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Columbia, Missouri
Wastewater System Facilities Planning Report

BV Project No. 132200
BV File: E-1.0
November 30, 2004

Mr. Steve Hunt
Sanitary Sewer Engineer
City of Columbia
Public Works Department
701 E. Broadway
PO Box 6015
Columbia, MO 65205

Dear Steve:

We are pleased to submit to you ten copies of the Wastewater System Facilities Planning Report for the City of Columbia. We appreciate the significant assistance and valuable input that City staff provided during this study. We trust that this report serves as a valuable tool to help you implement a program to meet the needs and demands of your growing community and surrounding area through Year 2030.

We are available at your convenience to discuss the contents of this report and answer questions concerning the proposed improvements. We have enjoyed working with you and look forward to more opportunities to work with you in the future.

Very truly yours,

BLACK & VEATCH CORPORATION

Larry Chapple, PE
Project Engineer

lwc/as
cc: Tom Ratzki
Jim Touslee
Blaine Bickel
Gary Beck, GBA

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Appendix C	I/I Investigation Upstream of WWTP (Not Included)
Appendix D	Flow Data Analysis Procedures and Definitions
Appendix E	Pump Station Inspection and Evaluation

Executive Summary

This Executive Summary presents the findings of the Wastewater Facilities Master Plan for the City of Columbia. The findings are based on providing conveyance and treatment improvement to handle projected Year 2030 wastewater flows and loads. The projected budget level opinions of cost for these improvements are:

Collection System Improvements	
Additional I&I Investigations	$ 3.3 million
Relief Sewer Improvements	$ 74.0 million
Sewer Extensions	$ 47.1 million
Future Pump Stations	$ 7.3 million
Sewer Rehabilitation	$ 20.3 million
Total	$ 152.0 million
Regional WWTP Improvements	
Rehabilitation of Existing Facilities	$ 13.5 million
Biosolids - Centrifuges	$ 2.2 million
Biosolids Dewatering Facilities	$ 7.7 million
Biosolids Heat Drying Facilities	$ 14.1 million
Wet Weather Improvements	$ 29.0 million
Expansion to meet Year 2030 flows (Two Phases)	$ 32.5 million
Total	$ 99.0 million

This program represents a capital improvements program to meet projected Year 2030 needs that will be implemented over time based on need and funding capability of the City. A financial analysis, was performed as part of this study, determined that the current sewer use rate structure cannot support the funding required for these capital improvements. It is recommended that the City consider a combination of connection fee and service rate increases to keep annual rate increases below 10 percent. Four combinations of sewer service rate and connection fee increases were evaluated. The proposed approach is to increase connection fees by 25 percent in FY 2007, FY 2009 and FY 2011, with an additional 50 percent increase in FY 2013. This would keep the annual increase in sewer service sales revenues at 6 percent in FY2009, 7 percent in FY 2010, and at 8 percent, from FY 2011 through FY 2014. Beyond 2014, annual rate increases of 3 and 2 percent would be required. Recognizing that actual customer growth, inflation, facility needs, and economic conditions will change from what has been assumed in this analysis, annual review of these criteria and their impact on sewer rates and connection fees are recommended.

The following implementation plans for the collection system and for the wastewater treatment plant are recommended.

COLLECTION SYSTEM IMPLEMENTATION PLAN

The recommended plan for the collection system includes I/I removal, relief sewer and sewer extensions to address both immediate needs and the projected Year 2030 demands of the system. The plan identifies what areas need to be addressed first based on sewer backup data, eminent growth, etc. Some identified projects require additional data collection to verify sewer slopes and peak flows. These projects are identified and scheduled to allow for modification to the plan once the data is collected. Major features of the plan are as follows:

1. Conduct I/I evaluation for eight selected basins over the first five years. Begin work in the Flat Branch and Southwest sub-watersheds where sewer backups occur on an annual basis.
2. Conduct additional investigations in five sub-watersheds including elevation data collection on approximately 800 manholes and flow monitoring of approximately 11 sites. Installation of event recorders on existing pump stations is also recommended.
3. Install approximately 146,000 feet of relief sewers by the year 2010, 92,000 feet of relief sewer by the year 2020 and 148,000 feet of relief sewer by the year 2030. Initial relief sewer should be installed in the Lower Hinkson Creek and Southwest sub-watersheds which currently experience backups on an annual basis.
4. Install approximately 57,000 feet of sewer extension by the year 2010, 94,000 feet by the year 2020 and 112,000 feet by the year 2030. This report is based on no sewers being constructed in the Rock Bridge Memorial State Park.
5. Remove three of the 18 City owned pump stations by 2020. These pump stations will be removed as new sewer extensions eliminate their need.
6. Install three future growth pump stations to be located in the Little Bonne Femme Watershed to serve future growth in this watershed. Upper Little Bonne Femme Pump Station is anticipated to be installed by 2015, Middle Little Bonne Femme Pump Station by 2020 and Clear Creek Pump Station No. 2 by 2030.
7. Conduct sewer rehabilitation based on findings of I/I investigations. Rehabilitation to begin in Flat Branch and Southwest sub-watersheds.

WASTEWATER TREATMENT IMPLEMENTATION PLAN

The recommended plan for the treatment plant will continue to use the existing plant and wetlands; implement a program to assess performance of chemically enhanced primary treatment with existing facilities; perform repair and rehabilitation projects with a priority on constructing up to $2.2 million of odor control improvements; increase initially the existing mechanical plant's treatment capacity by adding one 6.3 mgd treatment train; add biosolids dewatering and eventually biosolids heat drying; and increase wet weather pumping and treatment capabilities. The expanded plant can be operated in one of three modes to determine ways to maximize treatment and defer adding more mechanical treatment. If necessary, another 6.3 mgd train can be added in the future to meet Year 2030 needs. The following implementation program is recommended.

1. Install thickening centrifuges as planned to improve solids removal from the mechanical plant.
2. Implement a program to assess performance of chemically enhanced primary treatment (CEPT) with existing facilities. Increased solids removal in the primary basins and I/I basins will not eliminate the need for an additional mechanical plant treatment train. However, if effective, the loadings to the wetlands will be reduced, extending the life and capacity of both the treatment plant and the wetlands. Using iron salts prior to the I/I Clarifiers will also help reduce concentrations of sulfides in the I/I Clarifier effluent.
3. Perform the recommended rehabilitation improvements outlined in Chapter 6. Priority should be given to odor control improvements at the plant. Expanding the existing mechanical plant capacity is required to before some of major existing liquid treatment units can be removed from service for rehabilitation.
4. Add one 6.3 mgd mechanical train to increase the mechanical treatment plant capacity to 18.9 mgd.
5. Implement wet weather improvements to handle higher flows. This program can be phased based on peak wet weather flows established for interim periods prior to 2030.
6. Implement a program to assess the performance of wetlands at flows and loadings that approach the values used in sizing the wetlands. Effluent quality and impact to surrounding environment should be assessed. While this could be implemented before the additional mechanical train is on line, it is recommended that this be done after the train is on line. Should stressing the wetlands result in unfavorable results, the third train would provide adequate capacity to handle the incoming flow.
7. Implement the first phase of solids handling improvements, which is to add biosolids dewatering technology. These improvements could be implemented with or independent of construction of the first train of plant expansion or the rehabilitation improvements.
8. Implement the second phase of solids handling improvements, which is to add heat drying of biosolids.
9. Add a second 6.3 mgd train should it be determined that the second train is required.

BASIS FOR RECOMMENDED PLANS

The following paragraphs present the information and findings used to develop the recommended implementation plans.

Service Area, Planning Period, and Projected Needs

- The design year for this Master Plan is 2030.
- Columbia's service area, as defined for this study, includes approximately 123,000 acres of which 32,000 acres are currently served by the existing sewer system. Figure ES-1 shows limits of study area.
- Year 2030 population served by Columbia Regional Facilities projected to be 175,000, which is about a 70 percent increase over current population served. Approximately 85 percent of the growth is projected to occur in the Hinkson Creek and Perche Creek areas where the existing treatment plant is located.
- Year 2030 projected wastewater flow, including commercial and industrial is 28.4 mgd.
- Year 2030 projected peak flow to the plant is 143 mgd, with a peak day flow of 69 mgd.

Regulatory

Current and potential future regulatory requirements were considered in determining what improvements and upgrades were required in the collection system and treatment facilities.

- EPA's Sanitary Sewer Overflow (SSO) policy is currently under review and is expected to require the collection system manager, in this case the City of Columbia, to develop a Capacity assurance, Management, and Operation and Maintenance (CMOM) program with short term and long term goals for eliminating SSOs.
- The current NPDES permit limits the amount of BOD and TSS that may be discharged to the Eagle Bluffs Conservation Area. Alternatives to expand plant capacity will be based on continued use of the wetlands, which could impact future effluent limits requirements.
- Disinfection could be required in the future. From City discussions with MDNR, it is unclear if MDNR will require disinfection before or after wetlands polishing. This would have a significant impact on the type and size of disinfection provided and needs to be defined by MDNR before a definitive solution can be developed.
- Nitrification and phosphorus removal could be required in the future. Mechanical treatment was considered in this study for nutrient removal. Using wetlands to remove nutrients, such as nitrogen and phosphorus, would require harvesting of the cattails or other vegetation to remove nutrients from the liquid waste stream.

Collection System Assessment

A collection system evaluation was conducted to determine the needs of the sanitary sewer system for collection and conveyance of wastewater to treatment facilities. The evaluation included:

1. Monitoring flow and rainfall to assess collection system response to rainfall.
2. Predicting future capacity needs based on growth projections from the City and County.
3. Established design flow criteria for sizing collection system improvements.
4. Developing a computer capacity model to predict current and future capacity needs of the main interceptors and lift stations in the existing system.
5. Investigating eight of the existing lift stations identified by City to determine improvements to address operation and capacity needs.
6. Developing a preliminary plan for sewer extensions to handle growth in the existing and future service area.

Findings from the evaluation include:

1. A 10-year storm event was selected for future growth design flow criteria for the City.
2. Twelve (12) of the 49 existing flow basins experienced excessive Infiltration/Inflow (I/I) during the flow monitoring period.
3. Existing System Improvements. The proposed improvements to the existing system are presented in Table ___.
   - If current I/I levels are reduced through I/I inspections and I/I source removal, some relief sewer projects may be reduced or eliminated from the plan. It is recommended that each of these flow basins be inspected to identify and remove cost-effective I/I sources.
   - The computer capacity model identified approximately 404,000 feet of sewer that will require relief to handle the design storm event and projected Year 2030 flows. Up to 50 projects were identified to provide relief for these sewers. Sixteen (16) of these projects are in areas where documented manhole overflows, basement backups or sewer surcharging has occurred and are considered high priority.
   - Additional data should be collected for twenty-eight (28) of the identified relief sewer projects. Limited actual data was available to use in the modeling. Additional data could result in more realistic design flows and existing capacities, which may eliminate the need for some of the relief sewer projects identified with the current hydraulic model.
   - The existing lift station assessment process identified thirteen (13) lift stations that could be replaced by future gravity sewer extensions and one (1) lift station that requires improvements to improve operation. Stations not planned for immediate

elimination should be monitored to verify that they can handle existing and projected flow rates.

4. Service to Future Growth Areas.
   - By the year 2030, approximately 276,000 feet of sewer extensions and three (3) new lift stations will be needed to serve this additional growth.
   - Two lift stations and associated force mains will be located in the Little Bonne Femme watershed. No sewers will be located in the Rock Bridge Memorial State Park.
   - For ultimate development, approximately 1.1 million feet of sewer interceptor extensions will be needed to serve the 91,000 acres currently not served by the City's regional plant.
5. Implementation Plan for Collection System. The proposed implementation plan along with the projected budget level cost opinions are presented at the beginning of this Executive Summary.

Wastewater Treatment

1. The existing mechanical plant lies near the confluence of Hinkson and Perche Creeks. Four wetlands treatment units located along Perche Creek downstream of plant provide polishing of the mechanical plant effluent. Wetlands effluent is sent to the Eagle Bluffs Conservation Area.
   - The existing activated sludge plant with primary treatment has a rated capacity of 12.6 mgd. With wetlands polishing of the plant effluent, the design capacity of the plant, as stated in the NPDES permit, is 20.6 mgd.
   - An assessment of the existing treatment facilities indicates that approximately $13.5 million of improvements to existing facilities should be implemented.
   - Approximately $24 million of thickening centrifuges, biosolids dewatering and heat drying improvements were identified in the Biosolids Management Study to improve handling of solids both for existing and future facilities.
   - Additional treatment capacity is required to meet Year 2030 needs.
2. A two step process used for determining what approach to take to meet future treatment needs. Step 1 was to select location for future treatment facilities. Step 2 was to select the type of treatment to implement.

- Step 1 - Site Selection. Alternative locations for treatment facilities included continued use of existing site, or relocating all or part of treatment at a new site.
    - Continued use of wetlands was a consideration in the evaluation.
    - A location in Little Bonne Femme watershed was considered and dismissed because it would require pumping up to 10 times the amount of wastewater from Hinkson/Perche Creek to Little Bonne Femme as compared to pumping wastewater from Little Bonne Femme to a Hinkson/Perche Creek site. Also, this location could not effectively use wetlands as part of the treatment process.
    - It was determined that the best location for treatment facilities is the existing plant site because it offers a capital cost savings of at least $9.0 million by using existing treatment facilities; it allows continued use of wetlands units and minimizes the pumping required to bring wastewater to the plant for treatment.
- Step 2 - Treatment Methods Selection. City staff participated in a screening process to select three treatment alternatives for further consideration. Continued wetlands use was a considered.
    - Key observations about continued wetlands use to meet future needs include:
        a. Wetlands treatment has performed generally as predicted by the design equations. However, the wetlands have not yet been subjected to "design" BOD and TSS loadings used in design to confirm effective treatment at those conditions.
        b. Columbia's wetlands are configured to operate in series, which subjects the first unit to higher BOD and TSS loadings that the other units. The design equations do not address operating in series. Monitoring performance of the first unit is recommended.
        c. The wetlands can be used as part of the wet weather treatment process.
        d. Expanding wetlands treatment to meet Year 2030 would require approximately 485 acres to provide sufficient land for the 210 acres of wetlands treatment required and would still require additional mechanical plant improvements.
    - The three alternatives selected were:
        a. Alternative 1 - Continue use of wetlands polishing and add two parallel 6.3 mgd mechanical trains. One train could be built in the near future with the second built as growth dictated.

b. Alternative 2 - Add one parallel 6.3 mgd mechanical train and use I/I clarifiers to treat flow in excess of 18.9 mgd. Blend I/I effluent and plant effluent and send to wetlands for polishing.

c. Alternative 3 - Add one parallel 6.3 mgd mechanical train as in Alternative 3 but also implement chemically enhanced treatment in the primary clarifiers and I/I clarifiers. Blend I/I effluent and plant effluent and send to wetlands for polishing.

- Budget level capital, annual O&M and present worth cost opinions were developed for each alternative. Total project costs and present worth costs of the three alternatives were within five percent of each other, which for budget level purposes could be considered equal. Table 8-4 presents a summary of the three Alternatives considered.
- Each alternative requires the addition of at least one 6.3 mgd train and would involve continued use of the wetlands for effluent polishing for discharge to Eagle Bluffs Conservation Area. The wetlands would also be used for wet weather flow conditions.
- If Alternative 1 is implemented, only one train would have to be constructed initially with the second one constructed when flows exceed plant capacity. By building only one train initially, plant staff would have adequate facilities to operate the plant as described in any of the three alternatives. If operating the plant as described for Alternative 2 or 3 yields acceptable performance, building of a second mechanical train could be delayed, perhaps indefinitely.

3. Implementation Plan for Wastewater Treatment. The implementation plan proposed for wastewater treatment improvements and budget level cost opinions are presented at the beginning of this Executive Summary.

FINANCIAL ANALYSIS

1. An analysis was conducted to assess the impact financing the collection and treatment systems capital improvements would have on the City Sewer Utility's required revenues. The proposed capital improvements cannot be funded without revenue adjustments.
2. The cost of the proposed capital improvements and new debt service were added to the current and projected future revenue requirements to cover existing debt service and operation and maintenance expenses to establish the projected revenue requirements through Year 2030.

3. Four funding scenarios that utilized combinations of increases to sewer sales revenues and sewer connection fees were considered for meeting the projected revenue requirements. A two percent per year growth rate in customers was used in each scenario.

4. It is recommended that the City consider a combination of connection fee and service rate increases that keep annual service rate increases below 10 percent. The proposed approach is to increase connection fees by 25 percent in FY 2007, FY 2009 and FY 2011, with an additional 50 percent increase in FY 2013. This would keep the annual increase in sewer service sales revenues at 6 percent in FY2009, 7 percent in FY 2010, and at 8 percent, from FY 2011 through FY 2014. Beyond 2014, annual rate increases of 3 and 2 percent would be required. Recognizing that actual customer growth, inflation, facility needs, and economic conditions will change from what has been assumed in this analysis, an annual review of these criteria and their impact on sewer rates and connection fees are recommended.

CHAPTER 1.0

INTRODUCTION

1.1 PURPOSE

This report covers a study of existing and future wastewater collection and treatment facilities. The City of Columbia, Missouri contracted with Black & Veatch to conduct a facilities planning study and prepare a report to investigate the physical condition and operational capabilities of the existing wastewater treatment facilities and develop an expansion plan to cost-effectively position the City for future growth and development through the year 2030.

1.2 SCOPE

The study includes developing a plan for additional capacity and expansion of the service area served by the City's Regional Wastewater Treatment Facility located at the confluence of the Hinkson and Perche Creeks, updating the City's sanitary sewer master plan, and creating a computer hydraulic model of the City's sanitary sewer collections system. Primary tasks performed include:

- Document growth projections developed by the City Planning Department and Boone County Regional Wastewater Authority and predict associated wastewater flows and loads through the year 2030.
- Assess the condition and capacity of the existing collection and treatment facilities.
- Conduct an odor assessment at the treatment plant and identify an odor control methodology to address odors identified from the assessment.
- Evaluate alternative methods to expand existing collection system and treatment facilities to meet future growth based on anticipated future regulatory requirements for discharge of treated wastewater into the receiving stream.
- Develop a computer capacity model of the collection system.
- Develop opinions of cost associated with the recommended upgrade/expansion alternative.

George Butler Associates served as a subconsultant to Black & Veatch for this project with primary responsibility for the collection system assessment and computer modeling.

1.3 BACKGROUND

A Planning Report on Wastewater Collection and Treatment for the City of Columbia was prepared in 1973 by Black & Veatch to evaluate existing facilities and plan for additional capacity and expansion of the service. The 1973 report covered the City and adjacent area and provided the local planning that was required for incorporation into the Standard Metropolitan Statistical Area and the Regional and State-wide plans for the management of water quality. Since then, the City has made improvements and expansion of their collection and treatment facilities. However, portions of the City's wastewater infrastructure are nearing capacity and are in need of improvement.

The City of Columbia owns and operates two wastewater treatment facilities, the Columbia Regional Wastewater Treatment Facility (NPDES Permit: MO-0097837) and the Columbia Regional Airport Lagoon (MO-0092924). This study will focus on the Columbia Regional Wastewater Treatment Facility and associated collection system.

The Columbia Regional Wastewater Treatment Facility was completed and fully operational in 1983 and provides wastewater treatment for the entire corporate limits for the City of Columbia using a complete mix activated sludge process. It was designed to treat average day flows of 13.0 mgd. The facility's capacity was expanded by the construction of wetlands treatment units to treat approximately 20.6 mgd average day flows. The City uses a land application of liquid biosolids management program. In August 2000, Black & Veatch prepared a report titled "Evaluation of Biosolids Management Program and Alternatives" to assess alternative long-term disposal methods. The study offered the following observations about long-term biosolids management solutions:

- Land application of dewatered biosolids is the most cost-effective of the alternatives considered.
- Land application of Heat Dried Solids was considered the most favorable alternative from a non-cost perspective.

CHAPTER 2.0

STUDY AREA CONDITIONS AND POPULATION PROJECTIONS

2.1 DESCRIPTION OF EXISTING SERVICE AREA

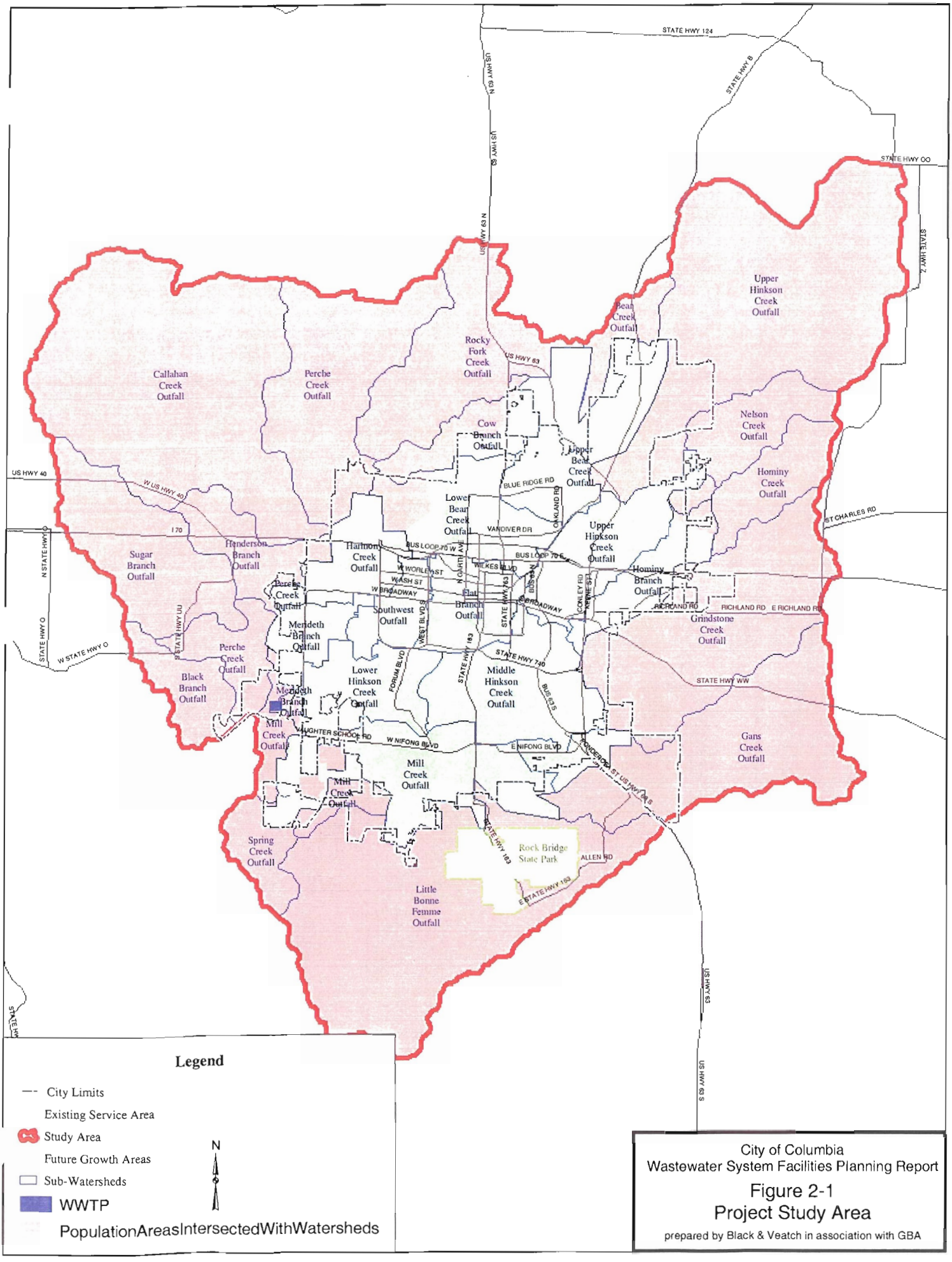
2.1.1 General. Columbia's wastewater collection system currently provides sanitary sewer service for approximately 32,000 acres of developed land. The collection system utilizes approximately 3,000,000 feet of sanitary sewer pipe and 18 pump stations to transport wastewater flow to the Columbia Regional Wastewater Treatment Plant. A map of the City's existing sewer service area is provided in Figure 2-1.

2.1.2 Population Demographics. The 2003 population for Columbia is estimated to be 89,200. Enrollment at Stephens College, Columbia College and the University of Missouri-Columbia accounts for nearly 40% of the City's population.

2.1.3 Land Use. Currently, the sanitary sewer service area for the City of Columbia consists of about one-third commercial, one-third residential and one-third farm use. Land use characteristics were estimated from zoning designations on a current parcel map.

2.1.4 Topography. Wastewater flow currently treated at the Columbia Regional Wastewater Treatment Plant flows from three distinct watersheds: Perche Creek, Hinkson Creek and Little Bonne Femme Creek. The Mill Creek watershed drains to the Hinkson Creek watershed and is considered a distinct outfall in the existing collection system. The Perche Creek, Hinkson Creek and Mill Creek outfall sewers flow to a common pump station located just prior to the treatment plant. Flow from the Little Bonne Femme watershed is pumped north over the ridge into the Mill Creek watershed. The Little Bonne Femme watershed flows naturally by gravity south to the Missouri River.

2.1.5 Flooding History. A review of historical basement backup / sewer overflow records indicates that flooding due to surcharged sewers occurs primarily in the Flat Branch and Southwest outfall areas of the Hinkson Creek watershed.


STATE HWY 124
US HWY 63 N
US HWY 63
STATE HWY B
STATE HWY OO
STATE HWY Z
US HWY 63 N
Upper Hinkson Creek Outfall
Bear Creek Outfall
Rocky Fork Creek Outfall
US HWY 63
Callahan Creek Outfall
Perche Creek Outfall
Cow Branch Outfall
Nelson Creek Outfall
Upper Bear Creek Outfall
Hominy Creek Outfall
US HWY 40
W US HWY 40
BLUE RIDGE RD
OAKLAND RD
Lower Bear Creek Outfall
ST CHARLES RD
170
VANDIVER DR
Upper Hinkson Creek Outfall
Henderson Branch Outfall
Harmony Creek Outfall
BUS LOOP 70 W
BUS LOOP 70 E
N STATE HWY O
Sugar Branch Outfall
W WORLEY ST
WILKES BLVD
WASH ST
W BROADWAY
Hominy Branch Outfall
Perche Creek Outfall
Flat Branch Outfall
BUS 63 N
CONLEY RD
KRENE ST
E BROADWAY
RICHLAND RD
RICHLAND RD E RICHLAND RD
STATE HWY UU
Southwest Outfall
WEST BLVD S
STATE HWY 763
Grindstone Creek Outfall
Meredeth Branch Outfall
STATE HWY O
W STATE HWY O
STATE HWY 763
STATE HWY 740
Perche Creek Outfall
FORUM BLVD
Lower Hinkson Creek Outfall
Middle Hinkson Creek Outfall
STATE HWY WW
Black Branch Outfall
Meredeth Branch Outfall
BUS 63 S
Mill Creek Outfall
RIGHTER SCHOOL RD
W NIFONG BLVD
E NIFONG BLVD
Gans Creek Outfall
Mill Creek Outfall
Mill Creek Outfall
PROVIDENCE RD
ST US HWY 63 S
STATE HWY 763
Rock Bridge State Park
ALLEN RD
Spring Creek Outfall
Little Bonne Femme Outfall
E STATE HWY 163
US HWY 63
US HWY 63 S
Legend
City Limits
Existing Service Area
Study Area
Future Growth Areas
Sub-Watersheds
WWTP
PopulationAreasIntersectedWithWatersheds
N
City of Columbia
Wastewater System Facilities Planning Report
Figure 2-1
Project Study Area
prepared by Black & Veatch in association with GBA

2.2 DESCRIPTION OF FUTURE SERVED AREAS

2.2.1 General. The future development boundaries established for this study for the Columbia sanitary sewer collection system include parts of the Perche Creek, Hinkson Creek (which includes the Mill Creek watershed) and Little Bonne Femme watersheds. The future sewered area includes approximately 91,000 acres. The Boone County Regional Sewer District currently serves many developments with localized treatment within the future development boundary. It is anticipated that these regional pockets of development within Boone County eventually will be served by Columbia's sanitary sewer collection system once adequate sewer extensions have been constructed.

2.2.2 Population Demographics. The future population projections are based on the Traffic Analysis Zone (TAZ) study produced by the City of Columbia Planning Department in 2000. This study was conducted in cooperation with the Missouri Department of Transportation I-70 Environmental Impact Statement (EIS) project. The study included the following information for each TAZ: 2000 population; 2030 population; and whether the TAZ is expected to be sewered by 2030.

Some additions were made to the City TAZ system in this study. Additional zones were created or existing zones were expanded to cover the entire study area. From the 2000 and 2030 populations, a constant annual growth rate was determined for each TAZ and the populations for five-year increments were calculated.

Utilizing the modified TAZ system, an ultimate development population for each TAZ was also calculated. The ultimate development density was assumed to be either 1.5 people per acre or the 2030 density, whichever was greater. The ultimate population of the study area is equal to the ultimate population density times the area of the TAZ.

The five year incremented and ultimate population projections for the City by watershed within the study area are shown in Tables 2-1 and 2-2. Table 2-1 represents the projected connected population for TAZ areas that will be sewered by 2030. Not all of these areas currently send flow to the Columbia Regional WWTP but eventually will be served by that plant. Table 2-2 represents the projected connected population if all areas' population is included.

Table 2-1

Projected Population by Major Watershed - Sewered Areas Only[1]

Watershed	Area, acres	Year						
		2000[2]	2005	2010	2015	2020	2025	2030
Hinkson	48,900	71,249	73,997	77,361	81,605	87,209	94,947	106,968
Little Bonne Femme	26,036	9,436	10,125	11,006	12,156	13,735	16,060	20,271
Perche	48,794	22,622	24,446	26,763	29,783	33,810	39,378	48,205
Total	123,730	103,307	108,568	115,130	123,544	134,754	150,385	175,444

(1) Population is total population for sewered areas within the Study Area. Plan is to have all population connected to the WWTP through improvements recommended in this report by year 2030.

(2) Not all of the population for year 2000 is connected to the Columbia Regional WWTP. Approximately 88,700 people were estimated to be connected to the WWTP in year 2000. Further discussion about connected population for year 2000 is presented in Chapter 4.

Table 2-2

Projected Population by Major Watershed - All Areas

Watershed	Area, acres	Year							
		2000	2005	2010	2015	2020	2025	2030	Ult.[1]
Hinkson	48,900	74,102	76,939	80,400	84,745	90,464	98,322	110,472	143,844
Little Bonne Femme	26,036	12,441	13,210	14,179	15,422	17,098	19,529	23,856	48,621
Perche	48,794	27,284	29,181	31,578	34,688	38,820	44,496	53,472	98,088
Total	123,730	113,827	119,330	126,157	134,855	146,382	162,347	187,800	290,553

(1) Ultimate population based on area being fully developed.

2.2.3 Land Use. For the purposes of this study, the land use characteristics of the future service area are projected to be consistent with the existing land use characteristics.

2.2.4 Topography. Future sewered areas in the Perche Creek and Hinkson Creek watersheds will tie into the existing outfall sewers for each watershed. In the Little Bonne Femme watershed, future sewered areas to the east of the Rock Bridge Memorial State Park will be pumped north to the Mill Creek watershed along the eastern edge of the park. Future sewered areas to the west of the park will be served by a new regional pump station that pumps to the Mill Creek interceptor in the Hinkson Creek watershed.

CHAPTER 3.0

REGULATORY

3.1 GENERAL

The wastewater services provided by the City of Columbia must meet the standards and requirements of various regulatory agencies. The United States Environmental Protection Agency (EPA) and the Missouri Department of Natural Resources (MDNR) are the regulatory agencies that establish and enforce effluent regulations that apply to the Columbia wastewater collection and treatment systems. This section addresses current and possible future regulatory requirements that impact wastewater operations at Columbia. The treatment plant effluent is not discharged to a receiving stream but through wetlands treatment units to the Eagle Bluffs Conservation Area.

3.2 NPDES PERMIT REQUIREMENTS

3.2.1. Current Permit Requirements. The Columbia Regional Wastewater Treatment Plant (CRWWTP) currently operates under NPDES permit number MO-0097837, which was last revised March 12, 2004 and is set to expire May 4, 2005.

Outfall #001 is located at the discharge side of the Effluent Pump Station. A pipeline from the pump station carries effluent to the Eagle Bluffs Conservation Area, which is identified in the permit as the receiving stream. Effluent from the mechanical plant and the I&I clarifier and holding lagoon flows by gravity through four wetlands treatment units pumped to the Eagle Bluffs Conservation Area. Sampling for Outfall #001 is taken at the Effluent Pump Station located at Wetlands Treatment Unit 3. Outfall #001 effluent limits for the major parameters stated in the current permit are presented in Table 3-1.

Outfall #002 is an emergency discharge point located at diversion structure where effluent from the final basins join flow from the I/I clarifiers and holding lagoon. This combined effluent is sent to the wetlands normally. Outfall #002 is only to be activated when the combined effluent cannot be sent to the wetlands. When activated, 002 flow is to be monitored. BOD and TSS weekly average concentrations shall not exceed 45 mg/L. Sampling for BOD and TSS are grab samples taken once/day. The permit states that Outfall #002 discharges to the Hinkson Creek.

Outfalls #003 and #004 are stormwater discharge points from the treatment plant grounds and discharge to Hinkson Creek as well. The permit requires monitoring only if required at the request of the MDNR.

Table 3-1
Current NPDES Effluent Limitations for the Columbia Regional WWTP Outfall #001

Effluent Parameter	Final Effluent Limitations			Monitoring Requirements	
	Daily Max	Weekly Ave	Monthly Ave	Measurement Frequency	Sample Type
Flow, mgd	Report			Once / weekday	24 hr total
BOD, mg/L		45	30	Once / weekday	24 hr composite
TSS, mg/L (Note 1)		45	30	Once / weekday	24 hr composite
pH, SU	Between 6.0-9.0 pH units	No averaging	No averaging	Once / weekday	grab

Notes:

1. Total suspended solids (TSS) may be exceeded periodically due to heavy use by waterfowl. The effluent limits for TSS during these periods shall be a weekly average of 100 mg/L and monthly average of 70 mg/L. Documentation of the heavy waterfowl usage shall be documented by the City and confirmed by the Missouri Department of Conservation.

The permit requires Whole Effluent Toxicity testing once a year and metals testing once a quarter. Quarterly monitoring of groundwater is required at the Sludge Application Area and at the Wetland Cells Areas.

Wetlands units effluent is pumped by the Effluent Pumping Station through a force main to a junction structure located just ahead of the Conservation Area. The junction structure can receive flow from the plant and from the Missouri River up to 60 mgd. Flow to Eagle Bluffs is limited to 60 mgd and based on discussions with the Missouri Conservation Agency any increase in flow to the conservation area would require discussion and approval of MDNR. Average day wastewater flow is much less than this but during peak wet weather conditions, future flow rates in excess of 60 mgd could come to the plant. The impact of these higher flows will need to be addressed in the proposed improvements to the plant.

3.3.2 Future Requirements. MDNR is giving strong consideration to requiring disinfection and ammonia and phosphorus removal to discharges into the Missouri and Mississippi Rivers similar to what is being required for smaller receiving waters in the state. Because Columbia's WWTP effluent passes through wetlands treatment units for polishing and is discharged to a Conservation Area instead of a receiving stream or river, the level of treatment requires special consideration. Discussions with MDNR during Columbia's most recent NPDES permit renewal included whether or not disinfection may be required for plant effluent prior to discharge to the

Eagle Bluffs Conservation Area. Natural disinfection using the wetlands is possible but may not be consistently effective in achieving a 200 MPN /100mL that has been seen as the typical fecal coliform limit required by MDNR for other facilities. Fecal counts in the wetlands effluent would also be impacted by wildlife fecal matter discharged within the wetlands. Special considerations for these occurrences may be required, similar to the higher TSS loadings permitted during periods of "heavy waterfowl use". What will specifically be required for discharges to Eagle Bluffs is too difficult to predict at this time. For planning purposes, a budget level opinion of cost to disinfect on a per mgd basis will be developed.

MDNR is also considering ammonia and phosphorus removal for larger rivers, however, it is not yet clear how this would impact limits for effluent going to the Conservation Area. This Master Plan will consider treatment options flexible enough to accommodate ammonia and phosphorus removal processes.

3.3 INDUSTRIAL PRETREAMENT

The Clean Water Act required EPA to develop a method to regulate wastewater discharges from industry. EPA developed the industrial pretreatment program in the early 1980s and that program is still in effect today. The rules governing the pretreatment program are published in the Code of Federal Regulations (40 CFR Part 403). Since Missouri is a delegated state, the State administers the program, with oversight by EPA.

The industrial component of the wastewater entering the Columbia Regional WWTP is approximately nine percent based on influent flow. Flow, BOD and total suspended solids data were obtained from the City for the following industrial users to determine the industrial contribution to wastewater treated at the Regional Wastewater Treatment Plant:

ABC Labs
3M Company
Columbia Foods
Diggs Packing Company
Diggs Hot Dog Facility
Square D Company
UMC Power Plant

3.4 SANITARY SEWER OVERFLOWS

EPA's Sanitary Sewer Overflow policy (SSO Policy) is currently under review on the Federal Register. It is anticipated that 19,000 sewer systems in the United States will have their

permits expanded to address the policy. The City of Columbia will be affected by this policy. The SSO Policy is intended to clarify and expand requirements under the Clean Water Act and to improve the sewer infrastructure by requiring communities to reduce and/or eliminate SSOs. At the heart of the SSO Policy is Capacity Assurance, Management, Operation and Maintenance (CMOM), a program to be adopted by the affected communities. The SSO Policy has been in review since March of 2001 and many communities have already begun to adopt a CMOM program. The final direction of CMOM and its impact on system managers is unclear at this time. The enforcement of the policy may also vary from region to region. Based on the current SSO policy under review, the following requirements for CMOM will need to be met:

- The system manager will need to develop a CMOM program.
- The city/utility CMOM plan will be part of its NPDES permit.
- The plan will have short-term and long-term goals for the elimination of SSOs.

An SSO is sewage that escapes the sanitary sewer system and planned treatment process. The number of SSOs that occur annually on a national basis is not known. It has been estimated by EPA that 40,000 overflows happen every year. In 1996, it was estimated that 30 percent of the municipal sewer systems experience wet weather SSOs. SSOs can occur in many forms such as:

- Basement Backups
- Overflows from Manholes
- Pump Station Overflows
- System Breaks
- Bypasses

Some of the basic reasons for sewers to overflow include:

- Excessive Infiltration and Inflow
- Undersized Sewer Systems
- Pipe Failures
- Equipment Failures
- Deteriorating Sewer Systems
- Pump Station Power Outages

The system manager will be required to develop a CMOM Program that includes annual maintenance of equipment, training of personnel, and the monitoring and tracking of system indicators such as complaints, backups and pump station failures. As part of the permit, a CMOM program summary has to be on file. The summary and permit will include proposed goals that provide sufficient information for the permitting authority and public to understand the premise of the program. Periodic audits will be conducted to establish the progress of the CMOM Program. The audit may uncover deficiencies in many areas of the maintenance and management of the system. System indicators will be at the heart of the audits. These indicators have not been established but may include:

- Pipe Failures
- SSO Events
- Complaints
- Pump Station Failures
- Ratio of Peak Hourly Flow to Average Daily Flow
- Ratio of Peak Monthly Flow to Average Annual Flow

Tracking these indicators from one year to the next will establish trends in the system's performance and provide an indication of the direction of the program.

Currently, Columbia does not have controlled SSOs. All flow is routed to the treatment plant and flow that exceeds the capacity of the mechanical plant is treated by the I&I clarifiers and stored in the I&I holding lagoon. If the capacity of the lagoon is exceeded, the excess flow is combined with the mechanical plant effluent and sent to the wetlands treatment units. As discussed earlier in this Chapter, Outfall #002 is to be used as an emergency discharge when flow cannot go to the wetlands.

3.5 REGULATIONS FOR BIOSOLIDS MANAGEMENT

The August 2000 Report titled "Evaluation of Biosolids Management Program and Alternatives" prepared for the City by Black & Veatch included a discussion about regulatory considerations for biosolids. Little has changed in the regulations of biosolids since that report. A summary of the regulatory considerations discussed in that report are presented here.

The beneficial reuse of biosolids and biosolids products on land is regulated by both the Missouri Department of Natural Resources and the U.S. Environmental Protection Agency. Missouri state law has incorporated the federal biosolids regulations, 40 CFR Part 503 Rule,

Standards for the Use or Disposal of Sewage Sludge, into its standards. The Part 503 standards establish the minimum standards for biosolids management, with the MDNR standards being more stringent in some areas. Compliance with MDNR requirements will ensure compliance with USEPA requirements. The State of Missouri does not at present intend to accept primacy to administer Part 503, but is the primary enforcing agency.

Part 503 establishes the primary standards affecting Columbia's biosolids management program. The MDNR has established certain equipment and process design standards, and general land application standards related to biosolids management. These standards, which can be more stringent than the 503 standards, are provided in the Code of State Regulations (CSR), Rules of Department of Natural Resources, Division 20 - Clean Water Commission. The standards address various aspects of the site geology, soils, biosolids stabilization, storage, and spreading methods, crops, public access, and monitoring. MDNR projects a cautiously positive attitude regarding beneficial reuse of biosolids. Agricultural management aspects, such as nutrient loading rates, are handled through various Water Quality Initiative publications such as WQ426, Best Management Practices for Biosolids Land Application. Biosolids composting regulations and design guidelines are not addressed in the Missouri Code of Regulations.

The biosolids from Columbia's Regional Wastewater Treatment Plant are well suited for beneficial use with acceptable metals and fecal coliform concentrations and high nutrient content. With the exception of copper, the average metals concentrations (based on 1997 and 1998 data considered in the Biosolids Report) are well below EPA's maximum allowable concentrations. The maximum copper concentrations for those periods exceeded the more stringent pollutant concentrations, which could prevent classification of the biosolids as an Exceptional Quality material. The primary effect of the higher copper concentrations on future biosolids management is the need to monitor cumulative metals loadings to the soil that could significantly limit the outlets for many distribution and marketing programs.

CHAPTER 4.0

HISTORICAL AND FUTURE FLOWS AND LOADS

Analysis of historical flow and load data can provide a good assessment of current wastewater characteristics that can be used to project future flows and loads resulting from growth in the study area. Establishing unit flow and load factors on a per capita basis is a common means to predict future flows and loads by relating flow and load to population. Wastewater contributions commonly come from residential, commercial and industrial sources. If the rate of industrial or commercial growth is projected to be the same as residential growth, then all future flows and loads will increase at a rate that parallels population growth, thus a per capita flow and load factor can be applied for all sources. If the residential growth rate is expected to be different than industrial or commercial growth, then the existing contribution from each source must be identified and different rates of growth applied to predict future conditions. From discussions with the City, it is anticipated that the commercial growth rate will mirror residential growth, but the industrial growth rate is expected to be greater than the residential growth rate. Therefore future flows and loads from residential and commercial sources will be based on population growth. Future industrial flows and loads will be based on a different growth rate as discussed in the section that follows about industrial growth.

4.1 HISTORICAL FLOWS, LOADS, AND PER CAPITA UNIT FACTORS

Plant operating data from January 2000 through May 2003 and collection system flow monitoring data taken during the period from April 30 to August 6, 2003 were used to establish values for annual average flow and loads; maximum month flow and loads; and peak day and peak hour flows. Annual average, maximum month and peak day flow and load values are used in sizing treatment plant process units. Peak day and peak hour hydraulic conditions are used to size collection system sewers, pumping stations, force mains, and excess flow treatment facilities. These terms are defined in the following paragraphs.

An annual average value is the arithmetic average of all daily data within a year and is commonly used to represent the design capacity of a wastewater treatment plant. Future annual average values will equal the historical per capita unit flow or load multiplied by the population projected to be connected to the regional WWTP.

Monthly averages are the arithmetic averages of daily data within a calendar month. Maximum month is the highest of these averages for the year. While treatment plant capacity is commonly expressed as an annual average flow rating, facility sizing is usually controlled by

maximum month conditions. Future maximum month values will be calculated in the same manner as for annual average values.

Peak day and peak hour values are used to size some of the treatment processes, including excess wet weather flow treatment facilities, and raw wastewater pump stations and force mains. Peak hour flows are commonly used to size collection systems and are a consideration when sizing pump station facilities. Values for future peak day and peak hour flows were developed from the collection system model.

4.1.1 Historical Flows and Loads.

Plant operating data for years 2000 through 2002 were reviewed for flow, biochemical oxygen demand (BOD), total suspended solids (TSS), and ammonia nitrogen. Ammonia was considered even though the current permit does not have ammonia limits because it is possible that nitrification and denitrification may be required in the future.

Flow is measured at the raw wastewater pump station, the influent to the wetlands, and at the effluent pumping station following the wetlands. From discussions with plant staff, it was decided that flow values recorded at the influent to the wetlands should be used for this analysis.

Influent sampling occurs at the raw wastewater pumping station. The sampling occurs downstream of where plant sidestreams are returned therefore the plant's recorded influent data includes sidestream contributions. Table 4-1, located at the end of this chapter, presents a summary of the plant data, calculated average values for the three year period and maximum month values. The "total" values for each year reflects adjustments made to the recorded plant influent to discount sidestream contributions to BOD, TSS and ammonia.

4.1.2 Industrial Contribution.

The plant operating data does not distinguish between residential/commercial and industrial sources. An industrial contribution was calculated using data collected by the City for the following industries and subtracted from the total plant flows and loads:

ABC Labs
Columbia Foods
Diggs Hot Dog Facility
UMC Power Plant
3M Company
Diggs Packing Company
Square D Company

Table 4-1
Historical Per Capita Unit Influent Flow and Load Factors

	2000	2001	2002	Ann Ave / Max Mo See Note 1	Per Capita Unit Factor	Influent Data Adjustment for sidestreams
Population (connected)	88,700					
Flow, mgd						
Ave (Total)	13.64	14.57	12.74	13.6		0.00%
Ave (Industrial)	1.13	1.09	1.13	1.1	8.6 % of Res/Com	No sidestream
Ave (Res + Comm)= Total - Indust	12.51	13.48	11.61	12.5	141 gpcd	adjustment
Max Month (Total)	15.70	18.60	19.20	19.2		Flow values
MM (Industrial)	1.24	1.20	1.24	1.2		are plant
MM (Res + Comm) = Total - Indust	14.46	17.40	17.96	18.0	203 gpcd	effluent flow
Influent BOD, ppd						
Ave (Total)	25,021	25,470	24,408	24,966		13.40%
Ave (Industrial)	3,153	3,363	3,869	3,462	16.1 % of Res/Com	
Ave (Res + Comm)= Total - Indust	21,868	22,107	20,539	21,505	0.243 ppcd	
Max Month (Total)	30,566	30,390	28,176	30,566		
MM (Industrial)	3,468	3,699	4,256	4,256		
MM (Res + Comm) = Total - Indust	27,098	26,691	23,920	27,098	0.306 ppcd	
Influent TSS, ppd						
Ave (Total)	28,653	26,257	22,946	25,952		18.00%
Ave (Industrial)	1,811	1,433	1,970	1,738	7.2 % of Res/Com	
Ave (Res + Comm)= Total - Indust	26,842	24,824	20,976	24,214	0.273 ppcd	
Max Month (Total)	42,804	36,535	30,543	42,804		
MM (Industrial)	1,992	1,576	2,167	2,167		
MM (Res + Comm) = Total - Indust	40,812	34,959	28,376	40,812	0.461 ppcd	
Influent Ammonia, ppd						
Ave (Total)	998	1,052	876	975		45.40%
Ave (Industrial)	161	102	83	115	13.4 % of Res/Com	
Ave (Res + Comm)= Total - Indust	837	950	793	860	0.010 ppcd	
Max Month (Total)	1,219	1,154	1,029	1,219		
MM (Industrial)	177	112	91	177		
MM (Res + Comm) = Total - Indust	1,042	1,042	938	1,042	0.012 ppcd	

Notes

1 Year 2000 Population is the estimated connected population to Columbia Regional WWTP only.

2 An average of the three years' data used for average conditions. Maximum month values are the maximum value of the three years considered.

3 Flow values presented reflect the following conditions:
   a) Flow values are the recorded flow values at the diversion structure (influent to wetlands)
   b) Industrial component is taken out as shown above to determine per capita flow from residential and commercial sources. Future industrial growth will be predicted independently (see Table 4-2).

4 Plant influent characteristics measured downstream of where side streams are returned to plant. For BOD, TSS and Ammonia loadings:
   a) the sidestream contribution must be subtracted from the recorded influent concentrations. The percentage shown reflects estimated sidestream contribution for each constituent.
   b) The industrial component of each constituent is taken out as shown above to determine per capita load from residential / commercial sources. Future industrial growth will be predicted independently (see Table 4-2)

On average, these industries contributed approximately 9 percent of the total plant influent flow, 16 percent of the BOD, 7 percent of the TSS, and about 13 percent of the ammonia. From discussions with City staff, it was decided that for year 2030, the industrial contribution on a flow and load basis will be 15 percent of the residential / commercial contribution.

4.1.3 Connected Population and Per Capita Unit Factors

Table 4-1 indicates how the industrial contribution is subtracted from the total flow and loads to determine the existing residential / commercial contribution to the plant. Future residential/ commercial contributions will be based on population growth and the residential/ commercial per capita unit factors presented in Table 4-1 for flows and loads. These per capita unit factors are equal to daily flow or load values divided by the population estimated to be connected during that period. The total population estimated for Year 2000 for areas expected to be sewered by Year 2030 is approximately 103,300. However, not all of this population was served by the regional plant in Year 2000. The Year 2000 connected population is estimated to be about 88,700. The historical average annual day per capita unit factors appear reasonable and are considered appropriate for predicting future residential and commercial demand.

4.2 FUTURE FLOWS AND LOADS

4.2.1 Future Annual Average and Maximum Month Flows and Loads

Future annual average and maximum month flow and loads will be used to size treatment facilities to meet future needs and will be projected based on the historical per capita unit factors presented in Table 4-1. Population projections for Year 2030 and ultimate development are presented in Chapter 2. For facility sizing, Year 2030 and ultimate flows and loads will be based on 100 percent of the projected population being connected to the Columbia Regional WWTP collection system. Table 4-2 presents the projected annual average and maximum month flow by watershed for Year 2030 and for ultimate development in the service area. Industrial contribution is shown independent of watershed values as it is difficult to predict in which watershed industrial development will occur. Table 4-3 presents projected flows and loads in five year increments from 2000 to 2030.

Table 4-2
Projected Flow for Year 2030 and Ultimate Development

Watershed	Year 2030		Ultimate	
	AA	MM	AA	MM
	141	203	141	203
Perche Creek	6.8	9.7	13.8	19.9
Hinkson Creek	15.1	21.8	20.3	29.2
Little Bonne Femme	2.8	4.1	6.9	9.9
Total (Residential + Commercial)	24.7	35.6	41.0	59.0
Industrial AA = 15% of AA Residential / Comm.				
MM = 20% of Industrial AA	3.7	4.4	6.2	7.4
Total (Including industrial)	28.4	40.0	47.2	66.4

1 Residential and Commercial Flow based on multiplying connected population times unit flow factors for annual average and maximum month in Table 4-1.

Table 4-3
Projected Flow and Loads in 5 Year Increments

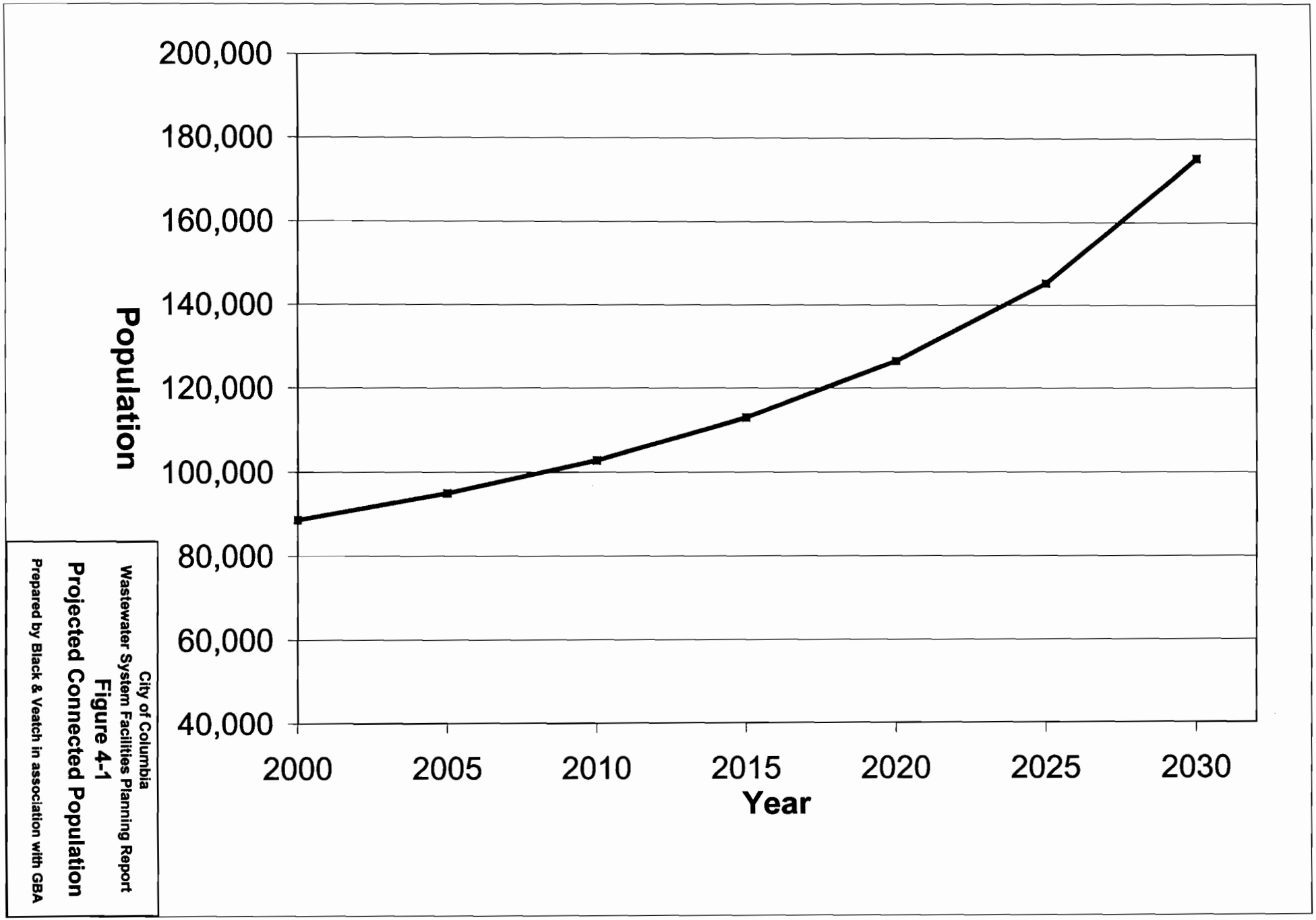
	2000	2005	2010	2015	2020	2025	2030
Projected Connected Population	88,700	95,014	102,906	113,025	126,507	145,306	175,444
Flow							
Ann Ave per capital flow, gpcd	141	141	141	141	141	141	141
Res+Comm AA Flow, mgd	12.5	13.4	14.5	15.9	17.8	20.5	24.7
Indust AA Flow, mgd	1.1	1.5	1.9	2.4	2.8	3.3	3.7
Total AA Flow, mgd	13.6	14.9	16.4	18.3	20.6	23.8	28.4
Max Mo. per capital flow, gpcd	203	203	203	203	203	203	203
Res+Comm MM Flow, mgd	18.0	19.3	20.9	22.9	25.7	29.5	35.6
Indust MM Flow, mgd	1.2	1.8	2.3	2.8	3.4	3.9	4.4
Total MM Flow, mgd	19.2	21.1	23.2	25.7	29.1	33.4	40.0
BOD							
Ann Ave per capital load, ppcd	0.243	0.243	0.243	0.243	0.243	0.243	0.243
Res+Comm AA load, ppd	21,505	23,088	25,006	27,465	30,741	35,309	42,633
Indust AA load, ppd	3,462	4,880	6,298	7,717	9,135	10,553	11,971
Total AA load, ppd	24,967	27,968	31,304	35,182	39,876	45,862	54,604
Max Mo. per capital load, ppcd	0.306	0.306	0.306	0.306	0.306	0.306	0.306
Res+Comm MM load, ppd	27,098	29,074	31,489	34,586	38,711	44,464	53,686
Indust MM load, ppd	4,256	6,080	7,905	9,729	11,554	13,378	15,202
Total MM load, ppd	31,354	35,154	39,394	44,315	50,265	57,842	68,888
TSS							
Ann Ave per capital load, ppcd	0.273	0.273	0.273	0.273	0.273	0.273	0.273
Res+Comm AA load, ppd	24,214	25,939	28,093	30,856	34,536	39,669	47,896
Indust AA load, ppd	1,738	2,450	3,162	3,874	4,586	5,298	6,010
Total AA load, ppd	25,952	28,389	31,255	34,730	39,122	44,967	53,906
Max Mo. per capital load, ppcd	0.461	0.461	0.461	0.461	0.461	0.461	0.461
Res+Comm MM load, ppd	40,812	43,801	47,440	52,105	58,320	66,986	80,880
Indust MM load, ppd	2,167	3,096	4,025	4,954	5,883	6,812	7,741
Total MM load, ppd	42,979	46,897	51,465	57,059	64,203	73,798	88,621
Ammonia							
Ann Ave per capital load, ppcd	0.010	0.010	0.010	0.010	0.010	0.010	0.010
Res+Comm AA load, ppd	860	950	1,029	1,130	1,265	1,453	1,754
Indust AA load, ppd	115	163	210	257	304	352	399
Total AA load, ppd	975	1,113	1,239	1,387	1,569	1,805	2,153
Max Mo. per capital load, ppcd	0.012	0.012	0.012	0.012	0.012	0.012	0.012
Res+Comm MM load, ppd	1,042	1,140	1,235	1,356	1,518	1,744	2,105
Indust MM load, ppd	177	253	329	405	481	557	633
Total MM load, ppd	1,219	1,393	1,564	1,761	1,999	2,301	2,738

Notes:
1 Year 2000 Connected Population for Existing Sewered Areas Connected to Columbia Regional WWTP
2 Year 2030 population assumes all population in sewered areas will be connected to Columbia Regional WWTP
3 Initial Industrial Flow based on historical data

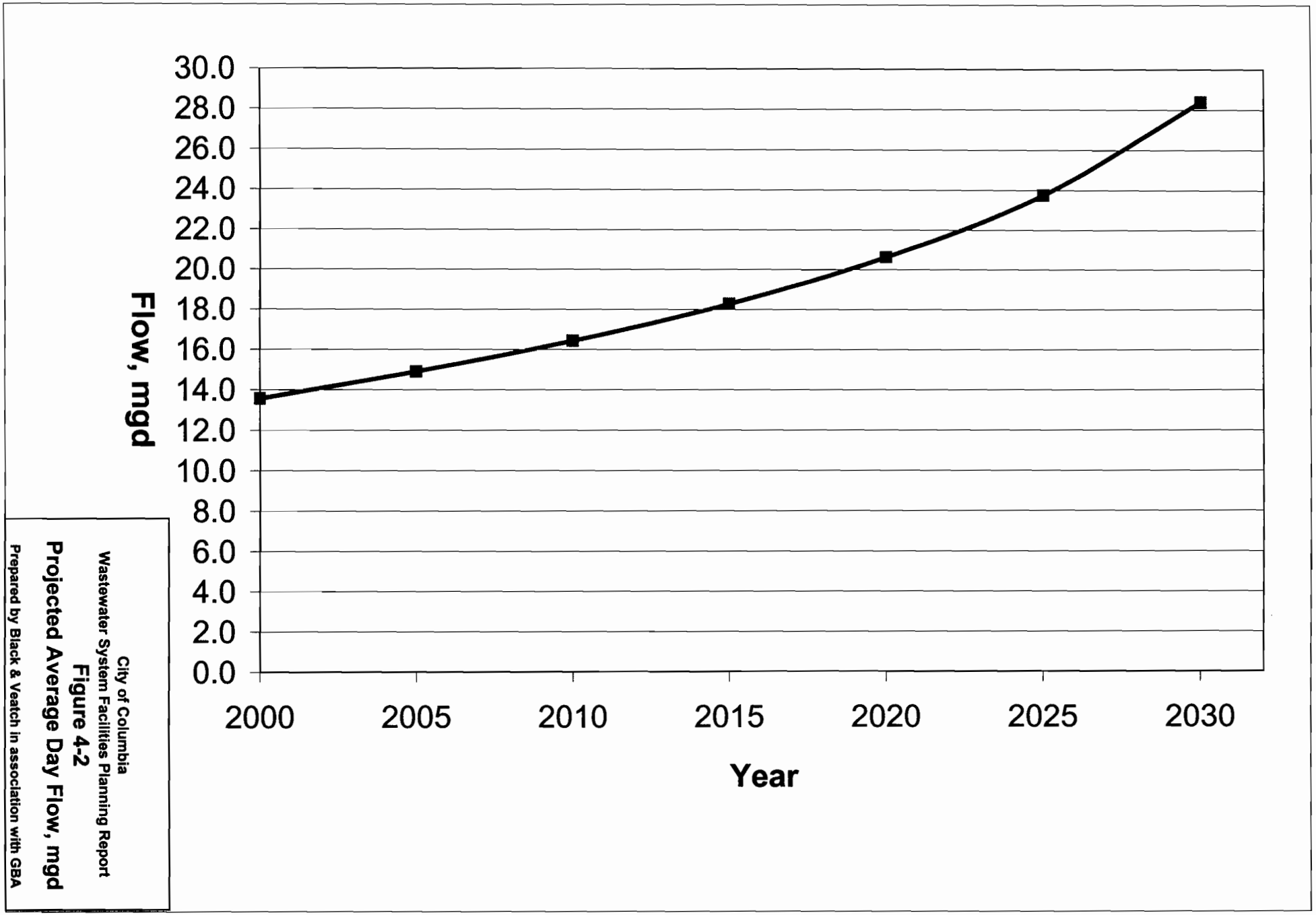
The population growth generally follows the growth rate predicted in the TAZ projections developed by the City's planning department. An adjustment was made to account for starting in Year 2000 with an estimated connected population that is less than the total population for 2000 and reaching the goal of having 100 percent of the population connected to the Columbia Regional WWTP system by 2030. The per capita unit factors from Table 4-1 were multiplied by the project population to calculate the flows and loads presented in Table 4-3. Figure 4-1 presents a graph of the projected connected population and Figure 4-2 presents a graph of the annual average flow increases projected for the study area.

4.2.2 Future Peak Flows

Future peak daily and hourly flows will be used to size treatment facilities to meet future needs. A hydrograph was developed in the hydraulic model for the Year 2030 flows at the WWTP. The hydrograph includes a base flow value that has been assigned based on population, which was determined from the TAZ files and criteria, a static infiltration value based on developed area and a dynamic inflow value based on developed area and the design criteria presented in Chapter 5. The peak hourly flow is the highest instantaneous flow for a 24-hour period, as calculated by the hydraulic model for the design storm event. This value is approximately 143 mgd for Year 2030. The peak daily flow is the average flow for a 24-hour period, as calculated by the hydraulic model for the design storm event. This value is approximately 68 mgd for Year 2030.



City of Columbia
Wastewater System Facilities Planning Report
Figure 4-1
Projected Connected Population
Prepared by Black & Veatch in association with GBA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Flow, mgd
2000
2005
2010
2015
2020
2025
2030
Year
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Figure 4-2
Projected Average Day Flow, mgd
Prepared by Black & Veatch in association with GBA

CHAPTER 5.0
COLLECTION SYSTEM EVALUATION

5.1 EXISTING SYSTEM INVENTORY

The existing sanitary sewer system in the City of Columbia was inventoried and is defined by the following components: gravity sewer lines, pump stations, and force mains.

5.2 ASSESSMENT

5.2.1 Gravity Sewers. The City of Columbia collection system consists of approximately 2,891,000 lineal feet of gravity sewer lines. Table 5-1 summarizes the length of gravity sewers for each watershed. Approximately fifty-four percent (54%) of the lines in the system were inventoried from record drawings.

Table 5-1
Gravity Sewer Inventory

Watershed	Total (ft)	IDM
Hinkson Creek	1,419,602	2,844
Mill Creek	406,519	709
Perche Creek	1,064,489	2,193
TOTAL:	2,890,610	5,747

IDM = inch diameter miles

5.2.2 Pump Stations and Force Mains. The City of Columbia maintains a total of twenty-three pump stations of which nineteen are within the area served by the Regional Wastewater Treatment Plant. Fifteen (15) of these pump stations were integrated into the model. The pump stations and force mains are listed in Table 5-2. Figure 5-5 illustrates the location of the pump stations. The raw wastewater pump station which lifts wastewater to the treatment plant and the effluent pump station are not included in this summary and are described in Chapter 6.

Table 5-2
Pump Station and Force Main Inventory

Pump Station Name	Year Built[1]	Structure Type [2]	No. of Pumps	Firm Cap. [3] (gpm)	Firm Cap. (mgd)	Force Main Diameter (in)	Force Main Length (ft)
Clear Creek	1986/2003	SL	2 sets of 2 in series	980	1.41	10	4,442
Ewing Industrial	1998	SUB	2	80	0.11	4	1,942
Hinkson Creek	1977	WP/DP	2	800	1.15	8	39
Little Bonne Femme	1993	SUB	4	2,100	3.02	14	6,313
North Hampton	1997	SUB	2	250	0.36	6	2,218
Valley View	1974	SL	2	80	0.11	6	235
Victoria South	2000	SUB	2	120	0.17	2 ½	3,000
Woodrail	1981	SL	2	80	0.11	4	701
Concord Industrial Park	1991	SUB	2	3	0.004	2	[3]
Haystack Acres #1	1997	SUB	2	26	0.04	2	614
Haystack Acres #2	1997	SUB	2	99	0.14	4	423
Haystack Acres #3	1997	SUB	2	78	0.11	3	1,719
Sunset Mobile Home Park	1993	WP/DP	2	200	0.28	6	1,627
Deer Ridge	2002	SUB	2	200	0.28	6	2,032
Cow Branch	2003	SUB	3	1,600	2.30	12	3,871
Thornbrook	2003	SUB	2	230	0.33	6	2,134
Cascades	2003	SUB	2	600	0.86	10	9,865
Inland Truck	1995	SUB	2	50	0.07	1.5	[4]
Lift Station at City Landfill	2003	SUB	2	75	0.10	4	[4]

Notes:

1. Year Built is based on date when drawings were conformed to construction records.
2. SL - Suction Lift
   SUB - Submersible
   WP/DP - Wet Pit / Dry Pit
3. Firm Capacity equals the capacity of the pump station with the largest pump out of service.
4. Unknown - Data could not be located in record information.
5. Shaded cells identify assumed information

5.3 COLLECTION SYSTEM FLOW AND RAINFALL MONITORING

Detailed flow and rainfall analysis information including parameter definitions, analysis methodology and comprehensive tables can be found in Appendix D. A summary of this analysis is presented in the following sections.

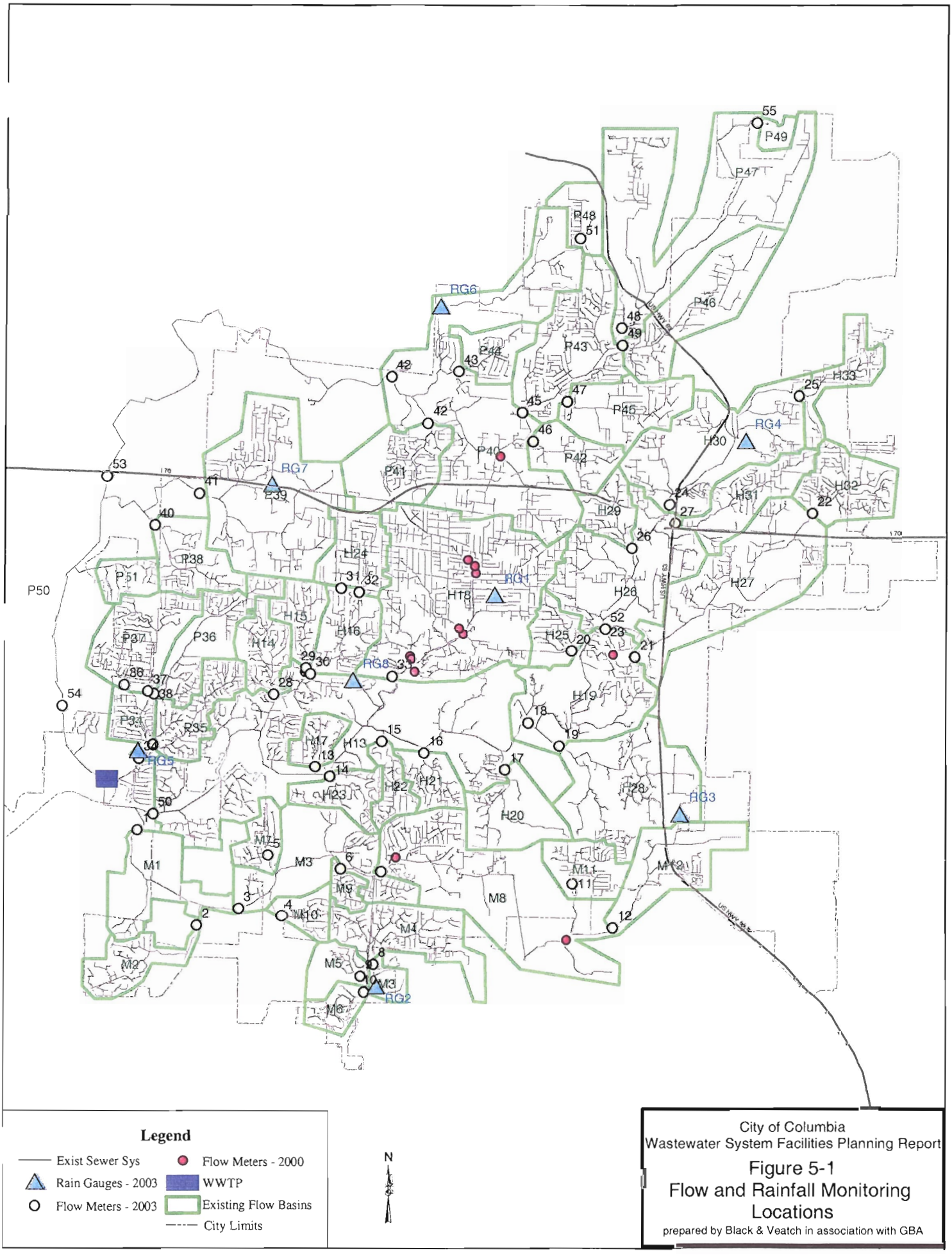
5.3.1 Flow Meter and Rainfall Gauge Locations. Fifty-five (55) flow monitoring sites were established in this study. Data from eight (8) rain gauges were also used for this study. Flow and rainfall were monitored for a fourteen-week period from April 30, 2003 to August 6, 2003. In addition, fifteen (15) sites were flow monitored in 2000 and were utilized for this analysis.

The City assisted with the flow meter site selection based on tributary area and the existing sewer layout. The meters subdivided the study area into fifty (50) flow basins, which were isolated from one another. This allowed for the establishment of flow parameters and determination of excessive flow from each basin. Detailed information on flow parameters for base flow, infiltration and inflow for each flow basin can be found in Appendix D. Figure 5-1 indicates the flow basin boundaries, rain gauge locations and flow meter locations. To show the interconnectivity of the basins, a flow basin diagram was developed and is presented in Figure 5-2.

5.3.2 Rainfall. Eight (8) continuously recording rain gauges recorded rainfall data for the 2003 study period. The rainfall data was compared to historical standard rainfall and intensity curves was made to determine the representative return interval for each recorded storm event. Table 5-3 summarizes the recorded rain events and their return intervals. Rainfall data collected from each rain gauge along with information on annual rainfall for Columbia, Missouri can be found in Appendix D. The greatest return interval storm event was a 3.6-year storm event recorded on 6/25/2003.

5.3.3 Basin Peak Flows. The flow parameters developed from flow monitoring were combined to determine the cumulative peak sanitary sewer flows. Individual basin peak flows were then calculated from the cumulative values. The individual basin peak flows and their ratio to base flows are shown in Table 5-4. Cumulative peak flows and their ratio to base flows are shown in Table 5-5. Information on the development of the flow parameters can be found in Appendix D.

5.3.4 Monitored Flow Basins with Excessive I/I. Table 5-6 presents a summary of the excessive wet weather flow (I/I) indicators for the metered basins for this study. Values in the table that are considered excessive are highlighted. These highlighted basins should be considered for I/I investigations and I/I removal. These basins are shown graphically in Figure 5-3.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Exist Sewer Sys
Rain Gauges - 2003
Flow Meters - 2003
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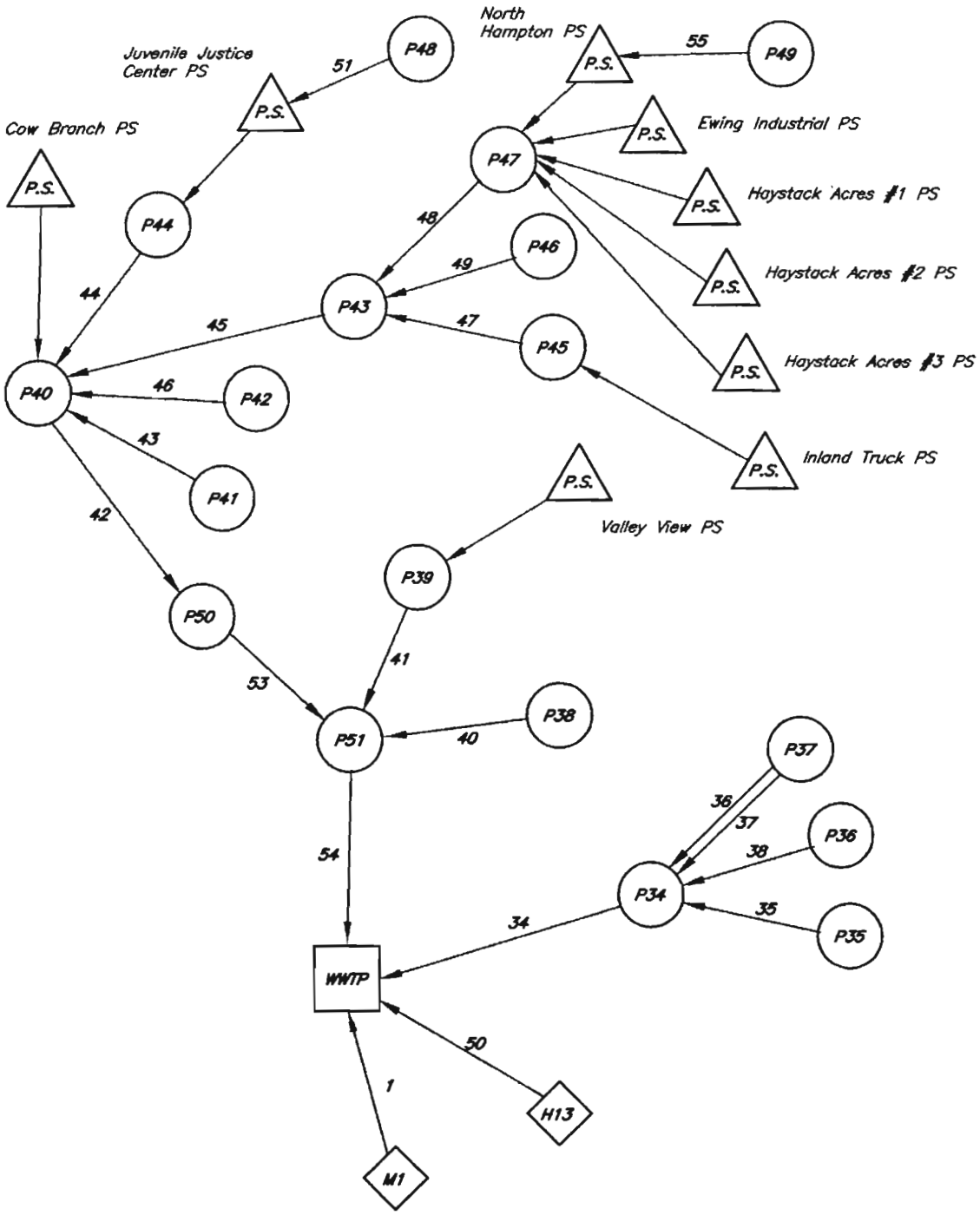
City of Columbia
Wastewater System Facilities Planning Report
Figure 5-1
Flow and Rainfall Monitoring Locations
prepared by Black & Veatch in association with GBA



LEGEND

- (12) **MONITORED FLOW BASIN**
- **SEWER**
- PS **PUMP STATION**
- WWTP **WASTEWATER TREATMENT PLANT**
- 99 **FLOW METER NUMBER**

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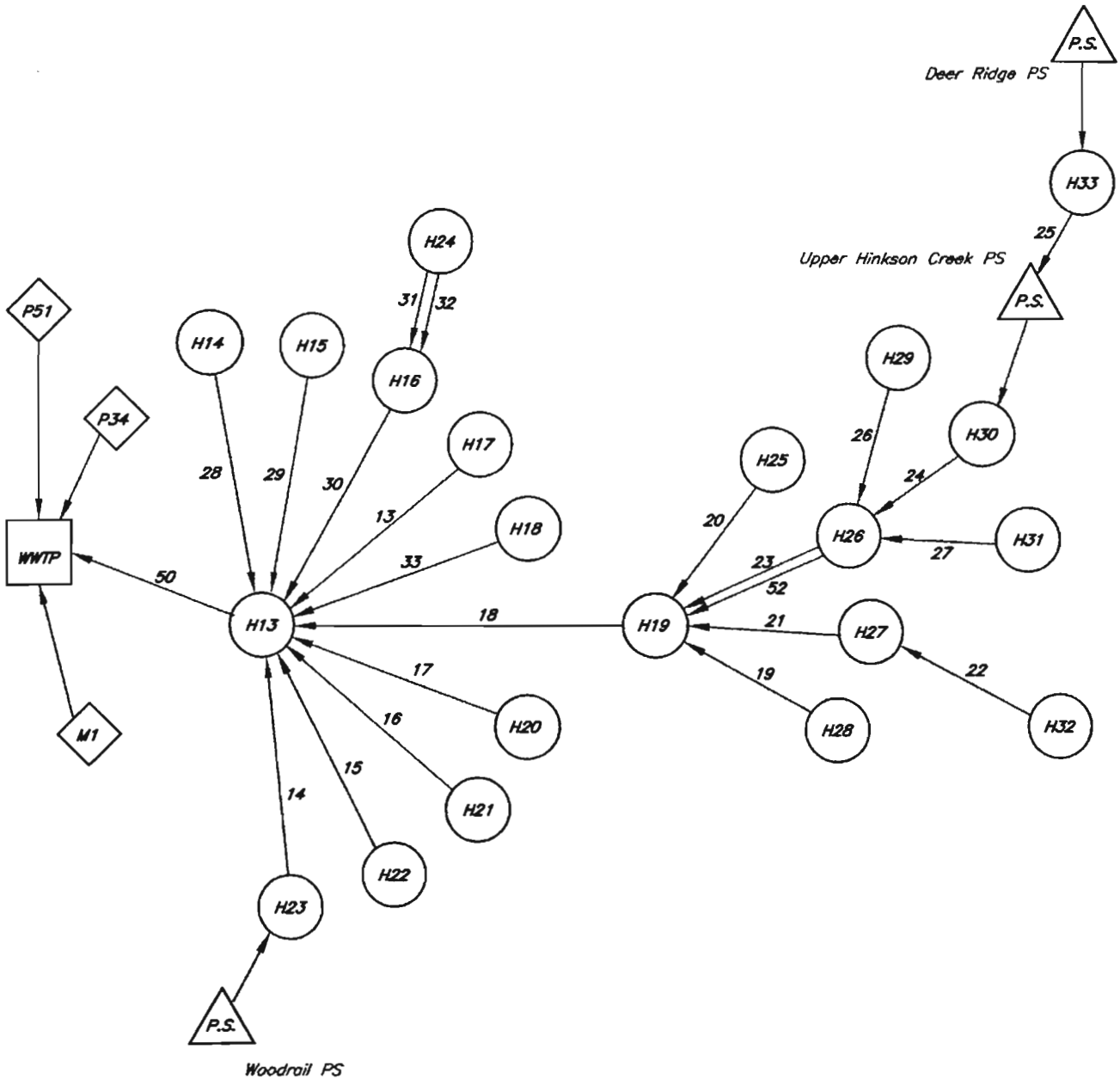
Figure 5-2A
Basin Flow Diagram
Perche Creek Outfall
Prepared by Black & Veatch in association with GBA



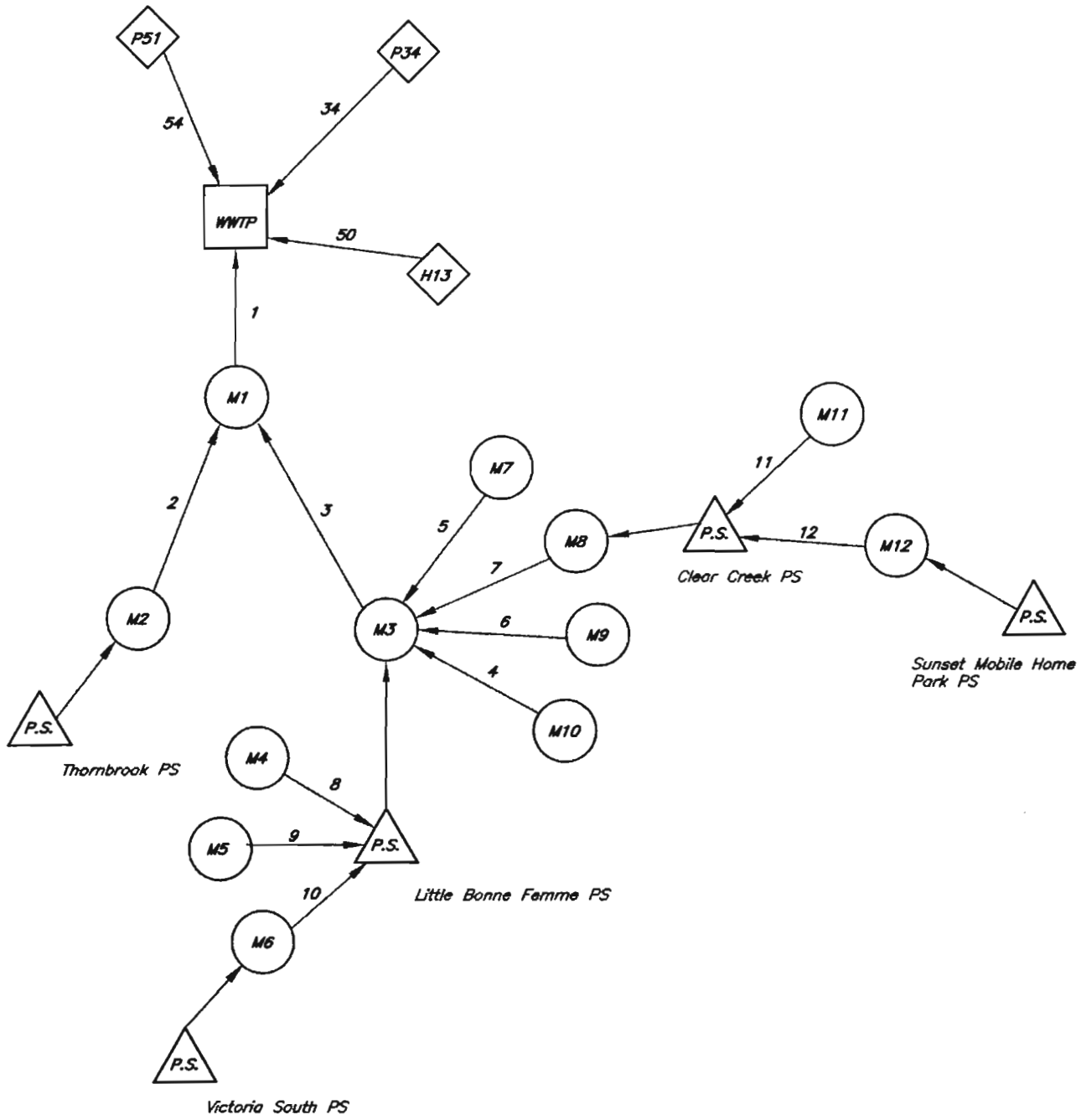
LEGEND

- (12) **MONITORED FLOW BASIN**
- **SEWER**
- PS **PUMP STATION**
- WWTP **WASTEWATER TREATMENT PLANT**
- 99 **FLOW METER NUMBER**

City of Columbia
Wastewater System Facilities Planning Report

Figure 5-2B
Basin Flow Diagram
Hinkson Creek Outfall

Prepared by Black & Veatch in association with GBA



LEGEND

- (12) **MONITORED FLOW BASIN**
- **SEWER**
- PS **PUMP STATION**
- WWTP **WASTEWATER TREATMENT PLANT**
- 99 **GBA METER NUMBER**

City of Columbia
Wastewater System Facilities Planning Report

Figure 5-2C
Basin Flow Diagram
Mill Creek Outfall

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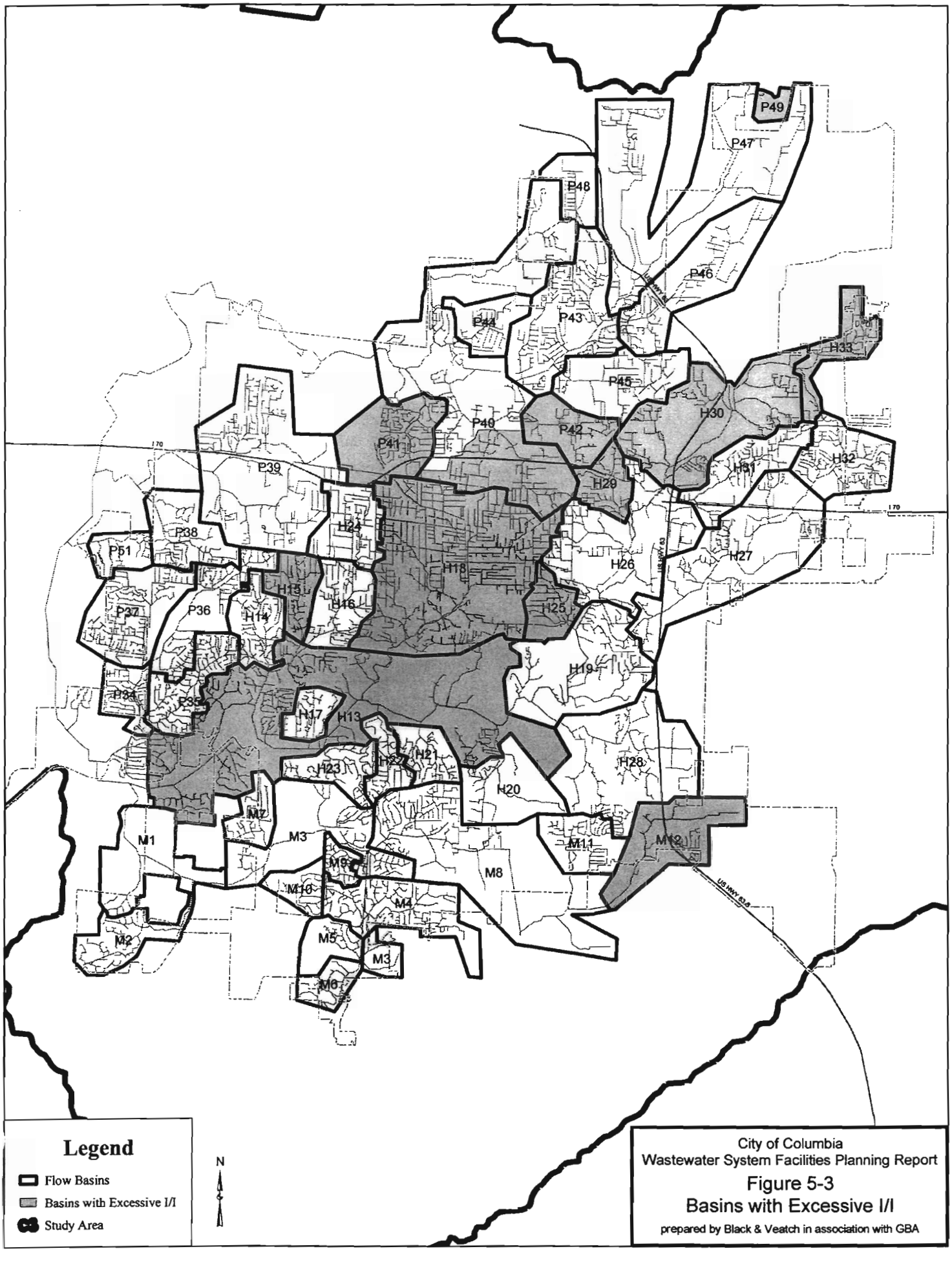
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Basins with Excessive I/I
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City of Columbia
Wastewater System Facilities Planning Report
Figure 5-3
Basins with Excessive I/I
prepared by Black & Veatch in association with GBA

Table 5-3 Rainfall Summary			
Date	Rainfall Total (in)	60-min Intensity (in/hr)[1]	Recurrence Interval[2]
5/4/2003	1.32	0.81	0.28
5/6/2003	0.07	0.07	0.06
5/8/2003	0.47	0.43	0.13
5/10/2003	1.16	0.55	0.16
5/14/2003	0.14	0.13	0.07
5/15/2003	0.53	0.52	0.15
5/16/2003	0.05	0.03	0.05
5/19/2003	0.14	0.14	0.07
5/20/2003	0.38	0.32	0.10
5/24/2003	0.47	0.21	0.08
5/30/2003	0.19	0.13	0.07
6/2/2003	1.26	0.36	0.11
6/6/2003	0.36	0.15	0.07
6/10/2003	0.48	0.36	0.11
6/11/2003	0.81	0.57	0.17
6/12/2003	1.38	1.28	0.76
6/13/2003	0.72	0.36	0.11
6/25/2003	3.38	2.02	3.62
6/26/2003	1.06	0.63	0.19
7/1/2003	0.74	0.56	0.17
7/9/2003	0.65	0.65	0.20
7/10/2003	0.55	0.20	0.08
7/17/2003	0.21	0.06	0.06
7/28/2003	0.21	0.21	0.08
Total	16.73		

Notes:
(1) The storm intensities are based on the maximum amount of rainfall for a 60-minute period for each storm event.
(2) Recurrence intervals are based on a 60 minute time of concentration and extrapolated from historical IDF curves.

Table 5-4 - Basin Peak Flow Rates										
Basin	Individual Area (acres)	Base Flow (MGD)	Peak Base Flow (MGD)	Infiltration (MGD)	1-Year Inflow (MGD)	10-Year Inflow (MGD)	1-Year Peak Flow[1] (MGD)	10-Year Peak Flow[1] (MGD)	1-Year Ratio[3]	10-Year Ratio[3]
M1	525	0.125	0.179	N/A	0.37	1.03	na	na	na	na
M2	330	0.011	0.064	0.009	0.51	1.32	0.58	1.39	53	126
M3	855	0.466	0.829	0.106	1.66	4.68	2.59	5.62	6	12
M4	602	0.431	0.690	0.262	1.26	3.23	2.21	4.19	5	10
M5	209	0.007	0.025	0.005	0.19	0.45	0.22	0.48	32	69
M6	172	0.010	0.100	0.003	0.07	0.17	0.17	0.27	17	27
M7	199	0.069	0.148	0.040	0.10	0.28	0.29	0.47	4	7
M8	1444	0.010	0.021	0.121	1.03	2.84	1.17	2.98	117	298
M9	101	0.046	0.105	0.013	0.23	0.59	0.35	0.71	8	15
M10	170	0.041	0.166	0.003	0.13	0.33	0.30	0.50	7	12
M11	329	0.097	0.203	0.046	0.40	1.12	0.65	1.36	7	14
M12	608	0.288	0.726	0.156	2.28	5.39	3.16	6.28	11	22
H13	2744	1.614	2.050	0.276	11.30	31.08	13.63	33.40	8	21
H14	309	0.141	0.278	0.122	0.56	1.44	0.96	1.84	7	13
H15	251	0.528	0.818	0.026	0.99	2.34	1.84	3.18	3	6
H16	375	0.138	0.177	0.089	0.61	1.69	0.88	1.96	6	14
H17	178	0.036	0.067	0.016	0.12	0.28	0.20	0.36	6	10
H18	2112	2.832	3.993	0.712	8.82	22.70	13.52	27.40	5	10
H19	970	0.350	0.501	0.167	0.35	0.97	1.02	1.64	3	5
H20	483	0.047	0.099	0.019	0.50	1.28	0.61	1.40	13	30
H21	235	0.042	0.079	0.006	0.28	0.65	0.36	0.74	9	18
H22	195	0.062	0.149	0.024	0.26	0.62	0.44	0.79	7	13
H23	279	0.053	0.117	0.020	0.17	0.46	0.30	0.59	6	11
H24	380	0.253	0.445	0.082	0.68	1.75	1.21	2.28	5	9
H25	235	0.318	0.611	0.171	2.24	5.30	3.02	6.08	9	19
H26	1141	0.389	0.681	0.314	0.46	1.30	1.46	2.30	4	6
H27	1228	0.028	0.043	0.010	0.58	1.55	0.63	1.60	23	57
H28	1092	0.149	0.240	0.030	0.38	1.04	0.65	1.31	4	9
H29	233	0.094	0.217	0.112	2.10	4.93	2.43	5.26	26	56
H30	1064	0.152	0.283	0.004	0.80	2.06	1.09	2.35	7	15
H31	459	0.130	0.237	0.056	1.06	2.72	1.35	3.01	10	23
H32	478	0.476	0.995	0.135	0.93	2.57	2.06	3.70	4	8
H33	312	0.063	0.266	0.031	0.72	1.70	1.02	1.99	16	32

(Continued)

Notes:
(1) - Peak Flow = Peak Base Flow + Infiltration + Inflow
(2) - Area information for 2000 meters provided by the City; represents estimated developed area for each topographic metered area.
(3) - 1-Year and 10-Year Ratio is the ratio of Peak Flow to Base Flow.

Table 5-4 Basin Peak Flow Rates (Continued)										
Basin	Individual Area (acres)	Base Flow (MGD)	Peak Base Flow (MGD)	Infiltration (MGD)	1-Year Inflow (MGD)	10-Year Inflow (MGD)	1-Year Peak Flow[1] (MGD)	10-Year Peak Flow[1] (MGD)	1-Year Ratio[3]	10-Year Ratio[3]
P34	219	0.038	0.063	0.004	0.18	0.49	0.25	0.56	7	15
P35	384	0.155	0.285	0.055	0.38	0.97	0.72	1.31	5	8
P36	504	0.169	0.321	0.161	0.42	1.13	0.90	1.61	5	10
P37	605	0.280	0.664	0.097	1.38	3.24	2.14	4.00	8	14
P38	415	0.125	0.226	0.080	0.52	1.34	0.83	1.65	7	13
P39	1496	0.706	1.052	0.156	1.05	2.91	2.26	4.12	3	6
P40	2308	0.825	1.031	0.240	2.16	6.11	3.43	7.38	4	9
P41	573	0.277	0.432	0.238	1.52	3.92	2.19	4.59	8	17
P42	341	0.152	0.213	0.051	1.00	2.35	1.26	2.62	8	17
P43	861	0.154	0.208	0.120	1.46	3.91	1.79	4.23	12	27
P44	274	0.028	0.076	0.006	0.35	0.83	0.43	0.91	15	33
P45	548	0.212	0.367	0.040	0.74	1.74	1.14	2.14	5	10
P46	776	0.509	0.713	0.146	0.98	2.32	1.84	3.18	4	6
P47	2010	1.109	1.575	0.078	1.46	3.92	3.12	5.57	3	5
P48	227	0.029	0.057	0.004	0.19	0.53	0.25	0.59	9	20
P49	81	0.017	0.058	0.004	0.38	0.90	0.44	0.96	26	57
P50	15	0.013	0.016	0.013	0.01	0.03	0.04	0.05	3	4
P51	185	0.030	0.038	0.017	0.33	0.87	0.38	0.93	13	31
2000-1 [2]	966	0.362	0.691	0.193	2.83	6.67	3.71	7.55	10	21
2000-2	550	0.316	0.578	0.318	0.98	2.30	1.88	3.20	6	10
2000-3	2000	0.343	0.648	0.103	0.84	2.17	1.59	2.92	5	9
2000-4	260	0.570	1.015	0.126	0.85	2.00	1.99	3.14	3	6
2000-5&6	213	0.080	0.201	0.062	0.72	1.71	0.98	1.97	12	25
2000-7	80	0.217	0.427	0.045	0.65	1.53	1.12	2.00	5	9
2000-8	290	0.138	0.316	0.103	1.85	4.38	2.27	4.80	16	35
2000-9&10	220	0.287	0.646	0.066	1.06	2.52	1.77	3.23	6	11
2000-11	200	0.255	0.456	0.060	1.56	3.70	2.08	4.22	8	17
2000-12	340	0.252	0.358	0.075	1.34	3.18	1.77	3.61	7	14
2000-13	375	0.420	0.798	0.157	2.05	4.86	3.01	5.82	7	14
2000-14	275	0.123	0.335	0.070	1.36	3.19	1.76	3.59	14	29
2000-15	442	1.205	1.675	0.041	2.10	4.95	3.82	6.67	3	6

Notes:
(1) Peak Flow = Peak Base Flow + Infiltration + Inflow
(2) Area information for 2000 meters provided by the City; represents estimated developed area for each topographic metered area.
(3) - 1-Year and 10-Year Ratio is the ratio of Peak Flow to Base Flow.

Table 5-5
Cumulative Peak Flow Rates

Basin	Cum. Area (acres)	Cumulative Base Flow (MGD)	Peak Base Flow (MGD)	Cum. Infiltration (MGD)	Cum. "K"	1-Year Inflow (MGD)	10-Year Inflow (MGD)	1-Year Peak Flow[1] (MGD)	10-Year Peak Flow[1] (MGD)	1-Year Ratio[4]	10-Year Ratio[4]
M1	5,544	1.216	1.739	0.764	0.0023	3.86	10.90	6.36	13.40	5	11
M2	330	0.011	0.064	0.009	0.0035	0.51	1.32	0.58	1.39	53	126
M3	4,689	1.080	1.922	0.755	0.0031	4.36	12.33	7.04	15.01	7	14
M4	602	0.431	0.690	0.262	0.0048	1.26	3.23	2.21	4.19	5	10
M5	209	0.007	0.025	0.005	0.0015	0.19	0.45	0.22	0.48	32	69
M6	172	0.010	0.100	0.003	0.0009	0.07	0.17	0.17	0.27	17	27
M7	199	0.069	0.148	0.040	0.0014	0.10	0.28	0.29	0.47	4	7
M8	2,381	0.395	0.845	0.323	0.0019	1.70	4.68	2.86	5.85	7	15
M9	101	0.046	0.105	0.013	0.0052	0.23	0.59	0.35	0.71	8	15
M10	170	0.041	0.166	0.003	0.0017	0.13	0.33	0.30	0.50	7	12
M11	329	0.097	0.203	0.046	0.0033	0.40	1.12	0.65	1.36	7	14
M12	608	0.288	0.726	0.156	0.0061	2.28	5.39	3.16	6.28	11	22
H13	14,753	7.895	10.027	2.422	0.0068	26.01	71.53	38.46	83.98	5	11
H14	309	0.141	0.278	0.122	0.0041	0.56	1.44	0.96	1.84	7	13
H15	251	0.528	0.818	0.026	0.0072	0.99	2.34	1.84	3.18	3	6
H16	754	0.391	0.500	0.171	0.0042	1.19	3.29	1.86	3.96	5	10
H17	178	0.036	0.067	0.016	0.0012	0.12	0.28	0.20	0.36	6	10
H18	2,112	2.832	3.993	0.712	0.0095	8.82	22.70	13.52	27.40	5	10
H19	7,212	2.149	3.073	1.030	0.0035	6.53	17.94	10.63	22.05	5	10
H20	483	0.047	0.099	0.019	0.0023	0.50	1.28	0.61	1.40	13	30
H21	235	0.042	0.079	0.006	0.0022	0.28	0.65	0.36	0.74	9	18
H22	195	0.062	0.149	0.024	0.0025	0.26	0.62	0.44	0.79	7	13
H23	279	0.053	0.117	0.020	0.0016	0.17	0.46	0.30	0.59	6	11
H24	380	0.253	0.445	0.082	0.0041	0.68	1.75	1.21	2.28	5	9
H25	235	0.318	0.611	0.171	0.0155	2.24	5.30	3.02	6.08	9	19
H26	3,209	0.828	1.449	0.517	0.0033	3.12	8.82	5.09	10.78	6	13
H27	1,706	0.504	0.781	0.145	0.0024	1.48	3.95	2.40	4.88	5	10
H28	1,092	0.149	0.240	0.030	0.0009	0.38	1.04	0.65	1.31	4	9
H29	233	0.094	0.217	0.112	0.0164	2.10	4.93	2.43	5.26	26	56
H30	1,376	0.215	0.400	0.035	0.0023	1.38	3.55	1.81	3.98	8	19
H31	459	0.130	0.237	0.056	0.0052	1.06	2.72	1.35	3.01	10	23
H32	478	0.476	0.995	0.135	0.0052	0.93	2.57	2.06	3.70	4	8
H33	312	0.063	0.266	0.031	0.0042	0.72	1.70	1.02	1.99	16	32
				(Continued)							

Notes:

(1) - Peak Flow = Peak Base Flow + Infiltration + Inflow

(2) - Area information for 2000 meters provided by the City; represents estimated developed area for each topographic metered area.

(3) - Cumulative time of concentration and inflow values could not be accurately determined due to the dynamic upstream effects of the Clear Creek Pump Station.

(4) - 1-Year and 10-Year Ratio is the ratio of Peak Flow to Base Flow.

Table 5-5 Cumulative Peak Flow Rates (Continued)

Basin	Cum. Area (acres)	Cum. Base Flow (MGD)	Peak Base Flow (MGD)	Cum. Infiltration (MGD)	Cum. "K"	1-Year Inflow (MGD)	10-Year Inflow (MGD)	1-Year Peak Flow[1] (MGD)	10-Year Peak Flow[1] (MGD)	1-Yr Ratio[4]	10-Yr Ratio[4]
P34	1,712	0.642	1.072	0.317	0.0029	1.82	4.88	3.21	6.27	5	10
P35	384	0.155	0.285	0.055	0.0022	0.38	0.97	0.72	1.31	5	8
P36	504	0.169	0.321	0.161	0.0023	0.42	1.13	0.90	1.61	5	10
P37	605	0.280	0.664	0.097	0.0041	1.38	3.24	2.14	4.00	8	14
P38	415	0.125	0.226	0.080	0.0029	0.52	1.34	0.83	1.65	7	13
P39	1,496	0.706	1.052	0.156	0.0019	1.05	2.91	2.26	4.12	3	6
P40	7,999	3.312	4.140	0.927	0.0032	7.49	21.17	12.56	26.24	4	8
P41	573	0.277	0.432	0.238	0.0061	1.52	3.92	2.19	4.59	8	17
P42	341	0.152	0.213	0.051	0.0053	1.00	2.35	1.26	2.62	8	17
P43	4,503	2.030	2.741	0.392	0.0027	4.42	11.83	7.55	14.96	4	7
P44	274	0.028	0.076	0.006	0.0021	0.35	0.83	0.43	0.91	15	33
P45	548	0.212	0.367	0.040	0.0025	0.74	1.74	1.14	2.14	5	10
P46	776	0.509	0.713	0.146	0.0023	0.98	2.32	1.84	3.18	4	6
P47	2,091	1.126	1.599	0.082	0.0022	1.70	4.54	3.38	6.22	3	6
P48	227	0.029	0.057	0.004	0.0023	0.19	0.53	0.25	0.59	9	20
P49	81	0.017	0.058	0.004	0.0076	0.38	0.90	0.44	0.96	26	57
P50	8,014	3.325	4.123	0.940	0.0024	4.93	13.56	9.99	18.62	3	6
P51	10,110	4.186	5.274	1.193	0.0037	7.80	20.72	14.27	27.18	3	6
2000-1[2]	966	0.362	0.691	0.193	0.0053	2.83	6.67	3.71	7.55	10	21
2000-2	2,550	0.678	1.241	0.125	na[3]	na[3]	na[3]	na[3]	na[3]	na[3]	na[3]
2000-3	2,000	0.343	0.648	0.103	0.0010	0.84	2.17	1.59	2.92	5	9
2000-4	260	0.570	1.015	0.126	0.0053	0.85	2.00	1.99	3.14	3	6
2000-5&6	213	0.080	0.201	0.062	0.0055	0.72	1.71	0.98	1.97	12	25
2000-7	80	0.217	0.427	0.045	0.0148	0.65	1.53	1.12	2.00	5	9
2000-8	290	0.138	0.316	0.103	0.0104	1.85	4.38	2.27	4.80	16	35
2000-9&10	220	0.287	0.646	0.066	0.0079	1.06	2.52	1.77	3.23	6	11
2000-11	200	0.255	0.456	0.060	0.0127	1.56	3.70	2.08	4.22	8	17
2000-12	340	0.252	0.358	0.075	0.0064	1.34	3.18	1.77	3.61	7	14
2000-13	375	0.420	0.798	0.157	0.0089	2.05	4.86	3.01	5.82	7	14
2000-14	275	0.123	0.335	0.070	0.0090	1.36	3.19	1.76	3.59	14	29
2000-15	2,045	3.004	4.176	0.578	0.0087	9.73	22.89	14.48	27.64	5	9

Notes:

(1) - Peak Flow = Peak Base Flow + Infiltration + Inflow

(2) - Area information for 2000 meters provided by the City; represents estimated developed area for each topographic metered area.

(3) - Cumulative time of concentration and inflow values could not be accurately determined due to the dynamic upstream effects of the Clear Creek Pump Station.

(4) - 1-Year and 10-Year Ratio is the ratio of Peak to Base Flow.

Table 5-6
Summary of I/I Parameters

Basin	K Coefficient	IDM[3]	Individual 1-Yr Peak Flow Ratio[1]	Individual 1-Yr Inflow Rate (gpd/1000ft)	Individual Infiltration Rate (gpd/1000ft)
M1	0.0023	60.6	N/A	19,316	N/A
M2	0.0035	52.2	53	16,471	290
M3	0.0065	139.6	6	23,070	1,476
M4	0.0048	103.1	5	19,205	4,004
M5	0.0015	14.2	32	20,469	535
M6	0.0009	20.0	17	5,008	226
M7	0.0014	29.2	4	5,391	2,095
M8	0.0019	173.1	117	11,172	1,314
M9	0.0052	23.0	8	15,225	858
M10	0.0017	23.8	7	8,355	193
M11	0.0033	46.1	7	13,286	1,511
M12	0.0061	54.3	11	87,127	5,969
H13	0.0159	664.0	8	49,680	1,213
H14	0.0041	68.1	7	12,923	2,819
H15	0.0072	48.1	3	31,228	818
H16	0.0044	75.4	6	15,773	2,291
H17	0.0012	35.6	6	5,233	700
H18	0.0095	182.4	5	30,753	2,483
H19	0.0014	236.7	3	4,879	2,305
H20	0.0023	39.0	13	20,144	770
H21	0.0022	41.5	9	10,511	227
H22	0.0025	38.0	7	11,661	1,062
H23	0.0016	57.6	6	4,987	604
H24	0.0041	83.4	5	14,347	1,729
H25	0.0155	37.6	9	91,193	6,967
H26	0.0014	220.4	4	2,746	1,869
H27	0.0013	143.2	23	7,388	128
H28	0.0009	131.8	4	5,732	456
H29	0.0164	48.7	26	77,493	4,140
H30	0.0017	135.7	7	68,664	343
H31	0.0052	83.2	10	20,733	1,099
H32	0.0052	104.3	4	9,005	1,305
H33	0.0042	45.2	16	29,245	1,258
P34	0.0023	64.3	7	5,351	117
P35	0.0022	105.7	5	5,738	835

(Continued)

Table 5-6 Summary of I/I Parameters (Continued)

Basin	K Coefficient	IDM	Individual 1-Yr Peak Flow Ratio[1]	Individual 1-Yr Inflow Rate (gpd/1000ft)	Individual Infiltration Rate (gpd/1000ft)
P36	0.0023	89.2	5	7,572	2,893
P37	0.0041	112.3	8	19,156	1,350
P38	0.0029	66.1	7	12,217	1,874
P39	0.0019	186.6	3	9,023	1,335
P40	0.0032	341.2	4	13,552	1,505
P41	0.0061	95.7	8	25,198	3,936
P42	0.0053	42.6	8	37,598	1,917
P43	0.0047	183.6	12	14,329	1,179
P44	0.0021	42.6	15	12,493	213
P45	0.0025	71.9	5	16,751	908
P46	0.0023	98.8	4	18,062	2,678
P47	0.0020	189.1	3	21,085	1,125
P48	0.0023	13.6	9	17,688	368
P49	0.0076	1.3	26	47,987	505
P50	0.0024	279.9	3	272	383
P51	0.0086	235.4	13	7,891	408
2000-1[2]	0.0053	N/A	10	44,468	3,033
2000-2	0.0032	N/A	6	7,941	5,320
2000-3	0.0010	N/A	5	5,629	690
2000-4	0.0053	46.2	3	39,668	5,880
2000-5&6	0.0055	33.5	12	43,948	3,784
2000-7	0.0148	9.2	5	107,172	7,420
2000-8	0.0104	67.5	16	51,027	2,841
2000-9&10	0.0079	47.5	6	34,978	2,178
2000-11	0.0127	44.9	8	53,780	2,068
2000-12	0.0064	78.6	7	27,353	1,531
2000-13	0.0089	N/A	7	38,226	2,928
2000-14	0.0090	N/A	14	46,932	2,416
2000-15	0.0104	N/A	3	7,750	497

Notes: [ ] = Excessive Inflow/Infiltration (I/I)

Excessive I/I Criteria

"K" Coefficient > 0.005

1-Yr Inflow Rate > 25,000 gpd/1000 ft

Infiltration Rate > 4,500 gpd/IDM

1-Yr Peak Flow Ratio > 10

(1) - 1-Yr Peak Flow Ratio = 1-Yr Peak Flow / Base Flow

(2) - Area information for 2000 meters provided by the City; represents estimated developed area for each topographic metered area.

5.3.5 Sewer Overflows and Backups. The City has experienced sewer overflows in the form of manhole overflows and basement backups. These occur mainly in the Flat Branch and Southwest sub-watersheds. During the study period, a 4-inch rainfall occurred on March 26, 2004. As a result of this storm, six manhole overflows and 15 basement backups were recorded by City staff. These backups were in the general vicinity of other historical backup information provided.

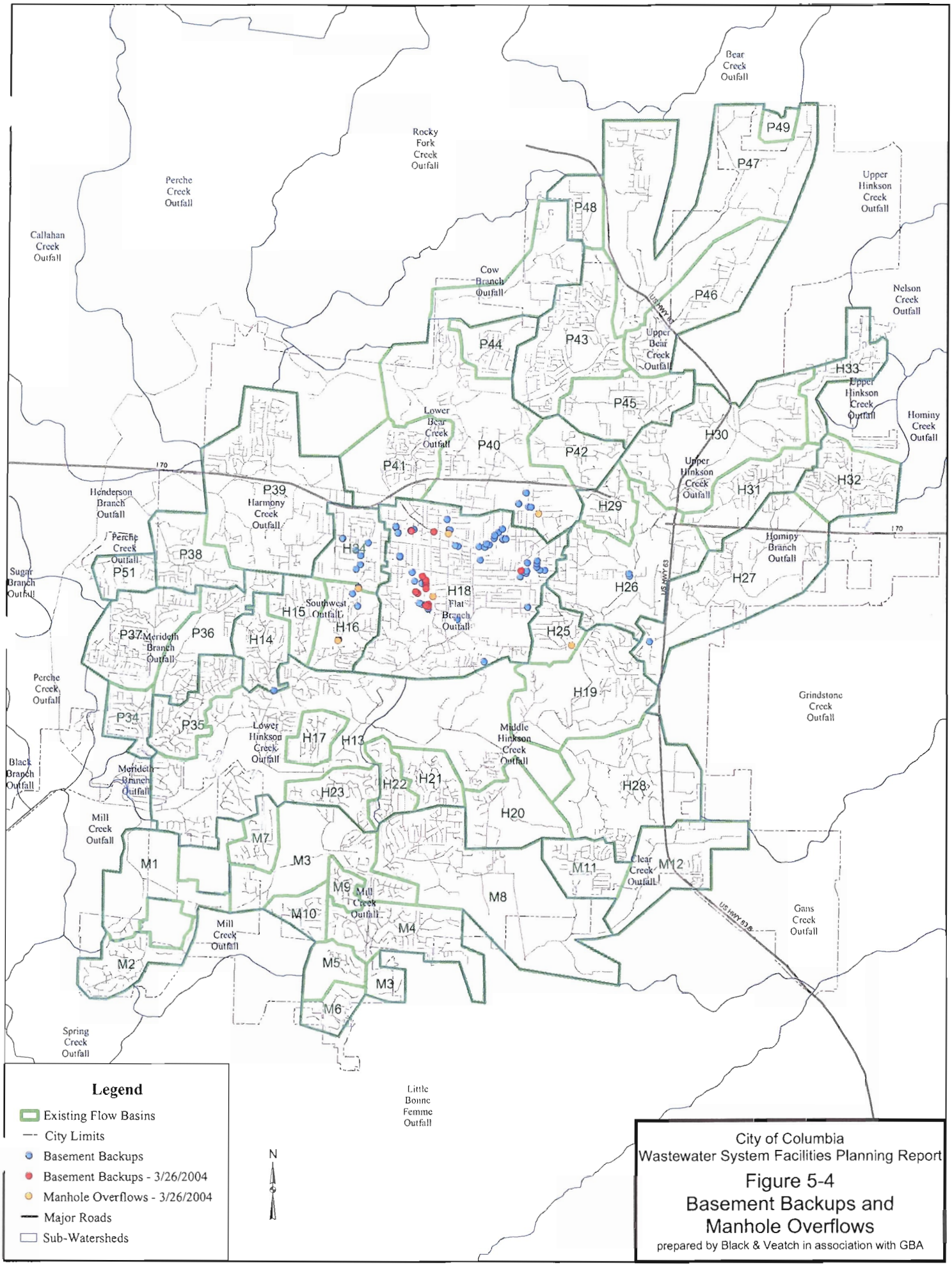
The overflows and backups for the March 26 storm as well as backups that have occurred in previous years are shown in Figure 5-4.

5.3.6 Design Flow Parameters. The design flow parameters presented below were developed based on flow monitoring data and average daily flows observed in the collection system. The parameters include values for peak base flow, peak infiltration flow, and a recommended inflow coefficient "K." These criteria have been developed to allow the City to size sewers for new development or to analyze the impact of new development on the existing system.

Peak Base Flow Criteria - Peak base flow consists of residential and commercial wastewater production and dry weather base infiltration, with an applied peaking factor. The average daily flow (ADF) used for this study was 141 gallons/capita/day (gpcd). A peaking factor of two (2) was utilized to develop a peak base flow value. This value was consistent with data collected during flow monitoring in 2000 and 2003.

Peak Infiltration Criteria - Peak infiltration consists of rainfall induced infiltration. The average peak infiltration for the flow monitoring sites during this study was approximately 200 gpd per acre, with the high value being approximately 870 gpd per acre. A parameter value of 500 gpd per acre was chosen to conservatively predict the future impact of infiltration on the collection system.

Inflow Criteria – Flow data from seventy (70) flow monitoring sites were evaluated to calculate a cumulative "K" value, as previously described. The weighted "K" average for all 70 sites is 0.005. This value is somewhat skewed because it includes the high inflow rates from older parts of the City. Since the time that those sewers were constructed, sewer materials and installation practices have improved. The City's current design standard of 0.007 cfs/acre is comparable to a "K" value of 0.003. The City chose to use a "K" value of 0.003 for this project.



City of Columbia
Wastewater System Facilities Planning Report

Figure 5-4
Basement Backups and Manhole Overflows

prepared by Black & Veatch in association with GBA

Summary of Criteria - In summary, the design flow criteria recommended for the city to use to evaluate new development is as follows:

- Peak Base Flow = 282 gpcd
- Peak Infiltration Flow = 500 gpd / acre
- Inflow Coefficient "K" = 0.003
- Design Storm = 10-Year

5.4 I/I INVESTIGATION NEAR WWTP PUMP STATION

5.4.1 Introduction and Background. Currently, the City experiences high flows during major storm events at the wastewater treatment plant. The flows significantly increase when the treatment plant pump station wet-well level reaches an elevation of 30 feet. The high magnitude of flow and mentioned wet-well level is only achieved during major storm events. Wastewater treatment plant personnel also notice fish and other aquatic life in the holding basins after such events. As part of this project, a supplementary study was conducted. The purpose of this study was to flow monitor the major outfall sewers entering the wastewater treatment plant pump station and attempt to isolate the source of wet weather flow entering the sanitary sewer system once the wet-well flow elevation reaches 30 feet. Appendix C contains additional information and the results of this study.

5.4.2 Conclusions and Recommendations. Consistent data agreement existed between base flow measurements of the flow meters and the base flows measured by the pump station meters. Also, total wet weather flow volumes for the flow meters and the pump station meter existed for the 6/2/03 and 6/25/03 storms. Only the 6/12/03 storm provided higher flow volumes from the pump station meter than the flow meters. Since the 6/12/03 storm is the only storm that caused the wet well levels to exceed 30 feet, this would indicate that a major leak or leaks exist in the main interceptors downstream of the meters. The leak is most likely activated when the creeks exceed their banks and find a hole or holes from the surface to the pipe. In order to identify the precise location of these leaks, the following inspection activities should be conducted downstream of the flow meter locations:

- Walk surface of interceptors to look for holes at surface above pipe.
- Smoke test interceptors to identify major leaks in pipe.
- Televise interceptors to identify major defects that cause leaks in pipe.

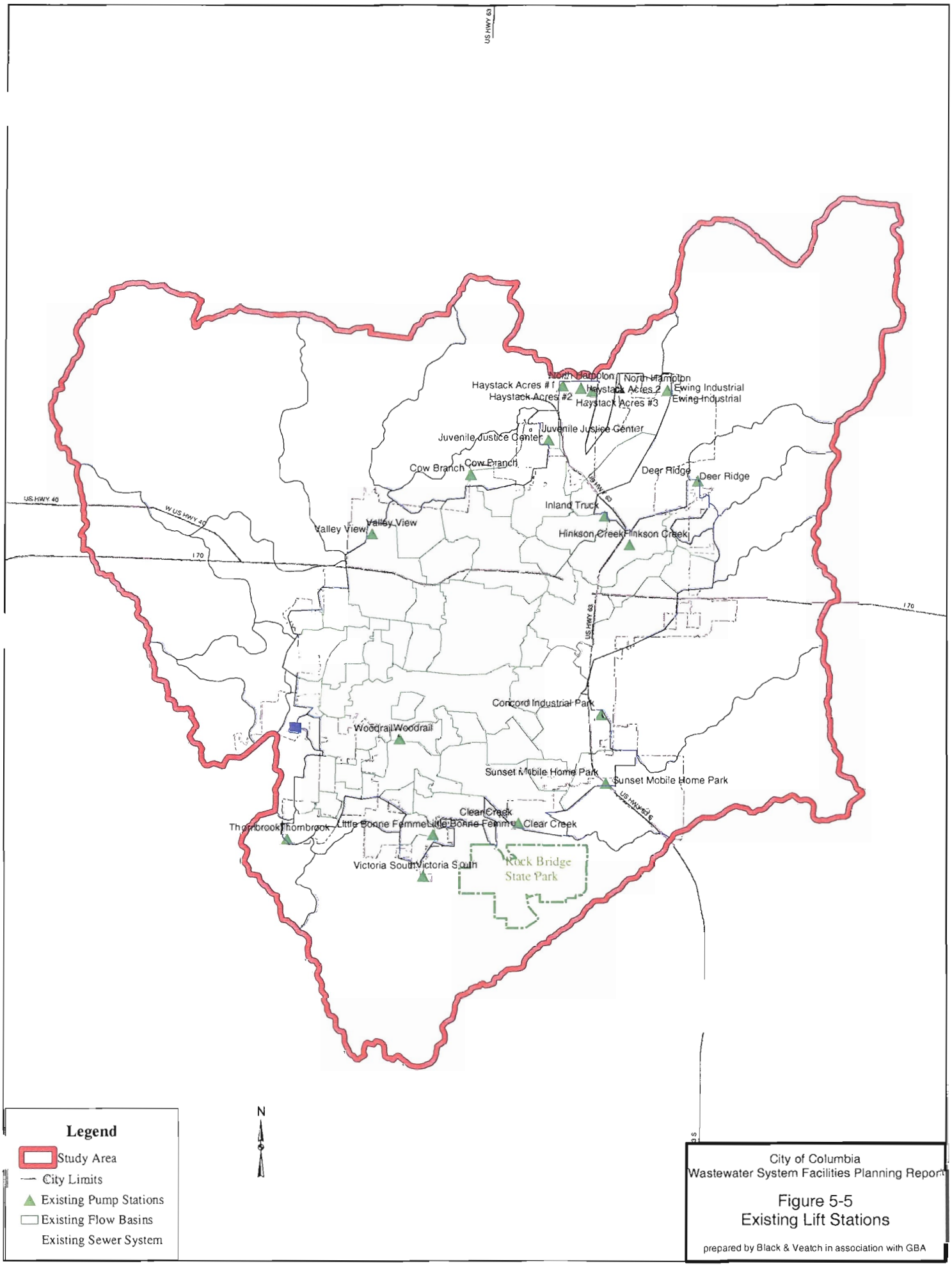
5.5 PUMP STATION AND FORCE MAIN EVALUATION

This section provides a summary assessment of the 19 existing pump stations and force mains located in the City's collection system that is served by the Regional WWTP. Data were collected for all 19 pump stations. Eight were inspected by Black and Veatch in January 2004. Inspection reports for these eight stations are included as Appendix E. The pump station locations are shown in Figure 5-5. The following tasks were performed:

- Prepare an inventory of the collection system pump stations based on as-built records, pump curves, and other related data, where available.
- Perform an on-site inspection of eight selected stations to evaluate pumping capacity; to evaluate structural, mechanical, and electrical conditions; to determine conformance with MDNR design standards; and to evaluate force main detention times or other conditions which contribute to odor generation.
- Evaluate pump station alternatives including pump station consolidation and elimination (discussed in Chapter 7).
- Evaluate SCADA options for pump stations, including continual surveillance, alarm needs, remote control needs, and best communication system.

5.5.1 Inventory. Data were collected from the City for pump station evaluation. Information was taken from as-built drawings, the City's *Pump Station Quick Reference Manual*, operation & maintenance manuals, and the pump station inspections. Where data collected from inspections differed from the other sources, the inspection data were used. For example, data obtained from a nameplate were deemed more reliable than data from a reference source. Data that could not be located were identified as "unknown". A summary of the inventory is provided in Table 5-2.

5.5.2 Inspections. Eight stations were selected by the City for on-site inspections. The purpose of these inspections was to evaluate pumping capacity; to evaluate structural, mechanical, and electrical conditions; to determine conformance with MDNR design standards; and to evaluate force main detention times or other conditions which contribute to odor generation. Appendix E summarizes the inspections, which were performed at the following eight pump stations: Clear Creek, Ewing Industrial Park, Hinkson Creek (Mexico Gravel), Little Bonne Femme, North Hampton Village, Valley View, Victoria South, and Woodrail.


US HWY 63
Haystack Acres #1
Haystack Acres #2
North Hampton
Haystack Acres 2
Ewing Industrial
Haystack Acres #3
Juvenile Justice Center
Cow Branch
Deer Ridge
US HWY 40
W US HWY 40
Inland Truck
Valley View
Hinkson Creek
I 70
Concord Industrial Park
Woodrail
Sunset Mobile Home Park
Clear Creek
Thornbrook
Little Bonne Femme
Victoria South
Rock Bridge State Park
N
Legend
Study Area
City Limits
Existing Pump Stations
Existing Flow Basins
Existing Sewer System
City of Columbia
Wastewater System Facilities Planning Report
Figure 5-5
Existing Lift Stations
prepared by Black & Veatch in association with GBA

5.5.3 SCADA Evaluation. Most of the stations presently communicate a general alarm to the WWTP via telemetry or an auto dialer. Either method of communication is acceptable, especially given the size and complexity of the City's stations. It is stated in the MDNR design standards that pump station alarms are to be communicated to a facility which is staffed 24 hours a day. The only station noted in the records not meeting this requirement was the Concord Park station, which was only equipped with local alarms. This station should be equipped with an auto dialer reporting a general station alarm to the WWTP.

Remote control of stations and indication of equipment status, run-time, wetwell level, and other operational data through a SCADA system is not required to conform to MDNR standards. Such a system may benefit the City through increased monitoring and control capabilities and data collection all from a central location. Table 5-7 summarizes the SCADA and alarm needs evaluation and includes other select information related to the stations.

Table 5-7
Pump Station Assessment and SCADA Evaluation

Pump Station	Back-Up Power[1]	Existing Alarm Notification	Alarm Needs	Spare Pump	Emergency Detention Basin (gallons)	
Clear Creek	DPF	Telemetry	Adequate	Yes[3]	270,000	
Ewing Industrial	PG	Auto Dialer	Adequate	Yes[3]	No	
Hinkson Creek (Mexico Gravel)	PG	Telemetry	Adequate	Yes[3]	No	
Little Bonne Femme	DPF	Telemetry	Adequate	Yes[3]	No	
North Hampton Village	PG	Telemetry	Adequate	Yes[3]	No	
Valley View	PG	Auto Dialer	Adequate	Yes[3]	No	
Victoria South	PG	Auto Dialer	Adequate	Yes[3]	30,000	
Woodrail	PG	Auto Dialer	Adequate	Yes[3]	No	
Concord Industrial Park	PG	Local	Add AD[2]	Yes[3]	No	
Haystack Acres No. 1	PG	Auto Dialer	Adequate	Yes[3]	No	
Haystack Acres No. 2	PG	Auto Dialer	Adequate	Yes[3]	2,875	
Haystack Acres No. 3	PG	Auto Dialer	Adequate	Yes[3]	3,150	
Sunset Mobile Home Park	PG	Auto Dialer	Adequate	Yes[3]	No	
Deer Ridge	G	Auto Dialer	Adequate	Yes[3]	No	
Cow Branch	G	Auto Dialer	Adequate	Yes[3]	No	
Thornbrook	G	Auto Dialer	Adequate	Yes[3]	No	
Cascades	G	Auto Dialer	Adequate	Yes[3]	No	
Inland Truck	G	Local	Adequate	Yes	No	
Lift Station at City Landfill	G	Auto-dialer	Adequate	Yes	No	

Notes:
1 PG – Portable Generator
DPF – Dual Power Feed
G – On-Site Generator
2 Add an Auto Dialer to this station
3 Station is equipped with at least one pump as a stand-by plus a portable pump for use as spare.

5.6 FUTURE GROWTH SEWER FACILITIES

The future development boundaries for this study are shown in Figure 5-6. The study area identified for future growth includes about 91,000 acres in parts of the Perche, Hinkson and Little Bonne Femme watersheds. The entire area is expected to ultimately be served by the City of Columbia's sewer collection system.

5.6.1 Method of Analysis. The following sections describe the methods used to identify the new collection system sewer facilities for the future growth study area.

5.6.2 Defining Sewer Drainage Basins. The study area was first divided into the three watersheds: Perche, Hinkson and Little Bonne Femme. The currently non-sewered area was then subdivided into sub-watersheds to allow for easier referencing of the new sewer interceptors. The basins were numbered, with an alpha prefix designating the watershed initial and "F" for future. For example, HF18 is future basin number 18 in the Hinkson Creek watershed.

These drainage basins separate the existing sewers from the future sewers. Future sewers in the Perche and Hinkson watersheds ultimately drain to the site of the existing wastewater treatment plant. The sewers in the Little Bonne Femme watershed flow by gravity towards the Missouri River south of the City and will be pumped to the Mill Creek interceptor. The Rock Bridge Memorial State Park is located within the Little Bonne Femme watershed. Since gravity sewers will not be built within the park, this area was excluded from the future growth study. The future drainage basins are illustrated in Figure 5-6.

5.6.3 Layout of Future Interceptor Lines. After the sewer drainage basins were defined, the future sewer interceptor lines were laid out. The following criteria were followed in laying out the future sewer interceptor lines:

- New interceptor lines were drawn along the natural drainage valleys of the watersheds based on a contour map of the study area.
- New interceptor lines extend to within ½ mile of the top of the major ridgelines of the watersheds.
- Future interceptor lines were connected to the existing system generally at the nearest manhole.

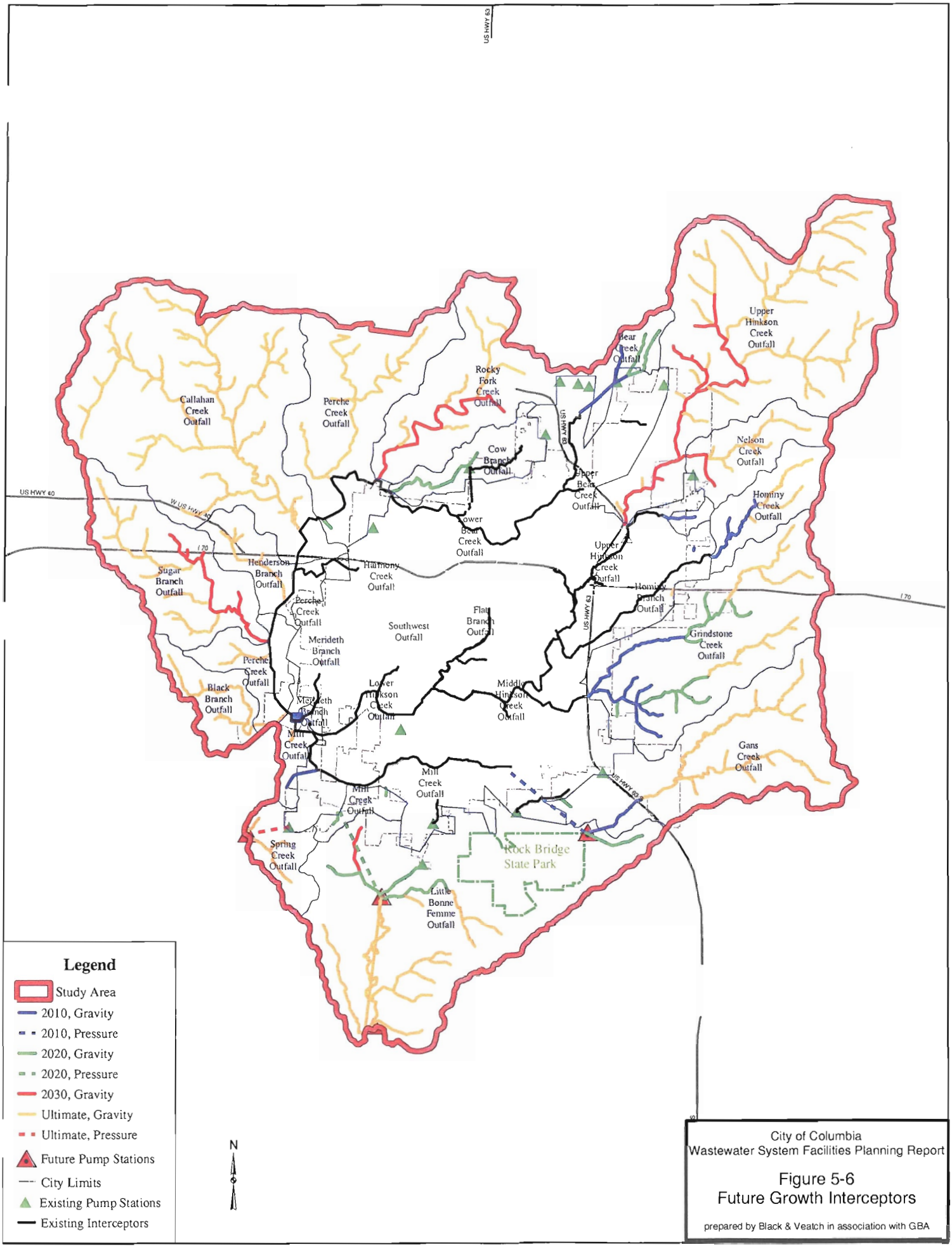

US HWY 63
Callahan Creek Outfall
Perche Creek Outfall
Rocky Fork Creek Outfall
Bear Creek Outfall
Upper Hinkson Creek Outfall
Cow Branch Outfall
Nelson Creek Outfall
US HWY 40
W US HWY 40
Upper Bear Creek Outfall
Hominy Creek Outfall
Lower Bear Creek Outfall
I 70
Sugar Branch Outfall
Henderson Branch Outfall
Harmony Creek Outfall
Upper Hinkson Creek Outfall
Perche Creek Outfall
Hominy Branch Outfall
Flat Branch Outfall
Southwest Outfall
Grindstone Creek Outfall
Merideth Branch Outfall
Perche Creek Outfall
Black Branch Outfall
Lower Hinkson Creek Outfall
Middle Hinkson Creek Outfall
Merideth Branch Outfall
Mill Creek Outfall
Gans Creek Outfall
Mill Creek Outfall
Mill Creek Outfall
Spring Creek Outfall
Rock Bridge State Park
Little Bonne Femme Outfall
Legend
Study Area
2010, Gravity
2010, Pressure
2020, Gravity
2020, Pressure
2030, Gravity
Ultimate, Gravity
Ultimate, Pressure
Future Pump Stations
City Limits
Existing Pump Stations
Existing Interceptors
N
City of Columbia
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Figure 5-6
Future Growth Interceptors
prepared by Black & Veatch in association with GBA

5.6.4 Defining Sub-Basin Areas. After the interceptor lines were laid out, the sub-watersheds were further subdivided into sub-basins. Each sub-basin was then assigned to a reach of sewer line that it naturally drained to. This reach of sewer line was labeled with an upstream node at the upstream edge of the sub-basin and a downstream node at the downstream edge of the sub-basin. The sub-basins range in size from 20 to 800 acres, with most sub-basins being around 200 acres. This general sub-basin size was established to keep sewer reaches from becoming too long and to keep the design flows for each sewer reach from being exaggerated at the upstream end.

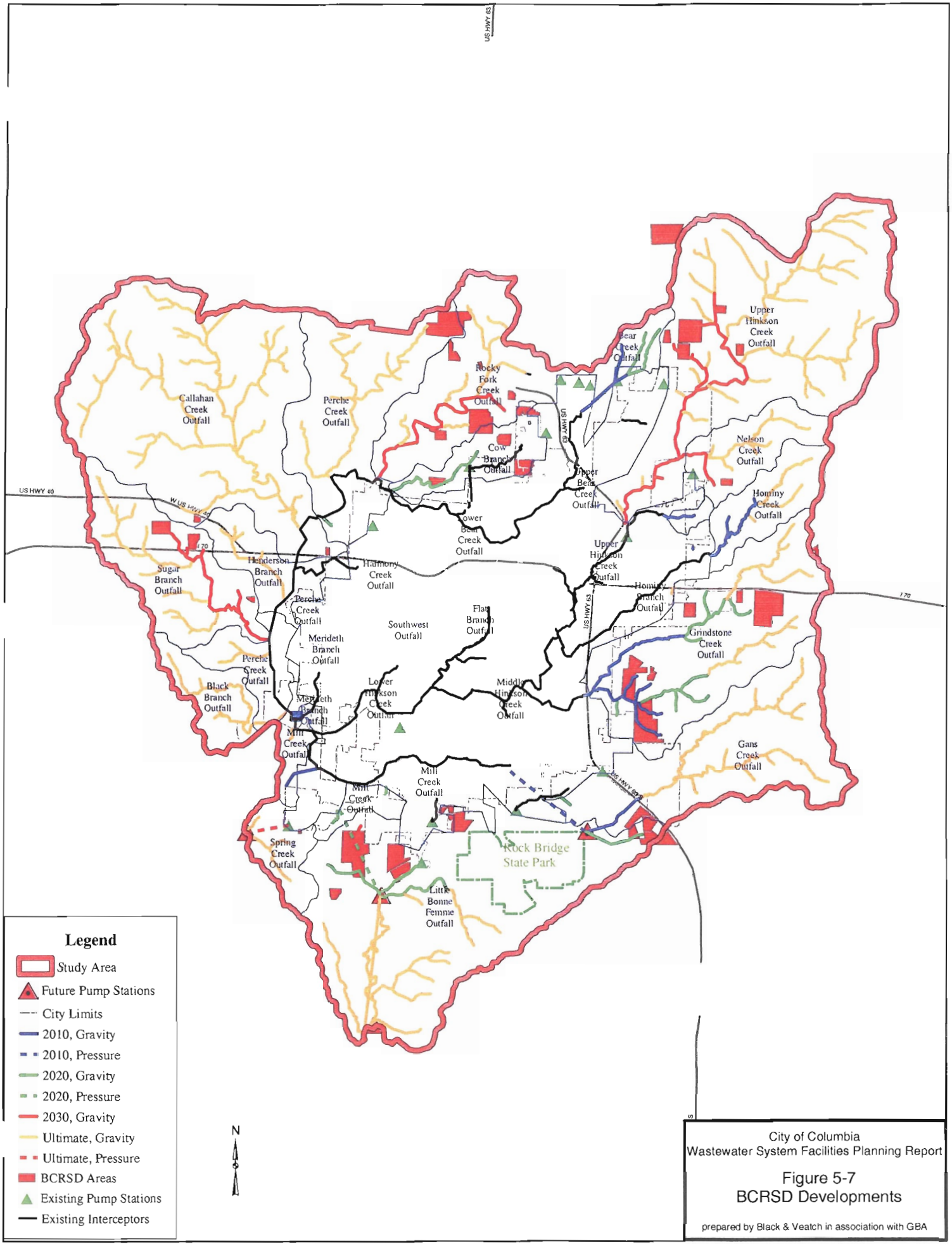
5.6.5 Design Flows. Design flows were calculated from projected populations. The future populations are based on the Traffic Analysis Zone (TAZ) study produced by the City of Columbia. The details of this study are presented in further detail in Chapter 2. After defining the sub-basins and dividing the interceptor lines into a series of sewer reaches, design flows were calculated for each sewer reach. To determine the design flow for each reach, the design flow criteria previously presented was used. Design flows for ultimate development were used to size interceptors for this report. Five year incremental flows were used to establish the impact on the existing sewer system.

5.6.6 Future Pumping Facilities. Gravity sewers will ultimately provide service for the Perche and Hinkson Creek watersheds. The current practice of installing smaller intermediate pump stations to existing interceptors in other basins for exterior growth will continue. These intermediate pump stations should be retired once gravity sewers become available.

The Little Bonne Femme watershed will continue to require pumping to the Mill Creek Watershed. Rock Bridge State Park covers about 4,100 acres of the Little Bonne Femme watershed. Future flows upstream of the park will require pumping into the Mill Creek Watershed.

5.6.7 Resulting Facilities. A total of 1,076,060 feet of sewer is planned for ultimate future growth. These sewers are illustrated in Figure 5-6. Four pump stations and associated force mains will also be needed in the Little Bonne Femme watershed. A detailed summary of the future growth interceptors is included in Appendix B.

5.6.8 Boone County Regional Sewer District Plans. Boone County Regional Sewer District (BCRSD) serves the sewered developments outside the City's service area within Boone County. BCRSD recently completed a Master Plan of their service area in which certain developments are identified for future connection to the City's collection system. In addition, there are areas that the BCRSD anticipates will not be served by City sewer extensions. These areas and their relative proximity to the future sewer system are highlighted in Figure 5-7. The BCRSD plans will assist in prioritizing the City's plans in providing sewer service in the future and were considered in prioritizing future extension projects for the City.


Legend
Study Area
Future Pump Stations
City Limits
2010, Gravity
2010, Pressure
2020, Gravity
2020, Pressure
2030, Gravity
Ultimate, Gravity
Ultimate, Pressure
BCRSD Areas
Existing Pump Stations
Existing Interceptors
N
US HWY 63
US HWY 40
W US HWY 40
I-70
Callahan Creek Outfall
Perche Creek Outfall
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Gans Creek Outfall
Spring Creek Outfall
Rock Bridge State Park
Little Bonne Femme Outfall
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Figure 5-7
BCRSD Developments
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5.7 COLLECTION SYSTEM HYDRAULIC CAPACITY MODELING

Hydraulic capacity analysis of the collection system was performed to determine the location of overloaded sewer line segments for a 10-year storm event. This analysis was performed using the computer modeling software *Hydra*. Both the existing collection system and the future growth interceptors were included in the model. Multiple scenarios were modeled using flows for existing conditions as well as projected future flows to analyze the system.

5.7.1 Description of Hydraulic Model. The sanitary sewer system model was developed using sewer network data, flow monitoring data, and the flow routing computer program, *Hydra*. The model incorporates measured system parameters such as time of concentration, tributary area, rainfall duration, and rainfall intensity to determine peak system flow.

The *Hydra* modeling software, developed and distributed by Pizer, is a fully dynamic model that supports the Peaking Factor Method. *Hydra*'s Peaking Factor Method routes flows through pumps and diversions through the use of hydrographs (time step representation of flows generated by domestic and rainfall induced sources).

5.7.2 Modeling Parameters and Assumptions. The following parameters and assumptions were used for the hydraulic model:

- Storm Event/Level of Protection = 10-Year Storm
- Minimum slope was used for the sewer slopes where slope was not available from record drawings
- Mannings friction coefficient for pipe roughness = 0.013

Flow parameters for existing system were based on flow monitoring results. Flow parameters for future development were based on the following:

- Inflow volume = 1.5% rain to sewer (1.5% was the average volume observed entering the system from flow monitoring data)
- Base Flow = 141 gpd/capita
- Infiltration = 500 gpd/acre

5.7.3 Calibration of Model. For the existing flow conditions, the model was calibrated to peak base flow and peak flow (base flow and inflow) at manholes that were flow monitored. For base flow, an average daily volume and a common diurnal curve was determined from flow monitoring data for each flow basin. The diurnal curve was adjusted so that the peak base flow at each metering point was within 5% of the calculated cumulative peak base flow for the basin. For inflow, an average percent of volume of rainfall entering the sewers was determined from flow monitoring data for each basin. This was translated into a volume of rainfall for the design storm. A hydrograph shape was also constructed from flow monitoring data for each flow basin. The hydrograph shape was adjusted so that the peak flow (peak base flow plus inflow) at each metering point was within 5% of the calculated cumulative peak flow for the basin. The model was not calibrated for infiltration. Constant infiltration determined from flow monitoring was added during the model runs.

The model was also calibrated for future development. An initial hydrograph shape was constructed based on those observed during flow monitoring. A percent rainfall captured of 1.5% was chosen based on flow monitoring data for newer flow basins. The hydrograph shape and percent rainfall captured remained consistent for all future growth areas. The hydrograph shape was adjusted so that the flows where the future growth areas entered the existing system were within 10-15% of the calculated peak flow at those points.

5.7.4 Results of Hydraulic Model. The hydraulic model was run for existing conditions as well as for future growth conditions in five-year intervals through 2030. Base flow, constant infiltration and inflow were injected as flows to the model. A summary of the results is shown in Table 5-8. Overloaded lines for the 2030 scenario are shown in Figure 5-8.

Table 5-8
Summary of Model Results

Scenario	Number of Overloaded Lines	Percent of Lines Overloaded	Peak Flow at WWTP (MGD)
Existing	1,828	13%	101
2010	1,898	13%	119
2020	1,937	14%	127
2030	2,008	14%	143

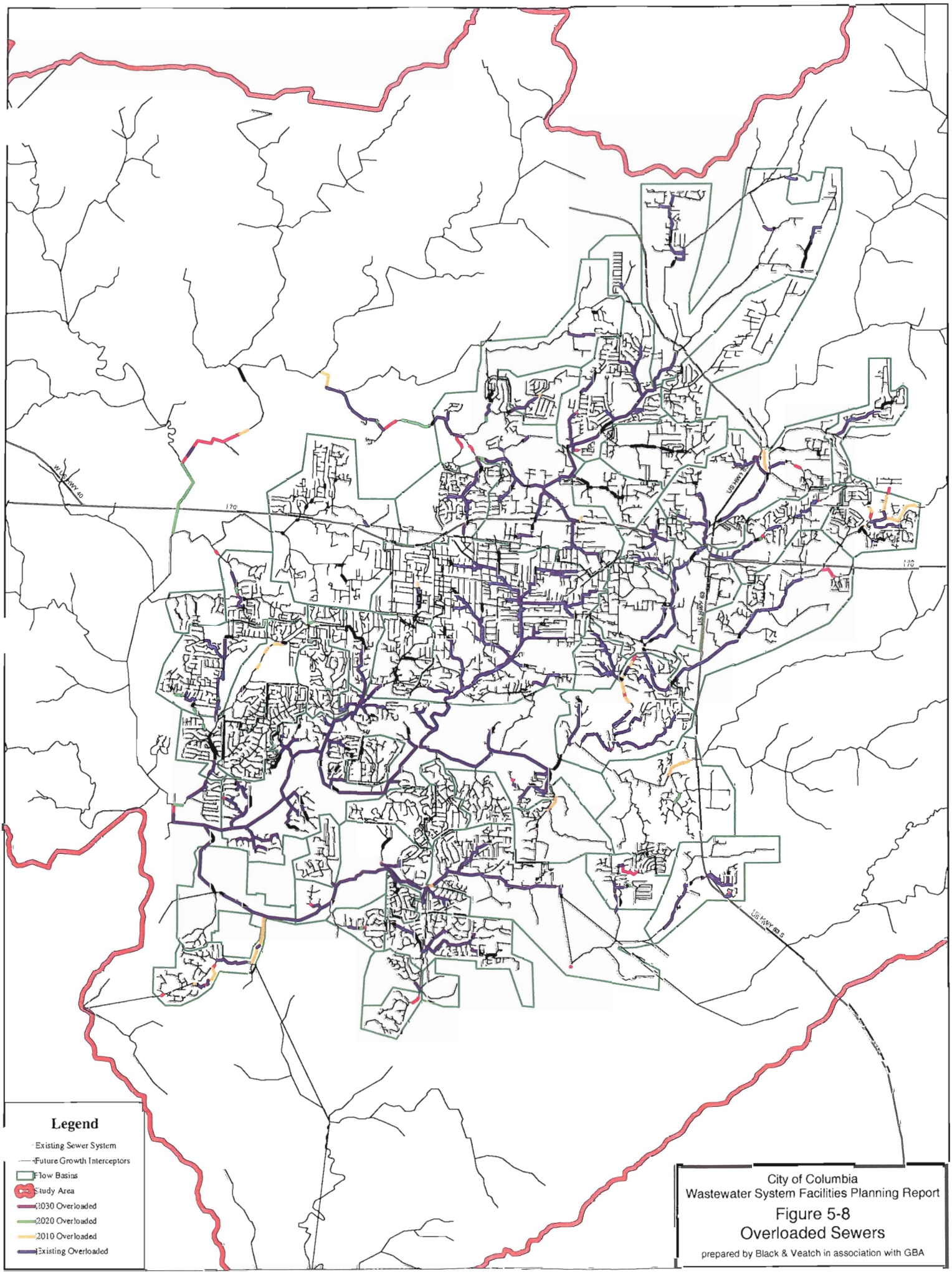

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Figure 5-8
Overloaded Sewers

prepared by Black & Veatch in association with GBA

5.8 I/I COST-EFFECTIVE REMOVAL ANALYSIS

The results of I/I removal programs in sewer systems identified as having excessive I/I have previously shown the ability to remove between 20 to 30 percent of identified I/I. To estimate the impact of projected I/I removal on relief sewer costs for the existing system, flow monitored basins identified as having excessive I/I were reduced in model flow by 20% and new relief sewers and costs were estimated. By reducing I/I by 20%, there is the potential for approximately 6 percent relief sewer construction cost savings when analyzing a 10-year design storm event with Year 2030 future growth impact on the existing system. The majority of the cost savings are realized in the Hinkson Creek watershed (86%).

5.9 COLLECTION SYSTEM MAINTENANCE AND RENEWAL

To maintain the useful service of a sanitary sewer collection system requires continual monitoring and corrective measures as system defects are discovered. Sewer systems are prone to blockages or restrictions in the pipe caused by roots, sediment build-up, grease, debris or partial collapses. As with any infrastructure, sewers are also susceptible to deterioration caused by wear and tear from years of service.

5.9.1 Asset Management System. The network established for the computer model for this project is an excellent basis for a geographical information system (GIS) and/or an asset management system. The model network required extensive effort to inventory and route the system. Asset management systems are used to schedule and track improvements and maintenance of a system. Utilizing GIS and asset management computer programs, the City can graphically assess and plan for maintenance activities and capital improvements. These computer programs will require investment in data collection and maintenance. However, if properly maintained, the data can be used to expedite projects, assist in identifying the actual needs of the system and raise the level of performance of operation and maintenance for the City.

5.9.2 Television Inspections. Generally, system conditions are observed from internal pipe inspections through closed-circuit televising of sewer lines. Comprehensive television inspections of older line segments, especially vitrified clay (VCP) pipe segments are recommended on a 5 to 10 year basis. The goal of comprehensive television inspections is to identify and repair defects in the system before negative effects are caused.

5.9.3 Line Cleaning. Cleaning the sanitary lines is also recommended on a cycle basis. Generally cleaning is conducted more frequently than television inspection. Periodic cleaning of a sewer system is a common and necessary operation of a municipality.

5.9.4 Root Control. Root growth control is also recommended for sewer systems. Generally root growth problem areas are identified through television inspection programs. There are three types of root growth control commonly practiced.

- Root cutting is performed by cutting the roots with a saw blade attached to a cleaning hose. This reduces the amount of roots in the sewer system. However this method is a temporary solution because the roots soon grow back, often heavier.
- Root inhibitors control root intrusions with a chemical or biological material. This foaming material can be sprayed inside the pipe with standard line cleaning equipment. Over time, the roots will die and biologically degrade. The roots will eventually grow back though not as thick as if the line had been root cut.
- Cured-In-Place-Pipe (CIPP) and sliplining can also provide effective methods for controlling root intrusion. This process is primarily used where roots are at the majority of the joints in the pipe and are a continual problem. This process has become more favorable over recent years due to its convenience and diminishing costs.

5.9.5 Model and Network Maintenance. As part of this project, the City will receive a comprehensive model of the sewer system. The computer model is an excellent tool for planning system development. The model will need to be kept current as new lines are added and removed from the system. The City should adopt a method of updating the network and model as as-built records are submitted to the City. In addition, it is recommended that the City recalibrate the model with flow monitoring data to identify changes in flow on a 10 year basis. Updates to the Master Plan of the collection system should be conducted to adjust recommendations based on actual growth and flows.

5.9.6 Pump Stations. Common pump station maintenance includes regularly scheduled site visits and replacement of wearing parts such as bearings, o-rings, etc. Though these routine activities are necessary, these types of operations do not determine if a pump station is transporting flows as intended. To determine if a pump station is performing at its design level, it is suggested that wet-well draw down tests be conducted periodically. The result of a wet-well draw down test

provides the operating flow capacity and resulting head. This information can be plotted against a system curve and pump curve to establish the pump's performance. Further analysis of this information can help determine the cause of pump deficiencies such as impeller wear, excessive force main losses or motor problems. Solutions to such problems may include:

- Pigging of force mains to remove sediment build-up.
- Repairing or replacing impellers.
- Check and clean air release valves.

CHAPTER 6.0

WASTEWATER TREATMENT PLANT FACILITIES ASSESSMENT

6.1 GENERAL DESCRIPTION OF WWTP

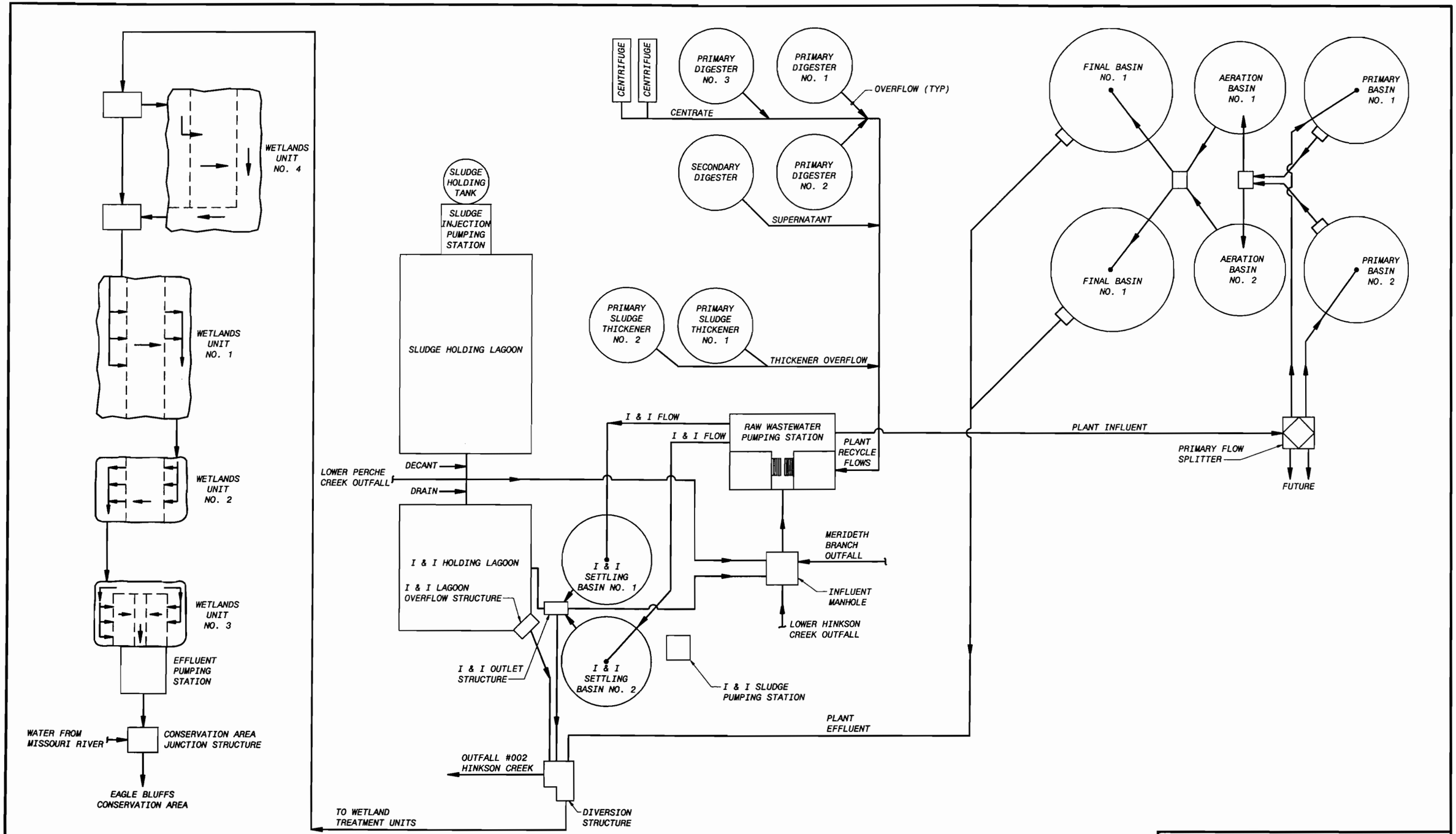
The Columbia Regional Wastewater Treatment Facility (MO-0097837) was completed in 1983 and is a complete mix activated sludge treatment facility designed to treat an average flow of 13.0 mgd and a peak flow of 26 mgd. The facility's treatment capacity was expanded to 17.7 mgd (per NPDES permit) average flow by the construction of three wetland treatment units in 1990. In 1999, a fourth unit was constructed and a rated capacity of 20.6 mgd was assigned to the treatment plant. The mechanical treatment facilities are located at the confluence of Hinkson and Perche Creeks southwest of Columbia. The wetland units are located downstream of the mechanical treatment along Perche Creek and extend to the Missouri River bottoms. Effluent from the wetlands is discharged to the Eagle Bluffs Conservation Area. The facility provides wastewater treatment for the entire corporate limits for the City of Columbia.

6.2 FACILITIES DESCRIPTION

The plant consists of an influent pump station, two mechanical bar screens, two primary basin, two aeration basins, two final basins, two I/I basins, an I/I holding lagoon, two gravity thickeners, two thickening centrifuges, three primary anaerobic digesters, a secondary digester, sludge holding lagoon, sludge holding tank and pump station, land application fields, and wetland treatment units. Wetlands effluent is pumped to the Eagle Bluffs Conservation Area. Figures 6-1 and 6-2 present a liquid treatment flow schematic and solids handling flow schematic respectively.

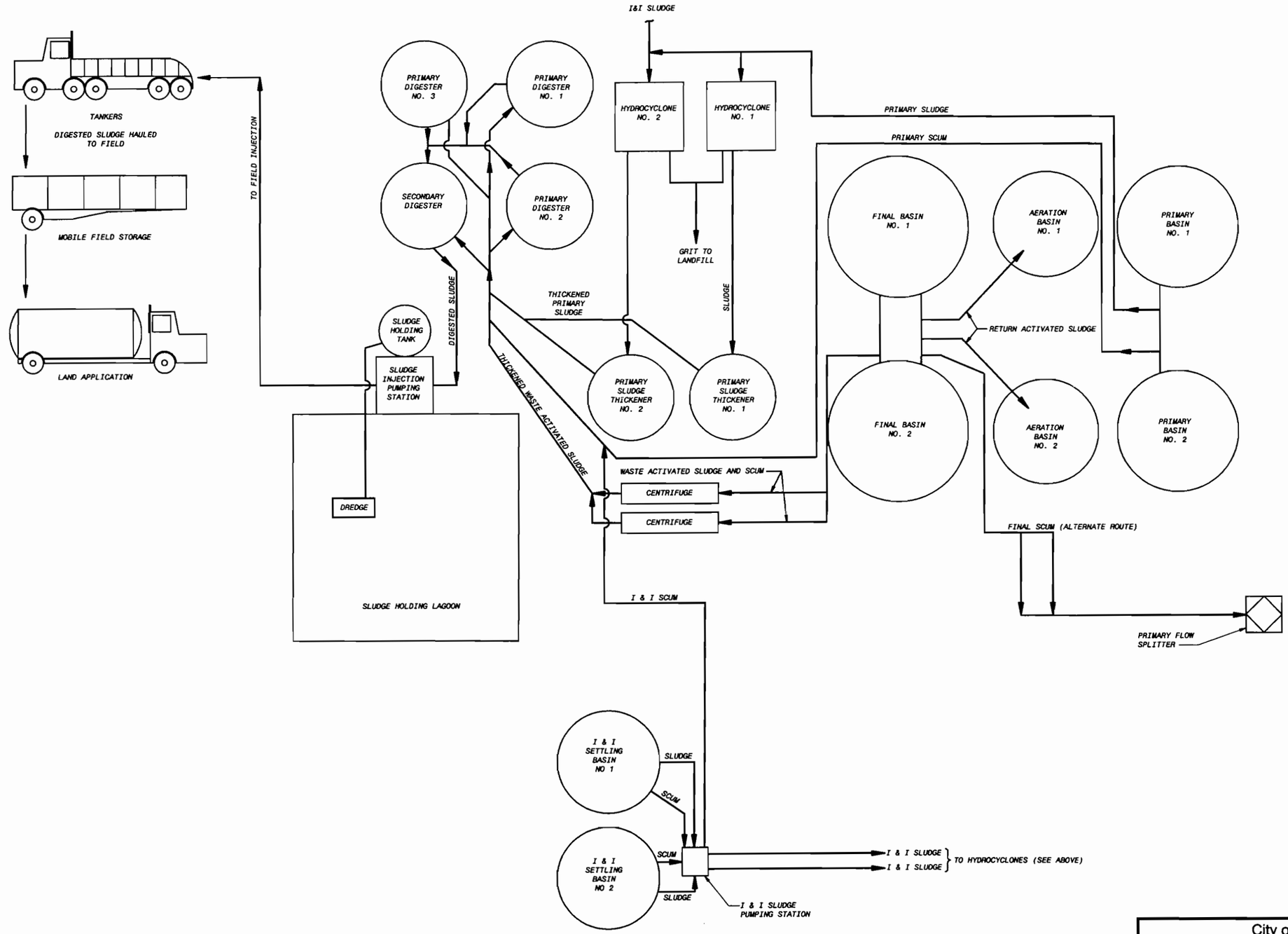
Flow comes to the plant influent manhole through the 24 inch Meredith Branch Interceptor, the 72 inch Lower Perche Creek interceptor, and the 60 inch Lower Hinkson Creek interceptor. A 72 inch line carries the wastewater to the two mechanically cleaned bar screens at the wastewater pump station. Screenings are raked from the screens into a portable dumpster dedicated to each bar screen. The dumpsters are emptied by using a forklift to dump the screenings into a 20 yard container that is taken to the landfill for disposal along with grit. The City's Solid Waste Utility hauls the container to the landfill.

The pump station houses six 5,500 gpm vertical non-clog centrifugal pumps with variable frequency drives, which are used to pump screened wastewater to the liquid treatment processes or to the I/I (infiltration/inflow) basins. Magnetic flow meters on each line measure flow to each process. Flow in excess of what the liquid treatment plant can effectively treat is pumped to the I/I basins. The pump station also houses a package unit septage receiving station to receive



City of Columbia
Wastewater System Facilities Planning Report
Figure 6-1
Columbia Regional WWTP
Existing Liquids Schematic
Prepared by Black & Veatch in association with GBA

CCG. DWG. NO.:132200-2000-323-C-T000071B6



City of Columbia
Wastewater System Facilities Planning Report
Figure 6-2
Columbia Regional WWTP
Existing Solids Schematic
Prepared by Black & Veatch in association with GBA

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grease and hauled waste. Plant process sidestreams, including sludge lagoon decant, gravity thickener decant, centrate from thickening centrifuges are returned to the pump station just ahead of the bar screens.

6.2.1 Liquid Treatment.

The liquid treatment process consists of two parallel trains, each with a primary clarifier, aeration basin, and final basin. The primary splitter box divides the flow between the two process trains. A junction box between the primary and aeration basins and a junction box between the aeration basins and final basins provide a means to divert flow around any basin, which allows the basin to be taken out of service for maintenance.

The primary basins have rubber sludge scrapers and a surface skimmer to direct flotables to a scum beach. Primary sludge is pumped to grit classifiers and the gravity thickeners. The thickened sludge is pumped to the primary anaerobic digesters. Scum is pumped to the primary anaerobic digesters.

The circular aeration basins have four two-speed stationary mechanical aerators. Wastewater enters the center of the basin. Two effluent boxes at the perimeter of the basin collect the mixed liquor and send it to the final basins.

Each final basin has a 60 feet diameter flocculation well with floc mixers. Each final basin has rubber sludge scrapers, a scum skimmer, and a rotating scum collection trough. Air lift pumps are used to return activated sludge from the final basins to the aeration basins through 30 inch diameter return lines. The final basin effluent is sent to the wetlands unit through the diversion structure at the south end of the treatment plant site.

6.2.2 I/I Treatment.

Flow in excess of what the liquid treatment facilities can effectively treat is diverted to one of the I/I basins. In wet weather conditions, the I/I clarifier effluent is sent to the I/I holding lagoon until such time that that the flow can be returned to the plant for treatment. If the holding lagoon is filled, overflow from the I/I holding lagoon or the I/I clarifier effluent can be directed to the diversion structure that leads to the wetlands. When not in service, the contents of the I/I basins are drained back to the influent pump station.

6.2.3 Wetlands and Effluent Pump Station

The City has four operational wetland treatment units with a total effective treatment area of 130 acres. Effluent from the mechanical plant, including from the I&I treatment system, is sent to the wetlands for polishing to reduce BOD and TSS concentrations before it is pumped to the Eagle Bluffs Conservation Area. The wetlands treatment units can only be operated in series.

Flow can be diverted around each treatment unit using a bypass channel for Units 1, 2, and 3 and a pipeline for unit 4.

The effluent pump station houses four 13,900 gpm (20 mgd) constant speed vertical turbine mixed flow pumps. Effluent from wetlands unit 3 is pumped to a discharge well adjacent to the effluent pump station operating floor. Flap gates were connected to the effluent pump discharge pipes to prevent flow from backing up through the pumps. These were replaced with check valves to better respond to water hammer when the pumps shut off. A composite sampler collects effluent samples. Effluent is discharged to the Eagle Bluffs Conservation Area.

6.2.4 Solids Handling.

Primary sludge is pumped to hydroclone degritting units then thickened using gravity thickeners before being pumped to the primary digesters. Grit is hauled to a landfill. Primary scum is pumped directly to the primary digesters. Secondary scum is also pumped to the primary digesters. Secondary sludge is thickened using centrifuges and pumped to the primary anaerobic digesters. Sludge from the I/I basins are handled in the same manner as the primary sludge.

Anaerobic digestion is performed in three primary digesters and one secondary digester. Biogas is recovered for energy production. Digested biosolids are sent to the sludge holding lagoon for storage. The lagoon can be decanted to thicken solids to approximately 5%. A dredge is used to pump biosolids from the lagoon to a 330,000 gallon holding basin. From the holding basin, biosolids can be conveyed either to tanker trucks for off-site land application or to the distribution system for land application at the City-owned property.

6.3 PLANT CAPACITY ASSESSMENT

The purpose of this plant assessment is to assess the rated capacity for this plant and determine the ability of each facility to achieve its rated capacity. The rated capacity for this plant is based on meeting as a minimum the MDNR criteria as established in Title 10 - Department of Natural Resources Code of State Regulations 10 CSR 20. Chapter 8 provides performance requirements for many of the processes. Where no specific criteria are presented in 10 CSR-20 Chapter 8, values that are based on Black & Veatch design criteria are used. Table 6-1 presents a summary of the rated capacity for each of the major process units.

Table 6-1 Columbia Regional WWTP Existing Mechanical Plant Facilities Capacity Assessment		
Process Description	**Rating Criteria** [1]	**Process Capacity**
Bar Screens Two-6 ft wide screen channel, 1" openings	MDNR min 5/8" openings 1.25 fps < Velocity < 3 fps	44 mgd each screen 88 mgd Total
Raw Water Pumping 6 pumps @ 5,500 gpm all with AFDs	Provide Firm Capacity at Peak Flow, mgd	Total:~47 mgd (6 pumps) Firm:~40 mgd (5 pumps)
Primary Basins Two-105 ft diameter with 12 ft +/- side water depth	Average Flow Rate: 1,000 gpdsf Peak Hour Flow Rate: 1,500 gpdsf	Ave Flow (2 clar.)= 17.3 mgd Peak Flow (2 clar.)= 26 mgd
Aeration Basins Two-90ft diameter with 18 ft side water depth Complete Mix Activated Sludge	Permissible organic loading = 40 ppd BOD/ 1,000 cu ft F/M loading of from 0.2-0.5 ppd BOD/ lb MLVSS. Max Month = 64 ppd BOD/ 1,000 cu ft [3]	14,600 ppd influent BOD [4] Ave Flow (2 basins) = 14.5 mgd Peak Flow (2 basins)= 26 mgd
Final Basins Two-115 ft diameter with 12 ft +/- side water depth	Surface overflow rate, gpdsf Ave. Rate = 625[2] MM Rate = 700[2] Peak Hr Rate= 1,200 Solids Loading Rate, ppd/sf MM Rate = 25[2] Peak Hour Rate = 50	MM Loading = 25 ppd/ sf (Based on MM condition of 12.6 mgd aeration basin rating at 3,000 mg/L MLSS) Peak Hour Loading = 45 ppd/ sf (25 mgd peak hour flow plus 12 mgd RAS flow at 3,000 mg/L MLSS) Ave Flow = 12.6 mgd (at MM loadings) MM Flow Rate = 14.5 mgd (at AA loadings) Peak Hr Flow = 25.0 mgd MM Loading= 520,000 ppd Peak Loading= 1,040,000 ppd
I&I Settling Basins Two-115 ft diameter with 12 ft side water depth	Average Flow Rate: 1,000 gpdsf Peak Hour Flow Rate: 1,500 gpdsf	Ave Flow (2 clar.)= 20.8 mgd Peak Flow (2 clar.)= 31.0 mgd
I&I Holding Lagoon		Max Storage: 6.1 mil gal to be

Table 6-1 Columbia Regional WWTP Existing Mechanical Plant Facilities Capacity Assessment		
Process Description	**Rating Criteria** [1]	**Process Capacity**
One-(333 x 293 x 15 deep)ft w/ sloping sides	Volume: 10.9 mil gal	used during periods of wet weather
Effluent Pumping 4 vertical turbine pumps @ 13,500 gpm constant speed	Provide Firm Capacity at Peak Flow, mgd	Total:~80 mgd (4 pumps) Firm:~60 mgd (3 pumps)
Primary Sludge Pumping (one pump is standby)	2 pumps – 125 gpm pumps 1 two-speed (125/250 gpm)	Total Capacity = 500 gpm Firm Capacity = 250 gpm
Primary Scum Pumping	2 pumps – 75 gpm pumps	Total Capacity: 150 gpm Firm Capacity: 75 gpm
Waste Sludge and Scum Pumping Two sludge pumps and one scum pump	3 pumps - 175 gpm pumps (scum pump is backup for the sludge pumps)	Total Capacity: 525 gpm Firm Capacity: 350 gpm
Return Sludge Pumping	4 pumps – 3.25 mgd	Total Capacity = 13 mgd Firm Capacity = 9.75 mgd
Thickened Primary Sludge Pumping	3 pumps- 75 gpm pumps (one pump is standby)	Total Capacity = 225 gpm Firm Capacity = 150 gpm
Thickened Waste Activated Sludge Pumping (one pump is standby)	2 pumps – 75 gpm pumps	Total Capacity = 150 gpm Firm Capacity = 75 gpm
I&I Sludge Pumping (one pump is standby or used for scum pumping)	2 pumps – 150 gpm pumps	Total Capacity: 300 gpm Firm Capacity: 150 gpm
I&I Scum Pumping (the standby sludge pump is backup for scum pumps @ 150 gpm)	1 pump – 75 gpm pump	Total Capacity = 225 gpm Firm Capacity = 75 gpm
Hydrocyclones Three-(used to separate grit from the primary sludge)	MDNR requires 2 units min Maximum inflow solids concentration 5000 mg/l (for these particular hydrocyclones)	Design Inflow = 250 gpm each Peak Inflow = 300 gpm each

Table 6-1
Columbia Regional WWTP
Existing Mechanical Plant Facilities Capacity Assessment

Process Description	Rating Criteria [1]	Process Capacity
Centrifuges Two-(used to thicken waste activated sludge to 3 - 5%)	125 gpm each (manufacturer rating)	Total capacity = 250 gpm Firm capacity = 125 gpm Solids Capacity = 9,550 lb/d
Primary Sludge Thickeners Two-25 ft diameter, with 10 ft +/- side water depth	Thicken to 5% solids Solids Loading Rate: 46,000 lb/day	Total Capacity = 0.72 mgd Firm Capacity = 0.36 mgd
Digestion Primary Digesters Three-60 ft diameter, with 30 ft side wall depth Secondary Digester One-60 ft diameter, with 30 ft side wall depth	Volume: 687,350 gal each 100 ppd bVSS / 1,000 cf [5] 15 day HRT to meet Class B sludge Volume: 645,050 gal	Total Design Flow= 111,310 gpd Loading 41 ppd bVSS / 1,000 cf 69 ppd VSS / 1,000 cf 28 day HRT @ 4% inlet solids.
Primary Digester Sludge Recirculation Pumping (two pumps are standby)	5 pumps – 300 gpm pumps	Total Capacity = 1,500 gpm Firm Capacity = 1,200 gpm
Secondary Digester Sludge Recirculation Pumping (one pump is standby)	3 pumps – 150 gpm pumps	Total Capacity = 450 gpm Firm Capacity = 300 gpm
Sludge Holding Basin One - 60 ft diameter, 10.3 ft deep	Volume: 240,000 gal	Max Storage: 7 days
Sludge Holding Lagoon One – 12 ft storage depth	Volume: 6.8 mil gal	Max Storage: 180 days
Sludge Injection Pumping (one pump is standby or can be used for lagoon recirculation)	2 pumps – 840 gpm pumps	Total Capacity = 1,680 gpm Firm Capacity = 840 gpm

1. Unless otherwise noted, criteria based on MDNR standards found in 10 CSR 20-8.
2. B&V design value.
3. Criteria shown is actual BOD load into aeration basins based on analysis of current plant performance data and plant meeting permit criteria.
4. This is BOD load to basins and not BOD load to plant.
5. MDNR standard is 80 ppd VSS / 1,000 cf. Digester process at Columbia has demonstrated good performance at the process design value shown in table.

Generally, the mechanical plant is performing as originally designed. Based on recent historical plant data, flow that the activated sludge plant can effectively treat at critical conditions is in the range of 12.6 mgd for maximum month loading conditions, which is a little less than the original design flow of 13 mgd. This can be attributed to the current influent BOD and TSS concentrations being greater than was predicted twenty years ago. The original design was based on an average BOD concentration of 165 mg/L. The current annual average BOD concentration is 238 mg/L. This is not to say that flows greater than 12.6 mgd cannot be effectively treated. Using historical annual average BOD and TSS concentrations, the plant can effectively treat flows of up to 14.5 mgd at current annual average BOD concentrations.

A rated design capacity of 20.6 mgd was established when the I&I basins and wetlands treatment units were included as part of the treatment process. Plant data indicate that the wetlands units have not yet been loaded to the design BOD loadings, thus their ability to achieve effective treatment at the rated design capacity could not be confirmed. However, the data also indicate that treatment generally follow the predicted removal rates at lower flow and loadings.

Removal of solids from the final basins is a concern. The existing thickening centrifuges have limited capacity, which limits how quickly waste activated sludge can be removed from the final basins. The centrifuges also have demonstrated capture rates in the 50 to 60 percent range, which results in excess solids being recycled back through the treatment plant. Improvements to the waste activated sludge thickening process are being addressed as part of the scope for this study.

6.4 LIQUID TREATMENT FACILITIES ASSESSMENT

An inspection was conducted July 13-14, 2003 of the treatment facilities. The purpose of the inspection was to assess the condition of the facilities to identify improvements needed to restore or maintain the equipment performance at rated capacities. The following paragraphs present a summary of the findings.

6.4.1 Influent Manhole/ Screenings/ Raw Wastewater Pump Station/ Flow Metering.

The influent manhole receives flow from three interceptors and from a gravity line that drains the I/I basins and directs it to the Raw Wastewater Pump Station through a 72 inch line. The 72 inch line enters a chamber just ahead of the mechanically cleaned bar screens. Inspection of the lower screenings channel and the 72 inch influent line could not be done because of high H2S levels. Two 6 foot wide continuous chain driven front cleaned back return rake screens bring screenings up to the grade floor of the pumping station for discharge into screening containers (one for each screen). Bar spacing is 3/8". The screens now have stainless steel chains and aluminum rakes. Normal screen operation is controlled with a timer for two minutes every 30 minutes. Flow

passes through one screen except when high flows require both screens. Screens are continuously operating during storm events to limit build up on the screens. Screen use is alternated every two weeks. Staff described signs of sulfide attack on the concrete walls and equipment in the screen channels. The screens are approaching twenty years of service and show signs of wear and corrosion. These should be replaced in the next 5-10 years.

The screenings are discharged into a screenings container that is manually positioned for a front end loader to lift the container and its contents into a 20 yard container that is hauled to landfill. A conveyor system had been used in the past and operators advise that the current method of handling the screenings container is preferred.

A package septage receiving station was installed in 1998 in the screen room. It is designed to receive grease/septage from septage haulers and waste activated sludge from other treatment facilities. Screenings and solids removed from the septage is sent to a dumpster for hauling to a landfill. Septage is not flow paced when sent to the plant. The possibility of adding a second unit for redundancy or a storage tank to help with pacing flow to the plant was discussed and decided that there was little benefit.

6.4.2 Primary Treatment.

The primary distribution box can split flow four ways using eight fixed weirs to split flow to four basins (two existing and two future units). Operators claim that there is an uneven flow split between the two existing basins. Adding an energy dissipation plate in the distribution box could help achieve a more even flow split. Ferrous chloride is fed into the distribution box downstream of the weirs for sulfide control at the rate of 5 lbs of iron/mgd. A rusty coating was observed on the aluminum grating, which suggests accumulation of iron residue on the grating. There are no covers over the distribution box.

The primary basins are generally in good condition. The main bearing for the basin equipment will probably need to be replaced within the next 5-10 years. This requires removing the walkway. Sulfide levels in the range of 2 to 3 ppm were detected at the effluent launders. Some cracking was observed in the walls. Weirs have been submerged when flows reach 13.5 to 15 mgd per basin, which could be expected as the design peak hydraulic flow to each basin is 13.0 mgd.

6.4.3 Aeration Basins

The aeration basin distribution box receives flow from the two primary basins. Normal operation is to keep the flows separated and directed to the respective aeration basin. Operators have opened the isolation sluice gate at the box to try to better balance the flow between the aeration basins. Surface aerators supply mixing and oxygen to the aeration basins. Operators advise that it is becoming more difficult to find replacement parts for the aerators. Diffused aeration should be considered to reduce power costs.

6.4.4 Final Basins

Aeration Basin effluent enters the Final Basin Distribution Box and is directed to the aeration basins. The isolation gate in the distribution box is normally kept closed. Plant staff advises that the sludge blankets are kept high because the existing waste activated sludge thickening centrifuges are having trouble keeping up with the waste sludge production. When the liquid treatment facilities cannot effectively treat the incoming flow because of the high sludge blanket, a portion of the flow is diverted to the I/I basins for treatment. The centrifuges' limited capacity appears to limit how much flow can be sent through the final basins. Biological scum was observed in the flocculation wells.

The main bearings for the clarifier equipment will need replacing in next 5-10 years. Changing to spiral scrapers and use of energy dissipating inlets should be considered to improve solids capture and removal. No significant odor was detected at the basins.

6.4.5 I/I Settling Basins and I/I Holding Lagoon

The I/I settling basins were originally designed to handle wet weather flows that exceed what the secondary treatment plant could effectively treat. The excess flow is sent to the I/I basins for solids removal before being sent to the I/I lagoon for temporary storage. The stored flow is returned to the secondary plant once it is capable to receive and treat it. If flow to the I/I lagoon fills the lagoon, the overflow is directed to the diversion structure used to send treatment plant effluent to the wetlands units. Plant operating data indicate that the I&I basins' solids removal efficiency is in the range of 52 percent BOD removal and 72 percent solids removal, which is similar to the primary basins removal efficiency. These removal efficiencies are higher than would normally be expected due in part to the large amount of solids returned to the head of the plant in the recycle streams.

With the addition of four wetlands treatment units and increased flows to the plant, the I/I basins have also been used for primary treatment of flows that cannot be treated by the secondary plant. The I/I clarifier effluent is blended with the secondary treatment plant effluent and sent to the wetlands for treatment. The 20.6 mgd design flow listed on the City's current NPDES is

based on the method of operation. When possible, the I/I basins are not used in this mode. The plant has been able to effectively treat flows in the range of 19 mgd with this operation.

6.4.6 Wetlands Treatment

The wetlands treatment system was originally designed to provide polishing of the secondary treatment plant effluent before it is discharged to the Eagle Bluffs Conservation Area. Three wetlands units were constructed in 1990 and designed to operate in series only. Treatment Unit No. 4 was completed in 2000. Treatment units 1, 2, and 3 have a bypass ditch that can be used when a unit must be taken out of service. The 72 inch plant effluent line that travels between the mechanical plant and treatment unit No. 1 passes by the newer unit 4 and can be used to send flow to Unit 1 when Unit 4 is taken out of service. Table 6-2 presents acreage covered by each treatment unit.

Table 6-2
Wetlands Unit Size

Treatment Unit	No. of Cells	Acres
4	5	40
1	8	48
2	4	22
3	6	21

Notes:
1. Wetlands design based on 58 mg/L BOD and 43 mg/L TSS influent concentrations. The wetlands design equations are based on retention time.
2. Plant effluent passes through Unit 4, 1, 2 and 3 in that order. Units can only be operated in series.

Plant data indicate that the wetlands treatment units have provided additional treatment to the mechanical plant effluent. While the wetlands have not been subjected to loading rates that would confirm the original design, the plant data do indicate that the BOD removal is consistent with the predicted performance calculated using the original design equations. When the fourth wetlands unit was added, the treatment plant capacity rating was increased to 20.6 mgd based on an influent BOD concentration of 58 mg/L and an average predicted wetland effluent BOD concentration of 30 mg/L. The design equations used to establish this rating are based on overall retention time in the units using the following three methods:

1. An empirical method that was used for the original design.
2. The EPA Design Manual "Constructed Wetlands and Aquatic Plant Systems for Municipal Wastewater Treatment". 1988.

3. The WPCF Manual of Practice for Natural Systems - 1989.

A literature search was conducted to determine what other approaches have been considered for wetlands design. It appears that methods based on retention time are preferred over methods based on BOD surface loadings. The area methods found do not consider the depth of the water in the wetlands, but does use the calculated retention time that is based on water volume. However, the retention method does not appear to account for more concentrated area loadings in individual treatment units that can occur when treatment units are operated in series, such as is being done with Columbia's treatment units. Only one of the three models includes temperature as a parameter.

Operating the wetlands in series results in the entire mass BOD loading from the mechanical plant coming to unit 4 first instead of being more evenly distributed over all of the treatment units. As loadings to the wetlands approach the levels used to size treatment units, particular attention should be given to how the initial treatment unit responds to having the entire BOD loading passing through it.

Operators indicated that they have noticed odors in the influent channel to the first treatment unit (No. 4), which appears to be from solids in the plant effluent settling out in the influent channel. The most likely source of the odor is effluent from the I/I clarifiers, which is blended with the mechanical plant effluent and fed to wetlands. Recently, the I/I clarifiers have been used more regularly to treat a portion of the plant influent flow. Effluent from the I/I clarifiers essentially receives the same level of treatment as the primary clarifiers can provide. Solids that are not removed in the I/I clarifiers contain BOD and sulfides that pass on to the wetlands. Given the long travel time and normally low velocities in the plant effluent pipeline and the wetlands influent channel, these solids can settle out and begin to biodegrade, releasing hydrogen sulfide. To help control odor release at the wetlands, iron salts in the I/I clarifiers could be added to increase the amount of solids removal and to help control hydrogen sulfide release.

6.4.7 Effluent Pump Station

The effluent pump station receives treated effluent from the wetlands treatment process and pumps it to a junction structure that leads to the Eagle Bluffs Conservation Area. The junction structure also receives water pumped from the Missouri River to provide water to the wetlands as well. The effluent pump station is designed to handle up to 60 mgd of flow, which is the hydraulic capacity of the plant effluent pipeline to the wetlands treatment units. The pump station and force main are generally in good operating condition. The full capacity of the pump station can only be used when the Conservation Area's flow control structures are configured to accept the flow. Coordination with the Missouri Department of Conservation is required to assure that the Conservation Area can receive the pumped flow from the plant. Also, from discussions with the

Department of Conservation, sending higher flow rates to the Eagle Bluffs would require discussions with MDNR to determine if higher flow rates could be accepted.

6.5 SOLIDS HANDLING

Solids handling facilities include screenings handling, grit removal from primary sludge, and thickening, digestion, and land application of primary and waste activated sludge.

6.5.1 Screenings.

Screenings are removed from the wastewater at the Raw Wastewater Pumping Station ahead of the pumping station wetwell. The containers are emptied approximately every two days with a fork lift into a 20 cy container that also receives grit. The City's Public Works Solid Waste Division exchanges 20 cy containers every two weeks and takes screening and grit to landfill for disposal. Originally a conveyor system was used to send screenings to a container. That was abandoned and staff is pleased with the current method of screenings disposal.

6.5.2 Primary Sludge and Scum Pumping

The primary sludge pump house is located between Primary Basins 1 and 2 with three primary sludge pumps and two primary scum pumps located in the basement. Two of the pumps are 125 gpm constant speed centrifugal pumps with the third pump having a 250 gpm capacity. The sludge pumps send primary sludge to grit hydroclones for degritting before going to the gravity thickeners. The pumps were rebuilt about five years ago. The pumps will need to be replaced within the next 5-10 years as part of the O&M maintenance budget.

Two 75 gpm Moyno progressive cavity pumps were installed in 1992 to replace the original scum pumps. They can be operated manually with the controls in the basement or the controls on the grade floor of the pump house. No improvements appear necessary for the scum pumps.

6.5.3 Return Sludge, Waste Activated Sludge, and Scum Pumping

The Final Sludge Pump House has return sludge pumps, waste activated sludge pumps, and scum pumps for the final basins 1 and 2 located in the basement. Four 3.25 mgd airlift return sludge pumps are used to return the activated sludge from the final basins to the aeration basins. Four centrifugal blowers are used to lift sludge into a distribution box where the sludge is split between the two aerations basins. The original design was based on providing one blower firm and one standby for each treatment train. Over time, the performance of the blowers does not permit the system to operate this way. Heat builds up in the blower room, especially during the summer. Operators would prefer a centrifugal type pump system with variable speed drives to better control sludge return rates.

Three waste activated sludge (WAS) and scum pumps are 175 gpm Moyno progressive cavity pumps with variable speed drives. WAS is pumped from the final basins to the thickening centrifuges located in the Digester Complex. The pumps are operated on a continuous basis to match the capacity of the centrifuges with one pump dedicated to each centrifuge. The third pump is used to pump scum directly to the primary digesters and as a standby for WAS pumping to the centrifuges. If new centrifuges are provided as is recommended in the Biosolids Management Report, new pumps with capacities to match the centrifuges will be required.

6.5.4 I/I Sludge and Scum Pumping

The I/I Pump House contains three sludge pumps and two scum pumps that serve the I/I Settling Basins. The three vertical centrifugal two-speed pumps have a rated capacity of 250 and 330 gpm. Sludge from the I/I basins is pumped to the hydroclones for degritting just like the primary sludge. The two 75 gpm Moyno progressive cavity scum pumps send scum directly to the primary digesters. The pumps are generally in good condition and no improvements are anticipated.

6.5.5 Degritting Primary and I/I Sludge.

Primary sludge and sludge from the I/I basins are sent to two hydroclone grit separators. Grit removed from the sludge is sent to a grit container for disposal. The degritted sludge is pumped to the gravity thickeners then sent to the primary digesters. Each hydroclone is rated at 250 gpm each. The hydroclones are experiencing maintenance problems. According to staff, breakdowns occur about every six months. Odor was observed in the room housing the hydroclones.

6.5.6 Thickening Centrifuges.

The existing Bird centrifuges do not have the capacity to keep up with current sludge production rates and achieve an effective capture rate for the solids. Current operation results in only a 50-60% solids capture efficiency, with the uncaptured waste activated sludge being recycled back to the primary basins for removal. This increase in solids loadings on the primary basins can accelerate the production of hydrogen sulfide in the basins which could increase the amount of odor emitted from the basins. Some of the recycled waste activated sludge will settle out in the primary basins, which gives the indication that the removal rate is higher than would be expected in a plant with normal recycle streams. Solids not settling out in the primary basins will pass on to the final basins, which increase the sludge blanket in the basins and create greater difficulty for operators to control solids concentrations in the final clarifier effluent.

6.5.7 Anaerobic Digesters.

Three primary digesters and one secondary digester are used to digest thickened primary and waste activated sludge and scum. One of the primary digesters is a modified secondary digester. The cover for the remaining secondary digester was changed to a spiral floating cover. The three primary digesters are fed thickened primary and waste activated sludge on a two hour cycle. The recirculating sludge pumps appear to be in good working order. Digested sludge from the three primary digesters is sent to the secondary digester and on to the sludge storage lagoon.

The current average biodegradable volatile suspended solids (bVss) loading in the digesters is 41 pounds per day / 1,000 cf of digester volume (ppd / 1,000 cf). The digesters are currently loaded to about 41% of design values Black & Veatch typically uses for digesters. By thickening primary sludge and waste activated sludge to 4 percent, the existing primary digesters can provide a 28 day hydraulic retention time, which is nearly twice the EPA criteria for Class B sludge. Based on projected sludge production for year 2030 flows, a fourth primary digester would be required to meet Year 2030 needs. The existing digester complex is adequate to meet up to Year 2020 projected sludge production rates.

Each primary digester has a sludge heater with a heating capacity of 650,000 btu/hr each. When Digester No. 3 was converted to a primary digester, a new Walker Process sludge heater was purchased. It has larger piping than the other two heaters and appears to be more effective in transferring heat to the sludge. Replacing the other two primary sludge heaters should be considered to improve heat transfer efficiency. One of the primary sludge heaters could replace the secondary digester heater.

Glass-lined ductile iron sludge gas piping connects the four digesters to the engine generator. Staff indicated that corrosion of the pipe has been a problem and have added a filter to reduce plugging and corrosion. This piping is being replaced with 316 stainless steel pipe as required. Replacement with stainless steel should be continued.

The engine generator used methane gas from the digesters to generate electricity. In 2001 and 2002 the generator has used over 20 million cubic feet annually and produced over 940,000 kWh each year. The city has plans to continue using the generator in this manner. Ferrous chloride added at the primary distribution box has significantly reduced hydrogen sulfide (H_2S) levels in the methane gas that feeds the generator. A relatively high H_2S level was detected in the generator exhaust during the inspection, which suggests that more chemical should be added.

6.5.8 Sludge Lagoon.

The sludge storage lagoon can store approximately 6.8 million gallons of sludge based on a maximum storage depth of 12 feet. It has sloped sides that are partially lined with concrete with the remainder of the sides and the bottom being earthen lined. Digested sludge is sent from

the secondary digester to the sludge lagoon until it can be taken to the land application site. A floating dredge is used to pump sludge to the digested sludge storage tank which serves as a wet well for the thickened sludge pump station. The thickened sludge pump station is used to load sludge trucks that transport the sludge to the land application site.

A decant structure along the south side of the lagoon sends sludge decant back to the head of the plant through the Perche Creek interceptor. Staff indicated that the decant structure does not appear to effectively collect decant from the entire lagoon. A second decant structure should be considered if the lagoon is to remain in operation.

A significant build up of struvite was observed in the manhole where the pipe from the decant structure discharges into the Perche Creek interceptor. Struvite can be controlled with iron salts and should be considered if the lagoon remains in service.

The Biosolids Management Program Evaluation report indicated that use of the sludge storage lagoon would be discontinued because the long term solution for sludge disposal would either be applying dewatered sludge to land or heat drying of sludge. Neither option would require a sludge storage lagoon. More discussion about the Biosolids Management Program is discussed in a later section of this chapter.

6.5.9 Sludge Injection Pump Station and Sludge Holding Basin.

The Sludge Injection Pump House was originally designed to pump thickened digested sludge either to the land application site located northwest of the treatment plant or to trucks that would haul the sludge to landfill or other land application sites. Space was provided for two pumps in the basement of the pump station. One original pump was replaced with a Fairbanks Morse pump. A replacement for the other pump has not been installed because the current wiring in the motor control centers (MCC) cannot accommodate both pumps. One of the two MCCs is dedicated to the sludge holding lagoon dredge. Electrical service upgrade is required including a new MCC for the second sludge injection pump.

The circular concrete sludge holding basin can store approximately 330,000 gallons of sludge and serves as a wetwell for the Sludge Injection Pump Station. It receives sludge from the lagoons through a dredge. Three submersible Flyght mixers provide mixing to keep the sludge homogenous. The basin is uncovered.

6.5.10 Biosolids Management Program.

Currently, the City land applies thickened digested biosolids. Tanker trucks transport the thickened biosolids to remote land application sites for injection. In August 2000, Black & Veatch submitted a report titled "Evaluation of Biosolids Management Program and Alternatives" that evaluated the City's current biosolids practice and other alternatives to determine the most appropriate long term biosolids management program. During an alternatives screening workshop,

it was determined that the current practice was not a viable long term (10-20 years) management option primarily because of the increased truck traffic. By 2010, more than 30 tanker truckloads of biosolids must be hauled to off-site land application sites. This high traffic volume was determined to be incompatible with the roads and bridges that must be used to get to the land application sites.

The report indicated that land application of dewatered biosolids is the most cost-effective management option and had a project capital cost opinion of approximately $6.9 million in Year 2000 $. However, land application of heat dried biosolids offered more "non-cost" benefits yet had a project capital cost opinion of approximately $11.1 million in Year 2000 $. These costs were based on processing 15 dry tons per day (dtpd) annual average and 22 dtpd maximum month quantities of anaerobically digested sludge. The sludge quantities used in that report were based on a projected 22 mgd annual average flow for Year 2020.

6.6 Ancillary Systems

6.6.1 HVAC.

The central heating plant consists of a sludge gas boiler and a fuel oil boiler. Heating is provided throughout the plant using a 6 inch heating water loop made of fiberglass insulated buried piping and steel piping inside buildings. Staff indicated that joint failures are common are a due to resin in the joints becoming brittle at high temperatures.

Ventilation appears to be adequate in most of the areas. Exceptions would be the screen room and raw wastewater pump station wetwell and screen channel areas. Improved ventilation and possible odor control should be considered.

6.6.2 Odor Control

An odor survey was conducted at the treatment plant in July 2003 to collect air and liquid data for identifying potential sources for odor. The facilities were ranked according to potential for significant odor generation. Based on the findings of the survey, alternative methods for odor control were evaluated and improvements identified. The odor control evaluation report can be found in Appendix F to this report. The following processes were identified as having some odor potential.

- High H_2S levels were detected at the four digester transfer boxes. These boxes are not covered and odor could escape to the atmosphere.
- H_2S levels in excess of 200 parts per million (ppm) were detected in the exhaust for the Engine Generator. The exhaust is located on the roof of the digester complex.
- Moderately strong H_2S levels were detected at the gravity thickeners, which are open to the atmosphere.
- Moderate levels of H_2S were detected in the screen room, primary distribution box

and primary clarifiers.

- H_2S levels at the sludge holding lagoon and sludge holding basin were found to be low. However, based on experience at other facilities, these types of facilities can be potential sources for odor.
- As discussed previously, some odors have been noticed at the inlet to Wetlands Treatment Unit No. 4 that appear to be the result of using I/I clarifiers for treatment of plant influent regularly.

The plant currently has no vapor phase odor control systems. Ferrous chloride is added to the wastewater to control H2S in the liquid process which can carry on through the solids handling facilities. Misters have been located around the plant to help enhance the fragrance of the air in and around the treatment plant.

Upgrades to the existing plant should consider odor control measures.

6.6.2 Electrical Systems

An inspection of the electrical systems at the plant was conducted in January 2004. Appendix G presents a memorandum describing observations from the inspection with a summary presented here. Two individual overhead electrical services bring power to the plant from Columbia Water and Light. These services originally came from two different substations. As residential development occurred around the plant the service lines were re-routed by the utility and transmitted power now comes from a single substation. Should a fault occur at the utility substation, both the primary and secondary power feeds to the plant would be lost. Consideration should be given to a backup power source. The existing generator would not provide sufficient power to meet emergency needs.

These services are brought to medium voltage switchgear located in an outdoor aisle-protected enclosure. The power distribution systems were designed with redundancy. The switchgear feeds four pairs of medium voltage transformers with each pair of transformers fed from both busses. The transformers have performed well, with minor corrosion observed on some of the units. From discussions with plant staff it appears that the loads are not equally divided among the transformers. A maintenance program in which oil levels in the transformers should be checked regularly and the transformers checked for "hot spots" should be considered.

Replacing analog metering systems with solid-state devices in the existing switchgear should be considered. These devices could be configured to send alarms to a new control system provide advance notice of fluctuations in power service.

The Sludge Injection Pumping Station does not have a secondary power feed. The MCC for one of the sludge pumps is currently used for the dredge, thus there is no installed standby sludge injection pump.

During the inspection, it was discussed with staff that some level of SCADA could be considered to provide operational efficiency.

6.6.3 Non-Potable Water System

Final basin effluent is used for non-potable water in the plant. The non-potable booster station is located in the basement of the Digester Complex. Generally the system is in good condition; however, plugging is experienced on occasion. Automatically back-washed strainer should be considered for the system to reduce plugging.

6.6.4 Chemical Feed systems

Chemical feed systems include ferrous chloride added to wastewater at the primary distribution box and chlorine which is used for the non-potable water system and gravity thickeners and is sometimes fed to the return activated sludge for filamentous growth control. Both systems appear to be operating adequately.

6.6.5 Ancillary Buildings and Roads.

Ancillary buildings include the Administration Building, Vehicle Storage Building, a pole barn storage area. Generally these structures are in good condition. The following improvements should be considered:

- Staff suggested an additional 500 square feet of laboratory area be considered at the administration building.
- Additional parking is needed at the administration building.
- Relocate oil drums from the wash bay of the vehicle maintenance building to the pole barn so the wash bay can be used as intended.
- Additional storage up to 1200 sf.

The roads are generally in good condition but heavy traffic from the sludge hauling trucks will begin to take its toll on the road.

6.7 Proposed Improvements to Existing Facilities

The facilities assessment findings discussed in this chapter were presented to City staff with proposed methods to repair, replace, or improve existing facilities. The rehabilitation improvements selected by staff were then identified as either improvements that City staff would implement as part of their regular O&M repair and rehabilitation program or as improvements that should be included as part of a major rehabilitation program that could be combined with a plant expansion as timing permits. The improvements presented here are only those improvements that are to be part of a major near term rehabilitation program. Other improvements that are required to meet growth needs are discussed in Chapter 8. It should be noted that several of the improvements proposed will have a significant impact on the plant operation because of the length of time a process unit must be out of service. Some of these improvements can only be made after the plant capacity is expanded.

Opinions of probable project costs are provided for the rehabilitation improvements in Table 6-3. HVAC; electrical; contingencies costs are included in the construction costs. Engineering, legal and administrative costs are added to the construction costs to get total project costs. Table 6-3 also presents a summary of project costs for the Biosolids Management improvements. The biosolids management improvements cost opinions that were presented in the 2001 Biosolids Management Assessment report reflected Year 2000 costs. These have been escalated to Year 2004 costs using ENR Building Cost Indices. The Biosolids Improvements have also been modified to reflect the projected Year 2030 solids production rates, instead of the Year 2020 rates used in the 2000 report.

Table 6-3 Repair and Rehabilitation Improvements to Existing Facilities, in Year 2004 $			
Structure or Process	**Proposed Improvements**	**Construction Cost Opinion (1)**	**Project Cost Opinion (2)**
Liquid Treatment			
Raw WW Pump Station	Screen Replacement	$1,400,000	$1,680,000
	Odor Control (Wetwell Area)	$1,080,000	$1,300,000
Primary Basin Flow Dist. Box	Odor Control and cover box. (Included in Primary Basins cost below.)	see primary basins	see primary basins
Primary Basins.	Odor control equipment, piping, launder covers both basins (if determined to be required after evaluating iron addition effectiveness in sulfide control). Also includes odor control for primary distribution box.	$790,000	$950,000
	Cost opinion based on Installing new drive units on the two basins.	$760,000	$910,000
Aeration	Replace Surface aerators with diffused aeration.	$2,040,000	$2,450,000
Final basins	New equipment with EDI and spiral scraper for sludge recovery	$1,160,000	$1,390,000
I & I Treatment Facilities	Odor Control equipment and launder covers (if required)	$540,000	$650,000
	Concrete line lagoon	$1,200,000	$1,440,000
Wetland Treatment Units	No special rehab projects. Normal O&M budget covering costs	none	none
Effluent Pump Station	None	none	$0
Solids Handling (not including improvements for dewatering or heat drying sludge)			
Primary Sludge Degritting	Use vortex type grit removal system to remove grit from wastewater prior to primary basins. If present grit removal system kept, add odor control to existing room.	See plant expansion costs	See plant expansion costs
Primary Sludge Thickening	Odor Control Improvements. Cover thickeners / provide odor control. Includes piping from digester influent boxes to odor control.	$380,000	$460,000
Final Sludge Pump House	Staff would prefer to replace this pumping system with centrifugal pumps w/ VFDs and flow meters. See if sludge line from each basin could be piped directly to the centrifugal RAS pumps and eliminate use of the RAS wetwell and associated odor.	$780,000	$940,000
Waste Activated Sludge Thickening	Replace or supplement if plant remains open. Provide a new building to house centrifuges (250-300 gpm units). Based on City of Columbia estimates ($2.19 million budgeted amount for total project)	$3,700,000	$2,190,000
Anaerobic Digestion	Odor control for digester influent boxes. (Included in thickener odor control costs)	see thickener odor control	see thickener odor control

Table 6-3 (cont'd) Repair and Rehabilitation Improvements to Existing Facilities, in Year 2004 $

Structure or Process	Proposed Improvements	Construction Cost Opinion [1]	Project Cost Opinion [2]
Sludge Storage	Add a 2nd decant structure at the SW corner of the lagoons to go with SE structure. To control struvite, add feed point for iron salts to sludge decant before it enters Perche Creek interceptor.	$90,000	$110,000
	Add cover and provide odor control.	$430,000	$520,000
Sludge Injection Pump Station	Electrical service upgrade will be included in Sludge dewatering improvements. Look at new MCC for second sludge injection pump.	included in Dewatering project	
Heating water piping system	Replace heating loop piping with steel pipe for carrier water with insulation.	$390,000	$470,000
Odor Control yard piping for all odor control systems.	Misc. yard piping for water service and sewer service to odor control areas located on the plant site.	$190,000	$230,000
Subtotal (including thickening centrifuges and building), rounded up to nearest $100,000			**$15,700,000**

1. Construction Cost includes general requirements, associated electrical, HVAC and contingencies.
2. Project Cost includes engineering, legal and administrative costs.

Rehabilitation Projects Total Project Cost Opinion (rounded nearest $100k) Excludes thickening centrifuge project [3]	**$13,500,000**
Rehabilitation of thickening centrifuges slated for 2004-5 (rounded to nearest $100k)	**$2,200,000**
Biosolids Management Improvements	
Biosolids Dewatering (based on dewatering centrifuges and land application program) [4]	**$7,700,000**
Biosolids Heat Drying (Must include costs of dewatering also - see above costs) [5]	**$14,100,000**
Total	**$37,500,000**

Notes:

1. Construction Cost includes general requirements, associated electrical, HVAC and contingencies.
2. Project Cost includes engineering, legal and administrative costs.
3. Improvements proposed to restore capacity of original treatment facilities. Most improvements cannot be performed until plant capacity is increased to allow process units to be removed from service for repairs.
4. Biosolids Management Program for Dewatering and Land Application Program are also required for a heat drying option. Constructing dewatering initially can serve as an intermediate phase to ultimately install a heat drying system.
5. Heat Drying Improvements not anticipated to be implemented until after Year 2015. Dewatering Improvements presented above would be required to implement Heat Drying.

6.7.1 Influent Manhole/ Screenings/ Raw Wastewater Pump Station/ Flow Metering.

Rehabilitation improvements focus on the existing screens, improvements to the plant sewer system to reduce back ups into basements of plant facilities, replacing a 48 inch and odor control of the raw wastewater wetwell. The existing screens should be replaced. The budget level cost is based on replacing the screens in kind. Other options such as fine screens could be considered provided there is a need for better screenings removal. If heat drying biosolids is pursued in the future, fine screens is one option that offers improved quality of the product. No cost is included for fine screens as part of the rehabilitation. An optional cost for fine screens ahead of grit removal is provided in the cost for heat drying improvements.

Staff mentioned that when high water levels occur in the wetwell the plant sewer can back up into the basement of the digester complex and other pump stations. A possible solution would be to route the plant sewer to a pit near the Raw Wastewater Pumping station and pump to flow into the wetwell. This would create a physical break between the plant sewer flow and the wetwell level and protect from having backups. However, the cost of this improvement is significant and staff should consider the benefit gained.

Improved ventilation and odor control has been included in the rehabilitation of the wetwell, the screen channels, and screen room. When conducting the plant inspection, H2S levels were great enough in the upper areas of the wetwells that continuing into the wetwell was not done. Confinement and removing malodorous air for treatment should be considered.

6.7.2 Primary Treatment.

Changing to ferric chloride from ferrous chloride should be considered. No capital cost is required for this change. If odor persists from the primary basins after implementing higher doses of chemical, covering the primary distribution box and the primary basin launders should be considered. Air collected from beneath the covers would be treated with activated carbon.

Cracks observed in the basin walls should be repaired. It is also recommended that when a basin is emptied for maintenance, the walls be inspected to determine if other cracking or distress has occurred. Staff advised that this will be performed within the O&M annual budget and will not require a capital project.

The main bearings of the two clarifier drive units need to be rebuilt or replaced. For budget purposes the cost of replacing the units has been included.

6.7.3 Aeration Basins

The two-speed surface aerators need to be replaced. Parts for the aerators are becoming difficult to obtain and diffused aeration offers more efficient transfer of energy and oxygen throughout the aeration basin. Diffused aeration would also eliminate excessive spray of the mixed liquor into the atmosphere which could be considered an odor source. Improvements would include adding diffusers and air piping to the basins. Air would be provided by blowers housed in a building.

6.7.4 Final Basins

New clarifier equipment with energy dissipating inlets (EDI) and spiral scraper technology is proposed for the two final basins. The energy dissipating inlets offer better settling of sludge and the spiral scrapers have been shown to improve sludge recovery for return to the aeration basins and for wasting sludge to the digesters.

6.7.5 I/I Settling Basins and I/I Holding Lagoon

Most of the improvements proposed are not considered critical. The condition of the I/I basin equipment may require replacement of the drive units, much like the primary basins, but based on discussions with City staff, this does not appear to warrant budgeting for replacement at this time.

A budget level cost for effluent launder covers and odor control has been included. However, as discussed in the odor control section, chemical addition to the wastewater may provide sufficient H_2S control that the covers and odor control equipment may not be required.

6.7.6 Wetlands Treatment and Plant Effluent Line to Wetlands

No specific improvements are identified for the wetlands for the capital repair and rehabilitation improvements. Upkeep of the wetlands is accomplished through the annual O&M budget.

The plant effluent line to the Wetland Treatment Unit No. 4 has a capacity limit of approximately 60 mgd. This is sufficient for current hydraulic capacity of the plant. If flow rates to the plant must be increased to meet future conditions, a second effluent line from the plant to the first wetlands unit will be required. The need for the additional line would be based on growth and is not considered to be a rehabilitation or repair type need. Further discussion about a second line is presented in Chapter 8.

6.7.7 Effluent Pump Station

A smaller pump to handle the low flow conditions could be considered but from discussions with staff is not an immediate need and is not included in the costs for rehabilitation. The degree of benefit this offers should be evaluated with normal flow conditions anticipated in the future to determine if such a modification is justified. An option may be to consider variable speed drive for one of the existing pumps.

6.7.8 Screenings Handling.

The plant staff are satisfied with the current method of handling screenings. No improvements are planned.

6.7.9 Primary Sludge and Scum Pumping

No major capital improvements to the primary sludge and scum pumps are envisioned. Pump replacement would fit within the normal O&M budget for the plant.

6.7.10 Return Sludge, Waste Activated Sludge, and Scum Pumping

Staff would like to consider something other than air lift pumps for the return activated sludge pumping. Consideration is given to using centrifugal type pumps; however, the piping and structure configuration make this modification extremely difficult and would require taken basins out of service. A cost has been developed based on using submersible axial flow pumps in place of the air lift pumps. One consideration is that the pumping head required in this application falls below the normal pumping heads for most pumps, with the exception of air lift pumps. Artificial inducing of head would be required. The existing building and wetwell limit options on types of pumps to use in place of the air lift pumps. Submersible axial flow pumps appear to be one that might work with the existing structure.

The existing waste activated sludge and scum pumps have a 175 gpm rated capacity each. With the installation of new centrifuges capable of handling up to 300 gpm flow rates, these pumps should be replaced with 300 gpm pumps. This will be performed within City's annual O&M budget.

6.7.11 I/I Sludge and Scum Pumping

No improvements are proposed for the existing sludge and scum pumping for the I/I Basins. However, leaks around penetrations in the basement of the I/I Pump House should be repaired. From discussions with City, this will be done through annual O&M budget.

6.7.12 Degritting Primary and I/I Sludge.

Hydroclones are currently used to degrit primary and I/I basin sludge. An alternative is to removal grit directly from the wastewater stream using grit basins. While this comes with a relatively higher cost than replacing the hydroclones, it offers the benefit of sending primary sludge directly to the digesters without using the gravity thickeners. It is important that sludge fed to the anaerobic digesters be as free of grit as possible to minimize inert solids build up in the digesters. Removing grit ahead of the primary basins allows for "thickening" of the primary sludge in the primary basins to the degree that gravity thickening could be eliminated. The cost presented for grit removal is based on providing 40 mgd of vortex type grit removal ahead of the primary basins and is included in the first plant expansion costs. If this approach is not taken, the hydroclones should be replaced and odor control added to the gravity thickeners. An opinion of cost is included to provide odor control for the thickeners.

6.7.13 Thickening Centrifuges.

A project is already planned to supplement and eventually replace the existing centrifuges with two new thickening centrifuges housed in a new building with an allocated cost of approximately $2.2 million.

6.7.14 Anaerobic Digesters.

Three projects were considered for repair and rehabilitation projects. One is odor control for the digester influent boxes. The cost for odor control is included in the odor control improvements for the thickeners. Another project would be to replace the two smaller primary sludge heaters with units similar to the Walker Heatex Unit type E, which is the newer more efficient heater in the system. One of the smaller primary sludge heaters would be used to replace the secondary sludge heater. The third improvement would be to replace the glass-lined sludge gas piping with stainless steel. This would eliminate the corrosion problem related to the ductile iron pipe. The city has added a filter to help with reducing corrosion and plugging, but replacement of the pipe with stainless steel should be implemented. Staff advised that both the heater replacement and pipe replacement will be implemented within the annual O&M budget and would not require a capital improvement project.

6.7.15 Sludge Lagoon.

The long term Biosolids Management Plan does not include continued use of the sludge lagoon. If the dewatering improvements are implemented, the lagoon would no longer be required. Abandoning use of the lagoon would eliminate potential for odors from the lagoon. Depending on how soon the lagoon is abandoned, consideration should be given to adding chemical to the lagoon decant for struvite control before it goes into the Perche Creek interceptor

manhole. Adding chemicals like iron salts or alum to the decant before it enters the interceptor could help control buildup of struvite in the interceptor and manhole.

6.7.16 Sludge Injection Pump Station and Sludge Holding Basin.

The electrical service upgrades to the sludge injection pump station will be done through O&M funds. Odor control improvements include covering the holding basin and treating malodorous air with activated carbon units.

6.7.17 Biosolids Management Program.

The improvements are presented in a two phase approach. The first phase will be to install a sludge dewatering facility. Digested sludge would be dewatered before being land applied. This would reduce the number trucks required for hauling sludge. The second phase would include a heat drying system to produce a Class A biosolids. Improvements for the dewatering facility can be used for the heat drying process. The sludge lagoon can be abandoned once the sludge dewatering facility is in place.

6.7.18 HVAC.

The underground heating loop piping should be replaced. Staff advised that this would be implemented on an as needed basis as part of their annual O&M budget. Work would be phased basis to minimize interruption to plant heating.

6.7.19 Odor Control

A two-phase approach to odor control is recommended. Phase 1 would include adding chemical to the primary distribution box and to the gravity thickeners to reduce H_2S levels in the liquid. The initial phase would also include treating air from the raw wastewater pump station wetwell area, the digester transfer boxes and possibly the gravity thickeners. Each area would be enclosed and ventilated. Air from these spaces would be treated using activated carbon.

The costs for odor control are included by structure in Table 6-3. Budget level project costs for Phase 1 improvements would be approximately $1.6 million and $2.2 million for Phase 2. It should be noted that adding covers and treating air from the primary basins and I/I basins may not be required depending on the effectiveness of the chemical addition to the liquid. This could reduce the Phase 2 improvements to about $500,000.

6.7.20 Non-Potable Water System

An automatic backwash strainer is recommended for the non-potable water system, which would be performed in annual O&M funds.

6.7.21 Chemical Feed systems

No needs were identified for the chemical feed systems that require a capital repair and rehabilitation project.

6.7.22 Ancillary Buildings and Roads

Generally the facilities are in good condition. The following improvements are not required now but should be considered in plant expansion improvements:

- Additional laboratory storage space. Staff suggested an additional 500 square feet of laboratory area be considered at the administration building.
- Additional parking is needed at the administration building. Space is limited to local personal vehicles away from plant operations.
- Relocate oil drums from the wash bay of the vehicle maintenance building to the pole barn so the wash bay can be used as intended.
- Plant staff requested an additional storage up to 1200 sf.

CHAPTER 7.0

COLLECTION SYSTEM ALTERNATIVES EVALUATION

7.1 INTRODUCTION

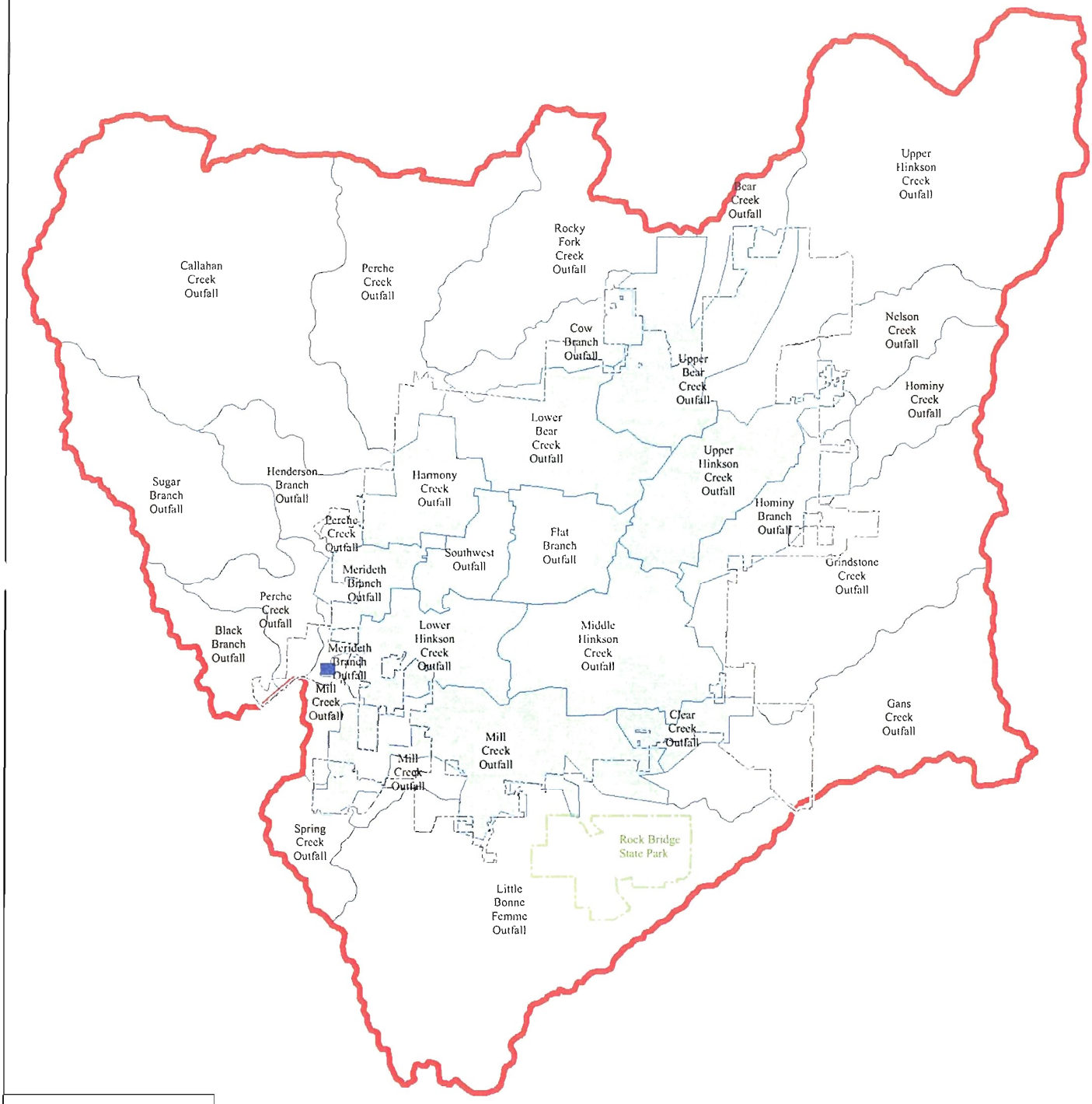
This chapter presents the collection system plan based on the analysis and evaluation results described in previous chapters. In previous chapters, alternatives were considered and the selection process was described for:

- Flow basins to conduct I/I evaluations.
- Selection of design criteria for future sewer extensions.
- Identifying relief sewers.
- Planning and routing of future sewer extensions and pump stations and the time frame for the inclusion of the improvements into the City's system.

The remainder of this chapter presents the collection system plan results based on analysis previously presented.

7.2 GENERAL

The City of Columbia's collection system generally lies within three major watersheds: Perche Creek, Hinkson Creek and Little Bonne Femme Creek. The Mill Creek watershed drains to the Hinkson Creek watershed and is considered a distinct outfall in the existing collection system. The following discussion of key existing system and future growth component recommendations will be grouped by these four watersheds. These major watersheds can be further divided into sub-watersheds which are generally named after creeks that flow through them. This process of separating the system into watersheds and sub-watersheds will aid with project phasing and illustration of the downstream impacts of proposed improvements. Figure 7-1 illustrates each of the watersheds and sub-watersheds within the study area.



City of Columbia
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Figure 7-1
Sub-Watershed Map

prepared by Black & Veatch in association with GBA

7.3 WATERSHED SUMMARY

Brief summaries of the Perche Creek, Hinkson Creek, Mill Creek and Little Bonne Femme Creek watersheds are presented in this section. A summary of the recommendations for each watershed and an implementation plan are presented at the end of this chapter. Detailed figures showing the recommended improvements for each sub-watershed are provided in Appendix B.

7.3.1 Perche Creek Watershed. The Perche Creek watershed has five sub-watersheds that are served by an existing collection system and nine sub-watersheds where a collection system can be added for future growth. This watershed includes 19,100 acres of existing development and 39,700 acres of potential future development. The Perche Creek watershed will incorporate most of the western and northern development for the City. The existing Perche Creek interceptor sewer was constructed to accommodate some of the growth in this area. Capacity problems have occurred in the Lower and Upper Bear Creek sub-watersheds' collection system. The Perche Creek interceptor is not expected to be overloaded until additional development has occurred.

7.3.2 Hinkson Creek Watershed. The Hinkson Creek watershed has eight sub-watersheds that are served by an existing collection system and four sub-watersheds where a collection system can be added for future growth. This watershed includes 15,500 acres of existing development and 26,700 acres of potential future development. The Hinkson Creek watershed includes much of the older development in the City including the downtown business district. Collection system capacity problems have occurred in the Upper Hinkson Creek and the Hominy Branch sub-watersheds, which can be expected to be compounded with further growth upstream of these areas. The lower reaches of the Hinkson Creek interceptor sewer do not show major capacity problems at this time but could potentially have problems once upstream capacity improvements are conducted that will remove upstream bottlenecks in the system.

7.3.3 Mill Creek Watershed. The Mill Creek watershed has two sub-watersheds that are served by an existing collection system and two sub-watersheds where a collection system can be added to accommodate future growth. This watershed includes 6,200 acres of existing development and 8,900 acres of potential future development. The Mill Creek watershed currently receives flow from development in the Little Bonne Femme watershed through pump stations and force mains. This practice is expected to continue in the future. Currently, the Mill Creek interceptor sewer is overloaded with existing flows. No major backups have been reported in this area, however, model results indicate that relief sewers will be needed for the interceptor to provide long term capacity for the existing and future development.

7.3.4 Little Bonne Femme Watershed. The Little Bonne Femme watershed includes approximately 1,200 acres of existing development, which is currently pumped to the Mill Creek watershed, and 14,200 acres of potential future development. For this study, the watershed has been divided into two sub-watersheds for which future sewer extensions will be required. These two sub-watersheds are named the Upper Little Bonne Femme and the Lower Little Bonne Femme. The Rock Bridge Memorial State Park lies between these two sub-watersheds. To avoid disturbing the Rock Bridge Memorial State Park land, wastewater flow from the Upper Little Bonne Femme region will be collected at a new pump station and transported through a force main to the Mill Creek Interceptor sewer. The lower Little Bonne Femme sub-watershed begins downstream of the park. Wastewater flow from the Lower Little Bonne Femme sub-watershed will also be directed to a new pump station and pumped to the Mill Creek interceptor sewer.

7.4 COLLECTION SYSTEM PLAN

7.4.1 Recommendations for I/I Investigations. Flow basins with high levels of I/I were previously identified in Chapter 5. In these basins, I/I investigations including smoke testing, dyed-water testing, manhole inspections, television inspections and building inspections are recommended to identify I/I sources for removal. I/I removal could potentially have a significant impact on relief sewer costs. Table 7-1 lists the basins recommended for I/I investigations, as well as the associated cost for performing these investigations. Cost opinions to remove cost-effective public sector I/I sources have also been developed and are shown in Table 7-2.

Table 7-1
Additional I/I Investigations

Watershed	Flow Basin	Flow Basin Footage	Evaluation Unit Cost ($/ft)	Evaluation Cost[(1)] ($)
Perche Creek Watershed				
Lower Bear Creek	P40	53,628	$4	$ 214,512
Lower Bear Creek	P41	60,463	$4	$ 241,852
Lower Bear Creek	P42	26,606	$4	$ 106,424
Upper Bear Creek	P49	7,918	$4	$ 31,672
Subtotal		148,615		$ 594,460
Hinkson Creek Watershed				
Lower Hinkson Creek	H13	227,463	$4	$ 909,852
Southwest Outfall	H15	31,780	$4	$ 127,120
Flat Branch Outfall	H18	286,798	$4	$ 1,147,192
Middle Hinkson Creek	H25	24,545	$4	$ 98,180
Upper Hinkson Creek	H29	27,055	$4	$ 108,220
Upper Hinkson Creek	H30	11,650	$4	$ 46,600
Upper Hinkson Creek	H33	24,640	$4	$ 98,560
Subtotal		633,931		$ 2,535,724
Mill Creek Watershed				
Clear Creek	M12	28,661	$4	$ 114,644
Subtotal		28,661		$ 114,644
Grand Total		811,207		$ 3,244,828

Notes:
(1) – Costs based on Evaluation work being contracted out.

Table 7-2
Projected Public Sector I/I Source Removal Costs

Watershed	Flow Basin	Flow Basin Footage	Rehabilitation Unit Cost ($/ft)	Rehabilitation Construction Cost	Capital Cost[(1)]
Perche Creek Watershed					
Lower Bear Creek	P40	53,628	$20	$ 1,072,560	$ 1,340,700
Lower Bear Creek	P41	60,463	$20	$ 1,209,260	$ 1,511,575
Lower Bear Creek	P42	26,606	$20	$ 532,120	$ 665,150
Upper Bear Creek	P49	7,918	$20	$ 158,360	$ 197,950
Total		148,615		$ 2,972,300	$ 3,715,375
Hinkson Creek Watershed					
Lower Hinkson Creek	H13	227,463	$20	$ 4,549,260	$ 5,686,575
Southwest Outfall	H15	31,780	$20	$ 635,600	$ 794,500
Flat Branch Outfall	H18	286,798	$20	$ 5,735,960	$ 7,169,950
Middle Hinkson Creek	H25	24,545	$20	$ 490,900	$ 613,625
Upper Hinkson Creek	H29	27,055	$20	$ 541,100	$ 676,375
Upper Hinkson Creek	H30	11,650	$20	$ 233,000	$ 291,250
Upper Hinkson Creek	H33	24,640	$20	$ 492,800	$ 616,000
Total		633,931		$ 12,678,620	$ 15,848,275
Mill Creek Watershed					
Clear Creek	M12	28,661	$20	$ 573,220	$ 716,525
Total		28,661		$ 573,220	$ 716,525
Grand Total		811,207		$ 16,224,140	$ 20,280,175

Notes:
(1) - Capital Cost includes 25% for contingency, engineering, legal, and administrative costs for construction type items.

7.4.2. Relief Sewer Recommendations. Potential relief sewer projects were identified for each watershed based on the results from modeling of the collection system and historical data provided by the City. The complete listing of the relief sewer projects (by sewer line segment) is provided in Appendix B. At this time, only a portion of the relief sewers are recommended for immediate implementation. Relief sewers identified by the model that did not have adequate elevation or flow monitoring data are recommended for additional investigation prior to confirming or eliminating the project from the final relief sewer plan. To assist in identifying immediate relief sewers, relief sewers needed for future growth and relief sewers that need additional investigation, the following categories were assigned to each potential project.

- Category 1 Relief Sewers – These relief sewers were identified by the model as being required for significantly overloaded reaches of sewer for existing conditions and have known problem areas. These known problem areas have experienced backups, manhole overflows or the flow meter site utilized for this study experienced surcharge conditions during wet weather events.

- Category 2 Relief Sewers – These relief sewers were identified by the model to be overloaded and have no recorded history of problems. These projects are suspected to be a problem as future growth occurs or upstream relief sewers are installed.

- Category 3 Relief Sewers – These relief sewers were identified by the model as overloaded but do not have a recorded history of problems and are not suspected to have additional loads from future growth or upstream relief sewers.

The categories assigned to the sewer projects were considered for prioritizing and scheduling of the improvements. Generally, relief sewer projects that have flow and elevation data and are a Category 1 relief sewer project were scheduled to be implemented in the short term. Category 2 relief sewers were scheduled for relief as future growth dictates. Category 3 relief sewer projects are for areas that do not appear to have immediate problems. The City should continue to monitor to determine if a problem exists in the potential relief sewer areas.

Additional investigation is recommended for a number of the relief sewer projects prior to design. This includes collecting elevation data to establish accurate sewer capacities and/or additional flow monitoring to establish appropriate design flows. In particular, the Flat Branch area has been assigned a high priority to determine system elevations because minimal elevation data were available for modeling and the area has had a history of basement backup problems. A summary of recommended additional investigations for potential relief sewer projects is provided in Table 7-3. The recommended relief sewer plan is provided in Table 7-4. Detailed relief sewer project information is provided in Appendix B.

Table 7-3
Additional Investigation for Relief Sewer Projects

Watershed	Project Identification	Inspection Priority	Project Length	Additional Manhole Elevation Units	Additional Flow Monitoring Units	Elevation Data Unit Cost ($)	Flow Meter Unit Cost ($)	Total Cost ($)
Perche Creek Watershed								
Lower Bear Creek	PP07[1]	1	7,872	0	Spring 2004	$50	$7,000	$0
Lower Bear Creek	PP05	2	7,589	30	0	$50	$7,000	$1,518
Lower Bear Creek	PP06	2	6,877	0	1	$50	$7,000	$7,000
Upper Bear Creek	PP09	2	5,546	22	1	$50	$7,000	$8,109
Upper Bear Creek	PP10[1]	2	4,816	0	Spring 2004	$50	$7,000	$0
Upper Bear Creek	PP11	2	6,709	27	1	$50	$7,000	$8,342
Upper Bear Creek	PP12	2	3,333	13	1	$50	$7,000	$7,667
Lower Bear Creek	PP14	2	4,711	19	0	$50	$7,000	$942
Merideth Branch	PP16	2	8,040	32	0	$50	$7,000	$1,608
Subtotal				144	4			$35,186
Hinkson Creek Watershed								
Southwest	HP10	1	2,999	12	0	$50	$7,000	$600
Flat Branch	HP11	1	87,218	349	0	$50	$7,000	$17,444
Southwest	HP12	1	4,048	16	0	$50	$7,000	$810
Middle Hinkson Creek	HP13	1	7,154	29	0	$50	$7,000	$1,431
Lower Hinkson Creek	HP14[2]	2	11,997	0	Spring 2004	$50	$7,000	$0
Lower Hinkson Creek	HP15	2	11,049	0	1	$50	$7,000	$7,000
Middle Hinkson Creek	HP16	2	4,833	19	1	$50	$7,000	$7,967
Middle Hinkson Creek	HP18[1]	2	7,624	0	Spring 2004	$50	$7,000	$0
Upper Hinkson Creek	HP19	2	9,264	37	0	$50	$7,000	$1,853
Upper Hinkson Creek	HP20	2	6,803	0	1	$50	$7,000	$7,000
Upper Hinkson Creek	HP21	2	7,146	29	1	$50	$7,000	$8,429
Upper Hinkson Creek	HP22[2]	2	4,326	0	Spring 2004	$50	$7,000	$0
Hominy Branch	HP23	2	8,089	32	1	$50	$7,000	$8,618
Lower Hinkson Creek	HP24	2	7,104	0	1	$50	$7,000	$7,000
Subtotal				523	6			$68,150
Mill Creek Watershed								
Clear Creek	MP09	1	5,788	23	0	$50	$7,000	$1,158
Mill Creek	MP05	2	1,084	4	0	$50	$7,000	$217
Mill Creek	MP06	2	11,036	44	0	$50	$7,000	$2,207
Mill Creek	MP07	2	5,075	20	1	$50	$7,000	$8,015
Mill Creek	MP08[2]	2	3,390	0	Spring 2004	$50	$7,000	$0
Clear Creek	MP10	2	8,090	32	0	$50	$7,000	$1,618
Subtotal				124	1			$13,215
Grand Total				791	11			$116,550

Table 7-4

Relief Sewer Construction Projects

Watershed	Project Identification	Relief Priority	Planning Year	Additional Investigation Needed	Project Length (ft)	Construction Cost ($)	Capital Cost ($)
Perche Creek Watershed							
Upper Bear Creek	PP04	1	2010		10,240	$ 1,807,208	$ 2,259,010
Lower Bear Creek	PP07	1	2010		12,441	$ 1,331,256	$ 1,664,070
Lower Bear Creek	PP08	1	2010		4,064	$ 407,925	$ 509,906
Merideth Branch	PP17	1	2010		2,688	$ 254,622	$ 318,278
Perche Creek	PP01	2	2020		10,181	$ 2,799,873	$ 3,499,841
Lower Bear Creek	PP02	2	2020(4)		12,223	$ 2,971,811	$ 3,714,764
Lower Bear Creek	PP03	2	2020(4)		9,012	$ 1,839,124	$ 2,298,905
Lower Bear Creek	PP05	3	2030	Yes	5,459	$ 563,219	$ 704,024
Lower Bear Creek	PP06	3	2030	Yes	2,091	$ 184,795	$ 230,994
Upper Bear Creek	PP09	3	2030	Yes	5,576	$ 483,520	$ 604,400
Upper Bear Creek	PP10	3	2030		4,816	$ 443,293	$ 554,116
Upper Bear Creek	PP11	3	2030	Yes	6,724	$ 764,629	$ 955,786
Upper Bear Creek	PP12	3	2030	Yes	3,333	$ 316,868	$ 396,085
Upper Bear Creek	PP13	3	2030		3,519	$ 322,513	$ 403,141
Lower Bear Creek	PP14	3	2030	Yes	4,711	$ 456,263	$ 570,329
Harmony Creek	PP15	3	2030		3,139	$ 283,877	$ 354,846
Merideth Branch	PP16	3	2030	Yes	8,008	$ 766,751	$ 958,439
Merideth Branch	PP18	3	2030		10,984	$ 3,197,531	$ 3,996,914
Subtotal					119,209	$ 19,195,078	$ 23,993,848
Hinkson Creek Watershed							
Upper Hinkson Creek	HP04	1	2010		8,708	$ 1,492,841	$ 1,866,051
Upper Hinkson Creek	HP05	1	2010		7,557	$ 1,210,685	$ 1,513,356
Upper Hinkson Creek	HP06	1	2010		5,185	$ 558,881	$ 698,601
Hominy Branch	HP07	1	2020(4)		14,810	$ 2,217,985	$ 2,772,481
Lower Hinkson Creek	HP08	1	2010		5,472	$ 900,008	$ 1,125,010
Southwest	HP09	1	2010		5,430	$ 516,447	$ 645,559
Southwest	HP10	1	2010	Yes	2,930	$ 331,082	$ 413,853
Flat Branch	HP11	1	2010	Yes	59,891	$ 7,402,333	$ 9,252,916
Southwest	HP12	1	2010	Yes	2,606	$ 249,999	$ 312,499

Notes:

(1) - Priority Legend

1. Current manhole overflows, backups and/or surcharge at meter sites.
2. No current problems - future impact due to growth or upstream relief.
3. No current problems - continue to monitor.

(2) - Capital Cost includes 25% for contingency, engineering, legal, and administrative costs for construction type items.

(3) - Further Studies May Reduce Relief Sewers.

(4) - Moved from 2010 to 2020 for financial planning purposes.

Table 7-4 (Continued)

Relief Sewer Construction Projects

Watershed	Project Identification	Relief Priority	Planning Year	Additional Investigation Needed	Project Length (ft)	Construction Cost ($)	Capital Cost ($)
Middle Hinkson Creek	HP13	1	2010	Yes	6,183	$ 610,321	$ 762,901
Lower Hinkson Creek	HP01	2	2020[4]		9,315	$ 4,320,771	$ 5,400,964
Middle Hinkson Creek	HP02	2	2020[4]		9,890	$ 3,814,419	$ 4,768,024
Lower Hinkson Creek	HP15	3	2030	Yes	10,520	$ 1,079,816	$ 1,349,770
Middle Hinkson Creek	HP16	3	2030	Yes	4,434	$ 441,431	$ 551,789
Middle Hinkson Creek	HP17	3	2030		7,843	$ 856,405	$ 1,070,506
Middle Hinkson Creek	HP18	3	2030		7,624	$ 695,452	$ 869,315
Upper Hinkson Creek	HP19	3	2030	Yes	5,639	$ 495,037	$ 618,796
Upper Hinkson Creek	HP20	3	2030	Yes	4,885	$ 436,758	$ 545,948
Upper Hinkson Creek	HP21	3	2030	Yes	4,942	$ 451,712	$ 564,640
Hominy Branch	HP23	3	2030	Yes	6,838	$ 633,340	$ 791,675
Lower Hinkson Creek	HP24	3	2030	Yes	7,104	$ 693,397	$ 866,746
Subtotal					197,806	$ 29,409,120	$ 36,761,400
Mill Creek Watershed							
Mill Creek	MP03	1	2010		9,384	$ 1,270,707	$ 1,588,384
Clear Creek	MP09	1	2010	Yes	3,019	$ 253,634	$ 317,043
Mill Creek	MP01	2	2020[4]		14,154	$ 3,812,823	$ 4,766,029
Mill Creek	MP02	2	2020[4]		12,388	$ 2,280,107	$ 2,850,134
Mill Creek	MP04	3	2030		8,322	$ 824,629	$ 1,030,786
Mill Creek	MP06	3	2030	Yes	9,175	$ 863,970	$ 1,079,963
Mill Creek	MP07	3	2030	Yes	4,227	$ 377,498	$ 471,873
Clear Creek	MP10	3	2030	Yes	8,090	$ 855,312	$ 1,069,140
Subtotal					68,759	$ 10,538,680	$ 13,173,350
Grand Total					385,774	$ 59,142,878	$ 73,928,598

Notes:

(1) - Priority Legend

1. Current manhole overflows, backups and/or surcharge at meter sites.
2. No current problems - future impact due to growth or upstream relief.
3. No current problems - continue to monitor.

(2) - Capital Cost includes 25% for contingency, engineering, legal, and administrative costs for construction type items.

(3) - Further Studies May Reduce Relief Sewers.

(4) - Moved from 2010 to 2020 for financial planning purposes.

7.4.3 Future Sewer Extensions. New sewer extension recommendations are based on the design criteria presented in Chapter 5. To plan for new sewer extensions, sewers needed through the year 2030 were projected based on discussions with the City and Boone County Regional Sewer District (BCRSD). New sewer extensions were proposed to each BCRSD development that was identified as having a future connection to the Columbia collection system. Refer to Appendix B for full details of the gravity sewer projects recommended in each future growth area. The future growth sewer recommendations are provided in Table 7-5.

7.4.4. Recommended Pump Station Improvements. Immediate need recommendations for the existing pump stations were made based on each station having the firm capacity to pass the peak flow from a 10-year design storm. The computer model results suggest that a majority of the stations have insufficient capacity to handle the projected peak flows tributary to the station. Before expanding pump station capacity, it is recommended that an event recorder be installed at these pump stations to determine if they actually are under capacity. Increased capacity should be based on information collected from the event recorder.

Future recommendations for the existing pump stations are also based on the firm capacity in relation to future peak flow, but include the added goal to eliminate or consolidate the station if feasible and economical. Table 7-6 identifies the recommended course of action for each station. The improvement alternatives considered included using the station in place, upgrading the station at existing location, and eliminating the station to a relief sewer, future sewer extension, or future pump station. Each lift station that is recommended for replacement by gravity sewer should be reviewed further before proceeding with the design of the project. A review of the alignment elevations, downstream sewer capacity and the suggested tie-in manhole elevation for each station should be completed to determine the feasibility of installing gravity sewers to eliminate pump stations.

7.4.5 Proposed Lift Stations to Serve Future Development. Proposed lift station recommendations to serve future development were made based on each lift station having the capacity to pass a 10-year design storm at Year 2030. Each of the future growth lift stations are located in the Little Bonne Femme watershed and will pump flows to the Mill Creek Interceptor. Table 7-7 summarizes the costs for the recommended future pump stations including associated force mains.

Table 7-5					
Future Growth Gravity Sewer Extension Recommendations					
Watershed	Project Identification	Planning Year Needed	Project Length (ft)	Construction Cost	Capital Cost[(1)]
Perche Creek Watershed					
Sugar Branch	PF3	2030	25,216	$ 4,276,183	$ 5,345,229
Cow Branch	PF7	2020	14,037	$ 1,659,839	$ 2,074,799
Rocky Fork	PF7	2030	27,162	$ 4,838,814	$ 6,048,518
Bear Creek	PF8	2010	11,079	$ 1,255,378	$ 1,569,223
Bear Creek	PF8	2020	12,696	$ 1,224,570	$ 1,530,713
Subtotal			90,190	$ 13,254,784	$ 16,568,480
Hinkson Creek Watershed					
Mill Creek	HF10	2010	4,309	$ 488,173	$ 610,216
Grindstone Creek	HF11	2010	20,754	$ 2,334,011	$ 2,917,514
Grindstone Creek	HF11	2020	16,917	$ 1,935,589	$ 2,419,486
Grindstone Creek	HF12	2020	16,773	$ 1,388,044	$ 1,735,055
Hominy Creek	HF13	2010	11,788	$ 1,491,514	$ 1,864,393
Upper Hinkson	HF14	2010	3,844	$ 355,200	$ 444,000
Nelson Creek	HF15	2030	6,101	$ 607,397	$ 759,246
Upper Hinkson	HF16	2030	39,695	$ 8,842,087	$ 11,052,609
Upper Hinkson	HF18	2030	8,040	$ 898,963	$ 1,123,704
Hominy Creek	HF29	2010	269	$ 22,774	$ 28,468
Subtotal			128,490	$ 18,363,752	$ 22,954,690
Mill Creek Watershed					
Mill Creek	MF19	2020	2,506	$ 219,188	$ 273,985
Clear Creek	MF20	2020	1,941	$ 219,941	$ 274,926
Subtotal			4,447	$ 439,129	$ 548,911
Little Bonne Femme Watershed					
Little Bonne Femme	LBFF23	2020	13,516	$ 1,721,288	$ 2,151,610
Little Bonne Femme	LBFF23	2030	5,434	$ 561,880	$ 702,350
Little Bonne Femme	LBFF24	2020	15,180	$ 2,115,749	$ 2,644,686
Gans Creek	LBFF25	2010	5,387	$ 1,185,173	$ 1,481,466
Subtotal			39,517	$ 5,584,090	$ 6,980,113
Grand Total			262,644	$ 37,641,755	$ 47,052,194

Table 7-6
Existing Pump Station Recommendations

Pump Station	Firm Station Capacity (gpm)	Recommended Plan[1]	Projected Elimination Date[2]
Clear Creek	980	1. Upgrade Existing Station	2008[7]
Ewing Industrial	83	1. Event Recorder[3] 2. Eliminate to FSE[4]	-
Hinkson Creek (Mexico Gravel)	800	1. Event Recorder[3] 2. Eliminate to RS[5]	-
Little Bonne Femme	2,100	1. Eliminate to FPS[6]	2020
North Hampton Village	250	1. Event Recorder[3] 2. Eliminate to FSE[4]	2009[8]
Valley View	83	1. Event Recorder[3] 2. Eliminate to FSE[4]	-
Victoria South	118	1. Event Recorder[3] 2. Eliminate to FPS[6]	2020
Woodrail	83	1. Event Recorder[3] 2. Use In Place	-
Concord Industrial Park	4	1. Eliminate to FSE	-
Haystack Acres No. 1	28	1. Eliminate to FSE	-
Haystack Acres No. 2	83	1. Event Recorder[3] 2. Eliminate to FSE[4]	-
Haystack Acres No. 3	98	1. Event Recorder[3] 2. Eliminate to FSE[4]	-
Sunset Mobile Home Park	20	1. Use In Place	-
Deer Ridge	200	1. Event Recorder[3] 2. Eliminate to FSE[4]	-
Cow Branch	1,600	1. Event Recorder[3] 2. Eliminate to FSE[4]	-
Thornbrook	Unknown	1. Event Recorder[3] 2. Use In Place	-

Notes:

1 Cost for eliminating stations (gravity line, station abandonment, etc.) are included with sewer costs.

2 Dates are provided if projected elimination date is prior to 2030, otherwise no date is shown.

3 Install event recorder to evaluate need for increased capacity at station prior to proposed elimination. The model indicated these stations to have tributary peak flows in excess of firm capacity. Installation of event recorder and tracking of events could be done with City forces.

4 Eliminate pump station to *future sewer extension*. Pump station elimination date to correspond with new sewer.

5 Eliminate to *relief sewer*. Pump station elimination date to correspond with new relief sewer.

6 Eliminate to *future pump station*. Once the Middle LBF Pump Station is constructed, these stations can be eliminated and flow sent to the Middle LBF pump station.

7 Improvements include a larger wetwell, more storage, and increasing pumping capacity to 1,300 gpm.

8 Date corresponds with the City's plan to eliminate the station in the next five years

Table 7-7
Future Pump Station Recommendations

Watershed	Pump Station	Planning Year Needed	Pump Station Size (mgd)	Force Main Length (ft)	Pump Station Construction Cost ($)	Force Main Construction Cost ($)	Total Construction Cost ($)	Total Capital Cost[1] ($)
Little Bonne Femme Watershed								
	Upper Little Bonne Femme	2010	1.6	6,700	$250,000	$270,000	$520,000	$650,000
	Middle Little Bonne Femme	2020	14.5	16,000	$1,750,000	$1,500,000	$3,250,000	$4,062,500
	Clear Creek	2030	8	4,500	$1,750,000	$300,000	$2,050,000	$2,562,500
Grand Total							$3,770,000	$7,275,000

Notes:
(1) - Capital Cost includes 25% for contingency, engineering, legal, and administrative costs for construction type items.

7.5 COLLECTION SYSTEM PLAN WATERSHED SUMMARY

A plan for the Columbia wastewater collection system is presented in Table 7-8. This plan addresses the needs of the existing collection system and plans for growth to the year 2030 including items which are critical to the operation of the collection system: I/I investigation and reduction, system rehabilitation, relief sewers, and future sewer extensions and pump stations.

7.6 COLLECTION SYSTEM IMPLEMENTATION PLAN

A collection system implementation plan was developed to provide the proper sequence to initiate and complete identified projects. The implementation plan considers high priority improvements based on current system problems such as repeated system backups or sewer overflows. The implementation plan also considers relief sewers and sewer extensions to accommodate future growth. The plan begins with a detailed listing of projects recommended for completion during each of the first five years up to the year 2010. Projects identified after year 2010 and up to year 2030 are included in the plan but are not initially scheduled. It is recommended that the capital improvements projects lists be reviewed annually and projects added to maintain a five year program for improvements. The recommended collection system implementation plan is shown in Table 7-9.

Table 7-8
Summary of Recommendations

Watershed	Description	Unit Quanity	Unit Cost ($)	Total Construction Cost ($)	Total Capital Cost[1] ($)
Perche Creek Watershed					
	I/I Inspections (ft)	148,615	$4	$594,460	$594,460
	Public Sector Rehabilitation (ft)	148,615	$20	$2,972,300	$3,715,375
	Additional Investigations			$35,186	$35,186
	Relief Sewer Projects (ft)	60,849	$188	$11,411,819	$14,264,774
	Potential Relief Sewer Projects (ft)	58,360	$133	$7,783,259	$9,729,074
	Future Sewer Extensions (ft)	90,190	$147	$13,254,784	$16,568,480
Subtotal				**$36,051,808**	**$44,907,348**
Hinkson Creek Watershed					
	I/I Inspections (ft)	633,931	$4	$2,535,724	$2,535,724
	Public Sector Rehabilitation (ft)	633,931	$20	$12,678,620	$15,848,275
	Additional Investigations			$68,150	$68,150
	Relief Sewer Projects (ft)	137,977	$171	$23,625,772	$29,532,215
	Potential Relief Sewer Projects (ft)	59,829	$97	$5,783,348	$7,229,185
	Future Sewer Extensions (ft)	128,490	$143	$18,363,752	$22,954,690
Subtotal				**$63,055,367**	**$78,168,240**
Mill Creek Watershed					
	I/I Inspections (ft)	28,661	$4	$114,644	$114,644
	Public Sector Rehabilitation (ft)	28,661	$20	$573,220	$716,525
	Additional Investigations			$13,215	$13,215
	Relief Sewer Projects (ft)	38,945	$196	$7,617,271	$9,521,589
	Potential Relief Sewer Projects (ft)	29,814	$98	$2,921,409	$3,651,761
	Future Sewer Extensions (ft)	4,447	$99	$439,129	$548,911
Subtotal				**$11,678,888**	**$14,566,645**
Little Bonne Femme Watershed					
	Future Sewer Extensions (ft)	39,517	$141	$5,584,090	$6,980,113
	Future Pump Stations and Forcemain	3	$1,940,000	$5,820,000	$7,275,000
Subtotal				**$11,404,090**	**$14,255,113**
Grand Total				**$122,190,152**	**$151,897,345**

Table 7-9
Collection System Implementation Plan

	Project	2006	2007	2008	2009	2010	2011-2030
I/I Investigations							
Southwest Outfall	H15	$127,120					
Flat Branch Outfall	H18		$280,000	$280,000	$280,000	$280,000	
Middle Hinkson Creek	H25		$98,000				
Clear Creek	M12			$115,000			
Upper Hinkson Creek	H29						$108,220
Upper Hinkson Creek	H30					$47,000	
Lower Hinkson Creek	H13				$200,000	$200,000	$510,000
Upper Hinkson Creek	H33						$99,000
Upper Bear Creek	P49						$32,000
Lower Bear Creek	P42					$106,424	
Lower Bear Creek	P41						$242,000
Lower Bear Creek	P40			$215,000			
SUBTOTAL		$127,120	$378,000	$610,000	$480,000	$633,424	$991,220
Additional Investigations							
Flat Branch	HP11	$18,000					
Southwest	HP10		$600				
Southwest	HP12		$800				
Middle Hinkson Creek	HP13		$1,500				
Clear Creek	MP09		$1,200				
Remaining Investigations							$95,109
SUBTOTAL		$18,000	$4,100	$0	$0	$0	$95,109
Relief Sewer							
Mill Creek	MP03			$1,588,000			
Upper Bear Creek	PP04					$1,129,500	$1,129,500
Upper Hinkson Creek	HP05					$756,500	$756,500
Upper Hinkson Creek	HP06				$699,000		
Flat Branch	HP11			$1,500,000	$1,500,000	$1,500,000	$4,752,000
Hominy Branch	HP07						$2,772,000
Lower Bear Creek	PP07				$1,664,070		
Lower Bear Creek	PP08					$509,900	
Lower Hinkson Creek	HP08	$1,125,000					
Merideth Branch	PP17					$318,000	
Clear Creek	MP09				$318,000		
Middle Hinkson Creek	HP13			$763,000			
Southwest	HP09			$645,559			
Southwest	HP10	$414,000					
Southwest	HP12		$312,499				
Lower Bear Creek	PP02						$3,715,000
Lower Bear Creek	PP03						$2,300,000
Lower Hinkson Creek	HP01						$5,401,000
Middle Hinkson Creek	HP02						$4,768,024
Mill Creek	MP01						$4,766,000
Mill Creek	MP02						$2,850,134
Remaining Relief Projects							$24,109,861
SUBTOTAL		$1,539,000	$312,499	$4,496,559	$4,181,070	$4,213,900	$57,320,019

Table 7-9 (continued) Collection System Implementation Plan							
	Project	**2006**	**2007**	**2008**	**2009**	**2010**	**2011-2030**
Future Sewer Extensions							
Bear Creek	PF8	$1,569,223					
Grindstone Creek	HF11		$2,917,514				
Upper Hinkson	HF14			$444,000			
Mill Creek	HF10			$610,216			
Hominy Creek	HF13				$1,864,393		
Hominy Creek	HF29				$28,468		
Gans Creek	LBFF25					$1,481,466	
Remaining Future Extensions							$38,136,915
SUBTOTAL		$1,569,223	$2,917,514	$1,054,216	$1,892,860	$1,481,466	$38,136,915
Future Lift Stations							
Upper Little Bonne Femme						$650,000	
Middle Little Bonne Femme							$4,062,500
Clear Creek							$2,562,500
SUBTOTAL		$0	$0	$0	$0	$650,000	$6,625,000
I/I Removal							
Sewer & Manhole Rehabilitation		$500,000	$500,000	$500,000	$750,000	$750,000	$17,280,000
SUBTOTAL		$500,000	$500,000	$500,000	$750,000	$750,000	$17,280,000
GRAND TOTAL		$3,753,343	$4,112,112	$6,660,775	$7,303,930	$7,728,790	$120,448,263

CHAPTER 8.0

TREATMENT ALTERNATIVES EVALUATION

The existing treatment plant capacity must be increased to meet Year 2030 projected flow of 28.4 mgd. Treatment alternatives were evaluated using a two step process. The first step was to identify the most appropriate site for the additional treatment capacity using either the existing plant site or a remote site. The second step was to determine the most suitable treatment system to meet the projected demand using the selected site.

Throughout this evaluation continued use of wetlands was always considered. Wetlands use was an important consideration in selecting the most appropriate site for expanding treatment capacity. In selecting the most appropriate treatment technology, alternative treatment processes included continued use of wetlands for mechanical plant effluent polishing and for wet weather flows.

To meet the 28.4 mgd Year 2030 demand, additional treatment capacity is required. The activated sludge process at the existing Columbia Regional Wastewater Treatment Plant has a rated capacity of 12.6 mgd based on current loading conditions. Using wetlands to polish plant effluent, the design capacity of the treatment plant, as stated in the NPDES permit, is 20.6 mgd. Depending on how much of the existing treatment plant is used, the additional treatment capacity required ranges from 7.8 mgd to 15.8 mgd. Table 8-1 presents the new treatment capacity required if none, all or part of the existing treatment capacity is used in the future.

Table 8-1
Additional Treatment Capacity Required to Meet Projected Year 2030 Needs

Level of Use of Existing Treatment Plant in Future	Existing Capacity Re-used, mgd	Amount of New Treatment Needed to Meet year 2030, mgd
Discontinue use of existing plant and wetlands	0.0[1]	28.4[1]
Use existing mechanical plant without wetlands	12.6[2]	15.8
Use existing mechanical plant with wetlands	20.6[3]	7.8[3]

Note:
1. If use of existing plant is discontinued, all treatment facilities will be new.
2. The existing mechanical plant is rated to provide 12.6 mgd if the wetlands treatment is not used.
3. The design basis for the wetlands treatment units claims that an additional 8 mgd of flow can be treated by using the wetlands to polish effluent from the mechanical plant. Further assessment is required to determine if this level of treatment can be achieved is required. To cover the range of projected treatment needs in 2030, the claimed performance of 20.6 mgd is used.

8.1 EVALUATION OF TREATMENT PLANT SITES

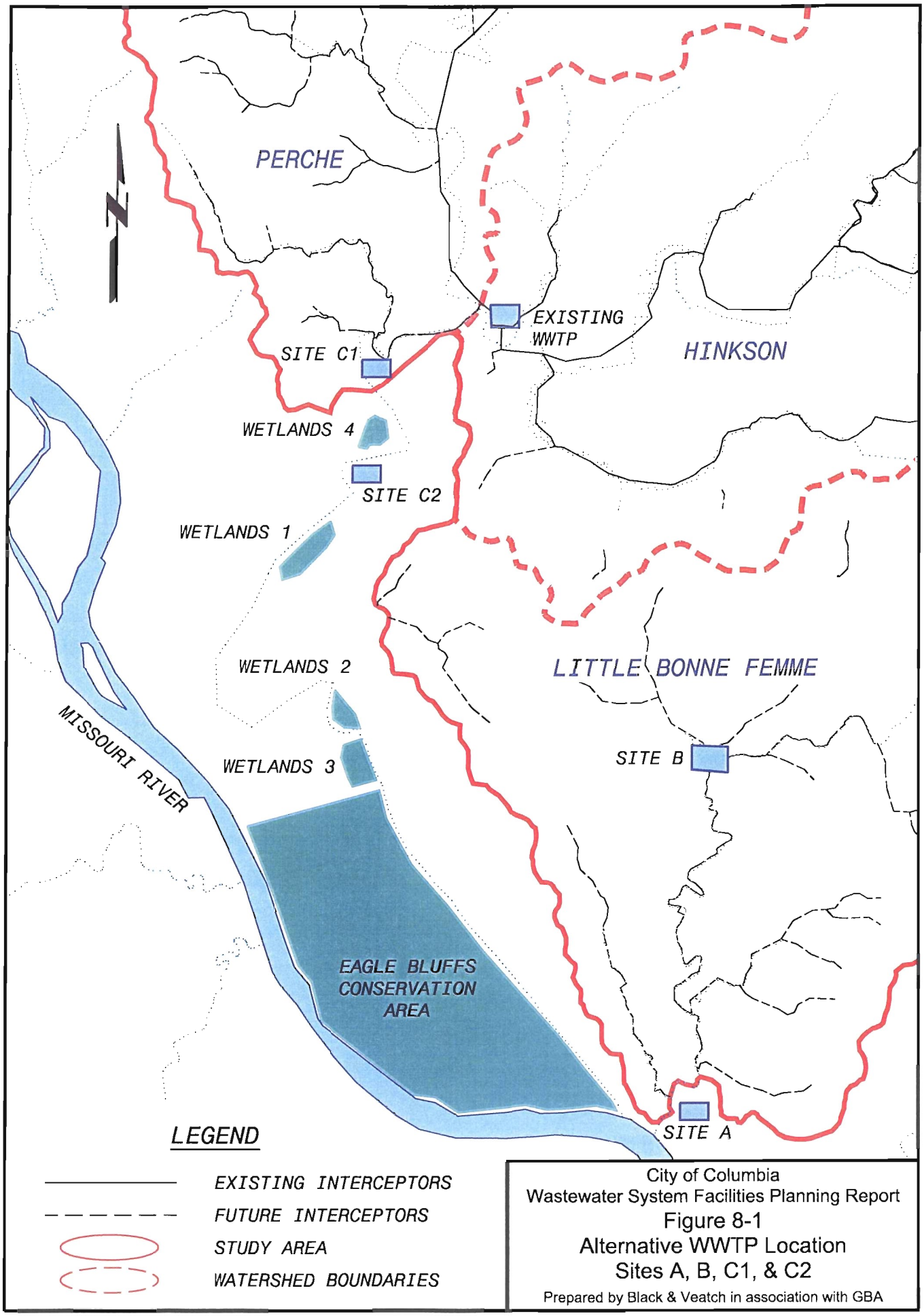
Columbia Regional WWTP's service area lies within three major watersheds: Perche Creek; Hinkson Creek (which includes Mill Creek area); and Little Bonne Femme. Currently, all flow from Perche Creek and Hinkson Creek can flow by gravity to the plant's raw wastewater pump station. Little Bonne Femme wastewater is pumped to the Hinkson / Mill Creek collection system for conveyance to the plant. The following three alternatives were established as part of the study scope to be evaluated as possible sites for future treatment.

1) Alternative 1 involves upgrading the existing facility and constructing additional treatment capacity at this site. The additional new treatment plant capacity required would range from 7.8 mgd to 15.8 mgd to supplement the existing treatment, depending on continued use of the wetlands and how much polishing can be achieved through wetlands.
2) Alternative 2 involves replacing the existing facility with a new wastewater treatment plant to serve Columbia's projected service area. The new facility could be located at the existing treatment plant site or a new remote site. This would require new treatment plant capacity of 28.4 mgd.
3) Alternative 3 involves upgrading the existing treatment facility and constructing additional facilities at a remote site. Similar to Alternative 1, the additional new treatment plant capacity required would range from 7.6 mgd to 15.8 mgd to supplement the existing treatment, depending on continued use of the wetlands and how much polishing can be achieved through wetlands.

By definition, the existing plant site will be used for Alternative 1. For Alternatives 2 and 3, a single remote site must be selected. Selecting a single site is considered reasonable because the advantages a remote site offers for Alternative 2 will apply to Alternative 3 as well.

The following three sites were considered for the remote site and are shown on Figure 8-1.

- Site A - at the confluence of Little Bonne Femme and Missouri River.
- Site B - approximately three miles north of Site A along Little Bonne Femme.
- Site C - in the vicinity of Wetlands Treatment Units 1 and 4 along Perche Creek downstream of the existing treatment plant. Depending on the land requirements and access to the site, the specific location could be either a site north or a site south of unit 4. These sites have been designated as C1 and C2, respectively.



City of Columbia
Wastewater System Facilities Planning Report
Figure 8-1
Alternative WWTP Location
Sites A, B, C1, & C2
Prepared by Black & Veatch in association with GBA

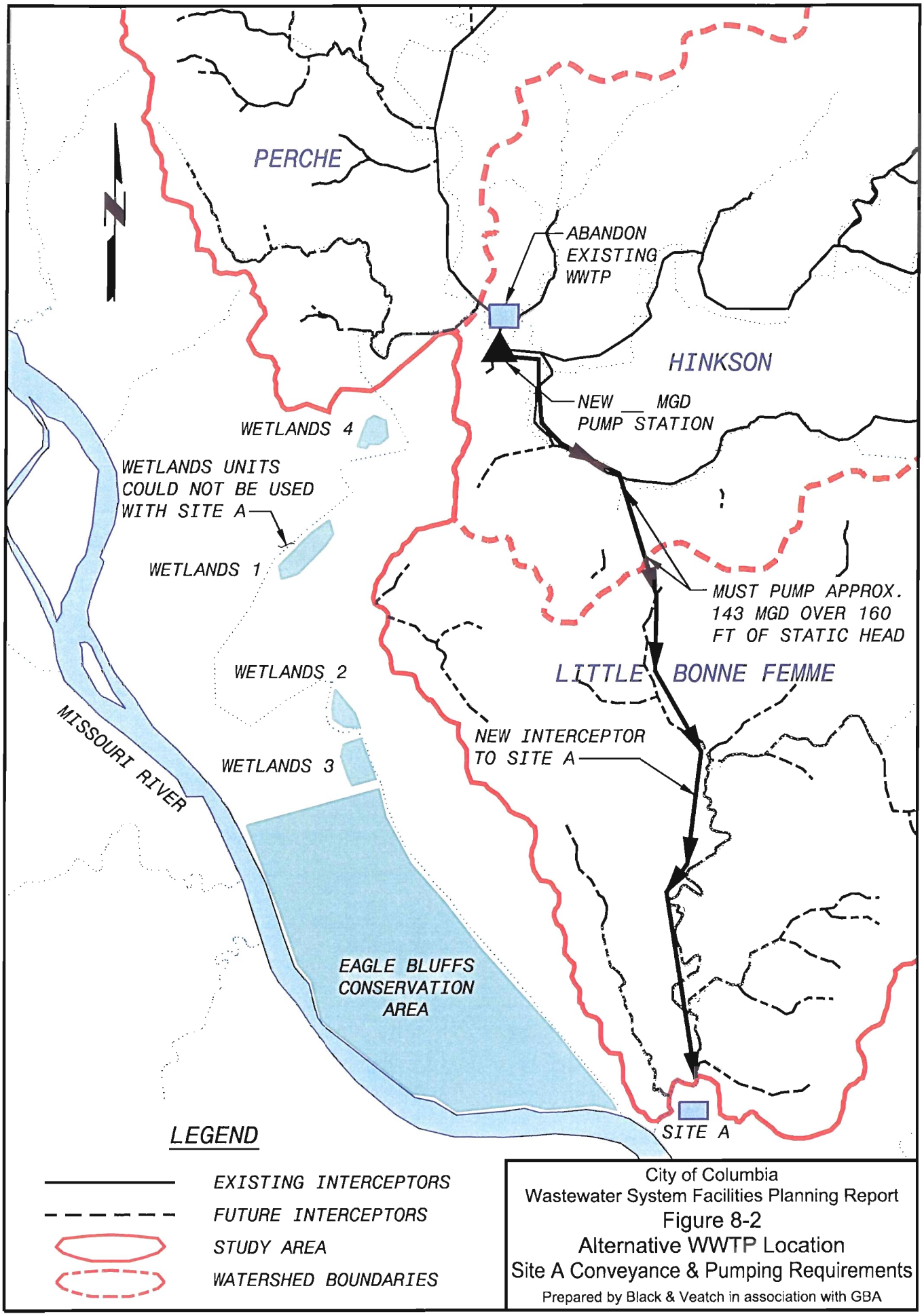
CYGNET ID: 132200-2000-323-C-T000071T7

8.1.1 - Step 1A - Selecting Remote Site to Use for Alternatives 2 and 3. Figures 8-2 through 8-4 present the conveyance system requirements to send flow to Sites A, B, and C (1 and 2) respectively. Because sites A and B are located in the Little Bonne Femme watershed, wastewater would have to be pumped from the Hinkson and Perche Creek watersheds to a treatment facility at either of these sites. Site C lies along Perche Creek downstream of the existing wastewater treatment plant site. Wastewater from the Little Bonne Femme watershed would have to be pumped to Site C. Low static head pumping of wastewater from Perche and Hinkson Creek watersheds would also be required.

Table 8-2 presents a comparison of how each site satisfies the criteria considered. Site C appears to offer the most benefits and should be used in the comparison of the three treatment alternatives. The two most notable advantages of Site C are that it is located in the Perche Creek / Hinkson Creek watershed area, where the greatest growth is expected to occur, and a plant at Site C could take advantage of continued use of the wetlands treatment units. The greatest growth through Year 2030 and for ultimate development is projected to occur in the Perche Creek and Hinkson Creek watersheds. Locating treatment facilities in this watershed significantly reduces the amount of pumping required to get wastewater from one watershed to the other. Table 8-2 shows that locating a new treatment plant at either site A or B would require a pumping station capacity of up to 143 mgd against a static head of ~160 feet whereas Site C would only require pumping approximately mgd of flow against 160 feet to get it from Little Bonne Femme to Site C. This is a significant difference that impacts capital cost and annual operating and maintenance costs.

The cost to construct and operate new treatment facilities at Sites A or B are expected to be the same since either will discharge to the Missouri River. The level of treatment required for Site C as compared to Sites A and B will be the same or less. If wetlands are not used in conjunction with a new plant at Site C, the plant effluent would probably be discharged to the Missouri and have the same limits as a plant located at Site A or B. If Site C plant effluent is discharged to the Eagle Bluffs Conservation Area, it is not anticipated that the level treatment will be greater than discharging to the Missouri River. For these reasons, Site C was used as the remote site for evaluating Alternatives 1, 2, and 3. It should be noted that Site B was also considered as a plant site in the 1973 Master Plan but use of a single plant at what is now the existing plant site was implemented. The cost to treat Little Bonne Femme flow at Site B in lieu of pumping the flow to the existing plant was reviewed in this study. It was determined that the cost to treat this flow would be approximately 4 to 5 times greater than pumping to the existing plant site.

8.1.2 - Step 1B - Evaluation of Alternatives 1, 2, and 3 Using Site C. Table 8-3 presents a comparison of Alternatives 1, 2, and 3 using Site C, which includes budget levels opinions of capital cost to expand treatment facilities.



City of Columbia
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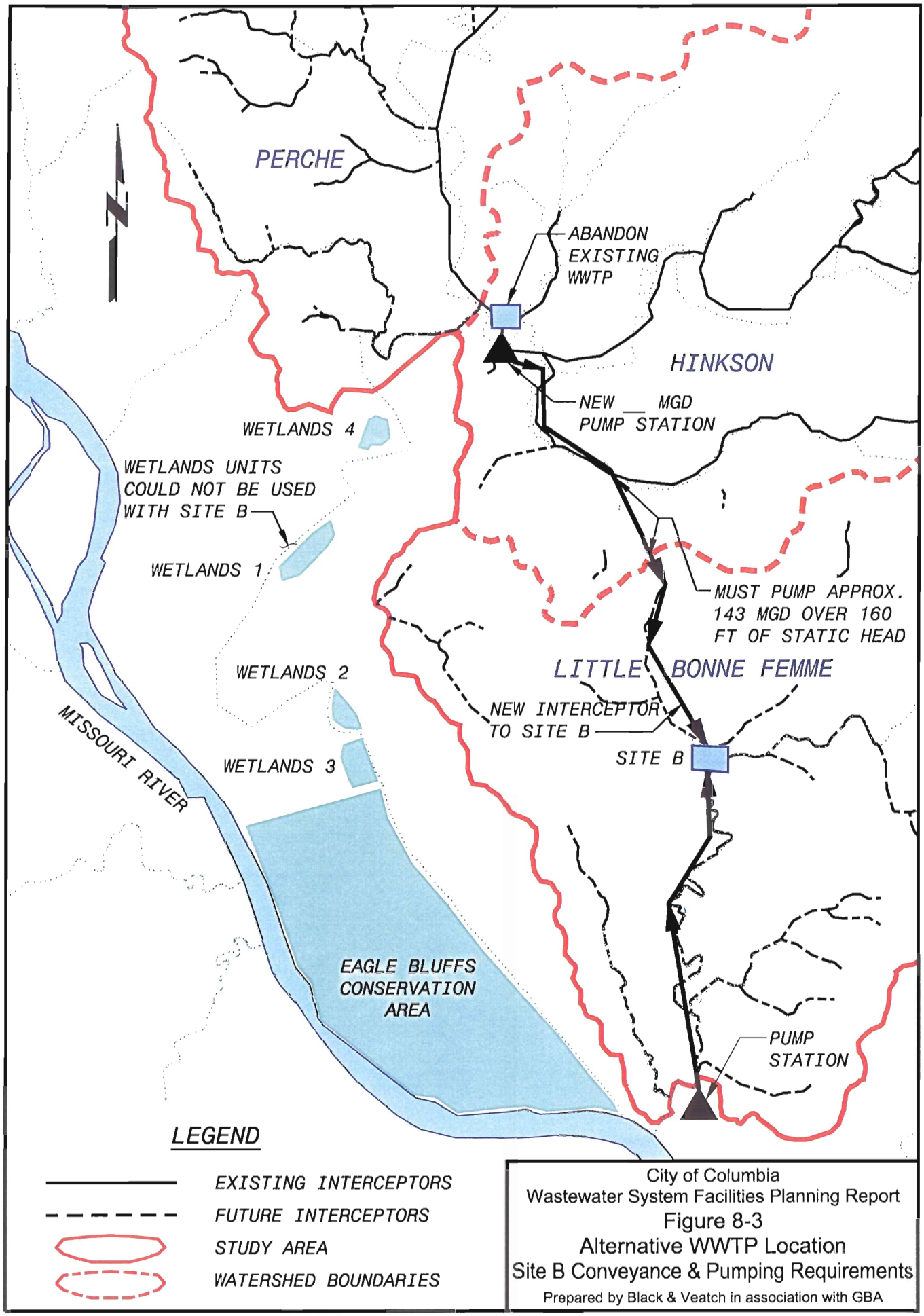
Figure 8-2
Alternative WWTP Location
Site A Conveyance & Pumping Requirements
Prepared by Black & Veatch in association with GBA

CYGNET ID: 132200-2000-323-C-T0000745X



City of Columbia
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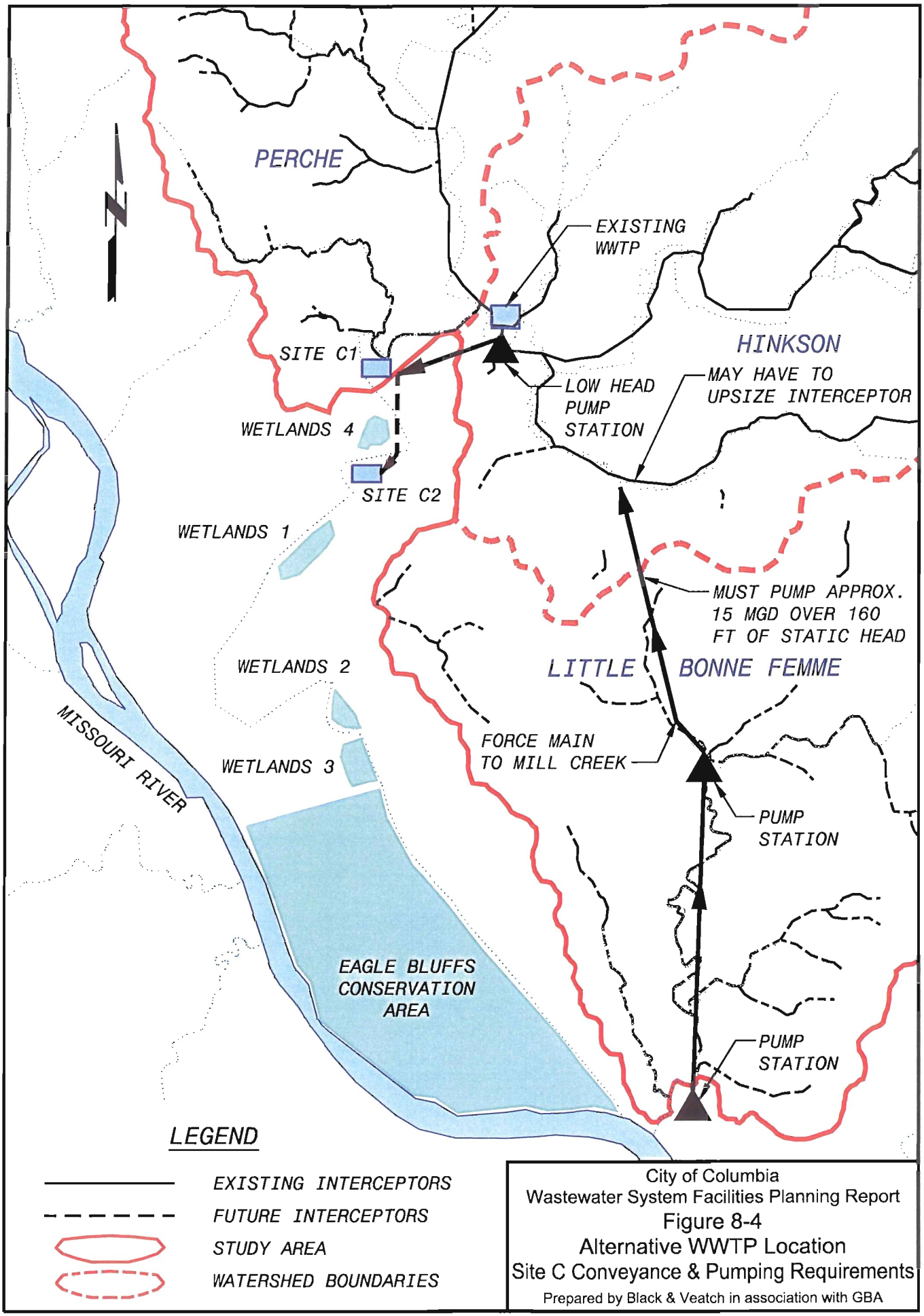
Figure 8-3
Alternative WWTP Location
Site B Conveyance & Pumping Requirements
Prepared by Black & Veatch in association with GBA

CYGNET ID: 132200-2000-323-C-T0000745Y



City of Columbia
Wastewater System Facilities Planning Report
Figure 8-4
Alternative WWTP Location
Site C Conveyance & Pumping Requirements
Prepared by Black & Veatch in association with GBA

CYGNET ID: 132200-2000-323-C-T0000745Z

Table 8-2
Comparison of Sites for New Wastewater Treatment Facilities

	Site A	Site B	Site C	Comments
Location	In Little Bonne Femme (LBF) watershed located at confluence of L. Bonne Femme and Missouri River.	In Little Bonne Femme upstream of Site A on the Little Bonne Femme Creek.	Along the Perche Creek near the existing Wetlands Units 1and 4	
Projected Future Flows - Year 2030				
Flow from Perche Creek	7.8			For this comparison, industrial component
Flow from Hinkson Creek	17.4			proportioned to each watershed based on
Flow from Little Bonne Femme	3.2			residential / commercial flow to each watershed
Total Flow	28.4			
Additional Treatment Capacity, Annual Average flow mgd	If existing treatment plant operation is discontinued			
	28.4			
Additional Treatment Capacity, Annual Average flow mgd	If Continuing to Use Existing Plant With Existing Wetlands Treatment			
Total 2030 flow to treat	28.4	28.4	28.4	Year 2030 projections used
Capacity of existing plant as Listed in NPDES permit	20.6	20.6	20.6	Wetlands treatment units included. The design basis for the wetlands treatment units claims that an additional 8 mgd of flow can be treated by using the wetlands to polish effluent from the mechanical plant. Further assessment is required to determine if this level of treatment can be achieved is required. To cover the range of projected treatment needs, the claimed performance of 20.6 mgd is used.
Future treatment capacity required	7.8	7.8	7.8	
Additional Treatment Capacity, AA mgd	If Continuing to Use Existing Plant Without Existing Wetlands Treatment			
Total 2030 flow to treat	28.4	28.4	28.4	Year 2030 projections used
Capacity of existing plant	12.6	12.6	12.6	Max Month loading basis.
Future treatment capacity required	15.8	15.8	15.8	
Evaluation Criteria				
Receiving waters for new Treatment located at each site	Missouri River	Missouri River (Requires a long plant outfall sewer)	Eagle Bluffs Conservation Area, Missouri River or both	Current plant is discharging to Eagle Bluffs Conservation Area.
Amount of Flow that must be conveyed from one watershed to WWTP				
Annual Average Flows, mgd				
Alternative 1	n/a	n/a	n/a	Alternative 1 all flow goes to existing site
Alternative 2 (all flow pumped to one site)	25.2	25.2	25.2	For Sites A & B, must pump flow from Hinkson and Perche to LBF sites. For Site C, can convey by gravity the Hinkson and Perche Creek flow and only have to pump LBF. Have concerns about using existing plant effluent line for interceptor to Site C because reaches of pipeline have an upward slope, which is not conducive to raw wastewater conveyance.
Alternative 3 (all future flow to this site based on wetlands treatment operation discontinued to determine greatest cost impact)	12.6	12.6	25.2	For Sites A & B, pumped flow equal to pumped flow for Alternative 2 minus existing plant capacity. For Site C, must pump LBF to site, rest can go by gravity.
Peak Flows, mgd				
Alternative 1	n/a	n/a	n/a	Alternative 1 all flow goes to existing site
Alternative 2 (all flow pumped to one new site)	140.0 Against 160 ft Static Head	140.0 Against 160 ft Static Head	14.2 Against 160 ft Static Head 154.2 Against ~10 ft Static Head	For Sites A & B, pump all of Hinkson and Perche to site. For Site C need to pump Little Bonne Femme (14 mgd) to existing site and 163 mgd of flow to Site C with low head pumping from existing plant site.
Alternative 3 (all future flow to this site based on wetlands treatment operation discontinued to determine greatest cost impact)	78.0 Against 160 ft Static Head	78.0 Against 160 ft Static Head	14.2 Against 160 ft Static Head 92.2 Against ~10 ft Static Head	For Sites A & B, pump all of Hinkson and Perche to site that exceeds wet weather capacity of existing plant. For Site C need to pump Little Bonne Femme (14 mgd) to existing site and 82 mgd of flow to Site C with low head pumping from existing plant site.
For Alternative 3, can wetlands be utilized as part of treatment if plant located on this site?	No	No	Yes	

Table 8-3
Comparison of Alternatives Using Site Near Wetlands 4 and 1 for New Facilities

	Alternative 1	Alternative 2	Alternative 3	Comments
Description	Upgrade and Improve the existing Columbia Regional WWTP and expand at this site (Scope 2.4a)	Replace existing WWTP at existing site or new treatment plant location. (Scope 2.4b)	Upgrade existing WWTP and construct new WWTP facilities to meet future needs at a new location. (Scope 2.4c)	
Projected Future Flows				
Flow from Perche Creek		7.8		For this comparison, industrial component proportioned to each watershed based on residential / commercial flow to each watershed
Flow from Hinkson Creek		17.4		
Flow from Little Bonne Femme		3.2		
Total Flow		28.4		
Evaluation Criteria				
Receiving waters / NPDES permit	Eagle Bluffs Conservation Area / Existing permit could be modified	Eagle Bluffs Conservation Area / Existing permit could be modified	Eagle Bluffs Conservation Area / Existing permit could be modified	Final evaluation will determine fate of wetlands. However, for this evaluation, continued use of wetlands anticipated.
Required Treatment Capacity, AA mgd	With Existing Wetlands Treatment Included			
Total 2030 flow to treat	28.4	28.4	28.4	Year 2030 projections used
Capacity of existing plant (see comments)	20.6	0.0	20.6	Wetlands treatment units included. The design basis for the wetlands treatment units claims that an additional 8 mgd of flow can be treated by using the wetlands to polish effluent from the mechanical plant. Further assessment is required to determine if this level of treatment can be achieved is required. To cover the range of projected treatment needs, the claimed performance of 20.6 mgd is used.
Future treatment capacity required	7.8	28.4	7.8	
Required Treatment Capacity, AA mgd	Without Wetland Treatment Included			
Total 2030 flow to treat	28.4	28.4	28.4	Year 2030 projections used
Capacity of existing plant	12.6	0.0	12.6	Max Month loading basis.
Future treatment capacity required	15.8	28.4	15.8	
Permit limits of receiving waters	Same	Same	Same	For any of the alternatives, continued use of wetlands treatment or discontinuing use is possible. Thus, each alternative would have comparable effluent limits.
Operational Considerations. Multiple plant operation.	Only One Plant	Only One Plant but would require low head pumping.	Would involve two plant locations	
Offsite impacts.	Development has moved closer to existing plant site.	Would be further away from current development.	Would impact surrounding areas of two sites.	
Implementation Obstacles - Construction issues	Interruption of existing operation likely. Could be minimized with effective construction sequencing	Could be constructed with virtually no interruption of existing facilities operation.	Interruption of existing operation likely but would be less than Alternative 1	
Implementation Obstacles - Infrastructure	Plant road and utilities currently exist. Some road improvements may need to be considered	Roads and utilities to accommodate new facilities would have to be constructed.	Roads and utilities to accommodate new facilities would have to be constructed.	
Maximize Reuse of Existing Facilities.	Best utilization of existing facilities	Would abandon all existing facilities	Would have to pump solids back to existing site to utilize full capacity of the existing digesters	
Land Use and Land Acquisition	Existing site has adequate land for expansion	If remote site selected would require the most land acquisition	Would require land acquisition for the expanded facilities	
Comparison of Planning Level Opinion of Probable Capital Costs (includes Contingencies, Engineering, Legal, or Administrative Costs)				
Additional Treatment required, mgd	15.8	28.4	15.8	Based on continuing wetlands treatment
Rehabilitation of Existing Plant	$37.5	$24.0	$37.5	Preliminary assessment of improvements indicate an opinion of probable project cost in range of $37.5 million (which includes approximately $24 million for biosolids management improvements that would be required for all alternatives). For Alternative 2, only the biosolids improvements would be required.
Cost of expanding treatment capacity	$32.5	$90.8	$41.5	For Alternative 2 projected cost opinion of new facilities presented based on original plant costs escalated to current 2004 $ using ENR's BCI indexing. Alt 1 and 3 cost opinions based on analysis of expanded facilities as presented later in this chapter.
Capital Cost of facilities to treat to higher effluent quality	same	same	same	Costs presented in line above are based on producing effluent quality for the increased treatment capacity to the level currently provided. Higher quality effluent costs would be the same for all three alternatives.
Other Costs to Consider (land acquisition, easements, permitting)	None	Cost of roads, utilities, land acquisition, and conveyance costs associated with a new site	Cost of roads, utilities, land acquisition, and conveyance costs associated with a new site. Would be less than Alt. 2 but much greater than alt. 1.	
Comparison of Opinion of Capital Costs for Treatment and Conveyance (Does not include cost of expanded wet weather facilities that will be same for all alternatives)	$70.0	$114.8	$79.0	Cost for alternatives 2 and 3 do not include the additional cost for pumping raw wastewater or constructing a new deep trunk sewer to convey all wastewater from existing site to new site for treatment. Alternative 3 costs include cost to pump sludge back to digesters at existing plant.
Difference	Base	> $44.8	> $9.0	

The following observations are made from this comparison.

- It appears that at least $35.8 million in construction cost can be saved by upgrading the existing treatment facilities (Alternatives No. 1 and No. 3) instead of discontinuing existing plant use and constructing a new 28.4 mgd treatment plant (Alternative No. 2).
- Alternative 2, by definition would not utilize the existing wetlands for treatment.
- There is adequate land at the existing site for expanding treatment facilities. The cost of land acquisition, utilities, roads, and other infrastructure would not be required.
- Keeping all treatment at one site (either Alternative 1 or 3) would reduce operations and maintenance costs when compared to using two treatment plants (Alternative 2).
- Even if wetlands are included as part of the treatment, flows in excess of the wetlands treatment capacity may require further levels of treatment. The level of treatment required should be established through discussions with MDNR.

Alternative No. 1 is recommended and further evaluation of treatment alternatives should be based on Alternative No. 1 which involves the continued use of the existing mechanical treatment plant and expanding mechanical treatment capacity at the existing site. It should be noted that this preliminary screening of alternatives is not intended to exclude use of the wetlands treatment units. Alternative No. 1 offers the same benefits over the other alternatives whether or not the wetlands are part of the treatment.

8.2 SELECTION OF TREATMENT PROCESSES TO EVALUATE

Alternative treatment technologies were evaluated in a workshop meeting with Columbia staff to meet the future needs. The alternatives ranged from keeping the existing mechanical plant and expanding the wetlands to expanding the mechanical plant and discontinuing wetlands use for treatment. A screening process was used to select three alternatives for further consideration. The following paragraphs present a discussion of wetlands treatment use.

8.2.1 - Continued Use of Existing Wetlands for Treatment Continued use of the existing wetlands for treatment should be considered. To date, the wetlands have provided effective polishing of plant effluent before discharge to the Conservation Area. This has been successful in part because the mechanical plant has been able to produce an effluent that the wetlands can effectively treat. The wetlands also can be used to handle and temporarily store wet weather flows for discharge to the conservation area. Peak flow rates to the plant are expected to approach 143 mgd with peak day flow rates of 60 mgd. To cover the range of possible treatment scenarios, abandoning wetlands was included as one of the alternatives. However, wetlands

treatment has been an effective part of Columbia's treatment process and demonstrates a commitment to seek environmentally friendly solutions for treatment.

8.2.2 - Expanding the Use of Wetlands for Treatment Consideration was given to expanding the wetlands to meet future needs. Using the original wetlands design equations, approximately 210 acres of additional wetlands is required. Based on current wetlands land requirements, land equal to approximately twice the wetlands treatment area is required for the wetlands, their containment berms, bypass channels, and buffer area to meet Year 2030 loading. There are two issues which led this alternative to be discounted from future consideration.

First is the level of wetlands treatment that should be counted on in the future because they must be operated in series. The four wetlands units for Columbia are operated "in series"; which means that all plant effluent passes through one unit before going to the next unit. Plant operating data indicate that to date the wetlands have been loaded to approximately half of the predicted design capacity and have matched the performance predicted by the design equations. However, there is concern that operating these units in series may limit performance as loading rates approach design conditions. The design equations do not appear to account for operating treatment units in series; which would place higher BOD loadings in the first cell of the treatment units than on subsequent cells and could impact the first cell's effectiveness to treat to the level predicted by the design equations. *Continued monitoring of the wetlands performance as loads increase is recommended. If the "design" treatment capacity of the wetlands cannot be achieved, more land would be required than is predicted by the original design equations.*

A second concern is availability of land. Figure 8-5 presents an aerial view that shows approximately 485 acres of property near the Regional plant that is owned by the City. This might be sufficient if the effective treatment capacity is as predicted in the original design equations. Residential development is approaching this area, which could be of concern. Construction of additional wetlands in the Missouri River basin should not be considered. Flooding that occurred in 1993 and again in 1995 caused damage to treatment units 2 and 3, which are located in the Missouri River flood plain. More units in the flood plain would exacerbate this situation. Other areas might be possible if better wetlands sites are identified.

If any additional wetlands are required, additional pumping and piping would be required to send flow through the new units. This was the conclusion of the 1998 study that evaluated sites for wetlands treatment unit No. 4.

Certainly any joint venture with the Conservation Agency to construct more wetlands should be explored. However, the above considerations should be factored into any plans to construct additional wetlands as well as the ability of the Eagle Bluffs Conservation Area to accept more flow from wetlands treatment.

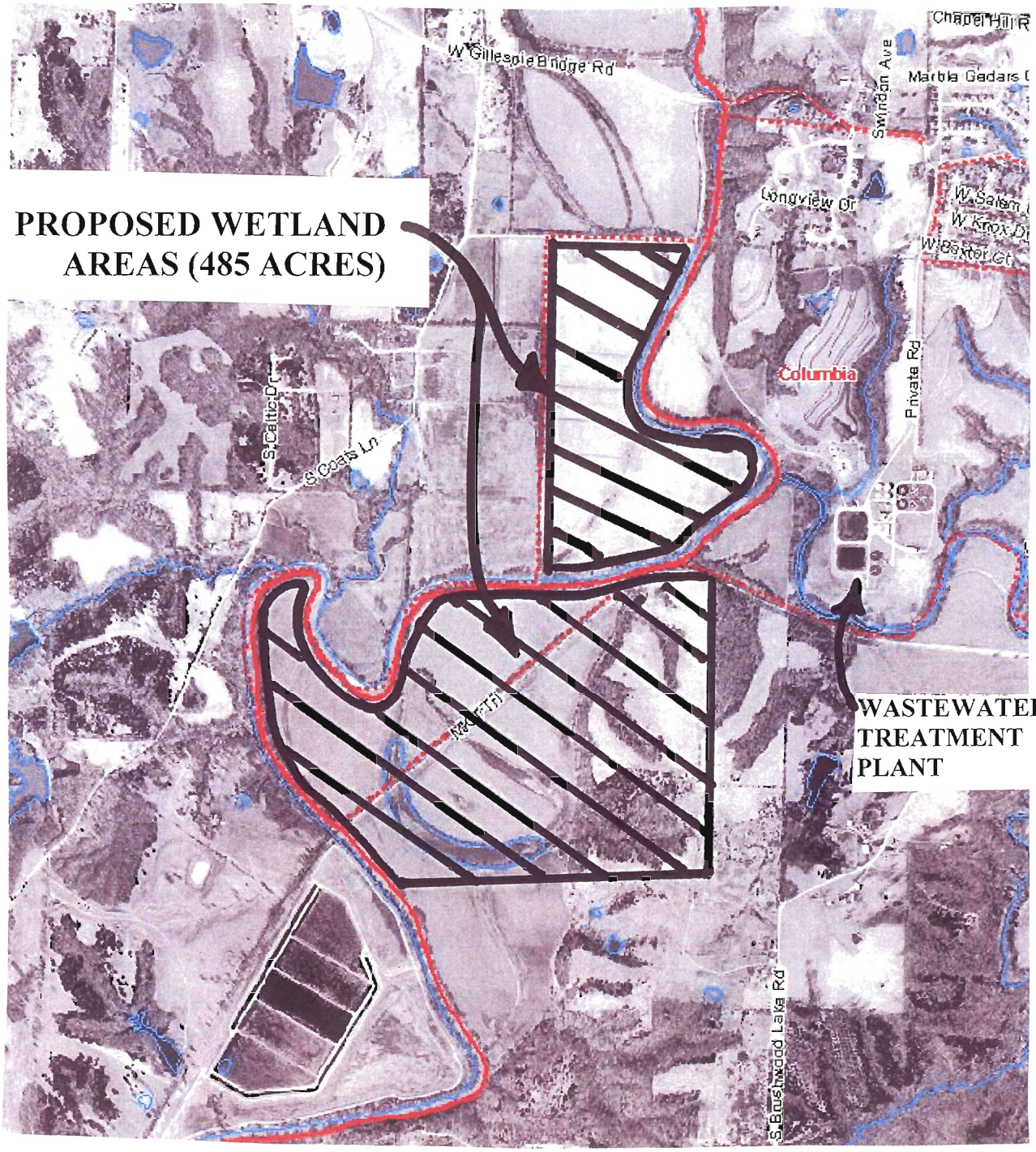


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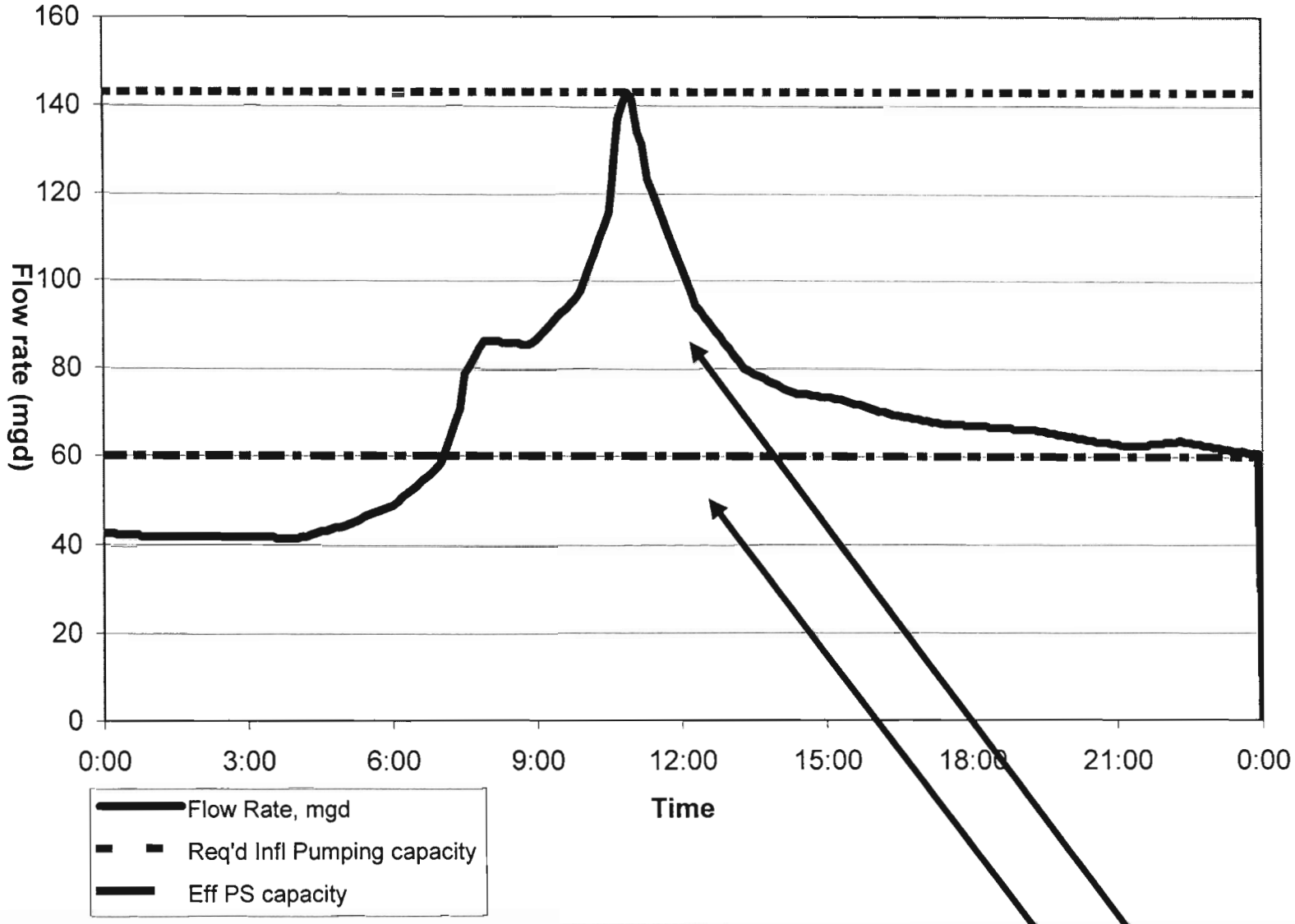
Figure 8-5

Wetlands Area

Prepared by Black & Veatch in assocation with GBA



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Wastewater System Facilities Planning Report

Figure 8-6

Year 2030 Projected Peak Flows @ WWTP

Prepared by Black & Veatch in association with GBA

- Only 60 mgd of plant effluent can flow by gravity through the effluent line from the diversion structure to the wetlands treatment unit.
- The Effluent Pump Station is limited to 60 mgd. This is also maximum flow rate that has been permitted for discharge to the Eagle Bluffs Conservation Area.

The following wet weather improvements are required for any of the three alternatives.

- A new Wet Weather Pump station that can supplement the raw wastewater Pump Station during high flow conditions.
- More wet weather treatment using more I/I clarification to supplement existing I/I clarifiers and the existing I/I lagoon.
- A parallel plant effluent line to convey higher flow rates to wetlands treatment unit No. 4 for temporary storage.

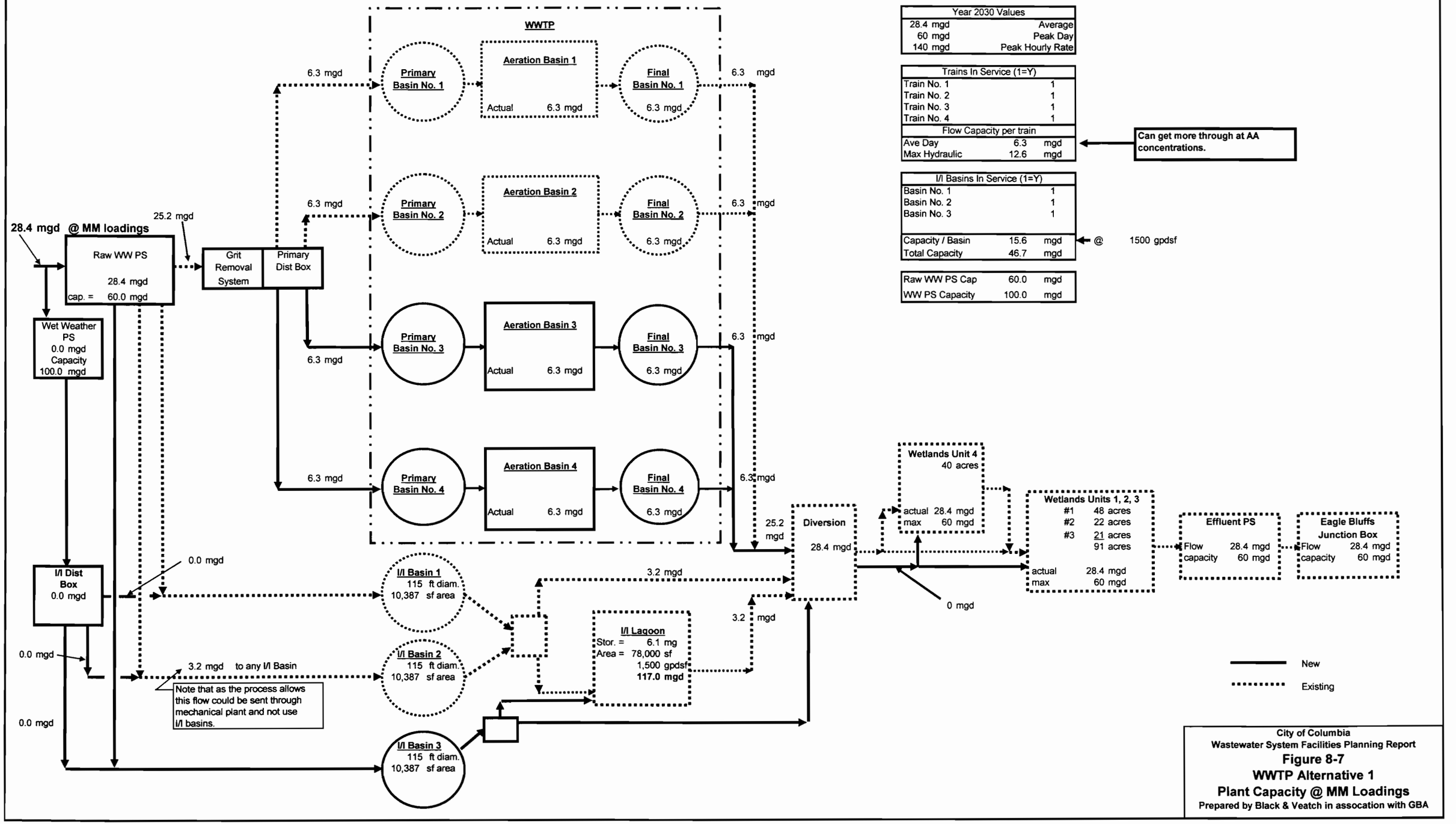
These improvements would be designed to receive, pump, treat, and temporarily store up to the 143 mgd peak flow rates. By using Wetlands Treatment Unit No. 4 for temporary storage, the Effluent Pump Station capacity will not have to be increased nor will the flow rate to the Conservation Area increase above the currently permitted 60 mgd rate.

It should be noted that for planning purposes, the City has elected to use the wetlands as part of the wet weather treatment process. This requires a parallel plant effluent line to the wetlands, which carries a significant capital cost. A lesser cost solution to handle flows in excess of 60 mgd may be possible. However, it would probably involve discharging wet weather flows directly to Perche Creek, which is not as environmentally friendly as using the wetlands; would require a new discharge permit; and would not take advantage of the wetlands for temporary storage or polishing. For this study, the City has opted to take advantage of the wetlands.

It is recommended that staging of the wet weather improvements be considered as part of the preliminary design. Designing to handle Year 2030 peak flow rates will probably not be required initially. Using a design peak flow less than the Year 2030 rate for an initial construction phase could defer construction of the parallel plant effluent line. Additional temporary storage could become available using the existing sludge storage lagoon. If the lagoon is no longer required for sludge storage, as is proposed in the biosolids management program, it could provide temporary storage for some of the wet weather flow. This could result in either deferring the parallel effluent line construction or reducing the size of that line.

8.2 EVALUATION OF ALTERNATIVES

Figures 8-7 through 8-9 present schematics of Alternatives 1, 2, and 3 respectively. Each alternative utilizes the existing wetlands for effluent polishing and uses the mechanical plant and to varying degrees the I/I clarifiers to treat normal flows. Each alternative can accommodate



Year 2030 Values	
28.4 mgd	Average
60 mgd	Peak Day
140 mgd	Peak Hourly Rate

Trains In Service (1=Y)	
Train No. 1	1
Train No. 2	1
Train No. 3	1
Train No. 4	1

Flow Capacity per train		
Ave Day	6.3	mgd
Max Hydraulic	12.6	mgd

Can get more through at AA concentrations.

I/I Basins In Service (1=Y)		
Basin No. 1	1	
Basin No. 2	1	
Basin No. 3	1	
Capacity / Basin	15.6	mgd
Total Capacity	46.7	mgd

@ 1500 gpdsf

Raw WW PS Cap	60.0	mgd
WW PS Capacity	100.0	mgd

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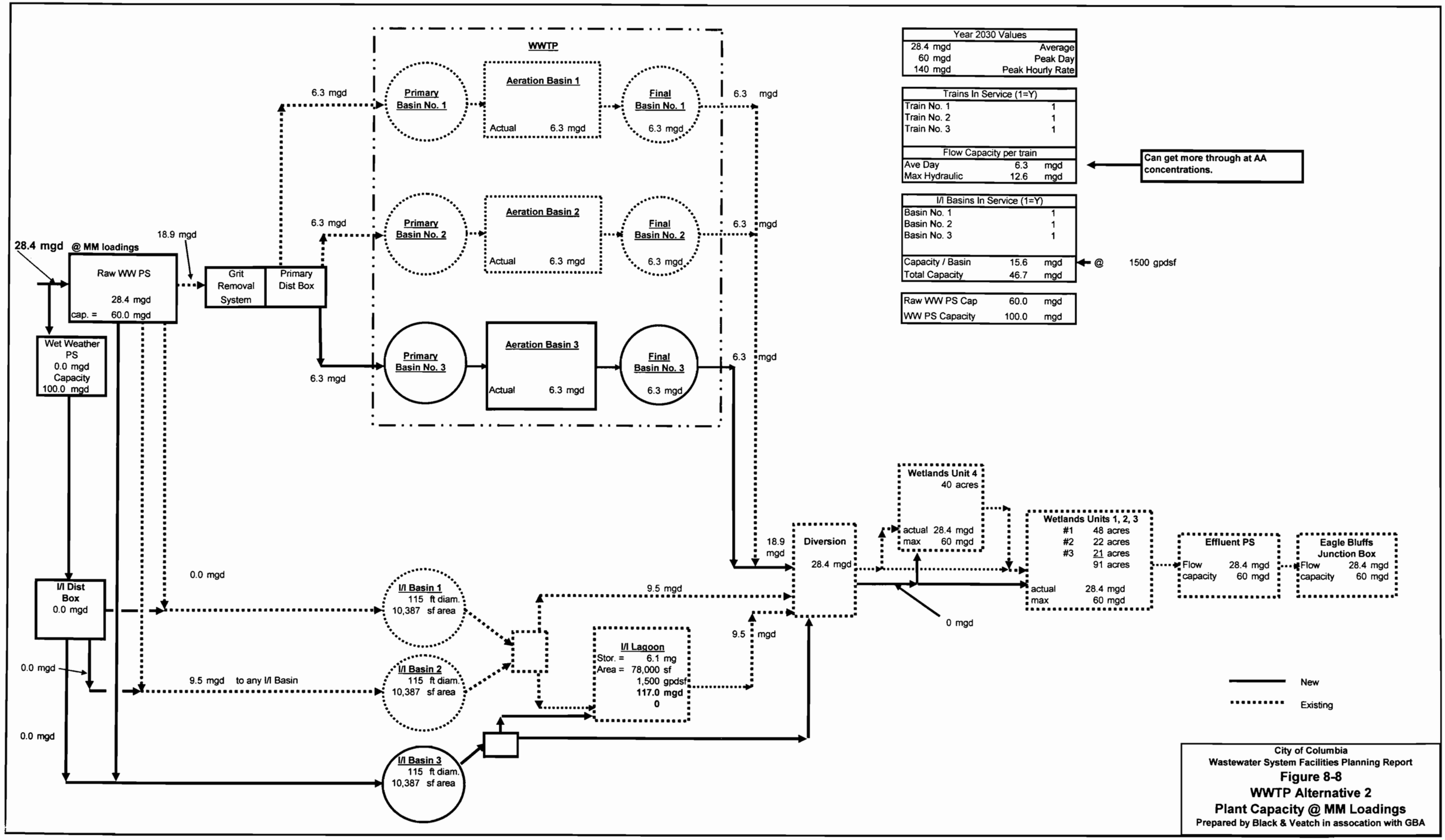
Figure 8-7
WWTP Alternative 1
Plant Capacity @ MM Loadings
Prepared by Black & Veatch in assocation with GBA



Year 2030 Values	
28.4 mgd	Average
60 mgd	Peak Day
140 mgd	Peak Hourly Rate

Trains In Service (1=Y)	
Train No. 1	1
Train No. 2	1
Train No. 3	1

Flow Capacity per train		
Ave Day	6.3	mgd
Max Hydraulic	12.6	mgd

← Can get more through at AA concentrations.

I/I Basins In Service (1=Y)		
Basin No. 1		1
Basin No. 2		1
Basin No. 3		1
Capacity / Basin	15.6	mgd
Total Capacity	46.7	mgd

← @ 1500 gpdsf

Raw WW PS Cap	60.0	mgd
WW PS Capacity	100.0	mgd

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Figure 8-8
WWTP Alternative 2
Plant Capacity @ MM Loadings

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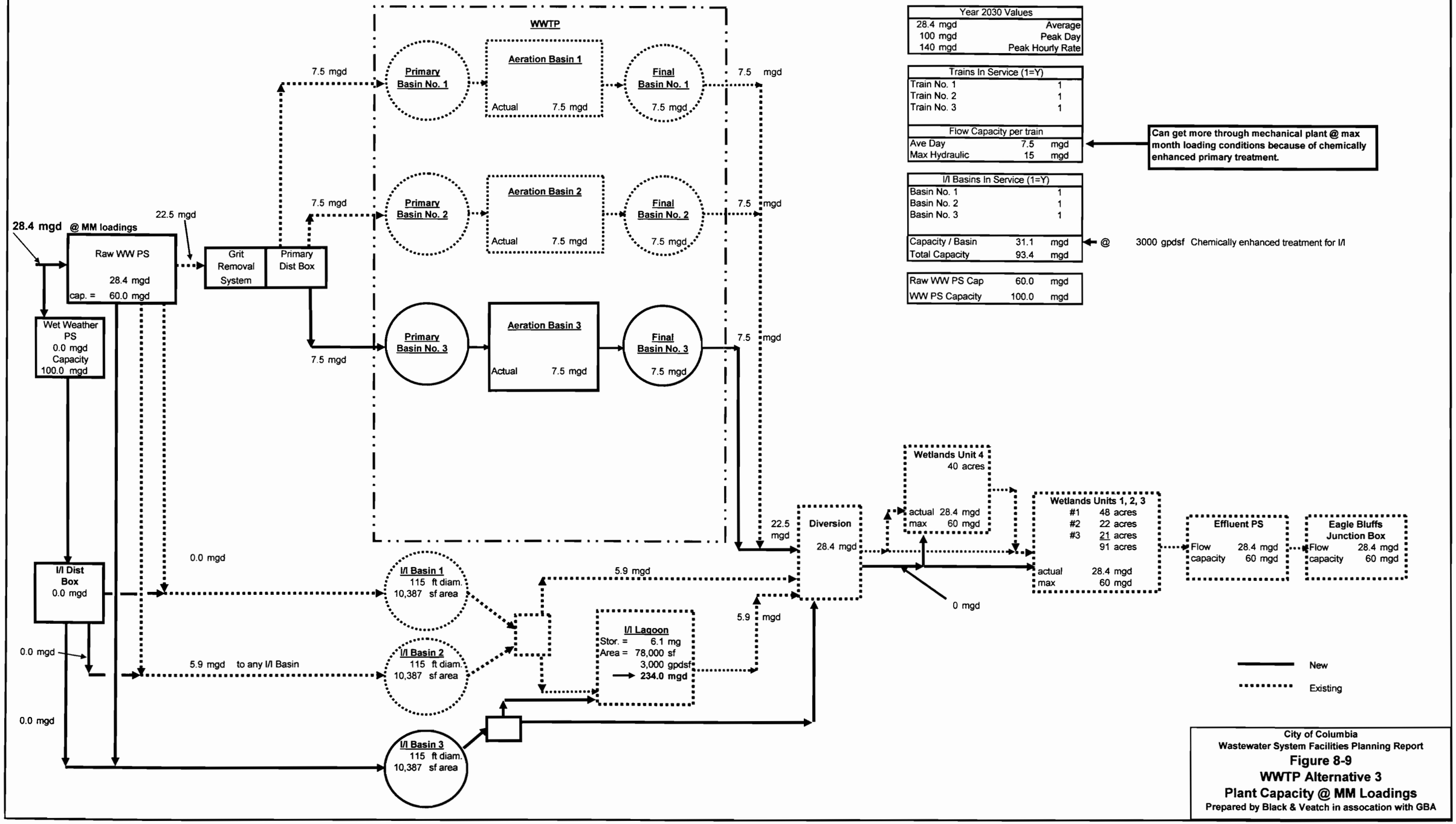

Year 2030 Values	
28.4 mgd	Average
100 mgd	Peak Day
140 mgd	Peak Hourly Rate

Trains In Service (1=Y)	
Train No. 1	1
Train No. 2	1
Train No. 3	1

Flow Capacity per train		
Ave Day	7.5	mgd
Max Hydraulic	15	mgd

Can get more through mechanical plant @ max month loading conditions because of chemically enhanced primary treatment.

I/I Basins In Service (1=Y)		
Basin No. 1	1	
Basin No. 2	1	
Basin No. 3	1	
Capacity / Basin	31.1	mgd
Total Capacity	93.4	mgd

@ 3000 gpdsf Chemically enhanced treatment for I/I

Raw WW PS Cap	60.0	mgd
WW PS Capacity	100.0	mgd

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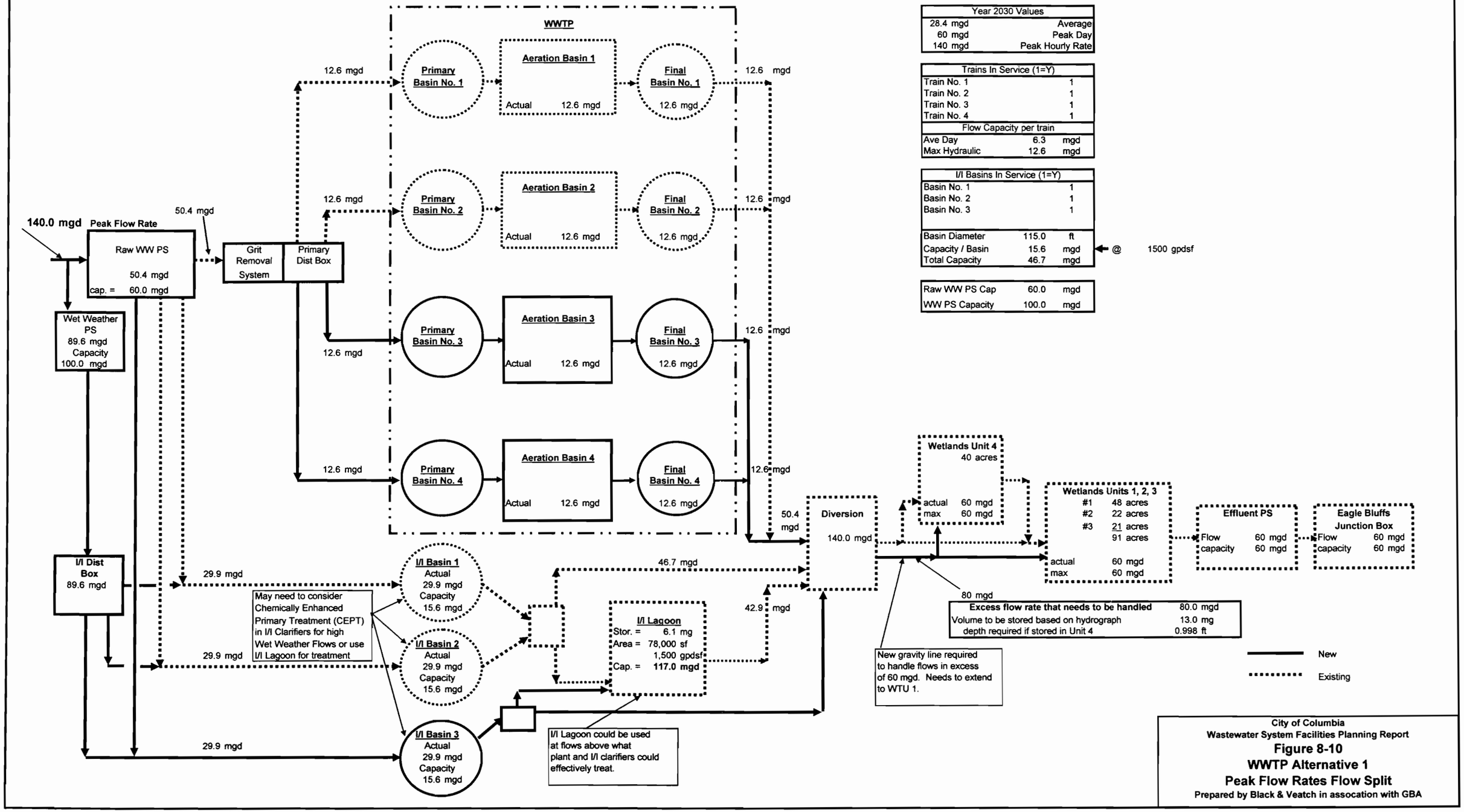
Figure 8-9
WWTP Alternative 3
Plant Capacity @ MM Loadings

Prepared by Black & Veatch in association with GBA

facilities for ammonia and phosphorus removal, with Alternative No. 1 offering the greatest ability to accommodate these improvements. As stated in Chapter 3, it is unclear at this time what disinfection requirements will be placed on the Regional Plant and if they will apply to plant effluent before entering the wetlands or after the wetlands. The impact of disinfection will apply to each alternative similarly. If required ahead of discharge to the wetlands, up to 143 mgd of disinfection capacity will be required. If disinfection is required after the wetlands, flow through the disinfection process could be regulated by using the storage capacity of the wetlands and facilities to handle 60 mgd (the effluent pumping station capacity) could be used.

Figures 8-10 through 8-12 present schematics indicating how wet weather flow would be routed through the mechanical plant and the I/I treatment system for each alternative. Sizing of these facilities are based on handling the peak flow rates predicted for Year 2030. In conceptual design, consideration should be given to collection system storage capacity which would reduce the peak flow rates coming to the plant.

Table 8-4 provides a comparison of each alternative, budget level cost opinions for capital cost and initial year operations and maintenance costs and twenty year present worth of each alternative.



Year 2030 Values	
28.4 mgd	Average
60 mgd	Peak Day
140 mgd	Peak Hourly Rate

Trains In Service (1=Y)	
Train No. 1	1
Train No. 2	1
Train No. 3	1
Train No. 4	1

Flow Capacity per train		
Ave Day	6.3	mgd
Max Hydraulic	12.6	mgd

I/I Basins In Service (1=Y)			
Basin No. 1		1	
Basin No. 2		1	
Basin No. 3		1	
Basin Diameter	115.0	ft	
Capacity / Basin	15.6	mgd	@ 1500 gpdsf
Total Capacity	46.7	mgd	

Raw WW PS Cap	60.0	mgd
WW PS Capacity	100.0	mgd

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Figure 8-10

WWTP Alternative 1

Peak Flow Rates Flow Split

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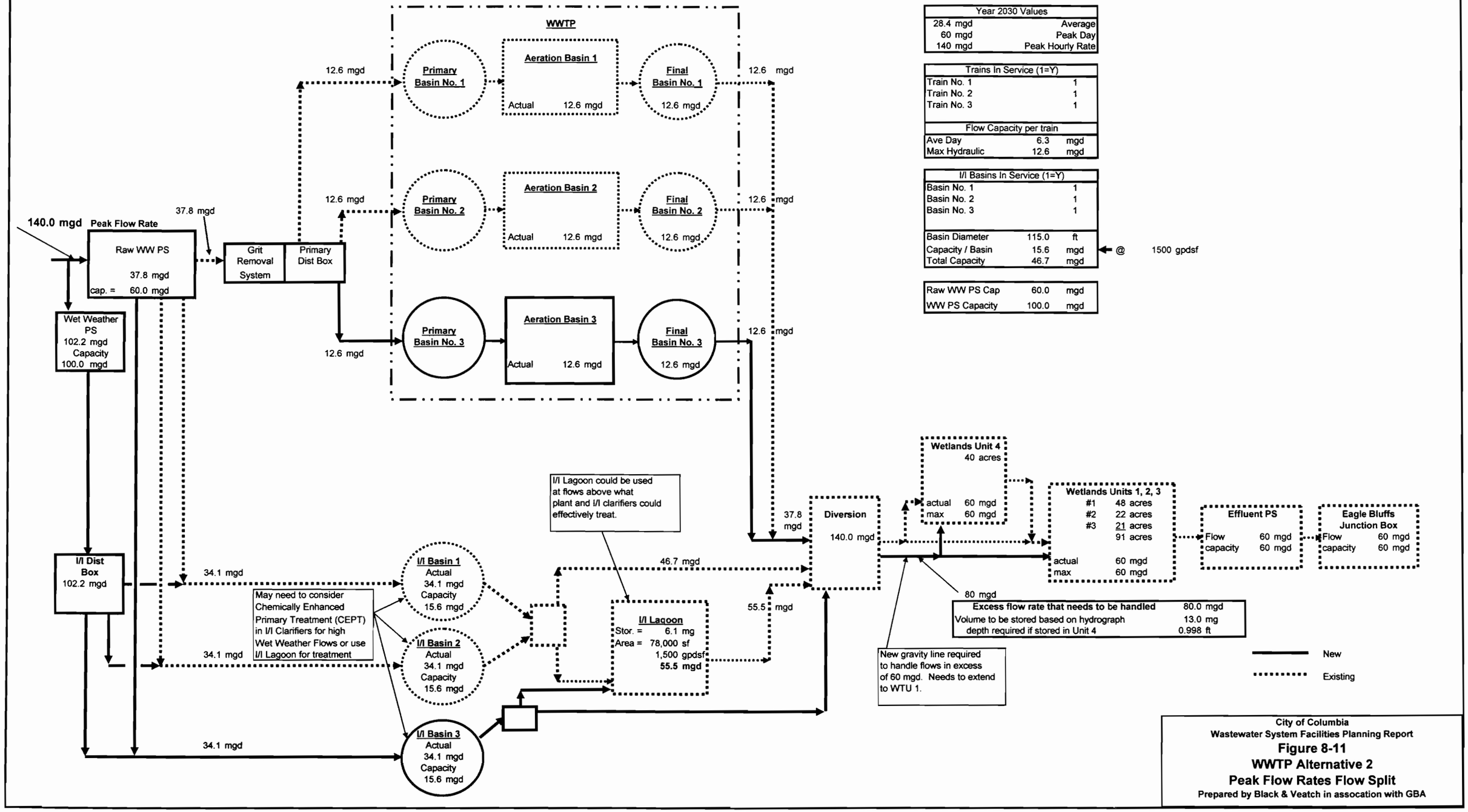

Year 2030 Values	
28.4 mgd	Average
60 mgd	Peak Day
140 mgd	Peak Hourly Rate

Trains In Service (1=Y)	
Train No. 1	1
Train No. 2	1
Train No. 3	1

Flow Capacity per train		
Ave Day	6.3	mgd
Max Hydraulic	12.6	mgd

I/I Basins In Service (1=Y)			
Basin No. 1		1	
Basin No. 2		1	
Basin No. 3		1	
Basin Diameter	115.0	ft	
Capacity / Basin	15.6	mgd	← @ 1500 gpdsf
Total Capacity	46.7	mgd	

Raw WW PS Cap	60.0	mgd
WW PS Capacity	100.0	mgd

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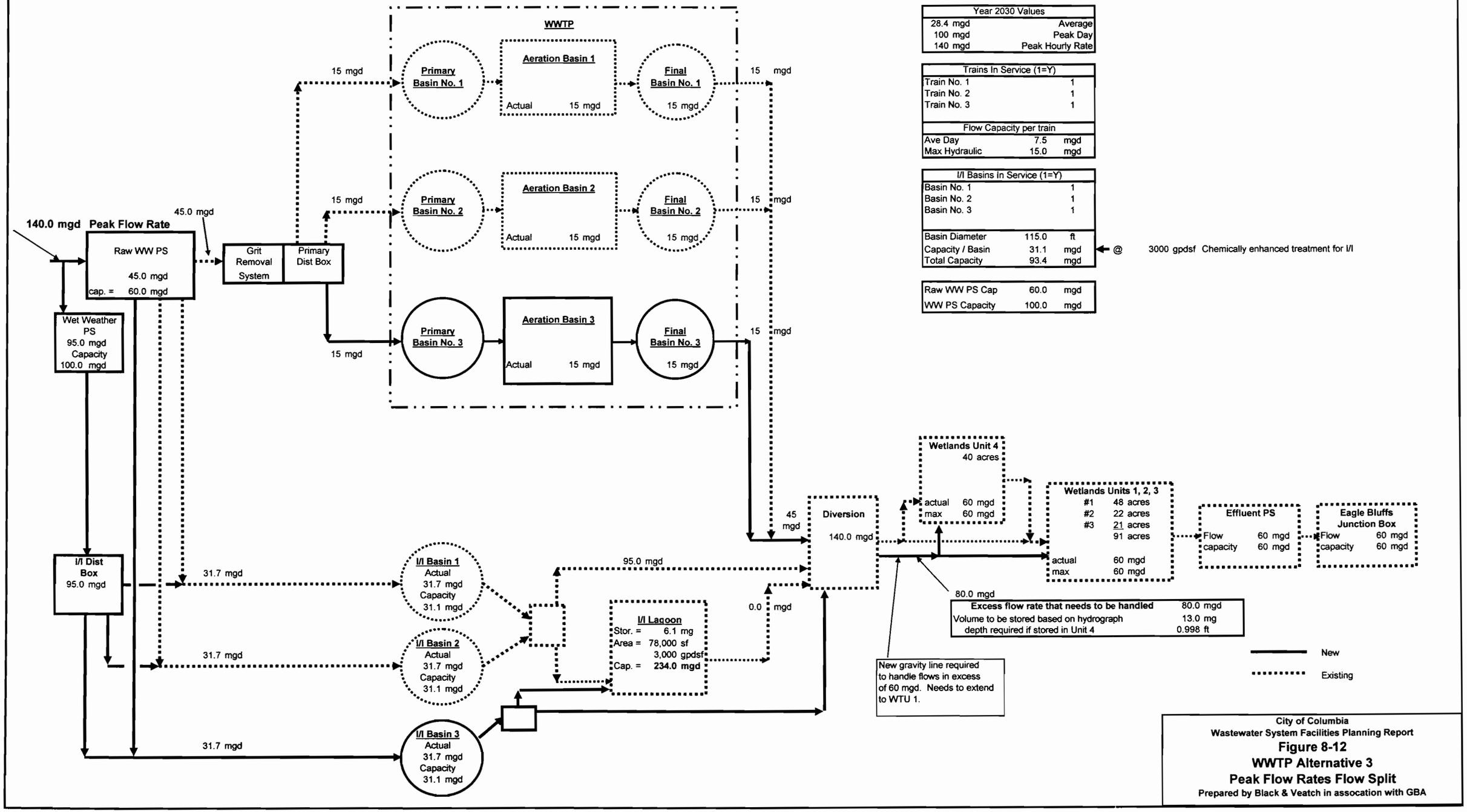
Figure 8-11

WWTP Alternative 2

Peak Flow Rates Flow Split

Prepared by Black & Veatch in assocation with GBA



Year 2030 Values	
28.4 mgd	Average
100 mgd	Peak Day
140 mgd	Peak Hourly Rate

Trains In Service (1=Y)	
Train No. 1	1
Train No. 2	1
Train No. 3	1

Flow Capacity per train		
Ave Day	7.5	mgd
Max Hydraulic	15.0	mgd

I/I Basins In Service (1=Y)		
Basin No. 1		1
Basin No. 2		1
Basin No. 3		1
Basin Diameter	115.0	ft
Capacity / Basin	31.1	mgd
Total Capacity	93.4	mgd

← @ 3000 gpdsf Chemically enhanced treatment for I/I

Raw WW PS Cap	60.0	mgd
WW PS Capacity	100.0	mgd

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Figure 8-12
WWTP Alternative 3
Peak Flow Rates Flow Split

Prepared by Black & Veatch in assocation with GBA

Table 8-4

Comparison of Treatment Alternatives for Columbia

		1	2	3
Description		Expand conventional activated sludge process in kind, continue wetlands use.	Add one 6.3 mgd train and use I&I clarifiers for normal flow; continue wetlands use.	Add one 6.3 mgd train and use Chemically Enhanced Primary Treatment. Continue wetlands use.
Improvements		Add two 6.3 mgd parallel trains to achieve a mechanical treatment capacity of ~25 mgd followed by wetlands polishing	Add one parallel train with 6.3 mgd capacity (same as existing) to achieve 18.9 mgd through mechanical plant. Treat remaining flow through I&I clarifiers. Send combined effluent to wetlands	One new train similar to Alt. 2 plus adding chemical addition to primary clarifiers to remove more solids to increase capacity of activated sludge process.
Capacity to be provided, Year 2030, mgd		28.4	28.4	28.4
Capacity of plant at AA loadings, mgd		~34.0	28.0	33.0
Capacity of plant at MM loadings, mgd		30.7	24.4	29.5
Advantages		Continued use of effective treatment system and wetlands use. Staff familiarity with operating this type of system. Proven technology. Can be modified for Bio P and total nitrogen control.	Could construct less mechanical plant by using I&I clarifiers for solids removal of a wastewater in excess of what the activated sludge plant can effectively handle.	Chemical additional provides phosphorus removal. Enhances BOD and TSS removal across primaries. Chemical can be used for odor control.
Concerns		Requires larger footprint for expansion than Alt. 2 or 3.	Puts greater reliance on wetlands for compliance with permit.	Chemical handling. Increased sludge production. Greater reliance on wetlands for compliance than for Alt 1 but less than Alt 2.
Flexibility to provide facilities for nitrification/denitrification and phosphorus removal?		Easily upgrade for total nitrogen removal by constructing anoxic zones with recycle.	Not as accommodating as Alt 1. Can Upgrade mechanical plant same as Alt 1 but may need to add treatment to handle flows sent to I/I clarifier. Concern about H_2S odor from I/I Clarifier	Generally the same issues as for Alternative 2, except odor is less of an issue if iron salt used for primary settling and to control H_2S
Wetlands included as part of treatment?		Yes	Yes	Yes
Send effluent to Eagle Bluffs?		Yes	Yes	Yes
Odor Control		Odor Control Improvements as suggested in Chapter 6.	Similar Improvements to Alt. 1. If using I/I clarifiers regularly greater odor potential as compared to Alt 1 & 3.	Similar to Alt. 1. If iron salts used, can apply doses to reduce sulfide levels in liquid processes.
Disinfection		Same [1]	Same [1]	Same [1]
Budget Level Cost Opinions				
Capital Costs	Year Built [2]			
Repair and Rehab Existing Facilities	Note 3	$13,500,000	$13,500,000	$13,500,000
Biosolids - Centrifuges	2005	$2,200,000	$2,200,000	$2,200,000
Biosolids - Dewatering Building	2015	$7,700,000	$7,700,000	$7,700,000
Biosolids - Heat Drying	2020	$14,100,000	$14,100,000	$14,100,000
Capital Cost for Wet Weather Improvements	Note 4	$29,000,000	$29,000,000	$29,000,000
Capital Cost for Expansion of Facilities	2015	$25,600,000	$28,800,000	$30,200,000
Capital Cost for 2nd 6.3 mgd train for Alt. 1	2022	$6,900,000	$0	$0
Total Project Costs [5]		$99,000,000	$95,300,000	$96,700,000
O&M Costs (In Initial Year 2008)[6]		$7,600,000	$7,600,000	$7,600,000
PW Costs, nearest $ MIL[7]		$194,000,000	$190,000,000	$191,000,000

Notes:

1 Disinfection improvements, if required by MDNR in future, will apply to each alternative similarly. If disinfection occurs before wetlands polishing must treat peak flow rates up to 143 mgd with a projected capital cost of ~$11,000 / mgd. If disinfection occurs after wetlands treatment must treat up to 60 mgd flow rates with a projected capital cost of ~$145,000/mgd.

2 Dates shown for Year Built established based on discussions with City staff for use in PW analysis. Actual dates will depend on actual growth and needs.

3 Repair and rehabilitation should begin as funds become available. Based on City direction, budgeting for R&R improvements will begin in 2010 and be spread over a ten year period.

4 Consider building in two phases one by 2015 and one by 2025

5 Does not include costs for ammonia or phosphorus removal nor disinfection.

6 O&M Costs are based on O&M costs for current plant operation plus prorated costs for expanded facilities in 2008. Initial year O&M will be same as all three alternatives start with same facilities improvements.

7 Present Worth based on 20 year period and 5.5% interest rate. (A lower interest rate may be achieved through SRF Loan)

8.4 - OBSERVATIONS AND RECOMMENDED PROGRAM FOR IMPLEMENTATION.

Observations. The following observations can be made:

- Expanding the existing mechanical plant capacity is required to meet future flows.
- Continued use of existing wetlands is recommended. The additional treatment capacity identified with wetlands polishing for each alternative is based on design equations used for original sizing of wetlands. The existing wetlands have not been loaded to this level and concerns exist whether loading the wetlands to this level, especially when the treatment units must be operated in series;
- Expanding the existing mechanical plant capacity is required before major existing liquid treatment units can be removed from service for rehabilitation.
- The cost to rehabilitate existing facilities, as presented in Chapter 6 and Table 8-4, will be the same for each alternative.
- The solids handling improvements capital costs and O&M costs, as presented in Chapter 6 and Table 8-4, will be the same for each alternative.
- Alternative 1 has the greatest dependence on mechanical treatment for normal flows. This provides the greatest assurance of compliance with permit requirements.
- Alternative 1 improvements can be phased to match growth in the community. One train can be constructed now and a second in the future.
- Alternative 2 places the greatest reliance on wetlands for treatment to meet permit limits. Using the I/I clarifiers for treatment of the plant influent in excess of what the mechanical plant can effectively treat may be the cause of odors that have been detected at the influent channel to the Wetlands Unit No. 4.
- Alternative 3 uses chemically enhanced primary settling to decrease the loads to the secondary plant thus increases treatment capacity of existing mechanical plant. Still places a high reliance on wetlands for treatment to meet permit. Chemical addition can also reduce the level of sulfides in the I/I clarifier effluent which could be the cause of odors that have been observed at the influent channel to Wetlands Unit No. 4.
- By phasing construction of Alternative 1, the initial year capital costs and initial year O&M costs will be essentially the same as for Alternatives 2 and 3.
- By adding one mechanical train, the mechanical plant has sufficient capacity to handle Year 2015 projected flows. Plant staff could also operate the plant as proposed for Alternatives No. 2 and 3 to determine their effectiveness to treat flows

beyond Year 2015 without the addition of a fourth train. Should either alternative prove to be effective, the need for a fourth train could be deferred to beyond Year 2030.

Recommended Implementation Program. It is recommended that the following treatment plant improvements program be implemented. Table 8-4 presents a proposed time line for these capital improvements. Timing of these improvements depend on growth, wetlands and plant performance, useful life of the existing facilities, and the funding capability of the City. A financial analysis is presented in Chapter 9 to address implementation of collection system and treatment plant improvements.

- Install thickening centrifuges as planned to improve solids removal from the mechanical plant.
- Implement a program to assess performance of chemically enhanced primary treatment (CEPT) with existing facilities. Increased solids removal in the primary basins and I/I basins will not eliminate the need for an additional mechanical plant treatment train. However, if effective, the loadings to the wetlands will be reduced, extending the life and capacity of both the treatment plant and the wetlands. Using iron salts prior to the I/I Clarifiers will also help reduce concentrations of sulfides in the I/I clarifier effluent.
- Perform the recommended rehabilitation improvements outlined in Chapter 6. Priority should be given to odor control improvements at the plant. Expanding the existing mechanical plant capacity is required to before some of major existing liquid treatment units can be removed from service for rehabilitation.
- Add one 6.3 mgd mechanical train to increase the mechanical treatment plant capacity to 18.9 mgd.
- Implement wet weather improvements to handle higher flows. This program can be phased based on peak wet weather flows established for interim periods prior to 2030.
- Implement a program to assess the performance of wetlands at flows and loadings that approach the values used in sizing the wetlands. Effluent quality and impact to surrounding environment should be assessed. While this could be implemented before the additional mechanical train is on line, it is recommended that this be done after the train is on line. Should stressing the wetlands result in unfavorable results, the third train would provide adequate capacity to handle the incoming flow.
- Implement the first phase of solids handling improvements, which is to add biosolids dewatering technology. These improvements could be implemented with or

independent of construction of the first train of plant expansion or the rehabilitation improvements.

- Implement the second phase of solids handling improvements, which is to add heat drying of biosolids.
- Add a second 6.3 mgd train should it be determined that the second train is required.

CHAPTER 9.0

FINANCIAL ANALYSIS

9.1 INTRODUCTION

This chapter presents an analysis of the estimated impact that financing the proposed improvements outlined in Chapters 6, 7 and 8 will have on the City's Sewer Utility's required revenue adjustments. The findings are presented in the form of projected cash flow statements, which indicate the timing and magnitude of future revenue adjustments. Four funding scenarios are presented, utilizing combinations of increases in sewer sales revenues and increases in sewer connection fees. These alternatives are presented as guidelines to the City for financial planning purposes. Recognizing that actual revenues and expenses may vary from those projected in this study because of changes in customer growth, water usage patterns, weather, economic conditions and other factors, the sewer financing plan should be reviewed on a regular basis. Alternative methods of recovering capital costs are also discussed.

9.2 GENERAL

For this analysis, the period has been defined as beginning October 1, 2003 and ending September 30, 2030. Unless otherwise noted, references in this report to a specific year are for the City's year ending September 30. Fiscal year 2004 revenues and revenue requirements are based on the Sewer Utility's approved budget. Revenues and revenue requirements were projected for the remaining years of the study based on a review of historical factors, and the Utility's operating budget, and the improvements proposed in Chapters 6, 7 and 8 of this report.

9.3 WASTEWATER UTILITY REVENUE

The principal source of revenue for the wastewater utility to meet annual revenue requirements is from charges for service to wastewater customers. Additional revenue is derived from interest income and other miscellaneous sources.

9.3.1 Wastewater Customer Growth. Table 9-1 presents a summary of the projected average number of wastewater customers. In FY 2003 the City provided wastewater service to 35,669 residential and commercial customers. As shown in Table 9-1, growth in the number of residential and commercial customers is conservatively estimated to increase by two percent per year.

9.3.2 Wastewater Volumes. Table 9-2 shows the projected billed wastewater volumes. Projected quantities are based on an analysis of billed volume per customer. Billed volume per customer is presumed to remain constant through the study period. Therefore, any increase in projected billed volumes is related to the projected increase in the number of customers.

9.3.3 Wastewater Revenue Under Existing Rates. A summary of projected wastewater revenue under existing rates is presented in Table 9-3. Projected revenue is estimated by applying service and volume charges for FY 2004 to the projected number of bills and projected volumes, respectively. Projected revenue increases in relation to the projected increase in the number of customers.

9.3.4 Other Wastewater Revenue. Sewer connection fees under the existing rates are projected to increase in relation to the growth in the number of customers. Other sources of wastewater revenue include sharecropping, BCRSD (Boone County Regional Sewer District) wholesale, interest income, and miscellaneous revenues.

9.4 WASTEWATER UTILITY REVENUE REQUIREMENTS

The revenue required to adequately provide for the continued operation of the wastewater utility must be sufficient to meet the revenue requirements for system operation. Revenue requirements include operation and maintenance expenses, expenditures for capital improvements met directly from revenues, principal and interest on outstanding debt, and provision for an adequate working capital reserve.

9.4.1 Wastewater Operation and Maintenance Expense. Operation and maintenance expense includes the annual costs associated with personnel services, supplies and materials, travel and training, intergovernmental charges, and utilities and services. Because these costs are an ongoing annual obligation of the utility, they are met from operating revenue as they are incurred.

A summary of total projected operation and maintenance expense is shown in Table 9-4. Operation and maintenance expense projections are based on budgeted amounts for FY 2004, with allowances for inflationary increases of 2.0 percent per year in accordance with utility staff direction. Additional increases in operating costs are anticipated when treatment plant rehabilitation and expansion is completed in 2015, and when an additional plant expansion is completed in 2021.

9.5 WASTEWATER UTILITY DEBT SERVICE REQUIREMENTS

Debt service on currently outstanding bonds consists of the principal and interest payments on the following issues:

1979 Sanitary Sewer Revenue Bonds (8/1/79)
1992 Sanitary Sewer Bonds Series B (6/1/92)
1999 Sanitary Sewer Bonds Series A (6/1/99)
1999 Sanitary Sewer Bonds Series B (12/1/99)
2000 Sanitary Sewer Bonds Series A (5/1/00)
2001 Sewer Special Obligation Bonds (11/13/01)
2002 Sanitary Sewer Bonds Series A (5/1/02)
2002 Sanitary Sewer Refunding Bonds (9/15/02)
2003 Sanitary Sewer Bond Series A (4/1/03)
2004 Sanitary Sewer Bond Series B (5/28/04)

At the beginning of FY 2004, outstanding principal on the above bond issues totaled $24,210,000. Annual principal and interest payments associated with these bond issues must be included in the determination of revenue requirements.

9.5.1 Wastewater Utility Major Capital Improvements. In conjunction with the Wastewater Master Plan, a multi-year major capital improvement program has been developed. The proposed capital improvements, summarized in Table 9-5, include repair and rehabilitation of the wastewater treatment plant, rehabilitation of thickening centrifuges, biosolids dewatering, biosolids heat drying, expansion of the wastewater treatment plant, and collection system improvements.

9.5.2 Capital Improvements Financing Plan. The major capital improvements financing plans are presented in Table 9-6 for funding scenarios A, B, C & D. These various capital financing plans have been developed to support the four scenarios described in Section 9.6 *Alternative Funding Scenarios*. Additional bond issues will be required to fund the major capital improvement program developed in this Master Plan.

Funds on hand at the beginning of the year are shown on Line 1. Capital improvements to be financed are shown on Line 2. For this analysis, these capital improvements are funded from State Revolving Loan Funds (SRF) (Line 3) and cash financing (Line 4) from annual revenues. Bond issuance expense and surety bond expense in lieu of a cash funded debt service reserve are shown on Line 5 and Line 6, respectively.

9.6 ALTERNATIVE FUNDING SCENARIOS

Total revenue requirements of the wastewater utility consist of operation and maintenance expense, debt service requirements, annual routine capital outlays, and system earnings utilized to finance major capital improvements. Revenue levels must also be sufficient to meet the existing revenue bond covenant that net earnings in each fiscal year shall not be less than 110 percent of the debt service requirement. It is also important that sufficient cash balances be maintained to offset fluctuations in revenues and expenditures, and provide for funds for use in emergencies. Charges for wastewater service provide the principal source of revenues to meet these requirements with additional revenue being derived from miscellaneous operating and non-operating income and from interest earnings.

For each funding scenario, increases in sewer sales revenues through FY 2007 are limited to the following increases, which have been approved by the City: 4 percent in FY 2005; 4 percent in FY 2006; and 3 percent in FY 2007.

Four funding alternatives are presented in Tables 9-7A, B, C and D.

- Scenario A assumes projected revenue requirements are funded solely from increases in annual sewer service sales revenues. The magnitude of the annual revenue increases is dictated by the bond covenant requirement that net revenues be at least 110 percent of debt service requirement. Because no other funding source is considered in this scenario, it represents the "worst case" in terms of the magnitude of future sewer rate increases, resulting in cumulative revenue increases of 160.9 percent for the period FY 2008 through FY 2030.

- Scenario B also increases sewer rates and evaluates the impact of increasing connection fees as well. This scenario assumes sewer connection fees are increased 50 percent in FY 2009 and an additional 50 percent in FY 2012 to mitigate required future increases in sewer sales revenues. Increases in sewer service sales revenues are assumed to generate the balance of the revenues required to support the projected revenue requirements. This scenario results in cumulative revenue increases of 145.7 percent for the period FY 2008 through FY 2030.

- Scenario C evaluates the impact of scheduling higher revenue increases earlier in the study period to take advantage of the compounding effect on the higher revenues. For comparison with Scenario A, no increases in connection fees are assumed, other than those increases related to growth in the number of customers. This scenario results in cumulative revenue increases of 155.1 percent for the period FY 2008 through FY 2030.

Each of these scenarios indicates that double-digit sewer service sales revenue increases are required for a two or three year period to meet projected revenue requirements. Such increases are higher than those historically implemented by the City, and are not desirable. Scenario D was developed to eliminate these double-digit revenue increases by utilizing additional increases in connection fees.

- Scenario D assumes connection fees are increased 25 percent in FY 2007, FY 2009 and FY 2011, with an additional 50 percent increase in FY 2013. This scenario results in cumulative revenue increases of 140.2 percent for the period FY 2008 through FY 2030. The maximum annual increase in sewer service sales revenues under this scenario is 8 percent during the period FY 2011 through FY 2014. It is noted that the assumed increases in connection fees will result in a fee of approximately $1,170 in 2013, which is less than the current average connection fee for a residential customer in 30 other cities surveyed (see following section).

Based on this analysis, it is recommended the City utilize Scenario D for planning purposes. Recognizing the significant requirements of the proposed capital improvement program, the annual revenue increases indicated in Scenario D appear reasonable.

Recognizing that actual customer growth, inflationary rates, project demands, and priorities will likely vary from the criteria used in this analysis, it is recommended that the City annually review and adjust these criteria as they refine their financing plan. A comprehensive sewer rate study should be considered to ensure that future sewer rate increases are applied equitably among customer classes, and a connection fee study should be conducted to determine the amount of fee that can be supported based on system investment.

9.7 CONNECTION FEE SENSITIVITY ANALYSIS

A connection fee sensitivity analysis was conducted to provide the City of Columbia an indication of how much revenue could be generated by increasing connection fees. The City assesses a connection fee for new connections to the sewer system. The sewer connection fee for a customer with a ¾ inch water meter is currently $400, and increases as the size of the water meter increases. A survey of sewer connection fees conducted by City of Columbia staff in mid-2003 found that fees for residential customers in 14 other cities ranged from $300 to $4,375, with an average of $1,377. Residential sewer connection fees in 16 additional cities were compiled by Black & Veatch for this report, and found to range from $200 to $3,743, with an

average of $1,411. The 16 cities in the Black & Veatch survey had a population range of 22,746 to 144,053 (2000 Census), with an average population of 58,851, compared with a 2000 census population of 69,101 for Columbia.

Of the 30 cities in the two surveys, 26 charge residential customers a connection fee that is greater than $400. Based on comparison with other cities, the $400 connection fee charged by the City of Columbia is low. It is recommended that the City conduct a connection fee study to determine the magnitude of connection fee that can be supported by the investment in sewer system facilities. The American Water Works Association Manual M1, Principles of Water Rates, Fees, and Charges, describes alternative methodologies for determination of supportable connection fees. The methodologies are applicable to sewer utilities as well as water utilities.

Table 9-8 illustrates the impact of increasing revenues from connection fees. Annual principal and interest payments on $1,000,000 debt at three percent interest for 20 years amounts to approximately $67,200. Bond covenants require that net revenues be at least 110 percent of principal and interest payments. Net revenues must therefore increase approximately $73,900 for each $1,000,000 of outstanding debt. Revenues under the current schedule of connection fees are projected to be $625,000 in FY 2005. For each ten percent increase in connection fee revenues, approximately $846,000 in additional debt can be supported. Connection fee (system development charges) philosophy and methodology is discussed in Section 9.11 of this chapter.

Table 9-1
Projected Accounts

Line	Classification	ACTUAL FY 2003	(1) FY 2004	(2) FY 2005	(3) FY 2006	(4) FY 2007	(5) FY 2008	(6) FY 2009	(7) FY 2010	(8) FY 2011	(9) FY 2012	(10) FY 2013	(11) FY 2014	(12) FY 2015	(13) FY 2016	(14) FY 2017	(15) FY 2018	(16) FY 2019	(17) FY 2020	(18) FY 2021	(19) FY 2022	(20) FY 2023	(21) FY 2024	(22) FY 2025	(23) FY 2026	(24) FY 2027	(25) FY 2028	(26) FY 2029	(27) FY 2030
		Projected Number of Accounts																											
		(accts)	(accts)	(accts)	(accts)	(accts)	(accts)	(accts)	(accts)	(accts)	(accts)	(accts)	(accts)	(accts)	(accts)	(accts)	(accts)	(accts)	(accts)	(accts)	(accts)	(accts)	(accts)	(accts)	(accts)	(accts)	(accts)	(accts)	(accts)
1	Residential	32,654	33,274	33,906	34,550	35,207	35,876	36,557	37,252	37,960	38,681	39,416	40,165	40,928	41,706	42,498	43,305	44,128	44,967	45,821	46,692	47,579	48,483	49,404	50,343	51,299	52,274	53,267	54,279
2	Commercial	3,016	3,076	3,137	3,200	3,264	3,329	3,396	3,464	3,533	3,604	3,676	3,749	3,824	3,901	3,979	4,058	4,140	4,222	4,307	4,393	4,481	4,570	4,662	4,755	4,850	4,947	5,046	5,147
3	Total	35,669	36,350	37,043	37,750	38,471	39,205	39,953	40,716	41,493	42,285	43,092	43,914	44,752	45,606	46,477	47,364	48,268	49,189	50,128	51,085	52,060	53,053	54,066	55,098	56,149	57,221	58,313	59,426

Table 9-2
Projected Billable Volumes

Line	Classification	ACTUAL FY 2003	(1) FY 2004	(2) FY 2005	(3) FY 2006	(4) FY 2007	(5) FY 2008	(6) FY 2009	(7) FY 2010	(8) FY 2011	(9) FY 2012	(10) FY 2013	(11) FY 2014	(12) FY 2015	(13) FY 2016	(14) FY 2017	(15) FY 2018	(16) FY 2019	(17) FY 2020	(18) FY 2021	(19) FY 2022	(20) FY 2023	(21) FY 2024	(22) FY 2025	(23) FY 2026	(24) FY 2027	(25) FY 2028	(26) FY 2029	(27) FY 2030
		Projected Billed Volume																											
		(100 cf)	(100 cf)	(100 cf)	(100 cf)	(100 cf)	(100 cf)	(100 cf)	(100 cf)	(100 cf)	(100 cf)	(100 cf)	(100 cf)	(100 cf)	(100 cf)	(100 cf)	(100 cf)	(100 cf)	(100 cf)	(100 cf)	(100 cf)	(100 cf)	(100 cf)	(100 cf)	(100 cf)	(100 cf)	(100 cf)	(100 cf)	(100 cf)
1	Residential	2,577,988	2,704,090	2,755,468	2,807,822	2,861,170	2,915,532	2,970,928	3,027,375	3,084,895	3,143,508	3,203,235	3,264,096	3,326,114	3,389,310	3,453,707	3,519,328	3,586,195	3,654,333	3,723,765	3,794,516	3,866,612	3,940,078	4,014,939	4,091,223	4,168,957	4,248,167	4,328,882	4,411,131
2	Commercial	2,239,555	2,361,871	2,409,108	2,457,290	2,506,436	2,556,565	2,607,696	2,659,850	2,713,047	2,767,308	2,822,654	2,879,107	2,936,689	2,995,423	3,055,332	3,116,438	3,178,767	3,242,342	3,307,189	3,373,333	3,440,800	3,509,616	3,579,808	3,651,404	3,724,432	3,798,921	3,874,899	3,952,397
3	Total	4,817,543	5,065,961	5,164,576	5,265,112	5,367,606	5,472,097	5,578,624	5,687,225	5,797,942	5,910,816	6,025,889	6,143,204	6,262,803	6,384,734	6,509,039	6,635,766	6,764,962	6,896,675	7,030,954	7,167,849	7,307,412	7,449,694	7,594,747	7,742,627	7,893,389	8,047,088	8,203,781	8,363,528

Table 9-3
Projected Revenues with Existing Rates

Line	Classification	ACTUAL 2003	(1) FY 2004	(2) FY 2005	(3) FY 2006	(4) FY 2007	(5) FY 2008	(6) FY 2009	(7) FY 2010	(8) FY 2011	(9) FY 2012	(10) FY 2013	(11) FY 2014	(12) FY 2015	(13) FY 2016	(14) FY 2017	(15) FY 2018	(16) FY 2019	(17) FY 2020	(18) FY 2021	(19) FY 2022	(20) FY 2023	(21) FY 2024	(22) FY 2025	(23) FY 2026	(24) FY 2027	(25) FY 2028	(26) FY 2029	(27) FY 2030
		Projected Revenue (With FY 2004 Existing Rates)																											
		($)	($)	($)	($)	($)	($)	($)	($)	($)	($)	($)	($)	($)	($)	($)	($)	($)	($)	($)	($)	($)	($)	($)	($)	($)	($)	($)	($)
1	Residential	3,818,371	4,137,300	4,215,900	4,296,000	4,377,600	4,460,800	4,545,500	4,631,900	4,719,900	4,809,600	4,901,000	4,994,100	5,089,000	5,185,700	5,284,200	5,384,600	5,486,900	5,591,200	5,697,400	5,805,600	5,915,900	6,028,300	6,142,900	6,259,600	6,378,500	6,499,700	6,623,200	6,749,100
2	Commercial	2,133,260	2,344,100	2,391,000	2,438,800	2,487,600	2,537,300	2,588,100	2,639,800	2,692,600	2,746,500	2,801,400	2,857,500	2,914,600	2,972,900	3,032,400	3,093,000	3,154,900	3,218,000	3,282,300	3,348,000	3,414,900	3,483,200	3,552,900	3,623,900	3,696,400	3,770,300	3,845,800	3,922,700
3	Total	5,951,631	6,481,400	6,606,900	6,734,800	6,865,200	6,998,100	7,133,600	7,271,700	7,412,500	7,556,100	7,702,400	7,851,600	8,003,600	8,158,600	8,316,600	8,477,600	8,641,800	8,809,200	8,979,700	9,153,600	9,330,800	9,511,500	9,695,800	9,883,500	10,074,900	10,270,000	10,469,000	10,671,800

Table 9-4

Historical & Projected Operation and Maintenance Expense

Line	Explanation	(1) BUDGET FY 2004 ($)	(2) BUDGET FY 2005 ($)	(3) FY 2006 ($)	(4) FY 2007 ($)	(5) FY 2008 ($)	(6) FY 2009 ($)	(7) FY 2010 ($)	(8) FY 2011 ($)	(9) FY 2012 ($)	(10) FY 2013 ($)	(11) FY 2014 ($)	(12) FY 2015 ($)	(13) FY 2016 ($)	(14) FY 2017 ($)	(15) FY 2018 ($)	(16) FY 2019 ($)	(17) FY 2020 ($)	(18) FY 2021 ($)	(19) FY 2022 ($)	(20) FY 2023 ($)	(21) FY 2024 ($)	(22) FY 2025 ($)	(23) FY 2026 ($)	(24) FY 2027 ($)	(25) FY 2028 ($)	(26) FY 2029 ($)	(27) FY 2030 ($)
	Administration																											
1	Personal Services	287,285	301,342	307,400	313,500	319,800	326,200	332,700	339,400	346,200	353,100	360,200	367,400	374,700	382,200	389,800	397,600	405,600	413,700	422,000	430,400	439,000	447,800	456,800	465,900	475,200	484,700	494,400
2	Supplies and Materials	19,331	15,971	16,300	16,600	16,900	17,200	17,500	17,900	18,300	18,700	19,100	19,500	19,900	20,300	20,700	21,100	21,500	21,900	22,300	22,700	23,200	23,700	24,200	24,700	25,200	25,700	26,200
3	Travel and Training	2,190	1,500	1,500	1,500	1,500	1,500	1,500	1,500	1,500	1,500	1,500	1,500	1,500	1,500	1,500	1,500	1,500	1,500	1,500	1,500	1,500	1,500	1,500	1,500	1,500	1,500	1,500
4	Intragovernmental Charges	595,575	585,820	585,800	585,800	585,800	585,800	585,800	585,800	585,800	585,800	585,800	585,800	585,800	585,800	585,800	585,800	585,800	585,800	585,800	585,800	585,800	585,800	585,800	585,800	585,800	585,800	585,800
5	Utilities, Services, & Misc.	106,895	63,150	64,400	65,700	67,000	68,300	69,700	71,100	72,500	74,000	75,500	77,000	78,500	80,100	81,700	83,300	85,000	86,700	88,400	90,200	92,000	93,800	95,700	97,600	99,600	101,600	103,600
6	Routine Annual	23,500	20,000	20,400	20,800	21,200	21,600	22,000	22,400	22,800	23,300	23,800	24,300	24,800	25,300	25,800	26,300	26,800	27,300	27,800	28,400	29,000	29,600	30,200	30,800	31,400	32,000	32,600
7	Other	2,535,747	2,612,513	2,664,800	2,718,100	2,772,500	2,828,000	2,884,600	2,942,300	3,001,100	3,061,100	3,122,300	3,184,700	3,248,400	3,313,400	3,379,700	3,447,300	3,516,200	3,586,500	3,658,200	3,731,400	3,806,000	3,882,100	3,959,700	4,038,900	4,119,700	4,202,100	4,286,100
8	Subtotal Administration	3,570,523	3,600,296	3,660,600	3,722,000	3,784,700	3,848,600	3,913,800	3,980,400	4,048,200	4,117,500	4,188,200	4,260,200	4,333,600	4,408,600	4,485,000	4,562,900	4,642,400	4,723,400	4,806,000	4,890,400	4,976,500	5,064,300	5,153,900	5,245,200	5,338,400	5,433,400	5,530,200
	Engineering																											
9	Personal Services	456,826	480,977	490,600	500,400	510,400	520,600	531,000	541,600	552,400	563,400	574,700	586,200	597,900	609,900	622,100	634,500	647,200	660,100	673,300	686,800	700,500	714,500	728,800	743,400	758,300	773,500	789,000
10	Supplies and Materials	26,912	21,771	22,200	22,600	23,100	23,600	24,100	24,600	25,100	25,600	26,100	26,600	27,100	27,600	28,200	28,800	29,400	30,000	30,600	31,200	31,800	32,400	33,000	33,700	34,400	35,100	35,800
11	Travel and Training	2,355	2,355	2,400	2,400	2,400	2,400	2,400	2,400	2,400	2,400	2,400	2,400	2,400	2,400	2,400	2,400	2,400	2,400	2,400	2,400	2,400	2,400	2,400	2,400	2,400	2,400	2,400
12	Intragovernmental Charges	43,106	37,371	37,400	37,400	37,400	37,400	37,400	37,400	37,400	37,400	37,400	37,400	37,400	37,400	37,400	37,400	37,400	37,400	37,400	37,400	37,400	37,400	37,400	37,400	37,400	37,400	37,400
13	Utilities, Services, & Misc.	22,884	23,850	24,300	24,800	25,300	25,800	26,300	26,800	27,300	27,800	28,400	29,000	29,600	30,200	30,800	31,400	32,000	32,600	33,300	34,000	34,700	35,400	36,100	36,800	37,500	38,300	39,100
14	Routine Annual	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
15	Other	16,000	56,700	57,800	59,000	60,200	61,400	62,600	63,900	65,200	66,500	67,800	69,200	70,600	72,000	73,400	74,900	76,400	77,900	79,500	81,100	82,700	84,400	86,100	87,800	89,600	91,400	93,200
16	Subtotal Engineering	568,083	623,024	634,700	646,600	658,800	671,200	683,800	696,700	709,800	723,100	736,800	750,800	765,000	779,500	794,300	809,400	824,800	840,400	856,500	872,900	889,500	906,500	923,800	941,500	959,600	978,100	996,900
	Treatment Plant Field Operations & Maintenance																											
17	Personal Services	1,566,814	1,642,477	1,675,300	1,708,800	1,743,000	1,777,900	1,813,500	1,849,800	1,886,800	1,924,500	1,963,000	2,002,300	2,042,300	2,083,100	2,124,800	2,167,300	2,210,600	2,254,800	2,299,900	2,345,900	2,392,800	2,440,700	2,489,500	2,539,300	2,590,100	2,641,900	2,694,700
18	Supplies and Materials	535,095	561,868	573,100	584,600	596,300	608,200	620,400	632,800	645,500	658,400	671,600	685,000	698,700	712,700	727,000	741,500	756,300	771,400	786,800	802,500	818,600	835,000	851,700	868,700	886,100	903,800	921,900
19	Travel and Training	3,510	3,510	3,500	3,500	3,500	3,500	3,500	3,500	3,500	3,500	3,500	3,500	3,500	3,500	3,500	3,500	3,500	3,500	3,500	3,500	3,500	3,500	3,500	3,500	3,500	3,500	3,500
20	Intragovernmental Charges	125,466	125,642	125,600	125,600	125,600	125,600	125,600	125,600	125,600	125,600	125,600	125,600	125,600	125,600	125,600	125,600	125,600	125,600	125,600	125,600	125,600	125,600	125,600	125,600	125,600	125,600	125,600
21	Utilities, Services, & Misc.	1,337,702	1,506,580	1,536,700	1,567,400	1,598,700	1,630,700	1,663,300	1,696,600	1,730,500	1,765,100	1,800,400	1,836,400	1,873,100	1,910,600	1,948,800	1,987,800	2,027,600	2,068,200	2,109,600	2,151,800	2,194,800	2,238,700	2,283,500	2,329,200	2,375,800	2,423,300	2,471,800
22	Routine Annual	145,000	290,000	295,800	301,700	307,700	313,900	320,200	326,600	333,100	339,800	346,600	353,500	360,600	367,800	375,200	382,700	390,400	398,200	406,200	414,300	422,600	431,100	439,700	448,500	457,500	466,700	476,000
23	Other	221,500	241,750	246,600	251,500	256,500	261,600	266,800	272,100	277,500	283,100	288,800	294,600	300,500	306,500	312,600	318,900	325,300	331,800	338,400	345,200	352,100	359,100	366,300	373,600	381,100	388,700	396,500
24	Subtotal O&M	3,935,087	4,371,827	4,456,600	4,543,100	4,631,300	4,721,400	4,813,300	4,907,000	5,002,500	5,100,000	5,199,500	5,300,900	5,404,300	5,509,800	5,617,500	5,727,300	5,839,300	5,953,500	6,070,000	6,188,800	6,310,000	6,433,700	6,559,800	6,688,400	6,819,700	6,953,500	7,090,000
	Line Maintenance																											
25	Personal Services	610,521	625,267	637,800	650,600	663,600	676,900	690,400	704,200	718,300	732,700	747,400	762,300	777,500	793,100	809,000	825,200	841,700	858,500	875,700	893,200	911,100	929,300	947,900	966,900	986,200	1,005,900	1,026,000
26	Supplies and Materials	118,960	120,511	122,900	125,400	127,900	130,500	133,100	135,800	138,500	141,300	144,100	147,000	149,900	152,900	156,000	159,100	162,300	165,500	168,800	172,200	175,600	179,100	182,700	186,400	190,100	193,900	197,800
27	Travel and Training	1,850	1,850	1,900	1,900	1,900	1,900	1,900	1,900	1,900	1,900	1,900	1,900	1,900	1,900	1,900	1,900	1,900	1,900	1,900	1,900	1,900	1,900	1,900	1,900	1,900	1,900	1,900
28	Intragovernmental Charges	88,294	88,080	88,100	88,100	88,100	88,100	88,100	88,100	88,100	88,100	88,100	88,100	88,100	88,100	88,100	88,100	88,100	88,100	88,100	88,100	88,100	88,100	88,100	88,100	88,100	88,100	88,100
29	Utilities, Services, & Misc.	68,290	89,382	91,200	93,000	94,900	96,800	98,700	100,700	102,700	104,800	106,900	109,000	111,200	113,400	115,700	118,000	120,400	122,800	125,300	127,800	130,400	133,000	135,700	138,400	141,200	144,000	146,900
30	Routine Annual	179,000	12,000	12,200	12,400	12,600	12,900	13,200	13,500	13,800	14,100	14,400	14,700	15,000	15,300	15,600	15,900	16,200	16,500	16,800	17,100	17,400	17,700	18,100	18,500	18,900	19,300	19,700
31	Other	696,000	755,500	770,600	786,000	801,700	817,700	834,100	850,800	867,800	885,200	902,900	921,000	939,400	958,200	977,400	996,900	1,016,800	1,037,100	1,057,800	1,079,000	1,100,600	1,122,600	1,145,100	1,168,000	1,191,400	1,215,200	1,239,500
32	Subtotal O&M Administration	1,762,915	1,692,590	1,724,700	1,757,400	1,790,700	1,824,800	1,859,500	1,895,000	1,931,100	1,968,100	2,005,700	2,044,000	2,083,000	2,122,900	2,163,700	2,205,100	2,247,400	2,290,400	2,334,400	2,379,300	2,425,100	2,471,700	2,519,500	2,568,200	2,617,800	2,668,300	2,719,900
	TOTAL																											
33	Personal Services	2,921,446	3,050,063	3,111,100	3,173,300	3,236,800	3,301,600	3,367,600	3,435,000	3,503,700	3,573,700	3,645,300	3,718,200	3,792,400	3,868,300	3,945,700	4,024,600	4,105,100	4,187,100	4,270,900	4,356,300	4,443,400	4,532,300	4,623,000	4,715,500	4,809,800	4,906,000	5,004,100
34	Supplies and Materials	700,298	720,121	734,500	749,200	764,200	779,500	795,100	811,100	827,400	844,000	860,900	878,100	895,600	913,500	931,900	950,500	969,500	988,800	1,008,500	1,028,600	1,049,200	1,070,200	1,091,600	1,113,500	1,135,800	1,158,500	1,181,700
35	Travel and Training	9,905	9,215	9,300	9,300	9,300	9,300	9,300	9,300	9,300	9,300	9,300	9,300	9,300	9,300	9,300	9,300	9,300	9,300	9,300	9,300	9,300	9,300	9,300	9,300	9,300	9,300	9,300
36	Intragovernmental Charges	852,441	836,913	836,900	836,900	836,900	836,900	836,900	836,900	836,900	836,900	836,900	836,900	836,900	836,900	836,900	836,900	836,900	836,900	836,900	836,900	836,900	836,900	836,900	836,900	836,900	836,900	836,900
37	Utilities, Services, & Misc.	1,535,771	1,682,962	1,716,600	1,750,900	1,785,900	1,821,600	1,858,000	1,895,200	1,933,000	1,971,700	2,011,200	2,051,400	2,092,400	2,134,300	2,177,000	2,220,500	2,265,000	2,310,300	2,356,600	2,403,800	2,451,900	2,500,900	2,551,000	2,602,000	2,654,100	2,707,200	2,761,400
38	Routine Annual	347,500	322,000	328,400	334,900	341,500	348,400	355,400	362,500	369,700	377,200	384,800	392,500	400,400	408,400	416,600	424,900	433,400	442,000	450,800	459,800	469,000	478,400	488,000	497,800	507,800	518,000	528,300
39	Other	3,469,247	3,666,463	3,739,800	3,814,600	3,890,900	3,968,700	4,048,100	4,129,100	4,211,600	4,295,900	4,381,800	4,469,500	4,558,900	4,650,100	4,743,100	4,838,000	4,934,700	5,033,300	5,133,900	5,236,700	5,341,400	5,448,200	5,557,200	5,668,300	5,781,800	5,897,400	6,015,300
40	Subtotal O&M Administration	9,836,608	10,287,737	10,476,600	10,669,100	10,865,500	11,066,000	11,270,400	11,479,100	11,691,600	11,908,700	12,130,200	12,355,900	12,585,900	12,820,800	13,060,500	13,304,700	13,553,900	13,807,700	14,066,900	14,331,400	14,601,100	14,876,200	15,157,000	15,443,300	15,735,500	16,033,300	16,337,000
	TOTAL (Without RA & Other)																											
41	Personal Services	2,921,446	3,050,063	3,111,100	3,173,300	3,236,800	3,301,600	3,367,600	3,435,000	3,503,700	3,573,700	3,645,300	3,718,200	3,792,400	3,868,300	3,945,700	4,024,600	4,105,100	4,187,100	4,270,900	4,356,300	4,443,400	4,532,300	4,623,000	4,715,500	4,809,800	4,906,000	5,004,100
42	Supplies and Materials	700,298	720,121	734,500	749,200	764,200	779,500	795,100	811,100	827,400	844,000	860,900	878,100	895,600	913,500	931,900	950,500	969,500	988,800	1,008,500	1,028,600	1,049,200	1,070,200	1,091,600	1,113,500	1,135,800	1,158,500	1,181,700
43	Travel and Training	9,905	9,215	9,300	9,300	9,300	9,300	9,300	9,300	9,300	9,300	9,300	9,300	9,300	9,300	9,300	9,300	9,300	9,300	9,300	9,300	9,300	9,300	9,300	9,300	9,300	9,300	9,300
44	Intragovernmental Charges	852,441	836,913	836,900	836,900	836,900	836,900	836,900	836,900	836,900	836,900	836,900	836,900	836,900	836,900	836,900	836,900	836,900	836,900	836,900	836,900	836,900	836,900	836,900	836,900	836,900	836,900	836,900
45	Utilities, Services, & Misc.	1,535,771	1,682,962	1,716,600	1,750,900	1,785,900	1,821,600	1,858,000	1,895,200	1,933,000	1,971,700	2,011,200	2,051,400	2,092,400	2,134,300	2,177,000	2,220,500	2,265,000	2,310,300	2,356,600	2,403,800	2,451,900	2,500,900	2,551,000	2,602,000	2,654,100	2,707,200	2,761,400
46	Routine Annual																											
47	Other																											
48	Subtotal O&M Administration	6,019,861	6,299,274	6,408,400	6,519,600	6,633,100	6,748,900	6,866,900	6,987,500	7,110,300	7,235,600	7,363,600	7,493,900	7,626,600	7,762,300	7,900,800	8,041,800	8,185,800	8,332,400	8,482,200	8,634,900	8,790,700	8,949,600	9,111,800	9,277,200	9,445,900	9,617,900	9,793,400
	TOTAL O&M	6,019,861	6,299,274	6,408,400	6,519,600	6,633,100	6,748,900	6,866,900	6,987,500	7,110,300	7,235,600	7,363,600	7,493,900	7,626,600	7,762,300	7,900,800	8,041,800	8,185,800	8,332,400	8,482,200	8,634,900	8,790,700	8,949,600	9,111,800	9,277,200	9,445,900	9,617,900	9,793,400

Table 9-5
Capital Improvement Program

Line	Project Name	Initial Year Cost Opinion	(1) 2004 ($)	(2) 2005 ($)	(3) 2006 ($)	(4) 2007 ($)	(5) 2008 ($)	(6) 2009 ($)	(7) 2010 ($)	(8) 2011 ($)	(9) 2012 ($)	(10) 2013 ($)	(11) 2014 ($)	(12) 2015 ($)	(13) 2016 ($)	(14) 2017 ($)	(15) 2018 ($)	(16) 2019 ($)	(17) 2020 ($)	(18) 2021 ($)	(19) 2022 ($)	(20) 2023 ($)	(21) 2024 ($)	(22) 2025 ($)	(23) 2026 ($)	(24) 2027 ($)	(25) 2028 ($)	(26) 2029 ($)	(27) 2030 ($)
1	Repair and Rehab Existing Facilities	13,500,000	-	-	-	-	-	-	1,350,000	1,350,000	1,350,000	1,350,000	1,350,000	1,350,000	1,350,000	1,350,000	1,350,000	1,350,000	-	-	-	-	-	-	-	-	-	-	-
2	Biosolids - Centrifuges	2,200,000	-	2,200,000	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
3	Biosolids - Dewatering Building	7,700,000	-	-	-	-	-	-	-	770,000	770,000	2,310,000	2,310,000	1,540,000	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
4	Biosolids Heat Drying	14,100,000	-	-	-	-	-	-	-	-	-	-	-	-	-	-	7,050,000	7,050,000	-	-	-	-	-	-	-	-	-	-	-
	WWTP Expansion																												
5	Wet Weather Improvements	29,000,000	-	-	-	-	-	-	-	1,450,000	1,450,000	4,350,000	4,350,000	2,900,000	-	2,900,000	5,800,000	5,800,000	-	-	-	-	-	-	-	-	-	-	-
6	Expansion of Facilities	25,600,000	-	-	-	-	-	-	-	2,560,000	2,560,000	7,680,000	7,680,000	5,120,000	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
7	WWTP Expansion 2nd 6.3 mgd train	6,900,000	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	690,000	3,105,000	3,105,000	-	-	-	-	-	-	-	-
	Collections System																												
8	Additional I/I Investigations	3,336,973	-	-	145,120	382,100	610,000	480,000	633,424	54,316	54,316	54,316	54,316	54,316	54,316	54,316	54,316	54,316	54,316	54,316	54,316	54,316	54,316	54,316	54,316	54,316	54,316	54,316	54,316
9	Relief Sewer	72,063,046	-	-	1,539,000	312,499	4,496,559	4,181,070	4,213,900	2,866,001	2,866,001	2,866,001	2,866,001	2,866,001	2,866,001	2,866,001	2,866,001	2,866,001	2,866,001	2,866,001	2,866,001	2,866,001	2,866,001	2,866,001	2,866,001	2,866,001	2,866,001	2,866,001	2,866,001	2,866,001
10	Sewer Extensions	47,052,194	-	-	1,569,223	2,917,514	1,054,216	1,892,860	1,481,466	1,906,846	1,906,846	1,906,846	1,906,846	1,906,846	1,906,846	1,906,846	1,906,846	1,906,846	1,906,846	1,906,846	1,906,846	1,906,846	1,906,846	1,906,846	1,906,846	1,906,846	1,906,846	1,906,846	1,906,846	1,906,846
11	Future Lift Stations	7,275,000	-	-	-	-	-	-	650,000	331,250	331,250	331,250	331,250	331,250	331,250	331,250	331,250	331,250	331,250	331,250	331,250	331,250	331,250	331,250	331,250	331,250	331,250	331,250	331,250
	I/I Removal	20,280,000	-	-	500,000	500,000	500,000	750,000	750,000	864,000	864,000	864,000	864,000	864,000	864,000	864,000	864,000	864,000	864,000	864,000	864,000	864,000	864,000	864,000	864,000	864,000	864,000	864,000	864,000
12	Total	249,007,213	0	2,200,000	3,753,343	4,112,112	6,660,775	7,303,930	9,078,790	12,152,413	12,152,413	21,712,413	21,712,413	16,932,413	7,372,413	10,272,413	20,222,413	20,222,413	6,712,413	9,127,413	9,127,413	6,022,413	6,022,413	6,022,413	6,022,413	6,022,413	6,022,413	6,022,413	6,022,413	6,022,413

Table 9-6

SCENARIO A, Capital Improvement Financing Plan

Line		(1) FY 2004	(2) FY 2005	(3) FY 2006	(4) FY 2007	(5) FY 2008	(6) FY 2009	(7) FY 2010	(8) FY 2011	(9) FY 2012	(10) FY 2013	(11) FY 2014	(12) FY 2015	(13) FY 2016	(14) FY 2017	(15) FY 2018	(16) FY 2019	(17) FY 2020	(18) FY 2021	(19) FY 2022	(20) FY 2023	(21) FY 2024	(22) FY 2025	(23) FY 2026	(24) FY 2027	(25) FY 2028	(26) FY 2029	(27) FY 2030
	Capital Improvement Fund																											
1	Beginning of Year Balance	7,277,345	7,277,345	5,077,345	1,324,003	91,890	151,115	527,185	88,395	435,982	303,569	231,156	178,742	106,329	33,916	401,503	419,090	436,677	104,263	216,850	349,437	267,024	204,611	182,198	159,784	137,371	114,958	92,545
2	Capital Investments	-	2,200,000	3,753,343	4,112,112	6,660,775	7,303,930	9,078,790	12,152,413	12,152,413	21,712,413	21,712,413	16,932,413	7,372,413	10,272,413	20,222,413	20,222,413	6,712,413	9,127,413	9,127,413	6,022,413	6,022,413	6,022,413	6,022,413	6,022,413	6,022,413	6,022,413	6,022,413	6,022,413
3	Net Bond Proceeds	-	-	-	3,000,000	7,000,000	8,000,000	9,000,000	12,500,000	12,000,000	21,500,000	21,000,000	16,000,000	5,000,000	9,000,000	19,000,000	19,000,000	3,000,000	6,500,000	6,000,000	1,500,000	1,000,000	-	-	-	-	-	-	-
4	Cash Financing	-	-	-	-	-	-	-	500,000	500,000	1,000,000	1,500,000	1,500,000	2,500,000	2,000,000	2,000,000	2,000,000	3,500,000	3,000,000	3,500,000	4,500,000	5,000,000	6,000,000	6,000,000	6,000,000	6,000,000	6,000,000	6,000,000	6,000,000
5	Bond Issuance Expense	-	-	-	60,000	140,000	160,000	180,000	250,000	240,000	430,000	420,000	320,000	100,000	180,000	380,000	380,000	60,000	130,000	120,000	30,000	20,000	-	-	-	-	-	-	-
6	Bond Expense	-	-	-	60,000	140,000	160,000	180,000	250,000	240,000	430,000	420,000	320,000	100,000	180,000	380,000	380,000	60,000	130,000	120,000	30,000	20,000	-	-	-	-	-	-	-
7	End of Year Balance	7,277,345	5,077,345	1,324,003	91,890	151,115	527,185	88,395	435,982	303,569	231,156	178,742	106,329	33,916	401,503	419,090	436,677	104,263	216,850	349,437	267,024	204,611	182,198	159,784	137,371	114,958	92,545	70,132

Table 9-6

SCENARIO B, Capital Improvement Financing Plan

Line		(1) FY 2004	(2) FY 2005	(3) FY 2006	(4) FY 2007	(5) FY 2008	(6) FY 2009	(7) FY 2010	(8) FY 2011	(9) FY 2012	(10) FY 2013	(11) FY 2014	(12) FY 2015	(13) FY 2016	(14) FY 2017	(15) FY 2018	(16) FY 2019	(17) FY 2020	(18) FY 2021	(19) FY 2022	(20) FY 2023	(21) FY 2024	(22) FY 2025	(23) FY 2026	(24) FY 2027	(25) FY 2028	(26) FY 2029	(27) FY 2030
	Capital Improvement Fund																											
1	Beginning of Year Balance	7,277,345	7,277,345	5,077,345	1,324,003	91,890	151,115	527,185	358,395	225,982	343,569	251,156	38,742	1,329	388,916	296,503	334,090	121,677	209,263	71,850	184,437	82,024	479,611	457,198	434,784	412,371	389,958	367,545
2	Capital Investments	-	2,200,000	3,753,343	4,112,112	6,660,775	7,303,930	9,078,790	12,152,413	12,152,413	21,712,413	21,712,413	16,932,413	7,372,413	10,272,413	20,222,413	20,222,413	6,712,413	9,127,413	9,127,413	6,022,413	6,022,413	6,022,413	6,022,413	6,022,413	6,022,413	6,022,413	6,022,413	6,022,413
3	Net Bond Proceeds	-	-	-	3,000,000	7,000,000	8,000,000	8,500,000	12,000,000	12,000,000	22,000,000	20,000,000	16,000,000	6,000,000	8,000,000	18,500,000	18,500,000	5,000,000	6,500,000	6,500,000	2,000,000	2,000,000	-	-	-	-	-	-	-
4	Cash Financing	-	-	-	-	-	-	750,000	500,000	750,000	500,000	2,300,000	1,535,000	2,000,000	2,500,000	2,500,000	2,250,000	2,000,000	2,750,000	3,000,000	4,000,000	4,500,000	6,000,000	6,000,000	6,000,000	6,000,000	6,000,000	6,000,000	6,000,000
5	Bond Issuance Expense	-	-	-	60,000	140,000	160,000	170,000	240,000	240,000	440,000	400,000	320,000	120,000	160,000	370,000	370,000	100,000	130,000	130,000	40,000	40,000	-	-	-	-	-	-	-
6	Bond Expense	-	-	-	60,000	140,000	160,000	170,000	240,000	240,000	440,000	400,000	320,000	120,000	160,000	370,000	370,000	100,000	130,000	130,000	40,000	40,000	-	-	-	-	-	-	-
7	End of Year Balance	7,277,345	5,077,345	1,324,003	91,890	151,115	527,185	358,395	225,982	343,569	251,156	38,742	1,329	388,916	296,503	334,090	121,677	209,263	71,850	184,437	82,024	479,611	457,198	434,784	412,371	389,958	367,545	345,132

Table 9-6

SCENARIO C, Capital Improvement Financing Plan

Line		(1) FY 2004	(2) FY 2005	(3) FY 2006	(4) FY 2007	(5) FY 2008	(6) FY 2009	(7) FY 2010	(8) FY 2011	(9) FY 2012	(10) FY 2013	(11) FY 2014	(12) FY 2015	(13) FY 2016	(14) FY 2017	(15) FY 2018	(16) FY 2019	(17) FY 2020	(18) FY 2021	(19) FY 2022	(20) FY 2023	(21) FY 2024	(22) FY 2025	(23) FY 2026	(24) FY 2027	(25) FY 2028	(26) FY 2029	(27) FY 2030
	Capital Improvement Fund																											
1	Beginning of Year Balance	7,277,345	7,277,345	5,077,345	1,324,003	91,890	151,115	777,185	138,395	45,982	53,569	501,156	498,742	196,329	83,916	431,503	49,090	66,677	154,263	266,850	379,437	237,024	214,611	192,198	169,784	147,371	124,958	102,545
2	Capital Investments	-	2,200,000	3,753,343	4,112,112	6,660,775	7,303,930	9,078,790	12,152,413	12,152,413	21,712,413	21,712,413	16,932,413	7,372,413	10,272,413	20,222,413	20,222,413	6,712,413	9,127,413	9,127,413	6,022,413	6,022,413	6,022,413	6,022,413	6,022,413	6,022,413	6,022,413	6,022,413	6,022,413
3	Net Bond Proceeds	-	-	-	3,000,000	7,000,000	8,000,000	7,750,000	11,000,000	11,000,000	21,000,000	21,000,000	15,500,000	6,000,000	9,500,000	19,000,000	19,000,000	5,000,000	6,500,000	6,500,000	3,000,000	-	-	-	-	-	-	-	-
4	Cash Financing	-	-	-	-	-	-	250,000	1,000,000	1,500,000	1,600,000	2,000,000	1,550,000	1,750,000	1,500,000	1,500,000	1,600,000	2,000,000	2,000,000	3,000,000	3,000,000	3,000,000	6,000,000	6,000,000	6,000,000	6,000,000	6,000,000	6,000,000	6,000,000
5	Bond Issuance Expense	-	-	-	60,000	140,000	160,000	155,000	220,000	220,000	420,000	420,000	310,000	120,000	190,000	380,000	380,000	100,000	130,000	130,000	60,000	-	-	-	-	-	-	-	-
6	Bond Expense	-	-	-	60,000	140,000	160,000	155,000	220,000	220,000	420,000	420,000	310,000	120,000	190,000	380,000	380,000	100,000	130,000	130,000	60,000	-	-	-	-	-	-	-	-
7	End of Year Balance	7,277,345	5,077,345	1,324,003	91,890	151,115	777,185	138,395	45,982	53,569	501,156	498,742	196,329	83,916	431,503	49,090	66,677	154,263	266,850	379,437	237,024	214,611	192,198	169,784	147,371	124,958	102,545	80,132

Table 9-6

SCENARIO D, Capital Improvement Financing Plan

Line		(1) FY 2004	(2) FY 2005	(3) FY 2006	(4) FY 2007	(5) FY 2008	(6) FY 2009	(7) FY 2010	(8) FY 2011	(9) FY 2012	(10) FY 2013	(11) FY 2014	(12) FY 2015	(13) FY 2016	(14) FY 2017	(15) FY 2018	(16) FY 2019	(17) FY 2020	(18) FY 2021	(19) FY 2022	(20) FY 2023	(21) FY 2024	(22) FY 2025	(23) FY 2026	(24) FY 2027	(25) FY 2028	(26) FY 2029	(27) FY 2030
	Capital Improvement Fund																											
1	Beginning of Year Balance	7,277,345	7,277,345	5,077,345	1,324,003	91,890	151,115	527,185	88,395	435,982	303,569	231,156	178,742	106,329	33,916	401,503	419,090	436,677	104,263	216,850	349,437	267,024	204,611	182,198	159,784	137,371	114,958	92,545
2	Capital Investments	-	2,200,000	3,753,343	4,112,112	6,660,775	7,303,930	9,078,790	12,152,413	12,152,413	21,712,413	21,712,413	16,932,413	7,372,413	10,272,413	20,222,413	20,222,413	6,712,413	9,127,413	9,127,413	6,022,413	6,022,413	6,022,413	6,022,413	6,022,413	6,022,413	6,022,413	6,022,413	6,022,413
3	Net Bond Proceeds	-	-	-	3,000,000	7,000,000	8,000,000	9,000,000	12,500,000	12,000,000	21,500,000	21,000,000	16,000,000	5,000,000	9,000,000	19,000,000	19,000,000	3,000,000	6,500,000	6,000,000	1,500,000	1,000,000	-	-	-	-	-	-	-
4	Cash Financing	-	-	-	-	-	-	-	500,000	500,000	1,000,000	1,500,000	1,500,000	2,500,000	2,000,000	2,000,000	2,000,000	3,500,000	3,000,000	3,500,000	4,500,000	5,000,000	6,000,000	6,000,000	6,000,000	6,000,000	6,000,000	6,000,000	6,000,000
5	Bond Issuance Expense	-	-	-	60,000	140,000	160,000	180,000	250,000	240,000	430,000	420,000	320,000	100,000	180,000	380,000	380,000	60,000	130,000	120,000	30,000	20,000	-	-	-	-	-	-	-
6	Bond Expense	-	-	-	60,000	140,000	160,000	180,000	250,000	240,000	430,000	420,000	320,000	100,000	180,000	380,000	380,000	60,000	130,000	120,000	30,000	20,000	-	-	-	-	-	-	-
7	End of Year Balance	7,277,345	5,077,345	1,324,003	91,890	151,115	527,185	88,395	435,982	303,569	231,156	178,742	106,329	33,916	401,503	419,090	436,677	104,263	216,850	349,437	267,024	204,611	182,198	159,784	137,371	114,958	92,545	70,132

Table 9-7A

SCENARIO A, Estimated Revenues and Revenue Requirements under Increased Rates

Line					(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)	(21)	(22)	(23)	(24)	(25)	(26)	(27)
					FY 2004	FY 2005	FY 2006	FY 2007	FY 2008	FY 2009	FY 2010	FY 2011	FY 2012	FY 2013	FY 2014	FY 2015	FY 2016	FY 2017	FY 2018	FY 2019	FY 2020	FY 2021	FY 2022	FY 2023	FY 2024	FY 2025	FY 2026	FY 2027	FY 2028	FY 2029	FY 2030
1	Sewer Sales - FY 2004 Rates				6,481,400	6,606,900	6,734,800	6,865,200	6,998,100	7,133,600	7,271,700	7,412,500	7,556,100	7,702,400	7,851,600	8,003,600	8,158,600	8,316,600	8,477,600	8,641,800	8,809,200	8,979,700	9,153,600	9,330,800	9,511,500	9,695,800	9,883,500	10,074,900	10,270,000	10,469,000	10,671,800
	Year	Projected Revenue Increase	Additional Required Revenue Increase	Projected Month Effective																											
2	FY 2004	4.50%		12	291,700	297,300	303,100	308,900	314,900	321,000	327,200	333,600	340,000	346,600	353,300	360,200	367,100	374,200	381,500	388,900	396,400	404,100	411,900	419,900	428,000	436,300	444,800	453,400	462,200	471,100	480,200
3	Projected FY 2005 *	4.00%	0.00%	12		276,200	281,500	287,000	292,500	298,200	304,000	309,800	315,800	322,000	328,200	334,600	341,000	347,600	354,400	361,200	368,200	375,400	382,600	390,000	397,600	405,300	413,100	421,100	429,300	437,600	446,100
4	Projected FY 2006 *	4.00%	0.00%	12			292,800	298,400	304,200	310,100	316,100	322,200	328,500	334,800	341,300	347,900	354,700	361,500	368,500	375,700	383,000	390,400	397,900	405,600	413,500	421,500	429,700	438,000	446,500	455,100	463,900
5	Projected FY 2007 *	3.00%	0.00%	12				232,800	237,300	241,900	246,600	251,300	256,200	261,200	266,200	271,400	276,600	282,000	287,500	293,000	298,700	304,500	310,400	316,400	322,500	328,800	335,100	341,600	348,200	355,000	361,900
6	Projected FY 2008 *	3.00%	3.00%	12					488,800	498,300	507,900	517,800	527,800	538,000	548,400	559,100	569,900	580,900	592,200	603,600	615,300	627,200	639,400	651,800	664,400	677,300	690,400	703,700	717,400	731,300	745,400
7	FY 2009	6.00%		12						528,200	538,400	548,800	559,500	570,300	581,300	592,600	604,100	615,800	627,700	639,900	652,200	664,900	677,700	690,900	704,300	717,900	731,800	746,000	760,400	775,100	790,200
8	FY 2010	6.00%		12							570,700	581,800	593,000	604,500	616,200	628,200	640,300	652,700	665,400	678,200	691,400	704,800	718,400	732,300	746,500	761,000	775,700	790,700	806,000	821,700	837,600
9	FY 2011	8.00%		12								822,200	838,200	854,400	870,900	887,800	905,000	922,500	940,400	958,600	977,200	996,100	1,015,400	1,035,000	1,055,100	1,075,500	1,096,300	1,117,600	1,139,200	1,161,300	1,183,800
10	FY 2012	10.00%		12									1,131,500	1,153,400	1,175,700	1,198,500	1,221,700	1,245,400	1,269,500	1,294,100	1,319,200	1,344,700	1,370,700	1,397,300	1,424,300	1,451,900	1,480,000	1,508,700	1,537,900	1,567,700	1,598,100
11	FY 2013	10.00%		12										1,268,800	1,293,300	1,318,400	1,343,900	1,369,900	1,396,500	1,423,500	1,451,100	1,479,200	1,507,800	1,537,000	1,566,800	1,597,100	1,628,000	1,659,600	1,691,700	1,724,500	1,757,900
12	FY 2014	12.00%		12											1,707,200	1,740,300	1,773,900	1,808,300	1,843,300	1,879,000	1,915,400	1,952,500	1,990,300	2,028,800	2,068,100	2,108,200	2,149,000	2,190,600	2,233,100	2,276,300	2,320,400
13	FY 2015	7.00%		12												1,137,000	1,159,000	1,181,400	1,204,300	1,227,600	1,251,400	1,275,600	1,300,300	1,325,500	1,351,200	1,377,400	1,404,000	1,431,200	1,458,900	1,487,200	1,516,000
14	FY 2016	6.00%		12													1,062,900	1,083,500	1,104,500	1,125,900	1,147,700	1,169,900	1,192,600	1,215,700	1,239,200	1,263,200	1,287,700	1,312,600	1,338,000	1,364,000	1,390,400
15	FY 2017	2.00%		12														382,800	390,300	397,800	405,500	413,400	421,400	429,500	437,900	446,300	455,300	464,100	472,800	481,900	491,300
16	FY 2018	2.00%		12															398,100	405,800	413,600	421,600	429,800	438,100	446,600	455,300	464,100	473,100	482,200	491,600	501,100
17	FY 2019	2.00%		12																413,900	421,900	430,100	438,400	446,900	455,600	464,400	473,400	482,500	491,900	501,400	511,100
18	FY 2020	2.00%		12																	430,300	438,700	447,200	455,800	464,700	473,700	482,800	492,200	501,700	511,400	521,300
19	FY 2021	2.00%		12																		447,500	456,100	464,900	474,000	483,100	492,500	502,000	511,700	521,700	531,800
20	FY 2022	2.00%		12																			465,200	474,200	483,400	492,800	502,300	512,100	522,000	532,100	542,400
21	FY 2023	2.00%		12																				483,700	493,100	502,700	512,400	522,300	532,400	542,700	553,300
22	FY 2024	2.00%		12																					503,000	512,700	522,600	532,800	543,100	553,600	564,300
23	FY 2025	2.00%		12																						523,000	533,100	543,400	553,900	564,700	575,600
24	FY 2026	2.00%		12																							543,700	554,300	565,000	576,000	587,100
25	FY 2027	2.00%		12																								565,400	576,300	587,500	598,900
26	FY 2028	2.00%		12																									587,800	599,200	610,800
27	FY 2029	2.00%		12																										611,200	623,100
28	FY 2030	2.00%		12																											635,500
29	Total Additional Revenue				291,700	573,500	877,400	1,127,100	1,637,700	2,197,700	2,810,900	3,687,500	4,890,500	6,254,000	8,082,000	9,376,000	10,620,100	11,208,500	11,824,100	12,466,700	13,138,500	13,840,600	14,573,500	15,339,300	16,139,800	16,975,400	17,847,500	18,758,700	19,709,600	20,702,900	21,739,500
30	Total Sewer Sales Revenue				6,773,100	7,180,400	7,612,200	7,992,300	8,635,800	9,331,300	10,082,600	11,100,000	12,446,600	13,956,400	15,933,600	17,379,600	18,778,700	19,525,100	20,301,700	21,108,500	21,947,700	22,820,300	23,727,100	24,670,100	25,651,300	26,671,200	27,731,000	28,833,600	29,979,600	31,171,900	32,411,300
31	Sewer Connection Fees **				573,600	625,000	637,500	650,300	663,300	676,600	690,100	703,900	718,000	732,400	747,000	761,900	777,100	792,600	808,500	824,700	841,200	858,000	875,200	892,700	910,600	928,800	947,400	966,300	985,600	1,005,300	1,025,400
32	Other Operating Revenue				311,200	311,200	311,200	311,200	311,200	311,200	311,200	311,200	311,200	311,200	311,200	311,200	311,200	311,200	311,200	311,200	311,200	311,200	311,200	311,200	311,200	311,200	311,200	311,200	311,200	311,200	311,200
33	Interest Income				800,000	409,000	354,000	197,000	67,000	35,000	46,000	49,000	45,000	52,000	54,000	51,000	53,000	48,000	62,000	94,000	113,000	86,000	55,000	67,000	70,000	71,000	86,000	126,000	215,000	356,000	553,000
34	Other Non-Operating Revenue				15,500	15,500	15,500	15,500	15,500	15,500	15,500	15,500	15,500	15,500	15,500	15,500	15,500	15,500	15,500	15,500	15,500	15,500	15,500	15,500	15,500	15,500	15,500	15,500	15,500	15,500	15,500
	Total Revenue				8,473,400	8,541,100	8,930,400	9,166,300	9,692,800	10,369,600	11,145,400	12,179,600	13,536,300	15,067,500	17,061,300	18,519,200	19,935,500	20,692,400	21,498,900	22,353,900	23,228,600	24,091,000	24,984,000	25,956,500	26,958,600	27,997,700	29,091,100	30,252,600	31,506,900	32,859,900	34,316,400
	Revenue Requirements																														
	Operating																														
35	Operation and Maintenance Expense				6,019,861	6,299,274	6,408,400	6,519,600	6,633,100	6,748,900	6,866,900	6,987,500	7,110,300	7,235,600	7,363,600	7,493,900	7,626,600	7,762,300	7,900,800	8,041,800	8,185,800	8,332,400	8,482,200	8,634,900	8,790,700	8,949,600	9,111,800	9,277,200	9,445,900	9,617,900	9,793,400
36	Operation and Maintenance Expense (From New Plant Expansion)				0	0	0	0	0	0	0	0	0	0	1,039,400	1,060,600	1,082,200	1,104,300	1,126,800	1,149,800	1,173,200	1,904,700	1,943,600	1,983,200	2,023,600	2,050,700	2,078,200	2,106,400	2,135,100	2,164,500	2,194,400
	Non Operating																														
37	Bank & Paying Agent Fees				58,000	58,000	58,000	58,000	58,000	58,000	58,000	58,000	58,000	58,000	58,000	58,000	58,000	58,000	58,000	58,000	58,000	58,000	58,000	58,000	58,000	58,000	58,000	58,000	58,000	58,000	58,000
38	Amortization				22,000	22,000	22,000	22,000	22,000	22,000	22,000	22,000	22,000	22,000	22,000	22,000	22,000	22,000	22,000	22,000	22,000	22,000	22,000	22,000	22,000	22,000	22,000	22,000	22,000	22,000	22,000
39	Net Revenue				2,373,539	2,161,826	2,442,000	2,566,700	2,979,700	3,540,700	4,198,500	5,112,100	6,346,000	7,751,900	8,578,300	9,884,700	11,146,700	11,745,800	12,391,300	13,082,300	13,789,600	13,773,900	14,478,200	15,258,400	16,064,300	16,917,400	17,821,100	18,789,000	19,845,900	20,997,500	22,248,600
	Debt Service																														
40	Existing Bonds - Principal & Interest				1,804,835	2,062,629	2,227,583	2,204,706	2,183,401	2,161,406	2,150,752	2,129,537	2,102,590	2,063,630	1,979,828	1,952,881	1,926,937	1,903,025	1,588,354	1,154,666	1,092,204	834,329	545,338	391,133	240,031	41,000	0	0	0	0	0
41	Proposed Bonds - Principal & Interest				-	-	-	117,600	476,100	985,800	1,562,700	2,304,800	3,125,400	4,304,500	5,730,000	6,945,500	7,589,700	8,082,600	9,079,600	10,356,700	11,006,400	11,345,300	11,762,600	11,989,400	12,070,600	12,098,600	12,098,600	12,098,600	12,098,600	12,098,600	12,098,600	12,098,600
42	Total Existing & Proposed Debt Service				1,804,835	2,062,629	2,227,583	2,322,306	2,659,501	3,147,206	3,713,452	4,434,337	5,227,990	6,368,130	7,709,828	8,898,381	9,516,637	9,985,625	10,667,954	11,511,366	12,098,604	12,179,629	12,307,938	12,380,533	12,310,631	12,139,600	12,098,600	12,098,600	12,098,600	12,098,600	12,098,600
43	Revenue Financed Capital					0	0	0	0	0	0	500,000	500,000	1,000,000	1,500,000	1,500,000	2,500,000	2,000,000	2,000,000	2,000,000	3,500,000	3,000,000	3,500,000	4,500,000	5,000,000	6,000,000	6,000,000	6,000,000	6,000,000	6,000,000	6,000,000
44	Routine Annual (from Budget)				347,500	322,000	328,400	334,900	341,500	348,400	355,400	362,500	369,700	377,200	384,800	392,500	400,400	408,400	416,600	424,900	433,400	442,000	450,800	459,800	469,000	478,400	488,000	497,800	507,800	518,000	528,300
45	Total Revenue Requirements				8,252,196	8,763,903	9,044,383	9,256,806	9,714,101	10,324,506	11,015,752	12,364,337	13,287,990	15,060,930	17,038,228	18,364,781	20,123,637	20,236,325	21,065,354	22,058,066	24,297,804	24,034,029	24,820,938	26,055,233	26,650,331	27,647,600	27,778,400	27,953,600	28,132,300	28,314,500	28,500,300
46	Annual Operating Balance/(Deficit)				221,204	(222,803)	(113,983)	(90,506)	(21,301)	45,094	129,648	(184,737)	248,310	6,570	23,072	154,419	(188,137)	456,075	433,546	295,834	(1,069,204)	56,971	163,062	(98,733)	308,269	350,100	1,312,700	2,299,000	3,374,600	4,545,400	5,816,100
47	Use of Reserves to Meet Rev. Req.				0	222,803	113,983	90,506	21,301	0	0	184,737	0	0	0	0	188,137	0	0	0	1,069,204	0	0	98,733	0	0	0	0	0	0	0
48	Net Annual Operating Balance				221,204	0	0	0	0	45,094	129,648	0	248,310	6,570	23,072	154,419	0	456,075	433,546	295,834	0	56,971	163,062	0	308,269	350,100	1,312,700	2,299,000	3,374,600	4,545,400	5,816,100
49	Projected Rate Increase				4.5%	4.0%	4.0%	3.0%	6.0%	6.0%	6.0%	8.0%	10.0%	10.0%	12.0%	7.0%	6.0%	2.0%	2.0%	2.0%	2.0%	2.0%	2.0%	2.0%	2.0%	2.0%	2.0%	2.0%	2.0%	2.0%	2.0%
50	Cumulative Rate Increase				4.50%	8.68%	13.03%	16.42%	23.40%	30.81%	38.66%	49.75%	64.72%	81.20%	102.94%	117.14%	130.17%	134.78%	139.47%	144.26%	149.15%	154.13%	159.21%	164.40%	169.68%	175.08%	180.58%	186.19%	191.92%	197.75%	203.71%
	Operating Fund Summary																														
51	Beginning of Year Balance				792,474	1,013,678	790,876	676,893	586,387	565,085	610,179	739,827	555,090	803,400	809,970	833,042	987,461	799,324	1,255,398	1,688,944	1,984,778	915,574	972,545	1,135,607	1,036,874	1,345,142	1,695,242	3,007,942	5,306,942	8,681,542	13,226,942
52	Operating Reserve Req in Rev Req				-	(222,803)	(113,983)	(90,506)	(21,301)	-	-	(184,737)	-	-	-	-	(188,137)	-	-	-	(1,069,204)	-	-	(98,733)	-	-	-	-	-	-	-	-
53	Net Annual Operating Balance				221,204	-	-	-	-	45,094	129,648	-	248,310	6,570	23,072	154,419	-	456,075	433,546	295,834	-	56,971	163,062	-	308,269	350,100	1,312,700	2,299,000	3,374,600	4,545,400	5,816,100
54	End of Year Balance				1,013,678	790,876	676,893	586,387	565,085	610,179	739,827	555,090	803,400	809,970	833,042	987,461	799,324	1,255,398	1,688,944	1,984,778	915,574	972,545	1,135,607	1,036,874	1,345,142	1,695,242	3,007,942	5,306,942	8,681,542	13,226,942	19,043,042
55	Annual Coverage Requirement				132%	105%	110%	111%	112%	113%	113%	115%	121%	122%	111%	111%	117%	118%	116%	114%	114%	113%	118%	123%	130%	139%	147%	155%	164%	174%	184%
56	Additional Bond Test						104%	113%	139%	153%	163%	176%	195%	202%	213%	202%	204%	206%	204%	200%	201%	210%	214%	219%	233%	249%	264%	278%	294%	310%	326%
56	Required Reserve Balance	Days of O&M	30.4		501,700	524,900	534,000	543,300	552,800	562,400	572,200	582,300	592,500	603,000	613,600	624,500	635,600	646,900	658,400	670,200	682,200	694,400	706,900	719,600	732,600	745,800	759,300	773,100	787,200	801,500	816,100

* City planned rate increases

** Sewer Connection Fees projected to increase at 2% per year reflecting growth in customers

Table 9-7B

SCENARIO B, Estimated Revenues and Revenue Requirements under Increased Rates

Line		Year	Projected Revenue Increase	Additional Required Revenue Increase	Projected Month Effective	(1) FY 2004	(2) FY 2005	(3) FY 2006	(4) FY 2007	(5) FY 2008	(6) FY 2009	(7) FY 2010	(8) FY 2011	(9) FY 2012	(10) FY 2013	(11) FY 2014	(12) FY 2015	(13) FY 2016	(14) FY 2017	(15) FY 2018	(16) FY 2019	(17) FY 2020	(18) FY 2021	(19) FY 2022	(20) FY 2023	(21) FY 2024	(22) FY 2025	(23) FY 2026	(24) FY 2027	(25) FY 2028	(26) FY 2029	(27) FY 2030
1	Sewer Sales - FY 2004 Rates					6,481,400	6,606,900	6,734,800	6,865,200	6,998,100	7,133,600	7,271,700	7,412,500	7,556,100	7,702,400	7,851,600	8,003,600	8,158,600	8,316,600	8,477,600	8,641,800	8,809,200	8,979,700	9,153,600	9,330,800	9,511,500	9,695,800	9,883,500	10,074,900	10,270,000	10,469,000	10,671,800
2		FY 2004	4.50%		12	291,700	297,300	303,100	308,900	314,900	321,000	327,200	333,600	340,000	346,600	353,300	360,200	367,100	374,200	381,500	388,900	396,400	404,100	411,900	419,900	428,000	436,300	444,800	453,400	462,200	471,100	480,200
3		Projected FY 2005 *	4.00%	0.00%	12		276,200	281,500	287,000	292,500	298,200	304,000	309,800	315,800	322,000	328,200	334,600	341,000	347,600	354,400	361,200	368,200	375,400	382,600	393,000	397,600	405,500	413,100	421,100	429,300	437,600	446,100
4		Projected FY 2006 *	4.00%	0.00%	12			292,800	298,400	304,200	310,100	316,100	322,200	328,500	334,800	341,300	347,900	354,700	361,500	368,500	375,700	383,000	390,400	397,900	463,600	413,500	421,500	429,700	438,000	446,500	455,100	463,900
5		Projected FY 2007 *	3.00%	0.00%	12				232,800	237,300	241,900	246,600	251,300	256,200	261,200	266,200	271,400	276,600	282,000	287,500	293,000	298,700	304,500	310,400	316,400	322,500	328,800	335,100	341,600	348,200	355,000	361,900
6		Projected FY 2008 *	3.00%	3.00%	12					488,800	498,300	507,900	517,800	527,800	538,000	548,400	559,100	569,900	580,900	592,200	603,600	615,300	627,200	639,400	651,800	664,400	677,300	690,400	703,700	717,400	731,300	745,400
7		FY 2009	6.00%		12						528,200	538,400	548,800	559,500	570,300	581,300	592,600	604,100	615,800	627,700	639,900	652,200	664,900	677,700	690,900	704,300	717,900	731,800	746,000	760,400	775,100	790,200
8		FY 2010	6.00%		12							570,700	581,800	593,000	604,500	616,200	628,200	640,300	652,700	665,400	678,200	691,400	704,800	718,400	732,300	746,500	761,000	775,700	790,700	806,000	821,700	837,600
9		FY 2011	6.00%		12								616,700	628,600	640,800	653,200	665,900	678,700	691,900	705,300	718,900	732,900	747,100	761,500	776,300	791,300	806,600	822,200	838,200	854,400	871,000	887,800
10		FY 2012	6.00%		12									666,300	679,200	692,400	705,800	719,500	733,400	747,600	762,100	776,800	791,900	807,200	822,800	838,800	855,000	871,600	888,500	905,700	923,200	941,100
11		FY 2013	10.00%		12										1,200,000	1,223,200	1,246,900	1,271,100	1,295,700	1,320,800	1,346,300	1,372,400	1,399,000	1,426,100	1,453,700	1,481,800	1,510,600	1,539,800	1,569,600	1,600,000	1,631,000	1,662,600
12		FY 2014	10.50%		12											1,412,800	1,440,200	1,468,100	1,496,500	1,525,500	1,555,000	1,585,100	1,615,800	1,647,100	1,679,000	1,711,500	1,744,700	1,778,500	1,812,900	1,848,000	1,883,800	1,920,300
13		FY 2015	8.00%		12												1,212,500	1,236,000	1,259,900	1,284,300	1,309,200	1,334,500	1,360,400	1,386,700	1,413,600	1,440,900	1,468,900	1,497,300	1,526,300	1,555,800	1,586,000	1,616,700
14		FY 2016	6.00%		12													1,001,100	1,020,500	1,040,300	1,060,400	1,081,000	1,101,900	1,123,200	1,145,000	1,167,200	1,189,800	1,212,800	1,236,300	1,260,200	1,284,700	1,309,500
15		FY 2017	2.00%		12														360,600	367,600	374,700	381,900	389,300	396,900	404,600	412,400	420,500	428,500	436,800	445,300	453,900	462,700
16		FY 2018	2.00%		12															374,900	382,200	389,800	397,600	405,500	413,600	420,600	429,100	437,100	445,800	454,200	463,000	472,000
17		FY 2019	2.00%		12																389,800	397,400	405,300	413,400	421,600	429,100	437,400	446,100	454,800	463,300	472,300	481,400
18		FY 2020	2.00%		12																	405,300	413,400	421,600	429,900	437,600	446,100	454,800	463,600	472,500	481,700	491,000
19		FY 2021	2.00%		12																		421,400	429,600	438,000	446,400	455,000	463,900	472,800	482,000	491,300	500,800
20		FY 2022	2.00%		12																			438,200	446,700	455,300	464,100	473,100	482,300	491,600	501,200	510,900
21		FY 2023	2.00%		12																				455,600	464,400	473,400	482,600	492,200	501,600	511,200	521,100
22		FY 2024	2.00%		12																					473,700	482,900	492,600	502,100	511,500	521,400	531,500
23		FY 2025	2.00%		12																						492,600	502,100	511,800	521,700	531,800	542,100
24		FY 2026	2.00%		12																							512,100	522,000	532,200	542,500	553,000
25		FY 2027	2.00%		12																								532,500	542,800	553,300	564,000
26		FY 2028	2.00%		12																									553,700	564,400	575,300
27		FY 2029	2.00%		12																										575,700	586,800
28		FY 2030	2.00%		12																											598,600
29	Total Additional Revenue					291,700	573,500	877,400	1,127,100	1,637,700	2,197,700	2,810,900	3,482,000	4,215,700	5,497,400	7,016,500	8,365,300	9,528,200	10,073,200	10,643,500	11,239,100	11,862,100	12,513,500	13,193,700	13,903,000	14,647,800	15,424,400	16,235,000	17,081,900	17,966,400	18,890,300	19,854,500
30	Total Sewer Sales Revenue					6,773,100	7,180,400	7,612,200	7,992,300	8,635,800	9,331,300	10,082,600	10,894,500	11,771,800	13,199,800	14,868,100	16,368,900	17,686,800	18,389,800	19,121,100	19,880,900	20,671,300	21,493,200	22,347,300	23,235,800	24,159,300	25,120,200	26,118,500	27,156,800	28,236,400	29,359,300	30,526,300
31	Sewer Connection Fees **					573,600	625,000	637,500	650,300	663,300	995,000	1,014,900	1,035,200	1,552,800	1,583,900	1,615,600	1,647,900	1,680,900	1,714,500	1,748,800	1,783,800	1,819,500	1,855,900	1,893,000	1,930,900	1,969,500	2,008,900	2,049,100	2,090,100	2,131,900	2,174,500	2,218,000
32	Other Operating Revenue					311,200	311,200	311,200	311,200	311,200	311,200	311,200	311,200	311,200	311,200	311,200	311,200	311,200	311,200	311,200	311,200	311,200	311,200	311,200	311,200	311,200	311,200	311,200	311,200	311,200	311,200	311,200
32	Interest Income					800,000	409,000	354,000	197,000	67,000	35,000	54,000	62,000	48,000	53,000	76,000	63,000	37,000	53,000	60,000	49,000	37,000	35,000	36,000	42,000	49,000	62,000	73,000	83,000	139,000	243,000	399,000
33	Other Non-Operating Revenue					15,500	15,500	15,500	15,500	15,500	15,500	15,500	15,500	15,500	15,500	15,500	15,500	15,500	15,500	15,500	15,500	15,500	15,500	15,500	15,500	15,500	15,500	15,500	15,500	15,500	15,500	15,500
34	Total Revenue					8,473,400	8,541,100	8,930,400	9,166,300	9,692,800	10,688,000	11,478,200	12,318,400	13,699,300	15,163,400	16,886,400	18,406,500	19,731,400	20,484,000	21,256,600	22,040,400	22,854,500	23,710,800	24,603,000	25,535,400	26,504,500	27,517,800	28,567,300	29,656,600	30,834,000	32,103,500	33,470,000
	Revenue Requirements																															
	Operating																															
35	Operation and Maintenance Expense					6,019,861	6,299,274	6,408,400	6,519,600	6,633,100	6,748,900	6,866,900	6,987,500	7,110,300	7,235,600	7,363,600	7,493,900	7,626,600	7,762,300	7,900,800	8,041,800	8,185,800	8,332,400	8,482,200	8,634,900	8,790,700	8,949,600	9,111,800	9,277,200	9,445,900	9,617,900	9,793,400
36	Operation and Maintenance Expense (From New Plant Expansion)					0	0	0	0	0	0	0	0	0	0	1,039,400	1,060,600	1,082,200	1,104,300	1,126,800	1,149,800	1,173,200	1,904,700	1,943,600	1,983,200	2,023,600	2,050,700	2,078,200	2,106,400	2,135,100	2,164,500	2,194,400
	Non Operating																															
37	Bank & Paying Agent Fees					58,000	58,000	58,000	58,000	58,000	58,000	58,000	58,000	58,000	58,000	58,000	58,000	58,000	58,000	58,000	58,000	58,000	58,000	58,000	58,000	58,000	58,000	58,000	58,000	58,000	58,000	58,000
38	Amortization					22,000	22,000	22,000	22,000	22,000	22,000	22,000	22,000	22,000	22,000	22,000	22,000	22,000	22,000	22,000	22,000	22,000	22,000	22,000	22,000	22,000	22,000	22,000	22,000	22,000	22,000	22,000
39	Net Revenue					2,373,539	2,161,826	2,442,000	2,566,700	2,979,700	3,859,100	4,531,300	5,250,900	6,509,000	7,847,800	8,403,400	9,772,000	10,942,600	11,537,400	12,149,000	12,768,800	13,415,500	13,393,700	14,097,200	14,837,300	15,610,200	16,437,500	17,297,300	18,193,000	19,173,000	20,241,100	21,402,200
	Debt Service																															
40	Existing Bonds - Principal & Interest					1,804,835	2,062,629	2,227,583	2,204,706	2,183,401	2,161,406	2,150,752	2,129,537	2,102,590	2,063,630	1,979,828	1,952,881	1,926,937	1,903,025	1,588,354	1,154,666	1,092,204	834,329	545,338	391,133	240,031	41,000	0	0	0	0	0
41	Proposed Bonds - Principal & Interest					-	-	-	117,600	476,100	985,800	1,543,100	2,251,600	3,058,200	4,256,900	5,657,200	6,844,700	7,528,100	8,009,800	8,959,200	10,202,700	10,916,900	11,311,800	11,748,700	12,009,100	12,143,500	12,199,500	12,199,500	12,199,500	12,199,500	12,199,500	12,199,500
42	Total Existing & Proposed Debt Service					1,804,835	2,062,629	2,227,583	2,322,306	2,659,501	3,147,206	3,693,852	4,381,137	5,160,790	6,320,530	7,637,028	8,797,581	9,455,037	9,912,825	10,547,554	11,357,366	12,009,104	12,146,129	12,294,038	12,400,233	12,383,531	12,240,500	12,199,500	12,199,500	12,199,500	12,199,500	12,199,500
43	Revenue Financed Capital						0	0	0	0	0	750,000	500,000	750,000	500,000	2,300,000	1,500,000	2,000,000	2,500,000	2,500,000	2,250,000	2,000,000	2,750,000	3,000,000	4,000,000	4,500,000	6,000,000	6,000,000	6,000,000	6,000,000	6,000,000	6,000,000
44	Routine Annual (from Budget)					347,500	322,000	328,400	334,900	341,500	348,400	355,400	362,500	369,700	377,200	384,800	392,500	400,400	408,400	416,600	424,900	433,400	442,000	450,800	459,800	469,000	478,400	488,000	497,800	507,800	518,000	528,300
45	Total Revenue Requirements					8,252,196	8,763,903	9,044,383	9,256,806	9,714,101	10,324,506	11,746,152	12,311,137	13,470,790	14,513,330	17,765,428	18,263,981	19,562,037	20,663,525	21,444,954	22,154,066	22,708,304	23,750,529	24,307,038	25,574,933	26,223,231	27,748,500	27,879,300	28,054,500	28,233,200	28,415,400	28,601,200
46	Annual Operating Balance/(Deficit)					221,204	(222,803)	(113,983)	(90,506)	(21,301)	363,494	(267,952)	7,263	228,510	650,070	(879,028)	142,519	169,363	(179,525)	(188,354)	(113,666)	146,196	(39,729)	295,962	(39,533)	281,269	(230,700)	688,000	1,602,100	2,600,800	3,688,100	4,868,800
47	Use of Reserves to Meet Rev. Req.					0	222,803	113,983	90,506	21,301	0	267,952	0	0	0	879,028	0	0	179,525	188,354	113,666	0	39,729	0	39,533	0	0	0	0	0	0	0
48	Net Annual Operating Balance					221,204	0	0	0	0	363,494	0	7,263	228,510	650,070	0	142,519	169,363	0	0	0	146,196	0	295,962	0	281,269	(230,700)	688,000	1,602,100	2,600,800	3,688,100	4,868,800
49	Projected Rate Increase					4.5%	4.0%	4.0%	3.0%	6.0%	6.0%	6.0%	6.0%	6.0%	10.0%	10.5%	8.0%	6.0%	2.0%	2.0%	2.0%	2.0%	2.0%	2.0%	2.0%	2.0%	2.0%	2.0%	2.0%	2.0%	2.0%	2.0%
50	Cumulative Rate Increase					4.50%	8.68%	13.03%	16.42%	23.40%	30.81%	38.66%	46.98%	55.79%	71.37%	89.37%	104.52%	116.79%	121.12%	125.55%	130.06%	134.66%	139.35%	144.14%	149.02%	154.00%	159.08%	164.26%	169.55%	174.94%	180.44%	186.05%
	Operating Fund Summary																															
51	Beginning of Year Balance					792,474	1,013,678	790,876	676,893	586,387	565,085	928,579	660,627	667,890	896,400	1,546,470	667,442	809,961	979,324	799,798	611,444	497,778	643,974	604,245	900,207	860,674	1,141,942	911,242	1,599,242	3,201,342	5,802,142	9,490,242
52	Operating Reserve Req in Rev Req					-	(222,803)	(113,983)	(90,506)	(21,301)	-	(267,952)	-	-	-	(879,028)	-	-	(179,525)	(188,354)	(113,666)	-	(39,729)	-	(39,533)	-	-	-	-	-	-	-	-
53	Net Annual Operating Balance					221,204	-	-	-	-	363,494	-	7,263	228,510	650,070	-	142,519	169,363	-	-	-	146,196	-	295,962	-	281,269	(230,700)	688,000	1,602,100	2,600,800	3,688,100	4,868,800
54	End of Year Balance					1,013,678	790,876	676,893	586,387	565,085	928,579	660,627	667,890	896,400	1,546,470	667,442	809,961	979,324	799,798	611,444	497,778	643,974	604,245	900,207	860,674	1,141,942	911,242	1,599,242	3,201,342	5,802,142	9,490,242	14,359,042
55	Annual Coverage Requirement					132%	105%	110%	111%	112%	123%	123%	120%	126%	124%	110%	111%	116%	116%	115%	112%	112%	110%	113%	120%	126%	134%	142%	149%	157%	166%	175%
56	Additional Bond Test							104%	115%	139%	153%	164%	169%	172%	180%	188%	182%	182%	185%	184%	181%	181%	190%	193%	196%	208%	222%	236%	249%	263%	278%	293%
56	Required Reserve Balance	Days of O&M	30.4			501,700	524,900	534,000	543,300	552,800	562,400	572,200	582,300	592,500	603,000	613,600	624,500	635,600	646,900	658,400	670,200	682,200	694,400	706,900	719,600	732,600	745,800	759,300	773,100	787,200	801,500	816,100

* City planned rate increases

** Sewer Connectin Fees projected to increase at 2% per year reflecting growth in customers.

Table 9-7C

SCENARIO C, Estimated Revenues and Revenue Requirements under Increased Rates

Line		Year	Projected Revenue Increase	Additional Required Revenue Increase	Projected Month Effective	(1) FY 2004	(2) FY 2005	(3) FY 2006	(4) FY 2007	(5) FY 2008	(6) FY 2009	(7) FY 2010	(8) FY 2011	(9) FY 2012	(10) FY 2013	(11) FY 2014	(12) FY 2015	(13) FY 2016	(14) FY 2017	(15) FY 2018	(16) FY 2019	(17) FY 2020	(18) FY 2021	(19) FY 2022	(20) FY 2023	(21) FY 2024	(22) FY 2025	(23) FY 2026	(24) FY 2027	(25) FY 2028	(26) FY 2029	(27) FY 2030
1	Sewer Sales - FY 2004 Rates					6,481,400	6,606,900	6,734,800	6,865,200	6,998,100	7,133,600	7,271,700	7,412,500	7,556,100	7,702,400	7,851,600	8,003,600	8,158,600	8,316,600	8,477,600	8,641,800	8,809,200	8,979,700	9,153,600	9,330,800	9,511,500	9,695,800	9,883,500	10,074,900	10,270,000	10,469,000	10,671,800
2		FY 2004	4.50%		12	291,700	297,300	303,100	308,900	314,900	321,000	327,200	333,600	340,000	346,600	353,300	360,200	367,100	374,200	381,500	388,900	396,400	404,100	411,900	419,900	428,000	436,300	444,800	453,400	462,200	471,100	480,200
3		Projected FY 2005 *	4.00%	0.00%	12		276,200	281,500	287,000	292,500	298,200	304,000	309,800	315,800	322,000	328,200	334,600	341,000	347,600	354,400	361,200	368,200	375,400	382,600	390,000	397,600	405,300	413,100	421,100	429,300	437,600	446,100
4		Projected FY 2006 *	4.00%	0.00%	12			292,800	298,400	304,200	310,100	316,100	322,200	328,500	334,800	341,300	347,900	354,700	361,500	368,500	375,700	383,000	390,400	397,900	405,600	413,500	421,500	429,700	438,000	446,500	455,100	463,900
5		Projected FY 2007 *	3.00%	0.00%	12				232,800	237,300	241,900	246,600	251,300	256,200	261,200	266,200	271,400	276,600	282,000	287,500	293,000	298,700	304,500	310,400	316,400	322,500	328,800	335,100	341,600	348,200	355,000	361,900
6		Projected FY 2008 *	3.00%	3.00%	12					488,800	498,300	507,900	517,800	527,800	538,000	548,400	559,100	569,900	580,900	592,200	603,600	615,300	627,200	639,400	651,800	664,400	677,300	690,400	703,700	717,400	731,300	745,400
7		FY 2009	10.50%		12						924,300	942,200	960,500	979,100	998,000	1,017,300	1,037,100	1,057,100	1,077,600	1,098,500	1,119,700	1,141,400	1,163,500	1,186,100	1,209,000	1,232,400	1,256,300	1,280,600	1,305,400	1,330,700	1,356,500	1,382,800
8		FY 2010	10.50%		12							1,041,100	1,061,300	1,081,900	1,102,800	1,124,200	1,146,000	1,168,100	1,190,700	1,213,800	1,237,300	1,261,300	1,285,700	1,310,600	1,336,000	1,361,800	1,388,200	1,415,100	1,442,500	1,470,500	1,498,900	1,528,000
9		FY 2011	10.50%		12								1,172,700	1,195,500	1,218,600	1,242,200	1,266,300	1,290,800	1,315,800	1,341,300	1,367,200	1,393,700	1,420,700	1,448,200	1,476,200	1,504,800	1,534,000	1,563,700	1,594,000	1,624,900	1,656,300	1,688,400
10		FY 2012	6.00%		12									754,900	769,500	784,400	799,600	815,000	830,800	846,900	863,300	880,000	897,100	914,400	932,100	950,200	968,600	987,400	1,006,500	1,026,000	1,045,800	1,066,100
11		FY 2013	6.00%		12										815,600	831,400	847,500	863,900	880,700	897,700	915,100	932,800	950,900	969,300	988,100	1,007,200	1,026,700	1,046,600	1,066,900	1,087,500	1,108,600	1,130,100
12		FY 2014	6.00%		12											881,300	898,400	915,800	933,500	951,600	970,000	988,800	1,008,000	1,027,500	1,047,400	1,067,600	1,088,300	1,109,400	1,130,900	1,152,800	1,175,100	1,197,900
13		FY 2015	7.00%		12												1,111,000	1,132,500	1,154,400	1,176,800	1,199,600	1,222,800	1,246,500	1,270,600	1,295,200	1,320,300	1,345,900	1,372,000	1,398,500	1,425,600	1,453,200	1,481,400
14		FY 2016	3.00%		12													519,300	529,400	539,600	550,100	560,700	571,600	582,700	594,000	605,500	617,200	629,100	641,300	653,700	666,400	679,300
15		FY 2017	2.00%		12														363,500	370,600	377,700	385,000	392,500	400,100	407,900	415,700	423,800	432,000	440,400	448,900	457,600	466,500
16		FY 2018	3.00%		12															567,000	577,900	589,100	600,500	612,200	624,000	636,100	648,400	661,000	673,800	686,800	700,100	713,700
17		FY 2019	3.00%		12																595,300	606,800	618,500	630,500	642,700	655,200	667,900	701,200	714,800	728,700	735,100
18		FY 2020	3.00%		12																	625,000	637,100	649,400	662,000	674,800	687,900	701,200	728,700	742,800	757,200
19		FY 2021	2.00%		12																		437,500	454,900	463,400	472,400	481,500	490,800	500,300	510,000	519,900
20		FY 2022	2.00%		12																			463,700	472,700	481,800	491,100	500,700	510,300	520,200	530,300
21		FY 2023	2.00%		12																			472,900	482,100	491,400	501,000	510,700	520,600	530,600	540,900
22		FY 2024	2.00%		12																				491,700	501,300	511,000	520,900	531,000	541,200	551,700
23		FY 2025	2.00%		12																					511,300	521,200	531,300	541,600	552,100	562,800
24		FY 2026	2.00%		12																						531,600	541,900	552,400	563,100	574,000
25		FY 2027	2.00%		12																							552,800	563,500	574,400	585,500
26		FY 2028	2.00%		12																								574,700	585,900	597,200
27		FY 2029	2.00%		12																									597,600	609,200
28		FY 2030	2.00%		12																										621,300
29	Total Additional Revenue					291,700	573,500	877,400	1,127,100	1,637,700	2,593,800	3,685,100	4,929,200	5,779,700	6,707,100	7,718,200	8,979,100	9,671,800	10,222,600	10,987,900	11,795,600	12,649,000	13,331,700	14,044,600	14,789,500	15,567,500	16,380,600	17,229,400	18,115,900	19,041,500	20,007,600	21,016,800
30	Total Sewer Sales Revenue					6,773,100	7,180,400	7,612,200	7,992,300	8,635,800	9,727,400	10,956,800	12,341,700	13,335,800	14,409,500	15,569,800	16,982,700	17,830,400	18,539,200	19,465,500	20,437,400	21,458,200	22,311,400	23,198,200	24,120,300	25,079,000	26,076,400	27,112,900	28,190,800	29,311,500	30,476,600	31,688,600
31	Sewer Connection Fees **					573,600	625,000	637,500	690,300	663,300	676,600	690,100	703,900	718,000	732,400	747,000	761,900	777,100	792,600	808,500	824,700	841,200	858,000	875,200	892,700	910,600	928,800	947,400	966,300	985,600	1,005,300	1,025,400
32	Other Operating Revenue					311,200	311,200	311,200	311,200	311,200	311,200	311,200	311,200	311,200	311,200	311,200	311,200	311,200	311,200	311,200	311,200	311,200	311,200	311,200	311,200	311,200	311,200	311,200	311,200	311,200	311,200	311,200
32	Interest Income					800,000	409,000	354,000	197,000	67,000	35,000	56,000	62,000	51,000	61,000	72,000	75,000	61,000	50,000	65,000	75,000	67,000	66,000	62,000	63,000	88,000	74,000	36,000	46,000	101,000	205,000	362,000
33	Other Non-Operating Revenue					15,500	15,500	15,500	15,500	15,500	15,500	15,500	15,500	15,500	15,500	15,500	15,500	15,500	15,500	15,500	15,500	15,500	15,500	15,500	15,500	15,500	15,500	15,500	15,500	15,500	15,500	15,500
34	Total Revenue					8,473,400	8,541,100	8,930,400	9,166,300	9,692,800	10,765,700	12,029,600	13,434,300	14,431,500	15,529,600	16,715,500	18,146,300	18,995,200	19,708,500	20,665,700	21,663,800	22,693,100	23,562,100	24,462,100	25,402,700	26,404,300	27,405,900	28,423,000	29,529,800	30,724,800	32,013,600	33,402,700
	Revenue Requirements																															
	Operating																															
35	Operation and Maintenance Expense					6,019,861	6,299,274	6,408,400	6,519,600	6,633,100	6,748,900	6,866,900	6,987,500	7,110,300	7,235,600	7,363,600	7,493,900	7,626,600	7,762,300	7,900,800	8,041,800	8,185,800	8,332,400	8,482,200	8,634,900	8,790,700	8,949,600	9,111,800	9,277,200	9,445,900	9,617,900	9,793,400
36	Operation and Maintenance Expense (From New Plant Expansion)					0	0	0	0	0	0	0	0	0	0	1,039,400	1,060,600	1,082,200	1,104,300	1,126,800	1,149,800	1,173,200	1,904,700	1,943,600	1,983,200	2,023,600	2,050,700	2,078,200	2,106,400	2,135,100	2,164,500	2,194,400
	Non Operating																															
37	Bank & Paying Agent Fees					58,000	58,000	58,000	58,000	58,000	58,000	58,000	58,000	58,000	58,000	58,000	58,000	58,000	58,000	58,000	58,000	58,000	58,000	58,000	58,000	58,000	58,000	58,000	58,000	58,000	58,000	58,000
38	Amortization					22,000	22,000	22,000	22,000	22,000	22,000	22,000	22,000	22,000	22,000	22,000	22,000	22,000	22,000	22,000	22,000	22,000	22,000	22,000	22,000	22,000	22,000	22,000	22,000	22,000	22,000	22,000
39	Net Revenue					2,373,539	2,161,826	2,442,000	2,566,700	2,979,700	3,936,800	5,082,700	6,366,800	7,241,200	8,214,000	8,232,500	9,511,800	10,206,400	10,761,900	11,558,100	12,392,200	13,254,100	13,245,000	13,956,300	14,704,600	15,510,000	16,325,600	17,153,000	18,066,200	19,063,800	20,151,200	21,334,900
	Debt Service																															
40	Existing Bonds - Principal & Interest					1,804,835	2,062,629	2,227,583	2,204,706	2,183,401	2,161,406	2,150,752	2,129,537	2,102,590	2,063,630	1,979,828	1,952,881	1,926,937	1,903,025	1,588,354	1,154,666	1,092,204	834,329	545,338	391,133	240,031	41,000	0	0	0	0	0
41	Proposed Bonds - Principal & Interest					-	-	-	117,600	476,100	985,800	1,513,700	2,162,000	2,901,400	4,032,900	5,444,400	6,640,200	7,309,600	7,850,100	8,861,100	10,138,200	10,866,400	11,261,300	11,698,200	11,997,800	12,081,800	12,081,800	12,081,800	12,081,800	12,081,800	12,081,800	12,081,800
42	Total Existing & Proposed Debt Service					1,804,835	2,062,629	2,227,583	2,322,306	2,659,501	3,147,206	3,664,452	4,291,537	5,003,990	6,096,530	7,424,228	8,593,081	9,236,537	9,753,125	10,449,454	11,292,866	11,958,604	12,095,629	12,243,538	12,388,933	12,321,831	12,122,800	12,081,800	12,081,800	12,081,800	12,081,800	12,081,800
43	Revenue Financed Capital						0	0	0	0	250,000	1,000,000	1,500,000	1,600,000	2,000,000	1,550,000	1,750,000	1,500,000	1,500,000	1,600,000	2,000,000	2,000,000	3,000,000	3,000,000	3,000,000	6,000,000	6,000,000	6,000,000	6,000,000	6,000,000	6,000,000	6,000,000
44	Routine Annual (from Budget)					347,500	322,000	328,400	334,900	341,500	348,400	355,400	362,500	369,700	377,200	384,800	392,500	400,400	408,400	416,600	424,900	433,400	442,000	450,800	459,800	469,000	478,400	488,000	497,800	507,800	518,000	528,300
45	Total Revenue Requirements					8,252,196	8,763,903	9,044,383	9,256,806	9,714,101	10,574,506	11,966,752	13,221,537	14,163,990	15,789,330	16,802,628	18,309,481	18,843,537	19,503,825	20,446,854	21,839,566	22,657,804	23,950,029	24,256,538	24,563,633	27,661,531	27,630,800	27,761,600	27,936,800	28,115,500	28,297,700	28,483,500
46	Annual Operating Balance/(Deficit)					221,204	(222,803)	(113,983)	(90,506)	(21,301)	191,194	62,848	212,763	267,510	(259,730)	(87,128)	(163,181)	151,663	204,675	218,846	(175,766)	35,296	(387,929)	205,562	839,067	(1,257,231)	(224,900)	661,400	1,593,000	2,609,300	3,715,900	4,919,200
47	Use of Reserves to Meet Rev. Req.					0	222,803	113,983	90,506	21,301	0	0	0	0	259,730	87,128	163,181	0	0	0	175,766	0	387,929	0	0	0	0	0	0	0	0	0
48	Net Annual Operating Balance					221,204	0	0	0	0	191,194	62,848	212,763	267,510	0	0	0	151,663	204,675	218,846	0	35,296	0	205,562	839,067	(1,257,231)	(224,900)	661,400	1,593,000	2,609,300	3,715,900	4,919,200
49	Projected Rate Increase					4.5%	4.0%	4.0%	3.0%	6.0%	10.5%	10.5%	10.5%	6.0%	6.0%	6.0%	7.0%	3.0%	2.0%	3.0%	3.0%	3.0%	2.0%	2.0%	2.0%	2.0%	2.0%	2.0%	2.0%	2.0%	2.0%	2.0%
50	Cumulative Rate Increase					4.50%	8.68%	13.03%	16.42%	23.40%	36.36%	50.68%	66.50%	76.49%	87.08%	98.30%	112.18%	118.53%	122.92%	129.61%	136.50%	143.59%	148.46%	153.43%	158.50%	163.67%	168.95%	174.32%	179.81%	185.41%	191.12%	196.94%
	Operating Fund Summary																															
51	Beginning of Year Balance					792,474	1,013,678	790,876	676,893	586,387	565,085	756,279	819,127	1,031,890	1,299,400	1,039,670	952,542	789,361	941,024	1,145,698	1,364,544	1,188,778	1,224,074	836,145	1,041,707	1,880,774	623,542	398,642	1,060,042	2,653,042	5,262,342	8,978,242
52	Operating Reserve Req in Rev Req					-	(222,803)	(113,983)	(90,506)	(21,301)	-	-	-	-	(259,730)	(87,128)	(163,181)	-	-	-	(175,766)	-	(387,929)	-	-	-	-	-	-	-	-	-
53	Net Annual Operating Balance					221,204	-	-	-	-	191,194	62,848	212,763	267,510	-	-	-	151,663	204,675	218,846	-	35,296	-	205,562	839,067	(1,257,231)	(224,900)	661,400	1,593,000	2,609,300	3,715,900	4,919,200
54	End of Year Balance					1,013,678	790,876	676,893	586,387	565,085	756,279	819,127	1,031,890	1,299,400	1,039,670	952,542	789,361	941,024	1,145,698	1,364,544	1,188,778	1,224,074	836,145	1,041,707	1,880,774	623,542	398,642	1,060,042	2,653,042	5,262,342	8,978,242	13,897,442
55	Annual Coverage Requirement					132%	105%	110%	111%	112%	125%	139%	148%	145%	135%	111%	111%	111%	110%	111%	110%	111%	110%	114%	119%	126%	135%	142%	150%	158%	167%	177%
56	Additional Bond Test							104%	115%	139%	178%	212%	238%	238%	225%	212%	200%	190%	191%	192%	192%	195%	204%	207%	210%	223%	240%	254%	268%	283%	299%	315%
56	Required Reserve Balance	Days of O&M	30.4			501,700	524,900	534,000	543,300	552,800	562,400	572,200	582,300	592,500	603,000	613,600	624,500	635,600	646,900	658,400	670,200	682,200	694,400	706,900	719,600	732,600	745,800	759,300	773,100	787,200	801,500	816,100

* City planned rate increases

** Sewer Connectin Fees projected to increase at 2% per year reflecting growth in customers.

Table 9-7D

SCENARIO D, Estimated Revenues and Revenue Requirements under Increased Rates

Line		Year	Projected Revenue Increase	Additional Required Revenue Increase	Projected Month Effective	(1) FY 2004	(2) FY 2005	(3) FY 2006	(4) FY 2007	(5) FY 2008	(6) FY 2009	(7) FY 2010	(8) FY 2011	(9) FY 2012	(10) FY 2013	(11) FY 2014	(12) FY 2015	(13) FY 2016	(14) FY 2017	(15) FY 2018	(16) FY 2019	(17) FY 2020	(18) FY 2021	(19) FY 2022	(20) FY 2023	(21) FY 2024	(22) FY 2025	(23) FY 2026	(24) FY 2027	(25) FY 2028	(26) FY 2029	(27) FY 2030
1	Sewer Sales - FY 2004 Rates					6,481,400	6,606,900	6,734,800	6,865,200	6,998,100	7,133,600	7,271,700	7,412,500	7,556,100	7,702,400	7,851,600	8,003,600	8,158,600	8,316,600	8,477,600	8,641,800	8,809,200	8,979,700	9,153,600	9,330,800	9,511,500	9,695,800	9,883,500	10,074,900	10,270,000	10,469,000	10,671,800
2		FY 2004	4.50%		12	291,700	297,300	303,100	308,900	314,900	321,000	327,200	333,600	340,000	346,600	353,300	360,200	367,100	374,200	381,500	388,900	396,400	404,100	411,900	419,900	428,000	436,300	444,800	453,400	462,200	471,100	480,200
3		Projected FY 2005 *	4.00%	0.00%	12		276,200	281,500	287,000	292,500	298,200	304,000	309,800	315,800	322,000	328,200	334,600	341,000	347,600	354,400	361,200	368,200	375,400	382,600	390,000	397,600	405,300	413,100	421,100	429,300	437,600	446,100
4		Projected FY 2006 *	4.00%	0.00%	12			292,800	298,400	304,200	310,100	316,100	322,200	328,500	334,800	341,300	347,900	354,700	361,500	368,500	375,700	383,000	390,400	397,900	405,600	413,500	421,500	429,700	438,000	446,500	455,100	463,900
5		Projected FY 2007 *	3.00%	0.00%	12				232,800	237,300	241,900	246,600	251,300	256,200	261,200	266,200	271,400	276,600	282,000	287,500	293,000	298,700	304,500	310,400	316,400	322,500	328,800	335,100	341,600	348,200	355,000	361,900
6		Projected FY 2008 *	3.00%	3.00%	12					488,800	498,300	507,900	517,800	527,800	538,000	548,400	559,100	569,900	580,900	592,200	603,600	615,300	627,200	639,400	651,800	664,400	677,300	690,400	703,700	717,400	731,300	745,400
7		FY 2009	6.00%		12						528,200	538,400	548,800	559,500	570,300	581,300	592,600	604,100	615,800	627,700	639,900	652,200	664,900	677,700	690,900	704,300	717,900	731,800	746,000	760,400	775,100	790,200
8		FY 2010	7.00%		12							665,800	678,700	691,900	705,300	718,900	732,900	747,000	761,500	776,300	791,300	806,600	822,200	838,100	854,400	870,900	887,800	905,000	922,500	940,400	958,600	977,200
9		FY 2011	8.00%		12								830,000	846,100	862,400	879,100	896,200	913,500	931,200	949,300	967,600	986,400	1,005,500	1,024,900	1,044,800	1,065,000	1,085,700	1,106,700	1,128,100	1,150,000	1,172,200	1,194,900
10		FY 2012	8.00%		12									913,800	931,400	949,500	967,900	986,600	1,005,700	1,025,200	1,045,000	1,065,300	1,085,900	1,106,900	1,128,400	1,150,200	1,172,500	1,195,200	1,218,300	1,242,000	1,266,000	1,290,500
11		FY 2013	8.00%		12										1,006,000	1,025,400	1,045,300	1,065,500	1,086,200	1,107,200	1,128,600	1,150,500	1,172,800	1,195,500	1,218,600	1,242,200	1,266,300	1,290,800	1,315,800	1,341,300	1,367,300	1,393,800
12		FY 2014	8.00%		12											1,107,500	1,128,900	1,150,800	1,173,100	1,195,800	1,218,900	1,242,500	1,266,600	1,291,100	1,316,100	1,341,600	1,367,600	1,394,100	1,421,100	1,448,600	1,476,700	1,505,300
13		FY 2015	7.00%		12												1,066,800	1,087,500	1,108,500	1,130,000	1,151,900	1,174,200	1,196,900	1,220,100	1,243,700	1,267,800	1,292,400	1,317,400	1,342,900	1,368,900	1,395,500	1,422,500
14		FY 2016	3.00%		12													498,700	508,300	518,200	528,200	538,500	548,900	559,500	570,300	581,400	592,700	604,100	615,800	627,800	639,900	652,300
15		FY 2017	3.00%		12														523,600	533,700	544,100	554,600	565,400	576,300	587,500	598,800	610,400	622,300	634,300	646,600	659,100	671,900
16		FY 2018	2.00%		12															366,500	373,600	380,800	388,200	395,700	403,400	411,200	419,200	427,300	435,600	444,000	452,600	461,400
17		FY 2019	2.00%		12																381,100	388,400	396,000	403,600	411,500	419,400	427,600	436,000	444,300	452,900	461,600	470,600
18		FY 2020	2.00%		12																	396,200	403,900	411,700	419,700	427,800	436,100	444,500	453,100	461,900	470,900	480,000
19		FY 2021	2.00%		12																		412,000	419,900	428,100	436,400	444,800	453,400	462,200	471,200	480,300	489,600
20		FY 2022	2.00%		12																			428,300	436,600	445,100	453,700	462,500	471,500	480,600	489,900	499,400
21		FY 2023	2.00%		12																				445,400	454,000	462,800	471,800	480,900	490,200	499,700	509,400
22		FY 2024	2.00%		12																					463,100	472,100	481,200	490,500	500,000	509,700	519,600
23		FY 2025	2.00%		12																						481,500	490,800	500,300	510,000	519,900	530,000
24		FY 2026	2.00%		12																							500,600	510,300	520,200	530,300	540,600
25		FY 2027	2.00%		12																								520,300	530,600	540,900	551,400
26		FY 2028	2.00%		12																									541,200	551,700	562,400
27		FY 2029	2.00%		12																										562,700	573,600
28		FY 2030	2.00%		12																											585,100
29	Total Additional Revenue					291,700	573,500	877,400	1,127,100	1,637,700	2,197,700	2,906,000	3,792,200	4,779,600	5,878,000	7,099,100	8,303,800	8,963,000	9,660,100	10,214,000	10,792,600	11,397,800	12,030,800	12,691,500	13,383,100	14,105,200	14,860,300	15,648,400	16,471,800	17,332,400	18,230,700	19,169,200
30	Total Sewer Sales Revenue					6,773,100	7,180,400	7,612,200	7,992,300	8,635,800	9,331,300	10,177,700	11,204,700	12,335,700	13,580,400	14,950,700	16,307,400	17,121,600	17,976,700	18,691,600	19,434,400	20,207,000	21,010,500	21,845,100	22,713,900	23,616,700	24,556,100	25,531,900	26,546,700	27,602,400	28,699,700	29,841,000
31	Sewer Connection Fees **					573,600	625,000	625,000	781,300	781,300	976,600	976,600	1,220,800	1,220,800	1,831,200	1,867,800	1,905,200	1,943,300	1,982,200	2,021,800	2,062,200	2,103,400	2,145,500	2,188,400	2,232,200	2,276,800	2,322,300	2,368,700	2,416,100	2,464,400	2,513,700	2,564,000
32	Other Operating Revenue					311,200	311,200	311,200	311,200	311,200	311,200	311,200	311,200	311,200	311,200	311,200	311,200	311,200	311,200	311,200	311,200	311,200	311,200	311,200	311,200	311,200	311,200	311,200	311,200	311,200	311,200	311,200
32	Interest Income					800,000	409,000	354,000	196,000	70,000	44,000	66,000	87,000	109,000	144,000	177,000	202,000	215,000	208,000	209,000	230,000	235,000	191,000	141,000	130,000	107,000	79,000	60,000	62,000	109,000	202,000	346,000
33	Other Non-Operating Revenue					15,500	15,500	15,500	15,500	15,500	15,500	15,500	15,500	15,500	15,500	15,500	15,500	15,500	15,500	15,500	15,500	15,500	15,500	15,500	15,500	15,500	15,500	15,500	15,500	15,500	15,500	15,500
34	Total Revenue					8,473,400	8,541,100	8,917,900	9,296,300	9,813,800	10,678,600	11,547,000	12,839,200	13,992,200	15,882,300	17,322,200	18,741,300	19,606,600	20,493,600	21,249,100	22,053,300	22,872,100	23,673,700	24,501,200	25,402,800	26,327,200	27,284,100	28,287,300	29,351,500	30,502,500	31,742,100	33,077,700
	Revenue Requirements																															
	Operating																															
35	Operation and Maintenance Expense					6,019,861	6,299,274	6,408,400	6,519,600	6,633,100	6,748,900	6,866,900	6,987,500	7,110,300	7,235,600	7,363,600	7,493,900	7,626,600	7,762,300	7,900,800	8,041,800	8,185,800	8,332,400	8,482,200	8,634,900	8,790,700	8,949,600	9,111,800	9,277,200	9,445,900	9,617,900	9,793,400
36	Operation and Maintenance Expense (From New Plant Expansion)					0	0	0	0	0	0	0	0	0	0	1,039,400	1,060,600	1,082,200	1,104,300	1,126,800	1,149,800	1,173,200	1,904,700	1,943,600	1,983,200	2,023,600	2,050,700	2,078,200	2,106,400	2,135,100	2,164,500	2,194,400
	Non Operating																															
37	Bank & Paying Agent Fees					58,000	58,000	58,000	58,000	58,000	58,000	58,000	58,000	58,000	58,000	58,000	58,000	58,000	58,000	58,000	58,000	58,000	58,000	58,000	58,000	58,000	58,000	58,000	58,000	58,000	58,000	58,000
38	Amortization					22,000	22,000	22,000	22,000	22,000	22,000	22,000	22,000	22,000	22,000	22,000	22,000	22,000	22,000	22,000	22,000	22,000	22,000	22,000	22,000	22,000	22,000	22,000	22,000	22,000	22,000	22,000
39	Net Revenue					2,373,539	2,161,826	2,429,500	2,696,700	3,100,700	3,849,700	4,600,100	5,771,700	6,801,900	8,566,700	8,839,200	10,106,800	10,817,800	11,547,000	12,141,500	12,781,700	13,433,100	13,356,600	13,995,400	14,704,700	15,432,900	16,203,800	17,017,300	17,887,900	18,841,500	19,879,700	21,009,900
	Debt Service																															
40	Existing Bonds - Principal & Interest					1,804,835	2,062,629	2,227,583	2,204,706	2,183,401	2,161,406	2,150,752	2,129,537	2,102,590	2,063,630	1,979,828	1,952,881	1,926,937	1,903,025	1,588,354	1,154,666	1,092,204	834,329	545,338	391,133	240,031	41,000	0	0	0	0	0	0
41	Proposed Bonds - Principal & Interest					-	-	-	117,600	476,100	985,800	1,562,700	2,304,800	3,125,400	4,304,500	5,730,000	6,945,500	7,589,700	8,082,600	9,079,600	10,356,700	11,006,400	11,345,300	11,762,600	11,989,400	12,070,600	12,098,600	12,098,600	12,098,600	12,098,600	12,098,600	12,098,600	12,098,600
42	Total Existing & Proposed Debt Service					1,804,835	2,062,629	2,227,583	2,322,306	2,659,501	3,147,206	3,713,452	4,434,337	5,227,990	6,368,130	7,709,828	8,898,381	9,516,637	9,985,625	10,667,954	11,511,366	12,098,604	12,179,629	12,307,938	12,380,533	12,310,631	12,139,600	12,098,600	12,098,600	12,098,600	12,098,600	12,098,600
43	Revenue Financed Capital					-	0	0	0	0	0	0	500,000	500,000	1,000,000	1,500,000	1,500,000	2,500,000	2,000,000	2,000,000	2,000,000	3,500,000	3,000,000	3,500,000	4,500,000	5,000,000	6,000,000	6,000,000	6,000,000	6,000,000	6,000,000	6,000,000
44	Routine Annual (from Budget)					347,500	322,000	328,400	334,900	341,500	348,400	355,400	362,500	369,700	377,200	384,800	392,500	400,400	408,400	416,600	424,900	433,400	442,000	450,800	459,800	469,000	478,400	488,000	497,800	507,800	518,000	528,300
45	Total Revenue Requirements					8,252,196	8,763,903	9,044,383	9,256,806	9,714,101	10,324,506	11,015,752	12,364,337	13,287,990	15,060,930	17,038,228	18,364,781	20,123,637	20,236,325	21,065,354	22,058,066	24,297,804	24,034,029	24,820,938	26,055,233	26,650,331	27,647,600	27,778,400	27,953,600	28,132,300	28,314,500	28,500,300
46	Annual Operating Balance/(Deficit)					221,204	(222,803)	(126,483)	39,494	99,699	354,094	531,248	474,863	704,210	821,370	283,972	376,519	(517,037)	257,275	183,746	(4,766)	(1,425,704)	(360,329)	(319,738)	(652,433)	(323,131)	(363,500)	508,900	1,397,900	2,370,200	3,427,600	4,577,400
47	Use of Reserves to Meet Rev. Req.					0	222,803	126,483	0	0	0	0	0	0	0	0	0	517,037	0	0	4,766	1,425,704	360,329	319,738	652,433	0	0	0	0	0	0	0
48	Net Annual Operating Balance					221,204	0	0	39,494	99,699	354,094	531,248	474,863	704,210	821,370	283,972	376,519	0	257,275	183,746	0	0	0	0	0	(323,131)	(363,500)	508,900	1,397,900	2,370,200	3,427,600	4,577,400
49	Projected Rate Increase					4.5%	4.0%	4.0%	3.0%	6.0%	6.0%	7.0%	8.0%	8.0%	8.0%	8.0%	7.0%	3.0%	3.0%	2.0%	2.0%	2.0%	2.0%	2.0%	2.0%	2.0%	2.0%	2.0%	2.0%	2.0%	2.0%	2.0%
50	Cumulative Rate Increase					4.50%	8.68%	13.03%	16.42%	23.40%	30.81%	39.96%	51.16%	63.25%	76.31%	90.42%	103.75%	109.86%	116.16%	120.48%	124.89%	129.39%	133.98%	138.65%	143.43%	148.30%	153.26%	158.33%	163.49%	168.76%	174.14%	179.62%
	Operating Fund Summary																															
51	Beginning of Year Balance					792,474	1,013,678	790,876	664,393	703,887	803,585	1,157,679	1,688,927	2,163,790	2,868,000	3,689,370	3,973,342	4,349,861	3,832,824	4,090,098	4,273,844	4,269,078	2,843,374	2,483,045	2,163,307	1,510,874	1,187,742	824,242	1,333,142	2,731,042	5,101,242	8,528,842
52	Operating Reserve Req in Rev Req					-	(222,803)	(126,483)	-	-	-	-	-	-	-	-	-	(517,037)	-	-	(4,766)	(1,425,704)	(360,329)	(319,738)	(652,433)	-	-	-	-	-	-	-
53	Net Annual Operating Balance					221,204	-	-	39,494	99,699	354,094	531,248	474,863	704,210	821,370	283,972	376,519	-	257,275	183,746	-	-	-	-	-	(323,131)	(363,500)	508,900	1,397,900	2,370,200	3,427,600	4,577,400
54	End of Year Balance					1,013,678	790,876	664,393	703,887	803,585	1,157,679	1,688,927	2,163,790	2,868,000	3,689,370	3,973,342	4,349,861	3,832,824	4,090,098	4,273,844	4,269,078	2,843,374	2,483,045	2,163,307	1,510,874	1,187,742	824,242	1,333,142	2,731,042	5,101,242	8,528,842	13,106,242
55	Annual Coverage Requirement					132%	105%	109%	116%	117%	122%	124%	130%	130%	135%	115%	114%	114%	116%	114%	111%	111%	110%	114%	119%	125%	133%	141%	148%	156%	164%	174%
56	Additional Bond Test							104%	115%	139%	153%	168%	180%	190%	191%	189%	179%	170%	175%	174%	171%	173%	182%	184%	188%	201%	215%	228%	242%	255%	270%	285%
56	Required Reserve Balance	Days of O&M	30.4			501,700	524,900	534,000	543,300	552,800	562,400	572,200	582,300	592,500	603,000	613,600	624,500	635,600	646,900	658,400	670,200	682,200	694,400	706,900	719,600	732,600	745,800	759,300	773,100	787,200	801,500	816,100

* City planned rate increases

** Sewer Connection Fees projected to increase at 2% per year reflecting growth in customers.

FY 2013	FY 2014	FY 2015	FY 2016	FY 2017	FY 2018	FY 2019	FY 2020	FY 2021	FY 2022	FY 2023	FY 2024	FY 2025	FY 2026	FY 2027	FY 2028	FY 2029	FY 2030

Table 9-8

Connection Fee Sensitivity Analysis

Line		(1) FY 2004 ($)	(2) FY 2005 ($)	(3) FY 2006 ($)	(4) FY 2007 ($)	(5) FY 2008 ($)	(6) FY 2009 ($)	(7) FY 2010 ($)	(8) FY 2011 ($)	(9) FY 2012 ($)	(10) FY 2013 ($)	(11) FY 2014 ($)	(12) FY 2015 ($)	(13) FY 2016 ($)	(14) FY 2017 ($)	(15) FY 2018 ($)	(16) FY 2019 ($)	(17) FY 2020 ($)	(18) FY 2021 ($)	(19) FY 2022 ($)	(20) FY 2023 ($)	(21) FY 2024 ($)	(22) FY 2025 ($)	(23) FY 2026 ($)	(24) FY 2027 ($)	(25) FY 2028 ($)	(26) FY 2029 ($)	(27) FY 2030 ($)
1	Connection Fee Revenue Under Existing Rates *	573,600	625,000	637,500	650,300	663,300	676,600	690,100	703,900	718,000	732,400	747,000	761,900	777,100	792,600	808,500	824,700	841,200	858,000	875,200	892,700	910,600	928,800	947,400	966,300	985,600	1,005,300	1,025,400
2	Additional Connection Fee Revenue (10%)	57,400	62,500	63,800	65,000	66,300	67,700	69,000	70,400	71,800	73,200	74,700	76,200	77,700	79,300	80,900	82,500	84,100	85,800	87,500	89,300	91,100	92,900	94,700	96,600	98,600	100,500	102,500
3	Additional Debt Supported	777,000	846,000	863,000	880,000	897,000	916,000	934,000	953,000	972,000	991,000	1,011,000	1,031,000	1,051,000	1,073,000	1,095,000	1,116,000	1,138,000	1,161,000	1,184,000	1,208,000	1,233,000	1,257,000	1,281,000	1,307,000	1,334,000	1,360,000	1,387,000
4	Additional Connection Fee Revenue (20%)	114,700	125,000	127,500	130,100	132,700	135,300	138,000	140,800	143,600	146,500	149,400	152,400	155,400	158,500	161,700	164,900	168,200	171,600	175,000	178,500	182,100	185,800	189,500	193,300	197,100	201,100	205,100
5	Additional Debt Supported	1,552,000	1,691,000	1,725,000	1,760,000	1,796,000	1,831,000	1,867,000	1,905,000	1,943,000	1,982,000	2,022,000	2,062,000	2,103,000	2,145,000	2,188,000	2,231,000	2,276,000	2,322,000	2,368,000	2,415,000	2,464,000	2,514,000	2,564,000	2,616,000	2,667,000	2,721,000	2,775,000
6	Additional Connection Fee Revenue (25%)	143,400	156,300	159,400	162,600	165,800	169,200	172,500	176,000	179,500	183,100	186,800	190,500	194,300	198,200	202,100	206,200	210,300	214,500	218,800	223,200	227,700	232,200	236,900	241,600	246,400	251,300	256,400
7	Additional Debt Supported	1,940,000	2,115,000	2,157,000	2,200,000	2,244,000	2,290,000	2,334,000	2,382,000	2,429,000	2,478,000	2,528,000	2,578,000	2,629,000	2,682,000	2,735,000	2,790,000	2,846,000	2,903,000	2,961,000	3,020,000	3,081,000	3,142,000	3,206,000	3,269,000	3,334,000	3,401,000	3,470,000

* Sewer Connectin Fees projected to increase at 2% per year reflecting growth in customers.

Capital Cost Recovery

Funding capital improvement costs of the sanitary sewer system may be accomplished through various methods. Only a few of these methods, however, have sufficient flexibility and revenue generating capacity to be used as the primary source of funding.

9.8 CASH FINANCING

Cash financing, often referred to as pay-as-you-go financing, involves allocating a portion of the annual revenue from sewer charges to pay for capital improvement expenditures. Cash financing typically utilizes revenues generated from charges for service, but could also include grants and tax revenues. Cash financing of capital improvements is limited by revenue sufficiency, reliability and priority. This can be a significant weakness of cash financing as competing demands for annual appropriations virtually rule it out as a source of funding for major capital improvements, land acquisition, and other large expenditures.

A major increase in cash funding for capital improvements can be achieved only by reducing appropriations to other programs, increasing revenues, or both; and if a shift in priorities is made in one year to accommodate cash financing of capital improvements, it can just as easily be reversed the next. This lack of stability from year to year makes it difficult to plan a thoughtful and coordinated program of system improvements based on cash financing. The implementation of a capital improvement program may experience significant delays as monies are accumulated. When projects are deferred, the eventual construction costs may rise due to the effects of inflation.

While cash financing is cheaper than debt financing because interest payments are avoided, the equity of cash financing is relatively low because current customers pay for long-lived facilities that provide benefits to future customers at little or no cost.

9.9 DEBT FINANCING

Revenue bonds and general obligation bonds are common funding methods for capital improvement projects and other capital outlays such as land and major equipment acquisition. Issuance of long term debt facilitates financing of large expenditures through loans which are repaid from revenues generated over a significant portion of the life of the acquired asset. Debt financing enhances the equity of cost recovery because new customers who benefit from the asset also help pay the cost associated with the asset.

When general tax revenues can be used for debt service, general obligation (GO) bonds are often issued because they normally receive more favorable bond ratings and

thus carry a lower rate of interest than revenue bonds issued by the same entity. Although GO bonds are guaranteed by the full faith and credit of the City and its resources, they may also be repaid from other sources of revenue such as user or service charges through a method referred to as "double-barrel" bonding. Revenue bonds are normally issued by enterprise fund operations, such as utilities that derive revenues primarily from user charges.

Both bond financing methods have advantages and disadvantages. GO bonds may benefit from lower interest rates and lower marketing costs because they are backed by the full faith and credit of the City. GO bonds may be preferred if the City is growing and the tax base is expanding rapidly. Revenue bonds may be more attractive than GO bonds when a dedicated and reliable source of revenue is available because the City's overall ability to issue GO bonds for other purposes is not diminished. Revenue bonds may be preferred when the utility is financially healthier than the City as a whole or if the City is approaching the debt ceiling for GO debt.

The ability to generate money for capital improvements through bonding is directly related to the capacity of the taxes, service charges, fees or other sources of revenue pledged to service the debt. In the case of GO bonds, it is subject to the financing capacity of the property and other general taxing authority and all other resources and assets. The bonding capacity for revenue bonds is a function of the charges, fees, or other resources that make up the revenue stream on which the sale is based.

Secondary revenue sources such as in lieu of construction fees and impact fees can also be used to repay revenue and general obligation bonds. They are not; however, stable and dependable funding sources on which to base a bond proposal, because their revenues are related to the pace of development.

The financial impact of revenue and GO bond financing on citizens and businesses is a function of the sources of revenue used for repayment. If revenue bonds are supported strictly by sewer service charges, the distribution of costs will be the same as that of the basic service charge rate structure. Use of secondary revenue sources could shift that distribution somewhat. GO bonding supported by the general revenues of the City would create a distribution proportionate to the sources of the general revenues, which may have little relationship to an individual taxpayer's contribution to costs associated with sanitary sewer service. However, if GO bonds are repaid from service charge revenues, the distribution will be based on the sewer rate methodology.

There are a number of variations available when structuring a bond issue. The issuer should discuss various bond structures with its financial advisor to ensure that benefits and risks of each structure are clearly understood.

- Double-barrel or combination bonds. The revenue stream of the issuer is pledged for repayment, and further backed by the full faith and credit of the City. Issuance of double-barrel bonds would be appropriate for a new enterprise fund with no track record of revenue generation.
- Floating or variable rate bonds. Interest rates are pegged to various market or treasury indices; interest rates are adjusted at specified intervals; and interest rates usually have a specified floor and ceiling. Such bonds are attractive to investors when there is an expectation that interest rates will rise.
- Original-issue discount bonds. These bonds are sold at a discount relative to par value, and at a low interest rate. These bonds are attractive when there is an expectation that interest rates will decline.
- Insured bonds. Payment of scheduled principal and interest payments is guaranteed through purchase of insurance, which typically results in the bonds receiving an AAA rating. Bonds are insured when the cost of the insurance is less than the additional interest that would be paid under the issuer's bond rating and the AAA rating.
- Bond anticipation notes. Debt issued for one year or less with the understanding that the notes will be converted to long term debt. Bond anticipation notes may be issued when interest rates are high and are expected to decline, or when the issuer is currently unable to meet all requirements for issuance of long term debt but expects to meet those requirements in the future.

9.10 STATE REVOLVING FUND LOAN

Loans and grants are available from the Missouri Department of Natural Resources (MDNR) through the State Revolving Fund (SRF) program. Because grants are directed toward small disadvantaged communities, the most probable form of assistance available to the City of Columbia is the leveraged loan. The SRF leveraged loan program provides financing at below market rates for eligible planning, design, and construction costs. Loans must be repaid within 20 years following completion of the construction contract. The interest subsidy is typically between 50 percent and 70 percent. An administrative fee of 0.5 percent of the outstanding balance is added. This structure currently results in a net cost of borrowing of less than 2.0 percent.

The loan recipient must authorize GO or revenue bonds to secure the debt. These bonds are then purchased by the State Environmental Improvement and Energy Resources Authority (EIERA) and resold on the open market. The proceeds of the bonds

are deposited with a trustee in the name of the loan recipient to be used for construction. As construction costs are incurred, state and federal funds are deposited into a reserve account in an amount equal to 50 percent or more of the construction cost. Interest earned on this reserve is credited to the interest portion of the debt on the bonds to provide the interest subsidy to the loan recipient.

Participation in the loan program requires filing a project proposal form and application. The applicant must meet certain requirements and may be required to provide additional information related to compliance history and technical, managerial, and financial capacity. Applications are ranked and placed on the Intended Use Plan in order of the number of priority points assigned. For some smaller capital projects, the cost of application and reporting may outweigh the benefits of the lower interest rate.

9.11 SYSTEM DEVELOPMENT CHARGES

Many utilities assess a capital recovery charge to meet costs for system capacity required by new customers. Generally levied at the time building or connection permits are required, the capital recovery charges are assessed for capacity requirements resulting from either changes in use of a premise served by an existing connection to the system, or a new connection to the system. Throughout this discussion, both sources of increased capacity requirements are included in the term "new customer."

The capital recovery charge is based on the principle that new customers or developers should pay for required system capacity, to the extent that service charges do not support the investment for the required capacity. Such charges may be referred to as capital recovery charges, development charges, system capacity charges, impact fees, system equity charges, or other terms.

The cost of providing capacity for new customers can contribute significantly to the need for capital financing and service rates and/or taxes to support the financing. Collection of a capital recovery charge to partially or wholly finance new customer capacity requirements can, over time, reduce the amount of financing and the magnitude of rate increase that otherwise might be required. Capital recovery charges may not entirely eliminate the need for future debt issues; however the decrease in debt financing needed will reduce debt service costs included in utility rates so that existing users are not heavily burdened by the costs of expansion caused by growth in system use by new customers. Capital recovery charges will also increase the utility's flexibility in timing debt issuance.

Developers sometimes oppose capital recovery charges because they add to up-front development costs. In other cases, developers support such fees because the utility might not otherwise be able to finance the facilities needed to accommodate growth.

9.11.1 Legal Considerations. The use of capital recovery charges to finance new customer service facilities has generally been concentrated in those areas experiencing moderate to rapid rates of growth, or in areas of scarce water supply such as Florida, Colorado, California, Texas and Arizona. Accordingly, many of the legislative and judicial requirements and precedents currently recognized in the industry have their origins in these areas.

A common standard for assessing the legality of capital recovery charges is the "rational nexus" or reasonable relationship test. This text requires that:

1. There is a reasonable connection between the need for additional facilities and the growth resulting from new development, i.e., new users has created a need for new capital facilities.
2. The capital recovery charges must not exceed a proportionate share of the cost incurred or to be incurred to accommodate the new users paying the fee, i.e., the fee must not exceed a new user's proportionate share of costs.
3. There is a reasonable connection between the expenditure of the fees collected and the benefits received by the new users paying the fees, i.e., all fees collected from new users actually, but not exclusively, benefit the new users.

Before applying the rational nexus test, courts have typically reviewed the municipality's statutory authority to levy a capital recovery charge. Some suggest that this review should be considered as the first criteria of a four-part rational nexus test. However, the establishment of legal authority to implement capital recovery charges is generally considered to be a separate issue and not part of the rational nexus test.

While there are no universally accepted industry standards governing the proper derivation and application of utility capital recovery charges, following is a brief discussion of certain common criteria which need to be recognized.

9.11.2 Proper Authorization Under Existing Law. A first step in implementing a capital recovery charge is to ascertain whether the utility has the proper legal authority for its enactment and enforcement. Challenges to established or proposed fees typically tend to center on three questions: First, do existing statutes, charters, grants of authority, etc. provide for, or at least allow, the utility to administer such a fee? Second, does the fee constitute an unlawful tax, in which case it may not be properly implemented without enabling legislation or approval by the electorate? Third, was the enacting ordinance properly drawn and adopted in accordance with applicable procedural requirements?

Numerous capital recovery charges have been challenged as an unlawful tax, in some instances successfully. Although laws and their interpretation may differ

significantly among various states, it may be significant to note that court decisions have, in varying degrees, ruled that capital recovery charges are not taxes so long as they do not exceed the reasonable cost of providing the service for which the fee is charged.

9.11.3 Uniformity of Application. Much of the criticism raised by developers and others across the nation regarding utility requirements for front end contributions and capital recovery charge payments for required service facilities, concerns allegations that utilities have adopted no uniform policy concerning the bases for such payments. The absence of such policies, some critics contend, can result in inconsistent treatment and in perceived, if not actual, financial discrimination among contributors. To provide assurance that all contributors are treated fairly and consistently and to reduce the potential threat of litigation or adverse legislation, some utilities have devoted considerable effort to the establishment of formal policies, rules and regulations, ordinances, etc. which set forth a system of uniform procedures and criteria to be recognized in establishing each new contributor's share of financial responsibility for utility development. Such policies can provide valuable ground rules to contributors and help assure them that all contribution amounts will be equitably determined and applied to their benefit.

9.11.4 Equitability. There appears to be considerable agreement in the utility industry and among legislators and the courts that capital recovery charges must be based on clearly defined needs and costs, and derived in a manner which fairly apportions costs in accordance with benefits provided. This is reflected both in court decisions and in manuals of practice published by the American Water Works Association (AWWA) and the Water Environment Federation (WEF).

Generally, AWWA and WEF refrain from citing specific procedures to be used in formulating capital recovery charges, thereby allowing utilities some latitude in meeting these two requirements. The manual *Financing and Charges for Wastewater Systems* briefly addresses two "most prominent" methods, including the "system buy-in" and "marginal/incremental cost" approaches. The *Principles of Water Rates, Fees and Charges* devotes an entire chapter to System Development Charges, including discussion of the equity (buy-in) method and the incremental cost method.

Irrespective of the specific methodology employed, it is important that such fees recognize only those costs associated with the provision of facility capacity required for growth and development, exclusive of both operation and maintenance expense and the costs of new or replacement facilities designed to meet the needs of existing utility customers. Further, in order to avoid overcharges, it is essential in deriving and applying capital recovery charges to recognize the effect of other possibly overlapping

contributions, and facilities financed through general service charges, so that the contributor's total payment responsibility does not exceed his share of the total cost or value of facilities required for service.

9.11.5 Methods of Calculating Capital Recovery Charges. The two basic methods for calculating capital recovery charges are the equity method and the incremental cost method. Either method may be appropriate depending on the utility's particular circumstances, and a combination of the two methods may be appropriate where some existing reserve capacity for growth is available and new capacity is planned.

The equity method, sometimes referred to as the system buy-in method, is based on the principle of achieving capital equity between new and existing customers by assessing new customers a fee that approximates the equity or debt-free investment of current customers. In this context, "equity" refers to that portion of system value for which there is no offsetting debt. It does not imply ownership of, nor title to, utility facilities.

The incremental cost method is based on the concept of new development paying for the incremental cost of system capacity needed to serve new development. The goal is to charge a fee for new customers that is sufficient to allow user rates to be revenue-neutral with respect to growth of the system. In systems experiencing rapid and expensive growth, this may be difficult to achieve.

9.11.6 Equity (Buy-In) Method. The equity method assumes that existing customers have provided equity in the existing system and that built-up equity should be applied to benefit those existing customers. The base level of the fee is set at the current level of system equity related to the capacity used to serve an existing equivalent residential customer. This approach is most appropriate when there is capacity available in existing facilities to serve new customers.

A key component of the equity method is determination of system equity. One measure of system value is original cost less accumulated depreciation (OCLD). The principal advantages of the OCLD method lie in its relative simplicity and stability, because the recorded costs of tangible property are held constant. The major criticism of OCLD pertains to the disregard of changes in the value of money over time attributed to inflation. Historically, prices have tended to increase rather than remain constant. Because the value of money varies inversely with changes in price, monetary values have declined; a fact not recognized by the OCLD approach. Since most utility systems are developed over time as the service area grows, each property addition was financed with

dollars of different purchasing power. When these outlays are added together to obtain a total plant value the result can be misleading.

Changes in the value of the dollar over time can be recognized by reproduction cost less accumulated depreciation (RCLD). Reproduction cost represents the cost of duplicating the existing facilities at current prices. (Replacement cost represents the estimated cost of facilities that would be built at the present time utilizing current technology.) Assuming original cost records are available, a reasonable estimate of reproduction cost can be determined by trending historical costs based on construction cost indices.

Whether using original cost or reproduction cost to establish asset value, accumulated depreciation should be deducted to reflect the value of the system available to new customers. In addition, outstanding long-term debt (in excess of available debt service reserves and unused construction funds) and any applicable contributions should be deducted from OCLD or RCLD to reflect system equity.

9.11.7 Incremental Cost Method. The premise that new system users should be responsible for the latest or next increment of costs which they cause to be incurred is the basis of the incremental cost method. Accordingly, capital recovery charges would be designed to derive the marginal or incremental cost of system expansion as may be determined by recent construction cost experience or planned future improvements.

In order to determine the true incremental cost of system expansion, it is necessary to conduct a detailed engineering analysis to establish the facilities required to increase the design capacity to a specific level to accommodate addition of new customers. Depending upon circumstances, the capacities of existing facilities which are available for new customers and their associated current value (RCLD) may also need to be recognized. The incremental cost of these specific facilities is then divided by the associated capacity provided to determine the incremental unit cost of additional capacity. In deriving capital cost recovery charges using the incremental cost method, the fee should be appropriately reduced to credit any obligation or debt which will be recovered from future users through the payment of ongoing user fees or other utility charges.

Use of this method is generally considered to be most appropriate when a significant portion of the capacity required to serve new customers must be provided by the construction of new facilities.

9.11.8 Combination of System Buy-In and Incremental Cost Method. This approach combines elements of both of the preceding methods to recognize certain advantages and minimize or eliminate certain drawbacks which may be associated with each under certain conditions. The combination method may be appropriate when a portion of the capacity required to serve new customers is available in the current system, but new facilities will need to be constructed to fully meet capacity requirements. Also, federal grant assistance and other non-utility based sources of funding (e.g. ad valorem taxes) used to help finance existing facilities, and which are recognized under the system buy-in method, may not be available to help pay for required new facilities. Although the incremental cost method recognizes the costs associated with constructing specific individual increments of new facility capacity required to meet growth needs, it can often be difficult to accurately ascertain that portion of capacity and associated value available to serve new customers in existing facility components.

By properly combining elements of each method, the value of system capacity can be established by recognizing the current value of all applicable existing service facilities, together with the estimated or actual cost of any required new service facilities. By combining these values and dividing by the associated total applicable service capacity, a reasonable measure of the value of system capacity applicable to new customer requirements can be derived.

9.11.9 Value-of-Service Method. The value-of-service method is sometimes employed to develop capital recovery charges for utilities. Although this method is simpler than the system buy-in, incremental, or combination methods, it does not typically recognize the direct cost or value of utility facilities required to provide service for the particular utility facilities involved. Rather, under this method, capital recovery charges are based on considerations such as the rates charged by other communities, the cost of service from available alternative facilities, or other similar measures. Because value of service measures are not typically based on the direct costs or value of facilities of the utility actually providing service, this method is not as readily supportable.

9.11.10 Economic Issues. Prior to implementing capital recovery charges, careful consideration should be given to the possibility of deterring growth in the service area. Capital recovery charges usually have the greatest negative economic impact on development projects that are in the planning stage. Phasing in the charge or setting an effective date in the future will mitigate the negative impact.

Consideration should also be given to when the charge is assessed and collected.

- At the time of platting. Collection of the charge when the development is platted allows the utility to collect the charges earlier in the project. At this stage, however, it may be difficult to determine the number of service units the development will require. Because of the number of estimates that must be made if the charge is paid at the time of platting, the calculation of the charge is less accurate and more difficult to defend.
- At issuance of the building permit. Because this is nearer the time service will be initiated, the impact of the new development can be better estimated. The exact impact is still not known, however.
- At the time service is requested. This is typically when the certificate of occupancy is issued or when the customer applies for water and sewer service. The utility receives the revenue later, but the service units are known at this time. Builders and developers may prefer this option because their carrying costs are lowered during the project. In fact, it is often the homeowner who directly pays the charge.

9.11.11 Administrative Issues. Procedures to administer the capital recovery charge program must be established, including a process for hearing appeals. Because capital recovery charges are assessed to recover the costs associated with new customers, it is important that receipts and expenditures be properly documented. Receipts should be accounted for in a manner similar to contributed facilities, rather than included as part of general operating revenues. Capital recovery charge funds should only be used for capital related purposes, i.e., construction of facilities or retirement of debt associated with facilities related to system growth.

STATE OF MISSOURI

DEPARTMENT OF NATURAL RESOURCES

MISSOURI CLEAN WATER COMMISSION

MISSOURI STATE OPERATING PERMIT

In compliance with the Missouri Clean Water Law, (Chapter 644 R.S. Mo. as amended, hereinafter, the Law), and the Federal Water Pollution Control Act (Public Law 92-500, 92nd Congress) as amended.

Permit No.:	MO-0097837
Owner:	City of Columbia
Address:	PO Box 6015, Columbia, MO 65205
Continuing Authority:	Same as above
Address:	Same as above
Facility Name:	Columbia Regional Wastewater Treatment Plant
Address:	4900 West Gillespie Bridge Road, Columbia, MO 65203
Legal Description:	See page 2
Receiving Stream:	See page 2
First Classified Stream and ID:	See page 2
USGS Basin & Sub-watershed No.:	See page 2

is authorized to discharge from the facility described herein, in accordance with the effluent limitations and monitoring requirements as set forth herein:

FACILITY DESCRIPTION

See page 2

This permit authorizes only wastewater discharges under the Missouri Clean Water Law and the National Pollutant Discharge Elimination System; it does not apply to other regulated areas. This permit may be appealed in accordance with Section 644.051.6 of the Law.

May 5, 2000
Effective Date

March 12, 2004
Revised

Stephen M. Mahfood, Director, Department of Natural Resources
Executive Secretary, Clean Water Commission

May 4, 2005
Expiration Date

Jim Hull, Director of Staff, Clean Water Commission

FACILITY DESCRIPTION (continued)

Outfall #001 - POTW - SIC #4952
Activated sludge/anaerobic sludge digester/sludge is being land applied/sludge storage basin/wetland treatment.
Design population equivalent is 174,058.
Design flow is 20.6 MGD.
Actual flow is 15.5 MGD.
Design sludge production is 3,435 dry tons/year.
Actual sludge production is 2,704 dry tons/year.
Legal Description: Sec. 18, T47N, R13W, Boone County
Receiving Stream: Eagle Bluffs Conservation Area (U)
First Classified Stream & ID: Missouri River (P) (00701)
USGS Basin and Subwatershed: (10300102-320003)

Outfall #002- POTW - SIC #4952
Emergency Discharge only, due to inability to get wastewater to the wetlands (flooding, line break or blockage, construction, etc.)
Legal Description: NE ¼, SW ¼, Sec. 29, T48N, R13W, Boone County
Receiving Stream: Hinkson Creek (P)
First Classified Stream & ID: Hinkson Creek (P) (01007)
USGS Basin and Subwatershed: (10310102-120002)

Outfall #003 - POTW - SIC #4952
Stormwater discharge from wastewater plant grounds.
Flow dependent upon precipitation.
Legal Description: NE ¼, SW ¼, Sec. 29, T48N, R13W, Boone County
Receiving Stream: Hinkson Creek (P)
First Classified Stream & ID: Hinkson Creek (P) (01007)
USGS Basin & Subwatershed: (10300102-120002)

Outfall #004 - POTW - SIC #4952
Stormwater discharge from wastewater plant grounds.
Flow dependent upon precipitation.
Legal Description: SE ¼, NW ¼, Sec. 29, T48N, R13W, Boone County
Receiving Stream: Unnamed Tributary to Hinkson Creek (U)
First Classified Stream & ID: Hinkson Creek (P) (01007)
USGS Basin & Subwatershed: (10300102-120002)

A. EFFLUENT LIMITATIONS AND MONITORING REQUIREMENTS

The permittee is authorized to discharge from outfall(s) with serial number(s) as specified in the application for this permit. The final effluent limitations shall become effective upon issuance and remain in effect until expiration of the permit. Such discharges shall be controlled, limited and monitored by the permittee as specified below:

OUTFALL NUMBER AND EFFLUENT PARAMETER(S)	UNITS	FINAL EFFLUENT LIMITATIONS			MONITORING REQUIREMENTS	
		DAILY MAXIMUM	WEEKLY AVERAGE	MONTHLY AVERAGE	MEASUREMENT FREQUENCY	SAMPLE TYPE
Outfall #001 Flow	MGD	*		*	once/weekday**	24 hr. total
Biochemical Oxygen Demand$_5$***	mg/L		45	30	once/weekday**	24 hr. composite
Total Suspended Solids*** (Note 1)	mg/L		45	30	once/weekday**	24 hr. composite
pH - Units	SU	****		****	once/weekday**	grab
MONITORING REPORTS SHALL BE SUBMITTED MONTHLY; THE FIRST REPORT IS DUE May 28, 2004.						
Whole Effluent Toxicity (WET) Test	% Survival	See Special Conditions			once/year	24 hr. composite
MONITORING REPORTS SHALL BE SUBMITTED ANNUALLY; THE FIRST REPORT IS DUE October 28, 2004.						
Total Arsenic	µg/L	160			once/quarter*****	24 hr. composite
Total Copper	µg/L	464			once/quarter*****	24 hr. composite
Total Zinc	µg/L	*			once/quarter*****	24 hr. composite
Total Nickel	µg/L	*			once/quarter*****	24 hr. composite
Total Cadmium	µg/L	576			once/quarter*****	24 hr. composite
Total Mercury	µg/L	19			once/quarter*****	24 hr. composite
Total Lead	µg/L	1520			once/quarter*****	24 hr. composite
Total Chromium	µg/L	496			once/quarter*****	24 hr. composite
Total Silver	µg/L	104			once/quarter*****	24 hr. composite
Total Cyanide	µg/L	176			once/quarter*****	grab
MONITORING REPORTS SHALL BE SUBMITTED QUARTERLY; THE FIRST REPORT IS DUE April 28, 2004.						
Outfall #002 - Emergency Discharge						
Flow	MGD		*		once/day	24 hr. total
Biochemical Oxygen Demand	mg/L		45		once/day	grab
Total Suspended Solids	mg/L		45		once/day	grab
pH - Units	SU		****		once/day	grab
MONITORING REPORTS SHALL BE SUBMITTED MONTHLY; THE FIRST REPORT IS DUE July 28, 2004. THERE SHALL BE NO DISCHARGE OF FLOATING SOLIDS OR VISIBLE FOAM IN OTHER THAN TRACE AMOUNTS.						

B. STANDARD CONDITIONS

IN ADDITION TO SPECIFIED CONDITIONS STATED HEREIN, THIS PERMIT IS SUBJECT TO THE ATTACHED Parts I, II & III STANDARD CONDITIONS DATED October 1, 1980 and August 15, 1994, AND HEREBY INCORPORATED AS THOUGH FULLY SET FORTH HEREIN.

A. EFFLUENT LIMITATIONS AND MONITORING REQUIREMENTS

The permittee is authorized to discharge from outfall(s) with serial number(s) as specified in the application for this permit. The final effluent limitations shall become effective upon issuance and remain in effect until expiration of the permit. Such discharges shall be controlled, limited and monitored by the permittee as specified below:

OUTFALL NUMBER AND EFFLUENT PARAMETER(S)	UNITS	FINAL EFFLUENT LIMITATIONS			MONITORING REQUIREMENTS	
		DAILY MAXIMUM	WEEKLY AVERAGE	MONTHLY AVERAGE	MEASUREMENT FREQUENCY	SAMPLE TYPE
Outfalls #003 & 004						
Flow	MGD		*	*	Monitoring will only be required at the request of the Department.	
Biochemical Oxygen Demand	mg/L		*	*		
Total Suspended Solids	mg/L		*	*		
pH - Units	SU		*	*		
MONITORING REPORTS SHALL BE SUBMITTED QUARTERLY; THE FIRST REPORT IS DUE July 28, 2004.						
Sludge Lagoon						
Lagoon Freeboard (Note 2)	feet	*			once/quarter*****	depth measurement
Groundwater Monitoring Wells at On- Site Sludge Application Area (Note 3)						
Water Level	feet	*			once/month*****	depth measurement
Total Suspended Solids	mg/L	*			once/month	grab
Total Dissolved Solids	mg/L	*			once/month	grab
Nitrate Nitrogen as N	mg/L	10			once/month	grab
Ammonia Nitrogen as N	mg/L	*			once/month	grab
pH - Units	SU	****		****	once/month	grab
Total Recoverable Copper	µg/L	1000			once/year	grab
Total Recoverable Zinc	µg/L	5000			once/year	grab
Total Recoverable Nickel	µg/L	100			once/year	grab
Total Recoverable Cadmium	µg/L	5			once/year	grab
Total Recoverable Mercury	µg/L	2			once/year	grab
Total Recoverable Lead	µg/L	15			once/year	grab
Total Recoverable Silver	µg/L	50			once/year	grab
Total Recoverable Arsenic	µg/L	50			once/year	grab
Total Recoverable Manganese	µg/L	*			once/year	grab
Total Recoverable Cyanide	µg/L	50			once/year	grab
Total Recoverable Molybdenum	µg/L	*			once/year	grab
Total Recoverable Selenium	µg/L	10			once/year	grab
Total Recoverable Aluminum	µg/L	*			once/year	grab

MONITORING REPORTS SHALL BE SUBMITTED ANNUALLY; THE FIRST REPORT IS DUE October 28, 2004. THERE SHALL BE NO DISCHARGE OF FLOATING SOLIDS OR VISIBLE FOAM IN OTHER THAN TRACE AMOUNTS.

B. STANDARD CONDITIONS

IN ADDITION TO SPECIFIED CONDITIONS STATED HEREIN, THIS PERMIT IS SUBJECT TO THE ATTACHED Parts I, II & III STANDARD CONDITIONS DATED October 1, 1980 and August 15, 1994, AND HEREBY INCORPORATED AS THOUGH FULLY SET FORTH HEREIN.

A. EFFLUENT LIMITATIONS AND MONITORING REQUIREMENTS

The permittee is authorized to discharge from outfall(s) with serial number(s) as specified in the application for this permit. The final effluent limitations shall become effective upon issuance and remain in effect until expiration of the permit. Such discharges shall be controlled, limited and monitored by the permittee as specified below:

OUTFALL NUMBER AND EFFLUENT PARAMETER(S)	UNITS	FINAL EFFLUENT LIMITATIONS			MONITORING REQUIREMENTS	
		DAILY MAXIMUM	WEEKLY AVERAGE	MONTHLY AVERAGE	MEASUREMENT FREQUENCY	SAMPLE TYPE
Groundwater Monitoring at Wetland Cells Area (Note 4)						
Water Level	feet	*			once/quarter*****	depth measurement
Conductivity	umhos/cm	*			once/quarter*****	grab
Nitrate Nitrogen	mg/L	*			once/quarter*****	grab
Total Nitrogen	mg/L	*			once/quarter*****	grab
Total Copper	µg/L	*			once/quarter*****	grab
Total Zinc	µg/L	*			once/quarter*****	grab
Total Nickel	µg/L	*			once/quarter*****	grab
Total Cadmium	µg/L	*			once/quarter*****	grab
Total Mercury	µg/L	*			once/quarter*****	grab
Total Lead	µg/L	*			once/quarter*****	grab
Toal Silver	µg/L	*			once/quarter*****	grab
Total Manganese	µg/L	*			once/quarter*****	grab
pH- Units	SU	****		****	once/quarter*****	grab

MONITORING REPORTS SHALL BE SUBMITTED ANNUALLY; THE FIRST REPORT IS DUE October 28, 2004. THERE SHALL BE NO DISCHARGE OF FLOATING SOLIDS OR VISIBLE FOAM IN OTHER THAN TRACE AMOUNTS.

B. STANDARD CONDITIONS

IN ADDITION TO SPECIFIED CONDITIONS STATED HEREIN, THIS PERMIT IS SUBJECT TO THE ATTACHED Parts I, II & III STANDARD CONDITIONS DATED October 1, 1980 and August 15, 1994, AND HEREBY INCORPORATED AS THOUGH FULLY SET FORTH HEREIN.

MO 780-0010 (8/91)

A. EFFLUENT LIMITATIONS AND MONITORING REQUIREMENTS (continued)

* Monitoring requirement only.
** Once each weekday means: Monday, Tuesday, Wednesday, Thursday, and Friday.
*** This facility is required to meet a removal efficiency of 85% or more.
**** pH is measured in pH units and is not to be averaged. The pH is limited to the range of 6.0-9.0 pH units.
***** Once per quarter in the months of March, June, September, and November.

Note 1- Total Suspended Solids (TSS) may be exceeded periodically due to heavy use by waterfowl. The effluent limits for TSS during these periods shall be a weekly average of 100 mg/L and monthly average of 70 mg/L. Each instance of heavy waterfowl usage shall be documented by the City and confirmed by the Missouri Department of Conservation.

Note 2 - depth measured from the top of the supernatant overflow weir to the top of the sludge layer.

Note 3 - Ground water samples will be collected from the monitoring wells located on the dedicated sludge disposal site. The depth of the water in the well shall be measured from the top of the well casing.

A. EFFLUENT LIMITATIONS AND MONITORING REQUIREMENTS (continued)

Note 4 - Ground water samples will be collected from monitoring wells located around the Wetland Area (eight locations, two wells per location). These include MW1-1A & MW1-1B, MW1-2A & MW1-2B, MW1-3A & MW1-3B, MW1-4A & MW1-4B, MW2-1A & MW2-1B, MW3-1A & MW3-1B, MW4-1A & MW4-1B, and MW4-2A & MW4-2B. Wells MW2-2A and MW2-2B will no longer be sampled. The depth of water in the well shall be measured from the top of the wall casing. The sample may be collected from the shallowest well at each location which contains ground water.

C. SPECIAL CONDITIONS

1. This permit may be reopened and modified, or alternatively revoked and reissued, to:
   (a) Comply with any applicable effluent standard or limitation issued or approved under Sections 301(b)(2)(C) and (D), 304(b)(2), and 307(a) (2) of the Clean Water Act, if the effluent standard or limitation so issued or approved:
      (1) contains different conditions or is otherwise more stringent than any effluent limitation in the permit; or
      (2) controls any pollutant not limited in the permit.
   (b) Incorporate new or modified effluent limitations or other conditions, if the result of a waste load allocation study, toxicity test or other information indicates changes are necessary to assure compliance with Missouri's Water Quality Standards.
   (c) Incorporate new or modified effluent limitations or other conditions if, as the result of a watershed analysis, a Total Maximum Daily Load (TMDL) limitation is developed for the receiving waters which are currently included in Missouri's list of waters of the state not fully achieving the state's water quality standards, also called the 303(d) list.

   The permit as modified or reissued under this paragraph shall also contain any other requirements of the Clean Water Act then applicable.

2. All outfalls must be clearly marked in the field.

3. Changes in Discharges of Toxic Substances

   The permittee shall notify the Director as soon as it knows or has reason to believe:
   (a) That any activity has occurred or will occur which would result in the discharge of any toxic pollutant which is not limited in the permit, if that discharge will exceed the highest of the following "notification levels:"
      (1) One hundred micrograms per liter (100 µg/L);
      (2) Two hundred micrograms per liter (200 µg/L) for acrolein and acrylonitrile; five hundred micrograms per liter (500 µg/L) for 2,5 dinitrophenol and for 2-methyl-4, 6-dinitrophenol; and one milligram per liter (1 mg/L) for antimony;
      (3) Five (5) times the maximum concentration value reported for the pollutant in the permit application;
      (4) The level established in Part A of the permit by the Director.
   (b) That they have begun or expect to begin to use or manufacture as an intermediate or final product or byproduct any toxic pollutant, which was not reported in the permit application.

4. Report as no-discharge when a discharge does not occur during the report period.

C. SPECIAL CONDITIONS (continued)

5. General Criteria. The following water quality criteria shall be applicable to all waters of the state at all times including mixing zones. No water contaminant, by itself or in combination with other substances, shall prevent the waters of the state from meeting the following conditions:
   (a) Waters shall be free from substances in sufficient amounts to cause the formation of putrescent, unsightly or harmful bottom deposits or prevent full maintenance of beneficial uses;
   (b) Waters shall be free from oil, scum and floating debris in sufficient amounts to be unsightly or prevent full maintenance of beneficial uses;
   (c) Waters shall be free from substances in sufficient amounts to cause unsightly color or turbidity, offensive odor or prevent full maintenance of beneficial uses;
   (d) Waters shall be free from substances or conditions in sufficient amounts to result in toxicity to human, animal or aquatic life;
   (e) There shall be no significant human health hazard from incidental contact with the water;
   (f) There shall be no acute toxicity to livestock or wildlife watering;
   (g) Waters shall be free from physical, chemical or hydrologic changes that would impair the natural biological community;
   (h) Waters shall be free from used tires, car bodies, appliances, demolition debris, used vehicles or equipment and solid waste as defined in Missouri's Solid Waste Law, section 260.200, RSMo, except as the use of such materials is specifically permitted pursuant to section 260.200-260.247.

6. Sludge and Biosolids Use For Domestic Wastewater Treatment Facilities
   (a) Permittee shall comply with the pollutant limitations, monitoring, reporting, and other requirements in accordance with the attached permit Standard Conditions.
   (b) If sludge is not removed by a contract hauler, permittee is authorized to land apply biosolids. Permit Standard Conditions, Part III shall apply to the land application of biosolids. Permittee shall notify the department at least 180 days prior to the planned removal of biosolids. The department may require submittal of a biosolids management plan for department review and approval as determined appropriate on a case-by-case basis.

7. Whole Effluent Toxicity (WET) tests will be conducted as follows:

SUMMARY OF WET TESTING FOR THIS PERMIT				
OUTFALL	A.E.C. %	FREQUENCY	SAMPLE TYPE	MONTH
#001	100%	Annually	24 hr. composite	August

   (a) Test Schedule and Follow-Up Requirements

      (1) Perform a single-dilution test in the months and at the frequency specified above. If the effluent passes the test, do not repeat the test until the next test period.
      Submit test results along with complete copies of the test reports as received from the laboratory within 30 calendar days of availability to the WPCP, Water Quality Section, P.O. Box 176, Jefferson City, MO 65102.

C. SPECIAL CONDITIONS (continued)

7. Whole Effluent Toxicity (WET) (continued)

(a) Test Schedule and Follow-Up Requirements (continued)

(2) If the effluent fails the test, a multiple dilution test shall be performed within 30 calendar days, and biweekly thereafter, until one of the following conditions are met:

(a) THREE CONSECUTIVE MULTIPLE-DILUTION TESTS PASS. No further tests need to be performed until next regularly scheduled test period.
(b) A TOTAL OF THREE MULTIPLE-DILUTION TESTS FAIL.

(3) The permittee shall submit a summary of all test results for the test series along with complete copies of the test reports as received from the laboratory to the WPCP, Planning Section, P.O. Box 176, Jefferson City, MO 65102 within 14 calendar days of the third failed test.

(4) Additionally, the following shall apply upon failure of the third test: A toxicity identification evaluation (TIE) or toxicity reduction evaluation (TRE) is automatically triggered. The permitee shall contact WPCP, Planning Section to ascertain as to whether a TIE or TRE is appropriate . The permittee shall submit a plan for conducting a TIE or TRE to the Planning Section of the WPCP within 60 calendar days of the date of DNR's direction to perform either a TIE or TRE. This plan must be approved by DNR before the TIE or TRE is begun. A schedule for completing the TIE or TRE shall be established in the plan approval.

(5) Upon DNR's approval, the TIE/TRE schedule may be modified if toxicity is intermittent during the TIE/TRE investigations. A revised WET test schedule may be established by DNR for this period.

(6) If a previously completed TIE has clearly identified the cause of toxicity, additional TIEs will not be required as long as effluent characteristics remain essentially unchanged and the permittee is proceeding according to a DNR approved schedule to complete a TRE and reduce toxicity. Regularly scheduled WET testing as required in the permit, without the follow-up requirements, will be required during this period.

(7) All failing test results shall be reported to WPCP, Planning Section, P.O. Box 176, Jefferson City, MO 65102within 14 calendar days of the availability of the results.

(8) When WET test sampling is required to run over one DMR period, each DMR report shall contain information generated during the reporting period.

(9) Submit a concise summary of all test results with the annual report.

(b) PASS/FAIL procedure and effluent limitations:

(1) To pass a single-dilution test, mortality observed in the AEC test concentration shall not be significantly different (at the 95% confidence level; $p = 0.05$) than that observed in the upstream receiving-water control sample. The appropriate statistical tests of significance will be those outlined in the most current USEPA acute toxicity manual or those specified by the MDNR.

C. SPECIAL CONDITIONS (continued)

7. Whole Effluent Toxicity (WET) (continued)

(b) PASS/FAIL procedure and effluent limitations (continued)

(2) To pass a multiple-dilution test:

(a) the computed percent effluent at the edge of the zone of initial dilution, Acceptable Effluent Concentration (AEC), must be less than three-tenths (0.3) of the LC_{50} concentration for the most sensitive of the test organisms; or,
(b) all dilutions equal to or greater than the AEC must be nontoxic. Failure of one multiple-dilution test is an effluent limit violation.

(c) Test Conditions

(1) Test Type: Acute Static non-renewal

(2) Test species: Ceriodaphnia dubia and Pimephales promelas (fathead minnow). Organisms used in WET testing shall come from cultures reared for the purpose of conducting toxicity tests and cultured in a manner consistent with the most current USEPA guidelines. All test animals shall be cultured as described in the most current edition of Methods for Measuring the Acute Toxicity of Effluents and Receiving Waters to Freshwater and Marine Organisms.

(3) Test period: 48 hours at the "Acceptable Effluent Concentration" (AEC) specified above.

(4) When dilutions are required, upstream receiving stream water shall be used as dilution water. If upstream water is unavailable or if mortality in the upstream water exceeds 10%, "reconstituted" water will be used as dilution water. Procedures for generating reconstituted water will be supplied by the MDNR upon request.

(5) Single-dilution tests will be run with:
(a) Effluent at the AEC concentration;
(b) 100% receiving-stream water (if available), collected upstream of the outfall at a point beyond any influence of the effluent; and
(c) reconstituted water.

(6) Multiple-dilution tests will be run with:
(a) 100%, 50%, 25%, 12.5%, and 6.25% effluent, unless the AEC is less than 25% effluent, in which case dilutions will be 4 times the AEC, two times the AEC, AEC, 1/2 AEC and 1/4 AEC;
(b) 100% receiving-stream water (if available), collected upstream of the outfall at a point beyond any influence of the effluent; and
(c) reconstituted water.

(7) If reconstituted-water control mortality for a test species exceeds 10%, the entire test will be rerun.

SUMMARY OF TEST METHODOLOGY FOR WHOLE-EFFLUENT TOXICITY TESTS

Whole-effluent-toxicity test required in NPDES permits shall use the following test conditions when performing single or multiple dilution methods. Any future changes in methodology will be supplied to the permittee by the Missouri Department of Natural Resources (MDNR). Unless more stringent methods are specified by the DNR,the procedures shall be consistent with the most current edition of Methods for Measuring the Acute Toxicity of Effluents and Receiving Waters to Freshwater and Marine Organisms,

Test conditions for Ceriodaphnia dubia:

Test duration:	48 h
Temperature:	25 ± 1°C Temperatures shall not deviate by more than 3°C during the test.
Light Quality:	Ambient laboratory illumination
Photoperiod:	16 h light, 8 h dark
Size of test vessel:	30 mL (minimum)
Volume of test solution:	15 mL (minimum)
Age of test organisms:	<24 h old
No. of animals/test vessel:	5
No. of replicates/concentration:	4
No. of organisms/concentration:	20 (minimum)
Feeding regime:	None (feed prior to test)
Aeration:	None
Dilution water:	Upstream receiving water; if no upstream flow, synthetic water modified to reflect effluent hardness.
Endpoint:	Pass/Fail (Statistically significant Mortality when compared to upstream receiving water control or synthetic control if upstream water was not available at $p \leq 0.05$)
Test acceptability criterion:	90% or greater survival in controls

Test conditions for (Pimephales promelas):

Test duration:	48 h
Temperature:	25 ± 1°C Temperatures shall not deviate by more than 3°C during the test.
Light Quality:	Ambient laboratory illumination
Photoperiod:	16 h light/ 8 h dark
Size of test vessel:	250 mL (minimum)
Volume of test solution:	200 mL (minimum)
Age of test organisms:	1-14 days (all same age)
No. of animals/test vessel:	10
No. of replicates/concentration:	4 (minimum) single dilution method 2 (minimum) multiple dilution method
No. of organisms/concentration:	40 (minimum) single dilution method 20 (minimum) multiple dilution method
Feeding regime:	None (feed prior to test)
Aeration:	None, unless DO concentration falls below 4.0 mg/L; rate should not exceed 100 bubbles/min.
Dilution water:	Upstream receiving water; if no upstream flow, synthetic water modified to reflect effluent hardness.
Endpoint:	Pass/Fail (Statistically significant Mortality when compared to upstream receiving water control or synthetic control if upstream water was not available at $p \leq 0.05$)
Test Acceptability criterion:	90% or greater survival in controls

Appendix B
Future Sewer Extensions
10-Year Ultimate Flows

Pipe Network ID	Project ID	Planning Year Needed	Length	Design Slope	Ultimate Design Flow (cfs)	Pipe Diameter	Unit Cost ($)	Cost ($)
373	HF10	ULTIMATE	1,585	0.00637	1.00	8	$85	$134,284
20	HF10-1	2010	2,330	0.01309	4.08	15	$113	$263,949
340	HF10-1	2010	1,979	0.01011	4.08	15	$113	$224,224
Sub-total			5,894					$622,458
12	HF11	2010	740	0.03206	46.94	36	$220	$162,888
13	HF11	ULTIMATE	618	0.00600	46.95	36	$220	$136,011
14	HF11	ULTIMATE	737	0.00600	21.51	27	$167	$123,170
15	HF11	ULTIMATE	409	0.12214	16.57	24	$149	$60,793
138	HF11	ULTIMATE	3,449	0.00580	4.38	15	$113	$390,722
140	HF11	ULTIMATE	5,150	0.00583	7.45	18	$124	$640,089
142	HF11	ULTIMATE	3,913	0.00045	9.83	18	$124	$486,429
143	HF11	2020	3,664	0.01365	11.05	18	$124	$455,431
146	HF11	2020	643	0.00694	13.46	21	$138	$88,362
148	HF11	2020	4,601	0.00694	15.66	24	$149	$683,213
154	HF11	2010	1,727	0.00868	20.25	24	$149	$256,507
156	HF11	2010	3,546	0.00846	23.16	27	$167	$592,821
335	HF11	ULTIMATE	1,708	0.01757	1.71	8	$85	$144,633
155	HF11-1	2020	1,779	0.02810	1.19	8	$85	$150,710
16	HF11-10	ULTIMATE	1,173	0.01705	0.95	8	$85	$99,377
153	HF11-2	2010	3,121	0.02403	1.75	8	$85	$264,365
150	HF11-3	2010	3,041	0.03124	1.20	8	$85	$257,556
151	HF11-4	2010	2,442	0.01843	2.82	10	$92	$225,596
152	HF11-4	2010	2,912	0.01545	3.46	12	$103	$301,107
149	HF11-5	2010	3,225	0.01550	1.15	8	$85	$273,171
147	HF11-6	2020	2,315	0.01944	1.53	8	$85	$196,049
144	HF11-7	2020	1,956	0.01534	2.00	10	$92	$180,762
145	HF11-7	2020	1,960	0.02041	2.80	10	$92	$181,061
141	HF11-8	ULTIMATE	810	0.02470	1.11	8	$85	$68,593
139	HF11-9	ULTIMATE	1,664	0.01202	1.54	8	$85	$140,975
Sub-total			57,302					$6,560,391
127	HF12	ULTIMATE	3,452	0.01304	1.53	8	$85	$292,403
129	HF12	ULTIMATE	3,928	0.00509	4.04	15	$113	$445,014
132	HF12	2020	3,493	0.00372	14.54	24	$149	$518,773
334	HF12	ULTIMATE	6,170	0.00486	10.99	21	$138	$848,332
135	HF12-1	2020	2,254	0.01331	1.66	10	$92	$208,296
133	HF12-2	2020	3,206	0.00780	1.87	10	$92	$296,273
131	HF12-3	2020	3,947	0.01900	3.18	10	$92	$364,702
130	HF12-4	ULTIMATE	7,780	0.00707	4.84	15	$113	$881,524
128	HF12-5	ULTIMATE	1,334	0.01874	0.95	8	$85	$112,986
Sub-total			35,565					$3,968,304
8	HF13	ULTIMATE	245	0.05932	13.28	21	$138	$33,675
9	HF13	ULTIMATE	907	0.01102	7.19	15	$113	$102,788
120	HF13	ULTIMATE	3,293	0.00607	2.77	12	$103	$340,546

Appendix B
Future Sewer Extensions
10-Year Ultimate Flows

Pipe Network ID	Project ID	Planning Year Needed	Length	Design Slope	Ultimate Design Flow (cfs)	Pipe Diameter	Unit Cost ($)	Cost ($)
121	HF13	ULTIMATE	5,365	0.00373	4.19	15	$113	$607,849
123	HF13	2010	1,668	0.00045	8.25	21	$138	$229,369
124	HF13	2010	4,582	0.00655	10.11	21	$138	$630,024
126	HF13	2010	3,089	0.00648	13.35	21	$138	$424,696
125	HF13-1	2010	2,449	0.02246	1.63	8	$85	$207,425
11	HF13-2	ULTIMATE	1,116	0.01344	0.92	8	$85	$94,510
10	HF13-3	ULTIMATE	582	0.01717	0.89	8	$85	$49,328
122	HF13-4	ULTIMATE	5,603	0.00803	3.25	12	$103	$579,305
Sub-total			28,899					$3,299,515
4	HF14	2010	798	0.02047	2.17	10	$92	$73,691
119	HF14	2010	3,047	0.02330	2.18	10	$92	$281,510
Sub-total			3,844					$355,200
102	HF15	ULTIMATE	4,914	0.00773	2.85	12	$103	$508,148
103	HF15	ULTIMATE	4,321	0.00740	4.61	15	$113	$489,619
106	HF15	ULTIMATE	3,840	0.00989	7.67	18	$124	$477,359
108	HF15	ULTIMATE	2,000	0.00900	9.90	18	$124	$248,560
111	HF15	2030	2,289	0.00175	13.53	18	$124	$284,576
110	HF15-1	2030	3,811	0.02256	1.74	8	$85	$322,821
109	HF15-2	ULTIMATE	1,685	0.03917	1.04	8	$85	$142,715
107	HF15-3	ULTIMATE	2,039	0.02845	2.24	8	$85	$172,678
104	HF15-4	ULTIMATE	2,983	0.02011	1.01	8	$85	$252,689
105	HF15-4	ULTIMATE	1,696	0.02359	1.25	8	$85	$143,629
101	HF15-5	ULTIMATE	992	0.01814	1.07	8	$85	$84,062
Sub-total			30,572					$3,126,857
1	HF16	2030	253	0.00045	83.74	48	$270	$68,224
88	HF16	2030	1,780	0.01236	51.00	36	$220	$391,563
89	HF16	2030	5,424	0.00221	53.70	48	$270	$1,461,790
95	HF16	2030	1,459	0.00274	55.91	48	$270	$393,273
97	HF16	2030	1,445	0.00138	59.52	48	$270	$389,295
98	HF16	2030	2,093	0.00287	61.39	48	$270	$564,058
100	HF16	2030	5,085	0.00275	64.98	48	$270	$1,370,467
113	HF16	2030	4,090	0.00098	78.37	48	$270	$1,102,357
115	HF16	2030	2,343	0.00256	80.23	48	$270	$631,444
116	HF16	2030	4,289	0.00373	82.38	48	$270	$1,156,009
118	HF16	2030	1,087	0.00368	83.82	48	$270	$293,073
117	HF16-1	ULTIMATE	1,656	0.00845	1.64	10	$92	$153,024
3	HF16-2	ULTIMATE	1,290	0.01085	1.44	8	$85	$109,282
114	HF16-3	2030	979	0.01430	1.53	8	$85	$82,942
112	HF16-4	2030	960	0.02083	13.98	18	$124	$119,319
99	HF16-5	ULTIMATE	3,542	0.03388	1.77	8	$85	$300,022
96	HF16-6	ULTIMATE	1,418	0.04230	2.02	8	$85	$120,133
2	HF16-7	2030	392	0.00511	0.72	8	$85	$33,164
91	HF16-7	2030	2,867	0.01116	1.75	10	$92	$264,867

Appendix B
Future Sewer Extensions
10-Year Ultimate Flows

Pipe Network ID	Project ID	Planning Year Needed	Length	Design Slope	Ultimate Design Flow (cfs)	Pipe Diameter	Unit Cost ($)	Cost ($)
92	HF16-7	2030	1,970	0.01015	3.81	12	$103	$203,706
94	HF16-7	2030	1,095	0.01096	4.58	15	$113	$124,030
333	HF16-7	2030	2,083	0.01344	2.72	10	$92	$192,505
93	HF16-7-1	ULTIMATE	2,325	0.02237	0.63	8	$85	$196,901
90	HF16-7-2	ULTIMATE	1,976	0.01822	0.95	8	$85	$167,333
332	HF16-8	ULTIMATE	3,895	0.01232	2.73	10	$92	$359,897
87	HF16-9	ULTIMATE	2,853	0.02033	2.02	8	$85	$241,679
Sub-total			58,650					$10,490,357
17	HF17	ULTIMATE	392	0.00045	1.61	18	$124	$48,748
75	HF17	ULTIMATE	2,007	0.01993	0.89	8	$85	$169,985
77	HF17	ULTIMATE	3,861	0.00518	4.47	15	$113	$437,488
78	HF17	ULTIMATE	2,222	0.00900	6.25	18	$124	$276,249
80	HF17	ULTIMATE	3,296	0.00607	8.59	18	$124	$409,692
84	HF17	ULTIMATE	2,162	0.00045	17.83	27	$167	$361,508
85	HF17	ULTIMATE	4,384	0.00456	19.07	27	$167	$732,926
331	HF17	ULTIMATE	2,167	0.00461	15.91	24	$149	$321,849
86	HF17-1	ULTIMATE	4,190	0.00239	34.11	36	$220	$921,804
330	HF17-2	ULTIMATE	2,455	0.02037	1.25	8	$85	$207,910
7	HF17-3	ULTIMATE	649	0.01540	3.55	12	$103	$67,147
18	HF17-3	ULTIMATE	3,838	0.01042	3.44	12	$103	$396,891
81	HF17-4	ULTIMATE	2,655	0.00753	1.75	10	$92	$245,318
82	HF17-4	ULTIMATE	1,889	0.01059	1.48	10	$92	$174,584
83	HF17-4	ULTIMATE	2,650	0.01510	3.74	12	$103	$273,997
79	HF17-5	ULTIMATE	3,257	0.01382	2.16	10	$92	$300,919
76	HF17-6	ULTIMATE	2,441	0.00820	2.34	12	$103	$252,349
Sub-total			44,516					$5,599,363
5	HF18	ULTIMATE	4,384	0.00228	9.43	24	$149	$651,080
52	HF18	ULTIMATE	4,818	0.01038	2.01	10	$92	$445,169
56	HF18	ULTIMATE	1,778	0.00844	3.98	15	$113	$201,419
57	HF18	ULTIMATE	1,536	0.00651	8.43	18	$124	$190,929
62	HF18	ULTIMATE	1,717	0.00291	14.79	27	$167	$287,141
65	HF18	ULTIMATE	4,747	0.00421	15.17	27	$167	$793,702
66	HF18	ULTIMATE	707	0.00204	22.44	36	$220	$155,494
68	HF18	ULTIMATE	5,524	0.00204	24.79	36	$220	$1,215,302
69	HF18	ULTIMATE	3,592	0.00204	25.66	36	$220	$790,332
6	HF18-1	ULTIMATE	2,221	0.01351	1.32	8	$85	$188,121
71	HF18-1	ULTIMATE	4,199	0.00476	3.70	15	$113	$475,726
74	HF18-1	2030	2,257	0.00443	9.27	21	$138	$310,357
328	HF18-1	2030	3,455	0.01158	6.17	15	$113	$391,474
73	HF18-1-1	ULTIMATE	4,025	0.02137	2.07	8	$85	$340,933
329	HF18-1-1	2030	2,327	0.02922	1.27	8	$85	$197,132
72	HF18-1-2	ULTIMATE	3,724	0.01074	2.04	10	$92	$344,113
70	HF18-1-3	ULTIMATE	2,302	0.01737	1.25	8	$85	$195,016
67	HF18-2	ULTIMATE	4,746	0.01370	1.35	8	$85	$401,964

Appendix B
Future Sewer Extensions
10-Year Ultimate Flows

Pipe Network ID	Project ID	Planning Year Needed	Length	Design Slope	Ultimate Design Flow (cfs)	Pipe Diameter	Unit Cost ($)	Cost ($)
63	HF18-3	ULTIMATE	7,667	0.00913	3.87	15	$113	$868,621
64	HF18-3	ULTIMATE	2,286	0.01749	1.39	8	$85	$193,664
327	HF18-3	ULTIMATE	1,795	0.01114	5.05	15	$113	$203,344
58	HF18-4	ULTIMATE	2,939	0.01021	1.49	10	$92	$271,588
59	HF18-4	ULTIMATE	2,303	0.00868	2.64	12	$103	$238,124
61	HF18-4	ULTIMATE	2,428	0.02265	4.86	12	$103	$251,094
326	HF18-4-1	ULTIMATE	1,960	0.00045	0.63	12	$103	$202,707
60	HF18-4-2	ULTIMATE	2,786	0.00179	1.44	12	$103	$288,083
55	HF18-4-3	ULTIMATE	2,427	0.02060	0.85	8	$85	$205,608
54	HF18-5	ULTIMATE	5,788	0.00777	4.15	15	$113	$655,778
53	HF18-6	ULTIMATE	3,900	0.01026	1.56	10	$92	$360,355
Sub-total			94,341					$11,314,373
27	HF29	2010	269	0.21909	1.79	8	$85	$22,774
19	HF30	ULTIMATE	837	0.05128	0.80	8	$85	$70,863
207	LBFF21	ULTIMATE	3,850	0.01558	3.95	12	$103	$398,111
209	LBFF21	ULTIMATE	2,645	0.00756	7.38	18	$124	$328,788
341	LBFF21	ULTIMATE	853	0.02344	4.05	12	$103	$88,217
339	LBFF21-1	ULTIMATE	2,487	0.02011	0.98	8	$85	$210,624
208	LBFF21-2	ULTIMATE	2,475	0.01616	3.49	12	$103	$255,864
Sub-total			12,310					$1,281,605
191	LBFF22	ULTIMATE	5,423	0.00738	6.31	18	$124	$674,127
194	LBFF22	ULTIMATE	3,903	0.01025	3.92	12	$103	$403,521
195	LBFF22	ULTIMATE	5,560	0.00719	6.38	18	$124	$691,168
Sub-total			14,886					$1,768,816
190	LBFF23	ULTIMATE	3,040	0.00329	45.27	54	$286	$869,557
192	LBFF23	ULTIMATE	7,351	0.00045	38.19	54	$286	$2,102,277
193	LBFF23	ULTIMATE	5,804	0.00861	36.54	30	$187	$1,085,384
196	LBFF23	ULTIMATE	6,381	0.00784	35.50	30	$187	$1,193,305
203	LBFF23	2020	3,962	0.00630	9.20	21	$138	$544,719
204	LBFF23	2030	5,434	0.01288	4.17	12	$103	$561,880
189	LBFF23-1	ULTIMATE	6,018	0.01994	1.22	8	$85	$509,709
182	LBFF23-2	ULTIMATE	2,815	0.03552	1.50	8	$85	$238,463
184	LBFF23-2	ULTIMATE	2,669	0.00045	4.06	24	$149	$396,302
186	LBFF23-2	ULTIMATE	3,191	0.01880	6.25	24	$149	$473,889
188	LBFF23-2	ULTIMATE	3,314	0.00302	9.52	24	$149	$492,188
187	LBFF23-2-1	ULTIMATE	5,136	0.02336	2.81	10	$92	$474,593
185	LBFF23-2-2	ULTIMATE	3,157	0.02217	1.76	8	$85	$267,421
183	LBFF23-2-3	ULTIMATE	2,746	0.02549	1.70	8	$85	$232,602
201	LBFF23-3	2020	3,052	0.00450	10.03	21	$138	$419,591
202	LBFF23-3	2020	2,480	0.00450	10.63	21	$138	$340,986
205	LBFF23-4	2020	4,023	0.01243	4.01	12	$103	$415,993

Appendix B
Future Sewer Extensions
10-Year Ultimate Flows

Pipe Network ID	Project ID	Planning Year Needed	Length	Design Slope	Ultimate Design Flow (cfs)	Pipe Diameter	Unit Cost ($)	Cost ($)
Sub-total			70,574					$10,618,858
197	LBFF24	2020	3,235	0.00210	9.85	24	$149	$480,369
198	LBFF24	2020	3,899	0.00210	10.79	24	$149	$578,969
200	LBFF24	2020	2,685	0.00210	14.56	27	$167	$448,972
179	LBFF24-1	2020	5,361	0.01511	5.33	15	$113	$607,439
199	LBFF24-2	ULTIMATE	2,545	0.00980	4.04	15	$113	$288,342
181	LBFF24-3	ULTIMATE	3,585	0.03069	1.84	8	$85	$303,628
206	LBFF24-3	ULTIMATE	4,001	0.00875	9.45	18	$124	$497,267
180	LBFF24-3-1	ULTIMATE	5,022	0.01991	7.40	15	$113	$569,019
Sub-total			30,333					$3,774,005
166	LBFF25	ULTIMATE	2,918	0.00343	3.30	15	$113	$330,645
167	LBFF25	ULTIMATE	4,302	0.00581	4.30	15	$113	$487,461
171	LBFF25	ULTIMATE	3,317	0.00754	7.28	18	$124	$412,348
173	LBFF25	ULTIMATE	4,002	0.00271	10.96	24	$149	$594,303
174	LBFF25	ULTIMATE	3,777	0.00271	12.10	24	$149	$560,827
175	LBFF25	ULTIMATE	4,400	0.00271	13.17	24	$149	$653,470
176	LBFF25	ULTIMATE	4,867	0.00411	14.22	24	$149	$722,815
177	LBFF25	ULTIMATE	5,884	0.00680	32.37	30	$187	$1,100,231
178	LBFF25	2010	5,387	0.00297	33.81	36	$220	$1,185,173
172	LBFF25-1	ULTIMATE	2,435	0.01643	1.81	8	$85	$206,269
168	LBFF25-2	ULTIMATE	1,978	0.01264	0.96	8	$85	$167,527
169	LBFF25-2	ULTIMATE	1,600	0.00625	1.31	12	$103	$165,491
170	LBFF25-2	ULTIMATE	1,986	0.00503	2.73	12	$103	$205,365
Sub-total			46,855					$6,791,923
157	LBFF26	ULTIMATE	2,971	0.00505	4.00	15	$113	$336,648
158	LBFF26	ULTIMATE	4,259	0.00587	6.72	18	$124	$529,348
159	LBFF26	ULTIMATE	1,842	0.00045	7.43	24	$149	$273,531
161	LBFF26	ULTIMATE	3,625	0.00276	9.65	24	$149	$538,277
163	LBFF26	ULTIMATE	2,341	0.01281	11.61	24	$149	$347,644
164	LBFF26	ULTIMATE	5,860	0.00427	14.65	24	$149	$870,281
337	LBFF26	ULTIMATE	1,151	0.00045	16.10	27	$167	$192,449
165	LBFF26-1	ULTIMATE	2,386	0.01257	1.58	8	$85	$202,069
336	LBFF26-2	ULTIMATE	2,151	0.01860	1.56	8	$85	$182,188
162	LBFF26-3	ULTIMATE	2,171	0.01151	1.71	10	$92	$200,614
160	LBFF26-4	ULTIMATE	1,539	0.01299	1.50	8	$85	$130,387
Sub-total			30,296					$3,803,437
21	MF19	2020	314	0.01665	0.64	8	$85	$26,632
338	MF19	2020	1,288	0.02718	0.65	8	$85	$109,080
22	MF19-1	2020	257	0.03580	3.00	10	$92	$23,716
23	MF19-1	2020	647	0.03092	3.02	10	$92	$59,760
Sub-total			2,506					$219,188

Appendix B
Future Sewer Extensions
10-Year Ultimate Flows

Pipe Network ID	Project ID	Planning Year Needed	Length	Design Slope	Ultimate Design Flow (cfs)	Pipe Diameter	Unit Cost ($)	Cost ($)
24	MF20	2020	617	0.00405	3.73	15	$113	$69,929
25	MF20	2020	1,324	0.01964	3.75	15	$113	$150,013
Sub-total			1,941					$219,941
218	PF1	ULTIMATE	3,148	0.01271	2.04	10	$92	$290,889
375	PF1	ULTIMATE	3,375	0.00045	3.45	21	$138	$464,111
343	PF1-1	ULTIMATE	1,900	0.00526	1.43	10	$92	$175,541
Sub-total			8,423					$930,540
210	PF2	ULTIMATE	3,013	0.01726	6.67	18	$124	$374,510
214	PF2	ULTIMATE	4,104	0.01121	2.50	10	$92	$379,170
215	PF2	ULTIMATE	3,011	0.00930	2.93	12	$103	$311,299
216	PF2	ULTIMATE	4,290	0.00839	4.87	15	$113	$486,109
217	PF2	ULTIMATE	3,580	0.00279	5.88	18	$124	$444,973
374	PF2	ULTIMATE	6,882	0.00045	9.88	36	$220	$1,514,005
211	PF2-1	ULTIMATE	1,857	0.01077	4.04	12	$103	$191,984
212	PF2-1	ULTIMATE	942	0.01593	3.50	12	$103	$97,372
213	PF2-1	ULTIMATE	1,393	0.01436	0.86	8	$85	$117,985
342	PF2-1	ULTIMATE	873	0.00573	0.91	8	$85	$73,913
28	PF2-2	ULTIMATE	1,125	0.02133	0.87	8	$85	$95,320
Sub-total			31,069					$4,086,640
223	PF3	2030	1,475	0.00136	19.47	33	$204	$300,167
224	PF3	2030	3,644	0.00329	23.89	33	$204	$741,617
225	PF3	2030	4,462	0.00045	26.32	48	$270	$1,202,466
227	PF3	2030	2,568	0.00467	16.59	27	$167	$429,318
228	PF3	2030	3,325	0.00541	15.79	24	$149	$493,696
230	PF3	ULTIMATE	2,553	0.01253	7.83	15	$113	$289,248
231	PF3	2030	2,482	0.00806	9.80	18	$124	$308,560
232	PF3	ULTIMATE	2,048	0.00045	7.23	15	$113	$232,059
234	PF3	ULTIMATE	2,441	0.01638	2.53	10	$92	$225,594
236	PF3	ULTIMATE	4,008	0.00699	12.09	21	$138	$551,167
238	PF3	ULTIMATE	1,000	0.00400	14.28	24	$149	$148,515
347	PF3	ULTIMATE	2,938	0.01021	1.85	10	$92	$271,442
348	PF3	ULTIMATE	1,151	0.00435	3.37	15	$113	$130,379
349	PF3	ULTIMATE	1,614	0.00930	5.14	15	$113	$182,820
370	PF3	2030	960	0.00045	26.34	48	$270	$258,604
226	PF3-1	ULTIMATE	2,609	0.00996	2.00	10	$92	$241,108
29	PF3-10	ULTIMATE	877	0.02851	0.85	8	$85	$74,261
31	PF3-2	ULTIMATE	915	0.02403	0.82	8	$85	$77,538
32	PF3-2	ULTIMATE	532	0.03383	0.74	8	$85	$45,071
219	PF3-2	ULTIMATE	2,298	0.02002	1.20	8	$85	$194,658
220	PF3-2	ULTIMATE	2,531	0.01185	4.17	12	$103	$261,755
344	PF3-2	ULTIMATE	2,016	0.01687	2.34	10	$92	$186,240
345	PF3-2	ULTIMATE	1,971	0.01116	3.52	12	$103	$203,824
221	PF3-3	ULTIMATE	3,144	0.02099	2.08	10	$92	$290,509

Appendix B
Future Sewer Extensions
10-Year Ultimate Flows

Pipe Network ID	Project ID	Planning Year Needed	Length	Design Slope	Ultimate Design Flow (cfs)	Pipe Diameter	Unit Cost ($)	Cost ($)
222	PF3-3	ULTIMATE	2,847	0.01335	3.04	12	$103	$294,420
30	PF3-4	2030	788	0.03301	0.64	8	$85	$66,714
237	PF3-5	2030	3,527	0.02212	1.46	8	$85	$298,717
350	PF3-5	2030	940	0.02978	0.82	8	$85	$79,631
351	PF3-5	2030	1,046	0.01529	2.38	10	$92	$96,694
229	PF3-6	ULTIMATE	3,434	0.01864	1.91	8	$85	$290,873
235	PF3-7	ULTIMATE	3,347	0.01793	1.80	8	$85	$283,498
346	PF3-8	ULTIMATE	1,708	0.01756	1.27	8	$85	$144,684
233	PF3-9	ULTIMATE	3,150	0.01619	1.41	8	$85	$266,828
Sub-total			74,351					$9,162,672
239	PF4	ULTIMATE	2,506	0.00479	9.21	21	$138	$344,570
240	PF4	ULTIMATE	2,270	0.00440	6.72	18	$124	$282,205
353	PF4	ULTIMATE	1,591	0.01257	1.16	8	$85	$134,794
376	PF4	ULTIMATE	5,695	0.00045	11.56	36	$220	$1,252,984
355	PF4-1	ULTIMATE	1,341	0.00895	2.78	12	$103	$138,694
354	PF4-2	ULTIMATE	1,499	0.00667	1.62	10	$92	$138,479
352	PF4-3	ULTIMATE	1,825	0.00657	1.98	10	$92	$168,674
Sub-total			16,729					$2,460,399
36	PF5	ULTIMATE	3,312	0.00453	27.94	36	$220	$728,548
37	PF5	ULTIMATE	1,110	0.00451	11.03	24	$149	$164,777
38	PF5	ULTIMATE	1,166	0.00429	7.84	21	$138	$160,271
244	PF5	ULTIMATE	2,409	0.00166	71.36	66	$319	$768,621
246	PF5	ULTIMATE	4,281	0.00117	64.36	66	$319	$1,365,591
247	PF5	ULTIMATE	3,411	0.00045	62.47	66	$319	$1,088,115
248	PF5	ULTIMATE	4,041	0.00045	63.74	66	$319	$1,289,047
271	PF5	ULTIMATE	1,392	0.02873	1.73	8	$85	$117,944
272	PF5	ULTIMATE	2,979	0.01343	2.55	10	$92	$275,289
273	PF5	ULTIMATE	3,061	0.00980	5.40	15	$113	$346,801
278	PF5	ULTIMATE	1,536	0.00325	10.74	24	$149	$228,117
281	PF5	ULTIMATE	3,978	0.00045	13.28	36	$220	$875,244
289	PF5	ULTIMATE	4,843	0.00103	16.92	36	$220	$1,065,372
368	PF5	ULTIMATE	2,554	0.00392	5.62	18	$124	$317,473
377	PF5	ULTIMATE	4,818	0.00370	73.19	66	$319	$1,537,076
245	PF5-1	ULTIMATE	2,134	0.00187	1.32	12	$103	$220,643
275	PF5-10	ULTIMATE	2,068	0.02660	0.82	8	$85	$175,129
276	PF5-10	ULTIMATE	1,571	0.01910	0.84	8	$85	$133,069
277	PF5-10	ULTIMATE	2,352	0.01063	2.87	12	$103	$243,208
369	PF5-11	ULTIMATE	4,200	0.00238	1.81	12	$103	$434,268
274	PF5-12	ULTIMATE	1,810	0.03315	1.52	8	$85	$153,304
356	PF5-2	ULTIMATE	1,450	0.00276	1.50	12	$103	$149,965
241	PF5-3	ULTIMATE	2,750	0.01963	3.35	10	$92	$254,127
242	PF5-3	ULTIMATE	4,153	0.00843	4.45	15	$113	$470,484
243	PF5-3	ULTIMATE	6,509	0.00230	8.76	24	$149	$966,637
250	PF5-3-1	ULTIMATE	2,323	0.00215	2.84	15	$113	$263,160

Appendix B
Future Sewer Extensions
10-Year Ultimate Flows

Pipe Network ID	Project ID	Planning Year Needed	Length	Design Slope	Ultimate Design Flow (cfs)	Pipe Diameter	Unit Cost ($)	Cost ($)
263	PF5-3-1	ULTIMATE	2,644	0.01135	3.45	15	$113	$299,578
249	PF5-4	ULTIMATE	5,479	0.02281	2.03	8	$85	$464,067
264	PF5-5	ULTIMATE	2,075	0.01205	31.14	42	$253	$525,076
284	PF5-6	ULTIMATE	2,294	0.00872	1.60	10	$92	$211,965
286	PF5-6	ULTIMATE	2,894	0.00346	8.53	21	$138	$397,969
287	PF5-6	ULTIMATE	3,117	0.00481	11.03	21	$138	$428,553
288	PF5-6	ULTIMATE	2,907	0.00139	11.65	27	$167	$486,097
359	PF5-6	ULTIMATE	1,519	0.01317	3.91	12	$103	$157,079
361	PF5-6-1	ULTIMATE	1,738	0.04604	1.43	8	$85	$147,170
290	PF5-6-2	ULTIMATE	1,736	0.01728	1.98	10	$92	$160,445
291	PF5-6-2	ULTIMATE	2,051	0.01463	1.66	8	$85	$173,721
360	PF5-6-2	ULTIMATE	1,350	0.01482	3.80	12	$103	$139,587
285	PF5-6-3	ULTIMATE	3,333	0.01500	1.10	8	$85	$282,345
39	PF5-6-4	ULTIMATE	1,082	0.00924	1.08	8	$85	$91,667
283	PF5-7	ULTIMATE	2,886	0.01559	1.23	8	$85	$244,418
282	PF5-8	ULTIMATE	2,820	0.00532	1.94	12	$103	$291,619
279	PF5-9	ULTIMATE	4,789	0.01044	2.23	10	$92	$442,457
Sub-total			120,926					$18,736,093
297	PF6	ULTIMATE	3,421	0.00409	10.03	24	$149	$507,987
298	PF6	ULTIMATE	2,957	0.00271	9.25	24	$149	$439,144
300	PF6	ULTIMATE	2,377	0.01430	3.43	12	$103	$245,792
301	PF6	ULTIMATE	3,368	0.01306	4.05	12	$103	$348,294
302	PF6	ULTIMATE	1,913	0.01045	5.12	15	$113	$216,771
304	PF6	ULTIMATE	1,504	0.00931	8.32	18	$124	$186,894
305	PF6	ULTIMATE	3,870	0.00258	20.84	30	$187	$723,608
362	PF6	ULTIMATE	2,714	0.00045	22.89	48	$270	$731,366
363	PF6	ULTIMATE	4,191	0.00045	23.70	48	$270	$1,129,582
371	PF6	ULTIMATE	690	0.02298	27.53	48	$270	$185,898
306	PF6-1	ULTIMATE	3,410	0.00997	5.25	15	$113	$386,326
321	PF6-1	ULTIMATE	5,270	0.01176	4.50	15	$113	$597,090
292	PF6-2	ULTIMATE	5,750	0.00035	3.70	24	$149	$853,921
293	PF6-2	ULTIMATE	3,543	0.00339	7.75	24	$149	$526,084
295	PF6-2	ULTIMATE	2,897	0.00138	8.41	24	$149	$430,133
296	PF6-2-1	ULTIMATE	2,528	0.04272	0.80	8	$85	$214,109
294	PF6-2-2	ULTIMATE	2,587	0.01237	1.49	8	$85	$219,122
303	PF6-3	ULTIMATE	1,359	0.01472	1.11	8	$85	$115,119
299	PF6-4	ULTIMATE	2,428	0.00330	1.81	12	$103	$251,031
44	PF6-5	ULTIMATE	1,058	0.01512	0.95	8	$85	$89,633
372	PF6-6	ULTIMATE	1,289	0.01540	3.42	12	$103	$133,257
Sub-total			59,123					$8,531,162
45	PF7	2030	2,207	0.00362	25.76	33	$204	$449,220
307	PF7	ULTIMATE	3,228	0.02013	3.86	12	$103	$333,826
308	PF7	ULTIMATE	3,331	0.00150	4.51	21	$138	$457,955
310	PF7	ULTIMATE	3,134	0.00788	13.04	21	$138	$430,953

Appendix B
Future Sewer Extensions
10-Year Ultimate Flows

Pipe Network ID	Project ID	Planning Year Needed	Length	Design Slope	Ultimate Design Flow (cfs)	Pipe Diameter	Unit Cost ($)	Cost ($)
313	PF7	2030	6,292	0.00461	17.36	27	$167	$1,051,952
315	PF7	2030	3,449	0.00174	21.53	33	$204	$701,878
317	PF7	2030	2,699	0.00445	23.50	33	$204	$549,301
318	PF7	2030	2,941	0.00293	25.34	33	$204	$598,426
320	PF7	2030	2,391	0.00293	28.11	33	$204	$486,650
367	PF7	ULTIMATE	2,541	0.00394	7.47	21	$138	$349,366
378	PF7	2030	3,040	0.00302	28.10	33	$204	$618,552
322	PF7-1	2020	2,568	0.01363	3.67	12	$103	$265,555
323	PF7-1	2020	2,844	0.00879	4.92	15	$113	$322,274
324	PF7-1	2020	5,432	0.00644	6.14	18	$124	$675,143
325	PF7-1	2020	3,193	0.00382	6.06	18	$124	$396,868
319	PF7-2	ULTIMATE	5,030	0.01312	2.46	10	$92	$464,787
316	PF7-3	ULTIMATE	3,399	0.02648	1.76	8	$85	$287,881
311	PF7-4	ULTIMATE	2,053	0.01461	2.59	10	$92	$189,674
312	PF7-4	ULTIMATE	3,405	0.00999	4.15	15	$113	$385,738
314	PF7-5	2030	4,143	0.01810	2.52	10	$92	$382,834
49	PF7-6	ULTIMATE	1,942	0.02318	5.51	15	$113	$219,987
50	PF7-6	ULTIMATE	2,801	0.00535	4.89	15	$113	$317,409
309	PF7-7	ULTIMATE	6,253	0.01439	2.48	10	$92	$577,748
Sub-total			78,315					$10,513,974
35	PF8	2020	2,102	0.01046	2.68	12	$103	$217,384
46	PF8	2010	1,971	0.00758	8.45	18	$124	$244,954
47	PF8	2010	3,046	0.00821	8.46	18	$124	$378,604
48	PF8	2010	1,601	0.00312	4.51	18	$124	$199,007
364	PF8	2020	5,204	0.00807	2.28	12	$103	$538,116
33	PF8-1	2010	1,867	0.00482	2.32	12	$103	$193,025
366	PF8-1	2010	2,595	0.00925	1.76	10	$92	$239,788
34	PF8-2	2020	1,630	0.01104	1.51	10	$92	$150,595
365	PF8-2	2020	3,760	0.01223	1.18	8	$85	$318,475
Sub-total			23,776					$2,479,949
40	PF9	ULTIMATE	2,229	0.00120	30.75	42	$253	$563,886
41	PF9	ULTIMATE	599	0.01670	1.20	8	$85	$50,709
256	PF9	ULTIMATE	4,077	0.00736	13.53	21	$138	$560,594
258	PF9	ULTIMATE	3,208	0.00624	18.54	24	$149	$476,336
259	PF9	ULTIMATE	2,521	0.00436	19.87	27	$167	$421,459
260	PF9	ULTIMATE	2,671	0.01685	20.85	27	$167	$446,601
261	PF9	ULTIMATE	3,037	0.00494	22.02	27	$167	$507,803
268	PF9	ULTIMATE	1,934	0.01551	1.11	8	$85	$163,845
269	PF9	ULTIMATE	3,863	0.01035	2.69	12	$103	$399,422
358	PF9	ULTIMATE	1,308	0.00765	10.99	21	$138	$179,796
251	PF9-1	ULTIMATE	3,523	0.01987	7.66	15	$113	$399,176
252	PF9-1	ULTIMATE	2,918	0.01371	4.28	12	$103	$301,741
253	PF9-1	ULTIMATE	1,844	0.01084	1.48	8	$85	$156,225
262	PF9-1	ULTIMATE	3,035	0.00988	8.79	18	$124	$377,283

Appendix B
Future Sewer Extensions
10-Year Ultimate Flows

Pipe Network ID	Project ID	Planning Year Needed	Length	Ultimate Design Slope	Ultimate Design Flow (cfs)	Pipe Diameter	Unit Cost ($)	Cost ($)
254	PF9-1-1	ULTIMATE	2,488	0.01005	1.83	10	$92	$229,894
43	PF9-1-2	ULTIMATE	1,917	0.01043	2.40	10	$92	$177,099
280	PF9-2	ULTIMATE	3,090	0.01618	1.86	10	$92	$285,542
257	PF9-3	ULTIMATE	2,401	0.01458	2.92	10	$92	$221,813
270	PF9-4	ULTIMATE	3,273	0.01528	1.77	10	$92	$302,434
255	PF9-5	ULTIMATE	3,558	0.00703	5.95	18	$124	$442,317
266	PF9-5	ULTIMATE	3,988	0.00878	7.77	18	$124	$495,705
357	PF9-5	ULTIMATE	3,132	0.00798	3.07	12	$103	$323,844
267	PF9-5-1	ULTIMATE	2,370	0.02321	0.78	8	$85	$200,714
265	PF9-5-2	ULTIMATE	1,416	0.01412	1.91	10	$92	$130,882
42	PF9-5-3	ULTIMATE	1,324	0.00755	1.58	10	$92	$122,367
Sub-total			65,725					$7,937,486
Grand Total			2,030,824					$277,400,647

Appendix B
Relief Sewer Recommendations
10-Year 2030 Flow Rates

Manhole		Existing Diameter	Existing Slope	Existing Length	Capacity	2030Flow	%	Recommended Pipe	Estimated Avg. Pipe	Unit	Segment Total
US	DS	(inches)	(ft/ft)	(ft)	(MGD)	(MGD)	Used	Diameter	Depth	Cost	Cost
PROJECT HP01											
10A37	10A38	60	0.0010	674	53.62	97.86	182%	84	27	$459	$ 309,642
10A36	10A37	60	0.0010	464	53.76	92.25	172%	84	27	$459	$ 212,968
10A81	10A36	60	0.0010	442	53.89	93.06	173%	84	16	$417	$ 184,457
10A35	10A81	60	0.0000	17	0.00	92.90	#DIV/0!	84	15	$417	$ 7,273
10A34	10A35	60	0.0010	621	53.77	89.26	166%	84	28	$459	$ 285,362
5N8	10A34	60	0.0010	630	52.97	90.10	170%	84	32	$505	$ 318,326
5N7	5N8	60	0.0010	595	53.64	90.78	169%	84	32	$505	$ 300,305
5N6	5N7	60	0.0010	546	52.60	91.31	174%	84	32	$505	$ 275,879
5N5	5N6	60	0.0010	595	53.64	91.62	171%	84	35	$505	$ 300,380
5N4	5N5	60	0.0010	563	53.73	86.68	161%	72	34	$476	$ 267,929
5N3	5N4	60	0.0010	499	53.48	87.16	163%	72	30	$476	$ 237,221
5N2	5N3	60	0.0010	481	53.32	87.46	164%	72	30	$476	$ 229,100
5N1	5N2	60	0.0010	305	52.07	87.51	168%	72	30	$476	$ 145,144
5O28	5N1	60	0.0010	468	54.09	87.99	163%	72	30	$433	$ 202,336
5O27	5O28	60	0.0010	478	53.48	89.65	168%	72	30	$433	$ 206,973
5O26	5O27	60	0.0010	573	52.81	83.01	157%	72	30	$433	$ 247,683
5O25	5O26	60	0.0011	416	54.89	84.21	153%	72	30	$433	$ 180,146
5O24	5O25	60	0.0010	472	53.85	85.39	159%	72	30	$433	$ 204,210
5K7	5O24	60	0.0010	475	53.12	85.54	161%	72	29	$433	$ 205,434
Project Length				9,315				Project Cost			$ 4,320,771
PROJECT HP02											
5K6	5K7	54	0.0010	275	40.72	60.43	148%	66	29	$393	$ 107,798
5O23	5K6	54	0.0010	380	39.81	60.61	152%	66	30	$393	$ 149,037
5O22	5O23	54	0.0010	252	40.99	60.73	148%	66	30	$393	$ 98,766
5J57DUP	5O22	54	0.0010	422	41.15	60.78	148%	66	30	$393	$ 165,889
5J56	5J57DUP	54	0.0010	705	39.61	60.88	154%	66	30	$432	$ 304,348
5J55	5J56	54	0.0010	556	40.47	61.16	151%	66	30	$432	$ 240,035
5J54	5J55	54	0.0010	580	40.33	61.13	152%	66	30	$432	$ 250,308
5J53	5J54	54	0.0010	675	40.18	61.49	153%	66	30	$393	$ 264,949
5J52	5J53	54	0.0010	674	40.48	61.83	153%	66	30	$393	$ 264,808
5J51	5J52	54	0.0010	682	39.96	61.89	155%	66	29	$393	$ 267,857
5J50	5J51	48	0.0018	662	39.66	61.88	156%	60	28	$366	$ 242,188
5J49	5J50	48	0.0018	189	40.05	61.87	154%	60	27	$366	$ 69,275
5F106	5J49	48	0.0016	702	37.37	62.02	166%	60	27	$366	$ 256,884
5F105	5F106	48	0.0016	500	37.26	62.22	167%	60	26	$366	$ 182,903

Appendix B
Relief Sewer Recommendations
10-Year 2030 Flow Rates

Manhole		Existing Diameter	Existing Slope	Existing Length	Capacity	2030Flow	%	Recommended Pipe	Estimated Avg. Pipe	Unit	Segment Total
US	DS	(inches)	(ft/ft)	(ft)	(MGD)	(MGD)	Used	Diameter	Depth	Cost	Cost
5G51	5F105	48	0.0016	523	37.30	62.37	167%	60	26	$366	$ 191,608
5G50	5G51	48	0.0015	301	36.43	62.42	171%	60	25	$366	$ 110,054
5G49	5G50	48	0.0016	532	37.43	62.46	167%	60	25	$366	$ 194,830
5G48	5G49	48	0.0016	555	37.07	62.88	170%	60	24	$366	$ 203,269
5G36	5G48	48	0.0016	478	37.15	63.24	170%	60	22	$366	$ 174,815
5G7A	5G36	30	0.0006	14	6.35	49.58	781%	60	10	$275	$ 3,732
5G8	5G7A	30	0.0340	235	49.03	49.56	101%	60	13	$303	$ 71,066
Project Length				9,890				Project Cost			$ 3,814,419
PROJECT HP03											
Project Length				0				Project Cost			$ -
PROJECT HP04											
4J145	4J157B	24	0.0346	414	27.26	16.65	61%	42	5	$230	$ 95,202
4F1	4J145	24	0.0014	293	5.46	16.64	305%	42	10	$230	$ 67,505
4F2A	4F1	24	0.0014	286	5.47	16.73	306%	42	10	$230	$ 65,747
4F2	4F2A	24	0.0014	7	5.47	16.73	306%	42	10	$230	$ 1,724
4F3	4F2	24	0.0014	187	5.47	16.73	306%	42	10	$230	$ 42,902
4F4	4F3	24	0.0014	382	5.47	16.82	308%	42	10	$230	$ 87,887
4F5	4F4	24	0.0014	321	5.47	16.90	309%	42	10	$230	$ 73,822
4F6	4F5	24	0.0014	260	5.47	16.95	310%	42	10	$230	$ 59,801
4F7	4F6	24	0.0014	260	5.47	16.98	311%	42	10	$230	$ 59,875
4F8	4F7	24	0.0014	174	5.47	16.98	311%	42	10	$230	$ 39,929
4F9	4F8	24	0.0014	308	5.47	16.97	310%	42	10	$230	$ 70,753
4G1	4F9	24	0.0014	379	5.47	17.03	312%	42	10	$230	$ 87,246
4G2	4G1	24	0.0014	249	5.47	17.03	312%	42	10	$230	$ 57,362
4G2A	4G2	24	0.0012	73	5.08	17.02	335%	42	10	$230	$ 16,720
4G6	4G2A	24	0.0012	178	5.08	8.57	169%	42	10	$230	$ 40,973
4G6A	4G6	24	0.0012	41	5.08	8.57	169%	42	10	$230	$ 9,377
4G7	4G6A	24	0.0012	290	5.08	17.24	339%	42	10	$230	$ 66,680
4G8	4G7	24	0.0012	375	5.08	17.32	341%	42	10	$230	$ 86,213
4G9B	4G8	18	-0.0153	407	#NUM!	6.25	#NUM!	36	10	$200	$ 81,381

Appendix B
Relief Sewer Recommendations
10-Year 2030 Flow Rates

Manhole		Existing Diameter	Existing Slope	Existing Length	Capacity	2030Flow	%	Recommended Pipe	Estimated Avg. Pipe	Unit	Segment Total
US	DS	(inches)	(ft/ft)	(ft)	(MGD)	(MGD)	Used	Diameter	Depth	Cost	Cost
2E117	2E118R	18	0.0237	53	10.48	13.05	124%	30	9	$170	$ 9,031
2E1	2E117	18	-0.0011	144	#NUM!	9.74	#NUM!	30	6	$170	$ 24,418
2E2	2E1	18	0.0012	321	2.34	9.77	417%	30	7	$170	$ 54,504
2E3	2E2	18	0.0143	149	8.14	9.77	120%	30	7	$170	$ 25,314
2E3A	2E3	18	0.0012	17	2.34	9.77	418%	30	5	$170	$ 2,881
4J138A	4J158	8	0.0040	36	0.50	0.55	112%	10	10	$84	$ 3,014
4J142	4J138A	8	0.0472	260	1.70	0.55	33%	10	9	$84	$ 21,873
4J143	4J142	8	0.0040	309	0.50	0.55	111%	10	10	$84	$ 25,963
4J144	4J143	8	0.0040	228	0.50	0.55	110%	10	10	$84	$ 19,123
4F12	4J144	8	0.0040	297	0.50	0.54	110%	10	10	$84	$ 24,929
4F11	4F12	8	0.0040	358	0.50	0.54	109%	10	10	$84	$ 30,098
4F10	4F11	8	0.0040	324	0.50	0.53	108%	10	10	$84	$ 27,186
4G19	4F10	8	0.0040	357	0.50	0.53	107%	10	10	$84	$ 30,007
4G20	4G19	8	0.0040	384	0.50	0.52	106%	10	10	$84	$ 32,255
4G21	4G20	8	0.0040	101	0.50	0.52	105%	10	10	$84	$ 8,507
4G28	4G21	8	0.0040	325	0.50	0.52	104%	10	10	$84	$ 27,298
4G29	4G28	8	0.0040	147	0.50	0.50	102%	10	10	$84	$ 12,318
4G8R	4G8	18	-0.4711	15	#NUM!	6.24	#NUM!	36	8	$200	$ 3,023
Project Length				8,708				Project Cost			$ 1,492,841
PROJECT HP05											
2E4	2E3A	18	0.0012	303	2.35	9.77	416%	30	5	$170	$ 51,534
2E5	2E4	18	0.0012	107	2.37	9.76	412%	30	7	$170	$ 18,222
2E6	2E5	18	0.0147	119	8.26	9.76	118%	30	6	$170	$ 20,225
2E6A	2E6	18	0.0029	182	3.68	9.76	265%	30	6	$170	$ 30,899
2E106A	2E6A	18	-0.0008	402	#NUM!	8.13	#NUM!	30	9	$170	$ 68,260
2E106	2E106A	18	0.0143	82	8.14	8.13	100%	30	13	$187	$ 15,304
2E107	2E106	18	-0.0005	292	#NUM!	8.15	#NUM!	30	11	$187	$ 54,661
2A1	2E107	18	0.0012	350	2.36	8.16	346%	30	8	$170	$ 59,474
2A2	2A1	18	0.0012	355	2.34	8.16	349%	30	9	$170	$ 60,383
2A3	2A2	18	0.0012	347	2.37	8.16	345%	30	10	$170	$ 58,949
2A4	2A3	18	0.0012	308	2.36	8.18	347%	30	10	$187	$ 57,595
2A5DUP	2A4	18	0.0013	403	2.47	8.20	332%	30	10	$170	$ 68,538
2B20DUP	2A5DUP	18	0.0012	350	2.36	8.22	348%	30	9	$170	$ 59,438
2B21	2B20DUP	18	0.0012	356	2.34	8.22	351%	30	9	$170	$ 60,452
2B22	2B21	18	0.0012	385	2.38	8.22	346%	30	9	$170	$ 65,491

Appendix B
Relief Sewer Recommendations
10-Year 2030 Flow Rates

Manhole		Existing Diameter	Existing Slope	Existing Length	Capacity	2030Flow	%	Recommended Pipe	Estimated Avg. Pipe	Unit	Segment Total
US	DS	(inches)	(ft/ft)	(ft)	(MGD)	(MGD)	Used	Diameter	Depth	Cost	Cost
2B23	2B22	18	0.0012	344	2.38	8.24	346%	30	9	$170	$ 58,486
2B24	2B23	18	0.0012	342	2.36	8.27	351%	30	9	$170	$ 58,090
2B25	2B24	18	0.0012	342	2.36	8.29	352%	30	9	$170	$ 58,212
2B26	2B25	18	0.0012	342	2.36	8.29	352%	30	9	$170	$ 58,188
2B27	2B26	18	0.0012	345	2.38	8.31	350%	30	10	$170	$ 58,591
2B28	2B27	8	0.0042	352	0.51	3.65	719%	18	10	$113	$ 39,787
2B29	2B28	8	0.0042	392	0.51	3.64	718%	18	10	$113	$ 44,246
2B30	2B29	8	0.0042	350	0.51	3.63	717%	18	10	$113	$ 39,579
2C14	2B30	8	0.0042	408	0.51	3.63	716%	18	10	$113	$ 46,082
Project Length				7,557				Project Cost			$ 1,210,685
PROJECT HP06											
4H65	4H64	18	0.0020	107	3.01	3.40	113%	21	10	$125	$ 13,390
4H66	4H65	18	0.0017	409	2.82	3.44	122%	21	10	$125	$ 51,078
4D41DUP	4H66	18	0.0022	296	3.17	3.43	108%	21	10	$125	$ 36,943
4D5	4D41DUP	18	0.0026	78	3.45	3.42	99%	21	10	$125	$ 9,708
4D6	4D5	15	0.0053	197	3.04	3.46	114%	18	10	$113	$ 22,279
4D7	4D6	15	0.0524	156	9.59	3.44	36%	18	10	$113	$ 17,608
4D8	4D7	15	0.0060	169	3.25	3.48	107%	18	10	$113	$ 19,124
4D9	4D8	12	0.0138	364	2.71	2.95	109%	15	10	$103	$ 37,470
4D10	4D9	12	0.0158	284	2.90	2.98	103%	15	10	$103	$ 29,227
4D11	4D10	12	0.0274	274	3.82	3.01	79%	15	10	$103	$ 28,263
2A6	4D11	12	0.0093	141	2.22	3.01	135%	15	10	$103	$ 14,474
2A7	2A6	12	0.0145	256	2.78	3.02	109%	15	10	$103	$ 26,360
2A8	2A7	12	0.0161	349	2.93	3.03	103%	15	10	$103	$ 35,991
2A104	2A8	12	-0.0141	220	#NUM!	3.03	#NUM!	15	10	$103	$ 22,652
2A9	2A104	12	0.0134	118	2.67	2.75	103%	15	10	$103	$ 12,186
2A10	2A9	12	0.0154	323	2.86	2.80	98%	15	10	$103	$ 33,260
2A65	2A10	12	0.0172	224	3.03	2.86	95%	15	10	$103	$ 23,028
2A11	2A65	12	0.0171	151	3.02	2.74	91%	15	10	$103	$ 15,539
2A107	2A11	12	0.0182	174	3.11	2.82	90%	15	10	$103	$ 17,909
2A12	2A107	12	0.0190	185	3.18	2.67	84%	15	10	$103	$ 19,028
2A61	2A12	12	0.0111	234	2.43	2.62	108%	15	10	$103	$ 24,122
2A13	2A61	12	0.0107	109	2.39	2.47	103%	15	10	$103	$ 11,198
2A71	2A13	12	0.0063	214	1.83	2.51	137%	15	10	$103	$ 22,049
2A14	2A71	12	0.0065	155	1.86	2.18	117%	15	10	$103	$ 15,994

Appendix B
Relief Sewer Recommendations
10-Year 2030 Flow Rates

Manhole		Existing Diameter	Existing Slope	Existing Length	Capacity	2030Flow	%	Recommended Pipe	Estimated Avg. Pipe	Unit	Segment Total
US	DS	(inches)	(ft/ft)	(ft)	(MGD)	(MGD)	Used	Diameter	Depth	Cost	Cost
Project Length				5,185				Project Cost			$ 558,881
PROJECT HP07											
4J129	4J128A	15	0.0014	278	1.57	7.90	503%	30	10	$170	$ 47,181
4J130	4J129	15	0.0020	104	1.88	7.90	421%	30	10	$170	$ 17,735
4J131	4J130	15	0.0020	164	1.88	7.90	421%	30	10	$170	$ 27,890
4J131B	4J131	15	0.0020	311	1.87	7.92	424%	30	10	$170	$ 52,921
4E22	4J131B	15	0.0020	198	1.88	7.91	421%	30	4	$170	$ 33,677
4E21	4E22	15	0.0020	272	1.88	7.91	420%	30	4	$170	$ 46,249
4E20	4E21	15	0.0403	169	8.40	7.88	94%	30	2	$170	$ 28,706
4E61	4E20	15	0.0021	247	1.90	7.87	414%	30	10	$170	$ 42,024
4E62	4E61	15	0.0020	208	1.86	7.87	424%	30	10	$170	$ 35,434
4E63	4E62	15	0.0020	305	1.86	7.87	423%	30	10	$170	$ 51,766
4E64	4E63	15	0.0020	273	1.86	7.87	423%	30	10	$170	$ 46,491
4E65	4E64	15	0.0031	193	2.33	7.86	337%	30	10	$170	$ 32,825
4E66	4E65	15	0.0014	209	1.56	7.86	505%	30	10	$170	$ 35,583
4E67	4E66	15	0.0017	151	1.74	7.85	452%	30	10	$170	$ 25,694
4E67A	4E67	15	0.0113	28	4.45	7.85	176%	30	7	$170	$ 4,814
4E68	4E67A	15	0.0009	267	1.28	7.84	613%	30	7	$170	$ 45,447
4E69	4E68	15	0.0020	394	1.86	7.83	420%	30	10	$170	$ 66,945
4E70	4E69	15	0.0020	185	1.87	7.81	417%	30	10	$170	$ 31,385
4E71	4E70	15	0.0020	172	1.86	7.81	420%	30	10	$170	$ 29,267
4E94	4E71	15	0.0015	79	1.59	7.80	490%	30	8	$170	$ 13,512
4E72	4E94	15	0.0020	214	1.86	7.80	420%	30	8	$170	$ 36,451
4E73	4E72	15	0.0020	294	1.88	7.79	415%	30	10	$170	$ 49,951
4E74	4E73	15	0.0021	123	1.92	7.79	405%	30	10	$170	$ 20,967
4E75	4E74	15	0.0020	191	1.87	7.78	417%	30	10	$170	$ 32,494
4E75A	4E75	15	0.0027	216	2.19	7.69	351%	30	6	$170	$ 36,689
4E76	4E75A	15	0.0010	165	1.34	7.63	568%	30	8	$170	$ 28,130
4F15	4E76	15	0.0020	243	1.88	7.62	405%	30	10	$170	$ 41,275
4F16	4F15	15	0.0054	358	3.08	7.61	247%	24	10	$135	$ 48,359
4F17	4F16	15	0.0053	357	3.04	7.62	251%	24	10	$135	$ 48,171
4F18	4F17	15	0.0051	391	3.00	7.63	255%	24	10	$135	$ 52,742
4F18A	4F18	15	0.0054	306	3.07	7.64	248%	24	10	$135	$ 41,300
4B1	4F18A	15	0.0050	472	2.96	7.64	258%	24	10	$149	$ 70,096
4B2	4B1	15	0.0079	406	3.72	7.55	203%	24	10	$149	$ 60,233
4B3	4B2	15	0.0050	311	2.97	7.56	254%	24	8	$135	$ 41,986
4B4	4B3	15	0.0050	403	2.95	7.58	257%	24	7	$135	$ 54,432
4B5	4B4	15	0.0050	351	2.96	7.60	256%	24	9	$135	$ 47,440

Appendix B
Relief Sewer Recommendations
10-Year 2030 Flow Rates

Manhole		Existing Diameter	Existing Slope	Existing Length	Capacity	2030Flow	%	Recommended Pipe	Estimated Avg. Pipe	Unit	Segment Total
US	DS	(inches)	(ft/ft)	(ft)	(MGD)	(MGD)	Used	Diameter	Depth	Cost	Cost
4B6	4B5	15	0.0049	418	2.93	7.43	254%	24	8	$135	$ 56,480
4B7	4B6	15	0.0052	348	3.02	7.29	241%	24	7	$135	$ 46,913
4C40	4B7	15	0.0049	353	2.92	7.28	249%	24	9	$135	$ 47,718
4C41	4C40	15	0.0080	399	3.75	7.29	194%	24	8	$135	$ 53,802
4C42	4C41	15	0.0060	378	3.25	7.18	221%	24	7	$135	$ 51,036
4C43	4C42	15	0.0060	401	3.24	7.19	222%	24	9	$135	$ 54,090
4C44	4C43	15	0.0080	349	3.75	6.85	183%	24	11	$149	$ 51,757
4C45	4C44	15	0.0049	303	2.94	6.68	227%	24	11	$149	$ 45,058
4C46	4C45	15	0.0049	339	2.94	6.65	226%	24	10	$135	$ 45,760
4C47	4C46	15	0.0051	336	2.98	6.65	224%	24	8	$135	$ 45,423
4C48	4C47	15	0.0048	277	2.91	6.69	230%	24	10	$135	$ 37,362
4C49	4C48	15	0.0055	394	3.12	6.72	216%	24	10	$135	$ 53,132
18O1	4C49	15	0.0057	391	3.17	6.73	212%	24	9	$135	$ 52,819
18O2	18O1	15	0.0056	310	3.13	6.67	213%	24	9	$135	$ 41,908
18O70	18O2	15	0.0006	234	1.06	6.66	628%	24	6	$135	$ 31,528
18O3	18O70	15	0.0246	60	6.56	6.66	101%	24	7	$135	$ 8,075
18O3A	18O3	15	0.0056	209	3.14	6.65	212%	24	7	$135	$ 28,231
18O4	18O3A	15	0.0056	301	3.13	6.65	213%	24	7	$135	$ 40,632
Project Length				14,810				Project Cost			$ 2,217,985
PROJECT HP08											
5K1	5K7	21	0.0083	319	9.34	31.36	336%	36	13	$220	$ 70,269
5K2	5K1	21	0.0060	498	7.97	31.13	390%	36	11	$220	$ 109,528
5K128	5K2	21	0.0067	347	8.42	22.78	271%	36	10	$200	$ 69,361
5K3	5K128	21	0.0043	157	6.72	20.54	306%	36	10	$200	$ 31,343
5K3A	5K3	21	0.0069	40	8.53	20.11	236%	30	10	$187	$ 7,473
5K4	5K3A	21	0.0060	191	7.96	20.09	253%	30	9	$170	$ 32,427
5K5	5K4	21	0.0057	270	7.75	19.95	257%	30	10	$170	$ 45,936
5L1	5K5	21	0.0063	272	8.14	18.70	230%	30	10	$170	$ 46,275
5L56	5L1	21	0.0061	303	8.00	17.64	221%	30	10	$170	$ 51,567
5L56A	5L56	21	0.0012	170	3.52	17.43	495%	30	8	$170	$ 28,877
5L55	5L56A	18	0.0066	190	5.55	16.92	305%	30	7	$170	$ 32,270
5L54	5L55	18	0.0061	152	5.33	16.79	315%	30	10	$170	$ 25,760
5L53	5L54	18	0.0125	411	7.61	16.68	219%	30	10	$170	$ 69,924
5L52	5L53	18	0.0124	96	7.58	16.39	216%	30	10	$170	$ 16,323
5L51	5L52	18	0.0070	178	5.71	13.84	243%	30	10	$170	$ 30,236
5L50	5L51	18	0.0066	259	5.53	13.72	248%	30	10	$170	$ 44,054
5L49	5L50	18	0.0064	115	5.45	13.53	248%	30	10	$170	$ 19,613

Appendix B
Relief Sewer Recommendations
10-Year 2030 Flow Rates

Manhole		Existing Diameter	Existing Slope	Existing Length	Capacity	2030Flow	%	Recommended Pipe	Estimated Avg. Pipe	Unit	Segment Total
US	DS	(inches)	(ft/ft)	(ft)	(MGD)	(MGD)	Used	Diameter	Depth	Cost	Cost
5L64A	5L49	15	0.0064	174	3.36	11.14	332%	24	8	$135	$ 23,533
5L63A	5L64A	15	0.0003	137	0.72	7.48	1044%	24	9	$135	$ 18,460
5L62	5L63A	15	0.0103	390	4.25	4.32	102%	18	10	$113	$ 44,036
5L46A	5L63A	8	0.0370	108	1.51	3.31	219%	15	5	$103	$ 11,134
5L45	5L46A	8	0.0102	467	0.79	3.33	421%	15	7	$103	$ 48,123
3I149	5L45	8	0.0161	228	0.99	3.32	335%	15	10	$103	$ 23,486
Project Length				5,472				Project Cost			$ 900,008
PROJECT HP09											
3I150	3I149	8	0.0189	324	1.08	3.32	308%	15	10	$103	$ 33,330
3I151	3I150	8	0.0079	304	0.70	3.28	472%	15	10	$103	$ 31,326
3I42	3I151	8	0.0073	227	0.67	3.25	485%	15	10	$103	$ 23,353
3I43	3I42	8	0.0154	303	0.97	2.95	304%	15	10	$103	$ 31,256
3I32	3I43	8	0.0215	188	1.15	2.91	254%	15	10	$103	$ 19,383
3I30	3I32	8	0.0148	274	0.95	2.85	299%	15	10	$103	$ 28,196
3I29	3I30	8	0.0183	236	1.06	2.81	266%	12	10	$94	$ 22,151
3I26	3I29	8	0.0163	200	1.00	2.48	248%	12	10	$94	$ 18,780
3I25	3I26	8	0.0146	294	0.95	2.41	255%	12	10	$94	$ 27,591
3I24	3I25	8	0.0153	303	0.97	2.29	236%	12	10	$94	$ 28,518
3I23	3I24	8	0.0219	84	1.16	2.26	195%	12	10	$94	$ 7,939
3J46	3I23	8	0.0210	182	1.13	2.20	194%	12	10	$94	$ 17,127
3J47	3J46	8	0.0209	78	1.13	2.18	192%	12	10	$94	$ 7,307
3J48	3J47	8	0.0210	115	1.13	2.07	182%	12	10	$94	$ 10,793
3J49	3J48	8	0.0210	78	1.13	1.90	167%	12	10	$94	$ 7,363
3J50	3J49	8	0.0198	201	1.10	1.89	172%	12	10	$94	$ 18,911
3J60A	3J50	8	0.0200	145	1.11	1.86	168%	12	10	$94	$ 13,585
3J60	3J60A	8	-0.0463	73	#NUM!	1.85	#NUM!	12	10	$94	$ 6,843
3J61	3J60	8	0.0270	128	1.29	1.78	139%	12	10	$94	$ 12,072
3J62	3J61	8	0.0040	190	0.50	0.94	190%	12	10	$94	$ 17,853
3J63	3J62	8	0.0040	256	0.50	0.93	188%	12	10	$94	$ 24,027
3J64	3J63	8	0.0040	396	0.50	0.92	185%	12	10	$94	$ 37,222
3J65	3J64	8	0.0040	133	0.50	0.64	129%	10	10	$84	$ 11,173
3J66	3J65	8	0.0040	260	0.50	0.63	128%	10	10	$84	$ 21,813
3J24	3J66	8	0.0040	190	0.50	0.61	123%	10	10	$84	$ 15,951
3J21	3J24	8	0.0040	269	0.50	0.48	97%	10	10	$84	$ 22,585

Appendix B
Relief Sewer Recommendations
10-Year 2030 Flow Rates

Manhole		Existing Diameter	Existing Slope	Existing Length	Capacity	2030Flow	%	Recommended Pipe	Estimated Avg. Pipe	Unit	Segment Total
US	DS	(inches)	(ft/ft)	(ft)	(MGD)	(MGD)	Used	Diameter	Depth	Cost	Cost
Project Length				5,430				Project Cost			$ 516,447
PROJECT HP10											
3I1	5L61	15	0.0102	290	4.23	4.40	104%	18	10	$113	$ 32,782
3I2	3I1	15	0.0105	315	4.28	4.41	103%	18	10	$113	$ 35,565
3I3	3I2	15	0.0069	103	3.48	4.41	127%	18	10	$113	$ 11,606
3I3A	3I3	15	0.0108	227	4.36	4.41	101%	18	6	$113	$ 25,652
3I4	3I3A	15	0.0019	155	1.84	4.40	239%	18	6	$113	$ 17,560
3I5	3I4	15	0.0099	123	4.18	4.17	100%	18	10	$113	$ 13,856
3I6	3I5	15	0.0168	226	5.42	4.17	77%	18	7	$113	$ 25,565
3I7	3I6	15	0.0183	175	5.67	4.16	73%	18	7	$113	$ 19,798
3E52	3I7	15	0.0174	402	5.53	4.19	76%	18	10	$113	$ 45,415
3E53	3E52	15	0.0165	34	5.37	3.78	70%	18	10	$113	$ 3,845
3E54	3E53	15	0.0058	166	3.20	3.79	118%	18	5	$113	$ 18,743
3E55	3E54	15	0.0068	29	3.46	3.79	110%	18	5	$113	$ 3,308
3E56A	3E55	15	0.0050	84	2.97	3.53	119%	18	4	$113	$ 9,459
3E57	3E56A	15	0.0046	226	2.83	3.51	124%	18	5	$113	$ 25,551
3E58	3E57	15	0.0052	228	3.02	3.53	117%	18	5	$113	$ 25,793
3E59	3E58	15	0.0054	147	3.07	3.47	113%	18	5	$113	$ 16,582
Project Length				2,930				Project Cost			$ 331,082
PROJECT HP11											
3E2	3E1	30	0.0202	201	37.77	32.23	85%	42	10	$230	$ 46,172
3E3	3E2	30	0.0063	63	21.17	32.23	152%	42	10	$230	$ 14,509
3E114	3E3	42	0.0024	13	31.88	15.63	49%	42	8	$230	$ 2,887
3E115	3E114	42	0.0022	81	30.66	15.63	51%	42	8	$230	$ 18,733
3E116	3E115	42	0.0022	473	30.59	15.68	51%	42	9	$230	$ 108,761
3E117	3E116	42	0.0021	204	29.92	15.96	53%	42	8	$230	$ 46,989
3A122	3E117	42	0.0024	181	31.80	16.34	51%	42	6	$230	$ 41,615
3A74	3A122	42	0.0020	108	28.83	16.34	57%	42	6	$230	$ 24,729
3A123	3A74	42	0.0032	180	36.67	14.40	39%	42	6	$230	$ 41,488
3A124	3A123	42	0.0019	399	28.29	14.67	52%	42	6	$230	$ 91,713
3A125	3A124	30	0.0021	75	12.27	14.65	119%	42	6	$230	$ 17,273
3A96	3A125	30	0.0026	11	13.61	14.65	108%	42	7	$230	$ 2,634
3A96A	3A96	30	0.0056	174	19.83	29.31	148%	42	6	$230	$ 40,118
3A97A	3A96A	30	0.0056	187	19.91	29.30	147%	42	7	$230	$ 43,063

Appendix B
Relief Sewer Recommendations
10-Year 2030 Flow Rates

Manhole		Existing Diameter	Existing Slope	Existing Length	Capacity	2030Flow	%	Recommended Pipe	Estimated Avg. Pipe	Unit	Segment Total
US	DS	(inches)	(ft/ft)	(ft)	(MGD)	(MGD)	Used	Diameter	Depth	Cost	Cost
3A126	3A97A	30	0.0056	266	19.91	29.03	146%	42	7	$230	$ 61,137
3A102	3A126	18	0.0011	101	2.30	10.44	454%	42	8	$230	$ 23,200
3A103	3A102	21	0.0136	200	11.98	10.47	87%	42	10	$230	$ 46,021
3A106	3A103	21	0.0085	322	9.47	10.55	111%	42	10	$230	$ 74,000
3A107	3A106	18	0.0011	320	2.30	11.35	494%	42	10	$230	$ 73,559
3A23	3A107	18	0.0086	210	6.32	11.27	178%	42	10	$230	$ 48,224
3A134	3A23	18	0.0086	248	6.32	10.99	174%	42	9	$230	$ 57,093
3A21	3A134	18	0.0011	129	2.30	6.96	303%	42	10	$230	$ 29,655
3A18A	3A21	18	0.0011	303	2.30	6.69	291%	42	10	$230	$ 69,737
3A18	3A18A	18	0.0011	168	2.30	6.68	291%	42	10	$230	$ 38,592
3A17	3A18	18	0.0011	300	2.30	6.78	295%	42	10	$230	$ 69,098
3A14	3A17	18	0.0011	312	2.30	6.84	297%	42	10	$230	$ 71,669
3B2	3A14	18	0.0011	254	2.30	5.96	259%	42	10	$230	$ 58,501
3B4	3B2	18	0.0011	442	2.30	11.94	519%	42	10	$230	$ 101,561
3B4A	3B4	18	0.0011	79	2.30	11.87	516%	42	10	$230	$ 18,180
3B6	3B4A	18	0.0011	403	2.30	12.44	541%	42	10	$230	$ 92,782
3B6A	3B6	48	0.0011	9	31.44	12.35	39%	42	10	$230	$ 2,157
3B8	3B6A	18	0.0011	353	2.30	10.80	470%	42	10	$230	$ 81,146
3B10	3B8	18	0.0011	202	2.30	10.72	466%	42	10	$230	$ 46,492
3B12	3B10	18	0.0011	182	2.30	10.68	464%	42	10	$230	$ 41,889
3B14	3B12	12	0.0019	184	1.02	10.63	1046%	42	10	$230	$ 42,401
3B16	3B14	12	0.0019	183	1.02	10.51	1034%	42	10	$230	$ 42,012
3B18	3B16	12	0.0019	193	1.02	10.23	1006%	42	10	$230	$ 44,314
3B19	3B18	12	0.0019	224	1.02	10.19	1002%	42	10	$230	$ 51,604
3B22	3B19	18	0.0011	181	2.30	20.27	882%	48	10	$245	$ 44,262
3B24	3B22	18	0.0011	175	2.30	18.96	825%	48	10	$245	$ 42,770
3B24A	3B24	18	0.0011	18	2.30	18.92	823%	48	10	$245	$ 4,302
3B24B	3B24A	30	0.0006	155	6.35	18.84	297%	48	10	$245	$ 37,859
3B24C	3B24B	27	0.0007	97	5.12	18.76	367%	48	10	$245	$ 23,847
3B25A	3B24C	27	0.0006	76	5.12	18.74	366%	48	10	$245	$ 18,590
3B28	3B25A	42	0.0011	79	22.02	11.08	50%	42	10	$230	$ 18,269
3C2	3B28	18	0.0011	189	2.30	10.64	463%	42	10	$230	$ 43,401
3C3	3C2	18	0.0011	150	2.30	10.60	461%	42	10	$230	$ 34,593
3C6	3C3	15	0.0014	12	1.59	7.42	466%	36	10	$200	$ 2,467
3C7	3C6	8	0.0040	333	0.50	4.76	962%	24	10	$135	$ 44,987
3C8A	3C7	8	0.0040	24	0.50	4.69	946%	24	10	$135	$ 3,267
3C8	3C8A	10	0.0025	134	0.71	4.60	650%	24	10	$135	$ 18,038
3C9	3C8	10	0.0025	194	0.71	4.23	598%	24	10	$135	$ 26,185
4O48	3C9	10	0.0025	323	0.71	4.18	591%	24	10	$135	$ 43,638
4O49	4O48	10	0.0025	80	0.71	3.73	528%	24	10	$135	$ 10,782
4O50T	4O49	10	0.0025	20	0.71	3.72	526%	24	10	$135	$ 2,657

Appendix B
Relief Sewer Recommendations
10-Year 2030 Flow Rates

Manhole		Existing Diameter	Existing Slope	Existing Length	Capacity	2030Flow	%	Recommended Pipe	Estimated Avg. Pipe	Unit	Segment Total
US	DS	(inches)	(ft/ft)	(ft)	(MGD)	(MGD)	Used	Diameter	Depth	Cost	Cost
4O52	4O50T	10	0.0025	391	0.71	3.80	537%	24	10	$135	$ 52,841
4O55	4O52	8	0.0040	326	0.50	3.24	655%	18	10	$113	$ 36,798
4O64	4O55	8	0.0040	262	0.50	3.09	624%	18	10	$113	$ 29,618
4O63	4O64	8	0.0040	71	0.50	2.88	581%	18	10	$113	$ 8,027
4O62	4O63	8	0.0040	337	0.50	2.86	578%	18	10	$113	$ 38,081
4O61	4O62	8	0.0040	317	0.50	2.47	499%	15	10	$103	$ 32,624
4O76	4O61	8	0.0040	299	0.50	2.40	484%	15	10	$103	$ 30,829
4O77	4O76	8	0.0040	370	0.50	2.24	453%	15	10	$103	$ 38,070
4O79	4O77	8	0.0040	415	0.50	1.93	389%	15	10	$103	$ 42,728
4O80CO	4O79	8	0.0040	298	0.50	0.74	149%	10	10	$84	$ 25,030
4O81	4O80CO	8	0.0040	241	0.50	0.70	142%	10	10	$84	$ 20,230
4O96CO	4O81	8	0.0040	270	0.50	0.60	122%	10	10	$84	$ 22,652
4O97	4O96CO	8	0.0040	31	0.50	0.54	110%	10	10	$84	$ 2,611
4O98CO	4O97	8	0.0040	38	0.50	0.46	93%	10	10	$84	$ 3,161
4O99	4O98CO	8	0.0040	277	0.50	0.50	101%	10	10	$84	$ 23,230
5G81A	5G36	8	0.0040	20	0.50	0.71	143%	15	10	$103	$ 2,104
5G81	5G81A	8	0.0040	112	0.50	0.75	150%	15	10	$103	$ 11,530
5G79	5G81	8	0.0040	239	0.50	1.41	286%	12	10	$94	$ 22,442
5G78A	5G79	8	0.0040	227	0.50	1.32	266%	12	10	$94	$ 21,304
5G78	5G78A	8	0.0040	36	0.50	1.16	233%	12	10	$94	$ 3,409
5G71	5G78	8	0.0040	48	0.50	1.13	228%	12	10	$94	$ 4,540
5G70	5G71	8	0.0040	99	0.50	0.60	121%	10	10	$84	$ 8,323
5G69	5G70	8	0.0040	314	0.50	0.62	125%	10	10	$84	$ 26,410
5H6	5H5	8	0.0040	60	0.50	0.90	181%	10	10	$84	$ 5,050
5H7	5H6	8	0.0040	229	0.50	0.60	120%	10	10	$84	$ 19,199
5G23	5G22	8	0.0488	211	1.73	2.23	129%	15	10	$103	$ 21,717
5H1	5G23	8	0.0040	184	0.49	2.08	423%	15	10	$103	$ 18,960
5H2	5H1	8	0.0040	229	0.49	1.95	395%	15	10	$103	$ 23,559
5H3	5H2	8	0.0041	267	0.50	1.91	383%	15	10	$103	$ 27,452
5H4	5H3	8	0.0040	256	0.50	1.83	369%	15	10	$103	$ 26,340
5H5	5H4	8	0.0040	289	0.50	1.74	352%	15	10	$103	$ 29,758
5H20	5H5	8	0.0040	108	0.50	0.69	139%	10	10	$84	$ 9,071
5H19	5H20	8	0.0040	163	0.50	0.66	133%	10	10	$84	$ 13,705
5H18	5H19	8	0.0040	104	0.50	0.58	117%	10	10	$84	$ 8,759
5H17A	5H18	8	0.0040	69	0.50	0.52	104%	10	10	$84	$ 5,765
5H17	5H17A	8	0.0040	114	0.50	0.51	104%	10	10	$84	$ 9,593
3E9	3E6	12	0.0019	172	1.02	1.06	104%	15	10	$103	$ 17,698
3E10	3E9	12	0.0019	180	1.02	0.82	81%	12	10	$94	$ 16,954

Appendix B
Relief Sewer Recommendations
10-Year 2030 Flow Rates

Manhole		Existing Diameter	Existing Slope	Existing Length	Capacity	2030Flow	%	Recommended Pipe	Estimated Avg. Pipe	Unit	Segment Total
US	DS	(inches)	(ft/ft)	(ft)	(MGD)	(MGD)	Used	Diameter	Depth	Cost	Cost
3E11	3E10	8	0.0040	391	0.50	0.76	154%	10	10	$84	$ 32,836
3E11A	3E11	8	0.0040	281	0.50	0.71	143%	10	10	$84	$ 23,583
3E11B	3E11A	8	0.0040	117	0.50	0.68	138%	10	10	$84	$ 9,866
3E12	3E11B	8	0.0040	194	0.50	0.69	139%	10	10	$84	$ 16,285
3E13	3E12	8	0.0040	232	0.50	0.68	137%	10	10	$84	$ 19,464
3E14	3E13	8	0.0040	190	0.50	0.66	132%	10	10	$84	$ 15,975
4M6	4M5	12	0.0050	129	1.63	0.97	60%	15	10	$103	$ 13,271
4M7	4M6	12	0.0050	161	1.63	0.98	60%	15	10	$103	$ 16,623
4M8	4M7	10	0.0025	79	0.71	0.98	138%	15	10	$103	$ 8,095
4M9	4M8	12	0.0019	169	1.02	0.99	97%	15	10	$103	$ 17,447
4M10	4M9	12	0.0019	536	1.02	1.09	107%	15	10	$103	$ 55,249
4M11	4M10	12	0.0019	747	1.02	1.08	106%	15	10	$103	$ 76,935
4M156	4M11	8	0.0040	282	0.50	0.93	189%	12	10	$94	$ 26,461
4M12	4M156	8	0.0040	101	0.50	0.87	175%	10	10	$84	$ 8,496
4M190	4M12	8	0.0040	118	0.50	0.75	151%	10	10	$84	$ 9,926
4M13	4M190	8	0.0040	67	0.50	0.72	146%	10	10	$84	$ 5,610
4M14	4M13	8	0.0040	56	0.50	0.56	114%	10	10	$84	$ 4,717
3A76	3A75	8	0.0153	183	0.97	2.70	279%	15	6	$103	$ 18,884
3A77	3A76	8	0.0100	350	0.78	2.66	340%	15	5	$103	$ 36,099
3A78	3A77	8	0.0040	236	0.50	1.76	356%	15	10	$103	$ 24,310
3A78A	3A78	8	0.0040	258	0.50	2.39	483%	15	10	$103	$ 26,591
3A82A	3A78A	8	0.0040	177	0.50	2.33	471%	15	10	$103	$ 18,204
3A82	3A82A	8	0.0040	44	0.50	2.29	463%	15	10	$103	$ 4,530
3A86	3A82	8	0.0040	307	0.50	2.07	419%	15	10	$103	$ 31,669
3A87	3A86	8	0.0040	313	0.50	2.08	421%	15	10	$103	$ 32,284
3A87A	3A87	8	0.0040	47	0.50	2.01	406%	15	10	$103	$ 4,890
3A88	3A87A	8	0.0040	161	0.50	2.00	404%	15	10	$103	$ 16,549
3A88A	3A88	8	0.0040	25	0.50	1.96	397%	15	10	$103	$ 2,594
3E118	3A88A	8	0.0040	348	0.50	2.03	410%	15	10	$103	$ 35,873
3E130	3E118	8	0.0252	58	1.24	1.95	157%	15	10	$103	$ 5,933
3F1	3E130	8	0.0252	168	1.24	1.84	148%	15	10	$103	$ 17,331
3F1A	3F1	8	0.0040	150	0.50	1.80	364%	15	10	$103	$ 15,501
3F2	3F1A	8	0.0040	164	0.50	1.35	273%	12	10	$94	$ 15,380
3F3	3F2	8	0.0040	175	0.50	1.32	266%	12	10	$94	$ 16,415
3F4	3F3	8	0.0040	353	0.50	1.13	228%	12	10	$94	$ 33,226
3F4A	3F4	8	0.0220	88	1.16	1.06	91%	12	10	$94	$ 8,226
3F14A	3F4A	8	0.0040	145	0.50	0.96	194%	12	10	$94	$ 13,622
3F14	3F14A	8	0.0140	191	0.93	0.98	106%	10	10	$84	$ 16,047
3F15	3F14	8	0.0250	298	1.24	1.00	80%	10	10	$84	$ 25,037

Appendix B
Relief Sewer Recommendations
10-Year 2030 Flow Rates

Manhole		Existing Diameter	Existing Slope	Existing Length	Capacity	2030Flow	%	Recommended Pipe	Estimated Avg. Pipe	Unit	Segment Total
US	DS	(inches)	(ft/ft)	(ft)	(MGD)	(MGD)	Used	Diameter	Depth	Cost	Cost
3F16	3F15	8	0.0040	204	0.50	0.71	143%	10	10	$84	$ 17,166
3F18	3F16	8	0.0040	59	0.50	0.66	133%	10	10	$84	$ 4,956
3F19	3F18	8	0.0040	150	0.50	0.51	104%	10	10	$84	$ 12,621
3A12A	3A14	8	0.0040	26	0.50	0.73	148%	10	10	$84	$ 2,220
3A12	3A12A	8	0.0040	269	0.50	0.76	154%	10	10	$84	$ 22,575
3A11	3A12	8	0.0040	296	0.50	0.74	150%	10	10	$84	$ 24,897
3A11ACO	3A11	8	0.0040	252	0.50	0.53	108%	10	10	$84	$ 21,160
4M66	3A11ACO	8	0.0040	225	0.50	0.52	105%	10	10	$84	$ 18,902
3B92B	3B92A	8	0.0040	51	0.50	7.66	1547%	24	10	$135	$ 6,837
3B92C	3B92B	8	0.0040	173	0.50	7.65	1544%	24	10	$135	$ 23,300
3B93	3B92C	8	0.0040	124	0.50	7.61	1536%	24	10	$135	$ 16,799
3B94	3B93	8	0.0040	288	0.50	7.58	1531%	24	10	$135	$ 38,824
3B99	3B94	8	0.0040	62	0.50	7.43	1500%	24	10	$135	$ 8,373
3B99A	3B99AT	8	0.0040	37	0.50	7.35	1485%	24	10	$135	$ 5,040
3B99AT	3B99	8	0.0040	195	0.50	7.41	1497%	24	10	$135	$ 26,351
3B184T	3B99A	8	0.0040	116	0.50	7.34	1483%	24	10	$135	$ 15,674
3B100	3B184T	8	0.0040	154	0.50	7.14	1443%	24	10	$135	$ 20,778
3B101	3B100	8	0.0040	209	0.50	6.99	1413%	24	10	$135	$ 28,163
3B102	3B101	8	0.0040	89	0.50	6.87	1386%	24	10	$135	$ 11,962
3B104T	3B102	8	0.0058	342	0.60	6.11	1025%	24	10	$135	$ 46,147
3B104	3B104T	8	0.0058	28	0.60	5.82	976%	24	10	$135	$ 3,813
3B106	3B104	8	0.0058	279	0.60	5.81	974%	24	10	$135	$ 37,700
3B109	3B106	8	0.0040	376	0.50	5.01	1012%	24	10	$135	$ 50,770
3B111B	3B109	8	0.0040	228	0.50	4.93	995%	24	10	$135	$ 30,724
3B111A	3B111B	8	0.0040	52	0.50	4.87	984%	24	10	$135	$ 7,014
3B111	3B111A	8	0.0040	143	0.50	4.86	982%	24	10	$135	$ 19,271
3B198	3B111	8	0.0040	329	0.50	4.83	975%	24	10	$135	$ 44,455
3B113	3B198	8	0.0040	174	0.50	4.75	960%	24	10	$135	$ 23,424
3B197DUP	3B113	8	0.0058	122	0.60	3.89	652%	18	10	$113	$ 13,780
3B158	3B197DUP	8	0.0058	25	0.60	3.86	648%	18	10	$113	$ 2,877
3B159	3B158	8	0.0058	322	0.60	3.86	647%	18	10	$113	$ 36,393
3B160	3B159	8	0.0058	223	0.60	3.43	575%	18	10	$113	$ 25,177
3B161	3B160	8	0.0058	79	0.60	3.38	566%	18	10	$113	$ 8,900
3B161BCO	3B161	8	0.0040	131	0.50	3.24	654%	18	10	$113	$ 14,764
3C146	3B161BCO	8	0.0040	196	0.50	3.21	647%	18	10	$113	$ 22,125
3C147	3C146	8	0.0040	180	0.50	3.16	638%	18	10	$113	$ 20,298
3C148	3C147	8	0.0070	238	0.66	2.17	331%	15	10	$103	$ 24,546
3C157	3C148	8	0.0100	158	0.78	1.83	234%	12	10	$94	$ 14,854
3C157A	3C157	8	0.0100	175	0.78	1.79	229%	12	10	$94	$ 16,492

Appendix B
Relief Sewer Recommendations
10-Year 2030 Flow Rates

Manhole		Existing Diameter	Existing Slope	Existing Length	Capacity	2030Flow	%	Recommended Pipe	Estimated Avg. Pipe	Unit	Segment Total
US	DS	(inches)	(ft/ft)	(ft)	(MGD)	(MGD)	Used	Diameter	Depth	Cost	Cost
3C204DUP	3C157A	8	0.0050	175	0.55	1.32	240%	12	10	$94	$ 16,439
3C202DUP	3C204DUP	8	0.0075	99	0.68	1.27	188%	12	10	$94	$ 9,317
3C200DUP	3C202DUP	8	0.0100	147	0.78	1.25	159%	10	10	$84	$ 12,321
3C163	3C200DUP	8	0.0100	120	0.78	1.03	132%	10	10	$84	$ 10,083
3G159	3C163	8	0.0100	136	0.78	0.88	112%	10	10	$84	$ 11,434
3G158DUP	3G159	8	0.0100	176	0.78	0.89	114%	10	10	$84	$ 14,747
3G157DUP	3G158DUP	8	0.0100	185	0.78	0.89	114%	10	10	$84	$ 15,516
3G9	3G157DUP	8	0.0100	71	0.78	0.86	110%	10	10	$84	$ 5,954
3B143	3B106	8	0.0058	173	0.60	0.77	129%	10	10	$84	$ 14,540
3B114	3B113	8	0.0110	150	0.82	0.87	106%	10	10	$84	$ 12,617
3B115	3B114	8	0.0110	244	0.82	0.88	108%	10	10	$84	$ 20,510
3B117	3B115	8	0.0110	409	0.82	0.67	81%	10	10	$84	$ 34,377
3C131CO	3B117	8	0.0040	226	0.50	0.60	121%	10	10	$84	$ 18,966
3C155	3C147	8	0.0040	287	0.50	1.00	203%	12	10	$94	$ 26,937
3C156	3C155	8	0.0040	274	0.50	0.99	199%	12	10	$94	$ 25,796
3G1	3C156	8	0.0040	187	0.50	0.76	153%	10	10	$84	$ 15,675
3G2B	3G1	8	0.0040	153	0.50	0.75	151%	10	10	$84	$ 12,887
3G2A	3G2B	8	0.0040	65	0.50	0.59	119%	10	10	$84	$ 5,487
3G2	3G2A	8	0.0040	191	0.50	0.60	122%	10	10	$84	$ 16,029
3B45	3B6A	12	0.0019	306	1.02	2.15	211%	18	10	$113	$ 34,610
4N39	3B45	12	0.0019	308	1.02	2.17	214%	18	10	$113	$ 34,829
4N39B	4N39	10	0.0025	28	0.71	2.10	297%	18	10	$113	$ 3,185
4N38	4N39B	10	0.0025	295	0.71	2.18	308%	18	10	$113	$ 33,281
4N37	4N38	8	0.0040	302	0.50	1.10	223%	12	10	$94	$ 28,406
4N36	4N37	8	0.0040	308	0.50	1.08	219%	12	10	$94	$ 28,962
4N35	4N36	8	0.0040	314	0.50	1.06	214%	12	10	$94	$ 29,551
4N35A	4N35	8	0.0040	134	0.50	0.96	194%	12	10	$94	$ 12,555
4N139B	4N35A	8	0.0040	121	0.50	0.91	184%	12	10	$94	$ 11,341
4N139A	4N139B	8	0.0040	40	0.50	0.88	178%	10	10	$84	$ 3,366
4N139	4N139A	8	0.0040	72	0.50	0.87	176%	10	10	$84	$ 6,037
4N140	4N139	8	0.0040	221	0.50	0.90	181%	10	10	$84	$ 18,571
4N140A	4N140	8	0.0040	256	0.50	0.71	144%	10	10	$84	$ 21,513
4N141	4N140A	8	0.0040	254	0.50	0.69	138%	10	10	$84	$ 21,352
4N42A	4N38	8	0.0040	157	0.50	1.11	225%	12	10	$94	$ 14,757
4N42	4N42A	8	0.0040	184	0.50	1.13	228%	12	10	$94	$ 17,257
3B194DUP	3B22	8	0.0040	27	0.50	0.91	184%	12	10	$94	$ 2,516

Appendix B
Relief Sewer Recommendations
10-Year 2030 Flow Rates

Manhole		Existing Diameter	Existing Slope	Existing Length	Capacity	2030Flow	%	Recommended Pipe	Estimated Avg. Pipe	Unit	Segment Total
US	DS	(inches)	(ft/ft)	(ft)	(MGD)	(MGD)	Used	Diameter	Depth	Cost	Cost
3B74	3B194DUP	8	0.0040	113	0.50	0.87	176%	10	10	$84	$ 9,521
3B27	3B25A	12	0.0019	79	1.02	7.64	751%	15	10	$103	$ 8,186
3C4	3C3	10	0.0025	189	0.71	3.13	443%	21	10	$125	$ 23,612
4O34	3C4	10	0.0025	333	0.71	3.25	459%	21	10	$125	$ 41,651
4O32	4O34	10	0.0025	305	0.71	3.32	470%	21	10	$125	$ 38,121
4O31	4O32	10	0.0025	327	0.71	3.39	480%	21	10	$125	$ 40,820
4O29	4O31	10	0.0025	350	0.71	3.46	489%	21	10	$125	$ 43,706
4O25	4O29	8	0.0040	227	0.50	3.38	682%	18	10	$113	$ 25,616
4O173	4O25	8	0.0040	330	0.50	3.32	671%	18	10	$113	$ 37,263
4O23	4O173	8	0.0040	45	0.50	3.19	645%	18	10	$113	$ 5,029
4O167	4O23	8	0.0040	307	0.50	3.18	643%	18	10	$113	$ 34,682
4O160	4O167	8	0.0040	67	0.50	3.01	607%	18	10	$113	$ 7,555
4O169	4O160	8	0.0040	243	0.50	2.83	572%	18	10	$113	$ 27,471
4O170	4O169	8	0.0040	53	0.50	2.77	560%	18	10	$113	$ 6,010
4O168	4O170	8	0.0040	27	0.50	2.76	558%	18	10	$113	$ 3,092
4O146	4O168	8	0.0040	286	0.50	2.75	556%	18	10	$113	$ 32,279
4O146A	4O146	8	0.0040	160	0.50	1.99	402%	15	10	$103	$ 16,467
4O147	4O146A	8	0.0040	171	0.50	1.84	372%	15	10	$103	$ 17,654
4O147B	4O147	8	0.0040	32	0.50	1.73	349%	15	10	$103	$ 3,291
4O147A	4O147B	8	0.0040	66	0.50	1.72	348%	15	10	$103	$ 6,833
4O148	4O147A	8	0.0040	114	0.50	1.71	345%	15	10	$103	$ 11,725
4O151	4O148	8	0.0040	152	0.50	1.56	316%	15	10	$103	$ 15,650
4O152	4O151	8	0.0040	170	0.50	1.53	309%	15	10	$103	$ 17,538
4O153	4O152	8	0.0040	179	0.50	1.49	301%	15	10	$103	$ 18,397
4O132	4O153	8	0.0040	139	0.50	1.34	272%	12	10	$94	$ 13,086
4O131	4O132	8	0.0040	89	0.50	1.00	203%	12	10	$94	$ 8,331
4O130	4O131	8	0.0040	212	0.50	1.03	208%	12	10	$94	$ 19,958
4O129	4O130	8	0.0040	191	0.50	0.85	171%	10	10	$84	$ 16,043
4K138CO	4O129	8	0.0040	292	0.50	0.65	132%	10	10	$84	$ 24,558
4K137	4K138CO	8	0.0040	154	0.50	0.62	125%	10	10	$84	$ 12,898
4K136	4K137	8	0.0040	200	0.50	0.60	121%	10	10	$84	$ 16,807
4K135	4K136	8	0.0040	288	0.50	0.62	125%	10	10	$84	$ 24,157
4K35	4K135	8	0.0040	124	0.50	0.58	118%	10	10	$84	$ 10,451
4O145	4O146	8	0.0040	128	0.50	0.81	163%	12	10	$94	$ 12,071
4O144	4O145	8	0.0040	121	0.50	0.81	164%	12	10	$94	$ 11,345
4O142	4O144	10	0.0025	235	0.71	0.79	112%	12	10	$94	$ 22,094
4O141	4O142	10	0.0025	239	0.71	0.81	115%	12	10	$94	$ 22,497
4O139	4O141	10	0.0025	224	0.71	0.85	120%	12	10	$94	$ 21,038
4N114	4O139	8	0.0040	181	0.50	0.51	104%	10	10	$84	$ 15,235

Appendix B
Relief Sewer Recommendations
10-Year 2030 Flow Rates

Manhole		Existing Diameter	Existing Slope	Existing Length	Capacity	2030Flow	%	Recommended Pipe	Estimated Avg. Pipe	Unit	Segment Total
US	DS	(inches)	(ft/ft)	(ft)	(MGD)	(MGD)	Used	Diameter	Depth	Cost	Cost
4O32A	4O33	8	0.0040	306	0.50	0.84	170%	10	10	$84	$ 25,673
4O30A	4O32A	8	0.0040	167	0.50	0.78	157%	10	10	$84	$ 14,023
4O30	4O30A	8	0.0040	194	0.50	0.78	157%	10	10	$84	$ 16,308
4O27	4O30	8	0.0040	128	0.50	0.77	156%	10	10	$84	$ 10,752
4O26	4O27	8	0.0040	109	0.50	0.72	145%	10	10	$84	$ 9,182
4O26DT	4O26	8	0.0040	175	0.50	0.58	117%	10	10	$84	$ 14,731
4O24	4O26DT	8	0.0040	154	0.50	0.51	103%	10	10	$84	$ 12,964
4O24A	4O24	8	0.0040	14	0.50	0.48	96%	10	10	$84	$ 1,173
4O24B	4O24A	8	0.0040	110	0.50	0.50	101%	10	10	$84	$ 9,212
3C32	3C6	12	0.0019	136	1.02	9.40	925%	30	10	$170	$ 23,078
3C33	3C32	12	0.0019	166	1.02	9.37	922%	30	10	$170	$ 28,293
3C34	3C33	12	0.0019	189	1.02	8.75	861%	30	10	$170	$ 32,213
3C35	3C34	12	0.0019	212	1.02	8.31	817%	30	10	$170	$ 36,109
3C35A	3C35	12	0.0019	71	1.02	8.19	805%	30	10	$170	$ 12,106
3C36	3C35A	12	0.0019	136	1.02	8.17	804%	30	10	$170	$ 23,078
3C48	3C36	12	0.0019	158	1.02	8.03	790%	30	10	$170	$ 26,815
3C49CO	3C48	12	0.0019	137	1.02	7.98	785%	30	10	$170	$ 23,323
3C50	3C49CO	12	0.0019	171	1.02	7.95	782%	30	10	$170	$ 29,154
3C51	3C50	12	0.0019	318	1.02	7.77	764%	30	10	$170	$ 53,979
3C52	3C51	12	0.0019	78	1.02	7.39	727%	30	10	$170	$ 13,254
3C52B	3C52	12	0.0019	182	1.02	6.49	638%	30	10	$170	$ 31,014
3C53B	3C52B	12	0.0019	394	1.02	6.63	652%	30	10	$170	$ 66,942
3C53	3C53B	12	0.0019	295	1.02	6.45	635%	24	10	$135	$ 39,815
3C54CO	3C53	12	0.0019	188	1.02	6.24	613%	24	10	$135	$ 25,443
3C55	3C54CO	12	0.0019	256	1.02	6.19	609%	24	10	$135	$ 34,518
3C74	3C55	10	0.0025	246	0.71	4.18	591%	24	10	$135	$ 33,152
3C75	3C74	10	0.0025	290	0.71	4.12	583%	24	10	$135	$ 39,096
3C77	3C75	10	0.0025	123	0.71	3.90	551%	24	10	$135	$ 16,630
3C178CO	3C77	10	0.0025	172	0.71	3.79	536%	24	10	$135	$ 23,222
3C179	3C178CO	10	0.0025	246	0.71	3.75	531%	24	10	$135	$ 33,260
3C177	3C179	8	0.0040	135	0.50	2.09	422%	15	10	$103	$ 13,942
3C181	3C177	8	0.0040	99	0.50	1.93	389%	15	10	$103	$ 10,232
3C182	3C181	8	0.0040	221	0.50	1.90	384%	15	10	$103	$ 22,777
3C183	3C182	8	0.0040	134	0.50	1.85	374%	15	10	$103	$ 13,817
3C188	3C183	8	0.0040	178	0.50	1.82	368%	15	10	$103	$ 18,371
3C189	3C188	8	0.0040	158	0.50	1.63	329%	15	10	$103	$ 16,262
3C193	3C189	8	0.0040	270	0.50	1.63	328%	15	10	$103	$ 27,824
3C196B	3C193	8	0.0048	260	0.54	1.62	300%	15	10	$103	$ 26,804
3C194	3C196B	8	0.0245	16	1.23	1.49	121%	12	10	$94	$ 1,542
3C196A	3C194	8	0.0063	134	0.62	1.41	227%	12	10	$94	$ 12,625

Appendix B
Relief Sewer Recommendations
10-Year 2030 Flow Rates

Manhole		Existing Diameter	Existing Slope	Existing Length	Capacity	2030Flow	%	Recommended Pipe	Estimated Avg. Pipe	Unit	Segment Total
US	DS	(inches)	(ft/ft)	(ft)	(MGD)	(MGD)	Used	Diameter	Depth	Cost	Cost
3C205	3C196A	8	0.0040	14	0.50	1.38	278%	12	10	$94	$ 1,335
3C204	3C205	8	0.0040	192	0.50	1.43	289%	12	10	$94	$ 18,088
3C196	3C204	8	0.0040	38	0.50	1.39	280%	12	10	$94	$ 3,537
3G20	3C196	8	0.0112	357	0.83	1.29	156%	10	10	$84	$ 30,022
3G23	3G20	8	0.0100	185	0.78	1.07	137%	10	10	$84	$ 15,518
3G22	3G23	8	0.0100	192	0.78	0.90	115%	10	10	$84	$ 16,089
3C118	3C33	8	0.0040	264	0.50	0.64	129%	10	10	$84	$ 22,202
3C115B	3C118	8	0.0040	128	0.50	0.60	122%	10	10	$84	$ 10,748
3C89	3C52	8	0.0040	302	0.50	0.93	188%	12	10	$94	$ 28,384
3C88	3C89	8	0.0040	308	0.50	0.90	183%	12	10	$94	$ 28,990
3C86A	3C88	8	0.0040	248	0.50	0.87	176%	10	10	$84	$ 20,805
3C86	3C86A	8	0.0040	264	0.50	0.85	173%	10	10	$84	$ 22,202
3C127B	3C86	8	0.0040	136	0.50	0.48	97%	10	10	$84	$ 11,464
3C70CO	3C55	10	0.0025	135	0.71	1.61	227%	15	10	$103	$ 13,860
3C71	3C70CO	10	0.0025	176	0.71	1.65	234%	15	10	$103	$ 18,124
3D45CO	3C71	8	0.0040	158	0.50	1.41	284%	12	10	$94	$ 14,836
3D46	3D45CO	8	0.0040	106	0.50	1.37	276%	12	10	$94	$ 9,920
3D47	3D46	8	0.0040	69	0.50	1.17	236%	12	10	$94	$ 6,439
3D48CO	3D47	8	0.0040	166	0.50	1.00	202%	12	10	$94	$ 15,597
3D49	3D48CO	8	0.0040	152	0.50	1.01	204%	12	10	$94	$ 14,308
3D50	3D49	8	0.0040	60	0.50	0.77	155%	10	10	$84	$ 5,022
3D51	3D50	8	0.0040	96	0.50	0.51	104%	10	10	$84	$ 8,086
3C180A	3C179	10	0.0025	259	0.71	1.67	236%	15	10	$103	$ 26,658
3C180	3C180A	10	0.0025	19	0.71	1.21	172%	15	10	$103	$ 1,938
3C192	3C180	8	0.0100	279	0.78	0.81	104%	10	10	$84	$ 23,425
4O75	4O79	8	0.0040	22	0.50	0.87	175%	10	10	$84	$ 1,808
4O74	4O75	8	0.0040	177	0.50	0.88	178%	10	10	$84	$ 14,827
4O84	4O74	8	0.0040	243	0.50	0.89	179%	10	10	$84	$ 20,416
4O86	4O84	8	0.0050	379	0.55	0.92	165%	10	10	$84	$ 31,832
4O88	4O86	8	0.0040	128	0.50	0.84	170%	10	10	$84	$ 10,758
4O94	4O88	8	0.0040	187	0.50	0.73	148%	10	10	$84	$ 15,679
4O106	4O94	8	0.0040	361	0.50	0.60	121%	10	10	$84	$ 30,294
4N44	4N42	8	0.0040	310	0.50	0.69	138%	10	10	$84	$ 26,000
Project Length				59,891				Project Cost			$ 7,402,333

Appendix B
Relief Sewer Recommendations
10-Year 2030 Flow Rates

Manhole		Existing	Existing	Existing				Recommended	Estimated Avg.		Segment
		Diameter	Slope	Length	Capacity	2030Flow	%	Pipe	Pipe	Unit	Total
US	DS	(inches)	(ft/ft)	(ft)	(MGD)	(MGD)	Used	Diameter	Depth	Cost	Cost
PROJECT HP12											
3F71	3F67	12	0.0160	219	2.92	1.70	58%	18	10	$113	$ 24,787
3F159	3F71	12	0.0144	163	2.77	1.72	62%	18	6	$113	$ 18,447
3F72	3F159	15	0.0014	301	1.59	1.74	109%	18	10	$113	$ 33,992
3F79	3F72	15	0.0014	73	1.59	1.67	105%	18	10	$113	$ 8,204
3F88	3F88A	8	0.0040	83	0.50	1.26	255%	12	10	$94	$ 7,817
3G61	3F88	8	0.0040	44	0.50	1.26	255%	12	10	$94	$ 4,156
3G63	3G61	8	0.0040	141	0.50	1.24	250%	12	10	$94	$ 13,239
3G63A	3G63	8	0.0040	155	0.50	1.20	242%	12	10	$94	$ 14,537
3G155	3G63A	8	0.0040	156	0.50	1.20	242%	12	10	$94	$ 14,702
3G156	3G155	8	0.0040	40	0.50	1.19	241%	12	10	$94	$ 3,785
3G157	3G156	10	0.0025	164	0.71	1.20	169%	12	10	$94	$ 15,374
3G158	3G157	8	0.0040	98	0.50	1.15	232%	12	10	$94	$ 9,238
3G74	3G158	8	0.0040	34	0.50	1.14	229%	12	10	$94	$ 3,183
3F95	3F67	8	0.0040	213	0.50	0.80	161%	10	10	$84	$ 17,853
3F154	3F95	8	0.0040	50	0.50	0.74	149%	10	10	$84	$ 4,189
3F100	3F154	8	0.0040	196	0.50	0.71	143%	10	10	$84	$ 16,483
3F99	3F100	8	0.0040	256	0.50	0.65	131%	10	10	$84	$ 21,497
3F122	3F99	8	0.0040	220	0.50	0.62	125%	10	10	$84	$ 18,518
Project Length				2,606				Project Cost			$ 249,999
PROJECT HP13											
4I41B	4I41	15	0.0020	70	1.87	5.91	315%	24	10	$135	$ 9,514
4I48B	4I41B	15	0.0014	126	1.59	5.90	370%	24	10	$135	$ 16,958
4I48A	4I48B	15	0.0020	29	1.87	5.90	315%	24	10	$135	$ 3,877
4I48	4I48A	16	0.0080	54	4.45	5.90	133%	18	10	$113	$ 6,064
4I49	4I48	12	0.0177	251	3.07	5.90	192%	18	10	$113	$ 28,373
4I50	4I49	12	0.0177	136	3.07	5.90	192%	18	10	$113	$ 15,420
4I51	4I50	12	0.0395	135	4.59	3.73	81%	18	10	$113	$ 15,273
4I52	4I51	10	0.0025	247	0.71	3.52	498%	18	10	$113	$ 27,866
4J28	4I52	10	0.0025	46	0.71	3.47	491%	18	10	$113	$ 5,181
4J30A	4J28	10	0.0025	430	0.71	3.10	438%	18	10	$113	$ 48,600
4J30	4J30A	10	0.0025	191	0.71	3.00	424%	18	10	$113	$ 21,533

Appendix B
Relief Sewer Recommendations
10-Year 2030 Flow Rates

Manhole		Existing Diameter	Existing Slope	Existing Length	Capacity	2030Flow	%	Recommended Pipe	Estimated Avg. Pipe	Unit	Segment Total
US	DS	(inches)	(ft/ft)	(ft)	(MGD)	(MGD)	Used	Diameter	Depth	Cost	Cost
4J31	4J30	10	0.0025	219	0.71	2.96	418%	18	10	$113	$ 24,757
4J32	4J31	8	0.0040	214	0.50	2.72	550%	18	10	$113	$ 24,138
4J33	4J32	8	0.0040	183	0.50	2.68	541%	18	10	$113	$ 20,676
4J33A	4J33	8	0.0040	61	0.50	2.07	419%	15	10	$103	$ 6,307
4J34	4J33A	8	0.0040	249	0.50	1.99	403%	15	10	$103	$ 25,641
4J40	4J34	8	0.0040	208	0.50	1.49	300%	15	10	$103	$ 21,463
4J41	4J40	8	0.0040	38	0.50	1.44	291%	12	10	$94	$ 3,558
4J41A	4J41	8	0.0040	94	0.50	1.43	289%	12	10	$94	$ 8,880
4J41B	4J41A	8	0.0040	36	0.50	1.41	285%	12	10	$94	$ 3,370
4J42	4J41B	8	0.0040	35	0.50	1.41	284%	12	10	$94	$ 3,293
4J169CO	4J42	8	0.0040	87	0.50	0.73	147%	10	10	$84	$ 7,291
4J49	4J169CO	8	0.0040	160	0.50	0.71	143%	10	10	$84	$ 13,413
4J50	4J49	8	0.0040	241	0.50	0.68	137%	10	10	$84	$ 20,222
4J51	4J50	8	0.0040	108	0.50	0.58	117%	10	10	$84	$ 9,085
4J52	4J51	8	0.0040	303	0.50	0.58	117%	10	10	$84	$ 25,462
4J22	4J33	8	0.0040	312	0.50	0.57	115%	10	10	$84	$ 26,233
4I96	4I50	12	0.0130	47	2.63	2.17	82%	15	10	$103	$ 4,851
4I56	4I96	8	0.0040	7	0.50	1.65	333%	15	10	$103	$ 711
4I57	4I56	8	0.0040	252	0.50	1.51	306%	15	10	$103	$ 25,959
4I58	4I57	8	0.0040	72	0.50	1.46	294%	12	10	$94	$ 6,809
4I63	4I58	8	0.0040	312	0.50	0.76	153%	10	10	$84	$ 26,167
4I64	4I63	8	0.0040	75	0.50	0.69	139%	10	10	$84	$ 6,307
4I65	4I64	8	0.0040	164	0.50	0.68	137%	10	10	$84	$ 13,737
4I66	4I65	8	0.0040	223	0.50	0.64	130%	10	10	$84	$ 18,762
4J4	4I66	8	0.0040	254	0.50	0.60	122%	10	10	$84	$ 21,364
4J4A	4J4	8	0.0040	50	0.50	0.54	109%	10	10	$84	$ 4,197
4I59	4I58	8	0.0040	133	0.50	0.69	139%	10	10	$84	$ 11,149
4I60	4I59	8	0.0040	166	0.50	0.66	133%	10	10	$84	$ 13,956
4I61	4I60	8	0.0040	166	0.50	0.62	126%	10	10	$84	$ 13,904
Project Length				6,183				Project Cost			$ 610,321
PROJECT HP15											
10A82	10A35	12	0.0422	108	4.74	5.73	121%	24	10	$135	$ 14,597
10A83	10A82	12	0.0030	394	1.27	6.01	472%	24	22	$180	$ 70,809
10A84	10A83	12	0.0030	160	1.26	5.73	454%	24	22	$180	$ 28,817

Appendix B
Relief Sewer Recommendations
10-Year 2030 Flow Rates

Manhole		Existing Diameter	Existing Slope	Existing Length	Capacity	2030Flow	%	Recommended Pipe	Estimated Avg. Pipe	Unit	Segment Total
US	DS	(inches)	(ft/ft)	(ft)	(MGD)	(MGD)	Used	Diameter	Depth	Cost	Cost
10A85	10A84	12	0.0030	175	1.26	5.62	446%	24	19	$163	$ 28,546
10A86	10A85	12	0.0027	89	1.20	3.31	277%	18	17	$137	$ 12,231
10A87	10A86	8	0.0040	390	0.50	1.59	321%	15	10	$103	$ 40,144
9D5	10A87	8	0.0040	286	0.50	1.40	283%	12	10	$94	$ 26,849
10A102	10A86	8	0.0205	200	1.12	1.77	158%	15	10	$103	$ 20,613
10A100	10A102	8	0.0047	176	0.54	1.63	303%	15	10	$103	$ 18,141
10A99	10A100	8	0.0062	78	0.62	1.22	197%	12	10	$94	$ 7,363
10A98	10A99	8	0.0049	168	0.55	1.23	225%	12	10	$94	$ 15,790
10A95	10A98	8	0.0048	108	0.54	1.11	206%	12	10	$94	$ 10,148
10A94	10A95	8	0.0046	141	0.53	0.81	153%	10	10	$84	$ 11,839
10A93	10A94	8	0.0062	221	0.62	0.78	127%	10	10	$84	$ 18,582
10A92	10A93	8	0.0044	65	0.52	0.64	123%	10	10	$84	$ 5,492
5M67	10A85	8	0.0040	232	0.50	2.18	441%	15	10	$103	$ 23,931
5M66	5M67	8	0.0040	249	0.50	1.93	389%	15	10	$103	$ 25,673
5M65	5M66	8	0.0040	145	0.50	1.75	353%	15	10	$103	$ 14,967
5M63	5M65	8	0.0040	133	0.50	1.57	318%	15	10	$103	$ 13,744
5M55	5M63	8	0.0040	381	0.50	1.31	265%	12	10	$94	$ 35,853
5M54	5M55	8	0.0040	94	0.50	0.74	149%	10	10	$84	$ 7,936
5M52	5M54	8	0.0040	159	0.50	0.73	147%	10	10	$84	$ 13,344
5M51	5M52	8	0.0040	378	0.50	0.68	138%	10	10	$84	$ 31,774
5N9	5N5	8	0.1942	166	3.45	8.04	233%	18	10	$113	$ 18,732
5N33	5N9	8	0.0052	257	0.57	3.56	629%	18	5	$113	$ 29,066
5N35	5N33	8	0.0052	350	0.57	3.30	584%	18	6	$113	$ 39,594
5N39	5N35	8	0.0040	346	0.50	0.88	177%	10	10	$84	$ 29,075
5N41	5N39	8	0.0040	192	0.50	0.59	119%	10	10	$84	$ 16,111
5N45	5N35	8	0.0040	220	0.50	1.95	393%	15	10	$103	$ 22,675
5N46	5N45	8	0.0040	344	0.50	1.90	383%	15	10	$103	$ 35,401
5N47	5N46	8	0.0040	156	0.50	1.65	334%	15	10	$103	$ 16,037
5M1	5N47	8	0.0040	184	0.50	1.44	291%	12	10	$94	$ 17,298
5M2	5M1	8	0.0040	290	0.50	1.12	227%	12	10	$94	$ 27,253
5M3	5M2	8	0.0040	299	0.50	0.98	199%	12	10	$94	$ 28,137
5M4	5M3	8	0.0040	274	0.50	0.83	167%	10	10	$84	$ 23,030
5M5	5M4	8	0.0040	297	0.50	0.72	146%	10	10	$84	$ 24,950
5N10	5N9	8	0.0269	384	1.28	4.36	340%	15	10	$103	$ 39,504
5N11	5N10	8	0.0160	314	0.99	4.09	413%	15	10	$103	$ 32,375
5N14	5N11	8	0.0058	296	0.60	3.54	594%	15	10	$103	$ 30,456
5N15	5N14	8	0.0065	103	0.63	3.33	527%	15	10	$103	$ 10,645

Appendix B
Relief Sewer Recommendations
10-Year 2030 Flow Rates

Manhole		Existing Diameter	Existing Slope	Existing Length	Capacity	2030Flow	%	Recommended Pipe	Estimated Avg. Pipe	Unit	Segment Total
US	DS	(inches)	(ft/ft)	(ft)	(MGD)	(MGD)	Used	Diameter	Depth	Cost	Cost
5N16	5N15	8	0.0154	243	0.97	2.35	242%	12	10	$94	$ 22,810
5N17	5N16	8	0.0208	242	1.13	2.18	193%	12	10	$94	$ 22,724
5N18	5N17	8	0.0106	232	0.81	2.01	249%	12	10	$94	$ 21,847
5N19	5N18	8	0.0050	333	0.55	1.49	270%	12	10	$94	$ 31,293
5N20	5N19	8	0.0050	274	0.55	1.33	241%	12	10	$94	$ 25,749
5M26	5N20	8	0.0050	190	0.55	1.19	215%	12	10	$94	$ 17,869
Project Length				10,520				Project Cost			$ 1,079,816
PROJECT HP16											
6O16	6O36	8	0.0040	267	0.50	4.93	996%	24	10	$135	$ 36,055
6O19	6O16	8	0.0072	362	0.66	4.40	663%	18	10	$113	$ 40,952
6P1	6O19	8	0.0072	399	0.66	3.39	510%	15	10	$103	$ 41,052
6P2	6P1	8	0.0072	233	0.66	3.10	468%	15	10	$103	$ 23,975
6P3	6P2	8	0.0072	205	0.66	2.39	360%	15	10	$103	$ 21,159
6P4	6P3	8	0.0072	15	0.66	2.24	338%	15	10	$103	$ 1,596
6P5B	6P4	8	0.0072	393	0.66	2.35	354%	15	10	$103	$ 40,477
6P5	6P5B	8	0.0072	50	0.66	1.93	291%	12	10	$94	$ 4,674
6P5A	6P5	8	0.0072	102	0.66	1.89	285%	12	10	$94	$ 9,627
4M42	6P5A	8	0.0072	62	0.66	1.27	191%	12	10	$94	$ 5,791
4M33A	4M42	8	0.0072	277	0.66	1.31	197%	12	10	$94	$ 26,070
4M41A	4M33A	8	0.0072	220	0.66	1.18	177%	10	10	$84	$ 18,518
4M41	4M41A	8	0.0072	82	0.66	0.79	119%	10	10	$84	$ 6,849
4M34	4M41	8	0.0072	263	0.66	0.76	114%	10	10	$84	$ 22,132
5C38	5C14	8	0.0040	404	0.50	1.60	323%	15	10	$103	$ 41,571
5C39	5C38	8	0.0040	316	0.50	1.40	282%	12	10	$94	$ 29,676
5C40	5C39	8	0.0040	301	0.50	1.06	215%	12	10	$94	$ 28,263
5C41	5C40	8	0.0040	243	0.50	0.91	184%	12	10	$94	$ 22,812
5C53DUP2	5C41	8	0.0040	205	0.50	0.79	160%	10	10	$84	$ 17,215
5C42	5C53DUP2	8	0.0040	35	0.50	0.52	106%	10	10	$84	$ 2,969
Project Length				4,434				Project Cost			$ 441,431
PROJECT HP17											
6N25	6O24	18	0.0012	117	2.35	9.49	404%	30	10	$170	$ 19,956

Appendix B
Relief Sewer Recommendations
10-Year 2030 Flow Rates

Manhole		Existing Diameter	Existing Slope	Existing Length	Capacity	2030Flow	%	Recommended Pipe	Estimated Avg. Pipe	Unit	Segment Total
US	DS	(inches)	(ft/ft)	(ft)	(MGD)	(MGD)	Used	Diameter	Depth	Cost	Cost
6O26	6N25	18	0.0015	191	2.65	9.41	355%	30	8	$170	$ 32,449
6O27	6O26	18	0.0012	287	2.34	7.57	323%	30	6	$170	$ 48,775
6N1	6O27	18	0.0012	343	2.35	7.67	326%	30	6	$170	$ 58,286
6N2	6N1	18	0.0012	426	2.36	1.67	71%	18	6	$113	$ 48,118
6N3	6N2	18	0.0012	401	2.36	1.69	72%	18	7	$113	$ 45,261
6N4	6N3	18	0.0101	258	6.84	1.70	25%	12	9	$94	$ 24,226
6N5	6N4	10	0.0099	315	1.41	1.57	111%	12	10	$94	$ 29,563
6N6	6N5	10	0.0101	397	1.42	1.57	110%	12	10	$94	$ 37,337
6N7	6N6	10	0.0104	240	1.45	1.56	108%	12	10	$94	$ 22,559
6N26	6N7	8	0.0200	123	1.11	1.18	107%	10	10	$84	$ 10,365
6N14	6N1	10	0.0029	193	0.76	6.61	865%	24	10	$135	$ 26,105
6N15	6N14	10	0.0028	287	0.75	6.47	863%	24	10	$135	$ 38,722
6N209	6N15	8	0.0040	175	0.50	6.19	1250%	21	10	$125	$ 21,827
6N47	6N209	8	0.0040	172	0.50	4.69	946%	21	10	$125	$ 21,505
6N48	6N47	8	0.0187	354	1.07	4.56	426%	15	10	$103	$ 36,494
6N49	6N48	8	0.0410	271	1.59	2.08	131%	12	10	$94	$ 25,432
6N50	6N49	8	0.0511	88	1.77	3.78	214%	12	10	$94	$ 8,244
6N51	6N50	8	0.1220	59	2.73	3.72	136%	12	10	$94	$ 5,585
6N52	6N51	8	0.0356	145	1.48	3.57	242%	12	10	$94	$ 13,590
6N53	6N52	8	0.0397	350	1.56	3.47	223%	12	10	$94	$ 32,913
6N103	6N53	8	0.0879	112	2.32	1.16	50%	12	10	$94	$ 10,502
6N104	6N103	8	0.2077	81	3.57	1.09	30%	12	10	$94	$ 7,652
6N105	6N104	8	0.0351	231	1.47	1.11	76%	12	10	$94	$ 21,672
6N106	6N105	8	0.0695	128	2.06	0.83	40%	12	10	$94	$ 12,063
6N107	6N106	8	0.0252	193	1.24	0.80	65%	12	10	$94	$ 18,133
6N108	6N107	8	0.0039	133	0.49	0.72	148%	12	10	$94	$ 12,539
5B153	6N108	8	0.0013	104	0.28	0.67	236%	12	10	$94	$ 9,814
6N54	6N53	8	0.0412	168	1.59	2.11	133%	10	10	$84	$ 14,087
6N55	6N54	8	0.0463	214	1.68	2.04	121%	10	10	$84	$ 18,011
6N56	6N55	8	0.0429	146	1.62	1.93	119%	10	10	$84	$ 12,296
6N210	6N209	8	0.0115	79	0.84	1.39	165%	12	10	$94	$ 7,447
6N211	6N210	8	0.0043	95	0.51	1.33	259%	12	10	$94	$ 8,928
6N212	6N211	8	0.0046	92	0.53	0.60	113%	10	10	$84	$ 7,739
6O56	6O26	8	0.0055	54	0.58	2.07	356%	15	10	$103	$ 5,511
6O55	6O56	8	0.0047	198	0.54	2.03	378%	15	10	$103	$ 20,420
6O47	6O55	8	0.0036	71	0.47	1.89	403%	15	10	$103	$ 7,325
6O51	6O47	8	0.0042	347	0.51	1.79	352%	15	10	$103	$ 35,731
6O46	6O51	8	0.0048	205	0.54	1.54	284%	12	10	$94	$ 19,224

Appendix B
Relief Sewer Recommendations
10-Year 2030 Flow Rates

Manhole		Existing Diameter	Existing Slope	Existing Length	Capacity	2030Flow	%	Recommended Pipe	Estimated Avg. Pipe	Unit	Segment Total
US	DS	(inches)	(ft/ft)	(ft)	(MGD)	(MGD)	Used	Diameter	Depth	Cost	Cost
Project Length				7,843				Project Cost			$ 856,405
PROJECT HP18											
6K22	6K18A	12	0.0078	264	2.04	1.66	81%	15	10	$103	$ 27,212
6K23	6K22	12	0.0054	141	1.69	1.68	99%	15	10	$103	$ 14,553
6K23A	6K23	12	0.0019	83	1.02	1.68	165%	15	10	$103	$ 8,577
6K24	6K23A	12	0.0107	206	2.39	1.55	65%	15	10	$103	$ 21,224
6K25	6K24	8	0.0212	285	1.14	1.54	135%	12	10	$94	$ 26,804
6K26	6K25	8	0.0212	198	1.14	1.54	135%	12	10	$94	$ 18,580
6K27	6K26	8	0.0212	232	1.14	1.54	135%	12	10	$94	$ 21,843
6K28	6K27	8	0.0220	408	1.16	1.55	133%	12	10	$94	$ 38,366
6K29	6K28	8	0.0220	396	1.16	1.54	133%	12	10	$94	$ 37,231
6G1	6K29	8	0.0220	210	1.16	1.54	133%	12	10	$94	$ 19,708
6G2	6G1	8	0.0430	217	1.62	1.60	98%	12	10	$94	$ 20,357
6G3	6G2	8	0.0080	168	0.70	1.55	221%	12	10	$94	$ 15,808
6H6D	6G3	8	0.0132	510	0.90	1.35	150%	12	10	$94	$ 47,921
6H6C	6H6D	8	0.0080	305	0.70	1.31	188%	12	10	$94	$ 28,682
6H6B	6H6C	8	0.0220	300	1.16	1.33	115%	10	10	$84	$ 25,238
6H6A	6H6B	8	0.0254	265	1.25	1.36	109%	10	10	$84	$ 22,288
6H10	6H6A	8	0.0100	340	0.78	1.17	149%	10	10	$84	$ 28,569
6H19	6H10	8	0.0040	346	0.50	1.15	232%	10	10	$84	$ 29,082
6H11	6H19	8	0.0040	61	0.50	0.89	180%	10	10	$84	$ 5,157
4E50	6H11	8	0.0040	335	0.50	0.55	111%	10	10	$84	$ 28,122
6K20A	6K54	8	0.0040	134	0.50	0.98	198%	12	10	$94	$ 12,558
6K21	6K20A	8	0.0040	151	0.50	1.00	203%	12	10	$94	$ 14,225
6L7	6K21	8	0.0040	323	0.50	1.02	206%	12	10	$94	$ 30,397
6L8	6L7	8	0.0040	234	0.50	1.00	202%	12	10	$94	$ 22,035
6L9	6L8	8	0.0040	241	0.50	0.99	201%	12	10	$94	$ 22,637
6L10	6L9	8	0.0040	170	0.50	0.99	199%	12	10	$94	$ 15,937
6L12	6L10	8	0.0800	256	2.21	1.01	46%	10	10	$84	$ 21,475
6L13	6L12	8	0.0160	353	0.99	1.02	103%	10	10	$84	$ 29,679
6L14	6L13	8	0.0100	148	0.78	0.99	126%	10	10	$84	$ 12,460
6L15	6L14	8	0.0130	342	0.89	1.00	113%	10	10	$84	$ 28,727
Project Length				7,624				Project Cost			$ 695,452

Appendix B
Relief Sewer Recommendations
10-Year 2030 Flow Rates

Manhole		Existing Diameter	Existing Slope	Existing Length	Capacity	2030Flow	%	Recommended Pipe	Estimated Avg. Pipe	Unit	Segment Total
US	DS	(inches)	(ft/ft)	(ft)	(MGD)	(MGD)	Used	Diameter	Depth	Cost	Cost
PROJECT HP19											
2E91	2I7	8	0.0040	343	0.50	2.22	449%	15	10	$103	$ 35,314
2E92	2E91	8	0.0040	10	0.50	1.43	289%	12	10	$94	$ 939
2E93	2E92	8	0.0040	52	0.50	0.85	171%	10	10	$84	$ 4,388
2E94	2E93	8	0.0040	132	0.50	0.84	170%	10	10	$84	$ 11,110
2E95	2E94	8	0.0040	90	0.50	0.81	164%	10	10	$84	$ 7,600
2E96	2E95	8	0.0040	329	0.50	0.82	165%	10	10	$84	$ 27,628
2E97	2E96	8	0.0040	113	0.50	0.74	149%	10	10	$84	$ 9,527
2E100	2E97	8	0.0040	239	0.50	0.60	122%	10	10	$84	$ 20,074
2E88	2E91	8	0.0040	168	0.50	0.71	144%	10	10	$84	$ 14,115
2E87	2E88	8	0.0040	268	0.50	0.56	113%	10	10	$84	$ 22,524
2E86	2E87	8	0.0040	37	0.50	0.48	98%	10	10	$84	$ 3,104
2E81	2E86	8	0.0040	390	0.50	0.54	110%	10	10	$84	$ 32,736
2I13	2E92	8	0.0040	73	0.50	0.58	118%	10	10	$84	$ 6,100
2I15	2I13	8	0.0040	206	0.50	0.50	101%	10	10	$84	$ 17,301
2I1	2E104	8	0.0040	390	0.50	0.77	155%	10	10	$84	$ 32,800
4L80	2I1	8	0.0040	266	0.50	0.68	138%	10	10	$84	$ 22,323
4L79A	4L80	8	0.0040	305	0.50	0.64	129%	10	10	$84	$ 25,650
4H67	4H7	8	0.0040	155	0.50	1.73	349%	15	10	$103	$ 15,928
4L83	4H67	8	0.0040	242	0.50	1.61	326%	15	10	$103	$ 24,919
4L84	4L83	8	0.0040	282	0.50	1.43	289%	12	10	$94	$ 26,485
4L85	4L84	8	0.0040	139	0.50	1.08	219%	12	10	$94	$ 13,027
4L73	4L85	8	0.0040	299	0.50	1.05	213%	12	10	$94	$ 28,091
4L74	4L73	8	0.0040	197	0.50	0.72	145%	10	10	$84	$ 16,561
4L53	4L74	8	0.0040	410	0.50	0.70	141%	10	10	$84	$ 34,462
4H4	4H5	8	0.0040	186	0.50	0.55	112%	10	10	$84	$ 15,591
4H2	4H4	8	0.0040	172	0.50	0.52	106%	10	10	$84	$ 14,421
4H13	4H6	8	0.0040	147	0.50	0.50	100%	10	10	$84	$ 12,319
Project Length				5,639				Project Cost			$ 495,037
PROJECT HP20											

Appendix B
Relief Sewer Recommendations
10-Year 2030 Flow Rates

Manhole		Existing Diameter	Existing Slope	Existing Length	Capacity	2030Flow	%	Recommended Pipe	Estimated Avg. Pipe	Unit	Segment Total
US	DS	(inches)	(ft/ft)	(ft)	(MGD)	(MGD)	Used	Diameter	Depth	Cost	Cost
2E7	2E6A	18	0.0012	59	2.36	2.21	94%	18	10	$113	$ 6,688
2E8	2E7	18	0.0012	42	2.36	1.14	48%	15	10	$103	$ 4,290
2E8-1	2E8	10	0.1277	146	5.07	1.13	22%	12	10	$94	$ 13,771
2E8-2	2E8-1	10	0.0055	204	1.05	1.14	109%	12	10	$94	$ 19,191
2E8-3	2E8-2	10	0.0055	244	1.05	1.14	109%	12	10	$94	$ 22,903
2E8-4	2E8-3	10	0.0055	110	1.05	1.14	109%	12	10	$94	$ 10,338
2E8-5	2E8-4	10	0.0055	104	1.05	1.16	111%	12	10	$94	$ 9,765
2E8-6	2E8-5	10	0.0055	220	1.05	1.19	113%	12	10	$94	$ 20,720
2E8-7	2E8-6	8	0.0173	170	1.03	1.19	116%	12	10	$94	$ 16,023
2E8-8	2E8-7	8	0.0040	336	0.50	1.20	242%	12	10	$94	$ 31,601
2E8-9DUP	2E8-8	8	0.0040	108	0.50	1.16	234%	12	10	$94	$ 10,192
2F27DUP	2F113	8	0.0040	23	0.50	1.07	217%	12	10	$94	$ 2,168
2F28	2F27DUP	8	0.0210	276	1.13	0.96	85%	12	10	$94	$ 25,982
2F29	2F28	8	0.0347	242	1.46	0.96	66%	12	10	$94	$ 22,788
2F30	2F29	8	0.0040	202	0.50	0.95	192%	12	10	$94	$ 18,970
2F31DUP	2F30	8	0.0040	171	0.50	0.69	140%	10	10	$84	$ 14,324
2E9	2E7	8	0.0100	200	0.78	1.19	152%	10	10	$84	$ 16,793
2E10	2E9	8	0.2779	64	4.13	1.16	28%	10	10	$84	$ 5,346
2E11	2E10	8	0.0100	348	0.78	1.18	151%	10	10	$84	$ 29,239
2E12	2E11	8	0.0100	190	0.78	1.16	148%	10	10	$84	$ 15,984
2E13	2E12	8	0.0100	212	0.78	1.14	146%	10	10	$84	$ 17,782
2E14	2E13	8	0.0100	191	0.78	1.12	143%	10	10	$84	$ 16,013
2E47	2E14	8	0.1094	80	2.59	0.87	34%	10	10	$84	$ 6,693
2E48	2E47	8	0.0475	183	1.71	0.87	51%	10	10	$84	$ 15,379
2E50	2E48	8	0.0196	265	1.10	0.85	77%	10	10	$84	$ 22,268
2E52	2E50	8	0.0040	220	0.50	0.74	150%	10	10	$84	$ 18,475
2E53	2E52	8	0.0040	275	0.50	0.72	145%	10	10	$84	$ 23,072
Project Length				4,885				Project Cost			$ 436,758
PROJECT HP21											
2B52	2B53LS	12	0.0047	21	1.58	2.07	131%	30	22	$226	$ 4,857
2B46	2B45	8	0.0056	344	0.59	1.25	213%	12	10	$94	$ 32,332
2B47	2B46	8	0.0056	346	0.59	1.21	207%	12	10	$94	$ 32,546
2B48	2B47	8	0.0048	353	0.54	1.17	216%	12	10	$94	$ 33,202

Appendix B
Relief Sewer Recommendations
10-Year 2030 Flow Rates

Manhole		Existing Diameter	Existing Slope	Existing Length	Capacity	2030Flow	%	Recommended Pipe	Estimated Avg. Pipe	Unit	Segment Total
US	DS	(inches)	(ft/ft)	(ft)	(MGD)	(MGD)	Used	Diameter	Depth	Cost	Cost
2C23	2C18	8	0.0125	351	0.88	1.16	133%	10	10	$84	$ 29,461
2B27A	2B27	10	0.0054	231	1.04	1.37	131%	12	10	$94	$ 21,755
2B27B	2B27A	8	0.0040	174	0.50	1.34	270%	12	10	$94	$ 16,370
2B27C	2B27B	8	0.0040	195	0.50	1.35	273%	12	10	$94	$ 18,376
2B27D	2B27C	8	0.0040	270	0.50	1.36	275%	12	10	$94	$ 25,354
2B27E	2B27D	8	0.0040	104	0.50	1.33	268%	12	10	$94	$ 9,754
2B27F	2B27E	8	0.0040	258	0.50	1.35	273%	12	10	$94	$ 24,283
2B34F	2B27F	8	0.0040	297	0.50	1.35	272%	12	10	$94	$ 27,882
2B34E	2B34F	8	0.0040	50	0.50	1.31	265%	12	10	$94	$ 4,709
2B34D	2B34E	8	0.0040	218	0.50	1.33	270%	12	10	$94	$ 20,519
2B34C	2B34D	8	0.0040	285	0.50	1.33	269%	12	10	$94	$ 26,829
2B34B	2B34C	8	0.0040	132	0.50	1.30	262%	12	10	$94	$ 12,439
2B34	2B34B	8	0.0040	96	0.50	1.28	259%	12	10	$94	$ 9,004
2B35	2B34	8	0.0040	297	0.50	0.78	158%	10	10	$84	$ 24,940
2B1	2B35	8	0.0692	214	2.06	0.64	31%	10	10	$84	$ 17,935
2B2	2B1	8	0.0040	344	0.50	0.64	128%	10	10	$84	$ 28,863
2B3	2B2	8	0.0040	122	0.50	0.61	122%	10	10	$84	$ 10,272
2B34A	2B34	8	0.0040	95	0.50	0.52	104%	10	10	$84	$ 7,975
2B36	2B34A	8	0.0040	143	0.50	0.52	105%	10	10	$84	$ 12,052
Project Length				4,942				Project Cost			$451,712
PROJECT HP23											
NEW MHNO12963	NEW MHNO12911	8	0.0040	76	0.50	3.22	650%	18	10	$113	$ 8,622
NEW MHNO12913	NEW MHNO12963	8	0.0040	136	0.50	3.21	648%	18	10	$113	$ 15,382
NEW MHNO13140	NEW MHNO12913	8	0.0040	187	0.50	2.48	501%	15	10	$103	$ 19,295
17I109	NEW MHNO13140	8	0.0040	172	0.50	2.45	495%	15	10	$103	$ 17,675
17I110	17I109	8	0.0040	384	0.50	2.48	501%	15	10	$103	$ 39,525
NEW MHNO13137	17I110	8	0.0040	23	0.50	1.39	280%	12	10	$94	$ 2,197
17I111	NEW MHNO13137	8	0.0040	331	0.50	1.41	284%	12	10	$94	$ 31,085
17I112	17I111	8	0.0040	483	0.50	1.20	242%	12	10	$94	$ 45,380
17I113	17I112	8	0.0040	337	0.50	1.13	229%	12	10	$94	$ 31,646
17I114	17I113	8	0.0040	409	0.50	1.09	220%	12	10	$94	$ 38,469
17I115	17I114	8	0.0040	64	0.50	1.03	208%	12	10	$94	$ 6,061
17I116	17I115	8	0.0040	230	0.50	1.01	205%	12	10	$94	$ 21,592
17I117	17I116	8	0.0040	144	0.50	1.01	204%	12	10	$94	$ 13,511

Appendix B
Relief Sewer Recommendations
10-Year 2030 Flow Rates

Manhole		Existing Diameter	Existing Slope	Existing Length	Capacity	2030Flow	%	Recommended Pipe	Estimated Avg. Pipe	Unit	Segment Total
US	DS	(inches)	(ft/ft)	(ft)	(MGD)	(MGD)	Used	Diameter	Depth	Cost	Cost
17I118	17I117	8	0.0040	351	0.50	1.01	203%	12	10	$94	$ 32,952
17I119	17I118	8	0.0040	111	0.50	1.00	202%	12	10	$94	$ 10,476
NEW MHNO13141	17I110	8	0.0040	76	0.50	1.04	209%	12	10	$94	$ 7,160
17I121	NEW MHNO13141	8	0.0040	70	0.50	1.02	207%	12	10	$94	$ 6,623
17I122	17I121	8	0.0040	259	0.50	1.04	210%	12	10	$94	$ 24,341
17I123	17I122	8	0.0040	314	0.50	0.99	199%	12	10	$94	$ 29,537
17I124	17I123	8	0.0040	243	0.50	0.96	195%	12	10	$94	$ 22,801
17J142	17I124	8	0.0040	283	0.50	0.91	184%	12	10	$94	$ 26,582
17J143	17J142	8	0.0040	142	0.50	0.91	183%	12	10	$94	$ 13,373
17I66DUP	NEW MHNO12913	8	0.0040	33	0.50	0.86	173%	10	10	$84	$ 2,747
17I67	17I66DUP	8	0.0040	394	0.50	0.86	173%	10	10	$84	$ 33,087
17I68	17I67	8	0.0040	358	0.50	0.85	172%	10	10	$84	$ 30,080
17I69	17I68	8	0.0040	316	0.50	0.85	171%	10	10	$84	$ 26,552
17I70	17I69	8	0.0040	184	0.50	0.85	171%	10	10	$84	$ 15,485
17I71	17I70	8	0.0040	158	0.50	0.85	171%	10	10	$84	$ 13,296
17I72	17I71	8	0.0040	123	0.50	0.85	171%	10	10	$84	$ 10,349
17I73	17I72	8	0.0040	259	0.50	0.84	171%	10	10	$84	$ 21,746
17I74	17I73	8	0.0040	117	0.50	0.84	170%	10	10	$84	$ 9,808
17I75	17I74	8	0.0040	70	0.50	0.83	168%	10	10	$84	$ 5,905
Project Length				6,838				Project Cost			$ 633,340
PROJECT HP24											
5L64	5L64A	8	0.0050	77	0.55	6.43	1163%	21	10	$125	$ 9,646
5L65	5L64	8	0.0100	201	0.78	6.38	815%	18	10	$113	$ 22,714
5L66	5L65	8	0.0250	296	1.24	4.60	372%	18	10	$113	$ 33,481
5L66A	5L66	8	0.0040	302	0.50	4.24	856%	18	10	$113	$ 34,157
5L68	5L66A	8	0.0370	231	1.51	4.03	267%	12	10	$94	$ 21,719
5L69	5L68	8	0.0400	117	1.57	3.86	247%	12	10	$94	$ 10,954
5L70	5L69	8	0.0400	131	1.57	3.43	219%	12	10	$94	$ 12,285
5L71	5L70	8	0.0480	265	1.72	3.34	195%	12	10	$94	$ 24,896
5L72	5L71	8	0.0400	140	1.57	3.15	201%	12	10	$94	$ 13,155
5L94	5L65	8	0.0420	349	1.60	1.76	110%	10	10	$84	$ 29,278
5L93	5L94	8	0.0587	222	1.90	1.62	85%	10	10	$84	$ 18,650
5L135	5L93	8	0.0040	54	0.50	0.46	93%	10	10	$84	$ 4,526
5L85	5L135	8	0.0040	274	0.50	0.51	103%	10	10	$84	$ 23,037

Appendix B
Relief Sewer Recommendations
10-Year 2030 Flow Rates

Manhole		Existing Diameter	Existing Slope	Existing Length	Capacity	2030Flow	%	Recommended Pipe	Estimated Avg. Pipe	Unit	Segment Total
US	DS	(inches)	(ft/ft)	(ft)	(MGD)	(MGD)	Used	Diameter	Depth	Cost	Cost
5L115	5L52	8	0.0076	157	0.68	2.48	363%	15	10	$103	$ 16,148
5L116	5L115	8	0.0124	263	0.87	1.81	207%	12	10	$94	$ 24,735
5L48	5L49	8	0.0379	179	1.52	2.31	152%	12	10	$94	$ 16,844
5L47	5L48	8	0.0125	148	0.88	2.18	250%	12	10	$94	$ 13,901
5L38	5L47	8	0.0720	260	2.10	2.14	102%	12	10	$94	$ 24,398
5L28	5L38	8	0.0040	187	0.50	1.68	339%	12	10	$94	$ 17,582
5L27	5L28	8	0.0060	182	0.61	0.85	139%	10	10	$84	$ 15,280
5L26	5L27	8	0.0072	240	0.66	0.78	117%	10	10	$84	$ 20,199
5L25	5L26	8	0.0072	265	0.66	0.67	100%	10	10	$84	$ 22,246
5L23	5L25	8	0.0040	190	0.50	0.52	106%	10	10	$84	$ 15,942
5L29	5L28	8	0.0040	188	0.50	0.53	107%	10	10	$84	$ 15,785
5K182	5K2	8	0.0100	228	0.78	7.99	1021%	21	10	$125	$ 28,473
5K8	5K182	8	0.0778	82	2.18	7.51	344%	18	10	$113	$ 9,296
5K9	5K8	8	0.0120	144	0.86	5.63	656%	18	10	$113	$ 16,230
5K10	5K9	8	0.0238	349	1.21	5.53	458%	18	10	$113	$ 39,423
5K11	5K10	8	0.0279	177	1.31	4.83	369%	18	10	$113	$ 19,971
5K24	5K11	8	0.0040	113	0.50	3.27	660%	18	10	$113	$ 12,819
5K25	5K24	8	0.0156	169	0.98	3.19	326%	15	10	$103	$ 17,435
5K90	5K25	8	0.0040	205	0.50	1.86	375%	15	10	$103	$ 21,096
5K91	5K90	8	0.0040	229	0.50	0.52	106%	10	10	$84	$ 19,205
5K12	5K11	8	0.0137	144	0.92	1.43	156%	10	10	$84	$ 12,059
5K184	5K8	8	0.0031	348	0.44	1.88	431%	15	10	$103	$ 35,836
Project Length				7,104				Project Cost			$ 693,397
PROJECT MP01											
10A42	10A40	30	0.1137	12	89.65	30.40	34%	48	22	$326	$ 3,786
10A43	10A42	27	0.0020	485	8.88	30.40	342%	48	33	$359	$ 174,123
10A44	10A43	27	0.0020	482	9.05	30.47	336%	48	32	$359	$ 172,813
10A45	10A44	27	0.0051	173	14.38	30.47	212%	48	31	$359	$ 62,201
9D1	10A45	27	0.0022	478	9.41	30.45	324%	48	29	$326	$ 155,826
9D2	9D1	27	0.0022	491	9.41	30.78	327%	48	28	$326	$ 160,228
9D3	9D2	27	0.0022	502	9.39	31.05	330%	48	26	$326	$ 163,782

Appendix B
Relief Sewer Recommendations
10-Year 2030 Flow Rates

Manhole		Existing Diameter	Existing Slope	Existing Length	Capacity	2030Flow	%	Recommended Pipe	Estimated Avg. Pipe	Unit	Segment Total
US	DS	(inches)	(ft/ft)	(ft)	(MGD)	(MGD)	Used	Diameter	Depth	Cost	Cost
9D4	9D3	27	0.0022	525	9.35	31.24	334%	48	25	$326	$ 171,330
9C10	9D4	27	0.0022	525	9.35	31.34	335%	48	25	$326	$ 171,233
9C9	9C10	27	0.0022	395	9.42	31.35	333%	48	24	$326	$ 128,900
9C8	9C9	27	0.0022	289	9.37	31.34	334%	48	21	$326	$ 94,216
9C7	9C8	27	0.0022	283	9.40	31.34	333%	48	21	$326	$ 92,138
9C6	9C7	27	0.0022	459	9.42	31.79	337%	48	21	$326	$ 149,551
9B88	9C6	27	0.0342	64	37.13	31.69	85%	48	15	$296	$ 19,062
9C5	9B88	27	-0.0042	320	#NUM!	31.69	#NUM!	48	16	$296	$ 94,853
9C4	9C5	27	0.0022	492	9.44	32.25	341%	48	21	$326	$ 160,593
9C3	9C4	27	0.0022	442	9.45	32.77	347%	48	21	$326	$ 144,260
9C2	9C3	27	0.0013	494	7.11	33.25	468%	48	21	$326	$ 161,167
9C1	9C2	27	0.0013	490	7.14	33.68	472%	48	21	$326	$ 159,733
8O18	9C1	27	0.0012	490	7.03	34.08	485%	48	22	$326	$ 159,700
8O17	8O18	21	0.0071	498	8.64	34.08	395%	48	17	$296	$ 147,509
8O28	8O17	21	0.0009	293	3.12	34.07	1094%	48	13	$270	$ 78,861
8O16	8O28	21	0.0041	218	6.62	26.88	406%	36	13	$220	$ 47,982
8O15	8O16	21	0.0040	396	6.52	26.88	412%	36	17	$242	$ 95,948
8O14	8O15	21	0.0040	396	6.53	26.88	412%	36	17	$242	$ 95,915
8O13	8O14	21	0.0040	404	6.47	26.87	416%	36	17	$242	$ 97,651
8O12	8O13	21	0.0050	367	7.25	26.87	371%	36	17	$242	$ 88,842
8O11	8O12	21	0.0051	366	7.30	26.87	368%	36	16	$242	$ 88,503
8O10	8O11	21	0.0052	218	7.39	26.87	363%	36	15	$242	$ 52,786
8O29	8O28	15	0.00864	274	3.89	10.36	266%	24	10	$135	$ 36,968
8N3	8O29	15	0.00864	193	3.89	10.36	266%	24	10	$135	$ 26,109
8N4	8N3	15	0.00864	388	3.89	10.36	266%	24	10	$135	$ 52,416
8N5	8N4	15	0.00864	396	3.89	10.38	267%	24	10	$135	$ 53,524
8N6	8N5	15	0.01226	397	4.64	10.39	224%	24	7	$135	$ 53,633
8N7	8N6	15	0.00821	263	3.79	10.35	273%	24	9	$135	$ 35,520
8N8	8N7	15	0.00039	205	0.83	10.33	1249%	24	9	$135	$ 27,625
8N9	8N8	12	0.01565	247	2.89	10.31	357%	24	7	$135	$ 33,390
8N10	8N9	12	0.01538	395	2.86	10.29	359%	24	6	$135	$ 53,267
8N1	8N10	12	0.01400	347	2.73	10.25	375%	24	6	$135	$ 46,880
Project Length				14,154				Project Cost			$ 3,812,823
PROJECT MP02											
8O9	8O10	21	0.0050	353	7.23	26.87	372%	36	15	$242	$ 85,463
8O8	8O9	21	0.0066	357	8.34	26.77	321%	36	15	$242	$ 86,299

Appendix B
Relief Sewer Recommendations
10-Year 2030 Flow Rates

Manhole		Existing Diameter	Existing Slope	Existing Length	Capacity	2030Flow	%	Recommended Pipe	Estimated Avg. Pipe	Unit	Segment Total
US	DS	(inches)	(ft/ft)	(ft)	(MGD)	(MGD)	Used	Diameter	Depth	Cost	Cost
8K4	8O8	21	0.0070	336	8.59	26.67	310%	36	14	$220	$ 73,855
8K5	8K4	21	0.0065	363	8.26	26.58	322%	36	13	$220	$ 79,855
8K6	8K5	21	0.0069	362	8.50	25.97	305%	36	13	$220	$ 79,581
8K7	8K6	21	0.0066	378	8.37	25.88	309%	36	13	$220	$ 83,170
8K8	8K7	21	0.0067	351	8.41	24.68	294%	36	12	$220	$ 77,123
8K9	8K8	21	0.0067	350	8.42	24.59	292%	36	12	$220	$ 76,995
8K10	8K9	21	0.0067	375	8.40	24.49	292%	36	13	$220	$ 82,568
8K11	8K10	21	0.0068	375	8.47	23.83	281%	36	13	$220	$ 82,440
8K12	8K11	21	0.0066	331	8.34	23.73	285%	36	14	$220	$ 72,749
8L1	8K12	21	0.0068	330	8.44	23.64	280%	36	13	$220	$ 72,595
8L2	8L1	21	0.0066	328	8.34	23.54	282%	36	11	$220	$ 72,081
8L3	8L2	21	0.0066	227	8.31	23.46	282%	36	11	$220	$ 50,039
8L4	8L3	21	0.0074	242	8.84	23.40	265%	36	10	$220	$ 53,144
8L5	8L4	21	0.0064	244	8.24	23.33	283%	36	10	$200	$ 48,754
8L6	8L5	21	0.0043	383	6.72	23.26	346%	36	10	$200	$ 76,679
8L7	8L6	21	0.0042	409	6.66	23.16	348%	36	11	$220	$ 89,882
8L8	8L7	21	0.0041	274	6.54	23.05	353%	36	11	$220	$ 60,284
8L18DUP	8L8	21	0.0042	421	6.68	22.97	344%	36	13	$220	$ 92,668
8H13	8L18DUP	21	0.0038	74	6.31	22.86	362%	36	13	$220	$ 16,323
8H17DUP	8H13	18	0.4959	53	47.94	21.93	46%	30	11	$187	$ 9,989
8H14	8H17DUP	18	-0.1055	233	#NUM!	19.01	#NUM!	30	10	$170	$ 39,544
8H15	8H14	18	0.0068	332	5.59	18.94	339%	30	10	$170	$ 56,396
8H16	8H15	18	0.0067	304	5.59	18.77	336%	30	10	$170	$ 51,635
8G7	8H16	18	0.0067	304	5.58	18.77	337%	30	10	$170	$ 51,699
8G8	8G7	18	0.0068	437	5.63	18.68	332%	30	10	$170	$ 74,282
8G9	8G8	18	0.0066	191	5.52	18.57	336%	30	10	$170	$ 32,533
8G10	8G9	18	0.0065	271	5.49	18.52	337%	30	10	$170	$ 46,048
8G11	8G10	18	0.0068	152	5.61	18.44	329%	30	10	$170	$ 25,763
8G12	8G11	18	0.0068	357	5.62	18.40	327%	30	10	$170	$ 60,626
8G209	8G12	18	-0.0336	290	#NUM!	18.30	#NUM!	30	10	$170	$ 49,272
8G13A	8G209	18	0.0068	98	5.61	17.70	315%	30	10	$170	$ 16,689
8G13	8G13A	18	0.0069	18	5.66	13.20	233%	30	10	$170	$ 3,124
8G14	8G13	18	0.0287	499	11.54	12.75	110%	24	11	$149	$ 74,060
8H1DUP	8H13	8	0.0040	38	0.50	0.92	187%	12	10	$94	$ 3,579
8H3	8H1DUP	8	0.0040	262	0.50	0.97	196%	12	10	$94	$ 24,645
8H4	8H3	8	0.0040	343	0.50	0.95	192%	12	10	$94	$ 32,248
8H5	8H4	8	0.0040	244	0.50	0.91	184%	12	10	$94	$ 22,960
8G1	8H5	8	0.0040	355	0.50	0.90	181%	10	10	$84	$ 29,805
8G2	8G1	8	0.0040	95	0.50	0.80	161%	10	10	$84	$ 8,021
8G3	8G2	8	0.0040	310	0.50	0.82	165%	10	10	$84	$ 26,069

Appendix B
Relief Sewer Recommendations
10-Year 2030 Flow Rates

Manhole		Existing Diameter	Existing Slope	Existing Length	Capacity	2030Flow	%	Recommended Pipe	Estimated Avg. Pipe	Unit	Segment Total
US	DS	(inches)	(ft/ft)	(ft)	(MGD)	(MGD)	Used	Diameter	Depth	Cost	Cost
8K13	8K10	8	0.0040	340	0.50	0.58	118%	10	10	$84	$ 28,572
Project Length				12,388				Project Cost			$ 2,280,107
PROJECT MP03											
8H17	8G14	18	0.0045	374	4.55	12.68	279%	30	12	$187	$ 69,945
8H18DUP	8H17	15	0.0067	404	3.43	12.31	359%	30	14	$187	$ 75,618
8H19	8H18DUP	12	0.0069	401	1.92	11.93	622%	24	14	$149	$ 59,488
8D3	8H19	15	0.0070	320	3.50	11.22	320%	24	12	$149	$ 47,490
8D4	8D3	15	0.0066	339	3.41	11.19	328%	24	13	$149	$ 50,389
8D5	8D4	12	0.0100	388	2.31	9.13	396%	21	11	$138	$ 53,372
8D6	8D5	12	0.0099	391	2.30	9.07	394%	21	10	$138	$ 53,734
8D7	8D6	12	0.0104	154	2.35	9.01	383%	21	9	$125	$ 19,291
8D8	8D7	12	0.0099	290	2.30	8.98	391%	21	9	$125	$ 36,257
8D10	8D8	12	0.0100	287	2.31	8.96	388%	21	10	$125	$ 35,910
8D11	8D10	12	0.0102	131	2.33	8.97	385%	21	10	$125	$ 16,328
8D12	8D11	12	0.0099	382	2.30	8.93	388%	21	9	$125	$ 47,724
8D13	8D12	12	0.0100	399	2.31	8.93	386%	21	9	$125	$ 49,867
8D14	8D13	12	0.0095	338	2.25	8.93	397%	21	10	$125	$ 42,221
8D15	8D14	12	0.0089	258	2.18	8.90	408%	21	10	$125	$ 32,277
8D16A	8D15	12	0.0098	235	2.28	8.89	389%	21	10	$125	$ 29,366
8D16	8D16A	12	0.0096	167	2.26	8.85	392%	21	10	$125	$ 20,893
8D26	8D16	12	0.0019	201	1.02	8.84	869%	21	10	$125	$ 25,158
8D17	8D26	12	0.0103	167	2.34	8.83	377%	21	10	$125	$ 20,933
7P9	8D17	12	0.0107	380	2.39	8.82	369%	21	10	$125	$ 47,478
7P10	7P9	10	0.0127	408	1.60	8.82	551%	21	10	$138	$ 56,107
7P11	7P10	10	0.0128	359	1.61	8.82	548%	21	11	$138	$ 49,380
7P12	7P11	10	0.0118	419	1.55	8.78	568%	21	10	$138	$ 57,553
7P13	7P12	10	0.0109	405	1.48	8.73	590%	21	9	$125	$ 50,586
7P13A	7P13	10	0.0025	194	0.71	8.73	1235%	21	10	$125	$ 24,214
7P14	7P13A	10	0.0115	206	1.53	8.73	572%	21	10	$125	$ 25,739
7P15	7P14	10	0.0025	189	0.71	8.72	1234%	21	10	$125	$ 23,583
7P15A	7P15	10	0.0112	207	1.50	8.71	579%	21	10	$125	$ 25,849
7P19	7P15A	10	-0.3573	318	#NUM!	8.71	#NUM!	21	10	$125	$ 39,751
7P20	7P19	10	0.0110	351	1.49	8.71	585%	21	10	$125	$ 43,908
7P21	7P20	10	0.0110	322	1.49	8.70	585%	21	10	$125	$ 40,298
Project Length				9,384				Project Cost			$ 1,270,707

Appendix B
Relief Sewer Recommendations
10-Year 2030 Flow Rates

Manhole		Existing Diameter	Existing Slope	Existing Length	Capacity	2030Flow	%	Recommended Pipe	Estimated Avg. Pipe	Unit	Segment Total
US	DS	(inches)	(ft/ft)	(ft)	(MGD)	(MGD)	Used	Diameter	Depth	Cost	Cost
PROJECT MP04											
8O29	8O28	15	0.0078	274	3.69	4.02	109%	18	10	$113	$ 30,944
8N3	8O29	15	0.0078	193	3.69	4.03	109%	18	10	$113	$ 21,854
8N4	8N3	15	0.0078	388	3.69	4.03	109%	18	10	$113	$ 43,874
8N5	8N4	15	0.0078	396	3.69	4.05	110%	18	10	$113	$ 44,801
8N6	8N5	15	0.0123	397	4.64	4.14	89%	18	7	$113	$ 44,893
8N7	8N6	15	0.0082	263	3.79	4.19	110%	18	8	$113	$ 29,732
8N8	8N7	15	0.0004	205	0.83	4.22	510%	18	8	$113	$ 23,123
8N9	8N8	12	0.0156	247	2.89	4.20	145%	15	8	$103	$ 25,475
8N10	8N9	12	0.0154	395	2.86	4.22	147%	15	7	$103	$ 40,641
8N1	8N10	12	0.0140	347	2.73	4.21	154%	15	6	$103	$ 35,768
8N2	8N1	8	0.0894	153	2.34	3.98	170%	15	10	$103	$ 15,782
9B1	8N2	8	0.1085	198	2.58	3.97	154%	15	10	$103	$ 20,393
9B2	9B1	8	0.0052	283	0.56	1.73	307%	15	10	$103	$ 29,113
9B3	9B2	8	0.0072	283	0.66	1.74	263%	15	10	$103	$ 29,165
9B4	9B3	8	0.0071	124	0.66	1.74	263%	15	10	$103	$ 12,793
9B5	9B4	8	0.0065	242	0.63	1.75	277%	15	10	$103	$ 24,922
9B6	9B5	8	0.0057	264	0.59	1.75	296%	15	10	$103	$ 27,193
9B7	9B6	8	0.0059	379	0.60	1.76	292%	15	10	$103	$ 39,022
9B8	9B7	8	0.0059	143	0.60	1.73	288%	15	10	$103	$ 14,779
9B9	9B8	8	0.0050	319	0.55	1.77	320%	15	10	$103	$ 32,819
9B10	9B9	8	-0.0983	340	#NUM!	1.27	#NUM!	10	10	$84	$ 28,597
9B11	9B10	8	0.0920	244	2.37	1.25	53%	10	10	$84	$ 20,473
9A6	9B11	8	0.0200	382	1.11	0.87	79%	10	10	$84	$ 32,075
9A7	9A6	8	0.0095	375	0.76	0.90	118%	10	10	$84	$ 31,460
9A8	9A7	8	0.0093	255	0.76	0.90	119%	10	10	$84	$ 21,437
9A10	9A8	8	0.0060	224	0.61	0.90	148%	10	10	$84	$ 18,831
9A12	9A10	8	0.0580	276	1.89	0.90	48%	10	10	$84	$ 23,155
9A13	9A12	8	0.0050	205	0.55	0.87	158%	10	10	$84	$ 17,208
9A15	9A13	8	0.0047	270	0.54	0.85	158%	10	10	$84	$ 22,679
9A16	9A15	8	0.0092	257	0.75	2.52	336%	10	10	$84	$ 21,626
Project Length				8,322				Project Cost			$ 824,629
PROJECT MP05											

Appendix B
Relief Sewer Recommendations
10-Year 2030 Flow Rates

Manhole		Existing Diameter	Existing Slope	Existing Length	Capacity	2030Flow	%	Recommended Pipe	Estimated Avg. Pipe	Unit	Segment Total
US	DS	(inches)	(ft/ft)	(ft)	(MGD)	(MGD)	Used	Diameter	Depth	Cost	Cost
Project Length				0				Project Cost			$ -
PROJECT MP06											
8F28	8F1	8	0.0040	203	0.50	2.10	424%	15	10	$103	$ 20,903
8F29	8F28	8	0.0040	214	0.50	2.09	423%	15	10	$103	$ 22,072
8F30	8F29	8	0.0040	162	0.50	2.09	422%	15	10	$103	$ 16,728
8F31	8F30	8	0.0040	187	0.50	1.93	390%	15	10	$103	$ 19,219
8F32	8F31	8	0.0040	353	0.50	1.90	383%	15	10	$103	$ 36,360
8F33	8F32	8	0.0040	294	0.50	1.89	382%	15	10	$103	$ 30,288
8F34	8F33	8	0.0040	201	0.50	1.88	381%	15	10	$103	$ 20,696
8B1	8F34	8	0.0040	245	0.50	1.88	379%	15	10	$103	$ 25,223
8B7	8B1	8	0.0040	154	0.50	1.81	365%	15	10	$103	$ 15,858
8B8	8B7	8	0.0040	322	0.50	1.82	367%	15	10	$103	$ 33,175
8B9	8B8	10	0.0025	199	0.71	1.72	243%	15	10	$103	$ 20,529
8B17	8B9	10	0.0025	218	0.71	1.64	232%	15	10	$103	$ 22,490
8B18	8B17	10	0.0025	248	0.71	1.64	233%	15	10	$103	$ 25,501
8B19	8B18	10	0.0025	91	0.71	1.57	222%	15	10	$103	$ 9,362
8B40	8B19	10	0.0025	78	0.71	1.56	221%	15	10	$103	$ 7,997
8B113	8B40	10	0.0025	68	0.71	0.92	130%	12	10	$94	$ 6,388
8B98	8B113	10	0.0080	247	1.27	0.89	70%	12	10	$94	$ 23,189
8B126	8B98	10	0.0080	140	1.27	0.89	70%	12	10	$94	$ 13,132
8B124	8B126	10	0.0025	112	0.71	0.89	125%	12	10	$94	$ 10,574
8B119	8B124	8	0.0040	371	0.50	0.91	185%	12	10	$94	$ 34,894
8B118	8B119	10	0.0025	164	0.71	0.83	117%	12	10	$94	$ 15,463
8B117	8B118	10	0.0025	58	0.71	0.82	115%	12	10	$94	$ 5,455
8F95	8F1	8	0.0040	365	0.50	1.14	229%	12	10	$94	$ 34,294
8F96	8F95	8	0.0040	261	0.50	1.14	229%	12	10	$94	$ 24,564
8F100	8F96	8	0.0040	240	0.50	0.99	200%	12	10	$94	$ 22,605
8F101	8F100	8	0.0040	206	0.50	0.71	143%	10	10	$84	$ 17,279
8F102	8F101	8	0.0040	195	0.50	0.71	143%	10	10	$84	$ 16,338
8G118	8F102	8	0.0040	199	0.50	0.71	143%	10	10	$84	$ 16,693
8F103	8G118	8	0.0040	195	0.50	0.55	112%	10	10	$84	$ 16,400
8B55	8F103	8	0.0040	163	0.50	0.55	112%	10	10	$84	$ 13,665
8F2	8F1	8	0.0040	88	0.50	1.27	256%	12	10	$94	$ 8,302
8F3	8F2	8	0.0040	140	0.50	1.15	233%	12	10	$94	$ 13,140
8F4	8F3	8	0.0040	227	0.50	1.15	232%	12	10	$94	$ 21,380
8F5	8F4	8	0.0040	182	0.50	1.02	206%	12	10	$94	$ 17,120

Appendix B
Relief Sewer Recommendations
10-Year 2030 Flow Rates

Manhole		Existing Diameter	Existing Slope	Existing Length	Capacity	2030Flow	%	Recommended Pipe	Estimated Avg. Pipe	Unit	Segment Total
US	DS	(inches)	(ft/ft)	(ft)	(MGD)	(MGD)	Used	Diameter	Depth	Cost	Cost
8F6	8F5	8	0.0040	224	0.50	1.04	209%	12	10	$94	$ 21,076
8F7	8F6	8	0.0040	206	0.50	1.04	210%	12	10	$94	$ 19,367
8F8	8F7	8	0.0040	212	0.50	1.05	212%	12	10	$94	$ 19,967
8F9	8F8	8	0.0040	99	0.50	0.77	155%	10	10	$84	$ 8,345
8F10	8F9	8	0.0040	230	0.50	0.78	157%	10	10	$84	$ 19,326
8F11	8F10	8	0.0040	240	0.50	0.72	146%	10	10	$84	$ 20,130
8F12	8F11	8	0.0040	343	0.50	0.58	117%	10	10	$84	$ 28,847
8F13	8F12	8	0.0040	199	0.50	0.54	109%	10	10	$84	$ 16,708
8B39	8B40	8	0.0040	360	0.50	0.65	132%	10	10	$84	$ 30,205
8B38	8B39	8	0.0040	83	0.50	0.50	101%	10	10	$84	$ 6,959
8B37	8B38	8	0.0040	188	0.50	0.51	102%	10	10	$84	$ 15,766
Project Length				9,175				Project Cost			$ 863,970
PROJECT MP07											
8H25	8H19DUP	8	0.0040	190	0.50	0.74	150%	10	10	$84	$ 15,933
8G15	8H25	8	0.0040	348	0.50	0.76	153%	10	10	$84	$ 29,237
8G16	8G15	8	0.0040	183	0.50	0.76	154%	10	10	$84	$ 15,353
8G22	8G16	8	0.0040	137	0.50	0.77	155%	10	10	$84	$ 11,501
8G27	8G22	8	0.0040	117	0.50	0.71	143%	10	10	$84	$ 9,868
8G28	8G27	8	0.0040	65	0.50	0.71	143%	10	10	$84	$ 5,435
8G29	8G28	8	0.0040	111	0.50	0.71	144%	10	10	$84	$ 9,366
8G45	8G209	8	0.0040	146	0.50	0.55	112%	10	10	$84	$ 12,297
8G46	8G45	8	0.0040	313	0.50	0.58	117%	10	10	$84	$ 26,329
8G47	8G46	8	0.0040	300	0.50	0.56	112%	10	10	$84	$ 25,174
8G48	8G47	8	0.0040	105	0.50	0.51	103%	10	10	$84	$ 8,847
8G189	8G13	8	0.0040	249	0.50	1.92	388%	15	10	$103	$ 25,671
8G188	8G189	8	0.0040	216	0.50	1.65	332%	15	10	$103	$ 22,279
8G187	8G188	8	0.0040	294	0.50	1.55	314%	15	10	$103	$ 30,237
8G178	8G187	8	0.0040	229	0.50	1.53	309%	15	10	$103	$ 23,586
8G177	8G178	8	0.0040	66	0.50	1.36	275%	12	10	$94	$ 6,208
8G176	8G177	8	0.0040	303	0.50	1.18	239%	12	10	$94	$ 28,491
8G175	8G176	8	0.0040	316	0.50	0.62	125%	10	10	$84	$ 26,515
8G198DUP	8G176	8	0.0040	219	0.50	0.51	103%	10	10	$84	$ 18,394
8G199	8G198DUP	8	0.0040	319	0.50	0.51	103%	10	10	$84	$ 26,778

Appendix B
Relief Sewer Recommendations
10-Year 2030 Flow Rates

Manhole		Existing Diameter	Existing Slope	Existing Length	Capacity	2030Flow	%	Recommended Pipe	Estimated Avg. Pipe	Unit	Segment Total
US	DS	(inches)	(ft/ft)	(ft)	(MGD)	(MGD)	Used	Diameter	Depth	Cost	Cost
Project Length				4,227				Project Cost			$ 377,498
PROJECT MP09											
7L18	7L17	8	0.0164	355	1.00	1.76	176%	10	8	$84	$ 29,827
7L19	7L18	8	0.0182	194	1.06	1.76	167%	10	9	$84	$ 16,336
7L20	7L19	8	0.0167	274	1.01	1.76	174%	10	8	$84	$ 23,045
7L21	7L20	8	0.0172	268	1.03	1.75	171%	10	8	$84	$ 22,480
7L22	7L21	8	0.0225	249	1.17	1.76	150%	10	10	$84	$ 20,931
7L23	7L22	8	0.0225	245	1.17	1.78	151%	10	10	$84	$ 20,576
7L25	7L23	8	0.0225	110	1.17	1.19	101%	10	10	$84	$ 9,257
7L35A	7L25	8	0.0040	256	0.50	1.11	223%	10	10	$84	$ 21,501
7L24	7L23	8	0.0552	96	1.84	0.58	32%	10	10	$84	$ 8,044
7L4	7L24	8	0.1282	26	2.80	0.58	21%	10	10	$84	$ 2,216
5L34	7L4	8	0.0040	100	0.50	0.59	118%	10	10	$84	$ 8,382
5L5	5L34	8	0.0040	102	0.50	0.59	119%	10	10	$84	$ 8,547
7L6	5L5	8	0.0040	345	0.50	0.58	117%	10	10	$84	$ 28,995
7L11	7L6	8	0.0040	229	0.50	0.54	109%	10	10	$84	$ 19,212
7L11A	7L11	8	0.0040	65	0.50	0.53	108%	10	10	$84	$ 5,455
7L27	7L11A	8	0.0040	105	0.50	0.54	108%	10	10	$84	$ 8,831
Project Length				3,019				Project Cost			$ 253,634
PROJECT MP10											
7H4	7H3	15	0.0098	381	4.14	7.51	181%	21	10	$125	$ 47,650
7H5	7H4	15	0.0098	395	4.14	7.56	182%	21	10	$125	$ 49,342
7H6	7H5	15	0.0098	356	4.14	7.59	183%	21	10	$125	$ 44,525
7H7	7H6	15	0.0098	314	4.14	7.60	183%	21	10	$125	$ 39,302
7H11	7H7	15	0.0110	354	4.39	7.45	170%	21	10	$125	$ 44,239
7H12	7H11	15	0.0110	377	4.39	7.40	169%	21	10	$125	$ 47,106
7H13	7H12	15	0.0110	348	4.39	7.23	165%	21	10	$125	$ 43,550
7H14	7H13	15	0.0110	179	4.39	7.13	163%	18	10	$113	$ 20,214
7H19	7H14	15	0.0110	187	4.39	6.79	155%	18	10	$113	$ 21,155
7H20	7H19	15	0.0110	296	4.39	6.79	155%	18	10	$113	$ 33,444
7H21	7H20	8	0.0200	263	1.11	4.24	383%	15	10	$103	$ 27,085

Appendix B
Relief Sewer Recommendations
10-Year 2030 Flow Rates

Manhole		Existing Diameter	Existing Slope	Existing Length	Capacity	2030Flow	%	Recommended Pipe	Estimated Avg. Pipe	Unit	Segment Total
US	DS	(inches)	(ft/ft)	(ft)	(MGD)	(MGD)	Used	Diameter	Depth	Cost	Cost
7H1	7H21	8	0.0200	114	1.11	4.14	374%	15	10	$103	$ 11,757
6E1	7H1	8	-0.0131	246	#NUM!	4.10	#NUM!	15	10	$103	$ 25,347
6E2	6E1	8	-0.0131	212	#NUM!	4.00	#NUM!	15	10	$103	$ 21,834
6E4	6E2	8	-0.0131	336	#NUM!	3.92	#NUM!	15	10	$103	$ 34,646
6E5	6E4	8	0.0228	173	1.18	3.79	320%	15	10	$103	$ 17,863
6E6	6E5	8	-0.0131	130	#NUM!	3.72	#NUM!	15	10	$103	$ 13,361
6A1	6E6	8	-0.0131	248	#NUM!	3.67	#NUM!	15	10	$103	$ 25,573
6A3	6A1	8	0.0040	355	0.50	1.55	314%	15	10	$103	$ 36,558
68A	6A3	8	0.0040	355	0.50	1.46	296%	15	10	$103	$ 36,609
7D3DUP	68A	8	0.0040	363	0.50	1.38	278%	12	10	$94	$ 34,133
7D4	7D3DUP	8	0.0040	314	0.50	1.28	259%	12	10	$94	$ 29,535
7D5	7D4	8	0.0040	284	0.50	0.58	116%	10	10	$84	$ 23,833
6A2	6A1	8	0.0040	145	0.50	0.86	173%	10	10	$84	$ 12,197
6A4	6A2	8	0.0040	332	0.50	0.78	157%	10	10	$84	$ 27,893
6A5	6A4	8	0.0040	183	0.50	0.68	137%	10	10	$84	$ 15,353
6A7	6A5	8	0.0040	141	0.50	0.52	105%	10	10	$84	$ 11,825
6A13	7D4	8	0.0040	348	0.50	0.65	132%	10	10	$84	$ 29,221
6A14	6A13	8	0.0040	359	0.50	0.56	114%	10	10	$84	$ 30,162
Project Length				8,090				Project Cost			$ 855,312
PROJECT PP01											
11H1	11G3	54	0.0005	642	29.77	34.19	115%	60	10	$275	$ 176,536
11H2	11H1	54	0.0005	715	29.78	34.24	115%	60	10	$275	$ 196,627
11H3	11H2	54	0.0005	365	29.85	34.25	115%	60	10	$275	$ 100,308
12E4	11H3	54	0.0006	198	30.05	34.26	114%	60	10	$275	$ 54,453
12E3	12E4	54	0.0005	560	29.52	34.31	116%	60	10	$275	$ 153,901
12E2	12E3	54	0.0005	554	29.67	34.35	116%	60	10	$275	$ 152,315
12E1	12E2	54	0.0006	537	30.14	34.42	114%	60	10	$275	$ 147,671
12F5	12E1	54	0.0006	687	29.98	34.44	115%	60	10	$275	$ 188,951
12F4	12F5	54	0.0006	667	30.02	34.50	115%	60	10	$275	$ 183,499
12F3	12F4	54	0.0006	610	30.10	31.02	103%	60	10	$275	$ 167,788
12F2	12F3	54	0.0001	614	10.29	31.09	302%	60	10	$275	$ 168,732
12F1	12F2	54	0.0005	528	29.89	31.11	104%	60	10	$275	$ 145,152
12B1	12F1	54	0.0006	466	30.11	31.17	104%	60	10	$275	$ 128,240
12B2	12B1	54	0.0006	379	30.00	31.21	104%	60	10	$275	$ 104,280
12B3	12B2	54	0.0006	317	30.39	31.24	103%	60	10	$275	$ 87,142

Appendix B
Relief Sewer Recommendations
10-Year 2030 Flow Rates

Manhole		Existing Diameter	Existing Slope	Existing Length	Capacity	2030Flow	%	Recommended Pipe	Estimated Avg. Pipe	Unit	Segment Total
US	DS	(inches)	(ft/ft)	(ft)	(MGD)	(MGD)	Used	Diameter	Depth	Cost	Cost
12B4	12B3	54	0.0006	631	30.02	31.35	104%	60	10	$275	$ 173,606
12B5	12B4	54	0.0006	563	29.93	30.24	101%	60	10	$275	$ 154,718
12B6	12B5	54	0.0006	596	30.01	30.34	101%	60	10	$275	$ 163,823
12C7	12B6	54	0.0004	553	24.84	30.36	122%	60	10	$275	$ 152,133
Project Length				10,181				Project Cost			$ 2,799,873
PROJECT PP02											
1P3	1P4	42	0.0015	452	25.10	28.73	114%	48	10	$245	$ 110,832
1P2	1P3	42	0.0015	379	25.53	28.83	113%	48	10	$245	$ 92,772
1P1	1P2	42	0.0015	391	25.12	28.91	115%	48	10	$245	$ 95,794
1O1DUP	1P1	42	0.0015	533	25.12	28.99	115%	48	10	$245	$ 130,468
1K14	1O1DUP	42	0.0015	549	25.22	27.41	109%	48	10	$245	$ 134,418
1K13	1K14	42	0.0013	297	23.93	27.46	115%	48	10	$245	$ 72,812
1K12	1K13	42	0.0015	356	24.92	27.56	111%	48	10	$245	$ 87,256
1K11	1K12	42	0.0015	345	25.32	27.64	109%	48	10	$245	$ 84,570
1K10	1K11	42	0.0015	413	25.27	27.73	110%	48	10	$245	$ 101,179
1K9	1K10	42	0.0015	399	24.85	27.75	112%	48	10	$245	$ 97,860
1K8	1K9	42	0.0015	406	25.48	27.86	109%	48	10	$245	$ 99,543
1K7A	1K8	42	0.0007	194	17.54	27.94	159%	48	16	$296	$ 57,419
1K7	1K7A	42	0.0023	193	31.14	28.00	90%	48	15	$296	$ 57,241
1K6	1K7	42	0.0015	365	25.31	28.03	111%	48	10	$245	$ 89,475
1K5	1K6	42	0.0017	391	26.61	28.03	105%	48	10	$245	$ 95,707
1K4	1K5	42	0.0015	396	25.18	28.17	112%	48	10	$245	$ 96,977
1K3	1K4	42	0.0018	305	27.44	28.31	103%	48	10	$245	$ 74,733
1K2	1K3	42	0.0018	354	27.75	28.43	102%	48	10	$245	$ 86,608
1K1	1K2	42	0.0018	310	27.72	28.52	103%	48	10	$245	$ 75,965
1G15	1K1	42	0.0023	407	31.20	28.58	92%	48	10	$245	$ 99,599
1G14	1G15	42	0.0018	525	27.61	28.65	104%	48	10	$245	$ 128,545
1G13	1G14	42	0.0018	526	27.58	28.92	105%	48	10	$245	$ 128,831
1G12	1G13	42	0.0018	375	27.76	29.03	105%	48	10	$245	$ 91,967
1G11	1G12	42	0.0018	309	27.76	29.10	105%	48	10	$245	$ 75,743
1G10	1G11	42	0.0038	201	40.08	29.15	73%	48	10	$245	$ 49,312
1G9	1G10	36	0.0033	591	24.83	29.25	118%	42	10	$230	$ 135,970
1G8	1G9	36	0.0033	461	24.92	29.45	118%	42	10	$230	$ 105,921
1G7	1G8	36	0.0033	199	24.90	29.62	119%	42	10	$230	$ 45,785
1G6	1G7	36	0.0034	422	25.26	29.42	116%	42	10	$230	$ 97,073
1G5	1G6	36	0.0032	305	24.64	29.52	120%	42	10	$230	$ 70,138
1G4	1G5	36	0.0045	179	28.88	29.52	102%	42	10	$230	$ 41,246

Appendix B
Relief Sewer Recommendations
10-Year 2030 Flow Rates

Manhole		Existing Diameter	Existing Slope	Existing Length	Capacity	2030Flow	%	Recommended Pipe	Estimated Avg. Pipe	Unit	Segment Total
US	DS	(inches)	(ft/ft)	(ft)	(MGD)	(MGD)	Used	Diameter	Depth	Cost	Cost
1G3	1G4	36	0.0033	352	24.82	29.59	119%	42	10	$230	$ 80,937
1G2	1G3	36	0.0033	344	24.67	29.20	118%	42	10	$230	$ 79,116
Project Length				12,223				Project Cost			$ 2,971,811
PROJECT PP03											
1B89	1B90	30	0.0068	519	21.91	22.73	104%	42	10	$230	$ 119,278
1B88	1B89	30	0.0085	70	24.58	22.74	93%	42	10	$230	$ 16,151
1B79A	1B88	27	0.1785	13	84.82	22.74	27%	42	10	$230	$ 3,092
1B79	1B79A	27	0.0023	215	9.68	22.74	235%	42	10	$230	$ 49,423
1B78	1B79	27	0.0032	314	11.39	22.75	200%	42	10	$230	$ 72,204
1B77	1B78	27	0.0023	345	9.67	22.98	238%	42	10	$230	$ 79,292
1B76	1B77	27	0.0023	444	9.57	23.29	243%	42	7	$230	$ 102,197
1B75	1B76	27	0.0026	312	10.22	22.38	219%	42	10	$230	$ 71,819
1B74	1B75	24	0.0042	503	9.48	22.45	237%	36	10	$200	$ 100,577
1B73	1B74	24	0.0043	379	9.59	22.56	235%	36	10	$200	$ 75,718
1B72	1B73	24	0.0041	175	9.40	21.99	234%	36	10	$200	$ 35,047
1B71	1B72	24	0.0043	133	9.61	21.97	229%	36	10	$200	$ 26,521
1B86	1B71	24	0.0037	458	8.88	20.32	229%	36	10	$200	$ 91,637
1B87	1B86	24	0.0038	182	9.02	20.26	224%	36	8	$200	$ 36,437
2N7	1B87	24	0.0037	303	8.88	20.34	229%	36	10	$200	$ 60,525
2N8	2N7	24	0.0037	470	8.97	19.81	221%	36	10	$200	$ 93,959
2N9	2N8	24	0.0037	502	8.88	19.92	224%	36	10	$200	$ 100,419
2N64	2N9	24	0.0055	96	10.92	17.78	163%	36	8	$200	$ 19,102
2N10	2N64	24	0.0059	334	11.29	17.80	158%	36	11	$220	$ 73,430
2N11	2N10	24	0.0024	235	7.22	17.80	246%	36	10	$200	$ 46,964
2N12	2N11	24	0.0024	368	7.21	17.86	248%	36	10	$200	$ 73,663
2N12A	2N12	24	0.0045	99	9.80	17.82	182%	36	12	$220	$ 21,688
2N13	2N12A	24	0.0014	202	5.46	17.81	326%	36	11	$220	$ 44,458
2N14	2N13	24	0.0025	276	7.34	17.85	243%	36	10	$200	$ 55,128
2N15	2N14	24	0.0022	229	6.92	17.84	258%	36	10	$200	$ 45,855
2N16	2N15	24	0.0024	218	7.23	17.84	247%	36	10	$200	$ 43,607
2N17	2N16	21	0.0059	410	7.90	16.63	210%	30	10	$170	$ 69,782
2N72	2N17	21	0.0045	140	6.89	16.63	241%	30	10	$170	$ 23,768
2N18	2N72	21	0.0045	330	6.88	16.67	242%	30	10	$187	$ 61,667
2N19	2N18	21	0.0045	300	6.91	16.67	241%	30	10	$170	$ 51,000
2N20	2N19	21	0.0035	440	6.08	16.71	275%	30	10	$170	$ 74,716

Appendix B
Relief Sewer Recommendations
10-Year 2030 Flow Rates

Manhole		Existing Diameter	Existing Slope	Existing Length	Capacity	2030Flow	%	Recommended Pipe	Estimated Avg. Pipe	Unit	Segment Total
US	DS	(inches)	(ft/ft)	(ft)	(MGD)	(MGD)	Used	Diameter	Depth	Cost	Cost
Project Length				9,012				Project Cost			$ 1,839,124
PROJECT PP04											
2N21	2N20	21	0.0034	286	6.01	16.70	278%	36	10	$200	$ 57,184
2O1B	2N21	21	0.0017	293	4.20	16.70	398%	36	10	$220	$ 64,536
2O1A	2O1B	21	0.0065	107	8.29	15.40	186%	30	9	$170	$ 18,172
2O1	2O1A	21	0.0030	104	5.63	15.04	267%	30	9	$170	$ 17,730
2O2	2O1	21	0.0047	506	7.07	15.10	213%	30	10	$170	$ 86,009
2O3	2O2	21	0.0041	491	6.55	15.13	231%	30	10	$170	$ 83,542
2K1	2O3	21	0.0034	476	5.99	15.13	253%	30	10	$170	$ 81,004
2K2	2K1	21	0.0025	408	5.08	15.28	301%	30	10	$170	$ 69,382
2K100	2K2	21	0.0062	175	8.10	14.31	177%	30	11	$187	$ 32,737
2K40	2K100	21	0.0045	293	6.87	14.12	206%	30	12	$187	$ 54,773
2K41	2K40	21	0.0052	264	7.43	14.12	190%	30	10	$170	$ 44,819
2K42	2K41	21	0.0047	473	7.07	14.24	201%	30	10	$170	$ 80,347
2K43	2K42	21	0.0056	384	7.68	13.17	171%	30	10	$170	$ 65,342
2K44	2K43	21	0.0056	366	7.72	13.22	171%	30	10	$170	$ 62,287
2K45	2K44	21	0.0056	502	7.67	13.21	172%	30	10	$170	$ 85,343
2K46	2K45	21	0.0057	308	7.72	12.26	159%	30	10	$170	$ 52,352
2L1	2K46	21	0.0055	503	7.61	12.43	163%	30	10	$170	$ 85,442
2L23	2L1	21	0.0051	323	7.32	12.55	171%	30	9	$170	$ 54,859
2L2	2L23	21	0.0045	164	6.91	9.75	141%	30	10	$170	$ 27,819
2L3	2L2	21	0.0048	287	7.12	9.78	137%	30	10	$170	$ 48,792
2L4	2L3	21	0.0049	380	7.18	9.79	136%	30	10	$170	$ 64,681
2L5	2L4	21	0.0045	137	6.90	9.79	142%	30	8	$170	$ 23,356
2L19	2L5	21	0.0026	277	5.24	7.86	150%	30	10	$170	$ 47,043
2L20	2L19	21	0.0027	267	5.30	7.87	149%	30	10	$170	$ 45,399
2L21	2L20	21	0.0025	187	5.15	7.87	153%	30	10	$170	$ 31,730
2L22	2L21	21	0.0026	128	5.28	7.86	149%	30	10	$170	$ 21,842
15E21DUP	2L22	21	0.0025	447	5.19	7.89	152%	30	81	$249	$ 111,297
15E66	15E21DUP	21	0.0028	81	5.40	7.89	146%	30	10	$170	$ 13,741
15E22	15E66	21	0.0026	287	5.24	7.87	150%	30	10	$170	$ 48,817
15E23	15E22	21	0.0026	337	5.25	7.85	150%	30	10	$170	$ 57,314
15E24	15E23	21	0.0026	174	5.22	7.86	150%	30	10	$170	$ 29,576
15E25	15E24	21	0.0027	162	5.29	7.87	149%	30	10	$170	$ 27,531
15E26	15E25	21	0.0026	218	5.20	7.88	151%	30	10	$170	$ 37,115
15E74	15E26	21	0.0026	443	5.22	7.87	151%	30	10	$170	$ 75,294
Project Length				10,240				Project Cost			$ 1,807,208

Appendix B
Relief Sewer Recommendations
10-Year 2030 Flow Rates

Manhole		Existing Diameter	Existing Slope	Existing Length	Capacity	2030Flow	%	Recommended Pipe	Estimated Avg. Pipe	Unit	Segment Total
US	DS	(inches)	(ft/ft)	(ft)	(MGD)	(MGD)	Used	Diameter	Depth	Cost	Cost
PROJECT PP05											
1B1	1B90	12	0.1457	71	8.81	4.66	53%	18	11	$124	$ 8,873
1B2	1B1	12	0.0140	269	2.73	4.66	171%	18	10	$113	$ 30,386
1B3	1B2	12	0.0280	294	3.86	4.72	122%	18	10	$113	$ 33,197
1B4	1B3	8	0.0040	248	0.50	1.77	358%	18	10	$113	$ 28,011
1B6	1B4	8	0.0040	335	0.50	1.78	359%	18	10	$113	$ 37,843
1B7	1B6	8	0.0040	120	0.50	1.75	354%	18	10	$113	$ 13,515
1B10	1B7	8	0.0040	370	0.50	1.77	357%	18	10	$113	$ 41,821
1B16	1B10	8	0.0040	235	0.50	1.76	356%	18	10	$113	$ 26,536
1A38	1B16	8	0.0040	320	0.50	1.76	356%	18	10	$113	$ 36,159
1A37B	1A38	8	0.0040	107	0.50	1.74	351%	18	10	$113	$ 12,117
1A37	1A37B	8	0.0040	99	0.50	1.73	349%	18	10	$113	$ 11,170
1A36	1A37	8	0.0040	170	0.50	1.61	325%	18	10	$113	$ 19,258
1A33	1A36	8	0.0040	243	0.50	1.62	327%	18	10	$113	$ 27,440
1A32	1A33	8	0.0040	194	0.50	3.20	647%	18	10	$113	$ 21,928
1A31	1A32	8	0.0040	45	0.50	1.96	395%	15	10	$103	$ 4,647
1A30	1A31	8	0.0040	80	0.50	1.95	395%	15	10	$103	$ 8,189
1A57	1A30	8	0.0275	325	1.30	1.94	150%	12	10	$94	$ 30,559
1A24A	1A57	8	0.0220	316	1.16	1.95	168%	12	10	$94	$ 29,672
1A67	1A24A	8	0.0220	311	1.16	1.91	164%	12	10	$94	$ 29,196
1A67A	1A67	8	0.0040	114	0.50	1.34	270%	12	10	$94	$ 10,687
1A16	1A67A	8	0.0040	165	0.50	1.23	248%	12	10	$94	$ 15,503
1A15	1A16	8	0.0040	129	0.50	0.83	168%	10	10	$84	$ 10,802
1A67F	1A67	8	0.0040	5	0.50	0.54	110%	10	10	$84	$ 385
1A66	1A67F	8	0.0040	184	0.50	0.55	112%	10	10	$84	$ 15,444
1A65	1A66	8	0.0040	17	0.50	0.50	102%	10	10	$84	$ 1,410
1A58	1A65	8	0.0040	378	0.50	0.52	106%	10	10	$84	$ 31,790
1A59	1A58	8	0.0040	318	0.50	0.51	103%	10	10	$84	$ 26,681
Project Length				5,459				Project Cost			$ 563,219
PROJECT PP06											
1B70	1B71	10	0.0056	271	1.06	2.02	191%	15	10	$103	$ 27,941
1B69	1B70	8	0.0450	167	1.66	1.97	118%	12	10	$94	$ 15,676
1B68	1B69	8	0.0165	171	1.01	1.92	191%	12	10	$94	$ 16,089

Appendix B
Relief Sewer Recommendations
10-Year 2030 Flow Rates

Manhole		Existing Diameter	Existing Slope	Existing Length	Capacity	2030Flow	%	Recommended Pipe	Estimated Avg. Pipe	Unit	Segment Total
US	DS	(inches)	(ft/ft)	(ft)	(MGD)	(MGD)	Used	Diameter	Depth	Cost	Cost
1B67	1B68	8	0.0127	64	0.88	1.88	213%	12	10	$94	$ 5,989
1A157	1B67	8	0.0363	177	1.49	1.87	125%	10	10	$84	$ 14,887
1A150	1A157	8	0.0353	92	1.47	1.77	120%	10	10	$84	$ 7,712
1A150A	1A150	8	0.0631	130	1.97	1.76	90%	10	10	$84	$ 10,945
1A149	1A150A	8	0.0128	287	0.89	1.74	196%	10	10	$84	$ 24,081
1A147	1A149	8	0.0831	66	2.26	1.67	74%	10	10	$84	$ 5,522
1A148	1A147	8	0.0287	72	1.33	1.29	97%	10	10	$84	$ 6,006
1A80	1A148	8	0.0040	233	0.50	0.91	183%	10	10	$84	$ 19,593
1A81	1A80	8	0.1000	115	2.48	0.62	25%	10	10	$84	$ 9,651
1A82	1A81	8	0.0060	246	0.61	0.63	104%	10	10	$84	$ 20,702
Project Length				2,091				Project Cost			$ 184,795
PROJECT PP07											
2N5B	2N5A	12	0.0190	26	3.18	2.60	82%	18	10	$113	$ 2,922
2N1	2N5B	12	0.0019	77	1.02	2.60	256%	18	10	$113	$ 8,676
2N2	2N1	12	0.0040	190	1.46	2.59	178%	18	10	$113	$ 21,445
2N3	2N2	12	0.0040	272	1.46	2.65	181%	18	10	$113	$ 30,769
2N4	2N3	12	0.0040	239	1.46	2.69	184%	18	10	$113	$ 27,059
2M1	2N4	12	0.0040	354	1.46	2.72	186%	18	10	$113	$ 39,972
2M69	2M1	12	0.0040	116	1.46	2.66	182%	18	10	$113	$ 13,153
2M80	2M69	12	0.0037	163	1.40	2.68	191%	18	10	$113	$ 18,465
2M2	2M80	12	0.0031	30	1.29	2.66	207%	18	10	$113	$ 3,379
2M40	2M2	10	0.0025	63	0.71	2.47	349%	18	10	$113	$ 7,108
2M3	2M40	12	0.0060	232	1.79	2.35	131%	15	10	$103	$ 23,879
2M4	2M3	12	0.0060	305	1.79	2.37	132%	15	10	$103	$ 31,423
2M5	2M4	12	0.0060	296	1.79	1.91	107%	15	10	$103	$ 30,496
2M6	2M5	12	0.0060	198	1.79	1.93	108%	15	10	$103	$ 20,377
2M7	2M6	12	0.0090	317	2.19	1.96	90%	15	10	$103	$ 32,608
2M8	2M7	12	0.0019	325	1.02	1.84	181%	15	10	$103	$ 33,524
2M9	2M8	12	0.0396	320	4.59	1.85	40%	15	10	$103	$ 32,954
1A112	2M9	10	0.0020	319	0.63	1.49	235%	15	10	$103	$ 32,820
1A110	1A112	10	0.0050	319	1.00	1.48	147%	12	10	$94	$ 30,002
1A109	1A110	8	0.0040	136	0.50	0.71	143%	10	10	$84	$ 11,409
1A103B	1A109	8	0.0040	153	0.50	0.68	138%	10	10	$84	$ 12,875
1A103A	1A103B	8	0.0040	90	0.50	0.67	136%	10	10	$84	$ 7,570
1A103	1A103A	8	0.0040	28	0.50	0.66	133%	10	10	$84	$ 2,377
1A104	1A103	8	0.0040	218	0.50	0.67	135%	10	10	$84	$ 18,319

Appendix B
Relief Sewer Recommendations
10-Year 2030 Flow Rates

Manhole		Existing Diameter	Existing Slope	Existing Length	Capacity	2030Flow	%	Recommended Pipe	Estimated Avg. Pipe	Unit	Segment Total
US	DS	(inches)	(ft/ft)	(ft)	(MGD)	(MGD)	Used	Diameter	Depth	Cost	Cost
2N9-1	2N9	15	0.0059	259	3.21	7.61	237%	21	8	$125	$ 32,407
2N9-2	2N9-1	12	0.0255	184	3.68	7.57	205%	21	6	$125	$ 22,972
2N5A	2N9-2	12	0.0190	355	3.18	7.54	237%	21	10	$125	$ 44,354
2M13A	2N5A	8	0.0040	327	0.50	5.12	1035%	21	10	$125	$ 40,850
2M14	2M13A	8	0.0040	151	0.50	5.04	1017%	21	10	$125	$ 18,877
2M16	2M14	8	0.0040	556	0.50	4.99	1009%	21	10	$125	$ 69,496
2M43	2M16	8	0.0040	41	0.50	4.84	978%	21	10	$125	$ 5,143
2M43A	2M43	8	0.0040	97	0.50	4.76	962%	21	10	$125	$ 12,141
2M17	2M43A	8	0.0040	161	0.50	4.63	936%	21	10	$125	$ 20,106
2M18	2M17	8	0.0040	296	0.50	4.59	927%	21	10	$125	$ 37,011
2M19	2M18	8	0.0040	242	0.50	4.54	916%	21	10	$125	$ 30,208
2M191A	2M19	8	0.0040	297	0.50	4.50	909%	21	10	$125	$ 37,138
2M22	2M191A	8	0.0040	255	0.50	3.89	785%	18	10	$113	$ 28,780
2M21	2M22	8	0.0040	98	0.50	3.85	778%	18	10	$113	$ 11,035
2M23	2M21	8	0.0040	137	0.50	3.84	775%	18	10	$113	$ 15,505
2M23A	2M23	8	0.0040	20	0.50	3.65	736%	18	10	$113	$ 2,292
2M23B	2M23A	8	0.0040	215	0.50	3.64	736%	18	10	$113	$ 24,347
2M24	2M23B	8	0.0040	218	0.50	3.61	729%	18	10	$113	$ 24,675
2M25	2M24	8	0.0040	282	0.50	3.13	632%	18	10	$113	$ 31,883
2M26	2M25	8	0.0040	294	0.50	3.09	624%	18	10	$113	$ 33,259
4P42	2M26	8	0.0040	163	0.50	2.84	573%	18	10	$113	$ 18,417
4P42A	4P42	8	0.0060	182	0.61	2.11	347%	15	10	$103	$ 18,785
4P42B	4P42A	8	0.0083	152	0.71	2.08	292%	15	10	$103	$ 15,688
4P43A	4P42B	8	0.0040	28	0.50	2.06	415%	15	10	$103	$ 2,837
4P54	4P43A	8	0.0040	105	0.50	2.05	415%	15	10	$103	$ 10,834
4P55	4P54	8	0.0040	116	0.50	1.82	368%	15	10	$103	$ 11,897
4P58	4P55	8	0.0040	262	0.50	1.39	280%	12	10	$94	$ 24,615
4P58A	4P58	8	0.0040	167	0.50	1.35	272%	12	10	$94	$ 15,694
4P59	4P58A	8	0.0040	114	0.50	1.32	268%	12	10	$94	$ 10,718
4L2	4P59	8	0.0040	256	0.50	1.21	244%	12	10	$94	$ 24,038
4L3	4L2	8	0.0040	264	0.50	1.19	240%	12	10	$94	$ 24,863
4L4	4L3	8	0.0040	258	0.50	1.13	227%	12	10	$94	$ 24,276
4L26	4L4	8	0.0040	272	0.50	0.64	130%	10	10	$84	$ 22,863
4L26A	4L26	8	0.0040	215	0.50	0.61	124%	10	10	$84	$ 18,047
4L30	4L26A	8	0.0040	91	0.50	0.59	119%	10	10	$84	$ 7,677
4P41	4P42	8	0.0040	171	0.50	0.71	144%	10	10	$84	$ 14,347
4P40	4P41	8	0.0040	46	0.50	0.69	139%	10	10	$84	$ 3,876
4P37	4P40	8	0.0040	306	0.50	0.50	102%	10	10	$84	$ 25,725

Appendix B
Relief Sewer Recommendations
10-Year 2030 Flow Rates

Manhole		Existing Diameter	Existing Slope	Existing Length	Capacity	2030Flow	%	Recommended Pipe	Estimated Avg. Pipe	Unit	Segment Total
US	DS	(inches)	(ft/ft)	(ft)	(MGD)	(MGD)	Used	Diameter	Depth	Cost	Cost
Project Length				12,441				Project Cost			$ 1,331,256
PROJECT PP08											
2N35	2N16	15	0.0038	221	2.58	2.67	103%	18	10	$113	$ 25,022
2N36	2N35	15	0.0045	252	2.80	2.71	97%	18	10	$113	$ 28,493
2N37	2N36	10	0.0233	321	2.17	2.78	128%	15	10	$103	$ 33,097
2N38	2N37	10	0.0193	391	1.97	2.81	143%	15	10	$103	$ 40,283
2N39	2N38	10	0.0112	231	1.50	2.60	173%	15	10	$103	$ 23,821
2J8	2N39	10	0.0111	232	1.49	2.37	159%	15	10	$103	$ 23,854
2J9	2J8	10	0.0609	168	3.50	2.36	67%	15	10	$103	$ 17,275
2J10	2J9	10	0.0366	400	2.72	2.40	88%	15	10	$103	$ 41,209
2J11	2J10	10	0.0072	382	1.21	2.39	198%	15	10	$103	$ 39,374
2J12	2J11	10	0.0069	163	1.18	1.93	164%	15	10	$103	$ 16,794
2J13	2J12	10	0.0247	300	2.23	1.96	88%	12	10	$94	$ 28,219
2J14	2J13	10	0.0072	281	1.20	1.95	162%	12	10	$94	$ 26,376
2J15	2J14	10	0.0072	124	1.20	1.92	160%	12	10	$94	$ 11,650
2J16	2J15	10	0.0072	188	1.20	1.92	160%	12	10	$94	$ 17,699
2J17	2J16	8	0.0090	44	0.74	1.85	249%	12	10	$94	$ 4,153
2J18	2J17	8	0.0110	270	0.82	1.28	155%	10	10	$84	$ 22,648
2J19	2J18	8	0.0100	95	0.78	1.17	150%	10	10	$84	$ 7,959
Project Length				4,064				Project Cost			$ 407,925
PROJECT PP09											
2O4	2O1B	8	0.0040	287	0.50	1.60	324%	15	10	$103	$ 29,597
2O5	2O4	8	0.0040	94	0.50	1.57	318%	15	10	$103	$ 9,690
2O6	2O5	8	0.0040	76	0.50	1.37	278%	12	10	$94	$ 7,143
2O8	2O6	8	0.0040	395	0.50	1.38	278%	12	10	$94	$ 37,108
2O9	2O8	8	0.0040	315	0.50	1.37	276%	12	10	$94	$ 29,581
2O16	2O9	8	0.0200	233	1.11	1.36	123%	10	10	$84	$ 19,572
2O73	2O16	8	0.0200	31	1.11	1.34	121%	10	10	$84	$ 2,588
2O17	2O73	8	0.0200	225	1.11	1.26	114%	10	10	$84	$ 18,934
2O70	2O17	8	0.0197	297	1.10	1.27	116%	10	10	$84	$ 24,940
2O18	2O70	8	0.0197	63	1.10	1.21	110%	10	10	$84	$ 5,259
2O49	2O18	8	0.0200	143	1.11	1.21	109%	10	10	$84	$ 11,995
2O19	2O49	8	0.0200	168	1.11	1.04	94%	10	10	$84	$ 14,128
2O20	2O19	8	0.0200	263	1.11	0.90	82%	10	10	$84	$ 22,111

Appendix B
Relief Sewer Recommendations
10-Year 2030 Flow Rates

Manhole		Existing Diameter	Existing Slope	Existing Length	Capacity	2030Flow	%	Recommended Pipe	Estimated Avg. Pipe	Unit	Segment Total
US	DS	(inches)	(ft/ft)	(ft)	(MGD)	(MGD)	Used	Diameter	Depth	Cost	Cost
2O25	2O20	8	0.0200	284	1.11	0.83	75%	10	10	$84	$ 23,860
2O21	2O25	8	0.0200	40	1.11	0.73	66%	10	10	$84	$ 3,365
2P26	2O21	8	0.0200	260	1.11	0.75	67%	10	10	$84	$ 21,803
2P5	2P26	8	0.0200	62	1.11	0.66	60%	10	10	$84	$ 5,235
2P24	2P5	8	0.0200	246	1.11	0.66	60%	10	10	$84	$ 20,623
2P6	2P24	8	0.0200	77	1.11	0.64	58%	10	10	$84	$ 6,493
2P20	2P6	8	0.0040	350	0.50	0.64	130%	10	10	$84	$ 29,401
2P21	2P20	8	0.0040	135	0.50	0.64	128%	10	10	$84	$ 11,340
2P22	2P21	8	0.0040	360	0.50	0.66	133%	10	10	$84	$ 30,240
2P23	2P22	8	0.0040	315	0.50	0.66	133%	10	10	$84	$ 26,459
15I31	2P23	8	0.0040	180	0.50	0.65	131%	10	10	$84	$ 15,129
15I32	15I31	8	0.0040	92	0.50	0.55	111%	10	10	$84	$ 7,766
15I33	15I32	8	0.0040	186	0.50	0.53	107%	10	10	$84	$ 15,657
15I34	15I33	8	0.0040	77	0.50	0.53	107%	10	10	$84	$ 6,426
15A39	15I34	8	0.0040	322	0.50	0.46	93%	10	10	$84	$ 27,077
Project Length				5,576				Project Cost			$ 483,520
PROJECT PP10											
2L24	2L23	8	0.0147	344	0.95	3.64	383%	15	10	$103	$ 35,440
2L25	2L24	8	0.0147	370	0.95	3.38	356%	15	10	$103	$ 38,099
2L38	2L25	10	0.0147	65	1.72	3.34	194%	15	10	$103	$ 6,694
15I3	2L38	10	0.0147	325	1.72	3.37	196%	15	10	$103	$ 33,452
15I73	15I3	10	0.0147	164	1.72	3.34	194%	15	10	$103	$ 16,860
15I4	15I73	10	0.0147	81	1.72	3.11	181%	15	10	$103	$ 8,339
15I5	15I4	10	0.0212	250	2.07	3.10	150%	12	10	$94	$ 23,459
15I20	15I5	10	0.0100	404	1.42	1.84	129%	12	10	$94	$ 37,959
15I21	15I20	10	0.0150	388	1.74	1.83	105%	12	10	$94	$ 36,495
15I1137	15I21	10	0.0253	165	2.26	1.69	75%	12	10	$94	$ 15,525
15I22	15I1137	8	0.0253	232	1.24	1.62	131%	10	10	$84	$ 19,528
15I1147	15I22	8	0.0253	278	1.24	1.26	102%	10	10	$84	$ 23,370
15L123	15I1147	8	0.0253	84	1.24	1.09	88%	10	10	$84	$ 7,041
15I1197	15L123	8	0.0123	204	0.87	0.90	103%	10	10	$84	$ 17,160
15I6	15I5	8	0.0040	103	0.50	1.27	257%	12	10	$94	$ 9,728
15I67	15I6	8	0.0040	165	0.50	0.72	146%	10	10	$84	$ 13,889
15I68	15I67	8	0.0040	231	0.50	0.72	146%	10	10	$84	$ 19,443
15I69	15I68	8	0.0040	333	0.50	0.70	142%	10	10	$84	$ 27,933
15I70	15I69	8	0.0040	183	0.50	0.68	138%	10	10	$84	$ 15,390

Appendix B
Relief Sewer Recommendations
10-Year 2030 Flow Rates

Manhole		Existing Diameter	Existing Slope	Existing Length	Capacity	2030Flow	%	Recommended Pipe	Estimated Avg. Pipe	Unit	Segment Total
US	DS	(inches)	(ft/ft)	(ft)	(MGD)	(MGD)	Used	Diameter	Depth	Cost	Cost
15I71	15I70	8	0.0040	305	0.50	0.60	121%	10	10	$84	$ 25,624
15I72	15I71	8	0.0040	33	0.50	0.53	107%	10	10	$84	$ 2,774
15I177	15I72	8	0.0040	108	0.50	0.57	115%	10	10	$84	$ 9,091
Project Length				4,816				Project Cost			$ 443,293
PROJECT PP11											
15G36	15G35	24	0.0008	272	4.12	5.46	132%	30	10	$170	$ 46,292
15G37	15G36	24	0.0024	84	7.18	5.49	76%	30	10	$170	$ 14,356
15G38	15G37	24	0.0022	210	6.86	5.57	81%	30	10	$170	$ 35,658
15G39	15G38	24	0.0012	336	5.08	6.10	120%	30	10	$170	$ 57,192
15G40	15G39	24	0.0014	129	5.47	6.30	115%	30	10	$170	$ 22,013
15G41	15G40	24	0.0008	314	4.12	6.65	161%	30	10	$170	$ 53,324
15G43	15G41	24	0.0008	15	4.12	6.57	159%	30	10	$170	$ 2,633
15G2	15G43	8	0.0200	45	1.11	6.51	588%	18	10	$113	$ 5,051
15G4	15G2	8	0.0108	115	0.81	4.84	595%	18	10	$113	$ 12,969
15G5	15G4	8	0.0108	396	0.81	4.81	591%	18	10	$113	$ 44,779
15G6	15G5	8	0.0108	186	0.81	4.71	578%	18	10	$113	$ 21,056
15G7	15G6	8	0.0108	424	0.81	4.25	522%	15	10	$103	$ 43,655
15G8	15G7	8	0.0108	281	0.81	4.06	499%	15	10	$103	$ 28,989
15G1	15G8	8	0.0108	422	0.81	3.90	480%	15	10	$103	$ 43,445
15H1	15G1	8	0.0108	271	0.81	3.73	459%	15	10	$103	$ 27,888
15H2	15H1	8	0.0108	219	0.81	3.34	410%	15	10	$103	$ 22,544
15H3	15H2	8	0.0108	184	0.81	3.28	403%	15	10	$103	$ 18,991
15H4	15H3	8	0.0108	304	0.81	3.19	392%	15	10	$103	$ 31,334
15H5	15H4	8	0.0108	183	0.81	2.86	351%	15	10	$103	$ 18,828
15H6	15H5	8	0.0108	111	0.81	2.81	345%	15	10	$103	$ 11,382
15H7	15H6	8	0.0108	241	0.81	2.75	338%	15	10	$103	$ 24,831
15H8	15H7	8	0.0108	256	0.81	2.56	314%	15	10	$103	$ 26,389
15H9	15H8	8	0.0122	383	0.86	1.52	176%	10	10	$84	$ 32,171
15H10	15H9	8	0.0122	390	0.86	1.48	171%	10	10	$84	$ 32,796
15H15	15H8	8	0.0108	309	0.81	1.02	125%	10	10	$84	$ 25,958
15H47	15H15	8	0.0108	69	0.81	0.94	116%	10	10	$84	$ 5,785
15L8	15H47	8	0.0108	249	0.81	0.98	120%	10	10	$84	$ 20,902
15G3	15G2	8	0.0040	324	0.50	1.68	339%	15	10	$103	$ 33,418

Appendix B
Relief Sewer Recommendations
10-Year 2030 Flow Rates

Manhole		Existing Diameter	Existing Slope	Existing Length	Capacity	2030Flow	%	Recommended Pipe	Estimated Avg. Pipe	Unit	Segment Total
US	DS	(inches)	(ft/ft)	(ft)	(MGD)	(MGD)	Used	Diameter	Depth	Cost	Cost
Project Length				6,724				Project Cost			$ 764,629
PROJECT PP12											
16O5	16O2	8	0.0040	396	0.50	1.91	387%	15	10	$103	$ 40,801
16O6	16O5	8	0.0104	443	0.80	1.91	239%	12	10	$94	$ 41,658
16O7	16O6	8	0.0104	311	0.80	1.89	236%	12	10	$94	$ 29,251
16O11	16O7	8	0.0104	382	0.80	1.75	218%	12	10	$94	$ 35,927
16O12	16O11	8	0.0104	396	0.80	1.73	216%	12	10	$94	$ 37,178
16O13	16O12	8	0.0104	299	0.80	1.69	212%	12	10	$94	$ 28,133
16O14	16O13	8	0.0104	94	0.80	1.61	202%	12	10	$94	$ 8,818
16P1	16O14	8	0.0104	248	0.80	1.65	206%	12	10	$94	$ 23,301
16P2	16P1	8	0.0104	365	0.80	1.53	192%	12	10	$94	$ 34,352
16P3	16P2	8	0.0104	398	0.80	1.46	183%	12	10	$94	$ 37,450
Project Length				3,333				Project Cost			$ 316,868
PROJECT PP13											
2K8A	2K8	10	0.0147	265	1.72	2.05	119%	12	10	$94	$ 24,895
2K9	2K8A	10	0.0147	79	1.72	1.83	106%	12	10	$94	$ 7,438
2K10	2K9	10	0.0147	342	1.72	1.85	107%	12	10	$94	$ 32,123
2K10A	2K10	10	0.0115	351	1.52	1.85	121%	12	10	$94	$ 32,971
2K11	2K10A	10	0.0115	41	1.52	1.51	99%	12	10	$94	$ 3,855
2K12	2K11	10	0.0115	207	1.52	1.51	99%	12	10	$94	$ 19,476
2K13	2K12	10	0.0115	203	1.52	1.54	101%	12	10	$94	$ 19,113
2G18	2K13	10	0.0184	392	1.93	1.58	82%	12	10	$94	$ 36,844
2G18A	2G18	8	0.0122	65	0.86	1.55	180%	12	10	$94	$ 6,069
2G19DUP	2G18A	8	0.0122	336	0.86	1.10	127%	12	10	$94	$ 31,618
2G127	2G19DUP	8	0.0040	114	0.50	1.08	218%	12	10	$94	$ 10,705
2G126	2G127	8	0.0040	270	0.50	1.08	217%	12	10	$94	$ 25,349
2G20	2G126	8	0.0040	24	0.50	1.00	203%	12	10	$94	$ 2,286
2G21	2G20	8	0.0205	277	1.12	1.03	92%	10	10	$84	$ 23,232
2G22	2G21	8	0.0122	277	0.86	0.95	109%	10	10	$84	$ 23,235
2G23	2G22	8	0.0122	277	0.86	0.89	103%	10	10	$84	$ 23,304
Project Length				3,519				Project Cost			$ 322,513

Appendix B
Relief Sewer Recommendations
10-Year 2030 Flow Rates

Manhole		Existing Diameter	Existing Slope	Existing Length	Capacity	2030Flow	%	Recommended Pipe	Estimated Avg. Pipe	Unit	Segment Total
US	DS	(inches)	(ft/ft)	(ft)	(MGD)	(MGD)	Used	Diameter	Depth	Cost	Cost
PROJECT PP14											
1C8	1C7	15	0.0101	395	4.21	5.20	123%	18	10	$124	$ 49,070
1C9	1C8	15	0.0100	339	4.19	5.32	127%	18	11	$124	$ 42,096
1C56	1C9	8	0.0040	232	0.50	1.33	269%	12	10	$94	$ 21,807
1C57	1C56	8	0.0040	401	0.50	1.31	265%	12	10	$94	$ 37,728
1C58	1C57	8	0.0040	137	0.50	0.93	188%	12	10	$94	$ 12,877
1C59	1C58	8	0.0040	77	0.50	0.91	184%	12	10	$94	$ 7,212
1C60	1C59	8	0.0040	111	0.50	0.90	181%	10	10	$84	$ 9,294
1C65	1C60	8	0.0040	334	0.50	0.63	127%	10	10	$84	$ 28,080
1D37	1C65	8	0.0040	184	0.50	0.59	118%	10	10	$84	$ 15,483
1C13	1C13A	8	0.0040	46	0.50	1.32	267%	12	10	$94	$ 4,310
1C14	1C13	8	0.0040	392	0.50	1.31	264%	12	10	$94	$ 36,868
1C15	1C14	8	0.0040	170	0.50	1.30	263%	12	10	$94	$ 15,959
1C94	1C15	8	0.0040	209	0.50	1.17	236%	12	10	$94	$ 19,622
1C16	1C94	8	0.0040	179	0.50	1.12	227%	12	10	$94	$ 16,841
1C17	1C16	8	0.0040	252	0.50	1.14	230%	12	10	$94	$ 23,665
1C18A	1C17	8	0.0040	246	0.50	1.01	204%	12	10	$94	$ 23,156
1C18	1C18A	8	0.0040	165	0.50	0.98	198%	12	10	$94	$ 15,522
1C19	1C18	8	0.0040	363	0.50	0.97	196%	12	10	$94	$ 34,107
2P36	1C19	8	0.0040	91	0.50	0.97	195%	12	10	$94	$ 8,517
2P37	2P36	8	0.0040	136	0.50	0.98	197%	12	10	$94	$ 12,754
2P9	2P37	8	0.0040	108	0.50	0.61	123%	10	10	$84	$ 9,096
2P63	2P9	8	0.0040	145	0.50	0.61	124%	10	10	$84	$ 12,198
Project Length				4,711				Project Cost			$ 456,263
PROJECT PP15											
11C16	11C15	10	0.0141	396	1.69	1.89	112%	12	10	$94	$ 37,221
11B81	11C16	10	0.0139	301	1.68	1.91	114%	12	10	$94	$ 28,315
11B163	11B81	10	0.0148	88	1.73	1.90	110%	12	10	$94	$ 8,276
11B82	11B163	10	0.0120	104	1.56	1.82	117%	12	10	$94	$ 9,764
11B83	11B82	10	0.0126	113	1.60	1.71	107%	12	10	$94	$ 10,637
11B84	11B83	10	0.0141	332	1.69	1.73	103%	12	10	$94	$ 31,229
11B125	11B84	10	0.0163	258	1.81	1.74	96%	12	10	$94	$ 24,225
11B127	11B125	8	0.0040	431	0.50	1.69	342%	12	10	$94	$ 40,555
11B126	11B127	8	0.0040	194	0.50	0.84	170%	10	10	$84	$ 16,328

Appendix B
Relief Sewer Recommendations
10-Year 2030 Flow Rates

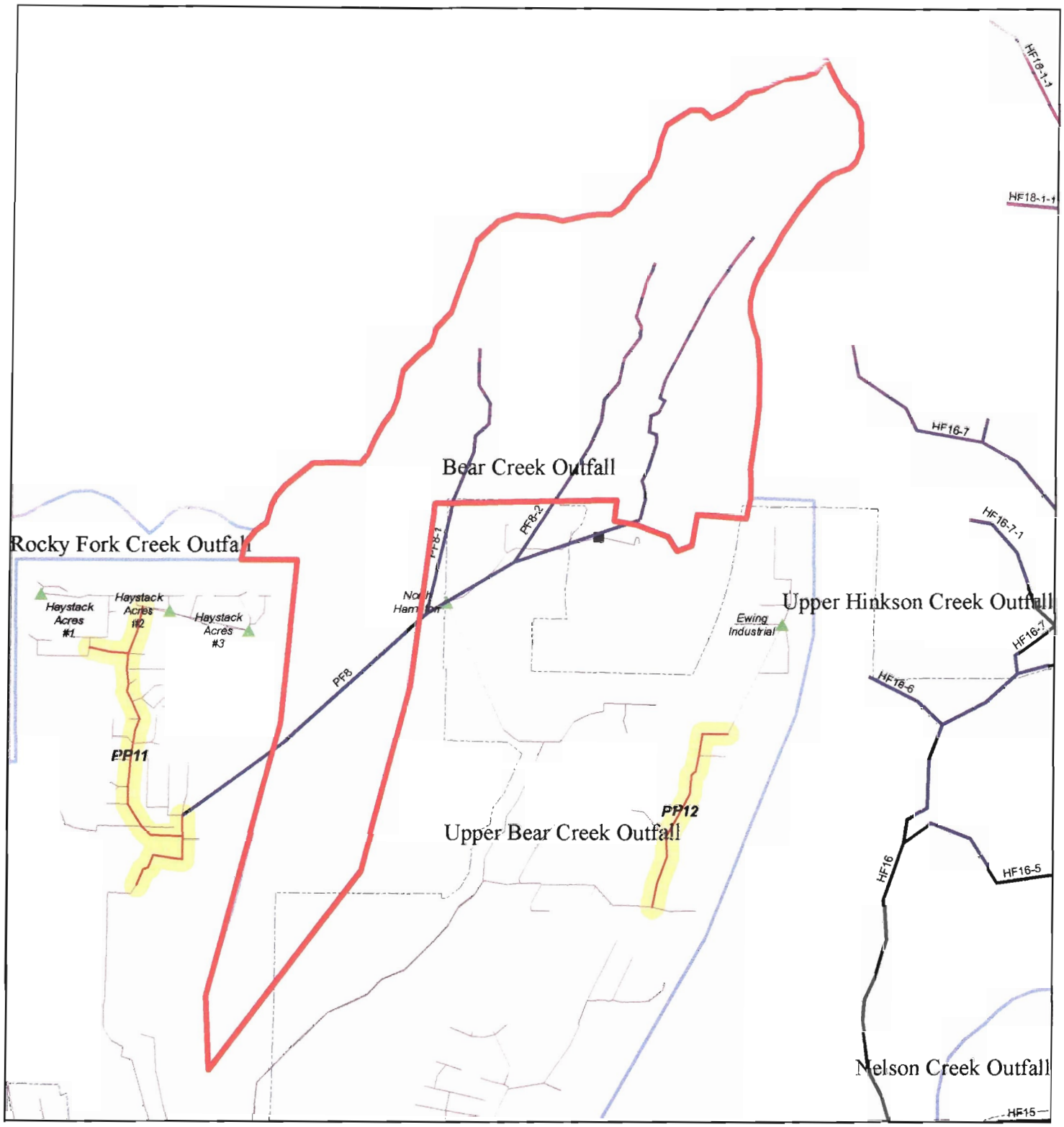
Manhole		Existing Diameter	Existing Slope	Existing Length	Capacity	2030Flow	%	Recommended Pipe	Estimated Avg. Pipe	Unit	Segment Total
US	DS	(inches)	(ft/ft)	(ft)	(MGD)	(MGD)	Used	Diameter	Depth	Cost	Cost
11B1	11B126	8	0.0210	6	1.13	0.84	74%	10	10	$84	$ 507
11B21	11B1	8	0.0040	189	0.50	0.60	120%	10	10	$84	$ 15,898
11B22	11B21	8	0.0040	232	0.50	0.59	120%	10	10	$84	$ 19,484
11B27	11B22	8	0.0040	305	0.50	0.55	112%	10	10	$84	$ 25,625
11B28	11B27	8	0.0040	188	0.50	0.55	111%	10	10	$84	$ 15,814
Project Length				3,139				Project Cost			$ 283,877
PROJECT PP16											
10C20	10C14	12	0.0084	358	2.12	2.81	132%	15	10	$103	$ 36,889
10C20A	10C20	12	0.0084	328	2.12	2.81	132%	15	10	$103	$ 33,795
10C21	10C20A	12	0.0083	284	2.10	2.75	131%	15	10	$103	$ 29,219
10C22	10C21	12	0.0089	85	2.18	2.74	126%	15	10	$103	$ 8,750
10D23	10C22	12	0.0086	241	2.14	2.67	125%	15	10	$103	$ 24,787
10D24	10D23	12	0.0134	344	2.68	2.66	99%	15	10	$103	$ 35,384
10D25	10D24	12	0.0063	359	1.84	2.57	140%	15	10	$103	$ 37,006
10D26	10D25	12	0.0066	299	1.88	2.45	130%	15	10	$103	$ 30,789
10D27	10D26	12	0.0067	379	1.89	2.43	128%	15	10	$103	$ 39,038
10D27A	10D27	12	0.0354	88	4.34	2.33	54%	15	10	$103	$ 9,083
10D28	10D27A	12	0.0352	199	4.33	2.30	53%	15	10	$103	$ 20,520
11A42	10D28	12	0.0050	248	1.64	2.29	140%	15	10	$103	$ 25,588
11A43	11A42	12	0.0048	259	1.61	2.31	144%	15	10	$103	$ 26,628
11A1	11A43	10	0.0308	91	2.49	2.30	92%	15	10	$103	$ 9,351
11A126	11A1	10	0.0025	18	0.71	2.30	325%	15	10	$103	$ 1,898
11A2	11A126	8	0.0040	379	0.50	1.94	391%	15	10	$103	$ 39,064
11A3	11A2	8	0.0040	323	0.50	1.94	391%	15	10	$103	$ 33,316
11A4	11A3	8	0.0040	68	0.50	0.99	200%	12	10	$94	$ 6,365
11A5	11A4	8	0.0040	402	0.50	0.69	138%	12	10	$94	$ 37,814
11A6	11A5	8	0.0040	399	0.50	0.68	138%	12	10	$94	$ 37,471
11A7	11A6	8	0.0040	401	0.50	0.67	136%	10	10	$84	$ 33,682
11A8	11A7	8	0.0040	132	0.50	0.66	133%	10	10	$84	$ 11,057
11A9	11A8	8	0.0040	186	0.50	0.66	132%	10	10	$84	$ 15,605
11A11	11A9	8	0.0040	191	0.50	0.55	111%	10	10	$84	$ 16,044
11A51	11A3	8	0.0040	234	0.50	0.94	190%	12	10	$94	$ 21,977
11A69	11A51	8	0.0040	169	0.50	0.93	188%	12	10	$94	$ 15,914
11A52	11A69	8	0.0040	62	0.50	0.77	156%	10	10	$84	$ 5,247
11A53	11A52	8	0.0040	176	0.50	0.77	155%	10	10	$84	$ 14,791
11A58	11A53	8	0.0040	223	0.50	0.68	138%	10	10	$84	$ 18,759

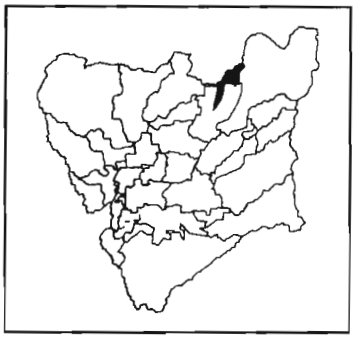
Appendix B
Relief Sewer Recommendations
10-Year 2030 Flow Rates

Manhole		Existing Diameter	Existing Slope	Existing Length	Capacity	2030Flow	%	Recommended Pipe	Estimated Avg. Pipe	Unit	Segment Total
US	DS	(inches)	(ft/ft)	(ft)	(MGD)	(MGD)	Used	Diameter	Depth	Cost	Cost
11A59	11A58	8	0.0040	163	0.50	0.55	111%	10	10	$84	$ 13,656
11A60	11A59	8	0.0040	123	0.50	0.55	111%	10	10	$84	$ 10,366
11A61	11A60	8	0.0040	223	0.50	0.55	110%	10	10	$84	$ 18,725
11A80	11A61	8	0.0040	190	0.50	0.54	110%	10	10	$84	$ 15,967
11A81	11A80	8	0.0040	277	0.50	0.55	111%	10	10	$84	$ 23,282
11A83	11A81	8	0.0040	106	0.50	0.53	108%	10	10	$84	$ 8,924
Project Length				8,008				Project Cost			$ 766,751
PROJECT PP17											
10G18	10C50	10	0.0094	256	1.38	1.83	133%	12	7	$94	$ 24,085
10G17	10G18	10	0.0201	240	2.01	1.86	92%	12	8	$94	$ 22,551
10G16	10G17	8	0.0280	216	1.31	1.75	134%	12	10	$94	$ 20,295
10H62	10G16	8	0.0454	211	1.67	1.74	104%	12	10	$94	$ 19,818
10D1A	10H62	8	0.0855	68	2.29	1.73	75%	12	6	$94	$ 6,379
10H1	10D1A	8	0.0093	195	0.76	1.39	184%	12	10	$94	$ 18,356
10H2	10H1	8	0.0040	131	0.50	1.34	271%	12	10	$94	$ 12,274
10H3	10H2	8	0.0040	107	0.50	1.33	269%	12	10	$94	$ 10,044
10H4	10H3	8	0.0040	277	0.50	1.35	272%	12	10	$94	$ 26,069
10H5	10H4	8	0.0040	156	0.50	1.33	268%	12	10	$94	$ 14,664
10H21A	10H5	8	0.0070	230	0.65	0.65	100%	10	16	$102	$ 23,358
10H22	10H21A	8	0.0065	353	0.63	0.64	101%	10	20	$102	$ 35,829
10H6	10H5	8	0.0040	249	0.50	0.64	129%	10	10	$84	$ 20,900
Project Length				2,688				Project Cost			$ 254,622
PROJECT PP18											
10E4	10E8	24	0.0025	512	7.30	7.37	101%	30	26	$226	$ 115,860
10E1	10E4	24	0.0036	97	8.82	7.37	84%	30	10	$170	$ 16,451
10E2	10E1	24	0.0100	150	14.68	7.37	50%	30	22	$226	$ 33,867
10E3	10E2	24	0.0035	363	8.63	7.38	85%	30	10	$170	$ 61,794
10B43	10E3	24	0.0022	387	6.83	7.43	109%	30	10	$170	$ 65,728
10B1	10B43	24	0.0021	406	6.67	7.45	112%	30	10	$170	$ 69,095
10B2	10B1	24	0.0020	397	6.58	7.47	114%	30	10	$170	$ 67,530
10B3	10B2	24	0.0020	437	6.58	7.51	114%	30	10	$170	$ 74,351

Appendix B
Relief Sewer Recommendations
10-Year 2030 Flow Rates

Manhole		Existing Diameter	Existing Slope	Existing Length	Capacity	2030Flow	%	Recommended Pipe	Estimated Avg. Pipe	Unit	Segment Total
US	DS	(inches)	(ft/ft)	(ft)	(MGD)	(MGD)	Used	Diameter	Depth	Cost	Cost
10B3A	10B3	24	0.0115	182	15.74	7.51	48%	30	15	$206	$ 37,499
10B4	10B3A	24	-0.0052	211	#NUM!	7.53	#NUM!	30	16	$206	$ 43,304
10B4A	10B4	24	0.0017	231	6.11	7.55	124%	30	10	$170	$ 39,212
10B5	10B4A	24	0.0021	202	6.69	7.56	113%	30	10	$170	$ 34,298
10B6	10B5	24	0.0020	232	6.53	7.59	116%	30	10	$170	$ 39,391
10B7	10B6	24	0.0020	202	6.53	7.61	117%	30	10	$170	$ 34,311
10B7A	10B7	21	0.0009	138	3.12	6.23	200%	30	11	$187	$ 25,774
10B8	10B7A	21	0.0026	88	5.21	6.20	119%	30	9	$170	$ 14,911
10B9	10B8	21	0.0016	485	4.09	6.20	151%	30	10	$170	$ 82,523
10C8	10B9	21	0.0014	395	3.87	6.21	161%	30	10	$170	$ 67,107
10C9	10C8	21	0.0014	221	3.91	6.23	160%	30	10	$170	$ 37,569
10C173	10C9	21	0.0027	306	5.38	6.25	116%	30	13	$187	$ 57,280
10C10	10C173	21	-0.0020	96	#NUM!	6.23	#NUM!	30	12	$187	$ 17,933
10C11	10C10	21	0.0014	304	3.86	6.24	161%	30	10	$170	$ 51,640
10C165	10C11	12	0.0048	201	1.60	1.74	109%	15	10	$103	$ 20,660
10C54	10C165	12	0.0042	271	1.50	1.76	117%	15	9	$103	$ 27,887
10C53	10C54	12	0.0037	281	1.40	1.77	126%	15	10	$103	$ 28,938
10E7	10E8	60	0.0040	606	106.28	110.02	104%	84	37	$505	$ 306,049
10E6	10E7	60	0.0002	513	24.72	110.64	448%	84	31	$505	$ 259,241
10E5	10E6	60	0.0014	526	62.48	111.08	178%	84	32	$505	$ 265,672
10A41	10E5	60	0.0013	713	60.97	111.35	183%	84	32	$505	$ 360,308
10A40	10A41	60	0.0013	696	61.73	111.40	180%	84	30	$459	$ 319,580
10A39	10A40	60	0.0010	604	53.24	95.98	180%	84	29	$459	$ 277,169
10A38	10A39	60	0.0010	533	53.27	97.06	182%	84	30	$459	$ 244,602
Project Length				10,984				Project Cost			$ 3,197,531
Total Length								Total Cost			$ 59,142,880





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Bear Creek Outfall

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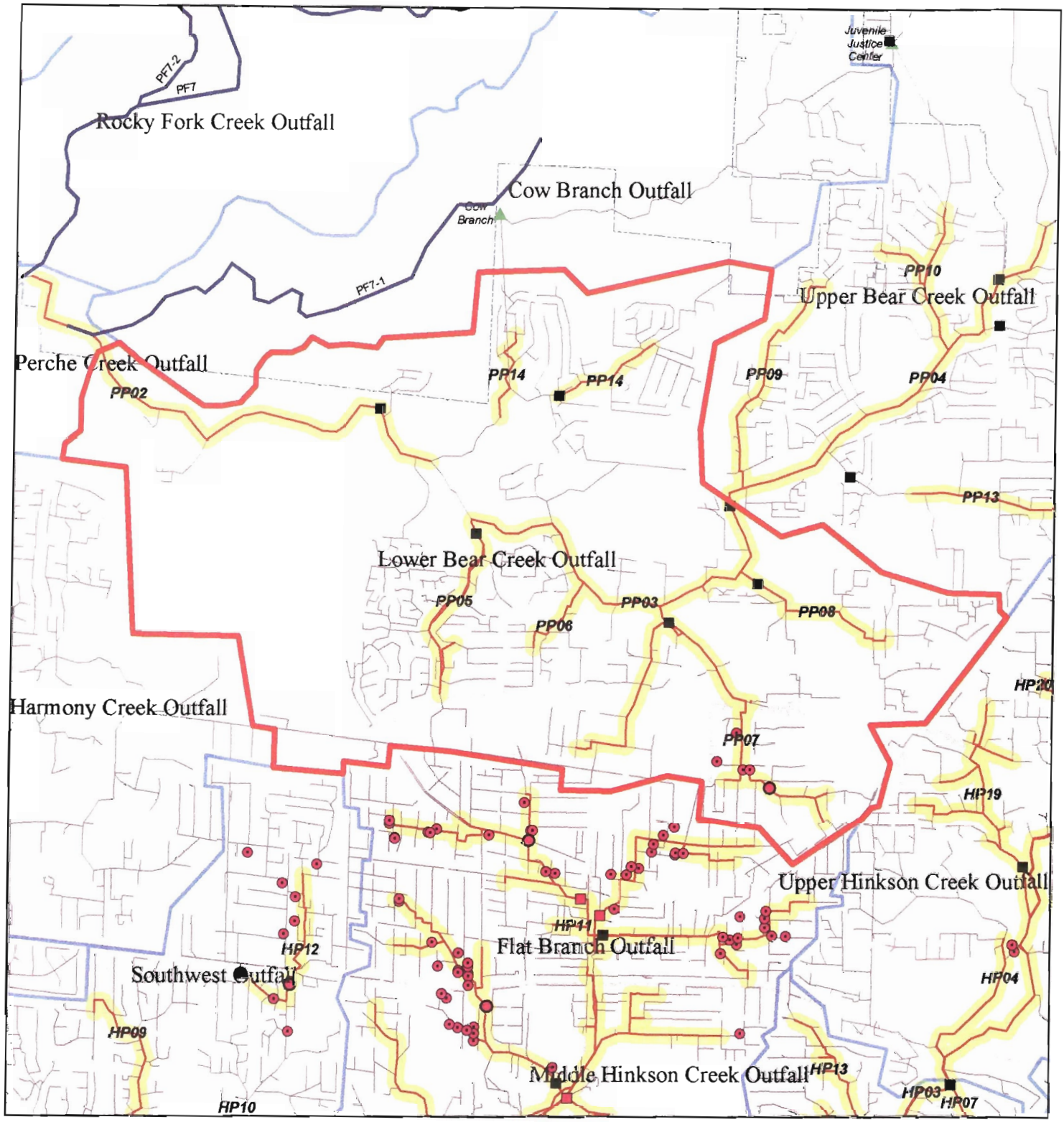

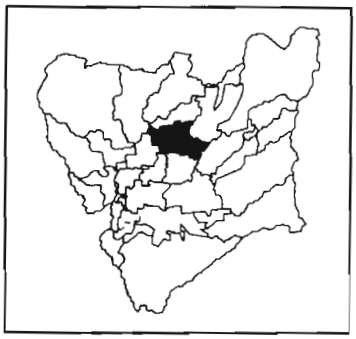

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Wastewater System
Facilities Planning Report

Lower Bear Creek Outfall

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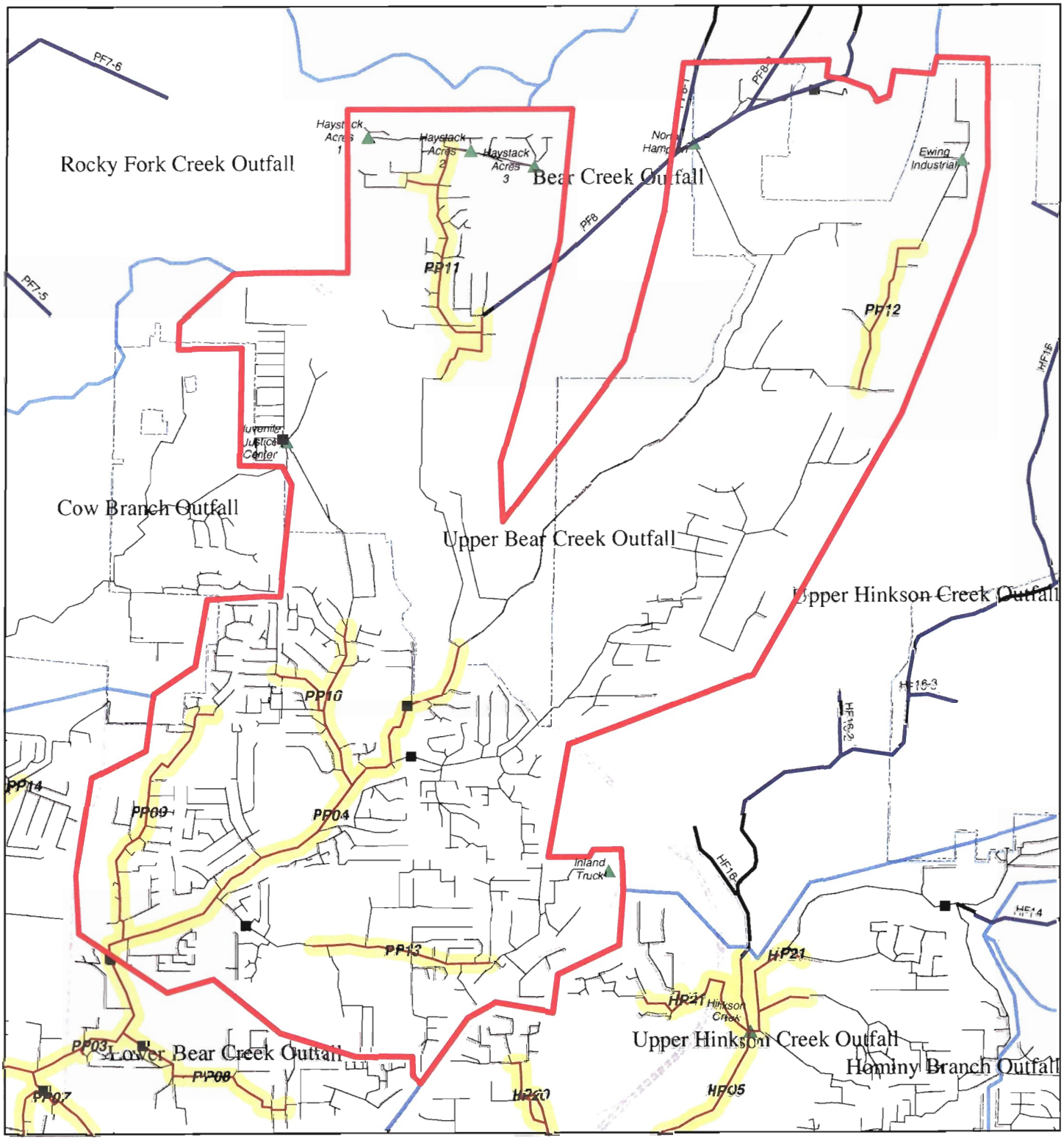

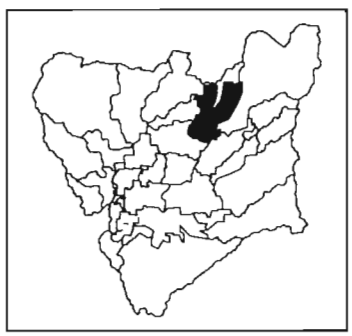

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Wastewater System
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Upper Bear Creek Outfall

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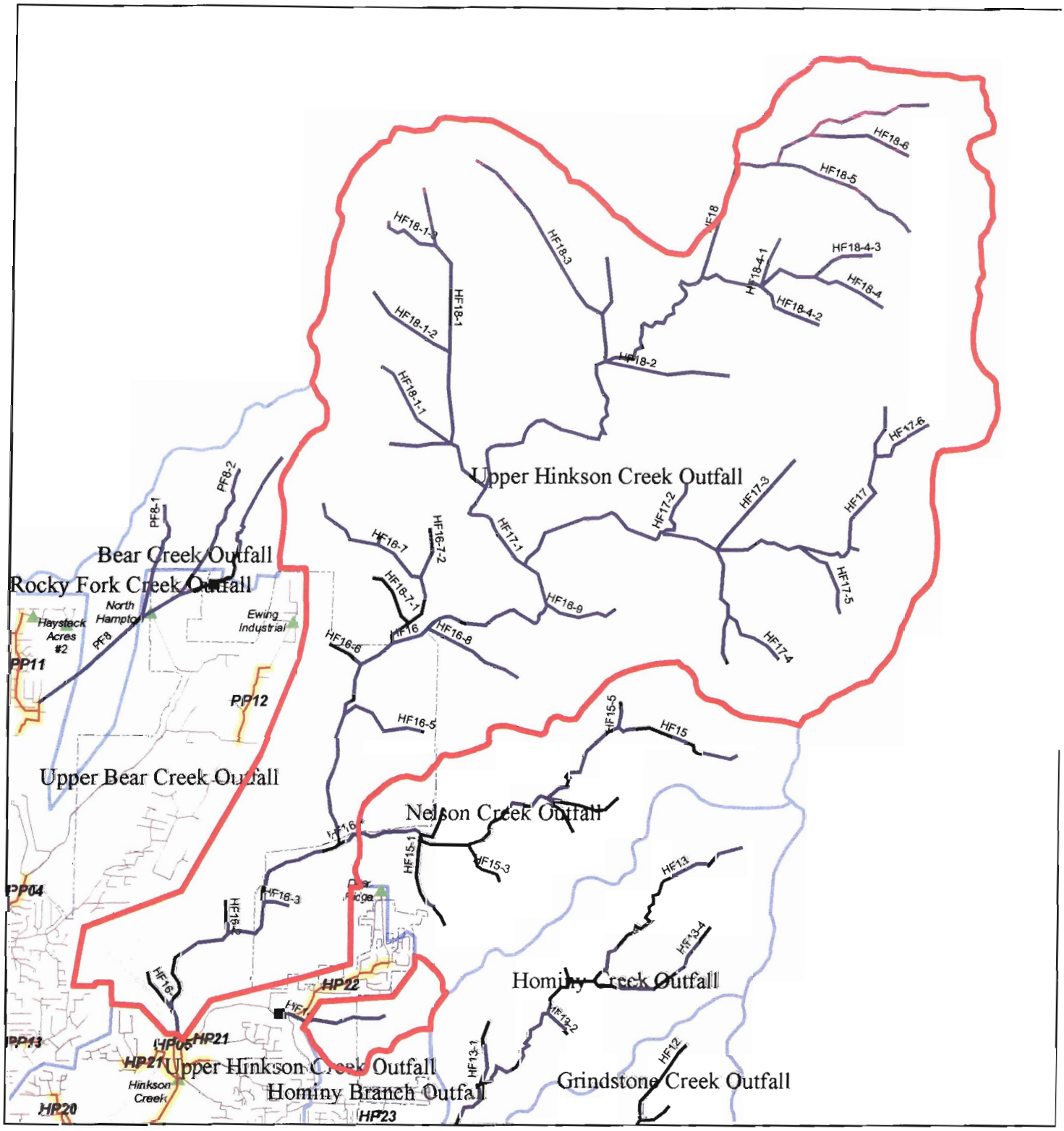

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Upper Bear Creek Outfall

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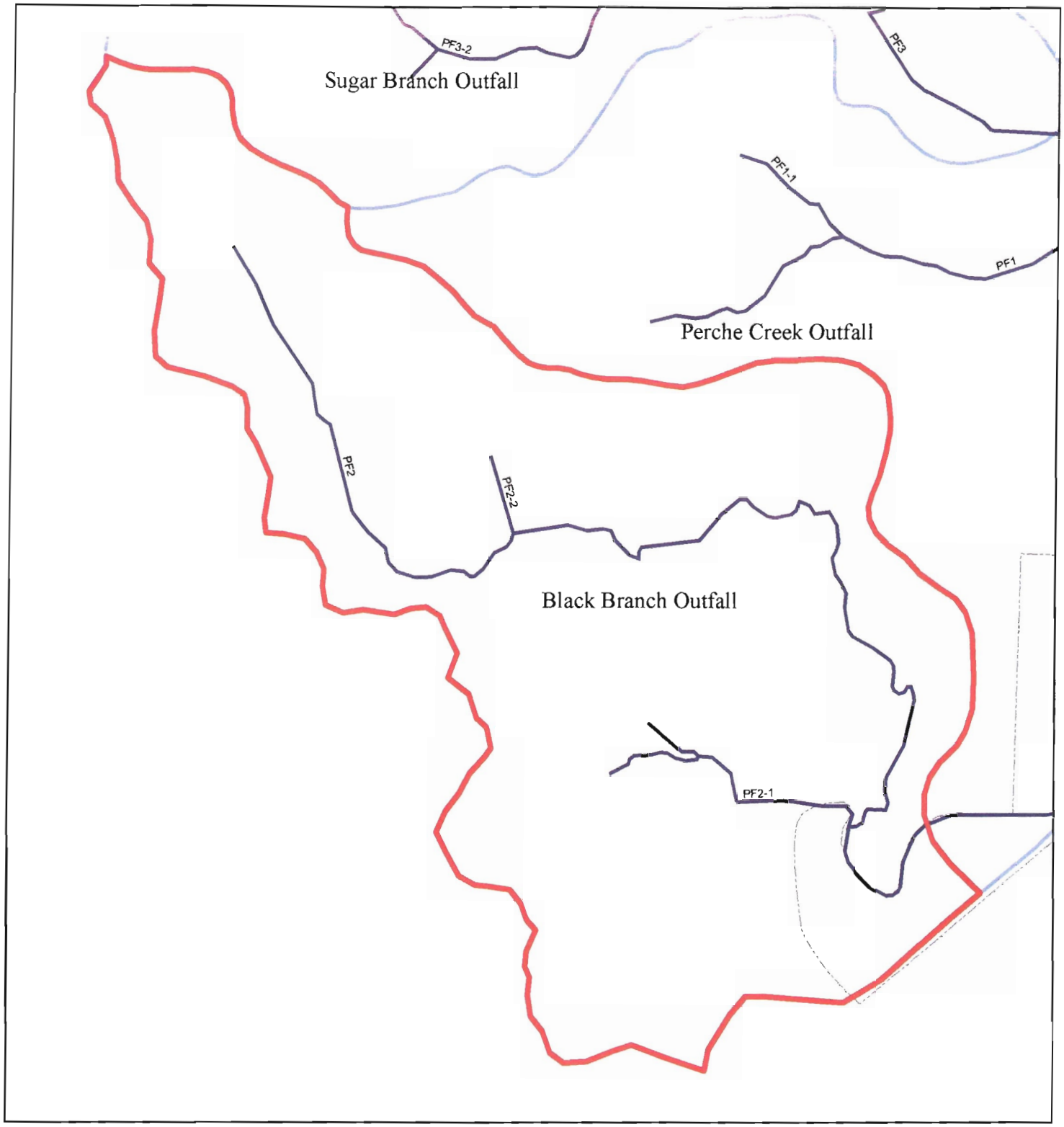

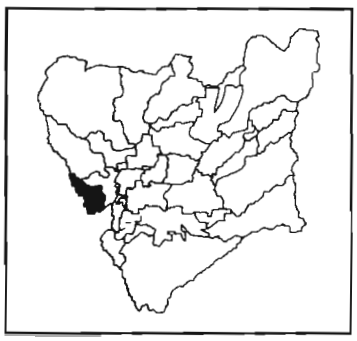

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Wastewater System
Facilities Planning Report

Black Branch Outfall

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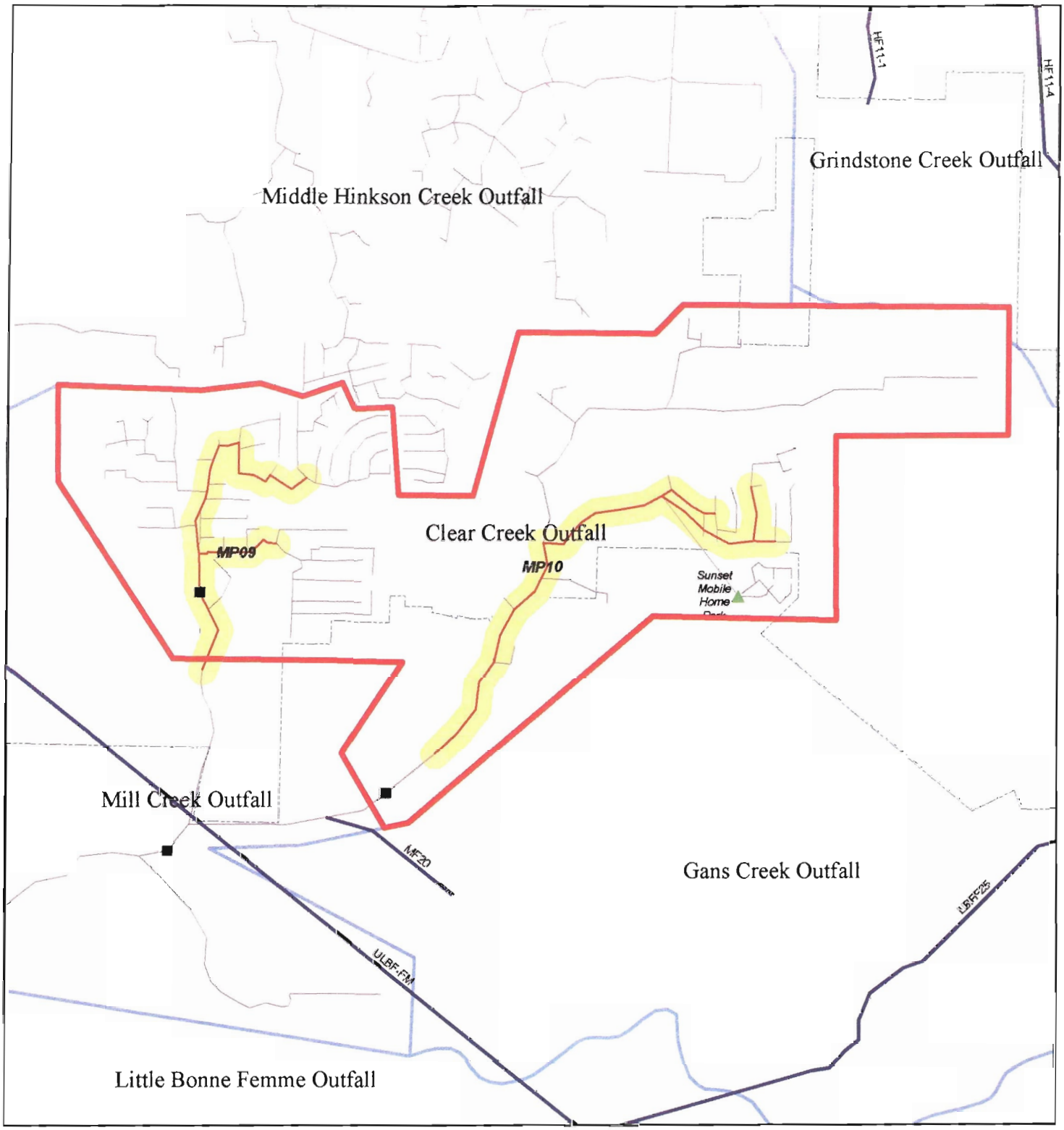

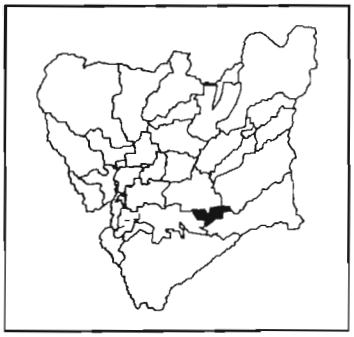

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Clear Creek Outfall

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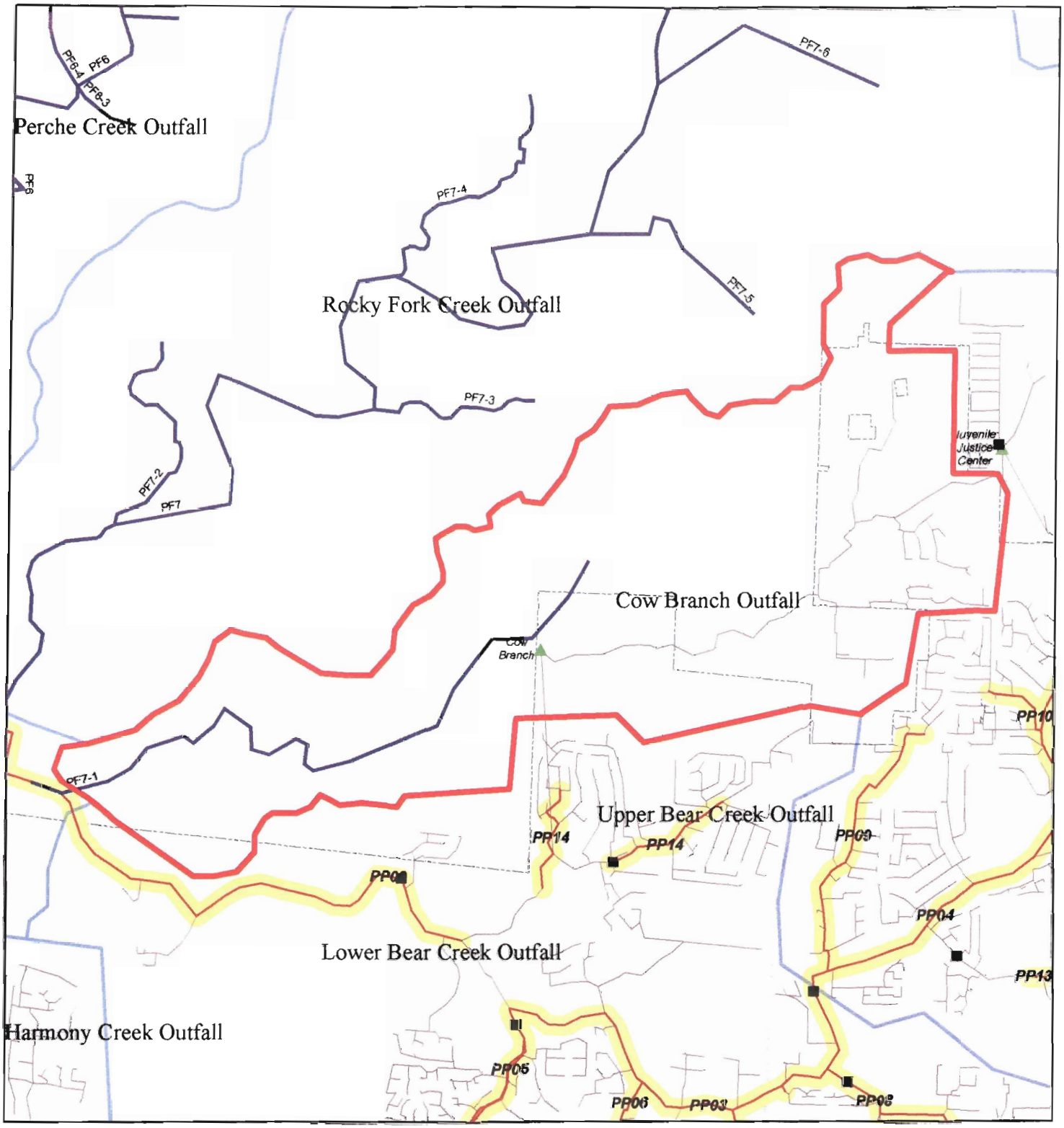

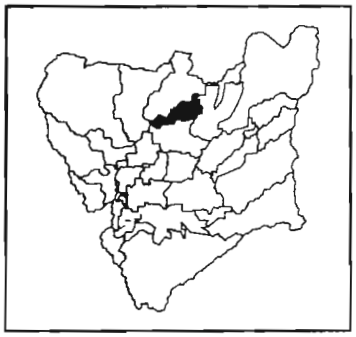

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Cow Branch Outfall

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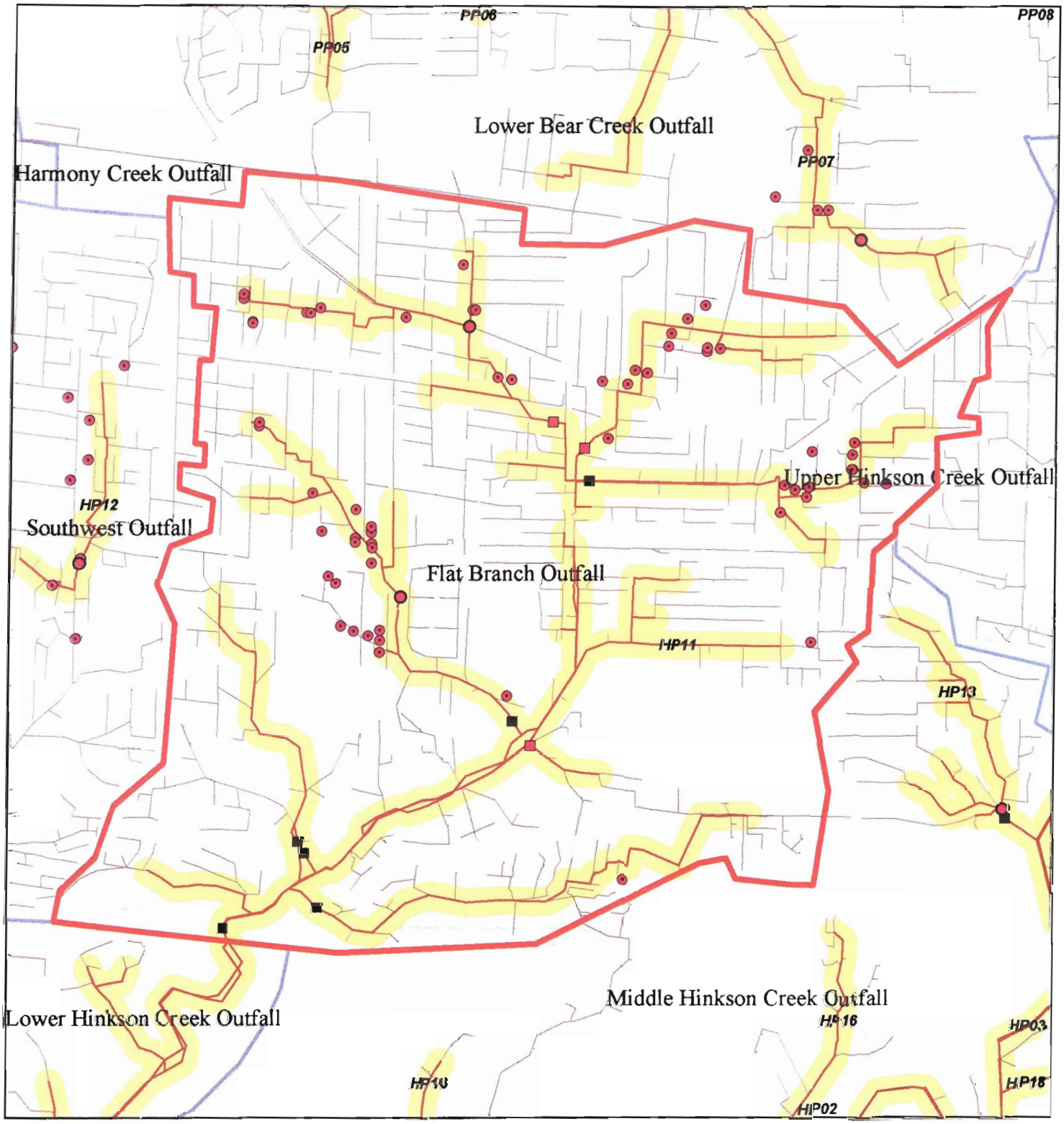

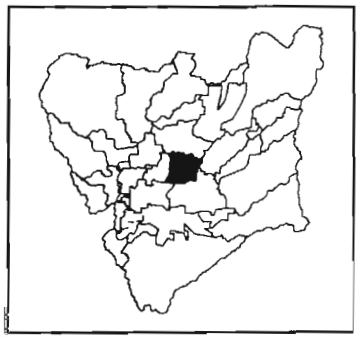

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Flat Branch Outfall

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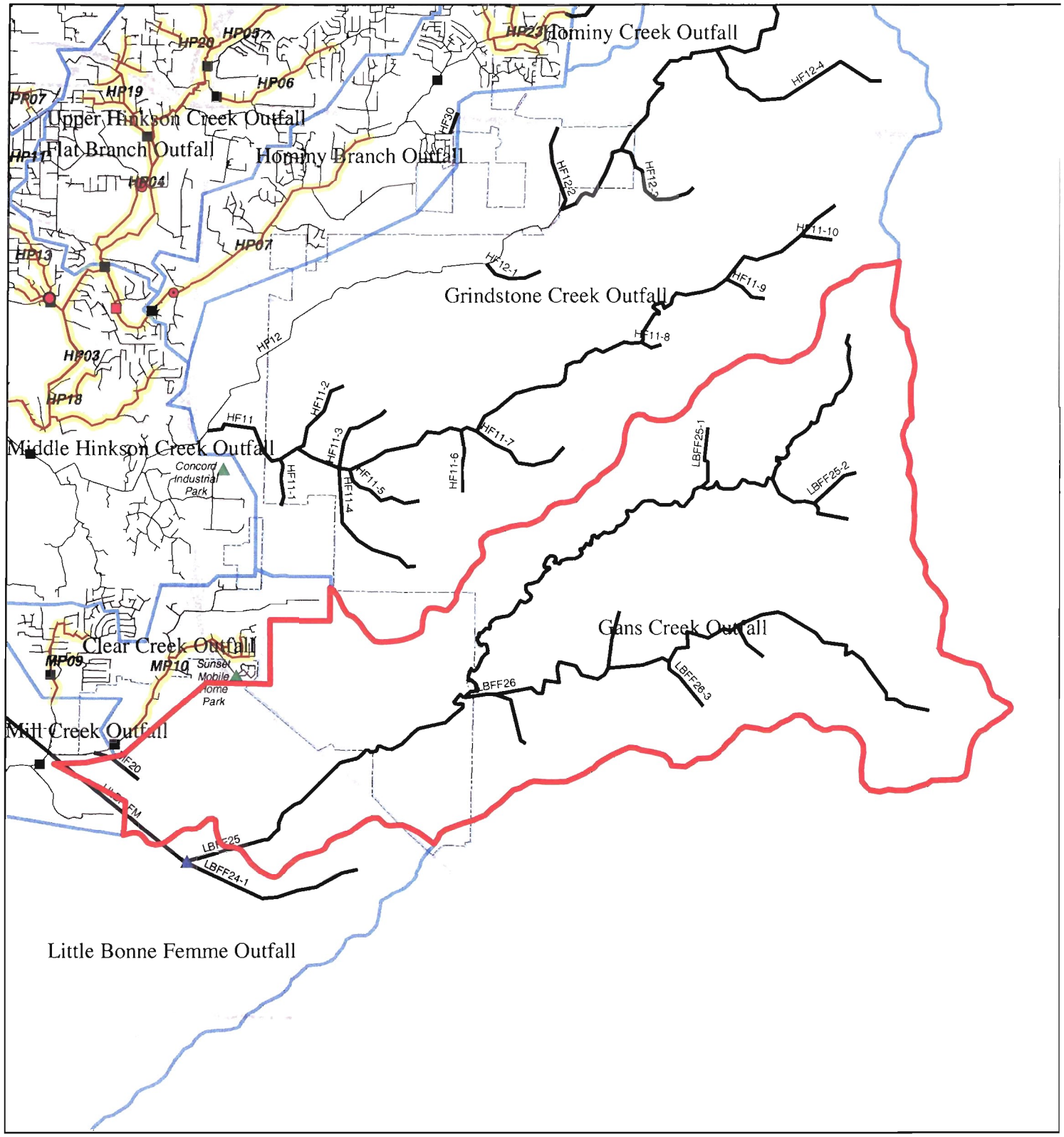

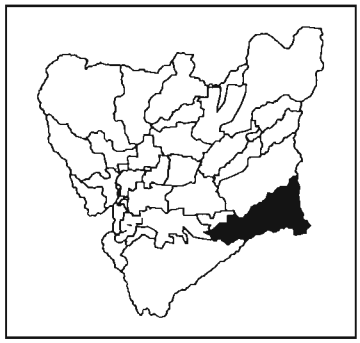

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Gans Creek Outfall

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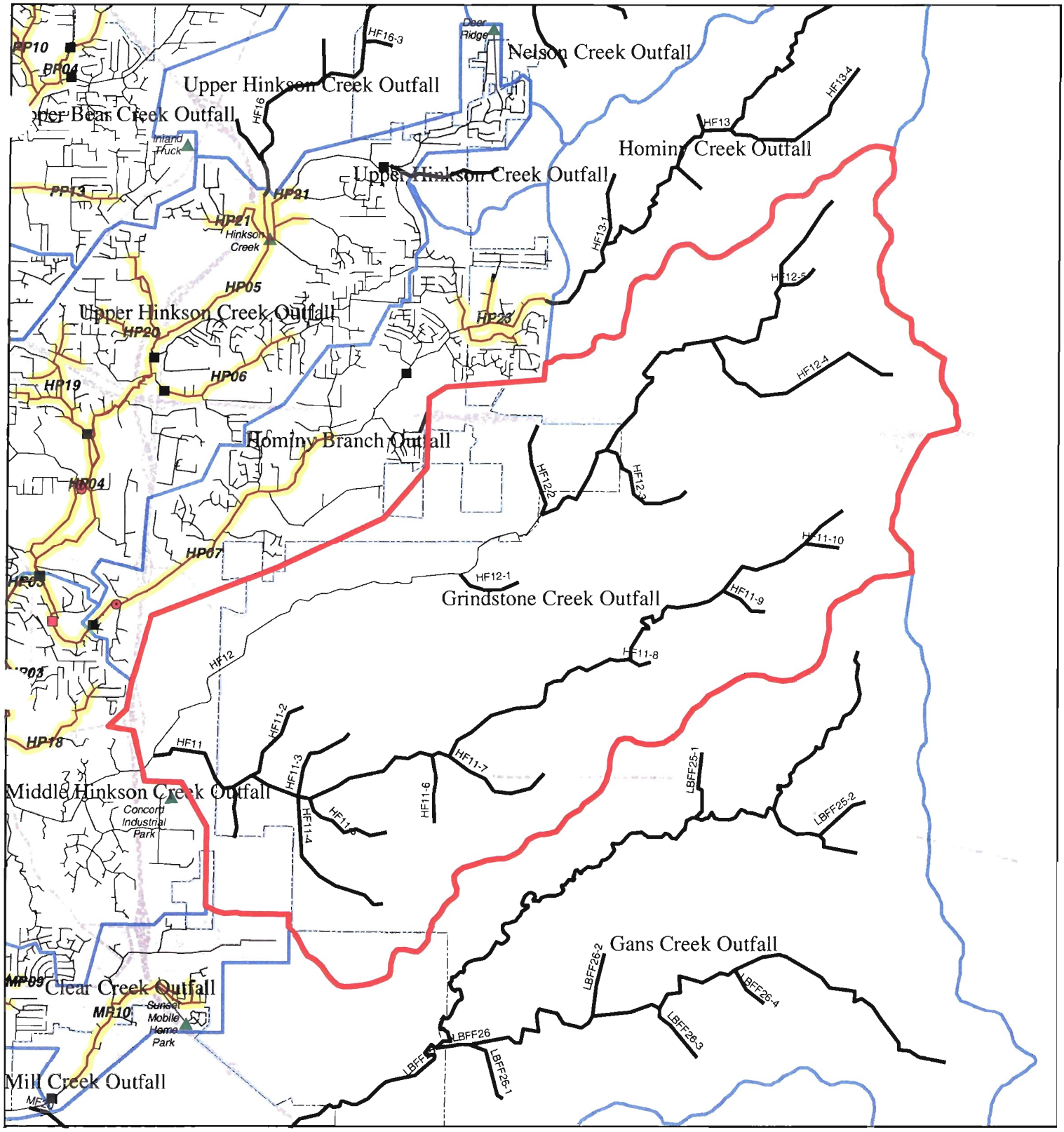

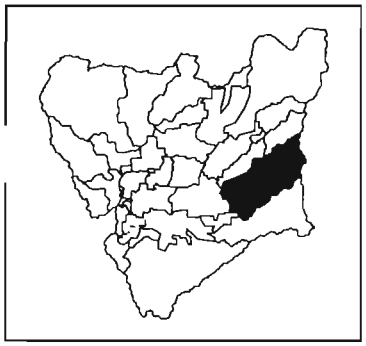

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City of Columbia
Wastewater System
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Grindstone Creek Outfall

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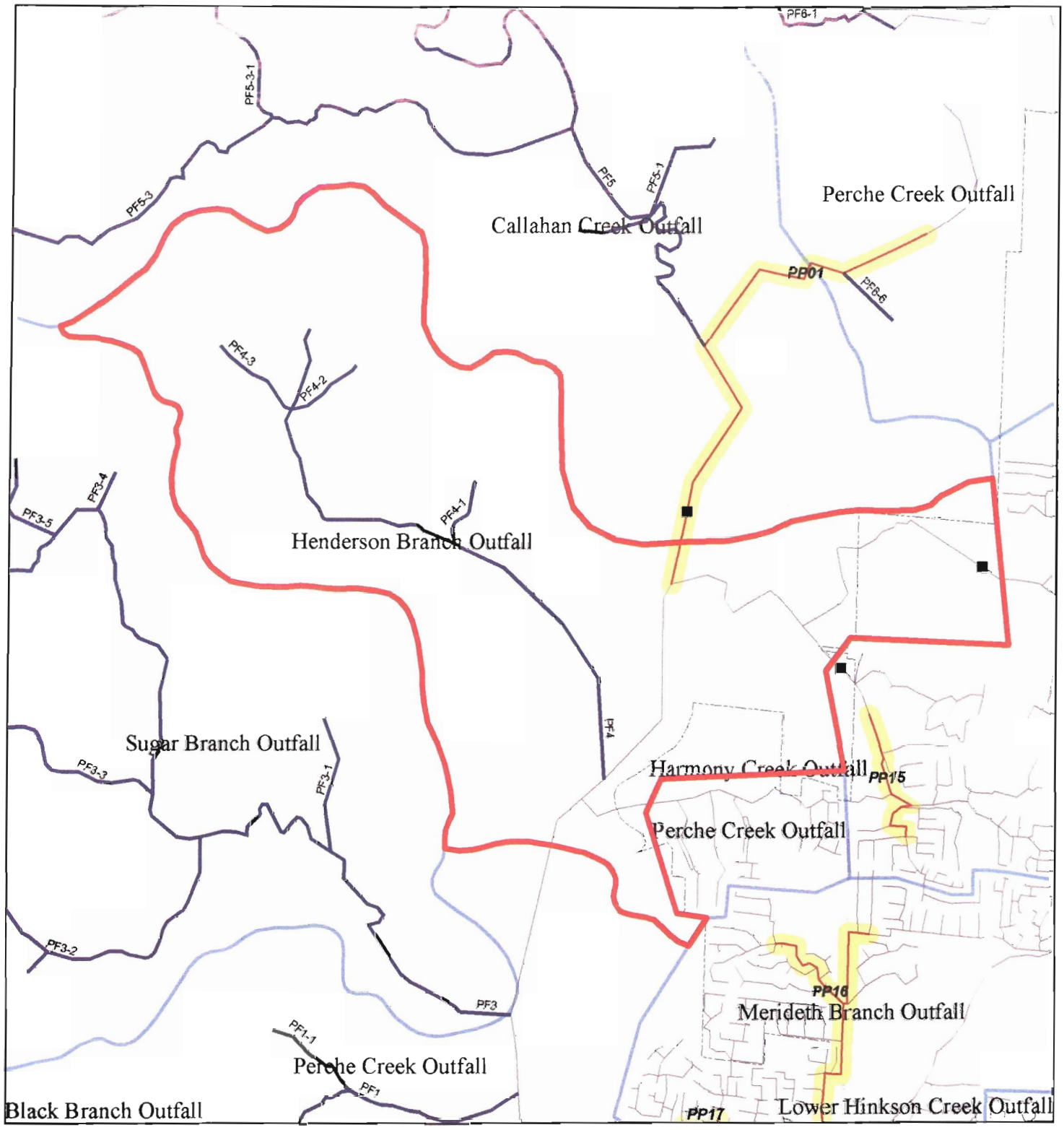

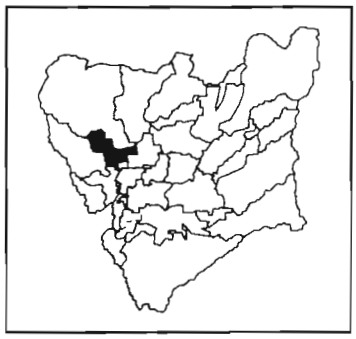

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Wastewater System
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Henderson Branch Outfall

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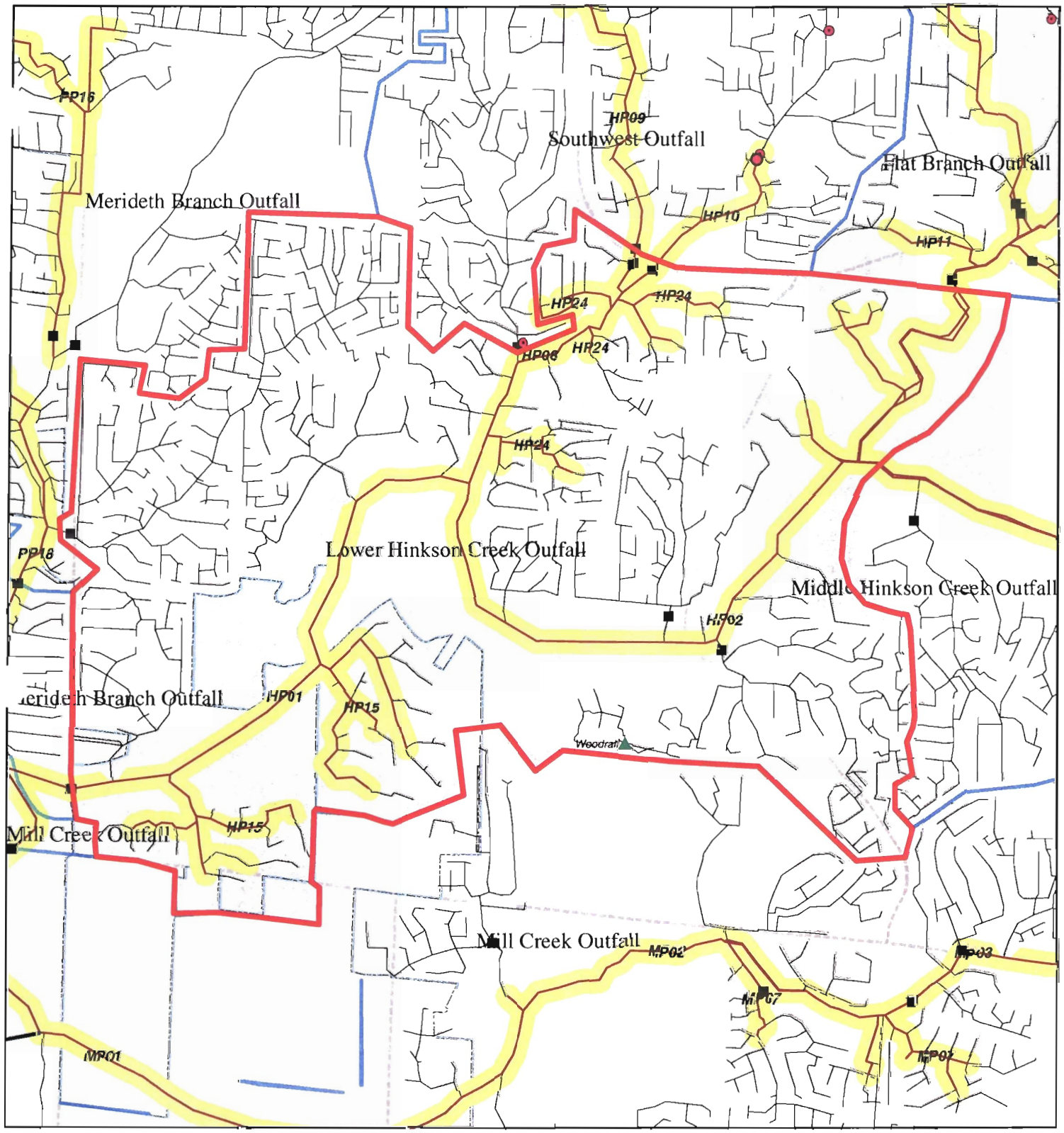

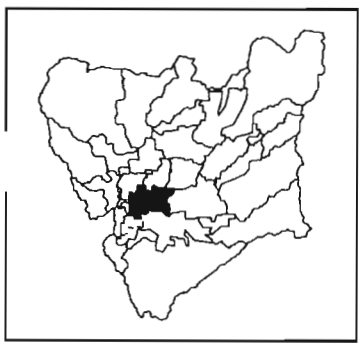

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City of Columbia
Wastewater System
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Lower Hinkson Creek Outfall

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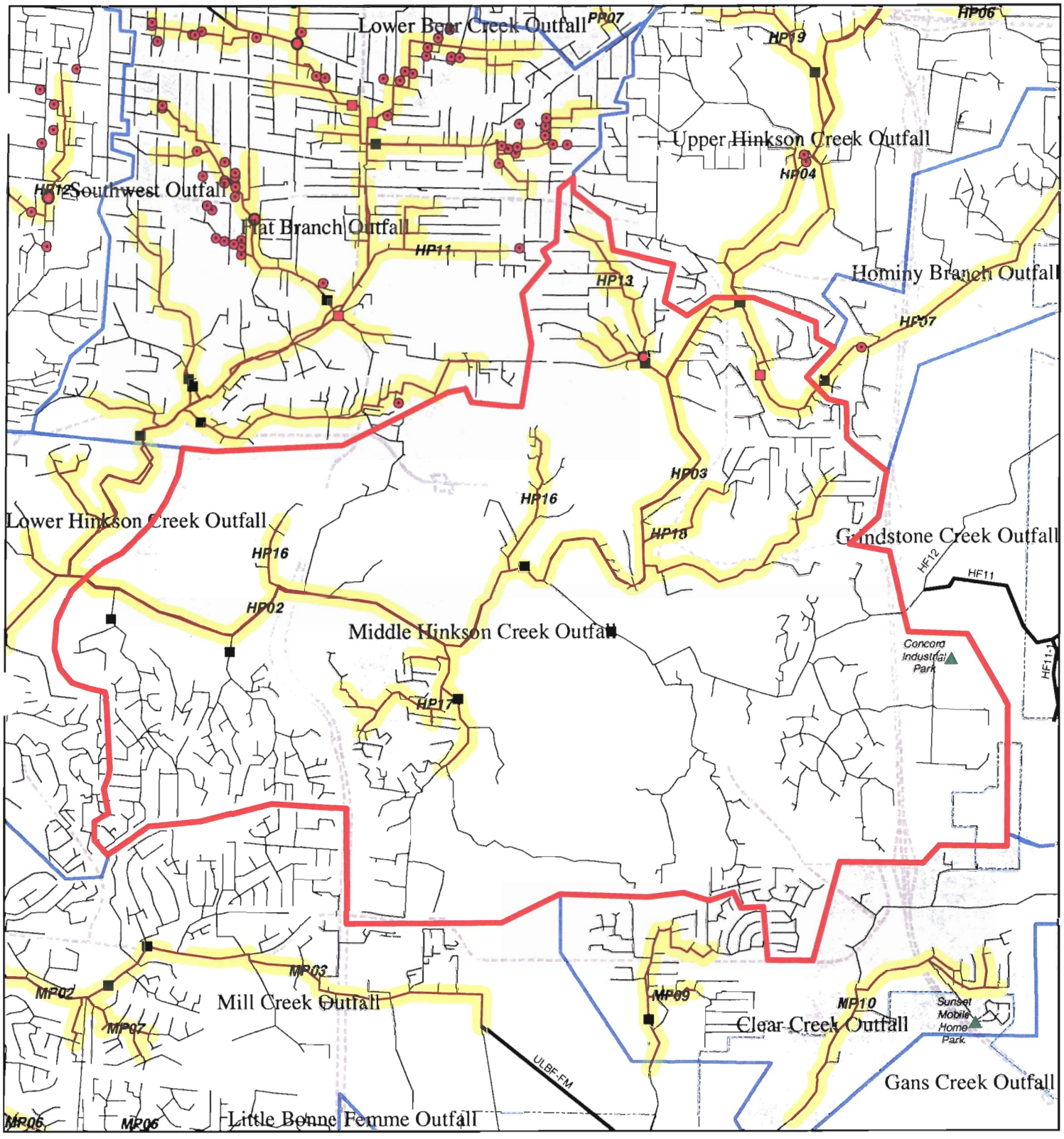

— Existing Sewer System
▲ Existing Pump Stations
Potential Relief Projects
— Potential Relief Sewers
▬ Future Gorwth Interceptors
▲ Future Pump Stations
■ Flow Meters
■ Flow Meters (Surcharged)
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● Manhole Overflows
Flow Basins with Excessive I/I
— City Limits

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Wastewater System
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Middle Hinkson Creek Outfall

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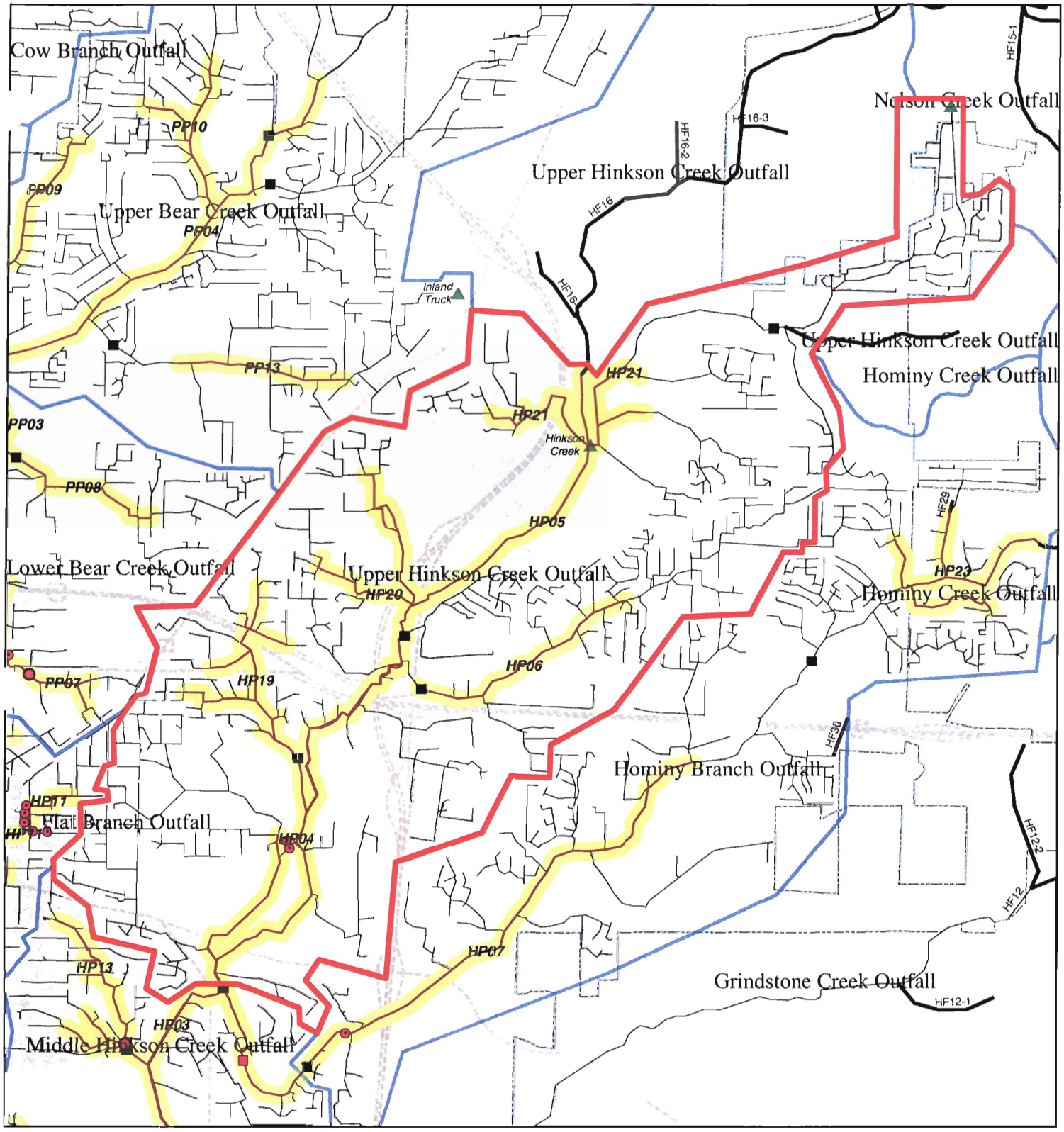

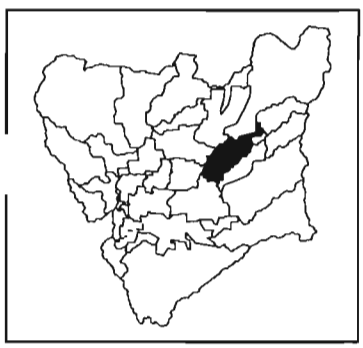

— Existing Sewer System
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Potential Relief Projects
— Potential Relief Sewers
— Future Growth Interceptors
▲ Future Pump Stations
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■ Flow Meters (Surcharged)
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Wastewater System
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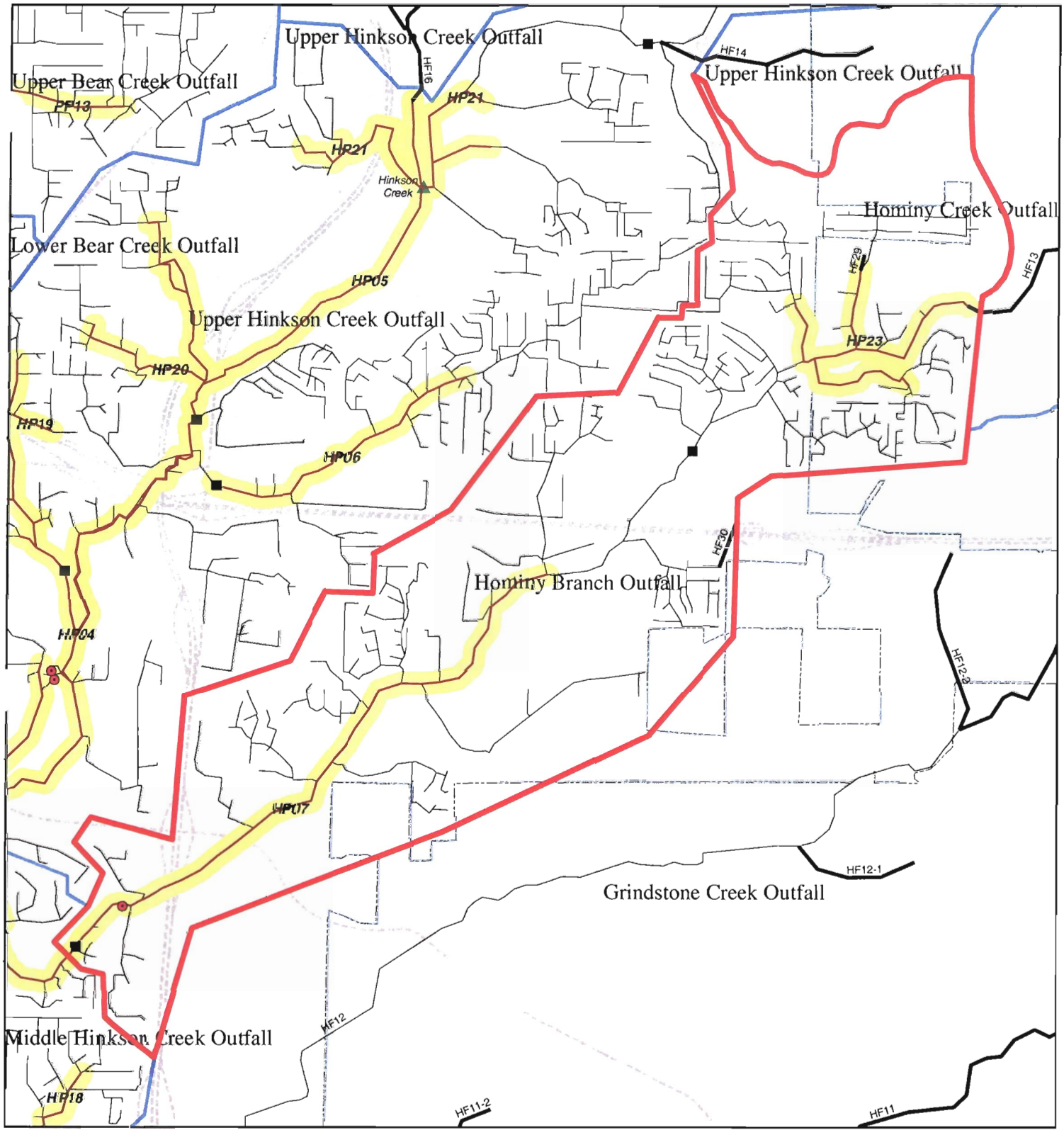
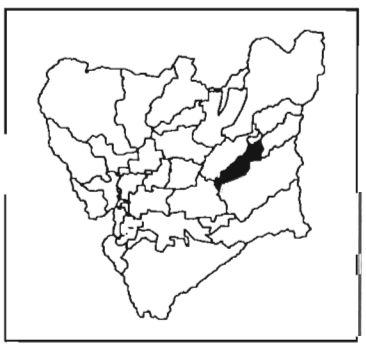
Upper Hinkson Creek Outfall

prepared by Black & Veatch in association with GBA



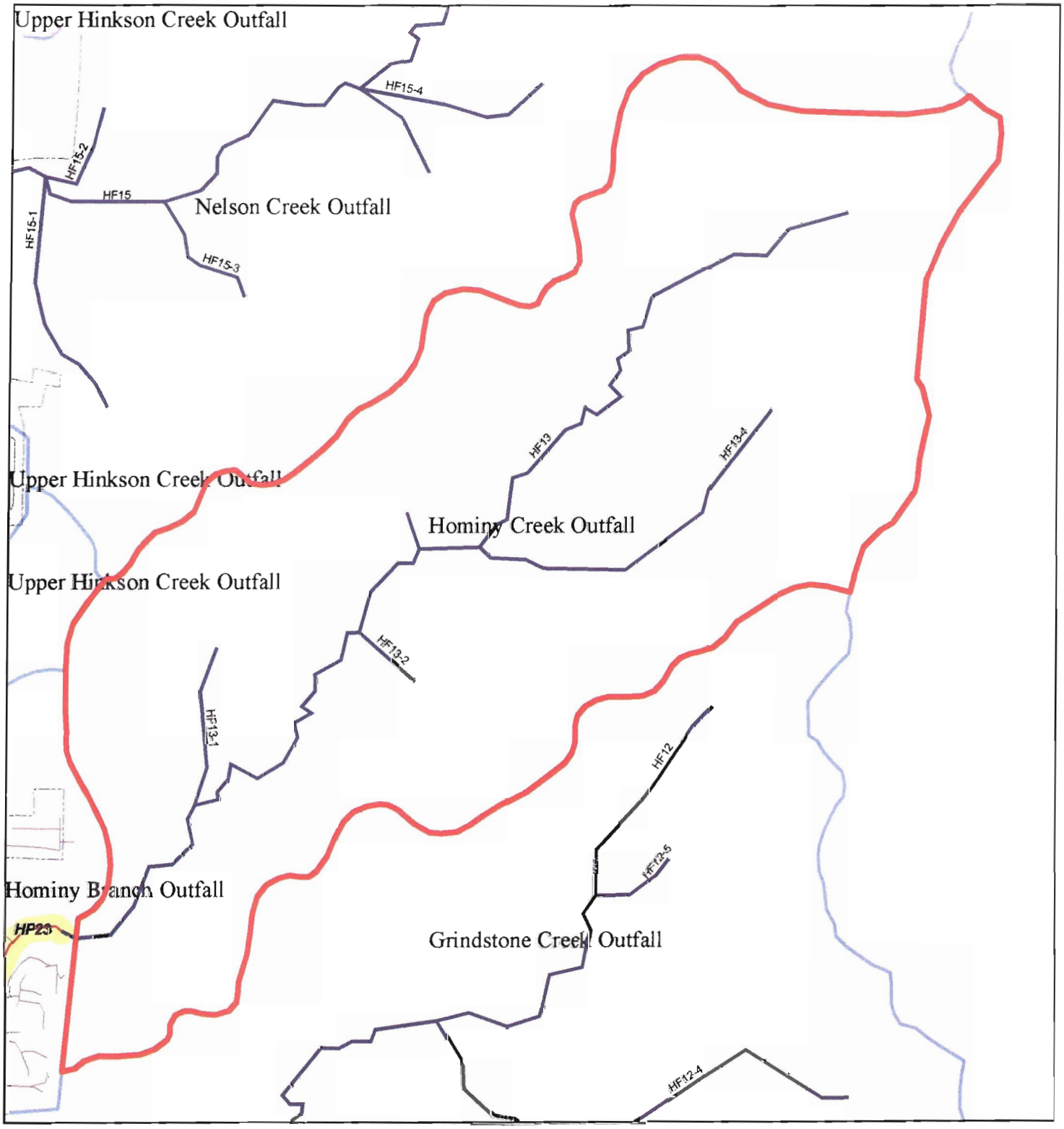


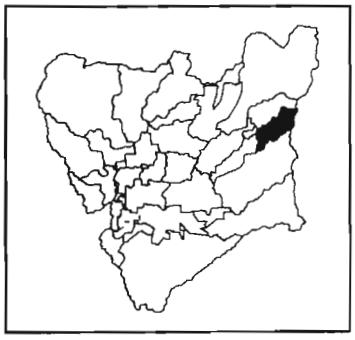
- Existing Sewer System
- Existing Pump Stations
- Potential Relief Projects
- Potential Relief Sewers
- Future Growth Interceptors
- Future Pump Stations
- Flow Meters
- Flow Meters (Surcharged)
- Basement Backups
- Manhole Overflows
- Flow Basins with Excessive I/I
- City Limits

City of Columbia
Wastewater System
Facilities Planning Report

Hominy Branch Outfall

prepared by Black & Veatch in association with GBA





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Wastewater System
Facilities Planning Report

Hominy Creek Outfall

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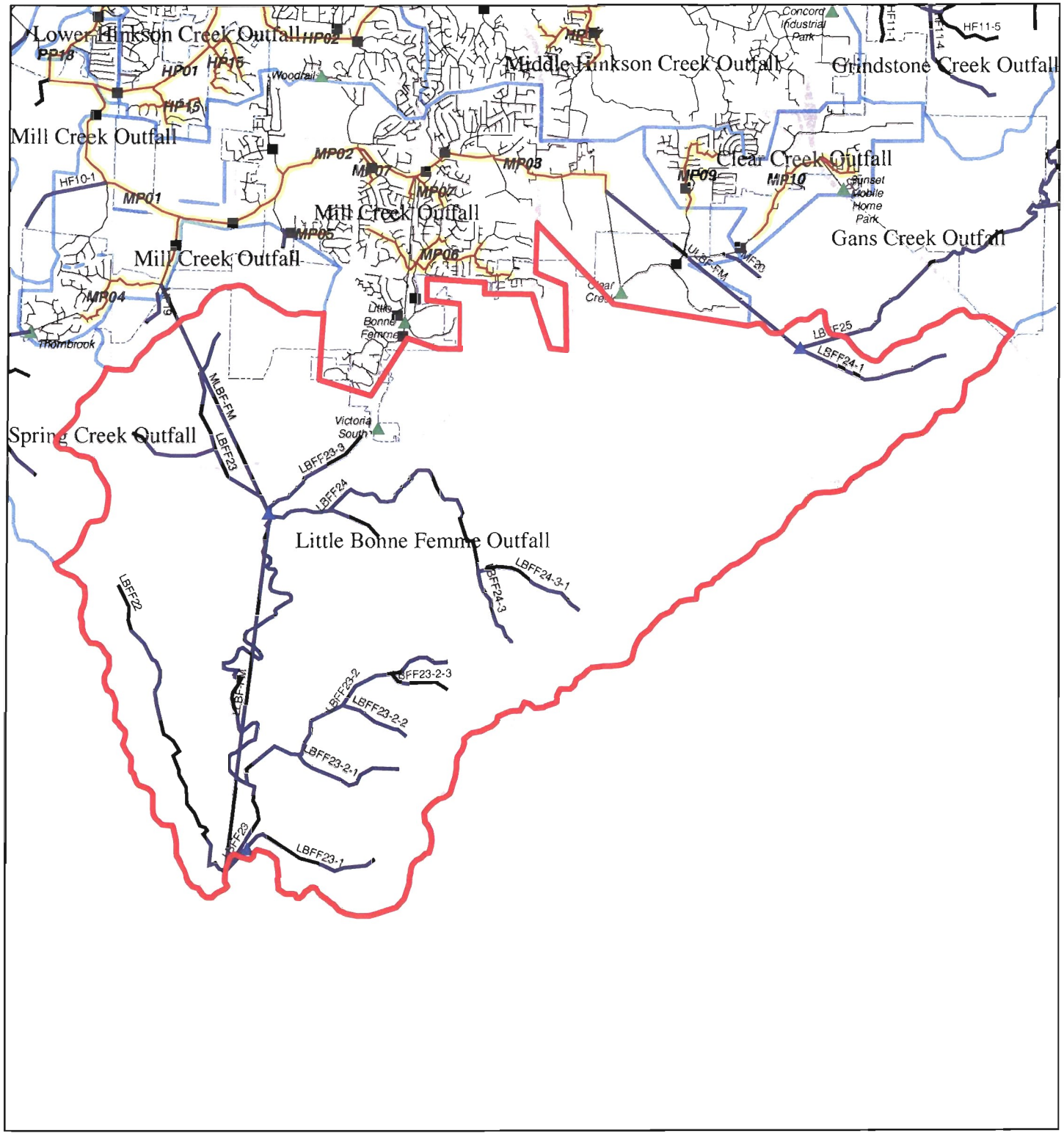

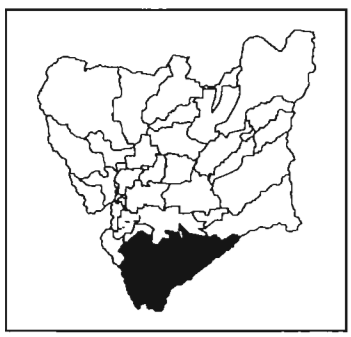

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City of Columbia
Wastewater System
Facilities Planning Report

Little Bonne Femme Outfall

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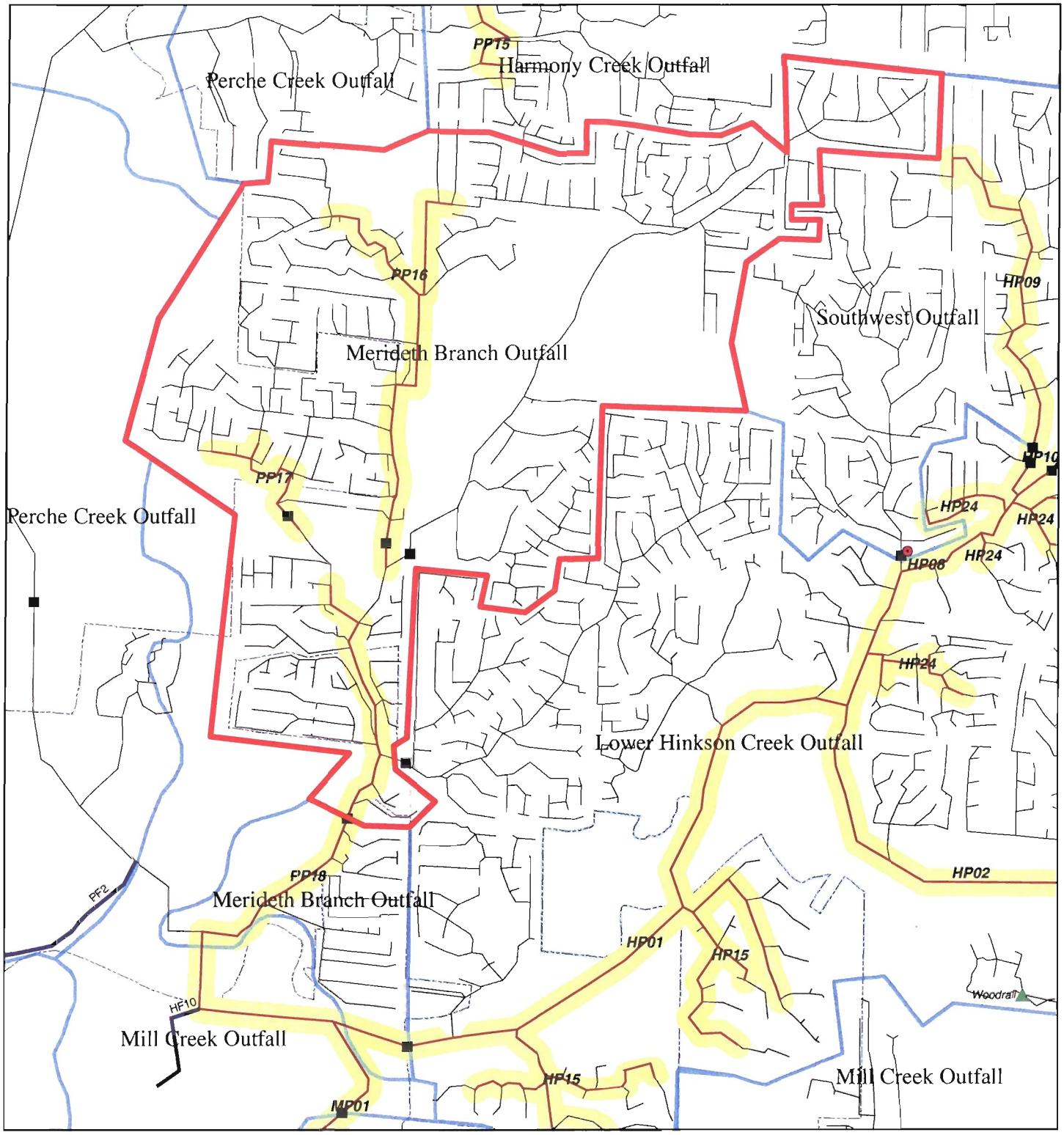

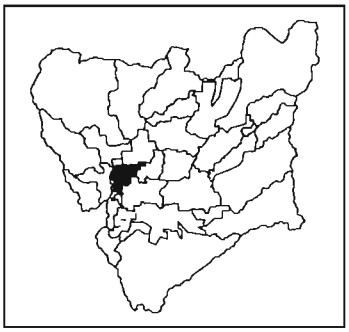

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- City Limits

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Wastewater System
Facilities Planning Report

Merideth Branch Outfall

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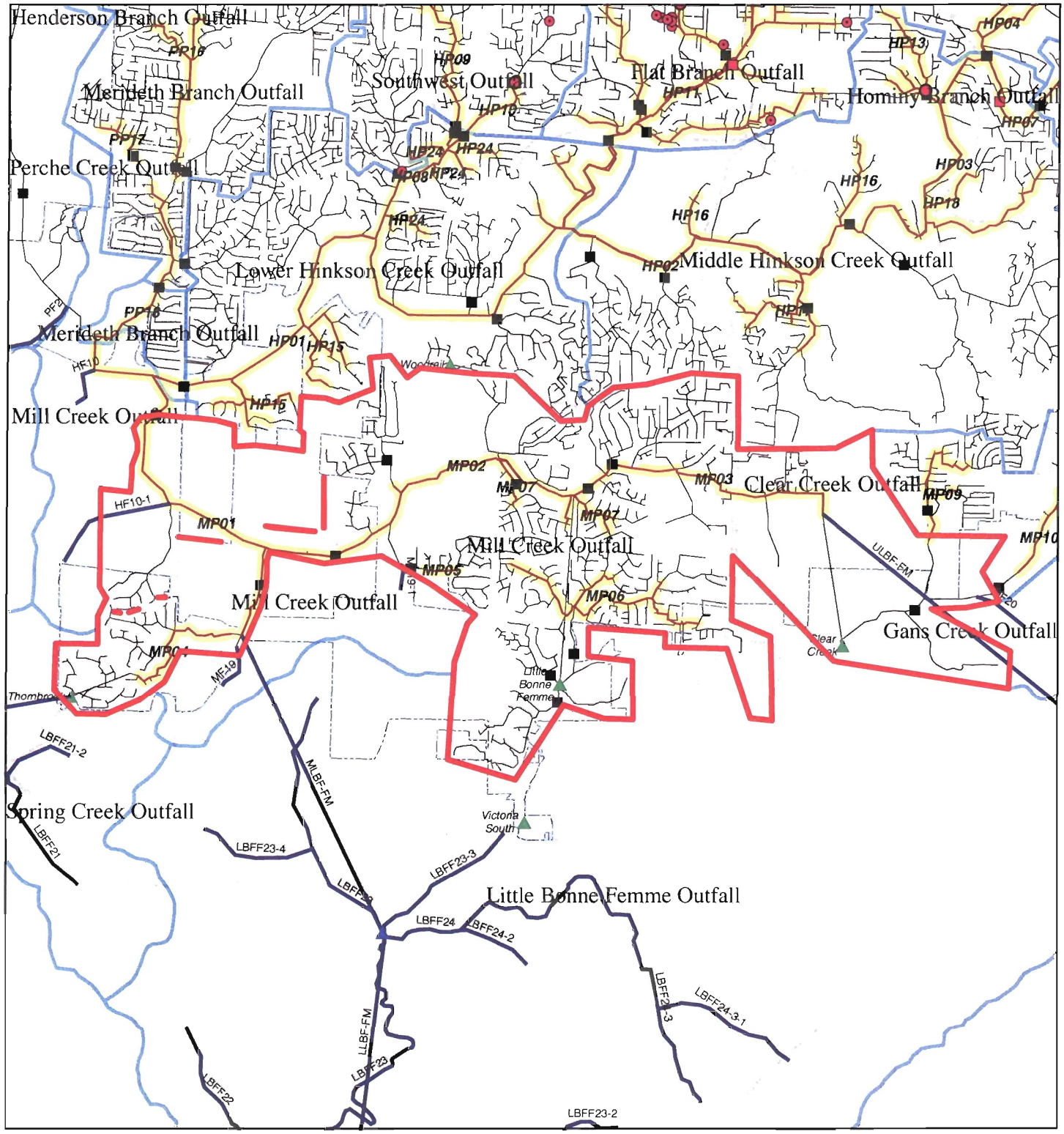

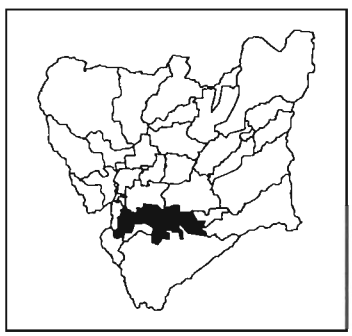

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City of Columbia
Wastewater System
Facilities Planning Report

Mill Creek Outfall

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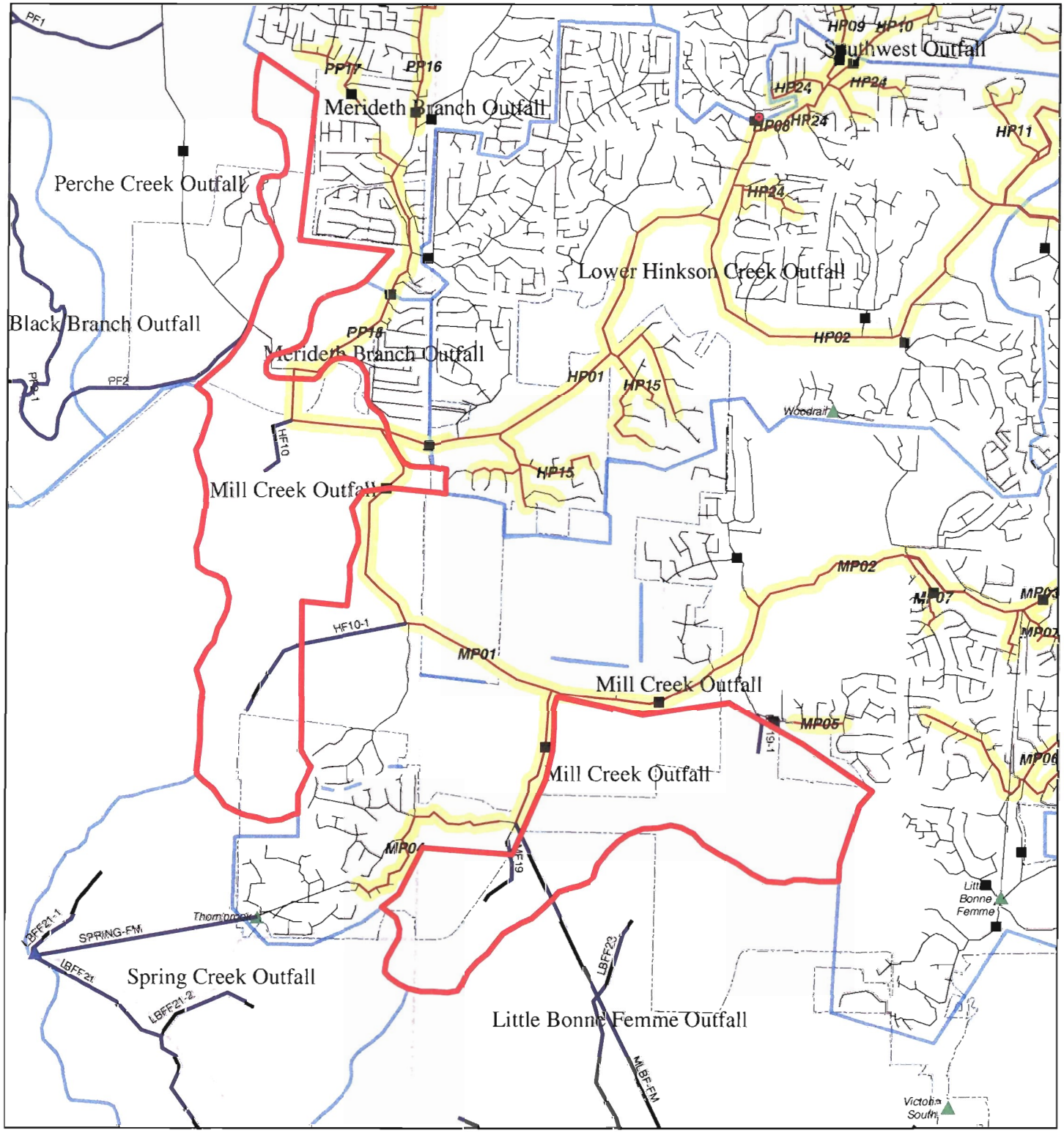

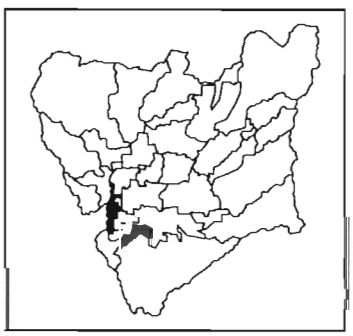

— Existing Sewer System
▲ Existing Pump Stations
Potential Relief Projects
— Potential Relief Sewers
— Future Growth Interceptors
▲ Future Pump Stations
■ Flow Meters
■ Flow Meters (Surcharged)
● Basement Backups
● Manhole Overflows
Flow Basins with Excessive I/I
— City Limits

City of Columbia
Wastewater System
Facilities Planning Report

Mill Creek Outfall (Future Growth)

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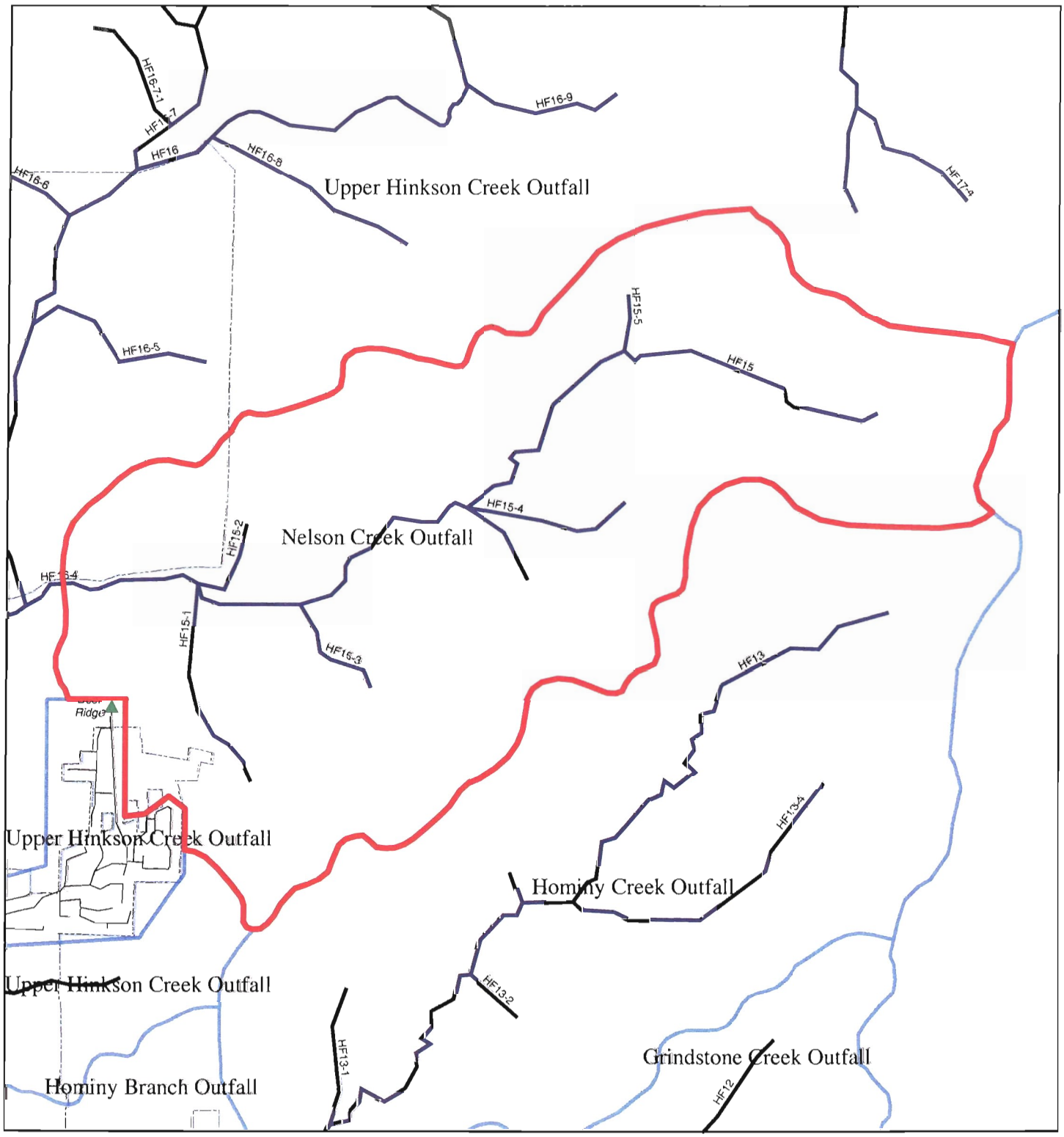

- Existing Sewer System
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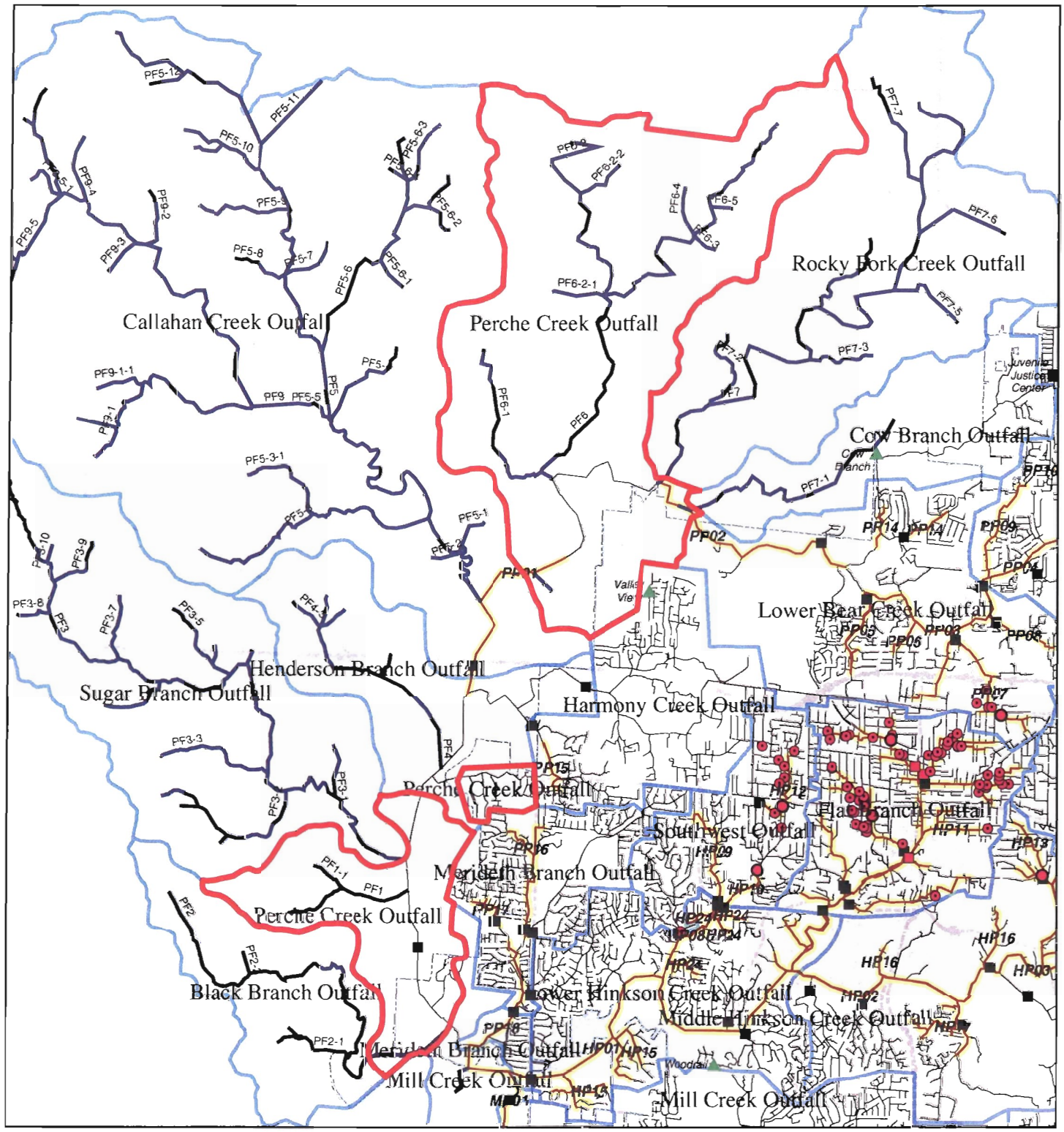
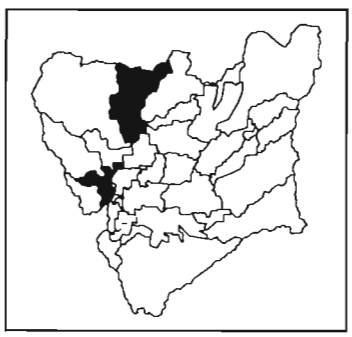
Wastewater System
Facilities Planning Report

Nelson Creek Outfall

prepared by Black & Veatch in association with GBA





— Existing Sewer System
▲ Existing Pump Stations
Potential Relief Projects
— Potential Relief Sewers
— Future Growth Interceptors
▲ Future Pump Stations
■ Flow Meters
■ Flow Meters (Surcharged)
● Basement Backups
● Manhole Overflows
Flow Basins with Excessive I/I
— City Limits

City of Columbia
Wastewater System
Facilities Planning Report

Perche Creek Outfall

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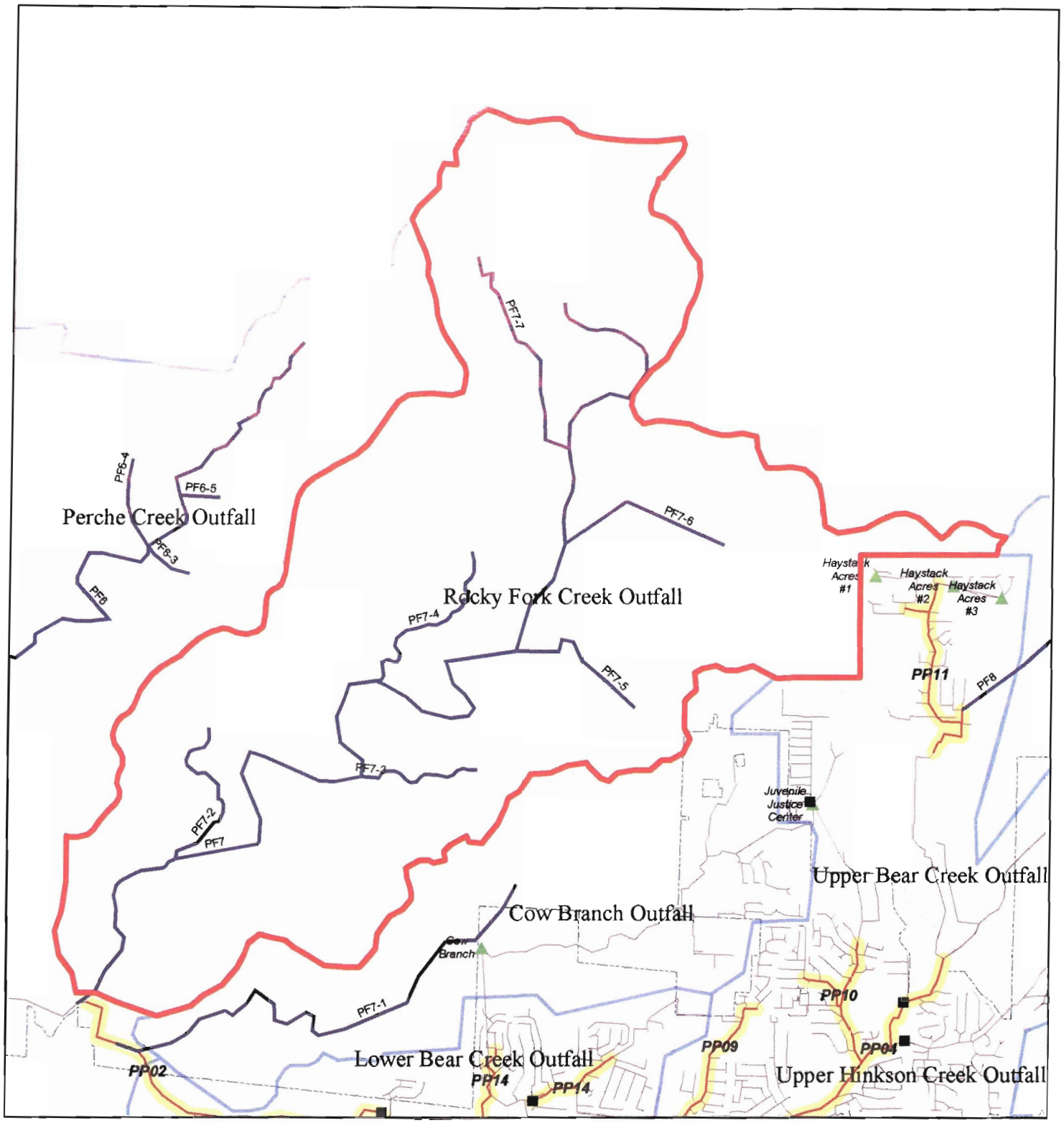

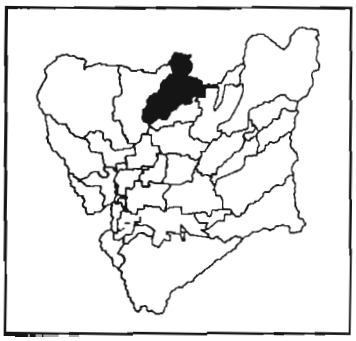

- Existing Sewer System
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- Potential Relief Sewers
- Future Growth Interceptors
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Wastewater System
Facilities Planning Report

Rocky Fork Creek Outfall

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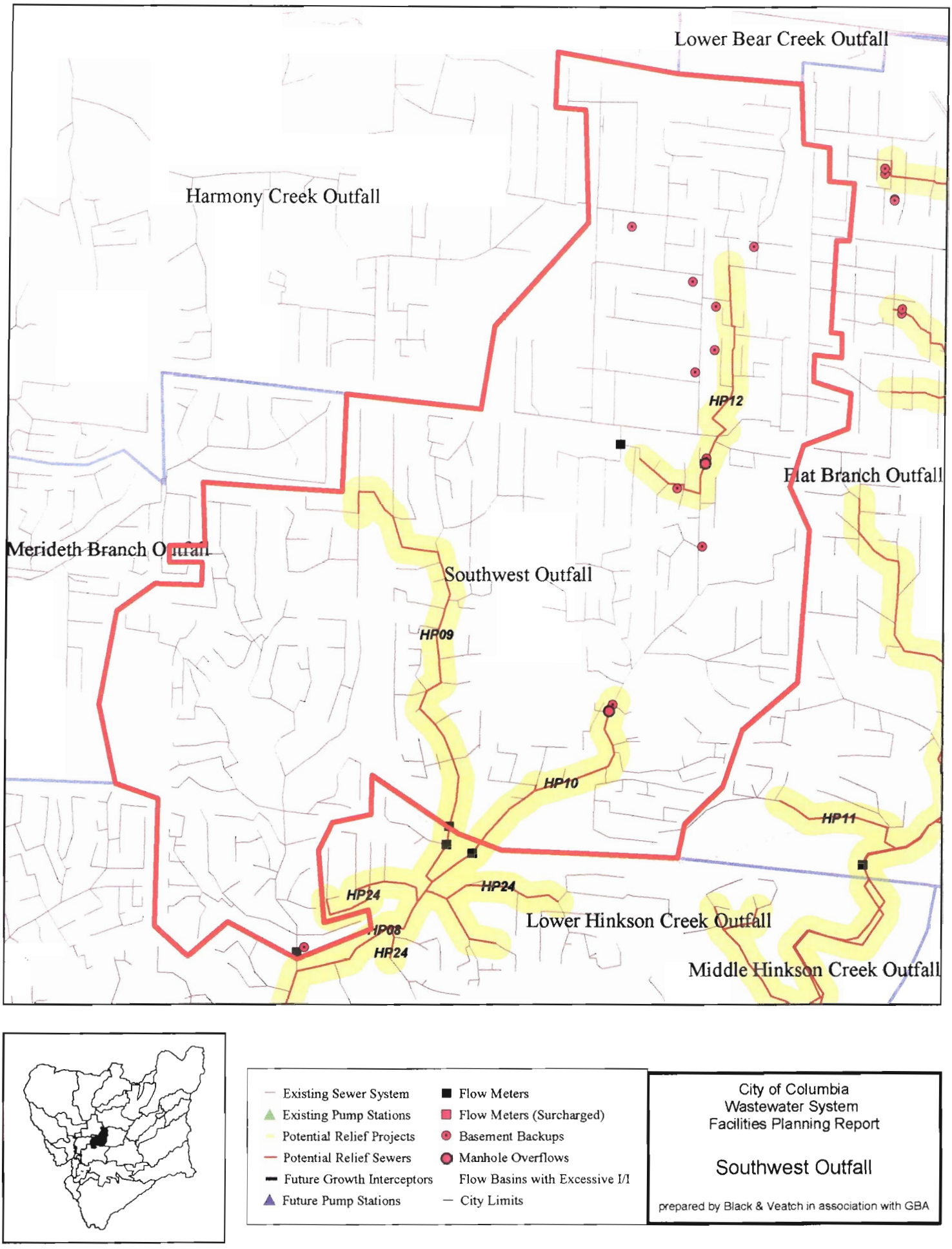

Existing Sewer System
Existing Pump Stations
Potential Relief Projects
Potential Relief Sewers
Future Growth Interceptors
Future Pump Stations
Flow Meters
Flow Meters (Surcharged)
Basement Backups
Manhole Overflows
Flow Basins with Excessive I/I
City Limits

City of Columbia
Wastewater System
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Southwest Outfall

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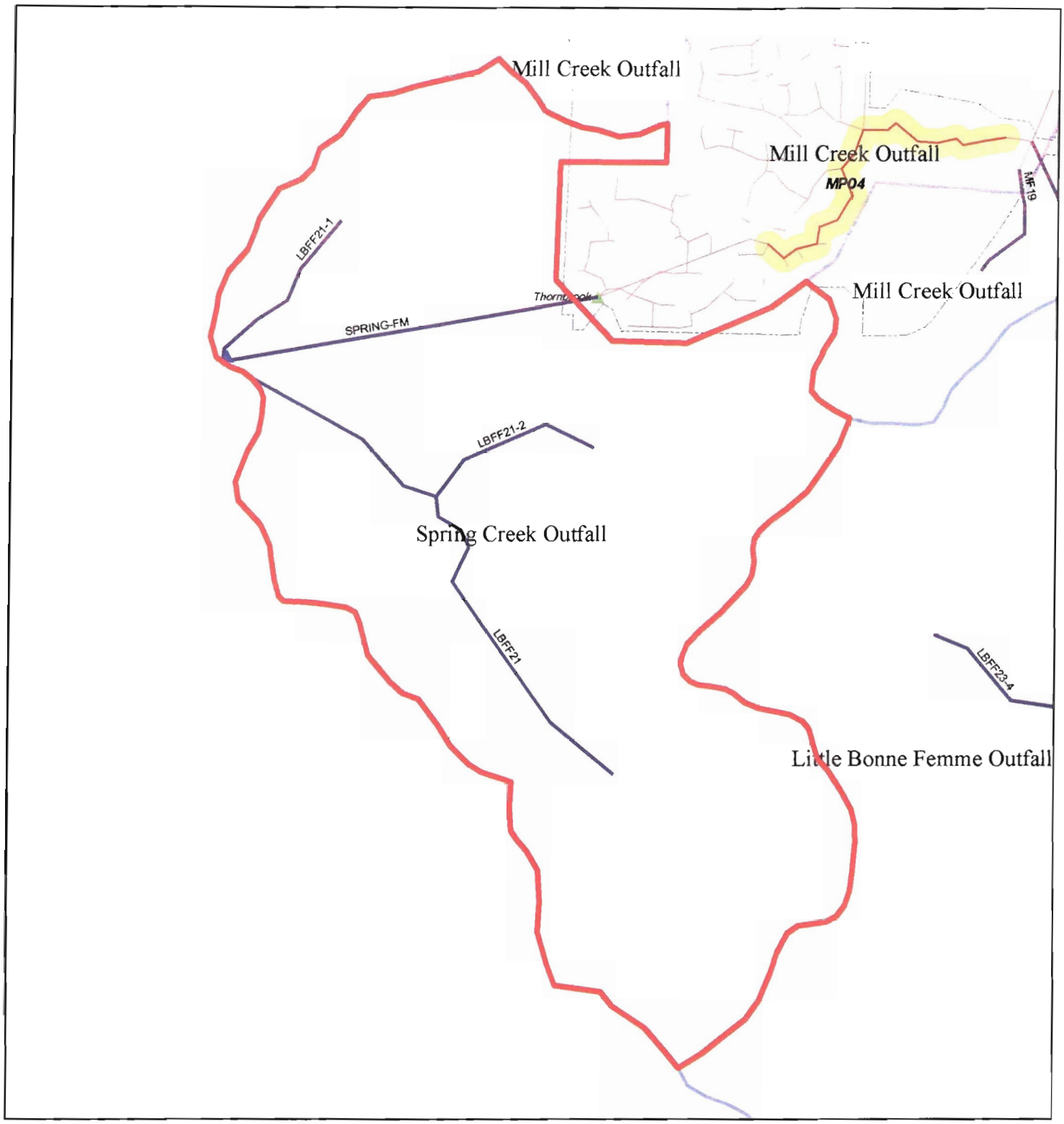

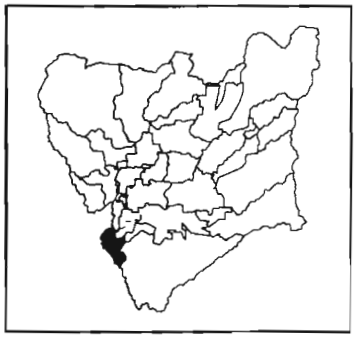

- Existing Sewer System
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Wastewater System
Facilities Planning Report

Spring Creek Outfall

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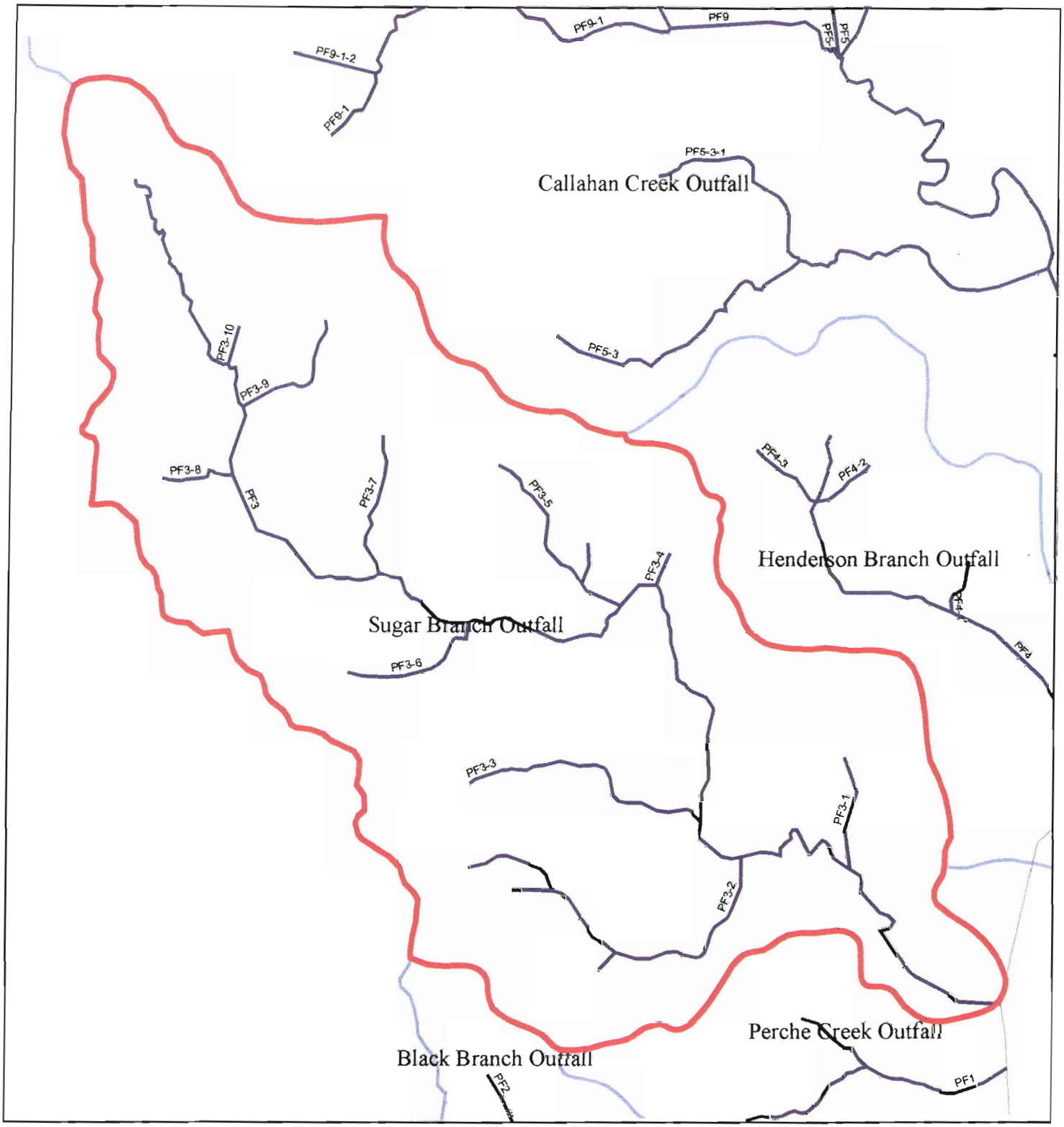

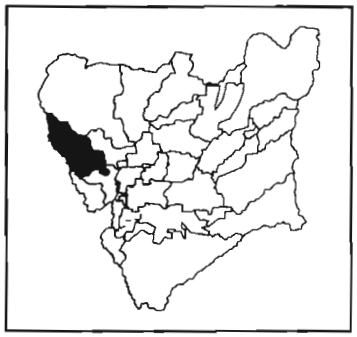

- Existing Sewer System
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- Flow Meters
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Facilities Planning Report

Sugar Branch Outfall

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APPENDIX C

I/I INVESTIGATION NEAR WWTP PUMP STATION

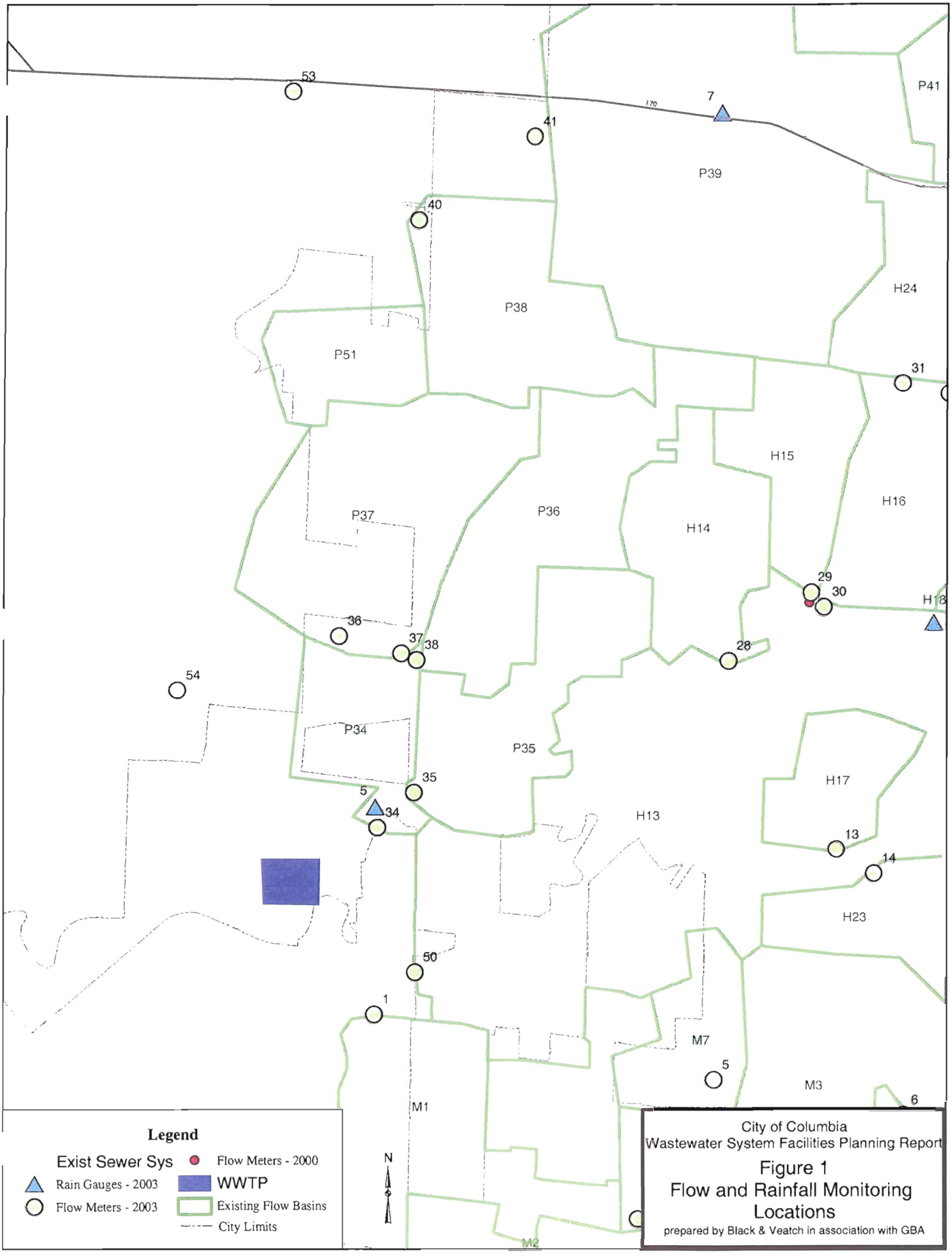
C.1 INVESTIGATION AND ANALYSIS

C.1.1. Introduction and Background. Currently, the City experiences high flows during major storm events at the wastewater treatment plant. The flows significantly increase when the treatment plant pump station wet-well level reaches an elevation of 30 feet. The high magnitude of flow and mentioned wet-well level is only achieved during major storm events. Wastewater treatment plant personnel also notice fish and other aquatic life in the holding basins after such events. As part of this project, a supplementary study was conducted. The purpose of this study was to flow monitor the major outfall sewers entering the wastewater treatment plant pump station and attempt to isolate the source of wet weather flow entering the sanitary sewer system once the wet-well flow elevation reaches 30 feet.

C.1.2. Flow and Rainfall Monitoring. Comprehensive flow and rainfall monitoring of the City's sewer system was conducted between April 30, 2003 and August 6, 2003. During this time, flow meters were installed upstream of the wastewater treatment plant pump station wet well. To avoid the impact of sewer surcharging by the pump station, the meters were installed far enough upstream to avoid the impact of the pumps' wet-well working elevations. A total of seven (7) flow meters were utilized for the purposes of this study. A listing of these seven meters is provided in Table 1. The location of the meters and rain gauges is shown in Figure 1.

Table 1
Flow Meter Locations

Flow Meter Number	Basin	Manhole	Dates of Installation	Location	Pipe Diameter (in)
34	P34	10B3A	5/15/03 - 8/6/03	4412 Pinebrook Ln	24
40	P38	11C11	5/8/03 - 8/6/03	316 Strawn Rd	12
41	P39	11D14	5/7/03 - 8/6/03	3511 I-70 Drive	18
53	P50	11H2	5/15/03 - 8/6/03	NW End of I-70 Drive	54
54	P51	10G5	5/15/03 - 8/6/03	Gillespie Bridge Rd & Old Coats Lane	60
1	M1	9D1	5/15/03 - 8/6/03	Brushwood Lake Rd	27
50	H13	10A38	5/15/03 - 8/6/03	MKT Trail Scott Blvd	60


53
41
7
P41
P39
40
P38
H24
P51
31
H15
H16
P37
P36
H14
29
30
H18
36
37
38
28
54
P34
P35
H17
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H13
13
14
H23
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M7
5
M3
6
M1
M2
Legend
Exist Sewer Sys
Flow Meters - 2000
Rain Gauges - 2003
WWTP
Flow Meters - 2003
Existing Flow Basins
City Limits
N
City of Columbia
Wastewater System Facilities Planning Report
Figure 1
Flow and Rainfall Monitoring Locations
prepared by Black & Veatch in association with GBA

For the purposes of this study, three (3) significant storm events were analyzed in detail. The recorded rainfall for these storms is provided in Table 2. Comprehensive rainfall data is provided in Appendix D. The June 25th, 2003 storm event provided the highest rain event at 2.84 inches. A second significant period of rain between June 10, 2003 and June 13, 2003 totaled approximately 3 inches. The third storm that was included in this analysis occurred on June 2, 2003.

Table 2
Rainfall Summary

Date	Rainfall Total (in)	60-min Intensity (in/hr)[(1)]	Recurrence Interval[(2)]
6/2/2003	1.26	0.36	0.11
6/10/2003	0.48	0.36	0.11
6/11/2003	0.81	0.57	0.17
6/12/2003	1.38	1.28	0.76
6/13/2003	0.72	0.36	0.11
6/25/2003	3.38	2.02	3.62

Notes:
(1) The storm intensities are based on the maximum amount of rainfall for a 60-minute period for each storm event.
(2) Recurrence intervals are based on a 60 minute time of concentration and extrapolated from historical IDF curves.

The seven (7) flow meters were utilized to measure flow from each of the three major watersheds of the system: Perche Creek Watershed; Hinkson Creek Watershed; and the Mill Creek Watershed. Due to the low elevation of the Perche Creek Interceptor, major surcharging occurred in the line during storm events. Therefore, three (3) flow meters upstream of the Perche Creek Interceptor were utilized to measure incoming flows from the watershed. These meters were approximately 22,000 feet upstream of the pump station. Minimal surcharging occurred in the Hinkson and Mill Creek Watersheds which were 4,000 feet and 5,000 feet upstream of the pump station, respectively.

The flows measured for each watershed during dry weather and wet weather storm events are summarized in Table 3. The data shows that the Hinkson Creek Watershed provides the highest flows to the pump station and has the highest I/I rate. The cumulative flow hydrograph for each storm event is shown in Figures 2, 3 and 4.

Table 3 Flow Data Summary							
		6/2/03		6/12/03		6/25/03	
Watershed	Base Flow (mgd)	Peak Flow (mgd)	Peak Flow Ratio	Peak Flow (mgd)	Peak Flow Ratio	Peak Flow (mgd)	Peak Flow Ratio
Mill Creek	1.24	3.48	2.81	6.41	5.17	6.41	5.17
Hinkson Creek	8.20	23.89	2.91	27.55	3.36	36.16	4.41
Perche Creek / Meredith Branch	0.67	2.39	3.57	2.52	3.76	4.83	7.20
Perche Creek	4.27	10.76	2.52	11.13	2.61	11.81	2.77

WWTP flow and wet-well levels were also measured at the wastewater treatment plant pump station. During wet weather conditions, the pump station transfers flows to the wastewater treatment plant or the infiltration and inflow (I/I) equalization basin. No flow bypasses the pump station and total flow leaving the collection system is measured at the pump station. The wet-well levels are measured at the pump station to initiate the operation of the station's six (6) pumps. A graph of the wet-well levels during the flow monitoring period is also shown in Figures 2, 3 and 4. Note that wet-well elevation of 30 feet was exceeded only during the June 12, 2003 storm event.

To compare the flows measured by the flow meters to the flow measured at the pump station, the cumulative watershed hydrographs were compared to the flow measured at the pump station. The total flow measured at the pump is also shown on Figures 2, 3 and 4 for comparative purposes.

C.2 CONCLUSIONS AND RECOMMENDATIONS

C.2.1 Conclusions and Recommendations. Consistent data agreement existed between the base flow measurements from the temporary flow meters and the base flows measured by the pump station meter. Also, total wet weather flow volumes for the flow meters were comparable to the pump station meter for the June 2, 2003 and June 25, 2003 storms. Only the June 12, 2003 storm provided higher flow volumes at the pump station meter than the temporary flow meters. During the June 12, 2003 storm event, an additional five (5) million gallons leaked into the system downstream of the temporary meters. This is illustrated in Figure 4. Since the June 12, 2003 storm is the only storm that caused the wet

well level to exceed 30 feet, this would indicate that major leaks exist in the main interceptors downstream of the temporary flow meters. The leak is most likely activated when the creeks exceed their banks and find a hole from the surface to the pipe. In order to identify the precise location of these leaks, the following inspection activities should be conducted downstream of the flow meter locations used in this study:

- Additional flow monitoring of main interceptors.
- Walk surface of interceptors to look for holes at surface above pipe.
- Smoke test interceptors to identify major leaks in pipe.
- Televise interceptors to identify major defects that cause leaks in pipe.
- Manhole inspections.

Estimated costs for these inspection activities are summarized in Table 4.

Table 4
Estimated Cost Summary for Additional Inspections

Item	Quantity	Unit Cost ($)	Total Cost ($)
Flow Monitoring			
Flow Meter Rental (70 days)	3 meters	$50/day	$10,500
Rain Gauge Rental (70 days)	2 gauges	$10/day	$1,400
Labor	96 hours	$70/hour	$6,720
Follow-Up Inspections			
Walk Surface	5,000 ft	$0.40/ft	$2,000
Smoke Test	5,000 ft	$0.80/ft	$4,000
Television Inspection	5,000 ft	$4.00/ft	$20,000
Manhole Inspection	40 MH	$150/MH	$6,000
Data Analysis	200 hours	$75/hour	$15,000
Total			$65,620

Figure 2
Total Flow and Wetwell Level for 6/2/03 Storm

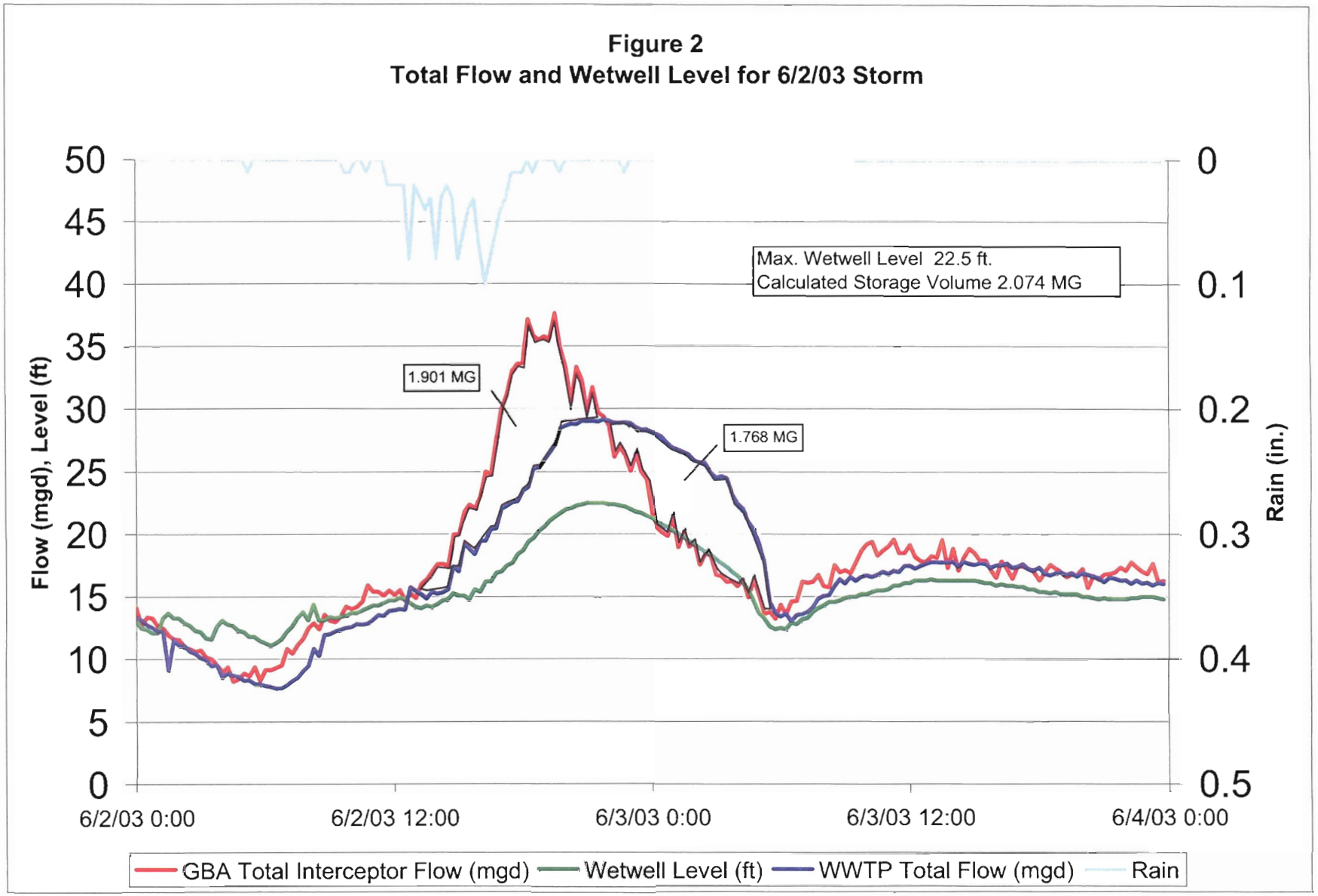


Figure 3
Total Flow and Wetwell Level for 6/25/03 Storm

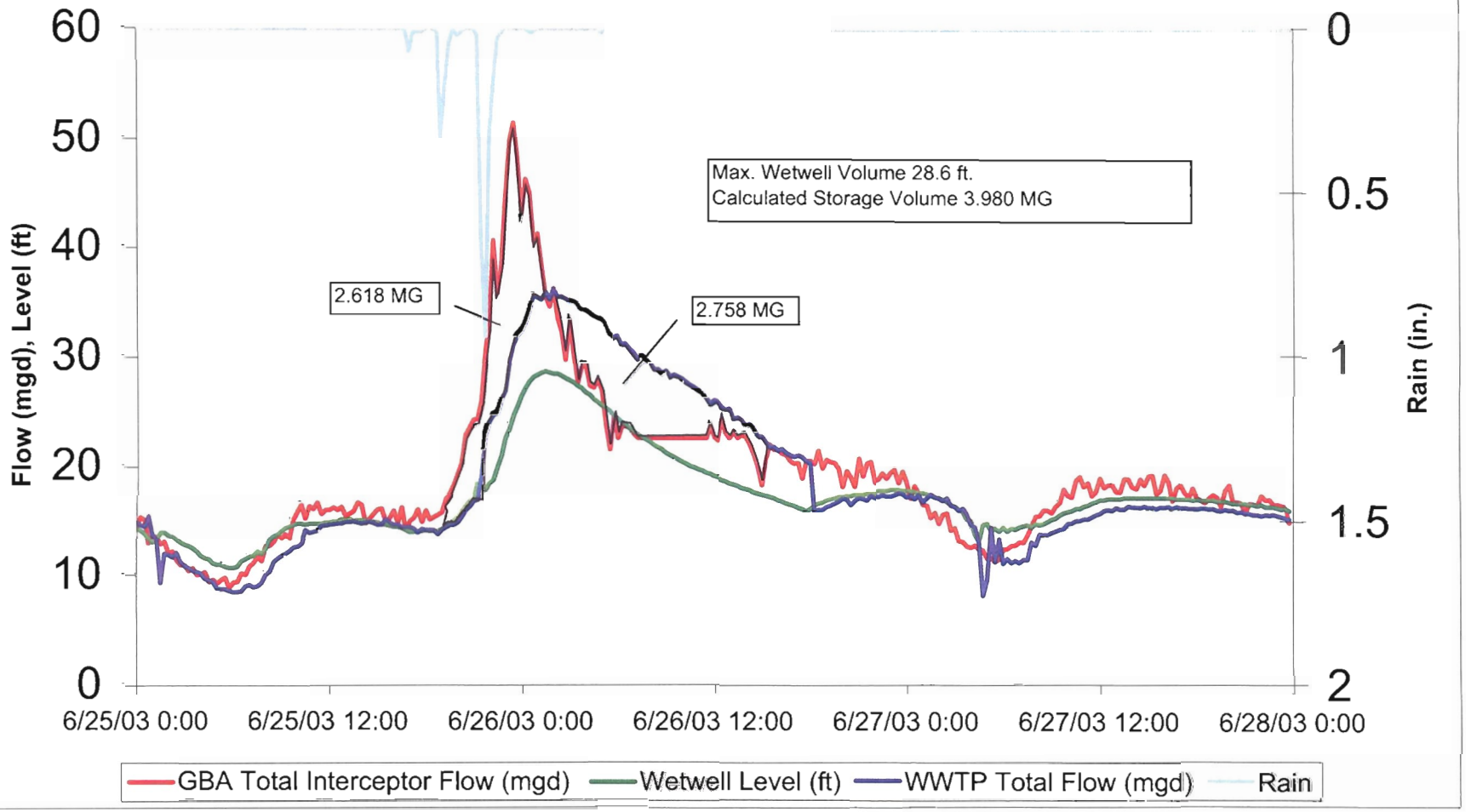
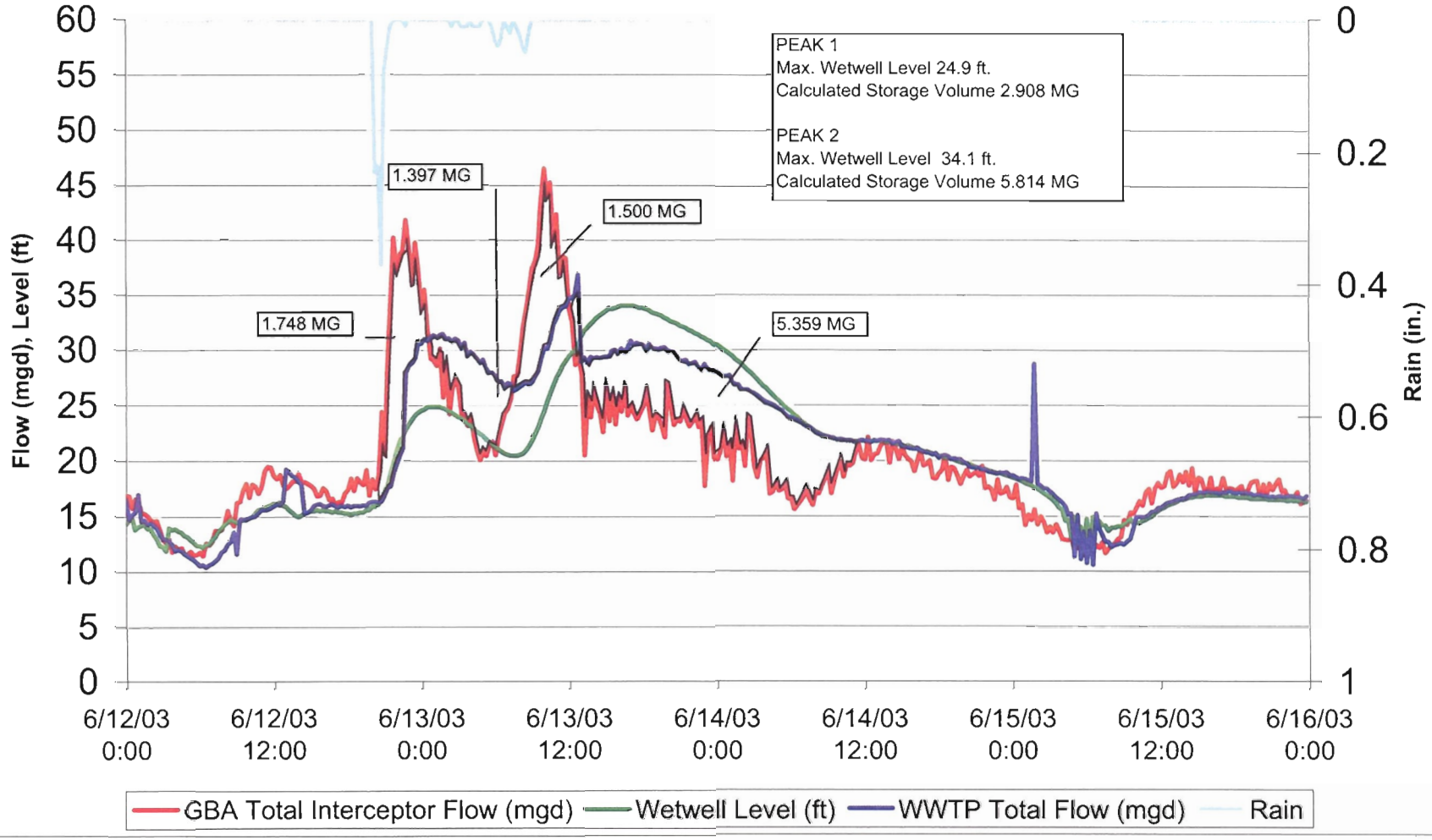


Figure 4
Total Flow and Wetwell Level for 6/12/03 Storm



APPENDIX D

FLOW MONITORING DATA ANALYSIS PROCEDURES AND DEFINITIONS

This section presents the flow and rainfall data analysis methodology, definitions and additional summary tables for the 2003 monitoring period. Results from the 2000 period are also included for comparison.

D.1 FLOW AND RAINFALL MONITORING

D.1.1 Flow Monitoring Locations. The monitoring sites were selected by GBA and the City based on tributary area and the existing sewer layout. The meters subdivided the study area into fifty (50) flow basins, which were isolated from one another. This allowed for the establishment of flow parameters and determination of excessive flow from each basin. Meter sites along with installation dates are shown in Table 1.

D.1.2 Rainfall Summary. Eight (8) rain gauges were used to determine rainfall totals and intensities throughout the project area. Each storm event was given a recurrence interval based on the standard rainfall intensity curves for the City of Columbia. A summary of storm events for each gauge can be found in Table 2.

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Table 1 Flow Meter Locations				
Basin	Manhole	Dates of Installation	Location	Pipe Diameter (in)
M1	9D1	5/15/03 - 8/6/03	Brushwood Lake Rd	27
M2	8N5	5/2/03 - 7/7/03	Old Mill Creek Rd & Crabapple	14
M3	8O10	5/1/03 -7/7/03	Old Mill Creek Rd	21
M4	8F123	4/30/03 - 7/22/03	907 Old Plank Rd	18
M5	8E1	5/1/03 - 7/7/03	5507 Carrick	8
M6	8E55	4/30/03 - 7/22/03	Pump Station on Old Plank Rd	8
M7	8L11	5/1/03 - 7/22/03	4104 White Pine Ct	8
M8	8G14	4/30/03 - 7/7/03	4207 Fall River Dr	18
M9	8G15	4/30/03 - 7/7/03	4204 Glen Eagle Dr	8
M10	8J6	5/1/03 -7/22/03	Muirfield & Sinclair	15
M11	7L21	5/2/03 - 7/23/03	1808 Scarborough Ct	8
M12	7G3	5/14/03 - 7/23/03	Red Barn on Bearfield Rd	18
H13	10A38	5/15/03 - 8/6/03	MKT Trail Scott Blvd	60
H14	5L2	5/1/03 - 7/22/03	1606 Stoney Brook	12
H15	3I149	5/8/03 - 7/8/03	Stadium Blvd Tennis Courts	8
H16	5L61	5/8/03 - 7/22/03	College Park & Stadium Blvd	15
H17	5J51B	5/14/03 - 7/22/03	MKT Nature Fitness Trail	12
H18	3E2	5/14/03 - 7/23/03	800 S Stadium	30
H19	6O38	5/2/03 - 7/7/03	Capen Park	48
H20	6N2	5/14/03 - 7/23/03	2402 Lubbock Ct	18
H21	5C7A	5/14/03 - 7/23/03	Epple Field	12
H22	5G31	5/14/03 - 7/23/03	2412 Lynnwood	8
H23	5J56	5/1/03 - 7/7/03	Club Woodrail	12
H24[1]	3F134	5/15/03 - 7/23/03	7 Westridge	8
	3F159	5/7/03 - 7/23/03	101 Tracy Dr	12
H25	4I49	5/2/03 - 7/7/03	710 Morningside	12
H26[1]	4J128	5/1/03 -7/7/03	Moon Valley Rd -West	24
	4J155	5/1/03 - 7/7/03	Moon Valley Rd -East	36
H27	4E69	4/30/03 - 7/23/03	Buck Run Rd	15
H28	6K58	5/14/03 - 7/23/03	Grindstone Park	42
H29	4G16	4/30/03 - 7/7/03	2210 Country Club Dr	18
H30	2E3A	4/30/03 - 7/21/03	Hwy 63 Connection	10
H31	4H65	4/30/03 - 7/7/03	3110 Clark Ln	18
H32	17M95	5/1/03 - 7/21/03	Clark Ln & Homury Creek	21
H33	17O8	5/14/03 - 7/21/03	Ballenger Ln	15

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Table 1
Flow Meter Locations (Continued)

Basin	Manhole	Dates of Installation	Location	Pipe Diameter (in)
P34	10B3A	5/15/03 - 8/6/03	4412 Pinebrook Ln	24
P35	10B15	5/5/03 - 7/22/03	2911 Scott	15
P36	10C15	5/5/03 - 7/22/03	Daniel Boone Ballpark	15
P37[(1)]	10G18	5/5/03 - 7/22/03	4704 Gage	10
	10C20	5/5/03 - 7/22/03	Daniel Boone Ballpark West	12
P38	11C11	5/8/03 - 8/6/03	316 Strawn Rd	12
P39	11D14	5/7/03 - 8/6/03	3511 I-70 Drive	18
P40	1G8	5/7/03 - 7/21/03	3404 Prairie View Dr	36
P41	1B2	5/7/03 - 7/21/03	Proctor Park	12
P42	2N36	5/1/03 - 7/21/03	Big Bear Blvd. & Bear Creek	15
P43	2N20	5/6/03 - 7/21/03	3000 Northland Dr	21
P44	1C13	5/14/03 - 7/21/03	Squirrel Dr	15
P45	2K4	5/6/03 - 7/21/03	1622 Sky Lane	15
P46	2H20	5/6/03 - 7/21/03	Oakland Gravel Rd - tan shed	18
P47	15E21DUP	5/6/03 - 7/21/03	Oakland Gravel Rd - Bridge	21
P48	15J10	5/7/03 - 7/21/03	Juvenile Justice Center LS	8
P49	34A14	5/16/03 - 7/7/03	Route B	8
P50	11H2	5/15/03 - 8/6/03	NW End of I-70 Drive	54
P51	10G5	5/15/03 - 8/6/03	Gillespie Bridge Rd & Old Coats Lane	60

Notes:

(1) -- Basin contains two outlet points which required two meters

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Table 2
Rainfall Summary

Date	GBA Rain Gauge 1 City Hall			GBA Rain Gauge 2 Little Bonne Femme LS		
	Total Rainfall (in)	60-min Intensity (in/hr) [1]	Recurrence Interval [2]	Total Rainfall (in)	60-min Intensity (in/hr) [1]	Recurrence Interval [2]
5/4/2003	0.68	0.35	0.1	1.03	0.63	0.2
5/6/2003	0.05	0.05	0.1	0.04	0.04	0.1
5/8/2003	0.18	0.12	0.1	0.28	0.24	0.1
5/10/2003	0.77	0.44	0.1	0.87	0.30	0.1
5/14/2003	0.01	0.01	0.1	0.01	0.01	0.0
5/15/2003	0.23	0.23	0.1	0.10	0.09	0.1
5/16/2003	0.05	0.03	0.1		No Data	
5/19/2003	0.09	0.09	0.1		No Data	
5/20/2003	0.33	0.28	0.1		No Data	
5/24/2003	0.47	0.21	0.1		No Data	
5/25/2003	0.01	0.01	0.1		No Data	
5/30/2003	0.06	0.04	0.1	0.06	0.03	0.1
6/2/2003	1.01	0.30	0.1	0.57	0.15	0.1
6/6/2003	0.16	0.06	0.1	0.12	0.04	0.1
6/10/2003		No Data		0.30	0.20	0.1
6/11/2003		No Data		0.06	0.05	0.1
6/12/2003	0.49	0.41	0.1	1.38	1.28	0.8
6/13/2003	0.31	0.14	0.1	0.11	0.03	0.1
6/14/2003		N/A			N/A	
6/25/2003	1.02	0.63	0.2	3.38	2.02	3.6
6/26/2003	1.06	0.63	0.2	0.05	0.05	0.1
7/1/2003	0.56	0.55	0.2		N/A	
7/9/2003		No Data		0.42	0.42	0.1
7/10/2003		No Data		0.41	0.17	0.1
7/17/2003		No Data		0.13	0.04	0.1
7/28/2003		No Data		0.10	0.08	0.1
Totals =	7.54			9.42		

Notes:

(1) - The storm intensities are based on the maximum amount of rainfall for a 60-min. period for each storm event.
(2) - Recurrence intervals are based on a 60-min. time of concentration and extrapolated from historical IDF curves.

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Table 2
Rainfall Summary (Continued)

Date	GBA Rain Gauge 3 3300 Lemone Blvd			GBA Rain Gauge 4 Hinkson Creek LS		
	Total Rainfall (in)	60-min Intensity (in/hr) [1]	Recurrence Interval [2]	Total Rainfall (in)	60-min Intensity (in/hr) [1]	Recurrence Interval [2]
5/4/2003	1.39	0.74	0.2	1.29	0.72	0.2
5/6/2003	0.07	0.06	0.1	0.07	0.07	0.1
5/8/2003	0.47	0.43	0.1	0.26	0.14	0.1
5/10/2003	1.31	0.36	0.1	1.49	0.49	0.1
5/14/2003	0.01	0.01	0.1	0.14	0.13	0.0
5/15/2003	0.21	0.14	0.1	0.39	0.39	0.1
5/16/2003	0.04	0.03	0.1		No Data	
5/19/2003	0.05	0.05	0.1		No Data	
5/20/2003	0.32	0.22	0.1		No Data	
5/24/2003	0.42	0.20	0.1		No Data	
5/25/2003		N/A			No Data	
5/30/2003	0.09	0.06	0.1	0.19	0.13	0.1
6/2/2003	1.14	0.34	0.1	1.26	0.36	0.1
6/6/2003	0.24	0.08	0.1	0.29	0.10	0.1
6/10/2003	0.48	0.36	0.1	0.62	0.30	0.1
6/11/2003	0.16	0.14	0.1	0.36	0.13	0.1
6/12/2003	0.32	0.27	0.1	0.73	0.14	0.1
6/13/2003	0.43	0.20	0.1	1.14	0.08	0.1
6/14/2003		N/A		0.05	0.01	0.1
6/25/2003	3.04	1.70	1.8	1.60	0.70	0.2
6/26/2003	0.01	0.01	0.1	0.04	0.03	0.1
7/1/2003	0.01	0.01	0.1	0.08	0.07	0.1
7/9/2003	0.48	0.48	0.1	0.51	0.51	0.1
7/10/2003	0.30	0.13	0.1	0.34	0.14	0.1
7/17/2003	0.09	0.04	0.1	0.21	0.06	0.1
7/28/2003	0.13	0.13	0.1	0.21	0.21	0.1
Totals =	11.21			11.27		

Notes:

(1) - The storm intensities are based on the maximum amount of rainfall for a 60-min. period for each storm event.
(2) - Recurrence intervals are based on a 60-min. time of concentration and extrapolated from historical IDF curves.

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Table 2
Rainfall Summary (Continued)

Date	GBA Rain Gauge 5 Scott Blvd & Current Rd			GBA Rain Gauge 6 Cow Branch LS		
	Total Rainfall (in)	60-min Intensity (in/hr) [1]	Recurrence Interval [2]	Total Rainfall (in)	60-min Intensity (in/hr) [1]	Recurrence Interval [2]
5/4/2003	1.32	0.81	0.3		No Data	
5/6/2003	0.06	0.06	0.1		No Data	
5/8/2003	0.20	0.17	0.1	0.24	0.21	0.1
5/10/2003	1.42	0.73	0.2	1.46	0.58	0.2
5/14/2003	0.03	0.02	0.1	0.13	0.12	0.0
5/15/2003	0.12	0.12	0.1	0.32	0.31	0.1
5/16/2003	0.04	0.02	0.1		No Data	
5/19/2003	0.14	0.14	0.1		No Data	
5/20/2003	0.38	0.32	0.1		No Data	
5/24/2003	0.40	0.18	0.1		No Data	
5/25/2003		N/A			No Data	
5/30/2003	0.11	0.07	0.1		No Data	
6/2/2003	1.13	0.31	0.1	1.14	0.30	0.1
6/6/2003	0.27	0.10	0.1	0.36	0.15	0.1
6/10/2003	0.59	0.48	0.1	0.54	0.35	0.1
6/11/2003	0.16	0.14	0.1	0.81	0.63	0.2
6/12/2003	0.96	0.89	0.3	0.87	0.33	0.1
6/13/2003	0.35	0.12	0.1	0.72	0.40	0.1
6/14/2003		N/A			No Data	
6/25/2003	2.84	2.00	3.5		No Data	
6/26/2003	0.03	0.02	0.1		No Data	
7/1/2003		N/A			No Data	
7/9/2003	0.21	0.21	0.1		No Data	
7/10/2003	0.55	0.20	0.1		No Data	
7/17/2003	0.11	0.04	0.1		No Data	
7/28/2003	0.08	0.06	0.1		No Data	
Totals =	11.50			6.59		

Notes:

(1) - The storm intensities are based on the maximum amount of rainfall for a 60-min. period for each storm event.
(2) - Recurrence intervals are based on a 60-min. time of concentration and extrapolated from historical IDF curves.

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Table 2
Rainfall Summary (Continued)

	GBA Rain Gauge 7 Blattner Home Furnishings			GBA Rain Gauge 8 Break Time		
Date	Total Rainfall (in)	60-min Intensity (in/hr) [1]	Recurrence Interval [2]	Total Rainfall (in)	60-min Intensity (in/hr) [1]	Recurrence Interval [2]
5/4/2003		No Data			No Data	
5/6/2003		No Data			No Data	
5/8/2003	0.01	0.01	0.1		No Data	
5/10/2003	1.16	0.55	0.2		No Data	
5/14/2003	0.05	0.05	0.1		No Data	
5/15/2003	0.53	0.52	0.2		No Data	
5/16/2003		No Data			No Data	
5/19/2003		No Data			No Data	
5/20/2003		No Data			No Data	
5/24/2003		No Data			No Data	
5/25/2003		No Data			No Data	
5/30/2003		No Data			No Data	
6/2/2003		No Data			No Data	
6/6/2003		No Data			No Data	
6/10/2003		No Data			No Data	
6/11/2003		No Data			No Data	
6/12/2003		No Data			No Data	
6/13/2003		No Data			No Data	
6/14/2003		No Data			No Data	
6/25/2003		No Data			No Data	
6/26/2003	0.07	0.04	0.1		No Data	
7/1/2003	0.07	0.05	0.1		No Data	
7/9/2003	0.38	0.38	0.1	0.21	0.21	0.1
7/10/2003	0.37	0.17	0.1	0.44	0.70	0.2
7/17/2003	0.07	0.04	0.1	0.07	0.03	0.1
7/28/2003	0.18	0.18	0.1	0.03	0.03	0.1
Totals =	2.89			0.75		

Notes:

(1) - The storm intensities are based on the maximum amount of rainfall for a 60-min. period for each storm event.
(2) - Recurrence intervals are based on a 60-min. time of concentration and extrapolated from historical IDF curves.

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D.2 WASTEWATER FLOW PARAMETER DEFINITIONS

Wastewater flows are comprised of three components. For the purpose of this study they are defined below.

D.2.1 Base Flow. Base flow is usually defined as the normal wastewater flow generated in the sewer system exclusive of infiltration and inflow. Base flow for this study was defined as normal wastewater flow generated in the sewer system exclusive of all infiltration and inflow. The daily base flow rate can be measured directly during dry weather conditions.

The instantaneous base flow rate varies throughout each day with the highest rates normally observed near 8:00 a.m. and 6:00 p.m. The ratio of peak instantaneous flow to total daily flow is defined as the base flow peaking factor.

D.2.2 Infiltration. Infiltration is defined as flows entering the wastewater collection system through defects below ground such as defective pipes, pipe joints and manholes. The rate of infiltration depends on the depth of groundwater above the defects as well as the percentage of the collection system below the groundwater table. The variation in groundwater levels and subsequent infiltration is seasonal and weather dependent. Since the groundwater levels are normally a relative constant over periods of several days, the peak infiltration can be considered as the maximum infiltration, which occurs during the maximum groundwater period of the year.

D.2.3 Inflow. Inflow is defined as rainfall-related water entering the collection system from sources such as private sewer laterals, down spouts, foundation drains, yard and area drains, storm sump pumps, manhole covers and cross connections from storm drains. Inflow is directly influenced by the intensity and duration of a storm event therefore is not a fixed quantity.

These three components are shown graphically in Figure 1.

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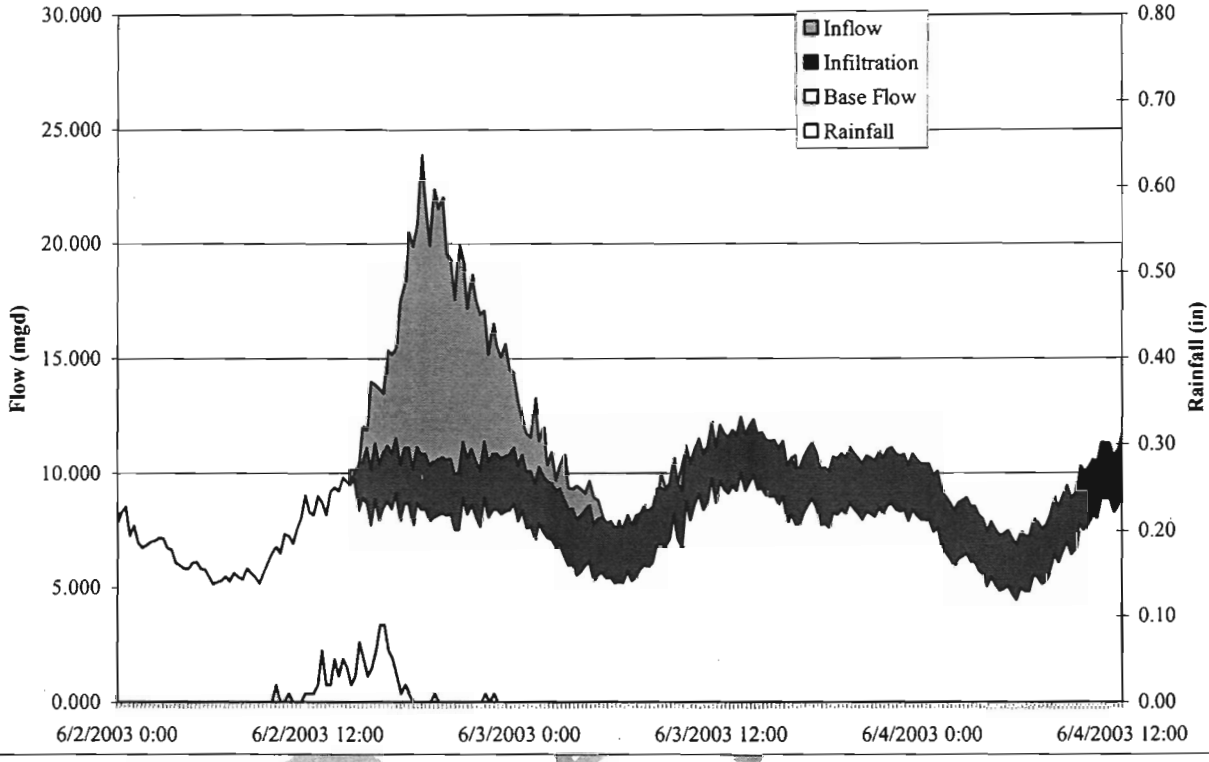
Figure 1
Wastewater Flow Parameters for 6/2/03 Storm
Basin H13



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D.3 WASTEWATER FLOW PARAMETER CALCULATIONS

D.3.1 Determination of Base Flow. Dry weather flows were utilized to determine base flow since infiltration was considered to be at its lowest. Also, a peaking factor was determined by the ratio of the peak daily flow recorded to the average daily flow:

$$\text{Peaking Factor} = \frac{\text{Peak Daily Flow}}{\text{Average Daily Flow}}$$

Peak base flow was then determined by multiplying the peaking factor by average base flow:

$$\text{Peak Base Flow} = \text{Peaking Factor} \times \text{Average Base Flow}$$

A peak base flow rate was calculated for each basin utilizing the flow data obtained from the flow meters. Dry weather flows were averaged and a peaking factor was calculated from the peak flows observed during this period. The peak base flows for each basin are listed in Table 3.

D.3.2 Determination of Infiltration. Maximum infiltration occurs when groundwater elevation is highest. To determine high groundwater infiltration, flow data from the days following significant rainfall events were analyzed. The total flow measured during these infiltration periods included base flow plus infiltration flow. Infiltration flow was determined by subtracting the average dry weather flow from the total flow measured during the infiltration periods. Night flow readings often were used for the analysis since the least temporal variation in base flow occurred during this period. Infiltration parameters are summarized in Table 4.

The infiltration rate is a good indicator for the "leakiness" of a sewer system and is typically used to compare the infiltration severity between different basins and different monitoring periods. Figure 2 shows a plot of the infiltration rates versus basin area for the flow basins in the 2003 and 2000 study area. There are twelve (12) flow basins in the 2003 study area and eight (8) flow basins in the 2000 study that fall above the *High Infiltration Rate Boundary* defined by GBA. The boundary lines in the figure are based on infiltration rates measured by GBA for other sewer systems in the Midwest.

D.3.3 Determination of Inflow. The inflow value for each monitoring site is calculated utilizing a constant based on the storm duration, intensity, and the monitored flow. This constant, "K," is used to estimate inflow values for different rainfall return intervals.

For each selected storm, the peak rainfall, peak flow, basin area, and time from peak rainfall to peak flow are used to calculate the "K" value at the flow monitoring point. A value for the base

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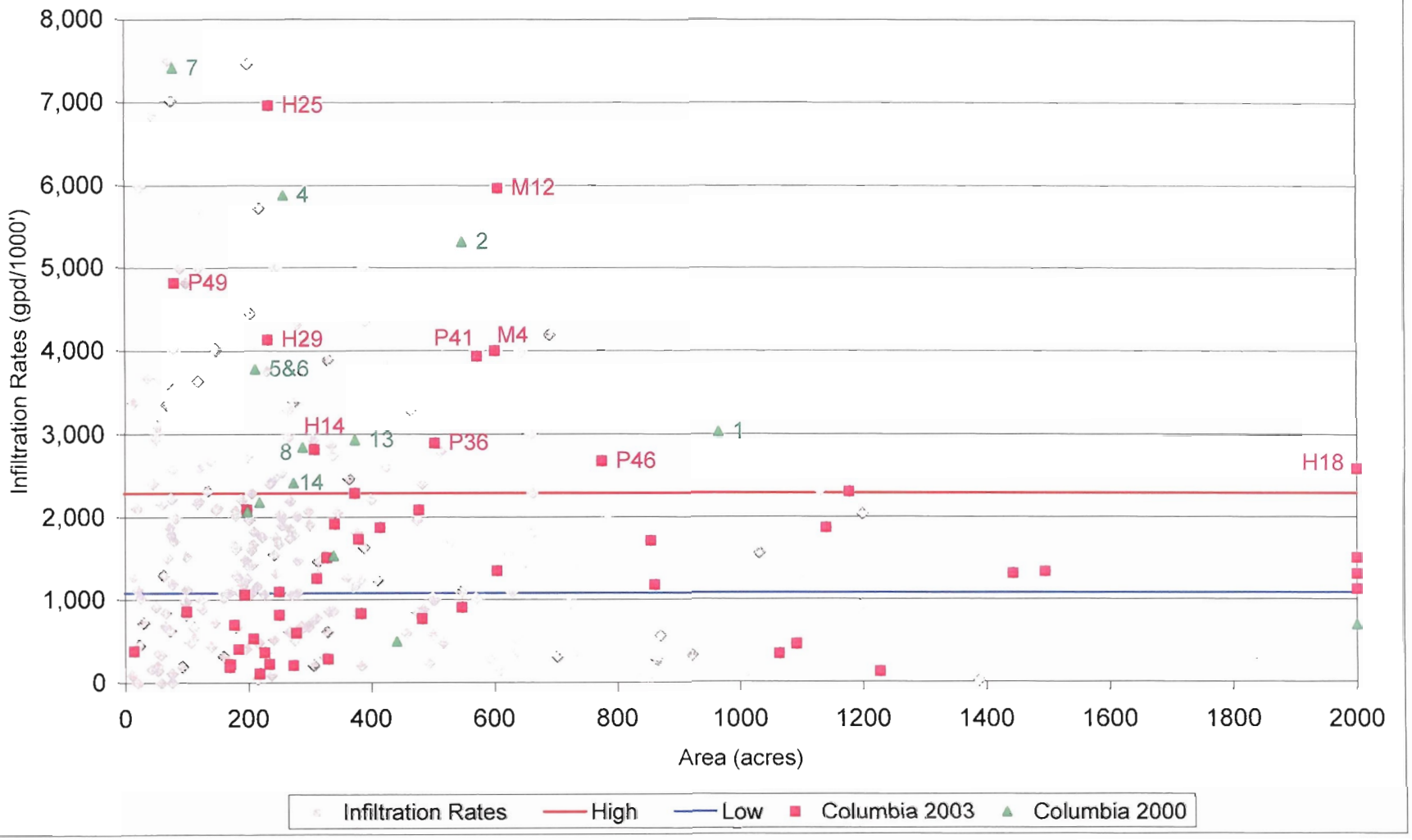
Figure 2
Infiltration Rates



flow and infiltration are subtracted from the peak flow to determine the peak inflow. Once the peak inflow is determined and rainfall intensity is calculated from the rainfall monitoring data, a "K" value can be determined and applied to the line segments that were monitored by the flow meter. Several "K" values are averaged together to arrive at a "K" value for the basin being monitored.

A basin and a cumulative inflow coefficient ("K" value) were determined for each monitoring site. Utilizing the inflow coefficient, the basin area, rainfall duration equal to the basin time of concentration, and the rainfall intensity curves, a one-year and a ten-year inflow value were calculated for each basin.

The relative accuracy of the "K" coefficient determined for each basin is higher for exterior basins that have only one sewer line outlet from the basin to be monitored. A decrease in the relative accuracy of the "K" coefficient is typical for interior flow basins or flow basins with multiple sewer line outlets in the form of parallel lines.

The results of the inflow analysis are shown in Table 5. Figure 3 shows a plot of the 1-year storm inflow rates versus basin area for the flow basins in the 2003 and 2000 study area. There are sixteen (16) flow basins in the 2003 study area and ten (10) flow basins in the 2000 study that fall above the *High Inflow Rate Boundary* defined by GBA. The boundary lines in the figure are based on inflow rates measured by GBA for other sewer systems in the Midwest.

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Figure 3
Inflow Rates

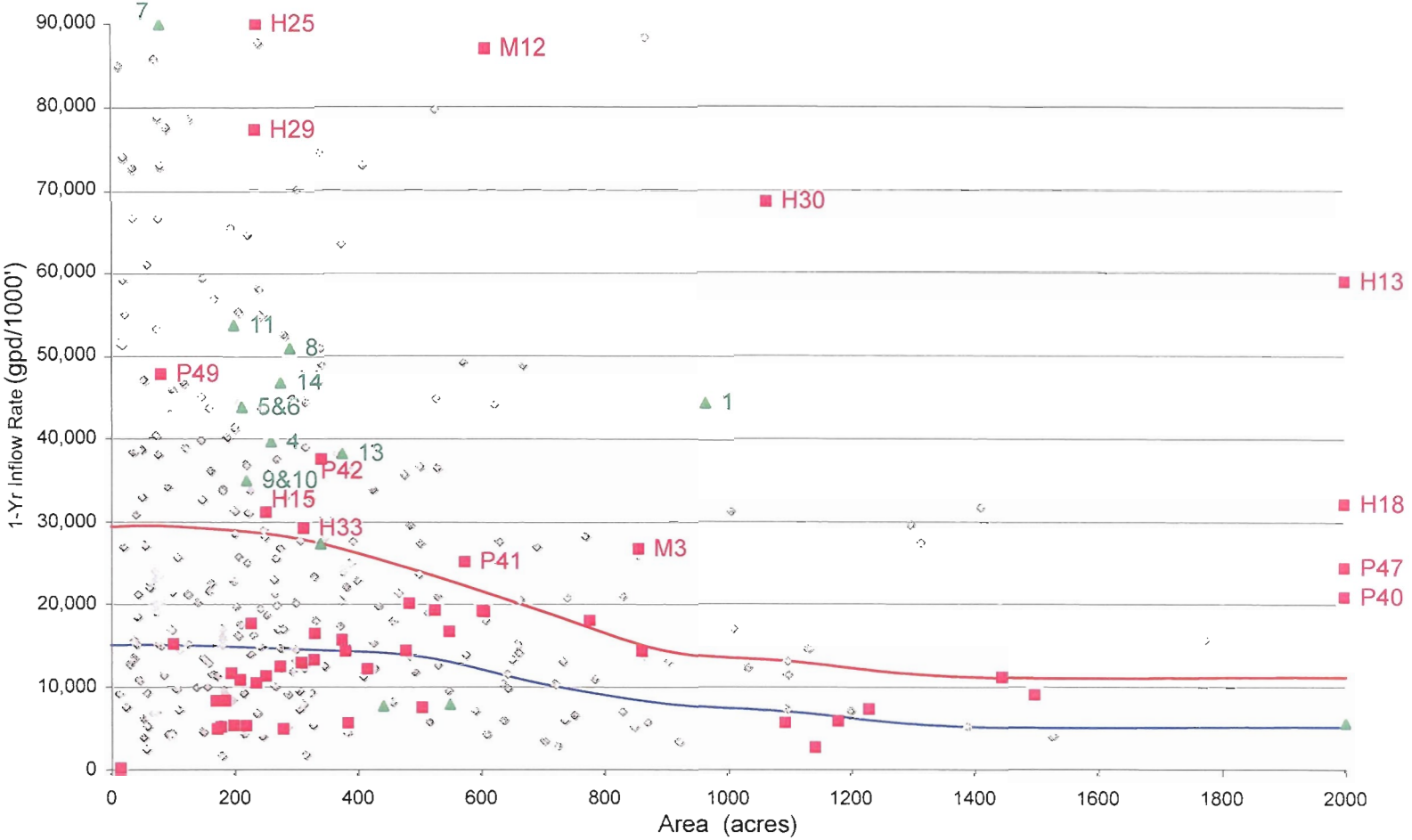

Table 3
Base Flow Summary

Basin	Individual Basin Area (acres)	Cumulative Basin Area (acres)	Individual Base Flow (MGD)	Cumulative Base Flow (MGD)	Cumulative Base Flow Peaking Factor	Cumulative Peak Base Flow [2] (MGD)	Individual Peak Base Flow (GPD)
M1	525	5544	0.125	1.216	1.43	1.739	178,750
M2	330	330	0.011	0.011	5.79	0.064	63,690
M3	855	4689	0.466	1.080	1.78	1.922	829,480
M4	602	602	0.431	0.431	1.60	0.690	689,600
M5	209	209	0.007	0.007	3.51	0.025	24,570
M6	172	172	0.010	0.010	9.96	0.100	99,600
M7	199	199	0.069	0.069	2.15	0.148	148,350
M8	1444	2381	0.010	0.395	2.14	0.845	21,400
M9	101	101	0.046	0.046	2.28	0.105	104,880
M10	170	170	0.041	0.041	4.05	0.166	166,050
M11	329	329	0.097	0.097	2.09	0.203	202,730
M12	608	608	0.288	0.288	2.52	0.726	725,760
H13	2744	14753	1.614	7.895	1.27	10.027	2,049,780
H14	309	309	0.141	0.141	1.97	0.278	277,770
H15	251	251	0.528	0.528	1.55	0.818	818,400
H16	375	754	0.138	0.391	1.28	0.500	176,640
H17	178	178	0.036	0.036	1.86	0.067	66,960
H18	2112	2112	2.832	2.832	1.41	3.993	3,993,120
H19	970	7212	0.350	2.149	1.43	3.073	500,500
H20	483	483	0.047	0.047	2.10	0.099	98,700
H21	235	235	0.042	0.042	1.87	0.079	78,540
H22	195	195	0.062	0.062	2.40	0.149	148,800
H23	279	279	0.053	0.053	2.20	0.117	116,600
H24	380	380	0.253	0.253	1.76	0.445	445,280
H25	235	235	0.318	0.318	1.92	0.611	610,560
H26	1141	3209	0.389	0.828	1.75	1.449	680,750
H27	1228	1706	0.028	0.504	1.55	0.781	43,400
H28	1092	1092	0.149	0.149	1.61	0.240	239,890
H29	233	233	0.094	0.094	2.31	0.217	217,140
H30	1064	1376	0.152	0.215	1.86	0.400	282,720
H31	459	459	0.130	0.130	1.82	0.237	236,600
H32	478	478	0.476	0.476	2.09	0.995	994,840
H33	312	312	0.063	0.063	4.22	0.266	265,860

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Table 3
Base Flow Summary (Continued)

Basin	Individual Basin Area (acres)	Cumulative Basin Area (acres)	Individual Base Flow (MGD)	Cumulative Base Flow (MGD)	Cumulative Base Flow Peaking Factor	Cumulative Peak Base Flow [2] (MGD)	Individual Peak Base Flow (GPD)
P34	219	1712	0.038	0.642	1.67	1.072	63,460
P35	384	384	0.155	0.155	1.84	0.285	285,200
P36	504	504	0.169	0.169	1.90	0.321	321,100
P37	605	605	0.280	0.280	2.37	0.664	663,600
P38	415	415	0.125	0.125	1.81	0.226	226,250
P39	1496	1496	0.706	0.706	1.49	1.052	1,051,940
P40	2308	7999	0.825	3.312	1.25	4.140	1,031,250
P41	573	573	0.277	0.277	1.56	0.432	432,120
P42	341	341	0.152	0.152	1.40	0.213	212,800
P43	861	4503	0.154	2.030	1.35	2.741	207,900
P44	274	274	0.028	0.028	2.70	0.076	75,600
P45	548	548	0.212	0.212	1.73	0.367	366,760
P46	776	776	0.509	0.509	1.40	0.713	712,600
P47	2010	2091	1.109	1.126	1.42	1.599	1,574,780
P48	227	227	0.029	0.029	1.98	0.057	57,420
P49	81	81	0.017	0.017	3.41	0.058	57,970
P50	15	8014	0.013	3.325	1.24	4.123	16,120
P51	185	10110	0.030	4.186	1.26	5.274	37,800
2000-1[1]	966	966	0.362	0.362	1.91	0.691	691,420
2000-2	550	2550	0.316	0.678	1.83	1.241	578,280
2000-3	2000	2000	0.343	0.343	1.89	0.648	648,270
2000-4	260	260	0.570	0.570	1.78	1.015	1,014,600
2000-5&6	213	213	0.080	0.080	2.51	0.201	200,800
2000-7	80	80	0.217	0.217	1.97	0.427	427,490
2000-8	290	290	0.138	0.138	2.29	0.316	316,020
2000-9&10	220	220	0.287	0.287	2.25	0.646	645,750
2000-11	200	200	0.255	0.255	1.79	0.456	456,450
2000-12	340	340	0.252	0.252	1.42	0.358	357,840
2000-13	375	375	0.420	0.420	1.90	0.798	798,000
2000-14	275	275	0.123	0.123	2.72	0.335	334,560
2000-15	442	2045	1.205	3.004	1.39	4.176	1,674,950

Notes:

(1) - Area information for 2000 meters provided by the City; represents estimated developed area for each topographical metered area.

(2) - Cumulative Peak Base Flow is the product of the Cumulative Base Flow and the Base Flow Peaking Factor.

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Table 4
Infiltration Summary

Basin	Basin Area (acres)	Cum. Area (acres)	Ind. Basin footage (ft)	Cum. Basin footage (ft)	IDM[3]	Cumulative Infiltration (MGD)	Individual Infiltration (MGD)	Basin Infiltration Rate (GPD/ 1000ft)	Ranking [2]
M1	525	5544	18,908	408,329	60.6	0.764	N/A	N/A	N/A
M2	330	330	31,083	31,083	52.2	0.009	0.009	290	57
M3	855	4689	71,828	358,338	139.6	0.755	0.106	1,476	30
M4	602	602	65,437	65,437	103.1	0.262	0.262	4,004	7
M5	209	209	9,341	9,341	14.2	0.005	0.005	535	49
M6	172	172	13,283	13,283	20.0	0.003	0.003	226	59
M7	199	199	19,095	19,095	29.2	0.040	0.040	2,095	21
M8	1444	2381	92,052	148,634	173.1	0.323	0.121	1,314	33
M9	101	101	15,160	15,160	23.0	0.013	0.013	858	42
M10	170	170	15,560	15,560	23.8	0.003	0.003	193	61
M11	329	329	30,446	30,446	46.1	0.046	0.046	1,511	28
M12	608	608	26,136	26,136	54.3	0.156	0.156	5,969	3
H13	2744	14753	227,463	1,431,880	664.0	2.422	0.276	1,213	36
H14	309	309	43,280	43,280	68.1	0.122	0.122	2,819	14
H15	251	251	31,780	31,780	48.1	0.026	0.026	818	44
H16	375	754	38,852	86,284	75.4	0.171	0.089	2,291	19
H17	178	178	22,844	22,844	35.6	0.016	0.016	700	46
H18	2112	2112	286,798	286,798	182.4	0.712	0.712	2,483	16
H19	970	7212	72,463	626,644	236.7	1.030	0.167	2,305	18
H20	483	483	24,674	24,674	39.0	0.019	0.019	770	45
H21	235	235	26,429	26,429	41.5	0.006	0.006	227	58
H22	195	195	22,589	22,589	38.0	0.024	0.024	1,062	40
H23	279	279	33,095	33,095	57.6	0.020	0.020	604	48
H24	380	380	47,432	47,432	83.4	0.082	0.082	1,729	26
H25	235	235	24,545	24,545	37.6	0.171	0.171	6,967	2
H26	1141	3209	168,011	282,289	220.4	0.517	0.314	1,869	25
H27	1228	1706	78,187	181,629	143.2	0.145	0.010	128	62
H28	1092	1092	65,718	65,718	131.8	0.030	0.030	456	52
H29	233	233	27,055	27,055	48.7	0.112	0.112	4,140	6
H30	1064	1376	11,650	36,290	135.7	0.035	0.004	343	56
H31	459	459	50,933	50,933	83.2	0.056	0.056	1,099	39
H32	478	478	103,442	103,442	104.3	0.135	0.135	1,305	34
H33	312	312	24,640	24,640	45.2	0.031	0.031	1,258	35
P34	219	1712	34,070	227,424	64.3	0.317	0.004	117	63
P35	384	384	65,877	65,877	105.7	0.055	0.055	835	43
P36	504	504	55,646	55,646	89.2	0.161	0.161	2,893	12
P37	605	605	71,831	71,831	112.3	0.097	0.097	1,350	31

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Table 4
Infiltration Summary (Continued)

Basin	Ind. Area (acres)	Cum. Area (acres)	Basin Basin footage (ft)	Cum. Basin footage (ft)	IDM[3]	Cumulative Infiltration (MGD)	Individual Infiltration (MGD)	Basin Infiltration Rate (GPD/ 1000ft)	Ranking [2]
P38	415	415	42,697	42,697	66.1	0.080	0.080	1,874	24
P39	1496	1496	116,844	116,844	186.6	0.156	0.156	1,335	32
P40	2308	7999	159,493	563,179	341.2	0.927	0.240	1,505	29
P41	573	573	60,463	60,463	95.7	0.238	0.238	3,936	8
P42	341	341	26,606	26,606	42.6	0.051	0.051	1,917	23
P43	861	4503	101,781	288,472	183.6	0.392	0.120	1,179	37
P44	274	274	28,145	28,145	42.6	0.006	0.006	213	60
P45	548	548	44,030	44,030	71.9	0.040	0.040	908	41
P46	776	776	54,521	54,521	98.8	0.146	0.146	2,678	15
P47	2010	2091	69,350	77,268	189.1	0.082	0.078	1,125	38
P48	227	227	10,872	10,872	13.6	0.004	0.004	368	55
P49	81	81	7,918	7,918	1.3	0.004	0.004	505	50
P50	15	8014	33,904	597,083	279.9	0.940	0.013	383	54
P51	185	10110	41,699	798,323	235.4	1.193	0.017	408	53
2000-1 [1]		966	63,641	63,641	N/A	0.193	0.193	3,033	10
2000-2	550	2550	59,774	123,415	N/A	0.125	0.318	5,320	5
2000-3	2000	2000	149,237	149,237	N/A	0.103	0.103	690	47
2000-4	260	260	21,428	21,428	46.2	0.126	0.126	5,880	4
2000-5&6		213	16,383	16,383	33.5	0.062	0.062	3,784	9
2000-7	80	80	6,065	6,065	9.2	0.045	0.045	7,420	1
2000-8	290	290	36,255	36,255	67.5	0.103	0.103	2,841	13
2000-9&10		220	30,305	30,305	47.5	0.066	0.066	2,178	20
2000-11	200	200	29,007	29,007	44.9	0.060	0.060	2,068	22
2000-12	340	340	48,989	48,989	78.6	0.075	0.075	1,531	27
2000-13	375	375	53,628	53,628	N/A	0.157	0.157	2,928	11
2000-14	275	275	28,978	28,978	N/A	0.070	0.070	2,416	17
2000-15	442	2045	82,519	270,951	N/A	0.578	0.041	497	51

Notes:

(1) - Area information for 2000 meters provided by the City; represents estimated developed area for each topographic metered area.
(2) - Ranking is based on Basin Infiltration Rate (GPD/1000 ft)
(3) - IDM = Inch Diameter Miles

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Table 5
Inflow Summary

Basin	Basin Area (acres)	Cum. Area (acres)	Time of Concentration		Inflow Coefficient		1-Year Inflow [2]		10-Year Inflow [2]		Ranking [4]
			Time (min)	Cum. Time (min)	Basin "K"	Cum. "K"	Basin (MGD)	Cum. (MGD)	Basin (MGD)	Cum. (MGD)	
M1	525	5,544	165	165	0.00234	0.00234	0.37	3.86	1.03	10.90	27
M2	330	330	90	90	0.00353	0.00353	0.51	0.51	1.32	1.32	33
M3	855	4,689	150	150	0.00652	0.00313	1.66	4.36	4.68	12.33	22
M4	602	602	90	90	0.00475	0.00475	1.26	1.26	3.23	3.23	28
M5	209	209	60	60	0.00149	0.00149	0.19	0.19	0.45	0.45	25
M6	172	172	90	90	0.00088	0.00088	0.07	0.07	0.17	0.17	60
M7	199	199	105	105	0.00138	0.00138	0.10	0.10	0.28	0.28	57
M8	1,444	2,381	105	105	0.00190	0.00190	1.03	1.70	2.84	4.68	44
M9	101	101	90	90	0.00520	0.00520	0.23	0.23	0.59	0.59	35
M10	170	170	90	90	0.00174	0.00174	0.13	0.13	0.33	0.33	48
M11	329	329	105	105	0.00328	0.00328	0.40	0.40	1.12	1.12	39
M12	608	608	60	60	0.00610	0.00610	2.28	2.28	5.39	5.39	3
H13	2,744	14,753	210	210	0.01593	0.00682	11.30	26.01	31.08	71.53	8
H14	309	309	90	90	0.00412	0.00412	0.56	0.56	1.44	1.44	40
H15	251	251	75	75	0.00720	0.00720	0.99	0.99	2.34	2.34	17
H16	375	754	105	105	0.00436	0.00422	0.61	1.19	1.69	3.29	34
H17	178	178	75	75	0.00122	0.00122	0.12	0.12	0.28	0.28	59
H18	2,112	2,112	90	90	0.00950	0.00950	8.82	8.82	22.70	22.70	18
H19	970	7,212	210	210	0.00141	0.00350	0.35	6.53	0.97	17.94	62
H20	483	483	90	90	0.00234	0.00234	0.50	0.50	1.28	1.28	26
H21	235	235	75	75	0.00215	0.00215	0.28	0.28	0.65	0.65	45
H22	195	195	75	75	0.00246	0.00246	0.26	0.26	0.62	0.62	43
H23	279	279	105	105	0.00158	0.00158	0.17	0.17	0.46	0.46	61
H24	380	380	90	90	0.00408	0.00408	0.68	0.68	1.75	1.75	36
H25	235	235	60	60	0.01551	0.01551	2.24	2.24	5.30	5.30	2
H26	1,141	3,209	150	150	0.00136	0.00327	0.46	3.12	1.30	8.82	63
H27	1,228	1,706	120	120	0.00130	0.00239	0.58	1.48	1.55	3.95	53
H28	1,092	1,092	105	105	0.00092	0.00092	0.38	0.38	1.04	1.04	55
H29	233	233	75	75	0.01635	0.01635	2.10	2.10	4.93	4.93	4
H30	1,064	1,376	90	90	0.00171	0.00228	0.80	1.38	2.06	3.55	5
H31	459	459	90	90	0.00524	0.00524	1.06	1.06	2.72	2.72	24
H32	478	478	105	105	0.00520	0.00520	0.93	0.93	2.57	2.57	47
H33	312	312	75	75	0.00421	0.00421	0.72	0.72	1.70	1.70	19
P34	219	1,712	120	120	0.00230	0.00294	0.18	1.82	0.49	4.88	58
P35	384	384	90	90	0.00224	0.00224	0.38	0.38	0.97	0.97	54
P36	504	504	120	120	0.00231	0.00231	0.42	0.42	1.13	1.13	52
P37	605	605	75	75	0.00414	0.00414	1.38	1.38	3.24	3.24	29

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Table 5
Inflow Summary (Continued)

Basin	Basin Area (acres)	Cum. Area (acres)	Time of Concentration		Inflow Coefficient		1-Year Inflow [2]		10-Year Inflow [2]		Ranking [4]
			Time (min)	Cum. Time (min)	Basin "K"	Cum. "K"	Basin (MGD)	Cum. (MGD)	Basin (MGD)	Cum. (MGD)	
P38	415	415	90	90	0.00286	0.00286	0.52	0.52	1.34	1.34	42
P39	1,496	1,496	105	105	0.00188	0.00188	1.05	1.05	2.91	2.91	46
P40	2,308	7,999	150	150	0.00315	0.00315	2.16	7.49	6.11	21.17	38
P41	573	573	90	90	0.00605	0.00605	1.52	1.52	3.92	3.92	21
P42	341	341	75	75	0.00534	0.00534	1.00	1.00	2.35	2.35	15
P43	861	4,503	135	135	0.00468	0.00271	1.46	4.42	3.91	11.83	37
P44	274	274	60	60	0.00209	0.00209	0.35	0.35	0.83	0.83	41
P45	548	548	75	75	0.00245	0.00245	0.74	0.74	1.74	1.74	32
P46	776	776	75	75	0.00231	0.00231	0.98	0.98	2.32	2.32	30
P47	2,010	2,091	135	135	0.00201	0.00224	1.46	1.70	3.92	4.54	23
P48	227	227	105	105	0.00226	0.00226	0.19	0.19	0.53	0.53	31
P49	81	81	60	60	0.00764	0.00764	0.38	0.38	0.90	0.90	9
P50	15	8,014	210	210	0.00238	0.00238	0.01	4.93	0.03	13.56	64
P51	185	10,110	270	270	0.00860	0.00373	0.33	7.80	0.87	20.72	50
2000-1 [1]	966	966	75	75	0.00530	0.00530	2.83	2.83	6.67	6.67	11
2000-2	550	2550	75	na[3]	0.00320	na[3]	0.98	na[3]	2.30	na[3]	49
2000-3	2000	2000	90	90	0.00100	0.00100	0.84	0.84	2.17	2.17	56
2000-4	260	260	60	60	0.00530	0.00530	0.85	0.85	2.00	2.00	13
2000-5&6	213	213	60	60	0.00550	0.00550	0.72	0.72	1.71	1.71	12
2000-7	80	80	75	75	0.01480	0.01480	0.65	0.65	1.53	1.53	1
2000-8	290	290	60	60	0.01040	0.01040	1.85	1.85	4.38	4.38	7
2000-9&10	220	220	60	60	0.00790	0.00790	1.06	1.06	2.52	2.52	16
2000-11	200	200	60	60	0.01270	0.01270	1.56	1.56	3.70	3.70	6
2000-12	340	340	60	60	0.00640	0.00640	1.34	1.34	3.18	3.18	20
2000-13	375	375	60	60	0.00890	0.00890	2.05	2.05	4.86	4.86	14
2000-14	275	275	75	75	0.00900	0.00900	1.36	1.36	3.19	3.19	10
2000-15	442	2045	75	75	0.01038	0.00870	2.10	9.73	4.95	22.89	51

Notes:

Cum. = cumulative

(1) - Area information for 2000 meters provided by the City; represents estimated developed area for each topographic metered area

(2) - 1-year, 10-year and 50-year inflow are based on the following formula: Q= KiA*.6463
(conversion factor from CFS to MGD)

(3) - Cumulative time of concentration and inflow values could not be accurately determined due to the dynamic upstream effects of the Clear Creek Pump Station.

(4) - Ranking is based on Basin 1-Year Inflow Rate (gpd/1000 ft)

D.3 ADDITIONAL FLOW MONITORING RESULTS

D.3.1 Surcharge. Gravity sewers are typically designed to operate without surcharge during peak flow events. Surcharge occurs when the depth of water in a sewer exceeds the top of the pipe. Surcharge was significant and chronic at several metering sites. Table 6 summarizes the surcharging that occurred during the flow monitoring period.

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Table 6
Surcharge Summary

Site ID	Basin	Date of Surcharge	Maximum Level (in)	Pipe Diameter (in)	Surcharge Level[(1)] (in)	Storm Intensity (in/hr)	Cause
1	M1	06/13/03	87	27	60	0.89	Backup
7	M8	06/12/03	57	18	39	1.28	Unknown
7	M8	06/25/03	97	18	79	2.02	Backup
10	M6	06/25/03	18	8	10	2.02	Backup
11	M11	06/25/03	67	8	59	1.7	Capacity
20	H25	05/10/03	27	12	15	0.44	Capacity
20	H25	06/12/03	14	12	2	0.41	Backup
20	H25	06/13/03	20	12	8	0.14	Capacity
20	H25	06/25/03	15	12	3	0.63	Capacity
21	H27	05/04/03	55	15	40	0.72	Unknown
21	H27	05/10/03	51	15	36	0.49	Unknown
21	H27	06/02/03	38	15	23	0.36	Backup
21	H27	06/12/03	79	15	64	0.14	Backup
21	H27	06/13/03	82	15	67	0.08	Backup
21	H27	06/25/03	78	15	63	0.70	Backup
24	H30	05/04/03	16	10	6	0.72	Backup
24	H30	05/10/03	45	10	35	0.49	Backup
24	H30	06/12/03	37	10	27	0.14	Backup
24	H30	06/13/03	55	10	45	0.08	Backup
27	H31	06/12/03	66	18	48	0.14	Capacity
27	H31	06/13/03	31	18	13	0.08	Capacity
29	H15	05/09/03	9	8	1	no storm	Capacity
29	H15	05/10/03	16	8	8	0.44	Unknown
29	H15	05/15/03	11	8	3	0.23	Backup
29	H15	05/19/03	11	8	3	0.09	Unknown
29	H15	6/12/03 to 6/21/03	12	8	4	0.41	Backup
29	H15	06/25/03	8	8	0	0.63	Capacity
29	H15	06/26/03	9	8	1	0.63	Capacity
29	H15	06/27/03	10	8	2	no storm	Unknown
29	H15	06/28/03	9	8	1	no storm	Capacity
29	H15	7/1/03 to 7/7/03	10	8	2	0.55	Unknown
30	H16	05/10/03	26	15	11	0.44	Backup
30	H16	06/25/03	46	15	31	0.63	Backup
31	H24	06/25/03	10	8	2	0.63	Unknown
32	H24	05/10/03	16	12	4	0.44	Unknown
32	H24	06/25/03	15	12	3	0.63	Backup

Notes:
(1) – Water Level Above Crown of Pipe

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Table 6
Surcharge Summary (Continued)

Site ID	Basin	Date of Surcharge	Maximum Level (in)	Pipe Diameter (in)	Surcharge Level[(1)] (in)	Storm Intensity (in/hr)	Cause
36	P37	06/12/03	11	10	1	0.89	Capacity
36	P37	06/25/03	10	10	0	2.00	Capacity
45	P43	05/10/03	100	21	79	0.58	Backup
45	P43	06/11/03	23	21	2	0.57	Backup
45	P43	06/12/03	28	21	7	0.32	Backup
45	P43	06/13/03	91	21	70	0.36	Capacity
46	P42	05/04/03	15	15	0	0.72	Capacity
46	P42	05/10/03	83	15	68	0.58	Unknown
46	P42	07/01/03	19	15	4	0.56	Unknown
47	P45	05/10/03	40	15	25	0.58	Backup
47	P45	06/13/03	20	15	5	0.36	Backup
50	H13	06/13/03	160	60	100	0.89	Backup
50	H13	06/26/03	93	60	33	2.00	Backup
51	P48	06/11/03	17	8	9	0.57	Capacity
51	P48	06/12/03	36	8	28	0.32	Capacity
51	P48	06/13/03	34	8	26	0.36	Capacity
53	P50	06/13/03	90	54	36	0.89	Backup
54	P51	06/02/03	68	60	8	0.31	Backup
54	P51	06/13/03	134	60	74	0.89	Backup
54	P51	06/14/03	138	60	78	no storm	Backup
54	P51	06/26/03	137	60	77	2.00	Backup
55	P49	06/12/03	10	8	2	0.32	Capacity

Notes:
(1) – Water Level Above Crown of Pipe

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APPENDIX E

PUMP STATION INSPECTION AND EVALUATION

E.1 INTRODUCTION

The City of Columbia's collection system utilizes 19 pump stations in locations where the interceptor sewer system has not yet been developed in the service area or the service area cannot be collected by gravity or would otherwise be cost prohibitive to do so. An inventory was prepared for each station based on record drawings and other data provided by the City. Selected inventory data is included in Chapter 5. Recommendations for future use (expansion, consolidation, or elimination) are included in Chapter 7.

In addition to preparing the inventory, eight stations were selected by the City to be inspected on-site. The purpose of the inspection was to perform testing to evaluate pumping capacity; to evaluate the structural, mechanical and electrical condition of the station; to verify conformance with MDNR design guidelines; and to evaluate force main detention times and conditions which contribute to odor generation.

Pumping capacity was evaluated by performing a wet well draw-down test. During the test, one pump was operated at a time, measuring the draw-down volume and the operation time. Then the wet well was allowed to fill with normal influent to the station up to the original pump start elevation, measuring the fill volume and time. This data, along with the wet well geometry was used to determine the operational flow rate of each pump at the station.

The stations and respective force mains were also evaluated with regard to odor generation. To prevent septicity and odor generation, it is desirable to limit the detention time in the wet well or the force main to 30 minutes at base or average flow rates. However, in many instances this cannot be accomplished in force mains of considerable length.

This appendix summarizes the inspections of the following pump stations: Clear Creek, Ewing Industrial Park, Hinkson Creek (Mexico Gravel), Little Bonne Femme, North Hampton Village, Valley View, Victoria South, and Woodrail.

E.2 CLEAR CREEK PUMP STATION

E.2.1 Description and Inventory.

The Clear Creek pump station was constructed in 1986 and modified in 2003. There are no above grade buildings associated with the station. The station is comprised of a below grade wet well, a below grade dry well, and an electrical cabinet. A new package station was added in 2003 and sits above grade mounted on the wet well in a removable fiberglass housing.

The original station was constructed as a wet pit/dry pit type station and was equipped with two 650 gallons per minute (gpm) pumps. The pumping equipment and the dry pit enclosure were provided as a packaged unit. The firm capacity of the station was 650 gpm with the lead pump meeting the firm capacity and the second serving as a stand-by. When the station was modified in 2003, a packaged, suction-lift type station was added. The new packaged station has four pumps operating as two sets of two pumps in series (each set is rated for 980 gpm at 202 feet). The new pumping system has a rated capacity of 980 gpm with the lead set of pumps meeting the firm capacity and the second set serving as a stand-by. The first pump in each set draws suction directly from the existing wet pit. The new system discharges through a common header which runs down through the access shaft into the dry pit of the old station where it ties into the 10 inch force main. One of the original 650 gpm pumps remains piped to the force main and serves only as a back-up. The new pumping system was considered to be temporary until a more permanent station could be designed and constructed. The new pumps are operated based on wet well level measured with a bubbler type level sensor. The station is equipped with a telemetry system to communicate a general station alarm to the WWTP. Overflow protection is provided through a portable generator and an excess flow storage basin.

E.2.2 Inspection and Evaluation.

Both sets of pumps operated very near the rated capacity as listed on the nameplates of the pumps. Pump Set No. 1 had combined flow rate of 1,003 gpm. Pump Set No. 2 had combined flow rate of 1,061 gpm. The original pumps were not tested. The average influent during the testing was 328 gpm.

The station was in good structural and mechanical condition since it was very recently installed. The condition of the wet well could not be assessed due to limited access. The electrical system is original to the 1986 portion of the station and should be upgraded once the pump station becomes permanent. The existing site has two power feeds which were terminated on service poles at the site. The disconnect switches are still present but do not operate. Instead, power is routed directly to main disconnects inside the locked control cabinet. The cabinet houses an automatic transfer switch (inoperable), lighting panel, and control panel. The temporary pump station has two sets of pumps, each of the four motors are rated for 40 hp. The incoming power feed does not have the rated capacity to run both sets of pumps simultaneously. The power services should be upgraded so that this is possible.

The following items do not meet the MDNR design guidelines (10 CSR 20-8.130 Sewage Pumping Stations). 1. A minimum of three pumps should be provided for stations handling flows greater than one million gallons per day (mgd). The system in place provides only two pumps with the design peak flow well beyond the one mgd guideline. 2. Wet well access is not suitable for inspection and maintenance. 3. Access to the dry pit (original station) should be

provided with either rest landings at 10 foot intervals or a man-lift elevator. The station was originally equipped with a man-lift, which was removed in 2003 to install the discharge header from the new pumping system. 4. The original wet well was equipped with a bar screen which was removed to install the new pumping system. Since the influent sewer is less than 30 inches in diameter, it meets the design guide. However, Black & Veatch would recommend adding a bar screen as a protective measure for the pumps.

With regard to odor generation, the wet well volume size is such that a pump will operate at least once every 30 minutes at base flow. Retention time in the force main was calculated to be 105 minutes based on base flow. The force main retention time is in excess of the desired limit of 30 minutes and may produce odors in the receiving manhole.

E.3 EWING INDUSTRIAL PUMP STATION (EI)

E.3.1 Description and Inventory.

The Ewing Industrial pump station was constructed in 1998. There are no above grade buildings associated with the station. The station is comprised of a below grade wet well, a below grade valve vault, and an above grade electrical cabinet. The station is a submersible type station and is equipped with two 80 gpm pumps, which discharge to a 4 inch force main. The pumps are operated based on wet well level measured with float switches. A general station alarm is communicated to the WWTP with an auto dialer. Overflow protection is provided through a portable generator and pump.

E.3.2 Inspection and Evaluation.

Both pumps operated slightly in excess of the rated capacity listed in the *Pump Station Quick Reference*. Pump No. 1 had a flow rate of 106 gpm and Pump No. 2 had a flow rate of 127 gpm. During testing there was no measurable influent to the station. Staff indicated that the station has very little run time. It was also observed at this station that the shutoff valve from each pump was located upstream of the check valve. City of Columbia standards require the shutoff valve to be downstream of the check valve.

The station was in good structural and mechanical condition. No concrete corrosion was observed in the wet pit or valve vault. Corrosion was noted on the ductile iron piping and valving. These surfaces should be cleaned and recoated. The electrical system was in satisfactory condition.

The station meets or exceeds MDNR design guidelines (10 CSR 20-8.130 Sewage Pumping Stations).

With regard to odor generation, the wet well volume size is such that a pump will operate at least once every 30 minutes at base flow. Retention time in the force main was calculated to

be 325 minutes based on base flow. The force main retention time is in excess of the desired limit of 30 minutes and may produce odors in the receiving manhole.

E.4 HINKSON CREEK (MEXICO GRAVEL) PUMP STATION (HC)

E.4.1 Description and Inventory.

The Hinkson Creek pump station was constructed in 1977. There are no above grade buildings associated with the station. The station is comprised of a below grade wet well and a below grade dry well. The station is a wet pit / dry pit type station and is equipped with two 800 gpm pumps, which discharge to an 8 inch force main. The pumps are operated based on wet well level measured a bubbler type level sensor. The station is equipped with a telemetry system to communicate a general station alarm to the WWTP. Overflow protection is provided through a portable generator and a bypass to the gravity interceptor sewer (the station only provides 10 feet of lift).

E.4.2 Inspection and Evaluation.

The measured flow rate for both pumps was much below the rated capacity listed on the nameplates and in the *Pump Station Quick Reference*. Pump No. 1 had a flow rate of 292 gpm and Pump No. 2 had a flow rate of 292 gpm. The only immediate explanation is our uncertainty with regard to the wet well diameter. The lower chamber of the wet well could not be accessed due to confined space restrictions and drawings were not available. The upper chamber was 6 feet in diameter, which was assumed in determining wet well volumes. The lower chamber may be larger in diameter than what was assumed. The average influent during the testing was 66 gpm, which may also be skewed by the wet well geometry.

The station was in good structural and mechanical condition. No concrete corrosion or damage was observed on the wet pit. However, the lower chamber was not inspected due to confined space limitations. The interior of the dry pit was in good condition. Coatings on the enclosure walls, piping, pumps, motors, valves and other items were in good condition. The electrical system was in satisfactory condition. However, there is evidence of corrosion around the exterior conduit fittings and there is a lack of seal fittings where conduits enter/exit the wetwell. Conduit fittings exterior to the dry/wet pit have corroded and one conduit connection has failed, leaving exposed wiring.

The following items do not meet the MDNR design guidelines (10 CSR 20-8.130 Sewage Pumping Stations) and/or other codes. 1. Conduits should be sealed and the conduit repaired to protect the exposed wiring.

With regard to odor generation, the wet well volume size is such that a pump will operate at least once every 30 minutes at base flow. Retention time in the force main was calculated to

be less than 1 minute based on base flow. Odor should not be generated due to force main retention time.

E.5 LITTLE BONNE FEMME PUMP STATION (LBF)

E.5.1 Description and Inventory.

The Little Bonne Femme pump station was constructed in 1993. The site has one above grade building of concrete block construction. The building consists of an electrical room and a chemical room. The electrical room houses the motor control center for the sewage pumps, lighting panel, and pump control cabinet. The chemical room houses odor control equipment including two 3,000 gallon liquid chemical tanks and appurtenant chemical feed pumps, valves, and piping. The odor control system is not presently used. The chemical feed equipment was used to dose an odor control agent to an on-site manhole upstream of the wet well. Other structures on-site include the inlet box/wet well, valve vault, and flow meter vault. The inlet box contains a basket screen, w/ JIB crane, and two 16 inch sluice gates w/ manual operators, which provide isolation of the divided wet well. The wet well is divided into two chambers, each containing two submersible pumps. The valve vault houses an 8 inch plug valve and an 8 inch check valve for each of the four pump discharges. The meter vault houses a 14 inch magnetic flowmeter, a 14 inch ball valve, and an air release.

The station is a submersible type station and is equipped with four 700 gpm pumps, which discharge to a 14 inch force main. The pumps are operated based on wet well level measured with level sensors. The station is equipped with a telemetry system to communicate a general station alarm to the WWTP. Overflow protection is provided through a dual power feed.

E.5.2 Inspection and Evaluation.

All the pumps operated in excess of the rated capacity listed in the *Pump Station Quick Reference*. Pumps No. 1, 2, 3, and 4 had flow rates of 962 gpm, 982 gpm, 954 gpm, and 835 gpm, respectively. The average influent during the testing was 312 gpm.

The station was in good structural and mechanical condition. No concrete corrosion was observed in the wet pit or valve vault. Corrosion was noted on the ductile iron piping in the wet pit. These surfaces should be cleaned and recoated. The electrical system was in satisfactory condition. However, it was noted that the rigid galvanized steel conduit has a large amount of corrosion on the conduit fittings. Staff also indicated that the JIB crane has problems with corrosion.

The station meets or exceeds MDNR design guidelines (10 CSR 20-8.130 Sewage Pumping Stations).

With regard to odor generation, the wet well volume size is such that a pump will operate

at least once every 30 minutes at base flow. Retention time in the force main was calculated to be 700 minutes based on base flow. The force main retention time is in excess of the desired limit of 30 minutes and may produce odors in the receiving manhole.

E.6 NORTH HAMPTON VILLAGE PUMP STATION (NHV)

E.6.1 Description and Inventory.

Records indicate that the North Hampton Village pump station was constructed between 1996 and 2002. There are no above grade buildings associated with the station. The station is comprised of a below grade wet well, a below grade valve vault, and an above grade electrical cabinet. The station is a submersible type station and is equipped with two 250 gpm pumps, which discharge to a 6 inch force main. The pumps are operated based on wet well level measured with float switches. The station is equipped with a telemetry system to communicate a general station alarm to the WWTP. Overflow protection is provided through a portable generator and pump.

E.6.2 Inspection and Evaluation.

Both pumps operated slightly below the rated capacity listed in the *Pump Station Quick Reference*. Pump No. 1 had a flow rate of 233 gpm and Pump No. 2 had a flow rate of 242 gpm. The average influent during the testing was 21 gpm.

The station was in good structural and mechanical condition. No concrete corrosion was observed in the wet pit or valve vault. Corrosion was noted on the ductile iron piping, valving, and the supports for the rail guides for the pumps. These surfaces should be cleaned and recoated. Significant grease deposits were noticed in the wet well. The grease build-up should be removed as it may interfere with the float switches and operation of the pumps. The only noted defect in the electrical system was that the conduits at the pump station do not have seal fittings where they enter/exit the wet well.

The following items do not meet the MDNR design guidelines (10 CSR 20-8.130 Sewage Pumping Stations) and/or other codes. 1. Conduits should be sealed.

With regard to odor generation, the wet well volume size is such that a pump will operate at least once every 30 minutes at base flow. Retention time in the force main was calculated to be 375 minutes based on base flow. The force main retention time is in excess of the desired limit of 30 minutes and may produce odors in the receiving manhole.

E.7 VALLEY VIEW PUMP STATION (VV)

E.7.1 Description and Inventory.

The Valley View pump station was constructed in 1974. The station is comprised of a

below grade wet well and a packaged station mounted above grade on the wet well enclosed in a fiberglass housing. The station is a suction lift type station and is equipped with two 80 gpm pumps, which discharge to a 4 inch force main. The pumps are operated based on wet well level measured with float switches. A general station alarm is communicated to the WWTP with an auto dialer. Overflow protection is provided through a portable generator and pump.

E.7.2 Inspection and Evaluation.

Both pumps operated in excess of the rated capacity listed in the *Pump Station Quick Reference*. Pump No. 1 had a flow rate of 168 gpm and Pump No. 2 had a flow rate of 128 gpm. The average influent during the testing was 5 gpm.

Despite the age of the station, it is still operating well mechanically and is in good structural condition. No concrete corrosion was observed in the wet pit. Corrosion was noted on the suction piping, steel base frame, and equipment within the enclosure. These surfaces should be cleaned and recoated. Significant grease deposits were noticed in the wet well. The grease build-up should be removed as it may interfere with the float switches and operation of the pumps. The electrical system was in satisfactory condition with minor corrosion noted on the conduit.

The station meets or exceeds MDNR design guidelines (10 CSR 20-8.130 Sewage Pumping Stations).

With regard to odor generation, the wet well volume size is such that a pump will operate at least once every 30 minutes at base flow. Retention time in the force main was calculated to be 10 minutes based on base flow. Odor should not be generated due to force main retention time.

E.8 VICTORIA SOUTH PUMP STATION (VS)

E.8.1 Description and Inventory.

Records indicate that the Victoria South pump station was constructed in 2000. There are no above grade buildings associated with the station. The station is comprised of a below grade wet well, a below grade valve vault, an open top storage basin, and an above grade electrical cabinet. The station is a submersible type station and is equipped with two 120 gpm pumps, which discharge to a 2 ½ inch force main. The pumps are operated based on wet well level measured with float switches. A general station alarm is communicated to the WWTP with an auto dialer. Overflow protection is provided through a portable generator and pump and an excess flow storage basin.

E.8.2 Inspection and Evaluation.

Both pumps operated significantly below the rated capacity listed in the *Pump Station Quick Reference*. Pump No. 1 had a flow rate of 16 gpm and Pump No. 2 had a flow rate of 17 gpm. The

average influent during the testing was 5 gpm. Based on available data, a system headloss/pump curve was prepared which indicated that with the 2 ½ inch force main, one pump should be operating between 30 and 40 gpm. To obtain a flow rate consistent with the rated capacity of the pumps, a larger force main would need to be installed. Provisions for such an extension were designed into the subdivision development plan. A 4 inch force main was installed parallel to the 2 ½ inch main from the station to the edge of the subdivision.

The station was in good structural condition. No concrete corrosion was observed in the wet pit or valve vault. Corrosion was noted on the rail guides for the pumps. These surfaces should be cleaned and recoated. The mechanical condition of the station was questionable. Even though most of the poor pump performance can be explained by the small diameter force main, the pumps are still performing at about half the anticipated flow rate. The station should be evaluated in more detail to identify the source of the poor performance and to consider installation of a larger force main. The condition of the emergency storage basin was acceptable. However, since the basin is open topped and in close proximity to adjacent homes, it will be a source of odor when in use.

The condition of the electrical system was also questionable. The main disconnect for the pump station is located on the utility service pole outside of the fenced area on the side of the adjacent berm. Immediate access to the disconnect is poor. The operator must exit the fenced area and traverse the berm to reach the disconnect. The utility service should be moved inside of the enclosed area and should be easily accessible from the pump station. The electrical control panel appears to have been recently replaced. A disconnected receptacle has been abandoned in place with the wires exposed. The receptacle, cable, and conduit should be removed. Conduit entering the control panel should be provided with seal fittings. The conduit terminations to the panels are also failing. The underside of the panel has been stressed and damaged. The conduits and seal fittings should be repaired or replaced. The proximity and accessibility to the open topped overflow basin associated with this pump station indicates that an autodialer may not be the best option for alarm communication. Black & Veatch would recommend continuous monitoring of power failure, pump failure, and wet well level. A telemetry system would be the most practical option.

The following items do not meet the MDNR design guidelines (10 CSR 20-8.130 Sewage Pumping Stations) and/or other codes. 1. The electrical cabinet and conduits should be repaired and sealed.

With regard to odor generation, the wet well volume size is such that a pump will operate at least once every 30 minutes at base flow. Retention time in the force main was calculated to be 50 minutes based on base flow. The force main retention time is in excess of the desired limit of 30 minutes and may produce odors in the receiving manhole.

E.9 WOODRAIL PUMP STATION (WR)

E.9.1 Description and Inventory.

The Woodrail pump station was constructed in 1981. The station is comprised of a below grade wet well and a packaged station mounted above grade on the wet well enclosed in a fiberglass housing. The station is a suction lift type station and is equipped with two 80 gpm pumps, which discharge to a 4 inch force main. The pumps are operated based on wet well level measured with float switches. A general station alarm is communicated to the WWTP with an auto dialer. Overflow protection is provided through a portable generator and pump.

E.9.2 Inspection and Evaluation.

Both pumps operated near the rated capacity listed in the *Pump Station Quick Reference*. Pump No. 1 had a flow rate of 84 gpm and Pump No. 2 had a flow rate of 73 gpm. The average influent during the testing was 11 gpm.

Despite the age of the station, it is still operating well mechanically and is in good structural condition. No concrete corrosion was observed in the wet pit. Corrosion was noted on the steel base frame and equipment within the enclosure. These surfaces should be cleaned and recoated. The electrical system was in satisfactory condition with minor corrosion noted on the conduit. The station meets or exceeds MDNR design guidelines (10 CSR 20-8.130 Sewage Pumping Stations).

With regard to odor generation, the wet well volume size is such that a pump will operate at least once every 30 minutes at base flow. Retention time in the force main was calculated to be 40 minutes based on base flow. The force main retention time is in excess of the desired limit of 30 minutes and may produce odors in the receiving manhole.