not used due to high maintenance
Sampling pump and motor #G6				Not used due to high maintenance
Sampling pump and motor #G7				Not used due to high maintenance
Sampling pump and motor #G8				Not used due to high maintenance
Sampling pump and motor #G9				Not used due to high maintenance
Building Mechanical				
Monorail hoist and motor (1 ton)		X		
Roof ventilation fans #1 - 5				Not reviewed.
Hot water heater				Not reviewed.
Electric heater units #1 - 5			X	
HVAC			X	Needs renovation

FACILITIES INSPECTION

Baltimore City CWWFMP - Patapsco WWTP
Facility Name: Final Treatment

Date: 12/18/97 and 1/15/98

Service: Chlorine Contact Buil g
Inspection Team:
Emerson, Wagner, Aylaian

Criteria	Condition: Good	Fair	Poor	Remarks
Sump pumps		X		2 sets of duplex pumps
Other				

Comments
Plant would like to evaluate total chlorine injection capacity - looking to increase capability in the future
There are no chlorine alarms

Recommendations

FACILITIES INSPECTION

Baltimore C... CWWFMP - Patapsco WWTP
Facility Name: Final Treatment

Date: 12/18/97

Service: Chlorine Contact Chamber
Inspection Team:
Emerson, Wagner, Kirk, Aylaian

Criteria	Good	Fair	Poor	Remarks
Architectural				
Structural				
Chlorine contact chamber #1	X			
Chlorine contact chamber #2	X			
Chlorine contact chamber #3	X			
Chlorine contact chamber #4	X			
Effluent Channel	X			
Influent Channel	X			
Slabs	X			
Gratings/Plates	X			
Equipment Supports	X			
Baffles	X			
Railings	X			
Scum well			X	Out of service
Process Mechanical				
Chlorine diffuser #1				Unable to observe
Chlorine diffuser #2				Unable to observe
Chlorine diffuser #3				Unable to observe
Chlorine diffuser #4				Unable to observe
Dual basket strainer		X		
Influent slide gate #1A	X			
Influent slide gate #1B	X			
Influent slide gate #2A	X			
Influent slide gate #2B	X			
Influent slide gate #3A	X			
Influent slide gate #3B	X			
Influent slide gate #4A	X			
Influent slide gate #4B	X			
Scum mixer			X	

FACILITIES INSPECTION

Baltimore City CWWFMP - Patapsco WWTP
Facility Name: Final Treatment

Date: 12/18/97

Service: Chlorine Contact Chambe
Inspection Team:
Emerson, Wagner, Kirk, Aylaian

Criteria	Good	Fair	Poor	Remarks
		Condition		
Scum pump			X	
Dewatering pump and motor #1		X		
Dewatering pump and motor #2		X		
Dewatering pump and motor #3	X			
Mechanical mixer and motor #1		X		Not used because of chlorine addition point
Mechanical mixer and motor #2		X		Not used because of chlorine addition point
Mechanical mixer and motor #3		X		Not used because of chlorine addition point
Mechanical mixer and motor #4		X		Not used because of chlorine addition point
Scum trough 1-1,2,3			X	
Scum trough 2-1,2,3			X	
Scum trough 3-1,2,3			X	
Scum trough 4-1,2,3			X	
Spray water pumps		X		
Pipes, Valves and Fittings		X		
Electrical				
Power				Not reviewed.
Lighting				Not reviewed.
Instrumentation				
Chlorine Analyzer #1			X	Out of service, sampling manual due to maintenance problems
Chlorine Analyzer #2			X	Out of service, sampling manual due to maintenance problems
Chlorine Analyzer #3			X	Out of service, sampling manual due to maintenance problems
Chlorine Analyzer #4			X	Out of service, sampling manual due to maintenance problems
Chlorine Analyzer #5			X	Out of service, sampling manual due to maintenance problems
Chlorine Analyzer #6			X	Out of service, sampling manual due to maintenance problems
Chlorine Analyzer #7			X	Out of service, sampling manual due to maintenance problems
Chlorine Analyzer #8			X	Out of service, sampling manual due to maintenance problems
Chlori Analyzer #9			X	Out of service, sampling manual due to maintenance problems
Chlorine Analyzer #10			X	Out of service, sampling manual due to maintenance problems

Baltimore City CWWFMP - Patapsco WWTP
Facility Name: Final Treatment

Date: 12/18/97

Service: Chlorine Contact Chambe
Inspection Team:
Emerson, Wagner, Kirk, Aylaian

Criteria	Good	Fair	Poor	Remarks
Drexelbrook flowmeter #1			X	Replaced with ultrasonic sensors
Drexelbrook flowmeter #2			X	Replaced with ultrasonic sensors
Drexelbrook flowmeter #3			X	Replaced with ultrasonic sensors
Drexelbrook flowmeter #4			X	Replaced with ultrasonic sensors
Drexelbrook flowmeter #5			X	Replaced with ultrasonic sensors
Dissolved oxygen analyzer			X	Out of service, sampling manual due to maintenance problems
Amperometric titrator #1			X	Out of service, sampling manual due to maintenance problems
Amperometric titrator #2			X	Out of service, sampling manual due to maintenance problems
Fischer & Porter Chameleon controller			X	Out of service, sampling manual due to maintenance problems
Building Mechanical				
Submersible sump pump #1		X		
Submersible sump pump #2		X		
Submersible sump pump #3		X		
Submersible sump pump #4		X		
Other				

Comments

Plant effluent sanpling for chlorine residual done manually due to maintenance problems - plant would like to get on-line analyzers working again

West Gallery chlorine solution pipe needs gas detector for better safety

Recommendations

FACILITIES INSPECTION

Baltimore ( )CWWFMP - Patapsco WWTP
Facility Name: Final Treatment

Date: 12/18/97
and 1/15/98

Service: Chlorine Storag ilding
Inspection Team:
Emerson, Wagner, Aylaian

Criteria	Condition: Good	Fair	Poor	Remarks
Architectural				
Office		X		No apparent roof leaks
Chlorinator room	X			No peeling paint, 2 exits
Evaporator room	X			No leaks or paint peeling, 2 exits
Storage room:	X			Peeling paint on ceilings
Roof	X			Coping could use joints pointed, fans O.K., insulation stones missing, guide wires broke
Trim	X			
Louvers	X			
Structural				
Concrete Walls		X		
Foundation		X		
Slabs		X		
Pedestals		X		
Equipment Supports		X		Common gas header from 3 sets of double scales, standby bank of 6 cylinders
Beams		X		
Baffles		X		
Railings		X		
Stairs		X		
Process Mechanical				
Chlorinator #1			X	All control is manual, no flow pacing
Chlorinator #2			X	Older W&T unit, working but needs replacement soon
Chlorinator #3			X	Older W&T unit, working but needs replacement soon
Chlorinator #4			X	Older W&T unit, working but needs replacement soon
Chlorinator #5			X	Older W&T unit, working but needs replacement soon
Chlorinator #6			X	Older W&T unit, working but needs replacement soon
Chlorinator #7			X	Older W&T unit, working but needs replacement soon
Chlorinator #8			X	Older W&T unit, working but needs replacement soon
Chlorin r #9			X	Older W&T unit, working but needs replacement soon
Chlorinator #10			X	C er W&T unit, working but needs replacement soon

FACILITIES INSPECTION

Baltimore C… CWWFMP - Patapsco WWTP
Facility Name: Final Treatment

Date: 12/18/97 and 1/15/98

Service: Chlorine Storage …ilding
Inspection Team:
Emerson, Wagner, Aylaian

Criteria	Condition: Good	Fair	Poor	Remarks
Evaporator #1			X	Older W&T unit, working but needs replacement soon
Evaporator #2			X	Older W&T unit, working but needs replacement soon
Evaporator #3			X	Older W&T unit, working but needs replacement soon
Evaporator #4			X	Older W&T unit, working but needs replacement soon
Pipes, valves and fittings		X		
Monorail/bridge crane		X		
Pipes, Valves and Fittings		X		
Electrical				
Power		X		
Lighting		X		Storage room lighting poor
Instrumentation				
W&T Acutec 35 - chlorinator room		X		
W&T Acutec 35 - evaporator room		X		
F&P Chloralert - control room		X		
W&T Accutec 35 in storage room		X		
Building Mechanical				
Safety shower and eyewash		X		Chlorine and evaporator rooms
Evapor… roof purge		X		S… off by chlorine alarms

Baltimore C)CWWFMP - Patapsco WWTP
Facility Name: Final Treatment

Date: 12/18/97 and 1/15/98

Service: Chlorine Storage Building
Inspection Team:
Emerson, Wagner, Aylaian

Criteria	Condition Good	Fair	Poor	Remarks
Other				

Comments

Recommendations

Needs monorail/bridge crane system for handling containers - currently moved by forklift

No cross ventilation in evaporator and chlorinator rooms: air in low and out low next to each door - bad arrangement - needs to be changed

Could use new bay doors and heat in storage room

FACILITIES INSPECTION

Baltimore City CWWFMP - Patapsco WWTP
Facility Name: Final Treatment

Date: 12/18/97

Service: Dechlorination Facility
Inspection Team:
Emerson, Wagner, Kirk, Aylaian

Criteria	Good	Fair	Poor	Remarks
	Condition			
Architectural				
Exterior/Interior Walls				
Roofing		X		No apparent leaks, copings O.K., sealant work required
Doors	X			
Ceiling	X			
Windows	X			
Trim	X			
Louvers				Not reviewed.
Structural				
Foundation				Not reviewed.
Slabs				Not reviewed.
Equipment Supports				Not reviewed.
Columns				Not reviewed.
Beams				Not reviewed.
Roof Framing				Not reviewed.
Ladders				Not reviewed.
Overflow Scupper				Not reviewed.
Process Mechanical				
SO(2) Cylinders	X			Always changing cylinders - need better storage arrangements
SO(2) Evaporator #1	X			Not enough capacity
SO(2) Evaporator #2	X			
Sulfonator #1	X			Not enough capacity
Sulfonator #2	X			
Sulfonator #3	X			
Sulfonator #4	X			
Sulfonator #5	X			
Sulfonator #6	X			
Dual S[illegible]) Load Cell Scales & Containers	X			2 se[illegible]f duplex chlorine scales, storage cradles in good shape, dual feed system O.K.

FACILITIES INSPECTION

Baltimore City CWWFMP - Patapsco WWTP
Facility Name: Final Treatment

Date: 12/18/97

Service: Dechlorination Facility
Inspection Team:
Emerson, Wagner, Kirk, Aylaian

Criteria	Condition: Good	Fair	Poor	Remarks
SO(2) Injector #1	X			
SO(2) Injector #2	X			
SO(2) Injector #3	X			
SO(2) Injector #4	X			
SO(2) Injector #5	X			
Pipes, Valves and Fittings		X		
Electrical				
Power				Not reviewed.
Lighting	X			All rooms
MCCs		X		
Annunciator Panel		X		
Instrumentation				
SO(2) Gas detector #1 - storage	X			EIT tox alarm unit
SO(2) Gas detector #2 - evap and feed	X			Interscan continuous monitoring system
SO(2) Gas detector #3				Not reviewed.
SO(2) Gas detector #4				Not reviewed.
SO(2) control system			X	Not working, all sulfonation equipment operating in manual
Building Mechanical				
HVAC	X			
Bridge Crane & Rails	X			
Storage				Not reviewed.
Roof exhausters - injector room		X		
Roof exhausters - sulfonator room			X	

Baltimore City CWWFMP - Patapsco WWTP
Facility Name: Final Treatment

Date: 12/18/97

Service: Dechlorination Facility
Inspection Team:
Emerson, Wagner, Kirk, Aylaian

Criteria	Good	Fair	Poor	Remarks
Other				

Comments
All instrumentation out of service - sampling is done manually as field probes don't work - need to reestablish on-line system
Building in good shape
Recommendations
Need additional evaporators, feeders and injectors

FACILITIES INSPECTION

Baltimore C CWWFMP - Patapsco WWTP
Facility Name: Final Treatment

Date: 12/18/97

Service: Plant Effluent Water Pump Station
Inspection Team:
Emerson, Wagner, Kirk, Aylaian

Criteria	Good	Fair	Poor	Remarks
Architectural				
Exterior/Interior Walls		X		East exterior wall damaged about 3/4 of the way up
Roofing		X		No roof leaks, coping good but sealant needs manitenance
Doors		X		
Ceiling		X		
Windows		X		
Trim		X		
Structural				
Concrete Walls	X			
Beams	X			
Slabs	X			
Columns	X			
Gratings	X			
Railings	X			
Process Mechanical				
Slide gate valve #1			X	
Slide gate valve #2			X	
Slide gate valve #3			X	
High service pump and motor J-1		X		
High service pump and motor J-2		X		
Low service pump and motor J-7		X		
Low service pump and motor J-8			X	
Injector water pumps J-4, J-5			X	J-4 in poor condition, J-5 removed
Automatic strainer and motor #1			X	Not in service
Automatic strainer and motor #1			X	Not in service
Spray water pump and motor #1			X	On standby
Spray water pump and motor #2			X	On standby
Chlorination pump and motor #1		X		Vertical
Chlorination pump and motor #2			X	Horizontal

Baltimore C CWWFMP - Patapsco WWTP
Facility Name: Final Treatment

Date: 12/18/97

Service: Plant Effluent Water Pump Station
Inspection Team:
Emerson, Wagner, Kirk, Aylaian

Criteria	Condition: Good	Fair	Poor	Remarks
Chlorination pump and motor #3				Not reviewed.
Pipes, Valves and Fittings		X		
Electrical				
Power				Not reviewed.
Lighting				Not reviewed.
MCC 3-2				Not reviewed.
Instrumentation				
Sampling pump and motor #1			X	Out of service - all samples pulled manually due to high maintenance of on-line units
Sampling pump and motor #2			X	Out of service - all samples pulled manually due to high maintenance of on-line units
Total organic carbon analyzer			X	Out of service - all samples pulled manually due to high maintenance of on-line units
Chlorine analyzer			X	Out of service - all samples pulled manually due to high maintenance of on-line units
Residual chlorine analyzer #1			X	Out of service - all samples pulled manually due to high maintenance of on-line units
Residual chlorine analyzer #2			X	Out of service - all samples pulled manually due to high maintenance of on-line units
Refridgerated sampler			X	Out of service - all samples pulled manually due to high maintenance of on-line units
Sigma sampler #1			X	Out of service - all samples pulled manually due to high maintenance of on-line units
Sigma sampler #2			X	Out of service - all samples pulled manually due to high maintenance of on-line units
Plant effluent D.O. meter #1			X	Out of service - all samples pulled manually due to high maintenance of on-line units
Plant effluent D.O. meter #2			X	Out of service - all samples pulled manually due to high maintenance of on-line units
Plant effluent ORP meter			X	Out of service - all samples pulled manually due to high maintenance of on-line units
Plant effluent pH meter			X	Out of service - all samples pulled manually due to high maintenance of on-line units
Turbidity meter #1			X	Out of service - all samples pulled manually due to high maintenance of on-line units
Turbidity meter #2			X	Out of service - all samples pulled manually due to high maintenance of on-line units
Plant effluent D.O. recorder #1			X	Out of service - all samples pulled manually due to high maintenance of on-line units
Plant effluent D.O. recorder #2			X	Out of service - all samples pulled manually due to high maintenance of on-line units
Colorimeter #1			X	Out of service - all samples pulled manually due to high maintenance of on-line units
Colorimeter #2			X	Out of service - all samples pulled manually due to high maintenance of on-line units
Colorimeter #3			X	Out of service - all samples pulled manually due to high maintenance of on-line units

Baltimore City CWWFMP - Patapsco WWTP
Facility Name: Final Treatment

Date: 12/18/97

Service: Plant Effluent Water Pump Station
Inspection Team:
Emerson, Wagner, Kirk, Aylaian

Criteria	Condition: Good	Fair	Poor	Remarks
Annunciator panel			X	Not used
Building Mechanical				
Air compressor/receiver and motor			X	Out of service
Pedestal sump pump and motor #1			X	Replaced with submersible sump pump in fair condition
Pedestal sump pump and motor #2			X	Replaced with submersible sump pump in fair condition
Monorail hoist - east		X		
Monorail hoist - center		X		
Monorail hoist - west		X		
Air handler #1		X		
Air handler #2		X		
Roof exhaust fans	X			
Electric heater units			X	
Emergency lighting				Not reviewed.
Hot water heater			X	
Sealing water pump and motor #1			X	
Sealing water pump and motor #2			X	
Floor drains		X		Unit under sample/analyzer plugged, others O.K.
Jib crane		X		
Other				

Comments

Plant effluent pH occasionally drops to below federal/state regs (ie. pH=6.0) - plant may need to add facilities for pH adjustment

Recommendations

Complete building rehabilitation in 5 - 10 years

CITY OF BALTIMORE, MARYLAND

COMPREHENSIVE WASTEWATER
FACILITIES MASTER PLAN

TASK 401

INVESTIGATION OF THE CONDITION
OF EXISTING FACILITIES

PUMPING STATION INSPECTIONS SUMMARY OF FINDINGS

DRAFT

SEPTEMBER 1999

WHITMAN, REQUARDT AND ASSOCIATES, LLP
ENGINEERS AND PLANNERS
BALTIMORE, MARYLAND

TABLE A

INSPECTION OF PUMPING STATIONS

SUMMARY OF FINDINGS

Facility	Overall Condition	General Nature of Improvements
Eastern Avenue Sewage Pump Station	Poor	Odor Control, Windows, Interior Walls, Ceilings, Mechanical Screens, Groundwater Intrusion in Lower Levels and Pump Pit, Surge Relief System
Locust Point Sewage Pump Station	Fair	Pump Motors, Site Grading and Paving, Cone Valves
McComas Sewage Pump Station	Good	Wet Well Lighting
Westport Sewage Pump Station	Fair	Mechanical Screen System
Charles Center Stormwater Pump Station	Good	
Colgate Stormwater Pump Station	Fair	Motor Control Center, Pumps, Motors, Interior Station Lighting
Highlandtown Stormwater Pump Station	Poor	Transformer, Exposed Wiring, Roof, Door, Paving, Interior Walls, Groundwater Intrusion of Interior Walls, Pumps, Motors, Ventilation

FACILITIES INS[illegible] [illegible]TION

Baltimore City | **Service: Sewage Pump Station**

Facility Name: Eastern Avenue Sewage Pump Station

Date: September 8, 1999

Inspection Team: Wagner, Harris

Criteria	Condition: Good	Fair	Poor	Remarks
Architectural				
Exterior/Interior walls			x	Paint peeling on walls throughout pump station. Active leaks below grade walls and ceilings
Roofing		x		Minor missing slate on roof. Elbows on roof drain pipes need to be reconnected.
Doors		x		
Ceiling		x		
Windows			x	Air leaks around windows/ Plexi-glass construction/ Poor visibility
Louvers		x		
Structural				
Structural Concrete		x		
Masonry		x		
Stairs		x		
Ladders		x		
Handrails/Grating		x		Needs minor grating replacement above the pump floor.
Sewage wet well		x		Dead zone near pumps 5 and 6 if pumps are not operating.
Exterior concrete paving and asphalt		x		
Process Mechanical				
Raw sewage lift pump #1		x		
Raw sewage lift pump #2		x		
Raw sewage lift pump #3		x		
Raw sewage lift pump #4		x		
Raw sewage lift pump #5		x		
Raw sewage lift pump #6		x		
Raw sewage lift pump #1 pipes, valves and fittings		x		
Raw sewage lift pump #2 pipes, valves and fittings		x		
Raw sewage lift pump #3 pipes, valves and fittings		x		
Raw sewage lift pump #4 pipes, valves and fittings		x		
Raw sewage lift pump #5 pipes, valves and fittings		x		
Raw sewage lift pump #6 pipes, valves and fittings		x		24" gate valve leaking around packing gland.
Station pipes, valves and fittings			x	Surge valves discharge into pump room.
Seal water system		x		
Air compressor system		x		
Bubbler air compressor system		x		

FACILITIES IN[illegible]CTION

Baltimore City				**Service: Sewage Pump Station**
Facility Name:			**Date:**	**Inspection Team:**
Eastern Avenue Sewage Pump Station			September 8, 1999	Wagner, Harris

Criteria	**Good**	**Fair**	**Poor**	**Remarks**
		Condition		
Vacuum priming system		x		
Influent screen			x	Broken flight on screen 1/ Excessive floatables passing through screens.
Ventilation		x		Exhaust from the wet well is vented on the west side of the pumping station at the entrance to the Public Works Museum.
Electrical				
Power	x			New per Sanitary Contract No. 8110
Lighting	x			New per Sanitary Contract No. 8110
Sewage lift pump motor #1		x		
Sewage lift pump motor #2		x		
Sewage lift pump motor #3		x		
Sewage lift pump motor #4		x		
Sewage lift pump motor #5		x		
Diesel engine pump # 6		x		
Influent/effluent screen motors		x		
Supply fan motors		x		
Exhaust fan motors		x		
MCC		x		
Engine/generator		x		Only powers minor systems. No generator for pumps.
Control panels		x		
Panelboards		x		
Vacuum priming system motors		x		
Switchgear	x			New per Sanitary Contract No. 8110
Transformers		x		
Bubbler air compressor motor		x		
Instrumentation				
Venturi flow meters		x		Meters buried. Only observed trannsmitter.
Bubbler system and control panel		x		
Chart recorders		x		
H2S sensors		x		
Building Mechanical				
Monorail		x		
Bridge Cranes		x		Bridge crane on the east end of the pump station is out of service.

FACILITIES IN ECTION

Baltimore City | **Service: Sewage Pump Station**

Facility Name: | **Date:** | **Inspection Team:**

Eastern Avenue Sewage Pump Station | September 8, 1999 | Wagner, Harris

	Condition			
Criteria	**Good**	**Fair**	**Poor**	**Remarks**
Exhaust duct		x		
Supply fans		x		
Exhaust fans		x		
Standby Generator		x		
Diesel fuel storage tank	x			
Air conditioning systems	x			New per Sanitary Contract No. 8110
Sump pump		x		
Electic Water Heater	x			New per Sanitary Contract No. 8110
Electric Unit Heater	x			New per Sanitary Contract No. 8110
Boiler	x			New per Sanitary Contract No. 8110
Recirculation Pumps	x			New per Sanitary Contract No. 8110
Blowers		x		Blower No. 1 is out of service due to discharge piping failure.

Recommendations

Install an odor control system to treat exhaust from wet well.
Connect surge valve discharge line to wet well.
Replace bar screens with new more efficient screens.
Repaint pump station interior. Sample test indicates presence of lead.
Replace plexi-glass windows with glass windows.
Waterproof below grade walls and slab.
Replace missing roof slate and reconnect roof drain pipe elbows.
Repair recessed gutter to eliminate interior leaks and prevent further paint peeling.

FACILITIES INS   CTION

Baltimore City		Service: Sewage Pump Station
Facility Name:	**Date:**	**Inspection Team:**
Locust Point Sewage Pump Station	September 9, 1999	Wagner, Harris

Criteria	Condition Good	Fair	Poor	Remarks
Architectural				
Exterior/Interior walls	x			
Roofing		x		
Doors	x			
Ceiling	x			
Louvers		x		
Structural				
Structural Concrete		x		Minor cracks in walls.
Masonry		x		
Stairs	x			
Handrails/Grating	x			
Sewage wet well		x		
Exterior concrete paving and asphalt			x	Site grading poor, standing water outside of station.
Process Mechanical				
Raw sewage lift pump #1		x		Nameplate data was painted over.
Raw sewage lift pump #2		x		Nameplate data was painted over.
Raw sewage lift pump #1 pipes, valves and fittings		x		Cone valve in poor condition. Active leaking around packing gland.
Raw sewage lift pump #2 pipes, valves and fittings		x		Cone valve in poor condition. Active leaking around packing gland.
Station pipes, valves and fittings		x		
Seal water system		x		
Air compressor system		x		
Bubbler air compressor system		x		
Ventilation		x		
Bar screen in Wet well		x		
Electrical				
Power		x		
Lighting		x		Wet well lighting is poor.
Sewage lift pump motor #1		x		2 vertical dry pit open drip proof motors.
Sewage lift pump motor #2		x		2 vertical dry pit open drip proof motors.
Ventilation System		x		
MCC		x		

FACILITIES INS[illegible]TION

Baltimore City | **Service: Sewage Pump Station**

Facility Name: Locust Point Sewage Pump Station

Date: September 9, 1999

Inspection Team: Wagner, Harris

Criteria	Condition: Good	Fair	Poor	Remarks
Engine/generator		x		
Bubbler air compressor motor		x		
Instrumentation				
Magnetic flow meter		x		
Chart recorders		x		
H2S sensors		x		
SCADA System	x			
Building Mechanical				
Monorail	x			
Exhaust duct		x		
Ventilation fans		x		
Standby Generator		x		
Diesel fuel storage tank	x			New above ground storage tank.
Sump pump		x		
Electric Water Heater		x		
Electric Unit Heaters		x		

Recommendations

Replace cone valves.

Regrade and repave driveway.

Replace non-submersible motors with submersible type motors. May also have to replace pumps to accomodate new motors.

FACILITIES IN CTION

Baltimore City
Facility Name:
McComas Sewage Pump Station

Date:
September 9, 1999

Service: Sewage Pump Station
Inspection Team:
Wagner, Harris

Criteria	Condition Good	Fair	Poor	Remarks
Architectural				
Exterior/Interior walls	x			
Roofing	x			
Doors	x			
Ceiling	x			
Louvers	x			
Structural				
Structural Concrete	x			
Masonry	x			
Stairs	x			
Ladders	x			
Handrails/Grating	x			
Sewage wet well	x			
Exterior concrete paving and asphalt	x			
Process Mechanical				
Raw sewage lift pump #1	x			
Raw sewage lift pump #2	x			
Raw sewage lift pump #1 pipes, valves and fittings	x			
Raw sewage lift pump #2 pipes, valves and fittings	x			
Station pipes, valves and fittings	x			
Seal water system	x			
Bubbler air compressor system	x			
Influent gates		x		
Ventilation	x			
Electrical				
Power	x			
Lighting		x		Wet well lights are not operating.
Sewage lift pump motor #1		x		
Sewage lift pump motor #2		x		
Supply fan motors	x			
Exhaust fan motors	x			

FACILITIES INS TION

Baltimore City | **Service: Sewage Pump Station**

Facility Name:	**Date:**	**Inspection Team:**
McComas Sewage Pump Station	September 9, 1999	Wagner, Harris

	Condition			
Criteria	**Good**	**Fair**	**Poor**	**Remarks**
MCC		x		
Engine/generator			x	Generator intake motor operated dampers are poor.
Bubbler air compressor motor		x		
Instrumentation				
Magnetic flow meter		x		
Chart recorders		x		
H2S sensors		x		
SCADA System	x			
Building Mechanical				
Monorail	x			Lifting hook needs to be painted yellow.
Bridge Crane				N/A
Exhaust duct		x		
Supply fans		x		
Exhaust fans		x		
Standby Generator		x		
Diesel fuel storage tank	x			New above ground storage tank.
Sump pump		x		
Electric Water Heater		x		
Electic Unit Heater		x		

Recommendations

Repair lights in wet well.

Paint lifting hook yellow.

FACILITIES INS TION

Baltimore City | **Service: Sewage Pump Station**

Facility Name: | **Date:** | **Inspection Team:**

Westport Sewage Pump Station | September 9, 1999 | Wagner, Harris

Criteria	Good	Fair	Poor	Remarks
	Condition			
Architectural				
Exterior/Interior walls		x		Paint peeling in pump room.
Roofing	x			Roof drain near diesel fuel storage tank needs to be repaired.
Doors	x			
Ceiling	x			
Windows	x			
Louvers	x			
Structural				
Structural Concrete		x		Minor ground water in pump pit.
Masonry	x			
Stairs	x			
Ladders	x			
Handrails/Grating	x			
Sewage wet well	x			
Exterior concrete paving and asphalt	x			
Process Mechanical				
Raw sewage lift pump #1		x		
Raw sewage lift pump #2		x		
Raw sewage lift pump #3		x		
Raw sewage lift pump #1 pipes, valves and fittings		x		
Raw sewage lift pump #2 pipes, valves and fittings		x		
Raw sewage lift pump #3 pipes, valves and fittings		x		
Station pipes, valves and fittings		x		
Seal water system		x		
Bubbler air compressor system		x		
Influent screen gates		x		
Ventilation		x		
Screen System			x	
Electrical				
Power	x			
Lighting	x			

FACILITIES INS[ ]TION

Baltimore City | **Service: Sewage Pump Station**

Facility Name: Westport Sewage Pump Station

Date: September 9, 1999

Inspection Team: Wagner, Harris

Criteria	Condition: Good	Fair	Poor	Remarks
Sewage lift pump motor #1		x		
Sewage lift pump motor #2		x		
Sewage lift pump motor #3		x		
Supply fan motors		x		
Exhaust fan motors		x		
MCC		x		
Engine/generator		x		
Bubbler air compressor motor		x		
Instrumentation				
Magnetic flow meter		x		
Chart recorders		x		
H2S sensors	x			
Building Mechanical				
Monorail	x			
Exhaust duct		x		
Supply fans		x		
Exhaust fans		x		
Standby Generator		x		
Diesel fuel storage tank	x			New above ground storage tank.
Sump pump		x		
Electric Unit Heater		x		

Recommendations

Replace screen system.

Waterproof pump pit.

Recoat pump room.

FACILITIES IN[illegible]CTION

Baltimore City | **Service: Sewage Pump Station**

Facility Name: Charles Center Storm Water Pump Station

Date: September 8, 1999

Inspection Team: Wagner, Harris

Criteria	Good	Fair	Poor	Remarks
	Condition			
Architectural				
Exterior/Interior walls	x			
Roofing	x			
Doors	x			
Ceiling	x			
Structural				
Structural Concrete	x			
Ladders		x		
Handrails/Grating		x		
Wet well		x		
Exterior concrete paving and asphalt	x			
Process Mechanical				
Lift pump #1		x		
Lift pump #2		x		
Lift pump #1 pipes, valves and fittings		x		
Lift pump #2 pipes, valves and fittings		x		
Station pipes, valves and fittings		x		
Seal water system				
Bubbler air compressor system		x		
Electrical				
Power		x		
Lighting		x		
Lift pump motor #1		x		
Lift pump motor #2		x		
Supply fan motor		x		
MCC		x		
Bubbler air compressor motor		x		
Instrumentation				
SCADA System	x			

FACILITIES IN[illegible] CTION

Baltimore City | **Service: Sewage Pump Station**

Facility Name:	**Date:**	**Inspection Team:**
Charles Center Storm Water Pump Station	September 8, 1999	Wagner, Harris

	Condition			
Criteria	**Good**	**Fair**	**Poor**	**Remarks**
Building Mechanical				
Sump pump		x		
Electric Unit Heater		x		

Recommendations

Since the pumps are relatively small, consideration should be given to replace inlet grates with a smaller opening to minimize the chance of larger solids jamming the pum

Fabricated bicycle type grating should be considered.

FACILITIES INS TION

Baltimore City | **Service: Sewage Pump Station**

Facility Name: | **Date:** | **Inspection Team:**

Colgate Storm Water Pump Station | September 8, 1999 | Wagner, Harris

Criteria	Condition: Good	Fair	Poor	Remarks
Architectural				
Exterior/Interior walls	x			
Roofing	x			
Doors	x			
Ceiling	x			
Louvers	x			
Structural				
Structural Concrete	x			
Masonry		x		Minor crack in interior bond beam (south wall).
Stairs	x			
Handrails/Grating	x			
Exterior concrete paving and asphalt	x			
Process Mechanical				
lift pump #1			x	Noisy gear reducer. Pump and motor reaching end of useful life.
lift pump #2			x	Noisy gear reducer. Pump and motor reaching end of useful life.
lift pump #1 pipes, valves and fittings		x		
lift pump #2 pipes, valves and fittings		x		
Station pipes, valves and fittings		x		
Seal water system		x		
Bubbler air compressor system		x		
Influent screen				None
Electrical				
Power		x		Supplied from Dundalk WWPS.
Lighting		x		Incandescent lighting hard to access.
lift pump motor #1		x		
lift pump motor #2		x		
MCC		x		Reaching end of useful life. Spare parts may be hard to locate.
Bubbler air compressor motor		x		
Instrumentation				
SCADA System	x			

FACILITIES INS[illegible]TION

Baltimore City		**Service: Sewage Pump Station**
Facility Name:	**Date:**	**Inspection Team:**
Colgate Storm Water Pump Station	September 8, 1999	Wagner, Harris

Criteria	Good	Fair	Poor	Remarks
Building Mechanical				
Standby Generator				None local. Supplied from Dundalk WWPS.
Sump pump		x		
Electric Unit Heater		x		

Recommendations

Replace MCC.

Upgrade interior station lighting.

Replacement of gear reducer may require pump and motor replacement as well. Due to the age of the pumps and motors, the availability of spare parts may be limited and therefore justify replacement.

FACILITIES I[illegible]ECTION

Baltimore City | | **Service: Sewage Pump Station**
Facility Name: | **Date:** | **Inspection Team:**
Highland Town Storm Water Pump Station | September 8, 1999 | Wagner, Harris

Criteria	**Good**	**Fair**	**Poor**	**Remarks**
Architectural				
Exterior/Interior walls			x	Below grade walls need repainting because of moisture intrusion.
Roofing			x	Possible roof leaks around interior leader penetrate.
Doors			x	Door frame corroding, has holes in frame.
Ceiling		x		
Structural				
Structural Concrete			x	Moisture intrusion in below grade concrete walls. / Needs minor concrete grouting around station bas
Masonry		x		
Stairs		x		
Ladders		x		
Handrails/Grating		x		
Wet well		x		
Exterior concrete paving and asphalt			x	Excessive cracks in driveway. Minor cracks in concrete sidewalk.
Process Mechanical				
Lift pump #1		x		Seal leaks around shaft.
Lift pump #2		x		Seal leaks around shaft.
Raw sewage lift pump #1 pipes, valves and fittings		x		
Raw sewage lift pump #2 pipes, valves and fittings		x		
Station pipes, valves and fittings		x		
Bubbler air compressor system		x		
Ventilation			x	
Electrical				
Power			x	Single 13 KV feeder, oil filled transformers located inside building. Exposed 13 KV wires.
Lighting		x		
Lift pump motor #1			x	Needs safety cage around motor.
Lift pump motor #2			x	Needs safety cage around motor.
Supply fan motors				N/A
Exhaust fan motors				N/A
MCC				
Engine/generator		x		
Transformers			x	Oil filled transformer located inside building.
Air compressor motor		x		

FACILITIES INSPECTION

Baltimore City — **Service: Sewage Pump Station**

Facility Name:
Highland Town Storm Water Pump Station

Date:
September 8, 1999

Inspection Team:
Wagner, Harris

Criteria	Condition: Good	Fair	Poor	Remarks
Instrumentation				
SCADA System	x			Recently installed.
Building Mechanical				
Standby Generator		x		
Diesel fuel storage tank	x			New above ground storage tank.
Sump pump		x		
Electric Unit Heater		x		

Recommendations

Replace 13 KV oil filled transformer with dry type or nonflammable liquid filled transformers. Insulate exposed wires.

Repave driveway.

Remove paint from below grade interior walls.

Waterproof below grade interior walls.

Install a ventilation system.

Install safety cage around motors.

Seal leaks in roof.

BALTIMORE CITY COMPREHENSIVE PLAN
TELEPHONE SURVEY OF DENITRIFICATION FACILITIES
FLUIDIZED BED REACTORS

Denitrification Process: FBR with 98% methanol addition

WWTP Data:

Name: Syvab WWTP

Location: Syvab, Sweden

Capacity: 30 MGD

Contact: Anders Osterman, anders.osterman@syvab.se

Phone No: 011-46-8-530-272-40

WW Characteristics Influent and Effluent:

Variations – Flow and Strength:

Average Daily in 2000: 29.1 MGD

Peak Daily (Dry Weather) in 2000: 64.5 MGD

Source (industrial, Storm, etc…):

Mixture of domestic and industrial (paper mill, brewery, and small industries.

Ann Avg 2000	Influent	Primary Effluent	Effluent
BOD_7	140 (50-250)		5.5 (2.6-14)
TSS	230 (84-500)	72 (29-250)	8.2 (1.1-50)
TN	30 (16-45)	27 (16-38)	4.1 (1.4-9.0)
TKN			
NH_3	17 (24-7.2)		0.44 (<0.1-3.8)
NO_2			
NO_3			2.5 (0.1-6.7)
TP	5.3	2.8	0.38 (0.1-0.92)

Treatment Process:

Primary Treatment

Screens, grit chamber, primary clarifier

Secondary Treatment

Phosphorous removal: Adding ferrous sulfate

Activated Sludge

Process: Single sludge carbonation-nitrification

Detention Time (HRT & SRT): HRT=4-5 hours, SRT=10-12 days

Temp: 10-20 C

pH maintained at 6.2

MLSS: 4000 mg/L

Type of Aeration: Diffused Air

Success (Rate of Nitrification): achieving annually 15-20 mg/L of NO3-N for influent ammonia levels 25-30 mg/L

Spontaneous denitrification is occurring in secondary clarifier, hence less nitrates level in FBR.

Denitrification Facility

Drum sieve:

In front of FBR: separates larger solids that may have passed through previous process.

Process Supplier:

US Filter Envirex

Year Installed:

1997

Number of Units:

4

Size of Unit:

38.5 sq. meters, 414 ft^2

Depth of Bed:

6m, 20 ft (0.5 mm sand)

Typical Feed Rate (Hydraulic and NO_3-N):

Hydraulic: 40 m/h, 16 gpm/ft^2,

Loading: 4 lbs NO_3/ft^2

Carbon Source and Dosages (based on flow, nitrates?):

Methanol,

At startup: 3 g Methanol/g NO_3-N reduced, at setpoint: 3.6 g Methanol /g NO_3-N,

Dr. Lange nitrate analyzer: nitrates before and after the FBR.

To control overdosing, TOC is monitored in the outlet of FBR within the control loop.

Denitrifiers adapt faster to methanol if they get ethanol initially.

Nitrate Removal Rate:

Achieving < 1 mg/L NO_3-N, 90% removal

Solids Production (In/Out): 0.5

TSS increase by 10 mg/L in effluent: If influent TSS is 10 mg/L then effluent TSS is 20 mg/L.

Increase in solids loading in sand filtration.

Effluent Recycle Rate:

Depends on influent flow, if < 6000 m3/h than effluent recycle increases to keep a constant fluidization of 6000 m3/h (1.6 gph).

Fluidization Rate:

40 m/h, 16 gpm/ft^2

Growth Control

Pump: at 10 ft

Frequency: Continuous

Solids Fate: Waste biomass goes head of plant.

MLSS: 20,000-40,000 mg/L

Sand Trap at the outlet recycled the escaping sand back to beds.

Waste biomass:

2000-4000 mg/L

Maximum Allowable media expansion: 10 ft, 100%

Media Loss:

Loose 10 to 15 times in year.

Refill 25% of sand volume

Temperature Effect:

Changes biomass concentration. This variation increases headloss resulting in process temporarily shut down for clogging check. Don't know for certain, headloss could have increased due to difference in sand density.

Operational Schedule

Operating Labor – No. of operators and hrs / day:

2 for FBR and sand filter. For FBR 1 hr/day.

Operation and Maintenance

Issues:

Sand can overflow, submersible pumps used to wash the surface overflow. Investigating alternatives to deal with overflow.

Snow melt and rain decrease nitrate concentration, and bacteria growth cannot be controlled by growth control device. Lower attached growth will show up as increase of solids in the outlet.

Increase in effluent TSS, leading to increase loading to sand filter.

Add 25% of initial sand volume every year..

Sufficient amount of phosphorous required for the denitrifiers to grow. Insufficient level of phosphorus leads to slimy biomass growth and increase in effluent suspended solids. At full denitrification, the FBR is consuming 0.35-0.4 mg/L of PO_4-P.

Problems (process temporarily shut down?)

Temporarily shut down the FBR for cleaning when there was increase in headloss. Thought the increase was due to clogging. Didn't notice any clogging. Assumed increase in headloss was due to variation in biomass concentration from cold to warm seasons.

Cost for TN reduction:

$1.5/kg of NO3-N rem., $3.3/lb of NO3-N rem.

Capital Cost:

Construction:	$1.4 million
Machinery Equipment:	$2.4 million
Installation and Follow-up:	$0.6 million
Total Cost:	$4.4 million

EVALUATION CRITERIA

Odor Issues: None

Implementation: start up period was long, not reliable bed height control and lack of phosphorous.

Reliability: bed control is an issue.

Flexibility: The process is flexible and the amount of nitrogen discharge can be adjusted.

Simplicity of Operation: require only one operator, very simple and easy to operate.

Flow Variations: Only a constant flow of 30 MGD can be treated by FBR. Flow greater than 30-MGD goes directly to sand filter. Effluent recycle is increased to maintain 30-MGD flow when the flow is less. Snow melt and rain decrease nitrate concentration, and bacteria growth cannot be controlled by growth control device. Lower attached growth will show up as increase of solids in the outlet.

Shock Loading: Doesn't effect the membrane.

Remarks:

In comparison to other denitrification filters chose FBR because it was efficient, cost effective and small footprint.

BALTIMORE CITY COMPREHENSIVE PLAN
TELEPHONE SURVEY OF DENITRIFICATION FACILITIES
FLUIDIZED BED REACTORS

Denitrification Process: FBR with Methanol

WWTP Data:

Name: Truckee Meadows Water Reclamation

Location: Reno, NV

Capacity: 42 MGD

Contact: Randall Gray, rgray@ci.sparks.nv.us

Phone No: 775-861-4102

WW Characteristics Influent and Effluent:

Variations – Flow and Strength:

Average Daily:

Peak Daily (Dry Weather):

Source (industrial, Storm, etc…):

2001 Ann Avg	Influent (mg/L)	Effluent (mg/L)
BOD	180	5
TSS	148	4
TKN	n/a	3
NH_3	n/a	2.33
NO_2	n/a	n/a
NO_3	n/a	0.34
TP	5.16	0.33
TN	n/a	3.33
PH	n/a	n/a

In calendar year 1999 and 2000 achieved TN and NO3-N less than 2 mg/L and 0.2 mg/L, respectively.

Treatment Process

Primary Treatment:

Grit tanks, primary sedimentation tank

Secondary Treatment:

Phosphorous stripping

Aeration Tanks

Aeration Type: Blowers

Nitrification Method

Process:

Nitrification Towers (upflow or downflow)

Units: 4

Size: n/a

Typical Feed Rate (Hydraulic and TKN):

pH maintained

Alkalinity Addition:

Lime

Type of Aeration: Blowers / Stainless Steel Aerators

Aeration Rate: n/a

Success (Rate of Nitrification)

Denitrification Facility

Process Supplier:

US Filter Envirex

Year Installed:

1980

Number of Units:

4

Size of Units:

20' X 40'

Depth of Bed: n /a

Typical Feed Rate (Hydraulic and NO_3-N):

Hydraulics: 6 – 9 gpm/ft2,

Loading: n/a

Carbon Source and Dosages (based on flow, nitrates?):

Methanol, flow pace, 3lbs/lb NO3-N rem.

Seasonal Nitrate Removal Rate: n/a

Solids Production (In /Out) % Removal:

Effluent Recycle Rate: n/a

Fluidization Rate:

11 gpm/ft^2

Growth Control

Pump

Frequency: n/a

Rate: n/a

Solids Fate – Existing GS

Waste Biomass

Maximum Allowable media expansion

Media Loss: Replenish with 100 cu. yds or 70 tons of sand yearly.

Temperature Effect: no effect for > 12 C

Operational Schedule

Operating Labor – No. of operators and hrs / day: One (1) operator on a 24 hour watch

Operation and Maintenance

Ease of Use – very little effort

Issues - None

Problems

Capital Cost:

$7 million

EVALUATION CRITERIA

Odor Issues:

some odor from sulfate reduction to sulfide

Implementation: n/a

Reliability: Very good thus far

Flexibility: No real need as of yet

Simplicity of Operation: Very good

Flow Variations: No real impact

Shock Loading: Not typical in waste stream

Remarks:

BALTIMORE CITY COMPREHENSIVE PLAN
TELEPHONE SURVEY OF DENITRIFICATION FACILITIES
FLUIDIZED BED REACTORS

Perchlorate Removal

WWTP Data:

Name: Longhorn Army Ammunition Plant

Location: Karnack, TX

Capacity: 50 gpm

Contact: Bill Corrigan, ces@shreve.net

Phone No: 903-679-3448

WW Characteristics Influent and Effluent:

Variations – Flow and Strength:

Average Daily: 35 gpm

Source (industrial, Storm, etc…): Ground water

Consists of metals and perchlorate

Treatment Process

Alkaline precipitation: remove metals

Air Stripping: remove volatiles

Fluid Bed Reactor: biological removal of perchlorate by producing chloride

Off Gas System

Aeration

Perchlorate Facility

Process Supplier: Envirogen

Year Installed:

Number of Units: 1

Size of Units: 5' Dia

Depth of Bed: 11ft

Typical Feed Rate:

Hydraulic: 1.8 gpm/ft^2 (Avg Flow)

2.5 gpm/ft^2 (Design Flow)

Nutrient Addition: 50% acetic acid, dilute phosphoric acid and urea

Seasonal Perchlorate Removal Rate:

Solids Production (In /Out) % Removal: Don't monitor.

Fluidization Rate: 11 gpm/ft^2

Growth Control Pump

Frequency: continuos

Solids Fate – (Primary, Digester GST…etc..)?

Media Loss:

Nominal as long as bed height is kept constant. The effluent goes to a capture tank with a screen where the carbon is separated and added back to FBR.

Temperature Effect: none never see low temperatures

Operational Schedule

Operating Labor – No. of operators and hrs / day

1 operator, 4 hours/day, for operating cleaning system and collecting samples for analysis.

Operation and Maintenance

Ease of Use: easy

Issues: Occasionally clean bed by spraying water at high velocity to shear the biomass of the carbon. This is done to prevent any overflow of bed. Bed height drops 1"/hour.

Problems:

During power outage, the media settles and it takes 24-48 hours for the system to operate.

Capital Cost: $450, 000 for Envirogen equipment and innoculant.

$200, 000 for installation, machinery, PLC, pumps.

$650, 000 Total cost

EVALUATION CRITERIA

Odor Issues:

As long as acetic acid is not overdosed, odor does not occur. For microbial growth and energy, bacteria use acetic acid and oxygen first. If more acetic acid is present once oxygen is eliminated bacteria use perchlorate and reduce perchlorate to chloride. If acetic acid is increased more, the microbes utilize sulfates for energy and reduce sulfates to sulfide resulting in odor. Monitor influent and effluent through ORP (oxidation-reduction potential).

Implementation: Startup within couple of weeks . Had no difficulty.

Reliability: Very reliable

Flexibility: able to achieve various perchlorate removal rate depending on nutrient dosing.

Simplicity of Operation: Very simple

Flow Variations: If we want to go from 35 gpm to 50 gpm, can't jump to 50 gpm. Have to gradually increase flow by 5 gpm per day.

Shock Loading: shock loadings of perchlorate do not effect removal rate.

Remarks:

Works well. Cleaning of bed has to be performed periodically to keep bed height constant.

BALTIMORE CITY COMPREHENSIVE PLAN
TELEPHONE SURVEY OF DENITRIFICATION FACILITIES
DOWNFLOW FILTERS

Denitrification Process: Denite® w/ Methanol Addition

WWTP Data:

Name: Howard-Curran Plant

Location: Tampa, FL

Capacity: 96 MGD

Contact: John Drapp, John.Drapp@ci.tampa.fl.us

Phone No: 813-247-3451 x205

WW Characteristics Influent and Effluent:

Variations – Flow and Strength:

Average Daily:

50-MGD at 2001 Ann. Avg. flow

Source (industrial, Storm, etc...):

1.6 MGD industrial contribution (BOD: 1260 mg/L, TSS: 610 mg/L, TKN: 53.3 mg/L)

Ann Avg 2001	Influent (mg/L)	Effluent (mg/L)
BOD	228	2.3
TSS	185	0.8
TKN		1.21
NH_3		0.15
NO_x		1.06
TN	35.2	2.26
TP	5.7	3.5

Treatment Process

Preliminary Treatment:

Preaeration of sewage (sulfide removal), air scrubbing, screening and primary sedimentation.

Screening; 3/8" spacing

Primary: 8, 5-MGD tanks, HRT: 1.2 hrs

Secondary Treatment :

Carbonation: Activated Sludge with pure oxygen closed vessel.

Greater than 90% BOD and TSS removal.

15-20% TN removal with suspended solids.

HRT: 1 hour, SRT: 0.4 days

Nitrification: Suspended Growth

A regulated stream of primary effluent bypasses the carbonaceous stage and be fed directly to the nitrification stage to supplement the food supply for the nitrifiers.

Detention Time (HRT & SRT):

HRT: 2 hour, SRT: 10-12 days

Aeration: Centrifugal compressors and membrane diffusers.

Success (Rate of Nitrification): > 95% of ammonia converted to nitrate-nitrogen. Produce 25-30 mg/L of nitrates.

Denitrification Facility

Process Supplier: Severn-Trent

Year Installed: 20 in 1979, additional 12 in 1991

Number of Units: 32- Two groups of ten and two groups of six. All in operation.

Size of Units: 10' X 105'

Depth of Bed: 4.5-5' of Sand

Typical Feed Rate (Hydraulic and NO_3-N):

Hydraulic: 1.45 gpm/ft^2 at 2001 Ann. Avg. flow

Nitrate: 0.36 lbs/ft^2 at 2001 Ann. Avg. flow

Nitrate Removal Rate: 90% removal

Solids Production (In /Out) % Removal: TSS levels < 1 mg/L.

Carbon Source and Dosages (based on flow, nitrates?):

Flow paced and fine tuned with nitrate analyzer (ChemScan)

Methanol/dose: reclaimed methanol (95% purity), 2.46 lbs/lb NO_3-N removed

Methanol facilities: 100,000-gal tank

Overdosing: Check every 4 hours effluent BOD, and methanol. If methanol flow rate is high, an alarm turns on.

Backwash: 5-min air, 25-min air-water, 15-min water

Pump

Frequency: Once a day

Rate: 6.5 gpm/ft^2

Fate:

25% of influent flow recycle to head of secondary

Blower

Rate: 5 scfm/ft^2

Bumping (NRC)

Frequency: Every 2.5 hours

Operational Schedule

Operating Labor – No. of operators and hrs / day:

One operator per day for filter and disinfectant facility, monitor effluent nitrates, methanol, and BOD.

Operation and Maintenance

Operation is easy. Now that they installed a nitrate analyzer, methanol dosing is in control.

Problems:

Occasionally had to temporarily shut down one of the filters to replace valves or perform maintenance.

Odor Issues: None, downflow process prevents any odorous gas to seep.

Implementation: easy to startup. For the expansion used backwash water to seed the filters.

Reliability: Very reliable have achieved less than TN of 3 mg/L.

Flexibility: Can achieve various nitrate levels depending methanol dosing.

Simplicity of Operation: Ever since a SCADA system and nitrate analyzer was added, operation was easy.

Flow Variations: During diurnal flows when turbidity is high, backwash flow to head of secondary increases and so does the solids loading.

Shock Loading: Only hydraulic loading has been an issue. Otherwise the filters work well.

Remarks:

Florida has several plants with Denite® filters and has been performing well.

BALTIMORE CITY COMPREHENSIVE PLAN
TELEPHONE SURVEY OF DENITRIFICATION FACILITIES
UPFLOW REACTORS

Denitrification Process: BIOSTYR

WWTP Data

Name: Freeport IL WWTP

Location: Freeport, IL

Capacity: 6.75 MGD

Contact: Kim Rees (815) 232-6017

Phone No: (815) 232-6017

WW Characteristics Influent and Effluent:

Variations – Flow and Strength:

Average Daily: 5 MGD

Peak Daily (Dry Weather): - 6 MGD

Source (industrial, Storm, etc…): Municipal, I&I, Some Industry (metal finishing and electroplating)

BOD : CBOD – influent (2ndary effluent) – 13, Biostyr effluent = 5 mg/L

TSS: 20 mg/L (2ndary effluent) , 11 mg/L Biostyr effluent

NH_3: Raw 17.5mg/L, secondary effluent 14.3 mg/L, Biostyr effluent 0.5 mg/L

PH: 7.5

Treatment Process

Primary Treatment – Grit Removal

Secondary Treatment – Influent and Effluent Characteristics – Activated Sludge (2 hour HRT)

Nitrification Method – Biological Aerated Filter

Process Supplier: BIOSTYR

Year Installed: August 2001

Number of Units: 7 Cells

Size of Units: Unknown

Depth of Bed: (Volume = 86,000 cf of media)

Typical Feed Rate (Hydraulic and NO_3-N):

Backwash

Pump

Frequency: Every 76 hours (Timed not based on head loss)

Rate: 115,000 gallons per event

Fate – (Primary, Digester GST…etc..)? – Primary clarifier

Blower – 50 HP Blowers

Used for both aeration and backwashing

Operational Schedule

Operating Labor – No new operators needed for facility

Operation and Maintenance – One new maintenance employee hired for equpt.

Ease of Use – Very satisfied. Some problems with air operated auto valves used to back wash and place on line.

Issues: None

Problems: None

EVALUATION CRITERIA

Odor Issues: None (Very aerated with a DO of 9 mg/L leaving the system)

Implementation:

Reliability:

Flexibility:

Simplicity of Operation:

Flow Variations:

Shock Loading:

Remarks:

BALTIMORE CITY COMPREHENSIV PLAN
TELEPHONE SURVEY OF DENITRIFICATION FACILITIES

Facility Type: Moving Bed Biofilm Reactor

WWTP Data:

- Name: Corby WWTP
- Location: Corby England
- Capacity 5 MGD (30% domestic, 70% food processing wastewater)
- Contact: Peter Staufert
- Phone No: 011-44-1733-414-100

WW Characteristics Influent and Effluent:

- BOD – 600 mg/L
- TSS – 573 mg/L
- NH3 – 28 mg/L – 0.5 mg/L effluent

Treatment Process

- Primary Treatment – 6 mil screens

MBBR facility:

- Manufacturer: Kaldness
- Year Installed 1998
- Number of Units- 2 trains
- Size of Units- 1 MG Tank
- Depth of Units – 26.3 feet
- Typical Feed Rate – 4 kg/cubic meter / day
- Solids Fate: solids are sent to a clarifier then to a belt press
- Operational Schedule- 24 hours a day continuous
- Operational Maintenance & Problems - none

Remarks: Very robust however at double the design load (8 kg/ m3/day) the growth rate is hard to handle a very large quantities of sludge are formed. Sludge can also tend to get odorous if not kept fresh through mixing and aeration.

APPENDIX C

Water Agreement with Baltimore City

WATER AGREEMENT
BALTIMORE CITY AND BALTIMORE COUNTY
SEPTEMBER 20, 1972

THIS AGREEMENT, made this 20th day of September, 1972, by and between the MAYOR AND CITY COUNCIL OF BALTIMORE, a municipal corporation (hereinafter referred to as the "City"), and BALTIMORE COUNTY, MARYLAND, a body corporate and politic (hereinafter referred to as the "County").

WHEREAS, the General Assembly of the State of Maryland has established through Legislative Acts that Baltimore City has a statutory obligation to supply water to the Metropolitan District of Baltimore County at cost, without profit or loss, and that the County has a corresponding obligation to pay the actual costs incurred by the City in the capital investment, the operation and maintenance, and the management entailed in the provision of water to the County, and

WHEREAS, by existing agreements and Legislative Acts by the General Assembly of Maryland, Baltimore City supplies filtered water to portions of Anne Arundel and Howard Counties and raw water to portions of Carroll and Harford Counties from the Baltimore Water System; and

WHEREAS, it is the purpose of the parties hereto to continue the operation of the Baltimore Water System and to establish a method for the computation and payment of expenses incurred by Baltimore City and Baltimore County in connection with said water system; and

WHEREAS, it is contemplated that by this Agreement Raw Water, Treatment, and Filtered Water Facilities which shall benefit Baltimore City and Baltimore County and other political subdivisions shall be constructed and/or improved;

NOW, THEREFORE, THIS AGREEMENT WITNESSETH:

That in consideration of the covenants, agreements and payments, hereinafter set forth, it is mutually covenanted and agreed as follows:

ARTICLE I <u>DEFINITIONS</u>

A. "Baltimore Water System" is hereby defined as the Raw Water, Treatment, and Filtered Water Facilities that serve all of Baltimore City and portions of Anne Arundel, Baltimore and Howard Counties with Filtered Water and portions of Harford and Carroll Counties with Raw Water.

B. "Capital Expenditure" is hereby defined as all costs involved in the construction and/or installation of any water facility and shall include but shall not necessarily be limited to the sum of the following items: Land and/or rights-of-way, surveys, borings, material, labor, preliminary design and field engineering, construction costs, supervision and inspection of construction, overhead, and all other contributing costs or expenses. Repair and/or rehabilitation costs, paid from bond money, may be considered a capital expenditure. Capital expenditures, as the term applies in this Agreement, shall be reduced by the amount of any grant from the Federal government, the State of Maryland, or any capital contributions by others than the parties to this Agreement.

C. "Debt Service" is hereby defined as the interest and amortization payments made during any given fiscal year on any given bond issue less any interest earned on temporary investments of unexpended bond funds plus interest that would have been earned on funds advanced to bond funds from other funds due to an expenditure of bond funds prior to issue. Interest earned on temporary investments shall be calculated by using the average monthly cash balance of each bond issue adjusted by the average percentage of available funds invested and multiplied by the average rate of earnings on investments.

D. "Director" shall mean the Director of Public Works of Baltimore City or Baltimore County, or their duly authorized representatives.

E. "Filtered Water" is water delivered to the distribution system after Filtration and Treatment.

F. "Filtered Water Facilities" are hereby defined as the Filtered Water Pipelines, Filtered Water Pumping Stations and Filtered Water Reservoirs that are used in the conveyance of Filtered Water to the consumer.

G. "Flow Distribution Method" requires a hydraulic analysis, usually done on an analog and/or digital computer, of the Water System or portion of the Water System based on the design requirements used to select any Improvement. Ratios of cost responsibility shall be developed by dividing the rate of Water to be supplied to each political subdivision by said Improvement under the design requirements used to select the Improvement.

H. "Incremental Volume Method" requires a tabulation of the estimated increase in peak daily Filtered Water usage projected for each political subdivision from the time the Improvement is to be placed in service until the end of the design period. Ratios of cost responsibility shall be developed by dividing the increase in peak daily Filtered Water usage projected for each political subdivision by the total increase in peak daily Filtered Water usage for all of the political subdivisions.

I. "Major repair and/or rehabilitation" is hereby defined as a restoration of a Filtered Water Facility which does not increase its capacity and whose cost exceeds $10,000.

J. "Metropolitan District of Baltimore County" shall mean that territory as outlined and defined in Section 1 of Chapter 539 of the Acts of 1924 and, such extensions as have been approved, and as may be hereafter approved.

K. "Political Subdivision" is hereby defined as the governments of Baltimore City, Baltimore County, Anne Arundel County, Howard County, Carroll County and/or Harford County.

L. "Raw Water" is water obtained from a river, stream, or reservoir prior to treatment.

M. "System Unaccounted Water" is hereby defined as the difference between Filtered Water delivered to the Baltimore Water System and the sum of the total metered and the total unmetered water consumption.

N. "System Volumetric Method" requires a tabulation of the actual quantity of Filtered Water, including Zonal Unaccounted Water, supplied to each political subdivision in all of the Zonal Distribution Systems. Ratios of cost responsibility shall be developed by dividing the actual quantity of Filtered Water, including Zonal Unaccounted Water, supplied to each political subdivision by the total quantity of Filtered Water, supplied to all the political subdivisions.

O. "Unmetered Consumption" is hereby defined as the number of flat rate water service bills issued during the current fiscal year for the First Zone multiplied by 13,300 cubic feet per year and the number of flat rate water service bills issued during the current fiscal year for the Second Zone multiplied by 19,500 cubic feet per year.

P. "Zone" is hereby defined as a subdivision of the Filtered Water portion of the Baltimore Water System in which a uniform static pressure range is maintained.

Q. "Zonal Distribution System" is the network of pipelines within a zone that conveys Filtered Water from a Treatment Plant, a Filtered Water Pumping Station, or a Filtered Water Reservoir to the consumer.

R. "Zonal Unaccounted Water" is hereby defined as the difference between the quantity of Filtered Water supplied to the zone and the sum of: (a) metered water consumption, (b) unmetered water consumption, and (c) quantity of Filtered Water delivered to other zones.

S. "Zonal Volumetric Method" requires a tabulation of the quantity of Filtered Water, including unaccounted water, actually supplied to each political subdivision in the Zonal Distribution System or Systems served by said Pipelines, Pumping Stations, and/or Storage Facilities. Ratios of cost responsibility shall be developed by dividing the quantity of Filtered Water, including unaccounted water, actually supplied to each political subdivision by the total quantity of Filtered Water, including unaccounted water, actually supplied to all the political subdivisions served by said Pipelines, Pumping Stations, and/or Storage Facilities.

ARTICLE II <u>RIGHTS OF CITY AND/OR COUNTY NOT TO BE ABROGATED</u>

A. Nothing in this Agreement shall limit or abrogate any right or rights delegated to Baltimore City or Baltimore County by Acts of the General Assembly of the State of Maryland.

B. It is further understood and agreed that the police, legislative, and governmental powers of the Mayor and City Council of Baltimore, Maryland, and the County Executive and County Council of Baltimore County, Maryland, are in no sense attempted to be abridged or restricted by this Agreement.

C. Each signatory hereto agrees to recognize all rights and privileges acquired by acquisition of property and/or rights-of-way, each from the other parties, and each such exception as may have been granted or will be granted each to the other and/or to other parties.

ARTICLE III <u>RESPONSIBILITIES FOR NEW FACILITIES</u>

Each party to this Agreement shall be responsible for planning, designing, and constructing Filtered Water Facilities located within its boundaries, except as authorized by the Acts of the General Assembly. Each party to this Agreement contributing to the cost of a Filtered Water Facility constructed by the other party shall have the right to review reports, plans, and financing of said facilities.

The planning, designing and constructing of all Raw Water Facilities, Raw Water Pipelines and Treatment Facilities shall be the responsibility of the City. The County shall have the right to review reports and plans of said Facilities. The financing of such Facilities, including the sharing of engineering and all other preliminary costs shall be the subject of future agreements.

ARTICLE IV JOINT PLANNING

In order to provide data on which to base plans for future increases in the capacity of existing facilities and the construction of new facilities, the City and the County shall continue to maintain a jointly-staffed office that shall make detailed hydraulic, economic, and statistical studies of the entire Baltimore Water System. Assigned personnel and costs associated therewith shall be borne exclusively by the party from which said assignments originate. All other costs related thereto shall be apportioned in the Annual Water Statement.

Other political subdivisions, not party to this Agreement, shall be invited by the City and Baltimore County to contribute personnel and a proportionate share of the office expenses for joint planning. If the other political subdivisions decline to actively participate in designing future improvements to the Baltimore Water System, the system shall be designed to meet requirements of the City, Baltimore County, and those other political subdivisions who form the joint planning office.

ARTICLE V CONSTRUCTION OF FILTERED WATER PIPELINES

All Filtered Water Pipelines and appurtenances shall be designed and constructed in accordance with the applicable codes, rules and regulations of the party within whose boundaries the construction is located.

ARTICLE VI INSPECTION OF PREMISES

The premises of all water supply properties in the territories of the parties to this Agreement may be entered and inspected by either party's Director or his representative after proper authorization has been secured.

ARTICLE VII OPERATION AND MAINTENANCE OF THE BALTIMORE WATER SYSTEM

Baltimore County, shall on an annual fiscal year basis, pay its proportionate share of all expenses resulting from the operation, maintenance and administration of the Raw Water Facilities, the Treatment Facilities, and the Filtered Water Facilities that constitute the Baltimore Water System.

A. All expenses involved with the operation, maintenance, and administration of the following facilities and/or functions shall be proportioned by the System Volumetric Method:

1. The collection, transmission and treatment of Raw Water.
2. The General Supervision of the Administration Section of the Division of Water Supply of Baltimore City except those charges excluded under Article IV of the Agreement.
3. The Engineering Services in the Division of Water Supply not charged to specific projects.
4. The operation and maintenance of all pipelines in the Zonal Distribution Systems within Baltimore City until June 30, 1972, and continuing thereafter, this item shall include only the operation and maintenance of pipelines twelve inches and larger in the Zonal Distribution Systems within Baltimore City.
5. The storerooms and yards utilized in the operation and maintenance of Filtered Water Facilities.

B. All expenses involved with the operation, maintenance and administration of the following facilities, including repairs not covered by Article IX, paragraph B of this Agreement, shall be proportioned by the Zonal Volumetric Method:

1. The chlorinator stations operating in conjunction with Filtered Water Pumping Stations, Reservoirs and Tanks in the Baltimore Water System.
2. The Filtered Water Pumping Stations supplying the Baltimore Water System.
3. The Filtered Water Reservoirs and Tanks supplying the Baltimore Water System.

C. All expenses involved with the operation, maintenance, and administration of the following facilities and/or functions shall be by actual expenses for these services rendered to Baltimore County.

1. The engineering services rendered by the City on County projects.
2. The field inspection rendered by the City on County projects.
3. The installation and repair of water meters and the investigation of complaints within Baltimore County.
4. The services rendered by the City Water Consumer Service Division for Baltimore County, including postage.
5. The operation and maintenance of the Zonal Distribution Systems within Baltimore County.

D. To the expenses set forth in paragraphs A, B and C of this Article shall be added an amount of six (6) per cent which shall represent all additional expenses incurred by Baltimore City, except as otherwise set forth in other Articles of this Agreement.

ARTICLE VIII METERED WATER BILLING AND CUSTOMER SERVICE CHARGES

A. Baltimore County shall, on an annual basis based on a fiscal year, bear its proportionate share of all expenses resulting from the preparation, issuance and collection of filtered water meter bills, including fire line bills, but excluding flat rate bills, as follows:

1. The amount chargeable for the processing of metered water bills and fire line bills by the Baltimore City Bureau of Collections is hereby established as forth (40) per cent of the direct expenses incurred by said Bureau. Except for expenses relating to Parking Meter Personnel, said expenses shall include salaries, miscellaneous expenses, telephone, payroll and office rental. To these expenses shall be added an amount of six (6) per cent which shall represent all additional expenses incurred by Baltimore City, except as otherwise set forth in other Articles of this Agreement.
2. The amount chargeable for the processing of metered water bills and fire line bills by the Baltimore City Bureau of Date Processing shall be all direct and indirect expenses incurred by the Metered Water Section of said Bureau. Said expenses shall include equipment rental, salaries, miscellaneous expenses, payroll and office rental. To these expenses shall be added an amount of six (6) per cent which shall represent all additional expenses incurred by Baltimore City, except as otherwise set forth in other Articles of this Agreement.
3. The amount chargeable to Baltimore County for the processing of metered water and fire line bills by the Bureau of Collections and the Bureau of Data Processing shall be based on the unit cost per metered water and fire line bills multiplied by the total number of said bills issued for the County. The unit cost of said bills shall be determined by dividing the sum of the expenses derived by the

procedures described in the foregoing paragraphs 1 and 2 by the total number of bills issued for metered water and fire lines.

B. Baltimore County shall, on an annual fiscal year basis, bear its proportionate share of all expenses resulting from the processing of complaints and requests for information, as follows:

1. The amount chargeable to the Baltimore Water System for the processing of complaints from water consumers shall be the product of expenses properly chargeable to the City's Customer Services Division and the ratio developed by dividing the number of water complaints by the total number of complaints processed by that Division. Said expenses shall include salaries, miscellaneous expenses, utilities, payroll and office rental. To these expenses shall be added an amount of six (6) per cent which shall represent all additional expenses incurred by Baltimore City, except as otherwise set forth in other Articles of this Agreement.
2. The amount chargeable to Baltimore County for the processing of complaints by the Customer Services Division shall be the product of expenses properly chargeable to the Baltimore Water System (as calculated in 1 above) and the ratio developed by dividing the number of Baltimore County Water accounts by the total number of accounts in the Baltimore Water System.

ARTICLE IX DEBT SERVICE

Debt Service resulting from bonds issued by either party to this Agreement for mutually beneficial improvements for which cash reimbursements have not been made by the party other than the issuer party shall be apportioned in the Annual Water Statement, as set forth in this Article.

A. For improvements accomplished after June 30, 1970:

1. Repair and/or rehabilitation of Raw Water and Treatment Facilities - System Volumetric Method.
2. Repair and/or rehabilitation of Filtered Water Pumping and Storage Facilities - Zonal Volumetric Method.

B. Capital expenditures from any bond issue for mutually beneficial improvements, accomplished or under way prior to June 30, 1970, that have been apportioned on the Fiscal 1970 Annual Water Statement shall be continued to be apportioned on the same basis as reflected in said Statement until such time as this Agreement may be amended in reference thereto.

C. The Debt Service allocated to each political subdivision shall be calculated in the following manner:

1. Debt Service during any fiscal year for each bond issue shall be divided by the total capital expenditures to date from that issue to obtain the debt service percentage for that year for each bond issue.
2. The capital expenditures apportioned, by the methods specified in paragraphs A and B of this Article, to each political subdivision from each bond issue shall be multiplied by the appropriate debt service percentage to obtain the debt service allocated to each political subdivision from each bond issue.

ARTICLE X MAJOR REPAIRS AND REHABILITATIONS TO FILTERED WATER PIPELINES, TWELVE INCHES AND LARGER IN DIAMETER

Costs for major repairs and/or rehabilitations to Filtered Water Pipelines, twelve inches and larger in diameter, in the Baltimore Water System shall be apportioned by the original capital construction allocation if the original allocation was made by the Flow Distribution Method. If this was not the Method originally used, then the above mentioned costs shall be apportioned by the Flow Distribution Method for the current design period. This Article shall apply regardless of the Method of Payment, i.e. cash contribution, debt service payments or by the Annual Water Statement.

ARTICLE XI <u>FUTURE FACILITIES</u>

A. Whenever new Water Facilities and/or enlargements, additions or improvements to existing Water Facilities that may be mutually beneficial to the parties to this Agreement and/or to other political subdivisions are deemed necessary by either party to this Agreement, the Director of the City or the County, in whichever the aforementioned work would be performed, shall promptly notify or be notified by the Director of the other party to this Agreement of the need for said work. Other political subdivisions, not party to this Agreement that may receive benefit from said work shall also be notified by the Director of the City/County wherein the work is to be performed. The Director of the City or the County in whichever said work would be performed shall prepare and transmit the the necessary preliminary studies, designs, and cost estimates to the Director of the other party to the other party to this Agreement for his review and approval. The Director shall also transmit the aforementioned design and cost information to any other political subdivision that may receive benefit from said work.

B. The capital expenditures for the mutually beneficial Water Improvements constructed after June 30, 1970, shall be apportioned to each benefitted political subdivision by the following methods:

1. Filtered Water Pipelines - Flow Distribution Method.
2. Filtered Water Pumping Station and Storage Facilities - Incremental Volume Method.

C. Capital expenditures allocated to each political subdivision shall be the responsibility of that political subdivision.

D. Before either party to this Agreement commences a Future Facility as defined in paragraph A of this Article the party not executing the work shall certify to the party executing the work that funds for its share of participation are available. In the event that funds are not available, the parties agree to attempt to obtain funds as expeditiously as possible.

E. Payment to the party executing the work shall be made by the other party on the basis of progress payments by the executing party based upon work completed. Such payment, billed on the 15th day of each month for the proportionate share of the amount of work completed as of the 1st day of the month, shall be due as of the 15th day of the following month.

F. On or before the 1st day of November of each year, the Directors shall prepare and exchange lists of mutually beneficial water facilities scheduled for construction in their respective political subdivisions during the two subsequent fiscal years. The said lists, submitted for reciprocal review by both parties to this Agreement and to other political subdivisions, shall include a general description of the projects, estimated costs, estimated ratios of cost responsibility and the purpose for which the proposed projects are intended. Within sixty (60) days after receipt of said lists of mutually beneficial facilities, the party receiving the list shall confirm its intention to financially participate in the costs as provided in this Article and Article IX. The approval of the City and Counties is subject to further approval in the Case of Baltimore City, by the Board of Estimates, in the case of Baltimore County, by the County Executive, and, in case of other political subdivisions, by appropriate resolution of the governing body.

ARTICLE XII <u>COSTS TO BE RECALCULATED ANNUALLY</u>

A. Annual Water Statement - On or before the 31st day of December of each year, the City shall submit to the County a statement showing computations of the County's share of costs for the preceding fiscal year. The computations shall be jointly prepared by the City and County as shown in the attached exhibit for fiscal 1970 and shall be in accordance with the principles and methods of costing as set forth in Articles VII, VIII and IX.

B. Payment - If the County's share of costs exceeds billed revenues from County consumers, less abatements, the County shall remit the difference to the City within sixty (60) days of receiving the Annual Water Statement. If billed revenues from County consumers, less abatements, exceed the County share of costs, the City shall remit the difference to the County within sixty (60) days of forwarding the Annual Water Statement.

ARTICLE XIII <u>ACCESS TO RECORDS</u>

Each party of this Agreement shall have ready access to all plans, office and field records, cost accounts and files of the Baltimore Water System of the other party.

Either party shall have ready access to all schedules, programs, and cost estimates relating to altering or enlarging the Baltimore Water System, or any part thereof.

Each party shall have ready access to all information, records, calculations, and data used to prepare the Annual Water Statement.

ARTICLE XIV <u>ARBITRATION</u>

In the event of any disagreement between the parties to this Agreement over the terms of the Agreement, the parties shall submit, on the demand of either, the matter to arbitration in the following manner: The County shall appoint one arbitrator and the City shall appoint one arbitrator. The two arbitrators so appointed shall select a third, who shall be chairman of the board of arbitration. If the two arbitrators are unable to agree upon the third arbitrator, the Chief Judge of the Court of Appeals shall be requested to designate such third arbitrator, and the written decision of the majority of the board of arbitration shall be final and binding upon both parties.

ARTICLE XV <u>TERM OF AGREEMENT</u>

This Agreement shall be retroactive to July 1, 1969 and shall continue in force and effect until amended by the parties hereto or until a new Agreement is made between the parties.

If it becomes necessary or desirable in the opinion of either party to amend this Agreement, such party shall so notify the other in writing at least 30 days before the end of any calendar year. Such party shall accompany its written notification with a draft of its desired amendment or new Agreement. If the parties are unable to agree, the present Agreement shall continue in force. In the case of disagreement, either party may initiate arbitration proceedings according to Article XIV, above.

If the parties agree to terminate this Agreement, it is understood that the City shall continue to furnish filtered water to consumers in the Baltimore water system, until Chapter 539 of the Acts of 1924 is amended or repealed.

IN WITNESS WHEREOF, the parties hereto have properly executed this Agreement, as of the day, month and year first above written.

ATTEST:

(CITY SEAL)

Lawrence ..., Deputy Treasurer

APPROVED AS TO FORM AND LEGAL SUFFICIENCY:

Charles T. LeViness 9-19-72
Chief Assistant Solicitor
Baltimore ... Department

MAYOR AND CITY COUNCIL OF BALTIMORE

By: ...
Mayor

APPROVED: SEP 20 1972
BOARD OF ESTIMATES OF BALTIMORE

By: ...
Richard Lidinsky
Clerk

ATTEST:

BALTIMORE COUNTY, MARYLAND

By: ...
Dale Anderson
for County Executive

APPROVED AS TO LEGAL FORM:

County Solicitor of Baltimore County

APPROVED:

Albert B. Kaltenbach, Director
Department of Public Works of Baltimore County

APPROVED AS TO LEGAL SUFFICIENCY:

County Solicitor of Baltimore County

APPENDIX D

Sewer Agreement with Baltimore City

SEWERAGE AGREEMENT

BALTIMORE CITY AND BALTIMORE COUNTY

MARCH 6, 1974

THIS AGREEMENT, made this 6th day of March, 1974, by and between the MAYOR AND CITY COUNCIL OF BALTIMORE, a municipal corporation (hereinafter referred to as the "City"), and BALTIMORE COUNTY, MARYLAND, a body corporate and politic (hereinafter referred to as the "County").

WHEREAS, the General Assembly of the State of Maryland by an Act known as Chapter 539, of the Acts of 1924, created a Metropolitan District within Baltimore County, Maryland, said district being contiguous to Baltimore City, and authorized the County to construct, maintain and operate sewerage systems within said Metropolitan District, and by an Act known as Chapter 729, of the Acts of 1939, authorized the County to enter into contractual agreements with the City for the disposal of sewage or drainage, and for the establishment, construction, operation and enlargement of water supply, sewerage or drainage systems, and for the costs, rentals, service charges or other fees in connection therewith; and

WHEREAS, the County and the City entered into agreements dated December 6, 1945, and January 30, 1963, providing for the construction of sewers and for the discharge of sewage from the Metropolitan District of the County into certain sewerage systems of the City; and

WHEREAS, since the agreements dated December 6, 1945, and January 30, 1963, there have been substantial increases in population, volume of sewage, operation and maintenance costs, and costs of construction of the jointly-used sewerage systems; and

WHEREAS, it is the purpose of the parties hereto to continue the operation of jointly-used sewerage systems between the City and the Metropolitan District of the County, and to establish a method for the computation and payment of costs incurred by the City and the County in connection with said jointly-used sewerage systems:

NOW, THEREFORE, THIS AGREEMENT WITNESSETH:

THAT IN CONSIDERATION of the covenants, agreements and payments hereinafter set forth, it is mutually covenanted and agreed as follows:

<u>ARTICLE I DEFINITION</u>

A. "Capital Expenditure" is hereby defined as the net costs involved in the construction and/or installation of any sewer facility and shall include, but not limited to, the sum of the following items: Land and/or rights of way, surveys, borings, material, labor preliminary design and field engineering, supervision, construction and inspection of construction, overhead, and all other contributing costs or expenses. Repair and/or rehabilitation costs, paid from bond money, may be considered a capital expenditure. Capital expenditures shall be exclusive of grants from the Federal government, the State of Maryland, or any capital contributions by others than the parties to this Agreement.

Copied from the original document for publication in the Water & Sewerage Plan

B. "Debt Service" is hereby defined as the interest and amortization payments made during any given fiscal year for any given bond issue less any interest earned on temporary investments of unexpected bond funds or sinking funds plus interest that would have been earned on funds advanced to bond funds from other funds due to an expenditure of bond funds prior to issue. Interest earned on temporary investments shall be calculated by using the average monthly cash balance of each bond issue adjusted by the average percentage of available funds invested and multiplied by the average rate of earnings on investments.

C. "Design Flow Method" is a method of cost allocation determined from a tabulation of the projected volume of sewage to be contributed by each party to this Agreement that was used to design the proposed jointly-used facility. Ratios of cost responsibility for additional facilities including the addition of secondary or advanced waste treatment are developed by dividing the designed ultimate capacity allocated to each party to this Agreement by the projected total designed ultimate capacity allocated to both parties to this Agreement. Ratios of cost responsibility for the expansion of existing facilities are developed by dividing the increase in flow projected for each political subdivision to the design year by the total increase in flow projected to the design year for all of the political subdivisions.

D. "Director" shall mean the Director of Public Works of Baltimore City or Baltimore County, or their fully authorized representatives.

E. "Facility" for the purpose of this Agreement shall mean any installation including real and personal property that is used or useful for the purpose of receiving, transmitting, pumping, treating and/or disposing of sewage or sludge.

F. "Jointly-used Facility" is hereby defined as any facility that receives, transmits, pumps, treats and/or disposes of the sewage from both parties to this Agreement.

G. "Metropolitan District of Baltimore County" shall mean that territory as outlined and defined in Section I of Chapter 539 of the Acts of 1924, and, such extensions as have been approved, and as may be hereafter approved, in accordance with the provisions and limitations of Section 14 of Chapter 539 of said Acts.

H. "Political subdivision" is hereby defined as the governments of Baltimore City and/or Baltimore County.

I. "Sanitary Sewer" is a pipe or conduit and specific purpose of which is to carry waste waters as defined below.

J. "Wastewater or Sewage" consists of the water-carried waste discharged from the dwellings, business buildings, institutions and industrial establishments, supplemented in some instances by industrial wastes, surface and sub-surface waters and storm waters.

K. "Storm Drain" is conduit or pipe through which storm water, condensate, cooling water, street wash and other wash waters or drainage flow and from which waste water is excluded.

L. "Storm water" is excess water running off from the surface of a drainage area during and immediately following rainfall, snowfall or other meterological precipitation.

M. "Subsurface water" is water that occurs in the lithosphere. It comprises suspended water and ground water.

N. "Surface water" is water that rests on or flows over the surface of the lithosphere.

O. "Volumetric Method" is a method determined by an annual tabulation of the volume of sewage contributed by each party to this Agreement to each jointly-used facility. Ratios of cost responsibility are developed by dividing the volume of sewage contributed by each party to this Agreement to the total volume of sewage that is received, transmitted, pumped, treated and/or disposed of by each jointly-used facility.

ARTICLE II RIGHTS OF CITY AND/OR COUNTY NOT TO BE ABROGATED

A. Nothing in this agreement shall limit or abrogate any rights or rights delegated to Baltimore City or Baltimore County by Acts of the General Assembly of the State of Maryland.

B. It is further understood and agreed that the police, legislative and governmental powers of the Mayor and City Council of Baltimore, Maryland, and of the County Executive and County Council of Baltimore County, Maryland, are in no sense attempted to be abridged or restricted by this Agreement.

C. Each signatory hereto agrees to recognise all rights and privileges acquired by acquisition of property and/or rights of way, each from the other and/or from other parties.

ARTICLE III RIGHT OF REVIEW

Each party contributing to the cost of a sewerage facility constructed by the other party shall have the right to review and approve reports, plans, bids and financing of said facility prior to award of a contract for said facility.

Any costs associated with said review shall be borne exclusively by the receiving party.

Nothing in this Article shall limit or abrogate any right or rights of the parties to this Agreement to enter into other agreements for the planning, designing and constructing of sewerage facilities.

ARTICLE IV LIMITATION OF TERRITORY

This Agreement applies to the Service Areas of the Back River Waste Water Treatment Plant and the Patapsco Waste Water Treatment Plant.

ARTICLE V INTERCONNECTIONS OF THE SEWERAGE SYSTEMS

To the extent hereinafter provided, each party to this Agreement shall permit the other party to discharge sewage from the other's sanitary sewers into its sanitary sewers by allowing the other party to connect to its sewers.

A. The sanitary sewers of either party shall be connected with the sanitary sewers of the other party only at such points and to such extent as may be designated by the other party in writing.

B. The Directors of Public Works of the respective parties shall transmit to their counterparts, not later than November 1 of each year, projections of flows from their subdivision to the other by point of entry. Based upon said criteria, the respective Directors of Public Works shall prepare a Six-Year Capital Improvement Program designed to accommodate the flows from one system into the other, together with those facilities required to handle the estimated flows within his respective subdivision.

C. By January 15 the Directors shall agree as to the appropriate division of costs of such jointly-used facilities, based on the design flow method.

D. Not later than July 1, the Directors shall notify their counterparts of those system facilities that have been included in the officially adopted Capital Improvement Program and shall also provide data by years on flows to be accommodated at each point of entry and capacities to be made available for the other parties flows, all predicated upon the completion of such improvements. Each such annual notification will be deemed to supercede all prior such notifications and shall be binding for the ensuing period.

E. The Director of the originating jurisdiction shall limit the number of connections and flows to those flows which the Director of the other party indicates may be safely accommodated. The parties to this Agreement do hereby acknowledge the statutory responsibility of the Department of Health and Mental Hygiene in reference to the adequacy of sewerage systems and agree to submit any disputes concerning the physical aspects of the system to said Department for adjudication.

F. Each party shall be notified in writing at least five (5) days before the making of any connections to its sewerage system by the other party so as to permit the inspection of construction of said connections at the site of said work.

ARTICLE VI STORM WATER, SURFACE WATER AND OTHER MATERIALS NOT TO BE DISCHARGED INTO SANITARY SEWERS

A. Storm water, surface water, subsurface water and other non-polluted wastes shall not be discharged into those sanitary sewers which drain into the jointly-used sanitary sewers of either party. No street inlet, catch basin storm drain, rain leader, cellar drain, garage drain or any other connection through which storm water, surface water, ground water or any other water not classified as sewage can flow shall be connected to the aforesaid sanitary sewers which drain into the jointly-used sewers of the City and the Metropolitan District.

B. Both parties agree to use every effort to prevent the owners of properties in the City and the Metropolitan District from discharging storm water into the sanitary sewers connecting with the sanitary sewers of either party, and if any such connections are detected, the Directors shall promptly use all means within their power to see that such connections, including storm inlets and other points of entry are abandoned and sealed.

C. No person, firm, corporation, manufacturing plant, or other establishment shall be permitted to discharge into any sanitary sewer of the City or Metropolitan District which drains into a sanitary sewer of the other party, any flammable liquids, acids, chemicals and/or materials or solids not normally present in domestic sewage, which in the judgment of the Directors of the City and the County may be detrimental to the sewerage system or any part thereof of either the City or the County or the operation of the said sewerage system or systems. The parties to this Agreement agree to recommend to their respective Councils mutually agreeable Industrial Waste Ordinances and to coordinate the introduction and legislative consideration of same to the end that such ordinances would be effective in both the City and County as of the same date. The provisions of this paragraph shall be superceded at such time as of the effective date of said ordinances.

D. The discharge of radioactive wastes into any of the sanitary sewers of the other party shall be limited as to quality and character in accordance with the latest rules and regulations of the Health Department of the State of Maryland, of the Commissioner of Health of the City of Baltimore, and of the Deputy State or County Health Officer of Baltimore County, Maryland, whichever of these rules and regulations are most stringent.

ARTICLE VII CONSTRUCTION OF SANITARY SEWERS

All sanitary sewers, house sewers, interceptors, manholes, bellmouths, and connections between the sanitary sewers of the City and the Metropolitan District shall be designed and constructed in accordance with the applicable codes, rules and regulations of the party within whose boundaries the construction is located.

ARTICLE VIII INSPECTION OF PREMISES

The premises of the properties in the territories defined in Article IV, which drain into sewers of the other party to this Agreement, may be entered with notice and inspected by the Director, or his representative, of the party into whose sewer or sewers the sewage drains. Private premises are excluded from the aforegoing stipulations and may be entered only after proper authorization has been secured by the Director, or his representative, of the jurisdiction within which such premises are located.

ARTICLE IX REPAIRS AND REHABILITATIONS

A. Whenever it becomes necessary for one of the parties to repair and/or rehabilitate as opposed to expanding any part of any jointly-used facility which receives, transmits, pumps, treats and/or disposes of sewage, the other party shall contribute its proportionate share of all costs resulting from the planning, designing and execution of said repair and/or rehabilitation, including all materials, labor, engineering and any and all other costs involved therein. The cost of items referred to in this Article shall be apportioned according to the Volumetric Method using the quantities of sewage contributed by both parties to this Agreement for the fiscal year preceding that in which the costs were incurred.

B. Upon agreement between both parties to the Agreement, expenditures for repairs and/or rehabilitations to jointly-used facilities may be considered capital expenditures if paid from bond money, the repayment for which by one party to the other shall be included in the annual debt service charge as calculated in Article XII, paragraph E of this Agreement.

ARTICLE X FINANCING OF ADDITIONAL FACILITIES

A. Before new sewerage facilities and/or enlargements, additions or improvements to existing sewerage facilities that may be jointly-used by the parties to this Agreement, are undertaken by either party to this Agreement, the Directors shall determine the party responsible for said work under this Agreement and the Director of the party responsible for said work shall promptly prepare and transmit the necessary preliminary studies, designs, and cost estimates to the Director of the other party for his review and approval.

B. The capital expenditures for the jointly-used sewerage facilities covered by this Article and constructed after June 30, 1969, shall be apportioned to each party to this Agreement by the Design Flow Method.

C. Before either party to this Agreement commences construction or installation of any additional sewerage facilities, each Director shall certify that funds for their respective shares of participation are available. In the event that funds are not available, the parties agree to attempt to obtain funds as quickly as possible.

D. Thirty days prior to advertising for bids on any project that affects any portion of the other parties' system, notification shall be given to that party which shall include the scope of the project, the cost, and the estimated construction schedule.

E. Payment to the party executing the work shall be made by the other party as the work progresses. Such payment, billed each month for the proportionate share of the payment for work completed, shall be due within 30 days of the rendering of such bill.

ARTICLE XI DETERMINATION OF SEWAGE FLOW

A. The total annual volume of sewage contributed by each party to each jointly-used facility shall be determined on a fiscal year basis as hereinafter set forth:

1. By November 1 of each year the Directors shall furnish their counterparts with an enumeration of each and every water service connection existing as of the preceding June 30 to every property and/or building, the sewage from which property and/or building enters any jointly-used facility of either party. Sewage flow from the properties and/or buildings so served shall be completed as follows:

(a) Each and every water service less than one inch in size that serves a property and/or building connected directly or indirectly to a jointly-used sewerage system shall be considered to contribute an annual volume of sewage per such installation which is equal to 100,000 gallons per year, plus an allowance of 15% for infiltration.

(b) Each and every water meter installation one inch and/or larger in size that serves a property and/or building connected directly or indirectly to a jointly-used sewerage system shall be considered to contribute an annual volume of sewage which is equal to the registered quantity of water flowing through the meter on a fiscal year basis adjusted to exclude that volume of metered water which does not enter the jointly-used sewerage system, plus an allowance of 15% for infiltration.

(c) The volume of sewage contributed by the properties and/or buildings described in the foregoing paragraphs of this Article shall be determined at each point of entry into the sewerage system of the other party. Each and every property and/or building described in the foregoing paragraph 1 (b) of this Article shall be separately identified at each point of entry into the sewerage system of the other party by the water meter account number; the name and address of said property and/or building; the registered quantity of water flowing through the water meter serving said property and/or building in a fiscal year basis; the percentage of metered water which enters the jointly-used sewerage system, and the annual volume of sewage contributed to the jointly-used sewerage system by said property and/or building. Whenever any property and/or building which uses water for any purpose from the water supply system or from any other sources in such a manner that the water so used is not discharged into a jointly-used sewerage system, the volume of sewage from the said property and/or building shall be adjusted to exclude the quantity of water which does not enter a jointly-used sewerage system as determined periodically by such reasonable methods as shall be mutually agreed by the Directors. The methods and calculations for each such determination shall be available for review as provided in Article XIV, Access to Records.

2. Whenever any property and/or building, the sewage from which property and/or building enters any jointly-used facility of either party, and is not served by the Baltimore City water supply system, the sewage flow shall be determined as follows:

   (a) Each and every single family dwelling shall be enumerated by point of entry and shall be considered to contribute an annual volume of sewage per dwelling which is equal to 100,000 gallons per year, plus an allowance of 15% for infiltration.

   (b) For all other such properties the volume of sewage shall be estimated annually by each point of entry, plus an allowance of 15% for infiltration.

   The total annual volume of sewage flow at each point of entry shall be the sum of the sewage flows determined in the preceding paragraphs of this Article.

B. In order to measure and record automatically the volume of sewage flowing from the sewerage system of one party into the sewerage system of the other party, recording registering flow meters satisfactory to both parties shall be constructed, installed, and ready for regular continuous service within two years after execution of this Agreement. Meters shall be installed at or near such points of entry as shall be agreed upon. The location of such meters shall be determined on the basis of the size of the sewer, the observed conditions of flow and the practical considerations for installing of metering equipment. Meters shall be installed by the party within whose boundary the meter is to be located. The cost of said meters, their installation, and their operation and maintenance shall be shared equally by both parties.

C. When sewage flow meters or pumping station meters measure the flow of sewage from an area that is entirely located within the geographic confines of one party, the reading from said meters shall supersede the method of determining the sewage contribution described in Paragraph A of this Article.

D. At any point of entry, or at a pumping station, by reason of a new meter installation or by reason of meter failure, where the sewage flow is accurately metered for a minimum of 120 days representative of average conditions in any year, then the daily flows for the entire year shall be considered to be the average daily flow for that period of the year that has been metered. The method of calculating the sewage flow as stipulated in Paragraph A, shall be used in every section of either party from which the sewage is not metered.

E. The enumerations of water meter services and properties not served by the Baltimore Water System is stipulated in this Article, Paragraph A; and the readings from the sewage flow meters and pumping station meters referred to in Paragraphs C and D shall be tabulated and summarized as of June 30 of each fiscal year. This tabulation and summary shall be rendered by each party to the other party, by November 1 of the next fiscal year.

F. Each party shall maintain all metering and recording equipment under its supervision in good operating condition. Should either party fail to maintain any meter within its boundaries in good operation condition, the Director of the other party may at his discretion, thirty days after written notice is given, cause the repair to be made or otherwise maintain the equipment and shall charge the other party for its share of the costs of such repair and maintenance.

ARTICLE XII DETERMINATION OF SEWERAGE SERVICE CHARGES

The sewerage service charges shall be computed by the Volumetric Method.

The calculations for charging each party for sewerage services rendered by the other party shall be composed of a sewerage service charge to each party for that party's share of operation and maintenance expenses of jointly-used facilities of the other party and an annual charge for debt service to each party for that party's share of the debt service of the other party as applied to the jointly-used facilities of the other party. Debt service applicable to jointly financed facilities shall be excluded from the calculation of annual sewerage service charges.

The County shall pay to the City annually a Sewerage Service Charge representing the County's share of direct costs incurred by the City for transporting, pumping, treating and/or disposing of County sewage during the preceding fiscal year. The City shall pay to the County annually a Sewerage Service Charge representing the City's share of direct costs incurred by the County for transporting and pumping of City sewage through or by any County pumping station during the preceding fiscal year. The above mentioned direct costs shall include all the operating and maintenance costs for jointly-used facilities reduced by the amount of direct costs recovered as surcharges under the Industrial Waste Ordinances. They shall also include an applicable percentage of the operating management costs reported for the City's Waste Water Division, as well as other Bureau expenses properly chargeable to the City's Sewerage System or their similar activities in the County as they may apply.

The County shall also pay to the City any surcharge collected from industry for reason of excessive BOD, suspended solids, or other constitutents above that limit considered by the City as that permitted without payment of a surcharge. Such surcharge shall be in accordance with the charges specified in the Industrial Waste Ordinance.

If at any time a jointly-used facility is no longer used by one of the parties to this Agreement, the said party will no longer by charged for the use of the facility.

A. Computation of Operation and Maintenance Costs

1. County's Share of City Operation and Maintenance Costs

(a) Determine the total annual sewage flow contributed by the County to (1) each jointly-used City-operated pumping station, (2) the Back River Waste Water Treatment Plant, and (3) the Patapsco Waste Water Treatment Plant, as provided in Article XI of this Agreement. For each jointly-used City operated facility, divide the County annual sewage flow through that facility by the annual Metered total flow through the facility to obtain a factor expressed as a percentage. This factor represents the County's proportionate share in the operating and maintenance costs for that facility. Multiply the total operating and maintenance costs, reduced by the amount recovered as surcharges under the Industrial Waste Ordinance for that facility including all payroll expenses (i.e. payroll, pensions, FICA payments, Workmen's Compensation payments and fringe benefits) and administration and supervision expenses which contribute directly to operation and maintenance, for each jointly-used City-owned facility by the percentage factor derived, as outlined above in this paragraph. The total of these partial costs is the amount of the County's obligation to the City for operating and maintaining said facilities.

(b) To compute the administration and supervision expenses applicable to each jointly-used City-operated pumping station, divide the operating and maintenance expense for each such pumping station by the total operating and maintenance expenses for all City-operated pumping stations to obtain factors expressed as a percentage. Multiply each percentage factor by the Administration and Supervision expenses for all City-operated pumping stations to determine the portion of said expenses allocated to each jointly-used City-operated pumping station. This allocated expense shall be considered as a direct cost and included as part of the operation and maintenance cost of each jointly-used City-operated pumping station.

2. City's share of County Operation and Maintenance Costs

(a) Determine the total annual sewage flow contributed by the City to each jointly-used County-operated pumping station, as provided in Article XI of this Agreement. For each jointly-used County facility, divide the City annual sewage flow through that facility by the annual metered total flow through the facility to obtain a factor expressed as a percentage. This factor represents the City's proportionate share in the operating and maintenance costs for that facility. Multiply the total operating and maintenance costs, including payroll expenses, (i.e., payroll, pensions, FICA payments, Workmen's Compensation payments and fringe benefits) and administration and supervision expenses

(See (b) below) which contribute directly to operation and maintenance for each jointly-used County-operated pumping station by the percentage factor derived as outlined above in this paragraph. The total of these partial costs is the amount of the City's obligation to the County for the operation and maintenance of said facilities.

(b) To compute the administration and supervision expenses applicable to each jointly-used County-operated pumping station, divide the operating and maintenance expense for each such pumping station by the total operating and maintenance expenses for for all County-operated pumping stations to obtain factors expressed as a percentage. Multiply each percentage factor by the Administration and Supervision expense of all County-operated pumping stations to determine the portion of said expenses allocated to each jointly-used County-operated pumping station. This allocated expense shall be considered as a direct cost and included as part of operating and maintenance cost of each jointly-used County-operated pumping station.

B. Computation of Operating Management Costs

1. Determine the County's total annual sewage flow by adding together the County's annual sewage flow to the Back River Waste Water Treatment Plant and the County's annual sewage flow to the Patapsco Waste Water Treatment Plant. Divide the total County flow so obtained by the total annual sewage flow to all City plants. Multiply the resulting percentage by the operating management costs for the Waste Water Division which are the sum of the costs for Administration and Water Pollution Control plus that portion of the Engineering and Construction Inspection Accounts not charged to specific projects. The product of this multiplication shall be the amount of the County's obligation to the City for the operating management portion of the Sewerage Service Charge.

2. Divide the total of the County's annual sewage flow metered through County-operated pumping stations by the total of the County's annual sewage flow to any and all points of discharge to obtain a factor showing the ratio of the total sewage pumped to the total annual sewage flow. Divide the City's annual sewage flow through all County-operated pumping stations by a total annual metered sewage flow through all such pumping stations to obtain a factor showing the City's proportion of the total annual sewage flow through all such pumping stations. The sum of the operating management costs of the County activities which parallel the Waste Water Division shall be multiplied by the product of the two factors outlined above in this paragraph. The result shall be the amount of the City's obligation to the County for the operating management portion of the Sewerage Service Charge.

C. Computation of Applicable Expenses of Other Bureau Services

1. Six (6) percent of the County's share of the sum of (a) the operation and maintenance costs and (b) the operating management costs, both as provided in Article XII, Paragraphs A and B of this Article,

shall be the amount of the County's obligation to the City for the expenses of the Other Bureau Services for the sewerage system charges.

2. Six (6) percent of the City's share of the sum of (a) the operating and maintenance costs, and (b) the operating management costs, both provided in Paragraph A and B of this Article, shall be the City's obligation to the County for the expenses of the Other Bureau Services of the County for the sewerage service charges.

D. Computation of Credit Resulting from the Sale of Products

For each of the Back River Waste Water Treatment Plant and the Patapsco Waste Water Treatment Plant, the sum of the annual receipts resulting from the sale of heat-dried sludge, sewage effluent, and sludge gas from each treatment facility shall be multiplied by the percentage of County annual sewage flow treated at the respective treatment facility for the applicable fiscal year. The sum of the products of these multiplications shall be the credit due to the County for the sale of products.

E. Computation of Debt Service

Debt Service resulting from bonds issued by either party to this Agreement for improvements to jointly-used facilities for which cash contributions have not been made shall be calculated as follows:

<u>County's Share of City's Debt Service</u>

1. Debt Service on outstanding indebtedness and capital expenditures made prior to July 1, 1969, for the jointly-used City-operated system, excepting the Patapsco Waste Water Treatment Plant and the 30-inch Patapsco Force Main, shall be calculated as follows:

(a) To obtain the percent of interest and amortization on the outstanding indebtedness, divide the total debt service for the applicable fiscal year applicable to the outstanding bonds issued prior to December 31, 1959, by the outstanding amount of bonds issued prior to December 31, 1959, in the same fiscal year, and multiply by one hundred.

(b) To obtain the charge for interest and amortization for the current fiscal year for each jointly-used facility, multiply the outstanding indebtedness applicable to each such facility minus the amortization in the preceding fiscal year by the current fiscal year's percentage of interest and amortization as calculated in (a) above.

(c) The debt service chargeable to Baltimore County for each jointly-used City-operated facility shall be the debt service for that facility, computed in a manner prescribed above, multiplied by the ratio which the annual sewage flow from Baltimore County bears to the total annual sewage flow through that facility. The sum of the debt service charges applicable to the County for each jointly-used City-operated facility shall be the amount of debt service to be paid by the County.

Sept., 1981

(d) The outstanding indebtedness as of July 1, 1969, for the jointly-used City-operated facilities after subtracting the preceding year's amortization shall be:

Sanitary Sewer System	$2,461,089.16
Eastern Avenue Pumping Station	963,787.45
Dundalk Pumping Station	161,642.24
Jones Falls Pumping Station	155,451,67
Back River Waste Water Treatment Plant	4,094,388.31

2. Debt service on capital expenditures for the Patapsco Waste Water Treatment Plant made after December 31, 1960, and debt service on capital expenditures for other jointly-used City-operated facilities made after June 30, 1969, shall be calculated as follows:

(a) Debt Service during any fiscal year for each bond issued shall be divided by the total capital expenditures to date from that issue to obtain the debt service percentage for that year for each bond issue.

(b) The capital expenditures from each bond issued shall be apportioned according to which jointly-used facility they were made for.

(c) For each bond issue, multiply the debt service percentage (as calculated in above (a) above) by the capital expenditures apportioned to each jointly-used facility to obtain the debt service allocated to each jointly-used facility from each bond issue.

(d) The total debt service allocated to each jointly-used facility shall be the sum of the allocations to each jointly-used facility from each bond issued as calculated in (a), (b), and (c) above.

(e) The debt service chargeable to Baltimore County for each jointly-used City-operated facility shall be the total debt service allocated to that facility multiplied by the ratio obtained in accordance with the provisions of Articles IX and X of this Agreement, except for debt service allocated to construction at the Patapsco Waste Water Treatment Plant before July 1, 1969, which shall be multiplied by the volumetric ratio. The sum of the debt service charges applicable to the County for each jointly-used City operated facility shall be the amount of debt service to be paid by the County.

<u>City's Share of County's Debt Service</u>

(a) The debt service on jointly-used County-operated facilities shall be calculated as in paragraph E-2, sections a, b, c, and d of this Article.

(b) The debt service chargeable to Baltimore City for each jointly-used County-operated facility shall be the total debt service allocated to that facility multiplied by the ratio obtained in accordance with the provisions of Article IX and X of this

Agreement. The sum of the debt service charges applicable to the City for each jointly-used County-operated facility shall be the amount of debt service to be paid by the City.

ARTICLE XIII - CHARGES TO BE RECALCULATED ANNUALLY

1. Each party shall by November 1st of each year, submit in writing to the other party the readings of all sewage flow meters installed in sewers, vaults, manholes, and pumping stations as stipulated in Article XI and shall also submit the number of water meter and water service connections and computed sewage flows, as stipulated in Article XI, which are connected to and/or tributary to the sewerage system of the other party and which sewage is ultimately treated at the Back River Waste Water Treatment Plant or the Patapsco Waste Water Treatment Plant for the preceding fiscal year. The report submitting the meter readings and calculated sewage flows shall specify such locations and points of entry into the sewerage system as herein provided.

2. On or before the 31st day of December of each year, the Director of each party shall submit to the Director of the other party a statement showing computations of the other party's share of costs for the preceding fiscal year. Each party's statements and computations shall be jointly prepared by the City and County and shall show the net total of the various sums, less credits, owed by one party to the other arrived at by the methods outlined in Article XII. Said sums so due and owing by each party to the other shall be payable within sixty (60) days after date of submittal of the statements.

3. In recognition of the City's role in financing the operating management, operating and maintenance and debt service costs of the sewerage system, the County agrees to make estimated quarterly payments to the City for services to be rendered in the ensuring quarter, on July 1, October 1, January 1 and April 1. Such quarterly payments to be equal to one-fourth of the County's share of the aforementioned costs as calculated on the latest available annual cost statement. Underpayments or overpayments will be adjusted on the annual cost statement.

ARTICLE XIV ACCESS TO RECORDS

Each party to this Agreement shall have ready access to all plans, office and field records, costs accounts, records and files of existing jointly-used sanitary sewerage facilities and installations of the other party.

Either party shall have ready access to all design data, schedules, programs and cost estimates relating to altering or enlarging the jointly-used sanitary sewerage system, or any part thereof, that serves or will serve both parties.

Each party shall have ready access to all information, records, calculations and data used to determine the total annual charge for sewerage service to the other party.

ARTICLE XV OPERATION AND MAINTENANCE OF FACILITIES

It is agreed by both parties that each party shall supervise the design, construction, operation and maintenance of the various facilities of their respective sewerage systems.

ARTICLE XVI ARBITRATION

Except as otherwise provided in Article V, Section E, in the event of any disagreement between the parties to this Agreement over terms of the Agreement including design, construction and financing of jointly-used facilities the parties shall submit, on the demand of either, the matter to arbitration in the following manner:

Each of the parties hereto shall appoint one arbitrator and the two arbitrators so appointed shall select a third arbitrator who shall be Chairman of the Board of Arbitrators. If the two arbitrators are unable to agree on a third arbitrator, the Chief Judge of the Court of Appeals of Maryland shall be requested to designate such third arbitrator, and the written decision of the majority of the Board of Arbitrators shall be final and binding upon both parties.

ARTICLE XVII TERM OF AGREEMENT

Since the agreements dated December 6, 1945 and January 30, 1963 between the Mayor and City Council of Baltimore and Baltimore County relating to the Patapsco River Waste Water Treatment Plant and Back River Waste Water Treatment Plant, respectively, have terminated, the parties hereto have mutually agreed that any payments hereunder shall be retroactive to July 1, 1969, and shall continue in force and effect until amended by the parties hereto or until a new agreement is made between the parties.

If it becomes necessary or desirable in the opinion of either party to amend this Agreement, such party shall so notify the other in writing at least 30 days before the end of any calendar year. Such party shall accompany its written notification with a draft of its desired amendment or new Agreement. If the parties are unable to agree, the present Agreement shall continue in force. In case of disagreement, either party may initiate arbitration proceedings according to Article XVI above.

Both parties agree that the termination of this Agreement shall not in any way affect the continued reception, transmission, pumping, treatment and/or disposal of sewage.

IN WITNESS WHEREOF, the parties hereto have properly executed this Agreement, as of the day, month and year first above written.

ATTEST:

(CITY SEAL)

Laurence B. Daley, Deputy Treasurer

APPROVED AS TO FORM AND LEGAL SUFFICIENCY:

~~Charles P. ...~~
Asst. ~~Chief~~ Assistant Solicitor
Baltimore Law Department

MAYOR AND CITY COUNCIL OF BALTIMORE

By: ______________________
Mayor

MAR 6 1974

APPROVED:
BOARD OF ESTIMATES OF BALTIMORE

By: ______________________
Richard A. Lidinsky
Clerk

ATTEST:

BALTIMORE COUNTY, MARYLAND

By: ______________________
Dale Anderson
County Executive

APPROVED AS TO LEGAL FORM:

County Solicitor of Baltimore County

APPROVED:

Albert B. Kaltenbach, Director
Department of Public Works
of Baltimore County

APPROVED AS TO LEGAL SUFFICIENCY:

County Solicitor of Baltimore County

Acting, Director
Baltimore City Department of Public Works

A G R E E M E N T

THIS SUPPLEMENTAL AGREEMENT, made this Mar. 20, 1985, by and between the MAYOR AND CITY COUNCIL OF BALTIMORE, a municipal corporation (hereinafter referred to as the "City"), and Baltimore County, Maryland, a body corporate and politic (hereinafter referred to as the "County").

WHEREAS, the General Assembly of the State of Maryland by an Act known as Chapter 539, of the Acts of 1924, created a Metropolitan District within Baltimore County, Maryland, said district being contiguous to Baltimore City, and authorized the County to construct, maintain and operate sewerage systems within said Metropolitan District, and by an Act known as Chapter 729, of the Acts of 1939, authorized the county to enter into contractual agreements with the City for the disposal of sewage or drainage, and for the establishment, construction, operation and enlargement of water supply, sewerage or drainage systems, and for the costs, rentals, service charges or other fees in connection therewith; and,

WHEREAS, the County and the City entered into agreements dated December 6, 1945, January 30, 1963 and March 6, 1974 providing for the construction of sewers and for the discharge of sewage from the Metropolitan District of the County into certain sewerage systems of the City; and,

WHEREAS, it is the purpose of the parties hereto to continue the operation of jointly-used sewerage systems between the City and the Metropolitan District of the County; and,

WHEREAS, the City and the County have approved User Charge Systems; and

WHEREAS, the City and the county have adopted sewer use ordinances that conform to the requirements contained in 40 CFR 403.8 (f) (1); and,

WHEREAS, the City and the County by separate agreement will provide for the operation of a pretreatment program including the reporting of toxic, incompatible or significant industrial wastes; and,

WHEREAS, the City and the County are making improvements to the Gwynns Falls Sewerage System; and,

WHEREAS, the Environmental Protection Agency, Region III, has promulgated regulations, referred to as the Guidance on Service Agreements dated May 1977, which regulations require that aforementioned agreement between the City and the County dated March 3, 1974 be supplemented,

NOW, THEREFORE, THIS SUPPLEMENTAL AGREEMENT WITNESSETH, THAT IN CONSIDERATION of the mutual convenants (sic) and promises between the parties hereto, the parties agree as follows:

City shall accept, convey and treat flows from the County's Dead Run and Gwynns Falls sewer service areas up to a maximum combined flow rate of 97.7 million gallons per day.

County shall initiate and continuously prosecute a program to reduce and control inflow-infiltration in its Gwynns Falls sewer service area when a reasonable interpretation of the peak rates of flow as shown by the Gwynns Falls sewage flow meter indicates that the peak rates of flow from the County's Gwynns Falls sewer service area, including the County's Powder Mill Run sub area, are exceeding or are likely to exceed 87.5 million gallons per day more frequently than the return period for the respective design peak rate of flow specified in the Patapsco 201 Facilities Plan or the Comprehensive Water and Sewer Plan for Baltimore County as subsequently adopted or revised and readopted by the Charter Government of Baltimore County. The peak rates of flow from the County's Gwynns Falls sewer service area shall be determined by subtracting from the peak rates of flow shown by the Gwynns Falls sewage flow meter when properly operating the peak rate of flow for the same rainfall event shown by the City's Powder Mill Run sewage flow meter when properly operating.

County shall initiate and continuously prosecute a program to reduce and control inflow-infiltration in its Dead Run sewer service area when a reasonable interpretation of the peak rates of flow as shown by the Dead Run sewage flow meter when properly operating indicates that the peak rates of flow from the County's Dead Run sewer service area are exceeding or are likely to exceed 15.7 million gallons per day more frequently than the return period for the respective design peak rate of flow specified in the Patapsco 201 Facilities Plan or the Comprehensive Water and Sewer Plan for Baltimore County as subsequently adopted or revised and readopted by the Charter Government of Baltimore County.

County shall initiate and continuously prosecute a program to reduce and control inflow-infiltration in both its Gwynns Falls sewer service area and its Dead Run sewer service area when a reasonable interpretation of the peak rates of flow as shown by the Gwynns Falls sewage flow meter and the Dead Run sewage flow meter when both meters are properly operating indicates that the combined peak rates of flow from the County's Gwynns Falls sewer service area, including the County's Powder Mill Run sub area, and the County's Dead Run sewer service area are exceeding or are likely to exceed 96.9 million gallons per day more frequently than the return period for the design peak rate of flow for the County's Gwynns Falls sewer service area specified in the Patapsco 201 Facilities Plan or the Comprehensive Water and Sewer Plan for Baltimore County as subsequently adopted or revised and readopted by the Charter Government of Baltimore County. The peak rates of flow from the County's Gwynns Falls sewer service area shall be determined as provided hereinbefore.

All flows in the County's Gwynns Falls and Dead Run sewers not originating within the limit of Baltimore City shall be classified as County flows.

County's obligation and liability for flows classified as County flows shall not be diminished by reason of origin of a portion or portions of said flows being beyond the limits of the County.

County shall include in any sewer service agreements with third parties relating to all or part of the flows classified under this agreement as County flows provisions relating to user charges and pretreatment of industrial wastes consistent with like provisions in force or contemplated to be in force between the parties to this agreement.

County shall share in proportion to its share of design flow rates and without payment of additional capital costs for this purpose all increases in allowable operational capacity above design flows rates as may subsequently be determined by the State Office of Environmental Programs after considering operating experience of the Gwynns Falls sewerage system, the Dead Run sewerage system and the Southwest Diversion sewerage system taken together as one operating system.

This Supplemental Agreement shall continue in force and effect until amended by the parties hereto or until a new agreement is made between the parties.

IN WITNESS WHEREOF, The parties hereto have properly executed this Supplemental Agreement, as of the day, month and year first above written.

ATTEST:
(CITY SEAL)

s/ James A. Vroonland
JAMES A. VROONLAND
CUSTODIAN OF THE CITY SEAL

MAYOR AND CITY COUNCIL OF BALTIMORE:

BY: s/ William D. Schaefer
MAYOR

APPROVED AS TO FORM
AND LEGAL SUFFICIENCY:

s/ illegible
ASSISTANT CITY SOLICITOR

APPROVED BY THE BOARD OF ESTIMATES:
MAR 20, 1985

s/ Richard A. Lidinsky
RICHARD A. LIDINSKY, DEPUTY COMPTROLLER
AND CLERK TO THE BOARD OF ESTIMATES

ATTEST:

s/ Patricia L. Kirkner

BALTIMORE COUNTY MARYLAND

s/ Donald Hutchinson
DONALD HUTCHINSON 2/13/85
COUNTY EXECUTIVE

APPROVED AS TO FORM AND
LEGAL SUFFICIENCY

s/ Stanley J. Schapiro
DEP. COUNTY SOLICITOR OF BALTIMORE COUNTY

APPROVED:

s/ Harry J. Pistel
HARRY J. PISTEL, DIRECTOR
DEPARTMENT OF PUBLIC WORKS OF BALTIMORE COUNTY

s/Francis W. Kuchta
FRANCIS W. KUCHTA, DIRECTOR
BALTIMORE CITY DEPARTMENT OF PUBLIC WORKS

APPENDIX E

Sewer Agreement with Anne Arundel County

SEWERAGE AGREEMENT

BALTIMORE COUNTY AND ANNE ARUNDEL COUNTY

APRIL 21, 1976

THIS AGREEMENT, made this 21st day of April, 1976, by and between BALTIMORE COUNTY, MARYLAND, hereinafter referred to as the FIRST PARTY and ANNE ARUNDEL COUNTY, MARYLAND, hereinafter referred to as the SECOND PARTY, each of said Parties a body corporate and politic of the State of Maryland.

WHEREAS, the First and Second Parties entered into an Agreement dated March 13, 1958 providing for discharge of sewage from certain sewerage systems of Second Party into certain sewerage systems of Second Party into certain sewerage systems of the First Party; and

WHEREAS, the First Party has entered into Agreements with Baltimore City for the disposal of sewage; and

WHEREAS, there have been substantial increases in population, volume of sewage, operation and maintenance costs, and costs of construction of jointly used facilities since the agreement was executed on March 13, 1958, and the Parties thereto desire to terminate said Agreement; and

WHEREAS, it is the intent of the parties hereto that the severage system of the First Party shall continue to receive sewage from the Second Party and that a method for the computation and payment of costs incurred by the First Party for collection, transmission and disposal of sewage from the Second Party be established:

NOW, THEREFORE, THIS AGREEMENT WITNESSETH:

THAT IN CONSIDERATION of the covenants, agreements and payments hereinafter set forth, it is mutually covenanted and agreed as follows:

ARTICLE I. <u>DEFINITIONS</u>

A. "Capital Expenditure" is hereby defined as the net costs involved in the construction and/or installation of any sewerage facilities and shall include, but not be limited to, the sum of the following items:

Land and/or easements, consultants' fees, material, labor, utility relocations, overhead which may include a proportionate allocation of in-house costs associated with design, field engineering, surveys, borings, materials testing, maps and record maintenance, inspection, right-of-way expenses, advertising, administrative, clerical and stenographic services, office space use, and building operation and maintenance; and all other contributing costs or expenses.

Capital expenditures shall be exclusive of grants from the Federal government, the State of Maryland, or any capital contributions by others than the parties to this Agreement. For the purposes of this Agreement, capital expenditures shall also mean any cash contribution by the First Party to Baltimore City for the construction and/or improvement of a City-owned jointly used facility.

B. "City" is hereby defined as the City of Baltimore, Maryland.

C. "Debt Service" is hereby defined as the sum of interest and amortization for a specific capital expenditure.

D. "Design Flow Method" is a method of cost allocation determined from a tabulation of the projected volume of sewage to be contributed by each party to this Agreement that was used to design the proposed jointly used facility. Ratios of cost responsibility of additional facilities, including the addition of secondary and advanced waste treatment,

Copied from the original document for publication in the Water & Sewerage Plan

are developed by dividing the designed ultimate capacity allocated to each party having a beneficial interest by the projected total designed ultimate capacity allocated to all beneficially interested.

Ratios of cost responsibility for the expansion of existing facilities are developed by dividing the increase in flow projected for each beneficially interested party to the design year by the total increase in flow projected to the design year for all beneficially interested parties.

E. "DIRECTOR" shall mean the Director of Public Works of either the First or Second Parties or their duly authorized representatives or agents.

F. "FACILITY", for the purpose of this Agreement, shall mean any installation, including real and personal property, that is used or useful for the purpose of receiving, transmitting, pumping, treating and/or disposing of sewage or sludge.

G. "JOINTLY USED FACILITY" is hereby defined as any facility that receives, transmits, pumps, treats, and/or disposes of the sewage from both parties to this Agreement.

H. "MAJOR REPAIR AND/OR REHABILITATION" is hereby defined as any restoration of a facility which does not increase the capacity of the facility.

I. "POLITICAL SUBDIVISION" is hereby defined as the governments of Baltimore County, Anne Arundel County, and/or Howard County.

J. "SANITARY SEWER" is a pipe or conduit, the specific purpose of which is to carry wastewater as defined below.

K. "PURCHASED DESIGN CAPACITY" of a jointly used facility is hereby defined as that portion of the total design capacity of a jointly used facility that the principal payments of either or both parties bear to the total capital expenditures for construction, improvements, and/or installation of said facility.

L. "WASTEWATER OR SEWAGE" consists of water-carried waste discharged from the dwellings, business buildings, institutions and industrial establishments, supplemented in some instances by industrial wastes, surface and subsurface waters and storm waters.

M. "STORM WATER" is excess water running off from the surface of a drainage area during and immediately folllowing rainfall, snowfall, or other meteorological precipitation.

N. "STORM DRAIN" is a drain through which storm water, storm runoff, condensate, cooling water, street wash and other wash waters or drainage flow and from which wastewater is excluded.

O. "SUBSURFACE WATER" is water that occurs in the lithosphere. It comprises suspended water and groundwater.

P. "SURFACE WATER" is water that rests on or flows over the surface of the lithosphere.

Q. "VOLUMETRIC METHOD" is a method determined by an annual calculation of the volume of sewage contributed by each party to this Agreement to each jointly used facility. Ratios of cost responsibility are developed by dividing the volume of sewage contributed by each Party to this Agreement to the total volume of sewage that is received, transmitted, pumped, treated and/or disposed of by each jointly used facility.

ARTICLE II. RIGHTS OF EITHER PARTY NOT TO BE ABROGATED

A. Nothing in this Agreement shall limit or abrogate any right or rights delegated to either Party by Acts of the General Assembly of the State of Maryland.

B. It is further understood and agreed that the police, legislative and governmental power of either Party are in no sense attempted to be abridged or restricted by this Agreement.

C. Each Party hereto agrees to recognize all rights and privileges acquired by acquisition of property and/or rights-of-way, each from the other and/or from other parties.

ARTICLE III. RIGHTS OF REVIEW

The Second Party shall, upon request, have the right to review reports, plans, bids and financing for the construction and/or improvement of any jointly used facility owned or operated by the First Party.

Any costs associated with said review shall be borne exclusively by the reviewing party.

Nothing in this Agreement shall limit or abrogate any right or rights of either Party to enter into other separate agreements for the planning, designing and constructing of sewerage facilities, one with the other or with other parties.

ARTICLE IV. LIMITATION OF TERRITORY

This Agreement applies only to that portion of Anne Arundel County which is served or will be served by the Baltimore County Patapsco Pumping Station.

ARTICLE V. CONNECTIONS TO SEWERAGE SYSTEM

A. The sanitary sewers of the Second Party shall be connected with the sanitary sewers of the First Party only at such points and to such sanitary sewers as may be designated by the First Party in writing.

B. The Second Party shall notify the First Party in writing at least five (5) days before making any connection to the sewerage system of the First Party so as to allow the inspection of construction of said connections at the site of said work.

C. At no time may the First or Second Party's use of a jointly used facility exceed their respective purchased design capacity, as between themselves, of said facility without the expressed written permission of the other Party.

D. The Second Party's Director shall transmit to the First Party's Director not later than November 1 of each year, projections of flows from the Second Party to the First Party by point of entry. Based upon said criteria, the respective Directors shall prepare a Six-Year Capital Improvement Program designed to accomodate the flows from one system into the other, including those facilities required to handle the estimated flows within each respective subdivision.

E. By January 15, following the receipt of criteria set forth in paragraph D above, the Directors shall agree as to the appropriate apportionment of costs of such jointly owned facilities, based on the design flow method.

F. Upon approval of the annual budget, the Directors shall notify their counterparts of those system facilities that have been included in the officially adopted Capital Improvement Program and shall also provide data by years on flows to be accomodated at each point of entry and capacities to be made available for the Second Party's flows, all predicated upon the completion of such improvements. Each such annual notification will be deemed to supercede all prior such notifications and shall be binding for the ensuing period.

G. The parties to this Agreement do hereby acknowledge the statutory responsibility of the State Department of Health and Mental Hygiene in reference to the adequacy of the sewerage systems and agree to submit any disputes concerning the physical aspects of the system to said Department for adjudication.

ARTICLE VI. STORM WATER, SURFACE WATER AND OTHER MATERIALS NOT TO BE DISCHARGED INTO SANITARY SEWERS

A. Storm water, surface water, subsurface water and other non-polluted wastes shall not be discharged into those sanitary sewers which drain into the jointly used sanitary sewers of the First Party. No street inlet, catch basin, storm drain, rain leader, cellar drain, garage drain or any other connection through which storm water, surface water, groundwater or any other water not classified as wastewaters can flow shall be connected to the aforesaid sanitary sewers which drain into the jointly used sewers of the First Party.

B. The Second Party agrees to use every effort to prevent the owners of properties in Anne Arundel County from discharging storm water into the sanitary sewers connecting with the sanitary sewers of the First Party, and if any such connections are detected, the Director of the Second Party shall promptly use all means within his power to see that such connections, including storm inlets and other points of entry, are abandoned and sealed.

C. No person, firm, corporation, manufacturing plant, or other establishment shall be permitted to discharge into any sanitary sewer of the Second Party which drains into a sanitary sewer of the First Party, any flammable liquids, acids, chemicals and/or materials or solids not normally present in domestic sewage, which in the judgment of the Directors of both or either Party may be detrimental to the sewerage system or any part thereof of the First Party, or the operation of the said sewerage.

The Second Party agrees that its Industrial Waste Ordinances shall conform to at least the minimum provisions of the First Party's Industrial Waste Ordinances, when adopted, as such provisions apply to wastewaters flowing from the Second Party's system into the First Party's system. The provisions of this paragraph shall be superceded at such time as of the effective date of adoption of the First Party's Industrial Waste Ordinance.

D. The discharge of radioactive wastes into any of the sanitary sewers of the Second Party shall be limited as to quantity and character in accordance with the latest rules and regulations of the State Department of Health and Mental Hygiene, Deputy State or County Health Officer of Anne Arundel County, and of the Deputy State or County Health Officer of Baltimore County, Maryland, whichever of these rules and regulations are most stringent.

ARTICLE VII. CONSTRUCTION OF SANITARY SEWERS

All sanitary sewers, house sewers, interceptors, manholes, bellmouths and connections between the sanitary sewers of both Parties shall be designed and constructed in accordance with the applicable codes, rules and regulations of the party within whose boundaries the construction is located.

ARTICLE VIII. INSPECTION OF PREMISES

The premises of the properties in the territory defined in Article VI, which drain into sewers of the First Party, may be entered with notice and inspected by the Director of the First Party. Private premises are excluded from the aforegoing stipulations and may be entered only after proper authorization has been secured.

ARTICLE IX. REPAIRS AND REHABILITATIONS

A. Whenever it becomes necessary for the First Party to make major repairs and/or rehabilitations to any part of any jointly used facility which receives, transmits, pumps, treats and/or disposes of sewage, the Second Party shall contribute its proportionate share of all costs resulting from the planning, designing and execution of the said repair and/or rehabilitation, including all materials, labor, engineering and any and all other costs involved therein. The cost of items referred to in this Article shall be apportioned according to the Volumetric Method, using the quantities of sewage contributed by both parties to this Agreement for the fiscal year preceding that in which the costs were incurred.

B. Payment by the Second Party to the First Party for repairs covered by this Article shall be made as the work progresses. Such payment, billed each month for the proportionate share of payment for the work completed, shall be due within 30 days of the rendering of such bill.

C. Upon agreement between both parties to this Agreement, expenditures for repairs and/or rehabilitation to jointly used facilities may be considered capital expenditures, if paid from bond money, the repayment for which by the Second Party to the First Party shall be included in the annual debt service charge as calculated by the Volumetric Method.

ARTICLE X. FINANCING OF ADDITIONAL FACILITIES

A. The capital expenditures for jointly used sewerage facilities constructed and/or improved after June 30, 1969, except as hereinafter provided, shall be apportioned to each party to this Agreement by the Design Flow Method.

Payment by the Second Party to the First Party for the Second Party's share of improvements to City-owned jointly used facilities for which the First Party will have paid the City the Second Party's share, will be based on the Design Flow Method. In this case, the share of the Second Party's cost responsibility shall be developed by dividing the projected volume of sewage to be contributed by the Second Party by the projected sum total volume of sewage flowing to the jointly used facility, exclusive of Baltimore City's projected flow. To calculate the Second Party's financial responsibility, multiply their share as calculated above by the First Party's payment to the City.

B. Before the First Party commences construction or installation of any additional sewerage facilities or improvements to existing sewerage facilities that may be jointly used by the parties to this Agreement, the Second Party shall certify that funds for their share of participation are available. In the event that funds are not available, the Second Party agrees to attempt to obtain funds as quickly as possible or to make other mutually agreeable arrangements for payments.

C. Payment to the First Party by the Second Party shall be made as the work progresses. Such payment, billed each month for the proportionate share of payment for work completed, shall be due within 30 days of the rendering of such bill.

D. Upon agreement between both parties to this Agreement, any capital expenditures for a jointly used facility may be entirely funded with the bond money of the First Party and repayment by the Second Party to the First Party shall be included in the annual debt service charge as calculated in Article XII, para. B.b. of this Agreement.

E. Whenever both Parties agree to increase either Party's purchased design capacity, as between themselves, of a jointly used facility, as stipulated in Article V, the financial responsibility shall be adjusted accordingly. The Party liable for the adjustment shall remit the owing amount to the other Party in a lump-sum cash payment no later than sixty (60) days after notice of said adjustment.

ARTICLE XI. DETERMINATION OF SEWAGE FLOW

A. In order to measure and record automatically the volume of sewage flowing from the sewerage system of the Second Party into the sewerage system of the First Party, recording registering flow meters satisfactory to both parties shall be constructed, installed and ready for regular continuous service at or near points of entry of sewage from the Second Party to the sewerage system of the First Party. The cost of said meters, their installation, and their operation and maintenance shall be borne entirely by the Second Party.

B. At any point of entry by reason of a new meter installation or by reason of meter failure, where the sewage flow is accurately metered for a minimum of 120 days in any twelve-month period, then the daily flows for the entire year shall be considered to be the average daily flow for that period of the year that has been metered.

C. By August 15 of each year, the Second Party shall forward to the First Party an annual summary of meter readings and flows at each point of entry for the preceding fiscal year. These flows will be used to calculate the annual sewer statement.

ARTICLE XII. DETERMINATION OF SEWERAGE SERVICE CHARGES

The calculations for charging the Second Party for sewerage services rendered by the First Party shall be composed of a sewerage service charge for the Second Party's share of operation and maintenance expenses of jointly used facilities and an annual charge for debt service for the Second Party's share of the debt service of the First Party as applied to the jointly used facilities.

The Second Party shall pay to the First Party annually a Sewerage Service Charge representing the Second Party's share of direct costs incurred by the First Party for transporting, pumping, treating and/or disposing of sewage during the preceding fiscal year. The aforementioned direct costs shall include all the operating and maintenance costs for jointly used facilities reduced by the amount of direct costs recovered as surcharges under the Industrial Waste Ordinance. They shall include all payroll expenses (i.e., payroll, pensions, FICA payments, Workmen's Compensation payments, leave with pay and fringe benefits), rentals, contractual services, supplies, materials, equipment expenses (i.e., maintenance and other minor repairs), utilities and other expenses, as well as other indirect Bureau expenses properly chargeable.

The Second Party shall also pay to the First Party any surcharge collected from industry for reason of excessive BOD, suspended solids, or other constituents above that limit considered by the First Party as that permitted without payment of a surcharge. Such surcharge shall be in accordance with the charges specified in Industrial Waste Ordinances.

If at any time a jointly used facility is no longer used by the Second Party, the Second Party will no longer be charged for the use of the facility.

All sewerage service charges shall be based on the Volumetric Method.

A. Computation of Operation and Maintenance Costs

a. Determine the First Party's costs for:

1. Operation and maintenance of Patapsco Pump Station.

2. Operation and maintenance of jointly used sewers.

3. Six percent (6%) of the sum of (1) and (2) above, which represents other indirect Bureau charges relating to sewerage services.

4. Divide the total annual sewage flow contributed by the Second Party to the Patapsco Pump Station (as stipulated in Article XI) by the total amount metered flow through the Patapsco Pump Station to obtain a factor expressed as a percentage appropriately adjusted for outages and overflows. Multiply the sum of 1,2, and 3 above by the percentage factor so derived, to obtain the Second Party's proportionate share in the operation and maintenance of Patapsco Pump Station and jointly used sewers.

b. Divide the total annual sewage flow contributed by the Second Party (as stipulated in Article XI) by the total annual sewage flow contributed by the First Party to the City's Patapsco Wastewater Treatment Plant to obtain a factor expressed as a percentage appropriately adjusted for outages and overflows. Multiply the amount that the First Party paid the City for treatment and disposal of sewage at the City's Patapsco Wastewater Treatment Plant by the percentage factor so derived, to obtain the Second Party's proportionate share in the treatment and disposal of sewage at the City Plant.

c. The sum of the costs derived in a. and b. above represents the Second Party's proportionate share in the First Party's operation and maintenance costs.

B. Computation of Debt Service

a. The Second Party's share of debt service resulting from bonds issued by the the First Party for improvements to jointly used facilities completed before June 30, 1969, except as hereinafter provided, shall be based on the Volumetric Method and shall be calculated as follows:

1. Construction and Improvements to Patapsco Pump Station and Force Main

Divide the total annual sewage flow contributed by the Second Party to the Patapsco Pump Station (as stipulated in Article XI) by the total annual metered flow through the Patapsco Pump Station to obtain a factor expressed as a percentage appropriately adjusted for outages and overflows. Multiply the First Party's annual debt service for the construction and improvements to the Patapsco Pump Station and Force Main by the percentage factor so derived, to obtain the Second Party's proportionate share in the debt service for the Pump Station and Force Main. Both Parties agree that the First Party's annual debt service for the construction of Patapsco Pump Station and Force Main is $39,746.00 ending June 30, 1999 or when the facilities are abandoned, whichever occurs first, and for the installation of the additional pump at the Patapsco Pump Station is $19,588.00 ending June 30, 1976.

2. Two Additional Primary Settling Tanks at the City's Patapsco Wastewater Treatment Plant

Divide the total annual sewage flow contributed by the Second Party to the Patapsco Pump Station (as stipulated in Article XI) by the total annual sewage flow contributed by the First Party to the City's Patapsco Wastewater Treatment Plant to obtain a factor expressed as a percentage appropriately adjusted for outages and overflows. Multiply the First Party's annual debt service for their cash contribution for primary Settling Tanks 5 and 6 at the City's Patapsco Wastewater Treatment Plant by the factor so derived, to obtain the Second Party's proportionate share for the additional tanks. Both Parties agree that the First Party's annual debt service for its cash contribution for the primary settling tanks is $1,890.00 ending June 30, 2002.

3. Patapsco Interceptor (from Stoney Run downstream to Patapsco Pump Station)

Divide the total annual metered sewage flow contributed by the Second Party to the Patapsco Interceptor at the Stoney Run entry point by the total annual metered flow through the Patapsco Pump Station to obtain a factor expressed as a percentage appropriate adjusted for outages and overflows. Multiply the First Party's annual debt service for the construction costs of the Patapsco Interceptor from Stoney Run downstream to the Patapsco Pump Station by the percentage factor so derived to obtain the Second Party's proportionate share in the debt service for that segment of the Patapsco Interceptor. Both Parties agree that the First Party's annual debt service for the construction of the above-mentioned segment of the Patapsco Interceptor is $36,660.00 ending June 30, 2012.

4. The sum of the costs derived in 1, 2 and 3 above represents the Second Party's proportionate share in the First Party's debt service for improvements to jointly used facilities.

b. If both Parties agree that repayment by the Second Party to the First Party for a capital expenditure for a jointly used facility made after June 30, 1969 shall be included in the annual debt service charge, as stipulated in Article X, para. D. of this Agreement, the Second Party shall pay debt service on its share of the capital expenditure as determined by the Design Flow Method.

C. The sum of the costs derived in A and B above shall constitute the Second Party's annual obligation for sewerage services provided by the First Party.

ARTICLE XIII. CHARGES TO BE RECALCULATED ANNUALLY

A. The Second Party shall, by August 15 of each year, submit in writing to the First Party the readings of all sewage flow meters at points of entry to the First Party's severage system as stipulated in Article XI. The report submitting the meter readings and flows shall specify such locations and points of entry into the sewerage system as herein provided.

B. On or before the 15th day of January of each year, the Director of the First Party shall submit to the Director of the Second Party a statement showing computations of the Second Party's share of costs for the preceding fiscal year. The statements and computations shall be jointly prepared by both Parties and shall show the net total of the various sums owed by the Second Party to the First Party arrived at by the methods outlined in Article XII. Said sums so due and owing to the Second Party to the First Party shall be payable within sixty (60) days after the date of submittal of the statements.

ARTICLE XIV. ACCESS TO RECORDS

Each party to this Agreement shall have ready access to all plans, office and field records, cost accounts, records and files of jointly used sanitary sewerage facilities and installation of the other party.

Either party shall have ready access to all design data, schedules, programs and costs estimates relating to altering or enlarging the jointly used sanitary sewerage system or any part thereof that serves or will serve both parties.

Each party shall have ready access to all information, records, calculations and data used to determine the total annual charge for sewerage service.

Each party shall have the right to audit the other Party's statements and accounts useful and/or necessary to the performance of this Agreement. Such audits shall be made at the auditing Party's expense.

ARTICLE XV. OPERATION AND MAINTENANCE OF FACILITIES

It is agreed by both parties that each party shall supervise the design, construction, operation and maintenance of the various facilities of their respective sewerage systems.

ARTICLE XVI. ARBITRATION

In the event of any disagreement between the parties to this Agreement over the terms of the Agreement, the parties shall submit, on the demand of either, the matter to arbitration in the following manner: The First Party shall appoint one arbitrator and the Second Party shall appoint one arbitrator. The two arbitrators so appointed shall select a third who shall be chairman of the board of arbitration. If the two arbitrators are unable to agree upon the third arbitrator, the Secretary of Health and Mental Hygiene of the State of Maryland shall be requested to designate such third arbitrator, and the written decision of the majority of the board of arbitration shall be final and binding upon both parties.

ARTICLE XVII. TERM OF AGREEMENT

The Parties hereto mutually agree to terminate the Agreement dated March 13, 1958 between Baltimore County and Anne Arundel County relating to sewerage services provided the Second Party by the First Party effective the date of this Agreement and further agree that any payments provided for in this Agreement shall be retroactive to July 1, 1972 and shall continue in force and effect until the parties hereto amend this Agreement or execute a new Agreement.

If it becomes necessary or desirable in the opinion of either party to amend this Agreement, such party shall so notify the other in writing at least 30 days before the end of any calendar year. Such party shall accompany its written notification with a draft of its desired amendment or new Agreement. If the parties are unable to agree, the present Agreement shall continue in force. In the case of disagreement, either party may initiate arbitration proceedings according to Article XVI, above.

Both parties agree that the termination of that Agreement shall not in any way affect the continued reception, transmission, pumping, treatment, and/or disposal of sewage.

IN WITNESS WHEREOF, the parties hereto have properly executed this Agreement as of the day, month and year first above written.

Reproduced from original:

ANNE ARUNDEL COUNTY, MARYLAND

Attest:

Mary H. Craig By: ____________________
County Executive

Approved as to Form and Legal Sufficiency:

____

Approved:

George F. Nemphos
Director of Public Works

BALTIMORE COUNTY, MARYLAND

Attest:

____________________ By: ____________________
County Executive

Approved as to Legal Form:

____
3/31/76

Approved:

____
Director of Public Works
3/31/76

Approved as to Legal Sufficiency:

____

APPROVED
BALTIMORE COUNTY EXECUTIVE BOARD
____________________ 4/7/76

Sept., 1981

V-6.09

AMENDMENT TO SEWER AGREEMENT
BETWEEN BALTIMORE AND ANNE ARUNDEL COUNTIES

For Capital Expenditure Allocation of the Patapsco Relief Interceptor, Pumping Station and Force Main

OCTOBER 20, 1981

THIS AGREEMENT, made this 20th day of October, 1981 by and between BALTIMORE COUNTY, MARYLAND, hereinafter referred to as the FIRST PARTY, and ANNE ARUNDEL COUNTY, MARYLAND, hereinafter referred to as the SECOND PARTY, each of said Parties a body corporate and politic of the State of Maryland.

WHEREAS, the First and Second Parties entered into an Agreement, dated April 21, 1976, to continue the operation of the jointly used severage system in the Patapsco Drainage Area between the Metropolitan District of Baltimore County and Anne Arundel County, and to establish methods for the computation and reimbursement of the costs incurred by the First Party in providing sewerage services to the Second Party; and

WHEREAS, the First Party intends to replace its Patapsco Sewage Pumping Station and Force Main with facilities of greater capacity and to construct a Relief Interceptor paralleling the existing original Patapsco Interceptor from the confluence of Deep Run and Patapsco River downstream to the new pumping station; and

WHEREAS, the First Party has designed said Facilities to accomodate certain existing and future flows from the territory of the Second Party; and

WHEREAS, the Second Party desires to connect to or otherwise use said Facilities; and

WHEREAS, Article X of the Sewer Agreement, dated April 21, 1976, stipulates that the capital expenditures of jointly used sewerage facilities of the type herein referred to shall be allocated by the Design Flow Method as defined in said Sewer Agreement; and

WHEREAS, the U.S. Environmental Protection Agency, as a condition to awarding Grant No. C-24070010 for financial aid for the Facilities pursuant to P.L. 92-500, requires an amendment to said Sewer Agreement to include certain provisions; and

WHEREAS, Article XVII of said Sewer Agreement provides that mutually agreeable amendments may be made to the Sewer Agreement;

NOW, THEREFORE, THIS AGREEMENT WITNESSETH:

THAT IN CONSIDERATION of the covenants, agreements and payments hereinafter set forth, it is mutually covenanted and agreed as follows:

A. The Sewer Agreement between Baltimore County and Anne Arundel County, dated April 21, 1976, is hereby amended.

B. DEFINITION

"Capital expenditure" is hereby defined as in the Sewer Agreement.

C. PATAPSCO RELIEF INTERCEPTOR

a. The peak design-flow allocation of the reinforced Patapsco Interceptor System for each jurisdiction by manhole (MH) designations as described by the attached schematic* is as follows:

*See Page V-6.23

Copied from the original document for publication in the Water & Sewerage Plan

Section	Baltimore County (mgd)	Howard County (mgd)	Anne Arundel County (mgd)	BWI Airport (mgd)
MH 34838 to MH 49188	13.80	16.10	- mgd	- mgd
MH 49188 to MH 49187	13.80	27.60	3.22	- mgd
MH 49187 to MH 49185	13.80	27.60	3.22	2.30
MH 49185 to MH 49180	13.80	27.60	6.78	2.30
MH 49180 to MH 49171	24.98	27.60	6.78	2.30
MH 49171 to MH 49170	26.85	27.60	6.78	2.30
MH 49170 to MH 49165	29.11	27.60	7.93	2.30
MH 49165 to Pump Station	29.56	27.60	7.93	2.30

b. Both Parties agree that for the purposes of this Agreement, the Second Party shall be deemed to be invested with an equity of peak flow in the original Patapsco Interceptor as shown in Column (2) in the table in this paragraph. In accord with paragraph a. above, the Second Party's percentage share of capital expenditures by manhole sections is calculated as follows:

Section (1)	Equity in Old Pipe (mgd-peak) (2)	Ultimate Requirement (mgd-peak) (3)	Capacity Increase (mgd-peak) (4)	Relief Capacity (mgd-peak) (5)	ANNE ARUNDEL County's Share (4)÷(5) = % (6)
MH 34638 to MH 49188	---	---	---	17.48	---
MH 49188 to MH 49187	.73	3.22	3.147	17.48	18.00%
MH 49187 to MH 49185	.73	3.22	3.147	17.48	18.00%
MH 49185 to MH 49180	.743	6.78	6.037	17.48	34.54%
MH 49180 to MH 49171	.743	6.78	6.037	46.71	12.92%
MH 49171 to MH 49170	.743	6.78	6.037	48.00	12.58%
MH 49170 to MH 49165	.743	7.93	7.187	50.26	14.30%
MH 49165 to Pump Station	.743	7.93	7.187	50.71	14.17%

c. The percentage in paragraph b. above shall be applied to capital expenditures as defined in the Sewer Agreement. For monthly progress billing purposes, an overall weighted-average percentage shall be calculated for the Second Party by applying the percentages in paragraph b. to the bid price of each Section. At the completion of construction, actual shares shall be calculated, using the percentages in paragraph b. and actual costs for each Section. For common costs which cannot be assigned to particular Sections (such as administrative and engineering costs, etc.), an actual overall weighted-average percentage shall be determined from those costs which can be assigned. Any differences between billed shares and actual shares shall be settled at completion of construction.

d. The Second Party agrees to limit its peak flows in the reinforced Patapsco Interceptor System at one time to its allocations as described in paragraph a. above during the service-life of the System.

e. Section B.a.3 of Article XII of the Sewer Agreement shall no longer have effect after calculation of F.Y. 1978 annual charges. The Second Party shall thenceforth have no liability for the First Party's debt service for construction of the original Patapsco Interceptor from its confluence with Stony Run downstream to the Pumping Station.

?. PATAPSCO PUMPING STATION AND FORCE MAIN

a. The initial pumping capacity for the replacement of Pumping Station and Force Main is designed for 45 mgd. (peak) with jurisdictional allocations as follows:

Baltimore County	20.7 mgd.
Anne Arundel County	6.5 mgd.
Howard County	17.8 mgd.

b. In accord with paragraph a. above, the Second Party's relative share of capital expenditures for the replacement Patapsco Pumping Station and Force Main shall be based upon the Design Flow Method and shall be 14.4%.

c. The Second Party agrees to limit its peak flow in the Patapsco Pumping Station and Force Main at any one time to its allocation described in paragraph a. above until the capacity of the Pumping Station is increased.

E. The Second Party recognizes the benefits it will receive from the construction of the Patapsco Pumping Station, Force Main and Relief Interceptor to be financed partially under U.S. Environmental Protection Agency's Grant No. C-240470010 to the First Party. Pursuant to the requirements of Public Law 92-500, as the same may be amended, the Second Party recognizes and accepts its obligation to impose appropriate sewer use charges and surcharges with constituent threshold limits as set forth in the Baltimore County Code at Article 34, Division 5, as may be amended from time to time, and to enforce provisions with regard to industrial wastes as set forth in the same Article 34, Division 5, and to implement whatever industrial costs recovery system may be required in the premises by the U.S. Environmental Protection Agency.

IN WITNESS WHEREOF, the parties hereto have properly executed this Agreement as of the day, month and year first above written.

BALTIMORE COUNTY, MARYLAND

Attest:

By: ________________ (Seal)
8-14-81

Approved as to Legal Form:

Assistant County Solicitor

Approved: 8/11/81

Director of Public Works

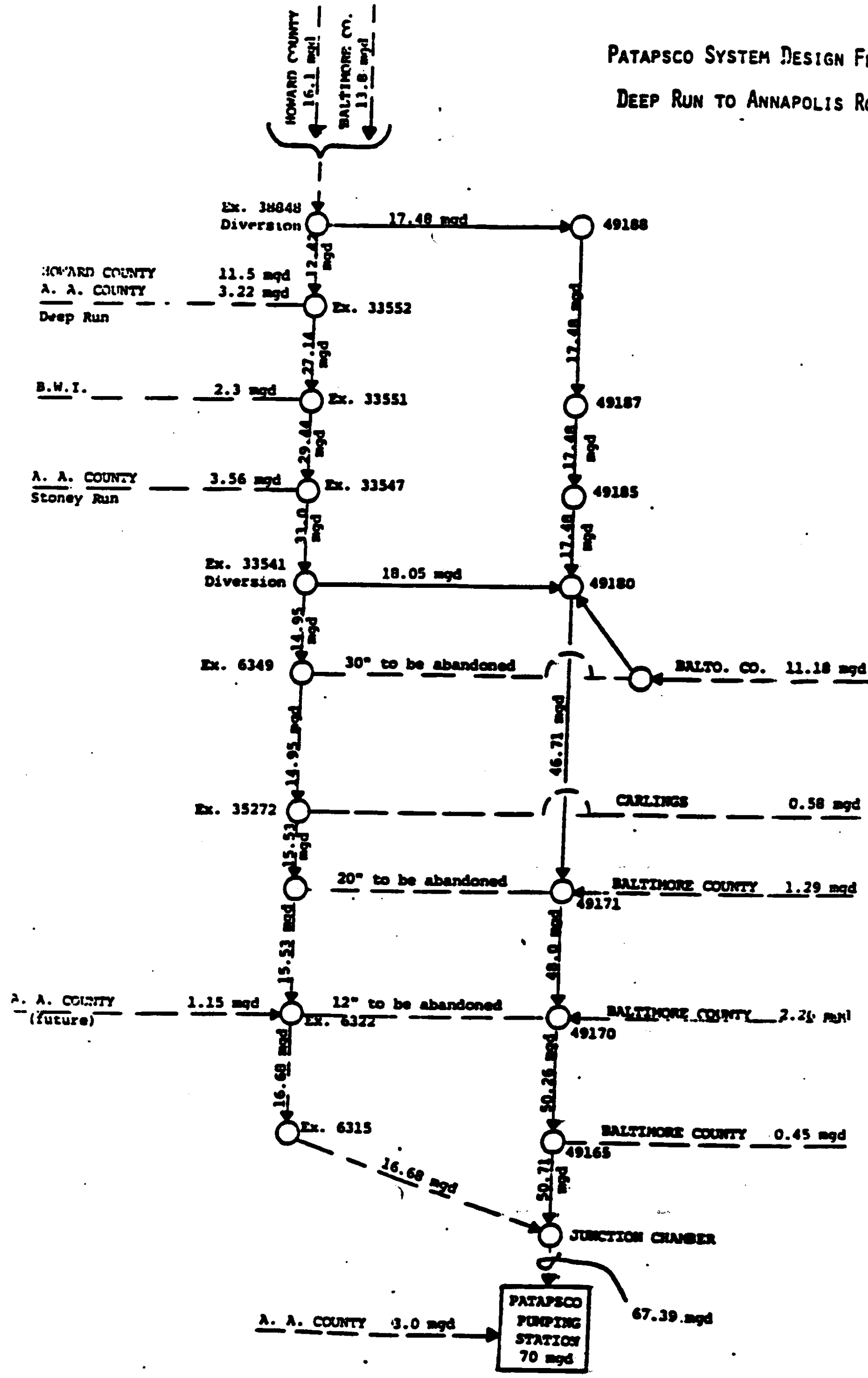
Approved as to Legal Sufficiency:

ANNE ARUNDEL COUNTY, MARYLAND

Signed by:
Director of Administration
Director of Public Works
County Solicitor

Rev.12 Oct., 1981

PATAPSCO SYSTEM DESIGN FLOWS
DEEP RUN TO ANNAPOLIS ROAD



Oct., 1981

V-6.13

APPENDIX F

Sewer Agreement with Howard County

SEWERAGE AGREEMENT
BETWEEN BALTIMORE COUNTY AND HOWARD COUNTY

MAY 6, 1963

THIS AGREEMENT, made this 6th day of May, 1963, by and between Baltimore County, Maryland, a municipal corporation, hereinafter called "Baltimore County", and the Howard COUNTY METROPOLITAN COMMISSION, hereinafter called "Howard County".

WHEREAS, Howard County proposes to construct a sewerage system in that part of the Patapsco River Drainage Area lying within Howard County and also to construct a sewerage system in that portion of the Little Patuxent Drainage Area upstream from Oakland Mills as shown on a map prepared by Whitman, Requardt and Associates dated September 28, 1959 and also referred to in a letter dated October 15, 1959 from Bernard L. Werner, Director of Public Works of Baltimore City, to the Chairman of the Howard County Metropolitan Commission; and

WHEREAS, said Baltimore County and Howard County are desirous of entering into an agreement to construct the Patapsco River Interceptor beginning at the confluence of Herbert Run and Patapsco River and running upstream to the confluence of Sucker Branch and said Patapsco River for the purpose of conveying sewage originating in said counties through the said interceptor and thence downstream from said Herbert Run to the facilities of Baltimore City for the eventual disposal thereof;

WHEREAS, the said parties have agreed hereto that the capital cost and other charges and expenses in connection therewith shall be apportioned among them as follows:

NOW, THEREFORE, THIS AGREEMENT WITNESSETH, that in consideration of the premises and mutual benefits accruing to each of the parties hereto, they agree and covenenant one with the other as follows:

BALTIMORE COUNTY AGREES:

ITEM 1. To award a contract for the construction of a 54-inch interceptor adjacent to the Patapsco River from the vicinity of the terminus of the existing Patapsco River Interceptor at Herbert Run upstream to a point sufficiently far to permit Howard County to connect its Deep Run Interceptor, which distance is approximately 4,600 feet, and to furnish Howard County with an itemized statement of the cost thereof, which said total cost will be paid one-half by said Howard County and one-half by said Baltimore County. The money is to be paid by said Howard County upon the completion thereof.

ITEM 2. That the said Baltimore County will undertake the construction, as soon as practicable, of the interceptor from its terminus as set forth in the preceding paragraph upstream to the confluence of Oak Forest Branch and the said Patapsco River, said interceptor to be 42 & 48 inch in diameter, and Howard County agrees to pay to said Baltimore County upon the completion thereof that portion of the cost as determined by the ratio of Howard County's 10 mgd capacity to the total capacity of the constructed interceptor.

[Copied from the original for inclusion in this Plan.]

HOWARD COUNTY AGREES:

ITEM 3. To award a contract for the construction of an interceptor 42 inch in diameter to convey sewage originating in Baltimore County and Howard County from the confluence of Sucker Branch and Patapsco River to a point in Baltimore County approximately 3,500 feet downstream from Ellicott City and to furnish Baltimore County with an itemized statement of the cost thereof which shall be apportioned between said Counties as follows: Howard County's share would be based on the same ratio as set forth in Item 2 above, that is, the ratio 10 mgd bears to the total capacity of the interceptor, and Baltimore County's share shall be the remainder. The money is to be paid by said Baltimore County upon the completion thereof.

ITEM 4. To award a contract for the construction of a temporary sewage treatment plant to be located at the terminus downstream of the interceptor described in the preceding paragraph, and to furnish Baltimore County with an itemized statement of the cost thereof, which said cost should be apportioned at the same ratio as set forth in the preceding paragraph and shall be reimbursed to Howard County upon completion thereof.

ITEM 5. To undertake, at a time mutually agreed upon, the construction of a 42 inch interceptor beginning at the confluence of Oak Forest Branch and the Patapsco River to the said treatment plant referred to in the preceding paragraph, the cost thereof to be apportioned on the same basis as set forth in Item 3 hereof, which said moneys are to be reimbursed to Howard County by said Baltimore County upon completion thereof.

ITEM 6. Howard County agrees to pay Baltimore County the cost of operation and and maintenance of the said Patapsco River Interceptor and pumping facilities in said Baltimore County and to reimburse Baltimore County for the operation and maintenance costs of Baltimore City's system, said reimbursement to be at the same rate that Baltimore County pays to Baltimore City. The amount of Howard County's share of said cost will be determined by the volume of sewage flowing through the various metering devices located in Howard County at the points of discharge of Howard County interceptors into the said Patapsco Interceptor.

ITEM 7. To reimburse Baltimore County for the operation and maintenance of said temporary sewage treatment plant located as above. Reimbursement to Baltimore County will be based upon the ratio of the actual sewage flows as measured by the metering device located in Howard County at the points of discharge of Howard County's Sucker Branch interceptor and Tiber Branch interceptor into the said Patapsco interceptor to the total flow in the said Patapsco interceptor into the temporary sewage treatment plant.

ITEM 8. It is mutually understood and agreed by the parties hereto that Howard County's capacity in the permanent facilities above mentioned upstream from the connection of the Deep Run Interceptor with the said Patapsco River Interceptor is an average daily flow of 5.0 mgd and a peak flow of 10.0 mgd. It is also mutually understood and agreed by the parties hereto that Howard County's flow downstream from the said Deep Run interceptor will be an estimated 10.0 mgd average daily flow and 20.0 peak flow and that the interceptors, pumping stations and treatment facilities at both Baltimore County and Baltimore City will provide these capacities for Howard County.

ITEM 9. At such time as Howard County transmits a volume of sewage through the Patapsco Pumping Station and Force Main system owned and operated by Baltimore County, Howard County will be responsible for debt service charges on the jointly used system. The appropriate debt service charge shall apply to the unamortized cost of the facilities and shall be computed by the ratio which the annual sewage flow from Howard County bears to the total annual sewage flow through the jointly used facility.

ITEM 10. Whenever it shall be necessary to enlarge existing facilities, construct or install any addition to the sewerage system under the supervision of Baltimore County or Baltimore City, which receive, transmit, pump, treat and/or dispose of sewage from Howard County, debt service will be payable to Baltimore County in the same ratio that the designed ultimate capacity allotted to Howard County bears to the total designed ultimate capacity allotted to serve all the parties through the jointly used facility.

IN WITNESS WHEREOF, the parties hereto have properly executed this Agreement, as of the day, month and year first above written.

ATTEST:

s/William A. Badger

s/Albert B. Kaltenbach
ALBERT B. KALTENBACH
Director, Department of Public Works

ATTEST:

BALTIMORE COUNTY, MARYLAND

s/ Ormsby S. Moore

By: s/Spiro T. Agnew
SPIRO T. AGNEW
County Executive

Approved as to Form and Legal Sufficiency
this 3rd day of May, 1963:

s/ Harry S. Shapiro
Asst. County Solicitor

ATTEST:

HOWARD COUNTY METROPOLITAN COMMISSION

s/Evelyn C. Meyer

By: s/Roger N. Laynor
Chairman

Approved as to Form and Legal Sufficiency
this 14th day of February, 1963:

s/LeRoy C. Moser
Member

s/
Counsel for the Commission

s/J.C. Jenkins
Member

s/David W. Force
County Commissioner Member

MODIFICATION OF JUNE 6, 1963 AGREEMENT

FEBRUARY 28, 1964

THIS MODIFICATION OF AGREEMENT is made this 28th day of February, 1964 by and between BALTIMORE COUNTY, MARYLAND, a municipal corporation, hereinafter called "Baltimore County", and the HOWARD COUNTY METROPOLITAN COMMISSION, hereinafter called "Howard County", to facilitate the early construction of the Patapsco River Interceptor as outlined in Item 1 of the Agreement dated 6th day of May, 1963 by and between Baltimore County and Howard County.

MODIFICATION OF ITEM 1: To allow Howard County, subject to Baltimore County approval, to award the contact for the construction of the 54-inch interceptor adjacent to the Patapsco River from the vicinity of the terminus of the existing Patapsco River Interceptor at Herbert Run upstream to a point sufficiently far to permit Howard County to connect its Deep Run Interceptor, which distance is approximately 4,600 feet. The total cost of the interceptor will be paid one-half by said Howard County and one-half by said Baltimore County. Baltimore County will pay said Howard County during the period of construction of the interceptor said Baltimore County's share of the cost upon receipt of monthly requisitions from said Howard County.

ATTEST:

s/Edgar J. DeMoss

s/ Ormsby S. Moore

s/Albert B. Kaltenbach
ALBERT B. KALTENBACH
Director, Department of Public Works

By: s/Spiro T. Agnew
SPIRO T. AGNEW
County Executive
Baltimore County, Maryland

Approved as to Form and Legal Sufficiency
this 27th day of February, 1964:

s/ Harry S. Shapiro
Asst. County Solicitor

APPROVED
BALTIMORE COUNTY EXECUTIVE BOARD

FEB 18 1964 s/

ATTEST:
s/Evelyn C. Meyer

HOWARD COUNTY METROPOLITAN COMMISSION
By: s/Roger N. Laynor
Chairman

Approved as to Form and Legal Sufficiency
this 22nd day of February , 1964

s/ ____________________
Member

s/ ____________________

s/Robert E. Wieder
Counsel for the Commission

APPROVED
BALTIMORE COUNTY EXECUTIVE BOARD
FEB 18 1964 ____________________

. 8/1/85

V-7.04

S E W E R A G E   A G R E E M E N T
B E T W E E N   B A L T I M O R E   C O U N T Y   A N D   H O W A R D   C O U N T Y

A U G U S T   2, 1 9 6 8

THIS AGREEMENT, made this second day of August, 1968, by and between Baltimore County, Maryland, a municipal corporation, hereinafter called "Baltimore County", and the Howard COUNTY METROPOLITAN COMMISSION, a body corporate and politic, hereinafter called "Howard County", revises the Agreement made May 6, 1963, and subsequent modification thereto dated February 28, 1964, with the exception of work that was completed prior to the date of this Agreement.

WHEREAS, Howard County proposes to construct a sewerage system in that part of the Patapsco River Drainage Area lying within Howard County and also to construct a sewerage system in that portion of the Little Patuxent Drainage Area upstream from Oakland Hills as shown on a map prepared by Whitman, Requardt and Associates dated September 28, 1959 and also referred to in a letter dated October 15, 1959 from Bernard L. Werner, Director of Public Works of Baltimore City, to the Chairman of the Howard County Metropolitan Commission; and

WHEREAS, said Baltimore County and Howard County are desirous of entering into an agreement to construct the Patapsco River Interceptor beginning at the confluence of Herbert Run and Patapsco River and running upstream to the confluence of Sucker Branch and said Patapsco River for the purpose of conveying sewage originating in said counties through the said interceptor and thence downstream from said Herbert Run to the facilities of Baltimore City for the eventual disposal thereof;

WHEREAS, Howard County is the applicant for all State and Fedral grants available
to both parties hereto for the said interceptor and said parties agree to share said State and Federal grants determined by the ratio of the design capacity for each county to the total design capacity for both counties. In each contract Baltimore County and Howard County will initially provide sufficient local funds to cover the cost of the entire project in proportion to their ultimate responsibilities. As grants are received by Howard County, Howard County will remit to Baltimore County the Baltimore County share of the grants.

NOW, THEREFORE, THIS AGREEMENT WITNESSETH, that in consideration of the premises and mutual benefits accruing to each of the parties hereto, they agree to and covenenant one with the other as follows:

ITEM 1. Howard County agrees to solicit bids for and award the contract for the construction of the interceptor from its present terminus approximately 200 feet north of Deep Creek upstream to the confluence of Oak Forest Branch and the said Patapsco River; said interceptor to be 48-inches and 54-inches in diameter. Administrative, legal and engineering services for the design and construction of this portion of the interceptor will be furnished to Howard County by Baltimore County. The cost to be pro-rated in accordance with the designed capacities as set forth below:

[Copied from the original for inclusion in this Plan.-

a) Oak Forest Branch to Dairy Branch (Santee Branch) the design capacity for Howard County is 12.0 mgd and for Baltimore County 27.6 mgd.

b) Dairy Branch (Santee Branch) to Bull Branch, the design capacity for Howard County is 12.0 mgd and 29.4 mgd for Baltimore County.

c) Bull Branch to Stillhouse Run, the design capacity for Howard County is 13.0 mgd and for Baltimore County 30.8 mgd.

d) Stillhouse Run to a point approximately 200' north of Deep Creek the design capacity for Howard County is 13.0 mgd and for Baltimore County 31.5 mgd.

ITEM 2. Howard County agrees to undertake at a time mutually agreed upon the construction of a 42-inch interceptor beginning at the confluence of Oak Forest Branch and Patapsco River and extending to the temporary treatment plant located approximately 3,000 feet south of the Tiber Branch. The total cost shall be apportioned in accordance with the design capacities noted below:

a) From the treatment plant to Thistle Branch, the design capacity for Howard County is 12.0 mgd and for Baltimore County 25.9 mgd.

b) Thistle Branch to Oak Forest Branch, the design capacity for Howard County is 12.0 mgd and for Baltimore County 26.0 mgd.

ITEM 3. Howard County agrees to pay Baltimore County upon invoicing the cost of operation and maintenance of the said Patapsco River Interceptor and pumping facilities in said Baltimore County and to reimburse Baltimore County for the operation and maintenance costs of Baltimore City's system, said reimbursement to be at the same rate as that in effect at the time Baltimore City bills Baltimore County. The amount of Howard County's share of above said costs will be determined by the volume of sewage flowing through the various metering devices located in Howard County at the points of discharge of Howard County Interceptors into the said Patapsco Interceptor.

ITEM 4. It is mutually understood and agreed by the parties hereto that Howard County's previously set forth capacities in the permanent facilities above mentioned upstream from the connection with the Deep Run Interceptor with the said Patapsco River Interceptor shall be provided for in the interceptors, pumping stations and treatment facilities of both Baltimore County and Baltimore City.

ITEM 5. At such time as Howard County transmits a volume of sewage through the existing Patapsco Pumping Station and Force Main system owned and operated by Baltimore County, Howard County will be responsible for debt service charges on the jointly used system. The appropriate debt service charge shall apply to the unamortized cost of the facilities and shall be computed by the ratio which the annual sewage flow from Howard County bears to the total annual sewage flow through the jointly used facility.

ITEM 6. Whenever it shall be necessary to enlarge existing facilities, construct or install any addition to the sewerage system under the supervision of Baltimore County or Baltimore City, which receive, transmit, pump, treat and/or dispose of sewage from Howard County, debt service will be payable to Baltimore County in the same ratio that the designed ultimate capacity allotted to Howard County bears to the total designed ultimate capacity allotted to srve all the parties through the jointly used facility.

IN WITNESS WHEREOF, the parties hereto hāve property executed this Agreement as of the day, month and year first above written.

ATTEST:

s/Thornton M. Mouring

s/Albert B. Kaltenbach
ALBERT B. KALTENBACH
Director, Department of Public Works

ATTEST:

s/Edward J. Jones

BALTIMORE COUNTY, MARYLAND

s/William Fornoff 8-2-68
for DALE ANDERSON, County Executive

Approved as to Form and Legal Sufficiency
this 31st day of July, 1968

s/
County Solicitor

ATTEST:

s/
Acting Secretary-Treasurer

HOWARD COUNTY METROPOLITAN COMMISSION

s/J. Calvin Voris
J. CALVIN VORIS, Chairman

Approved as to Form and Legal Sufficiency
this 23rd day of July, 1968

s/Robert E. Wieder
Counsel for the Commission

s/
Member

s/

BOARD OF COUNTY COMMISSIONERS OF
HOWARD COUNTY

s/Harry T. Murphy
Chairman

s/
Member

s/
Member

SEWERAGE AGREEMENT

BALTIMORE COUNTY AND HOWARD COUNTY

JUNE 4, 1979

THIS AGREEMENT, made this 4th day of June, 1979, by and between BALTIMORE COUNTY, MARYLAND, hereinafter referred to as the FIRST PARTY, and HOWARD COUNTY, MARYLAND, hereinafter referred to as the SECOND PARTY, each of said Parties a body corporate and politic of the State of Maryland.

WHEREAS, the First and Second Parties entered into agreements dated May 6, 1963 and August 2, 1968 providing for discharge of sewage from certain sewerage systems of Second Party into certain sewerage systems of the First Party; and

WHEREAS, the First Party has entered into agreements with Baltimore City for the disposal of sewage; and

WHEREAS, there have been substantial increases in population, volume of sewage, operation and maintenance costs, and costs of construction of jointly-used facilities since the agreements were executed on May 6, 1963 and August 2, 1968, and the Parties thereto desire to update said Agreements; and

WHEREAS, it is the intent of the parties hereto that the sewerage system of the First Party shall continue to receive sewage from the Second Party and that a method for the computation and payment of costs incurred by the First Party for construction of jointly-used facilities and for collection, transmission and disposal of sewage from the Second Party be established:

NOW, THEREFORE, THIS AGREEMENT WITNESSETH:

THAT IN CONSIDERATION of the covenants, agreements and payments hereinafter set forth, it is mutually convenanted and agreed as follows:

ARTICLE I, DEFINITIONS

A. "Capital Expenditure" is hereby defined as the net costs involved in the construction and/or installation of any sewerage facility and shall include, but not be limited to, the sum of the following items; Land and/or easements, consultants' fees, material, labor, utility relocations, overhead which may include a proportionate allocation of in-house costs associated with design, field engineering, surveys, borings, materials testing, maps and record maintenance, inspection, right-of-way expenses, advertising, administrative, clerical, and stenographic services, office space use and building operation and maintenance; and all other contributing costs or expenses. Capital expenditures shall be exclusive of grants from the Federal Government, the State of Maryland, or any capital contributions by others than the parties to this Agreement. For the purposes of this Agreement, capital expenditure shall also mean any cash contribution by the First Party to Baltimore City for the construction and/or improvement of a City-owned jointly-used facility.

B. "City" is hereby defined as the City of Baltimore, Maryland.

C. "Debt Service" is hereby defined as the sum of interest and principle for a specific capital expendture.

D. "Design Flow Method" is a method of cost allocation determined from a tabulation of the projected volume of sewage to be contributed by each party to this Agreement that was used to design the proposed jointly-used facility. Ratios of cost responsibility of

Copied from the original document for publication in the Water & Sewerage Plan

additional facilities, including the addition of secondary and advanced waste treatment, are developed by dividing capacity allocated to each party having a beneficial interest by the projected total designed capacity allocated to all beneficially interested. Ratios of cost responsibility for the expansion of existing facilities are developed by dividing the increase in flow projected for each beneficially interested party to the design year by the total increase in flow projected to the design year for all beneficially interested parties.

E. "Director" shall mean the Director of Public Works of either the First or Second Parties, or their duly authorized representatives or agents.

F. "Facility" for the purpose of this Agreement shall mean any installation, including real and personal property, that is used or useful for the purpose of receiving, transmitting, pumping, treating and/or disposing of sewage or sludge.

G. "Jointly-used Facility" is hereby defined as any facility that receives, transmits, pumps, treats, and/or disposes of the sewage from both parties to this Agreement.

H. "Major Repair and/or Rehabilitation" is hereby defined as any restoration of a facility which does not increase the capacity of the facility and which is not considered a routine maintenance item.
*

J. "Sanitary Sewer" is a pipe or conduit, the specific purpose of which is to carry waste water as defined below.

K. "Purchase Design Capacity" of a jointly-used facility is hereby defined as that portion of the total design capacity of a jointly-used facility that the principal payments of either or both parties bear to the total capital expenditures for construction, improvements, and/or installation of said facility.

L. "Waste Water or Sewage" consists of the water-carried waste discharged from the dwellings, governmental and commercial business buildings, institutions and industrial establishments, together with industrial wastes, surface and sub-surface waters and storm waters which may be present.

M. "Storm Water" is excess water running off from the surface of a drainage area during and immediately following rainfall, snowfall, or other meteorological precipitation.

N. "Storm Drain" is a drain through which storm water, storm run-off, condensate, cooling water, street wash and other wash waters or drainage flow and from which waste water is excluded.

O. "Subsurface Water" is water that occurs in the lithosphere. It comprises suspended water and ground water.

P. "Surface Water" is water that rests on or flows over the surface of the lithosphere.

Q. "Volumetric Method" is a method determined by an annual calculation of the volume of sewage contributed by each party to this Agreement to each jointly-used facility. Ratios of cost responsibility are developed by dividing the volume of sewage contributed by each Party to this Agreement to the total volume of sewage that is received, transmitted, pumped, treated and/or disposed of by each jointly-used facility.

R. "Constructed and/or improved" is hereby defined as any construction or improvement, which increases the designed capacity of the facility.

**No paragraph I in original Agreement*

ARTICLE II. RIGHTS OF EITHER PARTY NOT TO BE ABROGATED

A. Nothing in this Agreement shall limit or abrogate any right or rights delegated to either Party by Acts of the General Assembly of the State of Maryland.

B. It is further understood and agreed that the police, legislative and governmental power of either Party are in no sense attempted to be abridged or restricted by this Agreement.

C. Each Party hereto agrees to recognize all rights and privileges acquired by acquisition of property and/or rights-of-way, each from the other and/or from other parties.

ARTICLE III. RIGHT OF REVIEW

The Second Party shall, upon request, have the right to review reports, plans, bids and financing for major repairs and/or rehabilitation and construction and/or improvement of any jointly-used facility owned or operated by the First Party.

Any costs associated with said review shall be borne exclusively by the reviewing party.

Nothing in this Agreement shall limit or abrogate any right or rights of either Party to enter into other separate agreements for the planning, designing and constructing of sewerage facilities, one with the other or with other parties, providing such separate agreements do not conflict with or serve to negate prior agreements made between the two parties to this agreement.

ARTICLE IV. LIMITATION OF TERRITORY

This Agreement applies only to that portion of Howard County which is served or will be served by the Baltimore County Patapsco Pumping Station.

ARTICLE V. CONNECTIONS TO SEWERAGE SYSTEM

A. The sanitary sewers of the Second Party shall be connected with the jointly-used facilities of the First Party only at such points and as may be agreed to in writing.

B. The Second Party shall notify the First Party in writing at least five (5) days before making any connection to the jointly-used facilities of the First Party so as to allow the inspection of construction of said connections at the site of said work.

C. At no time may the First or Second Party's use of a jointly-used facility exceed their respective purchased design capacity, as between the parties hereto, of said facility without the expressed written permission of the other Party.

D. The Second Party's Director shall transmit to the First Party's Director, not later than November 1 of each year, projections of flows from the Second Party to the First Party by point of entry. Based upon said projections, the respective Directors shall prepare a Six Year Capital Improvement Program designed to accommodate the projected flows in the jointly-used facilities. The Director of the First Party shall transmit to the Director of the Second Party, by November 1 of each year, a listing of expected major repairs and/or rehabilitations and respective Directors shall prepare a schedule of such work and include their respective cost sharing in the adopted Fiscal Budget.

E. Upon approval of the annual budget, the Directors shall notify their counterparts of those system facilities that have been included in the officially adopted Capital Improvement Program and shall also provide data by years on flows to be accommodated at each point of entry and capacities to be made available for the Second Party's flows, all predicated upon the completion of such improvements. Each such annual notification will be deemed to supercede all prior such notifications and shall be binding for the ensuing period.

F. At least bi-monthly the Second Party shall forward to the Director of the First Party, a listing of allowed individual connections which admit flows into the sewerage system of the First Party. The list shall include connection locations and anticipated average and peak flows along with any seasonal variations.

G. The parties to this Agreement do hereby acknowledge the statutory responsibility of the State Department of Health and Mental Hygiene in reference to the adequacy of the jointly-used facilities and agree to submit any disputes concerning the physical aspects of the facilities to said Department for ajudication.

ARTICLE VI. STORM WATER, SURFACE WATER AND OTHER MATERIALS NOT TO BE DISCHARGED INTO SANITARY SEWERS

A. Storm water, surface water, subsurface water and other nonpolluted wastes shall not be discharged into those sanitary sewers which drain into the jointly-used facilities of the First Party. No street inlet, catch basin, storm drain, rain leader, cellar drain, garage drain, or any other connection through which storm water, surface water, ground water or any other water not classified as waste waters can flow, shall be connected to the aforesaid sanitary sewers which drain into the jointly-used facilities of the First Party.

B. The Second Party agrees to use every effort to prevent the owners of properties in Howard County from discharging storm water into the sanitary sewers connecting with the sanitary sewers of the First Party, and if any such connections are detected, the Director of the Second Party shall require that such connections, including storm inlets and other points of entry, are otherwise diverted or abandoned and sealed.

C. No person, firm, corporation, manufacturing plant, or other establishment, shall be permitted to discharge into any sanitary sewer of the Second Party, which drains into a sanitary sewer of the First Party, any flammable liquids, acids, chemicals and/or materials or solids not normally present in domestic sewage, which, in the judgment of the Directors of the Parties hereto, jointly or severally, may be detrimental to the sewerage system, or any part thereof, of the First Party or the operation thereof. The Second Party agrees that its Industrial Waste Ordinances shall conform to at least the minimum provisions of the First Party's Industrial Waste Ordinances, as such provisions apply to waste waters flowing from the Second Party's system into the First Party's system.

D. The discharge of radioactive wastes into any of the sanitary sewers of the Second Party shall be limited as to quantity and character in accordance with the latest rules and regulations of the State Department of Health and Mental Hygiene, Deputy State or County Health Officer of Howard County, and the Deputy State or County Health Officer of Baltimore County, Maryland, whichever of these rules and regulations are most stringent.

ARTICLE VII. CONSTRUCTION OF SANITARY SEWERS

All sanitary sewers, house sewers, interceptors, manholes, bell-mouths and connections between the sanitary sewers of both Parties shall be designed and constructed in accordance with the applicable codes, rules and regulations of the party within whose boundaries the construction is located.

ARTICLE VIII. INSPECTION OF PREMISES

The premises of the properties in the territory defined in Article IV, which drain into sewers of the First Party, may be entered with previous written notice and inspected jointly by the Directors or their representatives. Private premises are excluded from the aforegoing stipulations and may be entered only after proper authorization has been secured.

ARTICLE IX. REPAIRS AND REHABILITATIONS

A. Whenever it becomes necessary for the First Party to make major repairs and/or rehabilitations to any part of any jointly-used facility which receives, transmits, pumps, treats and/or disposes of sewage, the Second Party shall contribute its proportionate share of all costs resulting from the planning, designing and construction of the said repair and/or rehabilitation, including all materials, labor, engineering and any and all other costs involved therein. The cost of items referred to in this Article shall be apportioned according to the Volumetric Method using the quantities of sewage contributed by both parties to this Agreement, for the fiscal year preceding that in which the costs were incurred.

B. Payment by the Second Party to the First Party for repairs and/or rehabilitations covered by this Article shall be made as the work progresses. Such payment, billed each month for the proportionate share of payment for the work completed, shall be due within 30 days of the rendering of such bill.

C. Upon agreement between both parties to this Agreement, expenditures for repairs and/or rehabilitation to jointly-used facilities may be considered capital expenditures, if paid from bond money, the repayment for which to be made by the Second Party to the First Party, shall be included in the annual debt service charge as calculated by the Volumetric Method.

ARTICLE X. FINANCING OF ADDITIONAL FACILITIES

A. The capital expenditures for jointly-used sewerage facilities constructed and/or improved after June 30, 1969, except as hereinafter provided, shall be apportioned to each party to this Agreement by the Design Flow Method.

Payment by the Second Party to the First Party for the Second Party's share of improvements to City-owned jointly-used facilities for which the First Party will have paid the City the Second Party's share, will be based on the Design Flow Method. In this case, the share of the Second Party's cost responsibility shall be developed by dividing the design capacity to be contributed by the Second Party by the sum of the design capacities to the jointly-used facility, exclusive of Baltimore City's projected flow. To calculate the Second party's financial responsibility multiply its share as calculated above by the First Party's payment to the City.

Payment by the Second Party to the First Party for the Second Party's share of improvements to jointly-used facilities owned by the First Party will be based on the Design Flow Method. In this case, the share of the Second Party's cost responsibility shall be developed by dividing the design capacity to be contributed by the Second Party by the sum of the design capacities to the jointly-used facility. To calculate the Second Party's financial responsibility, multiply its share as calculated above by the First Party's capital expenditures associated with the improvements.

B. Before the First Party commences construction or installation of any additional sewerage facilities or improvements to existing sewerage facilities that may be jointly-used by the parties to this Agreement, the Second Party shall certify that funds for its share of participation are available. In the event that funds are not available, the Second Party agrees to attempt to obtain funds as quickly as possible or to make other mutually agreeable arrangements for payments.

C. Payment to the First Party by the Second Party shall be made as the work progresses. Such payment, billed each month for the proportionate share of payment for work completed, shall be due within 30 days of the rendering of such bill.

D. Upon agreement between both parties of this Agreement, any capital expenditure for a jointly-used facility may be entirely funded with the bond money of the First Party; and repayment by the Second Party to the First Party shall be included in the annual debt service charge as calculated in Article XII, paragraph B.b. of this Agreement.

E. Whenever both Parties agree to increase either Party's purchased design capacity, as between the Parties hereto, of a jointly-used facility, as stipulated in Article V, the financial responsibility for the construction, improvements, and/or installation of said facility shall be adjusted accordingly. The Party liable for the adjustment shall remit the owing amount to the other Party in a lump-sum cash payment no later than sixty (60) days after notice of said adjustment.

ARTICLE XI. DETERMINATION OF SEWAGE FLOW

A. In order to measure and record automatically the volume of sewage flowing from the sewerage system of the Second Party into the sewerage system of the First Party, recording and registering flow meters, satisfactory to and approved by the Directors of both Parties, shall be constructed, installed, and ready for regular continuous service at or near points of entry of sewage from the Second Party to the sewerage system of the First Party within one year from the date of this Agreement. The cost of said meters, their installation, and their operation and maintenance shall be borne entirely by the Second Party.

B. In the event of failure of meters installed per paragraph A above, the Second Party agrees to proceed with repairs within 60 days or to order replacements within 60 days.

C. If the Second Party cannot demonstrate progress towards replacing or repairing meters is being made within 60 days, as outlined in paragraphs A and B above, the First Party may cause said installation and/or repairs, including design, purchase of equipment and materials, labor, and entrance by the First Party unto the premises of the Second Party. The Second Party shall be liable for all of the above referred to costs and expenses incurred by the First Party for the installation and/or repairs referred to in this paragraph.

D. At least once monthly, the Second Party shall forward to the First Party the actual meter readings and recordings for each identified meter at each point of entry. By August 15 of each year, the Second Party shall also forward to the First Party an annual summary of meter readings and flows at each point of entry for the preceding fiscal year and reconciliations for any differences between the annual figures and the cumulative monthly figure.

E. In the event of meter failure, replacement, and/or repairs, where the sewage flow has been accurately metered for a minimum of 200 days in any twelve-month period, then the daily flows for the entire year shall be considered to be the same as the average daily flow of that period of the year that has been metered. In the event meter failure, replacement, and/or repairs where the sewage flow has been accurately metered for less than 200 dyas, then the sewage flow will be determined by a method mutually agreed upon by the two parties.

F. Until flow meters are installed, as stipulated in Paragraph A above, the calculation of the total annual sewage flow from the sewerage system of the Second Party to the sewerage system of the First Party shall be based on 100% of the metered water consumption of the contributing areas of the Second Party or on any other method mutually considered to be a more accurate representation of actual sewage flows.

ARTICLE XII. DETERMINATION OF SEWERAGE SERVICE CHARGES

The calculations for charging the Second Party for sewerage services rendered by the First Party shall be composed of a sewerage service charge for the Second Party's share of operation and maintenance expenses of jointly-used facilities and an annual charge for debt service for the Second Party's share of the debt service of the First Party as applied to the jointly used facilities.

The Second Party shall pay to the First Party annually a Sewerage Service Charge representing the Second Party's share of direct costs incurred by the First Party for transporting, pumping, treating and/or disposing of sewage during the preceding fiscal year. The aforementioned direct costs shall include all the operating and maintenance costs for jointly-used facilities, reduced by the amount of direct costs recovered as surcharges under the Industrial Waste Ordinance. Direct costs shall include all payroll expenses (i.e. payroll, pensions, FICA payments, Workmen's Compensation payments, leave with pay and fringe benefits), rentals, contractual services, supplies, materials, equipment expenses (i.e. maintenance and minor repairs), utilities, and other expenses, as well as other indirect Bureau expenses properly chargeable.

The Second Party shall also pay to the First Party that amount of surcharge collected from industry for reason of excessive Biological Oxygen Demand, suspended solids, or other constituents above that limit established by law of the First Party or as may be amended from time to time, as that permitted without payment of a surcharge. Such surcharge shall be in accordance with the charges established by the First Party.

If at any time a jointly-used facility is no longer used by the Second Party, the Second Party will no longer be charged for the use of the facility from the time of non-use but will be responsible for the previous period of use.

All sewerage service charges shall be computed as follows:

A. Computation of annual Operation and Maintenance Costs.

a. Determine the First Party's costs for:

1. Operation and maintenance of Patapsco Pump Station.

2. Operation and maintenance of jointly-used sewers.

3. Six percent (6%) of the sum of (1) and (2) above, which represents other indirect Bureau charges relating to sewerage services.

4. Divide the total annual sewage flow contributed by the Second Party to the Patapsco Pump Station (as stipulated in Article XI) by the total annual metered flow through the Patapsco Pump Station to obtain a factor expressed as a percentage appropriately adjusted for outages and overflows. Multiply the sum of 1, 2, and 3 above by the percentage factor so derived, to obtain the Second Party's proportionate share in the operation and maintenance of Patapsco Pump Station and jointly-used sewers.

b. Divide the total annual sewage flow contributed by the Second Party (as stipulated in Article XI) by the total annual sewage flow contributed by Anne Arundel County, Baltimore County, and Howard County, to the City's Patapsco Waste Water Treatment Plant through the Patapsco Pump Station to obtain a factor expressed as a percentage appropriately adjusted for outages and overflows. Multiply the amount that the First Party paid the City for treatment and disposal of sewage at the City's Patapsco Waste Water Treatment Plant by the percentage factor so derived, to obtain the Second Party's proportionate share in the treatment and disposal of sewage at the City Plant.

c. The sum of the costs derived in a and b above represents the Second Party's proportionate share in the First Party's operation and maintenance costs.

B. Computation of Debt Service

a. The Second Party's annual share of debt service resulting from bonds issued by the First Party for improvements to jointly-used facilities completed before June 30, 1969, except as hereinafter provided, shall be based on the Volumetric Method and shall be calculated as follows:

1. Construction and Improvements to Patapsco Pump Station and Force Main.

Divide the total annual sewage flow contributed by the Second Party to the Patapsco Pumping Station (as stipulated in Article XI) by the total annual metered flow through the Patapsco Pumping Station to obtain a factor expressed as a percentage appropriately adjusted for outages and overflows. To obtain the Second Party's proportionate share in the First Party's annual debt service for the pumping station and force main, multiply the factor so obtained above by the product of the quotient of $795,000.00 (the cost of said facilities) and $5,000,000.00 (proceeds of the Baltimore County Metropolitan District 17th Serial Bond Issue) and the First Party's annual debt service for the unamortized amount of the Baltimore County Metropolitan District 17th Serial Bond Issue. These payments by the Second Party shall continue until the facilities are abandoned or until the 17th Serial Bond Issue is fully amortized. To calculate the Second Party's share in the First Party's imputed annual debt service for the installation of an additional pump at the Patapsco Pumping Station, divide the total annual sewage flow contributed by the Second Party to the Patapsco Pumping Station (as stipulated in Article XI) by the total annual metered flow through the Patapsco Pumping Station to obtain a factor expressed as a percentage appropriately adjusted for outages and overflows; then multiply factor so obtained by $19,588.00. Such annual share of debt service shall be calculated for four (4) years.

2. Two Additional Primary Settling Tanks at the City's Patapsco Waste Water Treatment Plant.

Divide the total annual sewage flow contributed by the Second Party to the Patapsco Pump Station (as stipulated in Article XI) by the total annual sewage flow contributed by the First Party to the City's Patapsco Waste Water Treatment Plant to obtain a factor expressed as a percentage appropriately adjusted for outages and overflows. Multiply the First Party's annual debt service for their cash contribution for Primary Settling Tanks 5 and 6 at the City's Patapsco Waste Water Treatment Plant by the factor so derived, to obtain the Second Party's proportionate share for the additional tanks. Both Parties agree that the First Party's annual debt service for its cash contribution for the Primary Settling Tanks is $1,890.00 for 30 years.

3. Patapsco Interceptor (from Herbert Run downstream to Patapsco Pump Station)

The Second Party shall, annually and for forty (40) years from the date of this Agreement, pay the First Party the sum of Two Thousand and One Hundred and Fifty dollars ($2,150.00) which represents the Second Party's share of the First Party's annual debt service for the construction of the Patapsco Interceptor from Herbert Run downstream to the Patapsco Pumping Station. This amount is based upon the First Party's annual debt service of $36,660 and the Second Party's design flow allocation of 5.86% of the total ultimate design flow of the interceptor.

4. The sum of the costs derived in 1, 2 and 3 above represents the Second Party's proportionate share in the First Party's debt service for improvements to jointly used facilities.

b. If both parties agree that repayment by the Second Party to the First Party for a capital expenditure for a jointly used facility made after June 30, 1969 shall be included in the annual debt service charge, as stipulated in Article X, paragraph D, of this Agreement, the Second Party shall pay debt service on their share of the capital expenditure as determined by the Design Flow Method.

C. The sum of the costs derived in A and B above shall constitute the Second Party's annual obligation for sewerage services provided by the First Party.

ARTICLE XIII. CHARGES TO BE RECALCULATED ANNUALLY

A. The Second Party shall, by August 15 of each year, submit in writing to the First Party the readings of all sewage flow meters at points of entry to the First Party's sewerage system as stipulated in Article XI. The report submitting the meter readings and flows shall specify such locations and points of entry into the sewerage system as herein provided.

B. On or before the 15th day of January of each year, the Director of the First Party shall submit to the Director of the Second Party a statement showing computations of the Second Party's share of costs for the preceding fiscal year. The statement and computations shall be jointly prepared by both parties and shall show the net total of the various sums by the Second Party to the First Party arrived at by the methods outlined in Article XII. Said sums, so due and owing by the Second Party to the First Party, shall be payable within sixty (60) days after the date of submittal of the statements.

ARTICLE XIV. ACCESS TO RECORDS

Each party to this Agreement shall have ready access to all plans, office and field records, costs accounts, records and files for jointly used sanitary sewerage facilities and installations of the other party.

Either party shall have ready access to all design data, schedules, programs and costs estimates relating to altering or enlarging the jointly used sanitary sewerage system, or any part thereof, that serves or will serve both parties.

Each party shall have ready access to all information, records, calculations and data used to determine the total annual charge for sewerage service.

Each party shall have the right to audit the other Party's statements and accounts useful and/or necessary to the performance of this Agreement. Such audits shall be made at the auditing party's expense.

ARTICLE XV. OPERATION AND MAINTENANCE OF FACILITIES

It is agreed by both parties that each party shall supervise the operation and maintenance of the various facilities of their respective sewerage systems.

ARTICLE XVI. PATAPSCO SEWERAGE PUMPING STATION AND FORCE MAIN IMPROVEMENTS

The Second Party recognizes the benefits it will receive from the replacement of and improvement to the First Party's Patapsco Sewage Pumping Station and Force Main to be partially financed under Environmental Protection Agency's Grant No. C-240470010. Pursuant to P.L. 92-500, the Second Party recognizes the following obligations and agrees to the following provisions:

A. The Second Party agrees to limit its peak flow at any one time to 17.8 mgd during the service life of the initial pumping facilities. The initial pumping facilities are designed for a peak flow of 45 mgd to be allocated as follows:

Baltimore County	20.7 mgd
Howard County	17.8 mgd
Anne Arundel County	6.5 mgd

The Second Party agrees to fund 39.6% of the local costs associated with the improvements included within the scope of EPA Grant No. C240470010. This percentage is based upon the Design Flow Method of financing new facilities.

B. The Second Party agrees to levy a sewer user charge on each of its customers whose wastewaters flow into the First Party's Patapsco Sewerage System. Said user charge shall be designed to assure that each customer will pay its proportionate share of the Second Party's share of the First Party's cost of operation and maintenance (including replacement) of all waste treatment services provided by the First Party.

The Second Party further agrees to levy an extra-strength surcharge on each of its customers in accordance with Baltimore County's Sewer Ordinance (Bill No. 135-76). All revenue collected therefrom by reason of Baltimore County's costs in transporting and treating said extra-strength sewage shall be remitted to the First Party.

C. The Second Party agrees to enforce all the provisions of Baltimore County's Sewer Ordinance (Bill No. 135-76) as they apply to customers under the Second Party's jurisdiction.

The Second Party further agrees to report to the First Party the introduction of toxic, incompatible, or significant industrial wastes at least six (6) months prior to their acceptance into the sewerage system.

D. The Second Party agrees to develop and maintain an Industrial Cost Recovery System applicable to Grant No. C-240470010 which shall require all present and future industrial users to pay that portion of the grant amount allocable to the treatment of wastes from such users in conformance with all applicable Federal requirements.

ARTICLE XVII. ARBITRATION

In the event of any disagreement between the Parties of this Agreement over the terms of the Agreement, the Parties shall submit, on the demand of either, the matter to arbitration in the following manner: The First Party shall appoint one arbitrator, and the Second Party shall appoint one arbitrator. The two arbitrators so appointed shall select a third, who shall be chairman of the board of arbitration. If the two arbitrators are unable to agree upon the third arbitrator, the Secretary of Health and Mental Hygiene of the State of Maryland shall be requested to designate such third arbitrator; and the written decision of the majority of the board of arbitration shall be final and binding upon both Parties.

ARTICLE XVIII. TERMS OF AGREEMENT

The Parties hereto mutually agree to update the Agreements dated May 6, 1963 and August 2, 1968 between Baltimore County and Howard County relating to sewerage services provided the Second Party by the First Party, effective the date of this Agreement, and further agree that any payments provided for in this Agreement shall be retroactive to July 1, 1975 and shall continue in force and effect until the parties hereto amend this Agreement or execute a new Agreement.

If it becomes necessary or desirable, in the opinion of either party, to amend this Agreement or execute a new Agreement, such party shall so notify the other in writing at least 30 days before the end of any calendar year. Such party shall accompany its written notification with a draft of its desired amendment or new Agreement. If the parties are unable to agree, the present Agreement shall continue in force. In the case of disagreement, either party may initiate arbitration proceedings according to Article XVII, above.

IN WITNESS WHEREOF, the Parties hereto have properly executed this Agreement as of the day, month and year first above-written.

Original Agreement approved by:
County Executive of Baltimore County
County Executive of Howard County

AMENDMENT TO SEWER AGREEMENT
BETWEEN BALTIMORE AND HOWARD COUNTIES

FOR CAPITAL EXPENDITURE ALLOCATION OF THE PATAPSCO RELIEF INTERCEPTOR

JUNE 5, 1982

THIS AGREEMENT, made this fifth day of June, 1982 by and between BALTIMORE COUNTY, MARYLAND, hereinafter referred to as the FIRST PARTY, and HOWARD COUNTY, MARYLAND, hereinafter referred to as the SECOND PARTY, each of said Parties a body corporate and politic of the State of Maryland.

WHEREAS, the First and Second Parties entered into an Agreement, dated June 4, 1979, to continue the operation of the jointly used sewerage system in the Patapsco Drainage Area between the Metropolitan District of Baltimore County and Howard County, and to establish methods for the computation and reimbursement of the costs incurred by the First Party in providing sewerage services to the Second Party; and

WHEREAS, the First Party will construct a Relief Interceptor paralleling the existing original Patapsco Interceptor from the confluence of Deep Run and Patapsco River downstream to the First Party's new Patapsco Pumping Station; and

WHEREAS, the First Party has designed said Facilities to accomodate certain existing and future flows from the territory of the Second Party; and

WHEREAS, the Second Party desires to connect to or otherwise use said Facilities; and

WHEREAS, Article X of the Sewer Agreement dated June 4, 1979 stipulates that the capital expenditures of jointly used sewerage facilities of the type herein referred to shall be allocated by the Design Flow Method as defined in said Sewer Agreement; and

WHEREAS, the U.S. Environmental Protection Agency, as a condition to awarding Grant No. C-240470010 for financial aid for the Facilities pursuant to P.L. 92-500, requires an amendment to said Sewer Agreement to include certain provisions; and

WHEREAS, Article XVIII of said Sewer Agreement provides that mutually agreeable amendments may be made to the Sewer Agreement;

NOW, THEREFORE, THIS AGREEMENT WITNESSETH:

THAT IN CONSIDERATION of the covenants, agreements and payments hereinafter set forth, it is mutually covenanted and agreed as follows:

A. The Sewer Agreement between Baltimore County and Howard County dated June 4, 1979 is hereby amended.

B. DEFINITION

"Capital expenditure" is hereby defined as in the Sewer Agreement.

C. PATAPSCO RELIEF INTERCEPTOR

a. The peak design-flow allocation of the reinforced Patapsco Interceptor System for each jurisdicition by manhole (MH) designation as described by the attached schematic* is as follows:

See Page V-7.15

(Copied from the original document for publication in the Water & Sewerage Plan)

Section	Baltimore County (mgd)	Howard County (mgd)	Anne Arundel County (mgd)	BWI Airport (mgd)
MH 34848 to MH 49188	13.80	16.10	- mgd	- mgd
MH 49188 to MH 49187	13.80	27.60	3.22	- mgd
MH 49187 to MH 49185	13.80	27.60	3.22	2.30
MH 49185 to MH 49180	13.80	27.60	6.78	2.30
MH 49180 to MH 49171	24.98	27.60	6.78	2.30
MH 49171 to MH 49170	26.85	27.60	6.78	2.30
MH 49170 to MH 49165	29.11	27.60	7.93	2.30
MH 49165 to Pump Station	29.56	27.60	7.93	2.30

b. In accord with paragraph a. above, the Second Party's percentage share of capital expenditures by manhole sections is calculated as follows:

Section	Equity in Old Pipe (mgd-peak) (2)	Ultimate Requirement (mgd-peak) (3)	Capacity Increase (mgd-peak) (4)	Relief Capacity (mgd-peak) (5)	HOWARD County's Share (4)÷(5)= % (6)
MH 34838 to MH 49188	10.00	16.10	6.1	17.48	34.90%
MH 49188 to MH 49187	16.0	27.60	11.6	17.48	66.36%
MH 49187 to MH 49185	16.0	27.60	11.6	17.48	66.36%
MH 49185 to MH 49180	16.5	27.60	11.1	17.48	63.50%
MH 49180 to MH 49171	1.0	27.60	26.6	46.71	56.95%
MH 49171 to MH 49170	1.0	27.60	26.6	48.00	55.42%
MH 49170 to MH 49165	1.0	27.60	26.6	50.26	52.92%
MH 49165 to Pump Station	1.0	27.60	26.6	50.71	52.46%

c. The percentages in paragraph b. above shall be applied to capital expenditures as defined in the Sewer Agreement. For monthly progress billing purposes, an overall weighted average percentage shall be calculated for the Second Party by applying the percentages in paragraph b. to the bid price of each Section. At the completion of construction, actual shares shall be calculated, using the percentages in paragraph b. and actual costs for each Section. For common costs that cannot be assigned to specific Sections (such as administrative and/or engineering costs, etc.), an actual overall weighted-average percentage shall be determined from those costs which can be assigned. Any difference between billed shares and actual shares shall be settled at the time that the project is closed out.

d. The Second Party agrees to limit its peak flows in the reinforced Patapsco Interceptor System at any one time to its allocations as described in paragraph a. above during the service life of the System.

D. The Second Party recognizes the benefits it will receive from the construction of the Patapsco Relief Interceptor to be financed partially under U.S. Environmental Protection Agency's Grant No. C-240470010 to the First Party. Pursuant to the requirements of Public Law 92-500, the Second Party recognizes and accepts its obligation to impose appropriate sewer use charges and surcharges with constituent threshold limits as set forth in the Howard County Code at Section 20.307. Said threshold limits shall be in conformance with the Baltimore County Code (1978), Article 34, Division 5, as may be amended from time to time. The Second Party recognizes and accepts its obligation to enforce provisions with regard to industrial wastes as set forth in the Howard County Code, Section 18.122A. Said provisions shall be at least as stringent as those set forth in the Baltimore County Code.

Article 34, Division 5, as may be amended from time to time. The Second Party recognizes and accepts its obligation to implement whatever industrial cost recovery systems or pretreatment requirements may be required in the premises and territory by the U.S. Government Protection Agency.

IN WITNESS WHEREOF, the parties hereto have properly executed this Agreement as of the day, month and year first above written.

APPROVED:
BALTIMORE COUNTY, MARYLAND

ATTEST:

By: (Seal)
DONALD P. HUTCHINSON
County Executive

APPROVED AS TO FORM
AND LEGAL SUFFICIENCY:

APPROVED: 1/18/82

HARRY J. PISTEL
Director of Public Works

ATTEST:

WILLIAM E. EARLE
County Administrator

APPROVED:
HOWARD COUNTY, MARYLAND

By: (Seal)
J. HUGH NICHOLS
County Executive

APPROVED FOR SUFFICIENCY OF FUNDS:

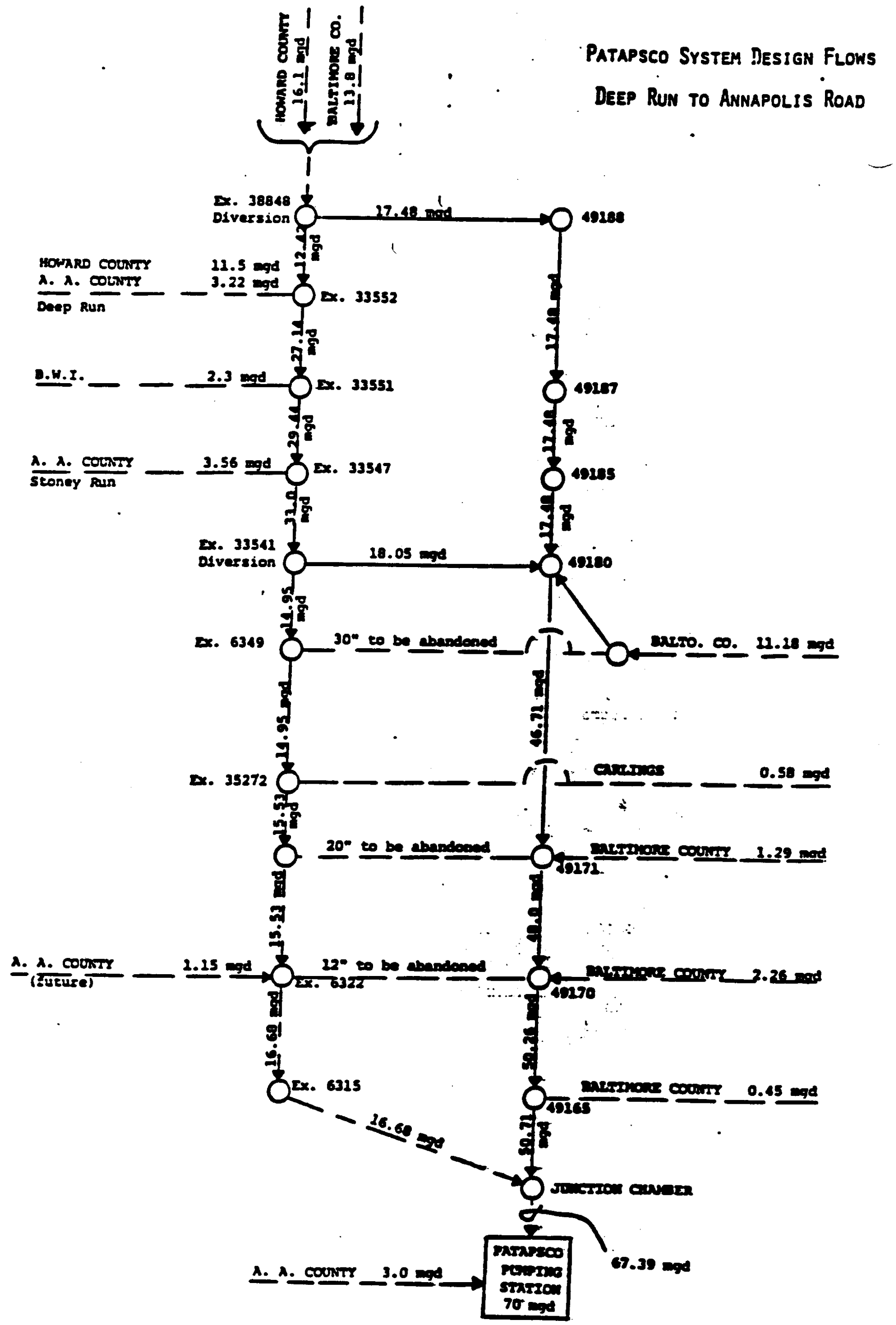
J. DARRELL CAMPBELL, Director/
Office of Finance

RECOMMENDED FOR APPROVAL:

4-16-82
GEORGE F. NEIMEYER, Director
Department of Public Works

APPROVED FOR LEGAL SUFFICIENCY:

TIMOTHY E. WELSH
County Solicitor



V-7.22 June, 1982

SEWERAGE AGREEMENT
BETWEEN BALTIMORE COUNTY AND HOWARD COUNTY

MAY 3, 1982

THIS AGREEMENT, made this third day of May, 1982, by and between Baltimore County, Maryland, a municipal corporation, hereinafter called "Baltimore County", and HOWARD COUNTY, MARYLAND, a body corporate and politic, hereinafter called "Howard County".

WHEREAS, Baltimore County and Howard County entered into two Agreements for the construction of the Patapsco Interceptor from Herberts Run to Suckers Branch (hereinafter referred to as "Patapsco Interceptor") which Agreements were dated May 6, 1963 (with a subsequent modification thereto dated February 28, 1964) and August 2, 1968 (hereinafter referred to respectively as the "1963 and 1968 Agreements"); and

WHEREAS, during the design of the Patapsco Interceptor the capacity was revised in two reaches without amending the Agreement and the actual cost sharing was based on the revised design capacity which is shown on Attachment A; and

WHEREAS, the Patapsco Interceptor from Herberts Run to Suckers Branch was constructed in accordance with the revised design capacity for both Baltimore County and Howard County for each reach of the interceptor as shown on Attachment A; and

WHEREAS, the Baltimore County design sewage flow is less than projected and Baltimore County does not have the need for all the design capacity specified in the before stated Agreements in the Patapsco Interceptor from upstream of Deep Run to the Tiber Branch; and

WHEREAS, Howard County is desirous of purchasing some of Baltimore County's unneeded design capacity in the Patapsco Interceptor from upstream of Deep Run to Tiber Branch.

NOW, THEREFORE, THIS AGREEMENT WITNESSETH, that in consideration of the promises and conditions contained herein and other good and valuable consideration, the sufficiency of which is hereby ackowledged, the parties agree and covenant as follows:

1. The design capacity in the 1963 and 1968 Agreements are hereby amended to reflect the revised design capacity shown on Attachment A.

2. Baltimore County agrees to sell to Howard County the design capacity in the Patapsco Interceptor upstream of Deep Run to Tiber Branch as shown in Attachment B.

3. Howard County agrees to pay Baltimore County the sum of $260,488 which is the cost of the design capacity shown on Attachment B. The cost of the design capacity includes the actual contruction costs, engineering fees, right-of-way costs, etc., and is exclusive of Federal and State grants received for funding the various reaches of the Patapsco. The derivation of this cost is shown on Attachments C and D.

[Copied from the original for inclusion in this Plan.]

4. Howard County agrees to pay Baltimore County the dollar amount stated in Item 2 within sixty (60) days of the date of execution of this Agreement.

5. This Agreement shall inure to and be binding upon the parties hereto, their successors and assigns.

6. This Agreement was made and entered into in Maryland and is to be construed under the laws of Maryland.

IN WITNESS WHEREOF, the parties hereto have caused these presents to be executed by their proper officers thereunto duly authorized the day and year first above written.

ATTEST:

s/William E. Eakle
William E. Eakle
County Administrator

HOWARD COUNTY, MARYLAND

s/J. Hugh Nichols
By: J. Hugh Nichols (Seal)
County Executive

APPROVED:

s/George F. Neimeyer 4-7-82
George F. Neimeyer, Director
Department of Public Works

APPROVED FOR LEGAL SUFFICIENCY
this 6th day of April, 1982.

s/Timothy E. Welsh
Timothy Welsh
County Solicitor

APPROVED FOR SUFFICIENCY OF FUNDS

s/J. D. Campbell 4-7-82
J. Darrell Campbell, Director
Office of Finance

ATTEST:

s/Patricia L. Kirkner

APPROVED:
BALTIMORE COUNTY, MARYLAND

By: s/Donald P. Hutchinson (Seal)
DONALD P. HUTCHINSON 5-3-82
County Executive

APPROVED AS TO FORM
AND LEGAL SUFFICIENCY:

s/Stanley J. Schapiro

APPROVED:

s/Harry J. Pistel
HARRY J. PISTEL
Director of Public Works

V-7.24 8/1/85

ATTACHMENT A

DESIGN CAPACITY BEFORE SALE IN THE PATAPSCO INTERCEPTOR FROM HERBERTS RUN TO SUCKERS BRANCH

Reach		Design Capacity (mgd)			
		Baltimore County		Howard County	
From	To	Per Agreement	Revised*	Per Agreement	Revised*
Herberts Run	Deep Run	**	***	**	***
Deep Run	Stillhouse Run	31.5	-	13.0	-
Stillhouse Run	Bull Branch	30.8	-	13.0	-
Bull Branch	Santee Branch	29.4	-	12.0	-
Santee Branch	Oak Forest Branch	27.6	-	12.0	-
Oak Forest Branch	Thistle Branch	26.0	-	12.0	-
Thistle Branch	3000 feet east of Tiber Branch	25.9	-	12.0	-
3000 feet east of Tiber Branch		24.9	-	10.0	12.0
Tiber Branch	Suckers Branch	17.9	24.9	10.0	3.0

*Revised by letters. Actual cost sharing was based on revised design capacity.

**50% by each party.

***Design capacity is increased through the Amendment to Sewer Agreement dated June 4, 1979 between Baltimore and Howard counties for Capital Expenditure Allocation of the Patapsco Relief Interceptor which Amendment is dated April 1982.

ATTACHMENT B

DESIGN CAPACITY AFTER SALE IN THE PATAPSCO INTERCEPTOR FROM DEEP RUN TO SUCKERS BRANCH

From	To	Design Capacity Being Sold	Baltimore County	Design Capacity (mgd)
Howard County				
Upstream of Deep Run	Stillhouse Run	3.1	28.4	16.1
Stillhouse Run	Bull Branch	3.1	27.7	16.1
Bull Branch	Santee Branch	3.1	26.3	15.1
Santee Branch	Oak Forest Branch	3.1	22.9	15.1
Oak Forest Branch	Thistle Branch	3.1	22.9	15.1
Thistle Branch	3000 feet east of Tiber Branch	3.1	22.8	15.1
3000 feet east of Tiber Branch	Tiber Branch	3.1	21.8	15.1
Tiber Branch	Suckers Branch	1.0	23.9	4.0

ATTACHMENT C

DERIVATION OF CONSTRUCTION COSTS FOR THE ADDITIONAL CAPACITY

Contract No.	Contract Costs Total	Contract Costs Federal & State	Local Cost (2) - (3)	Baltimore County MCD- %	Baltimore County $	Cost/MCD $ (7) ÷ (5)	Additional Capacity for Howard County mgd	Constrtion Cost $ (8) x (9)
(1)	(2)	(3)	(4)	(5) - (6)	(7)	(8)	(9)	(10)
1057 MH34848 to 39206	441,975	262,507	179,468	31.5-69.7	125,089	3,971	3.1	12,310
1058	510,971	354,655	156,316	30.8-70.3	109,890	3,568	3.1	11,061
1059	286,698	202,636	84,062	29.4-71.0	59,684	2,030	3.1	6,293
1060	508,515	393,946	114,569	27.6-69.7	79,855	2,893	3.1	8,968
145	1,124,503	859,075	265,428	26.0-68.4	181,553	6,982	3.1	21,644
146	792,817	611,672	181,145	25.9-68.3	123,722	4,777	3.1	14,809
25 Part A	-	-	-	24.9-67.5	150,508	6,044	3.1	18,736
25 Part B	-	-	-	24.9-89.3	79,662	3,199	1.0	3,199

Numbers in parentheses are column numbers.

ATTACHMENT D

DERIVATION OF THE SELLING PRICE

Contract No.	ENR Index	Escalated Cost	Age (Years)	Accumulated Depreciation (3) x (4) ÷ 75	Revised Selling Price (3) - (5)
(1)	(2)	(3)	(4)	(5)	(6)
1057 MH34848 to 39206	2.89	$35,576	12	$ 5,692	$29,884
1058	3.20	35,395	13	6,135	29,260
1059	3.20	20,138	13	3,491	16,647
1060	2.89	25,918	12	4,147	21,771
145	3.20	69,261	13	12,005	57,256
146	3.20	47,389	13	8,214	39,175
25 Part A	3.92	73,445	17	16,648	56,797
25 Part B	3.92	12,541	17	2,843	9,698
		$319,663		$59,175	$260,488

Numbers in parentheses are column numbers.

APPENDIX G

Sewer Agreement with State Aviation Administration
(Now Maryland Aviation Administration)

A G R E E M E N T

THIS AGREEMENT, made this 5th day of AUGUST, 1987 by and between BALTIMORE COUNTY, MARYLAND, a body corporate and politic hereinafter referred to as the FIRST PARTY, and the State of Maryland, State Aviation Administration,hereinafter referred to as the SECOND PARTY, a unit of the Department of Transportation, State of Maryland.

WHEREAS, the First Party has entered into agreements with Baltimore City for the disposal of sewage; and

WHEREAS, it is the intent of the parties hereto that the sewerage system of the First Party shall continue to receive sewage from the Second Party and that a method for the computation and payment of the costs incurred by the First Party for collection, transmission and disposal of sewage from the Second Party be established.

NOW, THEREFORE, THIS AGREEMENT WITNESSETH:

THAT IN CONSIDERATION of the covenants, agreements and payments hereinafter set forth, it is mutually covenanted and agreed as follows:

ARTICLE I. DEFINITIONS

A. "Capital Expenditure" is hereby defined as the net cost involved in the construction and installation of any sewerage facility and shall include, but not be limited to, the sum of the following items: Land, easements, consultants' fees, material, labor, utility relocations, overhead which may include a proportionate allocation of in-house costs associated with design, field engineering, surveys, borings, materials testing, maps and record maintenance, inspection, right-of-way expenses, advertising, administrative, clerical and stenographic services, office space use and building operation and maintenance; and all other contributing costs or expenses. Capital expenditure shall be exclusive of grants from the Federal government, the State of Maryland, or any capital contribution by others than the parties to this Agreement. For the purpose of this Agreement, capital expenditure shall also mean any cash contribution by the First Party to Baltimore City for the construction or improvement of a City-owned jointly-used facility.

B. "City" is hereby defined as the City of Baltimore, Maryland.

C. "Debt Service" is hereby defined as the sum of interest and amortization for a specific capital expenditure.

D. "Design Flow Method" is a method of cost allocation determined from a tabulation of the projected volume of sewage to be contributed by each party to this Agreement that was used to design the proposed jointly-used facility. Ratios of cost responsibility of additional facilities, including the addition of secondary and advanced waste treatment, are developed by dividing the designed ultimate capacity allocated to each party having a beneficial interest by the projected total designed ultimate capacity allocated to all beneficially interested parties. Ratios of cost responsibility for the expansion of existing facilities are developed by dividing the increase in flow projected for each beneficially interested party to the design year by the total increase in flow projected to the design year for all beneficially interested parties.

E. "Director" shall mean the Director of Public Works of Baltimore County or his duly authorized representative or agent.

F. "Administrator" shall mean the Administrator of the State Aviation Administration or any duly authorized representative or agent.

G. "Facility" for the purpose of this Agreement shall mean any installation, including real and personal property, that is used or useful for the purpose of receiving, transmitting, pumping, treating and disposing of sewage or sludge.

H. "Jointly-used Facility" is hereby defined as any facility that receives, transmits, pumps, treats, or disposes of the sewage from both parties to this Agreement.

I. "Major Repair or Rehabilitation" are hereby defined as any restoration of a facility which does not increase the capacity of the facility.

J. "Sanitary Sewer" is a pipe or conduit, the specific purpose of which is to carry waste water as defined below.

K. "Purchased Design Capacity" of a jointly-used facility is hereby defined as that portion of the total design capacity of a jointly-used facility that the principal payments of either or both parties bear to the total capital expenditures for construction, improvements, and installation of said facility.

L. "Waste Water or Sewage" consists of the water-carried waste discharged from dwellings, business buildings, institutions and industrial establishments, supplemented in some instances by industrial wastes, surface and sub-surface waters and storm waters.

M. "Storm Water" is excess water running off from the surface of a drainage area during and immediately following rainfall, snowfall, or other meteorological precipitation.

N. "Storm Drain" is a drain through which storm water, storm runoff, condensate, cooling water, street wash and other wash waters or drainage flow and from which waste water is excluded.

O. "Subsurface Water" is water that occurs in the lithosphere. It comprises suspended water and ground water.

P. "Surface Water" is water that rests on or flows over the surface of the lithosphere.

Q. "Volumetric Method" is a method determined by an annual calculation of the volume of sewage contributed by each party to this Agreement to each jointly-used facility. Ratios of cost responsibility are developed by dividing the volume of sewage contributed by each Party to this Agreement to the total volume of sewage that is received, transmitted, pumped, treated and disposed of by each jointly-used facility.

ARTICLE II. RIGHTS OF EITHER PARTY NOT TO BE ABROGATED

A. Nothing in this Agreement shall limit or abrogate any right or rights delegated to either Party by Acts of the General Assembly of the State of Maryland.

B. It is further understood and agreed that the police, legislative and governmental power of either Party are not to be abridged or restricted by this Agreement.

C. Each Party hereto agrees to recognize all rights and privileges acquired by acquisition of property and rights-of-way, each from the other and from other parties.

ARTICLE III. RIGHT OF REVIEW

A. The Second Party shall, upon request have the right to review reports, plans, bids and financing for the construction and improvement of any jointly-used facility owned or operated by the First Party.

B. Any costs associated with said review shall be borne exclusively by the reviewing party.

C. Nothing in this Agreement shall limit or abrogate any right or rights of either Party to enter into other separate agreements for the planning, designing and constructing of sewerage facilities, one with the other or with other parties.

ARTICLE IV. LIMITATION OF TERRITORY

This Agreement applies only to that portion of Baltimore/Washington International Airport which is served or will be served by the Baltimore County Sewerage System.

ARTICLE V. CONNECTIONS TO SEWERAGE SYSTEM

A. The sanitary sewers of the Second Party shall be connected with the sanitary sewers of the First Party only at such points and to such sanitary sewers as may be designated by the First Party in writing.

B. The Second Party shall notify the First Party in writing at least five (5) days before making any connection to the sewerage system of the First Party so as to allow the inspection of construction of said connections at the site of said work.

C. At no time may the Second Party's use of the jointly-used facility exceed its purchased design capacity, without the expressed written permission of the First Party.

D. The Administrator shall transmit to the Director not later than September 1 of each year, projections of flows from the Second Party to the First Party. Based upon said criteria, the First Party shall prepare a Six Year Capital Improvement Program designed to accommodate the flows from one system into the other, including those facilities required to handle the estimated flows.

E. By November 15, following the receipt of criteria set forth in paragraph D above, the Parties shall agree as to the appropriate apportionment of costs of such jointly-used facilities, based on the design flow method.

F. Upon approval of the annual budget, the Director shall notify the Administrator of those system facilities that have been included in the officially adopted Capital Improvement Program and shall also provide data by years on flows to be accommodated and capacities to be made available for the Second Party's flows, all predicated upon the completion of such improvements. Each such annual notification will be deemed to supersede all prior notifications and shall be binding for the ensuing period.

G. The Administrator shall limit sewage flows to those which the Director determines the Baltimore County system can safely accommodate.

H. The Parties of this Agreement do hereby acknowledge the statutory responsibility of the State Department of Health and Mental Hygiene in Oreference -sic- to the adequacy of the sewerage systems and agree to submit any disputes concerning the physical aspects of the system to said Department for adjudication.

ARTICLE VI. STORM WATER, SURFACE WATER AND OTHER MATERIALS NOT TO BE DISCHARGED INTO SANITARY SEWERS

A. Storm water, surface water, subsurface water and other non-polluted wastes shall not be discharged into those sanitary sewers which drain into the jointly-used sanitary sewers of the First Party. No street inlet, catch basin, storm drain, rain leader, cellar drain, garage drain or any other connection through which storm water, surface water, ground water or any other water not classified as waste water can flow shall be connected to the aforesaid sanitary sewers which drain into the jointly-used sewers of the First Party.

B. The Second Party agrees to use every effort to prevent the discharge of storm water into the sanitary sewers connecting with the sanitary sewers of the First Party, and if any such connections are detected, the Administrator shall promptly use all means within his power to see that such connections, including storm inlets and other points of entry are abandoned and sealed.

C. The Second Party agrees to limit its peak flow in the reinforced Patapsco Interceptor System to its allocation of 2.30 million gallons per day (mgd) as shown by the attached schematic during the service life of the system unless said allocation is modified in accordance with Article XVII or permission is granted in accordance with Article V-C.

D. The strength of the discharge of the Second Party shall be limited by the conditions of the Wastewater Discharge Permit issued by Baltimore County.

ARTICLE VII. CONSTRUCTION OF SANITARY SEWERS

All sanitary sewers, house sewers, interceptors, manholes, bellmouths, and connections between the sanitary sewers of both Parties shall be designed and constructed in accordance with the applicable codes, rules and regulations of the party within whose boundaries the construction is located..

ARTICLE VIII. INSPECTION OF PREMISES

The premises of the properties in the territory defined in Article IV, which drain into sewers of the First Party, may be entered with notice and inspected by the Director.

ARTICLE IX. REPAIRS AND REHABILITATION TO BALTIMORE COUNTY SYSTEM

A. Whenever it becomes necessary for the First Party to make repairs or rehabilitations to any part of Baltimore County's facilities as defined herein, the Second Party shall contribute its proportionate share of all costs resulting from the planning, designing and execution of the said repair or rehabilitation, including all materials, labor, engineering and any and all other costs involved therein. The cost of items referred to in this Article shall be apportioned according to the Design Flow Method.

B. Payment by the Second Party to the First Party for repairs covered by this Article shall be made as the work progresses.

ARTICLE X. FINANCING OF IMPROVEMENTS

A. The capital expenditures for jointly-used sewerage facilities constructed and/or improved after July 26, 1972, except as hereinafter provided, shall be apportioned to each party to this Agreement by the Design Flow Method.

B. Payment by the Second Party to the First Party for the Second Party's share of improvements to City-owned jointly-used facilities for which the First Party will have paid the City the Second Party's share, will be based on the Design Flow Method. In this case, the share of the Second Party's cost responsibility shall be developed by dividing the projected volume of sewage to be contributed by the Second Party by the projected sum total volume of sewage flowing to the jointly-used facility, exclusive of Baltimore City's projected flow. To calculate the Second Party's financial responsibility, multiply their share as calculated above by the First Party's payment to the City.

C. Before the First Party commences construction, installation, or payment for additional sewerage facilities or improvements to existing sewerage facilities that may be jointly-used by the parties to this Agreement, the Second Party shall certify that funds for their share of participation are available. In the event that funds are not available, the Second Party agrees to attempt to obtain funds as quickly as possible or to make other mutually agreeable arrangements for payments.

D. Payment to the First Party by the Second Party shall be made as the work progresses. Such payment, billed each month for the proportionate share of payment for work completed, shall be due within 30 days of the rendering of such bill.

E. Whenever both Parties agree to increase either Party's purchased design capacity, as between themselves, of a jointly-used facility, as stipulated in Article V, the financial responsibility for the construction, improvements, or installation of such facility shall be adjusted accordingly. The Party liable for the adjustment shall remit the due amount to the other Party in a lump-sum cash payment no later than sixty (60) days after notice of said adjustment.

ARTICLE XI. DETERMINATION OF SEWAGE FLOW

A. In order to measure and record automatically the volume of sewage flowing from the sewerage system of the Second Party into the sewerage system of the First Party, recording registering flow meters satisfactory to both parties shall be constructed, installed and ready for regular continuous service at or near points of entry of sewage from the Second Party to the sewerage system of the First Party. The First Party agrees that the present meter location, adjacent to Furnace Avenue, is satisfactory. The cost of said meters, their installation, and their operation and maintenance shall be borne entirely by the Second Party.

B. At any point of entry by reason of a new meter installation or by reason of meter failure, where the sewage flow is accurately metered for a minimum of 120 days in any twelve-month period, then the daily flows for the entire year shall be considered to be the average daily flow for that period of the year that has been metered.

C. The First Party agrees to maintain the metering and recording equipment installed by the Second Party in accordance with (A) above. The entire cost of this maintenance by the First Party shall be borne by the Second Party.

D. By August 15 of each year, the Second Party shall forward to the First Party an annual summary of meter readings and flows at point of entry for the preceding fiscal year. These flows will be used to calculate the annual sewer statement.

ARTICLE XII. DETERMINATION OF SEWERAGE SERVICE CHARGES

A. The calculations for charging the Second Party for sewerage services rendered by the First Party shall be composed of a sewerage service charge for the Second Party's share of operation and maintenance expenses of jointly-used facilities, and, where applicable, an annual charge for debt service for the Second Party's share of the debt service of the First Party as applied to the jointly-used facilities.

B. The Second Party shall pay to the First Party annually a Sewerage Service Charge representing the Second Party's share of direct costs incurred by the First Party for transporting, pumping, treating and disposing of sewage during the preceding fiscal year. The aforementioned direct cost shall include all the operating and maintenance costs for jointly-used facilities reduced by the amount of direct costs recovered as surcharge under the Industrial Waste Ordinance. They shall include all payroll expenses (i.e. payroll, pensions, FICA payments, Workmen's Compensation payments, leave with pay and fringe benefits), rentals, contractual services, supplies, materials, equipment expenses (i.e. maintenance and minor repairs), utilities, and other expenses, as well as other indirect expenses properly chargeable.

C. The Second Party shall also pay to the First Party any surcharge collected from industry for reason of excessive BOD, suspended solids, or other constituents above that limit considered by the First Party as that permitted without payment of a surcharge. Such surcharge shall be in accordance with the charges specified in Industrial Waste Ordinances.

D. If at any time a jointly-used facility is no longer used by the Second Party, the Second Party will no longer be charged for the use of the facility.

E. All sewerage service charges shall be based on the Volumetric Method.

1. Computation of Operation and Maintenance Costs.

a. Determine the First Party's costs for:
i. Operation and maintenance of Patapsco Pump Station.
ii. Operation and maintenance of jointly-used sewers.
iii. Six percent (6%) of the sum of (1) and (2) above, which represents other indirect Bureau charges relating to sewerage services.
iv. Divide the total annual sewage flow contributed by the Second Party to the Patapsco Pump Station (as stipulated in Article XI) by the total annual metered flow through the Patapsco Pump Station to obtain a factor expressed as a percentage appropriately adjusted for outages and overflows. Multiply the sum of 1, 2, and 3 above by the percentage factor so derived, to obtain the Second Party's proportionate share in the operation and maintenance of Patapsco Pump Station and jointly-used sewers.

b. Divide the total annual sewage flow contributed by the Second Party (as stipulated in Article XI) by the total annual sewage flow contributed by the First Party to the City's Patapsco Waste Water Treatment Plant to obtain a factor expressed as a percentage appropriately adjusted for outages and overflows. Multiply the amount that the First Party paid the City for treatment and disposal of sewage at the City's Patapsco Waste Water Treatment Plant by the percentage factor so derived, to obtain the Second Party's proportionate share in the treatment and disposal of sewage at the City Plant.

c. The sum of the costs derived in i. and ii. above represents the Second Party's proportionate share in the First Party's operation and maintenance costs.

2. Computation of Debt Service:

a. The Second Party's share of debt service resulting from bonds issued by the First Party on or after July 1, 1986, for improvements to jointly-used facilities shall be based on the design flow method.

ARTICLE XIII. CHARGES TO BE RECALCULATED ANNUALLY

A. The Second Party shall, by August 15 of each year, submit in writing to the First Party the readings of the sewage flow meter at point of entry to the First Party's sewerage system as stipulated in Article XI.

B. On or before the 15th day of January of each year, the Director shall submit to the Administrator a statement showing computations of the Second Party's share of costs ("Cost Statement") for the preceding fiscal year and which shall include the accumulated cost for the preceding fiscal year of direct, indirect and capital costs. In addition, the statement will include accumulated units of sewage treated during the fiscal year to which these costs apply. Said sums so due and owing by the Second Party to the First Party shall be payable within sixty (60) days after the date of submittal of the statements.

C. The Second Party agrees to make estimated quarterly payments to the First Party for services to be rendered in the ensuing fiscal year on July 1, October 1, January 1 and April 1. Such quarterly payments to be equal to one-fourth of the Second Party's share of the aforementioned costs as calculated on the latest available Cost Statement. By June 1, the First Party will submit to the Second Party a cost estimate for the current fiscal year based on actual expenditures through April 30 and projected expenditures for May and June, using the latest available cost distribution percentages. The differences between the current year estimate and the quarterly deposits, said sum due and owing shall be payable by June 30. Underpayments or overpayments will be adjusted on the Annual Cost Statement.

ARTICLE XIV. <u>ACCESS TO RECORDS</u>

A. Each Party to this Agreement shall have ready access to all plans, office and field records, cost accounts, records and files of jointly-used sanitary sewerage facilities and installations of the other Party.

B. Either Party shall have ready access to all design data, schedules, programs and cost estimates relating to altering or enlarging the jointly-used sewerage system, or any part thereof, that serves or will serve both Parties.

C. Each Party shall have ready access to all information, records, calculations and data used to determine the total annual charge for sewerage service.

D. Each Party shall have the right to audit the other Party's statements and accounts useful and necessary to the performance of this Agreement. Such audits shall be made at the auditing Party's expense.

ARTICLE XV. <u>OPERATION AND MAINTENANCE OF FACILITIES</u>

It is agreed by both Parties that each Party shall supervise the design, construction, operation and maintenance of the various facilities of their respective sewerage systems.

ARTICLE XVI. <u>ARBITRATION</u>

In the event of any disagreement between the parties to this Agreement over the terms of the Agreement, the parties shall submit, on the demand of either, the matter to arbitration in the following manner: The First Party shall appoint one arbitrator and the Second Party shall appoint one arbitrator. The two arbitrators so appointed shall select a third, who shall be chairman of the board of arbitration. If the two arbitrators are unable to agree upon the third arbitrator, the Secretary of Health and Mental Hygiene of the State of Maryland shall be requested to designate such third arbitrator, and the written decision of the majority of the board of arbitration shall be final and binding upon both parties.

ARTICLE XVII. <u>TERM OF AGREEMENT</u>

A. The Parties hereto mutually agree that any payments provided for in this Agreement shall be retroactive to July 1, 1986 and shall continue in force and effect until the Parties hereto amend this Agreement or execute a new Agreement.

B If it becomes necessary or desirable in the opinion of either party to amend this Agreement, such party shall so notify the other in writing at least 30 days before the end of the calendar year. Such party shall accompany its written notification with a draft of its desired amendment or new Agreement. If the parties are unable to agree, the present Agreement shall continue in force. In the case of disagreement, either party may initiate arbitration proceedings according to Article XVI, above.

IN WITNESS WHEREOF, the parties hereto have properly executed this Agreement, as of the day, month, and year first above written.

STATE OF MARYLAND
STATE AVIATION ADMINISTRATION

WITNESS:

s/Beverly R. Rhodes

APPROVED AS TO FORM AND LEGAL SUFFICIENCY

s/ illegible
Asst. Attorney General

s/ illegible
Administrator

BALTIMORE COUNTY, MARYLAND

WITNESS:

s/ Mary Carol Miller
Robert M. Infussi, Sr.
Executive Secretary
(acting)

By s/ Dennis F. Rasmussen
Dennis F. Rasmussen
County Executive

REVIEWED FOR FORM AND LEGAL SUFFICIENCY AND APPROVED FOR EXECUTION

s/ illegible
Dep. Co. Atty.

APPROVED:

s/ Gene L. Neff
Director of Public Works

REVIEWED FOR FORM AND LEGAL SUFFICIENCY AND APPROVED FOR EXECUTION

____

ARBITRATION BETWEEN MAYOR AND CITY COUNCIL
OF BALTIMORE AND BALTIMORE COUNTY, MARYLAND,
AS TO DETERMINATION OF COSTS OF FURNISHING
WATER TO THE METROPOLITAN DISTRICT
OF BALTIMORE COUNTY

DECISION OF BOARD OF ARBITRATION

ARBITRATION BETWEEN MAYOR AND CITY COUNCIL OF BALTIMORE AND BALTIMORE COUNTY, MARYLAND, AS TO DETERMINATION OF COSTS OF FURNISHING WATER TO THE METROPOLITAN DISTRICT OF BALTIMORE COUNTY

DECISION OF BOARD OF ARBITRATION

I. Introduction

This arbitration was undertaken pursuant to the provisions of Sections 34-19 and 34-26 of the Metropolitan District Act, Baltimore County Code of 1978, as amended.

Under Section 34-26, the Mayor and City Council of Baltimore must furnish water to the Metropolitan District of Baltimore County at cost and entirely without profit or loss.

This Section further provides that if the parties do not reach an agreement as to that cost, then cost shall be determined by arbitration in the manner provided by Section 34-19 of that Code.

Section 34-19 sets forth the procedure for arbitration, which is that each party appoint one arbitrator, then the two arbitrators select a third, who shall be chairman of the board of arbitration.

In the year 1982 and thereafter, the parties disagreed as to the determination of the cost of the City's furnishing water to the Metropolitan District and the City asked for arbitration. After some years, the County declined to arbitrate so the City entered suit in 1987 to compel arbitration.

Under date of December 1, 1987, the Circuit Court for Baltimore County determined that the dispute between the parties was subject to arbitration. The Court of Appeals of Maryland affirmed by a per curiam opinion filed September 15, 1988.

Arbitrators having been selected, the parties filed prepared testimony and exhibits prior to the hearings held in December, 1990. Counsel for the parties then filed briefs and oral argument was heard by the Board of Arbitration May 7, 1991. The matter was then submitted for decision.

II. The Issues for Arbitration

By agreement of the parties embodied in a Memorandum as to Jurisdiction and Procedure (Joint Exhibit 1), the issues for arbitration are as follows:

A. What is the proper method, under the Metropolitan District Act, for determining the cost to Baltimore City of furnishing water to consumers in the Metropolitan District of Baltimore County.

1. Is the City's proposed use of the utility basis for determining capital costs the proper measure of Baltimore County's responsibility for its share of such costs under the Metropolitan District Act.

a. Under the utility basis, what were the values at the appropriate valuation dates of the property used and useful in furnishing water to consumers in the Metropolitan District.

b. Under the utility basis, what were the reasonable cost of capital rates at the appropriate valuation dates.

2. Is the City's proposed allocation of operational and maintenance expenses on a functional cost basis the proper measure of determining Baltimore County's responsibility for its share of such costs under the Metropolitan District Act.

B. What should be the effective date for implementation of the methodology proposed by the City for determining the cost to Baltimore City of furnishing water to consumers in the Metropolitan District of Baltimore County.

1. What is the current value of the amounts due to the City counting from the date of implementation of the methodology proposed by the City.

2. What is the appropriate rate of interest applicable to amounts due the City from the date of the decision of the Board of Arbitration to the date of payment.

III. Summary of Testimony

The City's first witness was Howard J. Lobb, a registered professional engineer and a Senior Consultant in the engineering firm of Black & Vaetch, Kansas City, Missouri, where he has been associated since 1951. The firm was retained by the City in 1974 to conduct a water and wastewater study that culminated in its 1978 report (marked Baltimore City Exhibit 1-Schedule HJL-1). Mr. Lobb supervised coordination of the preparation of that report and also the updating for these proceedings. Its purpose was to present the revenue requirements, to allocate the costs of service using the utility basis, and to design rates.

From the updating, Mr. Lobb had four schedules prepared as follows:

Schedule HJL-2 shows the "Net System Investment to Be Allocated" for each of the update years 1980, 1982, 1984, 1986, 1988 and 1990 (estimated).

Schedule HJL-3 entitled "Net Allocated Rate Base" summarizes for each update the net rate base allocated to the City, to Baltimore County, and the other political subdivision's to which the City also supplies water. The utility basis of allocation was used, which Mr. Lobb espoused in his direct testimony. The Schedule shows that the net rate base allocable to Baltimore County has been decreasing since 1984 because of the County's continuing contribution of its share of new system facilities and also depreciation on the old plant.

The next Schedule, HJL-4, "City's Realized Return on Net Allocated Rate Base:", shows for each update the City's return for itself, for Baltimore County, and for the other jurisdictions (as a group). For each update year since 1980, the net realized rate of return from Baltimore County has been negative. Consequently, according to Mr. Lobb, the City of Baltimore customers have had to subsidize the cost of providing water service to Baltimore County.

On his Schedule HJL-5 "Indicated Increase in Baltimore County Revenue Reflecting Return on Net Allocated Rate Base equal to Weighted Costs of Capital", this witness provided the increase in revenues which the City would have received if its charges to Baltimore County had been developed on the utility basis, using the weighted cost of capital developed by another City witness (Henry G. Mulle). According to Mr. Lobb and this Schedule, there has been an underpayment of $24,468,800 for water service provided by the City for the years 1982 through 1989, plus an additional $2,183,800 estimated for the year 1990.

Mr. Lobb concluded his direct testimony by criticizing the current agreement between the City and the County as inappropriate in the manner in which it provides for the recovery of both operation and maintenance costs, and capital costs. Since the increase in annual usage in Baltimore County has exceeded that of the City, the current relative use of facilities by the County is in excess of the relative use upon which the capital costs of those facilities were originally allocated. Further, there are older facilities whose debt has been retired where the County's use of these facilities far exceeds the percentage of debt service shared by the County. Thus, Mr. Lobb says the County is using facilities paid for by the City's customers, yet the City has no way under its current agreement with the County to charge it for the use of those facilities.

The County's chief witness in opposition to Mr. Lobb was Paul R. Moul, a Senior Vice President of AUS Consultants-Utility Services Group, with whom he has been employed since

1974. AUS was engaged by the County to conduct a complete review of the 1972 City/County Water Agreement, to analyze the City's proposal to amend that Agreement, and to analyze each of the 1980-1989 Annual water Statements prepared jointly by the City and the County.

The result of the engagement is the AUS "Report to Baltimore County, Maryland, regarding rates and charges for water service provided by the City of Baltimore Water Department to Metropolitan District Customers" in Baltimore County introduced in the record with Mr. Moul's testimony. The report supports his opinion that the Agreement should not be amended to provide any change in the basic methodology of setting revenue requirements for Baltimore County customers in its Metropolitan District beyond the proposed functional cost allocation procedure.

According to Mr. Moul, "debt service" is the method, which should continue to be used to determine revenue requirements for Metropolitan District customers of the City's water system for these reasons:

1. The debt-service approach is the basis for the City's recovering all of its costs, without profit, pursuant to the 1924 Metropolitan District Act and the 1972 Agreement.

2. This approach is particularly well suited for municipally-owned utilities and it supplies the capital attraction standard used by the financial community and by the courts and utility commissions to determine financial adequacy and revenue requirements, while the City's evidence is insufficient to support any change in approach to a utility format.

3. The 1978 Black & Veatch Report to the city used debt service to determine overall water utility revenue needs for the City and this is in accordance with the American Water Works Association Water Rates Manual (AWWA No. M1).

4. The City's proposal advocates separate rates of return for inside and outside City customers with the higher rate of return assigned the latter, which is not justified, would be discriminatory, and would be anti-competitive pricing to outside City water uses.

5. The City's evidence in support of the proposed change to the utility basis is based upon various estimates made by Black & Veatch, which are not adequate because there is no verifiable link to the actual costs of the City's water system, no reconciliation of the B & V estimates and actual City costs.

Mr. Moul pointed out that the Annual Water Statements prepared for the last 20 years show that for 15 of those years the rates established for the metropolitan District were more than adequate to cover the City's actual costs with refund payments made to the County for excess revenues made by the City. Conversely, where revenues from County customers did not match the City's cost of service, the County reimbursed the City for the shortfall.

He did recommend that the Agreement be amended to the extent that revenue requirements for Metropolitan District Customers be based upon the functional cost allocation procedure proposed by the City. Under this approach, the

County's operation and maintenance cost responsibility could increased by $2,037,010 based on Fiscal Year 1989 data. However, prior to final acceptance of this new methodology, he stated that there would have to be explicit indication of which expenses are to be considered base costs, which are extra capacity costs, which customer costs (directly assignable to a particular political jurisdiction), and which, if any, need to be allocated on some weighted average of the foregoing. Also, there will be needed a delineation of the demand ratios required for the development of the maximum day and the peak hour extra capacity allocation. Mr. Moul said that the County would accept the historical ratios developed by the A.U.S. study and described in his testimony.

Finally, he pointed out that the County will require guidelines to develop jurisdictional capacity factors, which he said the City has yet to provide. The County proposes that these factors be applicable for a minimum of five years. (Note: reference is hereby made to pages 3, 4, 5, 28 and 29 of the AUS Study for details of the AUS recommendation for adoption of the functional cost basis of allocation of expenses).

In his testimony in rebuttal to the direct testimony of Mr. Moul, the City's witness Howard Lobb joined issue over the continuing use of the 1972 Water Agreement to determine Baltimore County's revenue requirements, as recommended by Mr. Moul. Mr. Lobb pointed out that the use of a cash basis to determine charges for providing water service to the County does not provide recovery of the City's full cost for the County's current use of facilities. Specifically, there are many facilities serving the County, which is using them at a far greater percentage than originally charged where the debt incurred for these facilities has been retired. Mr. Lobb contends that the utility basis would minimize the impact on outside charges of the method of financing of water facilities chosen by the City.

According to Mr. Lobb, the utility basis is a generally accepted methodology for assignment of costs among customers of a municipally owned utility and has been endorsed by the American Water Works Association. (Note: see pages 5-11, inclusive, of Lobb's prepared testimony as to this).

As to Mr. Moul's testimony that the utility basis is inappropriate because of the complexity of estimating the value of the rate base assignable to the County, while Mr. Lobb agrees that the calculations are complex, he contends that the utility basis is no more complex than the current method used. Rate base allocations were performed in the Black & Veatch 1978 study and subsequent updates. Such methods have been used by the Maryland Public Service Commission in evaluating charges for water to Anne Arundel County by the City.

Where the City's proposal would extend capital recovery beyond payment of the bonds financing plant and equipment, as pointed out by Mr. Moul, this will only extend the capital recovery period until the related facilities have been fully depreciated and allocated rate base reduced to zero, according to Mr. Lobb.

On Mr. Moul's contention that the City's proposal would result in discriminatory pricing of water service to Metropolitan District customers, Mr. Lobb responds that rates based upon cost of service principles would not be discriminatory. He further points out that the situation is common where outside city rates are greater than inside city rates for similar type service, referring to his Schedule HJL-9 showing that 41 out of 48 cities shown charge a greater outside city rate for the same kind of water service.

Mr. Lobb's rebuttal testimony also dealt with Mr. Moul's statement that there has not been presented by the City any verifiable link between B & V estimates and the actual costs of the City's water system. According to Mr. Lobb, these tie either to the City's audited financial statements or billing data supplied by the water utility's finance department or are based on the City/County Water Agreement.

Responding to the County's data requests in this regard, Mr. Lobb offered his Schedules HJL-7A through 7F plus HJL-10 and 11.

Mr. Moul testified that the City cannot support its higher rate of return claim for outside the city customers and maintain that a lower rate of return is adequate for inside City customers. Mr. Lobb's response is that the actual return realized from City customers is greater than that realized from service to Baltimore County, as shown by his Schedule HJL-4 Revised, but he does not state that such returns are adequate.

He also disputed the statement in the AUS report that a higher rate of return to County customers results in anti-competitive pricing by the City, contending that rates based on cost of service may result in different returns, but are not per se anti-competitive.

Mr. Lobb went on to testify that his exhibits give full credit to Baltimore County for annual depreciation and plant contributed where Baltimore County shares equitably in the City's total accumulated depreciation reserve.

The City's next witness was Henry G. Mulle, an independent financial and economic consultant with his own firm, specializing in risk analyses, cost of capital, and fair rate of return in public utility rate proceedings. His employment experience includes some eight years with waterworks service companies. His assignments have familiarized him with utility systems including American Waterworks, General Waterworks, and other water companies.

His testimony dealt with the "cost of capital "for Baltimore City in furnishing water service to its customers. His study covered the period from the late 1970's to the present to develop the costs of debt and of equity during that period. He found that the embedded cost of debt has averaged 4.3%, while new bonds today would cost about 7.8%. Where his equity cost rate has averaged 9.8% over the same period, his overall 1989-90 capital cost rate (after weighting) is 7.11%.

Mr. Mulle supports a shift to a utility basis of price regulation because it is the most certain way for a municipal utility to recover its full effective cost of service, including the cost of its equity investment in its plant. It is his opinion that this shift is not unique to Baltimore where American cities can no longer afford to provide public services to non-residents at less than cost (including cost of equity). His schedule (HGL-16) shows other municipalities in 17 other areas with returns greater than Baltimore's.

The County's opposition witness was Dr. John J. Boland, a Professor in the Department of Geography and Environmental Engineering at The Johns Hopkins University with extensive experience in utility ratemaking, including cost and rate studies for a number of water utilities.

His conclusion is that while the Metropolitan District may benefit from what may be termed equity capital in the City's water utility, the City does not bear the cost of that capital and is not entitled to earn a return on it. This is because there are no investors in the City water system, although Dr. Boland finds that there is a use of equity capital in that system. This capital is the result of involuntary customer contributions obtained primarily from the discrepancies between debt principal payments and depreciation charges.

Dr. Boland opines that since these transfers are involuntary, the City needed to do nothing to attract or retain this capital and so no return is applicable to customer-contributed equity capital. He does admit that all rate payers, i.e., customers, benefit from the existence of equity in the utility, primarily cost savings from lower-cost debt capital.

However, as he sees it, where the City-County Agreement insulates the City from all financial risk as regards County customers, there is no need for any reserve fund equivalent to an equity capitalization.

Testifying in rebuttal to Dr. Boland, Mr. Mulle stated that the fact that equity capital exists on the balance sheet of the City's water system governs its getting a return on that capital if the necessary debt capital is to be attracted at reasonable rates. He also quotes Bonbright that "cost" must include a capital-attractive rate of return on the total investment so a return on equity is part of the cost of Capital and of operations.

Mr. Mulle pointed out that there is an equity capital base provided by the City taxpayers, who have the ultimate overall, total risk of the enterprise. For him, there must be revenue to cover the risk by meeting all costs of operation, including a return on equity, which is not "profit", but a "cost" in the regulatory/utility sense.

Mr. Mulle concluded his rebuttal to Dr. Boland's testimony by declaring that the shift from cash-based to accrual accounting since 1980 has made a rate of return/rate base method a necessary change in defining the overall cost of service for most municipal enterprises. He says that the time has passed for this change to be recognized in the Agreement between the City and the County.

The third and last witness for the City was Jerry Silhan, Chief of the Water Engineering Division of the

Baltimore City Bureau of Water and Waste Water. He has been employed by the City since 1962. He has the degree of Bachelor of Science from The Johns Hopkins University, is a registered Professional Engineer in the State of Maryland, and a member of the American Water Works Association.

Mr. Silhan gave a historical overview of the relationship between Baltimore City and Baltimore County in the area of water supply, including the 1972 Agreement and the annual statements issued pursuant to that Agreement.

The Baltimore County Metropolitan District was created in 1924 by act of the Maryland State Legislature. The present day boundaries of the District reflect a great deal of extension since 1924, which continues today due to increasing development in the County. Under that act, the City was required to make extensions of water supply lines for and in the District whenever and wherever requested by the County. The City was required to make the extensions at cost (to include a proper charge for overhead). Water service rates were to be established by the City for all customers, such rates to be based on the cost of providing service (without defining "cost").

In 1945, another act amended the provision regarding the cost of water service, requiring the City to furnish water to County customers at cost, entirely without profit or loss. In 1972, the City and the County entered a formal written agreement (entered in evidence as Schedule JS-3, part of City Exhibit 6). Under that agreement, each party is responsible for the construction of new facilities within its own borders, but the City is responsible for construction of the central system facilities. Costs of such construction are to be shared by agreement, but no formal agreements have been consummated. The City has spent millions of dollars on central system improvements with Baltimore County sharing those costs on a current year volumetric basis.

Back in 1953, a joint board found that the area's residential and industrial growth was outstripping the capacity of the system's feeder mains. At that time the City's population peaked, while that of Baltimore County has continued to grow so that by the year 2000 the estimated service populations of the City and the County will be substantially equivalent. Usage of water has grown in the County to 101.3 MGD in 1988 versus 138.9 MGD in the City. The result is that the County is now using excess capacity in raw water source, filtration and distribution system facilities that the City had previously provided for its own anticipated growth.

Mr. Silhan says that there are substantial facilities that are used and useful in rendering water service to the County for which the City has not been compensated because they were financed and built prior to 1972 and the County is paying only on a volumetric basis. Many of the upgrades and improvements to the water system were necessitated by the development occurring in the County. Much of this construction was financed by the City through general obligation bonds. Under the debt service method, once the bond has been paid off, the

County ceases to reimburse the City, but continues to benefit from these facilities constructed to benefit county customers.

Under the 1972 Agreement, the parties prepare jointly an Annual Statement of Cost with the County paying any deficit to the City when operating costs exceed revenues, while the City remits the difference to the County when revenues exceed those costs. According to Mr. Silhan, the volumetric sharing of debt service under this procedure does not fully compensate the City for its past investment.

The City undertook to get the County to change to the utility approach as a fair and equitable way for the County to reimburse the City. The County took the position that any rate of return earned in excess of actual interest paid out by the city for County-used facilities would be profit. In 1982, the parties agreed that the arbitration provided by the 1945 Act and by the 1972 Agreement should be the way to resolve their differences.

However, no progress was made on going to arbitration so the City filed a mandamus action in 1987 to compel the County to arbitrate. In 1988, the Court of Appeals of Maryland affirmed the order of the Circuit Court for Baltimore County to proceed to arbitration. Since that time, it appears that the parties have been engaged in preparing their respective cases for arbitration, including the selection of the arbitrators.

The only challenge made by the County to Mr. Silhan's testimony and exhibits appears to be the contention in the AUS Report (County Exhibit 6) at page 21 that the City had an "over-built" water system initially designed for heavier City usage, which is not "over-built" today because County customers have "picked up the slack "through their growing usage. In his rebuttal testimony to this, Mr. Silhan points out that the City has had a legal obligation to provide water service to County customers since 1924 and built its system over the years to meet the growth and projected growth of the entire Metropolitan Area of Baltimore.

IV. Findings of Fact

1. Baltimore City, Maryland, is a body corporate and politic of the State of Maryland legally denominated as the Mayor and City Council of Baltimore (hereinafter "the City").

2. Baltimore County, Maryland is a separate corporate body politic of the State of Maryland so named (hereinafter called "the County").

3. The County adjoins the north, east, west and part of the southern boundaries of the City as shown by Schedule JS-1 of the City's witness, Jerry Silhan.

4. In 1853, the City was given the power of condemnation to acquire real estate for its water system, which was not restricted to land within the City. Subsequently, it acquired the properties, which have been and are now, the two principal reservoirs of its water system (Loch Raven and Prettyboy), each being in the County.

5. When the City extended its geographical limits by annexation in the year 1918, there were nine private water companies operating in the parts of Baltimore County acquired. These water systems were not designed to match the City's system and the City had to spend large sums to rehabilitate and improve them.

6. Four years later (1922), the first legislation was enacted by the Maryland General Assembly giving the County the right to hook into water lines into the City's water mains at the County's expense. Payment to the City for this service was the actual cost of delivering the water at the points of connection and meter with five per cent added and the actual cost of purifying the water with five per cent added, such costs to be determined by the Maryland Public Service Commission.

7. The Metropolitan District Act was enacted in 1924 by the Maryland General Assembly. It created the Metropolitan District of Baltimore County for the purpose of a water supply and sewage system within the District to be connected and to be part of the City's water and sewage systems. The City was required to extend water supply lines for and in the District whenever and wherever requested by the County. These extensions were to be made at cost and including a proper charge for overhead. Operating control was vested in the City with authority to establish rates for consumers in the District, such rates to be first approved by the Public Service Commission.

8. In 1931, a jointly sponsored cost study of the water system was completed by Dr. Abel Wolman for the County and Ezra B. Whitman for the City. This put cost allocation for both fixed and variable costs on a volumetric basis with fixed costs determined at original cost, reflected by outstanding indebtedness. At that time, a volumetric allocation was thought to be appropriate because the County's use of only 2% of the water system was considered insignificant and not having a major effect on plant capacity. The report was silent on the apportionment of the cost of major capital improvements to the water system.

9. In the year 1945, the Maryland General Assembly amended the Metropolitan District Act to provide what are its present terms, particularly Section 332 (c) as follows:

"The Mayor and City Council of Baltimore shall furnish water to the Metropolitan District of Baltimore County at cost and entirely without profit or loss. The Commissioners and the Mayor and City Council of Baltimore shall, from time to time, determine by agreement, if possible, the cost to Baltimore City of furnishing water to consumers in the Metropolitan District of Baltimore County. If no agreement is reached, then cost shall be determined by arbitration in the manner herein provided in Section 329. Cost, however, determined, shall be subject to revision from time to time by agreement of the respective authorities, or by arbitration on the demand of either of them."

10. Prior to enactment of the 1945 statute, there was a proposed amendment offered by the County's delegation that would have expressly prohibited a return on the City's investment in its water system. This amendment was not adopted.

11. Also, before the statute passed, the Baltimore Sun reported that the then City Solicitor, Simon Sobeloff, stated, during negotiations over the legislation with the County's representative, that he believed it to be true that the City had made a profit and that it was not fair to charge more than the water cost the City. This followed newspaper reports of claims by the Baltimore County Legislative Delegation that the City was earning more than $600,000 a year off of water supplied to County residents.

12. Due to increased development in Baltimore County after the year 1945, water shortages had occurred there. A Board of Advisory Engineers on Future Water Supply was created in 1951 for the City and the County.

13. In its 1953 report, the Board found that the water shortages were not of recent origin, but rather were the result of poor supply conditions in Baltimore County dating from before the time Baltimore City began operating the properties of the former Baltimore County Water and Electric Company. Although the City had financed the extension of feeder mains into County areas to interconnect and reinforce the water distribution systems in and to the County communities, the area's residential and industrial growth was outstripping the capacity of the feeder mains. The Board found that:

> if the Baltimore water distribution system is not immediately improved so that suitable water pressure can be maintained under peak demand conditions, the expected industrial development commensurate with the obvious industrial potential will not materialize. New industries will be discouraged and expansion of present manufacturing and processing plants will be deterred.

14. Pursuant to the recommendations of that report, the Susquehanna River Supply project was undertaken.

15. Another study on the cost of Furnishing Water Service to Baltimore County by Baltimore City was published in

1962. This study affirmed the principles of the 1931 report and recommended that they be continued.

16. Over the years until 1972, the City and the County had agreed informally on the determination of the cost of the City's furnishing water to County residents, modifying that determination from time to time. In 1972, they entered a formal written agreement which embodied the accumulated informal understandings. (Note: A copy of the Agreement is Schedule JS-3 part of the City's Exhibit 6).

17. The 1972 Agreement apportions responsibility for operation and repair of the total water system. The City is responsible for almost all of the operation and repair of the system, including the County's pumping stations, pipelines, reservoirs, meter reading, etc. County personnel perform some minor maintenance on the system located in the County. The Agreement provides a detailed breakdown of cost responsibility and the County reimburses the City for those operations in and benefiting the County. This includes the City's engineering services, field inspections, investigation of complaints, repair of water meters and all other services performed by City personnel for the County.

18. The 1972 Agreement does not cover the costs of new central system facilities. The cost for the rehabilitation of existing central system facilities is shared volumetrically. New filtered water facilities

that are built to benefit only one party are the responsibility of that party. For new facilities that are built to benefit both the City and one or more Counties, the cost responsibility is divided according to projected future use of the facility.

For all new construction, each political subdivision makes concurrent cash contributions for their share of costs as the facilities are constructed. This applies whether or not the project is allocated volumetrically or by future use.

For improvements which were finished or under way prior to June 30, 1970 and the capital expenditures are included in the 1970 Annual Water Statement for allocation of debt service, the apportionment is continued in the same manner as it was prior to 1970. Some of these allocations for mutually beneficial projects were done according to future use, but the majority of expenditures were allocated volumetrically.

19. To finance the construction and improvements to facilities serving both the City and the County, the City issued general obligation bonds which are paid for by City taxpayers. The life of the general obligation bonds is shorter than the life of the facilities financed by the bonds. This results in the bonds being amortized over a shorter period and paid off long before the end of the facility's useful life. As stated before, prior to 1972 most of the County's share

of the financing costs was allocated on a volumetric basis which did not adequately compensate City taxpayers for the County's ultimate responsibility for use of city funds during each bond's amortization period.

20. For facilities constructed after the 1972 Agreement, the City is compensated for construction costs because the City now requires the County to pay its share of those costs concurrent with construction. Under the proposal advanced by the City, the County's capital payments for post-1972 facilities would be credited to the proposed rate base and, hence, excluded from any cost of capital or depreciation expense charges. Nevertheless, there still are substantial facilities that are used and useful in rendering service to the County for which the City has not been compensated because they were financed and built prior to 1972 and the County is paying only on a volumetric basis.

21. The 1953 Report recommended significant improvements, at that time projected to cost more than $25,000,000, due to increased consumption by residences and businesses located in the County. The report found that "in the last decade, water consumption has increased more rapidly in the Towson area than in any other part of the Baltimore County Metropolitan District. This area is still growing apace and its potential for growth is great: (1953 Report, p. 57).

In addition, the report found that inadequate suction pressure at the Catonsville Pumping Station could be corrected "only by increased facilities in a zone of lower elevation" (id.). The report also found inadequate pressure in various parts of Baltimore County and, to correct these deficiencies, recommended upgrades to the existing water system, as well as installation of additional mains (id., pp. 55-58).

Much of this construction was financed by the City's residents through the general obligation bonds, even though much of the construction was for the primary benefit of County residents. The County's level of payment is derived from a volumetric allocation which is based on its water consumption. Under the debt service method, once the general obligation bond has been paid off, the bond is removed from the allocation and the County ceases to reimburse the City for use of the City's funds. Nevertheless, the County continues to benefit from these facilities which were constructed to benefit County residents.

22. The City's water Utility is a separate utility within the City's Bureau of Water and Waste Water, one of four bureaus in the City's Department of Public Works. Effective July 1, 1979, an amendment of the Baltimore City Charter established the Utility as a separate enterprise to be self-sustaining and operated without profit or loss to other funds or programs of the City.

23. This Water Utility supplies water to the City, as well as portions of Baltimore, Anne Arundel, Carroll and Howard Counties. It serves over 1,500,000 people by supplying approximately 97 billion gallons of water annually. Approximately 56% of its customers and usage are currently located within the City so the remaining 44% are in the surrounding County service areas. (Note: as of June, 1990).

24. Estimates of service area population and water usage for the years 1980, 2000, and 2025 are as shown at Page B-15 of the County's Exhibit No. 2 (Prospectus for the 1990-A Bond Offering) as follows:

		City of Baltimore	Percent of Total	Counties[2]	Percent of Total	Total
1980:	Population	786,800	52.1	722,900	47.9	1,509,700
	Water Use	150 mgd[1]	60.0	100 mgd	40/0	250 mgd
2000:	Population	757,400	46.1	884,800	53.9	1,642,200
	Water Use	156 mgd	49.7	158 mgd	50.3	314 mgd
2025:	Population	738,000	39.6	1,128,000	60.4	1,866,000
	Water Use	160 mgd	44.5	200 mgd	55.5	360 mgd

25. As shown by the City's Exhibit 6-Schedules JS-4 and JS-5, since the year 1950, the growth of population and the companion growth in consumption of water has been mostly in the suburban areas of Baltimore City, particularly Baltimore County. By the year 2000, the City's population is estimated to be 757,000 while the estimated service population of Baltimore County is 723,940.

[2] Baltimore, Anne Arundel, and Howard Counties.
[1] million gallons per day

26. This growth trend in population of the Baltimore Area is reflected clearly in the water consumption by the respective governmental entities. Schedule JS-5 shows consumption, i.e., annual water demand for the period 1950-1988.

27. As shown by this Schedule and as testified by the City's witness, Jerry Silhan, Baltimore City's demand has declined from 161.7 million gallons per day ("MGD") in 1950 to 138.9 MGD in 1988. Baltimore County's demand has increased from 17.7 MGD in 1950 to 101.3 MGD in 1988. Expressed on a volumetric percentage basis, the demand also is showing a reversal over the same period of time. In 1950, Baltimore City used 89.9% of total system demand, compared to Baltimore County's 9.8%. In 1988, Baltimore City used 52.5% compared to Baltimore County's 38.30%. In 1950, Baltimore County's volumetric percentage was just under 10%. 38 years later, its percentage has climbed to 38%. Thus, in less than 40 years, the County's volumetric percentage has nearly quadrupled. Baltimore County's use of the central system facilities is approaching equality with the City's use.

28. Customers in the Metropolitan District of Baltimore County are served through individual meters, but are billed by the City at rates set by the County rather than on the basis of the Rates and Charges established by the City.

29. While the City had executed the 1972 Agreement with the County, the then chief of its Water Engineering Division did not like its terms. It was noted that, over the previous ten years, the water consumption in the City had decreased in relation to the use of water in Baltimore, Anne Arundel and Howard Counties. To review the arrangements between the City and the County, the firm of Black & Veatch was engaged.

30. Black & Veatch submitted its report in February, 1978, which was under the direction of Howard J. Lobb, one of the City's witnesses in this proceeding.

31. The report recommended adoption of the utility basis approach to provide a return on the annual cost of capital devoted to water service, saying:

> "The value of the facilities in service is a measure of the capital which the owner has immobilized in commitment to providing service. If the owner could liquidate this capital through the sale of the facilities, he would have the equivalent capital to invest to offset other capital requirements at current costs of money. The current costs of capital, together with appropriate recognition of costs related to ownership risk, normally represents the return element of cost of service for a municipally-owned utility."

32. The report had found that the City's Water Department needed a 2-3% annual revenue increase to meet anticipated future expenses and that the required adjustment be made to water sales receipts from the political subdivisions (including Baltimore County). Otherwise, the revenue deficiency would have to be met by increased revenue from charges to City of Baltimore customers.

33. The year after the Black & Veatch report was published, the City's then Mayor wrote the respective County Executive of Anne Arundel, Baltimore and Howard Counties under date of August 10, 1979, saying:

> "owing to a continual decline in the City's population and water consumption, we believe the [methods which have evolved during the last 20 years for apportioning costs of new facilities] are now inequitable." Noting that the City had for more than 100 years financed construction of the water system through the sale of its general obligation bonds and that these past investments have purchased "a capacity in the system far beyond the expected City needs, the City cannot justify any further expenditures to build additional capacity that will be used to meet growing water demands in the

Counties, nor can the City permit the Counties to utilize existing system capacity without compensation."

34. In 1981, the then County Executive of Baltimore County responded by a letter opposing the utility method of accounting for costs of the water system, interpreting as "profit" any rate of return earned in excess of actual interest paid out by the City for county-used facilities, while objecting to the depreciation schedules.

35. The City's then Mayor responded by letter dated September 9, 1982, concluding that the Black & Veatch approach provided an equitable answer to prior City investments and the Mayor requested initiation of arbitration proceedings.

36. One month later, by letter dated October 8, 1982, the County Executive agreed that arbitration appeared to be the only way remaining to resolve the differences over determination of costs, stating that "any change in the 1972 Water Agreement should cover events from this time forward."

37. The City's proposed amendments to the 1972 Agreement (requested by the County's letter of October 8, 1982) were forwarded to County by letter dated November 16, 1982, requesting immediate negotiations or proceed to arbitration. It concluded that: "It is most important to the financial integrity of the water system that this matter be resolved at the earliest possible date."

38. Notwithstanding, over four and a half years passed, during which there were discussions between the parties and further requests by the City's Mayor for arbitration, many of which received no response from the County. Then, under date of July 14, 1987, contrary to its earlier agreement to proceed to arbitration, the County advised the City by letter that it would not do so (i.e. arbitrate).

39. On July 31, 1987, the City filed its Complaint in the Circuit Court for Baltimore County against the County to compel arbitration. After a hearing before Judge John Fader of that Court, he ordered the County to proceed to arbitration by judgment entered December 2, 1987. The Judge also ordered the County to select its arbitrator on or before January 20, 1988 (the City having previously done so with the County so advised).

40. Unconvinced, the County appealed, but the Court of Appeals of Maryland, by per curiam order on September 15, 1988, affirmed the judgment below. The City then had to get Judge Fader to order the County to designate its arbitrator by November 14, 1988, which was done.

41. Thereafter, counsel for the parties negotiated between themselves selection of a chief arbitrator, which was accomplished in March, 1990, after which these proceedings went forward on a schedule of mutual agreement.

42. Hearings were held in December 1990, after which briefs were filed and then oral argument heard May 8, 1991, with this matter then submitted for decision by the Board of Arbitration.

43. During almost nine years since the City first demanded arbitration in 1982, it has honored the 1972 Agreement and continued to provide water service to its County customers, even paying back monies to the County shown to be due by the year-end "true-up".

V. Conclusions of Law

1. This arbitration is subject to common law rules of arbitration and is a quasi-judicial proceeding.

2. The arbitrators are not bound by the Maryland Rules of Procedure or of admission of evidence.

3. The arbitrators may make a retroactive award in this proceeding.

4. Chapter 539 of the Acts of 1924 created the Metropolitan District of Baltimore County and authorized Baltimore City to construct water supply lines and a sewage system within the District. Under Section 6 of the Act, as soon as the water extensions had been constructed in the District, operating control became vested in the authorities of Baltimore City.

5. In 1945, the 1924 Act was repealed and reenacted by Chapter 1017 of the Acts of 1945 with amendments to certain sections, one being Section 332 (c) reading as follows: "The Mayor and City Council of Baltimore shall furnish water to the Metropolitan District of Baltimore County at cost and entirely without profit or loss. The

Commissioners and the Mayor and City Council of Baltimore shall, from time to time, determine by agreement, if possible, the cost to Baltimore City of furnishing water to consumers in the Metropolitan District of Baltimore County. If no agreement is reached, then cost shall be determined by arbitration in the manner herein provided in Section 329. Cost, however determined, shall be subject to revision from time to time by agreement of the respective authorities, or by arbitration on the demand of either of them."

6. Under the statute, the parties (Baltimore City and Baltimore County) may agree on any methodology or accounting principles to be used in determining "cost".

7. If the parties are unable to agree as to the determination of "cost", that is to be determined by arbitration and so is to be determined in this proceeding.

8. "Cost", as set forth in the statute, does not include "profit", which means net income after expenses, so the City cannot receive a return on its equity investment because of the statutory prohibition of "profit".

9. "Cost" may include depreciation and that is a proper expense of "cost" under the utility basis for determining costs. The statute's use of "cost" allows depreciation to be taken in that determination.

10. The statute (Metropolitan District Act) makes the determination of "cost" subject to revision from time to time.

11. Baltimore City and Baltimore County are not partners in the provision of water service to the Metropolitan District by Baltimore City. The District's water users are customers of the City's water system utility and the County is their agent in the provision of water service to them by the City.

12. The utility basis methodology is a reasonable method of determining the cost of providing water service to the Metropolitan District of Baltimore County but must exclude return on equity capital as "profit"

13. The functional cost allocation proposed by Baltimore City and accepted by Baltimore County for the Metropolitan District of Baltimore County is reasonable and properly allocates to the Metropolitan District of Baltimore County its proper share of operation and maintenance expenses.

14. The Metropolitan District of Baltimore County is not, and has not been, paying to Baltimore City the full cost of providing water service to Baltimore County as required by the Metropolitan District Act, when the utility basis method is applied (excluding return on equity).

15. It is within the Board's authority pursuant to Issue No. II, as submitted by the parties, to award retroactive implementation of the utility basis methodology (excluding return on equity) and functional cost allocation.

16. Cost, as set forth in the Metropolitan District Act, henceforth shall be defined by the utility basis methodology (excluding return on equity) and functional cost allocation. Baltimore City and the Metropolitan District of Baltimore County immediately shall revise the 1972 Agreement to so provide.

17. The definition of cost, as set forth in Paragraph 16, shall be deemed to have been implemented in fiscal year beginning July 1, 1983.

18. The Metropolitan District of Baltimore County shall pay to Baltimore City the cumulative sum of the amounts due to Baltimore City beginning with the fiscal year 1983 with interest to accrue at the statutory rate of 6% per annum

beginning sixty (60) days from the date of decision until the date of payment.

19. The arbitrators have authority to provide for interest on the monetary award herein.

VI. Decision of Arbitrators

A. The Board of Arbitration has the power and authority to change the method of determining costs

The parties (the City and the County) have stipulated that the threshold issue for arbitration is: "What is the proper method, under the Metropolitan District Act, for determining the cost to Baltimore City of furnishing water to consumers in the Metropolitan District of Baltimore County."

Yet the County has taken the position that the Arbitrators may not order any change to the Agreement dated September 20, 1972 between the parties (which embodies the historic debt-service methodology for determining costs) unless certain findings were to be made from the record. (See pages 53 and 54 of the County's Brief).

That position is contrary to the stipulation. It is contrary to the Metropolitan District Act's provision-repeated in the 1972 Agreement-that the Arbitrators may amend the agreement if proceedings are initiated, as they have been-where either party demands arbitration, as the City did in 1982. Further, such position appears contrary to the decision and opinion of Judge Fader in the 1987 action brought by the City to compel arbitration.

Even if the County's position were sound, the Board has concluded that the City is clearly not recovering its actual costs of service through the current debt-service methodology and that changes in usage alone have mandated adoption of the utility basis for determining costs. The County's third condition that the Board determine if the Public Service Commission would adopt that basis is irrelevant and facetious.

B. This is a cost-of-service proceeding

This is not a rate case, i.e. a determination of the rates which customers in the Metropolitan District should have paid or should pay now or in the future. The parties determine the rates paid or to be paid by these customers, subject to approval by the Public Service Commission of Maryland under Section 34-25 of the Metropolitan District Act.

Rather, this proceeding is to determine the "cost-of-service" for these customers, who constitute a class of customers of the City, based on political boundaries and the 1945 Statute, as amended, and as supplemented by the 1972 Agreement.

Black & Veatch were employed for this hearing by the City, not to develop rates, but to develop the cost of providing service to Baltimore County and that is what they did (T.40).

As part of their analysis to determine that cost, they had to determine the costs to every class of customer on the system which they did by a prorata allocation of the total cost to all the different jurisdictions (T.93-4).

C. The Utility Basis is the better method for developing costs for service to another political jurisdiction

Historically and under the 1972 Agreement to date, the parties (City and County) have used the cash or debt service methodology to determine the City's cost of service to customers in the Metropolitan District of Baltimore County.

In the early history of water rates, the utility operated out of the municipality's General Fund (T.53). For some years now, the City's Water Division has been an Enterprise Fund. Over the years, there has been a trend to base charges for water service on costs and the better manner to develop those costs is the utility basis, particularly where service is provided to other jurisdictions (T. 53-4).

Today, the majority of water utilities are under an enterprise fund basis and they are designing rates to cover their cost of capital on the utility basis (T.158-9).

The American Water Works Association (AWWA) is an organization of people involved in the water industry. It is recognized as the first and foremost water organization in the United States (T.142). It now has a number of manuals associated with developing rates and financing of water utilities (T.144) and they are recognized as the "bible of water rate making throughout the country" (T. 144).

AWWA endorses the utility basis of cost allocation to determine cost-of-service to customers in a particular political jurisdiction receiving water service from another. The <u>AWWA Revenue Requirements Manual M35</u> states the following on page 4:

"<u>Utility Approach</u>

> The utility approach to measuring revenue requirements is mandated for all investor owned water utilities and mandated or permitted for government-owned utilities in states where the utility is under the jurisdiction of state commissions or other regulatory bodies.
>
> The term "utility approach" or "utility basis" tends to have two uses in water utility rate making. One use involves the measuring of the revenue requirements of a utility, without concern for the allocation of those requirements among classes of customers served. Utility based revenue requirements may consist of operation and maintenance expenses, depreciation expense, return on rate base, and taxes and or other payments to the municipality's general fund. The second use of the term "utility basis" in rate making is in allocating revenue requirements, or total costs of service to be derived from water rates, among the classes of customers served."

See also the AWWA Water Rates Manual M1 (Second Edition, 1972) at pages 6 and 7:

> "Revenue Requirements of Suburban Areas
>
> Where water service to suburban areas is supplied by municipally owned utilities, it is suggested that the basis for rates in those areas should be determined on the utility basis. The assumption may be made that the water utility is the property of the citizens within the municipality and that outside users should pay a rate providing for operation and maintenance expense, plus local taxes, depreciation, and a reasonable return on the value of all property devoted to the service of the user outside the city. Such property would include an appropriate share of all production, transmission, and other facilities required to produce and transmit the water to that user, but would exclude those distribution mains and customer and fire facilities provided solely for serving the area within the City."

The AWWA Revenue Requirements Manual M 35 (First Edition, 1990) further states at page 5:

> "As described in Manual M1, the utility basis of cost allocation is an appropriate method for calculating the costs of service applicable to all classes of customers. It is particularly applicable to those customers located outside the geographical limits of a government-owned utility. **When a government-owned utility provides service to customers outside its geographical limits, the situation is similar to the relationship of an investor-owned utility to its customers because the owner (political subdivision) provides services to non-owner customers (customers outside its geographical limits). In this situation, the government-owned utility, like an investor-owned utility, is entitled to a reasonable return from non-owner customers based on the value of its plant required to serve those customers.** Some states have laws or guidelines intended to regulate the rates that government-owned utilities charge customers located outside their limits." (emphasis furnished)

D. Recommendations of the parties

The city's witness, Howard J. Lobb, testified in favor of the use of the utility basis and presented exhibits applying this method to the financial statements of the City's Water Division for the past ten years. In his rebuttal testimony, he stated why the City believes that capital costs for outside City non-owner customers should be recovered through depreciation expense and rate of return applied to allocated rate base:

> "The City has over the years made investment in the water system to serve both inside and outside City customers. The City is entitled to reimbursement from outside City customers based on the portion of facilities used by outside City customers. Charging the County

capital costs on a utility basis for annual depreciation expense and return provides the City the opportunity to recover its capital costs based on units of service which should reflect the estimated ultimate use of facilities by outside City customers.

It is the City's prerogative as to the method of water utility financing it chooses. The City may elect to revenue finance or debt finance improvements over a short or long period of time or pay for improvements out of general tax revenue, and the method of financing may change or be restructured. The method chosen will determine the level of water rates charged to inside City customers. Because outside City customers have no voice in controlling City financing decisions, they should be insulated from the method of financing chosen by the City. The utility basis of charging for annual depreciation expense and return minimizes the impact on outside City charges of the method of financing of water facilities chosen by the City. This is because outside City customers are charged annual depreciation expense and return only on their allocated rate base.

"Outside City customers should pay through charges for annual depreciation expense for the value of facilities financed by the City which is used up during the year or which is lost due to decay, inadequacy, or obsolescence. They should pay a return on the City's investment devoted to serving the outside City customer the same as a non-owner customer should pay a return to an investor-owned utility which utilizes and commits its funds to provide service to those non-owner customers."

"The utility basis of cost allocation is a generally accepted methodology for assignment of cost among customers of a municipally owned utility and has been endorsed by the American Water Works Association."

The County's witness, Paul R. Moul, opined that a shift to a rate base/rate of return method (i.e. the utility basis) is not an appropriate charge for establishing revenue requirements for the Metropolitan District. He testified:

"No. Rather, debt service is both the historically accepted and appropriate methodology to use to determine revenue requirements for Metropolitan District water customers. The debt service method is particularly well suited for municipally-owned utilities. The

> debt service approach fulfills the capital attraction standard used by the financial community to determine revenue adequacy. Standard & Poor's Corporation, a major bond rating agency, has indicated that debt service coverage is the key to financial analysis for municipally-owned utility systems issuing revenue bonds--a procedure followed by the City of Baltimore."

To this, Mr. Lobb replied that debt service by itself is not necessarily adequate to determine total capital cost cash needs, saying:

> "The current method of assigning volume related capital costs to Baltimore County based on current year's usage is inadequate. This is because the County's percentage usage of the capacity of joint use facilities has increased over time, and since historically the County has only been charged capital costs in proportion to its usage in a particular year, the County has cumulatively over history underpaid the City. There is no way in the current Water Agreement for the City to fully recover from the County the County's total share of the cost of joint use facilities."

E. <u>The Conclusions and decision of the Board</u>

The Board concludes that the utility basis method is the proper measure of the revenue requirements of the City's Water Division. It has become the preferred method for municipal utility operations which provide service to customers outside of the City limits. Its handling of capital related expenses substitutes long term depreciation for annual estimates of cash flow that can vary widely from year to year. This handling of capital related expenditures also allows the recovery of initial capital investment from future customers, an important consideration where the Metropolitan District's usage has grown so much and will continue.

F. Effect of the Metropolitan District Act

The Metropolitan District of Baltimore County was created by the Maryland General Assembly in 1924 requiring the City to extend water supply lines for and in the District whenever and wherever requested by the County, doing so "at cost, and including a proper charge for overhead" with water services rates for District customers to be first approved by the Maryland Public Service Commission.

In 1945, another statute was enacted by the General Assembly. Section 332(c) of the 1945 Act provides:

"The Mayor and City Council of Baltimore shall furnish water to the Metropolitan District of Baltimore County at cost and entirely without profit or loss. The Commissioners and the Mayor and City Council of Baltimore shall, from time to time, determine by agreement, if possible, the cost to Baltimore City of furnishing water to consumers in the Metropolitan District of

Baltimore County. If no agreement is reached, then cost shall be determined by arbitration in the manner herein provided in Section 329. Cost, however, determined, shall be subject to revision from time to time by agreement of the respective authorities, or by arbitration on the demand of either of them."

Under the utility method for determining the revenue requirement, also known as the rate base/rate of return method, a utility is entitled to a return on its equity capital.

The threshold and critical question in this proceeding is whether or not a return on the City's equity in its Water Utility is a "cost" or a "profit" within the meaning of the 1945 Act.

To answer this question, one must go back to the year 1945 and decide what the General Assembly intended by these words in the circumstances preceding and attendant to the enactment of Section 332(d). The evidence of record is found in the Journal of Proceedings of the House of Delegates of Maryland and certain newspaper articles in the Baltimore Sunpapers. The latter show that Baltimore County officials and legislators were seeking lower water rates where the City was said to be making more than $600,000 a year. They also show that the then City Solicitor, Simon Sobeloff, believed it true and so stated that "rates are excessive and yield the City a profit". On the other hand, the Journal extracts show that the legislation included, at one point before enactment, a provision "to exclude from the determination of Baltimore County water service costs any return to Baltimore City on its capital investment in water facilities", which provision was deleted before final enactment.

The City argues that this deletion evidences legislative intent that there be no prohibition of a return on the City's equity investment. Its Reply Brief cites various Maryland appellate decisions for the proposition that "while a committee's rejection of an amendment is clearly not an infallible indication of legislative intent, it may help for understanding of overall legislative history" citing NCR Corp. v. Comptroller 313 Md. 118, 544 A. 2d 7764 (1988) as the current state of the Maryland law. At best, the deletion is some evidence of legislative intent.

Taking into account, the history of the situation, that is, the parties themselves, Baltimore City and Baltimore County, the commencement and continuation of the supply of water by the City to the County with the City's operating from its General Funds and with no accounting after 1936, the admission of excessive rates and profit, the use of methodology set forth in the Whitman-Wolman Report of 1931, and other circumstances, a majority of the Board concludes that the word "profit" meant and means "the excess of income or revenue over expenditures" Webster's International Dictionary - Second Edition cited in U.S. Mintzes 304 F. Supp. 1305 (D. Md. 1960). See also Kaufman v. Liss 186 Md. 634 (1946) to the effect that "profits" arise after provision of expenses.

"In construing the meaning of a word in a statute, the cardinal rule is to ascertain and carry out the intent of the General Assembly. It is well settled that when the Legislature has chosen not to define a term used in a statute, that term should be given its ordinary and natural meaning". Dean v. Pinder

312 Md. 154 at 161, 538 A.2d 1184. In the present statute, there is no definition of the word "profit".

While a return on invested equity may be a cost for rate-making purposes of a utility operation, it is not an actual expenditure. In 1945 the members of the General Assembly were not dealing with a utility, but with a large municipality that they intended to be paid its actual costs, but no "profit" or income over expenses in supplying water to this particular neighboring county. Indeed, the City's own witness, Henry G. Mulle, speaking of profit in the sense of a utility, says (T. 334): "My definition of profit, which is a return on equity".

A majority of the Board agrees with the County's witness, Paul R. Moul, that the cost of equity is not a cost on the financial statement. Rather, "profit" is the amount shown at the bottom of that statement reflecting a return on equity (T.761-763).

In giving the term "profit" its ordinary meaning, it is clear to a majority of this Board that allowing the City to earn a return on the equity interest in property used to serve the County would permit the City to profit on its sale of water to the County. In public utility terms, it is the rate of return on common equity which is the traditional source of profit to the utility which is used to pay dividends, that is, to compensate the owners of the utility, its shareholders. While the dissent argues that a return on equity is a cost, just like any other cost to a utility, the analogy to the City's water operation fails. The City is not a public utility, nor is its water operation. While it is the majority's view is that the proper method of accounting in order to permit the City to recover its costs is that of public utility accounting, we must construe and apply the statutory mandate that the service be provided "entirely without profit or loss." The City water system is not a public utility. It does not have individual investor owners. It is statutorily prohibited from earning a "profit" from its sale of water to the County. So if we accept the City's contention that it should be treated as a public utility for its accounting purposes, as we have, we must similarly deny the City the opportunity to reap a profit from its selling of water to the County by denying it any return on equity, the source of public utility profits, in order to carry out the mandate of the statute.

G. <u>Application of the Board's decision</u>

The Board's decision is that the utility basis method is the proper method of determining the costs of the City's Water Division, and, according to the majority decision, there can be no return on its equity capital as far as customers in Baltimore County's Metropolitan District are concerned, because of the prohibition of any "profit" in the present Metropolitan District Act.

This means that the City is free to include a return on that equity in determining charges for water to other customers, including its own citizens and the other surrounding counties that are supplied water by the City.

It also suggests that the City seek relief from the Maryland Legislature if it wishes a return on its equity in its revenue requirement for its Baltimore County customers.

It must be noted that use of the utility basis permits the inclusion of depreciation expense with the concomitant removal of Baltimore County's obligation to participate in the direct payment of principal and interest on bonded indebtedness of the City heretofore jointly shared on a volumetric proportionate basis by the County and the City. Inclusion of depreciation expense will substantially benefit the City, as hereinafter set forth. (Note: this does not relieve the County of its obligation to pay its proportionate share of the embedded cost of the City's debt used to fund construction of jointly used plant and equipment).

Determination of depreciation expense requires determination of the values at the appropriate valuation dates of the City's property used and useful in furnishing water to consumers in the Metropolitan District. The Board has prepared an Appendix to this decision setting forth an effort to determine these values based on the evidence of record.

However, the rate base calculations which were provided during the proceeding used average figures, rather than actual, for certain years. Thus, the Board is not in a position to rely upon those figures to calculate the dollar amount which will flow from the decision of the Board majority. Rather, the Board expects that the City and the County will be able to promptly reach agreement on those calculations, as well as the impact of adoption of the functional cost allocation method for assigning costs, for the years for which the Board is awarding relief to the City. The Board offers to be of whatever assistance it can to the parties in resolving any ongoing disputes regarding costs upon which agreement cannot be reached.

The same functional cost method of allocating to the County its share of operation and maintenance expense must also be used for determining the amount of rate base allocable to the County to determine the amount of annual depreciation and return of interest costs of the County.

H. <u>The Arbitrators have the authority to order that the utility basis for determining costs be made retroactive.</u>

The County has argued that the Arbitrators may not order any payment for service rendered prior to the final date of their decision because retroactive rate-making is forbidden under Maryland law. (See pages 61-65, inclusive, of the County's Brief).

The fallacy of this argument is that this is not a rate-making procedure. Rates for customers of the City's water system in the Metropolitan District are set by the County. This is a proceeding to determine the costs of the City's supplying water to those customers. What rates are to be charged to individual customers for that is a matter for the parties to decide, not the Board.

Since this is not a rate-making procedure, the Maryland cases cited by the County at page 63 of its Brief have no application here. They stand for the proposition that rate-making is a legislative function establishing a rule for the future. Rather than a rate case, this is, in essence, a contractual dispute, wherein the City contends that the agreement which was reached by the parties many years ago does not accurately fix the actual cost to the City of providing water service to the County. This is an arbitration proceeding which the Maryland courts have held to be a quasi-judicial function. See 2 M.L.E. Arbitration and Award, Sec. 5 at p. 477; Litman v. Holtzman 219 Md. 353, 149 A 2d 385 (1959). In that case, the Court of Appeals stated (219 Md. at 359):

> "Where the agreement is to arbitrate differences or disputes, those who are to decide act quasi-judicially and may receive the evidence or views of a party to the dispute only in the presence of, or upon notice to, the other side, and may adjudge the matters to be decided essentially only on what is presented to them in the course of an adversary proceeding."

See also Chillum v. Button & Goode 242 Md. 509, 219 A. 2d 801 (1966) declaring that "An arbitration award is the decision of an extra judicial Tribunal which the parties themselves have created, and by whose judgment they have mutually agreed to abide."

In the court proceedings that preceded this arbitration, Judge Fader found this to be common law arbitration so that the arbitrators make findings of fact and give reasons for their opinion, citing Board of Education of P.G. County v. Prince George's County Educators Association 309 Md. 85, 522 A.2d 931 (1987). The latter decision quotes an old decision of the United States Supreme Court declaring : "Arbitrators are judges chosen by the parties to decide the matters submitted to them." (Note:

The Court of Appeals of Maryland affirmed Judge Fader by a per curiam opinion for the reasons set forth in his order dated December 2, 1987. See paragraphs 4 and 5 of his order as to this.)

Hence, we can and shall make the award herein retroactive.

Contrary to the County's allegation of a "windfall" to the City if there be a retroactive award herein, it is the County and its rate payers in the Metropolitan District who have had the "windfall" of underpaying the "actual costs" of the City in supplying their water for many years. Further, as testified by the City's witness, Jerry Silhan, the monies to be awarded as the result of this proceeding have been and are needed to rehabilitate and upgrade the existing water system. Such monies are required by the Enterprise Fund Amendment to the City's Charter to remain in that system. The Metropolitan District water customers will share pro rata in the expenditure of these monies for betterment of the system.

I. The Effective Date for Implementation Of The Utility Basis Methodology For Determining The Cost to Baltimore City Of Furnishing Water To Consumers In The Metropolitan District

The Board has concluded that the effective date for implementing the utility basis, as well as the functional cost basis for allocating O&M expenses, is the fiscal year beginning July 1, 1983. Unless the utility basis method and the functional cost allocation are implemented retroactively to that date, the result ultimately would be to penalize the City unjustly while rewarding the County for the County's delay in proceeding to arbitration, as required by the Metropolitan District Act. Such an outcome truly would be inequitable to both the City and to all consumers dependent upon the City's water system when the City has had the financial responsibility of maintaining and operating the system during the period of the County's delay and when the funds are needed to rehabilitate the system.

In 1978, a City-County study determined that improvements costing $100 million were needed for the water utility (City Ex. No. 6, p. 27). The City believed that proposed methods of cost allocation were inequitable because of the "continual decline in the City's population and water consumption" and because the proposed methods of cost allocation "would require the City to pay about 12% of total construction costs whereas without any additional County demands for water, the City would not have to expend any significant sums for capital improvements: (City Ex. No. 6, Schedule JS-8, p.2); see also city Ex. No. 6, p. 27). Accordingly, on August 10, 1979, Governor Schaefer, then Mayor of the City, wrote to the Executives of Baltimore County, Anne Arundel County, and Howard County, notifying them of the City's views (id.).

The response of the Baltimore County Executive, dated June 16, 1981, recognized that the Counties' future demands required expansion of the water system and admitted that the City had a right to be compensated for its expenses (City Ex. No. 6, Schedule JS-9). Nevertheless, he rejected the City's proposed utility accounting method because, in his opinion, it "would tie the County inextricably to the City's financial position" and because the County "interpret[s] as profit any rate-of-return earned in excess of actual interest paid out by the City for County-used facilities" (id.).

Mayor Schaefer's September 9, 1982 letter to the Baltimore County Executive (City Ex. No. 6, Schedule JS-10), indicated that the 1978 Study had been "the subject of numerous meetings and correspondence between the City and Baltimore County" (id.). Although the County had agreed to the allocation of O&M costs on a functional cost basis, no agreement had been reached on the proposed utility accounting method (id.). Accordingly, the Mayor requested initiation of arbitration proceedings (id.). One month later, by letter dated October 8, 1982, the Baltimore County Executive agreed that arbitration "appear[ed] to be the only remaining course to resolve our substantial differences on what will constitute a proper way of setting a cost on water utility operations and improvements benefiting Baltimore County" (City Ex. No. 6, Schedule JS-11). Mr. Hutchinson also stated the County's belief "that the proper scope is the costing of future water utility operations and improvements and that any change in the 1972 Water Agreement should cover events from this time forward" (id.) (emphasis added). This acceptance of arbitration by the County Executive in 1982 presents a strong basis for making the Award retroactive to that time. As Mr. Silhan's testimony showed, without any contradictory testimony by any County witness, from 1982 until the Court signed its Order in November 1988, the County refused to appoint its arbitrator.

The evidence clearly shows that there were six years of delay from the time the County first agreed to an arbitration until the County finally proceeded to appoint its arbitrator. The County delayed the arbitration proceeding through failure to respond to the City's requests, retracting its earlier agreement to arbitrate and forcing the City to take legal action to have the court order the County to proceed to arbitration. During this time, in compliance with the provisions of the 1945 Act, the City met its obligations and continued to provide water service to the Metropolitan District without payment by the County of the full cost thereof.

In examining whether a judicial decision should be applied retroactively or non-retroactively, the Supreme Court considers three factors:

> First, the decision to be applied non-retroactively must establish a new principle of law, either by overruling clear past precedent on which litigants may have relied, or by deciding an issue of first impression whose resolution was not clearly foreshadowed. . . .Second, it has been stressed that "we must . . .weigh the merits and demerits in each case by looking to the prior history of the rule in question, its purpose and effect, and whether retrospective operation will further or retard its operation.". . . .Finally, we have weighed the inequity imposed by retroactive application, for "where a decision of this Court could produce substantial inequitable results if applied retroactively, there is ample basis in our cases for avoiding the 'injustice or hardship' by a holding of non-retroactivity."

Chevron Oil Co. v. Huson, 404 U.S. 97, 106-07 (1971) (citations omitted). The facts in this protracted and lengthy proceeding clearly weigh in favor of applying the utility basis method retroactively.

The County cannot now argue that the concept of a utility basis method, even in this proceeding, is a new principle or that its resolution was not clearly foreshadowed. The disagreement between the parties actually arose in 1945 when the County attempted to lower its water costs through legislative action and the City argued that it was entitled to a return on its investment (Joint Ex. No. 4). Moreover, the County has been on notice since 1979 that the City desired to change the determination of cost to a utility basis method (City Ex. No. 6, Schedule JS-8). The County agreed to arbitrate the dispute in 1982 (id., Schedule JS-11), but the City had to seek mandamus to compel the County to begin the arbitration proceedings (City Ex. No. 6, pp. 34-35). That a judge of the Circuit Court for Baltimore County found the issue of return on investment was an arbitrable issue also should have put the County on notice that a decision might be applied retroactively if there were further delay in proceeding to arbitration. Moreover, as City Exhibit No. 12 clearly shows, by its delay, the County continued to receive millions of dollars of refunds from the City -- dollars which the City could, but to its credit, did not withhold during the pendency of this dispute. Unless the award is made retroactive, there will be no incentive for either party to proceed to arbitration without delay in the future.

The Supreme Court's third test, whether inequity would be imposed by retroactive application, must be answered in the negative. Rather, inequity would be imposed by a failure to apply the decision retroactively. As explained by Mr. Lobb and Mr. Silhan, the valuation of the City's rate base has declined with each passing year. Although originally the City funded all investment in water facilities, as Mr. Silhan testified, the 1972 Agreement now requires the County to fund an allocated portion of the investment in facilities on which construction was begun after 1972 (City Ex. No. 6, pp. 14-15). Accordingly, these contributions are not included in the City's rate base (City Ex. No. 1, p. 24; Schedule HJL-3 Revised). Moreover, from 1984 through 1990, the net rate base allocated to Baltimore County "has been decreasing at an average annual rate of approximately $1,240,000 to a level where it is now less than it was in 1980. This decline will continue as long as Baltimore County continues to contribute its share of new system facilities as it has been doing since 1972" (City Ex. No. 1, p. 24' see also City Ex. No. 1, Schedule JHL-3 Revised, Column 3). As the City-financed facilities age, "the accumulated depreciation of these facilities increases, thereby reducing net allocated rate base" (City Ex. No. 1, p.24).

Even though the County first agreed to arbitration in 1982, it made no movement toward proceeding with that arbitration and eventually attempted to retract its agreement in 1987; meanwhile, the City's rate base and been decreasing for the preceding three years and has continued to decrease each year since 1984. Accordingly, to order the implementation of the City's proposal, but to make it prospective only, would be to reward the County's fiscal irresponsibility while penalizing the City for living up to its legal obligations and its good faith efforts to resolve the disagreement through arbitration.

The County cannot be heard to argue that a retroactive application of return on investment is prohibited by provisions of the U.S. Constitution. See, e.g., United States v. Johnson, 457 U.S. 537 (1982); Great Northern R.R. Co. v. Sunburst Oil & Refining Co., 287 U.S. 358 (1932); United States ex rel. Angeles v. Fay, 333 F.2d 12 (2d Cir. 1964), aff'd, 381 U.S. 654 (1965);' Sunray Oil Co. v. Commissioner, 147 F.2d 962 (10th Cir.), cert. denied, 325 U.S. 861 (1945). In a long line of cases stemming from 1895, it has been held that retroactive application of judicial decisions does not constitute an impairment of contracts. See, e.g. Fleming v. Fleming, 264 U.S. 29 (1924); Tidal Oil Co. v. Flanagan, 263 U.S. 444 (1924) (the Constitutional prohibition "protecting the obligation of contracts against state action, is directed only against impairment by legislation") Moore-Mansfield Construction Co. v. Electrical Installation Co., 234 U.S. 619 (1914); Central Land Co. v. Laidley, 159 U.S. 103 (1895). Nor is it a violation of constitutional prohibitions against ex post facto laws. See, e.g., Frank v. Mangum, 237 U.S. 309 (1915). Moreover, it is neither a denial of due process, nor a denial of equal protection of the laws. See, e.g., Tidal Oil Co. v. Flanagan, 263 U.S. 444 (1924); Central Land Co. v. Laidley, 159 U.S. 103 (1895); Sunray Oil Co. v, Commissioner, 147 F.2d 962 (10th Cir.), cert. denied, 325 U.S. 861 (1945); Morton v. Dardanelle Special School District, 121 F.2d 423 (8th Cir.), cert. denied, 314 U.S. 655 (1941).

In Sunray Oil Co. v. Commissioner, supra, the Court upheld a deficiency assessment on income derived from oil and gas leases even though the income was derived at a time when such income was immune from taxation under a decision of the U. S. Supreme Court. 147 F.2d 962, 963. Subsequently, the Supreme Court overruled that decision and held that income from oil and gas leases was taxable. Id. Even though the outcome was detrimental to Sunray, the Tenth Circuit held that Sunray had no vested right in the Supreme Court's earlier decision and rejected Sunray's arguments that the income derived prior to the overruling decision remained exempt from taxation. Id. at 963-64. See also Massaglia v. Commissioner, 286 F.2d 258 (20th Cir. 1961).

Likewise, in People ex rel Rice v. Graves, supra, was held that a retroactive assessment of income taxes could be made even though the income had been exempt from taxation in prior years. Rice, 242 A.D. 128, 273 N.Y.S. 582 (1934), aff'd, 270 N.Y. 498, 200 N.E. 288, cert. denied, 298 U.S. 683 (1936). In 1928, the U.S. Supreme Court held that a state could not impose state income taxes on income derived from copyrights. For the years 1929, 1930, and 1931, Mr. Graves' income tax returns showed income derived from copyrights as non-taxable and he was advised expressly by the state that such income was tax exempt. 242 A.D. at 129. The U.S. Supreme Court overruled its earlier decision in 1932 and held that such income was taxable by the states. The state of New York then attempted to collect an income tax assessment against Mr. Graves' income for the years 1929, 1930, and 1931. Id. at 130. The Court upheld the assessment on the ground that income derived from a copyright was, and always had been, subject to state income tax. Id. at 134. Reasoning that Mr.

Graves had not entered into any contract nor acquired any vested right in reliance on the Supreme Court's earlier decision, there was nothing to prevent a retroactive assessment of income tax. Id. at 132-35. Although the Court recognized that the tax assessment might create a hardship for Mr. Graves, the Court reasoned that the hardship was no greater than that suffered previously by the state. Id. at 136.

In the instant proceeding, the County acquired no vested rights and has no substantial reliance interests that would be defeated by retroactive application of the Board's decision. Any harm to the County has been of the County's own making through its repeated failures to proceed to arbitration. As explained previously, the County sets the rates to be paid by residents of the Metropolitan District (City Ex. No. 6, p. 19) and those rates are billed and collected by the City; if those rates result in higher revenues than what is determined to be the cost of service for that year, the difference is refunded by the City to the County (City Ex. No. 6, p.19). City Exhibit No. 12 shows that for all but two of the last ten years the City has refunded substantial amounts of money to the County:

BALTIMORE CITY-COUNTY SETTLEMENT

	Revenue	Expenses	Over/(Under)
1980	$10,552,229.00	$ 9,368,634.40	$1,183,594.60
1981	11,964,517.94	10,187,936/68	1,776,581.26
1982	11,863,241.33	11,022,585.44	840,655.89
1983	11,504,497.11	11,841,123.12	(336,626.01)
1984	12,531,153.34	12,288,838.70	242,314.64
1985	11,968,852.06	13,423,209.77	(1,454,357.71)
1986	16,606,319.41	15,078,692.26	1,527,627.15
1987	18,629,773.30	15,157,212.86	3,472,560.44
1988	18,488,378.71	15,382,186.93	3,106,191.78
1989	18,630,714.51	16,747,000.64	1,883,713.87
1990	23,002,670.79	18,001,670.79	5,000,000.00 EST

(City Ex. No. 12). Any hardship to the County is no greater than the hardship under which the City has been operating.

The impact of the retroactive application of this decision, in reality, will benefit the County and its residents in the long run. As Mr. Silhan testified, the County benefits from mains that are 12-inch or larger diameter, whether those mains are located in the City or in the County (Tr. 456). Many of those mains are constructed of unlined cast iron and there is a natural tendency toward a buildup of corrosion, thereby decreasing the capacity of the mains (Tr. 453). As Mr. Silhan explained:

> The average age of our system is probably in excess of 50 years, and in fact, we have got some cast iron mains which are as much as 125 years old. At the rate of $4 million per year, which is indicated as our spending level in 1991 [see County Ex. No. 2, p. B-2], we will be able to rehabilitate our system in approximately 75 years. Considering that some of the mains are already 125 years old, it looks as though we are a bit behind in trying to keep our system in good order . . . .
>
> * * * * * *
>
> I, as Chief of the Utility Engineering Division, recommended to the Director of Public Works that we increase this program to at least $6 million a year. Six million

> dollars a year would have gotten our cycle time down probably lower than 50 years, which I deem still not to be acceptable, but realistically with the availability of funds we gave it a shot for $6 million. We were turned down. (Tr. 453-55) (emphasis added).

An additional two million dollars a year from the County would enable the City to complete its mains cleaning program twenty-five years sooner than it otherwise will be able to do, thereby benefiting Metropolitan District consumers as well as consumers in the City. Mr. Silhan also testified to other necessary projects for which additional capital is necessary (Tr. 457-62). The Sedimentation Basins Replacement Program for Montebello Plant No. 1 requires a total cost of $10 million (Tr. 459; County Ex. No. 2, p. B-21). The Ashburton treatment plant, the City's newest plant, was built in 1956 and is now almost forty years old (Tr. 460). The City Water Utility submitted a budget request for approximately $15 million to upgrade the plant, but because of the amount of funds available, the project was downgraded to approximately $500,000 a year for the next six years (id.). The projects are necessary to maintain the "basic functions of the plant, structural, chemical feed systems, instrumentation" (Tr. 461). Additional funding would be required if the plants do not meet the new more stringent requirements of the Safe Drinking water Act (id.). As Mr. Silhan explained, the costs of improvements to treatment plants are allocated on a volumetric basis in the year of construction (id.). Based on the current volumetric allocation, Baltimore County would pay approximately 36 to 37 percent of the total cost of the improvements in the year construction was begun, but this allocation does not account for any future change in usage.

Under common-law rules of arbitration, any dispute may be submitted to arbitration whether or not it constitutes a cause of action cognizable by the courts. See, e.g., Deshon v. Scott, 202 Ky. 575, 260 S.W. 355 (1924); Continental Bank Supply Co. v. International Bhd. of Bookbinders, 239 Mo. App. 1247, 201 S.W.2d 531 (1947). Moreover, an arbitration award must be made on all matters which are included within the agreement for arbitration. Washington Homes, Inc. v. Interstate Land Dev. Co., Inc., 281 Md. 712, 382 A.2d 555 (1978). See also Gold Coast Mall Inc. v. Larmar Corp., 298 Md. 96, 468 A.2d 91, 104 (1983) ("Where there is a broad arbitration clause, calling for the arbitration of any and all disputes arising out of the contract, all issues are arbitrable unless expressly and specifically excluded."); Chillum-Adelphi Volunteer Fire Dep't., Inc. v. Button & Goode, Inc., 242 Md. 509, 219 A.2d 801 (1966); Niles-Bement-Pond Co. v. Amalgamated Local 405, 140 Conn. 32, 97 A.2d 898 (1953); Thatcher Implement & Mercantile Co. v. Brubaker, 193 Mo. App. 627, 187 S.W. 117 (1916); Staklinski v. Pyramid Electric Co., 6 N.Y.2d 159, 160 N.E.2d 78, 188 N.Y.S.2d 541 (1959); Ruppert v. Egelhofer, 3 N.Y.2d 576, 148 N.E.2d 129, 170 N.Y.S.2d 785, (1958); Freydberg Bros., Inc. v. Corey, 177 Misc. 560, 31 N.Y.S.2d 10, aff'd mem., 263 A.D. 805, 32 N.Y.S. 2d 129, reh'g denied, 263 A.D. 858, 32 N.Y.S.2d 783 (1941) ("There is no rule of law limiting the relief which an arbitrator may award to money judgments, even in cases where no equitable decree would be proper if the controversy between the parties were being determined by a court rather than by arbitrators"); Houston Saengerbund v. Dunn, 41 Tex. Civ. App. 376, 92 S.W. 429 (1906). One of the issues submitted by the parties for arbitration was the effective date for implementation of the City's proposed methodology (Joint Ex. No. 1, Exhibit A). Therefore, the Board has been called upon to decide this issue, and it hereby decides that the effective date should be July 1, 1983, (beginning of fiscal year).

While the City has proposed that the award be made retroactive to 1982, it is to be noted that the City's Water Division operates on a fiscal year beginning July 1st of each calendar year. Then, the City's demand for arbitration was by letter dated September 9, 1982 and the County's letter of response agreeing to arbitration was dated October 9, 1982. A fair assumption is that ensuing arbitration proceedings would have pre-empted the time until July 1, 1983 and, also, that a prompt award then would not have been retroactive, but prospective.

As a matter of convenience to both parties, the award should be made effective at the beginning of a fiscal year, not during a fiscal year, and July 1, 1983 is the reasonable date established by the record herein.

J. INTEREST ON THE ARBITRATION AWARD

The last issue stipulated for the Board to decide is: "What is the appropriate rate of interest applicable to amounts due the City from the date of the decision of the Board to the date of payment?"

Hence, it is within the Board's authority to award interest to accrue from the date of its decision until the date of payment of the award (plus accrued interest) to the City by the County.

An arbitration panel may, without specific statutory or contractual authority, award post-decision interest. Maryland Port Administration v. C. J. Langenfelder & Son, Inc., 50 Md. App. 525, 438 A 2d 1374 (1982) with the footnote (50 Md. App. at 546): "with regard to the implied authority of arbitrators to provide for interest on monetary awards, see Harson v. Board of Education 333 A. 2d 580 (N.J. Super. 1975) . . . ".

Harson involved an arbitration award which the defendant had not paid. The court concluded that interest was justified from the date of the arbitration award saying: "The general rule is that an arbitration award for a sum of money carried interest from the time it is due and payable", citing 6 C.J.S. Arbitration and Award, Sec. 80 b(3)(j) at 224.

While it is clear that there may be interest on the arbitration award herein, the question remains as to the rate of interest. The City of Baltimore has requested 10%

In Federal Savings and Loan Insurance Corporation v. Quality Inns, Inc. 876 F.2d 353 (CCA4, 1989), the appellate court found that the lower court was bound by Maryland's legal rate of interest, which is six per cent rather than the ten per cent legal rate of interest on judgments. It noted that the Maryland courts have interpreted the statutory rate of ten per cent to apply only to judgments.

Since this is an arbitration award, not a judgment, we believe that the rate of interest on that award must be six per cent (6%) and so provide herewith.

Although the Board might award interest from the date of its decision, such an award seems less than just when the decision does not calculate the actual damages, but leaves the parties to work out the number. The parties should have a time, albeit short, to reach the number before interest starts to run. Therefore, interest will begin sixty (60) days from the date of this decision on whatever amount is ultimately determined.

7. The total amount due and payable by and from Baltimore County to Baltimore City applying the utility basis of cost determination (without return on equity) and the functional cost allocation method from fiscal year 1982, to date through fiscal 1990 has been approximated by the Board to be some 10.3 million dollars as shown by Appendix A to this decision. As previously stated, the Board has used the evidence of record, which does not include actual numbers for each fiscal year. Moreover, the figures used in Appendix A are taken from the exhibits of the City's Witness, Howard Lobb, and have not been agreed to by the County. The County's witness , Paul Moul, testified that if ordered by the Board to adopt the utility method and the functional cost allocation procedures, the County and the City could reach agreement on the relevant figures. The Board expects that the parties will be able to reach such agreement within sixty (60) days from the date of this decision.

Of the approximate 10.3 million dollars awarded to the City by this decision over 6 million dollars represents additional dollars which would have been paid by the County to the City in operation and maintenance expenses on a functional cost allocation basis. The record clearly shows that the County has been willing to bear this expense from the very outset of this dispute.

CONCLUSION

The 1945 Act clearly provides that "cost, however determined, shall be subject to revision from time to time . . ." 1945 Act, Section 332 (c). The appropriate interpretation is that cost should be determined in light of today's circumstances. The evidence presented in this proceeding clearly demonstrated that the 1972 Agreement between the City and the County does not comply with the 1945 Act's requirement that the City provide water to the County at cost and without loss. Due to shifts in the population since the 1950's, the justification for the original determination of cost is no longer valid. Accordingly, the appropriate determination of cost in light of today's circumstances is the utility basis methodology and functional cost allocation, but without any return on equity because that would be "profit" prohibited by the 1945 Act. (Note: Arbitrator Charles E. Woods dissents, finding that a return on equity would be a proper "cost" within the meaning of the statute. His written dissent as to that and other issues is appended to this decision).

In 1982, the County agreed that arbitration was necessary to resolve the dispute and agreed that any change to the existing determination of cost should be from 1982 forward. Therefore, and for the reasons previously set forth, it is appropriate, and within the Board's authority in ruling on one of the issues which the parties submitted to the Board, to order that implementation of the City's proposal be made retroactive.

Since the City's Water Utility operates on a fiscal year beginning July 1st, it is not feasible to make the award retroactive to July 1, 1982 where the parties did not agree to arbitrate until later that year. However, where the County agreed that any change determined by arbitration would be from that time forward, the Board's decision is that the award be made retroactive to the fiscal year beginning July 1, 1983 and continuing through the fiscal year ending June 30, 1990, with the total award for that period to be determined by the parties in accordance with this decision.

In addition, the Board awards interest at the rate of six per cent (6%) per annum beginning sixty (60) days from the date of this decision until the date of payment.

Harrison M. Robertson, Jr.

Harrison M. Robertson, Jr.

Charles E. Woods

Richard B. McGlynn

Date: August 22 1991

Appendix A

The schedules on the pages of this Appendix show the approximate total amounts of additional cost due to the City from the County for the fiscal years ended June 30, 1984 through 1990. The amount to which the full Board agrees is $10,273,869. and reflects the use of the Utility Basis and the functional cost allocation/base-extra capacity methods for cost allocation. It represents added cost because of use of depreciation rather than repayment of principal, added operation and maintenance expenses, and interest.

For the minority, there is an added line showing the amount of return on the City's equity investment at a rate of return equal to the inflation rate as measured by the consumers price index (CPI) for urban areas.

With this return on equity in the amount of $5,468,200, the total increases to $15,742,069. As is emphasized throughout this analysis, these amounts are only approximations in that all data necessary to make accurate cost calculations are not in the record.

The County, subject to its right to participate in the final determination of cost, has agreed that the use of the functional cost allocation/base-extra capacity methods should be used for determining amounts of O&M expenses applicable to County consumer uses. These methods are equally applicable to determining rate base, and related annual capital expenses, e.g., depreciation and interest.

Also, the County as is shown in their Exhibit 6 agree that the City is entitled to a return on its inventory which is applicable to County consumer uses. Thus, this cost is included in the calculation.

Gross Revenues from Customers after adjustments for refunds - Compared to revised Cost using Utility Basis with Functional Cost Allocation Procedures and Base-Extra Capacity Method - and Additional Amounts of Cost due City of Baltimore - with and without return on equity.

	1984	1985	1986	1987
Gross Revenues......	$12,531,153	$11,968,852	$16,606,319	$18,629,773
Less: Adjustments...	(242,315)	1,454,358	(1,527,627)	(3,472,560)
Net Revenues........	$12,288,838	$13,423,210	$15,078,692	$15,157,213
Costs:				
O & M Expenses....	$11,530,600	$12,958,600	$14,386,700	$14,591,400
Depreciation......	1,571,200	1,595,500	1,619,800	1,697,600
Interest Expense..	580,000	624,800	530,500	332,300
Int. on Inventory.	49,732	23,693	40,378	33,503
Sub-total...........	$13,731,532	$15,202,593	$16,577,378	$16,654,803
Return on Equity....	847,900	772,200	780,000	730,700
Total Costs.........	$14,579,432	$15,974,793	$17,357,378	$17,385,503
Additional Amounts Due City of Baltimore				
Without Equity......	$ 1,442,694	$ 1,779,383	$ 1,498,686	$ 1,497,590
With Equity Return..	$ 2,290,594	$ 2,551,583	$ 2,278,686	$ 2,228,290

Data Sources:

Gross Revenues	- Baltimore City Exhibit 12 - It is noted that there are adjustments between years for City and County figures. These must be reconciled in actual calculations. See City Exhibit 13.
Adjustments:	- Baltimore City Exhibit 12.
Net Revenues	- Gross less adjustments
O&M Expenses	- From City Exhibit 2, HJL-7, Column 1 and 2 for both O&M and Depreciation.
Interest	- Estimated based upon use of functional cost allocation procedures.
Int.Inventory	- From Moul's Schedule 2, County Ex. 6.
Sub-total	- Addition of above items.
Equity Return	- See Appendix C.
Added Amounts due City	- Subtract actual revenues (net) from costs.

Note: All years are fiscal year ended June 30.

Gross Revenues from Customers after adjustments for refunds - Compared to revised Cost using Utility Basis with Functional Cost Allocation Procedures and Base-Extra Capacity Method - and Additional Amounts of Cost due City of Baltimore - with and without return on equity.

	1988	1989	1990	Totals
Gross Revenues......	$18,488,379	$18,630,715	$23,002,671	119,857,862
Less: Adjustments....	(3,106,192)	(1,883,714)	(5,000,000)	(13,778,050)
Net Revenues........	$15,382,187	$16,747,001	$18,002,671	106,079,812
Costs:				
O & M Expenses....	$14,796,100	$15,894,100	$16,992,200	101,149,700
Depreciation......	1,775,300	1,768,700	1,762,000	11,790,100
Interest Expense..	341,700	381,400	350,000	3,140,700
Int. on Inventory.	41,624	42,751	41,500	273,181
Sub-total..........	$16,954,724	$18,086,951	$19,145,700	116,353,681
Return on Equity....	713,700	899,400	724,300	5,468,200
Total Costs.........	$17,668,424	$18,986,351	$19,870,000	121,821,881
Additional Amounts Due City of Baltimore				
Without Equity......	$ 1,572,537	$ 1,339,950	$ 1,143,029	$10,273,869
With Equity Return..	$ 2,286,237	$ 2,239,350	$ 1,867,329	$15,742,069

Data Sources:

Gross Revenues	- Baltimore City Exhibit 12 - It is noted that there are adjustments between years for City and County figures. These must be reconciled in actual calculations. See City Exhibit 13.
Adjustments:	- Baltimore City Exhibit 12.
Net Revenues	- Gross less adjustments
O&M Expenses	- From City Exhibit 2, HJL-7, Column 1 and 2 for both O&M and Depreciation.
Interest	- Estimated based upon use of functional cost allocation procedures.
Int.Inventory	- From Moul's Schedule 2, County Ex. 6.
Sub-total	- Addition of above items.
Equity Return	- See Appendix C.
Added Amounts due City	- Subtract actual revenues (net) from costs.

Note: All years are fiscal year ended June 30
Total Column represents sum of the amounts in each year from June 30, 1984 through June 30, 1990.

City of Baltimore

Table of Contents - Dissent of Charles E. Woods

Appendix

I. What is the proper method, under the Metropolitan District Act, for determining the cost to Baltimore City of furnishing water to consumers in the Metropolitan District of Baltimore County.

I concur with the Board majority that the proper method for determining the cost to Baltimore City of furnishing water to Baltimore County is the utility basis. I do not concur that this must be without any allowance for the cost of the City's equity investment in that I have concluded that there is a return on equity which is entirely without profit as prescribed by the Act. I also have concluded that without this minimum return on equity the City will sustain a loss which is also prohibited under the Act.

As is pointed out on page 4 of the M-35, Revenue Requirement, AWWA Manual of Water Supply Practices, "The term "utility approach" or "utility basis" tends to have two uses in water utility rate making." Although the question before the Board is not rate making, the terms also have the same uses in the determination of "cost of service" which is the issue before the Board. Consumer rates are provided for in Section 34-25 of the Act and it is the Public Service Commission which has jurisdiction when there is a dispute over consumer water rates.

M-35 goes on to state, "One use involves the measuring of the revenue requirement....(and) The second use of the term "utility basis" in ratemaking is in allocating revenue requirements, or total cost of service to be derived from water rates among classes of customers." The Boards responsibility is to determine which procedures for cost of service are appropriate considering the specific mandate of the Act that cost will be "entirely without profit or loss.

In order that this determination meets the intent of the legislature, a careful review of the legislative history leading to the enactment of Section 34-26 is necessary.

II. Based upon a full review of the legislative history as included in the record, it is concluded that the County and City legislative delegations did consider "profit and loss" and "return on investment" as separate elements to be considered in determining cost.

Beginning on the bottom of page 9 of the City's "Initial Brief" and ending on page 15 is a summary of the legislative history leading to the enactment of Amendment 11 which was a substitute in lieu thereof for "all of Sub-section (c) of Section 332" on page 5 of the bill as printed for the third reading. (See Appendix I and pages 1466-1467 of March 13, 1945 Journal of Proceedings, Joint Exhibit 3.) Amendment 11 is now a part of Section 34-26 of the Act and reads in part, "The Mayor and City Council of Baltimore shall furnish water to the Metropolitan District of Baltimore County at cost and entirely without profit or loss." It provides mechanisms for the City and County to determine by agreement such costs as long as this agreement did not provide either a profit or a loss to the City. With some slight word changes and consolidations with other amendments, Amendment 11 became Section 34-26 of the Act, which is still in force per the record.

In the March 2, 1945 Baltimore Sun article, Simon E. Soboloff , city solicitor, is quoted as saying, in part, "It is unfair to write into the bill a formula for arriving at cost to the City, because you cannot in a law take into consideration all of the factors involved." If the Board is to consider as evidence newspaper statements by the City solicitor in which he is quoted as saying he believes that it is true that rates yielded to the city a profit then the Board also must consider other statements attributed to him in which he suggests that the County's proposed Amendment 4 (c) does not provide the flexibility necessary to take into account all of the factors involved in the development of water service costs, for then and the future.

The Board majority quotes, in part, from, "certain newspaper articles in the Baltimore Sun papers." They indicate, "The latter show that Baltimore County officials and legislators were seeking lower water rates where the city was said to be making more than $600,000 a year." They also show that the then City Solicitor, Simon Soboloff believed it true and so stated that, "rates are excessive and yield the City a profit..."

A close reading of the news articles and statements attributable to Soboloff lead me to conclude that he never in the articles on record conceded that any profit was at a $600,000 level. In fact, the article on page 7, column 2 of the February 27, 1945 edition link this allegation of a $600,000 figure to members of the "Baltimore County Delegation."

On page 46 of the County's Brief they argue that the Board <u>must</u> consider the record as a whole. They also state, "the intention of the parties to an agreement must be garnered from the terms considered as a whole, and not from the clauses considered separately." They go on to quote, "(W)e construe the instrument as a whole to determine the intention of the parties." Thus, for the Board to arrive at "intention" all statements must be considered in the context of the issues to be decided.

In the evolution from Amendment 4 (c) to Amendment 11 there is clear evidence that Soboloff's admonition for the need for flexibility was heeded. The specific and detailed terms proposed by the County delegation were deleted. The only condition which remains from this is that the City will provide water service to the county at cost and without a profit...to which was added the term "or loss."

On page 13 of the City's Brief excerpts from the Evening Sun article of March 8, 1945 are quoted and one states that the City insisted that cost include "cost of its water loans <u>amd other capital investments</u>." (underlining added for emphasis.) Thus, although the city solicitor Soboloff is reported to have said that he "agrees that Baltimore has been making a profit from water sold to Baltimore County.." and "You say that rates are excessive and yield the city a profit, I believe that is true. You say it is not fair to charge more than the water costs the City. I believe that is true," but later he says that the City held out, however, "for taking into consideration also the cost of its water loans and other capital investments," which it said, totaled $92,000,000. **This would support the position that the City did consider "profit" separate and different from "the costs of its...other capital investments."** Otherwise, why agree they made a profit and should not but still argue that consideration must be given to costs of its capital investments other than water loans.

Although it was argued by Counsel for the City that news articles do not have the same evidentiary value as do official documents, such as the Journal of Proceedings, if one is to accept excerpts from one article, then it follows that other relevant excerpts also should be given equal weight. The City's statement does provide evidence that the City did consider as a cost "capital investment" costs other than those for debt service.

From the explicit and detailed language describing the terms as proposed by the County delegation in Amendment 4(c) there are clear indications as to the goal, end and intent of the County in proposing such terms. Any search for intent and plain meaning or language of the County delegation must start with their proposed Amendment 4(c). This is a part of the "whole" process which County's brief admonishes the Board that it must consider in its decision.

It is apparent that the legislature in passing Amendment 11 did agree with Soboloff that the law should have the flexibility to allow for different cost calculations in that the section now specifically allows the City and County to determine costs as long as they do not result in a profit or a loss to the City. The County's specific and detailed terms were deleted from the bill as finally passed.

Amendment 11 was far different from Amendment 4(c) as drafted and proposed by County delegation legislators at the behest of County officials. 4(c) provided:

"The authorities of Baltimore City recognize and have always recognized the principle that service of water in Baltimore County from City owned facilities <u>should</u> be entirely without profit to the City of Baltimore. Said principle shall be recognized by the proper authorities of the City of Baltimore in practice as well as in theory and it is hereby declared to be against the public policy of this State for Baltimore City to retain for its use any profits from water charges paid by consumers in Baltimore County and such retention is prohibited.

Moreover <u>water service</u> on Baltimore County at cost is found to be compensatory to Baltimore County for the use of its facilities for service to Baltimore City without charge and for the annual loss of tax revenues which said county sustains by reason of the permanent removal from its assessable tax of property used by Baltimore City to create and maintain facilities in said County.

The word "cost" as used in this Section 332, shall mean the actual cost, entirely without profit to the City of Baltimore. In determining actual cost of water service to Baltimore County consumers <u>there shall be excluded any return whatsoever</u> to the City of Baltimore <u>on any capital investment</u> in water facilities.

However, there shall be included as part of cost, the actual debt service obligations of Baltimore City for <u>repayment of principal and interest</u> on loans for constructing or acquisition of facilities used in rendering water service to Baltimore County consumers, provided that the sum so included <u>shall represent only the proportion attributable to</u> Baltimore County <u>on the basis of its use by consumers</u> in said County as compared to its total use by Baltimore City; to the <u>end and intent</u> (1) there shall not be charged as a part of cost any debt service for facilities not used in rendering service in Baltimore County, and (2) debt service facilities used to furnish water service to Baltimore County consumers shall be allocated and charged in the ratio which use of a particular facility in Baltimore County bears to its total use by Baltimore City." (Emphasis added.)

Terms and conditions of this Amendment 4 (c) are so detailed and specific that a determination of intent is easy to arrive at. In fact, they even state, "to the end and intent" in tieing together the separate descriptions as to how debt service cost shall be allocated between the City and the County.

Removal of these detailed terms in favor of the use of the provision, "The Mayor and City Council of Baltimore shall furnish water to the Metropolitan District of Baltimore County at cost and entirely without profit or loss" is evidence that in the final wrap-up of this bill the legislature did heed Soboloff's pleas and did provide a cost calculation basis which did have the flexibility necessary to adapt to changed conditions and times. As long as the cost methods did not produce a profit or a loss to the City these costs procedures are acceptable. It is important to understand that such agreed upon costs must be such that they are capable of being used in this determination of "profit or loss" so as to insure that the mandate of the Act will be fully complied with.

It is significant that the prohibition of a profit in the proposed Amendment 4(c) is separate from the additional prohibition that the City should not receive any return on its investment whatsoever leading to the conclusion that the drafters of this proposed legislation did have separate meanings for each of these terms. This is supported by the fact that they did spell out the way in which debt service would be calculated and tied the two separate provisions together with the words "to the extent and end." Throughout this proposed amendment is evidence that the drafters did choose their words carefully and had expert advise from those in the water utility operating and financial areas of the county to assist them in this effort.

If the County legislative drafters had intended "actual cost without profit" to have the same meaning as "In determining actual cost of water service..there shall be excluded any return whatsoever to the City of Baltimore on any investment in water facilities" it is logical to conclude that they would have tied them together with the same careful wording as they did with the two debt service provisions. They do not say, "actual cost, entirely without profit" to the end and intent, in determining actual cost.."there shall be excluded any return whatsoever.." Thus, it is reasonable to conclude that the county drafters of this proposed amendment 4(c) did have separate meanings and intents for these two terms. This leads to the conclusion that they must have recognized the possibility that the City could receive a return on its investment other than that financed with debt which return would not produce a profit.

Conclusions of Law

1. The City of Baltimore did want costs to include a return on its investment, including where applicable a return on its equity investment.

2. The County of Baltimore did not want the City to enjoy a profit in providing water service to County consumers. Also it did not want the City to receive any return whatsoever on its investment in water utility facilities used for serving county consumers..other than reimbursement for the County's pro rata share of actual debt service. Since the only other source of funding for plant facilities came from City equity investment and, possibly at that time, from contributions of capital by the County, this leads to the conclusions that the County did not want the City to receive a return on its equity investment in plant used for providing water service to County consumers.

3. In the bill as finally enacted by the Legislature, these specific and detailed provisions of the County were deleted in favor of flexibility in cost determination, as long as the City did not enjoy a profit or sustain a loss.

4. The Act does not specifically preclude the City from receiving a return on its equity investment in water plant facilities used for serving County water service needs, as long as the City receives no profit or sustains no loss.

5. The record does support the conclusion that the County drafters of Amendment 4(c) did believe that "profit" and "return on investment" did have different and separate meanings by their action in including both terms in their proposed amendment. Although they did link the two provisions describing how debt service would be calculated with the term "to the end and intent" no such term was used for the linkage of profit and return on investment.

6. Because of the reports in the daily newspaper in which the City representatives were quoted as agreeing that they did enjoy a profit and should not while at the same time arguing that the City should receive consideration in the determination of cost the cost of their water loans and other capital investments, this supports the conclusion that the City negotiators who assisted in the drafting of the final language did believe that the City could receive a return on the City's equity investment and still avoid a profit.

III. Under the Utility Basis, what were the reasonable cost of capital rates at the appropriate valuation dates.

I concur with the Board majority as to the cost of debt used to finance utility plant facilities required for providing water service to Baltimore County consumers.

The term "profit" cannot be limited to the definition quoted in the majority's opinion which states, "....this Board concludes that the term "profit" meant and means "the excess of income or revenue over expenditures" Webster's International Dictionary-Second Edition, cited from U. S. Mintzes 304 F. Supp. 1305 (D. Md. 1960). They also reference Kaufman v Liss 196 Md. 634 (1946) to the effect that profit arises after the provision of expenses.

With this limited definition of profit, some of the flexibility urged by Soboloff in 1945 and which was endorsed by the Legislature in passage of the bill in its final form would not be available to the City and County in sharing of costs. As an example, the 1972 Agreement provides for the division of certain capital funding by the parties for construction projects when a portion of the plant is to be used for county water service needs. No such provision for sharing capital financing could take place if the only way in which costs could be calculated entirely without profit or loss would be when revenues less expenditures equal profit or if profit only arose after the provision of expenses. With such capital contributions there are no revenues involved and there are no expenses either. In utility accounting, expenses occur from operation and maintenance (O&M), taxes, and depreciation, not from capital contributions for construction. Thus, this type of sharing of capital costs does not fit the mold of the determination of "profit" as used in the majority's limited definition.

Article XI of the September 20, 1972 Agreement (City Exhibit 6, Schedule JS-3) does provide for the sharing of certain capital expenditures for new facilities, plant and/or equipment.

In the AWWA M-26 Manual of Water Supply Practices, Water Rates and Related Charges, First Edition, 1986, such capital contributions are defined, in part, as:

> Any amount of money, services, or property received by a water utility from any person or governmental agency which is provided at no cost to the utility. It represents an addition or transfer to the capital of the utility, and is utilized to offset acquisition, improvement, or construction costs of the utility's property, facilities, or equipment used to provide services to the public.

Contributed capital payments go directly into the balance sheet accounts and do not enter into the calculation as to whether the utility received any net income or profit.

In order to broaden the definition of "profit" so that it does provide for the needed flexibility referred to by Soboloff in the news articles, and in order to meet the flexibility which the Legislature provided in the bill as passed, other definitions from Webster in use in 1945 must be considered. The 1946 edition of the Webster Collegiate Dictionary also defines profit as an "available return; a gain" and goes no to refer to profit as an advantage or a benefit. It is to gain advantage; grow richer. As will be discussed later, one cannot gain an advantage or grow richer during inflationary times if one earns a rate of return equal to or less than the rate of inflation, regardless of the fact that one may have revenues in excess of expenses. In point of fact, if one earns a return at a rate which is less that the level of inflation then there is a loss sustained.

There are a number of other definitions of profit which were in use in 1945 by professionals in finance, economics, and even in the law. These are discussed in the Appendix of this analysis and conclusion of law. Acceptance of these more esoteric definitions is not necessary to conclude that a positive return on equity is possible at a level which does not provide a profit.

The way in which the City and County have provided for capital contributions in the 1972 Agreement may produce a profit or a loss to either party, albeit, not one which fits under the limited definition used by the majority. By making capital contributions, the county reduces construction costs which are funded by the City and thereby reduces its annual costs for depreciation and return on investment. In effect, the County is making advance capital payments to avoid future annual payments for such plant. The provisions of Article XI of this Aggreement which provides for the sharing of these costs probably was not contemplated by the Legislature in 1945 in that contributed capital payments were not common during the 40's.

Since under the majority's definition of profit there is required a revenue stream and offsetting expenses, this type of contribution program would not fit. A profit or a loss can occur but it would be outside of the calculation of net income as contemplated in the definition from the cited case law.

If the use for which either party paid should change a profit or a loss could occur. As an example, if the City's share of a facility was 40% based upon their projected use at its design capacity, and the county's share was 60%, and if after 10 years it was determined that the City actually required 50% of the capacity, based upon the Agreement it will have received a gain in that it receives the benefit of 50% of the plant for which it only paid 40%. If the opposite should occur and the County required 70% when it only paid for 60%, it enjoys a gain and the City has a loss in that the City paid for 10% of the capacity now used by the County and for which the City receives no payment.

A program of this nature indicates the wisdom of the need for a costing policy with flexibility to meet future conditions as argued by Soboloff. The only change required is to review the 1972 Agreement to insure that if use changes no profit or loss occurs to either party in the allocation of these capital construction costs.

From Webster we find that the word "profit" comes from Latin and French words meaning "to progress." If one has more dollars at the end of a period than one had at the start but these dollars are only equal to those held at the beginning of the period because of the impact of inflation, there is no gain and also no progress. At the same time if the dollars at the end of the period are equal to the purchasing power of the dollars at the start of the period because the return was equal to the rate of inflation, the individual also has not sustained a loss. With the City, all the process is seeking to achieve is to leave the city "whole" with no profit or loss. Thus, a return at the level of inflation meets this objective.

If this goal is met so will the legislative mandate that cost must be entirely without profit or loss also be met. That the Legislature could have predicted the impact of inflation is questionable. Such a prediction wasnot necessary. All that is necessary is to recognize that the statute as passed by the Legislature did provide for flexibility to meet changed conditions, one of which was inflation.

They may not have had this specific possibility in mind when enacting the bill but the fact that they did revise the bill so as to provide for future flexibility in defining costs does indicate their intent was to provide for changes in how costs would be established.

Capital contributions which were not envisioned as a viable way for cost sharing is another illustration. In 1945 such a cost sharing procedure was not contemplated but the Act does allow for this process as long as it does not produce a profit or a loss to the City. **A return on the equity investment of the City used for County plant needs at the rate of inflation is another technique which meets this goal of cost without profit or loss to the City.** It precludes a real loss to the City's investment dollars in a way that keeps the City "whole."

If the City received a return which provided it with an equity cost in excess of the rate of inflation, this would result in a profit for the City and as such, would be in violation of the specific mandate of the Act that cost must be entirely without profit. Thus, the portion of the cost of equity capital referred to by economists and financial advisors as the "pure interest" or "bare bones" cost of capital is not applicable to the cost determination for the City. (See Appendix A.) The language of the Act precludes such an element of cost. With this cost element included in the City's capital cost, at the end of the period it would end up with a greater purchasing power than before, ergo, a gain or benefit accrues and under the broad Webster definition, this is a profit.

Because most, if not all, of normal risks associated with investment are avoided under the "true-up" process whereby the City recovers all costs of providing County water service, the element of capital cost to recover the risk premium normal to cost determination will not be required with the City's equity cost. Therefore, this cost element has been removed from my determination of the City's equity investment in county used facilities.

This only leaves a return necessary to avoid a loss in the purchasing power of the City's investment due to the impact of inflation. This is a cost which the City cannot avoid <u>except</u> by receiving a return on its equity investment equal to the rate of inflation. Such a return is substantially less than what the City requested but one which can be justified within the constraint that it represent a cost <u>entirely without profit or loss</u> to the City. As previously noted, without this level of return the City <u>would</u> sustain a loss in that the value of its equity investment would be reduced by the effects of inflation on the purchasing power of these investment dollars.

Webster also defines loss as a failure to gain, win, obtain or utilize and relates loss to an amount by which the cost of an article or service exceeds the selling price or a decrease in amount, magnitude, degree or a diminution. Under this definition the City would sustain a loss if it did not receive a return at least equal to the rate of inflation in that it would not gain, and would have a diminution in the purchasing power of the dollars of equity investment in plant used for Baltimore County water service.

On page 2 of his direct testimony (City Ex. 3) Mulle outlines the legal and economic principles which he asserts guide the determination of the cost of capital. What he does not give is adequate emphasis as how these principles are affected by the Act's requirement that cost be "entirely without profit or loss." He does not address how the true-up process reduces risk and thereby reduces cost. Also, he does not address how this prohibition affects the element of equity cost referred to as "pure" or "bare-bones" interest. With substantially reduced risk and a ban on profit, the cost required to avoid a loss is reduced greatly. As discussed previously, I have concluded that these costs cannot be considered for the City in that they provide the opportunity for a "gain" to the City and under the broad definition of Webster, this provides the City with a profit.

Just as depreciation is a non-cash cost of doing business for a water utility which must be recovered from the user of the water service so that the utility avoids a loss, so a return on the equity investment of the utility must be received from the users so that the utility avoids a loss. Plant depreciates with use and so reduces its value (net book cost) and the amount of this reduced value (annual depreciation expense) must be a part of the cost of water service of the utility.

With inflation there also is a loss in value to the plant of the utility from one year to the next due to the impact of inflation on the purchasing power of the dollars invested. Debt holders reflect this cost as part of their interest expense which they must receive to induce them to invest funds in the utility. Without this increment of cost as a part of their interest requirement, they would sustain a loss in their investment and under these circumstances they would not provide the funds necessary to construct new plant and equipment.

To avoid a loss in the value of the plant funded by equity investment of the City, a return must be received equal to the rate of inflation. It is important to note that the Act says that the city must provide service but it must do so entirely without profit or loss. The Act does not say that service will be provided "partially" without profit or loss but entirely without profit or loss. This means that depreciation expense must be recovered from the users to avoid a loss and it also requires that the City receive a return on its equity investment to avoid a loss. Each of these elements can create a loss if they are not included in the cost of water service.

When the average worker receives a cost-of-living wage adjustment (COLA), he or she does not believe that they have enjoyed a gain or are better off than they were before. They realize that this increase only reflects the fact that their prior pay level does not provide the same level of purchasing power because of the inroads of inflation. With COLA they only maintain their status quo. If you would ask them if they enjoyed a profit, the response would be a unanimous "no way!"

Inflation has received such widespread publicity since the 40's that the average person is aware that if he or she had $1,000 at the start of the year and prices rose across the board at a rate of 10%, the $1,000 they had could not purchase the same goods and services at the end of the period unless they earned at a rate equal to the inflation rate of 10%. They realize that would sustain a real loss without such a return.

The same applies to the City of Baltimore. Without a return on its equity investment equal to the rate of inflation, the City sustains a loss. There is no gain even if they have a positive return or net income unless this net income exceeds the level of inflation. All the City does is maintain its "status quo" and break even with this level of return. Thus, there is no loss and no profit as mandated by the Act.

Under the Act, the City is required to provide water service to the County, albeit, it is not specifically required to do so with the use of its equity investment. In other words, there is no specific ban which prevents the city from financing the necessary water plant and facilities 100% with debt. For reasons that I could not find explained in the record, the City did not choose to take this route and determined that the debt and equity ratio of the utility as a whole would be used to finance the plant required for County purposes.

Therefore, it is my conclusion that the only significant risk for the City's equity investment is that of inflation. A return each year on the City's average equity investment used to finance County required plant equal to the rate of inflation as measured by the Consumers Price Index (CPI) will provide a level of cost recovery by the City which will avoid a loss while at the same time does not provide the City with a profit.

IV. Comments re: Majority Conclusions of Law and Decision

V. Conclusions of Law

I concur with the 19 Conclusions of Law set forth in the body of this decision, with the following exceptions:

6. Under the statutes, the parties (Baltimore City and Baltimore County) may agree on any methodology or accounting principles to be used in determining "cost" as long as such principles and methods provide a measure as to whether a profit or a loss has occurred so as to insure that such methods are in compliance with the Act which mandates that cost be entirely without profit or loss. It is my conclusion that the 1972 Agreement did not so comply as is explained in my dissent.

7. If the parties are unable to agree to the determination of "cost", that is to be determined by arbitration and so is to be determined in this proceeding. Cost so determined in this proceeding must be calculated in a way whereby they are entirely without profit or loss and in a manner whereby this condition can be measured.

8. "Cost" as set forth in the statute, does not include "profit" nor does it permit a "loss" to the City which means that any net income received by the City must be at a level whereby it does not provide a "profit" or a "loss." There is a level of net income which can produce this result.

9. Cost must include annual depreciation expense and that is a proper expense of "cost" under the utility basis for determining costs. The statute's use of "cost" allows depreciation to be taken in that determination, and in fact mandates that such amount be included so as to accurately measure net income to insure that a profit or a loss does not occur.

12. The utility methodology is a reasonable method of determining the cost of providing water service to the Metropolitan District of Baltimore County. Because it is the method which determines net income, it must be used so that cost so measured can be compared to revenue received to insure that no profit or loss occurs.

Delete from 14, 15 and 16 the exclusion "excluding return on equity" in my concurrence.

VI DECISION OF ARBITRATORS

A. In the "Decision of Arbitrators" the Chairman, writing forcefully for the majority, states, "Even if the County's position were sound, the Board has concluded that the City is clearly not recovering its actual costs of service through the current debt-service methodology..." and to this I fully concur.

C. My observation would be that the "utility basis" is not only the "better" method, but the only method available under the Act in that it is the method which measures "net income" which is a precursor for the determination as to whether a profit or a loss has resulted. This must be done to meet the standard of the Act which mandates that cost must be entirely without profit or loss to the City.

D. Moul is quoted as saying under the recommendations of the parties that the debt service method is the accepted and appropriate methodology to determine "revenue requirements." He fails to recognize that this is a cost of service study, not a revenue requirement proceeding and under the Act such cost of service must be measurable in a way to determine if a profit or a loss has occurred. This requires the use of the utility basis, not the debt-service method.

F. See my discussion of Soboloff's comments, definitions of profit in use in 1945 in the body of my dissent. On page 48 it is argued that while return may be a cost for rate making purposes, it is not an actual expenditure. The same is true for depreciation expenses, which is a cost, one used in cost of service analysis, but it is not an actual expenditure. It is the loss in value of the capital through the use of the plant which this capital financed. So is the impact of inflation a loss in value of the capital and as such is a cost which can be recovered without a profit occurring and is necessary to avoid a loss to the City. Thus, I cannot agree that "profit" is the amount shown at the bottom of the income statement reflecting a return on equity unless such return exceeds the rate of inflation.

See the discussion of the different common meanings for profit in the body of this dissent. Although, as stated on page 49, the City is not an "investor-owned" public utility, it is a water utility operating under the enterprise system and as such all of the same accounting, reporting, and costing characteristics of a utility apply, as spelled out in Statement 1, Governmental Accounting and Financial Reporting Principles, The National Council on Governmental Accounting, page 7, Proprietary Funds, (6) Enterprise Funds - to account for operations that are financed and operated in a manner similar to private business enterprises - where the intent of the governing body is that the costs (expenses, including depreciation) of providing goods or services to the general public be financed or recovered primarily through user charges...."

Thus, under generally accepted accounting principles (GAAP) as applied to government owned operations, the water utility operations of the City will be treated as will other public utilities. (See footnote in City of Baltimore Comprehensive Annual Financial Reports for the fiscal years ended June 30, 1984 through 1990.)

It is noted that at the request of a Board member this Statement 1 along with reference to AWWA Journals and manuals and the Comprehensive Financial Reports of the City for the years in question were all placed into the record at the Oral Arguments.

City of Baltimore

Cost of Equity Investment in Plant Facilities

used by County of Baltimore

Fiscal Year Ended June 30,	Average Rate Base	Less: Average Debt Financed	Average Equity Financed	Rate of Return	Amount of Return (Cost)
1984	$32,800,000	$12,200,000	$20,600,000	4.14%	$ 847,900
1985	31,400,000	11,600,000	19,800,000	3.56%	772,200
1986	29,800,000	9,800,000	20,000,000	3.94%	780,000
1987	29,000,000	9,500,000	19,500,000	3.90%	730,700
1988	28,000,000	10,000,000	18,000,000	4.07%	713,700
1989	27,000,000	9,600,000	17,400,000	5.01%	899,400
1990	26,000,000	10,500,000	15,500,000	4,83%	724,300
	Total- Fiscal Years ended June 30, 1984-1990				$5,468,200
1991	25,200,000	10,000,000	15,200,000	3.923%	596,300
					$6,064,500

Note: 1984 through 1986 CPI number is estimated and in actual determination of amount of added cost, the actual numbers must be used.

All rate bases, debt and equity portions of the capital structure are approximate based upon numbers in record. The actual amounts will have to be calculated using the procedures which are recommended by the Board of an average rate base, and average capital structure.

This dissent, consisting of twenty (20) numbered pages and Appendix A through H represents my conclusions of law and decision which supplement those of the Majority, in which I join except as detailed in this dissent.

August _____, 1991

Charles E. Woods

APPENDIX A

Cost of Capital - Rate of Return on Investment

Pure Interest, or Bare Bones Rate or Risk-free time Value of money.	) This would be the minimum) an investor would require) with no risk in order to) forgo current spending for) current consumption and in-) vest the funds. Implicit is) that when one disinvested in) the future one would receive) equal purchasing power plus the) "risk-free" interest in order to) meet this test.
	Plus
Risk Premium	) Because one cannot predict the) future with exactness, there is) uncertainty as to what will occur,) and this creates risks.) Some risks would be:) The actual rate of inflation) Acts of God - Floods, storms,) Fires, etc.) Acts of man - strikes, market) changes, defaults or bankruptcy,) loss of customer, and judicial or) legislative changes.
	Plus
Inflation	) Changes in the cost of money, unit) costs of operation and maintenance) expenses and cost of construction.

Most of these elements of "cost" of capital are avoided with the equity investment of the City through the true-up process and thus would not be considered in the calculation of the "Cost" of equity capital of the City. The one which they cannot avoid is the impact of inflation on the purchasing power of their investment. In order to avoid loss to the City, while at the same time avoiding any profit, only inflation should be considered in determining their cost. Uncertainty as to the "rate of inflation" is avoided by this true-up process.

By using the rate of inflation as the measure of the City's cost of equity, the inroads of future inflation will be avoided. The purpose of return is not to recover any effects of past inflation. It is designed to insure that in the future the County of Baltimore consumers do pay their full share of the cost of providing water service as mandated in the Act. This minimum return at the level of inflation will insure that the City does not incur any future losses in its equity investment because of the impact of inflation. Combined with the "utility basis" and the functional cost allocation procedures/base-extra capacity method of properly allocating cost to the consumers benefiting from such costs, the City will be in a position whereby it does meet the mandate of the Act that it will provide for the water service needs of the County at cost entirely without profit or loss.

This Appendix A is provided as background on how an economist and/or financial analyst looks at the "elements of cost" which make up the "cost of capital. Some would add to these listed costs the administrative costs and others may even relate the cost to taxable or non-taxable situations. It's purpose is to provide a foundation as to how I arrived at my conclusion with respect to which elements of "cost." must be considered with the City's equity investment in water utility facilities allocated for use in providing to Baltimore County consumers with water service.

It also includes those elements of cost which I have concluded must not be considered because of the prohibition of the Act that cost must be "entirely without profit or loss."

Much of this material was obtained from presentations made by Mulle for use at the National Association of Regulatory Utility Commissioners (NARUC) seminar on Regulation for Water Utilities.

Other Definitions of Profit

Economics, Paul A. Samuelson, 1948, Page 599, First View: Profit as "Implicit" Factor Return...Obviously, part at least of reported profits are merely the return to the owner of the firm for the capital supplied by them. Thus, part may be the return to the personal work provided by the owner of the firm...Part may be the rent return on self-owned natural resources; part the equivalent of interest on the owner's capital...This shows the first principle about profit: Much of what is ordinarily called profit is really nothing but interest, rents, and wages under a different name. Implicit interest, implicit rent, and implicit wages are the names economists give to this part of profit - i.e., to the earnings of self-used factors.

Economics, Lipsey, Steiner and Purvis, 5th Ed., pages 151-161. If there is some industry in which all firms revenues exceed opportunity costs (including costs of capital), all the firms will be earning profits. Profits are revenues in excess of costs.

Economic profits on goods (and services) sold are defined as the difference between revenues from sales and the opportunity costs of the resources used to make them. The cost of using something in a particular venture is the benefit foregone (or opportunity lost) by not using it in its best alternative use.

Profits: An advantage, benefit or gain, pecuniary gain, the compensation accruing to enterpreneurs for the assumption of risk in business enterprise as distinguished from wages, rent or interest. To derive benefit, New Expanded Webster's Dictionary.

Professor Ward S. Curren, George M. Ferris Professor of Corporation Finance and Investment, Trinity College, Hartford, Connecticut in a personal letter to me dated June 6, 1986, stated:

> "You are correct about the term profit. You may cite the following economic textbook references:
> Lipsey, Steiner, and Purvis, Economics, 7th Ed., (New York, Harper Row, 1984) pp. 180-181, 386.
> Samuelson and Nordhaus, Economics, 12th Ed., (New York, Mc-Graw-Hill, 1985) pp. 654, 660-661.
> ....In essence profit is the return above what is necessary to attract and maintain capital in a firm. That firm may be the City of Baltimore or the Baltimore Gas and Electric Company. There is no substantive economic difference between the two as far as the use of plant and equipment. There is an institutional difference. The former will have a lower cost of capital or required return than the latter only because the holder of municipal obligations does not have to pay income taxes on the interest whereas the owner of the stocks, and bonds used to finance the investment does have to pay income taxes. In economics this is a question of the redistribution of income, yet it allows the City of Baltimore to build and maintain facilities at a lower return than if they were built and maintained by a private or investor owned utility."

It is noted that Professor Curren did not have available atthe time he wrote this a copy of the Act and thus was not aware of the prohibition as to cost being entirely without profit or loss to the City. The return necessary to attract and maintain capital in the institution is its "cost" while any return above this would be a "profit" to the owners of the capital.

Appendix B

A Key to Modern Economics, Wright, David Mc Cord, (Professor of Economics, University of Virginia), The Mc Millan Company, New York, 1954.

"The first type of "profits" which are not really profits, is called by economists "wages of management." If a man owns his own unincorporated business, he may under some circumstances believe that he is making a substantial profit when to the economist he is making no profit at all. Suppose..he clears over and above all other expenses a net revenue of $7,000 a year. He may call this his profit, but in many cases it is really wages; for if the business, instead of being personally owned...was a corporation, it would have to hire a manager who might require at least $7,000 a year in order to work..Thus the apparent profit is only wages...and actrually may (produce) a loss." Another example cited in this text is when the owner owns the store and does not pay himself rent where as if he rented to another, he would collect rent. Thus, part of the so-called profit is a cost of a resource necessary to run the business. Wright goes on to state, "Again, if a man is operating a business with his own money and does not have to borrow from anyone, he may be earning what he calls a profit; yet in fact these so-called profits may only equal the interest which he would normally get had he chosen to invest his money in some other line."

He adds that what the uninformed may call a "profit" is in reality the cost of the use of the funds. It is only when the net income from the business less these "implicit" costs exceed the total cost is a "profit" actually achieved from the operation.

Land Economics, a quarterly journal of Planning, Housing & Public Utilities, Volume XXVIII, Number 2, May, 1952.
Rate of Return and the Value of Money in Public Utilities,
Walter A. Morton, Professor, Dept. of Economics, U of Wisconsin.

"In order to prevent gradual expropriation of utility property in the event of inflation, the rate of return should contain an inflation adjustment which is applied only to the common...equity." Page 91.

"By changes in the value of money we mean simply changes in the purchasing power, which is measured by various indexes of prices." Page 94.

"If, on the other hand, an adjustment (for inflation) is desired, it can be effected either by changing the rate of return or by altering the rate base, or by doing both." Page 95.

"In a period of stable prices, or even when prices fluctuate mildly with the business cycle, the difference between nominal and real dollars is of little significance. This, however, obviously ceases to be true in the event of permanent major changes in the value of money." Page 96.

"The factors which will determine the amount of the inflation adjustment are: (1) the index used to measure the degree of inflation, (2) the weight accorded this result, and (3) the decision regarding application of the adjustment to the common equity." Page 115.

" Any inflation adjustment should be limited to the stockholder's equity....." Page 106.

APPENDIX C

Difference Between City's Proposed Return on Rate Base and Amount Granted by Woods

Fiscal Year Ended June 30,	Revised Interest on Debt	Return on Equity Investment	Total Return Allowed	City Proposed Return	Difference
1984	$ 580,000	$ 847,900	$1,427,900	$2,612,400	(1,184,500)
1985	624,800	772,200	1,397,000	2,510,300	(1,113,300)
1986	530,500	780,000	1,310,500	2,408,100	(1,097,600)
1987	332,300	730,700	1,063,000	2,029,600	(966,600)
1988	341,700	713,700	1,055,400	1,651,100	(595,700)
1989	381,400	899,400	1,280,800	1,719,200	(438,400)
1990	350,000	724,300	1,074,300	1,787,200	(712,900)
Subtotal	$3,140,700	$5,468,200	$8,608,900	14,717,900	(6,109,000)
1991		596,300	---	Not Available	
Total		$6,064,500			

Sources: Return on Equity investment by Woods, See Schedule on page 16 of his analysis

City Proposed Return from Column (3), Schedule HJL-6, City Exhibit 2.

Revised interest on debt is an estimate based upon the use of the functional cost allocation procedures and base-extra capacity method of allocating costs of debt interest.

Note: Above numbers are estimates only based on figures in record. In that certain costs were based upon an averaging procedure in City's exhibits, these numbers at the best are only approximations as to the amount due the City and will have to be revised by the parties based upon the guidelines set forth by the Board.

Page 1 of 1.

APPENDIX D

Balance Sheet for Year Ended June 30, 1984
Distribution by Asset Type

	Totals	Baltimore County	Baltimore City	Other Counties	Other Assets
Property					
Buildings.......	$300,191.0				
Equipment.......	11,638.0				
Sub-total.....	$311,829.0				
Land...........	12,245.0	$ 97,959.2	$181,646.5	$44,468.3	
Less: Accum Deprec	(157,092.7)	(49,943.9	(93,346.6	(13,802.2)	
Net Plant.........	$166,981.3	$ 48,015.3	$ 88,299.9	$30,666.1	
Less:					
Direct Cont.....	(40,739.5)	(17,274.0)	(4,082.1)	(19,383.4)	
Accum. Amort....	4,900.5	1,832.7	791.9	2,275.9	
Rate Base.........	$131,142.3	$ 32,574.0	$ 85,009.7	$13,558.6	
CWIP.............	$ 1,774.7				$ 1,774.7
Current Assets....	$ 19,146.0				
Less: Cur. Liab...	(3,329.0)				
Net...........	$ 15.817.0				$15,817.
Restricted Assets.	$ 13,400.0				
Less: Rest. Liab..	(50.0)				$13,350.
Net...........	$ 13,350.0				
Issuance Costs....	$ 308.0				$ 308.
Total Assets......	$162.392.0	$ 32,574.0	$ 85,009.7	$13,558.6	$31,249.
Debt					
Genl. Obl. Bonds..	$ 52,410.0				
Revenue Bonds.....	10,000.0				
Other Debt.......	0.0				
Total.........	$ 62,410.0				
Equity:					
Contributed	$104,453.0				
Less; Rate Base Offset....	(40,739.5)				
Net............	$ 63,713.5				
Retained Earnings:					
Reserved-rev. bonds.........	$ 3,082.0				
Future Oblg....	10,268.0				
Total.......	$ 13,350.0				
Unreserved.....	$ 18,018.0				
Amort. of Cont.	$ 4,900.5				
Total Equity.....	$ 99,982.0				
Total Debt/Equity	$162,392.0	$ 32,574.0	$ 85,009.7	$13,558.6	$31,249.7

APPENDIX D
Summary Balance Sheet - Water Utility
Fiscal Year Ended
June 30, 1984

Description	Total	Less: Capital Used for specific asset Debt	Equity	Capital to be allocated	Debt	Equity
Rate Bases:						
Balt. County...$	32,574.0			32,574.0	12,109.0	20,465.0
Balt. City.....	85,009.7			85,009.7	31,601.3	53,408.4
Other Counties.	13,558.6			13,558.6	5,040.2	8,518.4
CWIP...........	1,774.7			1,774.7	659.7	1,115.0
Curr. Assets/Net	15,817.0			15,817.0	5,879.8	9,937.2
Rest. Assets....	13,350.0	$ 4,767.0	3,082.0	5,501.0	2,045.0	3,456.0
Issuance Costs..	308.0	308.0		---		
	$162,392.0	$ 5,075.0	3,082.0	154,235.0	57,335.0	96,900.0
Capital Structure						
Debt...........$	62,410.0	$ 5,075.0		57,335.0	37.1738%	
Equity.........	99,982.0		$3,082.0	96,900.0	62.8262%	
	$162,392.0	$ 5,075.0	3,082.0	154,235.0	100.0000%	

Sources of Data:

Totals" City Exhibit 8, pages 3 and note 5, pages 8 and 9 for year 1984. Also, Lobb's rebuttal testimony, schedule HJL-7D, City Exhibit 2.

Note: Certain data "netted" to arrive at Capital Structure, viz., Current Assets have Current Liabilities subtracted to arrive at "Net Current Assets."

Page 2 of 6

Balance Sheet for Year Ended June 30, 1986
Distribution by Asset Type

	Totals	Baltimore County	Baltimore City	Other Counties	Other Assets
Property					
Buildings.......	$305,264.0				
Equipment.......	17,321.0				
Sub-total.....	$322,585.0				
Land...........	12,242.0	$100,128.1	$189,598.3	$45,100.6	
Less: Accum Deprec	(169,739.7)	(54,674.0)	(101,397.5)	(13,668.2)	
Net Plant.........	$165,087.3	$ 45,454.1	$ 88,200.8	$31,432.4	
Less:					
Direct Cont.....	(42,685.4)	(18,567.8)	(4,366.9)	(19,750.7)	
Accum. Amort.....	6,504.8	2,588.8	960.0	2,956.0	
Rate Base.........	$128,906.7	$ 29,475.1	$ 84,793.9	$14,637.7	
CWIP.............	$ 12,363.7				$12,363.7
Current Assets....	$ 22,952.0				
Less: Cur. Liab...	(3,428.0)				
Net...........	$ 19,524.0				$19,524.0
Restricted Assets.	$ 25,735.0				
Less: Rest. Liab..	(1,629.0)				$24,106.0
Net...........	$ 24,106.0				
Issuance Costs....	$ 309.0				$ 309.0
Total Assets......	$185,209.4	$ 29,475.1	$ 84,793.9	$14,637.7	$56,302.7
Debt					
Genl. Obl. Bonds..	$ 42,340.0				
Revenue Bonds.....	27,550.0				
Other Debt........	1,539.0				
Total.........	$ 71,429.0				
Equity:					
Contributed	$109,694.0				
Less; Rate Base Offset....	(42,685.4)				
Net............	$ 67,008.6				
Retained Earnings:					
Reserved-rev. bonds........	$ 4,760.0				
Unreserved........	$ 35,507.0				
Amort. of Cont. Capital.........	$ 6,504.8				
Total Equity......	$113,780.4				
Total Debt/Equity.	$185,209.4	$ 29,475.1	$ 84,793.9	$14,637.7	$56,302.7

Source: 1986 Comprehensive Financials, page 33, Enterprise Fund Balance Sheet, Water Utility, page 33, and footnotes. Some of theliabilities have been netted. (See reconciliation.)

APPENDIX D

Summary Balance Sheet - Water Utility
Fiscal Year Ended
June 30, 1986

Description	Total	Less: Capital Used for Specific Assets Debt	Less: Capital Used for Specific Assets Equity	Capital to be Allocated	Debt	Equity
Rate Base:						
Baltimore County	29,475.1			29,475.1	9,685.3	19,789.8
Baltimore City	84,793.9			84,793.9	27,862.8	56,931.1
Other Counties	14,637.7			14,637.7	4,809.9	9,827.8
CWIP	12,363.7			12,363.7	4,062.6	8,301.1
Net Current Asset	19,524.0			19,524.0	6,415.6	13,108.4
Restricted Assets	24,106.0	$17,764.0	$4,760.0	1,582.0	519.8	1,062.2
Issuance Costs	309.0	309.0		---	---	---
Totals - Assets	$185,209.4	$18,073.0	$4,760.0	162,376.4	53,356.0	109,020.4
Capital Structure						
Debt	$ 71,429.0	$18,073.0		$53,356.0	32.8594%	
Equity	113,780.4		$4,760.0	109,020.4	67.1406%	
Total - Capital	$185,209.4	$18,073.0	$4,760.0	162,376.4	100.0000%	

To: Allocate capital structure between various asset groups, viz., Rate Bases, CWIP, Net Current Assets, Restricted Assets and Issuance Costs. First, capital used for specific asset funding is deleted from the total Capital and the balance is allocated on the basis of ratio of individual assets to total. 32.8594% of the Baltimore County Rate Base is allocated to debt funding and the balance of 67.1406% of the Rate Base is allocated to Equity funding.

Restricted Assets represent Revenue Bond Note Construction Account which is restricted to future construction projects and as of the date of this balance sheet has not been used for funding rate base. Also, there is a separate item of equity allocated to fund Revenue Bond and Note Debt Service Accounts in restricted assets.

Reconcile to Comprehensive Balance Sheet, page 33, Water Utility.

Balance Sheet totals as shown above.	$185,209.4
Add: Current Liabilities (netted to current assets)	3,428.0
Restricted liabilities netted	1,629.0
Contributed Capital, net of amortization, deducted from plant balances	36,180.6
Total - page 33, Water Utility Enterprise Fund Balance Sheet	$226,447.0

Balance Sheet for Year Ended June 30, 1988
Distribution by Asset Type

	Totals	Baltimore County	Baltimore City	Other Counties	Other Assets
Property					
Buildings.......	$338,159.0				
Equipment.......	18,906.0				
Sub-total.....	$357,065.0				
Land............	12,237.0	$110,058.7	$204,041.1	$55,202.2	
Less: Accum Deprec	(181,911.7)	(58,296.6	(104,665.5)	(18,949.6)	
Net Plant.........	$187,390.3	$ 51,762.1	$ 99,375.6	$36,252.6	
Direct Cont.....	(55,643.3)	(27,819.0)	(6,242,9)	(21,581.4)	
Accum. Amort....	8,250.0	3,484.0	1,152.4	3,613.6	
Rate Base.........	$139,997.0	$ 27,427.1	$ 94,285.1	$18,284.8	
CWIP.............	$ 12,589.7				$12,589.7
Current Assets....	$ 21,756.0				
Less: Cur. Liab...	(3,786.0)				
Net...........	$ 17,970.0				$17,970.0
Restricted Assets.	$ 12,344.0				
Less: Rest. Liab..	(3,479.0)				$ 8,865.0
Net...........	$ 8,865.0				
Issuance Costs....	$ 211.0				$ 211.0
Total Assets......	$179,632.7	$ 27,427.1	$ 94,285.1	$18,284.8	$39,635.7
Debt					
Genl. Obl. Bonds..	$ 33,000.0				
Revenue Bonds.....	28,045.0				
Other Debt........	2,608.0				
Total.........	$ 63,653.0				
Equity:					
Contributed	$124,329.0				
Less; Rate Base Offset....	(55,643.3)				
Net............	$ 68,685.7				
Retained Earnings:					
Reserved-rev. bonds........	$ 3,210.0				
Unreserved........	$ 35,834.0				
Amort. of Cont. Capital.........	$ 8,250.0				
Total Equity......	$115,979.7				
Total Debt/Equity.	$179,632.7	$ 27,427.1	$ 94,285.1	$18,284.8	$39,635.7

Data Sources: Total column from Comprehensive Annual Financial Report, Balance Sheet, Enterprise Fund, Water Utility, and also source of Other Assets.
Rate base data from City Exhibit 2, Lobb schedule HJL.

<u>APPENDIX D</u>
Summary Balance Sheet - Water Utility
Fiscal Year Ended
June 30, 1988

Description	Total	Less: Capital Used for specific Asset Debt	Equity	Capital to be Allocated	Debt	Equity
Assets						
Rate Bases:						
Balt. County...$27,427.1				$27,427.1	$9,874.7	$17,552.4
City Baltimore.	94,285.1			94,285.1	33,945.7	60,339.4
Other Counties.	18,284.8			18,284.8	6,583.1	11,701.7
CWIP.............	12,589.7			12,589.7	4,532.7	8,057.0
Net Curr. Assets.	17,970.0			17,970.0	6,469.8	11,500.2
Rest'd Assets....	8,865.0		3,210.0	5,655.0	2,036.0	3,619.0
Issuance Costs...	211.0	211.0		---		
Total	$179,632.7	$211.0	$3,210.0	176,211.7	63,442.0	112,769.7
Capital Structure						
Debt............	$63,653.0	211.0		$63,442.0	36.0033%	
Equity.........	115,979.7		3,210.0	112,769.7	63.9967%	
Total	$179,632.7	$211.0	$3,210.0	$176,211.7	100.0000%	

Sources of Data: See prior year

<u>APPENDIX D</u>

<u>Comments re: Balance Sheet Analysis</u>

As can be seen from the 1984 Balance Sheet, only $131,141,000. of the capital funds were used for rate base financing, with the balance of $31,249,000 being used for other utility purposes.

In calculating the amount of cost associated with rate base funding, if there are significant amounts and cost of capital used for non-rate base purposes, these should be deleted before determining the cost of capital used for County of Baltimore plant financing. It may be that the administrative cost of such an analysis on an on-going basis exceeds the benefits from the greater accuracy of this type of analysis. The parties should make a determination as to the costs of providing this data as compared to the benefits to be derived, and if there are significant positive benefits, they may choose to use this type of analysis in future cost determinations,

EXHIBIT E
City of Baltimore
Calculation of Rate and Amount of Return on County of Baltimore Rate Base for fiscal years ended June 30, 1984, 1986 and 1988.

	(1) Amount of Capital	(2) Percent of Total	(3) Rate of Return (Annual)	(4) Composite Rate	(5) Amount of (1)x(3)=	(6) Return (1)x(4)= (total)
Year 1984						
Majority Basis						
Debt	$12,109,000	37.174%	4.79%	1.7806%	$ 580,000	---
Equity	20,465,000	62.826%	---	---	---	
Total	$32,574,000	100.000%	---	1.7806%	$ 580,000	$ 580,000*
Minority Basis						
Debt	$12,109,000	37.174%	4.79%	1,7806%	$ 580,000	---
Equity	20,465,000	62.826%	4.143%	2,6028%	847,900	---
Total	$32,474,000	100.000%	---	4.3834%	$1,427,900	$1,427,900
Year 1986						
Majority Basis						
Debt	$ 9,685,300	32,8594%	5.510%	1,810%	$ 530,500	---
Equity	$19,789.800	67.1406	---	---	---	
Total	$29,475,100	100.000%		1,810%	$ 530,500	$ 530,500
Minority Basis						
Debt	$ 9,685,300	32.8594%	5,510%	1.8105%	$ 530,500	---
Equity	19,789.800	67.1406%	3.94%	2.6453%	780,000	---
Total	$29,475,100	100,000%	---	4.4558%	$1,310,500	$1,310,500
Year 1988						
Majority Basis						
Debt	$ 9,874,700	36.003%	3.46%	1,2457%	$ 341,700	---
Equity	17,552,400	63.997%	----	---	---	---
Total	$27,427,100	100.000%	---	1.2457%	$ 341,700	$ 341,700
Minority Basis						
Debt	$ 9,874,700	36.003%	3.460%	1,2457%	$ 341,700	---
Equity	27,427,400	63.997%	4.066%	2,602%	713,700	---
Total	$27,427,100	100.000%	---	3.8477%	$1,055,400	$1,055,400

*Note: Numbers are rounded. Also, these figures are approximations only and must be re-calculated using actual data as developed by the parties. This will include rate base, capital structures, return on embedded debt and for the minority the actual rate of inflation as measured by the CPI.

Source of Data: Rate Base: Lobb's schedules, Return on Debt from Mulle's Schedule HGM-1, City Ex. 3, and Return on Equity from Appendix F. Capital structure percent from Appendix D.

Page 4 of 4

APPENDIX F

Consumer Price Index for All Urban Consumers*

July for Year	Consumer Price Index*	Percent Change from Prior Year
1982	292.2	---
1983	299.3	2.430%
1984	311.7	4.143%
1985	322.8	3.561%
1986	330.0	3.94%
1987	342.0	3.902%
1988	354.9	4.066%
1989	372.7	5.015%
1990	390.7	4.830%

Source: U.S. Department of Labor, Bureau of Labor Statistics, Washington, D.C., 20212. This data was obtained from several sources and did not always agree, thus, it must be checked for accuracy when used in actual determination of cost. Its purpose is to illustrate the process as to how a return on equity at the level of inflation can be determined for the City's equity investment assigned to County water uses based on the proportion of such plant funded by equity from the City.

APPENDIX G

On page 2 of his direct testimony, Henry G.Mulle, outlines the legal and economic principles which he asserts guide the determination of the cost of capital (City Ex. 3.) What he does not do adequately is relate these to the special circumstances which govern the determination of cost of capital for the City in providing for County service. These special circumstances relate to the prohibition which is specifically spelled out in the Act. that cost must be entirely without profit or loss to the City. He does not give sufficient recognition as to how the true-up process does reduce the risk of operation and thus its cost of equity.

On page 4 he does refer to a "singular definition stated by Garfield and Lovejoy in the text, Public Utilities Economics, 1964, Prentice-Hall, Inc, pp. 44 and 45, which includes operation and maintenance expenses, provision for depreciation, taxes other than income taxes, income taxes, cost of debt and the cost of common equity." What he fails to do is point out that these cost must be used in order for the results of operation to be measured in a way to insure that neither a profit or a loss occurs. Although taxes are not a factor in costs to the City, the other elements for the determination if a profit or a loss occurs are essential in measuring if results are in compliance with the Act's mandate of no profit or loss.

Also, as is pointed out in reviewing his article on Risk, he did not adequately reflect any adjustment in cost of equity capital necessary because of the reduced risk associated with the true-up process. The full effect of the 1972 Agreement on risk, profit or loss, and cost was not factored into his cost determination. As an example, the impact of capital contributions on reduced funding needs of the City was not specifically considered in his analysis.

In the January 15, 1976 issue of the Public Utilities Fortnightly article, Some Testimony on Risk, Henry G. Mulle defined risk as, "Risk is the uncertainty concerning the probability of a happening or event. In business it is largely concerned with the probability of achieving a level of profit or return. All risk of this nature is generally referred to as investment risk, and is subdivided into two types - business risk and financial risk." With the true-up process between the City and the County in order to establish "actual cost" of providing water service to the County users, much of the uncertainty of business is removed in that after the fact, the actual costs are determined. The City is made "whole" as to these costs. The only risk is that of inflation and the possibility that the City may not properly calculate their costs so as to avoid a loss and thus incur a loss, albeit, one which they do not realize that they have incurred.

As was shown in the analysis of the data from 1980 through 1989, the City did incur a loss by having a negative net income from providing water service to County consumers. It also sustained an even larger loss when the impact of inflation's impact on its investment dollars is factored into the equation. These types of losses can be avoided in the future (both as to erroneous cost calculations and the effects of inflation) by use of the "utility basis" and the "functional cost allocation procedures/base-extra capacity methods" for the allocation of all costs and by the allowance of a return on the equity investment of the City at a level equal to the rate of inflation.

With the continued use of procedures whereby the County contributes its share of future capital needs (and with revised procedures to insure that each party - City and County - pay their fair share of these costs if use patterns change) this will further reduce the City's risk and thereby reduce the need for any other element of "equity capital cost" to compensate the City for risk taking.

Appendix G

Comments re: Paul R. Moul's Transcript Testimony

On page 761 of the transcript, Moul responded to the question as to how costs are defined by stating, "Costs are defined under generally accepted accounting principles that are recorded on income statements, operating costs, maintenance costs, depreciation, taxes other than income, income taxes, interest expenses, and there are other miscellaneous things." (Underlining for emphasis added.) Thus, he concludes that in order to determine profit or loss, one must include as one cost depreciation expense. Whe responding on page 761 to the question as to how you define the word profit, his response was, "A profit? Speaking as a financial analyst is the amount shown on the bottom of the income statement which occurs when revenues or sales exceed costs shown on that income statement, any positive figure."

Although we may question his response when he claims that all positive figures equate to a profit (see analysis as to impact of inflation on this issue) his response does show that for determining if a profit occurs, regardless of whether net income is always a profit, the income statement must be used in this determination. One cost he concedes must be deducted in this process is depreciation. This puts to question his prior testimony where he stated that the "use of the rate base rate of return methodology in this particular circumstance is not the way to remedy the situation that apparently bothers the city." He adds,"I don't think that is the way to go, in spite of the fact that I'm keenly aware that equity has a cost." On page 716 he states that the debt service method should be used to determine rates (costs) to county consumers. Since rates are not the issue before the Board, but "cost of service" is, the debt service method cannot be used for determining costs in that this method contains elements which are not costs for income statement purposes, which statement he concedes is necessary to determine if a profit or a loss occurs.

Plant funded from current revenues and payments of debt principle, also funded from current revenues, are not costs for purpose of determining net income. These are elements under the debt service method of revenue requirement determination. These are balance sheet items, not net income statement items. (See discussion on this issue re: Statement 1, National Council of Governmental Accounting.)

Thus, one must conclude that there is an inconsistency in these two positions taken by Moul. His assertion that net income requires the use of depreciation expense and this calculation comes from the Income Statement does not jibe with his conclusion that the debt service method of revenue determination is acceptable for use in the cost of service calculation for Baltimore County consumers water service needs.

On page 2 of his direct testimony (City Exhibit 5), Paul R. Moul states, "The only change which is warranted at this time is a shift away from a volumetric allocation as it applies to the operating expenses of the City water system." There are two flaws in this assertion. First, if a shift away from a "volumetric allocation" is "warranted" for the operation and maintenance (O&M) expenses then it follows that other costs should also shift from volumetric allocation procedures to functional cost allocation procedures/base-extra capacity methods. Plant is designed to reflect these functions (e.g., peak loads) and thus the annual costs associated with this plant (depreciation, interest, return) will vary with these functions as well as with volume. Thus, plant cost must also be allocated on similar bases if there is to be consistency in the way in which costs are allocated.

Also, if costs are to be "entirely without profit or loss" these costs must be measurable in a way whereby it can be determined if a profit or a loss occurs. This requires the use of depreciation as a cost, and if the amount of this cost applicable to County uses is to accurately to reflect the County consumers use of the property, functional cost allocation procedures must be used. Interest and return on equity are other costs of a similar nature, viz., the share applicable to County uses must be determined by functional cost procedures. When Moul, in testimony at the hearing, admitted that in order to determine if a profit or loss occurs, net income must be calculated, he indirectly concedes that depreciation must be one such cost. This means that for both profit and loss and accurate allocation of annual plant costs, functional cost procedures must be used.

It is not proper to use a measure of cost if that measure does not accurately reflect the actual amount of cost applicable to the county. To do this is to mask the possibility that either a profit or a loss may have occurred which would be contrary to the mandate of the Act.

Dr. John J. Boland, Ph.D.,P.E., re: Cost of Service

The foundation for Dr. Boland's conclusion that the equity investment of the City in water facilities is "costless" is explicitly stated on page 609 of the transcript where he states, "Now, I should say here that, first of all, contrary to what members of the board may have heard or read, I have no quarrel with the free enterprise system. I would be in big trouble as an economist if I did. I am entirely in favor of earning a return on equity; I think it is, there is absolutely nothing wrong with it. I have no problem with government-owned utilities doing it either. Absolutely no problem. I do have a problem when that equity is costless, calling that return cost. Cost cannot be created when it does not exist." (Emphasis added.) On page 611 he adds, I think that is the main point that I would like to make from my testimony, and that is that that which does not have a cost to the utility can't be redefined as cost."

The difficulty with this conclusion that the City's equity has no cost is most economist relate cost of capital to its opportunity cost, or what it could earn in alternative uses. It is not necessary for capital to have on-going annual acquisition cost to the utility to have a "cost," albeit, it also is my conclusion that the equity capital of the utility does have cost to the utility. As an example, when a developer or others contributed capital (CIAC) to the utility they do so to avoid on-going future costs associated with water service. To them the benefit of lower future water charges exceed the cost of contributed capital and thus, they are willing to make the contribution of capital.

Unfortunately, the board did not raise the issue of the impact of inflation on the City's equity to Dr. Boland and thus there is no record as to his position on this issue. On page 622 of the transcript in answer to the question, "You do believe there is equity in the city system," he replied, "I believe there is equity in the City system." Later on page 623 and 624 he asserts that his assignment did not encompass an independent study as to the sources of the

City equity although he did indicate that he did review the City's financials. "I have the same information about the sources of that equity as I have about the sources of equity today, and that is the testimony of the City witnesses. That is all I know about the source.." (Lines 18-21, Pg. 623 Tr.) He did not comment as to whether he reconciled Lobb's data with the actual true-up to determine if there was a net income or a loss from serving county consumers for the years 1980-1990, the data which is in the record. He also did not comment on the source of the City's equity increase during this period. (Such increases were in addition to county contributions of capital which amounts were deducted from the rate base and capital structure calculation by Lobb.) On page 632 when asked, "Do you subscribe to the generally accepted economic definition of what is a profit, that return over and above the cost of funds?" his reply was, "The witness: Yes sir, I certainly hope so." On pages 679-685 of the transcript, after a lengthy discussion as to the nature of the question as to whether the City could replace its equity investment with debt, Dr. Boland replied, "So it would not seem to violate the Charter as we have just read it. Now, the question is whether it would seem to violate the assumption regarding the Baltimore County arrangement." (The agreement which is subject to revision.)

After a careful review of Dr. Boland's prepared and oral testimony along with other sources of data, both in the record and from other authoritative references, I have concluded that the City did have alternative, albeit limited, opportunities for alternative uses of its equity capital. The City could have used their equity for inner City water service needs and thus reduce the need for outside debt financing.

As discussed in other sections of this dissent, the rate of return on this equity would be at the level of inflation so as to avoid conflicts with the Act that mandates cost to be "entirely without profit or loss."

As discussed in other sections of this dissent and conclusions of law, the issue as to why the City elected to allocate its county used rate base on a proportional basis between debt and equity is not fully explained in the record. It would seem that Dr. Boland does not see any problem with 100% funding of County used plant by debt as long as the amounts did not include any plant funded by County contributions of capital. He states, (pg . 684-685, lines 15 on), "So to the extent that those contributions that we don't know about have come from the county and not the city, I would argue that the county in that case would be asked to double-pay for certain costs." To this I would fully agree but as Lobb testified and his schedules show, he did reduce rate base by county contributions and by federal grants. Boland goes on to say, "To the extent that they have not, if they have entirely come from the City, then I wouldn't see how that could conflict with the legislation." He adds, "I would point out that what you are proposing would be exactly the same as simply asking the county to buy that rate base and let the county finance it. I think what you are saying is in effect just exactly the same." To which Chairman Robertson commented (pg. 685, lines 7 and 8), "Well, that was my solution two days ago. Give them the money." Them being the City and to this I also concur.

I would also concur with Boland's conclusion that this would require a careful determination as to the capital amounts involved through a joint program with City and County personnel participating in the calculation of the capital costs. (Pg. 685, lines 9-14.)

APPENDIX H

On page 163 of the American Water Works Association (AWWA) Water Utility Accounting text, second edition, it states, "Depreciation of utility plant assets is an economic fact that must be given explicit and systematic recognition, by both investor-owned and municipally owned water utilities, as a cost of rendering water service." (Underlining added for emphasis.) It goes on to state that depreciation expense is of interest to management as an element to be considered in the determination of net income. ....and indirectly influences cash flows to the extent it is a factor in setting rates. On page 3 of the AWWA M-1 Manual, Water Rates, it says, "depreciation is a real part of the cost of operating a utility, whether publically or privately owned....The annual depreciation expense component of revenue requirements provides for the recovery of the utility's capital investment over the anticipated useful life of the depreciable assets." The National Council on Governmental Accounting (NCGA) in its Statement 1, Governnmental Accounting and Financial Reporting Principles, (March 1979) which is an update of principles developed since 1934 (page 1 of Statement) says, "Depreciation of fixed assets accounted for in a proprietary fund should be recorded in the accounts of that fund. Depreciation is also recognized in those trust funds where expenses, net income and/or capital maintenance are measured." An enterprise fund is one such proprietary fund for which depreciation must be reported. It says that depreciation is an important element in the income determination process. Not to reflect depreciation will cause the income statement to refelct a "net income" which is not accurate. Any calculation of net income or net loss which does not include an annual depreciation expense applicable to operations will be inaccurate and not in conformity with generally accepted accounting principles (GAAP) as applied to government owned enterprise funds. In the introduction, it says:

"As developed by this Council and its predecessor Committees since 1934, these principles are specific fundamental tenets which, on the basis of reason, demonstrated performance, and general acceptance by public administrators, accountants, auditors, and others concerned with financial operations, are generally recognized as essential to effective management control and financial reporting."

APPENDIX H

City of Baltimore

Conversion from Budgetary or Rate Setting Reporting to Determination of Net Income *

1988

	Budgetary or Rate Setting Reporting	Adjust to GAAP Cost Reporting	Adjust to Functional Cost Allocation	Pro Forma Income Statement
Gross Revenues...........	$15,563,264			$15,563,264
Operating and Maintenance.	14,190,620		605,480	14,796,100
Depreciation Expenses.....	---	1,775,300		1,775,300
Debt Service Payments.....	1,063,085	(1,063,085)		---
Capital Projects funded by Revenues..........	(16,080)	16,080		---
	16,912	(16,912)		---
Total	$15,254,537	711,383	605,480	$16,571,400
Utility Operating Income.	$ 308,727	(711,383)	(605,480)	$(1,008,136)
Less:				
Interest Expenses........	$ 267,103		74,597	341,700
Interest on Inventory....	41,624			41,624
Net Income or (Loss)	$ -0-	$(711,383)	$(680,077)	$(1,391,460)

Additional Revenues required to fully recover actual costs of providing water service to County - excluding any cost for equity return.................$ 1,391,460

* Numbers are for illustrative purposes only in that data from one source does not agree with other sources.

This illustrates that the use of an improper accounting procedure can mask the fact that there is a loss, contrary to the mandate of the Act. It could also result in an undetected "profit" to the City. The use of the Debt Service method of determining revenue requirement shows no profit or loss but this is because certain items of cost which must be included to determine net income were not, while some items which are not a part of the process of calculating net income (debt service principal payments and funding of capital construction costs from revenue) were included. See page 771 of county witness Moul where he states, "Costs are defined under generally acepted accounting principles that are recorded on income statements, operating costs, maintenance costs, depreciation,....interest." Thus, be inference, he concludes that to determine if a profit or a loss occurs, you must use GAAP and depreciation, while bond principal payments are not a part of the calculation. (See Appendix G.)

APPENDIX I

Reservoir Watershed Management Agreement

Baltimore City, Baltimore County, Carroll County

RESERVOIR WATERSHED MANAGEMENT AGREEMENT

BALTIMORE CITY, BALTIMORE COUNTY & CARROLL COUNTY

JUNE 29, 1979

THIS AGREEMENT, made this 29th day of June, 1979 by and between the MAYOR AND CITY COUNCIL OF BALTIMORE, a municipal corporation (hereinafter called "City"), BALTIMORE COUNTY, MARYLAND, a body corporate and politic (hereinafter called "Baltimore County"), and CARROLL COUNTY, MARYLAND, a body corporate and politic (hereinafter called "Carroll County").

WHEREAS, the General Assembly of the State of Maryland has established through Article 4, Subtitle 25 of the Code of Public Local Laws of Maryland that Baltimore City has a statutory obligation to protect and otherwise improve reservoir watersheds for the purpose of securing a pure and constant supply of water; and

WHEREAS, Article 4, Subtitle 25 of the Code of Public Local Laws of Maryland authorizes the City and Counties to enter into agreements as may be necessary for these purposes; and

WHEREAS, Baltimore City, Baltimore County, and Carroll County have participated in preparation of a Water Quality Management Plan for the Baltimore Metropolitan Region under Section 208 of PL 92-500 (hereinafter called "208") and have approved said plan; and

WHEREAS, this Agreement represents the preferred alternative for reservoir management as specified in the revised (October 1978) "208" plan; and

WHEREAS, the parties recognize the importance of maintaining high water quality in the water supply reservoirs to insure a continued supply of high quality water at a reasonable rate; and

WHEREAS, the parties desire that the benefits of and responsibilities for necessary actions be equitably shared by all parties; and

WHEREAS, the "208" Plan recommends the continuance of "208" Coordinating Committee composed of local elected officials of each of the participating jurisdictions;

WHEREAS, the "208" Coordinating Committee has an ongoing need for technical information and advice.

NOW, THEREFORE, BE IT RESOLVED, that in consideration of the covenants and agreements hereinafter set forth, it is mutually covenanted and agreed as follows:

ARTICLE I - RIGHTS OF CITY, BALTIMORE AND CARROLL COUNTIES NOT TO BE ABROGATED

A. Nothing in this Agreement shall limit or abrogate any right or rights delegated to Baltimore City, Baltimore or Carroll Counties by acts of the General Assembly of the State of Maryland.

B. It is further understood and agreed that the police, legislative and governmental powers of the Mayor and City Council of Baltimore, the County Executive and County Council of Baltimore County, and the Carroll County Commissioners are in no sense attempted to be abridged or restricted by this Agreement.

C. (Deleted by signatories)

D. Each signatory hereto further agrees that this Agreement can be terminated by any party within one month notice to the "208" Coordinating Committee.

Copied from the original document for publication in the Water & Sewerage Plan

ARTICLE II - ESTABLISHMENT OF A RESERVOIR WATERSHED MANAGEMENT PROGRAM

A. Organization

1. The program shall be conducted by representatives of the local "208" lead agencies from Baltimore City and Baltimore County and representatives of Carroll County.

B. Function

1. Continuous review and evaluation of existing problems and proposed actions potentially affecting the water supply watersheds which may include development proposals, plans, Best Management Practices, and other activities which affect reservoir water quality. These reviews and evaluations shall be conducted within the framework of and closely coordinated with the "208" Plan and State and local public laws and programs.

2. Report to the Coordinating Committee and local governments the results of these reviews and evaluations and recommend alternative solutions.

ARTICLE III - ROLE OF THE "208" COORDINATING COMMITTEE

The "208" Coordinating Committee members from Baltimore City, Baltimore County, and Carroll County shall review and discuss the report of the Reservoir Management Program.

IN WITNESS WHEREOF, the parties hereto have properly executed this Agreement as of the day, month, and year first above written.

Original Agreement approved by:

The Mayor and City Council of Baltimore
County Executive of Baltimore County
President, Board of County Commissioners of Carroll County

1984 RESERVOIR WATERSHED MANAGEMENT AGREEMENT

Effective June 4, 1984

THIS AGREEMENT is effective the 4th day of June, 1984 by and among the MAYOR AND CITY COUNCIL OF BALTIMORE, a municipal corporation (hereinafter called "City"), BALTIMORE COUNTY, MARYLAND, a body corporate and politic (hereinafter called "Baltimore County"), and CARROLL COUNTY, MARYLAND, a body corporate and politic (hereinafter called "Carroll County"), the DEPARTMENT OF HEALTH AND MENTAL HYGIENE, a State agency, the DEPARTMENT OF AGRICULTURE, a State agency, the REGIONAL PLANNING COUNCIL, a State intergovernmental agency, the WATER QUALITY COORDINATING COMMITTEE, an intergovernmental body created by compact (hereinafter called "Coordinating Committee" or "Committee"), and the BALTIMORE COUNTY SOIL CONSERVATION DISTRICT and the CARROLL SOIL CONSERVATION DISTRICT (hereinafter called the "Districts").

WHEREAS, the first Reservoir Watershed Management Agreement executed in 1979 by the City, Baltimore County, and Carroll County provided that the signatories review problems and actions affecting the water supply reservoir watersheds and report results and recommendations to the Water Quality Coordinating Committee; and

WHEREAS, the above parties agree that the 1979 Agreement needs to be strengthened by the addition of specific functions which provide goals toward which reservoir management can be directed, by an organizational framework, and by later incorporation by reference of policies to coordinate work by the signatory governments and governmental agencies to achieve the goals; and

WHEREAS, the General Assembly of the State of Maryland has established through Article 9, Section 325 of the Code of Public General Laws of Maryland that the State Department of Health and Mental Hygiene has statutory power to issue, modify, or revoke permits governing discharge of pollutants into waters of the State; and

WHEREAS, the General Assembly of the State of Maryland has established through Article 4, Subtitle 25 of the Code of Public Local Laws of Maryland, that Baltimore City has a statutory obligation to protect and otherwise improve reservoir watersheds for the purpose of securing a pure and constant supply of water; and

WHEREAS, Article 4, Subtitle 25 of the Code of Public Local Laws of Maryland authorizes the City and Counties to enter into agreements as may be necessary for these purposes; and

†Copied from the original document for publication in this Plan

WHEREAS, Baltimore City, Baltimore County, Carroll County, the Regional Planning Council, the Coordinating Committee, the Districts, and the State Department of Health and Mental Hygiene have participated in preparation of a Water Quality Management Plan for the Baltimore Metropolitan Region under Section 208 of P.L. 92-500 (hereinafter called the "Clean Water Plan") and said plan has been approved; and

WHEREAS, the Districts have participated in the development of the State Plan for the Control of Sediment and Animal Wastes to protect water quality (hereinafter called the "State Agricultural Plan") and are the Local Lead Agencies to implement this plan; and

WHEREAS, the General Assembly of the State of Maryland has created the Department of Agriculture pursuant to Agriculture Article 2-101 et seq., Annotated Code of Maryland, with general authority relating to the fostering, protection and development of the agricultural interest of the State; and

WHEREAS, the Maryland Department of Agriculture through the State Soil Conservation Committee is the lead agency in agricultural nonpoint source pollution control as designated in "Maryland's Statewide Agriculture Water Quality Management Program for the Control of Sediment and Animal Wastes", and in that capacity, coordinates with the soil conservation districts; and

WHEREAS, this Agreement represents the preferred alternative for reservoir management as specified in the Clean Water Plan; and

WHEREAS, the parties recognize the importance of maintaining high water quality in the water supply reservoir to ensure a continued supply of high-quality potable water at reasonable cost; and

WHEREAS, the parties desire that the benefits of and responsibilities for necessary actions be equitably shared by all parties; and

WHEREAS, the Clean Water Plan recommends the continuance of the Coordinating Committee composed of local elected officials of each of the participating jurisdicions and certain State officials, as set forth in Section 2.01(a) of "THE BALTIMORE REGIONAL PLANNING COUNCIL AREAWIDE WASTE TREATMENT MANAGEMENT PLANNING COMPACT"; and

WHEREAS, the Coordinating Committee has an ongoing need for technical information and advice, and has created a Reservoir Watershed Protection Subcommittee and a Reservoir Watershed Technical Group to aid in its work;

NOW, THEREFORE, BE IT RESOLVED, that in consideration of the covenants and agreements set forth hereinafter, it is mutually covenanted and agreed as follows:

ARTICLE I - RIGHTS OF SIGNATORIES NOT TO BE ABROGATED

A. Nothing in this Agreement shall limit or abrogate any right or rights delegated to any of the governments or agencies which are signatories to this Agreement by acts of the General Assembly of the State of Maryland.

B. It is further understood and agreed that the police, legislative and governmental powers of the City, the County Executive and County Council of Baltimore County, the Carroll County Commissioners, and the State of Maryland are in no sense attempted to be abridged or restricted by this Agreement nor are powers of any signatories restricted.

C. Each signatory hereto agrees that participation by any party of this agreeement can be terminated by that party with three months notice to the Coordinating Committee.

ARTICLE II ESTABLISHMENT OF A RESERVOIR WATERSHED MANAGEMENT PROGRAM

A. Organization: The program shall be conducted by the signatories as described below.

The Coordinating Committee shall advise the local governments on coordination of work activities toward conduct of the functions set forth in Article II, Section B. The Committee members from the signatory governments and agencies shall review and discuss the reports of the Reservoir Management Program provided for in Article II, Section B, Subsection 4.

The Committee's Reservoir Watershed Protection Subcommittee (hereinafter called the "Subcommittee"), is a special committee of the Coordinating Committee consisting of one Coordinating Committee member or alternate from each of Baltimore City and Baltimore, Carroll, and Howard Counties. The Districts will designate one member each to participate fully in the Subcommittee's meetings. The Departments of Agriculture and Health and Mental Hygiene will also designate one person each to participate fully in the Subcommittee's meetings. The Subcommittee will assist the Committee in its discussions concerning intergovernmental coordination.

The Reservoir Watershed Technical Group (hereinafter called the "Technical Group"), consists of one technical staff representative each from Baltimore City and Baltimore and Carroll Counties designated by the Subcommittee members from the respective jurisdiction and one representative each designated by the Regional Planning Council, the State Department of Health, the State Department of Agriculture and the two Districts. It will provide technical advice and assistance to the Subcommittee and the Committee.

B. <u>Goals and Functions</u>

1. The above organizations shall periodically review and evaluate existing problems and proposed actions which may affect the water supply watersheds as:

   a. Sources of high-quality raw water for the metropolitan water supply system water; and

   b. Desirable places for existing recreational, environmental enhancement, aesthetic, wildlife, and other beneficial uses.

2. Baltimore City, Baltimore County, and Carroll County will work in cooperation with Baltimore County Soil Conservation District, Carroll Soil Conservation District, the Regional Planning Council, the Department of Agriculture, and the State Department of Health and Mental Hygiene as expeditiously as possible in cooperatively developing and applying balanced pollution control policies and measures for the water supply watersheds to:

   a. Prevent increased phosphorus and sediment loadings to all three reservoirs; and

   b. Reduce phosphorus loadings in Loch Raven Reservoir to pre-1970 levels; and

   c. Reduce phosphorus loadings in Liberty and Prettyboy Reservoirs to acceptable levels.

3. The reviews and evaluations cited in Section B.1 may include reservoir protection policies, development proposals, plans, Best Management Practices, and other matters that affect reservoir water quality and shall be conducted within the framework of and coordinated with the Clean Water Plan, the State Agricultural Plan and State and local laws and programs.

   Cooperative arrangements should be developed to ensure that all parties participate actively in work to improve reservoir water quality. Alternative solutions to major reservoir water quality problems should be evaluated and cost-effective measures selected, where feasible, to achieve reservoir goals.

4. The Technical Group shall report at least semi-annually to the Subcommittee and shall provide technical assistance to the Subcommittee for an annual report by the Subcommittee to the Coordinating Committee and local governments on the following:

   a. The results of these reviews and evaluations;

b. Recommended policies to deal with present or anticipated problems; selected policies shall be incorporated by reference into this Agreement upon approval by all members of the Reservoir Watershed Protection Subcommittee followed by approval by the Coordinating Committee unless there is written objection by one or more of the signatories to this Agreement.

c. Proposed work activities and budget for at least the coming year; and

d. Other matters as found necessary or desirable for reservoir watershed protection.

5. The report "Action Strategy for the Reservoir Watersheds" is hereby approved by the signatories. The signatories hereby commit themselves to expeditious implementation of the work activities listed in Chapter III on a continuing basis to incorporate into the recommendations, through the process provided for in Subsection 4.b. above, significant enhancements and technological advances as they become available.

This report is also hereby approved as a proposed amendment to the 1982 Water Quality Management Plan for the Baltimore Region.

ORIGINAL AGREEMENT SIGNED BY:

Mayor, Baltimore City
County Executive, Baltimore County, Maryland
President, Board of County Commissioners, Carroll County
Secretary, State Department of Health and Mental Hygiene
Secretary, State Department of Agriculture
Chairman, Regional Planning Council
Chairman, Water Quality Coordinating Committee
Chairman, Baltimore County Soil Conservation District
Vice Chairman, Carroll Soil Conservation District

†See the following pages for an excerpt from Chapter III of the report "Action Strategy for the Reservoir Watersheds".

POLLUTION CONTROL ACTION PLAN

New or Strengthened Action	Current Action	Organization Overseeing Implementation/Timing Of New Action	Comments
POINT SOURCE POLLUTION CONTROLS			
New Municipal Discharges of Treated Sewage:			
• Prohibit new discharges exceeding 1,000 gallons per day except where failing septic systems must be corrected. Encourage land treatment in such cases.	• OEP evaluates the impact of the discharge in the receiving waters, develops effluent limits to ensure protection of water quality standards, and issues NPDES discharge permits. • OEP presently encourages the use of land treatment as an alternative to conventional treatment and surface discharge.	Office of Environmental Programs (OEP) and Baltimore & Carroll Counties via water and sewerage plans/ upon execution of agreement.	This would eliminate virtually all potential phosphorous contributions from these sources.
Existing Municipal Discharges of Treated Sewage:			
NPDES Permitting Process			
Local agencies will evaluate draft permits for total loads as well as concentration.	OEP can now set phosphorus limits in its NPDES permits based on total loads and/or concentrations.	OEP issues permits. Local governments review draft permits/upon execution of Agreement.	
• Land Treatment			
Continue to encourage use of land treatment. When this is not feasible, OEP will set final effluent limits of 0.3 mg/l total phosphorus within the watersheds.	OEP encourages the existing dischargers when doing facilities plans or engineering studies, to convert to land treatment. Where land treatment is not feasible, OEP sets effluent limits of 1.0 mg/l in the NPDES discharge permit.	OEP/1984	The action would reduce phosphorus from existing sources to the minimum possible level, given surface discharges and planned plant expansions.
• Hampstead Plant			
Expedite construction to meet 1984 NPDES permit requirements.	County is pursuing federal and state funding for treatment plant expansion and upgrading.	OEP, Carroll County/ after signing 1984 Reservoir Agreement.	The 1984 permit restricts phosphorus concentration to less than 1.0 mg/l.
Contingent on EPA commitments to funding OEP will revise NPDES permit to set final total phosphorus limit at 0.3 mg/l.	County agreed early in 1984 to comply with a discharge permit limiting phosphorus to 1.0 mg/l.	OEP/when federal funding concurrence for additional phosphorus removal is reached with EPA.	Total phosphorus load discharge at 0.3 mg/l level by year 2000 will be less than at present. (See Hampstead Data Summary in Appendix).

†COPIED FROM CHAPTER III OF THE REPORT "ACTION STRATEGY FOR THE RESERVOIR WATERSHEDS" FOR INCLUSION IN THIS PUBLICATION.

[illegible] 4/23/85

New or Strengthened Action	Current Action	Organization Overseeing Implementation/Timing Of New Action	Comments
Design necessary additional phosphorus removal facilities and submit grant amendment to OEP and EPA.		Carroll County/prior to end of EPA contract period contingent on funding concurrence by U.S. Environmental Protection Agency (EPA).	After completion of the Hampstead Project, Carroll County will no longer be eligible for 75% EPA grants for additional phosphorus removal facilities. (See Appendix cited above.)
• Manchester Plant			
Implement land treatment plan.	Land treatment is now being evaluated under "201" facilities planning.	Town of Manchester/ as soon as possible.	Land treatment could remove 100% of the phosphorus.
Accept all effluent from Dutterer's food processing plant.	Discharge now flows into tributary to Prettyboy Reservoir and (ultimately) into Loch Raven Reservoir.	Town of Manchester/as soon as the "201" construction grant is assured.	The hook-up of Dutterer's facility to the Manchester plant could be initiated after the Manchester land application system is approved by OEP.
• Dutterer's Processing Plant			
Establish schedule of compliance in NPDES permit to require connection to Manchester plant or treatment to 2.0 mg/l phosphorus by January 1, 1986.	Plant effluent now flows into Prettyboy Reservoir and (ultimately) into Loch Raven Reservoir.	OEP/after signing 1984 Reservoir Agreement.	
• Montrose School			
Install land treatment system.	Treated effluent now flows into Liberty Reservoir	DHMH, Maryland Environmental Service, and Department of General Services/1986.	
•Sewage Overflows:			
Retrofit older, pre-existing pumping stations to comply with current State standards for back-up system.	DHMH/OEP requires back-up systems for all new sewage pumping stations.	Baltimore and Carroll Counties with grant assistance from EPA and OEP, subject to ranking on State Construction Grant Priority List/after signing 1984 Reservoir Agreement.	The combination of these measures would reduce the odds of an overflow significantly, and if one should occur, it would be controlled in the storage lagoon.
Secondary power sources and/or reserve capacity storage, in addition to back-up pumps.			
Assist in securing 75% EPA grant funding for above preventative facilities.		OEP/after signing 1984 Agreement.	
Install above back-up facilities.		Baltimore and Carroll Counties/to be done as needed.	

New or Strengthened Action	Current Action	Organization Overseeing Implementation/Timing Of New Action	Comments
New Industrial Point-Source Discharges (non-sewage):			
• Limit significant total phosphorus discharges to that provided by an industrial technology equivalent to that for the Hampstead plant.	OEP develops and issues NPDES discharge permits for all new industrial discharges. Limits are based on industry-wide EPA criteria and consideration of water quality standards in the immediate receiving waters.	OEP/on approval of 1984 Reservoir Agreement and renewal of NPDES permits.	Helps to minimize future increases in phosphorus loadings.
Existing Industrial Point-Source Discharges (non-sewage):			
• Review all existing discharge permits in the three watersheds to determine if phosphorus is present at any significant levels. In cases where it is, OEP will (at the time of regular permit renewal) add total phosphorus limits of 2.0 mg/l or less to the discharge permit.	OEP has developed and issued NPDES discharge permits for all existing industrial discharges. Limits are based on industry-wide EPA criteria and maintenance of water quality standards in immediate receiving waters.	OEP/after signing Reservoir Agreement.	Existing industrial discharge permits do not contain limits for phosphorus.
vate On-Site Systems:			
• Accelerate study of innovative and alternative systems and communication of results to local governments.	OEP is now studying innovative systems and funding to local governments for such studies.	OEP/after signing Reservoir Agreement.	This was aided by passage of this budget item in in Governor's 1984 Bay Initiatives package.
NONPOINT SOURCE POLLUTION CONTROLS Agricultural and Rural			
• Set annual goals for treatment of on-farm problems which contribute to water pollution in the reservoir watersheds.	The Soil Conservation Districts set annual goals for work within their entire jurisdictions. The goal of both SCDs is to prepare a conservation plan for every farm in each county.	Baltimore County and Carroll Soil Conservation Districts (SCDs)/after signing the Reservoir Agreement.	This is conditional on retention of present staff and additional budgetary support from State and local governments in order to augment the staff.

[Further Comments]

Carroll County: A 10-year program in Carroll County's Liberty and Prettyboy Watersheds (75,000 acres of farmland) to reach an estimated 750 farms in need of conservation improvement with implementation of a completed Soil Conservation and Water Quality Plan on each farm would require about 1.5 Soil Conservationists and 3.0 Soil Conservation Technicians at a 10-year total cost of $1,139,822 in salary and overhead costs and $3 million in State cost-share funds.

Baltimore County: A 10-year program in Baltimore County's Loch Raven, Prettyboy, and Liberty Watersheds covering about 50,000 acres with 525 farms needing conservation improvement would require additional staffing of about one Soil Conservationist and one Technician at a 10-year total cost of $538,416 in salary and overhead costs and $3 million in State cost-share funds.

The above costs for Carroll and Baltimore Counties are detailed in Appendix B.

New or Strengthened Action	Current Action	Organization Overseeing Implementation/Timing Of New Action	Comments
• Concentrate treatment efforts on designated critical areas with potential problems or existing critical problems.	The Maryland "208" Agricultural Water Quality Management Program for the Control of Sediment and Animal Wastes and the regional "208" plan designate critical areas. One technical staff person for water quality implementation by Baltimore County SCD is funded by OEP through 1984.	Baltimore and Carroll Counties SCDs/after signing the Agreement.	One-on-one contact by both SCDs with the landowners has proven most effective in all programs but is a time-consuming process.
• Increase funding for SCD staffing for reservoir protection.			
Support State Chesapeake Bay Initiatives for additional funding for SCD technical staffs. Work to secure assignment of adequate new staff to SCDs responsible for the reservoir watersheds. Baltimore County will need at least two new persons for the reservoir watersheds, and Carroll County will need at least 4.5 (See Appendix B). The counties should receive an equitable share of State funding based on severity of designated Agricultural Critical Areas (see letter in Appendix D).	The bay initiative would provide $1.5 million for 42 new SCD positions through the Maryland Department of Agriculture in FY '85. This would later increase to a total of 80 new positions for the coming 5 years. When fully funded, it is MDA's goal for each SCD to have added positions to provide a base staff of at least a manager, a planner, two technicians, and a secretary. These would be augmented by roving teams consisting of one planner and two technicians which would focus on priority problem areas.	All signatories to 1984 Reservoir Agreement.	Increased staff is necessary to complete installation of Best Management Practices on all farms within ten years. Preliminary estimates of work load are summarized in Appendix B-4.
Increase local government budgetary support of SCDs. Baltimore County and Carroll County will add at least one position each as soon as practicable in their budget cycles.	Local governments now partially support their SCD budgets.	Baltimore County FY/1986 budget; Carroll County FY/1985 budget.	
• Assist farmers through cost-sharing and technical assistance in installing agricultural Best Management Practices, with priority on first solving worst problems which can be treated cost-effectively.			
Double Pipe Creek Rural Clean Water Project; give special attention to 4,000 acres of this project within the Liberty Reservoir Watershed.	Work is underway on this project.	Carroll SCD	Over 2/3 money spent on Best Management Practices; 1-1/2 years left before deadline. Projected SCS staff did not materiall

New or Strengthened Action	Current Action	Organization Overseeing Implementation/Timing Of New Action	Comments
. iney Run Clean Lakes Project: expand into other critical subwatersheds with DHMH and EPA approval. This proposed expansion will concentrate on animal waste producers in the entire Loch Raven Watershed.	Work is underway on the present Piney Run Project.	Baltimore County SCD	EPA concurrence is needed for expansion to include entire Loch Raven Watershed.
Maryland Agricultural Cost-Share Program	The program is now being implemented by the State Departments of Agriculture and Health and Mental Hygiene and the Soil Conservation Districts. A total of $1.3 million is now earmarked for the reservoir watershed.	Maryland Department of Agriculture and Baltimore and Carroll counties SCDs.	The reservoirs were targete in 1983 to receive $1.3 million in cost-share funds. Six million will be needed to implement this reservoir strategy, $3 million in eac county (see Appendix B).
Encourage substantial increase in cost-share ceiling of $5,000 for animal waste management system.	The bay initiative calls for an additional $2 million in cost-sharing funds for FY 1985, $6 million in FY 1986, and a total of $70 million over the coming ten years.	Reservoir Agreement signatories.	Many animal waste facilities cost $25,000 or more.
Expedite use of cost-sharing funds.	Both SCDS are now encouraging the use of these State funds.	Baltimore and Carroll Counties SCDs.	Cost-share funds not used may be reallocated to other parts of the State.
rove advertisement of gram through one-on- ; contact with land- ers.	Being done now within limits of manpower.	Baltimore County SCD/ when adequate funding and staffing is available.	Additional staff will accelerate this effort.
Prepare an inventory of animal waste producers in each watershed and contact major waste producers concerning management practices and cost-sharing.		Baltimore and Carroll Counties SCDs/when adequate funding and staffing is available. Baltimore County's funding depends on expansion of the Piney Run Clean Lakes Project mentioned previously.	Animal wastes are significant sources of phosphorus.
USDA Agricultural Stabilization and Conservation Service and Agricultural Conservation Program; give special attention to reservoir watershed.	Now being implemented through SCDs.	Baltimore and Carroll Counties SCDs/after signing agreement.	This program has limited funds and a ceiling of $3,500 per landowner per year.
* Place new emphasis on "problem farms". Apply the procedures specified in the Maryland "208 Agricultural Plan" (1979) to farms causing water pollution.	The 208 Agricultural Plan is being updated to deal with nutrients. The 208 Plan spells out the enforcement procedure for farms suspected of causing excessive water pollution.	Maryland Department of Agriculture, OEP and Baltimore and Carroll Counties SCDs.	MDA through the SCDs emphasizes the outreach program to identify and solve problems.*

.f a farmer is unwilling to cooperate, the SCD refers the matter to the local Agricultural Task Force. If the task force is unable to resolve the problem, the matter is referred to OEP for enforcement. OEP will then direct the farmer to respond to the solution determined by the SCD. OEP will take further enforcement action if necessary.

New or Strengthened Action	Current Action	Organization Overseeing Implementation/Timing Of New Action	Comments
Mason-Dixon Program. Encourage assignment of Mason-Dixon staffing to SCDs with reservoir protection responsibilities.	Mason-Dixon will provide $300,000 in federal technical assistance grants and $190,000 in cost-sharing grants to farmers for eight counties in Maryland, including Baltimore and Carroll Counties. Six USDA SCS Soil Conservationists and Technicians have been assigned to work within the Maryland area on critical soil erosion problems.	Carroll & Baltimore Counties SCDs.	Mason-Dixon Project proposes 200 man-hours/year additional to be provided thru SCS to Carroll County and 2080 to Baltimore County.*

* Mason-Dixon not expected to provide manpower to carry out completely the program in Carroll County. It focuses on erosion control, not water quality. This will offset reductions in the regular SCS budget; net gain is not expected in Carroll County SCS staffing.

Urban and Suburban

* Comprehensive Plans

New or Strengthened Action	Current Action	Organization Overseeing Implementation/Timing Of New Action	Comments
Incorporate reservoir protection policies in county water and sewer plans.	Both jurisdictions have planned in their land use and zoning plans to minimize new zoning for urban development in reservoir watersheds.	Baltimore and Carroll Counties/when water and sewer plans are revised.	Continued stress on reservoir protection will be necessary in county comprehensive plans and zoning ordinances.*

* Baltimore County will endeavor to strengthen its reservoir protection zone by reducing maximum density from 0.2 dwellings per acre to 0.1 d.u./a.

New or Strengthened Action	Current Action	Organization Overseeing Implementation/Timing Of New Action	Comments
Approve or disapprove water and sewer plans based on consistency with approved reservoir strategy.	OEP now approves or disapproves water and sewer plans based on current policies.	OEP/after approval of Reservoir Agreement.	
Adopt policies to maintain vegetated buffers along streams in new subdivisions.	Baltimore County now studying.	Baltimore and Carroll Counties/after signing Agreement.	

* Toxic Wastes

New or Strengthened Action	Current Action	Organization Overseeing Implementation/Timing Of New Action	Comments
RPC and local governments should aid in defining State policies to keep toxic or hazardous waste disposal sites out of watersheds which feed into water supply reservoirs.	The Water Quality Coordinating Committee has endorsed HB 585 which would keep hazardous waste sites out of reservoir watersheds.	Local governments can make recommendations. State Department of Natural Resources and OEP must implement State law.	

* Septic Systems

New or Strengthened Action	Current Action	Organization Overseeing Implementation/Timing Of New Action	Comments
Give high priority to executing sanitary surveys of failing septic systems to focus on reservoir watersheds.*	Sanitary surveys are now being done as needed within the counties.	Baltimore and Carroll County Health Departments/within two years after after signing Agreement.	

* Give early attention to correcting failing septic systems in the Phoenix area and other areas within the watersheds. Alternatives to sewering should be considered where feasible.

w or Strengthened Action	Current Action	Organization Overseeing Implementation/Timing Of New Action	Comments
Promote maintenance of septic systems by homeowner education through building permit and subdivision processes.		Baltimore and Carroll County Health Departments/after signing Agreement.	This will prolong the life of septic systems and minimize water pollution.
License scavengers and provide facilities for disposal into the sewer system.		Baltimore County/after signing Agreement.*	

* The City of Westminster is preparing a grant application for its sewage treatment plant which could enable it to accept some Carroll County septage.

Provide revolving loan fund for homeowners to replace failing septic systems.		Baltimore County after voter approval of loan fund.	
• Stormwater Management			
Review and revise, as found necessary, design standards for streets, curbs, gutters, parking --eas, and reduce imper- .us surfaces in develop- .nt within watersheds for water quality management.	Design standards are now reviewed biennially for cost, safety, and other factors.	Baltimore and Carroll County Departments of of Public Works/after approval of 1984 Reservoir Agreement.	
Immediately study feasibility of developing and using stormwater practices, at least within the reservoir watersheds, which provide higher water quality than State requirements through increased detention times, use of wet ponds, infiltration, and other means.	Local governments must revise their stormwater ordinances to meet State regulatory requirements by June 30, 1984.	Baltimore and Carroll Counties/within one year after approval of 1984 Reservoir Agreement.	The technologies of urban stormwater management need to be evaluated and results from the retrofitting study (below) need to be evaluated. Effective on-site infiltration can provide immediate water quality benefits.
Participate in Baltimore City-sponsored stormwater management retrofitting study and make commitment to continued maintenance of test ponds.	Baltimore City is presently organizing a multi-agency study to measure pollutant reductions by retrofitted ponds.	Baltimore and Carroll Counties/1984.	
Review and revise as necessary policies for inspection and maintenance of stormwater management facilities. Maintenance should be considered at the begin-n--g of each development ...ect.	New State regulations require local policies for inspection and maintenance.	Baltimore and Carroll Counties now underway.	

New or Strengthened Action	Current Action	Organization Overseeing Implementation/Timing Of New Action	Comments
• Sediment and Erosion Control			
Designate at least one additional person in the Carroll County Public Works Department whose primary function will be inspection of implementation for sediment and erosion ordinance. Study need for additional personnel.	Carroll County has trained its building inspectors to evaluate sediment and erosion control ordinance enforcement. Baltimore County has a number of full-time sediment and erosion control inspectors.	Carroll County/1984	
Conduct quarterly evaluation of implementation for sediment and erosion control requirements.	Baltimore County conducts a quarterly field evaluation of its sediment and erosion control program.	Baltimore and Carroll Counties/after signing 1984 Reservoir Agreement.	
Strengthen sediment and erosion control on State and county projects.	The State Department of Natural Resources is now inspecting State construction sites.	Baltimore and Carroll Counties and State agencies/1984.	
• Public Education			
Develop and implement public education program for reservoir protection.		1984 Reservoir Agreement signatories/after execution of Agreement.	

THE BALTIMORE WATERSHED AGREEMENT

MEMORANDUM OF UNDERSTANDING
BY AND BETWEEN
MAYOR AND CITY COUNCIL OF BALTIMORE
AND
BALTIMORE COUNTY, MARYLAND
FOR
WATERSHED MANAGEMENT COOPERATION

THIS MEMORANDUM OF UNDERSTANDING made this _________ day of ______________________________, 2006 by and between the **Mayor and City Council of Baltimore**, a municipal corporation of the State of Maryland (hereinafter referred to as "City of Baltimore") and Baltimore County, Maryland, a body corporate and politic of the State of Maryland (hereinafter referred to as "Baltimore County").

WHEREAS, although politically independent, the City of Baltimore and Baltimore County are part of a greater metropolitan area, having developed in relation to one another historically and geographically. The citizens of the City of Baltimore and Baltimore County value and enjoy the recreational, economic, and aesthetic water resources associated with streams in our inter-jurisdictional watersheds within the Patapsco and Back River Basin; and

WHEREAS, this geographical relationship dictates that the quality of surface water resources within the City of Baltimore is influenced by water sources originating in the Gwynns Falls, Jones Falls, Back River, and Baltimore Harbor watersheds of Baltimore County. Inter-jurisdictional cooperation is also critical for the management and protection of Baltimore City-owned municipal water supply reservoirs and other facilities located in Baltimore County; and

WHEREAS, in 1993 and 2000, the City of Baltimore and Baltimore County each signed local Partnership Agreements with the State of Maryland to work cooperatively as part of the Chesapeake Bay Tributary Strategy Teams in the development and implementation of watershed protection and restoration programs. The City of Baltimore and Baltimore County seek to strengthen partnerships and cooperative efforts with Federal and State agencies in carrying out those agreements, and desire to coordinate strategies that address Chesapeake 2000 Bay Agreement goals and objectives for natural resources and habitat, including protection and restoration of forest corridors and wetlands; and

WHEREAS, the major inter-jurisdictional watersheds are served by citizen-based watershed organizations and regional non-profit water quality and natural resource organizations, all of which interact with the environmental agencies and programs in the City of Baltimore and Baltimore County; and

WHEREAS, the City of Baltimore and Baltimore County, in response to provisions of the Federal Clean Water Act pertaining to non-point sources of water pollution and as authorized by the Maryland General Assembly, entered into a regional Reservoir Watershed Management Agreement with other jurisdictions in 1979. The Agreement was strengthened, with other agencies participating in 1984, and was re-affirmed in 1990 and again in 2003. In 2005 a new agreement that broadens the issues of concern and improves reservoir management was drafted and signed. The City of Baltimore and Baltimore County will continue to work cooperatively to protect the regional drinking water supplies through the management program facilitated by the Baltimore Metropolitan Council; and

WHEREAS, enhanced coordination between the City of Baltimore and Baltimore County will help each jurisdiction implement watershed-based strategies to control and reduce sources of non-point source pollution. It will facilitate the development of programs to comply with revised water quality criteria and standards in response to Total Maximum Daily Loads (TMDLs) as required by the Federal Clean Water Act, and with the continuing Municipal Separate Storm Sewer System permit issued by the Maryland Department of the Environment to meet provisions of the Federal Clean Water Act's National Pollutant Discharge Elimination System (NPDES); and

WHEREAS, future environmental regulatory programs will place an increasing responsibility on the City of Baltimore and Baltimore County for compliance. Through increased cooperation and coordination, the City of Baltimore and Baltimore County can promote unified strategies to meet their responsibilities more effectively and efficiently and can collaborate in seeking funding for programs. A watershed agreement will assist in securing the necessary funding for enhanced stormwater maintenance, coordination of watershed monitoring, and implementation of restoration programs; and

WHEREAS, the City of Baltimore and Baltimore County signed the first regional Memorandum of Understanding on October 3, 2002, and have made considerable progress since then in aligning water monitoring and management programs, engaging watershed organizations to assist in meeting water quality goals, and producing cooperative annual reports;

NOW THEREFORE, THIS MEMORANDUM OF UNDERSTANDING WITNESSETH that, in consideration of the mutual covenants set forth herein, and other good and valuable consideration, the receipt and sufficiency of which are hereby acknowledged, the parties hereto agree as follows:

I. The City of Baltimore and Baltimore County hereby acknowledge that they continue to embrace common goals for management of the natural resources of shared watersheds, including the national water quality goal to protect and restore the physical, chemical, and biological integrity of waters; the goal to protect, conserve, and restore forest resources to provide sustainable ecological and economic benefits; and to otherwise manage air, land, and water resources for the environmental, economic, recreational, and aesthetic benefits of the citizens of the City of Baltimore, Baltimore County, and this region.

- **We commit to improved management of our natural resources for the benefit of the citizens of the City of Baltimore and Baltimore County.**

II. The City of Baltimore and Baltimore County further acknowledge that, to achieve the goal of sustainable natural resources, specific commitments for improved management must be set in the following categories:

i. **Stormwater Management**, especially in the areas of public education, stormwater retrofits, stream restoration, management of impervious surfaces and the identified funding sources to support these needs;
ii. **Community Greening**, especially through the establishment and implementation of tree canopy goals and the enhancement of stream buffers;
iii. **Development and Redevelopment**, focusing especially on renewal of older communities and urbanized areas, protection of open space and agricultural land, and implementation of low impact development practices where appropriate;
iv. **Public Health**, emphasizing the ability of our streams and rivers to present safe recreational amenities for our communities;
v. **Trash,** which impacts water quality as well as the economic and aesthetic viability of our rivers and streams.

- **We will create goals of success for these five commitments by October 1, 2007.**

III. The City of Baltimore and Baltimore County further acknowledge that achievement of improved management in the areas stated above will require that the jurisdictions work together to develop specific action strategies. Development of the action strategies will be an open and iterative process and will take into account the legally binding requirements of existing State and Federal programs and the goals of the Chesapeake 2000 Bay Agreement.

- **We commit to develop action strategies by October 1, 2008.**

IV. The City of Baltimore and Baltimore County agree to continue to work cooperatively with watershed associations and interested organizations to develop and implement coordinated education and restoration programs and projects to benefit water quality and protect natural resources of the region. Watershed associations will be involved in the development of the action strategies committed to above; and, to the extent practicable, the jurisdictions will support watershed organizations through technical assistance, financial support, access to information, training and regular dialogue.

- **We recognize the value of citizen organizations and will continue our support and dialogue with them.**

V. The City of Baltimore and Baltimore County hereby agree to establish a working committee of principals from relevant agencies to coordinate implementation of this Memorandum of Understanding (hereinafter referred to as "Committee"). The Committee will oversee development of the action strategies, will meet regularly, with meetings open to the public, and will form five working groups that will develop the action strategies needed to meet our goals of success in II above. The Committee will be comprised of thirteen members: Baltimore City's directors of the Departments of Public Works, Planning, Recreation and Parks and Baltimore County's Departments of Public Works, Planning, Recreation and Parks and Environmental Protection and Resource Management; and six non-governmental members, three (3) appointed by the Mayor of the City of Baltimore and three (3) appointed by the Executive of Baltimore County. The Committee will annually review progress and prepare recommendations for future work. The Committee will be established and hold its first meeting no later than 90 days after the signing of this Memorandum.

- **We agree to establish a Committee of Principals.**
- **We agree to establish working groups to address the five commitments.**
- **We agree to jointly fund a committee facilitator.**

VI. The Committee will convene a biennial meeting with watershed and community associations and interested citizens to review the accomplishments of the prior years and to report on the "state of our watersheds".

- **A biennial meeting will be convened to review accomplishments with watershed and community associations.**
- **We agree to report on the state of our watersheds to the public on a biennial basis.**

VII. This Memorandum of Understanding shall commence upon execution by the parties and shall continue for six (6) years, unless terminated sooner by either party. It may be renewed, at the discretion of the parties, for additional six (6) year periods.

VIII. This Memorandum of Understanding constitutes the entire and full understanding of the parties hereto, and may not be modified except by means of a written amendment.

IX. The Recitals are incorporated herein.

X. This Memorandum of Understanding shall be governed by and construed under the laws of the State of Maryland.

IN WITNESS WHEREOF, the parties hereto have caused this Memorandum of Understanding to be executed the day and year first above written.

ATTEST/WITNESS: **MAYOR AND CITY COUNCIL OF BALTIMORE**

By:________________________________

By:____________________________________
George L. Winfield, Director
Department of Public Works

ATTEST/WITNESS **BALTIMORE COUNTY, MARYLAND**

By:________________________________

By:____________________________________
James T. Smith, Jr.
County Executive

REVIEWED AND APPROVED:

____
David A.C. Carroll, Director
Department of Environmental
Protection and Resource
Management, Baltimore County

APPROVED FOR LEGAL FORM AND SUFFICIENCY*
(Subject to Execution by A Duly Authorized County Official as Indicated)

____
OFFICE OF THE COUNTY ATTORNEY

*Approval of Legal Form and Sufficiency Does Not Convey Approval or Disapproval of Substantive Nature of Transaction. Approval is Based Upon Typeset Document-All Modifications Require Re-approval

____
OFFICE OF THE CITY ATTORNEY

*Approval of Legal Form and Sufficiency Does Not Convey Approval or Disapproval of Substantive Nature of Transaction. Approval is Based Upon Typeset Document-All Modifications Require Re-Approval

Leslie S. Winner
Chief Solicitor, Baltimore City

IN THE UNITED STATES DISTRICT COURT
FOR THE DISTRICT OF MARYLAND
NORTHERN DIVISION

UNITED STATES OF AMERICA and STATE OF MARYLAND,	)	
	)	
Plaintiffs,	)	
	)	Civil Action No.
v.	)	
	)	
BALTIMORE COUNTY, MARYLAND,	)	
	)	
Defendant.	)	
	)	

CONSENT DECREE

TABLE OF CONTENTS

IN THE UNITED STATES DISTRICT COURT
FOR THE DISTRICT OF MARYLAND
NORTHERN DIVISION

UNITED STATES OF AMERICA and STATE OF MARYLAND,	)	
Plaintiffs,	)	Civil Action No.
v.	)	
BALTIMORE COUNTY, MARYLAND,	)	
Defendant.	)	

CONSENT DECREE

WHEREAS, Plaintiff, the United States of America ("United States"), by the authority of the Attorney General of the United States and through its undersigned counsel, acting at the request and on behalf of the Administrator of the United States Environmental Protection Agency ("EPA"), has filed the Complaint in this action seeking injunctive relief and civil penalties pursuant to Section 309 of the Clean Water Act, 33 U.S.C. § 1319, naming as defendant Baltimore County, Maryland ("Baltimore County") pursuant to Section 309(b) of the Clean Water Act, 33 U.S.C. § 1319(b);

WHEREAS, Plaintiff, the State of Maryland, Department of the Environment ("MDE"), has joined in the Complaint and seeks injunctive relief and civil penalties for Baltimore County's alleged violations of Title 9, Subtitle 3 of the Environment Article, Annotated Code of Maryland;

WHEREAS, Baltimore County operates a sanitary sewer collection system that serves most citizens of Baltimore County who live inside the urban-rural demarcation line, some citizens of Anne Arundel and Howard Counties, and the facilities located at Baltimore-Washington International Airport owned by the State of Maryland;

WHEREAS, the United States and the State of Maryland allege that Baltimore County has violated and continues to violate Section 301 of the Clean Water Act, 33 U.S.C. § 1311, and Sections 9-322 and 9-323 of the Environment Article, Annotated Code of Maryland, by discharging untreated sewage from its sanitary sewer collection system to waters of the United States and to waters of the State of Maryland;

WHEREAS, Baltimore County asserts that it professionally and competently operates and maintains its sanitary sewer collection system;

WHEREAS, the Parties have negotiated in good faith and have reached a settlement of the issues raised in the Complaint. Baltimore County's agreement to this Consent Decree is not an admission of liability, nor is it an adjudication of any fact or law;

WHEREAS, the Parties agree, and the Court finds, that settlement of the claims alleged in the Complaint without further litigation or trial of any issues is fair, reasonable and in the public interest and that the entry of this Consent Decree is the most appropriate way of resolving the claims alleged in the Complaint.

NOW THEREFORE, it is hereby ORDERED, ADJUDGED and DECREED as follows:

I. JURISDICTION AND VENUE

1. This Court has jurisdiction over the subject matter of this action and over the Parties to this action pursuant to Section 309(b) of the Clean Water Act, 33 U.S.C. § 1319(b), and 28 U.S.C. §§ 1331, 1345, 1355, and 1367. The Complaint states claims upon which relief may be granted against Baltimore County under Section 309 of the Clean Water Act, 33 U.S.C. § 1319, and Sections 9-339 and 9-342 of the Environment Article, Annotated Code of Maryland, for injunctive relief and civil penalties. Venue is proper in this District pursuant to Section 309(b) of the Clean Water Act, 33 U.S.C. § 1319(b), and 28 U.S.C. §§ 1391(b) and 1395(a). Baltimore County waives any and all objections or defenses that it might have to the Court's jurisdiction to enter and enforce this Consent Decree or to venue in this

District.

II. BINDING EFFECT

2. The provisions of this Consent Decree shall apply to and be binding on the United States and the State of Maryland, and on Baltimore County, its agents, successors, and assigns.

3. Effective from the Date of Lodging of this Consent Decree until its termination, Baltimore County shall give written notice of and provide a copy of this Consent Decree to any person or entity to whom Baltimore County may transfer ownership or operation of any portion of its Collection System. Baltimore County shall notify EPA, MDE and the United States Department of Justice in writing of any successor in interest at least twenty-one (21) days prior to any such transfer. No transfer of ownership or operation of the Collection System shall relieve Baltimore County of its obligations to ensure that the terms of this Consent Decree are implemented.

4. Baltimore County shall be solely responsible for ensuring that performance of the work contemplated under this Consent Decree is undertaken in accordance with the deadlines and requirements contained in this Consent Decree, and any exhibits hereto. Any action taken by any contractor or consultant retained to implement Baltimore County's duties under this Consent Decree shall be considered an action of Baltimore County for purposes of determining compliance with this Consent Decree. In an action to enforce this Consent Decree, Baltimore County shall not assert as a defense against the United States, EPA or MDE any act or failure to act by any of its officers, council members, managers, commissioners, employees, agents, contractors, successors and assigns; however, this Consent Decree shall not limit Baltimore County's right to employ contractors and consultants and to take all appropriate action against any person or entity that causes or contributes to Baltimore County's failure to perform.

III. PURPOSE

5. The express purpose of the Parties entering into this Consent Decree is for Baltimore

County to take all measures necessary to comply with the Clean Water Act and the regulations promulgated thereunder, and the Maryland water pollution control laws and the regulations promulgated under such laws, with the goal of eliminating Sanitary Sewer Overflows.

IV. DEFINITIONS

6. Unless otherwise defined herein, the terms used in this Consent Decree will have the meaning given to those terms in the Clean Water Act, 33 U.S.C. §§ 1251 et seq., and the regulations promulgated thereunder or, if not defined in the Clean Water Act or its regulations, then as defined in Title 9, Subtitle 3 of the Environment Article, Annotated Code of Maryland, and the regulations promulgated thereunder. Any other words shall be given their ordinary meaning.

The following terms used in this Consent Decree, its appendices, and studies and plans submitted by Baltimore County and approved by EPA and MDE will be defined as follows:

A. "Annual Report" shall mean the annual progress report to be submitted by Baltimore County pursuant to Paragraph 20 of this Consent Decree.

B. "Building Backup" shall mean a release from the Collection System, through a lateral to a building or structure.

C. "Collection System" or "Separate Sanitary Sewer Collection System" shall mean the collection and transmission system (including all pipes, Force Mains, sanitary sewer lines, SSO Structures, Pump Stations, manholes, and appurtenances thereto) owned by Baltimore County and designed to convey only sewage, and not storm water, from residences, commercial buildings, industrial plants and institutions for treatment at Baltimore City's Patapsco or Back River wastewater treatment plants, including portions of the system added after the Effective Date.

D. "Date of Lodging of the Consent Decree" or "Date of Lodging" shall mean the date on which the Consent Decree is lodged with the United States District Court for the District of Maryland.

E. "Day" or "days" shall mean a calendar day or calendar days. When the day a report or other deliverable is due under this Consent Decree falls on a Saturday, Sunday or any Federal, State of Maryland or Baltimore County legal holiday, Baltimore County shall have until the next calendar day that is not one of the aforementioned days for submittal of such report or other deliverable, with the exception of overflow reports required by Paragraph 18 of this Consent Decree.

F. “Deliverable” shall mean any written plan, report, map, or other document required to be submitted by Baltimore County pursuant to Section V (Remedial Measures) identified on Appendix H to this Consent Decree. The Quarterly Reports and Annual Reports required to be submitted by Baltimore County pursuant to Section VI (Reporting Requirements), and any certification required to be submitted pursuant to this Consent Decree, are not “Deliverables” as defined in this Consent Decree.

G. “DEPRM” shall mean the Baltimore County Department of Environmental Protection and Resource Management, and any successor agency.

H. “Discharge” shall mean any “discharge of a pollutant” as defined in 40 C.F.R. § 122.2, and/or any “discharge” as defined in Section 9-101(b) of the Maryland Environment Code Annotated (1996 Repl. Vol.) (“(1) The addition, introduction, leaking, spilling or emitting of a pollutant into waters of this State; or (2) The placing of a pollutant in a location where the pollutant is likely to pollute.”), from the Collection System.

I. “DPW” shall mean the Baltimore County Department of Public Works, and any successor agency.

J. “Effective Date” shall mean the effective date of this Consent Decree as provided in Paragraph 79.

K. “Eligible SEP Costs” shall mean the costs of designing, planning, and implementing supplemental environmental projects (“SEPs”), but shall not include Baltimore County’s overhead, administrative expenses, legal fees, and contractor oversight.

L. “Force Main” shall mean any pipe that receives and conveys wastewater under pressure from the discharge side of a pump installed in a Pump Station.

M. “Gravity Sewer Line” shall mean a pipe that receives, contains and conveys wastewater not normally under pressure, but is intended to flow unassisted under the influence of gravity.

N. “Gravity Line Segment” shall mean that part of a Gravity Sewer Line that is between one manhole and the next closest manhole on the sewer line in question.

O. "Grease Generating Facility" shall mean any facility, including but not limited to food preparation, handling, and processing establishments, which conducts activities that routinely generate fats, oils and greases. The term “Grease Generating Facility” does not include a kitchen in an individual residential unit.

P. "Hydrograph" shall mean the graphical representation of flow volume over time of wastewater, infiltration, and inflow at a particular point in the Collection System. Hydrographs characterize diurnal variations in wastewater flow rates, as well as flow response to a wet weather event, at a particular point in the Collection System.

Q. “Hyetograph” shall mean the graphical representation showing the average rainfall distribution over the Baltimore County area. The graphs show rainfall intensity or volume as a function of time.

R. “Illegal Storm Water Discharge” shall mean the unauthorized discharge of storm water to the Collection System, whether such discharge occurs through an illegal connection or through an authorized connection, from a privately-owned source of inflow and/or infiltration, including but not limited to areaway drains, sump pumps, foundation drains, roof drains, and defective laterals.

S. "Major Gravity Line" shall mean any of the following:

i. all Gravity Sewer Lines that are ten inches in diameter or larger;

ii. all eight-inch lines that are necessary to accurately represent flow attributable to a specific service area in any Collection System Sewershed;

iii. all Gravity Sewer Lines that convey wastewater from one Pump Station service area to another Pump Station service area;

and

iv. All Gravity Sewer Lines that have caused or contributed, or that Baltimore County knows are likely to cause or contribute, to capacity-related Sanitary Sewer Overflows.

T. "Non-Pump Station SSO Structure" shall mean any SSO Structure located anywhere in the Collection System other than at a Pump Station.

U. "Parties" shall mean the United States of America, the State of Maryland, and Baltimore County.

V. "Pump Station" shall mean facilities owned by Baltimore County and comprised of pumps which lift wastewater to a higher hydraulic elevation, including all related electrical, mechanical, and structural systems necessary to the operation of the pump(s), but shall not include grinder pumps.

W. "Pump Station Design Capacity" shall mean the capacity that a Pump Station is designed to pump with its largest pump out of service.

X. "Pump Station SSO Structure" shall mean any SSO Structure located at a Pump Station.

Y. "Quarterly Report" shall mean the quarterly progress report to be submitted by Baltimore County pursuant to Paragraph 19 of this Consent Decree.

Z. "Sanitary Sewer Overflow" or "SSO" shall mean any spill, release, or Discharge from the Collection System, including all Building Backups.

AA. "Sanitary Sewer Overflow Structure" or "SSO Structure" shall mean any structure in Baltimore County constructed for the purpose of allowing discharge from the Separate Sanitary Sewer Collection System at a point prior to connection with the Baltimore City collection system or the headworks of either the Patapsco or Back River wastewater treatment plants.

BB. "Sewer Basin" or "Sewershed" shall mean a section of Baltimore County's Collection System that is a distinct drainage and/or wastewater collection area and designated as such by Baltimore County.

CC. "Substantial Completion" shall mean, when used in reference to construction projects required under this Consent Decree, the date, as certified by the Engineer in charge of a construction project, when the construction project or specified part thereof is sufficiently completed, in accordance with the contract documents, such that the project or specified part thereof can be used to accomplish the purposes for which it was intended.

DD. "United States" shall mean the United States of America, acting on behalf of EPA.

V. REMEDIAL MEASURES

7. Elimination of Sanitary Sewer Overflows.

A. **General Requirements**. Baltimore County shall develop and implement the measures set forth in Paragraphs 7 through 18 with the goal of eliminating all SSOs from Baltimore County's Collection System.

B. **Sanitary Sewer Overflow Characterization Report**.

i. No later than ninety (90) days after the Effective Date of this Consent Decree, Baltimore County shall submit to EPA and MDE a Sanitary Sewer Overflow Characterization

Report that includes:

(a) A map depicting the Collection System and all of its appurtenances as described below. The map shall depict the locations of all known SSO Structures and the sanitary sewers associated with those SSO Structures, as well as all outfalls, manholes, and Pump Stations;

(b) Identification of the Sewersheds that contribute flow to the Baltimore County Collection System;

(c) Identification, including mapping, of the location, frequency, date, duration, and volume (measured durations and volumes where available, or best estimates) of SSOs (on a per event basis) since June 2000 to the extent such information is available; and

(d) Identification of each known cause or condition that contributed to each SSO identified in Paragraph 7.B.i(c).

ii. Baltimore County shall update the Sanitary Sewer Overflow Characterization Report on an annual basis to include SSO events and other new or corrected information identified during the prior year. Baltimore County shall submit the updated Sanitary Sewer Overflow Characterization Report as part of the applicable Annual Report.

C. **Monitoring and Elimination of Sanitary Sewer Overflow Structures**. Baltimore County shall monitor all Sanitary Sewer Overflow Structures ("SSO Structures") in its Collection System in accord with the procedures set forth below. Baltimore County shall eliminate all Non-Pump Station SSO Structures in accord with the procedures and schedules set forth below.

i. **Monitoring of SSO Structures**. As of the Date of Lodging of this Consent Decree, Baltimore County had identified 64 SSO Structures located at or relating to Pump Stations ("Pump Station SSO Structures") (identified on Appendix A1 to this Consent Decree) and 38 additional SSO Structures located within its Collection System ("Non-Pump Station SSO Structures") (identified on Appendix A2 to this Consent Decree). Baltimore County shall conduct monitoring of each Pump Station and Non-Pump Station SSO Structure as set forth in this Paragraph 7.C.i, and shall report the results of such monitoring for each SSO Structure pursuant to Paragraph 7.C.ii., below, for Non-Pump Station SSO Structures until such time as Baltimore County certifies elimination of the respective SSO Structure pursuant to Paragraph 7.C.iv., below, and for Pump Station SSO Structures until termination of the Consent Decree.

(a) Monitoring of Pump Station SSO Structures. Baltimore County shall monitor each Pump Station SSO Structure for potential discharges by monitoring wet well levels and activation of the wet well high level alarms at the Pump Station. By 270 days from the Effective Date, Pump Station SSO Structures shall be monitored by a level sensing device (e.g., Red Cap probe or liquid level chart) connected to the SCADA system and set to trigger an alarm before or when the wet well level reaches the invert elevation of the SSO Structure. Baltimore County shall conduct periodic field tests of the level sensing device and SCADA system to ensure the accuracy of the elevation and the proper transmission of information regarding a discharge from the SSO Structure.

(b) Monitoring of Non-Pump Station SSO Structures. As of the Date of Lodging of this Consent Decree, Baltimore County is monitoring 9 Non-Pump Station SSO Structures through the use of a level monitor capable of recording the presence or absence of discharge, and 29 Non-Pump Station SSO Structures through the use of continuous flow meters. The method of monitoring for each Non-Pump Station SSO Structure as of the Date of Lodging is identified on Appendix A2 to this Consent Decree.

(1) Baltimore County shall monitor all Non-Pump Station SSO Structures that are not equipped with flow meters by inspecting the level monitors at least monthly, and within 5 days of any rainfall event that is one inch or greater in a 24-hour period ("one inch, 24-hour rainfall event"). If any of these SSO Structures show evidence of discharge, Baltimore County shall, within 30 days of discovery of such discharge, install a flow meter at the SSO Structure and report the

installation of such meter to EPA and MDE in the next quarterly report required pursuant to Paragraph 7.C.ii., below.

(2) Baltimore County shall monitor all Non-Pump Station SSO Structures that are equipped with flow meters by continuous use of such flow meters.

ii. **Reporting of Monitoring Information**. Baltimore County shall record, maintain, and submit to EPA and MDE in each Quarterly Report the following information regarding any discharges from SSO Structures during the prior calendar quarter.

(a) With respect to Pump Station SSO Structures and Non-Pump Station SSO Structures that are not equipped with flow meters:

(1) name, corresponding number, and full address of the SSO Structure;
(2) date of monitoring event;
(3) reason for monitoring event (e.g., routine monitoring or rain event)
(4) date of relevant weather conditions (if applicable)
(5) description of relevant weather conditions (e.g., type of precipitation, location of rain gauge and storm event);
(6) presence/absence of discharge;
(7) receiving waters (if applicable);
(8) identified cause (if applicable);
(9) details of corrective action taken or planned.

(b) With respect to Non-Pump Station SSO Structures that are equipped with flow meters:

(1) name, corresponding number, and full address of the SSO Structure;
(2) date of discharge;
(3) duration of overflow;
(4) date of relevant weather conditions (if applicable);
(5) description of relevant weather conditions (e.g., type of precipitation);
(6) gallons discharged;
(7) receiving waters;
(8) identified cause; and
(9) details of corrective action taken or planned.

(c) In addition to the above reporting requirements, Baltimore County must also report any discharges from the SSO Structures as required by Paragraph 18 of this Consent Decree and with any applicable federal and state reporting requirements.

iii. **Submission of Non-Pump Station SSO Structures Elimination Plan**. Within one year of the Date of Lodging of the Consent Decree, Baltimore County shall submit to EPA and MDE for review and approval a Non-Pump Station SSO Structures Elimination Plan for the Elm Road and Ripple Road Non-Pump Station SSO Structures that shall provide for the elimination of those SSO Structures as set forth below. Within two years of the Effective Date, Baltimore County shall submit to EPA and MDE for review and approval a Non-Pump Station SSO Structures Elimination Plan that shall provide for the elimination of all other known Non-Pump Station SSO Structures in the Collection System that have not been eliminated at the time of submission of the Elimination Plan. For each Non-Pump Station SSO Structure, the Elimination Plans shall include each of the following elements:

(a) Summary of Monitoring and Evaluation Data. Baltimore County shall provide:

(1) a summary of all available monitoring data, including an analysis of the activation threshold, frequency of activation, duration and volume of discharges during the monitoring period, and instances of flow metering inoperability (including period of inoperability, cause, corrective action, and projected return to service);

(2) identification of the receiving waters or other discharge area;

(3) an analysis of the likely underlying cause of the capacity issue(s) being alleviated by the SSO Structure discharges, including a summary of any available information regarding the original reason for installation of the SSO Structure; and

(4) a preliminary assessment of the potential impacts of immediate closure of the SSO Structure.

(b) Evaluation of Mitigation Activities. Baltimore County shall conduct an evaluation of potential mitigation measures to reduce the amount and duration of discharges from the SSO Structure and to mitigate the impacts associated with such discharges. The mitigation measures evaluated should include short-term collection activities (*e.g.*, the use of vacuum trucks), the use of temporary constructed bypasses of lines with insufficient capacity to reduce the amount and duration of discharges, and the implementation of more rapid and effective containment and removal response activities to mitigate the impacts of discharges. Baltimore County shall implement the mitigation measures most appropriate to mitigate impacts of discharges from the relevant SSO Structure until the SSO Structure is eliminated. Baltimore County shall report in each Quarterly Report any mitigation measures taken with respect to a discharge from an SSO Structure during the prior calendar quarter.

(c) Plan and Schedule for Elimination. Baltimore County shall develop a proposed plan and schedule that provides for elimination of each Non-Pump Station SSO Structure as follows:

(1) for the Elm Road Non-Pump Station SSO Structure, no later than 18 months from the Date of Lodging of the Consent Decree;

(2) for the Ripple Road Non-Pump Station SSO Structure, no later than 24 months from the Date of Lodging of the Consent Decree;

(3) for all other Non-Pump Station SSO Structures included in the Elimination Plan, as soon as practicable but no later than the earlier of one year after the completion of the I/I Evaluation and Long-Term Capacity Evaluation required by Paragraph 9 for the Sewershed in which the Non-Pump Station SSO Structure is located, or six years after the Effective Date. EPA and

MDE may extend the schedule for elimination of any individual Non-Pump Station SSO Structure upon a demonstration by Baltimore County that the specific circumstances relevant to that Non-Pump Station SSO Structure justify an extension.

iv. **Implementation of Elimination Plan and Certification of Elimination**. Within 30 days after approval or approval with conditions by EPA and MDE of the Elimination Plans, as provided in Section VIII (Review and Approval Procedures) of this Consent Decree, Baltimore County shall implement the Elimination Plans as approved and consistent with the approved scheduled contained therein, and the approved Elimination Plans shall be incorporated into, and become enforceable under, this Consent Decree. For each Non-Pump Station SSO Structure eliminated pursuant to this Paragraph 7.C., Baltimore County shall certify to EPA and MDE that such Non-Pump Station SSO Structure has been eliminated and shall summarize the actions taken by the County to eliminate the Non-Pump Station SSO Structure in the Quarterly Report for the calendar quarter in which the Non-Pump Station SSO Structure was eliminated.

v. **Post-Elimination Monitoring**. For each Non-Pump Station SSO Structure eliminated pursuant to this Paragraph 7.C., Baltimore County shall evaluate the hydraulic impacts, such as related SSOs, of the elimination of the SSO Structure on the relevant portions of the Collection System for a period of 18 months following elimination of the SSO Structure. By agreement of the parties, the hydraulic impacts evaluation period may be shortened to less than 18 months. Baltimore County shall consider this information in its evaluation of the long-term capacity and peak flow management of its Collection System as required by Paragraph 9.

vi. **Required Response to Certain Discharges from Pump Station SSO Structures**. If, during the monitoring of Pump Station SSO Structures required pursuant to Paragraph 7.C.i. above, Baltimore County identifies a discharge from a Pump Station SSO Structure that is caused by an event other than the complete loss of pumping capacity at the Pump Station, Baltimore County shall conduct an analysis of the likely underlying cause of the discharge and, within 90 days of detection of the discharge, submit to EPA and MDE for review and approval a proposed plan and schedule for preventing further discharges arising from the same cause. This requirement shall include discharges from a Pump Station SSO Structure that result from exceeding the Pump Station Design Capacity.

vii. **Application to Newly-Discovered SSO Structures**. The requirements of this Paragraph 7.C. shall also apply to any SSO Structures that are identified after the Date of Lodging of the Consent Decree. To the extent that a Non-Pump Station SSO Structure is discovered after submission of the original Elimination Plan required by Paragraph 7.C.iii., Baltimore County shall submit to EPA and MDE, within 180 days of discovery of the additional Non-Pump Station SSO Structure, a supplement to the original Elimination Plan that contains the same information for, and proposes a plan and schedule for, elimination of the newly-discovered Non-Pump Station SSO Structure.

D. **Construction Projects**. Baltimore County shall complete the Collection System construction projects identified in Appendix B according to the milestone dates set forth therein. The milestone dates set forth in Appendix B are incorporated into, and enforceable under, the Consent Decree as if fully set forth herein. In each Quarterly Report, Baltimore County shall summarize the status of the projects required by Paragraph 7.D. (as listed on Appendix B) as of the end of the prior calendar quarter. Following completion of each construction project identified on Appendix B, Baltimore County shall certify to EPA and MDE that construction has been completed and shall provide a plan for post-construction monitoring consistent with Paragraph 7.D.iii., below, in the Quarterly Report for the calendar quarter in which construction was completed.

i. For construction projects listed on Appendix B that have commenced or are scheduled to commence prior to two years from the Effective Date, Baltimore County shall retain any relevant rainfall and flow monitoring data collected prior to commencement of construction of such project.

ii. For construction projects listed on Appendix B and scheduled to commence construction after two years from the Effective Date, Baltimore County shall monitor flow and rainfall for eighteen (18) months prior to commencement of construction as necessary to allow the characterization of flow in the portions of the Collection System and overflows impacted by such construction project(s). Such flow and rainfall monitoring shall be performed in accordance with the requirements of Paragraph 9.

iii. Following completion of any construction project listed on Appendix B, Baltimore County shall monitor flow and rainfall for a period of eighteen (18) months to ascertain the effectiveness of the construction project. Such flow and rainfall monitoring shall be performed in accordance with the requirements of Paragraph 9.

iv. By agreement of the Parties, the flow and rainfall monitoring period(s) required by Paragraph 7.D.ii and iii may be shortened to less than 18 months.

v. Any flow and rainfall monitoring data collected by Baltimore County pursuant to this Paragraph prior to the submission of the Sewershed Repair, Replacement, and Rehabilitation Plan for the Sewershed in which the relevant construction project is located shall be considered in developing the relevant SRRR Plan, and shall be made available to EPA and MDE upon request. Any flow and rainfall monitoring data collected by Baltimore County pursuant to this Paragraph after the submission of the SRRR Plan for the Sewershed in which the relevant construction project is located shall be considered by Baltimore County as part of its ongoing evaluation of Collection System performance and shall be made available to EPA and MDE upon request.

E. **Reporting Requirements**. Baltimore County shall report to EPA and MDE on its performance of the requirements in this Paragraph 7 as specifically set forth in Section VI (Reporting Requirements) of this Consent Decree.

8. **Collection System Inspection**.

A. **General Requirements.** Baltimore County shall conduct a comprehensive inspection of its Collection System in accord with the criteria set forth in this Paragraph in order to identify causes or potential causes of SSOs.

B. **Submission of Inspection Plan.** Within 60 days of the Effective Date, Baltimore County shall submit a proposed Collection System Inspection Plan to EPA and MDE for approval pursuant to Section VIII (Review and Approval Procedures) of this Consent Decree. Baltimore County's Inspection Plan shall provide for the inspection of Gravity Sewer Lines, Force Mains, manholes, and other appurtenances as set forth in Paragraph 8.C. and D. below, and shall specifically include:

i. Specific inspection activities directed at identifying system defects that may cause SSOs, including but not limited to, design and construction defects, structural defects, debris, root intrusion and grease accumulation, that should be given priority consideration for future repair, replacement or rehabilitation or more frequent maintenance.

ii. A list of all sewer sub-basins that will be inspected pursuant to Paragraph 8.C.i.-iii. below, and a proposed schedule for completing those inspections.

iii. A list of all Gravity Line Segments that Baltimore County believes are subject to the exemptions from CCTV inspection requirements set forth in Paragraph 8.C.vi.

C. **Gravity Sewer Line Inspection.**

i. Within 18 months of the Effective Date:

(a) Baltimore County shall perform closed circuit television ("CCTV") inspections of all Gravity Sewer Lines greater than or equal to 8 inches and less than or equal to 27 inches in diameter that are located within sewer sub-basins in which non-Pump Station SSO Structures are located and/or in which Baltimore County has identified potential structural defects based on the presence of SSOs or on demonstrated insufficient capacity occurring prior to the Effective Date.

(b) Baltimore County shall perform CCTV inspections, or inspections using comparable methods accepted as industry standard for larger lines, of all Gravity Sewer Lines greater than 27 inches in diameter that are located within sewer sub-basins in which Non-Pump Station SSO Structures are located and/or in which Baltimore County has identified potential structural defects based on the presence of SSOs or on demonstrated insufficient capacity occurring prior to the Effective Date. In performing these inspections, Baltimore County shall not be required to disrupt service in these lines.

(c) Following completion of the requirements set forth in Paragraphs 8.C.i.a. & b., above, Baltimore County shall certify that all such requirements have been completed and summarize the actions taken by Baltimore County to complete these requirements in the Quarterly Report for the calendar quarter in which the requirements were completed.

ii. Within 6 years of the Effective Date, Baltimore County shall perform CCTV inspections of all Gravity Sewer Lines greater than or equal to 8 inches and less than or equal to 27 inches in diameter that are located within sewer sub-basins in which the average year of original pipe installation is 1960 or earlier and/or in which Baltimore County has identified potential structural defects based on the presence of root blockages or other blockages occurring prior to the Effective Date, and which are located within the following Sewer Basins:

Herring Run
Jones Falls
Patapsco
Gwynns Falls
Dead Run
West Low Level
Stemmers Run

Following completion of the inspection requirements of Paragraphs 8.C.ii., 8.C.iv., 8.D.i., and 8.D.ii(b)(1) for any Sewershed, Baltimore County shall certify that all such requirements have been completed for that Sewershed and summarize the actions taken by Baltimore County to complete these requirements in the Quarterly Report for the calendar quarter in which the requirements were completed.

iii. Within 9 years, 6 months of the Effective Date, Baltimore County shall perform CCTV inspections of all Gravity Sewer Lines greater than or equal to 8 inches and less than or equal to 27 inches in diameter that are located within sewer sub-basins in which the average year of original pipe installation is 1960 or earlier and/or in which Baltimore County has identified potential structural defects based on the presence of root blockages or other blockages occurring prior to the Effective Date, and which are located in any Sewer Basin other than those basins listed in Paragraph 8.C.ii. above. Following completion of the inspection requirements of Paragraphs 8.C.iii., 8.C.iv., 8.D.i., and 8.D.ii(b)(1) for any Sewershed, Baltimore County shall certify that all such requirements have been completed for that Sewershed and summarize the actions taken by Baltimore County to complete these requirements in the Quarterly Report for the calendar quarter in which the requirements were completed.

iv. **<u>CCTV Inspection of Gravity Lines Larger than 27" in Diameter</u>**. Baltimore County shall perform CCTV inspections, or inspections using comparable methods accepted as industry standard for larger lines, of all Gravity Sewer Lines greater than 27 inches in diameter. In performing these inspections, Baltimore County shall not be required to disrupt service in these lines. Baltimore County shall complete such inspections in each Sewer Basin within the time period provided for completion of CCTV inspection in that basin pursuant to Paragraph 8.C.ii. & iii. above.

v. **<u>CCTV Inspection Following SSOs</u>**. Beginning 75 days from the Date of Lodging of the Consent Decree, Baltimore County shall conduct CCTV inspection of any Gravity Line Segment of the Collection System where an SSO has occurred within 10 working days of when Baltimore County discovers or has knowledge of the occurrence of the SSO, unless

(a) Baltimore County identifies the cause of the SSO as a blockage in a County-owned lateral adjacent to the Gravity Line Segment and cleans the County-owned lateral;

(b) Baltimore County identifies the cause of the SSO as a blockage in the Gravity Line Segment directly visible from the manhole; or

(c) Baltimore County has previously inspected the Gravity Line Segment with CCTV pursuant to this Paragraph 8.C.v. due to a prior SSO for which Baltimore County is in the process of developing or implementing corrective action.

vi. **Exceptions to CCTV Requirements**.

(a) Specific Segments. The following Gravity Line Segments shall be exempt from the inspection requirements set forth in Paragraph 8.C.i.-iv. above:

(1) Any Gravity Line Segment that has been structurally rehabilitated by pipe relining or replacement within the 10-year period prior to the Effective Date.

(2) Any Gravity Line Segment that has been inspected by CCTV as part of a rehabilitation or construction project that is ongoing as of the Effective Date.

(b) Alternative Methods. Prior to performing CCTV inspection of any gravity line pursuant to Paragraph 8.C.i.-iii. above, Baltimore County may seek approval from EPA and MDE to use one or more alternative methods of inspection that will provide comparable or equivalent information.

vii. **Inspection Criteria**. Baltimore County shall perform CCTV inspections required by this Paragraph in accordance with "Specification Guidelines: Wastewater Collection Systems Maintenance and Rehabilitation" prepared by the National Association of Sewer Service Companies ("NASSCO"); the "Handbook: Sewer System Infrastructure Analysis and Rehabilitation, EPA/625/6-91/030," Oct. 1991 (hereinafter "SSES Handbook"); and sound engineering practice.

D. **<u>Other Inspections</u>**.

i. <u>Manholes and Other Appurtenances.</u> Baltimore County shall perform inspections, using appropriate methodologies, of all manholes and other appurtenances located within or immediately adjacent to the gravity line segments to be inspected pursuant to Paragraph 8.C.i.-iv. above. Inspection of these manholes and other appurtenances shall be completed within the time periods set forth in Paragraph 8.C.i.-iv. above for inspection of the related gravity line segments.

ii. **<u>Force Mains</u>**.

(a) <u>Inspection/Evaluation</u>. Baltimore County shall perform inspections, or other appropriate evaluations, of all Force Mains in its Collection System. Inspection/evaluation of Force Mains shall be carried out utilizing one or more methodologies appropriate to the specific characteristics of each Force Main, which methodologies may include, but are not limited to, visual/CCTV, radiography, ultrasonic/sonar and coupon sampling. Baltimore County shall determine the appropriate inspection/evaluation methodology by performing a risk assessment for each Force Main to determine the risk of failure, based on criteria such as pipe material, diameter, age, depth, profile, flow conditions, operating conditions, soil conditions, internal/external corrosion protection, past performance, transient analysis, and consequence of failure. Force Main inspections/evaluations shall be carried out in such a manner as to allow adequate assessment of the condition of each Force Main. Baltimore County shall consider alternatives for integrating Force Main location information developed during the inspection process into its "Miss Utility" locator program.

(b) <u>Timing</u>.

(1) Baltimore County shall perform the requirements set forth in Paragraph 8.D.ii.(a) above for all Force Mains installed prior to 1980 and the Dundalk, Forge Acres, and Bird River Force Mains within the time periods set forth in Paragraph 8.C.ii.-iii. above for completion of inspections within the Sewershed in which the Force Main is located.

(2) Baltimore County shall perform the requirements set forth in Paragraph 8.D.ii.(a) above for all Force Mains not covered by 8.D.ii(b)(1) above prior to termination of the Consent Decree. Following completion of these inspection requirements, Baltimore County shall certify that all such requirements have been completed and summarize the actions taken by Baltimore County to complete these requirements in the Quarterly Report for the calendar quarter in which the requirements were completed.

E. **Implementation of Inspection Plan.** Within 30 days after approval or approval with conditions by EPA and MDE of the Inspection Plan, as provided in Section VIII (Review and Approval Procedures) of this Consent Decree, Baltimore County shall implement the Inspection Plan as approved consistent with the approved schedules contained therein, and the approved Inspection Plan shall be incorporated into, and become enforceable under, this Consent Decree. Baltimore County shall identify and record all deficiencies identified through the inspections required by this Paragraph for purposes of reporting and addressing those deficiencies in the SRRR Plans as required by Paragraph 10.

F. **Reporting Requirements**. Baltimore County shall report to EPA and MDE on its performance of the requirements in this Paragraph 8 as specifically set forth in Section VI (Reporting Requirements) of this Consent Decree.

9. **Rainfall and Flow Monitoring**.

A. **General Requirements**. Baltimore County shall collect rainfall and flow monitoring data as set forth below and utilize that data to perform evaluations of (i) inflow/infiltration ("I/I") into the Collection System, (ii) the Collection System's capacity to collect and convey peak flows experienced by or predicted for the Collection System without causing dry-weather and wet-weather SSOs, and (iii) the effectiveness of measures implemented by Baltimore County pursuant to this Consent Decree to reduce I/I and to increase system capacity.

B. **Rainfall and Flow Monitoring**. Baltimore County shall submit a Rainfall and Flow Monitoring Plan as required by Paragraph 9.B.v. below, and shall collect rainfall and flow monitoring data pursuant to this Paragraph 9.B. and its Rainfall and Flow Monitoring Plan as approved by EPA and MDE.

i. **Rainfall Monitoring**. Baltimore County shall collect rainfall data as necessary to allow the characterization of flow from each Sewershed service area, the characterization of every known SSO, the development of the Model as required by Paragraph 14, and evaluation of the effectiveness of measures implemented by Baltimore County pursuant to this Consent Decree to reduce I/I and to increase system capacity. Baltimore County shall monitor the contribution from rainfall to each Sewershed within Baltimore County's jurisdictional boundary by using (a) a distribution of rain gauges, (b) multiple rain gauges in concert with Doppler radar, or (c) other monitoring methodologies, subject to review and approval by EPA and MDE, that produce information at least as representative as the use of rain gauges in concert with Doppler radar. If Baltimore County elects to use rain gauges only, Baltimore County shall use a network of appropriately distributed rain gauge stations with a minimum coverage of one rain gauge station per two (2) square miles with no fewer than three (3) rain gauge stations per Sewershed. If Baltimore County elects to use rain gauges in concert with Doppler radar, Baltimore County shall use a network of appropriately distributed rain gauge stations with a minimum coverage of one (1) rain gauge station per ten (10) square miles as well as data collected using Doppler radar that provides a minimum resolution of one (1) pixel per four (4) square kilometers. Baltimore County shall also measure rainfall occurring in portions of the Collection System Sewersheds outside the Baltimore County limits by using appropriately distributed rain gauges located at the upstream jurisdictional boundary(s) (i.e., Baltimore County/Howard County and/or Baltimore County/Anne Arundel County) in the respective Sewershed(s), and, if Baltimore County is proceeding under subparagraph (b) above, by using Doppler radar, to achieve a resolution as close to one pixel per four square kilometers as is practical. Baltimore County shall also, where practical and appropriate, locate additional rain gauges within Sewershed areas outside its jurisdiction, on properties owned or operated by Baltimore County (such as water treatment facilities), or where practical and appropriate, by agreement with third parties. Baltimore County shall locate, install, operate, calibrate, and maintain all rain gauges, and shall utilize Doppler radar data (if utilized), in accordance with the manufacturer's/service provider's recommendations and good industry practices.

ii. **Flow Monitoring.** Flow data shall be collected using a system of permanent and temporary flow monitors, including the flow or the pump run time records available from all Pump Stations located in the Collection System.

(a) Baltimore County shall collect flow data at such locations in the Collection System as are necessary to allow the characterization of flow from each Sewershed service area, the characterization of every known SSO, the development of the Model as required by Paragraph 14, and evaluation of the effectiveness of measures implemented by Baltimore County pursuant to this Consent Decree to reduce I/I and to increase system capacity.

(b) Baltimore County shall inspect all flow meters with sufficient frequency to meet the data requirements set forth in Paragraph 9.B.iii., below. Baltimore County shall maintain and calibrate all flow meters per the manufacturer's specifications or shall propose alternative maintenance or calibration procedures and criteria for approval by EPA and MDE.

iii. Baltimore County shall conduct its flow and rainfall monitoring in accordance with the SSES Handbook, the NASSCO Guidelines, and sound engineering practices. Baltimore County's flow and rainfall monitoring network shall be designed, installed, operated and maintained to provide data representative of actual rainfall and flow conditions and of sufficient quality for use in the development, calibration, and verification of the Model as required by Paragraph 14, for at least ninety percent (90%) of the time each meter experiences measurable flow. Monitoring site selection, equipment selection and installation, calibration, and maintenance, and data quality assurance checks shall all be carried out to optimize monitoring accuracy, to minimize the loss of data due to meter downtime, and shall all conform with the equipment manufacturers' recommendations and current, good engineering practice. Field calibration results for each meter, along with an evaluation of the accuracy for each meter, shall be retained consistent with Section XVIII (Record Keeping) of this Consent Decree. These shall include (for flow monitoring) monitoring site diagrams, scattergraph plots of field data sets, manual field depth and velocity measurements, and (if the site is free flowing) the appropriate pipe curve.

iv. Rainfall and flow data shall be handled and analyzed using appropriate, industry-accepted quality assurance and quality control procedures that will assure that the measurements are representative of actual rainfall and flow conditions and that the data are of sufficient quality for use in the development, calibration, and verification of the Model as required by Paragraph 14.

v. By no later than 180 days from the Effective Date, Baltimore County shall submit a Rainfall and Flow Monitoring Plan, and accompanying implementation schedule, to EPA and MDE for review and approval. This Plan shall describe in detail the approach that Baltimore County will utilize to monitor rainfall and flow in each Sewershed, including any areas of the Sewershed outside of Baltimore County's jurisdiction. The Plan also will provide a detailed discussion of the technical basis for the proposed approach to rainfall monitoring, including the number of rain gauges to be used in each Sewershed and their approximate locations. The Plan shall also identify the estimated number and general location of flow monitoring points in each Sewershed and provide a map that identifies the location of each rain gauge and flow monitor. It is recognized that details such as particular monitoring locations may change based upon field inspection activities; however, the Plan shall describe how the proposed flow monitoring points will allow the collection of data that is adequate to support successful calibration and verification of the Model, as required by Paragraph 14.B., and characterization of the Collection System's response to wet weather events as required by Paragraph 9.C.ii. The Plan shall also describe how Baltimore County, consistent with Paragraph 9.B.vi. below, proposes to ensure that its monitoring program will be capable of evaluating the effectiveness of measures implemented by Baltimore County pursuant to this Consent Decree (including Paragraphs 7, 10, and 13) to reduce I/I and to increase system capacity.

vi. Within one year of approval of its Rainfall and Flow Monitoring Plan, and on an annual basis thereafter until termination of the Consent Decree, Baltimore County shall evaluate the number and placement of flow monitors and rain gauges throughout the Collection System and in each Sewershed and make any modifications necessary to ensure that the then-current number and placement of flow monitors and rain gauges capture representative wastewater flow and rainfall data sufficient to satisfy the requirements of this Paragraph 9.B., including evaluation of the impact on the Collection System or Sewershed of the completion of any repair, replacement or rehabilitation projects designed to reduce I/I or to increase capacity. In each Annual Report, Baltimore County shall summarize the results of the evaluation for the prior year, including the location of rain gauges or flow monitors changed during the prior calendar year, and provide a revised location map.

C. **Evaluation of Monitoring Data**. Baltimore County shall complete an Inflow/Infiltration Evaluation and a Long-Term Capacity/Peak Flow Management Evaluation for each Sewershed as set forth in Paragraphs 9.C.i. and ii. below. Baltimore County shall complete each Evaluation no later than 60 days prior to the date by which it is required to submit the SRRR Plan for the relevant Sewershed pursuant to Paragraph 10, and shall summarize and incorporate the results of the Evaluations in the SRRR Plan for the relevant Sewershed.

i. **Inflow/Infiltration Evaluation**. For each Sewershed, Baltimore County shall complete the evaluation of I/I into the Collection System within that Sewershed. These evaluations shall include identification of sources of infiltration, sources of inflow, and methods for reducing I/I into the Collection System. As part of these required I/I evaluations, Baltimore County shall utilize the rainfall and flow monitoring data collected pursuant to this Paragraph: (a) to determine baseline normalized (e.g., gallons/inch-mile) I/I rates in each Sewershed; (b) to determine the efficacy of the capital projects completed pursuant to Paragraph 7 to reduce I/I rates; and (c) to predict the effectiveness of the capital projects required by Paragraph 7 but not yet completed, and any additional rehabilitation or other corrective action proposed by Baltimore County in each SRRR Plan to reduce peak wet weather flows and/or to address portions of the Collection System with insufficient capacity, including actual or potential SSOs. For purposes of this Paragraph 9 only, the term "evaluation" shall be interpreted in accordance with the meaning ascribed to that term in sub-chapters 3.3, 3.4, 3.5, 3.6 and Chapter 4 of the SSES Handbook and in accordance with the technical procedures for identification of I/I set forth in sub-chapters 3.3, 3.4, 3.5, 3.6, and Chapter 4 of the SSES Handbook. Following completion of the I/I Evaluation for any Sewershed, Baltimore County shall certify that the I/I Evaluation has been completed for that Sewershed and summarize the actions taken by Baltimore County to complete the I/I Evaluation in the Quarterly Report for the calendar quarter in which I/I Evaluation was completed.

ii. **Long-Term Capacity/Peak Flow Management Evaluation**. Baltimore County shall use the data and information collected and analyzed in Paragraphs 8 and 9 to evaluate whether the construction projects required by Paragraph 7.D. of the Consent Decree and the projects Baltimore County proposes to complete pursuant to Paragraph 10 will ensure adequate long-term transmission capacity in the Collection System. At a minimum, Baltimore County shall evaluate the hydraulic capacity of all Major Gravity Lines, Force Mains, Pump Stations, and relevant appurtenances (collectively referred to as “Modeled Components” for purposes of this Paragraph 9.C.ii.).

(a) As part of the evaluation required by this subparagraph, Baltimore County shall use the information, including I/I rates, that it is required to develop pursuant to this

Paragraph of the Consent Decree to assess existing and long-term capacity of the Collection System, to evaluate the ability of the Collection System to transmit peak flows experienced by and predicted for the Collection System, and to identify appropriate measures to address capacity issues with the goal of eliminating capacity-related SSOs. Baltimore County shall use flow data and rainfall data collected pursuant to this Paragraph and the Model required by Paragraph 14 both to accurately represent wastewater flow attributable to each service area and to estimate the impact of peak flows experienced by the Collection System on the capacity of the Modeled Components to manage peak flows. Peak flows shall be determined using flow monitoring conducted pursuant to this Paragraph and shall take into account variables including, but not limited to: the average age of the gravity sewer system; soil-type and porosity (where applicable); maximum, minimum and average yearly groundwater elevations; proximity to surface water bodies; tidal influence; amount of drainage area; service area size; land use; historic I/I data; seasonal population patterns (where applicable); Collection System construction materials; and year 2025 predicted population and land uses.

(b) Baltimore County shall determine predicted peak flows for each of its Sewersheds under baseline and future flow conditions for, at a minimum, 2, 10, and 20 year/24-hour storm events. In developing the Hyetographs and Hydrographs for these storm events, Baltimore County shall utilize either (i) an SCS Type II rainfall distribution, or (ii) an alternative rainfall distribution that is more representative of actual Baltimore County rainfall patterns than the SCS Type II distribution. If Baltimore County utilizes an alternative rainfall distribution pursuant to Paragraph 9.C.ii(b)ii., Baltimore County shall provide with its analysis an explanation of its determination that the alternative rainfall distribution was more representative. Baseline conditions shall be those in effect at the time flow metering is completed in each Sewershed. Future conditions shall be based on reasonable population projections for year 2025. Baltimore County shall include in its evaluation the effects of completion of the capital projects required under Paragraph 7 and any projects that it proposes to complete pursuant to each SRRR Plan developed pursuant to Paragraph 10. The baseline reference for those projects shall be the period during which rainfall and flow monitoring were last carried out. Baltimore County may consider the utilization of existing, practical in-line storage capacity (i.e., storage capacity that can be used without modification to the existing system and that does not cause any SSOs) in evaluating the capacity of the Collection System and the ability of the Modeled Components to manage peak flows resulting from storm events.

(c) Baltimore County shall develop rainfall Hyetographs and I/I Hydrographs for each Sewershed. The Hyetographs and Hydrographs shall be developed using:

(1) Available historical rainfall and flow data;

(2) Rainfall and flow data collected pursuant to this Paragraph, or otherwise;

(3) Population data;

(4) Winter water use records; and

(5) Other appropriate information.

Baltimore County shall identify and apply widely-used and accepted engineering methodologies to determine baseflow rates and diurnal baseflow variation, dry weather infiltration, relationships between rainfall and wet weather flow volumes and rates in each portion of each Sewershed, and to identify a representative Hydrograph shape(s). The Hyetographs and I/I Hydrographs shall be developed for the storm recurrence frequencies identified in subparagraph (b) above. The I/I Hydrographs shall be integrated with baseline wastewater, rainfall, and flow data and used in the Model to understand the flow through the Modeled Components.

(d) In evaluating the impact of the capital improvement projects required by Paragraphs 7.D. and 13.B. of the Consent Decree, and the capital projects that Baltimore County proposes in any SRRR Plan, on the adequacy of long-term transmission capacity and the ability of the Collection System to transmit peak flows, Baltimore County shall account for the Collection System's existing and modeled capacity, the estimated population and wastewater flow rates for the year 2025, and estimated sewer deterioration rates, and shall use the results of that evaluation to:

(1) Identify any Modeled Components that restrict flow of wastewater through the Collection System that cause or contribute, or are likely to cause or contribute, to SSOs from the Collection System;

(2) Quantify the maximum flow that any Modeled Component identified in 9B.ii.(d)(1) above can convey without causing or contributing to an SSO;

(3) Identify all Modeled Components that cannot manage peak flows during a full range of storm events listed in Paragraph 9.B.ii(b) without causing or contributing to an SSO; and

(4) Identify the improvements to the Collection System necessary to ensure adequate long-term capacity consistent with the SSES Handbook during a full range of storm events specified in this Paragraph 9.C.ii.

(e) The improvements Baltimore County shall consider to assure adequate capacity shall include expansion and/or replacement of Modeled Components, including Pump Stations, reduction of inflow and infiltration, and installation of larger replacement sewers or relief sewers.

(f) Following completion of the long-term capacity/peak flow management evaluation for any Sewershed, Baltimore County shall certify that the long-term capacity/peak flow management evaluation has been completed for that Sewershed and summarize the actions taken by Baltimore County to complete the long-term capacity/peak flow management evaluation in the Quarterly Report for the calendar quarter in which the long-term capacity/peak flow management evaluation was completed.

(g) It is not the purpose of this Consent Decree to require Baltimore County to design or otherwise construct its Collection System to any specific recurring storm interval, or any particular event modeled pursuant to this Consent Decree.

D. **Reporting Requirements**. Baltimore County shall report to EPA and MDE on its performance of the requirements in this Paragraph 9 as specifically set forth in Section VI (Reporting Requirements) of this Consent Decree.

10. **Sewershed Repair, Replacement and Rehabilitation Plans**.

A. **General Requirements**. Following completion of the Collection System Inspection required by Paragraph 8, and considering the rainfall and flow monitoring data collected pursuant to Paragraphs 7.D. and 9, Baltimore County shall prepare a Sewershed Repair, Replacement and Rehabilitation Plan ("SRRR Plan") for each Sewershed that describes the deficiencies identified through the Collection System Inspection and provides for the performance of any repair, replacement, rehabilitation or other corrective action necessary to address those deficiencies. Baltimore County shall complete implementation of the SRRR Plans for all 32 Sewersheds in its Collection System by no later than 14 years, six months from the Effective Date.

B. **Development and Submission of SRRR Plans and Schedules.** Within one year of completion of the Collection System Inspection for each Sewershed as required by Paragraph 8, Baltimore County shall prepare and submit to EPA and MDE for approval, pursuant to Section VIII (Review and Approval Procedures) of this Consent Decree, a SRRR Plan for that Sewershed. Each SRRR Plan shall provide for future repair, replacement, and rehabilitation of Collection System components within that Sewershed in accordance with a prescribed schedule that provides for completion of construction and implementation of each project to be performed pursuant to the approved SRRR Plan by no later than 4 years from EPA and MDE approval or approval with conditions of the SRRR Plan pursuant to Section VIII (Review and Approval Procedures) of this Consent Decree. In proposing schedules for implementation of the SRRR Plans, Baltimore County shall prioritize the work to be performed in each Sewershed based on an evaluation of the rehabilitation activities that are expected to contribute most effectively to the prevention of SSOs.

C. **Criteria for SRRR Plans.** Within each SRRR Plan, Baltimore County shall:

i. Evaluate the effectiveness of the projects completed or proposed to be completed pursuant to Paragraph 7.D. for the relevant Sewershed. Baltimore County shall use rainfall and flow monitoring data collected in accordance with requirements of Paragraphs 7.D. and 9 of the Consent Decree, and shall use the Model developed in accordance with Paragraph 14 of the Consent Decree, to demonstrate the effectiveness of the construction projects;

ii. Identify all deficiencies in the relevant Sewershed discovered during the Collection System Inspection conducted pursuant to Paragraph 8;

iii. Identify all corrective actions taken (including date completed), or to be taken, by Baltimore County (including but not limited to preventative maintenance, repair, replacement, or rehabilitation) to address the deficiencies identified during inspection of the relevant Sewershed;

iv. Describe the priority scheme used to set priorities for correcting identified deficiencies within each Sewershed, including any decision not to correct an identified deficiency;

v. Describe the decision-making criteria used to select future corrective action;

vi. Propose a plan and schedule for implementing rehabilitation and other corrective action determined necessary to correct deficiencies in the relevant Sewershed identified during the inspections required by Paragraph 8, taking into consideration the Long-Term Capacity/Peak Flow Management analysis performed for the relevant Sewershed pursuant to Paragraph 9; the prioritization scheme to be applied to correction of these deficiencies; and an estimate of the cost necessary to complete any proposed rehabilitation and other corrective actions. For purposes of this Paragraph only, the term "rehabilitation" shall be interpreted in accordance with the meaning ascribed to that term in Chapters 5.4 and 6 of the SSES Handbook, and in accordance with the technical procedures for sewer system rehabilitation set forth in Chapter 6 of the SSES Handbook.

vii. Propose a plan and schedule for eliminating those physical connections (i.e., cross connections) between the Collection System and the storm water collection system that allow or have the potential to allow sanitary waste to be discharged to the storm water collection system;

viii. Present the results of the long-term capacity/peak flow management evaluation conducted pursuant to Paragraph 9.C.ii, and determine for each Sewershed the range of storm events as specified in Paragraph 9.C.ii(b) for which the Collection System in its existing condition can convey peak flows without the occurrence of SSOs. As part of its analysis, Baltimore County shall identify all modeled Collection System Components and Pump Stations that cause or contribute to flow restrictions or that have the potential to cause or contribute to overflows;

ix. Consistent with the results of the long-term capacity/peak flow management evaluation conducted pursuant to Paragraph 9.C.ii, project for each Sewershed the range of storm events as specified in Paragraph 9.C.ii(b) for which the Collection System will be able to convey peak flows without the occurrence of SSOs. Such projection shall assume completion of the construction projects required by Paragraph 7 of this Consent Decree, and completion of the proposed rehabilitation or other corrective action projects recommended by the SRRR Plan required by this Paragraph 10. As part of its analysis, Baltimore County shall identify all modeled Collection System components and Pump Stations that cause or contribute to flow restrictions or that have the potential to cause or contribute to overflows;

x. Present the results of the rainfall and flow monitoring conducted in the Sewershed, including a map that depicts all monitored locations, dates of monitoring, a description of quality assurance and quality control analyses performed for samples collected and data analyzed and the results of those analyses (i.e., summarize data quality assurance and data "lost" or "qualified"), and present the results of the I/I evaluation performed pursuant to Paragraph 9.C.i., including a description of the smoke testing and dye testing activities performed in the Sewershed, a summary of the results of such testing, a quantification of the rates of I/I for the Sewershed and the portions of the Sewershed's Collection System impacted by I/I, and any identified sources of I/I to the Collection System located in the Sewershed;

xi. Baltimore County shall incorporate into each SRRR Plan a description of additional data collection activities that will be implemented after the completion of rehabilitation and other corrective action(s) proposed pursuant to Paragraphs 10.B. and 10.C. to evaluate their effectiveness consistent with Paragraph 10.E. (Performance Assessment) below.

D. **Approval and Implementation of SRRR Plans**. Within 30 days after approval or approval with conditions by EPA and MDE of an SRRR Plan for a specific Sewershed, as provided in Section VIII (Review and Approval Procedures) of this Consent Decree, Baltimore County shall implement the SRRR Plan as approved and consistent with the approved schedules contained therein. Each approved SRRR Plan shall be incorporated into, and become enforceable under, this Consent Decree. In each Quarterly Report, Baltimore County shall provide a summary of Baltimore County's progress in completing implementation of each SRRR Plan during the prior calendar quarter. Following completion of the implementation of the SRRR Plan for any Sewershed, Baltimore County shall certify that the SRRR Plan has been implemented for that Sewershed and summarize the actions taken by Baltimore County to complete the SRRR Plan in the Quarterly Report for the calendar quarter in which the SRRR Plan was completed.

E. **Performance Assessment**. Baltimore County shall conduct a Performance Assessment of the work performed in each Sewershed as required under Paragraphs 7, 10, and 13 to determine the effectiveness of the evaluation and corrective action work performed.

i. The Performance Assessment shall, at a minimum,

(a) evaluate the number and causes of SSOs that occur on an annual basis in each Sewershed;

(b) quantify the reduction of I/I in each Sewershed;

(c) evaluate the effectiveness of repair, replacement, and rehabilitation projects in addressing identified structural and/or capacity issues;

(d) evaluate the effectiveness of preventative and proactive maintenance practices in reducing root, grease, and other blockages.

ii. The Performance Assessment shall be completed for each Sewershed within 18 months after complete implementation of the SRRR Plan for that Sewershed.

iii. Baltimore County shall submit a Performance Assessment report for each Sewershed summarizing the results of the Performance Assessment for that Sewershed to EPA and MDE for review and comment within 90 days after completion of the Performance Assessment for that Sewershed.

iv. Following completion of the Performance Assessment, Baltimore County shall modify its Collection System operation and maintenance program as appropriate to achieve the purpose of this Consent Decree.

F. **Reporting Requirements**. Baltimore County shall report to EPA and MDE on its performance of the requirements in this Paragraph 10 as specifically set forth in Section VI (Reporting Requirements) of this Consent Decree.

11. **Fats, Oils, and Grease Control Program**.

A. **Summary of Requirements.** Baltimore County shall perform a comprehensive review of its current procedures for the control of fats, oils, and grease ("FOG Program") within its Collection System and implement specific modifications to its FOG Program to improve its effectiveness, with the goal of eliminating SSOs caused or contributed to by fats, oils, and grease (hereinafter collectively "grease") blockages.

B. **Continuation of Current FOG Program**. Until such time as more stringent FOG controls are implemented through the FOG Program Modification Plan developed pursuant to this Paragraph 11, Baltimore County shall continue to enforce its current FOG Program, including specifically the County requirements authorized by the Code of Baltimore County, Food Service Facility Regulations § 1.01.01, which requires, among other things, that all new and certain remodeled Grease Generating Facilities must install a grease abatement system as a prerequisite to qualification for an operating permit; the Code of Baltimore County, Article 20, Title 5, Waste Water Regulation; and the National Standards of Plumbing Code Illustrated (1996 and 1998 Supplement), Sec. 6.1.1, Interceptors.

C. **Review of Current FOG Program and Evaluation of Potential Improvements**. Within 180 days of the Date of Lodging, Baltimore County shall complete a preliminary review of its current FOG program to identify deficiencies in the Program, including conflicts regarding inter-departmental requirements, and to make recommendations to ensure that the requirements of this Paragraph 11 can be satisfied within the time frames provided. Within 30 days of completing this preliminary review, the County shall submit a report on the findings of the review to MDE and EPA for review and comment. In conducting its review, Baltimore County shall, at a minimum:

i. Review applicable statutes and regulations to determine whether the County has sufficient statutory and regulatory authority to effectively identify and control sources of fats, oils and grease that may enter the Collection System, including the authority to require grease abatement devices and best management practices ("BMP's") and to assess penalties for noncompliance, and identify and evaluate potential modifications to resolve any identified deficiencies.

ii. Review current DEPRM and DPW enforcement practices, including but not limited to, field inspection methodologies, violation notification, penalty assessment, and administrative and judicial enforcement processes.

iii. Review current DEPRM and DPW database assets to ascertain the type of information available, frequency of data collection and entry, and accessibility of data.

D. **Database and GIS Mapping of Grease Generating Facilities**.

i. Within one year of the Effective Date, Baltimore County shall create a database of Grease Generating Facilities that includes for each Facility the address, owner/responsible party, presence or absence of a grease abatement system, history of violations, inspection history, and any other information relevant to assessing the Facility's potential contribution to grease-related blockages and/or SSOs.

ii. Within one year of the Effective Date, Baltimore County shall use its geographical information system ("GIS") to develop a map that identifies the following: (a) SSOs caused or contributed to by grease blockages since June 30, 2000; (b) the locations of all known Grease Generating Facilities; and (c) the locations of any Grease Generating Facilities that have been the subject of enforcement actions by Baltimore County due to FOG-related blockages since June 30, 2000.

iii. The database and map required in Paragraph 11.D.i. & ii., above, shall be updated at least semi-annually to reflect the ongoing inspection and enforcement histories of all new and existing Grease Generating Facilities. Baltimore County shall provide the most recent version of the database and map to EPA and MDE as part of each Annual Report.

E. **Survey and Inspection of Potential Grease Generating Facilities**.

i. Within one year of the Effective Date, Baltimore County shall develop and incorporate criteria for FOG evaluation, including criteria for assessing the risk that a Grease

Generating Facility will cause or contribute to a grease blockage in the Collection System, into the protocol for routine inspections of permitted food service facilities and inspection of other Grease Generating Facilities over which Baltimore County exercises FOG-related jurisdiction, and develop revised inspection forms for recording FOG-related information;

ii. Within one year of the Effective Date, Baltimore County shall conduct a baseline FOG inspection of each Grease Generating Facility in the County's service area. The baseline inspection, which may be conducted concurrently with other routine Facility inspections, shall determine whether the Facility(ies) are equipped with a grease abatement system, whether the systems are being operated and maintained properly, and whether grease hauler removal information is being maintained; and

iii. Within eighteen (18) months of the Effective Date, Baltimore County shall enter all FOG information obtained from the baseline inspections into the database and GIS maps developed pursuant to Paragraph 11.D.

iv. Following completion of the baseline inspection requirements set forth in Paragraph 11.E.ii., Baltimore County shall certify completion of such requirements and summarize the actions taken by Baltimore County to complete such requirements in the Quarterly Report for the calendar quarter in which such requirements were completed.

F. **<u>Notice to Responsible Parties</u>**.

i. Within one year of the Effective Date, Baltimore County shall notify in writing the responsible party(ies) for each Grease Generating Facility of the general obligation to prevent the discharge of fats, oils and grease to the Collection System.

ii. Following EPA and MDE approval of Baltimore County's FOG Program Modification Plan under Paragraph 11.G., and no later than 90 days after completion of the requirements of Paragraph 11.E.ii., Baltimore County shall notify in writing each responsible party for each Grease

Generating Facility of the obligations under the County's FOG Program and provide additional information to assist in achieving compliance with those obligations, including contact information for approved grease transport services. Baltimore County shall thereafter provide such notice on an annual basis.

iii. Following completion of the notice requirements set forth in Paragraph 11.F.i. and ii.(excluding the annual notice requirement), Baltimore County shall certify completion of such requirements and summarize the actions taken by Baltimore County to complete such requirements in the Quarterly Report for the calendar quarter in which such requirements were completed.

G. **Review and Modification of Current FOG Program**. Baltimore County shall complete a comprehensive review of its current FOG Program, as well as the information collected during the baseline inspections required by Paragraph 11.E., to determine the Program's effectiveness, to evaluate potential improvements and alternatives, and to propose specific modifications to improve the Program's effectiveness in preventing grease blockages within the Collection System. By no later than 60 days after the completion of the baseline inspections required by Paragraph 11.E., Baltimore County shall submit to EPA and MDE, for approval pursuant to Section VIII (Review and Approval Procedures) of this Consent Decree, a FOG Program Modification Plan that summarizes the results of Baltimore County's FOG Program review; proposes specific modifications, implementation plans and schedules for, at a minimum, each of the Program components identified in this Paragraph 11.G.; and provides for full implementation of the proposed modifications by no later than two years from final approval by EPA and MDE pursuant to Section VIII (Review and Approval Procedures) of this Consent Decree of Baltimore County's FOG Program Modification Plan. In developing its FOG Program Modification Plan, Baltimore County shall:

i. Propose specific modifications to address any conflicts or deficiencies in Baltimore County's statutory and regulatory authority identified during or subsequent to Baltimore

County's review conducted pursuant to Paragraph 11.C., and a schedule for development and enactment of such modifications;

ii. Evaluate alternative methods, including permitting and contract programs, for assigning specific, enforceable responsibilities to Grease Generating Facilities to eliminate discharges of fats, oils and grease to the Collection System, and propose a specific plan and schedule for implementing such a program (including procedures for timely notification of violations, escalation of enforcement actions, and the imposition of civil penalties and injunctive relief) within Baltimore County's service area;

iii. Evaluate alternative methods for implementing grease abatement system management, operation and maintenance standards, including best management practices that address acceptable technology (including type, size and proper installation of abatement systems), on-site record keeping requirements, cleaning frequency, cleaning standards, use of additives, and ultimate disposal of grease removed, and propose a specific plan and schedule for adopting and implementing such standards and practices within Baltimore County's service area;

iv. Evaluate all methods of effecting grease management, including best management practices ("BMPs") and cleaning practices, at Grease Generating Facilities not currently required to implement a grease abatement system, and propose a specific plan and schedule for implementing such standards and practices within Baltimore County's service area. Baltimore County shall also consider additional steps for such Facilities, including whether (a) to revise regulations to require installation and operation of grease abatement systems, (b) to implement a program for increased cleaning by Baltimore County of the main into which the relevant lateral connects, (c) to require the Grease Generating Facilities to regularly clean the lateral pipes that connect to Baltimore County's Collection System, and/or (d) to implement any other equally effective program or remedial measure for reducing FOG blockages. As part of this evaluation, Baltimore County shall also consider the extent to which multi-person residential buildings contribute FOG to the Collection System and consider alternatives for reducing such FOG contributions;

v. Evaluate alternative methods for scheduling, prioritizing, and conducting regular inspections to assess compliance by Grease Generating Facilities with prohibitions on the discharge of fats, oils and grease to the Collection System, and propose a specific plan and schedule for incorporating revised compliance requirements into the inspection protocol and database design and for implementing ongoing FOG inspections within Baltimore County's service area;

vi. Evaluate staffing and ancillary requirements necessary to improve the effectiveness of Baltimore County's FOG Program, and propose a plan and schedule for securing funding for and training the necessary staff;

vii. Evaluate potential performance indicators that may be used to measure the effectiveness of the FOG Program, including measurements for the reduction in the frequency of FOG-related SSOs and blockages, and propose a plan for tracking effectiveness under Baltimore County's modified FOG Program to be used in conducting ongoing FOG Program evaluations under Paragraph 11.I; and

viii. Evaluate public education and outreach and compliance assistance efforts necessary to inform commercial and residential property owners and occupants about the need to minimize the introduction of grease into the Collection System, and propose a plan for implementing such efforts within Baltimore County's service area, consistent with Paragraph 11.F.

H. **Implementation of FOG Program Modification Plan**. Upon approval or approval with conditions by EPA and MDE of Baltimore County's FOG Program Modification Plan, pursuant to Section VIII (Review and Approval Procedures) of this Consent Decree, Baltimore County shall implement the Plan as approved and according to the approved schedule(s), and the FOG Program Modification Plan shall be incorporated into, and become enforceable under, this Consent Decree. In each Quarterly Report, Baltimore County shall provide a summary of Baltimore County's progress in completing implementation of its approved FOG Program Modification Plan during the prior calendar quarter. Following implementation of the FOG Program Modification Plan, Baltimore County shall certify completion and summarize the actions taken by Baltimore County to implement the FOG Program Modification Plan in the Quarterly Report for the calendar quarter in which such requirements were completed.

I. **Annual Evaluations of Modified FOG Program**. Within one year of implementation of the FOG Program Modification Plan pursuant to Paragraph 11.H., above, and on an annual basis thereafter, Baltimore County shall evaluate the effectiveness of its modified FOG Program using the performance indicators developed pursuant to Paragraph 11.G.vii., above. The results of each annual evaluation should be included in the next Annual Report submitted to EPA and MDE pursuant to Section VI (Reporting Requirements).

J. **Reporting Requirements**. Baltimore County shall report to EPA and MDE on its performance of the requirements in this Paragraph 11 as specifically set forth in Section VI (Reporting Requirements) of this Consent Decree.

12. **Illegal Storm Water Discharges**.

A. **General Requirements**. Baltimore County shall, through the use of methodologies such as CCTV and smoke and dye testing during the performance of the Collection System inspections required pursuant to Paragraph 8, seek to identify Illegal Storm Water Discharges to the Collection System, and upon identification shall eliminate such discharges, where such discharges, individually or cumulatively, are likely to cause or contribute to an SSO.

B. **Specific Requirements**.

i. Elimination of Illegal Storm Water Discharges.

(a) Within 30 days of identifying an Illegal Storm Water Discharge into the Collection System, Baltimore County shall notify the owner of the connection (including all associated laterals or other privately-owned conduits used to transport discharge to the connection) that is the source of such discharge that the connection is the source of an illegal discharge, and shall require the owner to take all appropriate steps to eliminate the illegal discharge.

(b) Within 180 days after notifying the owner to eliminate the Illegal Storm Water Discharge, if the owner has failed to eliminate the illegal discharge, Baltimore County shall take all lawful and appropriate steps including, but not limited to, repairing, rehabilitating, or replacing the connection that is the source of the discharge, or initiating enforcement action to cause the repair, rehabilitation, replacement, or termination of that service connection.

(c) Alternatively, Baltimore County may require the owner to pay the appropriate fines and/or authorize the discharge if Baltimore County ensures through the provision of adequate sewer system capacity that the discharge will not cause or contribute to an SSO.

(d) The foregoing remedies shall not be exclusive of other administrative or judicial remedies provided by law or regulation.

ii. **Reporting Requirements**. Baltimore County shall report to EPA and MDE on its performance of the requirements in this Paragraph 12 as specifically set forth in Section VI (Reporting Requirements) of this Consent Decree.

13. **Pump Station Inspection, Rehabilitation, Repair and Replacement**.

A. **General Requirement**. Baltimore County shall undertake the measures set forth in this Paragraph, with the goal of eliminating SSOs related to Pump Stations in the Baltimore County Collection System.

B. **Pump Station Rehabilitation/Repair**. Baltimore County shall complete the specific Pump Station rehabilitation, repair, and replacement projects identified in Appendix C in accordance with the milestone dates set forth in Appendix C. The milestone dates set forth in Appendix C are incorporated into, and enforceable under, the Consent Decree as if fully set forth herein. In each Quarterly Report, Baltimore County shall summarize the status of the projects required by this Paragraph 13.B. (as listed on Appendix C) as of the end of the prior calendar quarter. Following completion of each construction project identified on Appendix C, Baltimore County shall certify to EPA and MDE that construction has been completed in the Quarterly Report for the calendar quarter in which construction was completed.

C. **Pump Station Backup Power**. Baltimore County shall ensure that adequate backup power is maintained for each Pump Station.

i. Within one year of the Effective Date, and for each calendar year thereafter during the period that this Consent Decree is in effect, Baltimore County shall complete an evaluation of the effectiveness of its existing Pump Station backup power program, including the use of portable generators as backup power for multiple stations, in preventing SSOs relating to power outages at Pump Stations during the preceding year. Baltimore County shall submit the results of the annual evaluation to EPA and MDE in the applicable Annual Report.

ii. If any Pump Station experiences an SSO due to loss of power Baltimore County shall, within 180 days of the discovering the SSO, submit a plan to EPA and MDE for review and approval that provides for either (1) installation of a permanent backup generator or other on-site backup power source at the affected Pump Station, (2) procurement of additional portable generators sufficient to prevent future SSOs due to loss of power at the affected Pump Station, or (3) implementation of other measures, approved by EPA and MDE, designed to prevent further SSOs relating to power outages at the affected Pump Station. Upon approval or approval with conditions by EPA and MDE of Baltimore County's plan under this Paragraph 13.C.ii., Baltimore County shall implement the Plan as approved and according to the approved schedule(s). Following implementation of the approved plan, Baltimore County shall certify completion and summarize the actions taken by Baltimore County to implement the approved plan in the Quarterly Report for the calendar quarter in which the plan requirements were completed.

D. **Pump Station Remote Monitoring**.

i. By agreement of the Parties, Baltimore County shall install a supervisory control and data acquisition ("SCADA") system for remote monitoring of Pump Stations as provided for in its Contract No. 02119 with Hartwell Engineering, Inc. ("SCADA Contract"). Baltimore County shall ensure, and shall certify to EPA and MDE in the applicable Quarterly Report, that the SCADA system is installed, operational, and capable of satisfying the requirements of this Paragraph 13.D. with respect to each Pump Station by no later than the Effective Date of this Consent Decree.

(a) For each Pump Station, the SCADA system shall continuously poll, report, and transmit, at a minimum, the following parameters, where the referenced attributes are present:

(1) Wet well high level and low level alarms;

(2) Dry well flood alarms;

(3) Dry well sump pumping failure, where available;

(4) Flow (instantaneous and average) determined from a flow meter;

(5) Failure of any one of the following parameters (as a single alarm):

(i) loss of three-phase power;

(ii) single phase condition;

(iii) phase reversal;

(iv) over-voltage and under-voltage;

(v) use of standby power;

(vi) failure of standby power; and

(vii) second power source;

(6) Pump failure (for each pump);

(7) Pump running times;

(8) Pump starts; and

(9) Remote signal failure alarms.

(b) With respect to all Pump Stations, system monitoring data of wet well levels shall be stored in an archival data base for a period of five years. In addition, the Pump Station operating hours for each pump shall be recorded monthly and entered into an archival data base. Baltimore County shall retain for each month the 24-hour maximum and the monthly average flow data for each Pump Station in accord with Section XVIII (Record Keeping).

(c) The new SCADA system shall enable Baltimore County to store a record of each alarm generated by the SCADA system that includes the date, time, location, and parameter of the alarm. Baltimore County shall maintain alarm information for a minimum of five years and make this information available to MDE or EPA upon request.

ii. Prior to the implementation of the SCADA system required by this Paragraph 13.D., Baltimore County shall continue to monitor its Pump Stations using its existing system. Baltimore County shall archive all available alarm data generated by its current system for the five-year period prior to implementation of the new SCADA system.

E. **<u>Pump Station Inspection and Evaluation</u>**.

i. **<u>Pump Station Classification</u>**. For purposes of this Paragraph, each of the Pump Stations in Baltimore County's Collection System has been designated as either Tier 1, 2, or 3. The listing of Pump Stations by tier is attached to this Consent Decree as Appendix D.

ii. **Pump Station Inspection**. Until such time as Baltimore County fully implements the SCADA system required by Paragraph 13.D., Baltimore County shall conduct a physical inspection of each Pump Station at least once per week. Following implementation of continuous monitoring of each Pump Station under the new SCADA system, Baltimore County shall conduct a physical inspection of each Tier 1 Pump Station at least once per week, each Tier 2 Pump Station at least once every two weeks, and each Tier 3 Pump Station at least once per month.

(a) Baltimore County shall conduct the inspections required by this Paragraph 13.E.ii. in accordance with the inspection checklists attached to this Consent Decree as Appendix E. Baltimore County may modify the inspection checklists consistent with appropriate engineering and operation standards. Baltimore County shall provide EPA and MDE with a description of any modifications to the inspection checklists and an updated version of the checklists within the Annual Report for any year in which such modifications were made.

(b) Upon completion of the engineering evaluation/condition assessment required by Paragraph 13.F. below, Baltimore County shall update the inspection checklist(s) to ensure that the inspection protocol is sufficient to verify that each Pump Station is in good working order.

(c) Completed checklists and inspection reports shall be maintained by Baltimore County in accordance with the requirements of Section XVIII (Recordkeeping).

iii. For each deficiency identified during an inspection conducted in accordance with requirements of this Paragraph 13.E., Baltimore County shall either correct the deficiency within twenty-four hours, or, alternatively, issue a work order for the correction of the deficiency, in which Baltimore County shall assign a priority ranking in accordance with the ranking system attached to this Consent Decree as Appendix F, and complete action necessary to correct such deficiency consistent with the priority ranking and the impact of the deficiency on the functionality of

Baltimore County's Collection System. All identified deficiencies within Priority Classifications 2, 3, or 4 shall be corrected by no later than six (6) months from the date of the inspection in which that deficiency was first observed, unless such deficiencies are otherwise scheduled for correction pursuant to a separate requirement under this Consent Decree. Baltimore County may seek approval from EPA and MDE for an extension of time to correct any deficiency within Priority Classification 2 based on the limited availability of remedial materials.

iv. In addition to the actions required by subparagraph iii., above, in the event that any deficiency is identified that results in an SSO, Baltimore County shall act immediately to implement emergency measures to prevent or mitigate an SSO until the deficiency is corrected.

F. **Pump Station Engineering Evaluation/Condition Assessment**. Baltimore County shall perform or arrange for performance of an engineering evaluation and condition assessment by a professional engineer licensed in the State of Maryland for each Pump Station in its Collection System, except as set forth in Paragraph 13.F.v., below.

i. Each engineering evaluation/condition assessment required by this Paragraph 13.F. shall, at a minimum, include an assessment of the Pump Station's pumping system and mechanical, electrical, structural, and architectural condition. The engineering evaluation/condition assessment shall also determine whether the Pump Station utilizes an SSO Structure and, if so, evaluate whether such SSO Structure can be eliminated or modified so as to mitigate the potential impacts of discharges from the SSO Structure.

ii. Baltimore County shall complete each required engineering evaluation/ condition assessment within the time frames set forth below.

Tier 1 Pump Stations:	Within one year of Effective Date.
All Tier 2 or Tier 3 Pump Stations That Were Placed Into Service More Than 25 Years Prior to the Date of Lodging and That Have Experienced a Non-Power-Related SSO Since June 2000:	Within two years of Effective Date.
All Remaining Tier 2 Pump Stations:	Within three years of Effective Date.
All Remaining Tier 3 Pump Stations:	Within five years of Effective Date.

iii. Within 30 days of the completion of an engineering evaluation/condition assessment, Baltimore County shall submit to EPA and MDE for review and comment a report that identifies the scope of the evaluation and condition assessment, identifies the specific criteria applied during the evaluation, provides a summary of deficiencies identified, provides a summary of items due for scheduled replacement, and identifies appropriate remedial responses, including a summary of anticipated remedial costs.

iv. For each deficiency or instance of non-performing equipment identified during an engineering evaluation/condition assessment conducted in accordance with requirements of this Paragraph 13.F, Baltimore County shall assign a priority ranking in accordance with the following ranking system focusing on the prevention, mitigation, and correction of SSOs:

Priority 1	Impact on capability of Pump Station to operate at full capacity, personnel safety, or structural or building integrity issues.
Priority 2	Station equipment reliability issues, chronic maintenance problems, and Mechanical and Electrical Code issues.
Priority 3	Housekeeping, station appearance, or minor station operation or maintenance issues.

(a) For each identified Priority 1 or Priority 2 deficiency, Baltimore County shall include in or with its report a specific schedule that provides for completion of a remedial response to such deficiency consistent with its assigned priority, but not later than two years from completion of the engineering evaluation/condition assessment. Baltimore County shall implement each remedial response under this subparagraph (a) consistent with the proposed schedule, and each such schedule shall be incorporated into and enforceable under this Consent Decree. EPA and MDE may extend the schedule for completion of a remedial response activity upon demonstration by Baltimore County that the specific circumstances relevant to that response activity justify an extension. Following implementation of the required repairs for each Pump Station, Baltimore County shall certify completion and summarize the actions taken by Baltimore County in the Quarterly Report for the calendar quarter in which the repair requirements were completed.

(b) In the event that any deficiencies identified during the engineering evaluation/condition assessment result in an SSO, Baltimore County shall act immediately to correct the deficiency or to implement emergency measures to prevent or mitigate an SSO until the deficiency is corrected.

v. Baltimore County shall not be required to perform an engineering evaluation/condition assessment pursuant to this Paragraph 13.F. for the following Pump Stations:

(a) The following Pump Stations that were placed into service less than 10 years prior to the Date of Lodging of this Consent Decree:

Middle Back River Neck	Beachwood Estates
Rosalie Avenue	Beachwood Estates North
Bowleys Quarters	Reistertown Village
Holly Neck	Franklin Station
Vincent Farms	Hopewell Point
Back River Neck	

(b) The following Pump Stations for which Baltimore County has completed a recent engineering evaluation,

Whitemarsh
Hawthorne #1
Woodwind
Texas
Cockeysville

provided that Baltimore County certifies that it has complied or will comply with the requirements of Paragraph 13.F.iv., above, for each such Pump Station within two (2) years of the Effective Date.

(c) Any Pump Station that Baltimore County has committed, through specific allocation of capital budget funding, to replace in its entirety, where such commitment occurs prior to the deadline for completion of an engineering evaluation/condition assessment under this Paragraph. Baltimore County shall provide notice to EPA and MDE, including appropriate documentation, regarding any Pump Stations for which it intends to utilize this exemption at least 30 days prior to the date when the engineering analysis and condition assessment would otherwise be due pursuant to Paragraph 13.F.ii., above.

vi. Notwithstanding Paragraph 13.F.v. above, EPA and MDE may direct that Baltimore County perform an engineering evaluation/condition assessment pursuant to this Paragraph 13.F. for any of the Pump Stations identified in Paragraph 13.F.v(a) or (b) in the event that performance data, including the occurrence of SSOs, for that Pump Station collected after the Date of Lodging indicates that such an evaluation is necessary.

G. **<u>Pump Station Equipment Inventory</u>**.

i. Within two hundred seventy days (270) of the Effective Date, Baltimore County shall complete an asset inventory and attribute database for all equipment and systems in each Pump Station and update its maintenance records to include all new information. Following completion of the requirements of this Paragraph 13.G.i., Baltimore County shall certify that all such requirements have been completed and summarize the actions taken by Baltimore County to complete these requirements in the Quarterly Report for the calendar quarter in which the requirements were completed.

ii. Within two hundred seventy days (270) of the County's selection of a Pump Station information management system pursuant to Paragraph 13.H. and identification of the relevant system specifications, Baltimore County shall assign a unique identification number to each critical component at each Pump Station and update its maintenance records to include the identification numbers. If physically practicable, Baltimore County shall place an identification tag on each critical component. Following completion of the requirements of this Paragraph 13.G.ii. Baltimore County shall certify that all such requirements have been completed and summarize the actions taken by Baltimore County to complete these requirements in the Quarterly Report for the calendar quarter in which the requirements were completed.

iii. In the event that a rehabilitation, repair, or replacement project requires replacement of a critical component at a Pump Station, Baltimore County shall assign identification numbers to the new components and update its maintenance records within thirty (30) days of project completion.

H. **Pump Station Information Management System**. Within three years of the Effective Date, Baltimore County shall convert or transfer its existing Pump Station maintenance record keeping system, including all equipment inventory information, into an electronic information management system capable of collecting and tracking information regarding the operation, performance and maintenance of all Pump Stations. Baltimore County may accomplish this conversion or transfer either by expanding its Collection System Utilities Management Application to include Pump Station information or through use of an independent management system that is compatible with the Utilities Management Application. Following completion of the requirements of this Paragraph 13.H., Baltimore County shall certify that such requirements have been completed and summarize the actions taken by Baltimore County to complete these requirements in the Quarterly Report for the calendar quarter in which the requirements were completed.

I. **Pump Station Preventative Maintenance**. Baltimore County shall implement a Pump Station preventative maintenance program to ensure the proper operation and maintenance of its Pump Stations that includes the following measures:

i. Within ninety (90) days of completion of each rehabilitation/repair project required under Paragraph 13.B, Baltimore County shall update its preventative maintenance standard operating procedures and schedules to reflect all new and/or rehabilitated equipment.

ii. Within ninety (90) days of the Effective Date, Baltimore County shall develop a procedure (or document existing procedures) for determining the cause of equipment and/or system failures at Pump Stations and identifying preventive maintenance measures for minimizing future failures.

iii. Routinely track preventative maintenance of Pump Stations, including, but not limited to, the following:

(a) Appropriate, necessary and periodic service and calibration of all instrumentation, including flow meters, liquid level sensors, alarm systems, elapsed time meters, and remote monitoring equipment;

(b) Appropriate, necessary and periodic inspection and service for each Pump Station, including engines, motors, generators, pumps, wet wells, Pump Station valves, and related equipment; and

(c) Appropriate, necessary and periodic inspection and testing and, if necessary, servicing of all pumps including impellers, seals and bearings, wear clearances, couplings, drives and motors.

J. **Pump Station Operation and Maintenance Manuals**. Within one year of the Effective Date, Baltimore County shall ensure that an updated operation and maintenance manual is maintained for and located at each Tier 1 and Tier 2 Pump Station. Each operation and maintenance manual shall reflect current station configuration, equipment, and characteristics, and shall provide operating parameter value ranges representing recommended operating levels, a summary of historical pump run times, and detailed procedures to prevent overflows or spills while performing repairs at each

Pump Station. Baltimore County shall update the operation and maintenance manual for each Pump Station at which a rehabilitation, repair, or replacement project has been performed no later than 90 days after the date for completion of the project.

K. **<u>Reporting Requirements</u>**. Baltimore County shall report to EPA and MDE on its performance of the requirements in this Paragraph 13 as specifically set forth in Section VI (Reporting Requirements) of this Consent Decree.

14. **<u>Collection and Transmission System Model</u>**.

A. Using the INFOWORKS CS computerized collection and transmission system modeling program for its Collection System, Baltimore County shall implement and maintain a computerized collection and transmission system model or models (the "Model") for the Collection System to evaluate the impact of I/I rehabilitation projects, proposed system modifications, upgrades, and expansions to the transmission capacity and performance of the Collection System. Baltimore County shall develop a Model or Models meeting the requirements of this Paragraph for each Sewershed that includes the Model elements identified in Paragraph 14.B. To the extent practical, Baltimore County shall coordinate the development of its Model(s) with the City of Baltimore's modeling efforts. The Model(s) and the data collection activities upon which they are based, shall be developed and implemented so as to ensure that the Model(s) are integrated to the extent necessary to function in a hydraulically representative fashion for the Collection System. The integrated Model(s) shall allow Baltimore County to assess the capacity of its Collection System, as provided herein, and to identify the measures necessary to address capacity limitations as required by Paragraph 9.

B. **<u>Model Elements</u>.**

i. The Model required by this Paragraph shall, at a minimum, be used for predicting:

(a) Rate of wastewater flow and temporal variation of rate of flow in the Force Mains and the Major Gravity Lines;

(b) Hydraulic pressure (psig) or hydraulic grade line ("HGL") of wastewater at any point in Force Mains and the Major Gravity Lines;

(c) Flow capacity of each of the Pump Stations in the Collection System;

(d) Flow capacity of each Pump Station with its back-up pump out-of-service;

(e) Peak flows to and/or from each Pump Station during storm events of a magnitude of up to 20 years; and

(f) Likelihood and location of SSOs within those portions of each Sewershed modeled under high flow conditions, including Pump Station service areas where the Pump Station's back-up pump is out-of-service, and considering available wet well capacity, existing, functional off-line storage capacity, and normal in-line storage capacity.

ii. The Model shall also be:

(a) Configured based on representative, accurate and verified system attribute data (i.e., pipe sizes and invert elevations, manhole rim elevations, etc.);

(b) Calibrated using spatially and temporally representative rainfall data and flow data, either existing or obtained under this Consent Decree pursuant to Paragraph 9; and

(c) Verified using spatially and temporally representative rainfall data and flow data; that data shall be independent of the data used to calibrate the Model.

C. **Model Project Approach Report**.

i. Within one hundred and fifty (150) days from the Effective Date of this Consent Decree, Baltimore County shall submit to EPA and MDE for approval pursuant to Section VIII

(Review and Approval Procedures) of this Consent Decree a report that sets forth a project approach and detailed schedule of development, installation and implementation of the Model for the Collection System (the "Project Approach Report"). The Project Approach Report shall include, at a minimum, the following information:

(a) Identification of all input parameters, constants, assumed values and expected outputs; and

(b) A digital map of the Collection System that identifies and characterizes both the portions of the Collection System that shall be included in the Model and the portions of the Collection System that shall be excluded from the Model.

ii. The Project Approach Report required by this Paragraph 14.C. shall also identify how the Model will be adapted to predict wastewater flows through the Collection System, including:

(a) Identification of specific types of input data that are to be used and how attribute data accuracy and representativeness will be assured;

(b) Configuration of the Model;

(c) Procedures and protocols for performance of sensitivity analyses (i.e., how the Model responds to changes in input parameters and variables);

(d) Procedures for calibrating the Model to account for values representative of the Collection System using actual system data (e.g., precipitation and flow data), which include measures to assure that calibration variables such as pipe friction factors, are kept within generally-accepted realistic ranges;

(e) Procedures for verification of the Model's performance using actual system data (e.g., precipitation and flow data);

(f) Procedures and methodologies for the generation of wet weather Hydrographs for each Sewershed flow monitoring basin; and

(g) Approach to documenting the implementation of the above procedures and the results of calibration and verification efforts.

D. Within sixty (60) days of approval or approval with conditions by EPA and MDE, as provided in Section VIII (Review and Approval Procedures), Baltimore County shall begin implementation of the Project Approach Report, and the Project Approach Report as approved shall be incorporated into, and become enforceable under this Consent Decree.

E. **Model Certification.** Baltimore County shall complete implementation of the Model for each Sewershed, on or before submission of the SRRR Plan for the respective Sewershed required under Paragraph 10, and shall certify to EPA and MDE that:

i. The Model includes the elements required by Paragraph 14.A. and B. to complete the work required by Paragraph 9.C.; and

ii. The Model has been calibrated (including the performance of sensitivity analyses) and verified in accordance with the Project Approach Report using actual system data (e.g., flow data) from permanent and temporary monitoring points in the Collection System.

Baltimore County shall provide its certification and shall describe the results of the Model calibration and verification for each Sewershed in the applicable Quarterly Report.

15. **Collection System Operation and Maintenance.**

A. **General Requirements.** Baltimore County shall develop and implement a comprehensive maintenance program for the Collection System and Collection System components to provide for the proper operation and maintenance of equipment while minimizing failures, malfunctions, line blockages, and SSOs.

B. **Submission of Operation and Maintenance Plan**. Within 120 days of the Effective Date, Baltimore County shall submit for review and comment by EPA and MDE a comprehensive operation and maintenance plan that shall provide for, at a minimum, the following:

i. A gravity line inspection program that provides for

(a) CCTV or other inspection of Gravity Sewer Lines as required by Paragraph 8 of this Consent Decree;

(b) CCTV inspection, consistent with the requirements of Paragraph 8.C., of all Gravity Sewer Lines greater than or equal to 8 inches and less than or equal to 27 inches in diameter that were constructed prior to 1980, to be completed within 15 years of the Effective Date. Baltimore County shall not be required to re-inspect gravity line segments inspected pursuant to the requirements of Paragraph 8.C. solely for the purpose of complying with the requirements of this Paragraph 15.B.i(b). In each Annual Report, Baltimore County shall summarize its progress toward completion of the requirements set forth in Paragraphs 15.B.i(b) and 15.B.v(b) as of the end of the prior calendar year. Following completion of the requirements set forth in Paragraphs 15.B.i(b) and 15.B.v(b), Baltimore County shall certify that all such requirements have been completed and summarize the actions taken by Baltimore County to complete these requirements in the Quarterly Report for the calendar quarter in which the requirements were completed.

(c) Ongoing CCTV or comparable inspection of the Collection System necessary to maintain a current assessment of the condition of the Collection System, including a program goal of inspecting all Gravity Sewer Lines greater than 8 inches in diameter on a regular, scheduled basis that provides for inspection of the entire Collection System every 15 years.

ii. A sewer line cleaning program adequate to address blockages and potential blockages within the Collection System. In addition to addressing ongoing cleaning requirements, the cleaning program shall provide for the cleaning of all Gravity Sewer Lines greater than 8 inches in diameter within 7 years of the Effective Date, and shall provide for the regular, scheduled cleaning of all such lines thereafter at least every 7 years. In each Annual Report, Baltimore County shall summarize its progress toward completion of the initial cleaning requirements set forth in this Paragraph 15.B.ii. as of the end of the prior calendar year. Following completion of the requirement for cleaning all Gravity Sewer Lines greater than 8 inches in diameter within 7 years of the Effective Date, Baltimore County shall certify that such requirement has been completed and summarize the actions taken by Baltimore County to complete the requirement in the Quarterly Report for the calendar quarter in which the requirement was completed.

iii. Routine preventative maintenance of Pump Stations consistent with Paragraph 13.I.;

iv. Routine preventative maintenance of grinder pumps;

v. Inspection of manholes

(a) Inspection of manholes as provided in Paragraph 8.D;

(b) Inspection of manholes located within or immediately adjacent to gravity line segments to be inspected pursuant to Paragraph 15.B.i.b. above;

(c) Routine inspection of manholes that are entered for the purposes of cleaning, inspection, or other routine maintenance activities.

vi. Procedures for ensuring that new sewers and connections are properly designed and constructed (including testing of new sewer installations) to prevent SSOs and to ensure that new connections of inflow sources are prohibited;

vii. Procedures for ensuring that rehabilitation projects are properly designed and constructed (including testing of rehabilitation installations) to prevent SSOs;

viii. A root control program that addresses, at minimum, scheduling and performing corrective measures including both short-term mitigation of root intrusion (i.e., routine maintenance) and rehabilitation of the areas in which root intrusion has caused recurring blockages (i.e., sewer replacement or relining), and a proposal that includes scheduled inspection and cleaning of known problem areas;

ix. Procedures for responding to, investigating, mitigating, correcting, and preventing Building Backups.

x. Procedures for identification of all known locations where Baltimore County does not have ready physical and legal access to the Collection System, the causes for lack of access, and its strategy for obtaining and maintaining access to such location;

xi. Procedures for documenting complaints (including procedures for ensuring that complaints reach the appropriate departments), work orders, updates to equipment inventory, and changes to Collection System components, as well as entry of such data into databases comprising the information management system required under Paragraph 16;

xii. Procedures for corrective maintenance response and reporting;

xiii. Procedures to ensure that staff receive regular training, including wastewater operator certification as required, to avoid potential SSOs relating to operator error; and

xiv. A FOG program consistent with the requirements of Paragraph 11.

C. **Implementation of Operation and Maintenance Program**. Baltimore County shall begin implementation of its operation and maintenance plan within 90 days of submittal to EPA and MDE for comment.

D. **Reporting Requirements**. Baltimore County shall report to EPA and MDE on its performance of the requirements in this Paragraph 15 as specifically set forth in Section VI (Reporting Requirements), Paragraph 20.B.xiii. & ix., of this Consent Decree.

16. **Information Management System Program**.

A. **Utilities Management Application for Collection System**. By agreement of the Parties, Baltimore County shall implement its planned Utilities Management Application to establish, update, and coordinate data systems used to collect information regarding the operation, maintenance and performance of the Collection System, as provided in Baltimore County Contract No. 42235, attached as Appendix G. Baltimore County shall install all hardware and software necessary for the Utilities Management Application and ensure that such hardware and software are operational and that the County has beneficial use of the specified features by no later than September 1, 2005. Baltimore County shall certify completion of these requirements in the applicable Quarterly Report.

B. **Geographic Information System**. As part of its information management system programs above, Baltimore County shall use a computerized geographic information system ("GIS") to map the Collection System.

i. The GIS shall be able to:

(a) Display all Collection System components and Pump Stations;

(b) Use embedded objects (or other alternative, equivalent methods) to link to schematic diagrams and attribute data (including inventory information) for Collection System components;

(c) Display by color coding the portions of the Collection System that have been inspected and rehabilitated; and

(d) Display the location(s) at which samples from flow meters and rain gauges have been collected for development of the model required under Paragraph 14.

ii. Baltimore County shall install all hardware and software necessary for the GIS system and ensure that the system is operational and that the County has beneficial use of the specified features by no later than one year from the Effective Date. Following completion of these requirements, Baltimore County shall certify in the applicable Quarterly Report, and, if requested, demonstrate to EPA and MDE, that the GIS is fully functioning and capable of displaying the information described in Paragraph 16.B.i., above. Baltimore County shall complete the installation of, and transfer of all relevant data to, the GIS System for each Sewershed by no later than the date that the SRRR Plan for such Sewershed is due under Paragraph 10.

C. **Global Positioning System**.

i. Within one hundred and twenty (120) days of the Effective Date of this Consent Decree, Baltimore County shall have global positioning system (GPS) units available to its Utilities Maintenance Division for use to correct and/or update component information on the Collection System maps. Baltimore County shall certify completion of this requirement in the applicable Quarterly Report.

ii. Baltimore County shall use GPS units or other equivalent methods to record the location of sewer maintenance work related to the removal of tree roots and/or grease. Baltimore County shall track and plot this information as part of its root and grease programs required by Paragraph 15.

D. **Inventory of Collection System Components**.

i. Within two (2) years of the Effective Date, the Utilities Management Application shall include an inventory database of the Collection System components. Following completion of this requirement, Baltimore County shall certify in the applicable Quarterly Report, and, if requested, demonstrate to EPA and MDE, that the Utilities Management Application is functioning and capable of displaying the information identified in Paragraph 16.D.ii., below.

ii. By no later than the date that the SRRR Plan for the relevant Sewershed is due pursuant to Paragraph 10, the inventory database shall include, for each component in such Sewershed, a unique identification number and a corresponding data file that stores the following information:

(a) Identification number;

(b) Capacity (e.g., for pipes: diameter, for valves: flow rate);

(c) Date of installation;

(d) Location of installation (address and/or latitude and longitude);

(e) Useful life and scheduled date for repair, replacement, or rehabilitation;

(f) Repair history;

(g) Make and model, if applicable;

(h) Type (e.g., material of construction, configuration of valve, etc.); and

(i) Service status (i.e., whether or not component is in service).

E. **Update Inventory of Collection System Components.** Beginning two years from the Effective Date, Baltimore County shall update, within ninety (90) days of completion of any inspection, condition assessment, or rehabilitation of a Collection System component required pursuant to the terms of this Consent Decree, the Utilities Management Application inventory database such that the updated inventory database includes, for the relevant component, the information described in Paragraph 16.D.ii.

F. **Reporting Requirements**. Baltimore County shall report to EPA and MDE on its performance of the requirements in this Paragraph 16 as specifically set forth in Section VI (Reporting Requirements) of this Consent Decree.

17. **Emergency Response Plan**

A. Baltimore County shall develop and implement an Emergency Response Plan to respond adequately to the occurrence of Discharges from its Collection System and to protect the health and welfare of persons in the event of Discharges.

B. **Specific Requirements**. Within sixty (60) days of the Effective Date of this Consent Decree, Baltimore County shall provide to EPA and MDE, for approval pursuant to Section VIII (Review and Approval Procedures) of this Consent Decree, an Emergency Response Plan that addresses the actions to be taken by Baltimore County in the event of a Discharge. The Emergency Response Plan shall include, but not be limited to, the following:

i. A detailed description of the actions Baltimore County will undertake to provide notice to the public in the event of a Discharge in accordance with Environment Article, Section 9-331.1, Annotated Code of Maryland and regulations promulgated thereunder;

ii. A description of how Baltimore County shall notify MDE and EPA when Discharges occur. Baltimore County shall notify MDE of the occurrence of Discharges in accordance with Environment Article, Section 9-331.1, Annotated Code of Maryland and regulations promulgated thereunder;

iii. A description of how Baltimore County shall coordinate with local health departments regarding the posting of waters where a Discharge has occurred in accordance with the regulations promulgated under the Environment Article, Section 9-331.1, Annotated Code of Maryland;

iv. A detailed plan describing the standard operating procedures to be followed by Baltimore County personnel in responding to a Discharge, including the steps to be taken to minimize the volume of untreated wastewater discharge as a result of a Discharge;

v. A general identification of resources that Baltimore County shall make available to correct or repair conditions causing or contributing to the Discharge. This shall include an organizational chart identifying the operational units responsible for conducting such tasks;

vi. A plan to ensure adequate training of Baltimore County personnel responding to a Discharge.

C. Upon learning of an Discharge, Baltimore County shall perform monitoring, sampling, and analysis in accordance with the regulations promulgated under the Environment Article, Section 9-331.1, Annotated Code of Maryland. Baltimore County shall provide copies of field sample reports and laboratory analysis results to EPA and MDE upon request.

D. Upon approval or approval with conditions by EPA and MDE of Baltimore County's Emergency Response Plan, pursuant to Section VIII (Review and Approval Procedures) of this Consent Decree, Baltimore County shall implement the Plan as approved, and the Emergency Response Plan shall be incorporated into, and shall become enforceable under, this Consent Decree. The Parties agree to meet and confer, as needed, to discuss the development and implementation of Baltimore County's Emergency Response Plan.

E. Baltimore County shall review the Emergency Response Plan on an annual basis and update the Plan as necessary. Each annual update of the Emergency Response Plan shall be submitted to EPA and MDE for approval pursuant to Section VIII (Review and Approval Procedures) of this Consent Decree, and upon EPA and MDE approval shall be incorporated into, and become enforceable under, this Consent Decree. Baltimore County shall maintain a copy of the Emergency Response Plan required by this Paragraph 17 at each of its Tier 1 and Tier 2 Pump Stations.

F. Any dispute with respect to any portion of the Emergency Response Plan required by this Paragraph shall not delay the development or implementation of the undisputed portions of the Emergency Response Plan.

G. **Reporting Requirements**. Baltimore County shall report to EPA and MDE on its implementation of its Emergency Response Plan as specifically set forth in Section VI (Reporting Requirements) of this Consent Decree.

H. **Response to Building Backups**. Consistent with Paragraph 15.B.ix., Baltimore County shall also develop and implement procedures for responding to, investigating, mitigating, and correcting Building Backups.

18. **Reporting of Discharges and Building Backups and Record Keeping**.

A. **General Requirement**. Baltimore County shall report information about Discharges and Building Backups to MDE and EPA and keep appropriate records related to Discharges and Building Backups.

B. **Specific Requirements for Discharges**.

i. Baltimore County shall report to MDE by oral notification any Discharges within twenty-four (24) hours of the time Baltimore County first becomes aware of the Discharge.

ii. A written report shall also be provided to EPA and MDE within five (5) days of the time Baltimore County first became aware of the Discharge. Any written report shall be made to the Water Protection Division, United States Environmental Protection Agency, Region III and to the Compliance Program, Water Management Administration, MDE, and shall contain the information required under Code of Maryland Regulations (COMAR) 26.08.10.04 & .05.

C. **Specific Requirements for Building Backups**. On an annual basis, as part of each Annual Report to be submitted pursuant to this Consent Decree, Baltimore County shall report any known Building Backups. The report should include:

i. the location of the Building Backup;

ii. the cause of the Building Backup, if known;

iii. an estimate of the amount of sewage released into the building; and

iv. the location of sewage disposal (if known).

D. Baltimore County shall maintain for at least five years a list and description of any complaints from customers or others related to reported Building Backups.

E. Until termination of the Consent Decree, Baltimore County shall maintain records of the written reports required by Paragraph 18.B. and C., above, as set forth in Section XVIII (Record Keeping) of this Consent Decree.

VI. REPORTING REQUIREMENTS

19. **Quarterly Reporting**.

A. **Timing**. Beginning with the first full calendar quarter after the Effective Date, and for each calendar quarter thereafter until termination of the Consent Decree, Baltimore County shall submit to EPA and MDE a Quarterly Report containing the information set forth in Paragraph 19.B., below. The Quarterly Report shall be postmarked and sent by the 45th day after the end of the calendar quarter (which shall be May 15, August 14, November 14, or February 14, respectively, or the next business day consistent with the definition of "day" in Section IV of this Consent Decree). In lieu of submitting a separate Quarterly Report for any fourth calendar quarter, Baltimore County may submit a combined Quarterly and Annual Report, provided that the combined Report is submitted no later than the due date for the relevant Quarterly Report and includes all information required to be included in the Quarterly Report pursuant to this Paragraph 19 and all information required to be included in the Annual Report pursuant to Paragraph 20, below.

B. **Contents**. The Quarterly Report shall include the information set forth below regarding activities performed in the prior calendar quarter (or, in the case of the first Quarterly Report, activities performed since the Effective Date):

i. **SSO Structures**.

(a) Report the information required by Paragraph 7.C.ii.(a) & (b) with respect to any discharges from SSO Structures during the previous quarter;

(b) Identify any SSO Structure where a flow meter has been installed pursuant to Paragraph 7.C.i(b)(1) during the previous quarter and when such meter was installed; and

(c) Report mitigation measures undertaken pursuant to Paragraph 7.C.iii(b) with respect to any discharges from SSO Structures during the previous quarter.

ii. **Construction Projects**. Summarize the status of each of the projects identified on Appendices B and C, including whether Baltimore County anticipates completing the projects by the applicable deadlines.

iii. **Collection System Inspection**.

(a) Summarize Baltimore County's progress in completing the inspection requirements of Paragraph 8.C.i., including the total miles of gravity line and number of manholes and other appurtenances to be inspected, the miles of gravity line and number of manholes and other appurtenances inspected in the preceding quarter, and the miles of gravity line and number of manholes and other appurtenances remaining to be inspected, and report whether Baltimore County anticipates completing the required inspections by the applicable deadline;

(b) For each Sewershed, summarize Baltimore County's progress in completing the inspection requirements of Paragraphs 8.C.ii., 8.C.iii., 8.C.iv., and 8.D., including the total miles of gravity line and number of Force Mains, manholes and other appurtenances to be inspected, the miles of gravity line and number of manholes and other appurtenances inspected in the preceding quarter, and the miles of gravity line and number of manholes and other appurtenances remaining to be inspected, and report whether Baltimore County anticipates completing the required inspections by the applicable deadline; and

(c) Summarize Baltimore County's compliance during the previous quarter with the requirements in Paragraph 8.C.v. (CCTV Inspection Following SSOs), including the date of the SSO, the date of inspection of the corresponding Gravity Line Segment, the number of and location of Gravity Line Segments that were not inspected with CCTV within 10 working days following an SSO, and an explanation of any applicable exemptions asserted by Baltimore County.

iv. **SRRR Plan Implementation**. For each Sewershed, summarize Baltimore County's progress in implementing its approved SRRR Plan pursuant to Paragraph 10.D., and report whether Baltimore County anticipates completing implementation by the applicable deadline.

v. **FOG Program Modification**. Summarize Baltimore County's progress in implementing its approved FOG Program Modification Plan pursuant to Paragraph 11.H., and report whether Baltimore County anticipates completing implementation of the required modifications by the applicable deadline.

vi. **Supplemental Environmental Projects**. Summarize Baltimore County's efforts and progress in completing the SEP requirements pursuant to Section X, including the total expenditures for each SEP through the reporting period, any delays or problems encountered and the steps taken to resolve and prevent such delays and problems from continuing, and report whether Baltimore County anticipates completing its obligations with respect to each SEP by the applicable deadline.

vii. **Compliance Issues**.

(a) If Baltimore County completes a project or requirement during the previous quarter that is subject to a requirement that Baltimore County certify completion, Baltimore County shall be deemed to have certified completion of any such project or requirement by specifically identifying the project or requirement in the Quarterly Report and stating the date on which the project or requirement was completed.

(b) If a requirement due to be completed during the reporting period was not completed, Baltimore County shall provide an explanation for why the requirement was not completed, what steps are being taken to ensure prompt completion, and when Baltimore County anticipates completing the requirement.

(c) If Baltimore County becomes aware of any problems that may prevent it from meeting future compliance deadlines under any provision of this Consent Decree, Baltimore County should notify EPA and MDE of those anticipated problems in the next Quarterly Report, including an explanation of the problem, what steps are being taken to minimize delay, and when Baltimore County anticipates completing the requirement.

20. **Annual Reporting**.

A. **Timing**. By April 1 of the calendar year following the calendar year of the Effective Date, and on April 1 of each calendar year thereafter until termination of this Consent Decree, Baltimore County shall submit an Annual Report. The Annual Report shall cover the activities identified in Paragraph 20.B., below, that were performed in the preceding calendar year through December 31.

B. **Contents**. The Annual Report shall address the following subject areas as follows:

i. **SSO Structures**.

(a) Summarize Baltimore County's progress in implementing its approved Non-Pump Station SSO Structures Elimination Plan pursuant to Paragraph 7.C.iv., and report whether Baltimore County anticipates completing implementation by the applicable deadline;

(b) Summarize the results of any post-elimination monitoring conducted by Baltimore County pursuant to Paragraph 7.C.v. following elimination of any Non-Pump Station SSO Structure.

(c) Summarize Baltimore County's progress in implementing any plans required pursuant to Paragraph 7.C.vi. in response to certain discharges from Pump Station SSO Structures.

ii. **Rainfall and Flow Monitoring Plan**.

(a) Summarize the results of the annual evaluation required by Paragraph 9.B.vi. of the number and placement of flow monitors and rain gauges;

(b) Report whether and how the location of rain gauges and flow monitors have changed during the prior year and provide a revised location map as required by Paragraph 9.B.vi.

(c) Report and briefly explain any deviations during the prior year from the requirements in Paragraphs 9.B.i.-iv. or from Baltimore County's approved Rainfall and Flow Monitoring Plan submitted pursuant to Paragraph 9.B.v.

iii. **Evaluation of Rainfall and Flow Monitoring Data**.

(a) For each Sewershed, summarize Baltimore County's progress in completing the Inflow/Infiltration Evaluation required by Paragraph 9.C.i., and report whether Baltimore County anticipates completing implementation by the applicable deadline.

(b) For each Sewershed, summarize Baltimore County's progress in completing the Long-Term Capacity/Peak Flow Management Evaluation required by Paragraph 9.C.ii., and report whether Baltimore County anticipates completing implementation by the applicable deadline.

iv. **FOG Program**.

(a) Provide the results of the annual evaluation required by Paragraph 11.I. of the effectiveness of the modified FOG Program.

(b) Provide an updated database and map of Grease Generating Facilities as required by Paragraph 11.D.iii.

v. **Illegal Storm Water Discharges**. Identify any Illegal Storm Water Discharges to the Collection System that occurred during the reporting period and summarize the actions taken by Baltimore County in response to each such discharge, including Baltimore County's specific actions taken in compliance with Paragraph 12.

vi. **Pump Stations**.

(a) Report the results of the annual evaluation required by Paragraph 13.C.ii. of the effectiveness of Baltimore County's backup power program.

(b) Summarize Baltimore County's progress in implementing any plan required by Paragraph 13.C.iii. to address SSOs related to power outages at Pump Stations.

(c) For each Pump Station, list any deficiencies identified during the reporting period through the inspections required pursuant to Paragraph 13.E.ii. and assigned Priority Classification 2, 3, or 4 from Appendix F, and identify the date of the inspection in which that deficiency was first observed, the date on which the deficiency was corrected or is expected to be corrected, the nature of the correction, and, if the deficiency was not corrected within six months, an explanation of the reasons for the delay in correction.

(d) For each Pump Station, list any deficiencies identified during the reporting period through the Engineering Evaluations/Condition Assessments required pursuant to Paragraph 13.F. and assigned Priority Classification 1 or 2 pursuant to Paragraph 13.F.iv., and identify the date the deficiency was first identified, the date on which the deficiency was corrected or is expected to be corrected, the nature of the correction, and, if the deficiency was not corrected within two years, an explanation of the reasons for the delay in correction.

(e) Summarize Baltimore County's progress in completing the implementation of the Pump Station Information Management System as required by Paragraph 13.H., and report whether Baltimore County anticipates completing implementation by the applicable deadline.

vii. **Collection and Transmission System Model**. Summarize Baltimore County's progress in completing implementation of the Collection and Transmission System Model in each Sewershed as required by Paragraph 14.E., and report whether Baltimore County anticipates completing implementation by the applicable deadline.

viii. **Supplemental Collection System Inspection**. Summarize Baltimore County's progress in completing the inspection requirements of Paragraphs 15.B.i(b) and 15.B.v., including the total miles of gravity line and number of manholes and other appurtenances to be inspected, the miles of gravity line and number of manholes and other appurtenances inspected in the preceding year, and the miles of gravity line and number of manholes and other appurtenances remaining to be inspected, and report whether Baltimore County anticipates completing the required inspections by the applicable deadline.

ix. **Cleaning of Gravity Line Segments**. Summarize Baltimore County's progress in completing the requirement in Paragraph 15.B.ii. for cleaning of all Gravity Sewer Lines greater than 8 inches in diameter within 7 years of the Effective Date, including the total miles of gravity line to be cleaned pursuant to this requirement, the miles of gravity line cleaned during the reporting period, and miles of gravity line remaining to be cleaned to meet this requirement, and report whether Baltimore County anticipates completing the required cleaning by the applicable deadline.

x. **Collection System Inventory**. Summarize Baltimore County's progress in completing the implementation of the inventory database of Collection System components as required by Paragraph 16.D., and report whether Baltimore County anticipates completing implementation by the applicable deadline.

xi. **Emergency Response**. Report and briefly explain any deviations during the reporting period from Baltimore County's approved Emergency Response Plan submitted pursuant to Paragraph 17.

xii. **Reporting of Building Backups Consistent with Paragraph 18.C.**. Baltimore County shall report any known Building Backups, including for each such Building Backup:

(a) the location of the Building Backup;

(b) the cause of the Building Backup, if known;

(c) an estimate of the amount of sewage released into the building; and

(d) the location of sewage disposal, if known.

21. General Provisions.

A. All Quarterly and Annual Reports shall be submitted to the persons designated in Section XIX (Form of Notice) of this Consent Decree. Baltimore County shall provide at least one original executed copy of each Report to EPA (Sharon Fang, Water Protection Division, USEPA Region III) and to MDE (Chief, Enforcement Division, Compliance Program, Water Management Administration, MDE). All other copies may be provided electronically.

B. The Quarterly and Annual Reports shall be certified, consistent with the requirements of 40 C.F.R. § 122.22(a)(3), by the person responsible for compliance or by a person responsible for overseeing implementation of this Consent Decree, as follows:

> I certify under penalty of law that this information was prepared under my direction or supervision in accordance with a system designed to assure that qualified personnel properly gather and evaluate the information submitted. Based on my directions and my inquiry of the person(s) who manage the system, or the person(s) directly responsible for gathering the information, the information submitted is, to the best of my knowledge and belief, true, accurate, and complete.

C. Baltimore County shall not object to the authenticity of any certified Quarterly or Annual Report in any proceeding to enforce this Consent Decree.

VII. RIGHT OF ENTRY

22. A. EPA and MDE, together with their authorized representatives and contractors, shall each have authority at all reasonable times, upon the presentation of credentials, to enter the premises of Baltimore County to:

i. Monitor the progress of activities required by this Consent Decree;

ii. Verify any data or information submitted to the United States and Maryland;

iii. Obtain samples;

iv. Observe performance tests;

v. Inspect and evaluate any portion of the Collection System; and

vi. Review and copy any record required to be kept under the terms and conditions of this Consent Decree.

B. Upon request, Baltimore County shall provide EPA or MDE or their authorized representatives splits of any samples collected by Baltimore County or its consultants and contractors. Upon request, EPA or MDE shall provide Baltimore County splits of any samples collected by EPA or MDE.

C. These inspection rights are in addition to, and in no way limit or otherwise affect, EPA's and MDE's statutory authorities to conduct inspections, to require monitoring and to obtain information from Baltimore County as authorized by law.

VIII. <u>REVIEW AND APPROVAL PROCEDURES</u>

23. A. After receipt and review of any plan, program or other document which is required to be submitted for approval pursuant to this Consent Decree, EPA and MDE may (1) approve the submission; (2) approve the submission or portions of the submission upon specified conditions; (3) approve part of the submission and disapprove the remainder; or (4) disapprove the submission and direct Baltimore County to modify the submission.

B. In the event of approval of the complete submission, Baltimore County shall proceed to take any actions required by the plan, program or other approved document, as approved in writing by EPA and MDE.

C. In the event of written approval of portions of the submission or approval upon specified conditions, Baltimore County shall proceed to take the actions identified in the non-deficient portion of the plan, program, other document, or portion thereof, in accordance with any applicable conditions specified by EPA and MDE, subject only to Baltimore County's right to invoke the Dispute Resolution procedures set forth in Section XIII of this Consent Decree with respect to the conditions imposed or the disapproved portions. Implementation of any non-deficient portion of the submission shall not eliminate the potential of Baltimore County to incur stipulated penalties pursuant to Section XI.

24. Upon receipt of a notice of disapproval of all or part of a submission from EPA and MDE, Baltimore County shall, within 30 days, correct the deficiencies as directed by EPA's and MDE's written comments and resubmit the plan, program or other document for approval. Any stipulated penalties applicable to the original submission, as provided in Section XI of this Consent Decree, shall accrue during the 30-day period, but shall not be payable unless the resubmission is untimely or is disapproved in whole or in part.

25. In the event that a resubmitted plan, program or other document, or portion thereof, is disapproved by EPA and MDE, EPA and MDE may again require Baltimore County to correct the deficiencies in accord with Paragraph 24, subject to Baltimore County's right to invoke the Dispute Resolution Procedures set forth in Section XIII of this Consent Decree and the right of EPA and MDE to seek stipulated penalties as provided in this Section VIII.

IX. CIVIL PENALTY

26. Baltimore County shall pay a total civil penalty in the amount of $750,000.00 to the United States and the State of Maryland for violations as alleged by the United States and the State of Maryland in the Complaint. Baltimore County shall pay fifty percent (50%) of the civil penalty to the United States within thirty (30) days of the Effective Date of this Consent Decree in accordance with the procedures described in Paragraph 28, below. Baltimore County shall pay fifty percent (50%) of the civil penalty to the State of Maryland within thirty (30) days of the Effective Date in accordance with the procedures described in Paragraph 29, below.

27. The United States and the State of Maryland shall be deemed judgment creditors for purposes of collection of this penalty.

28. Payment of the civil penalty to the United States shall be made by Electronic Funds Transfer ("EFT") to the U.S. Department of Justice ("DOJ") lockbox bank, referencing DOJ No. 90-5-1-1-4402/2 and USAO File Number 2002V00703. Payment shall be made in accordance with instructions provided by the United States to Baltimore County following execution of this Consent Decree. Any EFT received at the DOJ lockbox bank after 11:00 A.M. Eastern Time will be credited on the next business day. Notice of the EFT shall simultaneously be mailed to the following:

Docket Clerk (3RC00)
U.S. EPA - Region III
1650 Arch Street
Philadelphia, PA 19103-2029;

Deane Bartlett (3RC20)
U.S. EPA - Region III
1650 Arch Street
Philadelphia, PA 19103-2029; and

Chief, Environmental Enforcement Section
Environment and Natural Resources Division
U.S. Department of Justice
P.O. Box 7611
Washington, D.C. 20044-7611
Re: DOJ No. 90-5-1-1-4402/2.

The transmittal letter forwarding such notice shall include the caption, civil action number and judicial district of this action.

29. Payment to the State of Maryland shall be made by tendering to the Maryland Department of the Environment, P.O. Box 2057, Baltimore County, MD 21203-2057, check made payable to: “Maryland Clean Water Fund.”

30. If Baltimore County fails to tender all or any portion of the civil penalty payment owed to the United States within thirty (30) days of the Effective Date, interest on the unpaid amount shall accrue in accordance with the provisions of 28 U.S.C. § 1961 and be paid from the date said payment is

due until all amounts owed are paid.

X. SUPPLEMENTAL ENVIRONMENTAL PROJECTS

31. Baltimore County shall perform the following supplemental environmental projects ("SEPs"), which the Parties agree are intended to secure significant environmental protection and improvements that are not otherwise required by law. As described below, Baltimore County shall expend at least $4,500,000 to complete the SEPs in accordance with the provisions of this Section X of the Consent Decree and Appendices I, J, and K, which are attached hereto and incorporated by reference into and enforceable under this Consent Decree.

A. **Patapsco BNR/ENR Design Project.** Baltimore County shall participate as appropriate in, and contribute funding in an amount up to $3,000,000, for the design of the Biological Nutrient Removal/Enhanced Nutrient Removal project at the Patapsco Wastewater Treatment Plant in Baltimore City ("Patapsco BNR/ENR Design Project"), as described more fully in Appendix I. Baltimore County shall complete the SEP in accordance with the procedures and schedule identified in Appendix I.

B. **Back River Debris Removal Project**.

i. Baltimore County shall design, install, and operate a trash collection system in Moore's Run (a tributary to Back River) near the Red House Run Pump Station to remove floating debris for landfill disposal, as described more fully in Appendix J. This SEP shall be completed within five (5) years of the Effective Date. Baltimore County's expenditures for design and implementation of this SEP shall not be less than, but may exceed, $200,000 in Eligible SEP Costs.

ii. Within 180 days after the Effective Date, Baltimore County shall submit a Statement of Work ("SOW") for this SEP to EPA and MDE, for review and approval pursuant to Section VIII (Review and Approval Procedures) of the Consent Decree, that includes a plan for implementation of the SEP, a schedule for implementation of the SEP including interim milestones, cost estimates for the various phases of the project, and a certification of the truth and accuracy of the statements in Paragraph 33 below. Upon approval by EPA and MDE of the SOW, the SOW shall be incorporated by reference into and enforceable under this Consent Decree.

C. **Stream Restoration Projects.**

i. Baltimore County shall design and implement the following stream restoration SEPs, as described more fully in Appendix K.

Gwynns Falls at Gwynnbrook Avenue

Paradise Avenue (tributary to West Branch of Herbert's Run)

Minebank Run Tributary at Waller Court

Herring Run at Collinsdale.

Construction of these SEPs shall be completed within five (5) years of the Effective Date.

ii. Baltimore County's expenditures for the SEPs identified in Paragraph 31.C.i. shall not be less than, but may exceed, $1,300,000 in Eligible SEP Costs. For purposes of the SEPs identified in Paragraph 31.C.i. and Appendix K, Eligible SEP Costs shall also include costs expended by Baltimore County for inspection, right-of-way acquisition, and monitoring. At the time that Baltimore County submits its SEP Completion Report(s) for the SEPs identified in Paragraph 31.C.i. and Appendix K, Baltimore County shall certify, consistent with the language set forth in Paragraph 21.B., that the Eligible SEP Costs identified by Baltimore County do not include costs that Baltimore County would have otherwise expended to preserve any aspect of its Collection System or other infrastructure from stream impacts in the affected areas.

iii. Within 180 days after the Effective Date, Baltimore County shall submit a Statement of Work ("SOW") for each of the SEPs identified in Paragraph 31.C.i. to EPA and MDE, for review and approval pursuant to Section VIII (Review and Approval Procedures) of the Consent Decree, that includes a plan for implementation of the SEP, a schedule for implementation of the SEP including interim milestones, cost estimates for the various phases of the project, and a certification of the truth and accuracy of the statements in Paragraph 33 below. Upon approval by EPA and MDE of the SOWs, each SOW shall be incorporated by reference into and enforceable under this Consent Decree.

D. In the event that Baltimore County has not expended $4,500,000 in Eligible SEP Costs, as required by Paragraph 31, within five years plus 180 days of the Effective Date, Baltimore County shall propose a substitute project or projects requiring expenditures of Eligible SEP Costs in an amount equal to or greater than the difference between $4,500,000 and the amount of Eligible SEP Costs actually paid by Baltimore County pursuant to this Paragraph 31. All proposed substitute projects are subject to the approval of EPA and MDE and must be consistent with EPA guidance regarding SEPs. In the event that EPA and MDE approve a substitute project or projects, Baltimore County shall, within 90 days of such approval, submit a Statement of Work ("SOW") for the SEP(s) to EPA and MDE, for review and approval pursuant to Section VIII (Review and Approval Procedures) of the Consent Decree, that includes a plan for implementation of the SEP(s), a schedule for implementation of the SEP(s) including interim milestones, cost estimates for the various phases of the project(s), and a certification of the truth and accuracy of the statements in Paragraph 33 below. Upon approval by EPA and MDE of the SOW(s), the SOW(s) shall be incorporated by reference into and enforceable under this Consent Decree. Disputes regarding EPA's and MDE's determination to approve or disapprove a substitute project or projects shall not be subject to Section XIII (Dispute Resolution) of this Consent Decree.

32. Baltimore County is responsible for the satisfactory completion of each SEP in accordance with the requirements of the Consent Decree. "Satisfactory completion" means that Baltimore County shall complete the project requirements in accord with all specifications in the relevant Appendices and in the approved SOWs. Baltimore County shall also ensure that it spends not less than the total SEP amount set forth in Paragraph 31, and the specific SEP amounts set forth in

Paragraph 31.B.i. (for the Back River Debris Removal Project), and in Paragraph 31.C.ii. (for the Stream Restoration Projects). Baltimore County recognizes and agrees that no part of Baltimore County's expenditures for these SEPs shall include or be reimbursed by federal or state funds, including federal or state low interest loans, contracts, or grants, or be specifically reimbursed by Howard County or Anne Arundel County. Baltimore County may use contractors and/or consultants in planning and implementing the SEPs.

33. With regard to the SEP, Baltimore County certifies the truth and accuracy of each of the following:

A. That all cost information provided to EPA and MDE in connection with EPA's and MDE's approval of the SEPs is complete and accurate and represents a fair estimate of the costs necessary to implement the SEPs;

B. That, as of the Date of Lodging of this Decree, Baltimore County is not required to perform or develop the SEPs by any federal, state, or local law or regulation, or as injunctive relief awarded in any other action in any forum, except that the Parties recognize that Baltimore County's payment of funds for the Patapsco BNR/ENR Design Project identified in Paragraph 31.A. will be undertaken consistent with the current Sewerage Agreement between Baltimore County and Baltimore City providing for the contribution by Baltimore County of a percentage of certain expenses relating to operation of Baltimore City's sewer system;

C. That Baltimore County has not received, and is not negotiating to receive, credit for the SEPs in any other enforcement action; and

D. That Baltimore County will not receive any reimbursement for any portion of the SEPs from any other person.

34. **SEP Completion Report.**

A. Within 30 days after the date set for completion of each SEP, Baltimore County shall submit a SEP Completion Report to EPA and MDE. The SEP Completion Report shall contain the following information regarding the relevant SEP:

i. A detailed description of the SEP as implemented;

ii. A description of any problems encountered in completing the SEP and the solutions thereto;

iii. An itemized list of all Eligible SEP Costs;

iv. Certification that the SEP has been fully implemented pursuant to the provisions of this Decree; and

v. A description of the environmental and public health benefits resulting from implementation of the SEP (with a quantification of the benefits and pollutant reductions, if feasible).

B. EPA and MDE may, in their sole discretion, require information in addition to that described in Paragraph 34.A., in order to determine the adequacy of SEP completion or eligibility of SEP costs.

C. After receiving the SEP Completion Report, EPA and MDE shall notify Baltimore County whether or not Baltimore County has satisfactorily completed the SEP. If the SEP has not been satisfactorily completed in accordance with all schedules, or if the total amount expended on performance of all SEPs is less than the amount set forth in Paragraph 31, or if the amount expended on the Back River Debris Removal Project is less than amount set forth in Paragraph 31.B.i., or if the amount expended on the Stream Restoration Projects is less than the amount set forth in Paragraph 31.C.ii., stipulated penalties may be assessed under Section XI (Stipulated Penalties) of this Consent Decree.

D. Disputes concerning the satisfactory completion of the SEPs and the amount of Eligible SEP Costs shall be resolved under Section XIII (Dispute Resolution) of this Decree.

35. Each submission required under this Section shall be signed by an official with knowledge of the SEP and shall bear the certification language set forth in Paragraph 21.B., above.

36. Any public statement, oral or written, in print, film, or other media, made by Baltimore County making reference to any SEP under this Decree shall include the following language:

> This project was undertaken in connection with the settlement of an enforcement action, United States and the State of Maryland v. Baltimore County, Maryland (D. Md.), taken on behalf of the U.S. Environmental Protection Agency under the Clean Water Act and by the State of Maryland under the Maryland Environment Article.

37. **Reporting Requirements**. Baltimore County shall report to EPA and MDE on its performance of the SEPs as specifically set forth in Section VI (Reporting Requirements) of this Consent Decree.

XI. STIPULATED PENALTIES

38. Baltimore County shall be liable to the United States and the State of Maryland for stipulated penalties for the following violations of this Consent Decree as specified below. Baltimore County shall not be liable for any stipulated penalties under this Consent Decree except as set forth in this Section XI.

A. **Designated Rehabilitation and Replacement Projects**. For each day that Baltimore County fails to achieve Substantial Completion of any project identified in Paragraph 7.D. and Appendix B, or in Paragraph 13.B. and Appendix C, in accordance with the applicable schedules set forth in those Paragraphs and Appendices, Baltimore County shall be liable for stipulated penalties as set forth below:

Period of Non-Compliance	Penalty per Day for Failure to Timely Complete
1st to 30th Day	$1,000
31st to 60th Day	$2,500
After 60 Days	$6,000

B. **Delays in Submission of Deliverables**. Baltimore County shall be liable for stipulated penalties for each failure to timely submit to the United States and the State of Maryland a Deliverable, including any required revision, update, or supplement to a Deliverable, subject to a deadline under Section V (Remedial Measures) or Section VI (Review and Approval Procedures) of this Consent Decree as set forth below:

Period of Non-Compliance	Penalty per Day for Failure to Timely Submit
1st to 30th Day	$1,000
31st to 60th Day	$1,500
After 60 Days	$2,250

In the event that Baltimore County is potentially liable for stipulated penalties under this Paragraph 38.B. and under another provision of this Paragraph 38 for failure to timely submit the same Deliverable, EPA and/or MDE, in their sole discretion, may demand payment of stipulated penalties from Baltimore County pursuant to either, but not both, of the applicable provisions.

C. **SSO Structures**.

i. For each day that Baltimore County fails to timely submit the Non-Pump Station SSO Structures Elimination Plan as required by Paragraph 7.C.iii., a supplemental Elimination Plan as required by Paragraph 7.C.vii., or a proposed plan and schedule regarding Pump Station SSO Structures as required by Paragraph 7.C.vi., Baltimore County shall be liable for stipulated penalties as set forth below:

Period of Non-Compliance	Penalty per Day for Failure to Timely Submit
1st to 30th Day	$1,000
31st to 60th Day	$2,500
After 60 Days	$6,000

ii. For each day that Baltimore County fails to timely complete elimination of a Non-Pump Station SSO Structure pursuant to the schedule set forth in the Non-Pump Station SSO Structures Elimination Plan required by Paragraph 7.C.iii., or a supplemental Elimination Plan as required by Paragraph 7.C.vii., Baltimore County shall be liable for stipulated penalties as set forth below:

Period of Non-Compliance	Penalty per Day per SSO Structure for Failure to Timely Complete
1st to 30th Day	$1,000
31st to 60th Day	$2,500
After 60 Days	$6,000

iii. For each failure to monitor an SSO Structure as required by Paragraph 7.C.i., including each failure to install and operate a continuous flow monitor as required, Baltimore County shall be liable for stipulated penalties as set forth below:

Period of Non-Compliance	Penalty per Day for Failure to Monitor
1st to 30th Day	$1,000
31st to 60th Day	$2,000
After 60 Days	$3,000

D. **Collection System Inspection**.

i. If Baltimore County fails to complete CCTV inspection of all required Gravity Line Segments or inspection of other components in a sewer sub-basin as required by Baltimore County's approved Collection System Inspection Plan and schedule, Baltimore County shall be liable for stipulated penalties of $250 per day for each mile of pipe not inspected and $50 per day for each manhole or other appurtenance or Force Main not inspected.

ii. For each failure to timely inspect with CCTV a Gravity Line Segment following an SSO as required by Paragraph 8.C.v., Baltimore County shall be liable for stipulated penalties as set forth below:

Period of Non-Compliance	Penalty per Day for Failure to Timely Complete
1st to 30th Day	$200
31st to 60th Day	$500
After 60 Days	$1,000

E. **Rainfall and Flow Monitoring**.

i. For each failure to comply with the requirements of its Rainfall and Flow Monitoring Plan, Baltimore County shall be liable for stipulated penalties as set forth below:

Period of Non-Compliance	Penalty per Day for Failure to Comply
1st to 30th Day	$250
31st to 60th Day	$500
After 60 Days	$1,000

ii. For each failure to comply with any requirements set forth in Paragraph 9.B.i. & ii., or the post-construction monitoring requirements set forth in Paragraphs 7.C.v. and 7.D.iii., Baltimore County shall be liable for stipulated penalties in the amount of $250.

iii. For each day that Baltimore County fails to timely complete and certify completion of an Inflow/Infiltration Evaluation or a Long-Term Capacity/Peak Flow Management Evaluation for a Sewershed as required by Paragraph 9.C., Baltimore County shall be liable for stipulated penalties as set forth below:

Period of Non-Compliance	Penalty per Day for Failure to Timely Complete
1st to 30th Day	$1,000
31st to 60th Day	$1,500
After 60 Days	$2,250

F. **SRRR Plans**. For each day that Baltimore County fails to timely complete construction and implementation of a project to be performed pursuant to an approved SRRR Plan and schedule, Baltimore County shall be liable for stipulated penalties as set forth below:

Period of Non-Compliance	Penalty per Day for Failure to Timely Complete
1st to 30th Day	$1,500
31st to 60th Day	$3,000
After 60 Days	$6,000

G. **FOG Program**.

i. For each failure to timely inspect a Grease Generating Facility as required by Paragraph 11.E.ii. or to timely provide written notice to a Grease Generating Establishment as required by Paragraph 11.F., Baltimore County shall be liable for stipulated penalties of $250 per Grease Generating Facility not timely inspected or notified. Baltimore County shall not be liable for stipulated penalties under this Paragraph in the event that it demonstrates that it sought to timely inspect, but was denied access to, a Grease Generating Facility owned or operated by the United States or the State of Maryland.

ii. For each day that Baltimore County fails to timely complete implementation of its approved FOG Program Modification Plan consistent with Paragraph 11.H., Baltimore County shall be liable for stipulated penalties as set forth below:

Period of Non-Compliance	Penalty per Day for Failure to Timely Complete
1st to 30th Day	$1,000
31st to 60th Day	$2,500
After 60 Days	$5,000

H. **Illegal Storm Water Discharges**. For each failure to comply with the requirements of Paragraph 12.B.i. regarding the elimination of Illegal Storm Water Discharges that are likely to cause or contribute to an SSO, Baltimore County shall be liable for stipulated penalties as set forth below:

Period of Non-Compliance	Penalty per Day for Failure to Comply
1st to 30th Day	$250
31st to 60th Day	$500
After 60 Days	$1,000

I. **Pump Stations**.

i. For each day that Baltimore County fails to timely complete implementation of an approved plan submitted pursuant to Paragraph 13.C.iii. regarding an SSO due to loss of power, Baltimore County shall be liable for stipulated penalties as set forth below:

Period of Non-Compliance	Penalty per Day for Failure to Timely Complete
1st to 30th Day	$1,000
31st to 60th Day	$1,500
After 60 Days	$2,250

ii. For each failure to timely correct a Pump Station deficiency as required by Paragraph 13.E.iii. or Paragraph 13.F.iv(a), Baltimore County shall be liable for stipulated penalties as set forth below:

Period of Non-Compliance	Penalty per Day for Failure to Timely Complete
1st to 30th Day	$1,000
31st to 60th Day	$1,500
After 60 Days	$2,250

J. **Operation and Maintenance Inspection and Cleaning Requirements**.

i. If Baltimore County fails to timely complete CCTV inspection of all Gravity Sewer Lines as required by Paragraph 15.B.i(b) or inspection of all manholes as required by

Paragraph 15.B.v(b), Baltimore County shall be liable for stipulated penalties of $250 per day for each mile of pipe not inspected and $50 per day for each manhole or other appurtenance not inspected.

ii. If Baltimore County fails to timely complete cleaning of all Gravity Sewer Lines greater than 8 inches in diameter within 7 years of the Effective Date as required by Paragraph 15.B.ii., Baltimore County shall be liable for stipulated penalties of $250 per day for each mile of pipe not cleaned.

K. **Emergency Response Plan**. For each failure to comply with the requirements of its approved Emergency Response Plan submitted pursuant to Paragraph 17, Baltimore County shall be liable for stipulated penalties in the amount of $1,000.

L. **Reporting of Discharges**. For each failure to provide oral or written notification of a Discharge as required by Paragraph 18.B., Baltimore County shall be liable for stipulated penalties of $2000.

M. **Quarterly and Annual Reporting**. For each failure to timely submit a complete Quarterly Report or Annual Report as required by Paragraphs 19 or 20, Baltimore County shall be liable for stipulated penalties as set forth below:

Period of Non-Compliance	Penalty per Day for Failure to Timely Submit
1st to 60th Day	$750
After 60 Days	$2,000

N. **Certifications**. For each failure to timely submit a certification required under Paragraphs 7.C.iv., 7.D., 8.C.i(c), 8.C.ii, 8.C.iii., 8.D.ii(b)(2), 9.C.i., 9.C.ii(f), 10.D, 11.E.iv., 11.F.iii., 11.H., 13.B., 13.C.iii., 13.D., 13.F.iv(a), 13.G.i., 13.G.ii, 13.H., 14.E., 15.B.i(b), 15.B.ii, 16.A., 16.B.ii., 16.C.i., or 16.Di.. of this Consent Decree, Baltimore County shall be liable for stipulated penalties as set forth below:

Period of Non-Compliance	Penalty per Day for Failure to Timely Submit
1st to 60th Day	$750
After 60 Days	$2,000

In the event that Baltimore County is potentially liable for penalties under any provision of Paragraph 38 for failure to timely perform a requirement of the Consent Decree and is also potentially liable for penalties under this Paragraph 38.N. for failure to timely certify performance of that same requirement, EPA and/or MDE, in their sole discretion, may demand payment of stipulated penalties from Baltimore County pursuant to either, but not both, of the applicable provisions.

O. **Civil Penalty**. For each day that Baltimore County fails to timely pay the civil penalty required under Section IX in accord with the schedule therein, Baltimore County shall be liable for stipulated penalties in the amount of $1000.

P. **Supplemental Environmental Projects**. In the event that Baltimore County fails to perform or complete a SEP in accordance with the terms of Section X (Supplemental Environmental Projects) of this Consent Decree, Appendices I, J, and K, as applicable, and any approved SOW, and/or to the extent that Baltimore County's expenditures of Eligible SEP Costs for the SEP do not equal or exceed the required cost for the relevant SEP(s) as set forth in Paragraph 31, Baltimore County shall be liable for stipulated penalties according to the provisions set forth below:

i. Except as set forth in Paragraph 38.P.ii. below, if Baltimore County fails to satisfactorily complete a SEP identified in Paragraph 31.B. or 31.C. above, Baltimore County shall be liable for a stipulated penalty in the amount of the difference between the amount required to be spent for the SEP pursuant to Paragraph 31 and the Eligible SEP Costs actually expended by the County on the SEP, plus an additional stipulated penalty in the amount of 15% of the estimated cost of the SEP as set forth in Paragraph 31 and/or the applicable SOW.

ii. If Baltimore County fails to satisfactorily complete a SEP, but EPA and

MDE determine that Baltimore County has made good faith efforts to complete the SEP, Baltimore County shall be liable for a stipulated penalty in the amount of the difference between the amount required to be spent for the SEP pursuant to Paragraph 31 and the Eligible SEP Costs actually expended by the County on the SEP.

iii. If Baltimore County satisfactorily completes all SEPs, but fails to expend the total amount required under Paragraph 31, or the specific amounts required under Paragraphs 31.B.i. or 31.C.ii., Baltimore County shall be liable for a stipulated penalty in the amount of the difference between the amount required to be spent for the SEPs pursuant to Paragraph 31 and the Eligible SEP Costs actually expended by the County on the SEPs.

iv. For each day Baltimore County fails to timely complete a SEP, Baltimore County shall be liable for stipulated penalties as follows:

Period of Non-Compliance	Penalty per Day for Failure to Comply
1st to 30th Day	$150
31st to 60th Day	$300
After 60 Days	$600

The penalties under this subparagraph shall accrue until such time as Baltimore County notifies EPA and MDE that it no longer intends to complete the relevant SEP, at which time the stipulated penalties set forth in Paragraphs 38.P.i. or ii. immediately above shall apply.

v. **SEP Deliverables.** For failure to submit a SEP Completion Report as required by Paragraph 34, or to submit a SEP SOW as required by Paragraph 31, Baltimore County shall be liable for stipulated penalties in the amount of $500 for each day after the submission was originally due until the document is submitted.

39. **Discharges**.

A. For the first three years following the Effective Date of this Consent Decree, and as a result of the need to make numerous system, operational and procedural changes to implement the remedial measures required by this Consent Decree and to develop the logistical infrastructure necessary to implement these measures, Baltimore County shall be liable for stipulated penalties to the United States and the State of Maryland for each Discharge in the amounts set forth below:

Less than 100 gallons	$50
100 to 2,499 gallons	$250
2,500 to 9,999 gallons	$500
10,000 to 99,999 gallons	$1,875
100,000 to 999,999 gallons	$5,000
1 million or more gallons	$7,500

B. Commencing three years after the Effective Date of this Consent Decree, Baltimore County shall be liable for stipulated penalties to the United States and the State of Maryland for each Discharge in the amounts set forth below:

Less than 100 gallons	$125
100 to 2,499 gallons	$750
2,500 to 9,999 gallons	$1,250
10,000 to 99,999 gallons	$4,500
100,000 to 999,999 gallons	$10,000
1 million or more gallons	$15,000

C. For purposes of this Paragraph 39, when a Discharge subject to a stipulated penalty as set forth above is reported by someone other than a member of Baltimore County's inspection crews, and Baltimore County, upon inspection, determines that a Discharge is occurring, the Discharge shall be considered to have commenced at the date and time that Baltimore County first received the report of the Discharge for purposes of calculating the volume of the Discharge.

D. Notwithstanding Paragraphs 39.A. & B. above, Baltimore County shall not be liable for stipulated penalties for Discharges where such Discharges are from Non-Pump Station SSO Structures identified in Appendix A2 that have not been certified as eliminated pursuant to Paragraph 7.C.iv., are caused by wet weather events, and occur within six (6) years of the Effective Date. Baltimore County shall demonstrate that a Discharge was caused by a wet weather event using flow monitoring records or other engineering data.

40. Stipulated civil penalties shall automatically begin to accrue on the first day after performance is due, or on the day a violation occurs, whichever is applicable, and shall continue to accrue until the violation or deficiency is corrected. Stipulated penalties shall accrue simultaneously for separate violations of the Consent Decree.

41. Following written demand by EPA or MDE, stipulated penalties incurred by Baltimore County under this Consent Decree shall be paid fifty percent (50%) to the United States and fifty percent (50%) to the State of Maryland. All stipulated penalties payable to the United States shall be paid in accordance with the procedures set forth in Paragraph 28, and all stipulated penalties payable to the State of Maryland shall be paid in accordance with the procedures set forth in Paragraph 29.

42. Stipulated penalties incurred under this Consent Decree shall be tendered within thirty (30) days of Baltimore County's receipt of a demand for payment of such penalties by EPA and/or MDE, unless Baltimore County contests the demand in accordance with the dispute resolution provisions of this Consent Decree. If Baltimore County invokes the dispute resolution provisions in Section XIII of this Consent Decree, it shall deposit any disputed penalty in an interest-bearing escrow account within ten (10) days of invoking dispute resolution. The stipulated penalties that are the subject of the dispute, as well as interest earned thereon, shall be released in a manner consistent with the terms of the resolution of the dispute within sixty (60) days after the dispute is resolved. Stipulated penalties for any continuing violation shall accrue during the resolution of any dispute.

43. The stipulated civil penalties set forth above shall be in addition to any other rights or remedies which may be available to the United States and the State of Maryland or their agencies by reason of Baltimore County's failure to comply with the requirements of this Consent Decree, and all applicable federal, state or local laws, regulations, or permits.

44. In the event that a stipulated civil penalty is not paid when due, the stipulated civil penalty owed to the United States shall be payable with interest from the original due date to the date of payment at the statutory judgment rate set forth at 28 U.S.C. § 1961(a).

45. The United States or Maryland may, in their own behalf and in their unreviewable exercise of discretion, reduce or waive stipulated penalties otherwise due that sovereign under this Consent Decree.

XII. FORCE MAJEURE

46. "Force Majeure" for the purposes of this Consent Decree is defined as an event arising from causes beyond the control of Baltimore County or the control of any entity controlled by Baltimore County, including its agents, consultants and contractors, which delays or prevents the performance of any obligation under this Consent Decree. Unanticipated or increased costs or expenses associated with implementation of this Consent Decree and changed financial circumstances shall not, in any event, be considered “force majeure” events. Baltimore County shall adopt all reasonable measures to avoid or minimize such delay.

47. When Baltimore County knows or if Baltimore County should have known, by the exercise of reasonable diligence, of an event that might delay completion of any requirement of this Consent Decree, whether or not the event is a “force majeure” event, Baltimore County shall notify EPA and MDE, in writing, within thirty (30) days after Baltimore County first knew, or in the exercise of reasonable diligence under the circumstances, should have known of such event. The notice shall provide a description of the event and an explanation of the reasons for the delay, the anticipated duration of the delay, all actions taken or to be taken to prevent or mitigate the delay or the effect of the delay, the timetable by which those measures will be implemented, whether Baltimore County claims that the delay should be excused as a “force majeure” event, and its rationale for attributing such delay to a “force majeure” event if it intends to assert such a claim. Baltimore County shall include all

available documentation supporting its claim that the delay was attributable to a "force majeure" event. Further, where a contractor or subcontractor has not completed a construction project on time, Baltimore County shall state what steps it is taking to ensure performance by the contractor or subcontractor in question, and shall supply any documentation available to show the steps it has taken.

48. **Permits**. Where any compliance obligation under this Section requires Baltimore County to obtain a federal, state, or local permit or approval, Baltimore County shall submit timely and complete applications and take all other actions necessary to obtain all such permits or approvals. Baltimore County may seek relief under the provisions of this Section XII (Force Majeure) of this Consent Decree for any delay in the performance of any such obligation resulting from a failure to obtain, or a delay in obtaining, any permit or approval required to fulfill such obligation, if Baltimore County has submitted timely and complete applications and has taken all other actions necessary to obtain all such permits or approvals.

49. Failure to provide the required written notice to EPA and MDE shall render this Section void and of no effect as to the event in question, and shall be a waiver of Baltimore County's right to obtain an extension of time for its obligations based on such event.

50. If EPA and MDE find that a delay in performance is, or was, caused by a "force majeure" event, the time for performance of the specific obligation(s) under this Consent Decree that are caused by the "force majeure" event shall be extended for a period to compensate for the delay resulting from such event, and stipulated penalties shall not be due for such period. EPA and MDE will notify Baltimore County in writing of the length of the extension for performance of the obligation(s) caused by the "force majeure" event. An extension of one compliance date based on a particular event shall not automatically extend any other compliance date. Baltimore County shall make an individual showing of proof by a preponderance of the evidence that the "force majeure" event was the cause of the delay in performance for each requirement or compliance date for which an extension is sought.

51. In the event of a dispute regarding application of these provisions to a delay in performance, the dispute resolution provisions of Section XIII (Dispute Resolution) shall apply, and Baltimore County shall have the burden of proving by a preponderance of the evidence that the delay is, or was, caused by a "force majeure" event, and that the amount of additional time requested is necessary to compensate for that event. Baltimore County shall not be liable for stipulated penalties for any period of delay which was excused by the Court or EPA and MDE pursuant to this "Force Majeure" Section.

XIII. DISPUTE RESOLUTION

52. Unless otherwise expressly provided for in this Consent Decree, the dispute resolution procedures of this Section shall be the exclusive mechanism to resolve disputes between Baltimore County and EPA/MDE arising under or with respect to this Consent Decree. However, the procedures set forth in this Section shall not apply to actions by the United States and the State of Maryland to enforce obligations of Baltimore County that have not been disputed in accordance with this Section.

53. **Informal Dispute Resolution**. Any dispute which arises under or with respect to this Consent Decree shall in the first instance be the subject of informal negotiations between Baltimore County, EPA and MDE. The period for informal negotiations shall not exceed twenty (20) days from the time Baltimore County sends EPA and MDE a written Notice of Dispute, unless that period is modified by written agreement of Baltimore County, EPA and MDE. The Notice of Dispute shall state clearly the matter in dispute. If the parties cannot resolve their dispute within the informal negotiation period, then the position advanced by EPA and MDE shall be considered binding unless, within thirty (30) days of the conclusion of the informal negotiation period, Baltimore County invokes the formal dispute resolution procedures as set forth below.

54. **Formal Dispute Resolution**. Baltimore County shall invoke formal dispute resolution procedures, within the time period provided in the preceding Paragraph, by serving on the United States and Maryland a written Statement of Position regarding the matter in dispute. The Statement of Position

shall include, but may not necessarily be limited to, any factual data, analysis, or opinion supporting Baltimore County's position and any supporting documentation relied upon by Baltimore County.

55. The United States and Maryland shall serve a Statement of Position within forty-five (45) days of receipt of Baltimore County's Statement of Position. The United States' and Maryland's Statement of Position shall include, but may not necessarily be limited to, any factual data, analysis, or opinion supporting that position and all supporting documents relied upon by the United States and Maryland. The United States' and Maryland's Statement of Position will be binding on Baltimore County unless, within thirty (30) days of its receipt, Baltimore County serves on the United States and Maryland a motion for judicial review setting forth the matter in dispute, the efforts made to resolve it, the relief requested, and the schedule, if any, within which the dispute must be resolved to ensure orderly implementation of this Consent Decree.

56. The United States and Maryland shall respond to Baltimore County's motion within the time period allowed by the Local Rules of this Court, unless the parties stipulate otherwise. Baltimore County may file a reply memorandum, to the extent permitted by the Local Rules or the parties' stipulation, as applicable.

57. In any dispute under this Paragraph, Baltimore County shall bear the burden of demonstrating that Baltimore County's position best complies with the terms and conditions of, and furthers the objectives of, this Consent Decree. The United States and Maryland may argue that their position is reviewable only on the administrative record and must be upheld unless arbitrary and capricious or otherwise not in accordance with law.

58. Submission of any matter to the Court for resolution shall not extend any deadline set forth in this Consent Decree unless the Parties agree to such extension in writing or the Court grants an order extending such deadline. Stipulated penalties with respect to the disputed matter shall continue to accrue but payment shall be stayed pending resolution of the dispute as provided in Section XI

(Stipulated Penalties). Notwithstanding the stay of payment, stipulated penalties shall accrue from the first day of noncompliance with any applicable provision of this Consent Decree. In the event that Baltimore County does not prevail on the disputed issue, stipulated penalties shall be assessed and paid as provided in Section XI (Stipulated Penalties) and consistent with the Court's ruling.

XIV. EFFECT OF SETTLEMENT

59. Upon the Effective Date, this Consent Decree shall resolve the United States' and the State of Maryland's civil claims for violations of Section 301 of the Clean Water Act, 33 U.S.C. § 1311, and Sections 9-322 and 9-323 of the Environment Article, Annotated Code of Maryland, as alleged in the Complaint filed in this matter, through the Date of Lodging of this Consent Decree.

XV. NON-WAIVER PROVISIONS

60. The Parties agree that Baltimore County is responsible for achieving and maintaining complete compliance with all applicable federal and state laws, regulations, and permits, and that compliance with this Consent Decree shall be no defense to any actions commenced pursuant to said laws, regulations, or permits, except as otherwise expressly specified in the Consent Decree.

61. The United States and the State of Maryland, do not, by their consent to the entry of this Consent Decree, warrant or aver in any manner that Baltimore County's complete compliance with this Consent Decree will result in compliance with the provisions of the Clean Water Act, 33 U.S.C. §§ 1251 et seq. or with Maryland's water pollution control laws. Notwithstanding EPA's and MDE's review or approval of any plans, reports, policies, or procedures formulated pursuant to this Consent Decree, or any delay in such review or approval, Baltimore County shall remain solely responsible for any non-compliance with the terms of this Consent Decree, the Clean Water Act and regulations promulgated under that Act, and Maryland's Environment Article and implementing regulations.

62. The Parties reserve any and all legal and equitable remedies available to enforce the provisions of this Consent Decree.

63. This Consent Decree shall not limit any authority of EPA and MDE under the Clean Water Act or any applicable statute, including the authority to seek information from Baltimore County or to seek access to the property of Baltimore County.

64. Performance of the terms of this Consent Decree by Baltimore County is not conditioned on the receipt of any federal, state or local funds. Application for construction grants, state revolving loan funds, or any other grants or loans, or delays caused by inadequate facility planning or plans and specifications on the part of Baltimore County shall not be cause for extension of any required compliance date in this Consent Decree.

65. It is the intent of the Parties hereto that the clauses hereof are severable, and should any clause(s) be declared by a court of competent jurisdiction to be invalid and unenforceable, the remaining clauses shall remain in full force and effect.

66. The United States and the State of Maryland reserve all remedies available to them for violations of the Clean Water Act and the Maryland water pollution control laws by Baltimore County which are not alleged in the Complaint or which occur after the Date of Lodging of this Consent Decree.

67. This Consent Decree does not resolve criminal liability, if any, that any person might have for violations of the Clean Water Act.

68. Nothing in this Consent Decree shall be construed to limit the authority of the United States or the State of Maryland to undertake any action against any person, including Baltimore County, in response to conditions that may present an imminent and substantial endangerment to the health of persons or to the welfare of persons where such endangerment is to the livelihood of such persons. 33 U.S.C. § 1364.

69. Nothing in this Consent Decree shall limit Baltimore County's ability to modify its program for the design, planning, construction, operation and maintenance of its Collection System in any fashion not inconsistent with the Consent Decree.

XVI. NOT A PERMIT/ COMPLIANCE WITH OTHER STATUTES/REGULATIONS

70. This Consent Decree is not and shall not be construed as a permit issued pursuant to Section 402 of the Clean Water Act, 33 U.S.C. § 1342, nor as a modification of any existing permit so issued, nor shall it in any way relieve Baltimore County of its obligations to comply with permits, if any, otherwise required for any portion of its Collection System or related sanitary sewage treatment facilities, and with any other applicable federal or state law or regulation. Baltimore County must comply with any new permit, or modification of existing permits, in accordance with applicable federal and state laws and regulations.

71. Nothing herein shall be construed as relieving Baltimore County of the duty to comply with the Clean Water Act and the Maryland water pollution control laws, the regulations promulgated under those acts, and all applicable permits issued under those acts and regulations.

XVII. COSTS OF SUIT

72. Each party shall bear its own costs and attorney's fees with respect to matters resolved by this Consent Decree. Should Baltimore County subsequently be determined by the Court to have violated the terms and conditions of this Consent Decree, Baltimore County may be liable to the United States and the State of Maryland for any costs and attorney's fees incurred by the United States and the State of Maryland in prosecuting actions against Baltimore County for non-compliance with this Consent Decree.

XVIII. RECORD KEEPING

73. A. Baltimore County shall maintain copies of any reports, plans, permits and documents, submitted to EPA and MDE pursuant to this Consent Decree, including any underlying research and data, for a period of five (5) years from date of submission, except that all underlying research and data relating to any SRRR Plan shall be maintained until termination of the Consent Decree. Baltimore County shall require any independent contractor operating any portion of the

Baltimore County Collection System or implementing any portion of this Consent Decree to also retain such materials as set forth in this Paragraph 73.A. Baltimore County shall submit such supporting documents to EPA and MDE upon request.

B. In addition to the reports and documentation required to be provided by Baltimore County under the terms of this Consent Decree, Baltimore County shall also provide, upon the reasonable demand of EPA or MDE, any analytical data or any other documents requested by EPA or MDE to review work done, or to be done, by Baltimore County or to determine Baltimore County's compliance with the terms of this Consent Decree.

74. Baltimore County shall notify EPA and MDE thirty (30) days prior to the disposal or destruction of such records at the end of this five year period and shall, upon EPA's and MDE's request, make such records available to EPA and MDE prior to such disposal or destruction.

XIX. FORM OF NOTICE

75. Unless otherwise specified, all reports, notices, or any other written communications required to be submitted under this Consent Decree shall be sent to the respective Parties at the following addresses:

As to the United States:

Chief, Environmental Enforcement Section
Environment and Natural Resources Division
U.S. Department of Justice
1425 New York Avenue, N.W.
Washington, D.C. 20005
(Reference DOJ Case No. 90-5-1-1-4402/2)

As to EPA:

Deane Bartlett (3RC20)
Senior Assistant Regional Counsel
United States Environmental Protection Agency
Region III
1650 Arch Street
Philadelphia, PA 19103

Chief, NPDES Branch (3WP31)
Water Protection Division
United States Environmental Protection Agency
Region III
1650 Arch Street
Philadelphia, PA 19103

As to State of Maryland:

Principal Counsel
Office of the Attorney General
Maryland Department of the Environment
1800 Washington Boulevard
Baltimore, MD 21230

Chief,
Enforcement Division, Compliance Program
Water Management Administration
Maryland Department of Environment
1800 Washington Boulevard
Baltimore, MD 21230

As to Baltimore County:

Edward C. Adams, Jr. (or his successor), Director
Department of Public Works
111 W. Chesapeake
Towson, MD 21204

Jay L. Liner (or his successor), County Attorney
Office of Law
400 Washington Avenue
Towson, MD 21204

Notifications to or communications with any party shall be deemed submitted on the date they are received.

XX. MODIFICATION

76. This Consent Decree contains the entire agreement of the Parties and shall not be modified by any prior written agreement, representation or understanding. The Consent Decree may be modified by written consent of all of the Parties or, if the Parties cannot agree, by written Order of this Court. All modifications, with the exception of modifications deemed non-material by mutual

agreement of EPA, MDE, and Baltimore County, shall be in writing and must be filed with the Court before such modification will be deemed effective.

XXI. LODGING AND OPPORTUNITY FOR PUBLIC COMMENT

77. This Consent Decree shall be lodged with the Court for a period of thirty (30) days for public notice and comment, pursuant to the requirements of 28 C.F.R. § 50.7. The United States and the State of Maryland reserve the right to withdraw or withhold their consent if the comments regarding the Consent Decree disclose facts or considerations which indicate that this Consent Decree is inappropriate, improper, or inadequate. Baltimore County consents to the entry of this Consent Decree without further notice.

78. If for any reason this Court should decline to approve this Consent Decree in the form presented, this agreement is voidable at the sole discretion of any Party and the terms of the agreement may not be used as evidence in any litigation between the Parties.

XXII. EFFECTIVE DATE

79. The Effective Date of this Consent Decree shall be the date upon which this Consent Decree is entered by the Court.

XXIII. RETENTION OF JURISDICTION

80. This Court shall retain jurisdiction of this matter for the purposes of implementing and enforcing the terms and conditions of this Consent Decree and for the purpose of adjudicating all disputes among the Parties that may arise under the provisions of this Consent Decree, to the extent that this Consent Decree provides for resolution of disputes by the Court. Such jurisdiction shall not terminate until all requirements of this Consent Decree have been fulfilled and all disputes arising under this Consent Decree have been resolved.

XXIV. TERMINATION

81. The Consent Decree shall terminate when all of the following events have occurred:

A. Baltimore County certifies that it has completed all obligations under Section V (Remedial Measures) and Section X (Supplemental Environmental Projects) of this Consent Decree, and that it has maintained compliance with all other requirements of the Consent Decree for a period of one year following completion of its obligations under Section V. For purposes of this Paragraph 81.A., the obligations under Paragraph 11 (Fat, Oil and Grease Program), Paragraph 12 (Illegal Storm Water Discharges), Paragraph 13.I. (Pump Station Preventive Maintenance), Paragraph 15 (Collection System Operation and Maintenance), and Paragraph 17 (Emergency Response Plan) shall be considered to be completed provided that Baltimore County has developed and fully implemented the plans or programs required by those Paragraphs in accordance with the schedules approved by EPA and MDE up to the date of the filing of the Joint Motion for Termination.

B. Baltimore County has paid all civil penalties, costs, damages, stipulated penalties, and other sums due under this Consent Decree; and

C. the Parties file a Joint Motion to Terminate the Consent Decree with the Court and the Court grants the Motion.

82. The Consent Decree shall not terminate if, following certification by Baltimore County of compliance pursuant to Paragraph 81.A. above, the United States or the State of Maryland assert in writing that full compliance has not been achieved. If the United States or the State of Maryland dispute Baltimore County's full compliance, this Consent Decree shall remain in effect pending resolution of the dispute by the Parties or the Court in accordance with the Dispute Resolution provisions of this Consent Decree.

XXV. SIGNATORIES/SERVICE

83. The Acting Assistant Attorney General on behalf of the United States and the undersigned representatives of Baltimore County and the State of Maryland certify that they are fully authorized to enter into the terms and conditions of this Consent Decree and to execute and legally bind

such party to this document.

84. Baltimore County hereby agrees not to oppose entry of this Consent Decree by the Court or to challenge any provision of this Consent Decree unless the United States has notified Baltimore County in writing that it no longer supports entry of the Consent Decree.

85. Baltimore County agrees to accept service of process by mail with respect to all matters arising under or relating to this Consent Decree and to waive the formal service requirements set forth in Rule 4 of the Federal Rules of Civil Procedure and any applicable Local Rules of this Court including, but not limited to, service of a summons.

XXVI. INTEGRATION/APPENDICES

86. This Consent Decree and its Appendices constitute the final, complete, and exclusive agreement and understanding among the Parties with respect to the settlement embodied in the Decree and supercede all prior agreements and understandings, whether oral or written. Other than the Appendices, which are attached to and incorporated into this Decree, no other document, nor any representation, inducement, agreement, understanding, or promise, constitutes any part of this Decree or the settlement it represents, nor shall it be used in construing the terms of this Decree.

87. The following Appendices are attached to and incorporated into this Decree:

"Appendix A1" is the list of Pump Station SSO Structures

"Appendix A2" is the list of Non-Pump Station SSO Structures

"Appendix B" is the list of Collection System Construction Projects

"Appendix C" is the list of Pump Station Rehabilitation, Repair, and Replacement Projects

"Appendix D" is the list of Pump Stations by Tier

"Appendix E" is the Pump Station Inspection Checklist

"Appendix F" is the Pump Station Priority Ranking

"Appendix G" is the Utilities Management Application Contract

"Appendix H" is the list of Deliverables

"Appendix I" is the description of the Patapsco BNR/ENR Design SEP

"Appendix J" is the description of the Back River Debris Removal SEP

"Appendix K" is the description of the Stream Restoration SEPs

XXVII. FINAL JUDGMENT

88. Upon approval and entry of this Consent Decree by the Court, this Consent Decree shall constitute a final judgment between the United States, the State of Maryland, and Baltimore County. The Court finds that there is no just reason for delay and therefore enters this judgment as a final judgment under Fed. R. Civ. P. 54 and 58.

SO ORDERED this ______ day of ____________________ 200__.

____
UNITED STATES DISTRICT JUDGE

WE HEREBY CONSENT to the entry of the Consent Decree in the matter of *United States and State of Maryland v. Baltimore County, Maryland*, Case No. ___________ (D. Md.), subject to the public notice and comment requirements of 28 C.F.R. § 50.7.

FOR THE UNITED STATES OF AMERICA

_________ Date

KELLY A. JOHNSON
Acting Assistant Attorney General
Environment and Natural Resources Division
U.S. Department of Justice
Washington, D.C. 20530

_________ Date

JOHN C. CRUDEN
Deputy Assistant Attorney General
Environment and Natural Resources Division
U.S. Department of Justice
Washington, D.C. 20530

7-22-05
Date

A. KENT MAYO
Environmental Enforcement Section
Environment and Natural Resources Division
U.S. Department of Justice
P.O. Box 7611
Washington, D.C. 20044-7611

ROD J. ROSENSTEIN
United States Attorney
District of Maryland

7-22-05
Date

Larry D. Adams / by Kent Mayo

LARRY D. ADAMS (Bar No. 03118)
Assistant United States Attorney
Office of the United States Attorney
36 S. Charles Street, 4th Floor
Baltimore, MD 21201
Tel: 410-209-4801
Fax: 410-962-9947
E-mail: larry.adams@usdoj.gov

WE HEREBY CONSENT to the entry of the Consent Decree in the matter of *United States and State of Maryland v. Baltimore County, Maryland,* Case No. ___________ (D. Md.), subject to the public notice and comment requirements of 28 C.F.R. § 50.7.

7/20/05
Date

DONALD S. WELSH
Regional Administrator
U.S. Environmental Protection Agency
Region III
1650 Arch Street
Philadelphia, PA 19103

7/9/05
Date

WILLIAM C. EARLY
Regional Counsel
U.S. Environmental Protection Agency
Region III
1650 Arch Street
Philadelphia, PA 19103

6/27/05
Date

DEANE BARTLETT
Senior Assistant Regional Counsel
U.S. Environmental Protection Agency
Region III
1650 Arch Street
Philadelphia, PA 19103

WE HEREBY CONSENT to the entry of the Consent Decree in the matter of *United States and State of Maryland v. Baltimore County, Maryland*, Case No. ___________ (D. Md.), subject to the public notice and comment requirements of 28 C.F.R. § 50.7.

7.21.05
Date

THOMAS V. SKINNER
Acting Assistant Administrator
Office of Enforcement and Compliance Assurance
U.S. Environmental Protection Agency
Washington, DC 20460

WE HEREBY CONSENT to the entry of the Consent Decree in the matter of *United States and State of Maryland v. Baltimore County, Maryland*, Case No. ___________ (D. Md.), subject to the public notice and comment requirements of 28 C.F.R. § 50.7.

FOR THE STATE OF MARYLAND

7/1/05
Date

KENDL P. PHILBRICK
Secretary
Maryland Department of the Environment

7/1/05
Date

M. ROSEWIN SWEENEY
Principal Counsel
Maryland Department of the Environment

7/1/05
Date

JENNIFER L. WAZENSKI (Bar No. 12564)
Assistant Attorney General
Maryland Department of the Environment
1800 Washington Boulevard
Baltimore, MD 21230
Tel: 410-537-3058
Fax: 410-537-3943
E-mail: jwazenski@mde.state.md.us

WE HEREBY CONSENT to the entry of the Consent Decree in the matter of *United States and State of Maryland v. Baltimore County, Maryland*, Case No. ___________ (D. Md.), subject to the public notice and comment requirements of 28 C.F.R. § 50.7.

FOR BALTIMORE COUNTY

6/29/05
Date

Signature: [signature]
Name (print): James T. Smith, Jr.
Title: County Executive
Address: 400 Washington Avenue
Towson, MD 21204

Agent Authorized to Accept Service on Behalf of Above-signed Party:

Name (print): Jay L. Liner
Title: County Attorney
Address: 400 Washington Avenue
Towson, Maryland 21204

Ph. Number: (410) 887-4420

APPROVED FOR LEGAL FORM AND SUFFICIENCY*
(SUBJECT TO EXECUTION BY THE DULY AUTHORIZED ADMINISTRATIVE OFFICIAL AND CHAIRMAN OF THE COUNTY COUNCIL, AS INDICATED)

[signature]

Office of the County Attorney

*Approval of Legal Form and Sufficiency Does Not Convey Approval Or Disapproval of the Substantive Nature of This Transaction. Approval Is Based Upon Typeset Document-All Modifications Require Re-Approval

APPENDIX A-1

LIST OF PUMP STATION SANITARY SEWER OVERFLOW STRUCTURES

Appendix A-1 Pump Station SSO Structures

11/22/2004

Co. ID #	Type	Facility Name	Street Address	Disposition
89	PS	Bear Creek PS	500 Wise Avenue, Dundalk, MD 21222	HWA, WWLC
90	PS	Bear Creek Town PS	8608 Lynch Road, Dundalk MD 21222	HWA, WWLC
53	PS	Bengies PS	11425 Eastern Avenue, Middle River, MD 21220	HWA, WWLC
98	PS	Bread & Cheese PS	2601 North Point Boulevard, Dundalk, MD	HWA, WWLC
16	PS	Carroll Avenue PS	3406 Carroll Avenue, Randallstown, MD 21133	HWA
109	PS	Chesaco Park	301 Popular Avenue, Rosedale, MD 21237	HWA, WWLC
78	PS	Chesapeake Terrace PS	2212 Lincoln Road, Sparrows Point, MD 21219	HWA, WWLC
61	PS	Corsica Road PS	2208 Corsica Road, Essex, MD 21221	HWA, WWLC
66	PS	Country Ridge PS	600 Mansfield Road, Essex, MD 21221	HWA, WWLC
96	PS	Day Village PS	521 Avondale Rd., Dundalk, MD 21221	HWA
85	PS	Delmar PS	2801 Delmar Avenue, Sparrows Point, MD 21219	HWA. WWLC
69A	PS	Duck Creek PS	725 S. Riverside Drive, Essex, MD 21221	HWA. WWLC
97	PS	Dundalk PS	7908 Dundalk Avenue, Dundalk, MD 21222	HWA. WWLC
112	PS	East Point PS	8000 Eastern Blvd., Highlandtown, MD 21224	HWA. WWLC
87	PS	Edge Point PS	1706 Burnham Road, Dundalk, MD 21221	HWA
26	PS	Enchanted Hills PS	33 Enchanted Hills, Owings Mills, MD 21117	HWA
70	PS	Essex PS	326 Riverside Dr, Essex, MD 21221	HWA, WWLC
17	PS	Fieldstone PS	8808 Stonehaven Rd, Randallstown, MD 21113	HWA
72A	PS	Fort Howard PS	9210 Old Bay Road, Sparrows Point, MD 21219	HWA, WWLC
12	PS	Frederick Road PS	1809 Frederick Road, Catonsville, MD 21228	HWA, WWLC
94	PS	Gray Manor PS	7825 Trappe Road, Dundalk, MD 21222	HWA, WWLC
48	PS	Gunpowder PS	9301 Dundawan Road, Nottingham, MD 21236	HWA, WWLC
52A	PS	Harewood Park PS	6847 South River Dr., Middle River, MD 21220	HWA
132	PS	Hawthorne 1 PS	2100 Midthorne Rd, Middle River, MD 21220	HWA, WWLC
110	PS	Hawthorne 2 PS	600 Grovethorn Rd, Middle River, MD 21220	HWA, WWLC
63	PS	Helena Avenue PS	206 Helena Ave, Essex., MD 21221	HWA
65	PS	Hyde Park PS	1554 Galena Road, Essex, MD 21221	HWA
75	PS	Iroquois PS	7611 Iroquois Rd, Sparrows Point, MD 21219	HWA
15	PS	Kings Point PS	9701 Plowline Road, Randallstown, MD 21133	HWA, WWLC
76	PS	Lodge Forest PS	2315 Lodge Forest Rd., Sparrows Pt, MD 21219	HWA, WWLC
77	PS	Lodge Forest Manor PS	7725 Sparrows Pt Blvd., Sparrows Pt, MD 21219	HWA

Co. ID #	Type	Facility Name	Street Address	Disposition
95	PS	Lyons Home PS	119 Fleming Drive, Dundalk, MD 21222	HWA
67	PS	Marlyn Avenue PS	528 S. Marylyn Ave., Essex, MD 21221	HWA, WWLC
68	PS	Marlyn Manor PS	979 Homberg Ave, Essex, MD 21221	HWA
83	PS	Masseth Avenue PS	2528 Masseth Avenue, Sparrows Pt, MD 21219	HWA
7	PS	McTavish PS	101 McTavish Avenue, Catonsville, MD 21228	HWA, WWLC
19	PS	Merrymount PS	3300 Ben Valley Road, Randallstown, MD 21133	HWA, WWLC
27	PS	Montrose PS	98 Montrose Road, Owings Mills, MD 21117	HWA
81	PS	North Point PS	3107 Sparrows Point Road, Edgemere, MD 21219	HWA, WWLC
91	PS	North Point Village PS	7618 New Battle Grove Road, Dundalk, MD 21222	HWA, WWLC
10	PS	Oak Forest Park PS	407 Seminole Ave, Catonsville, MD 21228	HWA, WWLC
88	PS	Old Battle Grove PS	7548 Old Battle Grove Rd, Dundalk, MD 21222	HWA, WWLC
50	PS	Oliver Beach PS	13206 Susquehanna Road, Middle River, MD 21220	HWA, WWLC
54	PS	Orems Road PS	51 Fenway North, Essex, MD 21221	HWA, WWLC
5	PS	Patapsco PS	4612 Annapolis Rd., Halethorpe, MD 21227	HWA, WWLC
74	PS	Penwood Terrace PS	8006 Penwood Avenue, Sparrows Point, MD 21219	HWA
64	PS	Prices Cove PS	28 Hilltop Ave, Essex, MD 21221	HWA
18	PS	Randallsstown PS	5401 Old Court Road, Gwynn Oak, MD 21244	HWA, WWLC
60	PS	Red House Run PS	1100 68th St & Lake Drive, Rosedale, MD 21237	HWA, WWLC
25	PS	Reisterswood PS	230 Cedarmere Circle, Owings Mills, MD 21117	HWA
92	PS	Shore Road PS	2054 Shore Road, Dundalk, MD 21222	HWA, WWLC
56	PS	Stansbury Manor PS	20 Dogwood Dr, Middle River, MD 21220	HWA, WWLC
29	PS	Statonwood PS	8514 Topping Road, Pikesville, MD 21208	HWA
57	PS	Stemmers Run PS	1100 Hengemihle Ave, Essex, MD 21221	HWA, WWLC
30	PS	Stevenson PS	3305 Keyser Road, Pikesville, MD 21208	HWA
51	PS	Twin Rivers PS	13054 Harewood Road, Middle River, MD 21220	HWA
80	PS	Veronica Avenue PS	5402 Jarsey Avenue, Sparrows Point, MD 21219	HWA
79	PS	Waldman Avenue PS	7301 Waldman Avenue, Sparrows Point, MD 21219	HWA
93	PS	West Inverness PS	8403 Sandy Plains, Dundalk, MD 21222	HWA , WWLC
9	PS	Westwood PS	300 Parleight Road, Catonsville, MD 21228	HWA
49	PS	White Marsh PS	1235 Reames Road, Middle River, MD 21220	HWA, WWLC
55	PS	Wilson Point PS	1820 Wilson Point, Middle River, MD 21220	HWA
6	PS	Woodland Avenue PS	705 Woodland Dr., Halethorpe, MD 21227	HWA
11	PS	Woodwind PS	116 Woodwind Road, Catonsville, MD 21228	HWA

HWA	High Water Alarm
WWLC	Wet Well Level Chart

APPENDIX A-2

LIST OF NON-PUMP STATION SANITARY SEWER OVERFLOW STRUCTURES

Appendix A-2 Non-Pump Station SSO Structures

11/22/2004

Co. ID #	Type	Facility Name	Street Address	Disposition
20	SSO	Abbie Place	3425 Abbie Place	FM
41	SSO	Aiken Place	7829 Aiken Avenue	FM
22	SSO	Alter Road	Alter Road & Southern Cross Road	FM
37	SSO	Anneslie Road	740 Anneslie Road	FM
40	SSO	Briarcliff Road	1828 Briarcliff Road	FM
117	SSO	Briarwood Road	Briarwood Road north of Frederick Ro	FM
120	SSO	Charles Street	422 Charles Street	FM
106	SSO	Croydon Court	7204 Croydon Court	FM
101	SSO	Dogwood Road	5424 Dogwood Road	FM
47	SSO	DuBois Avenue	3131 DuBois Avenue	FM
53	SSO	Eastern Avenue	3001 Eastern Avenue	CSM
99	SSO	Edmonson Avenue	5809 Edmonson Avenue	FM
3	SSO	Edmonson Lane & Lee Drive	2013 Edmonson Lane	CSM
1	SSO	Elm Road	1317 Elm Road	FM
115	SSO	Essex Avenue	3008 Essex Road	FM
73B	SSO	Fort Howard	Fort Howard at end of Avenue "A"	CSM
114	SSO	Gaither Road	3429 Gaither Road & Sunset Lane	CSM
69B	SSO	Marlyn Avenue Bridge	West side of bridge	CSM
113	SSO	Marnat Road	Marnat Road & Hatton Road	FM
119	SSO	McCurley Avenue	McCurley Avenue at Oak Court	CSM
103	SSO	Montbel Avenue	5434 Montbel Avenue	FM
14	SSO	Morehead Road	6036 Morehead Road	FM
73D	SSO	North Point Road	NW of 9243 North Point Road	CSM
116	SSO	Nunnery Lane & Frederick	Nunnery Lane north of Frederick Road	FM
118	SSO	Overbrook Road	Overbrook Road near Medwick Garth	FM
36	SSO	Overbrook & Branbury Road	748 Overbrook Road	FM
24	SSO	Patterson Avenue	3902 Patterson Avenue	FM
121	SSO	Providence Road	806 Providence Road	CSM
44	SSO	Redwood Avenue	1810 Redwood Avenue	FM
31A	SSO	Rider Avenue	8206 Rider Avenue (rear)	FM
107	SSO	Ripple Road	3443 Ripple Road	FM
108	SSO	South Green Road	at North Green	FM
23B	SSO	Southern Cross	3909 Southern Cross	FM
23	SSO	Southern Cross Drive	Parsons & Southern Cross	FM
105	SSO	Sussex Road (Alley)	off Liberty Road (7120 Marston Road)	FM
104	SSO	Sussex Road (Bridge)	3601 Sussex Road	FM
128	SSO	Texas Avenue	3021 Texas Avenue	FM
73C	SSO	Todd Avenue	Todd Avenue & Cedar Avenue	CSM

	LEGEND
FM	Flow Metered
CSM	Cork Stick Monitored

APPENDIX B

COLLECTION SYSTEM CONSTRUCTION PROJECTS

APPENDIX B

BALTIMORE COUNTY COLLECTION SYSTEM

CONSTRUCTION PROJECTS

Project Name	Description	Completion Date
White Marsh Force Main	Replacement	6/30/07
Stemmers Run Force Main	Replacement	6/30/07
Herbert Run Interceptor Phase II	Replacement	6/30/08
Patapsco Interceptor	Rehabilitation	6/30/09
Wells Avenue	Rehabilitation	6/30/06

APPENDIX C

PUMP STATION REPAIR, REHABILITATION, AND REPLACEMENT PROJECTS

APPENDIX C

Baltimore County Pump Station Repair, Rehabilitation and Replacement Projects

Projects Needed to Correct Causes of Overflows (Last 5 Years)

Pump Station	Description	Est. Cost	Completion
White Marsh	Replacement	11.7M	6/30/07
Stemmers Run	Replacement	13.9M	6/30/07
Texas	Installation of new pumps, controls, motor control center, generator and HVAC	3.2M	10/31/06
Springdale "A"	New motor control center and generator	0.5M	6/30/06
Merryman's Br.	New motor control center and generator	0.5M	6/30/06
Edge Point	Installation of new pumps, piping, controls, valves, motor control center and structural changes	0.8M	12/31/06
Shore Road	Installation of new pumps, motor control center and generator. Site improvements, structural improvements and HVAC	0.8M	10/31/07
Lyons Home	Backup power and upgrade HVAC	0.5M	6/30/08
Country Ridge	Backup power and upgrade HVAC	0.5M	6/30/08
Day Village	Backup power and upgrade HVAC	0.5M	6/30/08
Lynch Point	Evaluate/replace force main	0.6M	9/30/06
Prices Cove	Evaluate/replace force main	0.4M	9/30/06
Kings Point	Installation of new pumps, motor control center, piping, valves, generator and HVAC	0.8M	1/31/07

APPENDIX D

PUMP STATIONS BY TIER

PUMPING STATION PRIORITY LIST

Priority Code 1

COCKEYSVILLE
DELMAR
GRAY MANOR
GUNPOWDER
LONG QUARTER
PATAPSCO
RED HOUSE RUN
STEMMERS RUN
TEXAS
WHITE MARSH

Priority Code 2

BEAR CREEK TOWN
BREAD & CHEESE
DUCK CREEK
DUNDALK
EAST POINT
EDGE POINT
ESSEX
GREEN HILL COVE
HAWTHORNE 1
KINGS POINT
LODGE FOREST
LOVETON ESTATES
LYONS HOLMES
MERRYMAN'S BRANCH
NORTH POINT VILLAGE
OREMS ROAD
RANDALLSTOWN
REISTERSWOOD
SPARROWS POINT
SPRINGDALE 1
SPRINGDALE 2
STEVENSON
VERONICA AVENUE
WOODLAND AVENUE

Priority Code 3

BACK RIVER NECK
BAURENSCHMIDT
BEACHWOOD
BEACHWOOD ESTATES
BEACHWOOD NORTH
BEAR CREEK
BENGIES
BIRD RIVER
BLENHURST
BLETZER
BOWLEYS QUARTERS
BUCHANAN
CAMPUS HILLS
CAPE MAY
CARROLL AVENUE
CEDAR BEACH
CHAPEL HILLS
CHESACO PARK
CHESAPEAKE TERRACE
CORSICA ROAD
COUNTRY RIDGE
DAY VILLAGE
ENCHANTED HILLS
FIELDSTONE
FORGE ACRES
FORT HOWARD
FRANKLIN STATION
FREDERICK ROAD
HAREWOOD PARK
HAWTHORNE 2
HELENA AVENUE
HYDE PARK
IROQUOIS
LODGE FOREST MANOR
LYNCH POINT
LYNHURST
MARINE OAKS
MARLYN AVENUE
MARLYN MANOR
MASSETH AVENUE
MCTAVISH
MERRYMOUNT
MIDDLE BACK RIVER NECK
MILLERS ISLAND
MONTROSE
NORTH POINT
OAK FOREST PARK
OLD BATTLE GROVE
OLIVER BEACH
PENINSULA
PENWOOD TERRACE
PRICES COVE
PUTNAM GREEN
QUAD AVENUE
REISTERSTOWN VILLAGE
RETTMAN'S LANE
ROSALIE AVENUE
ROSEBANK
SHORE ROAD
STANSBURY MANOR
STANTONWOOD
SUE CREEK
TEMPLEGATE
THOMPSON BLVD.
TURKEY POINT
TWIN RIVERS
VALLEY VILLAGE
VOGTS LANE
WALDMAN AVENUE
WEST INVERNESS
WESTWOOD
WILLOW AVENUE
WILSON POINT
WINDLASS RUN
WOODWIND
WYE ROAD

APPENDIX E

PUMP STATION INSPECTION CHECKLISTS

Attachment 5

Bureau of Utilities
Pumping Division
Pumping Station WEEKLY Certification Report

Station: ______________________ Time: __________ Station Class: __________
(Tier) (1 - 2 or 3)

Date: ________ Operator: ______________________

TASK NUMBER 1
Wastewater Pumps/Shafts And Sump Pumps
Yes No N/A
☐ ☐ ☐ Do they pump?
☐ ☐ ☐ Excessive noise or vibration?
☐ ☐ ☐ Lubricant leakage?
☐ ☐ ☐ Check & adjust packing, if necessary
☐ ☐ ☐ Are pumps on automatic?

TASK NUMBER 2
Motor Controls and Motors
Yes No N/A
☐ ☐ ☐ Do they run on hand?
☐ ☐ ☐ Excessive noise or vibration?
☐ ☐ ☐ Lubricant leakage?

TASK NUMBER 3
Auxiliary Power Units - Engines Generators/Right Angle Drives & Automatic Transfer Switch/ Auxiliary Feeders
Yes No N/A
☐ ☐ ☐ Check fluids & belts - fuel
☐ ☐ ☐ Does it run on hand?
☐ ☐ ☐ Simulate power failure (check special operations notes)
☐ ☐ ☐ Does the power transfer?
☐ ☐ ☐ Do the emergency lights work?

TASK NUMBER 4
Air Compressor Unit and Controls
Yes No N/A
☐ ☐ ☐ Bleed tank
☐ ☐ ☐ Do they run on auto (lead, lag)?
☐ ☐ ☐ Leakage - air or fluids?

TASK NUMBER 5
Level Controls
Yes No N/A
☐ ☐ ☐ Is station operating normally?
☐ ☐ ☐ Match chart patterns

TASK NUMBER 6
Variable Speed Motor Control Units
Yes No N/A
☐ ☐ ☐ Check electrolyte level
☐ ☐ ☐ Check temperature
☐ ☐ ☐ VFD's operating normally? (check special oper. notes)

TASK NUMBER 7
Hydraulic and Surge Relief Systems
Yes No N/A
☐ ☐ ☐ Check hydraulic fluid level
☐ ☐ ☐ Check leaks

TASK NUMBER 8
Valves - Checks, Cone Ball and Gate
Yes No N/A
☐ ☐ ☐ Open, close
☐ ☐ ☐ Leaks?

TASK NUMBER 9
Telemetry, Lighting and Emergency Light Circuits
Yes No N/A
☐ ☐ ☐ 10/12 signal and dialer
☐ ☐ ☐ Are all telemetry lights lit?

TASK NUMBER 10
Odor Control Systems
Yes No N/A
☐ ☐ ☐ Check levels (check special operations note

TASK NUMBER 12
Sump Pump & Controls
Yes No N/A
☐ ☐ ☐ Check operation

TASK NUMBER 13
General Facility Maintenan
Yes No N/A
☐ ☐ ☐ Secure

EXPLAIN ANY PROBLEMS HERE:

____
____
____
____
____
____
____
____
____

I CERTIFY THAT THE INFORMATION ON THIS FORM IS COMPLETE AND CORRECT:

____

ORIGINAL: OFFICE FILE
YELLOW: CREW CHIEF
PINK: STATION

Attachment 6

BUREAU OF UTILITIES
PUMPING DIVISION
MECHANICAL **MONTHLY INSPECTION REPORT**

TATION:	**OPERATOR:**
DATE:	**TIME:**

TASK NUMBER 1
Wastewater Pumps/Shafts and Sump Pumps

YES NO N/A
☐ ☐ ☐ Pump down wet well, break suction, check well condition.
☐ ☐ ☐ Check auto bleeder.

TASK NUMBER 4
Air Compressor Unit and Controls

YES NO N/A
☐ ☐ ☐ Inspect and clean air filters.
☐ ☐ ☐ Inspect and clean regulators and pressure switches.

TASK NUMBER 7
Hydraulic and Surge Relief Systems

Surge Relief Systems

YES NO N/A
☐ ☐ ☐ Check operation of system and make sure pump valves do not slam shut when pump is turned off.
☐ ☐ ☐ Air Valve Systems – inspect packing and add if needed; check for air leaks; grease drive gear; and check solenoids.

YES NO N/A
☐ ☐ ☐ Spring Valve Systems – inspect "O" rings for leaks; check levels in oil reservoirs, inspect & tighten all fittings and listen for any back surge.
☐ ☐ ☐ Tank System – inspect tank and level tubes; check all gauges; check operation of check valve; repack if needed, check air lines and operation of air pressure relief valve and clean.

Hydraulic Systems

YES NO N/A
☐ ☐ ☐ Inspect oil tank and oil lines for leaks.
☐ ☐ ☐ Inspect oil pump and oil pump motor; check operation and clean.
☐ ☐ ☐ Inspect air lines and solenoids for any leaks or other problems

TASK NUMBER 10
Odor Control Systems

YES NO N/A
☐ ☐ ☐ Timing circuits.
☐ ☐ ☐ Check hydrogen sulfide level.
☐ ☐ ☐ Check stock.

TASK NUMBER 11
Air Vent and Heating Systems

YES NO N/A
☐ ☐ ☐ Inspect ducts and louvers.
☐ ☐ ☐ Inspect belts and pulleys.
☐ ☐ ☐ Check limit switches, timers and related circuits.

TASK NUMBER 12
Sump Pump and Controls

YES NO N/A
☐ ☐ ☐ Clean pit.
☐ ☐ ☐ Check probes or sensors.

TASK NUMBER 13
General Facility Maintenance

YES NO N/A
☐ ☐ ☐ Check influent line.
☐ ☐ ☐ Grass/shrubs.
☐ ☐ ☐ Empty all trash cans/clean inside of station.

EXPLAIN PROBLEMS HERE:

____

____

____

I CERTIFY THAT THE INFORMATION ON THIS FORM IS COMPLETE AND CORRECT:

____

ORIGINAL: OFFICE FILE   YELLOW: CREW CHIEF   PINK: STATION

BUREAU OF UTILITIES
PUMPING DIVISION
***ELECTRICAL* MONTHLY INSPECTION REPORT**

'TATION:	**OPERATOR:**
DATE:	**TIME:**

TASK NUMBER 2
Motor Controls and Motors
Motors
YES NO N/A
☐ ☐ ☐ Use infrared for checking heat (look at devices).
☐ ☐ ☐ Amp readings taken.

Motor Controls
YES NO N/A
☐ ☐ ☐ Inspect all breakers, starters, timers, relays & other elec. devices in motor control center for signs of overheating & breakdown. Tighten all loose wire connections.
☐ ☐ ☐ Clean and inspect all motor starter contacts. Inspect and tighten all starter connections. Check coil for any signs of overheating. Check overloads for overheating and proper size.
☐ ☐ ☐ Check for loose connections.
☐ ☐ ☐ Vacuum out control cabinets.
☐ ☐ ☐ Check limit switches/timers (lock out circuit).

TASK NUMBER 3
Aux. Power Units – Engines, Generators/Right Angle Drives & Automatic Transfer Switch/Auxiliary Feeders
YES NO N/A
☐ ☐ ☐ Check connections.
☐ ☐ ☐ Inspect all breakers, timers, relays & other electrical devices for signs of overheating & breakdown. Tighten all loose wire connections.
☐ ☐ ☐ Infrared scan.

TASK NUMBER 5
Level Controls
YES NO N/A
☐ ☐ ☐ Check and adjust all levels – primary and backup.
☐ ☐ ☐ Check high water.
☐ ☐ ☐ Check red cap.
☐ ☐ ☐ Check low waters.
☐ ☐ ☐ Are levels correct?
☐ ☐ ☐ Check labeling.

TASK NUMBER 6
Variable Speed Motor Control Units
Flomatcher
YES NO N/A
☐ ☐ ☐ Record PEAK R.P.M. of variable speed motor; check if motor will run at 95% of nameplate R.P.M.
☐ ☐ ☐ Inspect air system using soap solution to check for air leaks; check air conn. & the tubes in wet well.

VFD Units
YES NO N/A
☐ ☐ ☐ Check fault history
☐ ☐ ☐ Check wiring for hot spots or if burned.
☐ ☐ ☐ Check for proper labeling.

TASK NUMBER 8
Valves – Checks, Cone, Ball and Gate
YES NO N/A
☐ ☐ ☐ Check open and close times.
☐ ☐ ☐ Check rapid close system.
☐ ☐ ☐ Lock out alarm circuit.

TASK NUMBER 9
Telemetry, Lighting and Emergency Light Circuits
YES NO N/A
☐ ☐ ☐ Check all telemetry circuits for proper operation.
☐ ☐ ☐ Test all emergency lights
☐ ☐ ☐ Check circuit labeling.
☐ ☐ ☐ Check ground faults.

TASK NUMBER 11
Air Vent and Heating Systems
YES NO N/A
☐ ☐ ☐ Inspect ducts and louvers.
☐ ☐ ☐ Inspect belts.
☐ ☐ ☐ Inspect pulleys.
☐ ☐ ☐ Check limit switches, timers and related circuits.

TASK NUMBER 12
Sump Pump and Controls
YES NO N/A
☐ ☐ ☐ Clean pit.
☐ ☐ ☐ Check probes or sensors.

TASK NUMBER 13
General Facility Maintenance
YES NO N/A
☐ ☐ ☐ Check influent line.
☐ ☐ ☐ Grass/shrubs.
☐ ☐ ☐ Empty all trash cans/clean inside of station.

EXPLAIN ANY PROBLEMS HERE:

____

____

____

I CERTIFY THAT THE INFORMATION ON THIS FORM IS COMPLETE AND CORRECT:

____

ORIGINAL: OFFICE FILE YELLOW: CREW CHIEF PINK: STATION

BUREAU OF UTILITIES
PUMPING DIVISION
MECHANICAL SEMI-ANNUAL AND ANNUAL INSPECTION REPORT

STATION:	OPERATOR:
DATE:	TIME:

TASK NUMBER 1
Wastewater Pumps/Shafts and Sump Pumps
Annually
Centrifugal Pumps

YES	NO	N/A	
☐	☐	☐	Replace packing, inspect sleeve and packing glands.
☐	☐	☐	Pump test and adjust clearance of impeller.

TASK NUMBER 4
Air Compressor Unit and Controls
Annually

YES	NO	N/A	
☐	☐	☐	Change oil.
☐	☐	☐	Check pop-off (pressure relief valve).

TASK NUMBER 7
Hydraulic and Surge Relief Systems
Semi-Annually
Surge Relief Systems

YES	NO	N/A	
☐	☐	☐	Inspect check valves; clean and/or repair.

Hydraulic Systems

YES	NO	N/A	
☐	☐	☐	Inspect systems electrical circuits; check operations of circuits and tighten any loose connections.

TASK NUMBER 10
Odor Control Systems
Annually

YES	NO	N/A	
☐	☐	☐	Diaphragms in pumps.
☐	☐	☐	Check timers.
☐	☐	☐	Prepare for season maintenance.

TASK NUMBER 11
Air Vent and Heating Systems
Annually

YES	NO	N/A	
☐	☐	☐	Lubricate motors.
☐	☐	☐	Clean.

TASK NUMBER 12
Sump Pump and Controls
Annually

YES	NO	N/A	
☐	☐	☐	Check pipe and valves.

TASK NUMBER 13
General Facility Maintenance
Annually

YES	NO	N/A	
☐	☐	☐	Paint.
☐	☐	☐	Inspect, clean and lubricate chain falls.

EXPLAIN PROBLEMS HERE:

____

____

____

I CERTIFY THAT THE INFORMATION ON THIS FORM IS COMPLETE AND CORRECT:

____

ORIGINAL: OFFICE FILE   YELLOW: CREW CHIEF   PINK: STATION

BUREAU OF UTILITIES
PUMPING DIVISION
***ELECTRICAL* SEMI-ANNUAL AND ANNUAL INSPECTION REPORT**

TATION:	**OPERATOR:**
DATE:	**TIME:**

TASK NUMBER 2
Motor Controls and Motors
Semi-Annually
Motor Controls
YES NO N/A
☐ ☐ ☐ Check for neatness and proper labeling.

Annually
Motor Controls
YES NO N/A
☐ ☐ ☐ Inspect, calibrate and certify all motor protection relays.

TASK NUMBER 3
Aux. Power Units – Engines, Generators/Right Angle Drives & Automatic Transfer Switch/Auxiliary Feeders
Annually
Automatic Transfer Switch/Auxiliary Feeder
YES NO N/A
☐ ☐ ☐ Disassemble – check all contacts.
☐ ☐ ☐ Test, certify and PM. Calibrate main breaker.

TASK NUMBER 5
Level Controls
Semi-Annually
YES NO N/A
☐ ☐ ☐ Inspect condition of wet well. Are all air lines and connections on?

TASK NUMBER 6
Variable Speed Motor Control Units
Semi-Annually
Flomatcher
YES NO N/A
☐ ☐ ☐ Vacuum out control cabinet and clean all components within.
☐ ☐ ☐ Inspect circulator pump for proper operation; check for water leaks and any trapped air in system.
☐ ☐ ☐ Inspect wire and lugs; on top of load cell; check to see if lugs or wire are loose or burned.

VFD Units
YES NO N/A
☐ ☐ ☐ Clean/vacuum out control cabinets.
☐ ☐ ☐ Check signal integrity and loss of signal.

TASK NUMBER 8
Valves – Checks, Cone, Ball and Gate
Semi-Annually
YES NO N/A
☐ ☐ ☐ Clean control cabinet; inspect cabinet controls and wiring.

TASK NUMBER 9
Telemetry, Lighting and Emergency Light Circuits
Annually
YES NO N/A
☐ ☐ ☐ Vacuum out lighting panel.
☐ ☐ ☐ Thermal imaging.

TASK NUMBER 11
Air Vent and Heating Systems
Annually
YES NO N/A
☐ ☐ ☐ Lubricate motors.
☐ ☐ ☐ Clean.

TASK NUMBER 12
Sump Pump and Controls
Annually
YES NO N/A
☐ ☐ ☐ Check pipe and valves.

TASK NUMBER 13
General Facility Maintenance
Annually
YES NO N/A
☐ ☐ ☐ Paint.
☐ ☐ ☐ Inspect, clean and lubricate chain falls.

EXPLAIN ANY PROBLEMS HERE:

____

____

____

I CERTIFY THAT THE INFORMATION ON THIS FORM IS COMPLETE AND CORRECT:

____

ORIGINAL: OFFICE FILE   YELLOW: CREW CHIEF   PINK: STATION

APPENDIX F

PUMP STATION REPAIR PRIORITY RANKING SYSTEM

Priority System for Pump Station
Maintenance/Repair Scheduling

Station Class	Wet and/or Dry Weather Capacity Impaired Backup equipment unavailable	Wet Weather Capacity Available Backup contingencies can be made	Wet Weather Capacity Available Full backup available	Preventative Maintenance Scheduled Repair Testing All systems fully operational	Capital Projects Facility Maintenance All systems fully operational
Tier I	4	3	3	2	1
Tier II	4	3	2	2	1
Tier III	4	3	2	1	1

Legend:

4 – **Urgent Repair**. Use emergency confirming purchase requisition to obtain needed parts/materials. Work overtime around the clock to complete repair when appropriate.

3 - **Priority Repair**. Obtain parts/materials through competitive purchase, expedite delivery. Work overtime when deemed efficient to complete job.

2 - **Routine Repair.** Scheduled maintenance. Standard purchase procedures utilized. Use overtime sparingly to maintain preventative maintenance crew/manning.

1 - **Capital Project Upgrades / Facility Maintenance.** Station operation not affected. No overtime.

C:\Connie\Memos 2003\Sewage Overflows 2003\Pump Station maintenance repair.doc

APPENDIX G

UTILITIES MANAGEMENT APPLICATION CONTRACT

CONTRACT

This Contract is made

BETWEEN

RJN Group, Inc.
200 West Front Street
Wheaton, IL 60187
(the "Contractor")

AND

BALTIMORE COUNTY, MARYLAND
400 Washington Avenue
Towson, Maryland
21204-4665
(the "County")

TABLE OF CONTENTS

M 4439-4
V# 36283393900

BALTIMORE COUNTY, MARYLAND
CONTRACT

THIS AGREEMENT made this 1 day of March, 2004, (the "Agreement") is by and between Baltimore County, Maryland, a body corporate and politic, (hereinafter "County" or "Client") and **RJN Group, Inc., 200 West Front Street, Wheaton, IL 60187** (hereinafter the "Contractor" or "RJN").

WHEREAS, the said Contractor, in consideration of the payments hereinafter specified and agreed to be made by said County, hereby covenants and agrees to perform all services, in strict and entire conformity with this Agreement and with Attachments A through E, and any Purchase Order subsequently issued, the **Request for Proposal, No. 204510, the response and any amendments or revisions thereto, all of which are attached hereto and incorporated herein (collectively, the "Bid").**

NOW THEREFORE, in consideration of the mutual promises and covenants, the parties hereto agree that the County shall pay the Contractor, an amount as set forth herein, for services rendered in accordance with this Agreement, the other attachments hereto and if applicable, the Bid and the Purchase Order all of which are hereby incorporated into and made a part of this Agreement. Notwithstanding any other terms or provisions of this Agreement, in the event the County is temporarily or permanently prevented, restricted or delayed in the performance of any or all of the duties and obligations imposed upon or assumed by it hereunder, by act of the General Assembly of Maryland or the Baltimore County Council, by a court of competent jurisdiction or by administrative delay not due to the fault of the County (and its members and agents) shall not be liable directly or indirectly for any claims caused to or suffered by the Contractor or any other person in connection with or as a result of such prevention, restriction or delay. In addition the parties hereto agree as follows:

1. <u>Contractor's Duties</u>.

The Contractor shall be an independent Contractor and not an employee of the County, and shall be responsible for the reporting and remittance of all state and federal taxes. The Contractor shall perform the services outlined in the Attachments hereto. The Contractor's services will be provided with due care and in a manner satisfactory to the County and in accordance with all applicable professional standards.

2. <u>Compensation</u>.

2.1 **In consideration of the services to be provided by the Contractor, the County shall pay the Contractor the agreed upon prices set forth in the Bid and attached hereto in specific detail as Attachment B.**

2.2 **The Contractor shall submit invoices to the County as indicated on Attachment B.** The Contractor's invoices shall reflect the:

- **Contractor's name**
- **Address**
- **Federal tax identification number**
- **Order number and line number(s) that correspond with resulting orders**
- **Services performed during the preceding billing period**

All invoices shall be submitted in duplicate to Baltimore County, Disbursements Section, 400 Washington Avenue, Room 148, Towson, MD 21204. Invoices in the proper form and approved by the County shall be paid by the County within thirty (30) days of receipt thereof. The County reserves the right to approve such invoices, in its sole discretion, and to request such detail and additional information as the County, in its discretion deems appropriate.

2.3 **In no event shall the compensation paid to the Contractor exceed the sum of Three Hundred Twenty Five Thousand Dollars and No Cents ($325,000.00) during the Initial Term of this Agreement, as defined below; provided, however, that the County may entertain a request for escalation in any year subsequent to the first year in accordance with Paragraph 5 of the Request For Proposal. In no event shall the total compensation paid to the Contractor under this Agreement exceed the sum of Seven Hundred Fifty-Two Thousand Dollars and No Cents ($752,000.00) during the entire term of this Agreement including renewals thereof.**

3. **<u>Term</u>.**

3.1 **This Agreement shall be effective when executed by Baltimore County. Except in the event of certain terminations in accordance with the terms of the Agreement, the license granted hereunder shall remain in effect in perpetuity. The Maintenance and Support Agreement (Attachment D) shall remain in effect for one hundred eighty (180) days after County's Final Acceptance of the Software (hereinafter defined as the "Initial Term").**

3.2 **The County reserves the right to renew the Maintenance and Support Agreement for four (4) one year periods (each a "Renewal Term") on the same terms and conditions set forth in the Maintenance and Support Agreement and herein. The County will automatically renew at the end of the Initial Term and each renewal term (except the last) unless it provides notice of non-renewal to the Contractor prior to the end of the then current term.** Unless set forth in a written amendment, the compensation, and manner of payment set forth in Paragraph 2 shall remain as is including the maximum amount of compensation available hereunder. In the event any renewal changes the terms and conditions set forth herein, the approval of the Baltimore County Council may be required.

4. <u>Contractor's Representations and Warranties</u>. The Contractor hereby represents the following:

4.1 **The Contractor is a corporation duly formed and validly existing under the laws of the State of Illinois and is qualified to do business and is in good standing in the State of Maryland.**

4.2 **The Contractor has the power and authority to consummate the obligations and responsibilities contemplated hereby, and has taken all necessary action to authorize the execution, delivery and performance required under this Agreement.**

4.3 **The person executing this Agreement for the Contractor warrants that he is the person set forth in the Procurement Affidavit with the authority to execute this Agreement on the Contractor's behalf.**

4.4 **The professional services to be provided under this Agreement shall be performed competently and with due care, and in accordance with all applicable laws, codes, ordinances and regulations and licensing requirements.**

4.5 The Contractor has obtained and shall continue to maintain, at its own cost, such licenses and certifications as are necessary to provide the services rendered under this Agreement, and shall present such licenses to the County upon its request for the same.

4.6 All representations and warranties made in the Procurement Affidavit and the Bid response remain true and correct in all respects.

5. <u>Termination for Convenience.</u>

The County may terminate this Agreement, without cause, by providing written notice thereof to the Contractor at least thirty (30) days prior to the intended date of termination at the address set forth below, or at such other address as may be later designated by the Contractor in writing. The Contractor acknowledges that the absence of a reciprocal right of termination for convenience does not render this Agreement illusory or unenforceable.

5.1 **In the event of termination without cause the Contractor shall be paid for all reasonable costs incurred by the Contractor up to the date of termination set forth in the written notice of termination. Payment shall be made in accordance with the provisions of Paragraph 2 of this Agreement.**

6. <u>Insurance.</u>

The Contractor shall be required to provide insurance required by the County pursuant to the attached insurance requirements in the form and in amounts acceptable to the County. The Contractor shall maintain the insurance coverages required by the County while this Agreement is in force, and provide documentation of such insurance in a form satisfactory to the County. Such documentation may, in the discretion of the County, be in the form of binders or declarations from the insurance company. In the event of a conflict between the provisions of the attached insurance requirements and this Agreement, the provisions of this Agreement shall prevail.

7. **Default**. The term "Default" as used in this Agreement shall mean the occurrence or happening, from time to time, of any one or more of the following:

7.1 **Representations and Warranties.** If any representation or warranty, expressed or implied, contained in this Agreement, and if applicable, the Bid shall prove at any time to be incorrect or misleading in any material respect either on the date when made or on the date when reaffirmed.

7.2 **Compliance with Covenants and Conditions.** If the Contractor shall fail to comply with the terms of any covenant, condition, agreement or any express or implied warranty contained in this Agreement.

7.3 **Performance of Contractual Obligations. If the services hereunder are not performed in good faith.**

7.4 **Conditions Precedent to Any Disbursement.** If the Contractor shall be unable to satisfy any condition precedent to its right to receive a disbursement.

8. **Remedies for Default.**

8.1 The County shall have the right upon the happening of any Default, without providing notice to the Contractor:

1. In addition to other available rights and remedies, to terminate this Agreement immediately, in whole or in part;
2. To suspend the Contractor's authority to receive any undisbursed funds; and/or
3. To proceed at any time or from time to time to protect and enforce all rights and remedies available to the County, by suit or any other appropriate proceedings, whether for specific performance of any covenant, term or condition set forth in this Agreement, or for damages or other relief, or proceed to take any action authorized or permitted under applicable law or regulations or this Agreement.

8.2 **Upon termination of this Agreement for default, the County may elect to pay the Contractor for services provided up to the date of termination, less the amount of damages caused by the default, all as determined by the County in its sole discretion.** If the damages exceed the undisbursed sums available for compensation, the County shall not be obligated to make any further disbursements hereunder.

9. **Remedies Cumulative and Concurrent.**

No remedy herein conferred upon or reserved to the County is intended to be exclusive of any other remedies provided for in this Agreement, and each and every such remedy shall be cumulative, and shall be in addition to every other remedy given hereunder, or under this Agreement, or now or hereafter existing at law or in equity or by statute. Every right, power and remedy given to the County shall be concurrent and may be pursued separately, successively or together against the Contractor, and every right, power and remedy given to the County may be exercised from time to time as often as may be deemed expedient by the County.

10. **Confidential Information.**

The Contractor shall not disclose any documentation and information disclosed to the Contractor in the course of its performance of duties hereunder with respect to the past, present and future County business, services and clients without the express written consent of the County.

11. **Conflict of Interest.**

The Contractor represents and warrants that there exists no actual or potential conflict of interest between its performance under this Agreement and its engagement or involvement in any other personal or professional activities. In the event such conflict or potential conflict arises during the term of this Agreement, or any extension thereof, the Contractor shall immediately advise the County thereof.

12. **Assignment.**

Neither the County nor the Contractor shall assign, sublet or transfer its interest or obligations under this Agreement to any third party, without the written consent of the other. Nothing herein shall be construed to create any personal or individual liability upon any employee, officer or elected official of the County, nor shall this Agreement be construed to create any rights hereunder in any person or entity other than the parties of this Agreement.

13. **Delegation of Duties.**

The Contractor shall not delegate the Contractor's duties under this Agreement without the prior written consent of the County.

14. **Indemnification.**

The Contractor shall indemnify and hold harmless the County, its employees, agents and officials from any and all claims, suits, or demands including attorney fees which may be made against the County, its employees, agents or officials resulting from any act or omission committed in the performance of the duties imposed by and performed under the terms of this Agreement by the Contractor or anyone under agreement with the Contractor to perform duties under this Agreement. The Contractor shall not be responsible for acts of gross negligence or willful misconduct committed by the County.

15. **Integration and Modification.**

This Agreement sets forth the entire agreement between the parties relative to the subject matter hereof. No representation, promise or condition, whether oral or written, not incorporated herein shall be binding upon either party to this Agreement. No waiver, modification or amendment of the terms of this Agreement shall be effective unless made in writing and signed by an authorized representative(s) of the party sought to be bound thereby.

16. **Fee Prohibition.**

The Contractor warrants and represents that it has not employed or engaged any person or entity to solicit or secure this Agreement, and that it has not paid, or agreed to pay any person or entity a fee or any other consideration contingent on the making of this Agreement. If any suit, claim, or demand shall arise concerning such a fee, the Contractor agrees to indemnify and hold harmless the County, from all such claims, suits or demands.

17. **No Partnership.**

Nothing contained in this Agreement shall be construed in any manner to create any relationship between the Contractor and the County other than expressly specified herein and the Contractor and the County shall not be considered partners or co-venturers for any purpose on account of this Agreement.

18. **Waiver of Jury Trial.**

THE CONTRACTOR AND THE COUNTY HEREBY WAIVE TRIAL BY JURY IN ANY ACTION OR PROCEEDING TO WHICH THE COUNTY AND/OR THE CONTRACTOR ARE PARTIES ARISING OUT OF OR IN ANY WAY PERTAINING TO THIS AGREEMENT. IT IS AGREED AND UNDERSTOOD THAT THIS WAIVER CONSTITUTES A WAIVER OF TRIAL BY JURY OF ALL CLAIMS AGAINST ALL PARTIES TO SUCH ACTIONS OR PROCEEDINGS, INCLUDING CLAIMS AGAINST PARTIES WHO ARE NOT PARTIES TO THIS AGREEMENT. THIS WAIVER IS KNOWINGLY, WILLINGLY AND VOLUNTARILY MADE BY THE COUNTY AND THE CONTRACTOR AND THE COUNTY AND THE CONTRACTOR HEREBY REPRESENT AND WARRANT THAT NO REPRESENTATIONS OF FACT OR OPINION HAVE BEEN MADE BY AN INDIVIDUAL TO INDUCE THIS WAIVER OF TRIAL BY JURY OR TO IN ANY WAY MODIFY OR NULLIFY ITS EFFECT. THE COUNTY AND THE CONTRACTOR FURTHER REPRESENT AND WARRANT THAT THEY HAVE BEEN REPRESENTED OR HAVE HAD THE OPPORTUNITY TO BE REPRESENTED, IN THE SIGNING OF THIS AGREEMENT AND IN THE MAKING OF THIS WAIVER, BY LEGAL COUNSEL, SELECTED OF THEIR OWN FREE WILL, AND THAT THEY HAVE HAD THE OPPORTUNITY TO DISCUSS THIS WAIVER WITH COUNSEL.

19. **Governing Law.**

This Agreement shall be governed and construed in accordance with the laws of the State of Maryland.

20. **Conflicting Terms.**

20.1 The Contractor acknowledges that any Purchase Order issued on or after the effective date of this Agreement is hereby integrated and made a part of this Agreement, provided, however that if a conflict arises between the provisions of this Agreement and the Purchase Order, the provisions of this Agreement shall prevail.

20.2 In the event of a conflict between the Bid and this Agreement, the provisions of this Agreement (without the conflicting terms in the Bid) shall prevail.

21. **Severability.**

If any of the provisions in this Agreement are declared by a court or other lawful authority to be unenforceable or invalid for any reason the remaining provisions hereof shall not be affected thereby and shall remain enforceable to the full extent permitted by law.

22. **Time is of the Essence.**

Time is of the essence with respect to performance of the terms and conditions of this Agreement.

23. **Funding.**

The failure of the County to appropriate sufficient funds in any future fiscal year to provide funds for this Agreement shall entitle the County to terminate this Agreement without prior notice to the Contractor.

24. **Counterparts.**

This Agreement may be executed in any number of counterparts and by different parties hereto in separate Counterparts, each of which when so executed and delivered shall be deemed to be an original and all of which taken together shall constitute but one and the same instrument.

25. **Ownership of Goods.**

All finished or unfinished work, reports, or goods that are the subject of this Agreement, shall be and shall remain the property of the County.

26. **Discrimination Prohibited.**

26.1 In the execution of the obligations and responsibilities hereunder, including, but not limited to, hiring or employment made possible by or relating to this Agreement, the Contractor shall not discriminate against persons because of race, creed, color, sex, age, political affiliation, marital status, religion, national origin or disability.

26.2 All solicitations or advertisements for employees shall state that the Contractor is an equal opportunity employer.

26.3 The Contractor shall not deny any person participation in, or the benefits of any program or activity related to this Agreement on the basis of race, creed, color, sex, age, political affiliation, marital status, religion, national origin, or disability.

27. **Reports / Information/Inspections/and Audits.**

27.1 Reports produced for the County under this contract should be on recycled and recyclable paper printed on both sides.

27.2 At any time during normal business hours and as often as the County may deem necessary, the Contractor shall make available to and permit inspection by the County, its employees or agents, all records, information and documentation of the Contractor related to the subject matter of this Agreement, including, but not limited to, all contracts, invoices, payroll, and financial audits.

28. **Notice.**

Any notice required to be delivered shall be deemed to have been received when the notice has been sent by certified mail, return receipt, overnight carrier, or hand delivered to the following address and individual or at such other address and/or such other individual a party may identify in writing to the other party:

FOR THE COUNTY:

Director, Department of Public Works
111 W. Chesapeake Avenue, Towson, Maryland 21204

FOR THE CONTRACTOR:

Robert A. Snodgrass
RJN Group, Inc.
200 West Front Street, Wheaton, Illinois 60187
630-682-4700 x352

29. **Political Contribution Disclosure Affirmation**

The Contractor affirms that it is aware of, and will comply with, the provisions of Sections 14-101 through 14-108 of the Election Law Article of the Annotated Code of Maryland, which require that every person who makes, during any 12-month period, one or more contracts, with one or more Maryland governmental entities involving cumulative consideration of at least $100,000.00, shall file with the State Board of Elections certain specified information to include disclosure of attributable political contributions in excess of $500 during defined reporting periods.

30. **HIPAA. § Compliance With Federal HIPAA And State Confidentiality Law**

A. The Contractor acknowledges its duty to become familiar with and comply, to the extent applicable, with all requirements of the federal Health Insurance Portability and Accountability Act (HIPAA), 42 U.S.C. §§ 1320 *et seq.* and implementing regulations including 45 CFR Parts 160 and 164. The Contractor also agrees to comply with the Maryland Confidentiality of

Medical Records Act (Md. Code Ann. Health-General §§4-301 *et seq.*, MCMRA). This obligation includes:

1. As necessary, adhering to the privacy and security requirements for protected health information and medical records under federal HIPAA and State MCMRA and making the transmission of all electronic information compatible with the federal HIPAA requirements; and

2. Providing good management practices regarding all health information and medical records.

B. If the County determines that functions to be performed constitute business associate functions as defined in HIPAA, the selected offeror must execute a business associate agreement as required by HIPAA regulations at 45 CFR §164.501. The fully executed business associate agreement must be submitted within 10 working days after notification of selection, or within 10 days after award, whichever is earlier. Upon expiration of the ten-day submission period, if the County determines that the selected offeror has not provided the HIPAA agreement required by this solicitation, the Procurement Officer, upon review of the Baltimore County Office of Law, may withdraw the recommendation for award and make the award to the next qualified offeror.

C. Protected Health Information as defined in the HIPAA regulations at 45 CFR 160.103 and 164.501, as amended from time to time, means information transmitted as defined in the regulations, that is individually identifiable; that is created or received by a healthcare provider, health plan, public health authority, employer, life insurer, school or university, or healthcare clearinghouse; and that is related to the past, present, or future physical or mental health or condition of an individual, to the provision of healthcare to an individual, or to the past, present, or future payment for the provision of healthcare to an individual. The definition excludes certain education records as well as employment records held by a covered entity in its role as employer.

31. **<u>No Waiver, Etc.</u>**

No failure or delay by the County to insist upon the strict performance of any term, condition, or covenant of this Agreement, or to exercise any right, power, or remedy consequent upon a breach thereof, shall constitute a waiver of any such term, condition, or covenant or of any such breach, or preclude the County from exercising any such right, power, or remedy at any later time or times.

IN WITNESS WHEREOF, the parties have executed this Agreement the day and year first written above.

WITNESS:

RJN Group, Inc.
Federal Identification No. 362838939

By: ______________________(SEAL)
Alan J. Hollenbeck, P.E.
President and CEO

WITNESS:

BALTIMORE COUNTY, MARYLAND, a body corporate and politic

By: ______________________
Anthony G. Marchione
Administrative Officer

APPROVED FOR LEGAL FORM AND SUFFICIENCY*
(Subject to Execution by A Duly Authorized County Administrative Official and County Council, if Indicated)

02-24-04
OFFICE OF THE COUNTY ATTORNEY 17165
*Approval of Legal Form and Sufficiency Does Not Convey Approval or Disapproval of Substantive Nature of Transaction. Approval is Based Upon Typeset Document. All Modifications Require Re-Approval.

REVIEWED AND APPROVED:

Thomas G. Iler
Office of Information Technology

REVIEWED AND APPROVED:

Edward C Adams / WWK
Edward C. Adams, Jr.
Department of Public Works

Revised: 0403

OFFICE OF BUDGET & FINANCE

FUNDS TOTALLING $ 146,201.00 ARE AVAILABLE AND ENCUMBERED IN THE CURRENT FISCAL YEAR. THE UNENCUMBERED BALANCE PAYABLE PURSUANT TO THE CONTRACT IS $ 178,799.00

DEPUTY DIRECTOR FOR FINANCE — DATE 2/20/04

030-070-7802-0512

CONTRACT AFFIDAVIT

A. AUTHORIZED REPRESENTATIVE

I HEREBY AFFIRM THAT:

I am the President and CEO and the duly authorized representative of RJN Group Inc. (the "Business") and that I possess the legal authority to make this Affidavit on behalf of myself and the business for which I am acting.

B. BID/PROPOSAL AFFIDAVIT AFFIRMATIONS VALID

I FURTHER AFFIRM THAT:

To the best of my knowledge, information, and belief, each of the affirmations, certifications, or acknowledgments contained in that certain Procurement Affidavit dated February 19, 2003, and executed by (me) (Alan J. Hollenbeck) for the purpose of obtaining the contract to which this Exhibit is attached remains true and correct in all respects as if made as of the date of this Contract Affidavit and as if fully set forth herein.

I DO SOLEMNLY DECLARE AND AFFIRM UNDER THE PENALTIES OF PERJURY THAT THE CONTENTS OF THIS AFFIDAVIT ARE TRUE AND CORRECT TO THE BEST OF MY KNOWLEDGE, INFORMATION, AND BELIEF.

Date: 02/12/04

By: [signature]
Name: Alan J. Hollenbeck, P.E.
Title: President and CEO
(Authorized Representative and Affiant)

Revised 04/03

ATTACHMENT A TO AGREEMENT

SERVICES TO BE PERFORMED

Utilities Infrastructure Management Application

Contractor shall provide to the County and shall be responsible for the installation, implementation, integration, training, maintenance and support of CASSWORKS, an automated system for managing Emergency Sewer Service, Tele-Jet, Inflow and Infiltration and Construction Units information and activities and to provide integration of related activities in the Bureau of Engineering for sanitary sewer and storm drain design. CASSWORKS will automate the logging, data capture, tracking, reporting, history, and processes, and will provide a "real-time" link to GIS for viewing, creating, updating, and analyzing utility information, and share data within Public Works and other county agencies – all as further described in the attached Software License Agreement, Maintenance Support Agreement and Software Source Code Escrow Agreement, each of which is incorporated herein.

Software licenses - 22 concurrent user licenses of CASS WORKS and one user license for 22 named users of CASS VIEW. Delivery and installation of software and verification of its successful operation as determined solely by the County Includes up to ten person/days on-site for project initiation tasks and software installation and up to one hundred hours for support services and project management. Training, includes up to 15 days of training on-site over 4 trips. Software basic training, advanced procedure training, and system administrator training are all covered.

Customized Infrastructure
Software includes up to six days for design workshops for GIS integration, keystroke integration, WinCan Integration, and any CASS WORKS enhancements necessary to meet the project requirements. Services to support the data translation effort, programming for integration routines, and program enhancements as required to meet the project requirements will be delivered using an estimated 500 person/hours. Data translation efforts will include appropriate digital data to be translated into the system based on data review and assessment activities. Hours are estimates and may be modified as a result of the design workshops. Up to two days for installation and testing is also included. It is anticipated that only data translation services will be provided in the first phase of the project.

Maintenance and support of Infrastructure software is based on 20% of the total licenses in force, billed annually. Support services include telephone support during the pilot testing period, two days for Pilot evaluation and production planning, and three days of on-site support time for the initial production use of the system.

THE ABOVE ARE IN ADDITION TO ANY OTHER SERVICES AS SET FORTH IN THE REQUEST FOR PROPOSAL 204510 AND THE BID.

Revision Date: 04/03

Attachment B to Agreement

Attachment B

Baltimore County Bureau of Utilities
Utilities Infrastructure Management System

RJN Project Task Details

Commodity Code: 209-41-030706

Software Infrastructure Management System	**Qty**	**Units**
CASS WORKS Sewer Maintenance Management	1	Module
CASS WORKS Storm Maintenance Management	1	Module
CASS WORKS Physical Inspection Management	1	Module
CASS WORKS System Management Module	1	Module
CASS WORKS Additional Concurrent Users	22	Users
CASSView	22	Users

Commodity Code: 209-41-030707

Training for Infrastructure Software	**Qty**	**Units**
Essentials Training	2	Days
System Administrator Training	2	Days
Work Order and Warehouse Procedure Training	6	Days
CASSView Training	2	Days
Production Training	3	Days
Direct Expenses / Phone Conference	4	Hours
Direct Expenses / Trip	4	Trips
Direct Expenses / Days	15	Days

Commodity Code: 209-41-030709

Implementation of Infrastructure Software	**Qty**	**Units**
Project Setup	2	Hours
Preparation	12	Hours
Initiation Workshop- System and Data Review / Notes GIS, WinCam, KeyStroke, Data Sources Work Order and Warehouse Procedure Review	8	Days
Installation and Testing	2	Days
Workshop and Meeting Notes	40	Hours
Project Management	60	Hours
Direct Expenses / Phone Conference	10	Hours
Direct Expenses / Trip	3	Trips
Direct Expenses / Days	10	Days

Commodity Code: 209-41-0307011

Customize Infrastructure Management Software	**Qty**	**Units**
Data Translation Routines and Testing Round One	120	Hours
Data Translation Routines and Testing Round Two	30	Hours
GIS Customization Design Meeting	2	Days
WinCam Customization Design Meeting	1	Days
KeyStroke Customization Design Meeting	1	Days
CASS WORKS Customization Design Meeting	2	Days
GIS Interface Programming	120	Hours
WinCam Interface Programming	30	Hours
KeyStroke Interface Programming	40	Hours
CASS WORKS Programming	70	Hours
Testing	60	Hours
Installation and Testing	2	Days
Direct Expenses / Phone Conference	2	Hours
Direct Expenses / Trip	3	Trips
Direct Expenses / Days	8	Days

Commodity Code: 209-41-030708

Maintenance of Infrastructure Software	**Qty**	**Units**
CASS WORKS Annual Maintenance and Support	15%	% of Total

Commodity Code: 209-41-0307010

Support for Infrastructure Management Software	**Qty**	**Units**
Training Support Phone	20	Hours
Evaluation Session	2	Days
Production Support	3	Days
Reports Programming and Assistance	40	Hours
Direct Expenses / Phone Conference	4	Hours
Direct Expenses / Trip	3	Trips
Direct Expenses / Days	8	Days

Optional Products and Services

Commodity Code: 209-41-030706

Software Infrastructure Management System	**Qty**	**Units**	**Rate**
CASS WORKS Plant Maintenance Management	1	Module	4,500.00
CASS WORKS Pavement Maintenance Management	1	Module	4,500.00
CASS WORKS Additional Concurrent Users	1	Users	1,000.00
CASSView (per PC)	1	Users	1,250.00

All prices offered in herein shall be firm against any increase for 2 years from the effective date of this Agreement. Thereafter the COUNTY may, in its sole discretion, purchase additional user licenses at a price mutually agreed upon by the parties hereto.

Commodity Code: 209-41-030707

Training for Infrastructure Software	**Qty**	**Units**	**Rate**
Training (On-Site)	2	Days	1,700.00

Commodity Code: 209-41-030709

Implementation of Infrastructure Software	**Qty**	**Units**	**Rate**
Clerical Personnel (Hourly)	1	Hours	60.00
Consulting and Professional Services (Hourly)	1	Hours	125.00

Commodity Code: 209-41-0307011

Customize Infrastructure Management Software	**Qty**	**Units**	**Rate**
Consulting and Professional Services (Hourly)	1	Hours	125.00
Testing and Quality Assurance (Hourly)	1	Hours	100.00

Commodity Code: 209-41-0307010

Support for Infrastructure Management Software	**Qty**	**Units**	**Rate**
Special Projects Support (Hourly)	1	Hours	125.00
Consulting and Professional Services (On-Site)	2	Days	1,700.00

Estimated Rate for Direct Expenses

Direct Expenses / Phone Conference	1	Hours	18.00
Direct Expenses / Trip	1	Trips	500.00
Direct Expenses / Days	1	Days	250.00

Direct expenses for travel, per diem, and materials have been estimated in the project total. Direct expenses will be charged as cost to the appropriate commodity code unless otherwise instructed.

ATTACHMENT B TO AGREEMENT

Baltimore County Utilities Infrastructure Management System

Contract Agreement Milestones

	Agreement Date and Start of Phase I	*Initiation Workshop Completed*	*Software Installation*	*Functional Acceptance*	*Final Acceptance*	*Start of Phase II*	*Approved Design*	*Installation*	*Functional Acceptance*	*Final Acceptance*	*Maintenance and Support Begins*
Days from Agreement Date	0	30	30	45	150	195	225	270	285	305	330
Payment Schedule	TOTALS					TOTALS					TOTALS
Commodity Code: 209-41-030706			35%	40%	25%						
Software Infrastructure Management System	64,000.00		22,400.00	25,600.00	16,000.00						
CASS WORKS *Sewer Maintenance Management Module*											
CASS WORKS Storm Maintenance Management Module											
CASS WORKS *Physical Inspection Management Module*											
CASS WORKS System Management Module											
CASSView											
For more detail on Software see Bid and following pages of this Exhibit											
Commodity Code: 209-41-030707											
Training for Software (see Payment Notes below)	31,322.00										
Essentials Training											
System Administrator Training											
Work Order and Warehouse Procedure Training											
CASSView Training											
Production Training											
For more detail on Training see Bid and following pages of this Exhibit											
Commodity Code: 209-41-030709		30%		30%	40%						
Implementation of Software	36,200.00	10,860.00		10,860.00	14,480.00						
For detail on Implementation see Bid and following pages of this Exhibit											
Commodity Code: 209-41-0307011							25%	25%	25%	25%	
Customize Software (see Payment Notes below)	74,386.00					74,386.00	18,596.50	18,596.50	18,596.50	18,596.50	
For detail on Customization see Bid and following pages of this Exhibit											
Commodity Code: 209-41-030708											
Maintenance of Software (see Payment Notes below)	9,600.00										
For detail on Maintenance see Bid and following pages of this Exhibit and *Software Maintenance and Support Agreement*											9,600.00
Commodity Code: 209-41-0307010	19,572.00				75%					25%	
Support for Software	14,679.00				14,679.00	4,893.00				4,893.00	
For detail on Support see Bid and following pages of this Exhibit and Software Maintenance and Support Agreement											
TOTALS Phase I	146,201					79,279.00					9,600.00
TOTAL OF PHASE I AND PHASE II	$235,080										

INVOICING AND PAYMENT NOTES

RJN shall invoice Client for all commodities with the exception of 209-41-030706, Software Infrastructure Management System, on a monthly basis for professional services fees incurred, up to the stated percentage by Contract Agreement Milestones in the above schedule. Payment shall be in accordance with Article 2 of the Contract Agreement. Billing on Commodity Code 209-41-030706, *Software Infrastructure Management* System shall only occur upon achievement of the Contract Agreement Milestones.

Attachment C to Agreement
RJN GROUP PROGRAM LICENSE AGREEMENT

Subject to the following terms and conditions, RJN Group, Inc. referred to as "Contractor" or "RJN" and Baltimore County, Maryland, referred to as the "County" or "Client" hereby enter into this RJN Group Program License Agreement "License" and agree as follows:

DEFINITIONS: As used in this License:

I. "Acceptance" or "Final Acceptance" means:

A. Functional Acceptance: After RJN has installed the applicable Phase Software the Client shall have a period of thirty (30) calendar days ("Acceptance Testing Period") to verify that the applicable Phase Software substantially conforms to the terms of the Agreement and is suitable to be put into production use (the "Functional Acceptance"). The acceptance criteria for the Software (the "Acceptance Criteria") shall be jointly developed and mutually agreed in writing by the Client and RJN no later than thirty (30) days in advance of the scheduled Acceptance Testing Period. If, during the Acceptance Testing Period, the Client determines that the applicable Phase Software does not meet the agreed upon Acceptance Criteria, the Client shall notify RJN in writing, and RJN shall modify or correct the applicable Phase Software (as the case may be) so that it satisfies the Acceptance Criteria within the Acceptance Testing Period (such Acceptance Testing Period to be extended as may be required to permit the Client to test the resolution provided for a period of fifteen (15) calendar days), unless both parties agree a further extension is necessary. Upon the Functional Acceptance, RJN and the Client will agree upon a firm Production Start Date. In the event the Client has provided its Functional Acceptance but chooses not to implement the applicable Phase Software on the Production Start Date, the Client agrees and acknowledges that all services performed and any expenses necessarily and actually incurred by RJN between the scheduled Production Start Date and the actual Production Start Date (and in connection with the applicable Phase Software) shall be considered a change order and subject to time and materials charges;

AND

B. Production Acceptance: Shall be provided not later than sixty (60) days from Functional Acceptance according to the following. In the event the Go-Live for the applicable Phase Software occurs and the Client has not reported any Severity Level 1 or 2 incidents to RJN, the Client shall, within the following five (5) business days certify in writing its Production Acceptance of the applicable Phase Software. If, during the thirty (30) day period after the Production Start Date of the applicable Phase Software, any bona fide Severity Level 1 or 2 incidents do occur, the parties agree that the thirty (30) day period shall be extended only by the number of calendar days as may be required to permit the Client to test the resolution provided for a period of fifteen (15) calendar days. Should the Client fail to report any Severity Level 1 or 2 incidents and also fail to certify Production Acceptance within the above prescribed time frames, the applicable Phase Software shall be deemed to be finally accepted.

II. "Maintenance Agreement" means the Maintenance and Support Agreement of even date herewith executed by and between RJN and the Client, incorporated herein and attached hereto for reference.

III. "Source Code Escrow Agreement" means the Master Preferred Agreement to be entered into by and among RJN, the Client, and Escrow Agent, in the form attached hereto as Attachment E, with RJN responsible for all fees and costs thereunder and Client responsible for reimbursing RJN for all such fees and costs pursuant to this Agreement. Attachment E is incorporated herein and attached hereto for reference and is to be executed simultaneous with or immediately after the execution of this Agreement.

IV. "Documentation" means user manuals, reference guides, training materials, release notes, on-line help and other materials in printed or electronic form, which facilitate use of the Software.

V. "Escrow Agent" means: DSI Technology Escrow Services, Inc. PO Box 45156, San Francisco, CA 94145-0156, (415)-398-7900.

VI. "Go-Live" means the date that is thirty (30) days after the Production Start Date.

VII. "Production Start Date" means the date that the applicable Phase Software is brought on-line and used to perform a process Client's data or functions in Client's actual operations.

VIII. "Services" means (i) compilation, testing, packaging and delivery of the Software and Documentation, (ii) project management, (iii) and user Training and Implementation Assistance and (iv) support and assistance from the Production Start Date as may be set forth in any project plan.

IX. "Agreement" means the Contract Agreement executed by RJN and the Client of even date herewith, incorporated herein and attached hereto for reference.

X. "Programs" means the Software and the Documentation.

XI. "Phase I" means the Programs to be provided by RJN to Client as further described in Attachment B of the Agreement attached hereto and incorporated herein.

XII. "Phase II" means the Programs to be provided by RJN to Client as further described in Attachment B of the Agreement attached hereto and incorporated herein.

XIII. "Severity Level One" means the Software is totally inoperative or the use of the Software for processing transactions is not possible.

XIV. "Severity Level Two" means the Software is impaired to the extent that critical functions are inoperative, that impact the Client's ability to perform basic operations or business functions.

XV. "Severity Level Three" means the Software is impaired to the extent that some non-critical functions are not operating.

XVI. "Training" means basic Software training, advanced procedure training and system administrator training as is further described in the Bid.

XVII. "System" or "Operating System" shall mean the Client system designed to control the hardware of a specific data-processing system for users and application programs; Operating System also controls the execution of programs; provides services, including but not limited to, resource allocation, scheduling, input/output control, and data management.

XVIII. "Software" means the proprietary software Computer Aided Support Systems (CASS WORKS®) a utilities infrastructure management application designed to automate processes and to log, track and analyze work performed. The core functions include database access, Graphical User Interface (GUI), menu selection, screen operations, query capabilities and reporting options, system administration and configuration, and data integration functions. The Software includes CASS VIEW, a GIS deployment tool providing direct access to GIS and CASS WORKS and custom features.

XIX. "Implementation Assistance" shall mean the on-site professional services rendered by RJN in support of the live operation of the Software, beginning with Production Start Date.

1. SOFTWARE

RJN sells and licenses the Software.

2. LICENSE

The Client is hereby granted a perpetual license to utilize the Programs in accordance with this License. The perpetual license is for twenty-two (22) concurrent users of CASS WORKS and one user License for CASSView for up to twenty-two (22) named users.

Client may not permit concurrent access to the Program by more than the number of users as shown above for which the License was ordered. Transfer of Program except for temporary use in case of a computer malfunction is prohibited. Transfer of Program to a higher capacity computer, and/or upgrade to use by additional concurrent users is subject to payment of a transfer or upgrade fee as specified in the applicable RJN Price List. Client may not use the Program for commercial timesharing, rental or service bureau use. The Program may not be transferred, sold, assigned, or otherwise conveyed to another party. Transfer of the Program outside the country in which delivery is taken by Client is not permitted without RJN's prior written consent. Client agrees not to cause or permit reverse engineering, disassembly, or decompilation of the Program and prohibits duplication of the programs except for a single backup or archival copy or as otherwise provided herein. Client agrees not to remove any product identification, copyright notices, or other notices or proprietary restrictions from the Program.

3. COPYING RESTRICTIONS

The Program is the proprietary product of RJN and is protected by copyright law. Client may make one copy of the Program for backup purposes and may also use the Program in separate development, testing, training and production environments; other copies shall be made only to the extent of the number of licensed users as shown above or as otherwise provided herein.

4. RJN'S RIGHTS

By virtue of this Agreement, Client acquires only the right to use the Program and does not acquire any rights of ownership of the Program or the media upon which it is embodied. RJN shall at all times retain all rights, title, and interest in the Program and the media.

5. INDEMNIFICATION

RJN warrants that it has all legal rights necessary to make the grant of license herein by having all ownership, right, title and interest in and to the Program or as legally authorized licensee of all such necessary rights from the owner thereof. RJN shall defend, indemnify and hold Client harmless against all liability to any third party arising from the alleged violation of any third parties' trade secrets, proprietary information, trademark, copyright, patent rights, or intellectual property rights in connection with the grant of a license to the Client for the Program under this Agreement.

If a claim is made by a third party that use of the Program or any portion thereof infringes a U.S. patent, copyright or trade secret, upon receipt of Client's written notice of such claim, RJN will have the option, in RJN's sole discretion, to: (i) replace the Program with software or a system that is non-infringing, (ii) modify the Program system to make it non-infringing, or (iii) remove same and refund to Client all Fees paid for same after deduction of an appropriate charge based on actual use by Client prior to such removal. Notwithstanding the above, RJN shall indemnify, defend and hold harmless Client against claims by any such third party that the Program or a portion thereof infringes a U.S. patent, copyright or trade secret, unless the infringement results from Client's act or omission not authorized by or permitted by this License.

6. TRAINING AND IMPLEMENTATION ASSISTANCE

Training will be conducted on-site using the Client's System and data and includes fifteen (15) days of Training over four (4) trips.

RJN agrees to provide qualified staff for Training and Implementation Assistance of Client. RJN shall provide its reasonable best efforts to minimize disruption at the Client's site during RJN's performance of the Services. RJN shall perform all Services in a skillful, competent, professional manner.

RJN shall designate a project manager (the "RJN Project Manager"), use its reasonable best efforts to adhere to a project plan (as described in Schedule B of the Agreement and the Bid) and updates thereto; and complete any and all data conversions prior to the applicable Phase Production Start Date. RJN hereby designates Mr. Scott Rebman as the RJN contact for Implementation Assistance. RJN shall provide Client with Documentation and hereby grants Client the right to copy (at the expense of Client) or reproduce Documentation furnished pursuant to this License, at no additional charge.

RJN shall notify Client prior to RJN's incurrence of any expenses. Thereafter, if approved by the Client, expenses will be paid upon Client's receipt of itemized receipts for such expenses. In addition to travel and accommodations, it is the understanding of Client that per diem expenses of RJN's employees are included in expenses. Total daily expense for lodging, meals and entertainment shall not collectively exceed One Hundred Eighty-Three Dollars ($183.00) per day. All expenses incurred by RJN under the Agreement are included in the costs and commodity items described in Schedule B to the Agreement. No additional costs or expenses beyond those shown in Schedule B shall be incurred by the Client for RJN expenses and to achieve Final Acceptance under the Agreement without the prior written approval of the Director, Department of Public Works.

7. TERMINATION

Client may terminate this Agreement at any time. RJN may terminate this Agreement if the Client materially breaches any of its terms and conditions. Upon Client's termination for convenience or termination for default due to a material breach of Client, Client shall cease using the Program and shall return to RJN all copies of the Program including all modifications and merged portions in any form.

The following shall constitute a material breach and/or event of default under this License:

(a) if the other party becomes insolvent or bankrupt or makes an assignment for the benefit of creditors, or if a receiver or trustee in bankruptcy is appointed for the other party, or if any proceeding in bankruptcy, receivership, or liquidation is instituted against the other party and is not dismissed within 90 days following commencement thereof; or

(b) if the other party materially defaults in the performance or observance of any of its obligations hereunder and fails to remedy the default within 30 days after receiving written demand therefor; or

(c) if either party breaches the prohibition against disclosure of confidential information as set out in the Agreement; or

(d) RJN defaults under the Agreement, License, the Maintenance Agreement or Source Code Escrow Agreement; or

(e) if RJN or a significant portion of RJN is sold and the terms of the Agreement, License, the Maintenance Agreement, or Source Code Escrow Agreement, are not fulfilled by its successors or assigns under the same terms and conditions as stated in the Agreement, License, Maintenance Agreement or Source Code Escrow Agreement, respectively; or

(f) if RJN ceases operations for a period of time in excess of five (5) business days for any reasons and its successors and assigns, if any, refuse to undertake RJN's obligations under the Agreement, License, the Maintenance Agreement or Source Code Escrow Agreement, pursuant to the same terms and conditions of the Agreement, License, the Maintenance Agreement or Source Code Escrow Agreement , respectively; or

(g) if RJN sells, assigns or transfers a portion of the Software for which a license is granted under the License to a third party purchaser and the third-party refuses to undertake all of RJN's corresponding obligations under the Agreement, License, the Maintenance Agreement or Source Code Escrow Agreement, pursuant to the same terms and conditions of the Agreement, License, Maintenance Agreement or Source Code Escrow Agreement, respectively.

A material breach by RJN shall automatically invoke the rights of the Client to exercise its rights and remedies as is described in (a) Section 8 of the Agreement, (b) this License, and (c) the Source Code Escrow Agreement.

RJN and Client acknowledge and agree that in the event RJN commits a material breach of the Agreement, License, the Source Code Escrow Agreement, or the Maintenance Agreement, such material breach shall qualify as an event of release in the Source Code Escrow Agreement, and the license granted herein shall survive any resulting termination of the License by Client. Nothing contained in this License shall effect the operation of the license granted by RJN to Client should the Client elect not to enter into a Maintenance Agreement provided, however, that Client is not in material breach of its obligations of the Agreement, the Maintenance Agreement, or hereunder. This Section shall survive the termination and expiration of the Agreement, License, Maintenance Agreement and the Source Code Escrow Agreement.

In the event of the termination of this License or the Agreement or the Maintenance Agreement on account of a material breach by RJN prior to completion of Functional Acceptance testing by Client, RJN shall refund to Client those sums and amounts paid by Client (up to the date of such termination) to RJN on account of license fees for the Programs.

RJN shall place the source code for the Software in an escrow account with Escrow Agent pursuant to the Source Code Escrow Agreement. If, pursuant to the Source Code Escrow Agreement, the Client obtains a copy of the source code, the Client shall be restricted in its use of the source code to only those places, purposes and uses which are permitted herein for the Software.

If the parties to the Source Code Escrow Agreement terminate their contractual relationship, RJN shall, within thirty (30) days prior to the termination of the Escrow Agreement, enter into another escrow agreement with a suitable escrow agent under the same terms and conditions or Client has the right to obtain the Source Code as set forth in the Escrow Agreement.

8. WARRANTY

The following warranties shall be effective for one hundred eighty (180) days from the date of Functional Acceptance.

RJN warrants the Programs to be free of defects in materials and workmanship under normal use for a period of one hundred eighty (180) days from the time of Final Acceptance. RJN agrees to correct or replace, at its own expense, any Software that does not conform. RJN further warrants that the Programs, unless modified by Client, shall substantially perform the functions described in the Documentation provided by RJN and the Bid when operated on the designated hardware and Operating System. The warranty does not cover the Program if it has been altered or changed in any way by anyone other than RJN. RJN is not responsible for problems caused by changes in the operating characteristics of computer hardware or computer operating systems which are made after the release of the Program, nor for problems in the interaction of the Program with non-RJN software and not covered by the Software. RJN will promptly replace any defective diskette/CD, Software, or Documentation without charge if the defective diskette/CD, Software or Documentation is returned to RJN within one hundred eighty (180) days of Final Acceptance. If Client reports a defect in the Program within the warranty period, RJN shall, at its option, correct such defect, or provide Client a reasonable procedure to circumvent the defect. In the event RJN is unable to remedy such non-conformance using prompt reasonable efforts, at the direction of Client, RJN shall promptly instruct the Escrow Agent in writing to promptly release the Source Code (as defined in **Attachment E**) to Client. The express warranties set out by RJN in the Bid, Agreement and in this License are in lieu of all other warranties.

9. ADDITIONAL LICENSES/ADDITIONAL MODULES

For a two-year period following the execution of the Agreement, RJN shall grant additional concurrent user licenses and provide licenses to additional Software modules, upon Client's written request and at the rates specified in Attachment B of the Agreement.

10. LIMITATIONS OF LIABILITY

RJN to the extent permitted by applicable law, shall not be liable for any indirect, special, incidental, consequential, or other similar damages arising from use of the Programs even if RJN or its agent has been advised of the possibility of such damages. RJN's liability for damages hereunder shall in no event exceed the greater of the (a) amount of actual damages incurred by the Client or (b) amount of paid licenses fees by Client. This limitation of liability shall not apply to claims for injuries to persons or damages to property caused by the negligence or fault of RJN or in the event of a third party claim for which RJN has a duty of indemnification under this License or to any claim that is covered by insurance or for a claim made for a material breach by RJN of Client confidential information.

11. EXPORT ADMINISTRATION

If the Program is for use outside the United States, Client agrees to first notify RJN. Client will comply fully with all relevant regulations of the United States Department of Commerce and with the United States Export Administration Act to assure that the Program and media are not exported in violation of United States law.

12. GOVERNING LAW

The Agreement is governed by the laws of the State of Maryland.

Attachment D to Agreement
RJN GROUP, INC.
MAINTENANCE AND SUPPORT AGREEMENT

Subject to the following terms and conditions of this RJN Group, Inc. Maintenance and Support Agreement ("Maintenance Agreement"), RJN Group, Inc. referred to as "RJN" or "Contractor" agrees to provide to Baltimore County, Maryland referred to as the "Client" or "County" maintenance and support for concurrent users of the Programs and for operation on the Client's System as indicated below.

DEFINITIONS:

I. "Defect" means a failure of the Software, Support Release or Technological Release to perform the designed functionality and caused by an error in the application.

II. "Escrow Agreement" means the Software Source Code Escrow Agreement executed of even date herewith by and between RJN, the Client, and Escrow Agent, attached hereto and incorporated herein.

III. "Maintenance" means Support Releases and Technological Releases as provided by RJN, without further license fees, in conjunction with Services.

IV. "License Agreement" means the Software License Agreement executed by and between RJN and the Client of even date herewith, attached hereto and incorporated herein.

V. "Support" means: (a) responding to inquiries concerning a reported Defect(s) in the Software; and (b) correction to problems diagnosed as Defects in the currently supported version of the Software. In the resolution of Defects, RJN may respond with a written response, CD-ROM or diskette, supplementary documentation, a temporary means of circumventing the problem pending a Support Release, or other correctional aids.

VI. "Support Release" means the improved releases of the Software, which is generally made available to supported customers. Support Releases may contain modifications, refinements and enhancements that RJN elects to incorporate into and make a part of the Software and does not separately price or market and may include resolution to known problems.

VII. "Technological Release" means technological improvements required to allow the Software to operate in conformance with current technology.

VIII. "Agreement" means the Contract Agreement executed by and between RJN and the Client of even date herewith and attached hereto and incorporated herein.

IX. "Cost Basis Total" means the collective concurrent user License fee determined annually to establish the cost basis and used to calculate the Annual Support Fee due hereunder as further described in Attachment B of the Agreement.

X. "Initial Support Period" means the period ending one hundred eighty (180) days after Final Acceptance and during which the Support and Maintenance provided by RJN under this Maintenance Agreement shall be without charge.

XI. "System" or "Operating System" means the Client system designed to control the hardware of a specific data-processing system for users and application programs; Operating

System also controls the execution of programs; provides services, including but not limited to, resource allocation, scheduling, input/output control, and data management.

XII. "Annual Support Fee" means the annual fee due hereunder and to be paid by Client to RJN on an annual basis commencing at the expiration of the Initial Support Period. Calculation of the Annual Support Fee shall be based upon the formula of twenty percent (20%) times the Cost Basis Total.

1. TERM OF AGREEMENT

This Maintenance Agreement shall become effective when authorized in writing by the Client and Maintenance and Support services shall begin at such time. Receipt by RJN of a fully executed Maintenance Agreement shall constitute authorization by Client.

2. AGREEMENT RENEWAL

RJN will provide written notice to the Client within thirty (30) days of expiration of the Initial Term and each subsequent annual term with information pertaining to any changes in Program support, cost, and/or scope. Renewal of this Maintenance Agreement shall be in accordance with Article 3 of the Agreement.

3. RESPONSIBILITIES OF RJN

RJN will assist in resolving both Oracle errors and application specific errors. RJN will provide the Client with Technological Releases, Support Releases and Support and Maintenance to the Program files. RJN will provide the Client with telephone support on a 1-800 toll free telephone line. Telephone, e-mail, and dial-up support shall be available workdays from 7:00 AM to 5:00 PM EST. RJN warrants that it shall perform Support in accordance with the standard of care and diligence normally practiced by software firms performing services of a similar nature and with the performance criteria set forth in the Bid and the Agreement and this Maintenance Agreement. RJN will make every effort to complete all agreed upon maintenance in a timely manner. If problems cannot be resolved within a reasonable time over the telephone, RJN will work with the Client to perform the following:

a) Define steps to duplicate and isolate the program or data issue.
b) Using dial-up access to the Client's System, RJN will attempt to duplicate and isolate the program or data issue.
c) RJN will assist the Client in preparing a back-up of the requested Program files and data (Oracle export) for in-house debugging by RJN Technical Support.
d) At an additional expense, RJN will provide on site assistance on a time and materials basis to duplicate, isolate, and correct the program or data issue.

In the provision of Support, RJN shall adhere to the following response standards:

SEVERITY LEVEL ONE

Severity Level One Response Time

RJN shall respond by telephone to the Client within one (1) hour of initial notification to RJN.

Severity Level One Resolution Time

RJN shall provide its best efforts to effect a resolution within twelve (12) hours of the initial notification.

Severity Level One Resolution

RJN shall provide a Program correction, Program patch or a procedure for Client to bypass or work around the error condition in order to resume operations. If a bypass procedure is utilized, RJN shall continue error correction activity, on a high priority basis, until a Program correction or patch is provided.

SEVERITY LEVEL TWO

Severity Level Two Response Time

RJN shall respond by telephone or electronic means to Client within two (2) hours of initial notification to RJN. If the initial notification was not by telephone or not during RJN's business hours, this response time shall start when the notification is received by Support personnel.

Severity Level Two Resolution Time

RJN shall provide its best efforts to effect a resolution within twenty-four (24) hours of initial notification to RJN.

Severity Level Two Resolution

RJN shall provide Client with a Program correction, Program patch or a procedure to bypass or work around the error condition in order to continue operations. If a bypass procedure is utilized, RJN shall continue error correction activity until a Program correction or Program patch is provided.

SEVERITY LEVEL THREE

Severity Level Three Response Time

RJN shall respond by telephone to Client within four (4) hours of initial notification to RJN. If the initial notification was not by telephone or not during RJN's business hours, this response time shall start when the notification is received by Support personnel.

Severity Level Three Resolution Time

RJN shall provide its best efforts to effect a resolution with a Support Release. For errors relating to the inability to generate certain reports, RJN shall provide a Program correction within thirty (30) days.

Severity Level Three Resolution

RJN shall provide Support Releases and any Technological Releases in the form of CD-ROM, diskette or electronic file transfer.

If RJN fails to effect a resolution of a Severity Level One, Two or Three incident within the response standards described herein, RJN will credit the Client 1/365th of the Annual Support Fee associated with this Maintenance Agreement for each twenty-four (24) hour period beyond the applicable response standard until RJN effects the resolution of the Severity Level incident.

During the Initial Support Period, for purposes of calculating the penalties as set forth above, the Annual Support Fee under this Maintenance Agreement shall be deemed to be Twelve Thousand Eight Hundred Dollars and No Cents ($12,800.00). Thereafter the penalties shall be calculated based upon the actual due and owing Annual Support Fee.

RJN shall endeavor to assist with all inquiries made to Support personnel. However, if the inquiry is not related to a problem with the Program, RJN shall be entitled to charge the Client on a time and materials basis at the rates set forth in Schedule B of the Agreement.

Escalation Procedure: If at any time the Client believes that RJN is not providing sufficient service on a Technical Service Request ("TSR"), the problem can be expedited by the Client contacting RJN's Customer Support Manager directly by telephone. The Customer Support Manager will return the call within two hours during the support to discuss the situation. If the Customer Support Manager cannot resolve the issue, the Client may request succeeding levels of escalation up to and including an officer in RJN's management. At each level of escalation, RJN's Management assumes responsibility for the problem, coordinating problem resolution, and bringing additional resources to the situation as needed. RJN will log all TSRs into a database and will provide an initial response to the Client on the problem within the established period of time for the assigned severity level. TSRs will remain open until no further action is required. This means that a mutually acceptable solution (fix or workaround) has been provided, and RJN has not received a call back from the Client in more than fourteen (14) days.

RJN shall maintain continuously and update the Software source code deposited with the Escrow Agent.

4. RESPONSIBILITIES OF CLIENT

As a condition to this Maintenance Agreement, Client agrees to provide on-site support for the System from client personnel, information systems staff or local third party contractor. Minimal responsibilities of this individual are:

a) The Client shall notify RJN immediately of any Program malfunction. The Client shall allow RJN required access via remote dial-up or backup of the Program files and data (Oracle export).

b) Coordinate upgrades of System hardware, network connectivity and Operating Systems with RJN Technical Support to ensure compatibility with installed version of Software, Oracle RDBMS, and other operational components. For Oracle RDBMS support that is provided directly from Oracle Corporation (fulluse licenses), this coordination will include RJN Technical Support, Client's support personnel, and an Oracle support representative.

c) Maintain and keep current support for the Oracle RDMBS through either RJN (runtime licenses) or with Oracle Corporation (fulluse licenses).

d) Maintain and keep current support contracts or provide internal support for System and Operating System, utility software, network, personal computer systems and network server hardware. This includes workstation and server protection for power interruption and software virus protection.

e) Perform backup and restore procedures of Operating System, configurations, and application software. This includes consistent and regular backups and exports of the Oracle RDBMS and System files according to the instructions and directions of RJN Technical Support.

f) Monitor and adjust database performance, available disk space and security. Other database administration duties include but are not limited to:

- controlling and monitoring user access to the database
- enrolling new users and maintaining System security
- planning for backup and recovery of database information
- maintaining archived backups
- modifying the database structure as directed by RJN Technical Support or Oracle

5. PAYMENT

RJN and Client agree that Support and Maintenance fees due under this Maintenance Agreement are waived by RJN for the Initial Support Period. Thereafter, the calculation of the Annual Support Fee shall be at a rate of twenty percent (20%) of the Cost Basis Total. Payment of all compensation under this Maintenance Agreement is governed by Section 2 and Schedule B of the Agreement attached hereto and incorporated herein.

6. GENERAL

Any purchase order issued by Client to RJN pertaining to this Agreement shall be deemed to incorporate the terms and conditions of this Agreement.

Termination of this Maintenance Agreement shall be governed by Sections 5 and 8 of the Agreement. However, in the event of the termination of this Maintenance Agreement by Client on account of a material default by RJN, Client shall retain the Program and the license granted to Client under the License Agreement shall survive. In addition, Client may pursue all rights and remedies as may be available under the Agreement, License Agreement, and the Source Code Escrow Agreement.

Attachment E to Agreement
SOFTWARE SOURCE CODE ESCROW AGREEMENT

Master Preferred Agreement

Master Preferred offers the flexibility of a modifiable contract combined with a high level of protection for both the depositor and the beneficiary. It allows for additional parties to accept contract conditions with a one-page addendum. It provides frequent correspondence between DSI and all parties to the agreement. The depositor and beneficiary will receive signed confirmations from DSI that every deposit has been inspected; an account history report every six months to notify them of the status of the escrow; and ongoing monitoring services to ensure compliance of contract terms.

Purpose

DSI's Master Preferred Agreement is generally used when:

- Both parties agree that a high level of escrow protection is needed
- The depositor or the beneficiary wants to establish an escrow contract that is executed once, defining the company's preferred terms.
- The depositor has multiple products to be licensed independently by various beneficiaries.
- Both parties want to reduce the time spent on negotiating the basic terms and conditions of the escrow agreement.
- Clients want to avoid setup costs when adding beneficiaries or depositors to their escrow account.

Features

Master Preferred customers benefit from these unique features.

- One agreement ensures consistency for all escrow requirements.
- Additional parties accept contract conditions with a one-page form.
- Tailored release conditions.
- Modification of terms for unique requirements
- Written notification detailing the contents of the initial deposit and each update.
- Semiannual account histories listing all deposit activity.
- DSI direct billing to beneficiary.
- Technical verification options.
- Audit trail of deposit created through inspection, date stamping of all deposit materials.
- Deposit inspection with signed receipt for all parties.
- Grant of use rights and deposit content definition.

Your DSI Representative is:
Christopher R. Perkins
2100 Norcross Pkwy, Suite 150
Norcross, GA 30071
Tel: 770-239-9200 X-117
FAX 770-239-9201
Email: Christopher.perkins@ironmountain.com

MASTER PREFERRED ESCROW AGREEMENT

Beneficiary Company Number 23207

This agreement ("Agreement") is effective March 1, 2004 among DSI Technology Escrow Services, Inc. ("DSI"), Baltimore County, Maryland ("Preferred Beneficiary") and any additional party signing the Depositor Acceptance Form attached to this Agreement ("Depositor"), who collectively may be referred to in this Agreement as the parties ("Parties").

A. Depositor and Preferred Beneficiary have entered or will enter into a Contract with attachments A through E, and/or other agreement regarding certain proprietary technology of Depositor (collectively referred to in this Agreement as the "License Agreement").

B. Depositor desires to avoid disclosure of its proprietary technology except under certain limited circumstances.

C. The availability of the proprietary technology of Depositor is critical to Preferred Beneficiary in the conduct of its business and, therefore, Preferred Beneficiary needs access to the proprietary technology under certain limited circumstances.

D. Depositor and Preferred Beneficiary desire to establish an escrow with DSI to provide for the retention, administration and controlled access of the proprietary technology materials of Depositor.

E. The parties desire this Agreement to be supplementary to the License Agreement pursuant to 11 United States Bankruptcy Code, Section 365(n).

ARTICLE 1 -- **DEPOSITS**

1.1. Obligation to Make Deposit. Upon the signing of this Agreement by the Parties, and the simultaneous signing of the Depositor Acceptance Form, Depositor shall deliver within fifteen (15) business days to DSI the proprietary technology and other materials required to be deposited by the License Agreement and the materials identified in Exhibit A, ("Deposit Materials") attached hereto and incorporated herein and such Exhibit shall be signed by the Preferred Beneficiary and the Depositor. DSI shall have no obligation to Depositor or Preferred Beneficiary with respect to the preparation, accuracy, execution by the other parties, signing, delivery or validity of Exhibit A.

1.2. Identification of Tangible Media. Prior to the delivery of the Deposit Materials to DSI, Depositor shall conspicuously label for identification each document, and readable compact disk upon which the Deposit Materials are written or stored. Additionally, Depositor shall complete Exhibit B to this Agreement, attached hereto and incorporated herein, by listing each such media by the item label description, the type of media and the quantity. Exhibit B shall be signed by Depositor and delivered to DSI with the Deposit Materials. Unless and until Depositor makes the initial deposit with DSI, DSI shall have no obligation with respect to this Agreement, except the obligation to notify the Parties regarding the status of the account as required in Section 2.2 below.

1.3. Acceptance of Deposit. When DSI receives the Deposit Materials and Exhibit B, DSI will conduct a visual deposit inspection. At completion of the deposit inspection, if DSI determines that the labeling of the media matches the item descriptions and quantity on Exhibit B, DSI will date and sign Exhibit B and mail a copy thereof to Depositor and Preferred Beneficiary. If DSI determines that the labeling does not match the item descriptions or quantity on Exhibit B, DSI will (a) note the discrepancies in writing on Exhibit B; (b) date and sign Exhibit B with the exceptions noted; and (c) mail a copy of Exhibit B to Depositor and Preferred Beneficiary. DSI's acceptance of the deposit occurs upon the signing of Exhibit B by DSI. Delivery of the signed Exhibit B to Preferred Beneficiary is Preferred Beneficiary's notice that the Deposit Materials have been received and accepted by DSI. OTHER THAN DSI'S INSPECTION OF THE DEPOSIT MATERIALS, AS DESCRIBED ABOVE, DSI SHALL HAVE NO OBLIGATION REGARDING THE ACCURACY, COMPLETENESS, FUNCTIONALITY, PERFORMANCE OR NON-PERFORMANCE OF THE DEPOSIT MATERIALS. However, DSI hereby acknowledges and agrees DSI's duty to safeguard, maintain and protect the Deposit Materials.

1.4. Depositor's Representations. During the term of this Agreement, Depositor represents as follows:

a. Depositor lawfully possesses all of the Deposit Materials deposited with DSI;

b. With respect to all of the Deposit Materials and any materials provided solely for verification, pursuant to Section 1.5 of the Agreement ("Test Materials") Depositor has the right and authority to grant to DSI and Preferred Beneficiary the rights as provided in this Agreement, provided further that DSI's or its independent contractor's use of any Deposit Materials or Test Materials, pursuant to Section 1.5 of this Agreement, is lawful and does not violate the rights of any third parties as long as such is in compliance with the terms hereof;

c. As of the effective date of this Agreement, the Deposit Materials are not the subject of any liens or encumbrances, however, any liens or encumbrances made after the execution of this Agreement will not prohibit or limit the rights and obligations of DSI under this Agreement;

d. The Deposit Materials consist of the proprietary technology and other materials identified either in the License Agreement, Exhibit A, or Exhibit B, as the case may be; and

e. The Deposit Materials are readable and useable in their current form or, if any portion of the Deposit Materials is encrypted, the decryption tools and decryption keys have also been deposited.

1.5. Available Verification Services. Upon receipt of Preferred Beneficiary's written request, the Parties may enter into a separate proposal agreement ("Statement of Work") pursuant to which DSI will agree, upon certain terms and conditions, to inspect the Deposit Materials consistent with one or several of the levels of verification described in the attached Technical Verification Options. Depositor consents to DSI's performance of the level of verification described in the Technical Verification Options attached hereto and incorporated herein. Depositor shall reasonably cooperate with DSI by providing its facilities, computer software systems, and technical and support personnel for verification whenever reasonably necessary at the sole expense of Preferred Beneficiary. If additional verification is elected after the Deposit Materials have been delivered to DSI, then only DSI, or at DSI's election, an independent contractor or company selected by DSI may perform the verification.

In either event DSI shall maintain the confidentiality of the Deposit Materials in accordance with Article 2 herein and any independent contractor chosen to review same shall be subject to the reasonable consent of Depositor, shall not be a competitor of Depositor and shall execute a confidentiality agreement in accordance with Article 2 herein.

1.6. Deposit Updates. Unless otherwise provided by the License Agreement, Depositor shall update the Deposit Materials within sixty (60) days of each release of a new version of the product or of any of the Deposit Materials, which is subject to the License Agreement or this Agreement. Such updates will be added to the existing deposit. All deposit updates shall be listed on a new Exhibit B and Depositor shall sign the new Exhibit B. DSI and Depositor shall each promptly forward a copy of each and every new Exhibit B to the Preferred Beneficiary. Each Exhibit B will be held and maintained separately within the escrow account. An independent record will be created which will document the activity for each Exhibit B. Any deposit updates shall be held in accordance with Sections 1.2 through 1.4 above. All references in this Agreement to the Deposit Materials shall include the initial Deposit Materials and any updates.

1.7. Removal of Deposit Materials. The Deposit Materials may be removed and/or exchanged only on written instructions signed by Depositor and Preferred Beneficiary, or as otherwise provided in this Agreement.

ARTICLE 2 – CONFIDENTIALITY AND RECORD KEEPING

2.1 Confidentiality. DSI and any independent contractors per Article 1.5, (for purposes of this Article 2 the term DSI shall include any independent contractors chosen per Article 1.5) shall have the obligation to reasonably protect the confidentiality of the Deposit Materials. Except as provided in this Agreement or any subsequent agreement between the Parties, including without limitation Section 1.5, DSI, shall not disclose, transfer, make available, or use the Deposit Materials. DSI shall not disclose the terms of this Agreement to any third party. If DSI receives a subpoena or any other order from a court or other judicial tribunal pertaining to the disclosure or release of the Deposit Materials, DSI will immediately notify the Parties unless prohibited by law. It shall be the responsibility of Depositor and/or Preferred Beneficiary to challenge any such order; provided, however, that DSI does not waive its rights to present its position with respect to any such order. DSI will not be required to disobey any order from a court or other judicial tribunal including, but not limited to, notices delivered pursuant to Section 7.6 below. DSI shall request of the competent authority requiring deposit or disclosure that such be deemed confidential and only disclosed in camera.

2.2 Status Reports. DSI shall provide to Depositor and Preferred Beneficiary a report profiling the account history semiannually.

ARTICLE 3 -- **RIGHT TO MAKE COPIES**

3 Right to Make Copies. Only with the prior written consent of Preferred Beneficiary shall DSI have the right to make copies of the Deposit Materials to perform this Agreement. DSI shall copy all copyright, nondisclosure, and other proprietary notices and titles contained on the Deposit Materials onto any copies made by DSI. With all Deposit Materials submitted to DSI, Depositor shall provide any and all instructions as may be necessary to duplicate the Deposit Materials, including, but not limited to, the hardware and/or software needed. Any copying expenses incurred by DSI as a result of a request to copy will be borne by the party requesting the copies. Depositor agrees to provide its reasonable cooperation in DSI's copying of the Deposit Materials in order for DSI to perform this Agreement.

ARTICLE 4 -- **RELEASE OF DEPOSIT**

4.1 Release Conditions. As used in this Agreement, "Release Condition" shall mean the following:

a) Bankruptcy proceedings are filed by Depositor; or
b) Dissolution or termination of Depositor as a corporate entity without a successor entity assuming the obligations to maintain the Source Code (as defined in the License Agreement) and the obligations hereunder and under the License Agreement; or
c) Depositor becomes insolvent, makes an assignment for the benefit of creditors or is placed or to be placed in receivership; or
d) Depositor's termination of support for the Software (as defined in the License Agreement) modules purchased by Preferred Beneficiary under the License Agreement; or
e) if any proceeding in bankruptcy, receivership, or liquidation is instituted against Depositor and is not dismissed within ninety (90) days following commencement thereof; or
f) if any lien or encumbrance is placed upon the Software or the Deposit Materials (as defined in the License Agreement).
g) if Depositor materially defaults in the performance or observance of any of its obligations hereunder and fails to remedy the default after all applicable cure periods within thirty (30) days after receiving written demand therefor; or
h) Depositor materially defaults under the License Agreement, after all applicable cure periods within thirty (30) days after receiving written notice thereof; or
i) if Depositor ceases operations for a period of time in excess of five (5) business days for any reasons and its successors and assigns, if any, refuse to undertake Depositor's obligations under the License Agreement, pursuant to the same terms and conditions of the License Agreement; or
j) if Depositor sells all or a portion of the Software (as defined in the License

Agreement) for which a license is granted to Preferred Beneficiary under the License Agreement to a third party purchaser and the purchaser of said Software (as defined in the License Agreement) or license(s) refuses to undertake all of Depositor's corresponding obligations under the License Agreement, pursuant to the same terms and conditions of the License Agreement; or

k) Depositor has ceased supporting the Software (as defined in the License Agreement) in compliance with it's obligations under the License Agreement between the parties; or

l) in the event that DSI notifies the Parties that DSI shall terminate this Agreement, the Preferred Beneficiary and Depositer shall, within thirty (30) days prior to DSI's termination of this Agreement, enter into another escrow agreement with a suitable escrow agent under the same terms and conditions stipulated herein or the notice of termination by DSI shall result in a Release Condition.

4.2 Filing For Release. If Preferred Beneficiary or Depositor ("requesting party") believes in good faith that a Release Condition has occurred, Preferred Beneficiary or Depositor respectively, may provide to DSI written notice of the occurrence of the Release Condition and a request for the release of the Deposit Materials. Such notice shall be signed by the Preferred Beneficiary or Depositor as the case may be on their respective letterhead. Unless DSI acknowledges or discovers independently, or through the Parties, its need for additional documentation or information in order to comply with this Section, DSI shall promptly provide a copy of the notice to each of the parties hereto by commercial express next day mail. Such need for additional documentation or information may extend the time period for DSI's performance under this Section, but not for more than ten (10) business days.

4.3 Contrary Instructions. DSI shall mail the notice requesting release of the Deposit Materials within three (3) business days of DSI's receipt thereof, to the non-requesting party. The non- requesting party shall have ten (10) business days to deliver to DSI and the requesting party written contrary instructions ("Contrary Instructions"). Contrary Instructions shall mean the written representation by the non-requesting party that a Release Condition has not occurred or has been cured. Contrary Instructions shall be signed by the non- requesting party on its letterhead. Upon receipt of Contrary Instructions, DSI shall promptly send a copy to the requesting party within three (3) business days of DSI's receipt thereof by next day commercial express mail. Additionally, DSI shall notify in writing, within three (3) business days, both Depositor and Preferred Beneficiary that there is a dispute to be resolved pursuant to Section 7.4 of this Agreement. Subject to Section 5.2 of this Agreement, DSI will continue to store the Deposit Materials without release pending (a) joint instructions from Depositor and Preferred Beneficiary; (b) dispute resolution pursuant to Section 7.4; or (c) an order from a court of competent jurisdiction.

4.4 Release of Deposit. If DSI does not receive Contrary Instructions from the non-requesting party, DSI shall immediately release the Deposit Materials to the requesting party. In no event shall the requesting party or non- requesting party be other than the parties to this agreement. Except as stated otherwise elsewhere herein, any fees due DSI under this Agreement shall be due solely from Preferred Beneficiary. Any copying expense due pursuant to the terms of this Agreement will be chargeable to the requesting party. Upon any such release, the escrow arrangement for the materials so released will terminate as it relates to the Depositor and Preferred Beneficiary involved in the release. The escrow arrangement will remain in place for the other Deposit Materials not released.

4.5 Right to Use Following Release. Unless otherwise provided in the License Agreement, upon release of the Deposit Materials in accordance with this Article 4, Preferred Beneficiary shall have the right to use the Deposit Materials for the sole purpose of continuing the benefits afforded to Preferred Beneficiary by the License Agreement. Preferred Beneficiary shall be obligated to maintain the confidentiality of the released Deposit Materials.

ARTICLE 5 -- **TERM AND TERMINATION**

5.1 Term of Agreement. The initial term of this Agreement is for a period of one (1) year. Thereafter, this Agreement shall automatically renew from year to year unless (a) Depositor and Preferred Beneficiary jointly instruct DSI in writing that the Agreement is terminated; (b) DSI instructs Depositor and Preferred Beneficiary in writing after its renewal date that the Agreement is terminated for nonpayment in accordance with Section 5.2; or (c) Preferred Beneficiary instructs DSI in writing that the Agreement is terminated due to an adjudged material breach of Agreement by DSI in which event Preferred Beneficiary may exercise any rights and remedies available under this Agreement, including but not limited to, suspension of DSI's authority to received undisbursed funds hereunder or enforce any other rights and remedies available under the Agreement, at law or in equity; or (d) Preferred Beneficiary reserves the right to terminate this Agreement, for any reason, by providing DSI and Depositor sixty (60) days written notice of its intent to terminate this Agreement; (e) DSI reserves the right to terminate this Agreement, for any reason, other than for nonpayment, by providing Depositor and Preferred Beneficiary sixty (60) days written notice of its intent to terminate this Agreement. The Depositor and Preferred Beneficiary understand and agree that the Deposit Materials will be delivered to DSI within fifteen (15) business days from the date hereof and that the Acceptance Form shall be signed within five (5) business days from the date hereof. If the Acceptance Form has been signed at a date later than this Agreement, the initial term of the Acceptance Form will be for one (1) year with subsequent annual terms to be adjusted to match the anniversary date of this Agreement.

5.2 Termination for Nonpayment. In the event of the nonpayment of fees owed to DSI under this Agreement, DSI shall provide written notice of delinquency to all Parties to this Agreement affected by such delinquency. Any such party shall have the right to make the payment to DSI to cure the default. If the past due payment is not received in full by DSI within one (1) month of the date of the party's receipt of such notice, then at any time thereafter DSI shall have the right to terminate this Agreement by sending written notice of termination to all parties. In the event DSI has so notified the parties and the one (1) month cure period has elapsed, then DSI shall have no obligation to take any action under this Agreement so long as any payment due to DSI remains unpaid and DSI may return all Deposit Materials to Depositor.

5.3 Disposition of Deposit Materials Upon Termination. Subject to the foregoing termination provisions, and upon termination of this Agreement, DSI shall destroy, return, or otherwise deliver the Deposit Materials in accordance with Depositor's instructions. If there are no instructions, DSI shall return them to Depositor. If DSI is unable to return the Deposit Materials to the Depositor at their last known address, DSI may at its discretion destroy the materials. DSI shall have no obligation to destroy or return the Deposit Materials if the Deposit Materials are subject to another escrow agreement with DSI or have been released to the Preferred Beneficiary or Depositor in accordance with Section 4.4.

5.4 Survival of Terms Following Termination. Upon termination of this Agreement, the following provisions of this Agreement shall survive:

a. The obligations of confidentiality with respect to the Deposit Materials;

b. The obligation to pay DSI any fees and expenses due under this Agreement, absent the event of an adjudged DSI material breach;

c. The provisions of Article 7; and

d. Any provisions in this Agreement which specifically state they survive the termination of this Agreement.

ARTICLE 6 -- **DSI'S FEES**

6.1 Fee Schedule. DSI is entitled to be paid its standard fees and expenses applicable to the services provided. DSI shall notify the Depositor and Preferred Beneficiary at least sixty (60) days prior to any increase in fees. DSI hereby agrees to cap any increase of fees hereunder to ten percent (10%). For any service not listed on DSI's standard fee schedule, DSI will provide a quote prior to rendering the service, if requested. All fees and expenses hereunder shall be paid by either party.

6.2 Payment Terms. DSI shall not be required to perform any service unless payment of any outstanding balances owed to DSI are paid in full. Initial fees are due upon receipt of a signed contract or receipt of the Deposit Materials whichever is earliest. Payments on all renewal and services invoices are due net thirty (30) days from date of the party's receipt of such invoice. If invoiced fees are not paid, DSI may terminate this Agreement in accordance with Section 5.2.

ARTICLE 7 -- **LIABILITY AND DISPUTES**

7.1 Right to Rely on Instructions. DSI may act in reliance upon any instruction, instrument, or signature reasonably believed by DSI to be genuine. DSI may only act and rely upon notices and communications received from the designated contact of Depositor and Preferred Beneficiary as designated on Exhibit C attached hereto and incorporated herein. DSI will not be required to inquire into the truth or evaluate the merit of any statement or representation contained in any notice or document. DSI shall not be responsible for failure to act as a result of causes beyond the reasonable control of DSI.

7.2 Indemnification. Depositor and Preferred Beneficiary each agree to indemnify, defend and hold harmless DSI from any and all claims, actions, damages, and expenses, costs, attorney's fees and other direct liabilities ("Liabilities") incurred by DSI relating in any way to this escrow arrangement except where it is adjudged that DSI acted with negligence, or willful misconduct. All liability of and indemnification by Preferred Beneficiary shall be subject to the limitations of liability as prescribed by the Maryland Local Government Tort Claims Act.

7.3 Limitation of Liability. In no event will DSI be liable for any incidental, indirect, special, exemplary, punitive or consequential damages, including, but not limited to, damages (including loss of data, revenue, and/or profits) costs or expenses (including legal fees and expenses), whether foreseeable or unforeseeable, that may arise out of or in connection with this Agreement. DSI shall be liable only for actual damages but in no event shall the collective liability of DSI exceed ten times the fees collectively paid under this Agreement. The foregoing limitation of liability does not apply with respect to any acts of gross negligence, willful misconduct, personal injury claims, property damage claims (excluding the Deposit), or intellectual property infringement.

7.4 Dispute Resolution. Any Party may submit any dispute relating to or arising from this Agreement to any court of competent jurisdiction in Baltimore County, Maryland for an interpleader or similar action. Unless adjudged otherwise, any costs of litigation incurred by DSI, including reasonable attorney's fees and costs, shall be divided equally and paid by Depositor and Preferred Beneficiary.

7.5 Controlling Law. This Agreement is to be governed and construed in accordance with the laws of the State of Maryland, without regard to its conflict of law provisions.

7.6 Notice of Requested Order. If any Party intends to obtain an order from any court of competent jurisdiction, which may direct DSI to take, or refrain from taking any action, that party shall:

a. Give DSI at least five (5) business days prior notice of the hearing;

b. Include in any such order that, as a precondition to DSI's obligation, DSI be paid in full for any past due fees and be paid for the reasonable value of the services to be rendered pursuant to such order; and

c. Ensure that DSI not be required to deliver the original (as opposed to a copy) of the Deposit Materials if DSI may need to retain the original in its possession to fulfill any of its other duties.

ARTICLE 8 -- **GENERAL PROVISIONS**

8.1 Entire Agreement. This Agreement, which includes and incorporates the Acceptance Form and Exhibits described herein, embodies the entire understanding among all of the parties with respect to its subject matter and supersedes all previous communications, representations or understandings, either oral or written. DSI is not a party to the License Agreement between Depositor and Preferred Beneficiary and has no knowledge of any of the terms or provisions of any such License Agreement. DSI's only obligations to Depositor or Preferred Beneficiary are as set forth in this Agreement. No amendment or modification of this Agreement shall be valid or binding unless signed by all the Parties hereto.

8.2 Notices and Correspondence. All notices regarding Articles 4 and 5, and any Deposit Materials, shall be sent by commercial express next day delivery. All other correspondence including invoices, payments and other documents and communications shall be sent First Class U.S. Mail and given to the parties at the addresses specified in the attached Exhibit C and Acceptance Form. It shall be the responsibility of the parties to notify each other as provided in this Section in the event of a change of physical and e-mail addresses. The parties shall have the right to rely on the last known address of the other parties. Any correctly addressed notice or last known address of the other parties that is relied on herein that is refused, unclaimed, or undeliverable because of an act or omission of the party to be notified as provided herein shall be deemed effective as of the first date that said notice was refused, unclaimed, or deemed undeliverable by the postal authorities by mail, through messenger or commercial express delivery services.

8.3 Severability. In the event any provision of this Agreement is found to be invalid or unenforceable, the parties agree that unless it materially affects the entire intent and purpose of this Agreement, such invalidity or unenforceability shall affect neither the validity of this Agreement nor the remaining provisions herein, and the provision in question shall be deemed to be replaced with a valid and enforceable provision most closely reflecting the intent and purpose of the original provision.

8.4 Successors and Assigns. This Agreement shall be binding upon and shall inure to the benefit of the successors and assigns of the Parties as such may be permitted in the License Agreement between Depositor and Preferred Beneficiary. However, DSI shall have no obligation in performing this Agreement to recognize any successor or assign of Depositor or Preferred Beneficiary unless DSI receives prior written consent of the Parties.

8.5 Waiver. Any term of this Agreement may be waived by the party entitled to the benefits thereof, provided that any such waiver must be in writing and signed by the party against whom the enforcement of the waiver is sought. No waiver of any condition, or breach of any provision of this Agreement, in any one or more instances, shall be deemed to be a further or continuing waiver of such condition or breach.

8.6 Regulations. Depositor is responsible for and warrants its compliance with all applicable laws, rules and regulations, including but not limited to customs laws, import, export, and re-export laws and government regulations of any country from or to which the Deposit Materials may be delivered in accordance with the provisions of this Agreement. Preferred Beneficiary is responsible for and warrants its compliance with all applicable laws, rules and regulations.

8.7 Attorney's Fees. In any litigation or other proceeding by which one party either seeks to enforce its rights under this Agreement (whether in contract, tort, or both) or seeks declaration of any rights or obligations under this Agreement (whether in contract, tort, or both), the prevailing party who has proven in court by court decree, judgment that the other party has materially breached its representation and/or warranty under this

Agreement shall be awarded reasonable attorneys' fees, together with any costs and expenses, to resolve the dispute and to enforce final judgment.

8.8 No Third Party Rights. This Agreement is made solely for the benefit of the Parties to this Agreement and their respective permitted successors and assigns, and no other person or entity shall have or acquire any right by virtue of this Agreement unless otherwise agreed to by all the Parties hereto.

8.9 Authority to Sign. Each of the Parties herein represents and warrants that the execution, delivery, and performance of this Agreement has been duly authorized and signed by a person who meets statutory or other binding approval to sign on behalf of its business organization as named in this Agreement and each party herein represents and warrants it shall perform its obligations under this Agreement.

8.10 Counterparts. This Agreement may be executed in any number of counterparts, each of which shall be an original, but all of which together shall constitute one instrument.

BALTIMORE COUNTY, MARYLAND
PREFERRED BENEFICIARY

By: [signature]

Name: Anthony G. Marchione

Title: Administrative Officer

Date: 02/25/04

DSI TECHNOLOGY ESCROW SERVICES, INC.

By: [signature]

Name: FRANK A. BRUNO

Title: REGIONAL SALES MANAGER

Date: 3/19/04

Baltimore County Office of Law
APPROVED FOR LEGAL FORM & SUFFICIENCY (subject to execution by a duly authorized County Administrative Official. Approval of Legal Form and Sufficiency Does Not Convey Approval Or Disapproval of the Substantive Nature of This Transaction.)

[signature] 02-24-04
Joyce A. Stroupe
Assistant County Attorney

RECOMMENDED FOR APPROVAL:

By: [signature]
Thomas G. Iler
Office of Information Technology

DEPOSITOR ACCEPTANCE FORM FOR MASTER PREFERRED AGREEMENT

Beneficiary Company Number 23207

Depositor, Preferred Beneficiary and DSI Technology Escrow Services, Inc. ("DSI"), hereby acknowledge that RJN Group, Inc. is the Depositor referred to in the Master Preferred Escrow Agreement ("Agreement") effective ______________, 20 04 with DSI as the escrow agent and Baltimore County, Maryland as the Preferred Beneficiary. Depositor hereby agrees to be bound by all provisions of such Agreement.

Deposit Account Number 24813

Notices and communications to Depositor should be addressed to:

Company Name: RJN Group, Inc.
Address: 200 West Front Street
Wheaton, Illinois 60187
Designated Contact: Alan J. Hollenbeck
Telephone: 630-682-4700
Facsimile: 630-682-4754
E-mail: ahollenbeck@rjn.com
Verification Contact: Bob Snodgrass
Telephone/E-mail: Same / bsnodgrass@rjn.com

Invoices should be addressed to:

RJN Group, Inc.
200 West Front Street
Wheaton, Illinois 60187
Contact: Alan J. Hollenbeck
630-682-4700
P.O.#, if required: ____________

RJN Group, Inc.
Depositor
By: [signature]
Name: Alan J. Hollenbeck
Title: President
Date: 02/12/04

Baltimore County, Maryland
Preferred Beneficiary
By: [signature]
Name: Anthony G. Marchione
Title: Administrative Officer
Date: 02/25/04

DSI Technology Escrow Services, Inc.
By:
Name: [signature]
Title: Regional Sales Manager
Date: 3/19/04

EXHIBIT A

MATERIALS TO BE DEPOSITED

Deposit Account Number 24813

Depositor represents to Preferred Beneficiary that Deposit Materials delivered to DSI shall consist of the following:

The following program files will be provided in readable compact disk form as Deposit Materials for each of the Identified CASS WORKS Modules:

1. Installation Routine Source Files
2. CASS WORKS Core executable source files
3. CASS WORKS Forms and Report source files
4. Required SQL and DDL (Data Definition Language) Script Files
5. Documentation Files

RJN Group, Inc.
Depositor

By: [signature]

Name: Alan J. Hollenbeck

Title: President

Date: 02/12/04

Baltimore County, Maryland
Preferred Beneficiary

By: [signature]

Name: Anthony G. Marchione

Title: Administrative Officer

Date: 02/25/04

EXHIBIT B

DESCRIPTION OF DEPOSIT MATERIALS

Depositor Company Name: RJN Group, Inc. (Required)

Deposit Account Number: 24813 (leave blank if this is a new deposit account)

Product Name & Version: CASS WORKS 8.2 (Required)
(Product Name will appear as the Exhibit B Name on Account History report)

All deposit materials shall be provided by Depositor to DSI in readable compact disk form.

DEPOSIT MATERIAL DESCRIPTION:

Quantity	Media Type	Size	Label Description of Each Separate Item
1	*Readable Compact Diskette*	CD-R 5 1/4	CASS WORKS 8.2
	Documentation		
	Other		

PRODUCT DESCRIPTION:
Environment Windows 2000/XP/or Higher

DEPOSIT MATERIAL INFORMATION:
Is the media or are any of the files encrypted? Yes (No) *(If yes, include any passwords and the decryption tools within your deposit)*
Encryption tool name ______ Version ______

Hardware required Pentium III, 800MHz, 512 MB RAM, minimum

Software required None

Other required information ______

I certify for **Depositor** that the above described **DSI** has visually inspected and accepted the Deposit Materials have been transmitted to DSI: above materials *(any exceptions are noted above)*:

Signature: [signature]	Signature: ______
Print Name: Alan J. Hollenbeck	Print Name: ______
Date: 03/08/04	Date Accepted: ______
E-Mail Address: ahollenbeck@rjn.com	Exhibit B#: ______

EXHIBIT C
DESIGNATED CONTACT

Deposit Account Number 24813

Notices, deposit material returns and communications to Depositor should be addressed:

Company Name: RJN Group Inc
Address: 200 West Front Street
Wheaton IL 60187

Designated Contact: Alan J. Hollenbeck
Telephone: 630 682 4700 x317
Facsimile: 630 682 4754
E-mail: AHollenbeck@RJN.com
Verification Contact: Bob Snodgrass
Telephone/e-mail: Same/ bsnodgrass@RJN.com

Notices and communications to Preferred Beneficiary should be addressed to:

Company Name: Baltimore County, Maryland
Address: 400 Washington Avenue
Towson, Maryland 21204
Attn: Director, OIT
Designated Contact: Thomas G. Iler, Director, OIT
Telephone: 410-887-2441
Facsimile: 410-821-8024
E-mail: tiler@co.ba.md.us
Verification Contact:

Fees for this agreement will be paid by
(Check box): Depositor and/or Preferred Beneficiary

Invoices to Depositor should be addressed to:

Company Name: RJN Group, Inc.
Address: 200 West Front St.
Wheaton, IL 60187
Billing Contact: Alan J. Hollenbeck
Telephone: 630 682 4700 x317
Facsimile: 630 682 4754
E-mail: AHollenbeck@RJN.com
P.O. #: 10-1913-00

Invoices to Preferred Beneficiary should be addressed to:

Company Name: Baltimore County, Maryland
Address: 400 Washington Avenue
Towson, Maryland 21204
Billing Contact: Thomas G. Iler, Director, OIT
Telephone: 410-887-2441
Facsimile: 410-821-8024
E-Mail: tiler@co.ba.md.us
P.O. #:

Requests from Depositor or Preferred Beneficiary to change the designated contact should be given in writing by the designated contact or an authorized employee of Depositor or Preferred Beneficiary.

Agreements, Deposit Materials and notices to DSI should be addressed to:
DSI Technology Escrow Services, Inc.
Attn: Christopher R. Perkins
2100 Norcross Parkway, Suite 150
Norcross, GA 30071
Telephone: 770-239-9200
Facsimile: 770-239-9201
E-mail: Christopher.perkins@ironmountain.com

All invoice fee remittances to DSI should be addressed to:
DSI Technology Escrow Services, Inc.
PO Box 27131
New York, NY 10087-7131

Date:

TECHNICAL VERIFICATION OPTIONS

LEVEL I - Inventory
This series of tests provides insight into whether the necessary information required to recreate the Depositor's development environment has been properly stored in escrow. These tests detect errors that often inhibit effective use of the escrow deposit.

Steps include: Analyzing deposit media readability, virus scanning, developing file classification tables, identifying the presence/absence of build instructions, and identifying materials required to recreate the Depositor's software development environment. At completion of testing, DSI will distribute a report to Preferred Beneficiary detailing DSI's investigation. This report will include build instructions, file classification tables and listings. In addition, the report will list required software development materials, including, without limitation, required source code languages and compilers, third-party software, libraries, operating systems, and hardware, as well as DSI's analysis of the deposit. When identifying materials required to recreate Depositor's software development environment, DSI will rely on information provided in Depositor's completed questionnaire (obtained via a DSI verification representative) and/or information gathered during DSI's testing experience.

LEVEL II - Build
This series of tests includes a standard effort to compile the Deposit Materials and build executable code.

Steps include: Recreating the Depositor's software development environment, compiling source files and modules, recreating executable code, and providing a listing of the hardware and software configurations necessary to recreate the Depositor's software development environment. DSI will also create a report detailing the steps necessary to recreate the development environment, problems encountered with testing, and DSI's analysis of the deposit.

LEVEL III - Validation
A Level III verification consists of testing the functionality of the compiled Deposit Materials (in a production setting or similar environment) and can be accomplished through one of the following three options:

Option A – With the Depositor's approval, executables created by DSI during Level II testing are provided to the Preferred Beneficiary for functionality testing.

Option B – The Preferred Beneficiary provides DSI with a copy of its licensed executables. DSI compares the executables created during Level II testing with the licensed executables and provides a comparison report to all parties.

Option C – DSI recreates the runtime environment for the licensed technology and installs the executables created during the Level II testing into that environment. (The environment is generally "scaled down" from the actual live environment.) DSI then runs test scripts supplied by the Preferred Beneficiary and provides a report of the test results to all parties. This may require Depositor approval.

For additional information about DSI Technical Verification Services, please contact a David Thomas at **(770) 239-9200 x-124** or by e-mail at **dthomas@dsiescrow.com**.

APPENDIX H

LIST OF CONSENT DECREE DELIVERABLES

LIST OF "DELIVERABLES" IN CONSENT DECREE

PARAGRAPH	REQUIREMENT
7.B.i.	Submission of SSO Characterization Report
7.B.ii.	Submission of updated SSO Characterization Report (in Annual Report)
7.C.iii.	Submission of Non-Pump Station SSO Structures Elimination Plans
7.C.vi.	Submission of plan and schedule for preventing discharges from Pump Station SSO Structures
7.C.vii.	Submission of Supplemental Elimination Plan for newly-discovered Non-Pump Station SSO Structures
7.D.	Submission of post-construction monitoring plan for each construction project identified in Appendix B
8.B.	Submission of Collection System Inspection Plan
9.B.v.	Submission of Rainfall and Flow Monitoring Plan
9.B.vi.	Submission of summary report regarding evaluation of flow monitoring and rainfall monitoring program (in Annual Report).
10.B.	Submission of SRRR Plan for each sewershed
10.E.	Submission of Performance Assessment Report for each sewershed
11.C.	Submission of Report on preliminary review of FOG Program
11.D.iii	Submission of Grease Generating Facilities database and map (in Annual Report)
11.G.	Submission of FOG Program Modification Plan
11.I.	Submission of results of annual evaluation of FOG Program (in Annual Report)
13.C.i.	Submission of results of annual evaluation of Pump Station backup power program (in Annual Report)

13.C.ii.	Submission of plan to address any SSO at a Pump Station due to loss of power
13.F.iii.	Submission of Engineering Evaluation/Condition Assessment for each applicable Pump Station.
13.F.vi.	Submission of additional Engineering Evaluation/Condition Assessment for exempt Pump Station if required by EPA/MDE
14.C.	Submission of Model Project Approach Report
15.B.	Submission of O&M Plan
17.B.	Submission of Emergency Response Plan
17.E.	Submission of annual updates to Emergency Response Plan
24 (in Section VIII)	Re-submission of plan, program, or other document after disapproval by EPA

APPENDIX I

PATAPSCO BNR/ENR DESIGN SUPPLEMENTAL ENVIRONMENTAL PROJECT

Appendix I

Baltimore County
Department of Public Works
Supplemental Environmental Project

Patapsco Wastewater Treatment Plant
Biological Nutrient Removal/Enhanced Nutrient Removal Design Project

In 2001, the City of Baltimore, in support of the Chesapeake Bay Agreement and in settlement of a judicial action against the City in United States of America et al. v. Mayor and City Council of Baltimore, Civil Action No. JFM-02-1524 (D. Md.), committed to design biological nutrient removal (BNR) improvements to the Patapsco Wastewater Treatment Plant, with the objective of reducing nutrient (i.e., nitrogen and phosphorous) discharge to the Patapsco River and ultimately to the Chesapeake Bay. Subsequently, the project has been expanded to include enhanced nutrient removal (ENR). The Patapsco BNR/ENR design will be developed through the 30 percent, 60 percent, 90 percent, 100 percent and bid-ready document stages, and will include the preparation of the civil, structural, hydraulic, process, mechanical, electrical, HVAC, instrumentation/control designs and preparation of the construction plans, specifications and cost estimates. All phases of the design are expected to be completed by August 31, 2009.

Pursuant to existing agreements between Baltimore County and the City of Baltimore, the County is responsible for a portion of the costs for the design of the BNR/ENR project. The United States and MDE have recognized the payment of up to a total of $3,000,000 of Baltimore County's portion of the BNR/ENR design costs as a supplemental environmental project.

The City will periodically bill the County throughout the design of the nutrient removal facilities. The County will provide the United States and the Maryland Department of the Environment with records of its payments to the City up to a total amount of $3,000,000. Baltimore County recognizes and agrees that no part of the expenditures for which Baltimore County seeks SEP credit may include or be reimbursed by federal or state funds, or be specifically reimbursed by Howard County or Anne Arundel County. Any payments for which Baltimore County seeks SEP credit must be made by no later than five years plus 180 days from the Effective Date of the Consent Decree.

APPENDIX J

BACK RIVER DEBRIS REMOVAL SUPPLEMENTAL ENVIRONMENTAL PROJECT

Appendix J

Baltimore County
Department of Environmental Protection and Resource Management
Supplemental Environmental Project

Back River Debris Removal Project

Baltimore County shall complete this project in accordance with the specific requirements of Section X (Supplemental Environmental Projects) of the Consent Decree and the Statement of Work (SOW) to be submitted pursuant to Paragraph 31.B.ii. of the Consent Decree and approved by the United States and the Maryland Department of the Environment. The SOW shall include a map showing the specific location of this project.

Baltimore County shall design and install a trash collection system in Moore's Run near the Red House Run Pumping Station. Moore's Run is a tributary of the Back River. A 42" force main that crosses Moore's Run temporarily catches large quantities of this debris. The Force Main crosses Moore's Run in two places, as the river splits around an island. The location of the force main at the Red House Run Pumping Station makes this an ideal location for a debris removal program. The debris is moved during heavy rain events, high tide or by the wind to the navigable waters and is deposited along the shorelines, in the channels and in the wetlands of Back River. The debris is caught in existing tidal wetlands and is detrimental to vegetation growth and aquatic life. There are large quantities of natural woody debris that add nutrients to the waterway as the material breaks down Not only is this unsightly to the residents of the River, but also is detrimental to the overall water quality of the river and is an environmental and navigational safety concern.

The collection system will include two trash booms which will divert trash and debris to a shore conveyor system along the shores of Moore's Run. The floating debris will be directed up the conveyor belt to a roll-off container. Baltimore County will assure that the trash and debris collected in the container will, on a regular basis, be hauled to an appropriate disposal facility. The conveyor system is mobile. It will be used primarily in Moore's Run near the Red House Pumping Station, but may be used in other waterways on an as-needed or emergency basis.

The estimated cost of this project (including *final design, inspection, right of way acquisition, construction and monitoring)* is $200,000.00.

Baltimore County shall complete this project within five (5) years of the Effective Date of the Consent Decree.

APPENDIX K

STREAM RESTORATION SUPPLEMENTAL ENVIRONMENTAL PROJECTS

Appendix K

Baltimore County
Department of Environmental
Protection and Resource Management
Supplemental Environmental Projects

Stream Restoration Projects

Baltimore County shall complete these projects in accordance with the specific requirements of Section X (Supplemental Environmental Projects) of the Consent Decree and the Statements of Work (SOWs) to be submitted pursuant to Paragraph 31.C.iii. of the Consent Decree and approved by the United States and the Maryland Department of the Environment. Each SOW shall include a map showing the specific location of the project.

These projects are intended to improve water quality and aquatic habitat through the reduction of sediments to receiving waters. Problems to be corrected include: stream bank instability, channel degradation, insufficient stream side buffers and degraded riparian ecosystems. These projects will utilize state-of-the art techniques based upon applied fluvial morphological principles and engineering hydraulics and will employ bioengineering techniques and natural materials to restore and provide natural stream functions.

Once constructed, each project shall be monitored to assess its effectiveness.

Baltimore County shall complete construction of these projects within five (5) years of Effective Date of the Consent Decree.

Gwynns Falls at Gwynnbrook Avenue Stream Restoration

Baltimore County will design and construct a restoration project of approximately 1,000 feet along the Gwynns Falls mainstem, and sections of two tributaries (total length 1,200). The current geometry of the mainstem is in disequilibrium and is severely eroding private property. The project will include the design and construction of a combination stormwater retrofit/stream restoration project to address channel erosion problems, improve water quality and restore a stressed riparian ecosystem. The design will utilize the application of fluvial morphological and hydraulic principles to create a stable stream channel that provides stream equilibrium and a balanced riparian ecosystem. These streams are located in a highly urbanized area and have experienced severe degradation. The estimated cost of design and construction (including *assessments, preliminary design, final design, inspection, right of way acquisition, construction and monitoring)* of this project is $650,000.00.

<u>Paradise Avenue Stream Restoration</u>

Baltimore County will design and construct a restoration project of approximately 1,000 feet of a tributary to the West Branch of Herbert Run. The current geometry of the mainstem is in disequilibrium and is severely eroding private property. This stream is located in a highly urbanized area and has experienced severe degradation. The project will apply fluvial morphological and hydraulic principles to create a stable stream channel that provides stream equilibrium and a balanced riparian ecosystem. The estimated cost of design and construction (including *assessments, preliminary design, final design, inspection, right of way acquisition, construction and monitoring)* of this project is $300,000.00.

<u>Herring Run at Collinsdale Stream Restoration</u>

Baltimore County will design and construct a restoration project of approximately 1,000 feet of the headwaters of Herring Run. The stream is severely eroded and has been the subject of complaints by property owners on Collinsdale Road. The current geometry of the mainstem is in disequilibrium and is severely eroding private property. The project will apply fluvial morphological and hydraulic principles to create a stable stream channel that provides stream equilibrium and a balanced riparian ecosystem. The estimated cost of design and construction (including *assessments, preliminary design, final design, inspection, right of way acquisition, construction and monitoring)* of this project is $300,000.00.

<u>Minebank Run Tributary at Waller Court Stream Restoration</u>

Baltimore County will stabilize approximately 200 linear feet of a tributary to Minebank Run. This project will address complaints by property owners on Waller Court and will complement the comprehensive stream restoration work conducted within the Minebank Run watershed. The current geometry of this tributary is in disequilibrium and is severely eroding private property. The project will apply fluvial morphological and hydraulic principles to create a stable stream channel that provides stream equilibrium and a balanced riparian ecosystem. The estimated cost of design and construction (including *assessments, preliminary design, final design, inspection, right of way acquisition, construction and monitoring)* is $65,000.00.