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Volume 2
Final Long-Term Control Plan

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Prepared for

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I certify under penalty of law that I have examined and am familiar with the information submitted in this document and all attachments and that this document and its attachments were prepared under my direction or supervision in a manner designed to ensure that qualified and knowledgeable personnel properly gather and present the information contained therein. I further certify, based on my inquiry of those individuals immediately responsible for obtaining the information, that I believe that the information is true, accurate, and complete. I am aware that there are significant penalties for submitting false information, including the possibility of fines and imprisonment.

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Acronyms and Abbreviations

AADF	annual average daily flow
AMSL	above mean sea level
BAI	Broadway Avenue Interceptor
BAF	biological aerated filter
BEACH	Beaches Environmental Assessment and Coastal Health
BioCEC	Biological and Chemically-Enhanced Clarification
BOD	biochemical oxygen demand
$CBOD_5$	5-day carbonaceous biochemical oxygen demand
CEPT	Chemically-Enhanced Primary Treatment
cfm	cubic feet per minute
CFU/mL	colony-forming unit per milliliter
City, the	City of Evansville
CIP	capital improvements plan
CIPP	cast-in-place pipe
CMOM	Capacity, Management, Operation, and Maintenance
CSOOP	Combined Sewer Overflow Operational Plan
CSO	combined sewer overflow
CSS	combined sewer system
CWA	Clean Water Act
Decree	Consent Decree approved by federal court in June 2011
DMR	Discharge Monitoring Report
DWF	dry-weather flow
E. Coli	*Escherichia coliform*
ECI	essential control and instrumentation
Elev.	Elevation
EPA	U.S. Environmental Protection Agency
EPBM	earth pressure balance machine
EVLAD	Evansville-Vanderburgh Levee Authority District

fps	foot per second
FRP	fiberglass reinforced plastic
ft	foot, feet
ft^2	square feet
ft^3	cubic feet
GI	green infrastructure
GM	geometric mean
gpm	gallons per minute
HD	high definition
HDPE	high density polyethylene
hp	horsepower
HR	Hydraulic Resistance Time
HRT	high-rate treatment
I/I	infiltration and inflow
IC	Indiana Code
IDEM	Indiana Department of Environmental Management
IDNR	Indiana Department of Natural Resources
in	inch
IOCP	Integrated Overflow Control Plan
lb/day	pounds per day
LF	linear feet
LTCP	Long-Term Control Plan
MG	million gallons
mg/L	milligrams per liter
mgd	million gallons per day
MH	manhole
MHI	median household income
mL	milliliter
mm	millimeter
NECA	National Electrical Contractors Association

NH4N	ammonia-nitrogen
NPDES	National Pollutant Discharge Elimination System
NPV	Net Present Value
NRDC	National Resources Defense Council
OF/yr	overflows per year
ORSANCO	Ohio River Valley Sanitation Commission
O&M	operations and maintenance
PACC	Program Alternative Cost Calculator
PCCMP	Post Construction Compliance Monitoring Program
PCMP	Post Construction Monitoring Program
PCI	Pigeon Creek Interceptor
PCS	Pollution Control Standards
PE	Primary Effluent
PLC	programmable logic controller
PS	pump station
QA/QC	Quality Assurance/Quality Control
RAS	return activated sludge
RWQC	Recreational Water Quality Criteria
RDII	rainfall-derived inflow and infiltration
scfm	standard cubic feet per minute
SEIM	Socioeconomic Indicator Matrix
SFLA	Shuffled Frog Leaping Algorithm
SRCER	Stream Reach Characterization Evaluation Report
SSES	sewer system evaluation survey
SSS	separate sanitary sewer
SSO	sanitary sewer overflow
SSRMP	Sanitary Sewer Remedial Measures Plan
STBM	slurry-shield tunnel boring machine
SWCD	Soil and Water Conservations District
SWD	sidewater depth

TBM	tunnel boring machine
TDH	total dynamic head
TEFC	totally enclosed, fan cooled
TM	technical memorandum
TMDL	total maximum daily load
TSS	total suspended solids
TWQ	total water quality
USACE	U.S. Army Corps of Engineers
USGS	U.S. Geological Survey
Utility, the	Evansville Water & Sewer Utility
VTU	Vertical Treatment Unit
UAA	use attainability analysis
UV	ultraviolet
WAS	waste activated sludge
WW_{CPHI}	wastewater cost per household indicator
WWF	wet-weather flow
WWTP	wastewater treatment plant

Terminology and Naming Conventions

The following terminology is used throughout to describe the Evansville Water & Sewer Utility's (the Utility's) wastewater collection and treatment system:

- **Alternative:** a grouping of projects basin-wide from which one can assess the level of performance
- **Basin or sewershed:** geographic areas currently served by a trunk sewer and the building blocks of the wastewater treatment plant (WWTP) service areas. The Utility considers trunk sewers in the separate sanitary sewer system (SSS) collection system to be pipes 12 inches or more in diameter. Flow from all but one of the Utility's SSS basins is transported through the combined sewer system (CSS), and most of the basins discharge the SSS flow into the CSS trunk sewers by gravity. Only one SSS basin pumps flow to another SSS basin. Basins are made up of multiple subbasins and are typically named using distinctive geographic features that make them easily identifiable.
- **Collector sewers:** sewers less than 12 inches in diameter. These sewers collect flow from homes and businesses and transport the flow to trunk sewers. The majority of the Utility's collector sewers are 8 and 10 inches in diameter.
- **Combined sewer overflow (CSO)**—about 770 sewer systems in the U.S. are designed to collect rainwater runoff, domestic sewage, and industrial wastewater in the same pipes. Most of the time, combined sewer systems convey all of their wastewater to a WWTP, where it is treated and then discharged to a water body. During periods of heavy rainfall or snowmelt, however, the wastewater volume in a combined sewer system can exceed the capacity of the sewer system or WWTP. For this reason, combined sewer systems are designed to overflow occasionally and discharge excess wastewater directly to nearby streams, rivers, or other water bodies.
- **Interceptors:** CSS trunk sewers that transport dry-weather flow (DWF) to the WWTP. During wet weather, the Utility maximizes the use of the interceptors for transport and storage of wet-weather flow (WWF).
- **Interceptor system or subsystem:** geographic areas containing multiple basins served by a single interceptor.
- **Option:** one of many projects, or grouping of projects, considered as part of alternatives development
- **Project:** one or more CSO control technologies in a specific area
- **Subbasins:** the basic building blocks of basins. In this case, subbasins are made up of the collector sewers and the properties assumed to discharge into the collector sewers.
- **Trunk sewers:** SSS sewers that are 12 inches or more in diameter. These sewers transport flow from the neighborhood collector sewers to CSS or SSS lift stations—or to combined sewer interceptors or the WWTP—via gravity.

- **Utility service area:** the geographic area currently served by the Utility and the area that could potentially be served by the Utility. Currently, the service area includes the City of Evansville and Vanderburgh County and consists of the East and West WWTP Service Areas.
- **Wastewater treatment plant service areas:** The geographic areas served by each of the Utility's WWTPs. Currently, the East and West Service Areas are separate and distinct, with no transfer of flow from one WWTP service area to the other. Each of the two service areas includes several interceptor systems.

SECTION 1

Introduction

1.1 Volume 2, Long-Term Control Plan Document Organization

This Long-term Control Plan (LTCP) is Volume 2 of the Integrated Overflow Control Plan (IOCP). This LTCP focuses on evaluations and recommendations for the control and mitigation of combined sewer overflows (CSOs). **This Volume includes a Recommended Plan set forth in Section 8 below, which was submitted to EPA and IDEM for review on May 31, 2013, and a final Negotiated Plan set forth in Section 9 below which is based upon an agreement between Evansville and EPA and IDEM for increased CSO control. The final Negotiated Plan supersedes the Recommended Plan. The analysis and work described in Sections 2 through 7 were performed in developing the May 31, 2013, Recommended Plan, but also provides information and background pertinent to the Final Negotiated Plan.**

Section 1 Background and Introduction. Section 1 summarizes the Evansville Water & Sewer Utility's (Utility) requirements and objectives in compiling this document.

Section 2 System Characterization. Section 2 provides an in-depth description of the combined sewer system (CSS) service area. It also summarizes analyses of existing baseline conditions of the CSS service area, and of the monitoring and modeling of the CSS and the receiving waters.

Section 3 Alternatives Evaluation Methodology. Section 3 outlines the approach and factors used to identify, develop, evaluate, and select projects that reduce the number, duration, and volume of CSO events.

Section 4 Alternative Screening – West Basin. Section 4 provides an overview of the CSO control technologies considered for the West Basin, the alternative screening process, and the screening results that led to identification of an appropriate list of alternatives for further evaluation.

Section 5 Alternative Screening – East Basin. Section 5 is similar to Section 4 described above, but focuses on the East Basin.

Section 6 Alternatives Evaluation. Section 6 provides an explanation of the alternatives evaluated to achieve 0, 1, 3, 4, 7, 8, and 12 CSO discharges in a typical year on an annual basis, as well as the costs and benefits associated with each alternative evaluated.

Section 7 Water Quality Modeling Assessment of CSO Control Measures. Section 7 provides an overview of receiving water quality for the range of level of control evaluated.

Section 8 Recommended Long-term Control Plan – May 31, 2013. Section 8 presents the plan and implementation schedule submitted to EPA and IDEM on May 31, 2013, and recommended for implementation and the basis of selection, including consideration of cost, benefits, water quality assessment, CSO Policy, and Consent Decree approved by federal court in June 2011 (Decree) requirements.

Section 9 Final Negotiated Long-term Control Plan and Schedule – January 15, 2016. Section 9 describes the final negotiated long-term control plan reached via agreement between

Evansville, EPA and IDEM regarding the level of CSO control, including the implementation schedule. This plan supersedes the Recommended Plan.

Section 10 Post Construction Monitoring Program. Section 10 presents the monitoring program planned to monitor the effectiveness of the control measures following construction.

Section 12 References Cited. Section 11 contains bibliographic references for the documents cited in this LTCP.

1.2 Background and Plan Introduction

1.2.1 Combined Sewer Overflows and Regulatory Requirements

Approximately 100 years ago, Evansville and many other cities across the United States began building sewers to carry stormwater away from homes, businesses, and streets to nearby rivers and streams. Later, when indoor plumbing was introduced, homes and businesses connected their sewage lines to those same storm sewers, making them "combined" sewers – or sewer pipes that by design carried both stormwater and wastewater to adjacent waterways. In the mid-20th century, Evansville and other cities upgraded the sewer infrastructure to include intercepting sewers along rivers and other waterways that route a portion of these flows to wastewater treatment plants (WWTPs). In dry weather, wastewater is sent to WWTPs for treatment. During rain events or snowmelt, CSOs occur when the amount of stormwater runoff and sanitary waste exceeds the capacity of the pipes, resulting in overflows into local water bodies. The required capital plan to address CSOs is referred to as the *CSO Long-term Control Plan (*LTCP). The LTCP, a *Sanitary Sewers Remedial Measures Plan* (SSRMP), and a *Facility Plan for the East and West WWTPs* comprise Evansville's *Integrated Overflow Control Plan* (IOCP) (CH2M HILL, 2013), which is a comprehensive, overarching plan to dramatically upgrade Evansville's sewer system to address sewer system overflows.

As noted above, an LTCP addresses the problem of CSOs discharging waste and pollutants into rivers and streams, typically during wet weather events when rain water enters and overwhelms the system. Until the 1950s, overflows from combined sewers were an accepted practice in communities as both stormwater and wastewater were collected in the same pipe and transported to waterways for disposal during wet weather. Communities across the country with CSSs are now required to develop long-term CSO control plans with the goal of reducing the number, duration, and volume of overflows and coming into compliance with the Clean Water Act (CWA) and the U.S. Environmental Protection Agency's (EPA's) 1994 *Combined Sewer Overflow Control Policy* (CSO Control Policy). Indiana has nearly 100 communities with CSOs and over 1,000 communities across the country are working to develop, fund and implement LTCPs, all at varying levels of completeness.

1.2.2 Evansville CSOs and Plan to Address Them

In Evansville, approximately two billion (2,000,000,000) gallons of combined wastewater and stormwater leave the sewer system through 22 outfalls in a typical year and are dumped without treatment directly into the Ohio River and Pigeon Creek. Overflows can occur with as little as a tenth of an inch (0.1") of rainfall, and Evansville experiences approximately 50 days of CSOs in a typical year. Consequently, during rain events raw sewage and other items in the sewer system are dumping into and polluting our waterways.

Evansville's commitment to address sewer overflows and improve operations are set forth in a federal Consent Decree, or agreement, entered into in 2010 between the City, EPA and the Indiana Department of Environmental Management (IDEM) that resolved certain allegations that Evansville was violating the CWA. The Decree was approved by a federal court in June 2011.

For the Recommended Plan, the Utility is proposing a two-phased, 28-year total LTCP schedule to address and dramatically reduce the number of CSOs that occur in Evansville. When complete, the plan will reduce overflows from approximately 50 activations per year to 12 during a typical year and increase the CSS's percent capture from 35 percent to 92 percent. The EPA CSO Control Policy seeks to have cities reduce overflows from 0 to 12 activations per year and increase percent capture from 75 to 100 percent. Therefore, the proposed LTCP meets the regulatory thresholds put forth by EPA and the CWA. It is worth noting that the complete elimination CSOs is cost-prohibitive and simply not practical – so residual CSOs will occur during some large storm events.

Additionally, limiting CSO activations to 12 in a typical year maximizes the water quality benefits on Pigeon Creek and the Ohio River. A robust water quality analysis of Pigeon Creek and the Ohio River has shown that the waterways are significantly impaired when they reach Evansville and reducing Evansville's CSO activations to less than 12 in a typical year results in no additional days of water quality compliance for *Escherichia coliform (E. Coli)* bacteria during the recreational season, from April to October.

The Recommended LTCP is comprised of a combination of remote storage, green sustainable infrastructure, increased treatment plant capacity, one remote high-rate treatment (HRT) facility, sewer separation in some areas, better control of existing flow to maximize existing sewer pipes, and a large wetland to address and treat overflows at Bee Slough--essentially eliminating the old concrete slough as a holding area for untreated sewage. The engineering team developing the plan evaluated thousands of options and combinations of solutions to arrive at a cost-effective plan that will make dramatic improvements to the sewer system to comply with the federal mandate and CWA while attempting to keep costs as low as possible for rate payers. The plan and engineering analysis to arrive at the projects and technologies to accomplish this goal are set forth below in this volume.

The plan and details set forth in this document include the information expected in an LTCP as described in the EPA CSO Control Policy. Many other aspects required to meet the intent of the CSO Control Policy and develop a comprehensive LTCP are documented in distinct reports required under other sections of the Decree. The submittal requirements presented in Appendix B of the Decree that have been completed and/or submitted to date are listed in Table 1-1, and all of the deliverables submitted thus far are available on the *Renew Evansville* website at www.renewevansville.com.

Table 1-1 Submittal Requirements Listed in Decree Appendix B

	Deliverable	Due Date	Status	Description
1	*Separate Sanitary Sewer System Evaluation Work Plan* (CH2M HILL, 2010a)	November 30, 2010	Submitted	Basis for conducting sewer system evaluation surveys (SSESs) on portions of the separate sanitary sewer (SSS)

Table 1-1 Submittal Requirements Listed in Decree Appendix B

	Deliverable	Due Date	Status	Description
2	*Sewer Overflow Response Plan 1.0* (CH2M HILL, 2010b)	December 1, 2010	Submitted	
3	*Public and Regulatory Participation Plan* (CH2M HILL, 2010c)	December 31, 2010	Submitted	
4	*West WWTP and 7th Avenue Pump Station Wet-weather Operating Plan* (CH2M HILL, 2011a)	January 31, 2011	Submitted	Documents current operational attributes of the 7th Avenue Lift Station and West Side Interceptor System, as well as the relationship between the 7th Avenue Lift Station and the West WWTP
5	*Modeling Work Plan, including Capacity Assessment Work Plan and Approach for Determining Critical Storm Duration* (CH2M HILL, 2011b)	April 30, 2011	Submitted	Basis for facilitating development, calibration, and validation of the hydraulic models
6	Installation of baffles in the secondary treatment system clarifiers at the West WWTP	April 30, 2011	Completed	Early Action Project required for Decree.
7	*Capacity Management Operation and Maintenance 2.0* (CH2M HILL, 2011c)	May 1, 2011	Submitted	
8	*Sewer Overflow Response Plan 2.0* (CH2M HILL, 2011d)	May 1, 2011	Submitted	
9	Utilization of a data system for tracking operating and maintenance activities	July 31, 2011	Completed	
10	*2011 Stream Reach Characterization and Evaluation Report Update (SRCER)* (CH2M HILL and LimnoTech, 2011)	August 31, 2011	Submitted	Documents the Utility's current understanding of the receiving waters
11	*West WWTP Stress Testing Protocols and Secondary Clarifier Capacity Report* (CH2M HILL, 2011f)	November 1, 2011	Submitted	Documents current operational attributes of the West WWTP
12	*West WWTP Step Feed and Contact Stabilization Study* (CH2M HILL, 2011g) *East WWTP Step Feed and Contact Stabilization Study* (CH2M HILL, 2011h)	November 1, 2011	Submitted	Document current operational attributes of the West and East WWTPs
13	*Stress Test Protocols* (CH2M HILL, 2011i)	November 1, 2011	Submitted	
14	Complete trunk sewer survey and condition assessment	November 30, 2011	Complete	Used as the primary means for data acquisition to adequately support development of the hydraulic models
18	*System Characterization and SSS Model Calibration Reports* (CH2M HILL, 2011j)	November 30, 2011	Submitted	Documents the Utility's current understanding of sewer system conditions
19	*Critical Storm Duration Analysis* (CH2M HILL, 2011l)	December 31, 2011	Submitted	Establishes the storm used to conduct the capacity assessment

Table 1-1 Submittal Requirements Listed in Decree Appendix B

	Deliverable	Due Date	Status	Description
20	*Revised Financial Analysis* (CH2M HILL, 2012b)	January 31, 2012	Submitted	
21	*CSO Alternative Screening Report* (CH2M HILL, 2012c)	January 31, 2012	Submitted	Presents the evaluation and screening of alternatives for the CSS
22	Installation of East WWTP Early Action Upgrades	March 1, 2012	Completed	
23	*Sanitary Sewer Systems Assessment Report* (CH2M HILL, 2012d)	March 31, 2012, updated July 31, 2012	Submitted	Presents results of SSES condition assessment and capacity assessment
24	Stress Test at East and West WWTPs	July 31, 2012	Completed	
25	Implement Maximum Treatable Flow Operations	July 31, 2012	Completed	
26	Submit Draft IOCP, CSO/SSS Capacity Alternatives Analysis, LTCP, SSRMP, Facility Plans for Expansions of the East and West WWTPs, and proposed implementation schedules	July 31, 2012	Submitted	
27	Revise the West and East WWTP maximum treatable flow designations in CSOOP	November 1, 2012	Completed	
28	Submit CMOM 3.0	November 30, 2012	Submitted	
29.	Submit Recommended IOCP, CSO/SSS Capacity Alternatives Analysis, LTCP, SSRMP, Facility Plans for Expansions of the East and West WWTPs, and proposed implementation schedules.	May 31, 2013	Submitted	

Notes:

CMOM = Capacity, Management, Operation, and Maintenance

CSOOP = Combined Sewer Overflow Operational Plan

1.3 Past CSO Control Summary

The Utility has invested well over $100 million in recent years to upgrade sewer infrastructure, eliminate constructed sanitary sewer discharge points, reduce chronic neighborhood flooding, lessen discharges from the sewer systems, and maximize capacity of the WWTPs. The Utility has also been working diligently to operate more efficiently and effectively.

The City of Evansville's (the City's) recent accomplishments related to CSO reduction are briefly summarized below. They were more thoroughly presented in the *Semi-Annual Report 2011-1, January 1, 2011 through June 30, 2011* (CH2M HILL, 2011e).

1.3.1 Maximizing Flow through Treatment

Since assuming operations from former contract operator in 2010, the Utility has greatly improved the operation of its sewer system and dramatically increased WWF through the East and West WWTPs, preventing millions of gallons of sewage from overflowing into waterways.

- The biological aerated filter (BAF) system was constructed at the West WWTP. This $24 million project was completed in late 2009.
- Treatment capacity at the West WWTP has increased from 20.6 mgd to 37 mgd on a sustained basis, with 23 mgd being treated by the activated sludge process (7 mgd through each of the three aeration/clarifier trains) and 14 mgd being treated by the BAF system.
- Sustained treatment capacity at the East WWTP has increased from 18 mgd to 26.0 mgd due, in part, to changing wet-well channel levels, increasing the pumps heads, and reprogramming the programmable logic controllers (PLCs).
- Operations were modified at the 7th Avenue Lift Station in September 2010 to prevent bypasses to the river and maximize flow to the West WWTP. Bypasses at the 7th Avenue Lift Station occurred frequently during the previous contract operator's tenure, but the Utility's new standard operating procedure prevents bypasses. As a result, millions of gallons of additional WWFs are now being fully treated.
- Density baffles were installed in the secondary clarifiers at the West WWTP in April 2011.
- Polymer systems were installed at the East and West WWTPs to help maximize flow.
- A bubbler system was installed to measure trunk sewer levels at CSO 011, 012, 013, 014 016, 024, and 025.
- Stress testing of the WWTPs was completed to better define their maximum treatment capacity. The results of the testing are incorporated into the *Facility Plan for the West and East Wastewater Treatment Plants* (Volume 4 of the IOCP) submitted concurrently with this LTCP.

1.3.2 Improving Collection and Conveyance

The Utility has completed or initiated many large capital projects and significant activities in recent years, including the following:

- On the southeast side of the service area, the Utility has implemented several sewer separation and neighborhood flooding abatement projects, which were identified as being the highest priority projects in the *2007 Stormwater Master Plan* (Clark Dietz, Inc., 2007a). A total of $65 million has been invested to reduce decades of chronic, problematic surface flooding and decrease CSO discharge volume. These projects include the following:
  - Lorraine Park Underground Detention Basin and Stormwater Pump Station (completed in 2007 at a cost of $3 million)
  - Raccoon Ditch Improvements (completed in 2007 at a cost of $1.8 million)
  - Vann Avenue Trunk Sewer (completed in 2008 at a cost of $6 million)

  - Dexter Villa/Southeast Alvord Sewer Separation (completed in 2010 at a cost of $10 million)
  - Southeast Brookside and Covert Avenue Outfall (currently under construction; estimated cost is $23.8 million)
  - Phases 1 and 2 of the Cass Avenue Stormwater Improvements (currently under construction; estimated cost for both phases is $6 million)
  - Phases 3 through 5 of the Cass Avenue Stormwater Improvements (currently in final design; engineer's estimate for all three phases is $13 million)

- The constructed sanitary sewer overflow (SSO) at Broadway and Johnson was eliminated at a cost of $7.5 million. This was the largest and most problematic SSO location in the Utility's system.
- Fourteen area-velocity flow monitors were procured in April 2010 and deployed throughout the SSS to record flow data for further analysis and input to the CSS hydraulic models.
- Thirteen area-velocity flow monitors were leased in April 2010 and deployed throughout the CSS to measure in-system flows to update and validate the CSS hydraulic models.
- Nineteen rain gauges were leased as part of the 2010 flow monitoring data-collection effort (3 of the 19 rain gauges were purchased for future use).
- Sixteen area-velocity flow monitors were purchased in January 2011 and deployed throughout sewer system in a second phase of flow monitoring. Data were collected from 25 rain gauges as part of the Phase 2 flow monitoring activities.
- Real-time monitoring was initiated along Pigeon Creek Interceptor (PCI) to understand system response during different wet-weather conditions and to determine how to maximize conveyance through the PCI by using existing infrastructure while reducing CSOs. Three of the Phase 2 flow monitors and 12 leased level sensors were placed along PCI for the real-time flow monitoring of the PCI.
- Overflow alarms were installed at all pump stations.
- Real time monitoring of CSOs was implemented. Real-time data are transmitted through the canopy system and are accessible by field staff. Six cellular units have been installed at locations were telemetry is restricted.
- The Utility has initiated the process of optimizing the PCI, and maximizing its capability to capture and treat more WWF. In May 2012, the Utility launched a project to collect and analyze flow and precipitation data in the PCI in conjunction with levee gate and pump station operational data to better understand the in-system conditions in the interceptor during rain events. This project includes the development of a real-time decision support system to facilitate and support operational decisions, with the goal of capturing more WWF in the system without causing surface flooding or backups into homes or businesses, while simultaneously meeting the operational objectives of the flood protection system. The project also includes a task to identify potential opportunities to store WWF in the sewer lines tributary to the PCI, with the same requirement that no surface flooding or backups occur as a result.

SECTION 2

System Characterization

A system characterization documents a detailed understanding of the CSS and its impact on the receiving waters. The system characterization established the baseline conditions that will be used to assess the effectiveness of the implemented LTCP.

The requirements for the system characterization program are described in Section C of Appendix C of the Decree. In accordance with Decree requirements, a system characterization document was submitted November 30, 2011 (*Initial System Characterization including Separate Sanitary Sewer Hydraulic Model Development*; CH2M HILL, 2011k). System characterization data are also found within the SRCER (CH2M HILL and LimnoTech, 2011) that was submitted August 31, 2011, and the *Sanitary Sewer Systems Assessment Report* (CH2M HILL, 2012d) submitted March 30, 2012 and updated July 31, 2012. Much of the information within this section is excerpted from those documents. Additional flow and water quality monitoring data were gathered in 2012 after completion of the earlier documents; therefore, updates to the hydraulic and water quality models were completed following submittal of the Draft LTCP on July 31, 2012 and are described within this section.

2.1 Objective of System Characterization

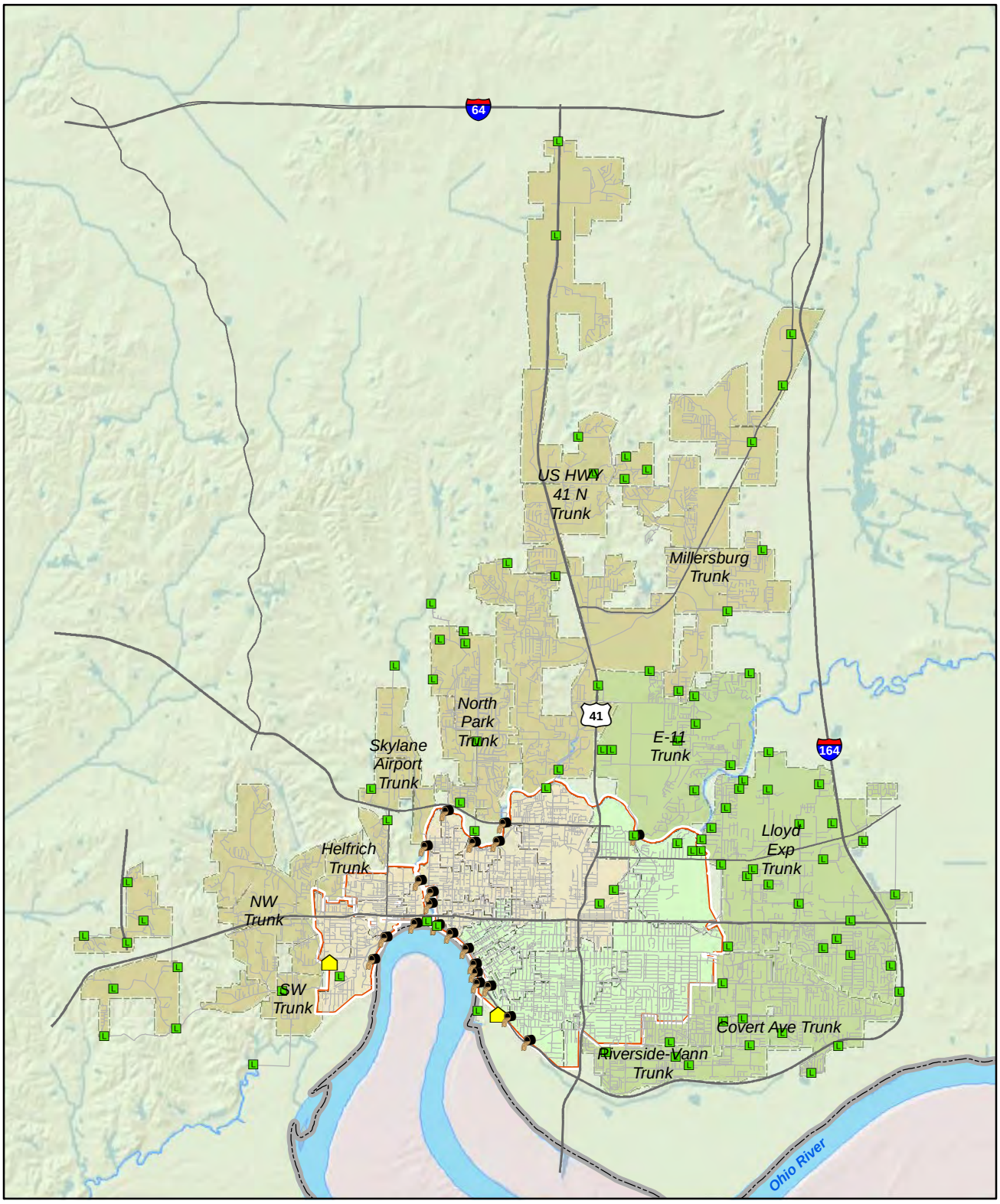
CSS characterization, monitoring, and modeling are performed to better understand how the system responds to various wet-weather events, the characteristics of the overflows, and the water quality impacts that may result from CSO discharges. Understanding the CSS characterization information is imperative to developing a CSO control plan that is adequate for meeting the requirements of the Decree and the CWA.

The major elements of a sewer system characterization are listed in the CSO Control Policy (EPA, 1994), with further description provided in the EPA's *Combined Sewer Overflows, Guidance for Long-Term Control Plan* (EPA 832-B-95-002) (1995). The Utility's CSS characterization was performed through review of existing information, field investigation, monitoring, and mathematical modeling of the sewer system.

2.2 Description of System/Overview of Existing Data

The Utility owns, operates, and maintains the sewer system, which serves approximately 67,800 households in the City of Evansville and portions of Vanderburgh County. The 65-square-mile service area contains over 800 miles of combined and SSS pipelines, two WWTPs with a total combined dry-weather capacity of 48 million gallons per day (mgd), and 90 lift stations. The collection and treatment system is comprised of two separate and distinct service areas: the West and East Service Areas. One WWTP serves each service area, with no transfer of flow from one WWTP service area to the other. An overview of the system is presented in Figure 2-1.

In the CSS, DWFs are conveyed to the West or East WWTP for treatment prior to their ultimate discharge to the Ohio River. During wet-weather events, when the total combined sewage flow exceeds the capacity of the sewer, a mixture of sewage and stormwater runoff may be discharged to Pigeon Creek, Bee Slough, and the Ohio River. The CSS service areas are approximately 25 percent of the overall service area and encompass approximately 16 square miles.



LEGEND

- Wastewater Lift Station
- CSO
- Wastewater Treatment Plant
- Major Roads
- Sewer Main
- Hydrography
- Combined Sewer Boundary

CSS Basin

- East CSS Basins
- West CSS Basins

SSS Basin

- East SSS Basins
- West SSS Basins

North

0 3,000 6,000 12,000

Feet

FIGURE 2-1
Evansville Sewer System Overview
Long-Term Control Plan
May 31, 2013

There are 22 CSO outfalls, as illustrated in Figure 2-2:

- 3 discharge to Bee Slough, which ultimately discharges to the Ohio River.
- 9 discharge directly to the Ohio River.
- 9 discharge to Pigeon Creek, which is a tributary of the Ohio River.
- 1 discharges to either Bee Slough or the Ohio River, depending on river stage.

The City and Vanderburgh County are protected from Ohio River and Pigeon Creek flooding by a flood protection system that consists of an earthen-levee and floodwall system and a system of WWF control gates and pump stations that pump water to receiving waters during elevated river and creek levels. The United States Army Corps of Engineers (USACE) operates the flood protection system.

A summary of the East and West Service Areas is provided in the following sections, including:

- Major Sewer Systems (West and East Service Areas, Sections 2.3 and 2.5, respectively)
- CSO Outfalls and Overflow Volumes (West and East Service Areas, Section 2.6)
- Levee Authority Pump Stations (PSs) (West and East Service Areas, Section 2.7)
- East and West WWTPs (West and East Service Areas, Section 2.8)

More detailed information on each service area is provided in the *Initial System Characterization including Separate Sanitary Sewer Hydraulic Model Development* (CH2M HILL, 2011k).

The system characterization was extended through the intensive monitoring and modeling program described in Sections 2.9 and 2.10. The monitoring measured flow and pollutant strength characteristics at selected sites that were both reasonably accessible and representative of the range of conditions characteristic of the Utility's system. System models were developed in distinct parts (East combined sewer area, West combined sewer area, East separated sewer area, West separated sewer area, and receiving waters) by multiple modeling teams to accommodate the accelerated schedule of the Decree. The sewer system hydrologic and hydraulic models were utilized to project the average annual flow and overflow volumes within the CSS, and existing typical year overflow volumes are described in Section 2.10.2.

2.3 West Major Sewer Systems

The West WWTP Service Area includes three systems:

- Western Basins System
- West Side Interceptor System
- Pigeon Creek Interceptor System

Figure 2-3 shows the West Service Area's major sewer systems, and the basins that comprise the systems are shown in Figure 2-4. Figure 2-5 provides the flow diagram for the West WWTP Service Area, and a description of each system is presented in the following sections.

2.3.1 Western Basins System

The Western Basin System consists of one CSS basin that gravity flows to the West WWTP.

2.3.1.1 Tekoppel-Walker CSS Basin

DWFs in this basin travel south through the Tekoppel-Walker Interceptor directly to the West WWTP. WWFs exceeding the capacity of the interceptor overtop the weir in the diversion structure and discharge to the Ohio River through CSO 020 or the 9th Avenue CSO.

2.3.2 West Side Interceptor System

Three basins comprise the West Side Interceptor System:

- 9th Avenue CSS Basin
- St. Joseph Avenue CSS Basin
- Broadway Avenue Interceptor CSS Basin

2.3.2.1 9th Avenue CSS Basin

DWFs in this basin travel south through the 9th Avenue Interceptor and then east to the 9th Avenue Lift Station. WWFs exceeding the capacity of the interceptor overtop the weir in the diversion structure and discharge to the Ohio River through CSO 020, or the 9th Avenue CSO outfall.

2.3.2.2 St. Joseph Avenue CSS Basin

DWFs in this basin generally travel south, where they merge with the flow from the Ohio Street Force Main in the Broadway Interceptor. WWFs exceeding the capacity of the St. Joseph Basin overtop the weir in the diversion structure and discharge to the Ohio River via CSO 022.

2.3.2.3 Broadway Avenue Interceptor CSS Basin

The Broadway Avenue Interceptor CSS Basin encompasses a service area of approximately 530 acres. Flows in this basin travel to the Broadway Interceptor and then to the West WWTP.

2.3.3 Pigeon Creek Interceptor System

The following CSS basins comprise the PCI System:

- Diamond Avenue CSS Basin
- Baker Street CSS Basin
- Oakley Street CSS Basin
- 6th Avenue CSS Basin
- Dresden Street CSS Basin
- Delaware Street CSS Basin
- Maryland Street CSS Basin
- Franklin Street CSS Basin
- Fulton Street PS Basin
- 7th Avenue East Basin

Flows from each of these basins are collected by the PCI and flow by gravity to the 7th Avenue Lift Station.

CSO	Name	Receiving Water	WWTP Service Area
001	Kentucky Avenue	Bee Slough	East
002	Cass Avenue	Bee Slough	East
103	Junction Box Prior to WWTP Headworks	Ohio River	East
004	Adams	Bee Slough	East
006	Fulton Avenue Pumping Station	Ohio River	West
008	Chestnut Street	Ohio River	East
009	7th Avenue West	Ohio River	West
010	Dress Plaza	Ohio River	East
011	Weinbach Lift Station (Oakhill Road)	Pigeon Creek	East
012	Maryland Street – West Bank	Pigeon Creek	West
013	Delaware Street	Pigeon Creek	West
014	Dresden Street	Pigeon Creek	West
015	7th Avenue East	Ohio River	West
016	Franklin Street	Pigeon Creek	West
017	6th Avenue	Pigeon Creek	West
018	Oakley Street	Pigeon Creek	West
020	9th Avenue	Ohio River	West
022	St. Joseph Avenue	Ohio River	West
123	West Plan CSO	Ohio River	West
024	Baker Street	Pigeon Creek	West
025	Diamond Avenue	Pigeon Creek	West
038	Oak / Riverside	Ohio River	East

WEST WWTP

EAST WWTP

Legend

East Service Area
- Separate Sewer Area
- Combined Sewer Area

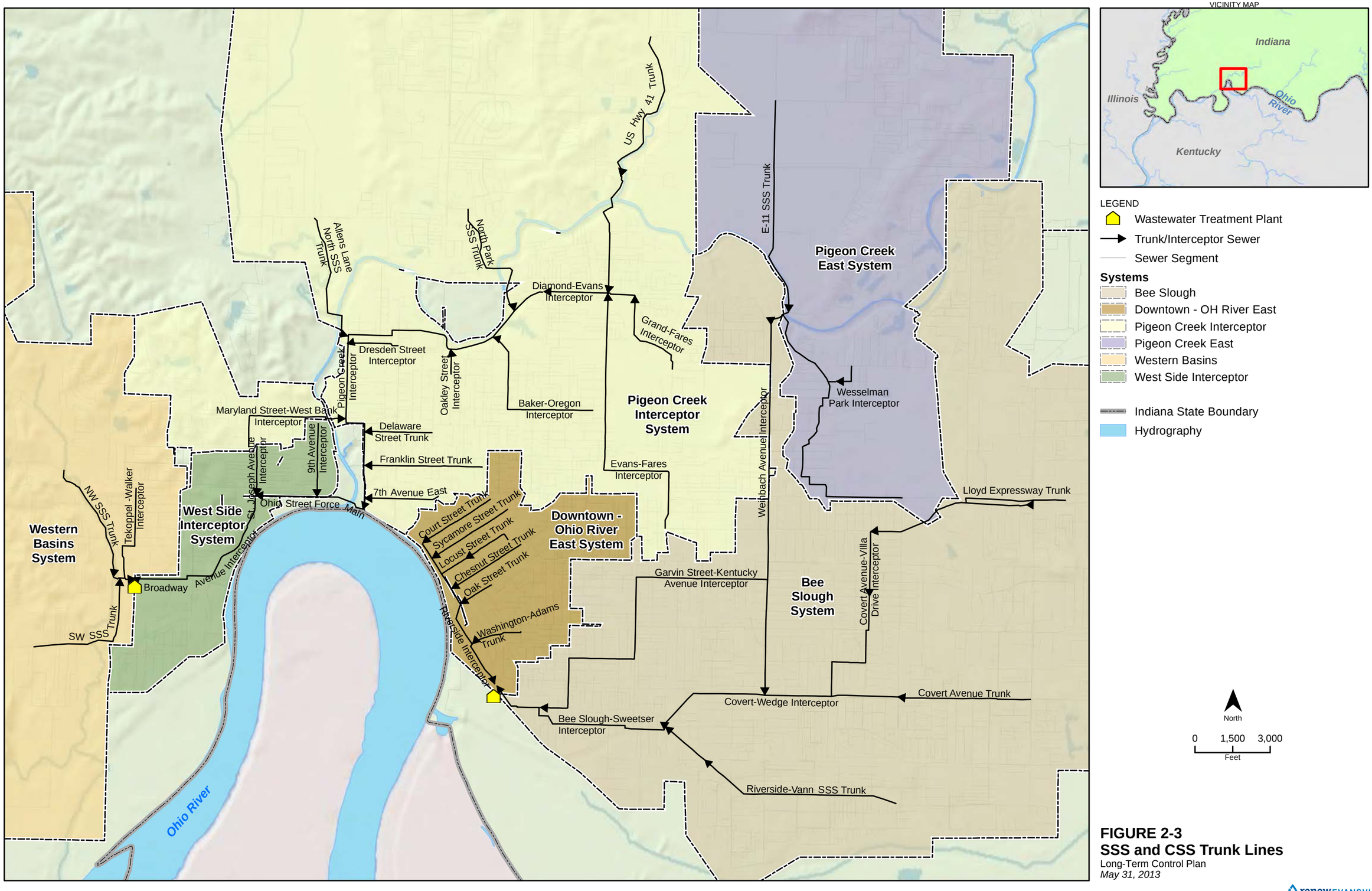
West Service Area
- Separate Sewer Area
- Combined Sewer Area

- Wastewater Treatment Plant
- CSO
- City Limits

North

FIGURE 2-2
Evansvillee CSO Locations
Long Term Control Plan
May 31, 2013

renewEVANSVILLE



VICINITY MAP

LEGEND

- Wastewater Treatment Plant
- Trunk/Interceptor Sewer
- Sewer Segment

Systems

- Bee Slough
- Downtown - OH River East
- Pigeon Creek Interceptor
- Pigeon Creek East
- Western Basins
- West Side Interceptor

- Indiana State Boundary
- Hydrography

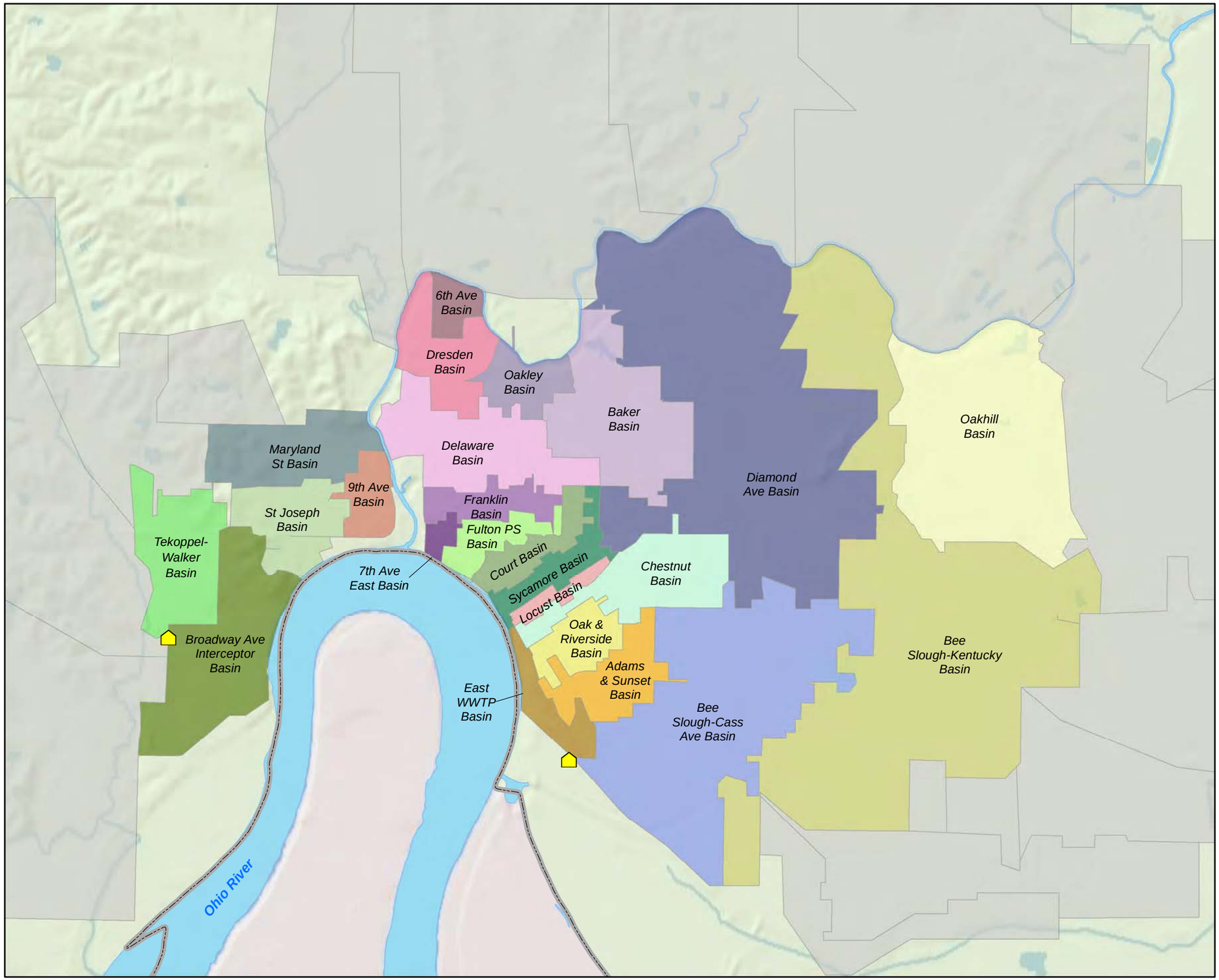
North

0 1,500 3,000

Feet

FIGURE 2-3
SSS and CSS Trunk Lines
Long-Term Control Plan
May 31, 2013

renewEVANSVILLE



VICINITY MAP



LEGEND

- Wastewater Treatment Plant
- Trunk/Interceptor Sewer
- Sewer Segment

CSS Basins

- 6th Ave Basin
- 7th Ave East Basin
- 9th Ave Basin
- Adams & Sunset Basin
- Baker Basin
- Bee Slough-Cass Ave Basin
- Bee Slough-Kentucky Basin
- Broadway Ave Interceptor Basin
- Chestnut Basin
- Court Basin
- Delaware Basin
- Diamond Ave Basin
- Dresden Basin
- East WWTP Basin
- Franklin Basin
- Fulton PS Basin
- Locust Basin
- Maryland St Basin
- Oak & Riverside Basin
- Oakhill Basin
- Oakley Basin
- St Joseph Basin
- Sycamore Basin
- Tekoppel-Walker Basin
- Other CSS Basin

- Indiana State Boundary
- Hydrography

0 1,500 3,000
Feet

FIGURE 2-4
CSS Basins Long-Term Control Plan
May 31, 2013

renewEVANSVILLE

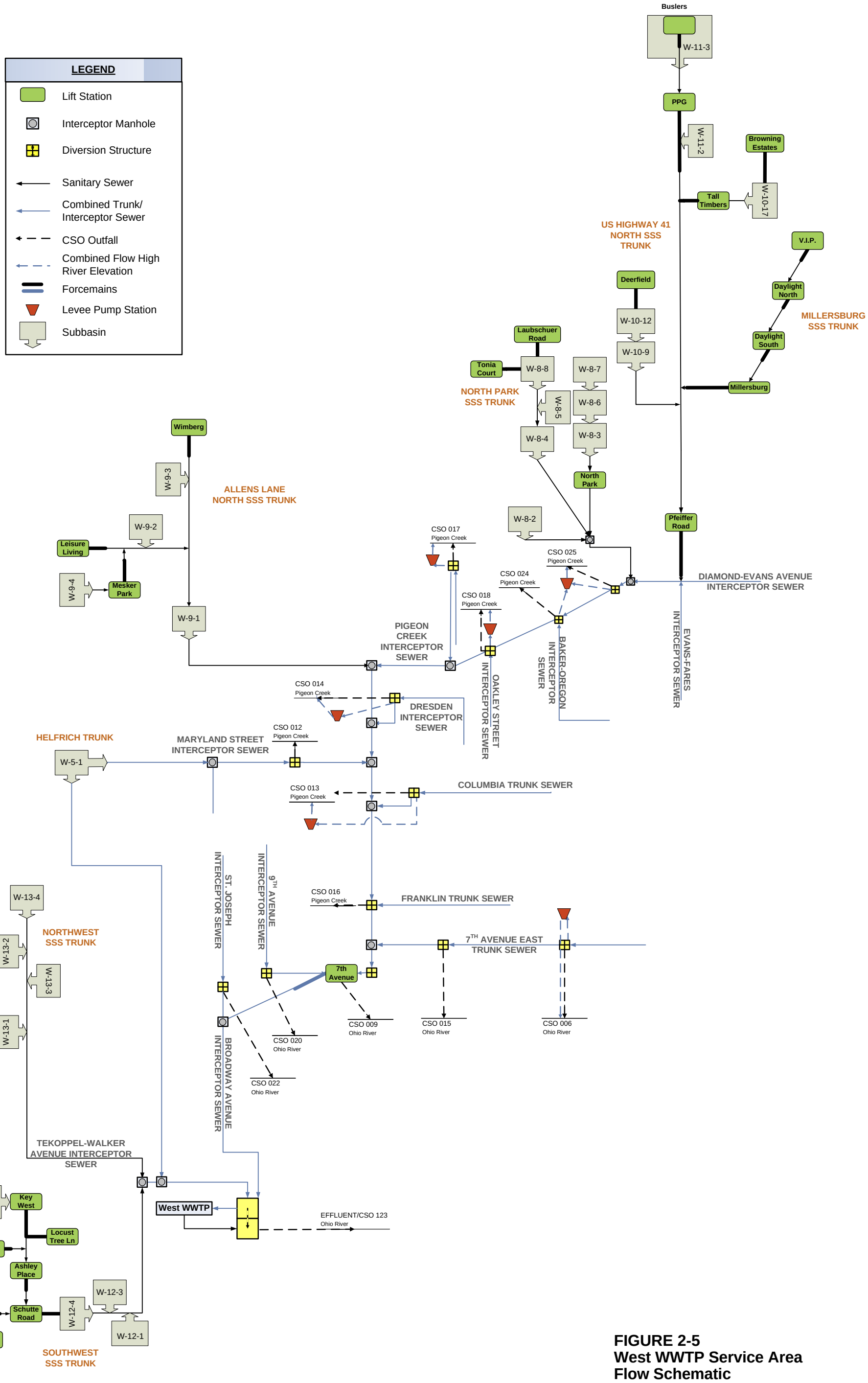


FIGURE 2-5
West WWTP Service Area Flow Schematic
Long-Term Control Plan
May 31, 2013

2.3.3.1 Diamond Avenue CSS Basin

The Evans-Fares Interceptor extends north to the Diamond-Evans Trunk Sewer. In addition, DWFs from the Pfeiffer Road PS are pumped by force main into the trunk sewer from the US Highway 41 SSS Basin. WWFs exceeding the capacity of the northern portion of the PCI are released through a gate in the diversion structure and discharged into Pigeon Creek via CSO 025.

2.3.3.2 Baker Street CSS Basin

DWFs travel north via the Baker-Oregon Interceptor toward the PCI. WWFs exceeding the capacity of this interceptor are released through a gate in the diversion structure and discharge into Pigeon Creek via CSO 024.

2.3.3.3 Oakley Street CSS Basin

DWFs in this basin travel to the PCI. WWF exceeding the capacity of this basin overtops a weir in the diversion structure and discharges into Pigeon Creek via CSO 018.

2.3.3.4 6th Avenue CSS Basin

DWF travels south to the PCI. During higher rivers stages, the 6th Avenue Levee PS pumps flow into Pigeon Creek. WWFs exceeding the capacity of this basin overtop a weir in the diversion structure and discharge into Pigeon Creek via CSO 017.

2.3.3.5 Dresden Street CSS Basin

SSS flows from Allens Lane North travel into the Dresden CSS Basin after being siphoned under Pigeon Creek. This SSS flow is conveyed to the PCI. DWF from the Dresden CSS Basin travels to the PCI via a throttle pipe in the Dresden Street Interceptor. WWFs exceeding the capacity of the throttle pipe are released through a gate in the diversion structure and discharge into Pigeon Creek via CSO 014. During high-creek stages, these flows are pumped into Pigeon Creek by the Dresden Levee PS.

2.3.3.6 Delaware Street CSS Basin

DWF travels east to the PCI via the Delaware Trunk Sewer. WWFs exceeding the capacity of the interceptor overtop a weir in the diversion structure and discharge into Pigeon Creek via CSO 013. During high-creek stages, these flows are pumped by the Delaware Street Levee Station.

2.3.3.7 Maryland Street CSS Basin

DWF in this basin travels east toward Pigeon Creek. DWF is siphoned under Pigeon Creek and into the PCI. WWFs exceeding the capacity of this basin are released through a gate in the diversion structure and discharge into Pigeon Creek via CSO 012.

2.3.3.8 Franklin Street CSS Basin

DWF travels west to the PCI via the Franklin Street Interceptor. WWFs exceeding the capacity of the throttle pipe are released through a gate in the diversion structure and discharge into Pigeon Creek via CSO 016.

2.3.3.9 Fulton Avenue PS Basin

The Fulton Avenue PS pumps WWFs from the Fulton CSO during high-river stages (CSO 006).

2.3.3.10 7th Avenue East CSS Basin

DWFs travel west through the basin and enter the PCI just upstream of the 7th Avenue Lift Station. WWFs exceeding the capacity of the trunk sewer discharge to Pigeon Creek via CSO 015.

2.4 Major West System Infrastructure

In addition to the West basins described in the previous section, the PCI and 7th Avenue Lift Station are major components impacting operation of the West Service Area.

2.4.1 Pigeon Creek Interceptor

The PCI is the main interceptor in the West Service Area and conveys flow from five of the seven separate sewer basins and the combined sewer basins to the 7th Avenue Lift Station. The PCI is over 16,000 feet (ft) in length, 48 to 66 inches in diameter, and ranges in depth from 25 to 30 ft. Flow data analysis and a multi-sensor evaluation were performed during 2011 to assess the condition of the PCI.

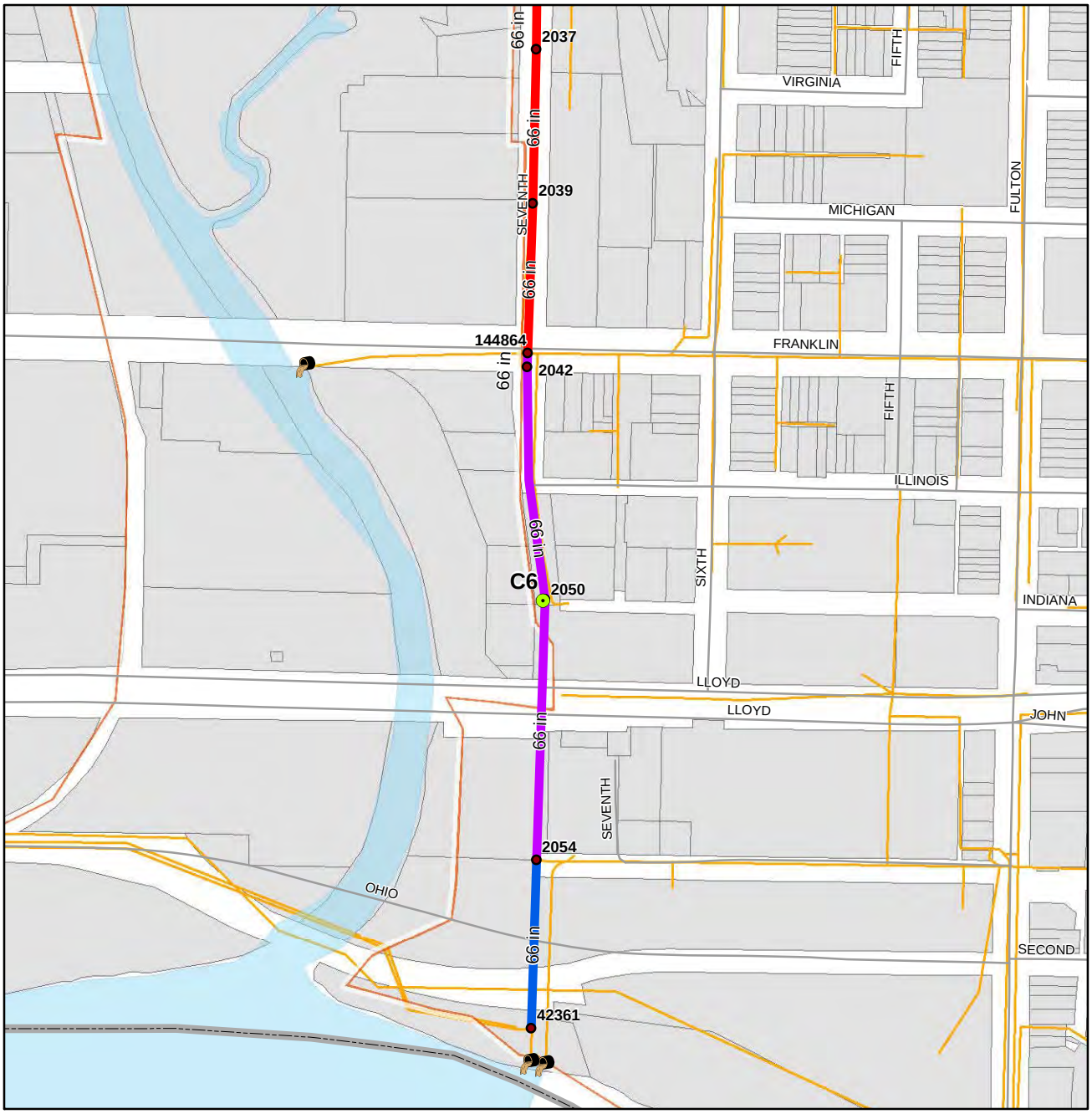
In flow monitoring, the average depth of water in the PCI during dry weather was measured as approximately 29 inches, and the average velocity was approximately 1.0 foot per second (fps). The average velocity is lower than the self-cleaning velocity of 2 fps, which can lead to sediment build-up. The flow monitoring evaluation was also useful in predicting and tracking sedimentation along the length of the PCI; this was done by comparing the measured flow to the flow calculated using Manning's Equation assuming various levels of sediment. The analysis predicted, on average, approximately 1 ft of sediment along the length of the PCI, which reduces the PCI capacity by 300,000 gallons. The sediment within the PCI decreases the amount of pipe available for conveyance and storage.

The PCI condition assessment was completed using high-definition (HD) profiling and sonar technologies on 41 segments (16,600 linear feet [LF]). HD profiling provided information on corrosion and the radial variation on size and shape of the pipe. The sonar technology was used to measure the depth of debris, average water level, and volume of debris. The analysis resulted in an estimate of 44,055 cubic feet of debris in the PCI, which equates to a reduction of over 48,000 gallons of capacity for conveyance and storage. The depth of debris is presented in Table 2-1 and Figures 2-6 through 2-11.

2.4.2 7th Avenue Lift Station

The 7th Avenue Lift Station pumps flows collected by the PCI to the West WWTP. The facility was constructed in the mid-1950s and includes two dry pit submersible pumps and a separate wet well with one screen. The station is over 50 ft deep from grade to the bottom of the wet well, and the operating floor area of the wet well is a confined space. The station does not have back-up power.

The pumps have separate discharges to the force main that carries flow to the West WWTP. The pumps are rated at approximately 20.5 mgd at 46 ft of total dynamic head (TDH). Staff report that the station capacity increases with higher wet well levels, which reduce the static head on the pumps. Flows of approximately 34 mgd have been pumped when the wet well is surcharged and both pumps are operating; however, the firm capacity of the station without significant surcharging is close to the rated capacity noted above.



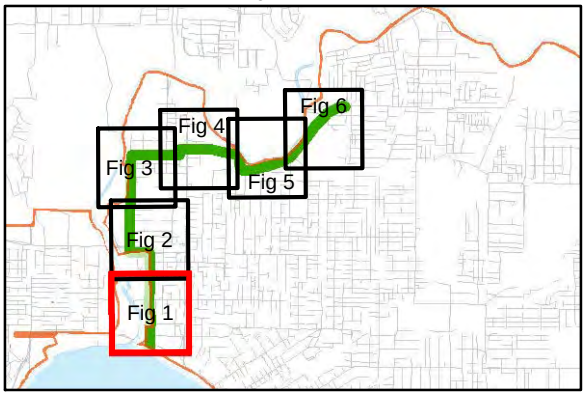
LEGEND

- Flow Monitors
- sManhole
- CSO
- Wastewater Treatment Plant
- Combined Sewer Boundary
- Hydrography
- Sewer Segment
- Parcels

Average Debris depth (in)

- 3 - 5 in
- 6 - 9 in
- 10 - 13 in
- 14 - 17 in
- 18 - 22 in

VICINITY MAP

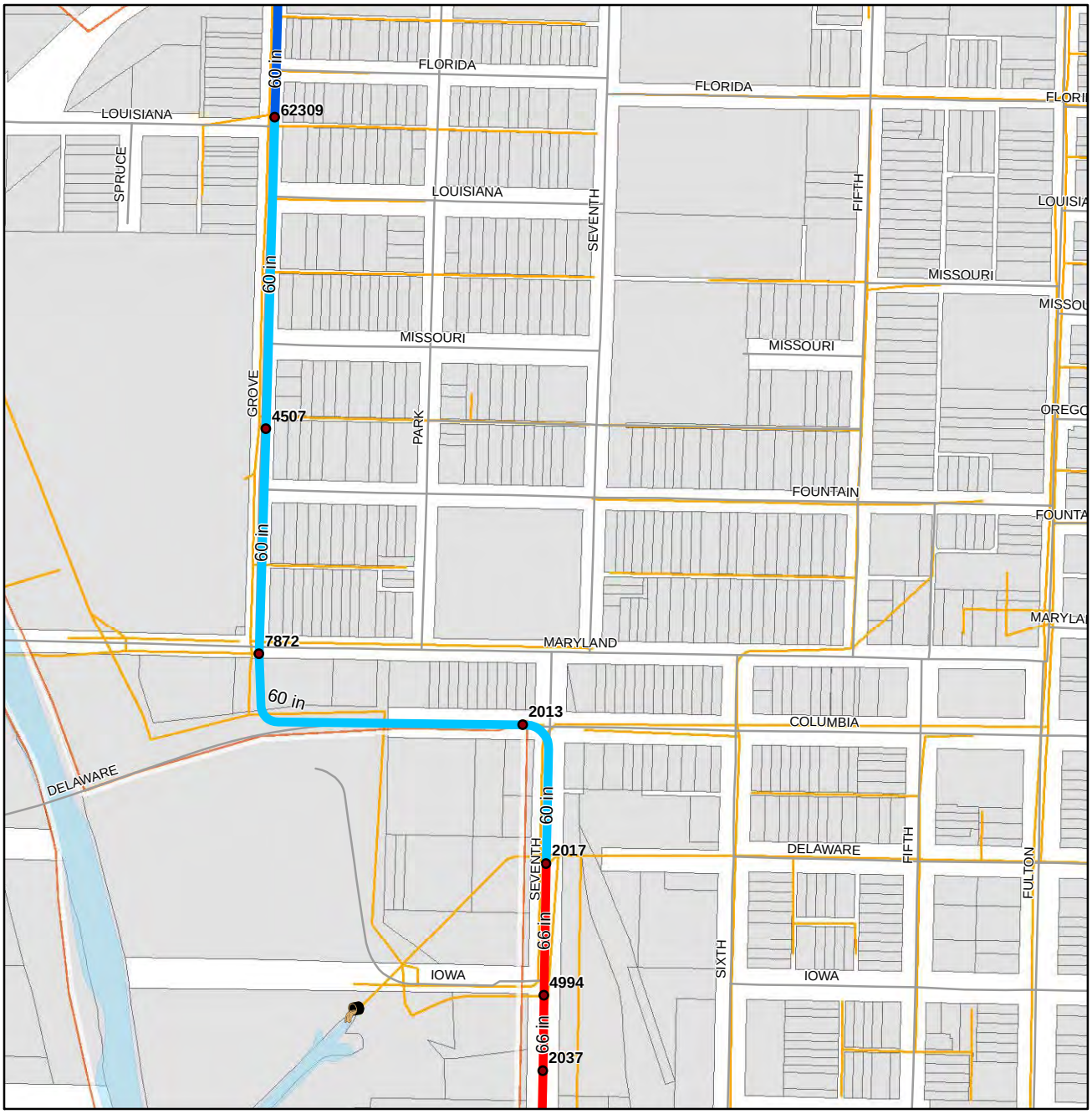


North

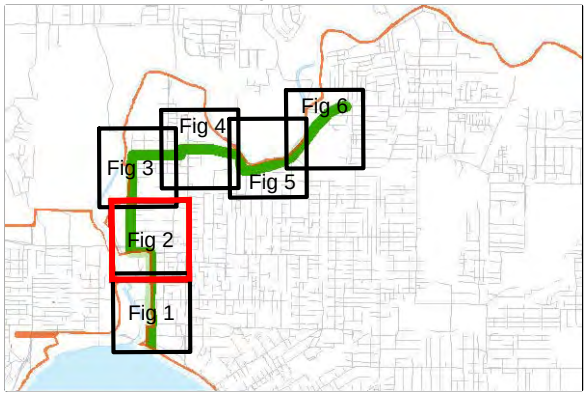
0 100 200 300 400

Feet

FIGURE 2-6
Pigeon Creek Interceptor Sonar Results
Long-Term Control Plan
May 31, 2013



VICINITY MAP



LEGEND

- Flow Monitors
- sManhole
- CSO
- Wastewater Treatment Plant
- Combined Sewer Boundary
- Hydrography
- Sewer Segment
- Parcels

Average Debris depth (in)

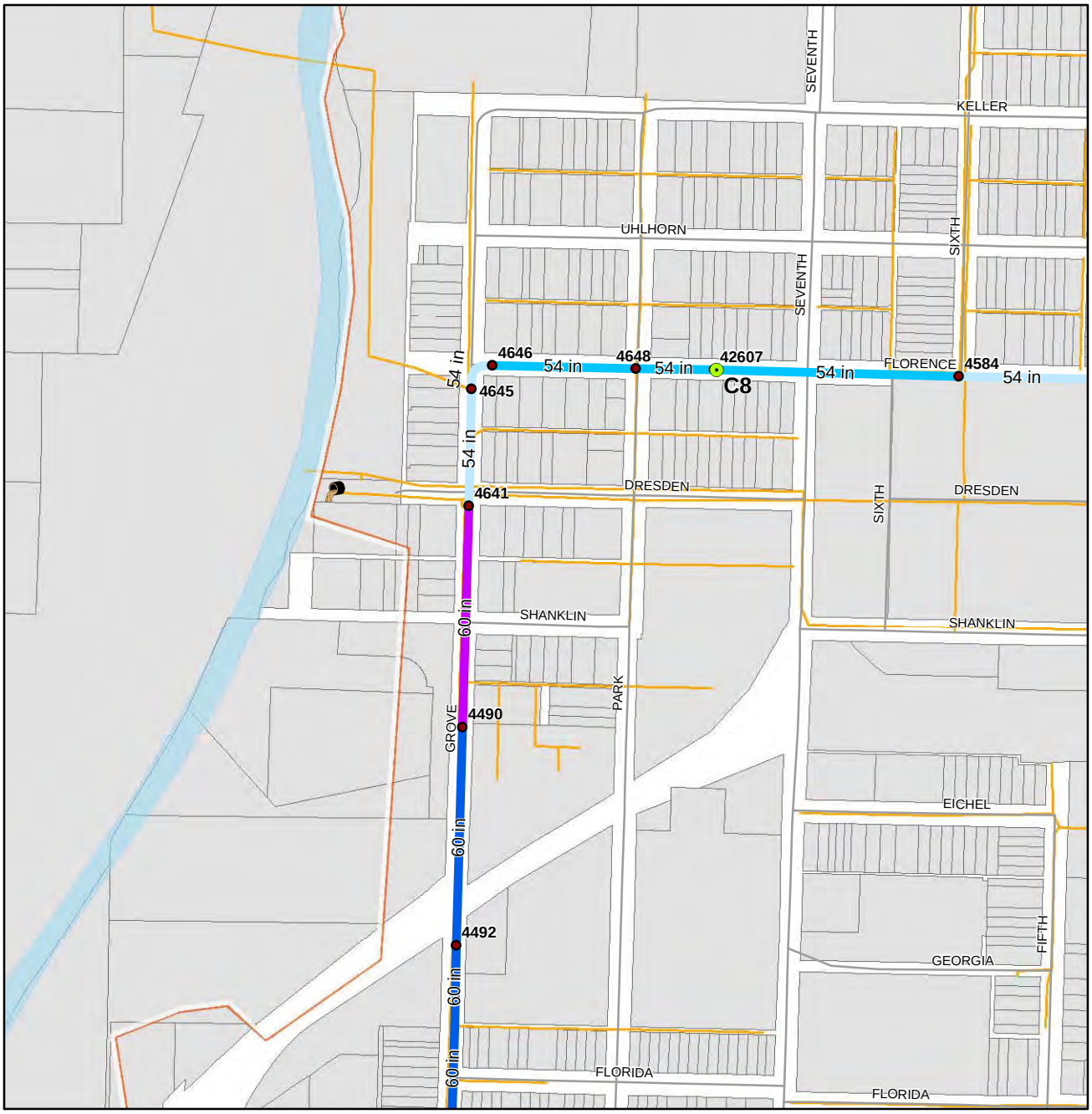
- 3 - 5 in
- 6 - 9 in
- 10 - 13 in
- 14 - 17 in
- 18 - 22 in

North

0 100 200 300 400

Feet

FIGURE 2-7
Pigeon Creek Interceptor Sonar Results
Long-Term Control Plan
May 31, 2013



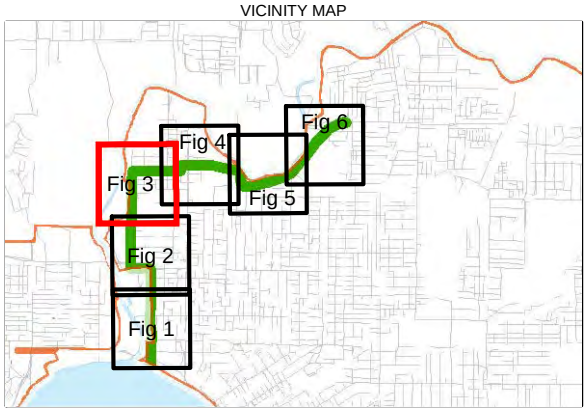
LEGEND

- Flow Monitors
- sManhole
- CSO
- Wastewater Treatment Plant
- Combined Sewer Boundary
- Hydrography
- Sewer Segment
- Parcels

Average Debris depth (in)

- 3 - 5 in
- 6 - 9 in
- 10 - 13 in
- 14 - 17 in
- 18 - 22 in

VICINITY MAP



North

0 100 200 300 400

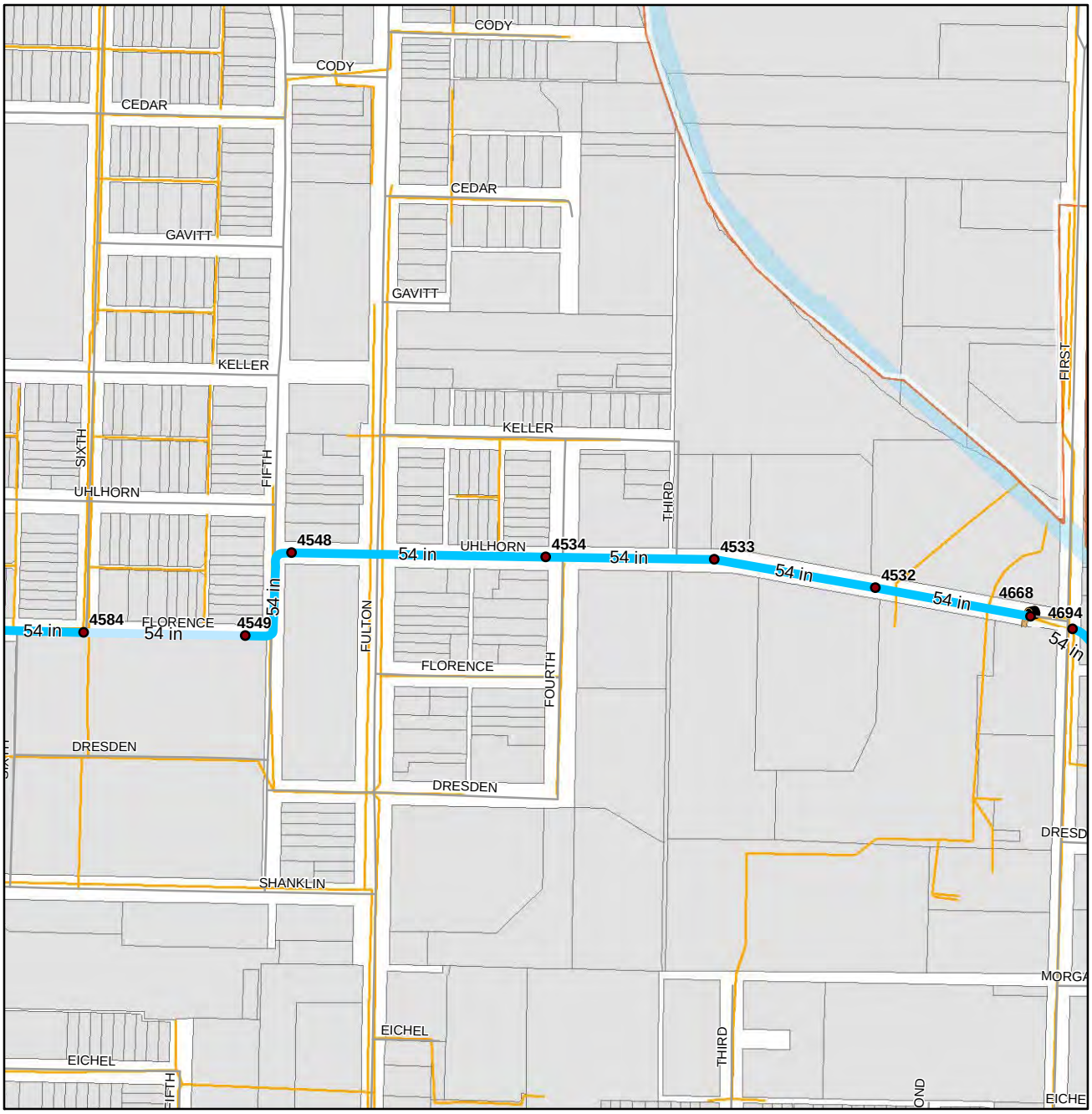
Feet

FIGURE 2-8

Pigeon Creek Interceptor Sonar Results

Long-Term Control Plan

May 31, 2013



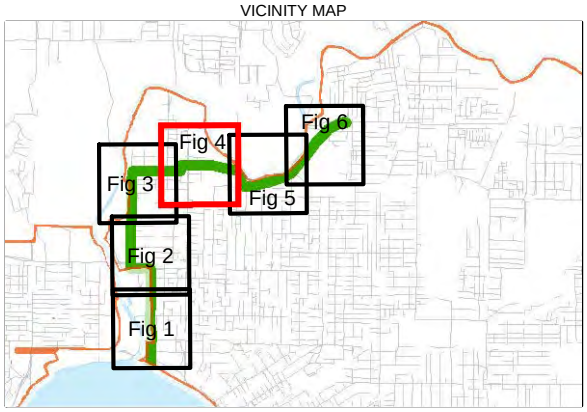
LEGEND

- Flow Monitors
- sManhole
- CSO
- Wastewater Treatment Plant
- Combined Sewer Boundary
- Hydrography
- Sewer Segment
- Parcels

Average Debris depth (in)

- 3 - 5 in
- 6 - 9 in
- 10 - 13 in
- 14 - 17 in
- 18 - 22 in

VICINITY MAP

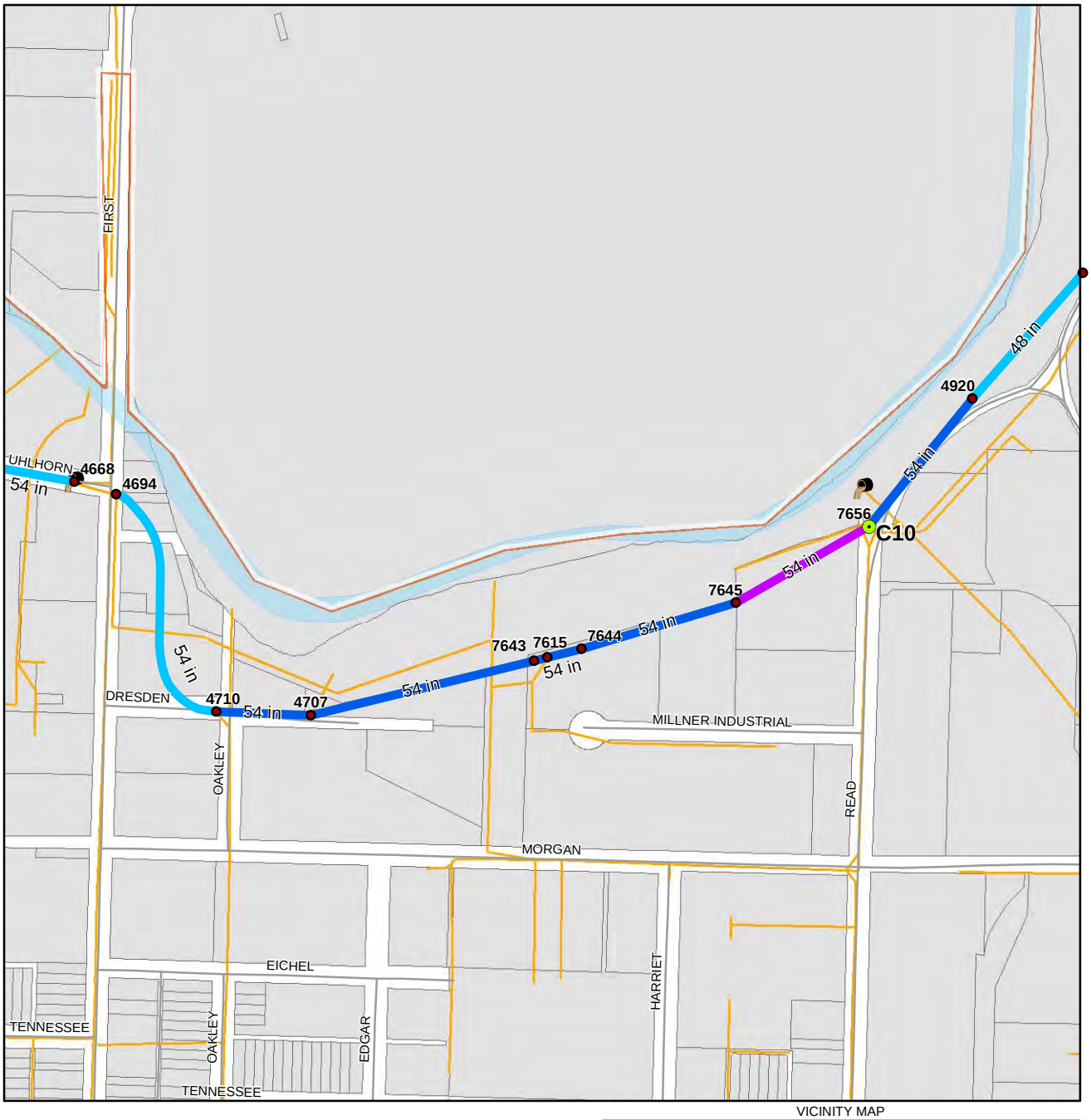


North

0 100 200 300 400

Feet

FIGURE 2-9
Pigeon Creek Interceptor Sonar Results
Long-Term Control Plan
May 31, 2013



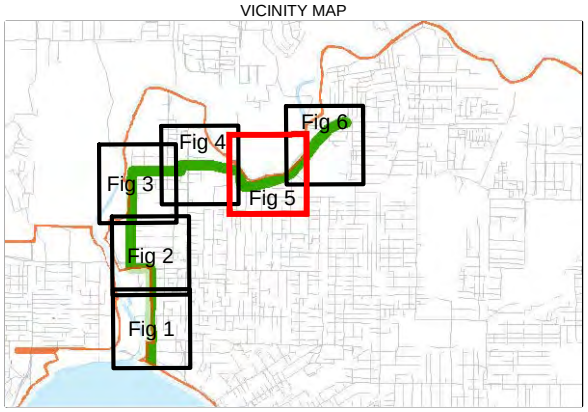
LEGEND

- Flow Monitors
- sManhole
- CSO
- Wastewater Treatment Plant
- Combined Sewer Boundary
- Hydrography
- Sewer Segment
- Parcels

Average Debris depth (in)

- 3 - 5 in
- 6 - 9 in
- 10 - 13 in
- 14 - 17 in
- 18 - 22 in

VICINITY MAP

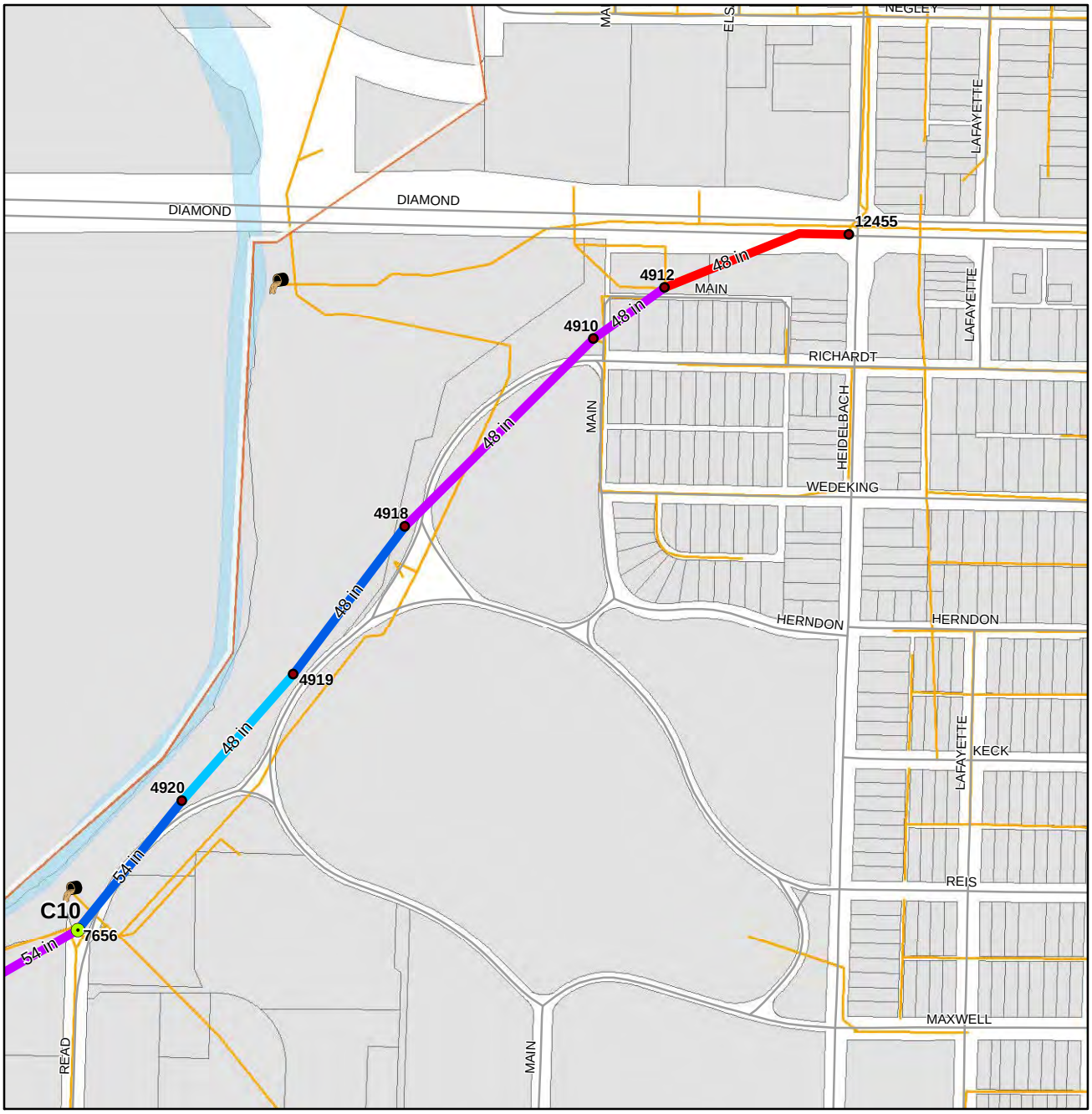


North

0 100 200 300 400

Feet

FIGURE 2-10
Pigeon Creek Interceptor Sonar Results
Long-Term Control Plan
May 31, 2013



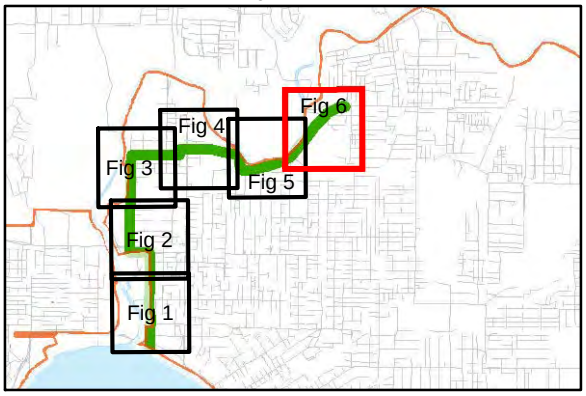
LEGEND

- Flow Monitors
- sManhole
- CSO
- Wastewater Treatment Plant
- Combined Sewer Boundary
- Hydrography
- Sewer Segment
- Parcels

Average Debris depth (in)

- 3 - 5 in
- 6 - 9 in
- 10 - 13 in
- 14 - 17 in
- 18 - 22 in

VICINITY MAP



North

0 100 200 300 400

Feet

FIGURE 2-11

Pigeon Creek Interceptor Sonar Results

Long-Term Control Plan

May 31, 2013

Table 2-1 Sonar Profile Results

No.	Asset No.	Distance (profiled) ft	Debris (ft^3)	Average Debris depth (in)	Average water level (in)	Diameter (in)
1	7656 - 7645	400	1350	14	28	54
2	7645 - 7644	420	1204	13	26	54
3	7644 - 7643	140	282	11	22	54
4	7643 - 4707	598	1223	10	23	54
5	4707 - 4710	232	443	10	24	54
6	4710 - 4694	757	1018	7	22	54
7	4668 - 4532	404	784	9	22	54
8	4532 - 4533	440	556	7	26	54
9	4533 - 4534	440	431	6	26	54
10	4534 - 4548	626	762	6	23	54
11	4548 - 4549	315	484	7	27	54
12	4549 - 4584	391	322	5	28	54
13	4584 - 42607	635	721	6	33	54
14	42607 - 4648	533	697	7	26	54
15	4648 - 4646	64	90	7	23	54
16	4646 - 4645	60	34	3	22	54
17	4645 - 4641	281	180	3	23	54
18	4641 - 4490	582	2209	15	33	60
19	4490 - 4492	575	1572	12	33	60
20	4492 - 62309	487	1355	12	35	60
21	62309 - 4507	799	1527	9	35	60
22	4507 - 7872	594	903	8	34	60
23	7872 - 2013	759	1480	9	28	60
24	2013 - 2017	399	504	7	30	60
25	2017 - 4994	307	1980	18	34	66
26	4994 - 2037	207	1583	22	32	66
27	2037 - 2039	411	2589	20	33	66
28	2039 - 144864	359	2145	19	34	66
29	144864 - 2042	50	285	17	31	66
30	2042 - 2050	587	2809	17	36	66
31	2050 - New MH	261	913	14	37	66

Table 2-1 Sonar Profile Results

No.	Asset No.	Distance (profiled) ft	Debris (ft^3)	Average Debris depth (in)	Average water level (in)	Diameter (in)
32	New MH - 2054	394	1284	13	34	66
33	2054 - 42361	433	1430	13	26	66
34	12455 - 4912	438	2110	19	34	48
35	4912 - 4910	236	1032	17	29	48
36	4910 - 4818A	565	2426	17	32	48
37	4918A - 4918	105	246	11	32	48
38	4918 - 4919	481	1089	11	32	48
39	4919 - 4920	418	543	7	33	48
40	4920 - 7556A	148	458	12	35	54
41	7556A - 7556	329	992	12	36	54
	Totals	**16,660**	**44,045**			

Notes:
ft^3 = cubic feet
in = inches

Surcharging in the wet well results in flow leaving the main influent channel and debris bypassing the screen. This exposes the pumps to the potential for plugging or impaired operation due to debris. Pump maintenance staff have also confirmed that the pumps are subject to damage due to cavitation.

The Utility changed the operation of the 7th Avenue Lift Station in August 2010 to minimize discharge from the 7th Avenue West CSO 009. Standard operation currently involves keeping the gate to the 7th Avenue West CSO 009 closed and reducing the pumping speed. The pumps are turned down during wet weather to control the flow to the West WWTP.

2.4.2.1 CSO 009

CSO 009 is not directly monitored due to difficulty in accessing the outfall and also due to the site conditions not being favorable to measuring flows using area-velocity flow monitors. Furthermore, under the new 7th Avenue Lift Station Standard Operating Procedure, the Utility avoids discharging CSO through Outfall 009. As a result, the outfall was not included in this analysis.

2.5 East Major Sewer Systems

The East WWTP Service Area consists of three major sewer systems:

- Ohio River East/Downtown System
- Bee Slough System
- Pigeon Creek East System

2.5.1 Ohio River East/Downtown System

The Ohio River East/Downtown System is comprised of the following CSS basins:

- Dress Plaza Basin
  - Court Street Basin
  - Sycamore Basin
  - Locust Street Basin
- Chestnut Street Basin
- Oak and Riverside Basin
- Washington and Adams Basin
- East WWTP Basin

Figure 2-3 shows the East Service Area's major sewer systems, and the basins that comprise the systems are shown in Figure 2-4.

2.5.1.1 Dress Plaza CSS Basins

The Court, Sycamore, and Locust Street trunk sewers flow southwest toward the Ohio River. The flow is then captured by the Riverside Drive Interceptor. Increased flow from wet-weather events is diverted from one of the three diversion structures at the downstream end of these trunk lines (010A, 010B, 010C) to the Dress Plaza CSO. During high river conditions (i.e., exceeding river stage of 26'), the combined flow is pumped into the Ohio River by the Sycamore Street Levee PS.

2.5.1.1.1 Court Street CSS Basin

DWFs in the Court Street CSS basin generally travel toward Riverside Drive and into the Riverside Interceptor, which flows to the East WWTP.

WWFs exceeding the trunk sewer capacity overtop the weir in the diversion structure and discharge to the Ohio River via CSO 010A.

2.5.1.1.2 Sycamore Street CSS Basin

The Sycamore Street CSS DWFs travel toward Riverside Drive and into the Riverside Interceptor, which flows to the East WWTP.

WWFs exceeding the capacity of the trunk sewer overtop the weir in the diversion structure and discharge to the Ohio River via CSO 010B.

2.5.1.1.3 Locust Street CSS Basin

DWFs in the Locust Street CSS Basin generally travel toward Riverside Drive and into the Riverside Drive Interceptor, which flows to the East WWTP.

WWFs exceeding the capacity of the trunk sewer overtop the weir in the diversion structure and discharge to the Ohio River via CSO 010C.

2.5.1.2 Chestnut Street CSS Basin

DWFs in the basin travel toward Riverside Drive and into the Riverside Drive Interceptor, which flows to the East WWTP.

WWFs exceeding the interceptor capacity overtop the weir and discharge to the Ohio River via CSO 008. During high river stages, flows are pumped out the K-5 Levee PS.

2.5.1.3 Oak and Riverside CSS Basin

DWFs in the Oak and Riverside CSS Basin travel toward Riverside Drive and into the Riverside Drive Interceptor, which flows west to the East WWTP.

WWFs exceeding the interceptor capacity overtop the weir and discharge to the Ohio River via CSO 038.

2.5.1.4 Washington and Adams CSS Basin

Flows in the basin generally travel to the headworks of the East WWTP.

WWFs exceeding the capacity of the interceptor sewer overtop the weir in the diversion structure, combine with flow from Bee Slough, and discharge to the Ohio River via CSO 103. During high Ohio River stages, the flow is pumped out the Evansville-Vanderburgh Levee Authority District (EVLAD) K-4 PS.

2.5.1.5 East WWTP Basin

The East WWTP Basin encompasses a service area of approximately 109 acres. Flows in the basin are directed to the East WWTP.

2.5.2 Bee Slough System

The Bee Slough System comprises the following CSS basins:

- Bee Slough Kentucky CSS Basin
- Bee Slough Cass CSS Basin

2.5.2.1 Bee Slough Kentucky CSS Basin

DWFs in this basin generally travel toward the west to the East WWTP.

WWFs exceeding the capacity of the basin overtop the weir in the diversion structure and discharge to Bee Slough via CSO 001.

2.5.2.2 Bee Slough Cass CSS Basin

DWFs in the basin generally travel toward the west to the East WWTP.

WWFs exceeding the capacity of the basin overtop the weir in the diversion structure and discharge to Bee Slough via CSO 002.

2.5.3 Pigeon Creek East System

The Pigeon Creek East System comprises the following CSS basin:

- Oakhill CSS Basin

2.5.3.1 Oakhill CSS Basin

DWFs in the Oakhill basin generally travel north via the Wesselman Park Interceptor to the Weinbach Lift Station. From the Weinbach Lift Station, flows are pumped south toward the East WWTP.

WWFs exceeding the interceptor capacity are released through a gate in the diversion structure and discharge to Pigeon Creek via CSO 011.

2.6 CSO Outfalls

The West CSS contains 14 CSO outfalls. Table 2-2 lists the outfalls, the receiving water to which the CSOs discharge, and the system where the CSO is located.

Table 2-2 West CSS Outfalls

CSO	Name	Major Sewer System	Receiving Water
006	Fulton Avenue PS	Pigeon Creek Interceptor	Ohio River
009	7th Avenue West	Pigeon Creek Interceptor	Ohio River
012	Maryland Street-West Bank	Pigeon Creek Interceptor	Pigeon Creek
013	Delaware Street	Pigeon Creek Interceptor	Pigeon Creek
014	Dresden Street	Pigeon Creek Interceptor	Pigeon Creek
015	7th Avenue East	Pigeon Creek Interceptor	Ohio River
016	Franklin Street	Pigeon Creek Interceptor	Pigeon Creek
017	6th Avenue	Pigeon Creek Interceptor	Pigeon Creek
018	Oakley Street	Pigeon Creek Interceptor	Pigeon Creek
024	Baker Street	Pigeon Creek Interceptor	Pigeon Creek
025	Diamond Avenue	Pigeon Creek Interceptor	Pigeon Creek
020	9th Avenue	West Side Interceptor	Ohio River
022	St. Joseph Avenue	West Side Interceptor	Ohio River
123	West Plant CSO	West Side Interceptor	Ohio River

The East WWTP Service Area contains eight CSO outfalls. Table 2-3 lists the outfalls, the receiving water to which the CSOs discharge, and the system where the CSO is located.

Table 2-3 East CSS Outfalls

CSO	Name	Major Sewer System	Receiving Water
001	Kentucky Avenue	Bee Slough	Bee Slough
002	Cass Avenue	Bee Slough	Bee Slough
103	Junction Box Prior to WWTP Headworks	Ohio River East/Downtown	Ohio River
004	Adams	Ohio River East/Downtown	Bee Slough
008	Chestnut Street	Ohio River East/Downtown	Ohio River
010	Dress Plaza	Ohio River East/Downtown	Ohio River
011	Oakhill/Weinbach	Pigeon Creek East	Pigeon Creek
038	Oak/Riverside	Ohio River East/Downtown	Ohio River

CSO 103 is located just east of the East WWTP. It functions as an overflow point for the East WWTP, and its operation is impacted by river stage, EVLAD K-4 pumping operation, and Bee Slough. Operation of CSO 103 is described in more detail in Section 2.7.

2.7 Levee Authority Pump Stations

The City and Vanderburgh County are protected from Ohio River and Pigeon Creek flooding by a flood protection system that consists of an earthen-levee and floodwall system, and a system of WWF control gates and pump stations that pump water through the levee during elevated river and creek levels. The EVLAD operates the flood protection system under USACE jurisdiction. EVLAD is also responsible for removing stormwater that may accumulate on the land side of the levee and be prevented from discharging by gravity into the Ohio River or Pigeon Creek due to high water levels in the receiving stream(s).

The West System has seven levee pump stations along Pigeon Creek and the Ohio River. Details are provided in Table 2-4.

Table 2-4 Evansville-Vanderburgh Levee Authority Lift Stations, West Service Area

Pump Station Identification	Location	Pump Size (gpm)	Total Pumping Capacity (gpm)	Pump Station Prepared for Pumping (ft/USGS Elev.)	Pump Start/ Stop Points (USGS Elev.)
Ohio Street	411 Fulton Avenue	23,250; 23,250; 23,250	69,750	34/362.70	362.02/360.02
H-4	Howell Street	42,300; 28,200; 14,100; 14,100; 1,200	99,900	34/362.70	351.92/350.12
Delaware Street	1601 W. Iowa St	113,400; 113,400; 113,400; 13,450; 13,450	367,100	36/364.70	346.52/339.52
Dresden Street	1725 Dresden St	31,400; 31,400; 31,400	94,200	37/365.70	370.02/369.02
6th Avenue	2412 Sixth Avenue	26,200; 26,200	52,400	39/367.70	367.52/358.02
First Avenue	801 Uhlhorn	30,833; 30,833; 30,833	92,499	40/368.70	368.52/366.52
Diamond Avenue	15 W. Richardt	143,600; 143,600; 143,600	430,800	35/366.70	364.52/355.52

Notes:
Elev. = Elevation
gpm = gallons per minute
USGS = United States Geological Survey

The East Service Area has three levee pump stations along the Ohio River. Table 2-5 provides additional details regarding the East WWTP Service Area EVLAD pump stations.

Table 2-5 Evansville-Vanderburgh Levee Authority Pump Stations, East Service Area

Pump Station Identification	Location	Pump Size (gpm)	Total Pumping Capacity (gpm)	Pump Station Prepared for Pumping (ft/USGS Elev.)	Pump Start/ Stop Points (USGS Elev.)
K-4	Sunset Park (701 Veterans Memorial Parkway)	38,000; 38,000	76,000	26/354.70	355.02/353.52
K-5	Chestnut Street (301 Riverside Drive)	11,000; 35,000; 35,000; 2,800	83,800	29/358.70	356.92/354.42
Sycamore Street	2 Sycamore Street	62,500; 62,500; 62,500	187,500	34/362.70	361.12/359.02

Operation of the K-4 PS impacts operations at the East WWTP as well as CSO 103. Operational interactions are described in further detail in Section 2.7.2.

2.7.1 CSO Outfalls Impacting Bee Slough

Bee Slough is a concrete-lined drainage channel in the East Service Area that runs parallel to Veterans Memorial Parkway and ultimately discharges into the Ohio River. It consists of approximately 5,300 ft of trapezoidal concrete-lined open channel, and at the intersection of Waterworks Road and Shawnee Drive it transitions into an enclosed elliptical pipe that conveys flow underground approximately 700 ft to its outfall into the Ohio River. It conveys stormwater from the Sweetser Avenue outfall and CSO discharges from CSO 001 (Kentucky), CSO 005[1] (Shadywood), CSO 002 (Cass), and CSO 004 (Adams & Sunset) to the Ohio River during wet weather events. CSO 001 and CSO 005 discharge flow into the most upstream end of Bee Slough by means of a single 108-inch pipe. CSO 002 discharges flow at the approximate mid-point of the open channel by means of a 96-inch pipe, and CSO 004 discharges flow by means of a 48-inch x 72-inch brick sewer into the enclosed elliptical pipe, just downstream of the intersection of Waterworks Road and Shawnee Drive.

The East WWTP's effluent and overflows from CSO 103 are conveyed through a common outfall directly to the Ohio River. This outfall runs parallel to Bee Slough on the south side of Veterans Memorial Parkway and its discharge into the Ohio River is located just upstream of the Bee Slough outfall (See Figure 2-12).

2.7.2 Ohio River Impacts on Bee Slough and the East WWTP

2.7.2.1 Evansville-Vanderburgh Levee Authority District and K-4 Pump Station

Table 2-6 lists key characteristics of the K-4 PS, which is the levee pump station that pumps WWFs from Bee Slough, East WWTP effluent, and overflows from CSO 103 into the Ohio River during high river levels. It is required to pump stormwater generated on the land side of the levee for storms up to and including the 100-year, 24-hour event. Because it would be uneconomical to provide capacity to pump flows generated by the 100-year storm through only pumping, K-4 utilizes a ponding area for flow equalization that includes Bee Slough, as well as the nearby low-lying areas to the east and west of Veterans Memorial Parkway near the East WWTP. Details regarding the extent of the K-4 Pump Station ponding area can be found in the *K-4 Basin Routing Analysis Technical Memorandum* (Clark Dietz, Inc., 2009), and an overview of K-4's high- and low-river operation and impacts on Bee Slough and the East WWTP is presented below.

Table 2-6 K-4 Pump Station Characteristics

Pump Station Identification	Location	Pump Size (gpm)	Total Pumping Capacity (gpm)	Pump Station Prepared for Pumping (ft/USGS Elev.)	Pump Start/ Stop Points (USGS Elev.)
K-4	Sunset Park (701 Veterans Memorial Parkway)	38,000; 38,000	76,000	26/354.70	355.02/353.52

[1] CSO 005 discharges into 108-inch outfall from CSO 001

2.7.2.2 K-4 Low River Condition Operations

Low river, or normal, conditions are when Ohio River levels are below an elevation of 355, or below 26 ft of river level.

2.7.2.2.1 Bee Slough Flows

WWFs conveyed by Bee Slough are discharged by gravity directly into the Ohio River through an outfall located adjacent to K-4. Though Bee Slough is relatively flat, flow does not accumulate or stand in Bee Slough for long after rain events have ended.

2.7.2.2.2 East WWTP Flows

During dry weather, sanitary sewage flows through diversion structure 103 and to the East WWTP. All influent flow receives secondary treatment and disinfection. Final treated effluent is conveyed back to diversion structure 103 and is discharged through the WWTP effluent sewer and into the Ohio River by gravity. As stated above, the WWTP effluent sewer runs parallel to Bee Slough and its discharge point is upstream and separate from the Bee Slough outfall.

During wet weather, if influent flow exceeds the East WWTP's maximum treatable flow rate, it backs up into the CSO 103 diversion structure and overtops the weir. The overflows mix with WWTP effluent and are discharged by gravity directly to the Ohio River through the effluent sewer.

2.7.2.3 K-4 High River Condition Operations

At river levels above 355, or 26 ft, EVLAD closes gates on the Bee Slough and East WWTP outfalls to prevent backflow of the river into the City and the EVLAD K-4 PS is activated to pump WWFs, East WWTP effluent, and flow from CSO 103 through the levee and into the Ohio River.

2.7.2.3.1 Bee Slough Flows

The EVLAD K-4 PS contains two very large vertical turbine pumps that require considerable water depth to operate without cavitation. Consequently, a combination of stormwater, CSO discharges, and East WWTP effluent backs up through the underground elliptical pipe and ponds in Bee Slough during periods when K-4 is in operation. The ponding generally extends all the way back to the CSO 001 outfall and it can occur for several days or weeks, depending on how long the Ohio River is at or above flood stage. This water can become stagnant, ultimately posing public health risks and causing aesthetic and odor issues, due to the settling out and accumulation of solids from CSO discharges.

2.7.2.3.2 East WWTP Flows

In addition to creating aesthetic and odor problems and public health risks, operation of the K-4 PS also has a significant impact on the East WWTP hydraulics. During high river conditions when the flood protection system gates are closed, East WWTP effluent flow and wet-weather overflows from CSO 103 are redirected to the K-4 PS to be pumped through the levee and to the Ohio River.

As noted above, the K-4 pumping points are set to prevent pump cavitation, and as a result, the pump-on and pump-off elevations are set higher than the weir elevation in diversion structure 103. This causes flow to back up in the effluent sewer and to flood diversion structure 103, which results in recirculation of WWTP effluent through the WWTP. The recirculation consumes treatment capacity, reducing the WWTP's ability to take in additional WWF for treatment.

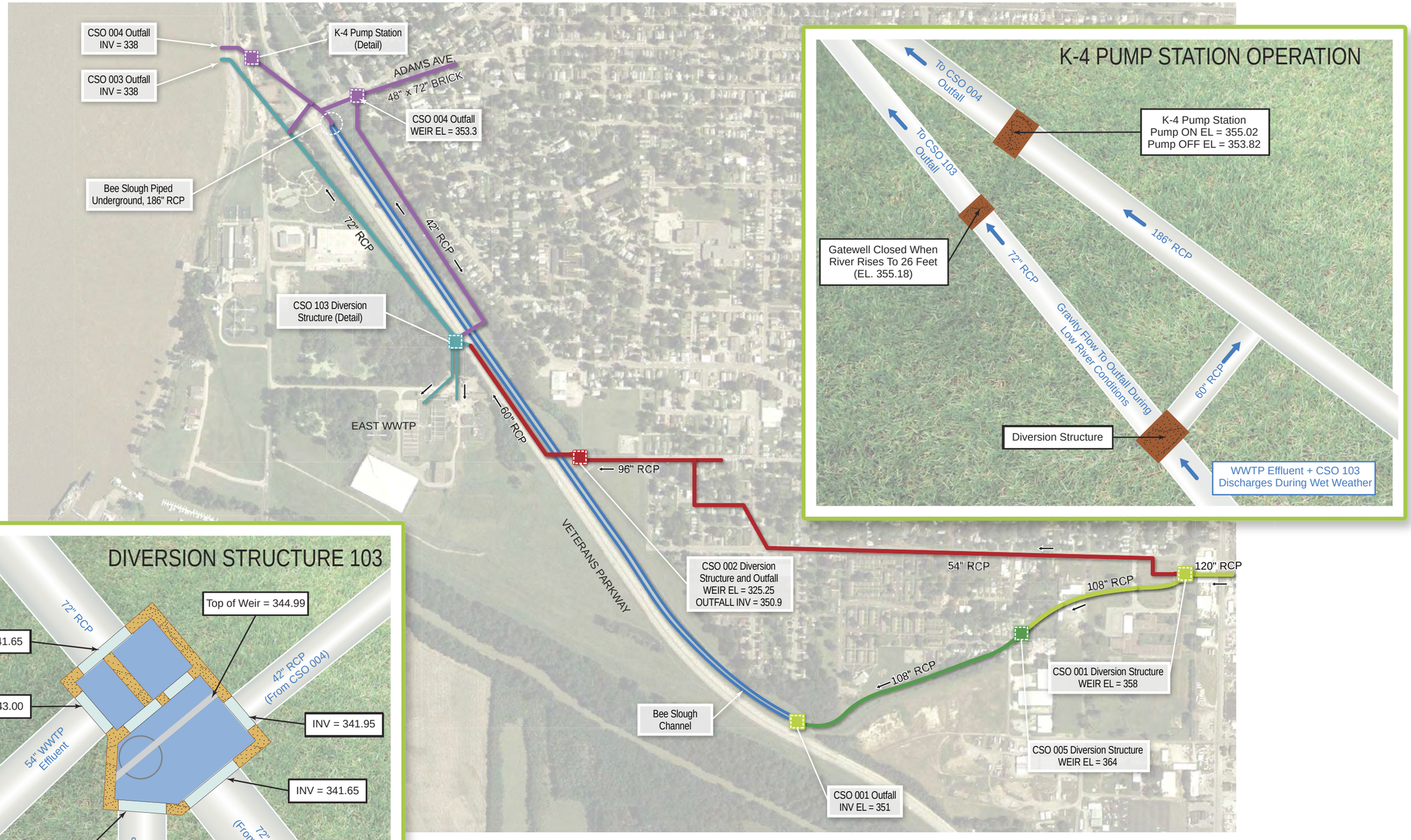


FIGURE 2-12
Bee Slough System Existing Conditions
Long-Term Control Plan
May 31, 2013

2.8 Wastewater Treatment Plants

As previously stated, the Utility operates two WWTPs, with no transfer of flow from one WWTP service area to the other.

2.8.1 West WWTP Overview

The West WWTP was originally constructed in the mid-1950s. Activated-sludge secondary treatment was added in the early 1970s, and BAF secondary treatment, which operates in parallel with the activated-sludge process, was added in 2009. Currently, the West WWTP provides preliminary treatment, primary clarification, secondary treatment, and disinfection.

The National Pollutant Discharge Elimination System (NPDES) permit states that the West WWTP has an average design flow of 21.7 mgd and peak sustained wet-weather flow of 30.6 mgd. The weekly and monthly mass limits in the permit are based on the sustained peak wet-weather flow. Under favorable operating conditions, the West WWTP's current peak wet-weather capacity is 37 mgd.

Raw wastewater enters the WWTP via a gravity sewer. The wastewater flows through a single mechanically cleaned bar screen before being pumped by the influent pumps. The influent pumps discharge upstream of a single vortex grit removal unit. After grit removal, the wastewater flows to the primary clarifiers. Primary effluent is split between the aeration tanks and the BAF for secondary treatment. Mixed liquor from the aeration tanks flows to the secondary clarifiers for liquid/solids separation. Secondary effluent from the clarifiers and from the BAF flows into the chlorine contact tank for disinfection. The disinfected effluent is dechlorinated prior to discharge into the Ohio River. Table 2-7 summarizes the unit processes at the West WWTP.

Table 2-7 Summary of West WWTP Unit Processes and Design Capacities

Unit Process	Type	Quantity	Size	Design Capacity
Preliminary Treatment				
Influent Screening	Mechanical	1	0.25-inch openings	40 mgd
Influent Pumping	Engine Driven	2		20 mgd
	Motor Driven	1		20 mgd
Grit Removal	Vortex Unit – 360° design Pista Grit	1	19-foot diameter	50 mgd
Primary Treatment				
Primary Clarification	Rectangular, chain and flight system	6	137-foot-long by 32-foot-wide by 8-foot, 8-inch SWD	39.6 mgd[a]
Secondary Treatment: Activated Sludge				
Aeration Tanks	Plug-flow tanks with ceramic grid fine bubble aeration system	3	342-foot-long by 30-foot-wide by 15-foot SWD	1.15 MG, each

Table 2-7 Summary of West WWTP Unit Processes and Design Capacities

Unit Process	Type	Quantity	Size	Design Capacity
Blowers	Positive displacement	4	5,050 cfm, each	15,150 cfm with largest unit out of service
Clarification	Circular, flat-bottom, peripherally fed	3	105-foot-diameter, 12-foot SWD	33 mgd[a]
Return Sludge Pumping	Non-clog, horizontally mounted	3	6-inch-diameter suction by 8-inch-diameter discharge; 50-hp TEFC motors	1,500 gpm at 64.6-foot TDH
Waste Sludge Pumping	Non-clog, horizontally mounted	3	6-inch-diameter suction by 6-inch-diameter discharge; 5-hp TEFC motors	625 gpm at 10.7-foot TDH
Secondary Treatment: BAF				
BAF	Aerated upflow w/ polystyrene beads	1	Six 11.5-foot-deep cells with bed of 4.5-mm polystyrene beads	20-mgd peak hour, 12.5-mgd sustained peak; operated at 14 mgd
Disinfection				
Chlorination	Gas chlorinators	2	2,000 lb/day	45.2 mgd
	12-pass serpentine contact tank	1	471,022 gallons	43 mgd[a]
Dechlorination	Sodium bisulfate pumps	2	20.8 gallons per hour	173 mgd
Other				
Effluent Pumping	Wet/dry well	3	20 mgd each	20 mgd each

[a] Capacity based on stress testing conducted April 2012. Stress Testing Report (CH2M HILL, 2012f) provides more information.

cfm = cubic feet per minute
hp = horsepower
lb/day = pounds per day
MG = million gallons
mm = millimeter
SWD = sidewater depth
TEFC = totally enclosed, fan cooled

Waste activated sludge (WAS) is thickened by gravity belt thickeners. Primary sludge and thickened secondary WAS are then pumped to the primary anaerobic digesters. The digested sludge is thickened by decanting in a secondary digester and is pumped through an interplant pipeline to the East WWTP, where it is dewatered with belt filter presses and trucked to an onsite storage pad. From there, dewatered solids are hauled to a landfill for disposal.

Figures 2-13 and 2-14 present the West WWTP site plan and process flow diagram (PFD), respectively.

2.8.2 East WWTP Overview

The East WWTP was originally constructed in the late 1950s and included preliminary and primary treatment. The primary effluent was disinfected using chlorine contact tanks that were adjacent to the primary clarifiers. The chlorine contact tanks provided 15 minutes of detention time at 14 mgd. When the activated-sludge system was added in the 1970s, a new chlorine contact tank was constructed to accommodate the change in the WWTP's hydraulic profile. The new contact tank was constructed to process a peak flow of 26 mgd with 15 minutes of detention time. Currently, the East WWTP provides preliminary treatment, primary clarification, secondary treatment, and disinfection. The NPDES permit states that the average-day design capacity is 18 mgd, and the current peak design flow is 22.5 mgd. Recent stress tests show that the WWTP can process up to 28 mgd under favorable operating conditions. The monthly and weekly mass limits for 5-day carbonaceous biochemical oxygen demand ($CBOD_5$), TSS, and ammonia have been calculated using peak design flow.

Raw wastewater flows by gravity to the WWTP. Two mechanically cleaned bar screens and two vortex grit removal units provide preliminary treatment upstream of the influent pumps. The preliminary treated wastewater is discharged from the influent pumps into the primary clarifiers. Flow is by gravity through the plant once it enters primary treatment. Effluent flows from the primary clarifiers to the aeration tanks for secondary treatment and then to the secondary clarifiers for liquid/solids separation. Secondary effluent from the clarifiers flows into the chlorine contact tank for disinfection. The disinfected effluent is dechlorinated prior to discharge into the Ohio River. During high-river stages, the final effluent is discharged into the drainage area of the K-4 Pump Station. The K-4 Pump Station pumps water from the drainage area over the levee and into the Ohio River.

WAS from the secondary clarifiers is thickened by gravity belt thickeners. Primary sludge and thickened secondary WAS are then pumped to the primary anaerobic digesters and fed to secondary digesters. Digested sludge is pumped to conditioning tanks, where it is blended with digested sludge from the West WWTP and dewatered by belt filter presses. Trucks then haul the dewatered sludge to the onsite storage building until a local trucking company hauls the dewatered sludge to a landfill for disposal.

Table 2-8 provides a summary of the unit processes and design capacities at the East WWTP.

Table 2-8 East WWTP Unit Process and Design Capacities Summary

Unit Process	Type	Quantity	Size	Design Capacity
Preliminary Treatment				
Influent Screening	Mechanical	2	0.25-inch openings	20 mgd each
Influent Pumping	Flygt – submersible non-clog centrifugal	4	Flygt motor -170 hp	16.5 mgd @ 47.5-foot TDH (each)
Grit Removal	Vortex unit – 270° design Pista Grit	2	18-foot diameter	30 mgd each[a]

Table 2-8 East WWTP Unit Process and Design Capacities Summary

Unit Process	Type	Quantity	Size	Design Capacity
Primary Treatment				
Primary Clarification	Rectangular with chain and flight system	7	103-foot-long by 32-foot-wide by 8-foot, 8-inch SWD	50 mgd[b]
Secondary Treatment: Activated Sludge				
Aeration Tanks	Plug-flow tanks with ceramic grid fine bubble aeration system	3	300-foot-long by 30-foot-wide by 15-foot SWD	3.03 MG[c]
Blowers	Positive displacement	4	5,050 cfm, each	40.6 mgd
Clarification	Circular, flat-bottom, peripherally fed	3	100-foot-diameter, 12-foot SWD	28 mgd[b]
Return Sludge Pumping	Non-clog, horizontally mounted	3	6-inch diameter suction by 6-inch-diameter discharge; 25-hp TEFC motors	1,480 gpm at 39.5-foot TDH
Waste Sludge Pumping	Non-clog, horizontally mounted	3	6-inch diameter suction by 6-inch diameter discharge; 5-hp TEFC motors	550 gpm at 13.6-foot TDH
Disinfection				
Contact Tank	Two-pass, serpentine	1	315,000 gallons	32.4 mgd[b]
Chlorination	Gas chlorinators	2	2,000 lb/day	64.8 mgd
Dechlorination	Sodium bisulfate pumps	2	20.8 gallons/hour	173 mgd
Other				
Flow Metering	Magmeter	2	16”	25 mgd each
Effluent Pumping	U.S. Army Corps of Engineers Pump Station	1		110 mgd

[a] At peak-hourly flow.

[b] Capacity based on stress testing conducted April 2012. Stress Testing Report (CH2M HILL, 2012d) provides more information

[c] Existing aeration tanks are permitted for 18-mgd average and 22.5-mgd peak by the City’s NPDES Permit, No. IN 0033073, dated February 1, 2012.

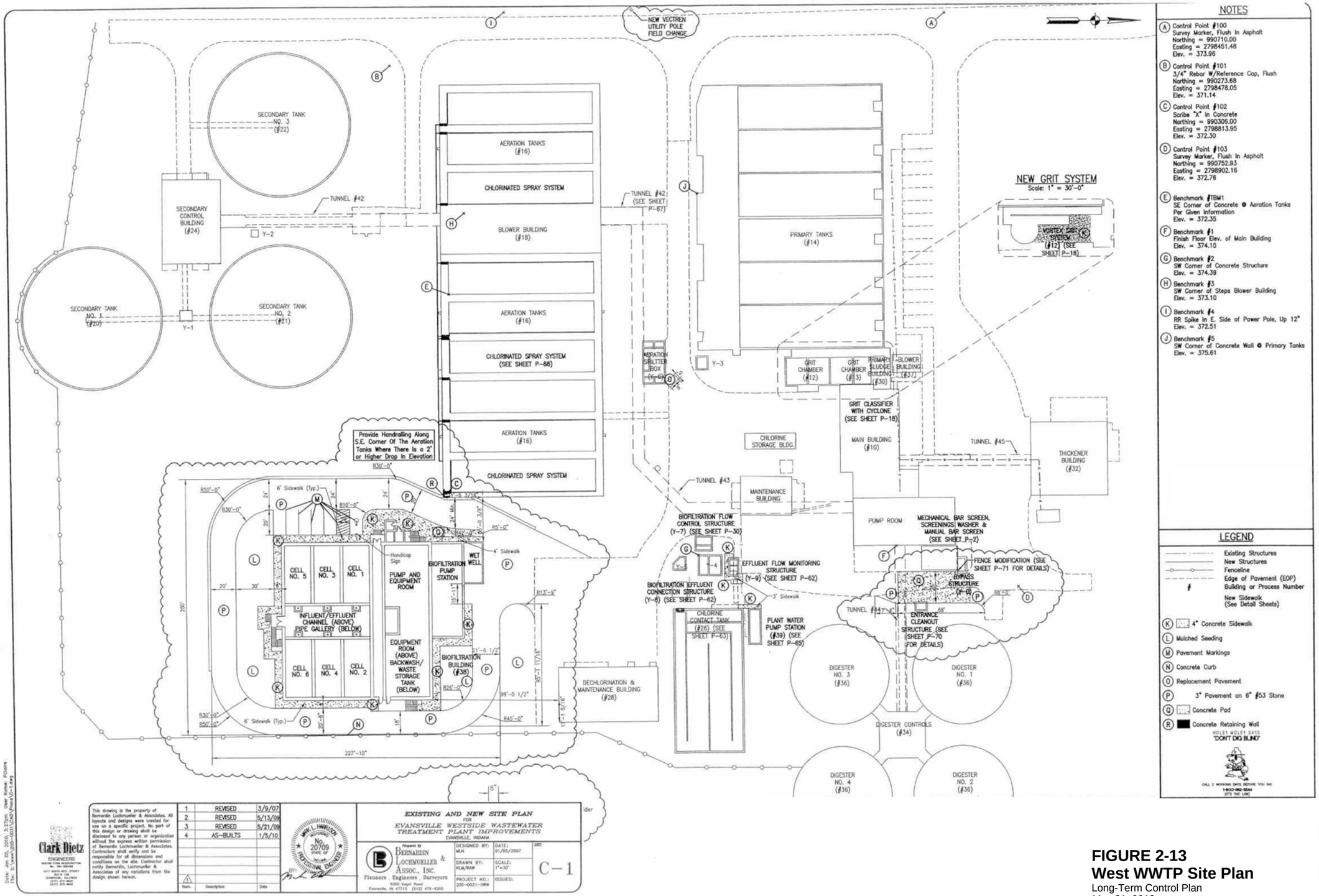


FIGURE 2-13
West WWTP Site Plan
Long-Term Control Plan
May 31, 2013

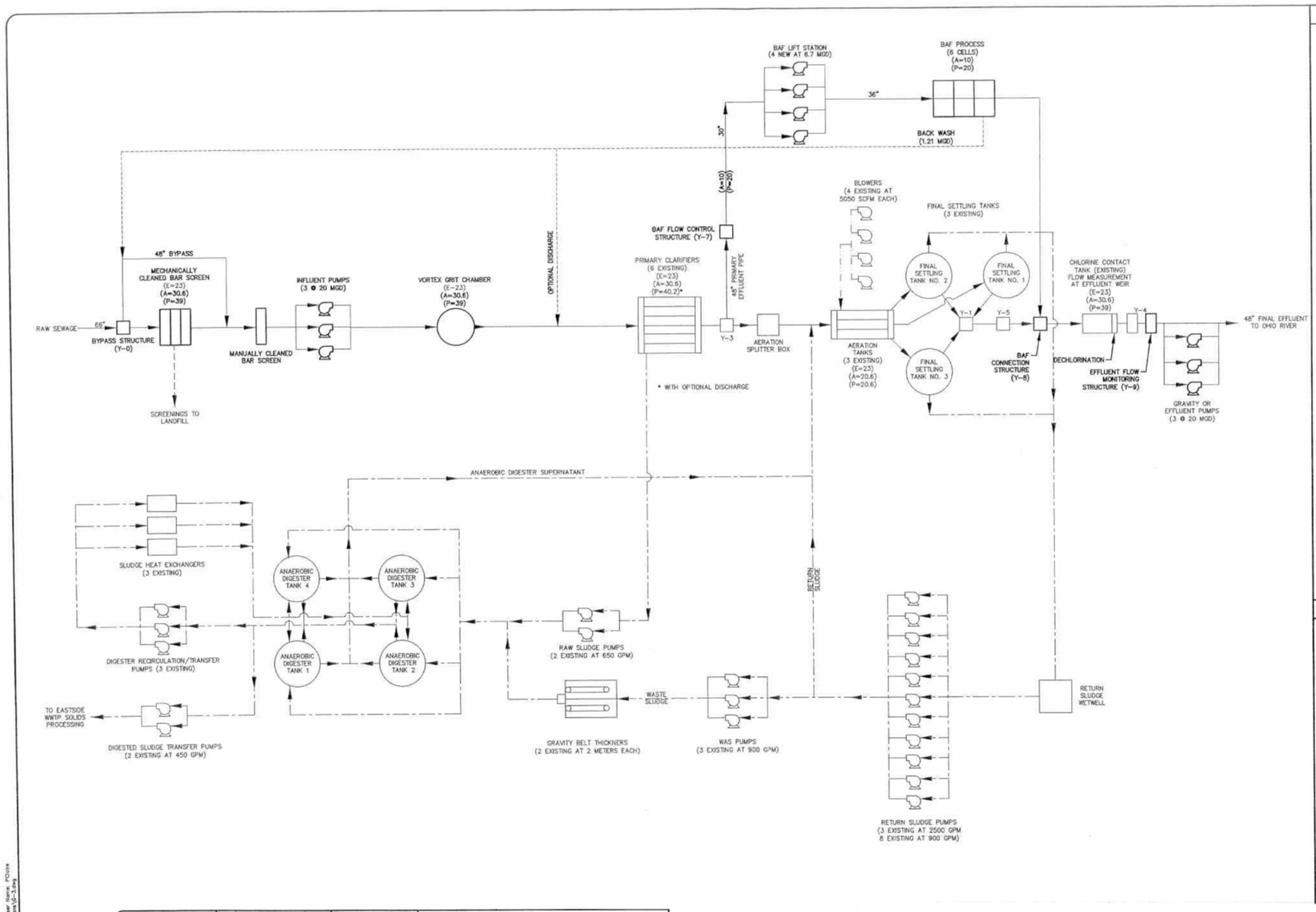


FIGURE 2-14
West WWTP Process Flow Diagram
Long-Term Control Plan
May 31, 2013

Figures 2-15 and 2-16 present the East WWTP site plan and process flow diagram (PFD), respectively.

2.9 CSS Flow Metering and Receiving Water Monitoring

The Utility's CSS flow metering and receiving water monitoring programs were summarized in *Initial System Characterization including Separate Sanitary Sewer Hydraulic Model Development* (CH2M HILL, 2011k). The receiving water monitoring program was described in the SRCER (CH2M HILL and LimnoTech, 2011), and the results were used to develop the Utility's receiving water quality model. The Utility's water monitoring program described in those documents included the following activities:

- Precipitation monitoring throughout the Utility's service area
- Conducting an inventory of flow monitors and level sensors owned by the Utility and used to collect in-system flow data to support hydraulic model development and to conduct specific studies of in-system hydraulic conditions
- Monitoring of CSO discharge
- Wet-weather sampling of CSO discharges and stream level, flow, and water quality in Pigeon Creek to support the SRCER update (CH2M HILL and LimnoTech, 2011)
- Evaluation of Ohio River Valley Water Sanitation Commission and USGS data for Ohio River flow, level, and water quality

In-system flow monitoring data were also collected between July and December 2012. These Phase III monitoring data were used to adjust the DWF and WWF in the CSS models between the July 31, 2012 Draft and May 31, 2013 Final IOCP submittals.

2.10 Hydraulic Models

Development and findings of the Utility's CSS and receiving water modeling programs and their characterization of the existing system are presented in *Initial System Characterization including Separate Sanitary Sewer Hydraulic Model Development* (CH2M HILL, 2011k).

2.10.1 Hydraulic Model Development

The Utility used the following applications for model development:

- Both the East and West Basin Separate system models were developed and calibrated in EPA SWMM.
- The East Combined System model was developed and approved by EPA using XP SWMM.
- The West Combined System Model was developed and approved by EPA in XP SWMM, and the team then updated the model using EPA SWMM.

The East and West CSS hydraulic models were developed in distinct steps:

- **East system CSS model development** - as presented in *Preliminary Modeling Report Combined Sewer – East System* (Clark Dietz, Inc., 2007b).
- **West system CSS model development** - as presented in *Preliminary Modeling Report Combined Sewer – West System* (Clark Dietz, Inc., 2009).

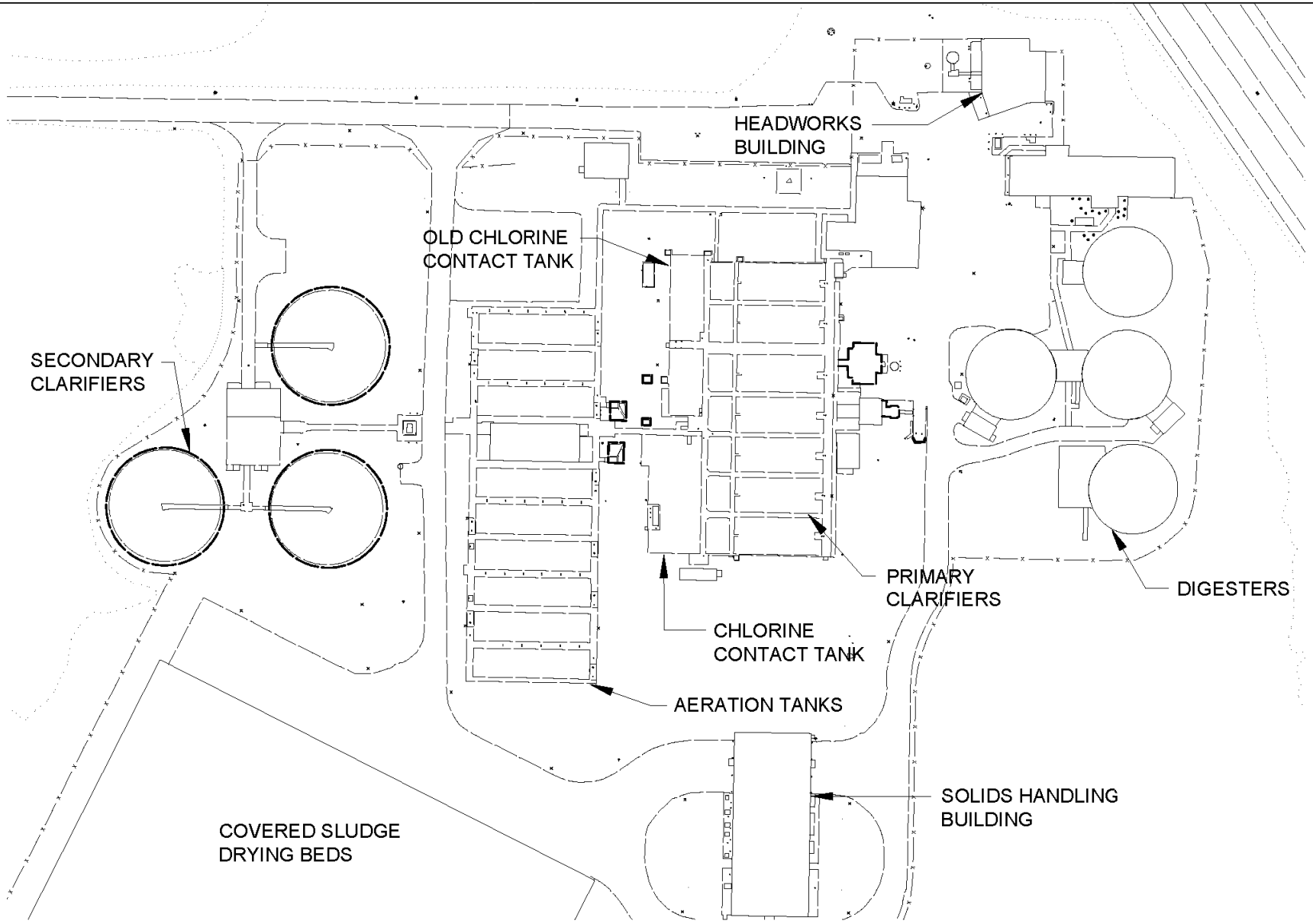


FIGURE 2-15
East WWTP Site Plan
Long-Term Control Plan
May 31, 2013

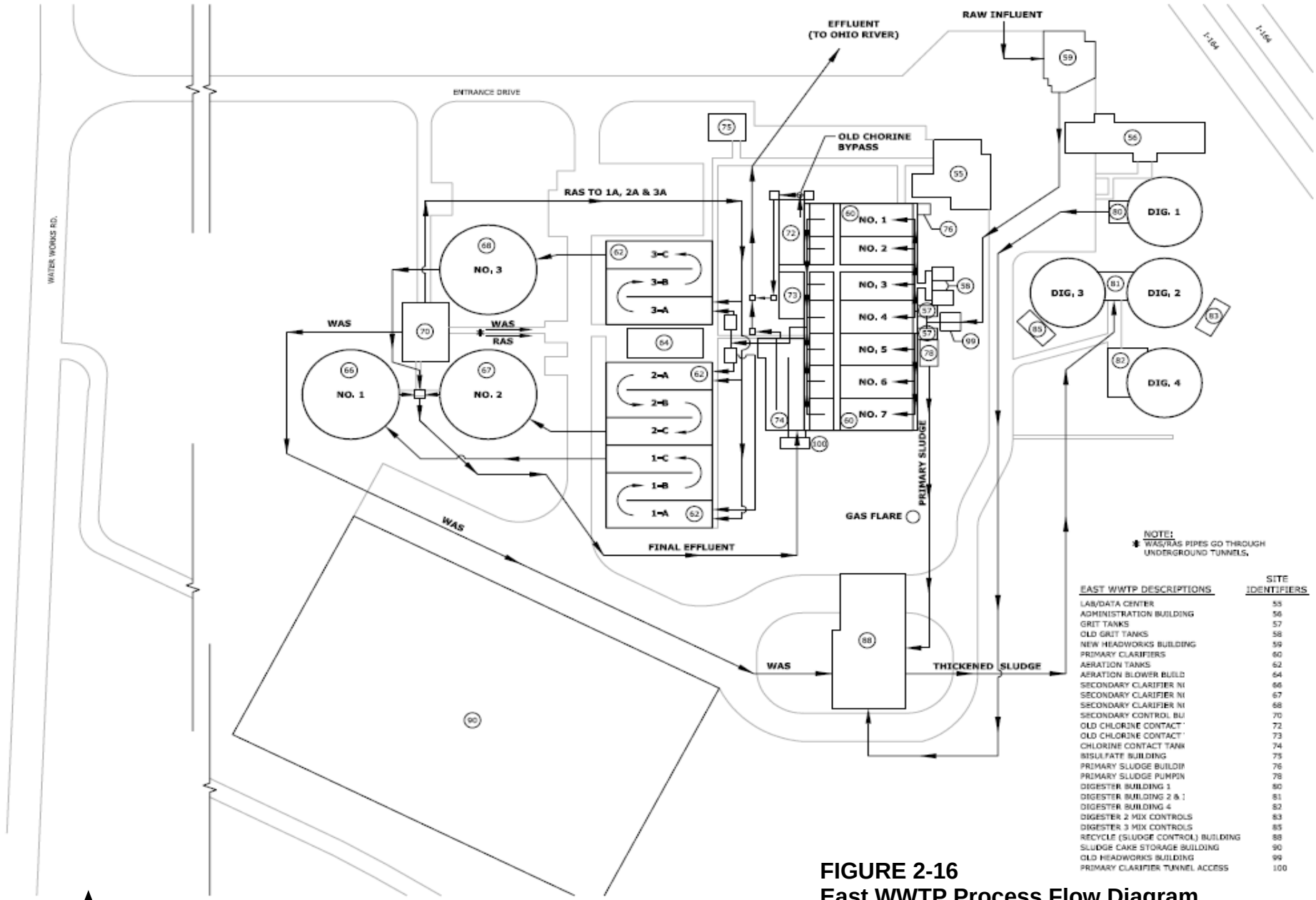


FIGURE 2-16
East WWTP Process Flow Diagram
Long-Term Control Plan
May 31, 2013

- **Selection of the typical year** - as presented in *Typical Precipitation Year Evaluation Report,* (Clark Dietz, Inc., 2008). This document, and all IOCP volumes, refers to Typical Year model results when presenting hydraulic model derived data.
- **Separate sewer system model development** - As presented in *Initial System Characterization including Separate Sanitary Sewer Hydraulic Model Development* (CH2M HILL, 2011k), hydraulic models were developed for each basin in the West and East SSS. Each SSS model was calibrated, with the exception of W-8. The calibration of the W-8 SSS basin could not be completed due to an apparent consistent loss of flow occurring between two flow monitors. The Utility continues to investigate this area in an ongoing effort to update the W-8 SSS model.
- **Integrating the SSS models into the CSS models** - The CSS models by Clark Dietz were updated in 2011 to reflect the SSS inputs. The 2009 models did not include the SSS basins; therefore, the SSS flows were originally represented as constant inflows at the boundary of the CSS network, and upstream rainfall-derived inflow and infiltration (RDII) flows were omitted from the system, as presented in *Initial System Characterization including Separate Sanitary Sewer Hydraulic Model Development* (CH2M HILL, 2011k). The SSS systems and flows were generally represented well in the integrated model; however, the CSS or flows were not accurately modeled. As a result, additional updates were completed in 2012 to better reflect CSS flows.
- **Updating the CSS models to better reflect the existing system -** The original CSS models were calibrated; however, the model did not accurately represent the existing system. The CSS model representation was improved between the Draft IOCP and Final IOCP submittals so that the activations and percent capture better represent the current system and more appropriately size LTCP projects. The modeling refinement consisted of:
  - Reviewing and updating the overflow/diversion structures based on 2011 survey information
  - Reviewing and updating the operational settings of control gates based on 2011 monitoring and data analysis
  - Reviewing and updating the EVLAD pump station operational informational based on EVLAD information
  - Reviewing and updating the 7th Avenue Lift Station and West WWTP influent pump station operational data based on 2011 monitored data
  - Updating the CSS DWF and WWF based on 2012 flow monitoring data
  - Applying seasonal adjustments for CSS and SSS DWFs

It should be noted that model refinements were focused on the major facilities within the CSS. Detailed reviews of the hydraulic parameters were not performed for all the pipes or manholes, or the model network within the SSS areas.

Based on the described development, the Utility's hydraulic modeling program includes the following elements:

- One merged hydraulic model represents combined and SSSs tributary to the West WWTP. The SSS portion of the model includes trunk sewers that are 12 inches in diameter and larger, and portions of the system that experience recurring SSOs.

- A second model represents the total basin tributary to the East WWTP. To characterize the performance of the Utility's East System, the SSS and CSS models are run separately and the results are combined external to the modeling software. This is referred to as an "integrated model." The SSS portion of the model includes trunk sewers that are 12 inches in diameter and larger, and portions of the system that experience recurring SSOs.

2.10.2 Typical Year Discharges and Volumes

The hydraulic models were used to characterize the frequency, volume, and location of sewer system overflows throughout the Utility's existing system, as of approximately 2012. In this document, that characterization is presented in terms of Typical Year annual overflow volumes. A summary of annual number of activations and overflow volume by CSO, service area, and receiving water body are provided in Figures 2-17 through 2-20 for the existing condition, future condition, and future baseline condition:

- Existing condition – 2012 flows, existing infrastructure
- Future condition – 2032 flows, existing infrastructure
- Future baseline condition – Future baseline represents 2032 flows including projects common to all alternatives (i.e., PCI cleaning, sewer separation

2.11 Receiving Water Quality Model

For the receiving water quality impact evaluation, the volumes of stream flow on Pigeon Creek and the Ohio River were estimated using available USGS stream flow gauges. The existing (approximately 2010) loadings to the receiving waters were calculated by combining the upstream loading documented in the receiving water model development (CH2M HILL and LimnoTech, 2011) with loadings estimated from the modeling of the sewer system. Since sewer system discharges are infinitely and unpredictably variable, the sewer system flow volumes were multiplied by characteristic concentrations for CSOs in calculating the overflow loadings. The receiving water impacts indicated by the water quality modeling and loadings are presented in Section 7.

Figure 2-17
Typical Year Hydraulic Modeling
Annual Modeled CSO Discharge Events
East and West Service Areas

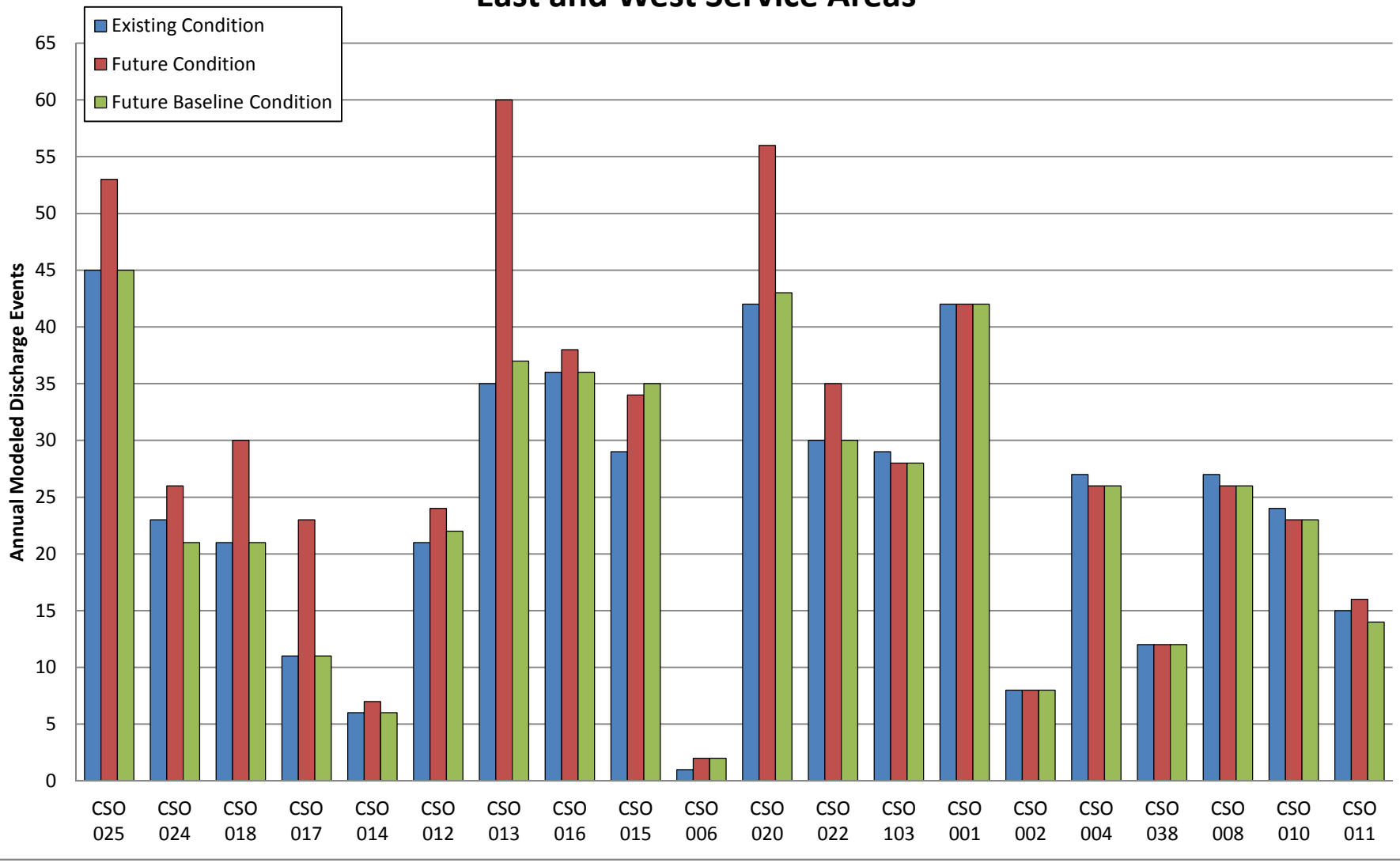


Figure 2-18
Typical Year Hydraulic Modeling
Annual Modeled CSO Discharge Volume
East and West Service Areas

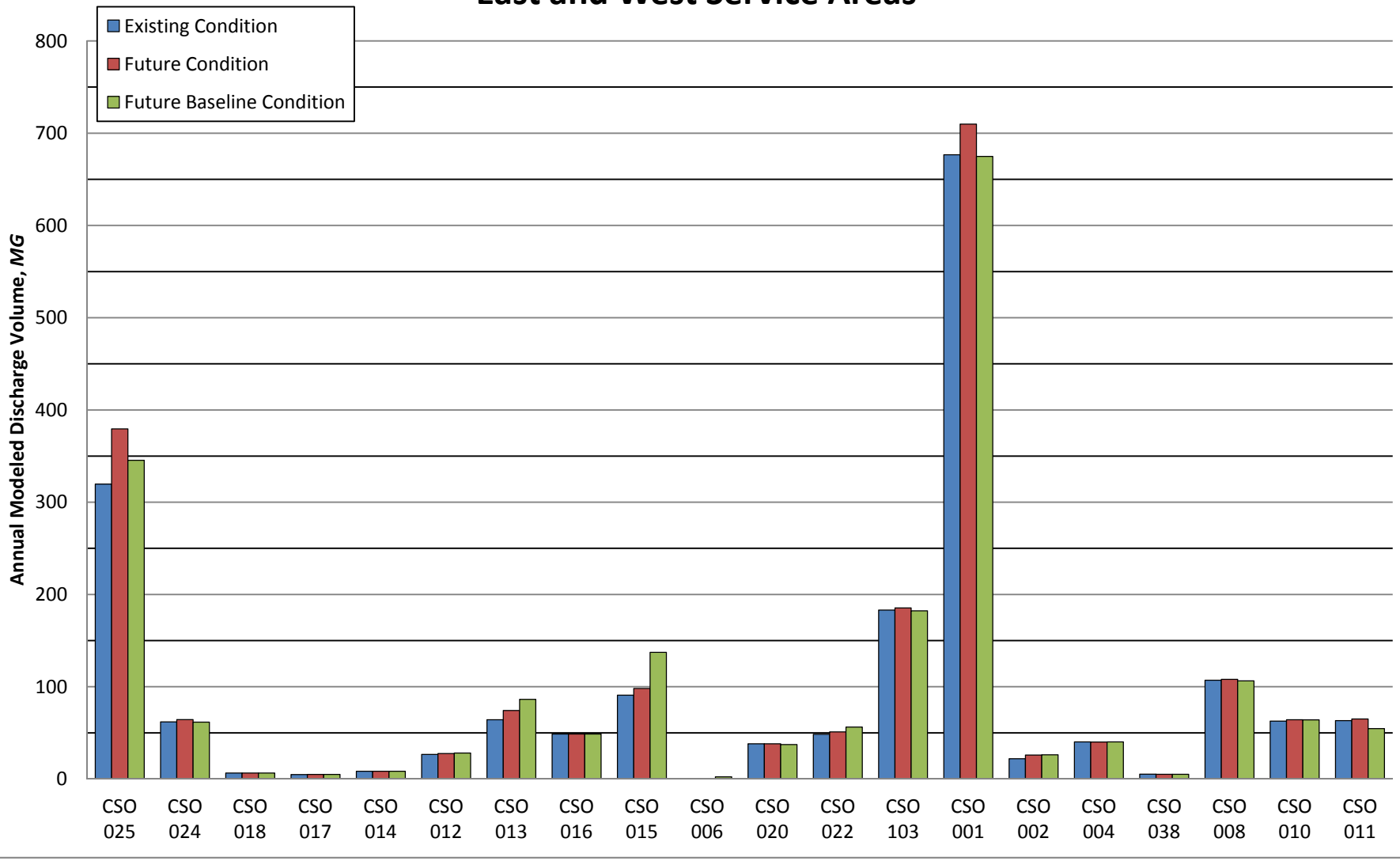


Figure 2-19
Typical Year Hydraulic Modeling
Annual Modeled CSO Discharge Volume
By Service Area

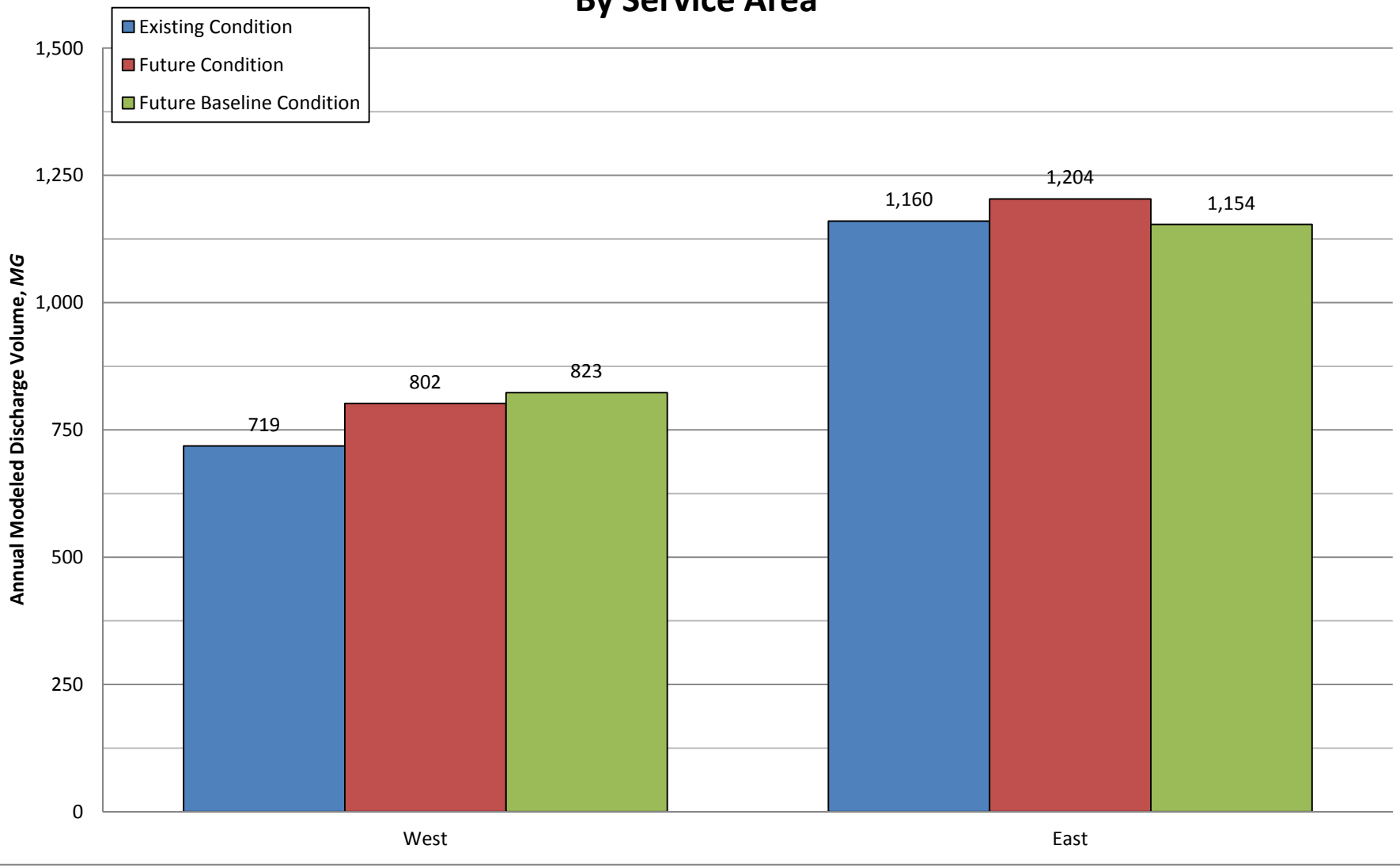
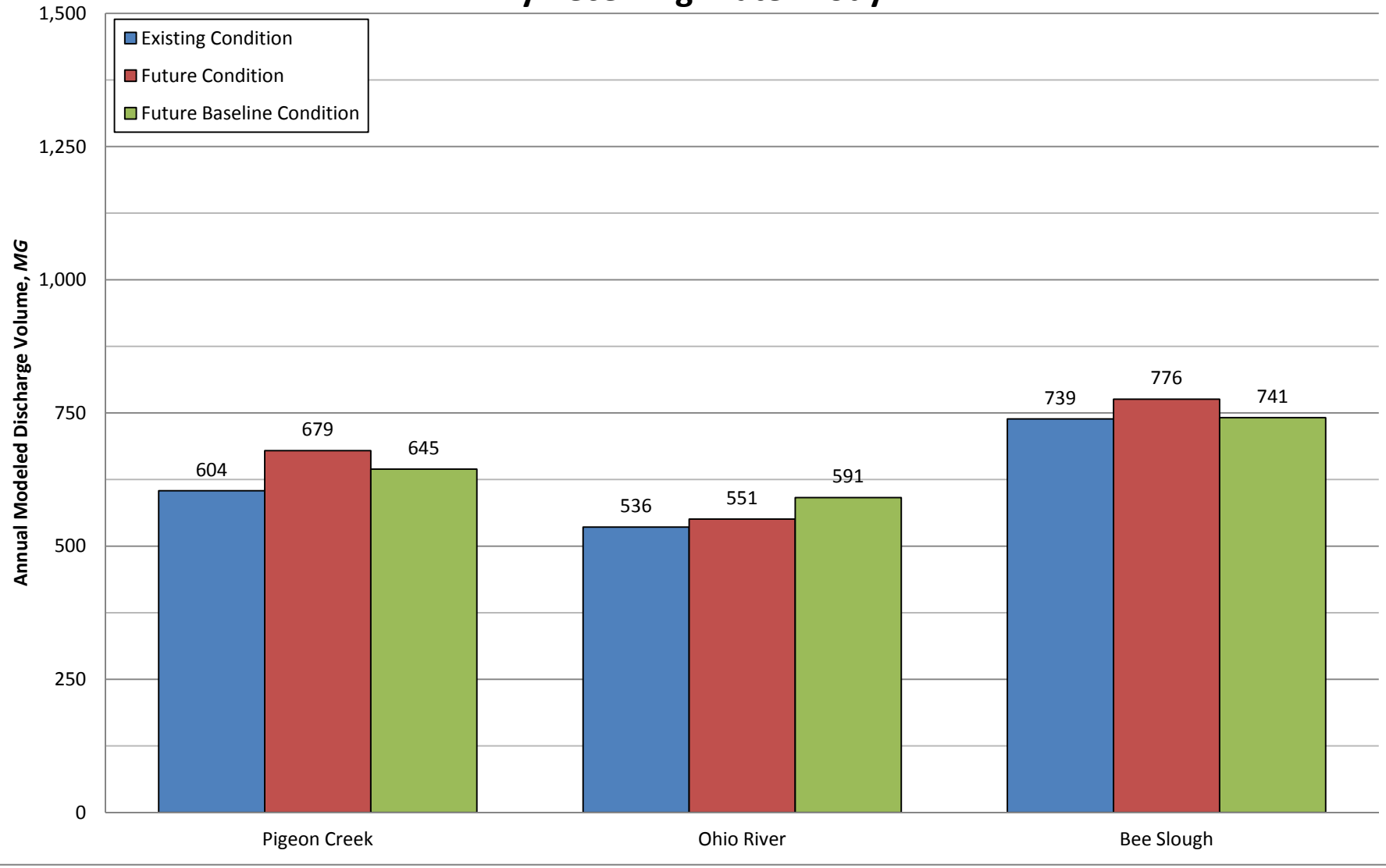


Figure 2-20
Typical Year Hydraulic Modeling
Annual Modeled CSO Discharge Volume
By Receiving Water Body



SECTION 3

Alternatives Evaluation Methodology

The LTCP approach to CSO reduction is based on identifying the solutions that provide the greatest benefit-cost ratio and/or improvement to overall performance of the CSS. This section summarizes the approach for identifying, screening, and evaluating site-specific WWTP upgrades and CSO controls, the processes for combining them into alternatives that balance overflow controls throughout the WWTP basins, and the methodology used to develop a range of alternatives for eliminating, reducing, or treating CSO discharges. Ultimately, a range of alternatives were evaluated to meet required CSO control targets specified in Appendix C, Section I, Paragraph 3 of the Decree.

The development and evaluation of applicable technologies, projects, and alternatives consisted of a structured approach to identify CSO controls suitable to protect water quality and designated uses. The approach consisted of the following steps:

1. Develop benefit metrics to evaluate the effectiveness of CSO controls (Section 3.2).
2. Develop project costing methodology (Section 3.3).
3. Identify potential CSO control measure technologies (Section 3.4). The options for potential consideration resulted from the *Combined Sewer Overflow Alternatives Analysis Screening Report* (CH2M HILL, 2012a). In general, the control measures considered include:
    - Increasing WWTP capacity
    - Maximizing conveyance to the WWTPs
    - Other in-system sewer system modifications such as sewer separation, storage, and satellite treatment
4. Identify specific control measure technologies applicable for consideration at each particular CSO location or CSO grouping (Section 3.4).
5. Develop and screen potential basin-wide alternatives (Sections 4 and 5) as described in Appendix C, Section I, Paragraph 2 of the Decree to identify an appropriate list of alternatives for further evaluation.
6. Evaluate the alternatives identified for further evaluation with regard to cost and effectiveness in terms of reduction of overflows as required by Appendix C, Section I, Paragraph 3 of the Decree (Section 6), including refinement to achieve the following system-wide levels of control:
    - Number of annual untreated Typical Year discharges: 0, 1, 3, 4, 7, 8, and 12
    - Percent capture for treatment: 100 percent, 90 percent, 85 percent, 80 percent, and 75 percent
7. Evaluate the effectiveness of the alternatives identified for further evaluation in terms of water quality improvements, as required by Appendix C, Section I, Paragraph 3 of the Decree (Section 7).
8. Select one final plan that balances maximized benefits early in the implementation while addressing affordability constraints through an implementation schedule (Section 8).

Following selection of the final plan, a schedule was developed for the design, construction, and implementation of the control measures as expeditiously as possible, given the Utility's affordability and project prioritization constraints. The schedule is discussed in detail in Section 8, and Section 9 summarizes the post-construction monitoring program to assess the effectiveness of the control measures implemented.

3.1 Development of Benefit Metrics

Benefit metrics were developed for the CSO technology screening, and subsequent alternatives evaluation, to objectively assess the benefits of the CSO controls.

Four primary screening categories were identified to evaluate the ability of the CSO technologies to meet the goals and objectives of the public and the Utility, as well as to address the requirements of the National CSO Policy (EPA, 1994) and the Consent Decree:

- **Performance Factors**—Gauge the effectiveness of the CSO technologies in reducing water quantities (discharged at the CSO structures, conveyed through the sewer system, or treated at the WWTPs). Performance factors are also used to evaluate the ability of a technology to improve water quality.
- **Implementation and Operation Factors**—Evaluate the ease of permitting, constructing, and operating the specific CSO technologies.
- **Safety Factors**—Assess the risks and potential safety hazards to Utility staff and public.
- **Community Impacts**—Evaluate the potential social and environmental effects on the community or neighborhoods of the various CSO technologies.

Specific benefit evaluation criteria were identified within each category. The criteria were selected by the Utility during a workshop held on January 11, 2012. These criteria, and a description regarding the application and consideration of each, are provided in Table 3-1.

Benefits of CSO control anticipated by the public represented in the Citizens Advisory Committee (CAC) were combined with the requirements of the National CSO Policy (EPA, 1994) and the Consent Decree to define the criteria used in control screening (CH2M HILL, 2012a) and throughout the alternatives evaluation. These criteria are summarized in Table 3-1.

Table 3-1 Benefit Screening Evaluation Criteria

Category/Criteria		Criteria Considerations
Performance Factors	Reduces combined sewer overflow volume	If the technology were to be implemented, could it reduce CSO volumes?
	Reduces runoff volume	Would this technology help reduce runoff volume for a service area where it may be implemented?
	Reduces frequency of untreated discharges	Would this technology reduce the number of CSO, SSO, or CSS releases?
	Reduces wet weather flows in system	Would this technology prevent wet weather flows from entering the sewer system?
	Reduces suspended solids	Would implementation of this technology reduce the suspended solids being released into the water bodies?
	Reduces bacteria	Would this technology reduce the amount of bacteria that enter the water bodies?
	Reduces floatables/trash	Would Does this technology keep floatables and trash from entering

Table 3-1 Benefit Screening Evaluation Criteria

Category/Criteria		Criteria Considerations
		the waterways?
Implementation and Operation Factors	Enhances Nine Minimum Controls	Would this alternative contribute to achieving the Nine Minimum Controls?
	Maximize use of existing infrastructure Reliability	Would the proposed technology have the ability to use available capacity that exists within the collection or treatment system? Is this technology tested in other similar situations? Is the equipment mechanically reliable?
	Flexibility (possibility of future expansion)	Would future expansion of the technology be possible?
	Land requirements	How much land does this require?
	Constructability	How difficult is the construction of this technology?
	Simplicity of operation and maintenance	Will operations require more staff or additional certifications or equipment? How often does it need to be maintained?
	Implementation time	How long from start until technology is fully functional?
	Synergy with other needs	Can this project be conducted with another department? Does it correspond to another City goal? Is there a project currently on the shelf using this technology?
Safety	Human health & safety (basement backups, street flooding, etc.)	Would this technology decrease the potential for exposure to raw sewage? Are there risks to the public or Utility staff due to potential exposure to chemicals? Does this technology pose unique risks to Utility personnel or the public?
	Emergency response time (street flooding, etc.)	Would this technology potentially improve emergency response time to a certain area by reducing street flooding?
Community Impacts	Protection of historical and cultural resources	Would the area the technology is being built in, or have an impact upon, have an effect on historic landmarks?
	Protection of environmental resources	Would this technology help the environment when implemented (flora, fauna, and water)?
	Short-term (noise, truck traffic, siting, etc.)	Would this technology have construction impacts that would disrupt a neighborhood?
	Long-term (open space creation, recreational opportunities, aesthetic improvements, etc.)	Could this technology be combined with community improvements, in order to make the community a better place than before it was implemented?

3.1.1 Benefit Criteria Weighting

Each of the screening categories and criteria were weighted based on the goals and objectives of the LTCP. The Utility and public place a high value upon public safety and neighborhood impacts, and it was determined that public safety and community improvements associated with the LTCP may best be achieved by:

- Reducing WWFs that contribute to SSOs, CSS releases, and flooding (street and basement)

- Reducing the quantity and volume of CSO discharges to achieve water quality improvements in Pigeon Creek and the Ohio River, thus reducing health concerns and increasing the duration for safe recreational use
- Selecting technologies that improve water quality, either through effective treatment or overall reduction of CSO discharges

Efficient and effective implementation, performance, and operation of the technologies selected will be essential to achieving public safety and community improvements; therefore, the Performance and Implementation and Operation categories were weighted most heavily for benefit evaluation. This approach allows the Utility to meet the CD requirement to place the highest priority on controlling overflows to sensitive areas, achieve the IOCP objectives outlined above, and attain the resulting benefits to public safety and the community. The weighting assigned to the four categories is summarized in Table 3-2 and is described in more detail below.

Table 3-2 Criteria Category Weighting

Category	Weighting
Performance Factors	40%
Implementation and Operation Factors	30%
Safety	10%
Community Impacts	20%

3.1.1.1 Performance Factors

As described above, reducing the frequency and volume of untreated discharges are priorities to be addressed by the CSO control technologies. Reduction of bacteria is also desired, but that criterion was assigned a lower weighting based on the reasoning that reductions in CSO volume and frequency will result in water quality improvements. The weightings of the performance factors criteria are provided in Table 3-3.

Table 3-3 Performance Factors Criteria Weighting

Criteria	Weighting
Reduces combined sewer overflow volume	25%
Reduces runoff volume	15%
Reduces frequency of untreated discharges	25%
Reduces wet weather flows in system	15%
Reduces suspended solids	5%
Reduces bacteria	10%
Reduces floatables/trash	5%

3.1.1.2 Implementation and Operation

The ability to effectively implement and operate the technologies ultimately selected would greatly affect the ability of the Utility to achieve the performance goals noted above. As a result, the following were assigned the greatest weight within this category: maximize use of existing

infrastructure, simplicity of operation and maintenance, enhances Nine Minimum Controls, reliability, and synergy. Synergy relates to the ability of the Utility to implement a project in conjunction with one or more other projects to be completed by other City department(s), serve a dual purpose (such as enhance park or recreation space while achieving source controls), or be executed at the same time as another project to minimize construction disruptions. Criteria weighting is summarized in Table 3-4.

Table 3-4 Implementation and Operation Factors Criteria Weighting

Criteria	Weight
Enhances Nine Minimum Controls	15%
Maximize use of existing infrastructure	20%
Reliability	15%
Flexibility (possibility of future expansion)	5%
Land requirements	5%
Constructability	5%
Simplicity of operation and maintenance	20%
Implementation time	5%
Synergy (with other needs, projects, departments)	15%

3.1.1.3 Safety

Safety was also considered for each technology. The human health and safety criterion refers to the potential risks or safety hazards to the public or Utility personnel posed by a technology, as well as the improvements that a technology may achieve by reducing basement backups and street flooding. Additionally, the Utility has included emergency response time improvements to factor in the ability of a technology to improve emergency response time in areas where severe street flooding is an issue. Criteria weighting is summarized in Table 3-5.

Table 3-5 Safety Factors Criteria Weighting

Criteria	Weight
Human health & safety (basement backups, street flooding, etc.)	75%
Emergency response time Improvements (street flooding, etc.)	25%

3.1.1.4 Community Impacts

As previously noted, community impacts are very important to the Utility. In addition to the desired reduction of overflow volumes and water quality improvements that will benefit the community, the community may also be affected by short- and long-term construction impacts. The Utility weighed long-term impacts more heavily, as they pose the greatest potential for lasting community benefits or detriment. Criteria weighting is summarized in Table 3-6.

Table 3-6 Community Impacts Criteria Weighting

Criteria	Weight
Protection of historical and cultural resources	25%
Protection of environmental resources	40%
Short-term (noise, truck traffic, siting, etc.)	10%
Long-term (open space creation, recreational opportunities, aesthetic improvements, etc.)	25%

3.1.2 Benefit Scoring

A scoring process was developed to assess the effectiveness of the CSO control measures. Each technology was assessed with respect to the criteria summarized above, and a score was assigned for each criterion. Technology-specific criterion scores were assigned using a scale of 0 through 4, with 0 indicating an adverse impact by the technology with respect to the criterion, and 4 indicating a very good or positive impact (Table 3-7).

Table 3-7 Scoring System

Description	Score
Very good/positive	4
Good/positive	3
Neutral	2
Poor/adverse	1
Very poor/adverse	0

Weighted criterion scores were calculated by multiplying the criterion score by the weighting factors assigned to the criterion and associated category. The total weighted benefit score was calculated by summing the weighted criteria scores for each control measure.

3.2 Project Costing Methodology

Opinions of probable capital cost were developed using the Program Alternative Cost Calculator (PACC), a spreadsheet tool developed by CH2M HILL for cost estimating (CH2M HILL, 2012e). The PACC is the latest generation of a tool initiated in Cincinnati (BBS, 2005) and evolved through several subsequent wet-weather programs. The PACC was used consistently in estimating costs for SSRMP and LTCP projects. It provides unit costs for estimating the planning level capital cost of each selected technology and was developed from the following sources:

- R.S. Means
- Richardson Process Plant Estimating Standards
- Mechanical Contractors Association – Labor Manual
- National Electrical Contractors Association (NECA) – Labor Unit Manual
- EPA references and standards
- Costs from various municipalities
- CH2M HILL historical data
- Vendor quotes on equipment and materials, where appropriate

Cost estimating experts from several national engineering consultants reviewed the PACC previously and judged it suitable for developing estimates at this planning level. AACE International[2] *Recommended Practice No. 18R-97* classifies such an estimate (prepared on the basis of limited information, where the preliminary engineering is from 1 percent to 15 percent complete) as a Class 4 estimate, Such estimates have an expected accuracy within plus 50 percent to minus 30 percent (AACE International, 2003). Costs generated using the PACC are estimated primarily on the basis of the size or capacity of the facility required, but they also include allowances for features unique to the particular installation. For example, relief-sewer costs may be adjusted for expected construction difficulties through bedrock, and storage costs may be adjusted to reflect extraordinary odor control needs. The PACC allows the combination of numerous distinct projects into basin-wide alternatives. The tool also estimates the life-cycle costs of the projects and alternatives, and allows rapid comparison of alternatives to aid in the selection of cost-effective alternatives.

Projected costs were updated to reflect January 2012 dollar values (*Engineering News-Record* Construction Cost Index of 8,301, based on a small cities adjustment using R.S. Means indexes for Cincinnati, Ohio, and Evansville).

In general, cost curves and estimates in the PACC include such costs to the contractor as labor, material, equipment, subcontractor cost, mobilization/construction access, contractor markups, and site restoration after construction is complete. Assumptions within the PACC tool include the following:

- Right-of-way costs
- Planning and preliminary design
- Design services
- Administrative costs
- Miscellaneous – permitting, test bore, essential control and instrumentation (ECI) inspector, right-of-way
- Capitalized interest
- Field engineering and inspection
- Project contingencies

The PACC was used to calculate operations and maintenance (O&M) and life-cycle cost estimates.

3.3 Evaluation of Potential CSO Control Measures

The evaluation of potential CSO control measures was based upon the *Combined Sewer Overflow Alternatives Analysis Screening Report* submitted to EPA on January 31, 2012 (CH2M HILL, 2012a). This report reviewed potential CSO control technologies, and the analysis identified numerous inflow reduction, sewer system modification, storage, and treatment technologies for potential inclusion in the LTCP. Technologies considered are summarized in Table 3-8.

[2] AACE International formerly was the Association for the Advancement of Cost Engineering.

Table 3-8 CSO Control Measures Considered

Classification	Available Technologies
Inflow Reduction	Stormwater Management/Green Infrastructure
	Industrial Pretreatment/Other Source Controls
	Partial Sewer Separation
	Complete Sewer Separation
Sewer System Modification	Flow Redirection
	Infiltration Reduction
	Interceptor Sewer Construction
	Relief Sewer Construction
	Relocation of CSO Outfalls
	Outfall Consolidation
	Pump Station Modifications
	Static Flow Control
	Variable Flow Control
	Real-Time Flow Control
Storage	Open Basins and Tanks
	Closed Storage Tanks
	Storage Conduits
	Storage Tunnels
	Existing Tunnels or Conduits (Abandoned)
Physical/Chemical Satellite Treatment	Floatables Control (Screening)
	Swirl Concentrators and Vortex Separators
	Sedimentation
	Compressed Media Filtration
	HRT/Ballasted Flocculation
	Disinfection/Dechlorination
Biological Treatment	New Secondary or Advanced WWTPs
	Increased Treatment Capacities at Existing Facilities
	Constructed Treatment Wetlands

Source: *Combined Sewer Overflow Alternatives Analysis Screening Report* (CH2M HILL, 2012a)

Table 3-9 identifies the control measures from further consideration and summarizes the reasons why those measures are not appropriate for CSO control in the Utility systems.

Table 3-9 CSO Control Screening Results

Technology[a]	Reason for Elimination
No Action	Taking no action would not achieve the water quality improvements or CSO discharge reduction goals. No action is, therefore, not appropriate for further consideration.
Complete Sewer Separation	Complete sewer separation is not applicable for further consideration due to the magnitude of work on private property, site restoration requirements, and implementation time that would be required to achieve relatively small improvements in water quality. Complete sewer separation was evaluated as part of the 2007 Stormwater Master Plan, and more cost-effective technologies were also identified at that time.
Relocation of CSO Outfalls	Evansville CSOs discharge to either Pigeon Creek, which discharges to the Ohio River, or the Ohio River itself. Therefore, relocation of outfalls would not produce a CSO volume reduction or water quality benefit to either receiving water. Additionally, given the spatial distance between each outfall, relocation is largely not feasible. Therefore, this option is not considered appropriate for further consideration.
New WWTP	Construction of a new plant was considered in 2004, and the results of the study indicated that a new plant would not benefit the community. A new WWTP was also considered as part of this technology screening, but this option is not considered viable due to intense development and limited land availability in the areas where a new WWTP would be most effective at reducing CSO volumes and activations. Additionally, Evansville's two existing plants have upgrade potential that make a third plant impractical.

[a] All control measures not listed here were retained for further consideration.

Source: *Combined Sewer Overflow Alternatives Analysis Screening Report* (CH2M HILL, 2012a)

3.3.1 Determination of CSO Control Technologies Applicable for Consideration at Each CSO or CSO Grouping

Control measures presented in Table 3-8 and not listed in Table 3-9 were considered potentially applicable to Evansville's system. The IOCP development team assessed which of those CSO control technologies may be appropriate for use at each CSO or CSO grouping to facilitate development of appropriate project options. The assessment of potentially applicable technologies at specific CSO locations was based upon land availability, CSO discharge volumes, system configuration, and a general assessment of constructability. The following steps were completed to assess the viability of each control technology at each CSO or CSO grouping:

1. Identify land available for potential CSO control storage and/or treatment facilities.
2. For each diversion structure or CSO, determine how WWF would be routed to and drained from the facility.

Figures 3-1 and 3-2 provides an overview of the storage and treatment locations identified, along with the acreage and assumed storage and/or treatment capacity limitations associated with each site.

Table 3-10 presents a summary of the CSO control technologies considered viable for each CSO or CSO grouping. Additional details regarding site-specific considerations, and why certain technologies were included or excluded from consideration at each CSO location within the West and East basins, are presented in Appendix A.

The analysis resulted in the following CSO groupings in the West and East Basins:

CSS technologies not considered viable for any particular CSO of CSO grouping due to site or system characteristics included:

- Industrial Pretreatment/Other Source Controls – Policies, ordinances, pretreatment requirements, etc., are in place to help control industrial flows to the system, and these will continue to be enforced by the Utility. Modifications of the requirements would not reduce wet weather volumes within the system; therefore, these source control requirements will be enforced by the Utility outside of the Decree.
- Infiltration Reduction – Infiltration reduction projects are applicable for consideration within the SSS, but are not applicable within the CSS. As a result, infiltration reduction is considered as part of the SSRMP and overall IOCP, but not the LTCP.

3.4 Screening of Basin-wide Alternatives

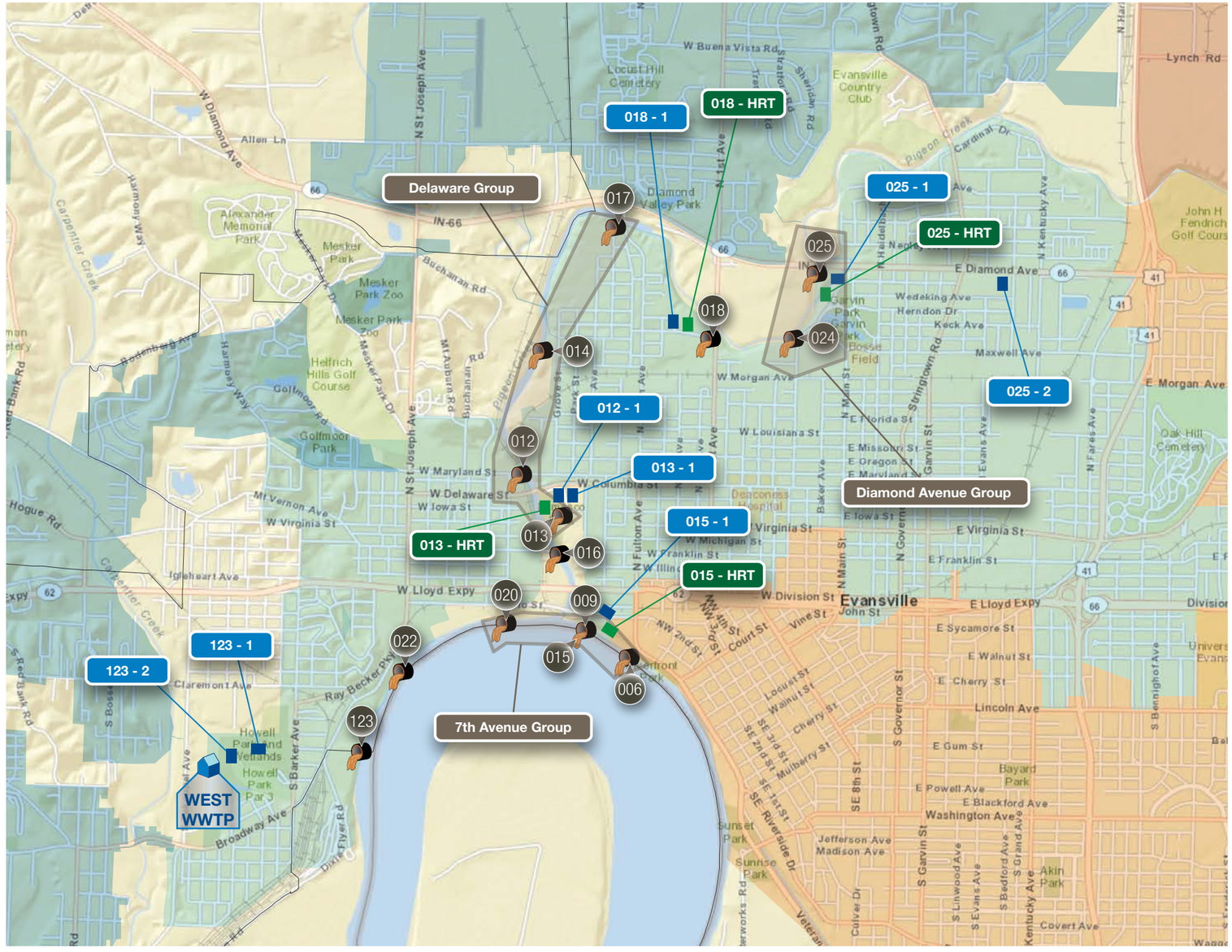
Following the evaluation of CSO technologies applicable at each CSO or CSO grouping, project groupings were modeled to assess alternative performance at the basin level. Consistent with Appendix C, Section I, Paragraph 2 of the Decree, the purpose of the basin-wide alternative screening evaluation was to identify an appropriate list of alternatives for further evaluation at each level of control prescribed by the Decree. The West and East basins were evaluated independently on the basis of the following:

- Project and alternative effectiveness in terms of overflow volume reduction
- Estimated capital and O&M costs

West and East basin alternative screening is described in Sections 4 and 5, respectively.

3.5 Evaluation of Alternatives and System-wide Level of Control

A limited number of alternatives were selected to move from the technology and alterative screening evaluation to the detailed alternatives evaluation to achieve the system-wide levels of control prescribed in the Decree. The alternatives evaluation consisted of a more detailed analysis of alternative cost, effectiveness, and water quality impacts as required per Appendix C, Section I, Paragraph 3 of the Decree. The detailed alternatives evaluation is described in Section 6.



CSO	Name	Receiving Water	WWTP Service Area
006	Fulton Avenue Pumping Station	Ohio River	West
009	7th Avenue West	Ohio River	West
012	Maryland Street – West Bank	Pigeon Creek	West
013	Delaware Street	Pigeon Creek	West
014	Dresden Street	Pigeon Creek	West
015	7th Avenue East	Ohio River	West
016	Franklin Street	Pigeon Creek	West
017	6th Avenue	Pigeon Creek	West
018	Oakley Street	Pigeon Creek	West
020	9th Avenue	Ohio River	West
022	St. Joseph Avenue	Ohio River	West
123	West Plan CSO	Ohio River	West
024	Baker Street	Pigeon Creek	West
025	Diamond Avenue	Pigeon Creek	West

Legend

East Service Area

- Separate Sewer Area
- Combined Sewer Area

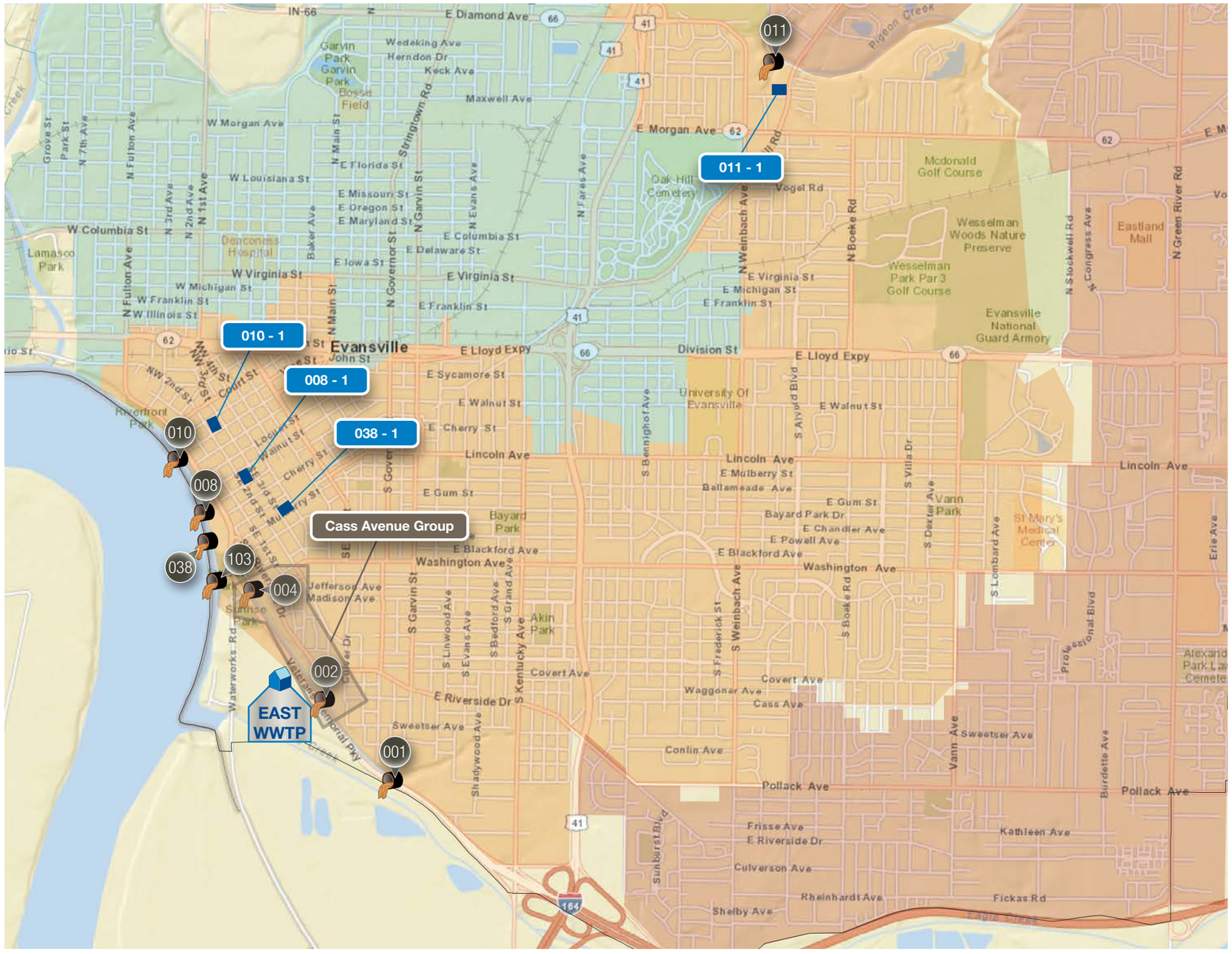
West Service Area

- Separate Sewer Area
- Combined Sewer Area

- Wastewater Treatment Plant
- CSO
- Storage Locations
- HRT Locations
- City Limits

North

FIGURE 3-1
West
Long Term Control Plan
May 31, 2013



CSO	Name	Receiving Water	WWTP Service Area
001	Kentucky Avenue	Bee Slough	East
002	Cass Avenue	Bee Slough	East
103	Junction Box Prior to WWTP Headworks	Ohio River	East
004	Adams	Bee Slough	East
008	Chestnut Street	Ohio River	East
010	Dress Plaza	Ohio River	East
011	Weinbach Lift Station (Oakhill Road)	Pigeon Creek	East
038	Oak / Riverside	Ohio River	East

Legend

East Service Area

- Separate Sewer Area
- Combined Sewer Area

West Service Area

- Separate Sewer Area
- Combined Sewer Area

- Wastewater Treatment Plant
- CSO
- Storage Locations
- City Limits

North

FIGURE 3-2
East
Long Term Control Plan
May 31, 2013

TABLE 3-10
CSO Control Technologies Considered Viable by CSS Basin

Screening Category:		Western Basins System			Pigeon Creek Interceptor System														West Side Interceptor System		
Technology Classification	**Technologies**	NW SSS Basin	SW SSS Basin	Tekoppel-Walker CSS Basin	US Highway 41/Millersburg SSS Basins	Diamond Ave CSS Basin (CSO 025)	North Park SSS Basin	Baker CSS Basin (CSO 024)	Oakley CSS Basin (CSO 018)	6th Avenue CSS Basin (CSO017)	Dresden Basin (CSO 014)	Allens Lane North SSS Basin	Helfrich SSS Basin	Maryland CSS Basin (CSO 012)	Delaware Basin (CSO 013)	Franklin Basin (CSO 016)	Fulton PS Basin (CSO 006)	7th Avenue PS (CSO 009)	7th Avenue East Basin (CSO 015)	9th Avenue (CSO 020)	Broadway Avenue Int CSS Basin	St. Joseph Avenue (CSO 022)
Inflow Reduction	Stormwater Management/Green Infrastructure	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	●	✗	✗	✗	✗	✗	●	●	●
	Industrial Pretreatment/Other Source Controls	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗
	Partial Sewer Separation	✗	✗	●	✗	●	✗	✗	✗	●	✗	✗	✗	●	✗	✗	✗	✗	✗	●	✗	●
Sewer System Modification	Flow Redirection	✗	✗	✗	✗	●	✗	●	●	●	●	✗	✗	●	✗	✗	✗	●	✗	●	✗	●
	Infiltration Reduction	●	●	✗	●	✗	●	✗	✗	✗	✗	●	●	✗	✗	✗	✗	✗	✗	✗	✗	✗
	Interceptor Sewer Construction	✗	✗	✗	✗	●	✗	●	●	●	●	✗	✗	●	●	●	●	●	●	✗	✗	✗
	Relief Sewer Construction	✗	✗	✗	✗	●	✗	●	●	●	●	✗	✗	●	●	●	●	✗	●	✗	✗	✗
	Outfall Consolidation	✗	✗	✗	✗	✗	✗	●	✗	✗	●	✗	✗	✗	✗	✗	✗	●	●	●	✗	●
	Pump Station Modifications	✗	✗	✗	✗	✗	✗	●	✗	✗	✗	✗	✗	●	✗	✗	✗	●	✗	●	✗	✗
	Static Flow Control	✗	✗	✗	✗	●	✗	●	●	●	●	✗	✗	●	●	●	●	●	●	●	✗	●
	Variable Flow Control	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗
	Real-Time Flow Control	✗	✗	✗	✗	●	✗	●	●	●	●	✗	✗	●	●	●	●	●	●	●	●	●
Storage	Open Basins and Tanks	✗	✗	✗	✗	●	✗	●	●	●	●	✗	✗	●	●	●	●	●	●	✗	●	✗
	Closed Storage Tanks	●	●	✗	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	✗	●	✗
	Storage Conduits	●	●	✗	●	✗	●	✗	✗	✗	✗	●	●	✗	✗	✗	✗	✗	✗	✗	●	✗
	Storage Tunnels	✗	✗	✗	✗	●	✗	●	●	●	●	✗	✗	●	●	●	●	●	●	✗	✗	✗
	Existing Tunnels or Conduits (Abandoned)	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	●	●	●
Physical/ Chemical Satellite Treatment	Floatables Control (Screening)	✗	✗	✗	✗	●	✗	●	●	●	●	✗	✗	●	●	●	●	●	●	●	✗	●
	Swirl Concentrators and Vortex Separators	✗	✗	✗	✗	●	✗	●	✗	✗	✗	✗	✗	●	●	✗	●	●	●	✗	✗	✗
	Sedimentation	✗	✗	✗	✗	●	✗	●	✗	✗	✗	✗	✗	●	●	✗	●	●	●	✗	✗	✗
	Compressed Media Filtration	✗	✗	✗	✗	●	✗	●	✗	✗	✗	✗	✗	●	●	✗	●	●	●	✗	✗	✗
	High Rate Treatment/Ballasted Flocculation	✗	✗	✗	✗	●	✗	●	✗	✗	✗	✗	✗	●	●	✗	●	●	●	✗	✗	✗
	Disinfection/Dechlorination	✗	✗	✗	✗	●	✗	●	✗	✗	✗	✗	✗	●	●	✗	●	●	●	✗	✗	✗
Biological Treatment	Increased Treatment Capacities at Existing Facilities	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●
	Constructed Treatment Wetlands	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗

TABLE 3-10
CSO Control Technologies Considered Viable by CSS Basin

Screening Category:		Pigeon Creek East System		Bee Slough System					Downtown-Ohio River East System						
Technology Classification	**Technologies**	E-11 SSS Basin	Oakhill CSS Basin (CSO 011)	Bee Slough-Kentucky Basin (CSO 001)	Bee Slough-Cass Avenue Basin (CSO 002)	Riverside-Vann SSS Basin	Covert Ave SSS Basin	Lloyd Expressway SSS Basin	Court CSS Basin (CSO 010)	Sycamore CSS Basin (CSO 010)	Locust CSS Basin (CSO 010)	Chestnut CSS Basin (CSO 008)	Oak & Riverside CSS Basin (CSO 038)	Adams & Sunset Basin (CSO 004)	East WWTP Basin
Inflow Reduction	Stormwater Management/Green Infrastructure	✗	✗	●	●	✗	✗	✗	●	●	●	●	●	●	●
	Industrial Pretreatment/Other Source Controls	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗
	Partial Sewer Separation	✗	●	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	●	✗
Sewer System Modification	Flow Redirection	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	●	●	✗
	Infiltration Reduction	●	✗	✗	✗	●	●	●	✗	✗	✗	✗	✗	✗	✗
	Interceptor Sewer Construction	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗
	Relief Sewer Construction	●	✗	✗	✗	●	●	●	●	●	●	●	●	●	✗
	Outfall Consolidation	✗	✗	●	●	✗	✗	✗	✗	✗	✗	✗	✗	●	●
	Pump Station Modifications	●	✗	✗	✗	●	●	●	✗	✗	✗	✗	✗	✗	✗
	Static Flow Control	✗	●	●	●	✗	✗	✗	●	●	●	●	●	●	✗
	Variable Flow Control	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗
	Real-Time Flow Control	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗
Storage	Open Basins and Tanks	✗	●	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗
	Closed Storage Tanks	●	●	●	●	●	●	●	●	●	●	●	●	●	✗
	Storage Conduits	●	✗	✗	✗	●	●	●	✗	✗	✗	✗	✗	✗	✗
	Storage Tunnels	✗	✗	✗	✗	✗	✗	✗	●	●	●	●	●	●	✗
	Existing Tunnels or Conduits (Abandoned)	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗
Physical/ Chemical Satellite Treatment	Floatables Control (Screening)	✗	●	●	●	✗	✗	✗	●	●	●	●	●	●	✗
	Swirl Concentrators and Vortex Separators	✗	●	●	●	✗	✗	✗	✗	✗	✗	✗	✗	●	✗
	Sedimentation	✗	●	●	●	✗	✗	✗	✗	✗	✗	✗	✗	●	✗
	Compressed Media Filtration	✗	●	●	●	✗	✗	✗	✗	✗	✗	✗	✗	●	✗
	High Rate Treatment/Ballasted Flocculation	✗	●	●	●	✗	✗	✗	✗	✗	✗	✗	✗	●	✗
	Disinfection/Dechlorination	✗	●	●	●	✗	✗	✗	✗	✗	✗	✗	✗	●	✗
Biological Treatment	Increased Treatment Capacities at Existing Facilities	●	●	●	●	●	●	●	●	●	●	●	●	●	●
	Constructed Treatment Wetlands	✗	✗	●	●	✗	✗	✗	✗	✗	✗	✗	✗	●	✗

Table 3-11 Summary of CSOs and CSO Groupings

CSO #	Name	Receiving Water	Service Area	CSO Group	Group Label
025	Diamond Avenue	Pigeon Creek	West	Diamond	025-G
024	Baker Street	Pigeon Creek	West	Diamond	025-G
018	Oakley Street	Pigeon Creek	West	None	
017	6th Avenue	Pigeon Creek	West	Delaware	013-G
014	Dresden Street	Pigeon Creek	West	Delaware	013-G
012	Maryland Street - West Bank	Pigeon Creek	West	Delaware	013-G
013	Delaware Street	Pigeon Creek	West	Delaware	013-G
016	Franklin Street	Pigeon Creek	West	7th Avenue	015-G
006	Fulton Avenue Pumping Station	Ohio River	West	7th Avenue	015-G
015	7th Avenue East	Ohio River	West	7th Avenue	015-G
009	7th Avenue West	Ohio River	West	7th Avenue	015-G
020	9th Avenue	Ohio River	West	7th Avenue	015-G
022	St. Joseph Avenue	Ohio River	West	None	
123	West Plant CSO	Ohio River	West	None	
011	Weinbach Lift Station (Oakhill Road)	Pigeon Creek	East	None	
010	Dress Plaza	Ohio River	East	None	
008	Chestnut Street	Ohio River	East	None	
038	Oak / Riverside	Ohio River	East	None	
004	Adams	Bee Slough	East	Cass Avenue	002-G
002	Cass Avenue	Bee Slough	East	Cass Avenue	002-G
103	Junction Box Prior to WWTP Headworks	Ohio River	East	Cass Avenue	002-G
001	Kentucky Avenue	Bee Slough	East	None	

3.6 Water Quality Improvements Associated with Evaluated Alternatives

Prior to selection of a final plan, the Utility used a water quality model of Pigeon Creek and the Ohio River to evaluate the in-stream water quality benefits of the basin-wide alternatives, as required per Appendix C, Section I, Paragraph 3 of the Decree. The water quality assessment is described in Section 7.

3.7 Selection of Final Plan

One system-wide alternative was selected for implementation based on the ability of the set of projects to meet the Decree and CSO Control Policy requirements, maximize non-cost and cost benefits. The final plan is described in Section 8.

SECTION 4

Alternative Screening – West Basin

The West CSS is a complex system, with the majority of the CSOs being located along the PCI. The configuration of the West CSS, CSO locations, PCI, and the relationship of PCI to the SSS trunk sewers initially suggested that proposed CSO control projects may need to be integrated across multiple CSOs, and that implementing projects at one CSO could potentially have either beneficial or adverse effects at nearby CSOs or in the SSS. In addition, a large number of CSO control technologies and various levels of control were required to be evaluated, which introduced an additional level of complexity and the potential to evaluate hundreds, if not thousands, of combinations and permutations of alternatives. Consequently, Evansville determined that a "traditional" alternatives evaluation may not identify the most cost-effective solution within the tight timeframe for IOCP development. The IOCP development team determined that an optimization approach using the heuristic global search algorithm could be used to evaluate the vast numbers of project combinations and permutations to narrow the analysis and identify a more manageable set of alternatives for detailed evaluation.

This section summarizes the process Evansville used to develop, screen, and evaluate the West CSS project alternatives and the analysis methodology used to compare the numerous basin-wide options.

4.1 Potential CSO Control Technologies

As noted in the previous section, the *Combined Sewer Overflow Alternatives Analysis Screening Report* submitted to EPA on January 31, 2012 identified numerous inflow reduction, sewer system modification, storage, and treatment technologies for potential inclusion in the LTCP, Tables A-1 through A-14 in Appendix A, present technologies considered viable at each West Basin CSO or CSO grouping.

The project components and size ranges considered in the optimization are summarized under the technology categories that survived the screening:

- Treatment
- Conveyance
- Storage
- Sewer separation
- Green infrastructure

4.1.1 Treatment

Treatment solutions for CSOs are designed to discharge WWFs that are treated to a level appropriate for discharge to the receiving waterways, either Pigeon Creek or the Ohio River. Two treatment solutions were considered as part of the screening analysis: increased treatment capacity at the West WWTP and HRT near existing CSOs. Table 4-1 summarizes screened treatment alternatives.

Table 4-1 Screened Treatment Alternatives

Alternative Name	Description	Sizes Considered	Affected CSOs	Notes
West WWTP Upgrade	Increase treatment capacity at West WWTP	45, 60, or 80 mgd	CSO 022	No existing overflow at the plant
Diamond Avenue HRT	HRT at CSO 025 (Diamond Avenue)	10, 20, 30, or 40 mgd	CSO 025	Used in combination with Diamond Avenue storage
7th Avenue HRT	HRT at 7th Avenue proposed storage / treatment location	5, 10, 20, or 30 mgd	CSO 015	Used in combination with 7th Avenue storage
CSO 013 HRT	HRT at CSO 013 (Delaware Avenue)	5, 10, 20, or 30 mgd	CSO 013	Used in combination with Delaware Avenue storage

4.1.2 Conveyance

Conveyance solutions provide additional hydraulic capacity in the system, via increased pumping capacity and/or additional pipe capacity, to convey flows to a location for storage or treatment. Conveyance solutions alone provide minimal benefit, but utilize either available existing or proposed storage or treatment facilities. Table 4-2 summarizes conveyance alternatives initially screened for consideration.

Table 4-2 Conveyance Alternatives Screened

Alternative Name	Description	Sizes Considered	Affected CSOs	Notes
Parallel PCI	Conveyance to 7th Avenue Lift Station for storage, satellite treatment, or conveyance to West WWTP	4-, 5-, 6-, or 7-ft diameter	CSO 015, 016, 013, 012, 014, 017, 018, 024, 025	
Force Main from 7th Avenue Lift Station to West WWTP	Conveyance from 7th Avenue Lift Station to West WWTP	20, 30 or 40 mgd	CSO 022	
CSO 016 Consolidation	Conveyance north to proposed CSO 013 storage, or south to proposed 7th Avenue storage	4-, 5-, or 6-ft diameter	CSO 016	
Additional Pumping- 7th Avenue Lift Station to West WWTP	Provide additional pumping capacity from 7th Avenue Lift Station to West WWTP	10, 20, 30, 40, or 50 mgd	CSO 015, and PCI CSOs	Potential to reduce level at 7th Avenue Lift Station and reduce CSO along PCI
CSO 014 Consolidation	Conveyance south to proposed CSO 012 storage	4-, 5-, or 6-ft diameter	CSO 013	Requires hydraulic structure to capture sanitary system influent
Ohio Street to 7th Avenue Lift Station	Conveyance from Ohio Street sewer to proposed 7th Avenue storage	6 ft		

4.1.3 Storage

Storage solutions provide varying levels of additional storage capacity to the West CSS, generally at locations near existing CSO control structures, capturing overflows and decreasing overflows into adjacent waterways. In general, vertical storage facilities were considered, with an estimated depth of 80 ft (assuming 100 ft to bedrock with 20-ft footings). The storage solutions were simulated by modifying the cross-sectional area to achieve the needed storage volume. For ease of simulation, this was modeled as a single storage node. During a more detailed constructability review, it may be found that multiple vertical storage facilities of given size are more feasible. An underground storage facility was modeled at the site of the old high school, based upon open land at this site. A storage facility with a depth of 13.5 ft was modeled with gravity inflow/outflow from the surcharged PCI.

Table 4-3 summarizes treatment alternatives considered in the optimization.

Table 4-3 Storage Options Screened

Option Name	Description	Sizes Considered	Affected CSOs	Notes
Diamond Avenue Storage	Vertical storage at Diamond Avenue	5, 10, 15, 20, 25, 30, 35 million gallons (MG)	CSO 025	
7th Avenue Storage	Vertical storage at 7th Avenue)	2, 4, 6, 8 MG	CSO 015, CSO 016	Includes option to consolidate overflows from CSO 016
12th Avenue Storage	Vertical storage at Maryland Avenue	1,2,3,4,5,6,7 MG	CSO 012, CSO 014	Includes large conveyance under river to bring flows from west of Pigeon Creek
13th Avenue Storage	Vertical storage at Delaware Avenue	1,2,3,4,5,6,7 MG	CSO 013	Includes option to consolidate overflows from CSO 016
WWTP Storage	Vertical storage south of WWTP	4, 8 ,12, 16, 20 24, 28 MG	CSO 022	Relieves the WWTP and Broadway Interceptor
CSO 018 Storage	Vertical storage at CSO 018	Modeled as overflow	CSO 018	
PCI Storage	Vertical storage north of Keller/Grove intersection	Modeled as overflow	CSOs	Direct relief of (not at CSO location)

Storage facilities treating combined sewer runoff are conservatively dewatered within 48 hours to avoid producing septic conditions and significant odor issues. Existing condition model simulations show the PCI surcharged for several days following the 1-year 3-hour storm event.

Because of the long duration of the surcharged PCI, dewatering of the storage tanks to the PCI would not be possible within 48 hours following many wet-weather events and was not considered viable. Therefore, the storage facilities were modeled using HRT for dewatering.

4.1.4 Sewer Separation

Storm sewer projects divert runoff from the combined system, but do not result in complete removal of inflow into the CSS in areas served by storm sewers. The Utility previously studied sewer separation alternatives, as described in the 2007 *Stormwater Master Plan Update* (Clark Dietz, Inc., 2007a). Stormwater separation solutions that have not yet been implemented were considered as potential project options.

Sewer separation projects were modeled to remove 75 percent of runoff for areas served by storm sewers; areas where storm sewers were added without performing separation of existing connections to combined sewer were estimated to remove 37.5 percent of runoff from the affected CSS areas. Table 4-4 summarizes separation projects considered in the West Basin.

Table 4-4 Screened West Basin Sewer Separation Projects

Project[a]	Modeling Approach
Diamond Avenue Phase I-IV	Complete Separation - 75% Runoff Reduction to CSS
Fulton and Columbia North	Storm Sewer Only - 37.5% Runoff Reduction to CSS
Fulton and Columbia South	Storm Sewer Only - 37.5% Runoff Reduction to CSS
St. Joseph Laterals	Complete Separation - 75% Runoff Reduction to CSS
Ray Becker and Bristol Myers	Storm Sewer Only - 37.5% Runoff Reduction to CSS
Sixth Avenue and Nestor Street	Storm Sewer Only - 37.5% Runoff Reduction to CSS

[a] Projects as described within the 2007 *Stormwater Master Plan Update* (Clark Dietz, Inc., 2007a)

4.1.5 Green Infrastructure

Green infrastructure (GI) such as permeable pavement, rain gardens, or green roofs may reduce system inflows by promoting infiltration, storage, and evapotranspiration. Initial review of the CSS identified specific potential areas for GI in the downtown area, bounded roughly by Delaware Avenue to the north, St. Joseph Street to the west (a portion of the area extends roughly 1,700 ft west of St. Joseph), Lloyd Expressway to the south, and Pigeon Creek to the east.

GI may be implemented in different degrees, or intensities, to manage greater or lesser volumes of stormwater runoff. A simplified modeling approach was implemented during the project screening process whereby 10 percent or 25 percent of the surface area of subcatchments managed by GI was removed from the model.

4.2 Optimization Screening Analysis

The control measure options identified in Table 3-10, and the pipe and storage sizing options identified in Tables 4-1 through 4-4, result in approximately 1,250 possible combinations of conveyance, storage, treatment, and sewer separation technologies in the West CSS. Due to the large number of potential West CSS alternatives, an optimization approach was developed to

screen the potential project combinations, i.e., alternatives, to gain insight regarding how the system reacts to particular projects, or project types, as well as to identify project combinations and sizing that may be most cost-effective.

Due to the hydraulic connectivity of CSOs in the West service area, and the consequent hydraulic interaction between potential solutions, a mathematical optimization approach able to address multiple combinations of projects and their system-wide impacts was utilized. The optimization approach employed a heuristic algorithm guiding an automated procedure to generate the various project combinations and permutations comprising distinct potential alternatives.

4.2.1 Optimization Algorithm

The optimization allowed definition of specific improvement combinations (user-defined runs), as well as the use of an algorithm to evaluate the numerous combinations of potential solutions, automatically selecting the next iteration of improvements for evaluation. The approaches were used in combination to ensure that specific alternatives were evaluated, while also evaluating a broad cross-section of other potential solutions. Key attributes of each approach included the following:

- **User-Defined Runs** – Evaluation of specific system changes identified by the planning team
  - Evaluated specific projects deemed reasonable based on system knowledge
  - Enabled consideration of single technologies to assess the system response to any particular potential improvement
  - Allowed definition of specific solutions of interest to the engineering team, the client, and other stakeholders for evaluation
  - Insight from user-defined runs provided initial solutions for the optimization algorithm driven evaluation
- **Optimization Algorithm** – Evaluation of project combinations generated by an automated procedure
  - Allowed evaluation of numerous potential permutations; however, variables and options need to be constrained to allow the optimization to converge on a solution
  - Sensitive to the set of alternatives that are then modified as the algorithm branches out into the solution space
  - Uses heuristic search techniques to explore solution space
  - "Learns" over time from evaluations; evolves an ever-improving population of solutions, while considering numerous inferior or even illogical solutions along the way

The algorithm used for the optimization screening assessment was the Shuffled Frog Leaping Algorithm (SFLA). SFLA divides the solution set into smaller subsets, performing local searches within each subset, and periodically "recombines" the most fit solutions from each subset with one another to distribute effective solution components throughout the population of potential solutions. SFLA uses randomness, constrained by algorithm tuning parameters, so that diverse regions of the solution space are evaluated.

The optimization screening was performed using the West existing system integrated model for 2032 flows as the base model to estimate CSO reductions (i.e., benefits) and life cycle costs across the full range of alternatives that the algorithm produced. This allowed the IOCP development team to estimate the total life cycle cost of each CSO control alternative screened and its performance, and to identify alternatives that potentially maximize overall effectiveness and benefits at any particular life-cycle cost. The optimization was performed by completing the following steps:

1. Define the analysis objectives – The objective of the optimization screening was to perform a comparative evaluation to identify alternatives that may reduce CSO volume in the most cost-effective manner. For the screening analysis, achieving the greatest reduction in CSO volume for the lowest possible cost was considered the best starting point for the detailed alternatives analysis and refinement analysis that followed.

   Alternatives appropriate for further evaluation were evaluated in terms of number of activations as part of the detailed alternatives evaluation that followed (Section 6). Refinement of alternatives with the ability to reduce overflow volumes in the most cost-effective manner and achieve the targeted levels of control, therefore, followed the alternatives screening evaluation.

2. Define the basic CSO controls proposed as the starting point for the analysis – The CSO controls described in Section 4.1 (relief sewers, WWTP expansion, HRT, etc.) were the starting point for the analysis.

3. Select an analysis event - Typical year model runs take hours of run time and computing power each, so a single representative storm was selected for the initial screening evaluation. The optimization screening was, therefore, modeled using the 1-year, 3-hour design event to quantify CSO volumes discharged at the 14 CSO locations in the West Service Area. Selecting a discrete design event rather than the Typical Year storm allowed comparison of alternatives based on CSO reduction as the measure for alternative performance. Evaluation of the number of activations and percent capture was not possible for the discrete design event, but these parameters were utilized as assessment parameters for a screening refinement step that followed the optimization screening.

4. Develop cost curves using the costing methodology described in Section 3.3

5. Set up and test optimization model – The optimization algorithm was linked to cost data and allowed system changes to be represented within the baseline hydraulic model.

6. Perform optimization screening analysis –Combinations defined by the IOCP development team were evaluated, as well as alternatives automatically generated by the optimization algorithm

4.2.2 Results of Individual Project Assessment Screening

Initial optimization runs were performed to evaluate the overall benefits derived from implementing specific individual projects at several of the large-volume CSO sites. This individual project analysis was a “starting point” sensitivity analysis that provided insight to the system’s response to specific improvements, as well as insight regarding which projects might prove to be the most cost-effective when combined to form overall service-area-wide alternatives. The projects that were evaluated are summarized in Table 4-5. These projects were chosen to better understand the performance of a variety of available CSO control

technologies and to understand whether there was a single solution that may make a significant improvement in the level of control across the entire West Service Area.

Table 4-5 Technology Comparison – Details of Specific Individual Projects and Corresponding Effectiveness

Project Name	Project Components	CSOs Controlled	Model/ Scenario ID[a]	CSO Volume Removed	$/gal Removed
Diamond HRT	• 5-MG storage at Diamond Ave. • 10 mgd HRT at Diamond Ave. • 17-MG storage at school site	025	4157	49%	$3.14
7th Avenue HRT	4-MG storage at 7th Avenue	015, 013	5971	5%	$8.31
Sewer Separation	Sewer separation projects (identified in Table 3-9 of Draft LTCP)	020, 022, 013, 016, 017	4248	5%	$8.63
Storage (CSO 012)	• 7-MG storage at CSO 012 • 5 mgd HRT • Consolidation of CSO 14 with CSO 12 (piping to convey flows)	012, 014	4292	10%	$9.59
PCI Relief Sewer (and 7th Avenue HRT)	• Cleaning of PCI • 4-ft-diameter PCI relief sewer to 7th Ave LS • 3-MG storage at 7th Avenue • 10 mgd HRT at 7th Avenue	013, 015, 024, 025	4324	13%	$10.91
GI	Green infrastructure at CSO 012, CSO 020, CSO 022	012, 020, 022	4308	6%	$16.83
FM (and WWTP)	• Force main from 7th Avenue to the West WWTP • West WWTP expansion to 60 mgd • 20-MG storage at WWTP 30 inch diameter FM from 7th Avenue to the WWTP • Upsizing 7th Avenue Lift Station by 20 mgd	015, 022	4260	10%	$26.15

[a] Model ID/Scenario ID were identification numbers randomly assigned to each model run. The numbers are provided for reference to link model input parameters and results (as presented in Appendix B).

Conclusions from the individual project screening assessment include:

- HRT at Diamond Avenue had the lowest life-cycle cost and highest benefit in terms of CSO volume reduction. Consistent with this finding, HRT at Diamond Avenue was a component of the most cost-effective alternatives evaluated as part of the optimization.

- Initial GI assessments indicated that several other gray infrastructure options provided greater CSO reduction and could be more cost-effectively implemented. GI was not completely eliminated from the alternatives screening. Gray options were focused on to achieve large-scale CSO reductions, and GI implementation was targeted for subbasins with lower CSO volumes, favorable soils, underutilized storm sewers, projects identified in the 2007 *Stormwater Master Plan* (Clark Dietz, Inc., 2007a), or areas with potentially difficult or extremely disruptive construction (such as the downtown subbasins).
- Pumping WWF from the 7th Avenue Lift Station directly to the West WWTP and expanding the WWTP to 60 mgd was the least cost-effective potential project when compared to the other individual projects considered. The conclusion that expanding the West WWTP treatment capacity was least cost effective was reinforced as part of the facility planning evaluation documented in *Volume 4 Facility Plan for the West and East Wastewater Treatment Plants* (CH2M HILL, 2012f), as well as in Typical Year model runs (described in Section 4.3) that were completed to verify the results.
- Constructing a PCI relief sewer in conjunction with HRT at the 7th Avenue Lift Station was more cost effective than conveying and pumping this flow directly to the West WWTP for treatment. This project was not as cost effective as HRT at Diamond Avenue; however, a PCI relief sewer was not eliminated from further consideration. This option was evaluated further as part of the refinement steps that followed the optimization screening assessment.

4.2.3 Results of Basin-wide Alternatives Screening

Each optimization screening model run included specific size parameters for the particular technology being evaluated at each point within the system. Appendix B provides a summary of the specific West Basin alternatives evaluated as part of the optimization screening evaluation and the screening results that were used for the comparative evaluation to assess alternatives that may potentially be the most cost effective combination of project options and sizing.

A scatterplot of the optimization screening results is presented as Figure 4-1. The data points circled in that figure indicate the knee of the curve for the discrete storm analysis, and those points represent the area of the curve where specific model runs/results were reviewed in detail to assess the project and alternative configurations that may potentially be the most promising project permutations for consideration during the Typical Year model run screening refinement and detailed alternatives evaluations that followed.

4.3 Typical Year Modeling Screening

Based on the optimization screening results using the discrete storm event, a limited number of high performing alternatives and specific technologies of interest were selected for screening using the Typical Year model. The Typical Year model runs were completed to better assess the potential cost and benefits for a select number of West alternatives, with benefits measured in terms of number of activations and percent capture. Basin-wide alternatives were modeled with the intent of achieving 100 percent, 90 percent, 85 percent, 80 percent, and 75 percent capture and 0, 1, 3, 4, 7, 8, and 12 discharges. The screening was completed by evaluating different promising alternatives for each targeted level of control. Similar to the optimization screening step, this Typical Year modeling screening process provided additional insight regarding system response to a range of potential project options. The insight gained from this

step allowed selection of an appropriate list of alternatives for further evaluation, as part of the detailed alternatives evaluation described in Section 6.

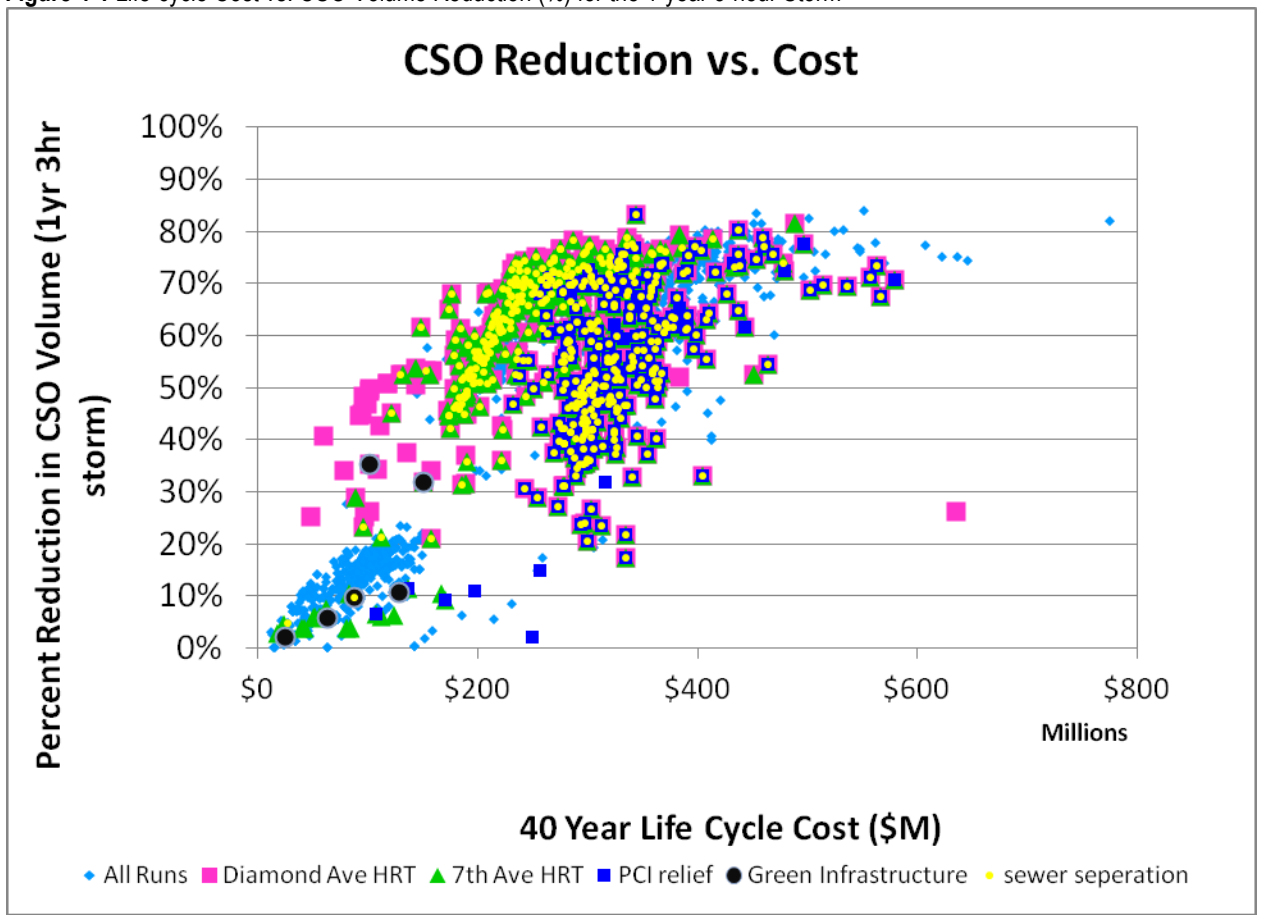
Throughout the plan development process, data refinements were made to the hydraulic models, costing data, and site constraints. The refinements made to the evaluation tools between the optimization screening and Typical Year screening evaluations included adjustment of the CSO diversion weirs, refinements to the costing allowances, and refinements to the 7th Avenue Lift Station projects and other project sizing/configurations based on site constraints. The Typical Year screening assessment was completed prior to completion of the Phase III flow monitoring; therefore, the Typical Year model screening analysis did not reflect the 2013 hydraulic model updates.

Typical Year modeling results from the optimization screening analysis are presented in Appendix B.

4.4 Alternatives Appropriate for Further Evaluation – West Basin

The majority of the most promising West basin alternatives in terms of cost, overflow volume reduction, and reduction in number of activations are different variations of the storage and HRT options. In order to evaluate a full range of possible CSO control technologies required by the Decree, the PCI relief sewer and tunnel alternatives were carried forward to the detailed alternatives evaluation presented in Section 6.

Figure 4-1 Life-cycle Cost vs. CSO Volume Reduction (%) for the 1-year 3-hour Storm



SECTION 5

Alternative Screening - East Basin

Similar to the alternative screening completed for the West Basin, screening of East alternatives was completed to identify a cost effective alternatives for more detailed evaluation. With the exception of the Oak Hill CSO (CSO 011), the East system CSOs are located within a mile of the East WWTP. The largest CSOs are directly impacted by WWTP operations (CSO 103), or discharge to Bee Slough (CSOs 001 and 002), which is immediately adjacent to the East WWTP. These factors, a congested downtown area, and associated space limitations result in fewer East project options and permutations. Optimization was, therefore, not used for screening East alternatives.

The baseline model updated the EPA approved 2009 East CSS model to 2012 conditions. Areas with sewer separation projects that were constructed, or are designed and scheduled for construction were removed from the model. The Vann Avenue Trunk Line, South East Side Separation, Lorraine Park Underground Storage, Oak Hill Road Reconstruction, Covert Avenue Outfall, Southeast Brookside and Cass Avenue Separation project areas were removed from the CSS model to reflect the updated system conditions. Additionally, the East WWTP capacity was increased to reflect 28 mgd.

5.1 Potential CSO Control Technologies

As described in Section 3, the *Combined Sewer Overflow Alternatives Analysis Screening Report* (CH2M HILL, 2012a) resulted in numerous inflow reduction, sewer system modification, storage, and treatment technologies identified for potential inclusion in the LTCP. Tables A-15 through A-22 found in Appendix A, present information regarding technologies considered viable at each East basin CSO or CSO grouping, as well as information regarding why other technologies were not considered viable at those locations.

Project components carried forward in the screening analysis include:

- Treatment
- Conveyance
- Storage
- Sewer separation
- GI

5.2 East Basin Alternative Screening Methodology

The approach for the East alternatives development consisted of identifying and assessing the benefits and costs of an array of potential CSO control measures. The relative simplicity of the East system enabled this procedure to be conducted in a step-wise fashion. In general, the following procedure was employed:

1. Develop East WWTP expansion alternatives, assess their impacts on the East system using the East CSS hydraulic model, estimate the life-cycle alternative costs, and select the alternative with the best benefit/cost performance.

2. Evaluate the benefit of additional conveyance capacity to transport additional flow to the East WWTP. Additional conveyance was modeled as tunnel storage/conveyance to demonstrate the potential benefits that may be achieved by increasing the Riverside Interceptor's capacity.
3. Develop Bee Slough CSO control measure alternatives, assess their impacts on the system and life-cycle cost, and select an alternative based on the benefit/cost performance. Due to the proximity of Bee Slough to the East WWTP, Bee Slough control options focused on storage and treatment. Tunnel storage/conveyance to transport flows from CSOs 001, 002, or 004 to the East WWTP was not evaluated.
4. Evaluate an array of other basin-wide conveyance, storage, satellite-treatment, etc. alternatives (or combinations thereof), and evaluate them on a benefit/cost basis.

5.3 Impact of East WWTP Expansion on CSO Volumes

Based upon the concept that additional capacity at the East WWTP may decrease CSOs in the Ohio River East/Downtown and Bee Slough Systems, East WWTP expansion alternatives were modeled prior to the evaluation of other system modifications. An analysis was conducted to evaluate the expansion of the East WWTP and the potential benefit for reducing CSO discharges (both frequency and volume) across the service area. A technical memorandum (TM) summarizing this analysis was submitted to EPA on January 18, 2013. Sections 5.3.1 through 5.3.3 provide an overview of the information included in the TM, including:

1. Summary of East WWTP expansion alternatives
2. Modeled CSOs with increased East capacity
3. Benefit/cost analysis of increased WWTP capacity

5.3.1 Summary of East WWTP Expansion Alternatives

Alternatives for expanding the West and East WWTPs were evaluated and are presented within the Facility Plan. The primary intent of the facility plans was to identify recommended improvements to increase the capacities of the West and East WWTPs to 40, 60, and 80 mgd and to provide a level of detail appropriate for comparison of alternatives in the West and East system-wide alternative analyses. Improvements that maximized the treatment capacity of the existing processes were identified first. Expanding those unit processes and/or utilizing other treatment technologies were then considered to increase capacity further. A separate technology screening was conducted as part of facility planning to identify which technologies to employ in the evaluation.

Table 5-1 summarizes the requirements and estimated costs to expand the East WWTP to 40, 60, and 80 mgd. Costs were developed using cost estimating guidelines prepared specifically for Facility Planning. Details can be found in Appendix A of the Facility Plan. As shown, two different 40-mgd expansion alternatives were considered at the East WWTP. The Primary Effluent Bypass alternative involved maximizing the existing activated sludge system at 26 mgd and bypassing 14 mgd around secondary treatment to disinfection facilities. The other 40-mgd alternative involved expanding the existing activated sludge system such that all 40 mgd received secondary treatment. The 60- and 80-mgd scenarios included expanding the existing activated sludge system as well.

Table 5-1 East WWTP Expansion Summary

Process Description	40 mgd – Primary Effluent Bypass	40 mgd	60 mgd	80 mgd
Preliminary Treatment				
Screening	None	None	New bypass channel and manual bar screen Replace two existing screens with two 30-mgd screens	New bypass channel and manual bar screen Replace two existing screens with two 40-mgd screens
Grit Removal	None	None	None	None
Pumping	None	None	Replace four existing pumps with four 20-mgd submersible pumps	Replace four existing pumps with four 20-mgd submersible pumps Expand wet-well and install one additional 20-mgd influent pump
Other	None	None	Modify existing H-flume Construct new flow splitter structure with automated plug valves	Modify existing H-flume Construct new flow splitter structure with automated plug valves
Secondary Treatment				
Additional Clarifier Capacity Required	None	One 150-ft-diameter clarifier, required ancillary equipment, and piping	One 150-ft-diameter clarifier and piping Two 123-ft-diameter clarifiers and piping	One 150-ft-diameter clarifier and piping Two 141-ft-diameter clarifiers and piping
Additional Aeration Capacity Required	None	One 1.4-MG tank	One 1.4-MG tank Two 0.625-MG tanks	One 1.4-MG tank Two 1.04-MG tanks
Additional Blower Capacity Required	None	Two turbo blowers, each at 11,300 scfm	Two turbo blowers, each at 11,300 scfm Two turbo blowers, each at 12,000 scfm	Two turbo blowers, each at 11,300 scfm Two turbo blowers, each at 13,300 scfm
Additional Return Activated Sludge/Waste Activated Sludge (RAS / WAS) Pumping Capacity Required	None	Three centrifugal pumps, 4,000 gpm at 40 ft TDH each	Six centrifugal pumps, 4,000 gpm at 40 ft TDH each	Six centrifugal pumps, 4,000 gpm at 40 ft TDH each
Other		None	Influent splitter box	Influent splitter box

Table 5-1 East WWTP Expansion Summary

Process Description	40 mgd – Primary Effluent Bypass	40 mgd	60 mgd	80 mgd
Disinfection				
UV System	None	Modify existing chlorine contact tank to accommodate 40-mgd UV system; upsize existing effluent piping	Construct new 40-mgd UV system; install new effluent piping to new junction structure	Construct new 40-mgd UV system; install effluent piping to new junction structure
Additional Contact Tankage Required	None	None	None	One new 176,000–gallon tank
Chemical Feed/ Storage Required	New Chemical Feed Building with three 7,500-gallon FRP storage tanks	None	New Chemical Feed Building with two 5,000-gallon FRP storage tanks	New Chemical Feed Building with three 7,500-gallon FRP storage tanks
Existing Contact Tank Modifications Required	Rehab contact tank walls Modify contact tank effluent weir Replace existing 48” sluice gate with automated gate and level sensor	Modify influent channel and effluent weir to accommodate UV hydraulics	None	Lower existing contact tank weir approximately 0.2 ft Add a second 48” sluice gate to existing influent channel
Other	Seal existing final effluent MH		Construct new UV diversion structure (approximately 10’x10’) with gates	Upsize existing effluent piping New UV diversion structure (approximately 10’x10’) with gates Construct new chlorinated effluent diversion structure to bypass existing contact tank
Effluent Conveyance (from WWTP to Pump Station)				
Disinfected Effluent Modifications Required	None	Replace existing 36” effluent line downstream of Parshall flume with a 54” line Replace existing 54” effluent line upstream of Parshall flume with a 54” line, approximately 2 ft deeper	Replace existing 36” effluent line downstream of Parshall flume with a 54” line	Replace existing 36” effluent line downstream of Parshall flume with a 54” line Replace existing 54” effluent line upstream of Parshall flume with a 54” line, approximately 2 ft deeper

Table 5-1 East WWTP Expansion Summary

Process Description	40 mgd – Primary Effluent Bypass	40 mgd	60 mgd	80 mgd
Effluent Metering Required	None	Replace existing structure with deeper structure (approximately 2 ft deeper) Upsize existing Parshall flume to 48" flume	Modify existing flume to improve hydraulics / functionality	Replace existing structure with deeper structure (approximately 2 ft deeper) Upsize existing Parshall flume to 48" flume
Effluent Pumping				
Pump Station Building Required	Construct new effluent pump station (approximately 20 ft tall/ 460 ft^2); wet-well approximately 32 ft deep	Construct new effluent pump station (approximately 20 ft tall/ 460 ft^2); wet-well approximately 32 ft deep	Construct new effluent pump station (approximately 20 ft tall/ 560 ft^2); wet-well approximately 32 ft deep	Construct new effluent pump station (approximately 20 ft tall/ 670 ft^2); wet-well approximately 32 ft deep
Effluent Pumping Required	Install three submersible pumps, 13,900 gpm each	Install three submersible pumps, 13,900 gpm each	Install four submersible pumps, 13,900 gpm each	Install five submersible pumps, 13,900 gpm each
Effluent Force Main Required	Slip-line existing 84" sewer with approximately 600 LF of 54" HDPE	Slip-line existing 84" sewer with approximately 600 LF of 54" HDPE	Slip-line existing 84" sewer with approximately 600 LF of 60" HDPE	Reline existing 84" sewer with approximately 600 LF of CIPP
Other	Add 60" sluice gate to existing bypass line to K-4 Pump Station	Add 60" sluice gate to existing bypass line to K-4 Pump Station	Add 60" sluice gate to existing bypass line to K-4 Pump Station	Add 60" sluice gate to existing bypass line to K-4 Pump Station
Total Capital Cost	**$12,730,000**	**$47,001,000**	**$98,501,000[a]**	**$114,803,000[a]**
NPV 40-Year O&M Cost	**$3,485,000**	**$4,210,000**	**$12,713,000**	**$18,677,000**

[a] Solids handling modifications would be required. The lowest cost option for solids handling modifications is $27.8M, and the added cost is not included in the total capital cost estimate

CIPP = cast-in-place pipe

FRP = fiberglass reinforced plastic

ft^2 = square feet

HDPE = high density polyethylene

MH = manhole

NPV = Net Present Value

scfm = standard cubic feet per minute

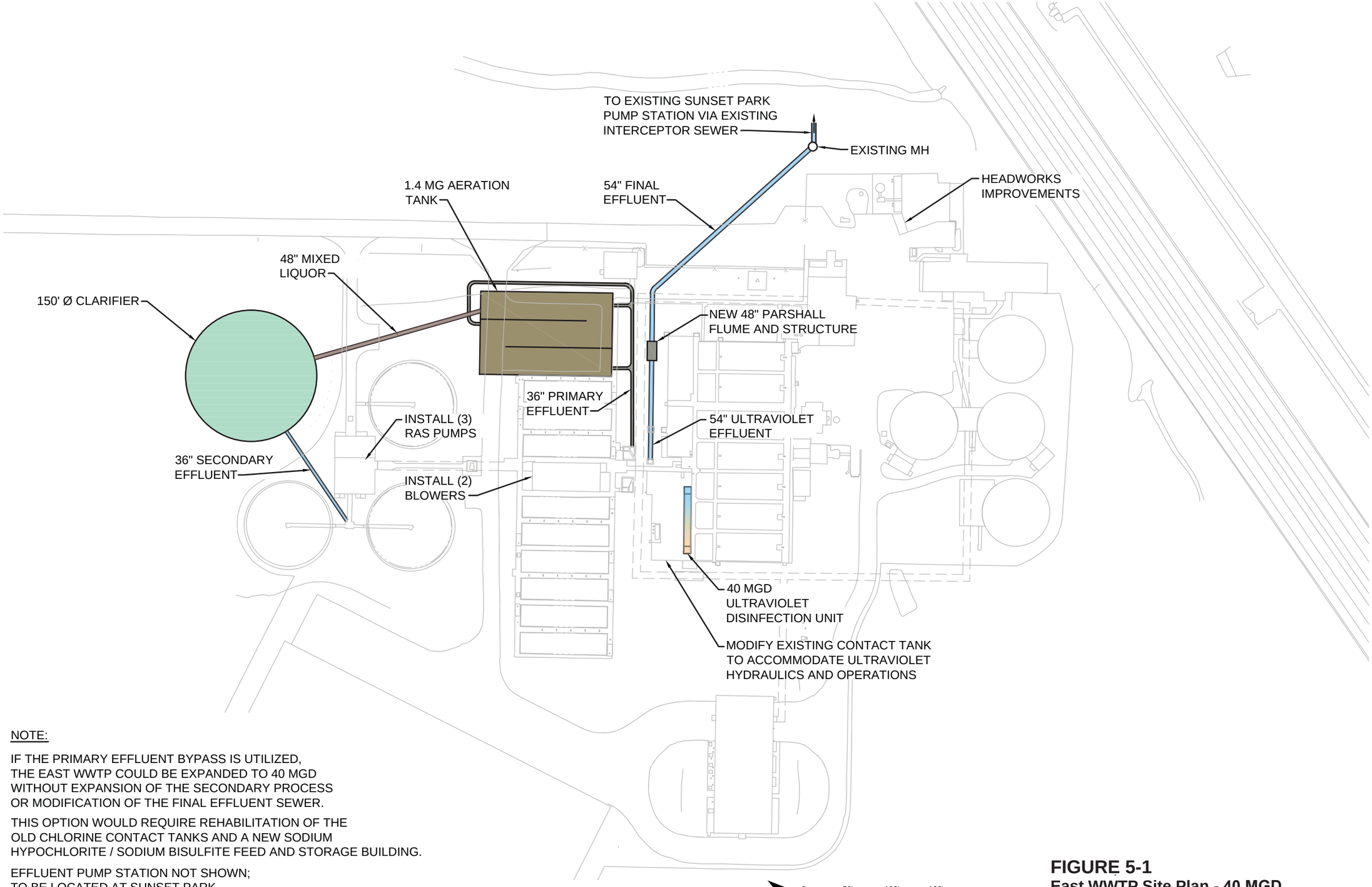
UV = ultraviolet

Figures 5-1 through 5-3 illustrate the proposed site plans. Refer to *Volume 4, Facility Plan for the West and East Wastewater Treatment Plants* of the IOCP for more details regarding the approach and development of these scenarios.

Constructing more than 40-mgd capacity at the East WWTP would require demolishing the existing sludge storage facility and modifying the WWTP's solids handling process. A conceptual evaluation of solids handling options for the WWTPs was conducted as part of facility planning. The lowest total capital cost option from this analysis that would allow decommissioning of the sludge storage area was $27.8 million. This cost would be in addition to the costs presented above. Further details of this analysis can be found in Appendix D of the Facility Plan.

5.3.2 Modeled CSOs with Increased East WWTP Capacity

Hydraulic modeling was performed to assess the system-wide impacts of increased capacity at the East WWTP. Plant capacities of 40, 60, and 80 mgd were evaluated, with CSO 103 closed to prevent WWF from bypassing the East WWTP. Closing CSO 103 was common to all scenarios considered. The impacts of increasing East WWTP capacity on the basis of percent capture, number of overflows, overflow volume, and peak overflow rate at each CSO, in the Typical Year, are summarized in Table 5-2.



NOTE:

IF THE PRIMARY EFFLUENT BYPASS IS UTILIZED,
THE EAST WWTP COULD BE EXPANDED TO 40 MGD
WITHOUT EXPANSION OF THE SECONDARY PROCESS
OR MODIFICATION OF THE FINAL EFFLUENT SEWER.

THIS OPTION WOULD REQUIRE REHABILITATION OF THE
OLD CHLORINE CONTACT TANKS AND A NEW SODIUM
HYPOCHLORITE / SODIUM BISULFITE FEED AND STORAGE BUILDING.

EFFLUENT PUMP STATION NOT SHOWN;
TO BE LOCATED AT SUNSET PARK

FIGURE 5-1
East WWTP Site Plan - 40 MGD
Long-Term Control Plan
May 31, 2013

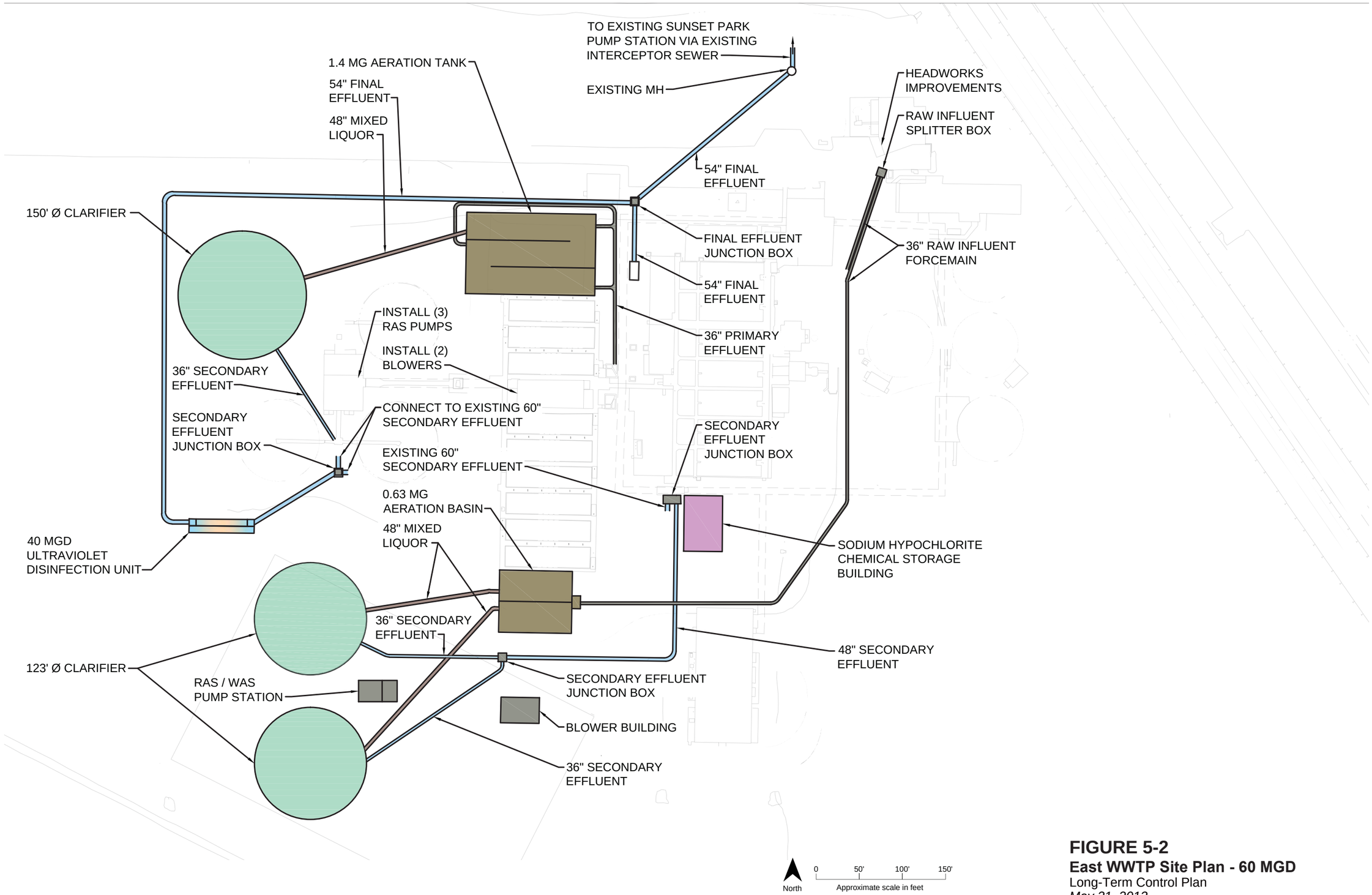


FIGURE 5-2
East WWTP Site Plan - 60 MGD
Long-Term Control Plan
May 31, 2013

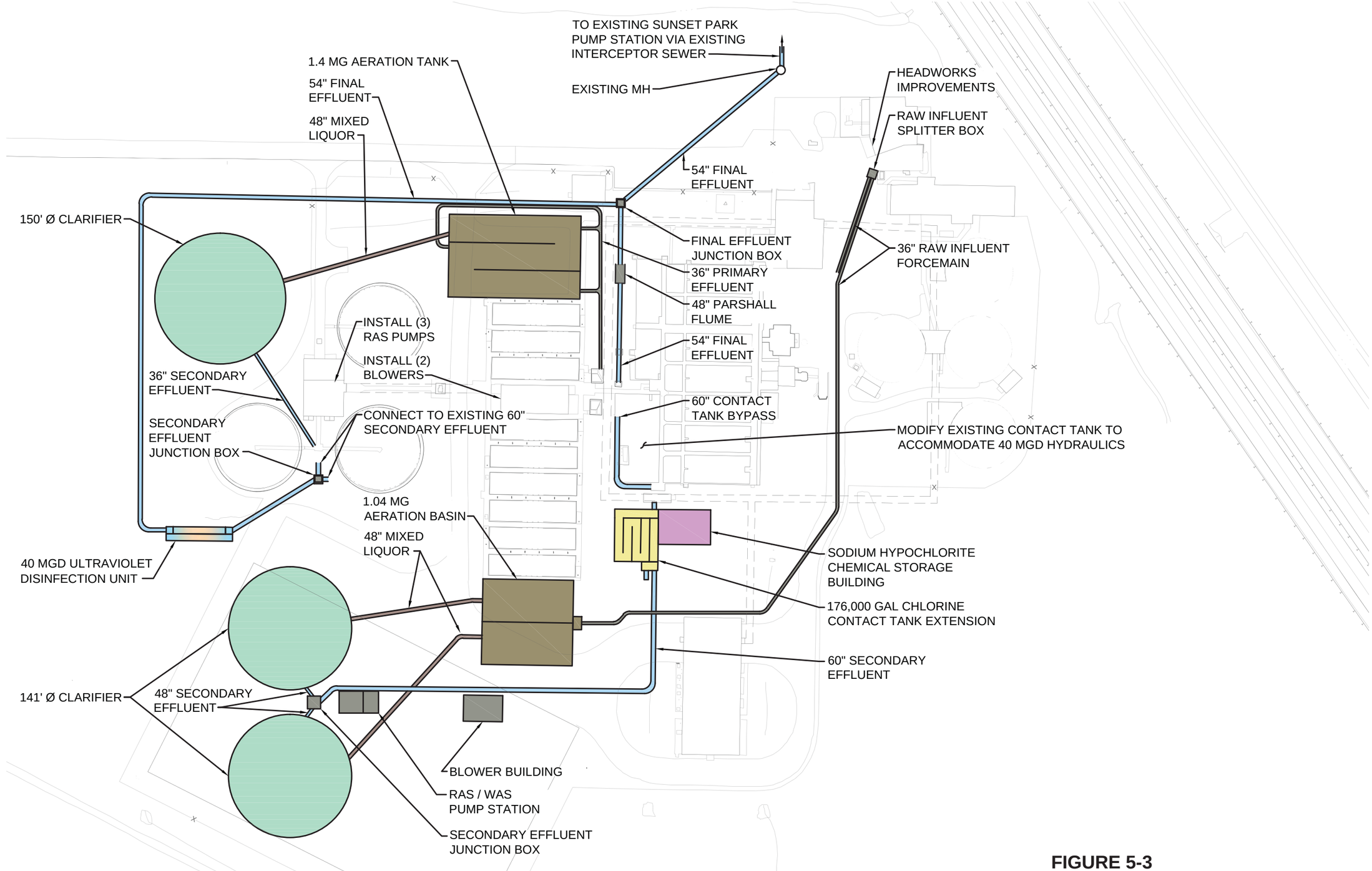


FIGURE 5-3
East WWTP Site Plan - 80 MGD
Long-Term Control Plan
May 31, 2013

renewEVANSVILLE

Table 5-2 Impact Summary of Increasing WWTP Capacity on CSOs, in the Typical Year

CSO	Criteria	40 mgd	60 mgd	80 mgd
103 - Junction Box	Percent Capture	100	100	100
	Number of Untreated Discharges	0	0	0
	Overflow Volume (MG)	0	0	0
	Peak Overflow Rate (mgd)	0	0	0
001 - Kentucky Avenue	Percent Capture	34	35	35
	Number of Untreated Discharges	38	38	38
	Overflow Volume (MG)	872	867	866
	Peak Overflow Rate (mgd)	229	229	228
002 - Cass Avenue	Percent Capture	83	92	96
	Number of Untreated Discharges	18	10	8
	Overflow Volume (MG)	105	50	26
	Peak Overflow Rate (mgd)	169	148	128
004 - Adams	Percent Capture	31	37	39
	Number of Untreated Discharges	29	29	29
	Overflow Volume (MG)	41	38	36
	Peak Overflow Rate (mgd)	54	54	54
008 - Chestnut Street	Percent Capture	56	59	60
	Number of Untreated Discharges	30	31	31
	Overflow Volume (MG)	108	101	99
	Peak Overflow Rate (mgd)	100	100	100
010 - Dress Plaza	Percent Capture	57	56	56
	Number of Untreated Discharges	25	25	25
	Overflow Volume (MG)	64	64	64
	Peak Overflow Rate (mgd)	74	74	102
011 - Oakhill/Weinbach	Percent Capture	60	60	60
	Number of Untreated Discharges	18	18	18
	Overflow Volume (MG)	91	91	91
	Peak Overflow Rate (mgd)	104	102	101
038 - Oak/Riverside	Percent Capture	85	86	86
	Number of Untreated Discharges	11	10	10
	Overflow Volume (MG)	5	4	4
	Peak Overflow Rate (mgd)	19	19	19

As indicated within Table 5-2, reductions in the criteria evaluated were most significant at CSOs 001, 002, 004, and 008. CSO 002 (Cass Ave) was particularly sensitive to WWTP capacity increases. Aggregate percent capture throughout the East system rose from 35 to 40 percent over the range of WWTP capacity increases; however, the aggregate number of untreated discharges (42) in the East system did not change.

5.3.2.1 Performance Factors

Each of the alternatives evaluated received the same score in the majority of the performance criteria, but there were moderate differences. Hydraulic modeling determined that increasing WWTP capacity to 60 and 80 mgd was more effective at reducing CSO discharges; therefore, the 60- and 80-mgd alternatives scored higher with respect to frequency of discharges. In addition, the 40 mgd – Primary Effluent Bypass alternative would not include expansion of the secondary treatment process. Therefore, that alternative scored lower than all other alternatives in terms of suspended solids reduction.

5.3.2.2 Implementation and Operation Factors

Scoring for expansion alternatives was most varied in the implementation and operation category. Differences were observed in the following three criteria:

- **Enhances Nine Minimum Controls** - Alternatives that included expansion of the secondary treatment process enhance Nine Minimum Controls to a higher degree. Furthermore, larger expansions do this more effectively than smaller expansions. Therefore, the 60- and 80-mgd alternatives scored highest, followed by the 40 mgd and 40 mgd – Primary Effluent Bypass alternatives, respectively.
- **Maximizes use of existing infrastructure** - The facility planning approach ensured that the treatment capacity of existing infrastructure was maximized in all scenarios assessed. However, the 40 mgd – Primary Effluent Bypass alternative does this to a higher degree because, due to hydraulics, it is the only alternative that enables the entire existing disinfection facilities to be utilized. Therefore, in this instance the 40 mgd – Primary Effluent Bypass alternative scored higher than all other alternatives.
- **Land Requirements** - Alternatives that included expansion of the secondary treatment process required significantly more land. Alternatives that required less land scored higher. As the 40 mgd – Primary Effluent Bypass required no secondary treatment expansion, it scored highest. The remaining 40-, 60-, and 80-mgd alternatives followed in decreasing score, respectively.

5.3.2.3 Safety and Community Impacts

All expansion alternatives scored the same in all criteria of both the Safety and Community Impacts categories.

5.3.3 East WWTP Expansion Summary and Conclusions

Results of the benefit/cost analysis are summarized in Table 5-3. The 60- and 80-mgd expansion alternative scored highest in non-cost factors (total benefit), followed by the 40-mgd alternatives. However, total capital costs significantly influenced the final alternative rankings. The 40 mgd – Primary Effluent Bypass alternative had the highest benefit/cost ratio by a wide margin, at 19.60. Therefore, the 40 mgd – Primary Effluent Bypass alternative was identified as the most cost-effective WWTP expansion alternative, and was utilized in the East system-wide alternatives analysis.

Table 5-3 Benefit/Cost Summary for WWTP Expansion Alternatives

Alternative	Technologies	Performance Score	Implementation and Operation Score	Safety Score	Community Impacts Score	Total Benefit	Capital Cost ($ Million)	Benefit/ Cost
1	40-mgd - Primary Effluent Bypass	1.04	0.855	0.2	0.4	2.495	12.730	19.60
2	40-mgd Conventional Treatment	1.06	0.825	0.2	0.4	2.485	48.208	5.15
3	60-mgd Conventional Treatment	1.16	0.855	0.2	0.4	2.615	121.701	2.15
4	80-mgd Conventional Treatment	1.16	0.855	0.2	0.4	2.615	138.003	1.89

This analysis concluded that WWTP expansion alone would not provide substantial CSO benefit. Therefore, additional conveyance, storage, and/or treatment capacity would need to be constructed in conjunction with WWTP expansion in order to reduce CSO discharge volumes and activation frequency. Additional conveyance, storage, and/or treatment options are described in the following sections.

5.4 Additional Conveyance Screening

As stated above, the WWTP expansion analysis demonstrated that WWTP expansion alone would not provide substantial CSO benefit. Additional conveyance to the WWTP was evaluated to determine whether conveyance capacity was a limiting factor contributing to CSOs, and to determine whether additional WWTP capacity may be more beneficial in conjunction with additional conveyance capacity. A tunnel alternative was evaluated to assess the potential benefit of upsizing or replacing the Riverside Interceptor.

For the screening analysis, a 6,500 LF tunnel was modeled from Court Street to the East WWTP. The 40-mgd East WWTP expansion option resulted in the highest benefit cost score, so the analysis assumed that the WWTP capacity was increased to 40 mgd. The analysis was completed assuming that the tunnel would be dewatered within 48 hours, resulting in a 20-foot diameter tunnel.

The screening evaluation concluded that the infrastructure noted above could reduce the number of activations to 1 at CSOs 008, 010, and 038, and to zero elsewhere in the East system, and achieve just under 100 percent capture. Additional conveyance to the WWTP would provide the ability to reduce CSOs throughout the East system; therefore, tunnel storage/ conveyance was evaluated as part of the detailed alternatives evaluation described in Section 6.

5.5 Bee Slough Control Measure Screening

As described in Section 2.5, CSOs 001, 002, and 004 discharge directly to Bee Slough, a concrete channel that runs adjacent to the East WWTP and ultimately discharges into the Ohio River.

Volumes from CSO 001, 002, and 004 comprise approximately 808 MG of the East system CSO volume in the typical year. Developing solution(s) that address the CSO discharges and mitigate the conditions that contribute to odor and aesthetic issues resulting from standing CSO water in Bee Slough is, therefore, a significant component of any East Basin alternative. Bee Slough is also specifically referenced in the Decree, so remedying the Bee Slough CSOs and associated odor and aesthetic issues are some of Evansville's highest priorities.

Numerous potential Bee Slough control measure technologies and project configurations were screened in order to select a cost-effective Bee Slough control measure for inclusion in any East Basin alternative. Each potential technology or configuration was developed taking into account the following:

- The peak flow rates from the three large CSO outfalls that discharge into Bee Slough (CSO 001, 002, 004) are over 10 times larger than the East WWTP's maximum treatable flow rate.
- Ohio River level and Levee Authority pumping operations control flow and water levels in Bee Slough.
- The Bee Slough outfall is the most upstream of Evansville's discharges to the Ohio River sensitive area, so under the CSO Control Policy Evansville must eliminate or relocate if physically possible and economically achievable, or if elimination or relocation is not physically possible or economically achievable, Evansville must protect water quality.
- These CSOs comprise approximately 70 percent of the total volume of CSO discharges to the Ohio River.
- Remediation of Bee Slough is the highest priority of the community due to aesthetic and odor issues and 100 percent capture of CSO discharges in the Typical Year was the overarching goal in developing CSO control alternatives.
- The Bee Slough control measure screening consisted of the following steps:
  - Identifying potential CSO control measures for Bee Slough
  - Evaluating the impact of the potential control measures
  - Performing a benefit/cost analysis of the potential control measures

5.5.1 Potential Bee Slough Control Measures

Viable technologies capable of remedying the aesthetic and odor issues in Bee Slough were identified, while taking into consideration physical constraints posed by the site.

The Utility commissioned a study in 2007 to develop and analyze options for constructing a large storage basin north of the East WWTP (the *Bee Slough Early Action Project Design Options Summary Report*; Ross & Baruzzini, 2007). A formal geotechnical investigation was conducted as part of the study to determine general subsurface conditions. The investigation concluded that, in the study area, sand boils could be expected during high river levels due to hydrostatic pressure in the sand soil layer, which lies at a depth of approximately 20 to 30 ft. Anecdotal information received through conversations with EVLAD's engineering consultant and local contractors has indicated that similar soil conditions exist throughout the ponding area, that sand boils occur in several locations within the ponding area, and that a clay cap exists in portions of the area south of the East WWTP, where many of the potential CSO control facilities would be expected to be located. No formal geotechnical investigation was performed in this area or in the Bee Slough area as part of IOCP development, so specific subsurface conditions in

this area have not been defined, nor are the risks involved in excavating in this area fully understood at this time. Consequently, any of the potential Bee Slough control measures that would involve excavation were viewed as higher risk than alternatives that did not involve excavation in this area.

In total, 17 potential project alternatives were developed for remediation of Bee Slough CSOs. Table 5-4 summarizes the key components of each potential project, and brief narratives and proposed layouts of each project option are provided in the following sections.

Options are presented/grouped by treatment technology. Alternatives 1 and 2 are storage-only options and include no treatment. Alternatives 3 through 7 assess a range of different satellite treatment/ HRT options, including Storm King, Actiflo, Chemically-Enhanced Primary Treatment (CEPT), and Vertical Treatment Unit (VTU) technologies. Alternatives 8 through 11 assess different configurations of wetland treatment systems. Lastly, Alternatives 12 through 17 assess a combination of treatment technologies.

Table 5-4 Summary of Bee Slough Control Measure Project Options

Option	Technology Type	Total Storage (MG)[a]	Pumping Capacity (mgd)	Treatment Technology	Treatment Capacity (mgd)
1	Storage	95	47.5	None	N/A
2	Storage	95	47.5	None	N/A
3	Satellite/HRT	None	None	Storm King	387
4	Satellite/HRT	None	9.3	Actiflo	200
5	Satellite/HRT	9.1	200	CEPT	200
6	Satellite/HRT	None	None	VTU	448
7	Satellite/HRT	None	None	VTU	387
8	Satellite/Biological	None	387	Wetlands	387
9	Satellite/Biological	9.1	200	Wetlands	200
10	Satellite/Biological	21.1	150	Wetlands	150
11	Satellite/Biological	21.1	150	Wetlands	150
12	Satellite/HRT and Wetlands	24	80	VTU/BioCEC[b]	223 / 80
13	Satellite/HRT and Wetlands	None	None	VTU/Wetlands	223 / 225
14	Satellite/HRT and Wetlands	None	1	VTU/Wetlands	223 / 225
15	Satellite/HRT and Wetlands	None	None	VTU/Wetlands	223 / 225
16	Satellite/HRT and Wetlands	None	120	VTU/Wetlands	223 / 225
17	Satellite/HRT and Wetlands	None	120	VTU/Wetlands	223 / 225

[a]Total storage volumes represent separate storage facilities only; values do not reflect storage volumes inherent to treatment systems, which can be significant

[b]BioCEC = Biological and Chemically-Enhanced Clarification, also known as BioActiflo

Summaries and conceptual layouts for each option are provided in Table 5-5 and Figures 5-4 through 5-16.

Table 5-5 Bee Slough Options

Option 1 (Storage Only)	**Overview** Alternative 1 consists of storage of total overflow from CSOs 001, 002, and 004 by means of deep vertical storage units, along with pumping facilities to convey flow to the East WWTP as treatment capacity becomes available. The conceptual layout is provided in Figure 5-4. The East System CSS hydraulic model was utilized to estimate storage requirements for the Typical Year, with an East WWTP treatment capacity of 60 mgd. Pumps were modeled to convey flow from storage facilities to the East WWTP to keep the WWTP's treatment rate at maximum capacity. This analysis showed that 95 MG of storage was needed to maintain 100 percent capture of CSOs 001, 002, and 004 during a Typical Year event. **Storage** A total storage volume of 95 MG was proposed in Alternative 1. Storage facilities were initially modeled at a single location near CSO 002, but due to space limitations, storage facilities were distributed among locations near CSO 001 and 002. Due to the large storage requirement, vertical shaft storage was selected to provide the high volume with a minimal footprint. For costing purposes, 65 MG of storage was proposed to capture flow from CSO 001, and 30 MG of storage was proposed to capture flow from CSO 002 and 004. Ten tanks were proposed in total. **Treatment** Additional treatment was not evaluated as part of this alternative. All flow would receive primary and secondary treatment at the East WWTP. Alternative 1 was one of the first alternatives considered and the assessment was conducted prior to the completion of facility planning, which ultimately identified the East WWTP's most cost-effective treatment capacity at 40 mgd. As noted above, required storage volume for this alternative was determined with the East WWTP capacity modeled at 60 mgd. If this scenario were re-evaluated with the East WWTP at 40 mgd, storage requirements would increase. However, because this alternative was already cost-prohibitive, no further analysis was conducted. **Pumping** Alternative 1 would require 47.5 mgd of pumping capacity. The vertical shaft storage tanks require submersible dewatering pumps located in a sump at the bottom of the tanks. Pumping capacity was based on dewatering storage tanks in 48 hours. **Challenges** This solution focused on capturing CSO volumes and storing them until treatment capacity at East WWTP becomes available. Storage holding time is a critical design criterion because CSO volumes have the ability to become septic, which would result in odor issues. For this reason, alternatives were developed with a 48-hour dewatering period in mind. Achieving complete dewatering in 48 hours would be very difficult in this scenario. During and immediately after the onset of storm events, the East WWTP would likely be at or near its maximum treatable flow rate. Analysis shows that it would require 89 hours to drain the 95 MG of storage with the WWTP treatment capacity at 60 mgd. Moreover, re-evaluating this alternative to reflect Facility Plan findings (treatment capacity at 40 mgd) would result in larger storage volumes and longer dewatering periods.

Table 5-5 Bee Slough Options (continued)

Option 2 (Storage Only)	**Overview** Alternative 2 would include storage of total overflow from CSOs 001, 002, and 004 by means of a soft earth tunnel, along with pumping facilities to convey flow to the East WWTP as treatment capacity becomes available. This option is similar to Alternative 1 except for the type of storage. In this alternative, a 20-ft diameter tunnel was assessed in lieu of vertical storage. The tunnel would extend 40,500 ft to achieve storage volume requirements, would extend along Bee Slough, and continue north adjacent to the Ohio River. **Storage** A total storage volume of 95 MG was proposed for this option. A 20-ft diameter tunnel stretching 40,500 ft would provide adequate storage volume. The depth to bedrock would be approximately 100 ft below the surface, but further geotechnical investigation would be required to confirm. **Treatment** Additional treatment was not evaluated as part of this alternative. All flow would receive primary and secondary treatment at the East WWTP. Alternative 2 was one of the first alternatives considered and the assessment was conducted prior to the completion of facility planning, which ultimately identified the East WWTP's most cost-effective treatment capacity at 40 mgd. As noted above, required storage volume for this alternative was determined with the East WWTP capacity modeled at 60 mgd. If this scenario were re-evaluated with the East WWTP at 40 mgd, storage requirements would increase. However, because this alternative was already cost-prohibitive, no further analysis was conducted. **Pumping** Alternative 2 would require 47.5 mgd of pumping capacity. The tunnel would require submersible dewatering pumps located in a sump at the bottom of the tunnel. Pumping capacity was based on dewatering storage tanks in 48 hours. **Challenges** A serious challenge associated with this alternative would be the alignment required to achieve 40,500 LF/95 MG of storage. The tunnel would need to be routed in a very meandering manner in order to stay along streets and within right-of-way boundaries; moreover, the meandering would require numerous drop shafts for cleaning/maintenance accessibility. Secondly, dewatering 95 MG in 48 hours would be very difficult in this scenario. During and immediately preceding a storm event, the WWTP would already be at capacity. Analysis shows that it would require 89 hours to drain the 95 MG of storage with the WWTP treatment capacity at 60 mgd. Moreover, re-evaluating this alternative to reflect facility planning findings (treatment capacity at 40 mgd) would result in larger storage volumes and longer dewatering periods. In addition, of all options associated with Bee Slough, the USACE is most concerned with tunneling. Significant coordination with the USACE would be required to evaluate whether the tunnel would compromise the integrity of Evansville's earthen levee. Lastly, such an extensive tunnel would likely pass near other CSO outfalls, but would not provide storage for them. CSO volumes from Bee Slough comprise approximately 70 percent of Evansville's annual overflow volume. This suggests that if tunneling were considered for capturing Bee Slough volumes, the incremental costs associated with capturing 100 percent of Evansville's annual overflow volume (or at least CSOs outside of Bee Slough) should be considered, and that tunneling would be more appropriate as a system-wide solution. For these reasons, Alternative 2 was not considered further.

Table 5-5 Bee Slough Options (continued)

Option 3 (Satellite/HRT)	**Overview** Alternative 3 would include a treatment solution only. Treatment capacity would be sufficient to treat overflow volumes from CSOs 001, 002, and 004. All flow would be routed to a facility for treatment. **Storage** This alternative included no storage. **Treatment** The treatment selected for this option was a Storm King unit, which is a vortex separation chamber with options to incorporate unique, non-powered, self-cleansing Swirl Cleanse screening technology. Storm King units are ideal for satellite treatment at overflow sites and have already been installed In the local area (Boonville, IN). Total treatment capacity would be 387 mgd, and at least 10 units would be required to be constructed to treat up to this peak flow rate. **Pumping** Alternative 3 would operate by gravity. Therefore, no pumping would be required. **Challenges** Performance of the Storm King units is still being studied, so the ability of the treatment units to consistently meet permitted effluent requirements is unknown at this time. As a result, this alternative was not carried forward due to the availability of alternatives that could potentially result in better treatment levels.

Table 5-5 Bee Slough Options (continued)

Option 4 (Satellite/HRT)	**Overview** Alternative 4 would include a combination of storage and treatment. In general, flows from CSOs 001, 002, and 004 would be conveyed to one of two HRT units. One unit would treat flows from CSO 001 while the other unit would treat flows from CSO 002 and 004. Flows in excess of the VTU capacity would be stored in adjacent storage facilities. The conceptual layout can be seen in Figure 5-5. **Storage** This alternative included underground storage tanks located at CSOs 001 and 002 with capacities of 16.1 MG and 2.5 MG, respectively. **Treatment** The HRT system selected for this alternative was Actiflo. The Actiflo process is a compact, conventional type water clarification system used in drinking water and wastewater applications. It utilizes microsand as a seed for floc formation. The microsand provides surface area that enhances flocculation and acts as a ballast or weight. The resulting sand ballasted floc has unique settling characteristics, which allow for clarifier designs with high overflow rates and short retention times. Each unit was proposed to provide 100 mgd of treatment capacity that would include screening, clarification, and UV disinfection. **Pumping** This option would operate by gravity. Therefore, no pumping would be required. To ensure this alternative is capable of operating by gravity, the Actiflo system would need to be constructed and installed at low elevations in the Bee Slough area. **Challenges** Due to the installation at low elevations, there are concerns about the effects of high river conditions. In particular, managing flood waters would need to be considered and addressed.

Table 5-5 Bee Slough Options (continued)

Option 5 (Satellite/HRT)	**Overview** This alternative would include a combination of storage, treatment, and conveyance. It would consist of treating CSOs 001, 002, and 004 by means of CEPT. All discharges from the CSOs would be conveyed by gravity to a common facility. Flows in excess of the treatment capacity would be pumped to an earthen storage basin on the west side of Veterans Memorial Parkway. Stored volumes would be drained back to treatment facilities as capacity becomes available. A conceptual site layout is shown in Figure 5-6. **Storage** This alternative would include 9.1 MG of storage by means of an open earthen basin adjacent to the East WWTP. Flow would be screened prior to entering the basin. **Treatment** The alternative would include 200 mgd capacity of CEPT and associated facilities that would operate by gravity. All flow would receive screening, clarification, and disinfection. **Pumping** This alternative would include a 187-mgd pump station capable of pumping excess flows to storage facilities. Flow would be screened prior to pumping and storage. **Challenges** The footprint associated with the CEPT process would be significant. In addition, coordination with the USACE would be required to repurpose the existing EVLAD K-4 PS ponding area for storage.

Table 5-5 Bee Slough Options (continued)

Option 6 (Satellite/HRT)	**Overview** Alternative 6 would include a combination of treatment and storage by means of two VTUs. One VTU would be located at and treat volumes from CSO 001. The other VTU would be located at CSO 002 and would treat flow from CSO 002 and conveyed flow from CSO 004. Overflows for the CSOs would flow by gravity into the VTUs for settling, filtration, and disinfection. A conceptual site layout is shown in Figure 5-7. **Storage** No additional storage facilities would be required for this alternative. **Treatment** The treatment selected for this option is two VTUs by Applied Engineering Technologies. The unit proposed to be located at CSO 001 would have a capacity of 225 mgd, and the unit proposed to be located at CSO 002 would have a capacity of 223 mgd, for a total capacity of 448 mgd. The VTU is a compact, high-performance, and cost effective solution. Liquid sodium hypochlorite and sodium bisulfate would be used for disinfection. In addition to the VTU, the treatment facility at CSO 002 would also include a diversion structure that would enable DWF to be conveyed to the East WWTP, and WWF to the VTU. The CSO 002 outfall structure would be removed. Furthermore, this alternative would include installing drains in Bee Slough capable of conveying flow to the East WWTP as treatment capacity becomes available. **Pumping** This alternative would operate by gravity. Therefore, no pumping would be required other than a submersible pump to drain the tank. **Challenges** Performance data for VTUs appear to meet current regulations for primary treatment. However, VTU technology is relatively new, and the performance may not meet future effluent requirements that may feature more stringent limits.

Table 5-5 Bee Slough Options (continued)

Option 7 (Satellite/HRT)	**Overview** Alternative 7 would include a combination of treatment and storage by means of one VTU. The VTU would be located near CSO 002. Overflows for the CSOs would be conveyed to the VTU for settling, filtration, and disinfection. A conceptual site layout is shown in Figure 5-8. **Storage** This option does not include separate storage facilities. **Treatment** The treatment selected for this option is a VTU by Applied Engineering Technologies. The unit proposed to be located at CSO 002 would have a total capacity of 387 mgd. The Vertical Treatment Unit is a compact, high-performance, and cost effective solution. Liquid sodium hypochlorite and sodium bisulfate would be used for disinfection. In addition to the VTU, the treatment facility at CSO 002 would also include a diversion structure that would enable DWF to be conveyed to the East WWTP, and wet weather to the VTU. The CSO 002 outfall structure would be removed. Furthermore, this alternative would include installing drains in Bee Slough capable of conveying flow to the East WWTP as treatment capacity becomes available. **Pumping** This alternative would operate by gravity. Therefore, no pumping would be required. **Challenges** The feasibility of using one VTU for CSOs 001, 002, and 004 would need to be evaluated further if this alternative is selected, as there are concerns with piping conflicts. Extending the 108-inch relief sewer from CSO 001 over to the VTU is of particular concern. Furthermore, piping coordination with CSO 002 and the Sweetser stormwater outfall would need to be considered and accounted for as well. In addition, performance data for VTUs appear to meet current regulations for primary treatment. However, VTU technology is relatively new, and the performance may not meet future effluent requirements that may feature more stringent limits.

Table 5-5 Bee Slough Options (continued)

Option 8 (Satellite/Wetlands)	**Overview** Alternative 8 would include a combination of treatment and conveyance. All flows from CSOs 001, 002, and 004 would be conveyed to a pump station, which would then pump flow into a wetlands treatment system. Flow from CSO 001 and 004 would be conveyed to pumping facilities by buried sewers. In the case of CSO 001, the buried sewer would be buried below the proposed wetlands. A conceptual site layout is shown in Figure 5-9. **Storage** This alternative would not include separate storage facilities. **Treatment** This alternative would include a wetlands treatment system totaling approximately 49 MG. Flow from CSOs 001, 002, and 004 would be pumped to wetlands on the west side of Veterans Memorial Parkway near the East WWTP. Most of the treatment would be conducted in this area of the wetland. Flow would then be conveyed by gravity through an existing culvert under Veterans Memorial Parkway and into polishing wetlands on the east side of the parkway. Raw CSO discharge would receive screening and grit removal prior to being pumped to the wetland. Wetland effluent would be disinfected with sodium hypochlorite. **Pumping** Due to the lack of storage facilities, this alternative would require a 387-mgd pump station to convey peak flow from the CSO discharges to the wetland adjacent to the East WWTP. **Challenges** Analysis showed that the costs of pumping peak flow from CSOs 001, 002, and 004 to the wetlands systems would be extremely high. In addition, the lower diversion structure and associated hydraulic gradeline at CSO 002 would require pumping facilities to be very deep.

Table 5-5 Bee Slough Options (continued)

Option 9 (Satellite/Wetlands)	**Overview** Alternative 9 would include a combination of storage, treatment, and conveyance. Discharges from CSOs 001, 002, and 004 would convey flow to a pump station near the East WWTP, where flow would then be pumped into a wetland treatment system. Flows in excess of pumping capacity would be diverted to underground storage facilities at CSO 001 and 002. Flow from CSO 001 and 004 would be conveyed to pumping facilities by buried sewers. In the case of CSO 001, the buried sewer would be below proposed wetlands. A conceptual site layout is shown in Figure 5-10. **Storage** This alternative would include underground storage tanks at CSOs 001 and 002 with capacities of 4.55 MG each. Storage facilities located at CSO 002 would store flow from CSO 002, as well as conveyed flow from CSO 004. **Treatment** The treatment system selected for this alternative was a wetlands treatment system. Flow from CSOs 001, 002, and 004 would be pumped into wetlands, which would be located on the west side of Veterans Memorial Parkway near the East WWTP. The wetland volume would be approximately 49 MG. Most of the treatment would take place in this area of the wetland. Flow would then be conveyed by gravity through an existing culvert under Veterans Memorial Parkway and into polishing wetlands on the east side of the parkway. Raw CSO discharge would be screened and have grit removal prior to being pumped into the wetland. Wetland effluent would be disinfected with sodium hypochlorite. **Pumping** This alternative would require a 200-mgd pump station to be located adjacent to the East WWTP. **Challenges** Low elevations of the CSO overflow weirs and concerns from the USACE about excavating adjacent to the levee require this alternative to include a large pump station. Raising CSO weirs and excavating for the wetland could greatly reduce or eliminate pumping requirements. However, the lack geotechnical data in this area is of great concern. These issues would need to be considered further in design.

Table 5-5 Bee Slough Options (continued)

Option 10 (Satellite/Wetlands)	**Overview** Alternative 10 is a variation of Alternative 9; the primary difference is the type and size of storage facilities. Alternative 10 would include a combination of storage, treatment, and conveyance. Discharges from CSOs 001, 002, and 004 would convey flow to a pump station near the East WWTP, where flow would then be pumped into a wetland treatment system. Flows in excess of pumping capacity would be diverted to vertical storage facilities at CSO 001 and 002. Flow from CSO 001 and 004 would be conveyed to pumping facilities by buried sewers. In the case of CSO 001, the buried sewer would be below proposed wetlands. A conceptual site layout is shown in Figure 5-11. **Storage** This alternative would include a vertical shaft storage tank located at CSOs 001 and 002, both with 10.55 MG of capacity. Storage facilities located at CSO 002 would store flow from CSO 002 as well as conveyed flow from CSO 004 **Treatment** The treatment system selected for this alternative was a wetlands treatment system. Flow from CSOs 001, 002, and 004 would be pumped into wetlands, which would be located on the west side of Veterans Memorial Parkway near the East WWTP. The wetland volume would be approximately 49 MG. Most of the treatment would take place in this area of the wetland. Flow would then be conveyed by gravity through an existing culvert under Veterans Memorial Parkway and into polishing wetlands on the east side of the parkway. Raw CSO discharge would be screened and have grit removal prior to being pumped into the wetland. Wetland effluent would be disinfected with sodium hypochlorite. **Pumping** The larger storage volumes in comparison to Alternative 9 reduce pumping requirements. This alternative would require a 150-mgd pump station to convey flow from the CSO discharges to the wetland adjacent to the East WWTP. **Challenges** Low elevations of the CSO overflow weirs and concerns from the USACE about excavating adjacent to the levee require this alternative to include a large pump station. Raising CSO weirs and excavating for the wetland could greatly reduce or eliminate pumping requirements. However, the lack geotechnical data in this area is of great concern. These issues would need to be considered further in design.

Table 5-5 Bee Slough Options (continued)

Option 11 (Satellite/Wetlands)	**Overview** Alternative 11 would include wetlands as an option for natural treatment. Flow from CSOs 001, 002, and 004 would be conveyed to storage facilities at the low-ponding areas near the East WWTP. Storage volumes would be pumped into a wetland treatment system that would extend on both sides of Veterans Memorial Parkway. **Storage** This alternative included 21.1 MG of storage and was proposed to be located in the low areas around the East WWTP. Facilities would include open storage basins with a concrete lining for easy maintenance. **Treatment** One hundred percent of the Typical Year discharges from CSOs 001, 002, and 004 would be treated through the wetland treatment system. Effluent quality is anticipated to exceed primary treatment. The wetland system included 20 acres of area generally bounded by the levee, the East WWTP, and Veterans Memorial Parkway. **Pumping** Alternative 11 would require 150 mgd of pumping to convey flow from storage facilities to the wetland system. **Challenges** Major challenges were identified early on in the development of this alternative: • The Levee Authority has expressed concern about the low areas being under substantial amounts of uplift pressure during high river conditions; sand boils being present adjacent to these areas support these concerns. A detailed geotechnical investigation would need to be completed. At minimum, it appears that a substantial number of piles would be required for structural stability. • Open CSO tanks would be adjacent to new homes, and owners already complain about odors from the WWTP. • Low areas considered for storage are considered natural wetland areas and would require extensive and costly mitigation measures. Due to these challenges, this alternative was not considered further.

Table 5-5 Bee Slough Options (continued)

Option 12 (Satellite/HRT and Wetlands)	**Overview** This alternative would include a combination of storage, treatment, and conveyance. It would consist of storage facilities at CSO 001, treatment by means of BioCEC, treatment by means of a VTU, and associated pumping. Discharges from CSOs 002 and 004 would flow by gravity to and would be treated by a single VTU. Discharges from CSO 001 would be conveyed by gravity to a pump station, where they would then be pumped to BioCEC facilities at the East WWTP. A conceptual site layout is shown in Figure 5-12. Multiple configurations of this alternative were assessed, which included BioCEC treatment capacities ranging from 40 to 120 mgd. The analysis showed that 80 mgd of BioCEC capacity was the lowest cost option. Therefore, that option was utilized in the Bee Slough analysis. **Storage** For this alternative, a storage capacity of 24 MG would be required to capture flow from CSO 001 in excess of the BioCEC treatment capacity. Vertical storage was used to reduce the footprint of the facility. Storage facilities would be located at CSO 001. **Treatment** This alternative would include two treatment systems: VTU and BioCEC. A 223-mgd VTU would be located at CSO 002 and would treat discharge from CSO 002 and 004. All flow would receive clarification, filtration, and disinfection. In addition to the VTU, 80-mgd of BioCEC capacity would be utilized to treat discharge from CSO 001. RAS would be transferred from the existing activated sludge system at the East WWTP to the proposed facilities during wet-weather events. The BioCEC facility would be located at the East WWTP, and would be capable of achieving secondary treatment equivalency along with disinfection. **Pumping** This alternative would include an 80-mgd pump station to convey flow to the BioCEC facilities. The pump station would be located just east of the East WWTP. **Challenges** BioCEC would require a highly skilled operation staff, which would require additional staffing and training by the Utility. Also, there are no known full-scale BioCEC facilities in operation with sufficient operating history to assure its effectiveness to consistently meet secondary treatment requirements. Furthermore, the transfer of activated sludge between the existing WWTP and the BioCEC facilities could cause process instability and water quality violations at the existing WWTP. In addition, constructing 40 mgd or more of BioCEC at the East WWTP would require demolishing the existing sludge storage facility and therefore modifying the WWTP's solids handling process. A cursory evaluation of solids handling options for the WWTPs was conducted as part of facility planning. The lowest cost option from this analysis that would allow decommissioning of the sludge storage area was $23.2 million. Further details of this analysis can be found in Appendix D of the Facility Plan.

Table 5-5 Bee Slough Options (continued)

Option 13 (Satellite/HRT and Wetlands)	**Overview** Alternative 13 would include only treatment solutions. It would consist of two VTUs as well as a wetlands treatment system. Flow from CSO 002 and 004 would be conveyed to a VTU located at CSO 002. Flow from CSO 001 would be conveyed to the VTU located at CSO 001. Effluent from the VTU at CSO 001 would then flow by gravity through a polishing wetland treatment system on the east side of Veterans Memorial Parkway. A conceptual site layout is shown in Figure 5-13. **Storage** This alternative would not include separate storage facilities. **Treatment** All flow from CSOs 001, 002, and 004 would receive screening, treatment, and disinfection by means of a VTU. The VTUs at CSO 001 and 002 would have 223- and 225-mgd capacity, respectively. In the case of CSO 001, VTU effluent and would then receive treatment from a 14-MG wetlands treatment system on the east side of Veterans Memorial Parkway in the Bee Slough area. In addition to the VTU, the treatment facility at CSO 002 would also include a diversion structure that would enable DWF to be conveyed to the East WWTP, and wet weather flow to the VTU. The CSO 002 outfall structure would be removed. Furthermore, this alternative would include removing the Bee Slough concrete channel in the wetland area, as well as installing drains in the downstream portions of Bee Slough capable of conveying flow to the East WWTP as treatment capacity becomes available. **Pumping** This alternative would operate by gravity. Therefore, no pumping would be required. **Challenges** Performance data for VTUs appear to meet current regulations for primary treatment. However, VTU technology is relatively new, and the performance may not meet future effluent requirements that may feature more stringent limits. In addition, the wetland system would improve VTU effluent quality, but for this alternative, the wetland system would only provide treatment for discharges from CSO 001.

Table 5-5 Bee Slough Options (continued)

Option 14 (Satellite/HRT and Wetlands)	**Overview** This alternative would include a combination of treatment and conveyance. It would consist of two VTUs, two wetland treatment systems, and an associated wetland pump station. One VTU is proposed to be located at CSO 001 and the other at CSO 002. The VTU located at CSO 002 would also treat flow from CSOs 002 and 004. The other VTU at CSO 001 would only treat CSO 001 flows. Effluent from the VTU at CSO 001 would also flow through a polishing wetland treatment system on the east side of Veterans Memorial Parkway. In addition, East WWTP effluent would be pumped to a wetland treatment system located west of the parkway and adjacent to the East WWTP. A conceptual site layout is shown in Figure 5-14. **Storage** This alternative would not include separate storage. **Treatment** All overflows from the CSOs would be conveyed by gravity into the VTUs for settling, filtration, and disinfection. In the case of CSO 001, discharge would flow by gravity through a VTU and would also receive treatment from a wetlands treatment system on the east side of Veterans Memorial Parkway in the Bee Slough area. The wetland treatment system would be approximately 49 MG and would extend from the East WWTP to the east side of Veterans Memorial Parkway. Effluent from the East WWTP would be pumped to the wetlands treatment system on the west side of the parkway, while the VTU effluent from CSO 001 would enter the wetland system on the east side of Veterans Memorial Parkway. In addition to the VTU, the treatment facility at CSO 002 would include a diversion structure that would enable DWF to be conveyed to the East WWTP and wet weather flow to the VTU. The CSO 002 outfall structure would be removed. Furthermore, this alternative would include removing the Bee Slough concrete channel in the wetland area, as well as installing drains in the downstream portions of Bee Slough capable of conveying flow to the East WWTP as treatment capacity becomes available. **Pumping** This alternative would include a 1-mgd pump station to pump East WWTP effluent to a wetlands treatment system. **Challenges** Performance data for VTUs appear to meet current regulations for primary treatment. However, VTU technology is relatively new, and the performance may not meet future effluent requirements that may feature more stringent limits. In addition, the wetland system would improve VTU effluent quality, but for this alternative, the wetland system would only provide treatment for discharges from CSO 001.

Table 5-5 Bee Slough Options (continued)

Option 15 (Satellite/HRT and Wetlands)	**Overview** Alternative 15 would include a combination of treatment technologies. It would include a VTU for treating CSOs 002 and 004 and wetland treatment for CSO 001. Flow from CSOs 002 and 004 would be conveyed to the VTU located at CSO 002. Flow from CSO 001 outfall would discharge into a wetland treatment system located on the east side of Veterans Memorial Parkway. **Storage** This alternative would not include separate storage facilities. **Treatment** CSOs 002 and 004 would receive treatment by means of a VTU. Liquid sodium hypochlorite and sodium bisulfate would be used for disinfection. CSO 001 would be treated by means of a wetland treatment system. The discharge from CSO 001 would flow by gravity into wetlands on the east side of Veterans Memorial Parkway in the Bee Slough area. Raw CSO discharge would receive screening and grit removal prior to flowing into the wetland. Wetland effluent would be disinfected with sodium hypochlorite. **Pumping** This alternative would operate by gravity. Therefore, no pumping was required. **Challenges** High flow rates from CSO 001 would result in very short detention times in the proposed wetland treatment system. This would ultimately result in effluent permit violations. For this reason, this alternative was not considered further.

Table 5-5 Bee Slough Options (continued)

Option 16 (Satellite/HRT and Wetlands)	**Overview** This alternative would include a combination of treatment and conveyance. It would include a VTU, two wetland treatment systems, and associated pumping facilities. The VTU would be located at CSO 002 and would treat discharges from CSOs 002 and 004. Discharges from CSO 001 would be conveyed by a buried sewer to pumping facilities adjacent to the East WWTP. From there, flow would be pumped to a wetland treatment system on the west side of Veterans Memorial Parkway. In the case of CSO 001, the buried sewer would lay below proposed wetlands. Flow in excess of the pump station capacity would overflow to a second wetland treatment system on the east side of Veterans Memorial Parkway. Surcharged flow would be screened prior to entering the surge area. A conceptual site layout is shown in Figure 5-15. **Storage** This alternative would not include separate storage facilities. **Treatment** All overflows from CSOs 002 and 004 would be conveyed by gravity into the VTU for settling, filtration, and disinfection. In addition to the VTU, the treatment facility at CSO 002 would also include a diversion structure that would enable DWF to be conveyed to the East WWTP, and wet weather flow to the VTU. The CSO 002 outfall structure would be removed. Furthermore, this alternative would include removing the Bee Slough concrete channel in the wetland area, as well as installing drains in the downstream portions of Bee Slough capable of conveying flow to the East WWTP as treatment capacity becomes available. Discharge from CSO 001 would be pumped to the wetland on the west side of Veterans Memorial Parkway, adjacent to the East WWTP. The wetland treatment system would be approximately 49 MG and would extend from the East WWTP to the east side of Veterans Memorial Parkway. Raw CSO discharge would receive screening and grit removal prior to being pumped to the wetland treatment system. Flow from CSO 001 in excess of the pump station capacity would be screened and allowed to overflow into the wetland on the east side of Veterans Memorial Parkway. All wetland effluent would be disinfected with sodium hypochlorite. **Pumping** This alternative would include a 120-mgd pump station to convey flow from CSO 001 to the wetland treatment system on the west side of Veterans Memorial Parkway. The pump station would not be capable of handling peak flows from CSO 001. Therefore, a second wetland treatment system is proposed on the east side of Veterans Memorial Parkway to treat excess flows. **Challenges** Analysis of this alternative showed that there is potential for flow surges in the east wetland treatment system to cause short circuiting of the entire treatment system, and could result in discharge of untreated flow. Further consideration regarding the design and operation of the wetland treatment system would be required.

Table 5-5 Bee Slough Options (continued)

Option 17 (Satellite/HRT and Wetlands)	**Overview** This alternative is a variation of Alternative 16; the only difference is how flows from CSO 001 would be conveyed to pumping facilities. Alternative 16 would pipe flow from CSO 001 to the pump station, while Alternative 17 would utilize the existing Bee Slough concrete channel to convey flow to the pump station. A cover would be placed on top of the channel and wetlands treatment system would be sit on top of the cover. This alternative would consist of a VTU, two wetland treatment systems, and associated pumping facilities. The VTU would be located at CSO 002 and would treat discharges from CSOs 002 and 004. Discharges from CSO 001 would be conveyed the Bee Slough channel to pumping facilities adjacent to the East WWTP. From there, flow would be pumped to a wetland treatment system on the west side of Veterans Memorial Parkway. In the case of CSO 001, the channel would be covered and would lie below proposed wetlands. Flow in excess of the pump station capacity would overflow to a second wetland treatment system on the east side of Veterans Memorial Parkway. Surcharged flow would be screened prior to entering the surge area. A conceptual site layout is shown in Figure 5-16. **Storage** This alternative would not include separate storage facilities **Treatment** All overflows from CSOs 002 and 004 would be conveyed by gravity into the VTU for settling, filtration, and disinfection. In addition to the VTU, the treatment facility at CSO 002 would also include a diversion structure that would enable DWF to be conveyed to the East WWTP, and wet weather flow to the VTU. The CSO 002 outfall structure would be removed. Furthermore, this alternative would include removing the Bee Slough concrete channel in the wetland area, as well as installing drains in the downstream portions of Bee Slough capable of conveying flow to the East WWTP as treatment capacity becomes available. Discharge from CSO 001 would be pumped to the wetland on the west side of Veterans Memorial Parkway, adjacent to the East WWTP. The wetland treatment system would be approximately 49 MG and would extend from the East WWTP to the east side of Veterans Memorial Parkway. Raw CSO discharge would receive screening and grit removal prior to being pumped to the wetland treatment system. Flow from CSO 001 in excess of the pump station capacity would be screened and allowed to overflow into the wetland on the east side of Veterans Memorial Parkway. All wetland effluent would be disinfected with sodium hypochlorite. **Pumping** This alternative would include a 120-mgd pump station to convey flow to the wetland treatment system. **Challenges** Analysis of this alternative showed that there is potential for flow surges in the east wetland treatment system to cause short circuiting of the entire treatment system, and could result in discharge of untreated flow. Further consideration regarding the design and operation of the wetland treatment system would be required. In addition, covering Bee Slough could present challenges. At its maximum width, the channel spans approximately 30 ft and the weight of a wetland treatment system on top of the cover would be considerable. Structural stability would need to be extensively assessed. Furthermore, solids could build up in corners and areas of low velocity in the covered portion of Bee Slough, and would therefore require regular cleaning. Lastly, a more detailed hydraulic analysis would need to be conducted to verify whether installing a wetland treatment system on top of the Bee Slough cover would adversely affect the diversion structure for CSO 001 and/or increase the risk of flooding in upstream areas.



Key Features:

- 10 DEEP VERTICAL STORAGE USED TO CAPUTRE ALL FLOW; FLOW PUMPED TO EAST WWTP AS CAPACITY BECOMES AVAILABLE. PUMPS SIZED FOR MAXIMUM 48 HOURS DETENTION TIME.
- ASSUMES EAST WWTP EXPANDED CAPACITY TO 60 MGD
- ALL FLOW TREATED AT EAST WWTP. NO SATELITE TREATMENT FACILITY.

Key Challenges:

- STORED FLOWS COULD BECOME SEPTIC IF WWTP CAPACITY IS NOT AVAILABLE WITHIN 48 HOUR TIME LIMIT.

North

FIGURE 5-4
Option 1
Long-Term Control Plan
May 31, 2013



Key Features:

- (2) 100 MGD ACTIFLO TYPE HRT UNITS
- TREATMENT UNITS INCLUDE SCREENING, CLARIFICATION AND UV DISINFECTION
- EXCESS FLOWS STORED IN ADJACENT EQUALIZATION STORAGE BASIN
- ALL SYSTEMS ARE GRAVITY OPERATED

Key Challenges:

- FOR A GRAVITY OPERATED SOLUTION TREATMENT UNITS WOULD BE INSTALLED AT LOW ELEVATIONS. FLOOD WATER MANAGEMENT MEASURES WOULD NEED TO BE INCLUDED WITH DESIGN.

North

FIGURE 5-5
Option 4
Long-Term Control Plan
May 31, 2013



Key Features:

- 200 MGD CHEMICALLY ENHANCED PRIMARY TREATMENT (CEPT) FACILITY
- TREATMENT FACILITY INCLUDES SCREENING, CHEMICAL DISENFECTION WITH CHEMICAL STORAGE AND FEED SYSTEM
- EXCESS FLOWS ARE PUMPED TO AN EARTHEN EQUALIZATION BASIN

Key Challenges:

- A LARGE FOOT PRINT FOR THE CEPT FACILITY WOULD BE REQUIRED
- COORDINATION WITH UASCE TO UTILIZE EXISTING LEVEE PUMP STATION PONDING AREA FOR AN EQ BASIN

North

FIGURE 5-6
Option 5
Long-Term Control Plan
May 31, 2013



Key Features:

- VERTICAL TREATMENT UNIT (VTU) INCLUDES CHEMICAL DISINFECTION WITH CHEMICAL STORAGE AND FEED SYSTEM
- NO ADDITIONAL STORAGE
- PUMPING INCLUDED TO DEWATER VTU AT THE END OF EACH EVENT

Key Challenges:

- VTU TECHNOLOGY IS RELATIVELY NEW AND IT IS UNKNOWN IF THE UNITS WILL BE ABLE TO MEET MORE STRINGENT FUTURE EFFLUENT REQUIREMENTS

North

FIGURE 5-7
Option 6
Long-Term Control Plan
May 31, 2013



Key Features:

- SINGLE VERTICAL TREATMENT UNIT (VTU) TO TREAT ALL FLOW
- VTU INCLUDES CHEMICAL DISINFECTION WITH CHEMICAL STORAGE AND FEED SYSTEM AND DEWATERING PUMPS
- NO ADDITIONAL STORAGE

Key Challenges:

- VTU TECHNOLOGY IS RELATIVELY NEW AND IT IS UNKNOWN IF THE UNITS WILL BE ABLE TO MEET MORE STRINGENT FUTURE EFFLUENT REQUIREMENTS
- CONSTRUCTION OF THE 108" CONVEYANCE LINE TO THE VTU WOULD BE DIFFICULT AND POTENTIALLY NOT FEASIBLE

North

FIGURE 5-8
Option 7
Long-Term Control Plan
May 31, 2013



Key Features:

- 49 MG CAPACITY WETLANDS
- SCREENING AND GRIT REMOVAL REQUIRED FOR WETLANDS INFLUENT FLOW
- 387 MGD PUMP STATION
- LIQUID CHLORINE DISINFECTION
- NO SEPARATE STORAGE REQUIRED

Key Challenges:

- COST TO PUMP PEAK FLOW IS EXTREMELY HIGH

North

FIGURE 5-9
Option 8
Long-Term Control Plan
May 31, 2013



Key Features:

- 49 MG CAPACITY WETLANDS
- SCREENING AND GRIT REMOVAL REQUIRED FOR WETLANDS INFLUENCT FLOW
- 200 MGD PUMP STATION
- LIQUID CHLORINE DISINFECTION
- TOTAL EQUALIZATION STORAGE VOLUME OF 9.1 MG

Key Challenges:

- EXISTING WEIR ELEVATIONS RESULT IN DEEP STORAGE BASINS
- USACE HAS CONERNS ABOUT EXCAVATING ADJACENT TO THE LEVEE

North

FIGURE 5-10
Option 9
Long-Term Control Plan
May 31, 2013



Key Features:

- 49 MG CAPACITY WETLANDS
- SCREENING AND GRIT REMOVAL REQUIRED FOR WETLANDS INFLUENCT FLOW
- 150 MGD PUMP STATION
- LIQUID CHLORINE DISINFECTION
- TOTAL EQUALIZATION STORAGE VOLUME OF 21.1 MG

Key Challenges:

- EXISTING WEIR ELEVATIONS RESULT IN DEEP STORAGE BASINS
- USACE HAS CONCERNS ABOUT EXCAVATING ADJACENT TO THE LEVEE

North

FIGURE 5-11

Option 10

Long-Term Control Plan

May 31, 2013



Key Features:

- 24 MGD STORAGE VERTICAL STORAGE BASIN FOR CSO 001
- 80 MGD INFLUENT PUMP STATION TO BioCEC
- TREATMENT FOR CSO 001 BY BioCEC
- TREATMENT FOR CSO 002 AND CSO 004 BY VTU

Key Challenges:

- BioCEC REQUIRES HIGHLY SKILLED OPERATION STAFF
- NO KNOWN BioCEC FACILITIES IN OPERATION WITH SIGNIFICANT OPERATING HISTORY
- TRANSFER OF ACTIVATED SLUDGE BETWEEN THE EXISTING WWTP AND BioCEC FACILITY MAY CAUSE PROCESS INSTABILITY AND WATER QUALITY VIOLATIONS
- MODIFICATION OF THE EAST WWTP SOLIDS HANDLING PROCESS DUE TO DEMOLITION OF THE SLUDGE STORAGE FACILITY

North

FIGURE 5-12
Option 12
Long-Term Control Plan
May 31, 2013



Key Features:

- VERTICAL TREATMENT UNIT (VTU) INCLUDES CHEMICAL DISINFECTION WITH CHEMICAL STORAGE AND FEED SYSTEM AND DEWATERING CHOPPER PUMPS
- NO ADDITIONAL STORAGE
- 14 MG POLISHING WETLANDS TO TREAT CSO 001 VTU DISCHARGE
- REMOVE EXISTING CSO 002 OUTFALL STRUCTURE
- NEW WET WEATHER DIVERSION STRUCTURE TO DIRECT DRY WEATHER FLOW TO THE EAST WWTP
- BEE SLOUGH DRAINS TO EAST WWTP AS CAPACITY BECOMES AVAILABLE

Key Challenges:

- VTU TECHNOLOGY IS RELATIVELY NEW AND IT IS UNKNOWN IF THE UNITS WILL BE ABLE TO MEET MORE STRINGENT FUTURE EFFLUENT REQUIREMENTS

North

FIGURE 5-13

Option 13

Long-Term Control Plan

May 31, 2013



Key Features:

- VERTICAL TREATMENT UNIT (VTU) INCLUDES CHEMICAL DISINFECTION WITH CHEMICAL STORAGE AND FEED SYSTEM AND DEWATERING PUMPS
- 14 MG POLISHING WETLANDS TO TREAT CSO 001 VTU DISCHARGE
- REMOVAL OF BEE SLOUGH CONCRETE CHANNEL
- 49 MG OF WETLANDS TREATMENT FOR WWTP EFFLUENT
- BEE SLOUGH DRAINS TO EAST WWTP AS CAPACITY BECOMES AVAILABLE

Key Challenges:

- VTU TECHNOLOGY IS RELATIVELY NEW AND IT IS UNKNOWN IF THE UNITS WILL BE ABLE TO MEET MORE STRINGENT FUTURE EFFLUENT REQUIREMENTS

North

FIGURE 5-14

Option 14

Long-Term Control Plan

May 31, 2013



Key Features:

- VERTICAL TREATMENT UNIT (VTU) INCLUDES CHEMICAL DISINFECTION WITH CHEMICAL STORAGE AND FEED SYSTEM AND DEWATERING CHOPPER PUMPS
- BEE SLOUGH DRAINS TO EAST WWTP AS CAPACITY BECOMES AVAILABLE
- CSO 001 FLOWS PUMPED TO WETLAND WOULD REQUIRE SCREENING AND GRIT REMOVAL
- EQUALIZATION WETLANDS WOULD BE USED FOR FLOW IN EXCESS OF THE PUMP STATION CAPACITY
- EXCESS FLOW WOULD BE SCREENED BEFORE ENTERING EQUALIZATION WETLANDS
- WETLANDS EFFLUENT DISINFECTED WITH LIQUID CHLORINE

Key Challenges:

- POTENTIAL FOR FLOW SURCHAGES RESULTING IN DISCHARGE OF UNTREATED FLOW

North

FIGURE 5-15
Option 16
Long-Term Control Plan
May 31, 2013



Key Features:

- VERTICAL TREATMENT UNIT (VTU) INCLUDES CHEMICAL DISINFECTION WITH CHEMICAL STORAGE AND FEED SYSTEM AND DEWATERING CHOPPER PUMPS
- BEE SLOUGH DRAINS TO EAST WWTP AS CAPACITY BECOMES AVAILABLE
- CSO 001 FLOWS PUMPED TO WETLAND WOULD REQUIRE SCREENING AND GRIT REMOVAL
- EQUALIZATION WETLANDS WOULD BE USED FOR FLOW IN EXCESS OF THE PUMP STATION CAPACITY
- EXCESS FLOW WOULD BE SCREENED BEFORE ENTERING EQUALIZATION WETLANDS
- WETLANDS EFFLUENT DISINFECTED WITH LIQUID CHLORINE

Key Challenges:

- POTENTIAL FOR FLOW SURCHARGES RESULTING IN DISCHARGE OF UNTREATED FLOW
- STRUCTURAL STABILITY OF BEE SLOUGH COVER
- POTENTIAL FOR SOLIDS BUILD UP IN CONCRETE CHANNEL

North

FIGURE 5-16
Option 17
Long-Term Control Plan
May 31, 2013

5.5.2 Estimated Bee Slough Control Measure Costs

Table 5-6 summarizes the total capital, annual O&M, and 40-year life cycle costs for each option considered. As shown, capital costs ranged from $60.2 to $426.2 million. Alternative 7 had the lowest cost on both a capital and life-cycle basis. Costs were not developed for Alternatives 2, 3, 11, and 15 for the following reasons:

1. Alternative 2 consisted of a 95-MG tunnel. This alternative was removed from further consideration due to anticipated alignment, dewatering, and geotechnical challenges. Constructing the tunnel would require a meandering route to stay along streets and within right-of-way boundaries. Dewatering 95 MG in 48 hours would be very difficult in this scenario, particularly with the WWTP capacity already maximized. Lastly, extensive coordination with USACE would be required to evaluate whether the tunnel would compromise the integrity of Evansville's earthen levee.
2. Alternative 3 consisted of several HRT units manufactured by Storm King. This alternative was removed from further consideration due to the number of units that would be required in order to treat the peak flow rate.
3. Alternative 11 consisted of open basin storage and wetland treatment. It was removed from further consideration due to the open basin storage and wetland mitigation requirements. Storage was proposed adjacent to residential developments with documented odor problems. Constructing open CSO storage closer to these residents would exacerbate the current odor issue. Furthermore, existing wetlands would have to be removed to accommodate the new open basin storage, which would require extensive and costly mitigation.
4. Alternative 15 consisted of a VTU for CSOs 002 and 004, as well as wetland treatment for CSO 001. This alternative was removed from further consideration due to the anticipated performance of the wetland treatment system. The area and volume available on the Bee Slough side is minimal with respect to peak flows that CSO 001 is capable of producing. The wetland volume and detention time would not be sufficient to allow full treatment and would not achieve permit requirements for several storms in the Typical Year.

Table 5-6 Summary of Total Capital, O&M, and Life Cycle Costs

Alternative	Treatment Technology	Capital Cost	Annual O&M Cost	NPV 40-Year Life Cycle Cost
1	None/storage	$367,777,000	$727,000	$471,374,000
2	None/storage	-	-	-
3	Storm King	-	-	-
4	Actiflo	$189,944,000	$1,316,000	$261,106,000
5	CEPT	$108,068,000	$940,000	$164,967,000
6	VTU	$71,959,000	$572,000	$85,074,000
7	VTU	$60,243,000	$575,000	$73,433,000
8	Wetlands	$147,445,000	$4,551,000	$285,793,000
9	Wetlands	$123,767,000	$285,000	$153,581,000
10	Wetlands	$145,304,000	$249,000	$177,293,000
11	Wetlands	-	-	-

Table 5-6 Summary of Total Capital, O&M, and Life Cycle Costs

Alternative	Treatment Technology	Capital Cost	Annual O&M Cost	NPV 40-Year Life Cycle Cost
12	VTU/BioCEC	$211,294,000	$572,000	$274,723,000
13	VTU/Wetlands	$80,823,000	$580,000	$94,134,000
14	VTU/Wetlands	$91,077,000	$612,000	$106,053,000
15	VTU/Wetlands	-	-	-
16	VTU/Wetlands	$105,710,000	$614,000	$129,407,000
17	VTU/Wetlands	$108,429,000	$611,000	$132,598,000

5.5.3 Bee Slough Screening CSO 001 Findings

Evaluation of the Bee Slough control measure options resulted in the following conclusions regarding CSO 001:

- CSO 001's diversion structure is located far from the WWTP and it is hydraulically bottlenecked at the diversion structure; therefore, weir modifications would be unlikely to produce much CSO reduction benefit. This results in the need for a storage tank near the diversion structure or a relief sewer to the WWTP.
- Constructing storage near the CSO 001 diversion structure would not be economically feasible because of the unavailability of land and would be undesirable due to the diversion structure's proximity to a school.
- Adequate land for storage exists within the City-owned K-4 ponding area. The ponding area has been delineated to accept and equalize flows from an area larger than the CSO 001 drainage area.
- Currently, WWFs are conveyed through an outfall into Bee Slough, which flows past the WWTP before discharging to the Ohio River. Constructing a relief sewer from the diversion structure to the WWTP would be redundant, because the conveyance infrastructure already exists. Capture of the CSO flow for treatment may be achieved by diverting flow from Bee Slough to the East WWTP.

5.5.4 Bee Slough Screening Storage and Treatment Findings

Assessment of the Bee Slough control measure options resulted in the following findings regarding storage and treatment:

- CSO 001 discharges have high peaks, large volumes, and long durations. Conventional treatment using activated sludge or similar biologically active treatment processes could prove operationally challenging or infeasible due to the large difference between peak CSO flow rates and average daily dry-weather WWTP flow.
- The differences between the average dry-weather and peak WWF rates indicate that storage may be needed in order to economically treat CSO 001 flows without over-sizing the WWTP.
- Flows from CSO 001 would need to be pumped into treatment or storage due to differences in elevation between Bee Slough and the large ponding area located adjacent to the East WWTP, south of Veterans Memorial Parkway.

- Gravity in/pump out storage could be constructed in the area surrounding the Bee Slough concrete channel on the north side of Veterans Memorial Parkway; however, locating storage in that area would be undesirable due to the proximity of homes to this location.

5.6 Selected Bee Slough Control Measure for the Recommended Plan

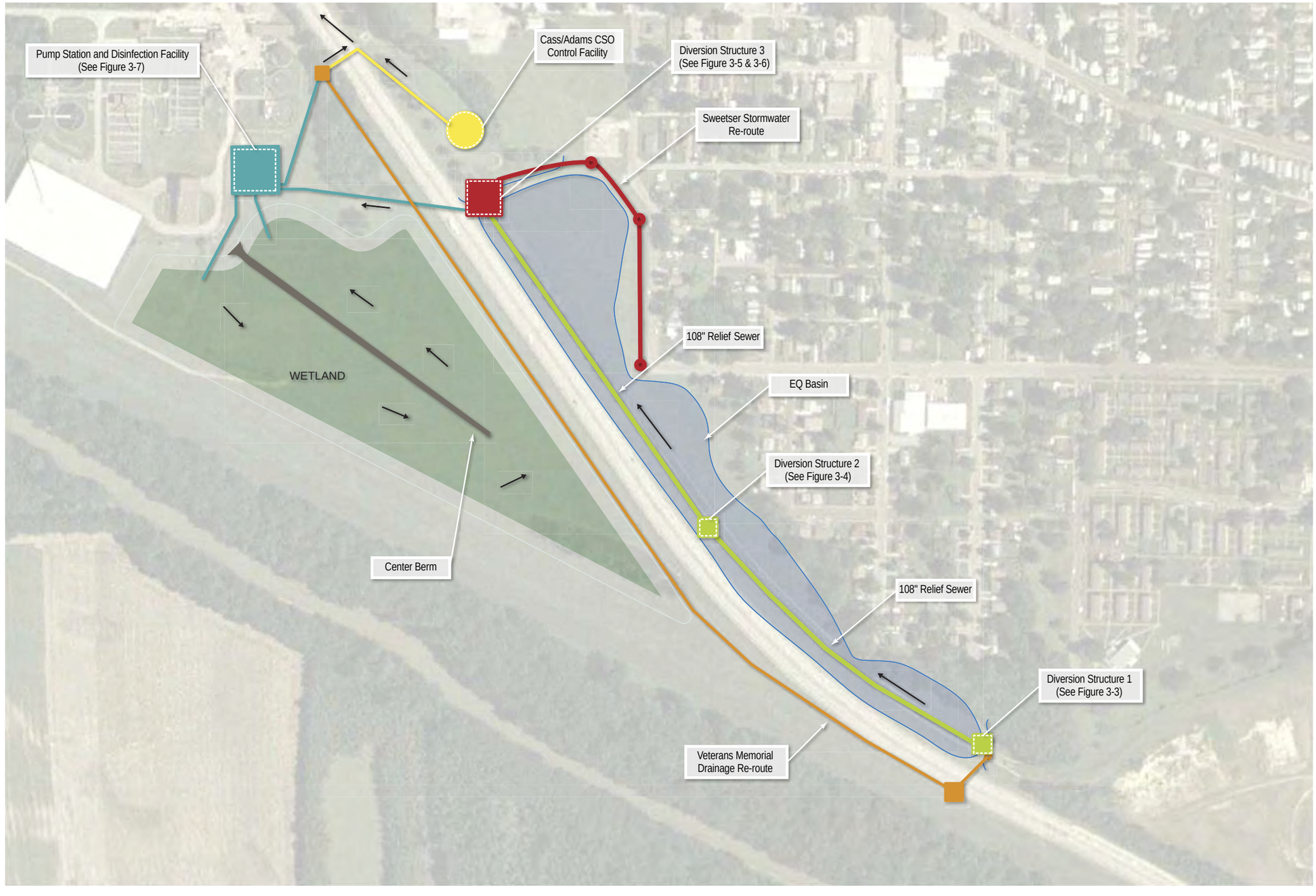
Based on the findings of the Bee Slough control measure screening analysis described in Section 5.5, Evansville selected one project option for inclusion in the basin- and system-wide alternatives evaluation. The selected option includes the Cass Avenue Treatment Facility and the Kentucky Avenue CSO Treatment Wetland. Figure 5-17 and Figure 5-18 show the site layout and process flow diagram of the proposed facilities, respectively. Key physical and operational aspects of each facility are summarized in the sections below. The selected Bee Slough control measure includes a wetland treatment system for treatment of CSO 001 discharges for the following reasons:

- A large volume storage basin would be needed to equalize WWFs for treatment, regardless of the choice of wet-weather treatment technology.
- Pumping of CSO flows into storage and/or treatment would be required for all control measure alternatives.
- A 2006 evaluation of a storage basin north of the WWTP concluded that constructing a concrete-lined basin was uneconomical in that location due to poor soils and high groundwater.
- A large tract of City-owned land is available adjacent to the WWTP.
- Any storage basin located within the K-4 ponding area would be subject to flooding for up to the 100-year, 24-hour rain event.
- Natural treatment systems provide treatment through storage and are capable of performing as well as or better than conventional treatment systems, and the treatment process can be more cost-effective than conventional treatment.
- Natural treatment systems can withstand flooding.
- Natural treatment systems can provide additional benefits beyond treating wastewater; for example, they can be a community amenity, can provide bird habitat, and are more aesthetically pleasing than conventional treatment systems.
- In this specific case, a natural treatment system can provide treatment for most, if not all, Typical Year discharges from CSO 001.

5.6.1 Cass/Adams CSO Treatment Facility

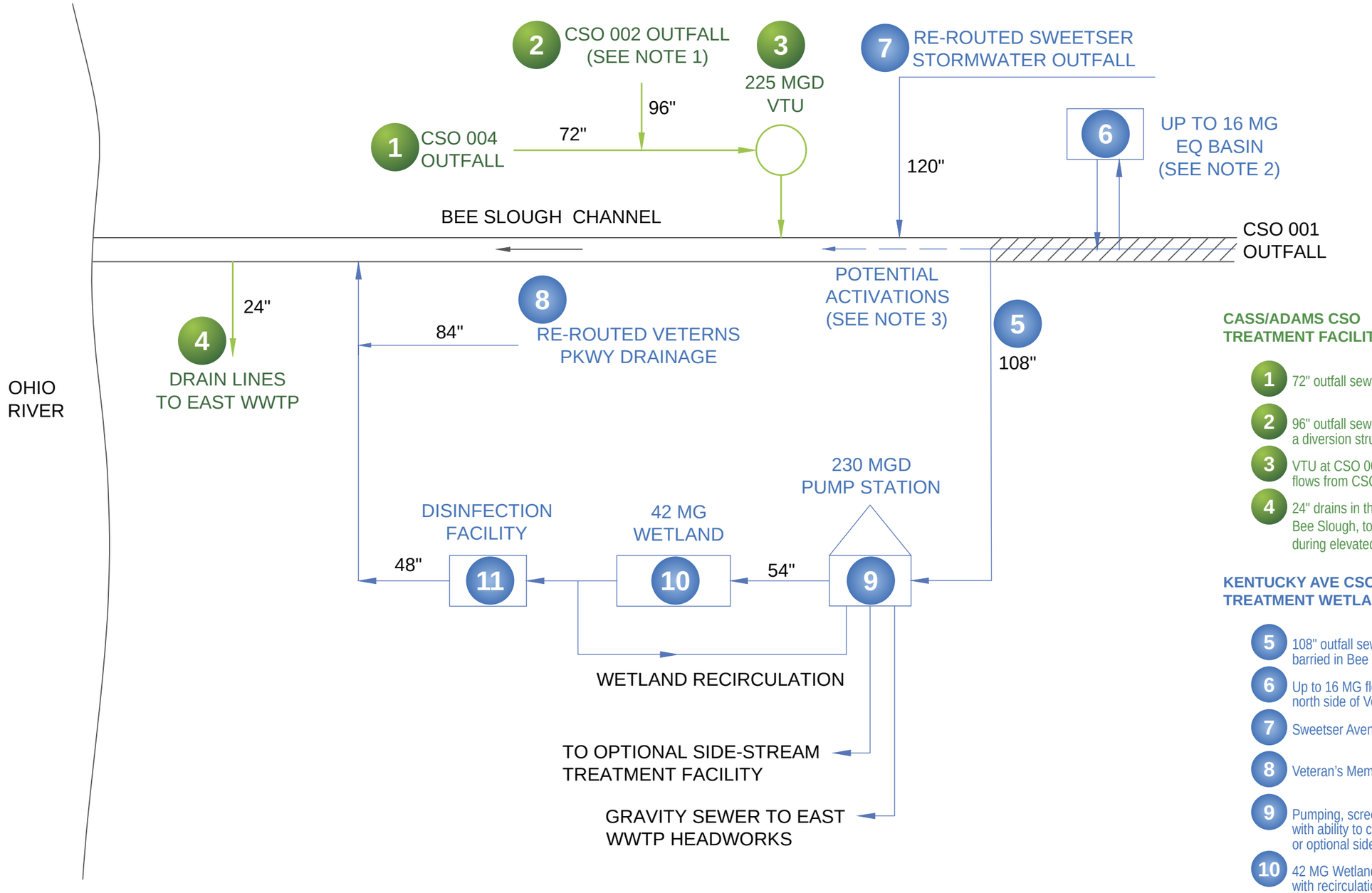
The Cass Avenue CSO Treatment Facility is intended to capture and treat 100 percent of the Typical Year overflow volumes from CSO 002 and 004. It would include conveyance, pretreatment, settling, filtration, and disinfection. All treatment processes would be provided by a single VTU. Key physical components of this facility include:

- Installing a 72-inch outfall sewer from the CSO 004 to the VTU
- Installing a 96-inch outfall sewer from- and constructing a diversion structure at CSO 002
- Constructing a VTU at CSO 002 capable of treating peak flows from CSOs 002 and 004
- Demolishing the CSO 002 outfall structure
- Installing drains in the downstream portions of Bee Slough



North

FIGURE 5-17
Bell Slough Control Measure Overview
Long-Term Control Plan
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CASS/ADAMS CSO TREATMENT FACILITY

1. 72" outfall sewer from CSO 004 to VTU
2. 96" outfall sewer from, and constructing a diversion structure, at CSO 002
3. VTU at CSO 002 capable of treating peak flows from CSOs 002 and 004
4. 24" drains in the downstream portions of Bee Slough, to convey flow to the East WWTP during elevated Ohio River levels

KENTUCKY AVE CSO TREATMENT WETLAND

5. 108" outfall sewer from CSO 001; barried in Bee Slough
6. Up to 16 MG flow EQ basin on north side of Veteran's Parkway
7. Sweetser Avenue stormwater outfall re-route
8. Veteran's Memorial Parkway drainage re-route
9. Pumping, screening, and grit removal facilities, with ability to convey flow to wetlands, East WWTP, or optional side-stream treatment facilities
10. 42 MG Wetland treatment system, with recirculation system
11. Liquid chlorine disinfection facilities

NOTES:

1. CSO 002 DIVERSION STRUCTURE NOT SHOWN; DRY WEATHER TO BE CONVEYED TO EAST WWTP
2. FLOW TO EQ BASIN IS DIVERTED BY THREE DIVERSION STRUCTURES NOT SHOWN
3. NUMBER OF ACTIVIATIONS IN TYPICAL YEAR WILL BE DETERMINED BY PUMP STATION AND EQ BASIN CAPACITY

FIGURE 5-18
Bell Slough Control Measure Process Flow Diagram
Long-Term Control Plan
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The VTU would be constructed near CSO 002 to which overflow volumes from CSOs 002 and 004 would be conveyed by gravity. All flow to the VTU would receive screening, settling, and filtration in a common facility. Disinfection would be provided by means of liquid sodium hypochlorite and sodium bisulfate. VTU effluent would be discharged in the downstream segment of Bee Sough.

The wet weather diversion structure would be constructed to enable DWF to be conveyed to the East WWTP, and wet weather flow to the VTU. Lastly, drains would be installed in the downstream portions of Bee Slough to convey flow to the East WWTP as treatment capacity becomes available.

5.6.1.1 VTU Treatment Process

The VTU process incorporates a vertical storage tank that can be constructed in a variety of ways, depending on local ground conditions. It is equipped with mechanical and process components that provide complete treatment (skimming, settling, screening, and disinfection) for all CSO and SSO discharge events. The shaft includes a vertical baffle wall at the mid-section, extending from the roof to an elevation above the base of the shaft. This layout streamlines a U-shaped flow from the influent sewers through the shaft, thus avoiding short-circuiting of flow, and ensuring sufficient disinfection contact time. The very low flow velocities would reduce head loss and promote the settling of solids at the bottom of the shaft.

During most storm events, the shaft would capture the entire overflow volume and would not require discharge to the river. During very large and less frequent storms, the shaft capacity would be exceeded and treated overflow would discharge to the receiving waters after passing through horizontal raked bar screens installed in the effluent portion of the shaft. These screens are compact, are easy to maintain, and do not require a screenings building. Screenings are cleaned using hydraulic combs with vegetable oil or hydraulic fluid. A recess in the floor of the channel captures large solids for future removal. Wastewater remaining in the shaft after storm events would be dewatered to the sanitary interceptor or to the East WWTP using submersible chopper pumps and a force main. All retained floatables and screenings would descend following the receding water to the frustum-shaped bottom of the shaft. When the water level in the shaft reaches a prescribed level above the bottom, the flushing system would be automatically activated. High-pressure nozzles would re-suspend accumulated solids and transport the floatables and screenings into the chopper dewatering pumps located at the bottom of the shaft. An optional rinsing cycle may be introduced using non-potable water. Shaft operation sequence is fully automated and can be monitored or controlled onsite or remotely.

5.6.2 Kentucky Avenue CSO Treatment Wetland

The Kentucky Avenue CSO Treatment Wetland is intended to capture and treat 100 percent of the Typical Year overflow volumes from CSO 001. It would include conveyance, pretreatment, pumping, wetlands treatment, and disinfection facilities. Key physical components include:

- Extending and burying the 108” outfall sewer from the CSO 001 outfall and eliminating the upstream portion of the concrete channel
- Constructing three junction structures along the proposed 108-inch outfall extension
- Re-routing Veteran’s Memorial Parkway drainage

- Pumping, screening, and grit removal facilities near the East WWTP, with the ability to convey effluent to the treatment wetland, the East WWTP, or optional side-stream treatment facilities
- Wetland treatment system on west side of Veteran's Memorial Parkway; and
- Disinfection facilities near the East WWTP

In general, an upstream portion of Bee Slough would be replaced with a buried 108-inch relief sewer extending from CSO 001 to pumping and preliminary treatment facilities near the East WWTP. Influent flows to the pump station would be screened and de-gritted prior to being discharged into an adjacent wetland treatment system. The wetland would provide treatment by means of physical and biological processes. Wetland effluent would then be conveyed to disinfection facilities prior to final discharge in the unmodified, downstream segment of Bee Slough. Pumping facilities would also have the ability to convey flow to the East WWTP headworks as well as directly to the East WWTP activated sludge system. The sections below provide more detail on key components and operations.

Table 5-7 Preliminary Summary of Control Facility Unit Processes and Design Capacities

Unit Process	Type	Quantity	Size	Total Design Capacity
Preliminary Treatment[a]				
Influent Screening	Mechanical	4	¼" openings	198 mgd
Influent Pumping	Motor Driven	7	Approx. 400 hp	198 mgd
Grit Removal	Pista Vortex Grit Unit	5	Approx. 40 mgd	198 mgd
Wetland Treatment System				
Wetland Design	Free water surface, fill and drain	1	20 acres x 8 ft max depth; approx 42 MG	See Note c
Disinfection[b]				
Chlorination	Multi-pass serpentine contact tank	1	0.21 – 0.63 MG	20 - 60 mgd
	Liquid sodium hypochlorite pumps		See Note c	See Note c
Dechlorination	Sodium bisulfate pumps		See Note c	See Note c

[a] Preliminary treatment facilities were initially sized to accommodate peak flows from CSO 001. Value engineering of recommended plan should include optimization of preliminary treatment capacity.

[b] Disinfection facilities were sized for a wetland release rate of 20 to 60 mgd. Value engineering of recommended plan should include optimization of disinfection capacity.

[c] Unit process quantity, size, and design capacity details to be determined during detailed design

5.6.2.1 Conveyance

All discharges from CSO 001 will be conveyed to pumping and pretreatment facilities by means of the extended 108-inch relief sewer. The relief sewer would be installed inside the existing Bee Slough channel, and this portion of Bee Slough would be eliminated. For general maintenance, the relief sewer would include three structures along the proposed alignment.

Structure 2 would also serve as a diversion structure for the K-4 pump station. It would allow the Levee Authority to continue to use both sides of Veteran's Parkway for ponding.

5.6.2.2 Preliminary Treatment and Pumping

Preliminary treatment, pumping, and disinfection facilities would all share a common structure. Flow from CSO 001 would be screened, pumped and then de-gritted prior to being conveyed to the wetland treatment system. Mechanical screens would provide firm screening capacity. Pump and screen sizes would be selected to accommodate the significant range of flows discharged from CSO 001 in the typical year. This facility would also include piping to enable the Utility to convey raw influent to the East WWTP by means of a gravity sewer. Furthermore, additional piping would allow screened and de-gritted flow to be pumped to the wetland treatment system and the East WWTP activated sludge system, which could serve as a side-stream treatment process. Refer to the Facility Plan for more information on the proposed facilities at the East WWTP.

Lastly, this pumping facility would also include infrastructure to allow wetland flow recirculation, i.e., when wetland volume is available, the pump station would pump wetland effluent back to the head of the wetland system for continued treatment.

5.6.2.3 Wetlands Treatment

The wetland treatment system proposed is of the free water surface, fill and drain type, with a total surface acreage of approximately 20. Due to USACE restrictions, the wetland would require a 10 foot high earthen berm to avoid ponding wetland volumes against any part of the existing levee. The wetland would also feature a center berm constructed with earthen footer and an alternative upper material such as fiberglass or concrete. In general, the flow would be routed in a serpentine manner. Flow would enter in the northwest corner and would travel southeast, around the center berm and back toward the northwest and to disinfection facilities. Preliminary design criteria are summarized in Table 5-8 below.

Table 5-8 Preliminary Wetland Design Criteria

Parameter	Value	Note
Type of Wetland Design:	Free Water Surface	
If Surface Wetland Design:	Fill and Drain	
Surface Acreage of Wetland (acres)	20	
Total Volume of Wetland (ft^3):	5,614,223	42 MG
Average Design Flow Rate (mgd)	Varies	AADF = total annual flow/365
Peak Design Flow Rate (mgd)	Varies	
Loading Rate (cubic meters per day)	Varies	Flow divided by total system area (33 acres)
Proposed Grit Removal	Vortex grit removal	
Proposed Floatable Removal	Mechanical screens	
Proposed Disinfection	Sodium hypochlorite	
Proposed Disinfection Rate:	20-30 mgd	

Table 5-8 Preliminary Wetland Design Criteria

Parameter	Value	Note
Type of water to be treated:	CSO and stormwater	
Influent Characteristics:		
BOD_5 (mg/L)	75	Source: Limno Tech. CSO 002 sampled 11/2010 and 6/2011
TSS (mg/L)	116	
Fecal Coliform (CFU/100 mL)	1,252,500	
E.Coli (CFU/100 mL)	1,156,922	
NH_3/NH_4 as Nitrogen (mg/L)	7.9	
Total Nitrogen (mg/L)	NA	
Total Phosphorus (mg/L)	NA	
Any Influent Sampling data available:	Yes	Source: Limno Tech. CSO 002 sampled 11/2010 and 6/2011
Proposed Effluent Characteristics:		
BOD_5 (mg/L)	Varies; Refer to section 3.3.3.2	
TSS (mg/L)	Varies; Refer to section 3.3.3.2	
Fecal Coliform (CFU/100 mL)	Refer to section 3.3.4	
E.Coli (CFU/100 mL)	Refer to section 3.3.4	
NH_3/NH_4 as Nitrogen (mg/L)	Varies; Refer to section 3.3.3.2	
Total Nitrogen (mg/L)	NA	
Total Phosphorus (mg/L)	NA	
Hydraulic Residence Time (HR):	Varies; target is 48 hrs	
Influent velocity into to wetland (FPS):	0.1 to 0.26; based on 100 mgd influent rate	Influent side of W splitter berm
Material used in Treatment Zone:	Plants, local clean fill	
Depth of media in Treatment Zone (ft):	1 ft typical; 8 ft flooding event	
Type of Membrane liner:	45 mil HDPE, minimum	
Depth of water in wetland during Peak Flow Condition (ft):	8	
Depth of Treatment Zone (ft):	Typically ~ 1 ft	
Material of Treatment Zone:	Plants, local clean fill	
Height of wetland berm (ft):	10	
Type of Membrane liner:	45 mil HDPE, minimum	
Description of Wetland Vegetation:		

Table 5-8 Preliminary Wetland Design Criteria

Parameter	Value	Note
Coverage:	~80%	
Density:	~10-50 stems/m^2	
Types of Plantings:	Bulrush	
First Flush Considerations:	Screen and grit removal	
Type of Pumps to be used:	Submersible	
Average groundwater depth in wetland footprint:	Below wetland grade	
Other Inlet/Outlet Considerations:	Common headworks/disinfection facility provides ability to recirculate wetland flows. Additional pipelines and drains would be provided to allow wetland to be drained to East WWTP for treatment; wetland could serve as a large storage basin for the East WWTP.	
General Description of Flow Path through wetland:	Serpentine flow around center berm; equalization and pretreatment in Bee Slough Wetland	
Floodplain, wetland, Waters of U.S. impacts or considerations:	Minimal impact anticipated related to final system sizing based upon preliminary analysis; wetland will be constructed on the land side of the levee	
Decrease in CSO Activations at CSO Outfall 001 (Kentucky Avenue):	All CSO discharges from CSO 001 will be routed through and treated by the proposed wetland	
Annual wastewater to be treated by wetland in typical year in hydraulic model:	Up to 872 MG	
Long-term maintenance considerations of wetland soils:	Typically none	

Notes:

AADF = average annual daily flow
CFU/mL = colony-forming unit per milliliter
mg/L = milligrams per liter
mL = millilliter

5.6.2.4 Anticipated Effluent Quality

A preliminary assessment of the anticipated effluent water quality from the wetland treatment system was conducted. The assessment utilized storm water volume data modeled as part of the standard Typical Year, in combination with available storm event water quality data. Specifically, the spreadsheet-based model was used to estimate improvement in biochemical oxygen demand (BOD), total suspended solids (TSS) and ammonia-nitrogen (NH4N). Wetland

performance was estimated by applying the first-order, area-based P-k-C* treatment wetland model (Kadlec and Wallace 2009), which predicts treatment wetland performance as a function of wetland area, inflow rate and parameter concentration, and ambient temperature for selected parameters. Storm events from the typical year were characterized into four inundation wetland depth categories: <1 ft, 1 to 3 ft, 3 to 6 ft and 6 to 8 ft, and flow rates from the minimum and maximum storm events in each category (by volume) were used as inputs.

Table 5-9 summarizes preliminary effluent concentrations and mass loads by wetland depth category. In summary, the proposed 20-acre Wetland is anticipated to provide a range of improvements to CSO flows, with average concentration reductions ranging from 27 to 40 percent BOD, 51 to 59 percent TSS and 13 to 27 percent NH4N, depending upon storm volume. These reductions are well within the range of reductions anticipated for wetland systems, and are consistent with expectations of loading and inflow concentration criteria established by treatment wetland literature. These range of reductions are consistent with the expected range of removals associated with primary wastewater treatment of $\leq$45 percent, $\leq$65 percent and $\leq$20 percent (Kadlec and Knight, 1996; Table 18-2). Predicted concentrations of BOD_5, TSS, and NH4N were 8 to 67 mg/L, 31 to 78 mg/L and 0.3 to 7.6 mg/L, respectively, which were well below values typically associated with wastewater receiving primary treatment and overlapping in range with values associated with secondary treatment (e.g., 10 to 45 mg/L BOD_5, 35 to 75 mg/L TSS and <1 to 20 mg/L NH4N; see Table 18-2 in Kadlec and Knight, 1996).

Based upon these analyses, and associated assumptions, the wetland will achieve, at a minimum, a quality equivalent to or better than primary treated effluent. Consistent effort by the Utility to target secondary treatment will allow the wetland system to discharge the highest effluent quality.

Table 5-9 Anticipated Effluent Water Quality from Preliminary Modeling, by Wetland Depth

Storm Volume (MG)	Wetland Depth (feet)	Number of Storms (Typical Year)	Parameter	Outflow (mg/L)		Mass Load (kg/ha*d)	
				Low	High	Min	Max
0 – 2	<1	6	BOD	8.2	25.2	4	34
			TSS	31	31	6.3	53
			NH4N	0.3	4.3	0.43	3.6
2-10	1-3	14	BOD	40	62	84	365
			TSS	35	63	131	564
			NH4N	6.1	7.4	8.9	38
10-23	3-6	7	BOD	60	67	308	635
			TSS	59	78	477	981
			NH4N	7.3	7.6	32	67
23-42	6-8	11	BOD	62	54	387	193
			TSS	65	48	598	298
			NH4N	7.4	7	41	20

5.6.2.5 Disinfection

Preliminary treatment, pumping, and disinfection facilities would all share a common structure. Wetland effluent would be conveyed to the disinfection side of the common facility. Liquid sodium hypochlorite would be utilized for disinfection. The contact tank would be sized for 15 minutes of detention time at the peak wetland effluent flow rate. All tankage and associated equipment would be appropriately sized to meet permitted bacteria standards. For operational flexibility, chlorinated effluent could be discharged from the contact tank to the Ohio River the following two ways:

1. The existing East WWTP effluent sewer. The proposed plan includes piping to the effluent end of Diversion Structure 103, which the East WWTP currently uses to discharge final effluent. This would likely be the Utility's preferred option, as this line would convey flow to the new East WWTP Effluent Pump Station to pump flow over the levee during high river stages. Utilizing this sewer and pump station would reduce the amount of water that would otherwise be trapped in Bee Slough until the river returns to lower stages.
2. At the unmodified portion of Bee Slough, just east of the East WWTP. Chlorinated effluent would discharge into Bee Slough and be conveyed to the Ohio River by gravity. This alternative discharge route would be effective during low river stages, and would likely only be utilized by the Utility during those times. Discharging into Bee Slough during high river stages would result in wetland effluent being ponded in the slough until river stages fall and slough could drain by gravity.

It is recommended that these options be further assessed in Advanced Facility Planning (AFP).

To avoid entrainment of plant stems and aquatic wildlife common to wetlands, flow would receive a course screening prior to entering the facility. The influent channel of the contact tank would include a sluice gate to divert flow back to the pump station wet well, which would enable recirculation of wetland flow if desired. In addition, the contact tank would also include a junction box capable of routing an additional flow stream from the East WWTP to the contact tank.

5.6.2.6 Other Aspects

In addition to the components mentioned above, the Kentucky Avenue CSO Wetland would include:

- Constructing drains between the headworks/disinfection structure and the East WWTP will allow Evansville to drain the wetland or CSO 001 discharges to the East WWTP for conventional treatment.
- Rerouting of storm water inflows around Bee Slough. The Veteran's Memorial Parkway storm drain (which currently connects to the CSO 001 outfall) would be re-routed to the west side of the road an toward a junction structure located near the East WWTP.

5.6.3 Conceptual Operating Procedures

The Bee Slough control measure is intended to capture, treat, and disinfect up to and including the largest storm in the Typical Year. The Utility's overarching goal for this system is to maximize the use of the East WWTP to treat wet-weather flows and to achieve—to the extent practical—secondary treatment. Therefore, the Utility's intent will be to utilize the wetland

pumping and treatment system for storms that exceed the East WWTP's primary and secondary treatment capacities.

5.6.3.1 Flow Regimes

As operational flexibility is crucial in achieving the Utility's goal for this system, all new infrastructure proposed will be connected with the existing East WWTP headworks and treatment process. This results in numerous potential operating scenarios, the analysis and optimization of which should be conducted in AFP and or preliminary design. However, as part of the IOCP, general operational scenarios were developed for a series of six flow regimes. In this analysis, "total flow" was defined as the combined flow from CSO 001 and the East WWTP influent sewer. The breakdown of flow regimes is as follows:

- Wet-Weather Flow Regime 1 (WW-1) includes all scenarios where total flow is less than 28 mgd. In this case, all flow is routed through WWTP headworks. The WWTP primary and secondary processes are operated in series, with all flows receiving secondary treatment up to 28 mgd. All flow is disinfected prior to final discharge.

- Wet-Weather Flow Regime 2 (WW-2) includes all scenarios where total flow is between 28 and 40 mgd. In this case, the WWTP operates very similarly to WW-1. All flow is routed through WWTP headworks. The WWTP primary and secondary processes are operated in series, with flows up to 28 mgd receiving secondary treatment, and flows between 28 and 40 mgd receiving primary treatment only. In this scenario, the Primary Effluent (PE) Bypass is utilized for the flow treated by the primary process, and all flow is disinfected prior to final discharge.

- Wet-Weather Flow Regime 3 (WW-3) includes all scenarios where total flow is between 40 and 68 mgd. In this case, flow is pumped to the WWTP via the WWTP headworks and the new wetland pump station. WWTP primary and secondary processes are operated in parallel in this regime. All flow from the WWTP headworks is sent through the primary treatment process, and flow from the wetland pump station is sent through the secondary treatment process. All flow is disinfected prior to final discharge.

- Wet-Weather Flow Regime (WW-4) includes all scenarios where total flow is greater than 68 mgd. In this case, all WWTP processes are at capacity, and are operating as described in WW-3. Flow in excess of 68 mgd is routed to the wetland until the wetland is full. The volume in the wetland is routed to the WWTP as primary and secondary capacity becomes available, or sent to the wetland disinfection process if effluent water quality targets have been achieved by the wetland treatment process. All flow is disinfected prior to final discharge. The Utility's preference will be to discharge disinfected wetland effluent through the WWTP effluent sewer (which will be pumped during high river stages) if the effluent sewer and pump station have capacity available to convey the flow. Alternatively, effluent could be discharged into Bee Slough if necessary.

- Wet-Weather Flow Regime (WW-5) includes all scenarios where total flow is greater than flows experienced the Typical Year. In this case, all WWTP processes are at capacity, and are operating as described in WW-4. When the wetland reaches maximum capacity, flow control will shut influent gates at the wetland pump station, and excess flow will be discharged into Bee Slough via a new CSO 001 outfall/diversion structure.

- The Dry-Weather Flow Regime includes all dry-weather scenarios. In this case, all flow is routed to the WWTP headworks through the existing influent sewer, and the primary and secondary processes are operated in series. During extended periods of dry weather, a portion of treated effluent is routed to wetland to sustain plant life. There is no discharge from wetland in this scenario, because the wetland will be filled only to the extent necessary to maintain plant viability, and the gates that control wetland discharge will remain closed. If the wetland is brought online under any of the wet-weather operating scenarios, any water in the wetland will either be routed back through the East WWTP or sent through the wetland disinfection process and disinfected prior to discharge.

Table 5-10 summarizes the critical aspects of each scenario, and Figure 5-19 through Figure 5-24 illustrate the respective flow paths through the East WWTP and wetland facilities. Under all scenarios, the Utility anticipates and will design the system to capture and treat the first flush. Furthermore, all flow in all scenarios will meet primary treatment equivalency or better and will be disinfected.

5.6.3.2 Dry-weather Operation

The wetland treatment system has been planned for wet-weather treatment only. Consequently, the Utility does not intend on utilizing the wetland for treatment during dry weather and flow will not be discharged from it on dry days. Treated East WWTP effluent may be utilized to water the plants in the wetland to maintain viability during periods of extended dry weather, but only the amount of water needed to water the plants will be used, and the water will be held in the wetland and not discharged under this scenario.

5.6.3.3 Flow Control

Successful operation of the proposed system hinges on adequate flow control, the analysis and optimization of which will be conducted in AFP. At this time, flow control options have not been assessed beyond a basic planning level. However, it is anticipated that, due to the complex nature of the system, flow control will be automated to the extent possible. Specific areas where automatic control would likely bring significant value include the following:

1. Raw influent gate(s) located in the wetland pump station to protect the structure from flooding
2. Gate(s) in the wetland pump station to divert CSO 001 flow to the WWTP headworks facility
3. Gate(s) to control wetland effluent entering to the chlorine contact tank and or control to wetland water surface elevation
4. Gate(s) that divert wetland effluent back to the wetland pump station for recirculation
5. Valves in the wetland pump station force main to appropriately route flow from the wetland pump station to the wetland and or secondary treatment facilities at the East WWTP; and
6. Gate(s) to enable accurate control of PE Bypass scenarios at the East WWTP

Table 5-10 Summary of Wetland/WWTP Operations, by Flow Regime

			Facility Breakdown[a]						Other Operating Features		
Flow Regime	**Figure No.**	**Total Fow of CSO 001 and WWTP Influent Sewer**	**WWTP Headworks**	**WWTP Primary**	**WWTP Secondary**	**WWTP PE Bypass**	**Wetland Headworks**	**Wetland**	**Primary / Secondary Operation Mode**	**Final effluent discharge point**	**CSO 001 Activation**
-	-	(mgd)	(mgd)	(mgd)	(mgd)	(mgd)	(mgd)	(MG)	-	-	-
WW-1	1	<28	28	28	***28***[b]	0	0	0	series	WWTP Effluent Sewer	no
WW-2	2	28-40	**40**	**40**	***28***	12	0	0	series	WWTP Effluent Sewer	no
WW-3	3	40-68	**40**	**40**	***28***	**40**	28	0	parallel	WWTP Effluent Sewer	no
WW-4	4	>68	**40**	**40**	***28***	**40**	198	42	parallel	WWTP Effluent Sewer or Bee Slough[C]	no
WW-5	5	>Typical Year	**40**	**40**	***28***	**40**	**198**	**42**	parallel	WWTP Effluent Sewer or Bee Slough[C]	yes
Dry Weather	6	Dry Weather	28	28	28	0	0	0	series	WWTP Effluent Sewer	no

Notes:

[a]. Disinfection facilities are not shown. All flow is disinfected via liquid chlorine prior to final discharge.

[b]. Bold and underlined denotes maximum process capacity is reached.

[c]. Discharge point is dependent on river stage. During high river stages, if effluent sewer and pump station capacity is available, the wetland will discharge to the effluent sewer and be pumped to the Ohio River.

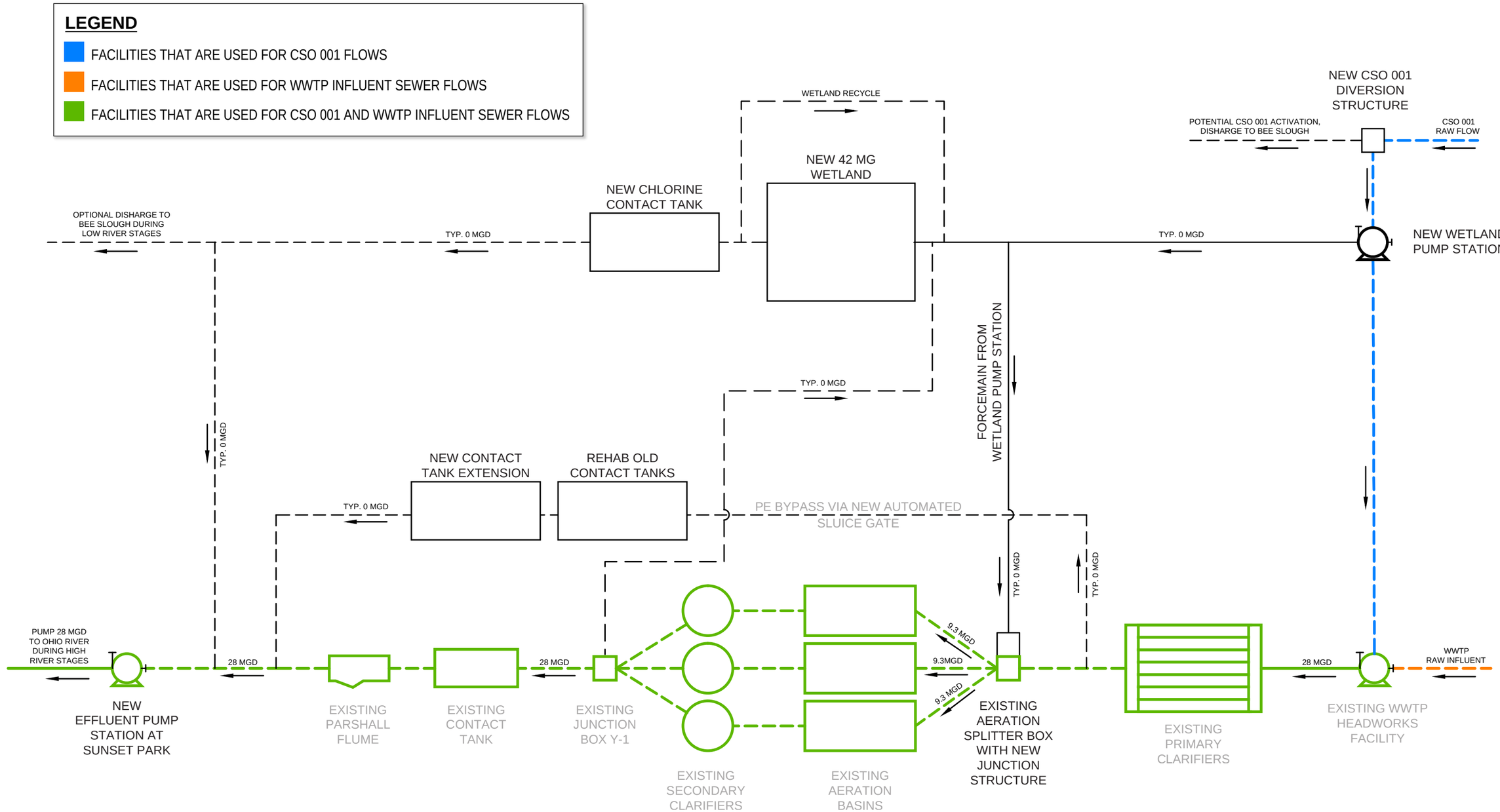


FIGURE 5-19
East WWTP and Wetland Process Flow Diagram
Flow Scenario WW-1
Total Flow Less Than 28 MGD
July 31, 2015

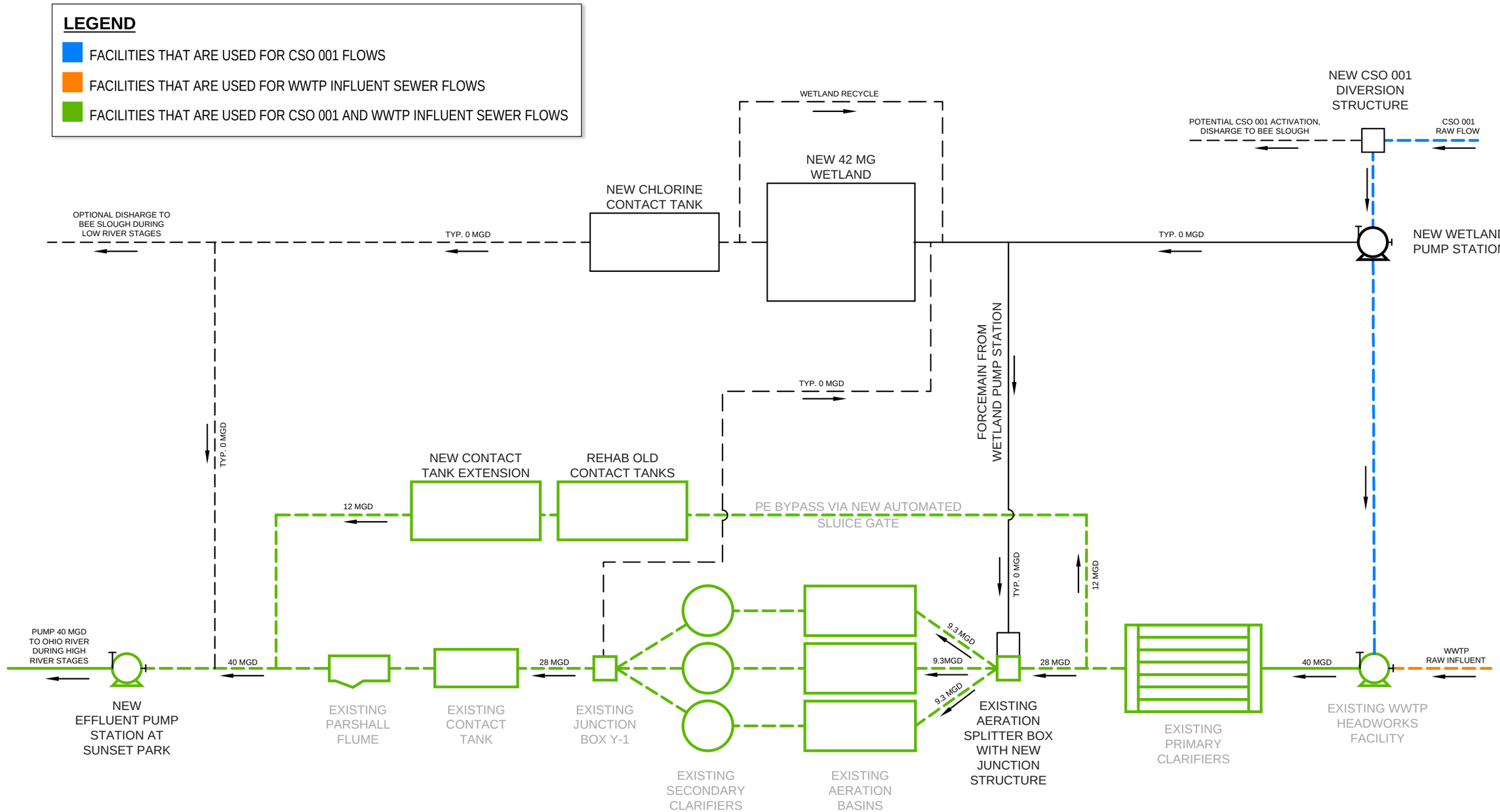


FIGURE 5-20
East WWTP and Wetland Process Flow Diagram
Flow Scenario WW-2
Total Flow Between 28 and 40 MGD
July 31, 2015

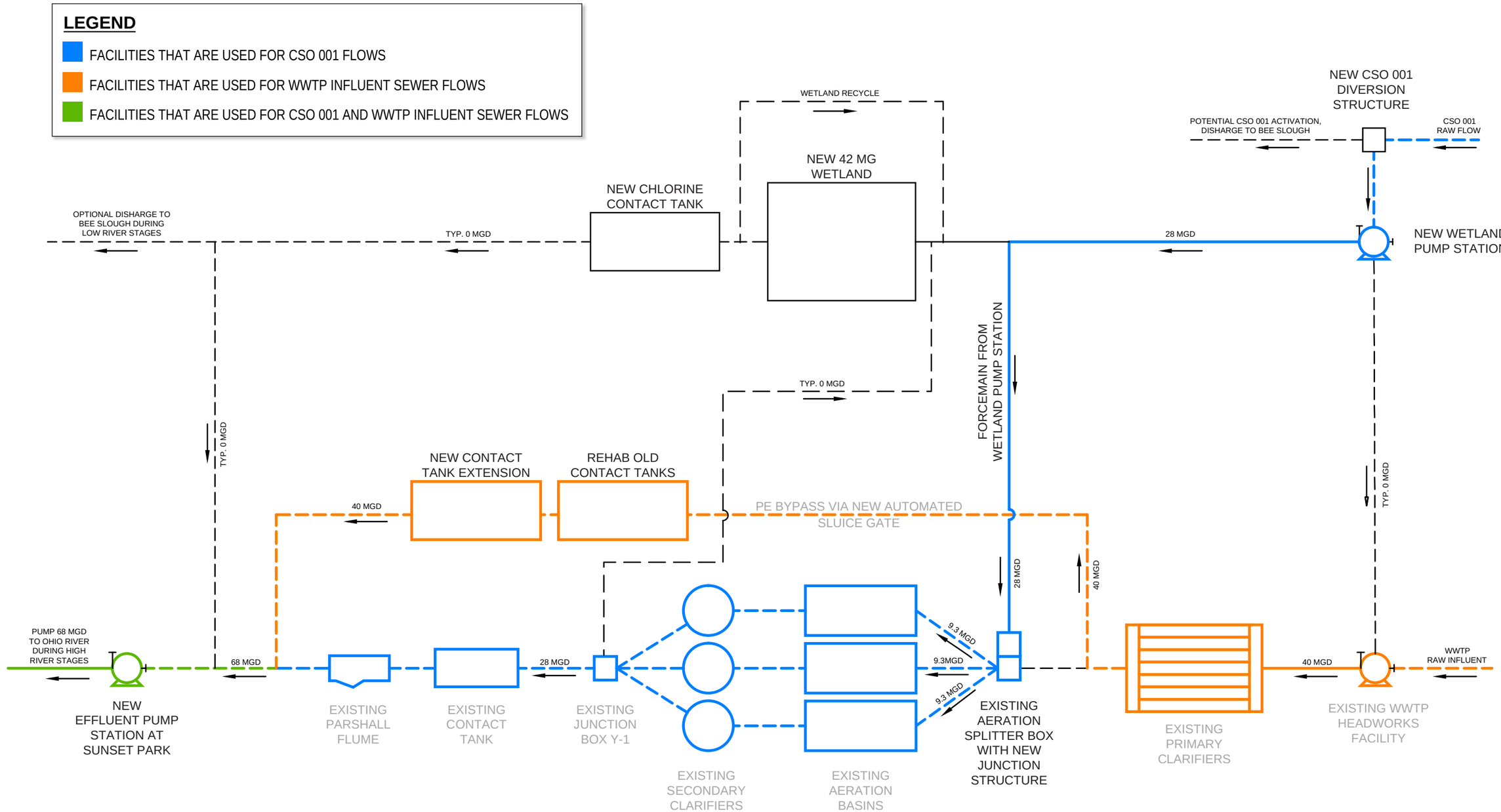


FIGURE 5-21
East WWTP and Wetland Process Flow Diagram
Flow Scenario WW-3
Total Flow Between 40 and 68 MGD
July 31, 2015

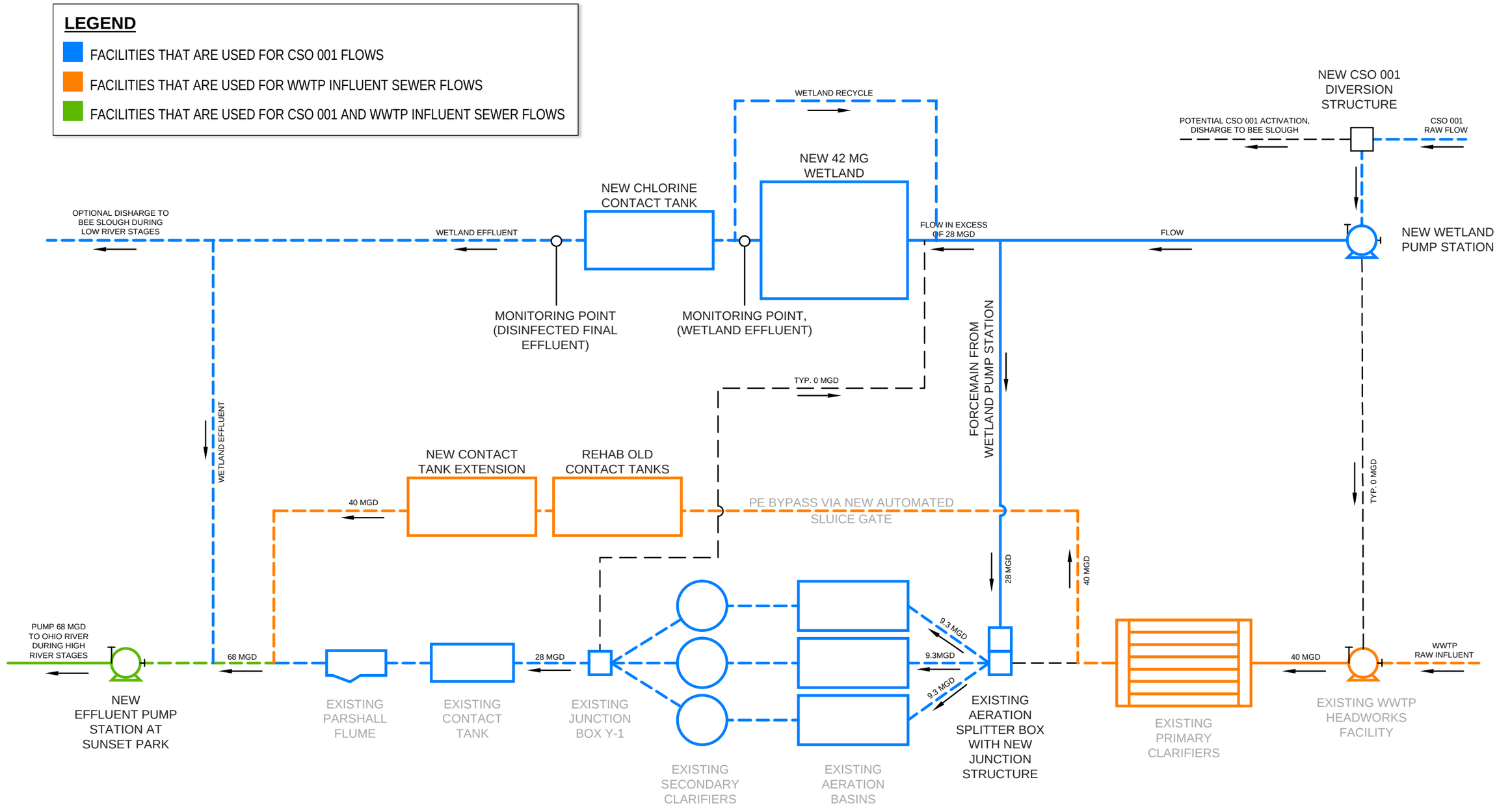


FIGURE 5-22

East WWTP and Wetland Process Flow Diagram

Flow Scenario WW-4

Total Flow Greater Than 68 MGD

July 31, 2015

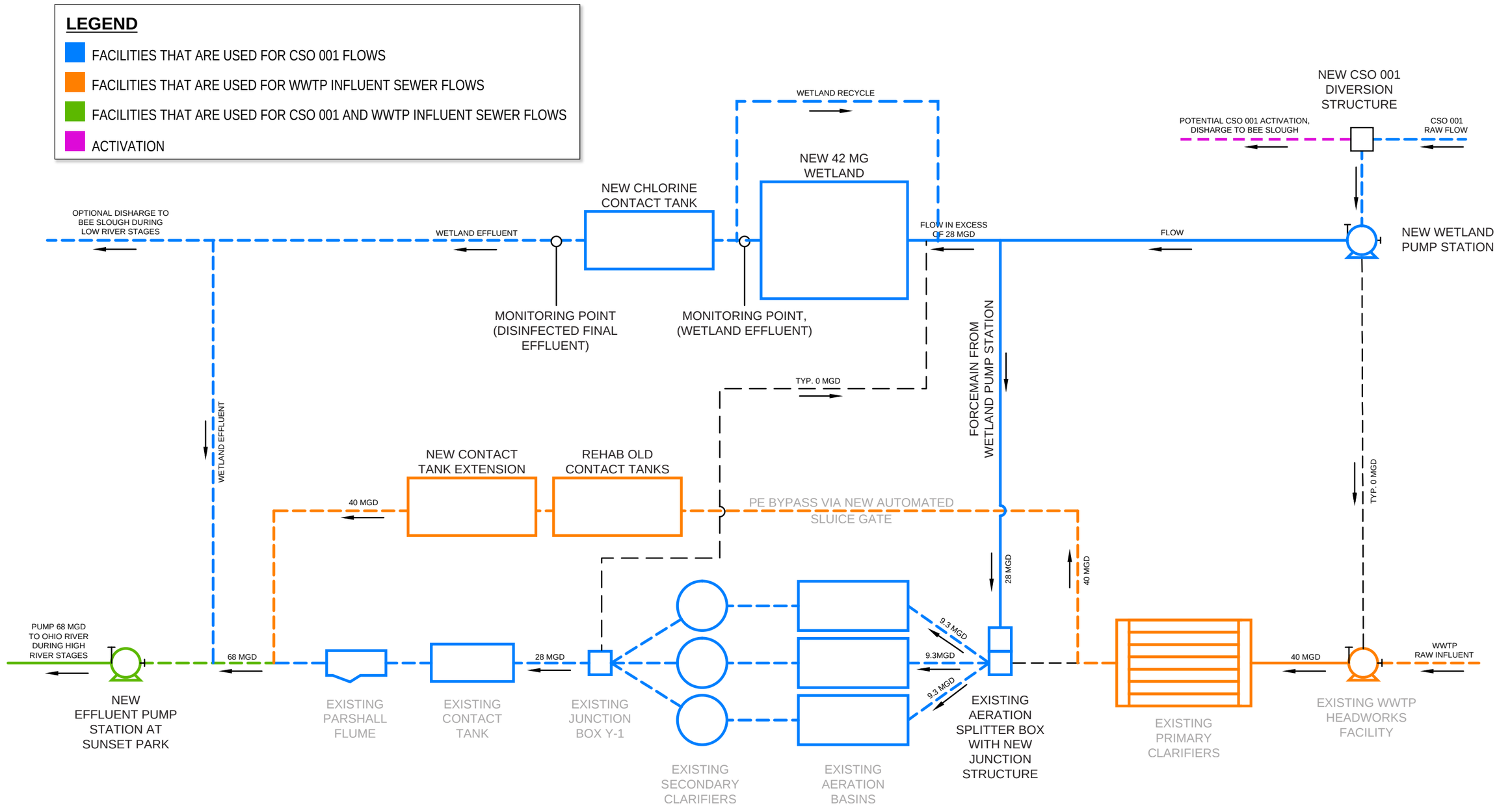


FIGURE 5-23
East WWTP and Wetland Process Flow Diagram
Flow Scenario WW-5
Total Flow Greater Than Typical Year
July 31, 2015

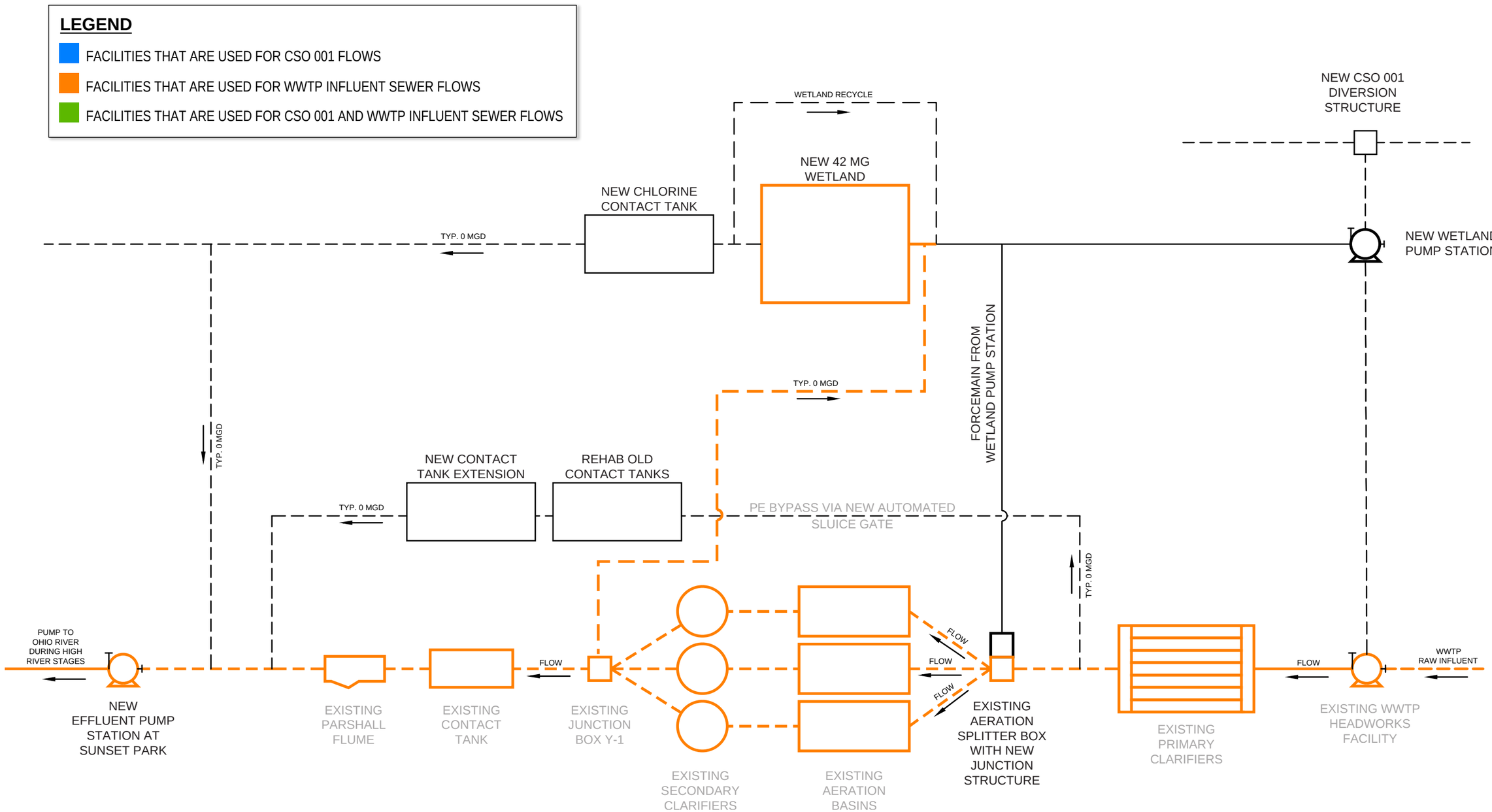


FIGURE 5-24
East WWTP and Wetland Process Flow Diagram
Flow Scenario Dry Weather
July 31, 2015

5.6.3.4 Monitoring Plan

Hydraulic monitoring and water quality sampling will be conducted at multiple locations within the wetland treatment system to track wetland performance and health and to establish a basis for operational adjustment, as needed. Inflow and outflow discharge rates will be measured and logged at short-time (e.g., 5 to 15 minutes) intervals to determine rates of filling and emptying the system during and after events. Wetland water levels will be logged using an ultrasonic transducer or similar method to track the depth and duration of storm events before, during, and after storm events.

Water quality will be sampled using a discrete-interval, flow-actuated continuous sampler at wetland inflow and outflow locations. Samples will be analyzed for TSS, $CBOD_5$, ammonia-nitrogen, and *E. Coli*. Based upon water level and flow data, samples will be withdrawn for analysis from times during the event corresponding to rising, plateau, and falling limbs of the wetland water level hydrograph. Inter-event samples will be collected as appropriate to characterize wetland baseline quality.

Wetland vegetation assessments will be performed quarterly during the first 2 years to confirm patterns of plant species establishment, and then annually in subsequent years. For each monitoring effort, vegetative cover will be measured using a cover class system on a gridded overlay of the wetland planting plan. Cover will be estimated by grid based on visual observations made from the wetland berm. Available imagery from construction documents, construction progress overflights, and from readily available commercial sources (e.g., Google Earth) will be used to complement the vegetation mapping. Replacement planting, if needed, will be based upon coverage trends within the wetland noted during monitoring assessments. Field assessments will include observations of wildlife use, aesthetics, presence of "free-from" parameters (e.g., floatable material, sheens, odors, etc.), evidence of erosion, and other typical incidental observations, if detected.

The final details of a hydraulic monitoring and water quality sampling protocol for the wetland treatment system will be developed following final design and before the wetland is put into service. The protocal will be consistent with Appendix H of the Decree, and will be submitted for approval to EPA and IDEM.

5.6.3.5 Anticipated Performance for Storms in the Typical Year

To facilitate a better understanding of the Bee Slough Control Measure's dynamic nature and overall performance, the entire control measure was modeled using the EPA SWMM 5.0.022. The following key components were incorporated from the East CSS XP SWMM model:

1. CSO 103 outfall components and controls
2. CSO 004 outfall and K4 PS components and controls
3. Bee Slough channel
4. The East WWTP Influent PS; and
5. Interconnecting piping near the East WWTP and Bee Slough

The simulated Typical Year flow time series from the East CSS model served as the flow inputs. In addition to existing facilities, the model also included components and controls representing the proposed systems and operating strategies (as presented above) for the East WWTP, wetland, VTU, WWTP Effluent PS and connecting piping. The specific objective of this modeling effort was to estimate volume and frequency of PE bypass events at the East WWTP, the

performance of the wetland, and the performance of the VTU, all in the Typical Year. For further detail about the modeling approach and set-up, refer to the Hydraulic and Operations Analysis of the Bee Slough Control Measure TM in Appendix E. This TM also compares the performance of an alternative operating scheme. The results of the modeling, with respect to the operating scheme (flow regimes) presented above are summarized as follows:

1. Operating the WWTP/Wetland system as previously defined would result in approximately 38 PE bypass occurrences in the Typical Year. Table 5-11 displays a breakdown of PE bypass occurrences by flow regime.
2. The wetland was utilized 30 times and treated approximately 450 MG in the Typical Year. The average maximum depth was approximately 2 ft. The wetland volume was exceeded once (Event 1), by approximately 20 MG. In addition, there were four instances where the wetland did not completely drain prior to the start of the next storm event. However, this did not negatively impact wetland performance (i.e., the wetland volume was not exceeded). Table 5-12 displays a breakdown of wetland performance by storm event.
3. Table 5-13 displays a breakdown of wetland operating levels in the Typical Year. Approximately 20 events (67 percent) fill the wetland to a depth of 4 ft or less. The wetland capacity is maximized one time in the Typical Year, which is the same event mentioned in Item 2 above.
4. Table 5-14 displays a summary of VTU performance during the Typical Year. The VTU captures approximately 229 MG of overflow. Analysis shows that that the majority of storm events result in small influent volumes to the VTU that do not exceed the VTU capacity. In these instances, captured volume is stored and drained to the WWTP headworks. While few storms result in treated discharge from the VTU, the associated volumes are relatively large; approximately 182 MG of treated effluent is discharged into Bee Slough.
5. Operating schemes different than the one presented above could result in lower PE bypass occurrences at the East WWTP. For example, analysis showed that 10 PE bypasses in the Typical Year could be achieved without negatively impacting wetland or VTU operations. Refer to Appendix E for more details. Further analysis of the operating schemes, including associated capital and O&M costs, and operational impacts, should be conducted in AFP to determine which scheme is most beneficial to the Utility.

Table 5-11 Breakdown of PE Bypass Occurrences

Flow Regime (mgd)[a]	Number of PE Bypass Events
1 (Q<28)	0
2 (28<Q<40)	3
3 (40<Q<68)	5
4 (Q>68)	30
Total	**38**

[a] Q is the total system flow

Table 5-12 Breakdown of Wetland Operating Level

Max Depth (ft)	Frequency
<1	4
1-2	6
2-4	10
4-6	8
6-8	2
>8[a]	1

[a] Depth greater than 8 feet indicates wetland capacity is exceeded. "Exceeded" means that a portion the volume of influent would receive less than 48 hours detention time in the wetland.

Table 5-13 VTU Performance, by Scenario

	Volume (MG)	Percent of Total Volume	Number of Occurrences
Drain to WWTP[a]	47.2	21%	32
Overflow/Effluent to Bee Slough Channel[b]	181.7	79%	14
Total Volume	**228.6**		

[a] When the captured volume does not exceed the VTU volume, the VTU unit acts as a storage tank. Flow is not discharged to Bee Slough. Rather, it is drained to the WWTP headworks.

[b] When the captured volume exceeds the VTU volume, treated flow is discharged from the VTU into Bee Slough

Table 5-14 Scenario 1 Wetland Performance, by Storm Event [a,b]

Event	Date	Duration (HR)	Max Depth (ft)	Max Inflow (mgd)	Avg Flow (mgd)	Treated Volume (MG)	Wetland Operated?	Completely Drained?	Volume Exceeded (MG)
1	1/3/2000 0:00	128	11.9	158.8	13.5	71.8	Yes	Yes	20.3
2	1/17/2000 19:00	637	0.1	0.0	0.0	0.0	No	Yes	0
3	2/13/2000 10:00	108	4.4	136.5	4.8	21.5	Yes	Yes	0
4	2/24/2000 0:00	66	2.1	52.1	2.0	5.5	Yes	Yes	0
5	2/26/2000 18:00	56	2.2	67.3	4.0	9.3	Yes	Yes	0
6	3/3/2000 13:00	188	0.1	0.0	0.0	0.0	No	Yes	0
7	3/11/2000 12:00	19	0.9	18.1	1.8	1.4	Yes	Yes	0
8	3/16/2000 5:00	86	3.3	87.3	3.9	14.0	Yes	Yes	0
9	3/19/2000 19:00	57	1.8	79.3	3.4	8.1	Yes	Yes	0
10	3/27/2000 0:00	150	0.1	0.0	0.0	0.0	No	Yes	0
11	4/2/2000 6:00	133	0.1	0.0	0.0	0.0	No	Yes	0
12	4/7/2000 20:00	94	2.7	52.4	2.4	9.5	Yes	Yes	0
13	4/24/2000 7:00	222	0.1	0.0	0.0	0.0	No	Yes	0
14	5/3/2000 13:00	151	0.1	0.0	0.0	0.0	No	Yes	0
15	5/9/2000 20:00	80	0.1	0.0	0.0	0.0	No	Yes	0
16	5/13/2000 4:05	138	0.1	0.0	0.0	0.0	No	Yes	0
17	5/18/2000 23:00	86	1.7	36.2	1.1	3.8	Yes	Yes	0
18	5/23/2000 0:00	84	0.1	0.0	0.0	0.0	No	Yes	0
19	5/26/2000 11:50	462	0.1	0.0	0.0	0.0	No	Yes	0
20	6/14/2000 20:00	50	1.5	35.4	1.4	2.9	Yes	NO	0
21	6/16/2000 22:00	94	6.9	168.5	12.7	49.6	Yes	Yes	0
22	6/21/2000 3:00	85	1.6	59.6	1.1	4.0	Yes	Yes	0
23	6/24/2000 16:00	38	0.1	0.0	0.0	0.0	No	Yes	0
24	6/26/2000 8:00	127	5.2	108.6	4.9	26.1	Yes	Yes	0
25	7/5/2000 6:00	72	0.9	23.0	0.5	1.6	Yes	Yes	0

Table 5-14 Scenario 1 Wetland Performance, by Storm Event [a,b]

Event	Date	Duration (HR)	Max Depth (ft)	Max Inflow (mgd)	Avg Flow (mgd)	Treated Volume (MG)	Wetland Operated?	Completely Drained?	Volume Exceeded (MG)
26	7/19/2000 1:00	97	3.5	137.4	3.4	13.9	Yes	Yes	0
27	7/29/2000 10:05	129	0.1	0.0	0.0	0.0	No	Yes	0
28	8/3/2000 22:00	20	0.8	21.6	1.6	1.3	Yes	Yes	0
29	8/5/2000 15:05	42	0.3	0.0	0.0	0.0	No	Yes	0
30	8/7/2000 9:00	257	0.3	4.9	0.0	0.2	No	Yes	0
31	8/18/2000 4:00	87	2.1	42.0	1.4	5.2	Yes	Yes	0
32	8/23/2000 11:00	87	4.7	127.2	6.5	23.5	Yes	Yes	0
33	8/27/2000 2:00	77	5.5	142.3	10.6	34.0	Yes	Yes	0
34	9/9/2000 14:00	62	1.2	50.0	1.2	3.2	Yes	NO	0
35	9/12/2000 4:00	75	5.7	146.2	8.9	27.8	Yes	Yes	0
36	9/20/2000 19:00	76	1.5	58.7	1.2	3.7	Yes	Yes	0
37	9/25/2000 7:00	67	5.7	167.0	10.7	29.9	Yes	Yes	0
38	10/5/2000 21:15	184	0.1	0.0	0.0	0.0	No	Yes	0
39	10/13/2000 17:00	101	4.6	82.7	5.2	21.9	Yes	Yes	0
40	10/17/2000 3:05	485	0.1	1.9	0.0	0.2	No	Yes	0
41	11/6/2000 10:00	60	0.9	15.1	0.6	1.5	Yes	NO	0
42	11/8/2000 22:00	93	3.9	118.0	4.3	16.7	Yes	Yes	0
43	11/13/2000 5:00	282	0.1	0.0	0.0	0.0	No	Yes	0
44	11/25/2000 0:00	87	2.0	73.8	1.6	5.7	Yes	Yes	0
45	12/11/2000 9:00	57	4.2	122.2	6.7	15.9	Yes	NO	0
46	12/13/2000 18:00	50	2.7	20.6	2.9	6.0	Yes	Yes	0
47	12/16/2000 3:00	93	2.9	75.6	2.6	9.9	Yes	Yes	0

[a] Highlighting denotes that the wetland capacity was exceeded. "Exceeded" means that a portion of the influent would simply receive less than 48 hours detention time in the wetland. All wetland effluent receives disinfection.

[b] Red font and underlining denotes that the wetland was unable to completely drain prior to the start of the next event.

5.6.4 Summary of Bee Slough Control Measure Costs for the Recommended Plan

The level of detail considered for development of the Bee Slough Control Measure presented above is beyond the capabilities of the PACC tool as used for development of the seventeen alternatives presented in Section 2. Therefore, a "bottom-up" pricing approach was utilized to estimate contractor costs for crew sizes, associated labor, equipment, materials, rates of construction, and overhead and profit. The Facility Planning Cost Estimating Guidelines in the Facility Plan, Volume 4 of the IOCP, were utilized. Table 5-15 summarizes the capital costs for the Bee Slough Control Measure.

Table 5-15 Summary of Capital Costs for Recommended Plan

Facility Component	Capital Cost (Million $)
Cass/Adams CSO Treatment Facility	
225 mgd VTU Facility[a]	47.02
Kentucky Avenue CSO Treatment Wetland	
198 mgd Pump Station[b]	59.23
42 MG Wetland System	7.47
20 - 60 mgd Disinfection[c]	5.31- 9.93
Junction Structures	1.23
Miscellaneous Piping[d]	17.91
Total[e]	$ 138.17

[a] VTU facility cost includes conveyance, treatment, and disinfection.

[b] Pump station was sized to handle peak flows from CSO 001 and 100% capture.

[c] Disinfection facilities were sized for a wetland release rate of 20-60 mgd.

[d] Miscellaneous piping includes relief sewer extension, and Veteran's Memorial Parkway drainage re-route.

[e] Total cost assumes 20 mgd disinfection facilities for Kentucky Avenue CSO Treatment Facility.

5.6.5 Opportunities for Value Engineering

Value engineering should be performed during advanced facility planning and or preliminary design. Development of this plan identified the following value engineering opportunities:

- Pump station capacity for Kentucky Avenue Treatment Wetland; optimize based on permitted overflows or percent capture in the typical year
- Disinfection capacity for Kentucky Avenue Treatment Wetland; optimize based on modeled wetland operation/discharge rate in the typical year
- Geotechnical conditions; new and or additional data regarding the existing subsurface conditions could greatly impact costs. For example, if subsurface conditions allow for excavation, it may be possible to convey flow to wetland treatment systems by gravity and eliminate extensive pumping requirements.
- Re-routing and sizing of Veteran's Memorial Parkway drainage; optimize conveyance capacity based on contributing area and modeled flows

- Interaction with East WWTP; optimize Kentucky Avenue Facility process capacities and configurations based on East WWTP wet-weather operations. Refer to Chapter 5 of the *Facility Plan For the West and East WWTPs* (CH2M HILL, 2013)

5.7 Other East Control Measures Alternatives Evaluation

Following the evaluation of East WWTP expansion, Riverside Interceptor, and Bee Slough control measure options, several other basin-wide alternatives building upon the baseline model were screened for the East CSS.

The specific East alternatives screened included the following options:

5.7.1 Alternative 1

- Close CSO 103 and upsize the treatment plant to 40 mgd

5.7.2 Alternative 2

- Alternative 1 project components
- Sewer separation projects identified in the Storm Water Master Plan - Akin Park, State Hospital, Boeke Road Outfall, Weinbach, and Keck. (Tributary to CSO 001, CSO 002, CSO 011)

5.7.3 Alternative 3

- Alternative 2 project components
- Selected Bee Slough control measure to achieve 100 percent capture of CSO 001, CSO 002, and CSO 004

5.7.4 Alternative 3A

- Alternative 3 project components
- 2-MG storage tank at CSO 011

5.7.5 Alternative 4

- Alternative 3 project components
- Recalibrate CSS model, verify existing sizes, and determine necessary system improvements
- Implement maximum GI
- Increase Riverside Drive Interceptor capacity:
  - Upsize 703 LF of 1-ft-diameter pipe to 2-ft-diameter pipe between Court St and Sycamore St (average depth 19.99 ft)
  - Upsize 754 LF of 1.75-ft-diameter pipe to 2.5-ft-diameter pipe between Sycamore St and Locust St (average depth 24.18 ft)
  - Upsize 670 LF of 2.25-ft-diameter pipe to 2.5-ft-diameter pipe between Locust St and Chestnut St (average depth 26.17 ft)
  - Upsize 347 LF of 2.25-ft-diameter pipe to 3.5-ft-diameter pipe between Chestnut St and Cherry St (average depth 32.95 ft)

  - Upsize 368 LF of 3-ft-diameter pipe to 3.5-ft-diameter pipe between Cherry St and Oak St (average depth 34.95 ft)
  - Upsize 53 LF of 0.833-ft-diameter pipe to 2-ft-diameter pipe between Adams/Sunset regulator and interceptor (average depth 15.80 ft)
- Storage to control downtown CSOs:
  - 12-MG storage tank at CSO 011 to achieve 100 percent capture

5.7.6 Alternative 4A

- Alternative 4 project components, with the exception of a 2-MG storage tank (rather than 12 MG) at CSO 011
- Weir modifications
  - Raise weir at CSO 008 by 1.82 ft
  - Raise weir 010B at CSO 010 by 0.86 ft

5.7.7 Alternative 7A

- Alternative 3 project components
- Storage to control downtown CSOs
  - 3.55-MG storage tank to capture CSO 008 at Chestnut St and SE 2nd St, including pump to dewater the tank in 48 hours, and conveyance to the tank (1,200 LF of 5-ft-diameter pipe)
  - 2.19-MG storage tank to capture CSO 010 at Bicentennial Park (City-owned), including pump to dewater the tank in 48 hours, and conveyance to the tank (900 LF of 4.5-ft-diameter pipe)
  - 2.87-MG storage tank to capture CSO 011 in open space near CSO, including pump to dewater the tank in 48 hours, and conveyance to the tank (200 LF of 5-ft-diameter pipe)
  - 0.29-MG storage tank to capture CSO 038 at SE 3rd St and Oak St, including pump to dewater the tank in 48 hours, and conveyance to the tank (1,500 LF of 2.75-ft-diameter pipe)

5.7.8 Alternative 7B

- Alternative 3 project components
- Storage to control downtown CSOs
  - 5.40-MG storage tank to capture CSO 008 at Chestnut St and SE 2nd St, including pump to dewater the tank in 48 hours, and conveyance to the tank (1,200 LF of 5-ft-diameter pipe)
  - 6.51-MG storage tank to capture CSO 010 at Bicentennial Park (City-owned), including pump to dewater the tank in 48 hours, and conveyance to the tank (900 LF of 4.5-ft-diameter pipe)
  - 2.87-MG storage tank to capture CSO 011 in open space near CSO, including pump to dewater the tank in 48 hours, and conveyance to the tank (200 LF of 5-ft-diameter pipe)

- 0.29-MG storage tank to capture CSO 038 at SE 3rd St and Oak St, including pump to dewater the tank in 48 hours, and conveyance to the tank (1,500 LF of 2.75-ft-diameter pipe)

5.7.9 Alternative 7C

- Alternative 3 project components
- Storage to control downtown CSOs
  - 6.72-MG storage tank to capture CSO 008 at Chestnut St and SE 2nd St, including pump to dewater the tank in 48 hours, and conveyance to the tank (1,200 LF of 5-ft-diameter pipe)
  - 6.51-MG storage tank to capture CSO 010 at Bicentennial Park (City-owned), including pump to dewater the tank in 48 hours, and conveyance to the tank (900 LF of 4.5-ft-diameter pipe)
  - 7.85-MG storage tank to capture CSO 011 in open space near CSO, including pump to dewater the tank in 48 hours, and conveyance to the tank (200 LF of 5-ft-diameter pipe)
  - 0.51-MG storage tank to capture CSO 038 at SE 3rd St and Oak St, including pump to dewater the tank in 48 hours, and conveyance to the tank (1,500 LF of 2.75-ft-diameter pipe)

5.7.10 Alternative 7D

- Alternative 3 project components
- Storage to control downtown CSOs:
  - 15.08-MG storage tank to capture CSO 008 at Chestnut St and SE 2nd St, including pump to dewater the tank in 48 hours, and conveyance to the tank (1,200 LF of 5-ft-diameter pipe)
  - 6.51-MG storage tank to capture CSO 010 at Bicentennial Park (City-owned), including pump to dewater the tank in 48 hours, and conveyance to the tank (900 LF of 4.5-ft-diameter pipe)
  - 16.59-MG storage tank to capture CSO 011 in open space near CSO, including pump to dewater the tank in 48 hours, and conveyance to the tank (200 LF of 5-ft-diameter pipe)
  - 0.69-MG storage tank to capture CSO 038 at SE 3rd St and Oak St, including pump to dewater the tank in 48 hours, and conveyance to the tank (1,500 LF of 2.75-ft-diameter pipe)

5.7.11 Alternative 7E

- Alternative 3 project components
- Storage to control downtown CSOs:
  - 6.03-MG storage tank to capture CSOs 008, 010, and 038 at Bicentennial Park (City-owned), including pump to dewater the tank in 48 hours, and conveyance to the tank (1,500 LF of 5.5-ft-diameter pipe, 900 LF of 6-ft-diameter pipe, and 700 LF of 2.75-ft-diameter pipe)

- 2.87-MG storage tank to capture CSO 011 in open space near CSO, including pump to dewater the tank in 48 hours, and conveyance to the tank (200 LF of 5-ft-diameter pipe)

5.7.12 Alternative 7EG

- Alternative 3 project components
- Storage to control downtown CSOs
  - 2.69-MG storage tank to capture CSOs 008 and 010 at Bicentennial Park (City-owned), including pump to dewater the tank in 48 hours, and conveyance to the tank (1,500 LF of 3.5-ft-diameter pipe and 900 LF of 5-ft-diameter pipe)
  - 2.87-MG storage tank to capture CSO 011 in open space near CSO, including pump to dewater the tank in 48 hours, and conveyance to the tank (200 LF of 5-ft-diameter pipe)
- Implement GI in all tributary sewersheds of CSOs 008 and 038.

Tables 5-16 and 5-17 depict the percent capture and number of overflows for the baseline and 13 alternatives.

Table 5-16 Percent Capture[a]

			Screened Alternative												
CSO	**Existing**	**Baseline**	**1**	**2**	**3**	**3A**	**4**	**4A**	**6**	**7A**	**7B**	**7C**	**7D**	**7E**	**7EG**
103	69%	75%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
001	40%	36%	34%	35%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
002	95%	96%	83%	83%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
004	61%	61%	31%	31%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
008	63%	63%	56%	56%	56%	58%	83%	91%	99%[b]	89%	96%	98%	100%	89%	96%
010	62%	62%	57%	56%	56%	56%	86%	85%	99%[b]	92%	100%	100%	100%	92%	92%
011	66%	60%	60%	64%	64%	82%	100%	79%	100%	83%	86%	97%	100%	83%	83%
038	90%	90%	85%	85%	85%	85%	100%	100%	99%[b]	99%	99%	100%	100%	99%	100%
Aggregate	29%	30%	35%	36%	87%	89%	98%	96%	99.9%	96%	98%	99%	100%	96%	97%

[a]Flows have not been filtered and also includes flows less than 0.01 mgd (except for the East Aggregate values).

[b]CSOs 008, 010, and 038 were combined during this alternative.

Table 5-17 Number of Overflows[a]

CSO	Existing	Baseline	Screened Alternative												
			1	2	3	3A	4	4A	6	7A	7B	7C	7D	7E	7EG
103	34	32	0	0	0	0	0	0	0	0	0	0	0	0	0
001	39	38	38	37	0	0	0	0	0	0	0	0	0	0	0
002	10	10	18	18	0	0	0	0	0	0	0	0	0	0	0
004	29	28	29	29	0	0	0	0	0	0	0	0	0	0	0
008	31	31	30	30	30	31	19	16	1[b]	10	4	2	0	10	8
010	25	25	25	25	25	25	15	15	1[b]	7	0	0	0	7	7
011	17	18	18	16	16	11	0	11	0	6	6	2	0	6	6
038	10	10	11	13	13	13	0	0	1[b]	1	1	0	0	1	0
Aggregate	43	42	42	41	31	31	20	18	1	10	6	2	0	10	9

[a] Flows have not been filtered and also includes flows less than 0.01 mgd (except for the East Aggregate values).

[b] CSOs 008, 010, and 038 were combined during this alternative.

5.8 Alternatives Appropriate for Further Evaluation – East Basin

Promising alternatives in terms of cost, overflow volume reduction, and reduction in number of activations included:

1. East WWTP expansion, downtown storage, and storage and/or treatment for Bee Slough CSOs
2. East WWTP expansion, tunnel storage/conveyance for downtown CSOs, and/or storage and treatment for Bee Slough CSOs
3. East WWTP expansion, downtown storage, and wetland and/or HRT for Bee Slough CSOs

These alternatives were evaluated as part of the detailed alternatives evaluation required per Appendix C, Section I, Paragraph 3 of the Decree.

SECTION 6

Alternatives Evaluation

A limited number of alternatives appropriate for further evaluation were selected from the West and East screening assessments and evaluated based on alternative cost, effectiveness, and water quality impacts as required per Paragraph I.3 of the Decree. Alternative screening described in the previous sections was completed using the SSS and CSS hydraulic models developed using the Phase I and Phase II flow monitoring data. The detailed alternatives evaluation was completed using the CSS hydraulic models which were updated to reflect the 2012 Phase III flow monitoring data. SSS inputs to the CSS models were also updated to reflect the 2013 flow projections and infiltration and inflow (I/I) reduction estimates.

6.1 Alternatives Evaluated to Achieve Prescribed Levels of Control

The East and West CSS alternatives discussed within Sections 4 and 5 were reduced to a finite set of site-specific projects whose size can be adjusted to achieve varying levels of control. The screening analysis indicated that storage/HRT technologies performed better on a life-cycle basis relative to the parallel relief, WWTP expansion, and tunnel alternatives, however, each of the options were evaluated as part of the detailed alternatives analysis.

The alternative screening resulted in identification of the following alternatives for further evaluation:

- **West Storage/HRT** – An alternative that includes distributed storage, two HRT facilities, additional PCI conveyance, and West WWTP expansion
- **West Parallel PCI Relief** – An alternative similar to the storage/HRT alternative, but with PCI conveyance sized in a manner to eliminate the distributed storage and HRT facilities
- **West Tunnel** – An alternative consisting of West WWTP expansion and a storage/transmission tunnel to r minimize or eliminate collection system storage basins and treatment units
- **East Storage/WWTP** – An alternative providing secondary treatment at the East WWTP, storage basins for downtown CSOs (038, 008, 010, and 011), and a combination of storage and treatment for the Bee Slough CSOs (001, 002, and 004)
- **East Storage/HRT/Wetlands** – An alternative providing secondary treatment at the East WWTP, storage basins for downtown CSOs (038, 010, and 011), wetland treatment for CSO 001, and storage and HRT for the other Bee Slough CSOs (002 and 004)
- **East Tunnel** – An alternative providing secondary treatment at the East WWTP, but with a storage/transmission tunnel to minimize or eliminate collection system storage basins and treatment units

6.2 Alternatives Evaluation Methodology

The assessment of the above listed alternatives included an evaluation of the technical feasibility and applicability of each project identified for each CSO outfall or groupings of

outfalls. The listed alternatives were further refined through additional modeling and site-specific analysis to develop a range of sizes to achieve the following system wide levels of control, as required per Appendix C, Section I, Paragraph 3:

- Number of annual untreated Typical Year discharges: 0, 1, 3, 4, 7, 8, and 12
- Percent capture for treatment: 100 percent, 90 percent, 85 percent, 80 percent, and 75 percent

Costs for each level of control were calculated using the costing methodology previously described (Section 3.2) to determine the most cost-effective sizing and approach for each prescribed level of control.

Details of each alternative evaluated are provided in Sections 6.2 through 6.5, and a comparison of the alternative costs is provided in Section 6.6.

6.2.1 Storage/HRT Alternatives

Storage/HRT alternatives were selected based on the optimization analysis and West and East Typical Year model runs performed during the alternative screening described in Sections 5 and 6. The following approach was used to develop the storage/HRT alternatives:

1. Remedy modeled SSOs in the SSS basins using the calibrated and refined hydraulic models. Proposed capacity improvement projects are sized to transport the largest Typical Year storm(s) in the West system, and the 2-year, 3-hour storm in the East system.
2. Update the CSS models to reflect the SSS improvements and CSS inputs.
3. Determine the size, configuration, and costs of projects that fully capture and treat CSOs during the Typical Year simulations (i.e. 0 activation, 100 percent capture alternative).
4. Reduce the pumping, storage, HRT, and conveyance infrastructure to achieve the required numbers of activations (1, 3, 4, 7, 8, and 12) and develop costs for each of the levels of control.
5. Confirm that stored CSO volumes can be sent to the WWTP within 48 hours for full secondary treatment.

Specific details on the storage/HRT alternatives evaluated are provided in Section 6.3.

6.2.2 Parallel Relief Alternatives

Parallel relief sewers were analyzed in conjunction with the pumping/storage infrastructure alternatives to eliminate the HRT and convey captured CSO to the WWTPs for full secondary treatment. Using the proposed infrastructure and model results from the storage/HRT alternatives, the parallel relief sewer alternatives were sized to convey flow that the storage/HRT alternatives would otherwise send to HRT. This approach allowed a direct comparison between satellite treatment versus flow conveyance to the WWTP for full secondary treatment.

Specific details on the parallel relief alternatives evaluation can be found in Section 6.4.

6.2.3 Deep Storage/Conveyance Tunnel Alternatives

The storage/conveyance tunnel alternatives utilized the storage/HRT hydraulic modeling results, 60-mgd West and East WWTP capacities, as appropriate, and replaced pumping, storage, and

HRT at all locations with a tunnel. Relief sewers included in the storage/HRT alternatives were included in the tunnel alternatives as the near-surface consolidation sewers. Modeling results were used to determine the peak flow capacity and storage required in the tunnel system, which dictated the tunnel size based on the alignment common to all alternatives.

Specific details on the tunnel alternatives evaluation are provided in Section 6.5.

6.3 Storage/HRT Alternatives Evaluation

West WWTP expansion to 45, 60, or 80 mgd were evaluated as part of the IOCP development. The 80-mgd West WWTP alternative was eliminated from consideration, as described in detail within the Facility Plan (Volume 4). The alternatives below are identified using the naming convention established during discussions with EPA prior to the May 2013 Final IOCP submittal, with the WWTP capacity added to distinguish between the alternatives. Because the West 1 alternative included both storage/HRT and a parallel relief sewer, West 1 alternatives also identify which capture and treatment technology is being evaluated. Each HRT technology is intended to meet primary treatment requirements and disinfect the treated effluent to *E. Coli* concentrations of less than 235 CFU/mL.

The sections below specifically describe how CSO is captured and treated, and the sizes/ capacities of the individual CSO controls are varied in order to achieve the different levels of control required in the Decree. Cost-performance data are presented in Section 6.6, including the specific project sizing used to develop the associated capital, life cycle, and total project cost of each alternative.

6.3.1 West 1-45 (Storage/HRT)

Major features included in this alternative:

- West WWTP at 45 mgd
- Two remote treatment units
  - One at the Diamond Avenue CSO
  - One at 7th Avenue Lift Station
- New 7th Avenue Lift Station with a total pumping capacity of 135 mgd
- Consolidation sewers:
  - Send flow from the 6th Avenue, Dresden, and Maryland CSOs to the Delaware CSO Storage Facility
  - Send the Franklin, Fulton, and 9th Avenue CSOs to the 7th Avenue Lift Station and CSO Control Facility

Project details for each CSO, or CSO grouping, are summarized in Figure 6-1 and provided in the following sections.

6.3.1.1 Diamond/Baker (CSOs 025/024)

- Construct and utilize storage as equalization for the HRT units. Storage is proposed to be located within the existing ponding area and north of Diamond Avenue, depending on the quantity of storage required to provide the desired level of control.

- Due to sewer depth, pump captured CSO into storage.
  - Diamond flow is diverted from the 90-inch into the storage/pumping facility via a new diversion structure located between the existing diversion structure and the levee/outfall gate control structure.
  - Baker flow is lifted into the existing 72-inch (this pipe flows north to the existing Diamond Avenue levee pump station) via a new lift station located upstream of the levee gate.
  - Tie the 72-inch into the storage/pumping facility.
- Utilize Actiflo as HRT and activate it when storage is half full.
- HRT effluent discharges back into the existing outfall and is pumped to Pigeon Creek by the levee station during high river levels.
- Pump stored flow that doesn't go through HRT into the PCI when the West WWTP flow is less than its peak design capacity and capacity exists within PCI.

6.3.1.2 Oakley (CSO 018)

- Construct a gravity in, gravity out storage basin on the abandoned Sonic property near the diversion structure.
- Direct flow into the storage tank, rather than to the CSO diversion structure.
- Discharge stored flow into the PCI when the West WWTP flow is less than is peak design capacity and capacity exists within PCI.
- Captured combined sewage volumes that exceed the storage tank volume would be discharged from the storage tank through a high level overflow/bypass connected to the existing outfall.

6.3.1.3 6th Avenue/Dresden/Maryland/Delaware (CSOs 017, 014, 012, 013)

- Construct a consolidation sewer to capture combined sewage and prevent discharges from 6th Avenue, Dresden, and Maryland CSO locations, and convey it to the Delaware Street Storage Facility to be constructed near CSO 013.
- Flow from the new consolidation sewer and the two Delaware diversion structures would be pumped into the Delaware Street Storage Facility due to sewer depth elevation differences.
- Pump stored flow into the PCI when the West WWTP flow is less than its peak design capacity.

6.3.1.4 Franklin/7th Avenue East/Fulton/9th Avenue

- Construct consolidation sewers that capture CSO from Franklin and 9th Avenue and convey it to the proposed new 7th Avenue Lift Station.
- Convey flows from Fulton Avenue to the new 7th Avenue Lift Station through the existing pipe that conveys this flow.
- Construct a new 7th Avenue Lift Station adjacent to the City's greenway trailhead on the property that lies just west of the Fulton Avenue levee pump station and just south of the Lloyd Expressway.
  - 45 mgd of pumping capacity to pump DWF and a portion of WWF to the West WWTP



CSO	Name	Receiving Water	WWTP Service Area
006	Fulton Avenue Pumping Station	Ohio River	West
009	7th Avenue West	Ohio River	West
012	Maryland Street – West Bank	Pigeon Creek	West
013	Delaware Street	Pigeon Creek	West
014	Dresden Street	Pigeon Creek	West
015	7th Avenue East	Ohio River	West
016	Franklin Street	Pigeon Creek	West
017	6th Avenue	Pigeon Creek	West
018	Oakley Street	Pigeon Creek	West
020	9th Avenue	Ohio River	West
022	St. Joseph Avenue	Ohio River	West
123	West Plan CSO	Ohio River	West
024	Baker Street	Pigeon Creek	West
025	Diamond Avenue	Pigeon Creek	West

Legend

East Service Area

- Separate Sewer Area
- Combined Sewer Area

West Service Area

- Separate Sewer Area
- Combined Sewer Area

- Wastewater Treatment Plant
- CSO
- Storage Basin
- High Rate Treatment Unit
- City Limits

Activation Points	Delaware CSO Control Facility		7th Ave CSO Control Facility		Oakley CSO Control Facility		Diamond Ave CSO Control Facility		Howell Park Control Facility		Total System Storage (MG)	Total System Satellite Treatment (MGD)
	Storage (MG)	Satellite Treatment (MGD)	Storage (MG)	Satellite Treatment (MGD)	Storage (MG)	Satellite Treatment (MGD)	Storage (MG)	Satellite Treatment (MGD)	Storage (MG)	Satellite Treatment (MGD)		
0	5		5.1	90	0.6		16.7	20	6.1		33.5	110
1	4.8		5.1	78	0.6		15	0	6.1		31.6	78
3	4.3		5.1	76	0.6		13.1	20	6.1		29.2	96
4	3.5		5.1	72	0.6		8.1	20	6.1		23.4	92
7	1.2		5.1	63	0.6		5	15	6.1		18	78
8	1.1		5.1	63	0.6		5	5	6.1		17.9	68
12	0.9		5.1	63	0.6		2		6.1		14.7	63

North

FIGURE 6-1
West 1-45
Long Term Control Plan
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  - 90 mgd of pumping capacity to pump WWF into an above-ground storage facility (will likely be split into two tanks)

- Utilize Storm King or other equivalent swirl concentrator technology for HRT. Activate HRT when storage is completely full.
- Drain storage tanks back into the 7th Avenue Lift Station by gravity and pump stored flow to the West WWTP when its flow is less than its peak design capacity and capacity exists within PCI.

6.3.1.5 St Joseph

- Increase the underflow pipe size and install flap gate to prevent backflow from the Broadway Avenue Interceptor (BAI).
- Raise the diversion structure weir to push more flow into the BAI and reduce CSO activations.

6.3.1.6 West WWTP/CSO 123

- Construct gravity in, gravity out storage basin in Howell Park to serve as equalization for the West WWTP.
- Construct new West WWTP headworks facility with the capability to pump 60 mgd and install only 45 mgd of pumping and screening capacity at this time.

6.3.2 East 1 (Storage/WWTP)

Major features included in this alternative:

- East WWTP capacities vary – see details below
- Discontinue use of CSO 103 for Typical Year storm events.
- New Kentucky Avenue CSO Pump Station with a total pumping capacity varying based on number of activations from the Kentucky Avenue CSO – see details below
  - Flow would be diverted out of the upstream end of Bee Slough at the existing Kentucky Avenue CSO outfall and into a new 108" sewer that would be buried within the existing concrete channel.
  - The pump station would include screening and grit removal facilities.
- Captured CSO from Kentucky would be pumped into a storage basin – total storage required varies based on WWTP and Kentucky Avenue CSO Pump Station capacities selected – see details below.
- Construct a storage/pumping facility to pump flow from the Cass and Adams CSOs to the 43-MG storage basin.
- Storage facilities located throughout downtown
- Storage facility at the Oak Hill CSO

Project details for each CSO, or CSO grouping, are summarized in Figure 6-2 and provided in the following sections.

6.3.2.1 Oak Hill

- Construct a below grade gravity in, pump out storage basin downstream of the diversion structure. The storage basin would be constructed on the same parcel as the diversion structure.
- Divert flow out of the diversion structure and into storage.
- Pump out stored flow into the sewer system upstream of the Weinback Lift Station when the East WWTP flow is less than the plants peak design capacity.
- CSO volumes that exceed the storage volume would discharge from the storage tank through a high level overflow/bypass that would connect to the existing outfall.
- A maximum 36-hour dewatering would be used if East WWTP has capacity.

6.3.2.2 Cass/Adams

Refer to the Bee Slough report for specific details. Remote treatment unit would serve as a storage/pumping facility to pump flow to East WWTP for treatment.

6.3.2.3 Dress Plaza

- Construct a below grade gravity in, pump out storage basin upstream of the three (3) existing diversion structures for CSO 010. This basin would be constructed in Bicentennial Park located on the southeast corner of 2nd and Vine. The parcel is currently owned by the City of Evansville for the use of the Parks Department.
- Construct a consolidation sewer from Court Street to storage basin as well as a consolidation sewer from Locust Street to the storage basin.
- Construct new diversion structures downstream of existing diversion structures and divert flow out of these new diversion structures into the consolidations sewers to flow into the storage basin.
- Pump out stored flow into the Riverside Interceptor when the East WWTP flow is less than the plants peak design capacity.
- A maximum 36-hour dewatering would be used if East WWTP has capacity.

6.3.2.4 Chestnut

- Construct a below grade gravity in, pump out storage basin upstream of the existing diversion structure. The storage basin would be constructed on the parcel located at 202 SE Second Street currently owned by the Evansville Lodge of Perfection #140.
- Construct a new diversion structure downstream of existing diversion structure. Divert flow out of this new diversion structure and into the storage basin.
- Pump out stored flow into the Riverside Interceptor when the East WWTP flow is less than the plants peak design capacity.
- A maximum 36-hour dewatering would be used if East WWTP has capacity.



CSO	Name	Receiving Water	WWTP Service Area
001	Kentucky Avenue	Bee Slough	East
002	Cass Avenue	Bee Slough	East
103	Junction Box Prior to WWTP Headworks	Ohio River	East
004	Adams	Bee Slough	East
008	Chestnut Street	Ohio River	East
010	Dress Plaza	Ohio River	East
011	Weinbach Lift Station (Oakhill Road)	Pigeon Creek	East
038	Oak / Riverside	Ohio River	East

Legend

East Service Area

- Separate Sewer Area
- Combined Sewer Area

West Service Area

- Separate Sewer Area
- Combined Sewer Area

- Wastewater Treatment Plant
- CSO
- Storage Basin
- High Rate Treatment Unit
- City Limits

Activation Points	Kentucky CSO Control Facility*		Cass Ave CSO Control Facility		Oak-Riverside CSO Control Facility		Dress Plaza Ave CSO Control Facility		Oakhill CSO Control Facility		Total System Storage (MG)	Total System Satellite Treatment (MGD)
	Storage (MG)	Satellite Treatment (MGD)	Storage (MG)	Satellite Treatment (MGD)	Storage (MG)	Satellite Treatment (MGD)	Storage (MG)	Satellite Treatment (MGD)	Storage (MG)	Satellite Treatment (MGD)		
0	68			226	Tunnel		Tunnel		12		37.1	
3	25			226	7.54		3.15		6.83		6.1	
7	13			226	6.1		2.36		2.97		11.43	
12	6			226	3.65		1.68		0.77		17.52	

* Kentucky Ave storage volumes correspond to a East WWTP Capacity of 68 MGD see section 6.3.2.7 for storage volumes corresponding to additional treatment plant configurations

North

FIGURE 6-2
East 1
Long Term Control Plan
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6.3.2.5 Oak/Riverside

- Construct a below grade gravity in, pump out storage basin upstream of the existing diversion structure. The storage basin could be constructed on two (2) parking lot parcels. One parcel is located at 408 SE Third Street, and is currently owned by Select Medical Property Ventures LLC. The other parcel is located at 500 SE Third Street, currently owned by the Walker Building Development LLC.
- Construct a new diversion structure downstream of existing diversion structure. Divert flow out of this new diversion structure and into the storage basin.
- Pump out stored flow into the Riverside Interceptor when the East WWTP flow is less than the plants peak design capacity.
- A maximum 36-hour dewatering would be used if East WWTP has capacity.

6.3.2.6 Kentucky/Shadywood

As described in Section 5, the number of residual untreated overflows from the Kentucky Avenue CSO is controlled by the pumping capacity of the proposed Kentucky Avenue CSO Pump Station. Table 6-1 lists the pump station sizes that correspond to the different activation levels.

Table 6-1 Pump Station Sizing

Activations	Pumping Capacity	Capital Cost ($)
0	198	59,190,000
3	195	58,840,000
7	118	47,280,000
12	68	39,810,000

6.3.2.7 East WWTP/CSO 103

Several options for East WWTP expansion were evaluated in conjunction with the Kentucky Avenue CSO Pump Station and CSO storage options. The following features were included under all East 1 options considered:

- Close CSO 103 gate to prevent overflows from Typical Year-type storms.
- Rehabilitate the existing chlorine contact tank for WWTP capacities up to 40 mgd, and construct additional disinfection capacity depending on the total amount of WWTP capacity constructed.
- Dedicate any proposed additional WWTP capacity to treating flows from the proposed Kentucky Avenue CSO Pump Station.
- Adjust wet-weather operations to either:
  - Provide full secondary treatment for all flows pumped by the existing headworks facility and/or the Kentucky Avenue CSO Pump Station, or

  - Utilize the primary effluent bypass to operate the primary and secondary processes in parallel and dedicate the primary process to the headworks flows and the secondary process to Kentucky Avenue CSO Pump Station flows

- Construct storage within levee ponding area south of the East WWTP. The total storage volume required is dependent upon the East WWTP capacity, and the total volume that can feasibly be constructed is 43 MG.

Table 6-2 lists the different options for East WWTP expansion and the operational approaches that could be used to treat flows through the headworks facility and the Kentucky Avenue CSO Pump Station.

Table 6-3 lists the different Kentucky Avenue CSO Pump Station capacities and activation levels as compared to the different East WWTP options, and the corresponding storage volume required for each combination of pumping and treatment capacities.

Table 6-4 lists the costs for the different Kentucky Avenue CSO Pump Station capacities and activation levels as compared to the different East WWTP options, and for the corresponding storage volume required for each combination of pumping and treatment capacities.

Table 6-5 lists the capital costs associated with the storage and treatment of Kentucky Avenue CSO discharges at the corresponding treatment and activation levels, and Table 6-6 lists the overall system-wide alternative costs that correspond to the treatment and activation levels.

6.3.3 East 3-40 (Storage/HRT/Wetland)

Major features included in this alternative:

- East WWTP at 40 mgd – see details below
- Discontinue use of CSO 103 for Typical Year storm events.
- New Kentucky Avenue CSO Pump Station and Disinfection Facility with a total pumping capacity of 230 mgd
  - Flow would be diverted out of the upstream end of Bee Slough at the existing Kentucky Avenue CSO outfall and into a new 108” sewer that would be buried within the existing concrete channel
  - The pump station and disinfection facility would be in a common structure located adjacent to the East WWTP
  - The pump station would include screening and grit removal facilities
- Captured CSO from Kentucky would be pumped into a 43-MG extended-detention treatment wetland.
- One remote treatment unit to treat flow from the Cass and Adams CSOs.
- Storage facilities located throughout downtown
- Storage facility at the Oak Hill CSO

CSO-by-CSO details are provided below.

Table 6-2 East WWTP KY Avenue CSO Treatment

Scenario	WWTP Capacities, MGD					Wet-Weather Operations - Peak Capacity Proposed (MGD) and Treatment Level					WWTP Improvements Capital Cost	Life Cycle Cost, 40-Year NPV	Comment
	Headworks	Primary	Secondary	Total	Effluent Pumping	Headworks Flows		KY Ave CSO Side Stream Flows		Blended Effluent?			
Existing	40	40	28	28	0	28	Secondary	Does Not Exist		No	-	-	Existing WWTP configuration
1	40	40	28	40	28	40/ 28/ 12	Primary/ Secondary/ PE Bypass	0	Wetland	Yes	12,730,000	16,215,000	Existing WWTP configuration utilizing PE bypass for headworks flows >28 MGD
2	40	40	40	40	40	40	Secondary	0	Wetland	No	47,001,000	51,211,000	Expansion of secondary process to match primary capacity
3	40	40	28	68	68	40	Primary	28	Secondary	Yes	21,182,000	25,176,000	Existing WWTP configuration utilizing parallel treatment for Headworks flows and KY Ave CSO flows
4	40	40	40	80	80	40	Primary	40	Secondary	Yes	58,696,000	63,679,000	Construct 12 MGD of additional secondary treatment; similar operation to Scenario 3
5	40	40	60	60	60	40	Secondary	20	Secondary	No	88,086,000	94,399,000	Construct 32 MGD of additional secondary treatment; utilize 20 MGD of new secondary capacity for KY Ave CSO
6	40	40	80	80	80	40	Secondary	40	Secondary	No	101,633,000	108,310,000	Construct 52 MGD of additional secondary treatment; utilize 40 MGD of new secondary capacity for KY Ave CSO

Note: All Scenarios include conversion to hypochlorite disinfection and construction of an effluent pump statio

Table 6-3 East Alt 1 Storage Volumes (MG)

Sum of Storage Vol		WWTP Option					
Activations	Pumping Capacity (mgd)	1	2	3	4	5	6
0	198	153	153	68	47	83	47
3	195	54	54	36	29	43	29
7	118	35	35	8	6	9	6
12	68	17	17	10	5	15	5

6.3.3.1 Oak Hill

- Construct below grade gravity in, pump out storage basin downstream of the diversion structure. The storage basin would be constructed on the same parcel as the diversion structure.
- Divert flow out of the diversion structure and into storage.
- Pump out stored flow into the sewer system upstream of the Weinback Lift Station when the East WWTP flow is less than the plants peak design capacity.
- CSO volumes that exceed the storage volume would discharge from the storage tank through a high level overflow/bypass that would connect to the existing outfall.
- A maximum 36-hour dewatering would be used if East WWTP has capacity.

6.3.3.2 Kentucky/Shadywood

Refer to the Bee Slough report for specific details.

6.3.3.3 Cass/Adams

Refer to the Bee Slough report for specific details.

6.3.3.4 Dress Plaza

- Construct a below grade gravity in, pump out storage basin upstream of the three (3) existing diversion structures for CSO 010. This basin would be constructed in Bicentennial Park located on the southeast corner of 2nd and Vine. The parcel is currently owned by the City of Evansville for the use of the Parks Department.
- Construct a consolidation sewer from Court Street to storage basin as well as a consolidation sewer from Locust Street to the storage basin.
- Construct new diversion structures downstream of existing diversion structures and divert flow out of these new diversion structures into the consolidations sewers to flow into the storage basin.

Table 6-4 East Alt 1 Storage Basin Capital Cost - Storage Capital Cost for WWTP Option

		Storage Capital Cost for WWTP Option					
Activations	Pumping Capacity (MGD)	1	2	3	4	5	6
0	198	$ -	$ -	$ -	$ -	$ -	$ -
3	195	$ -	$ -	$ 5,620,000	$ 4,480,000	$ 6,750,000	$ 4,480,000
7	118	$ 5,500,000	$ 5,500,000	$ 1,200,000	$ 890,000	$ 1,470,000	$ 890,000
12	68	$ 2,670,000	$ 2,670,000	$ 1,570,000	$ 770,000	$ 2,360,000	$ 770,000

Table 6-5 East Alt 1 Storage Basin Capital Cost - Storage and Treatment of Kentucky Ave CSO

			Storage and Treatment of Kentucky Ave CSO					
			1	2	3	4	5	6
			$ 12,730,000	$ 47,001,000	$ 21,182,000	$ 58,696,000	$ 88,086,000	$ 101,633,000
Activations	Pumping Capacity (MGD)	PS Capital Cost						
0	198	$ 59,190,000	$ -	$ -	$ -	$ -	$ -	$ -
3	195	$ 58,840,000	$ -	$ -	$ 85,642,000	$ 122,016,000	$ 153,676,000	$ 164,953,000
7	118	$ 47,280,000	$ 65,510,000	$ 99,781,000	$ 69,662,000	$ 106,866,000	$ 136,836,000	$ 149,803,000
12	68	$ 39,810,000	$ 55,210,000	$ 89,481,000	$ 62,562,000	$ 99,276,000	$ 130,256,000	$ 142,213,000

Table 6-6 East Alt 1 Storage Basin Capital Cost - Storage and Treatment of Kentucky Ave CSO

				Storage and Treatment of Kentucky Ave CSO					
				1	2	3	4	5	6
				$ 12,730,000	$ 47,001,000	$ 21,182,000	$ 58,696,000	$ 88,086,000	$ 101,633,000
Activations	Pumping Capacity (MGD)	PS Capital Cost	East Alt 1 Projects Captial Cost						
0	198	$ 59,190,000	$ 548,917,000	$ -	$ -	$ -	$ -	$ -	$ -
3	195	$ 58,840,000	$ 371,684,000	$ -	$ -	$ 457,326,000	$ 493,700,000	$ 525,360,000	$ 536,637,000
7	118	$ 47,280,000	$ 356,997,000	$ 422,507,000	$ 456,778,000	$ 426,659,000	$ 463,863,000	$ 493,833,000	$ 506,800,000
12	68	$ 39,810,000	$ 340,248,000	$ 395,458,000	$ 429,729,000	$ 402,810,000	$ 439,524,000	$ 470,504,000	$ 482,461,000

- Pump out stored flow into the Riverside Interceptor when the East WWTP flow is less than the plants peak design capacity.
- A maximum 36-hour dewatering would be used if East WWTP has capacity.

6.3.3.5 Chestnut

- Construct a below grade gravity in, pump out storage basin upstream of the existing diversion structure. The storage basin would be constructed on the parcel located at 202 SE Second Street currently owned by the Evansville Lodge of Perfection #140.
- Construct a new diversion structure downstream of existing diversion structure. Divert flow out of this new diversion structure and into the storage basin.
- Pump out stored flow into the Riverside Interceptor when the East WWTP flow is less than the plants peak design capacity.
- A maximum 36-hour dewatering would be used if East WWTP has capacity.

6.3.3.6 Oak/Riverside

- Construct a below grade gravity in, pump out storage basin upstream of the existing diversion structure. The storage basin could be constructed on two (2) parking lot parcels. One parcel is located at 408 SE Third Street, and is currently owned by Select Medical Property Ventures LLC. The other parcel is located at 500 SE Third Street, currently owned by the Walker Building Development LLC.
- Construct a new diversion structure downstream of existing diversion structure. Divert flow out of this new diversion structure and into the storage basin.
- Pump out stored flow into the Riverside Interceptor when the East WWTP flow is less than the plants peak design capacity.
- A maximum 36-hour dewatering would be used if East WWTP has capacity.

6.3.3.7 East WWTP/CSO 103

- Close CSO 103 gate to prevent overflows from Typical Year-type storms
- Add a fourth aeration basin and clarifier and rehabilitate chlorine contact tank to bring WWTP peak capacity to 40 mgd OR rehabilitate chlorine contact tank and re-activate the primary effluent bypass to treat 40 mgd through primary process and 28 mgd through secondary process.

6.3.4 East 3-68 PE Bypass (Storage/HRT/Wetland)

Major features included in this alternative:

- East WWTP at 68 mgd – see details below
- Discontinue use of CSO 103 for Typical Year storm events.
- New Kentucky Avenue CSO Pump Station and Disinfection Facility with a total pumping capacity of 230 mgd

  - Flow would be diverted out of the upstream end of Bee Slough at the existing Kentucky Avenue CSO outfall and into a new 108" sewer that would be buried within the existing concrete channel.
  - The pump station and disinfection facility would be in a common structure located adjacent to the East WWTP.
  - The pump station would include screening and grit removal facilities.
- Captured CSO from Kentucky would be pumped into a 43-MG extended-detention treatment wetland.
- One remote treatment unit to treat flow from the Cass and Adams CSOs.
- Storage facilities located throughout downtown
- Storage facility at the Oak Hill CSO

Project details for each CSO, or CSO grouping, are summarized in Figure 6-3 CSO-by-CSO details are provided below:

6.3.4.1 Oak Hill

- Construct a below grade gravity in, pump out storage basin downstream of the diversion structure. The storage basin would be constructed on the same parcel as the diversion structure.
- Divert flow out of the diversion structure and into storage.
- Pump out stored flow into the sewer system upstream of the Weinback Lift Station when the East WWTP flow is less than the plants peak design capacity.
- CSO volumes that exceed the storage volume would discharge from the storage tank through a high level overflow/bypass that would connect to the existing outfall.
- A maximum 36-hour dewatering would be used if East WWTP has capacity.

6.3.4.2 Kentucky/Shadywood

Refer to the Bee Slough report for specific details.

6.3.4.3 Cass/Adams

Refer to the Bee Slough report for specific details.

6.3.4.4 Dress Plaza

- Construct a below grade gravity in, pump out storage basin upstream of the three (3) existing diversion structures for CSO 010. This basin would be constructed in Bicentennial Park located on the southeast corner of 2nd and Vine. The parcel is currently owned by the City of Evansville for the use of the Parks Department.
- Construct a consolidation sewer from Court Street to storage basin as well as a consolidation sewer from Locust Street to the storage basin.
- Construct new diversion structures downstream of existing diversion structures and divert flow out of these new diversion structures into the consolidations sewers to flow into the storage basin.

- Pump out stored flow into the Riverside Interceptor when the East WWTP flow is less than the plants peak design capacity.
- A maximum 36-hour dewatering would be used if East WWTP has capacity.

6.3.4.5 Chestnut

- Construct a below grade gravity in, pump out storage basin upstream of the existing diversion structure. The storage basin would be constructed on the parcel located at 202 SE Second Street currently owned by the Evansville Lodge of Perfection #140.
- Construct a new diversion structure downstream of existing diversion structure. Divert flow out of this new diversion structure and into the storage basin.
- Pump out stored flow into the Riverside Interceptor when the East WWTP flow is less than the plants peak design capacity.
- A maximum 36-hour dewatering would be used if East WWTP has capacity.

6.3.4.6 Oak/Riverside

- Construct a below grade gravity in, pump out storage basin upstream of the existing diversion structure. The storage basin could be constructed on two (2) parking lot parcels. One parcel is located at 408 SE Third Street, and is currently owned by Select Medical Property Ventures LLC. The other parcel is located at 500 SE Third Street, currently owned by the Walker Building Development LLC.
- Construct a new diversion structure downstream of existing diversion structure. Divert flow out of this new diversion structure and into the storage basin
- Pump out stored flow into the Riverside Interceptor when the East WWTP flow is less than the plants peak design capacity.
- A maximum 36-hour dewatering would be used if East WWTP has capacity.

6.3.4.7 East WWTP/CSO 103

- Close CSO 103 gate to prevent overflows from Typical Year-type storms.
- Rehabilitate chlorine contact tank and re-activate the primary effluent bypass to treat 40 mgd through primary process.
- Construct additional 28 mgd of disinfection capacity and send 28 mgd from the new Kentucky Avenue CSO PS through secondary process in parallel to 40 mgd primary process for a total East WWTP treatment capacity of 68 mgd.

6.4 Parallel Relief Alternatives Evaluation

Parallel relief was evaluated for PCI.

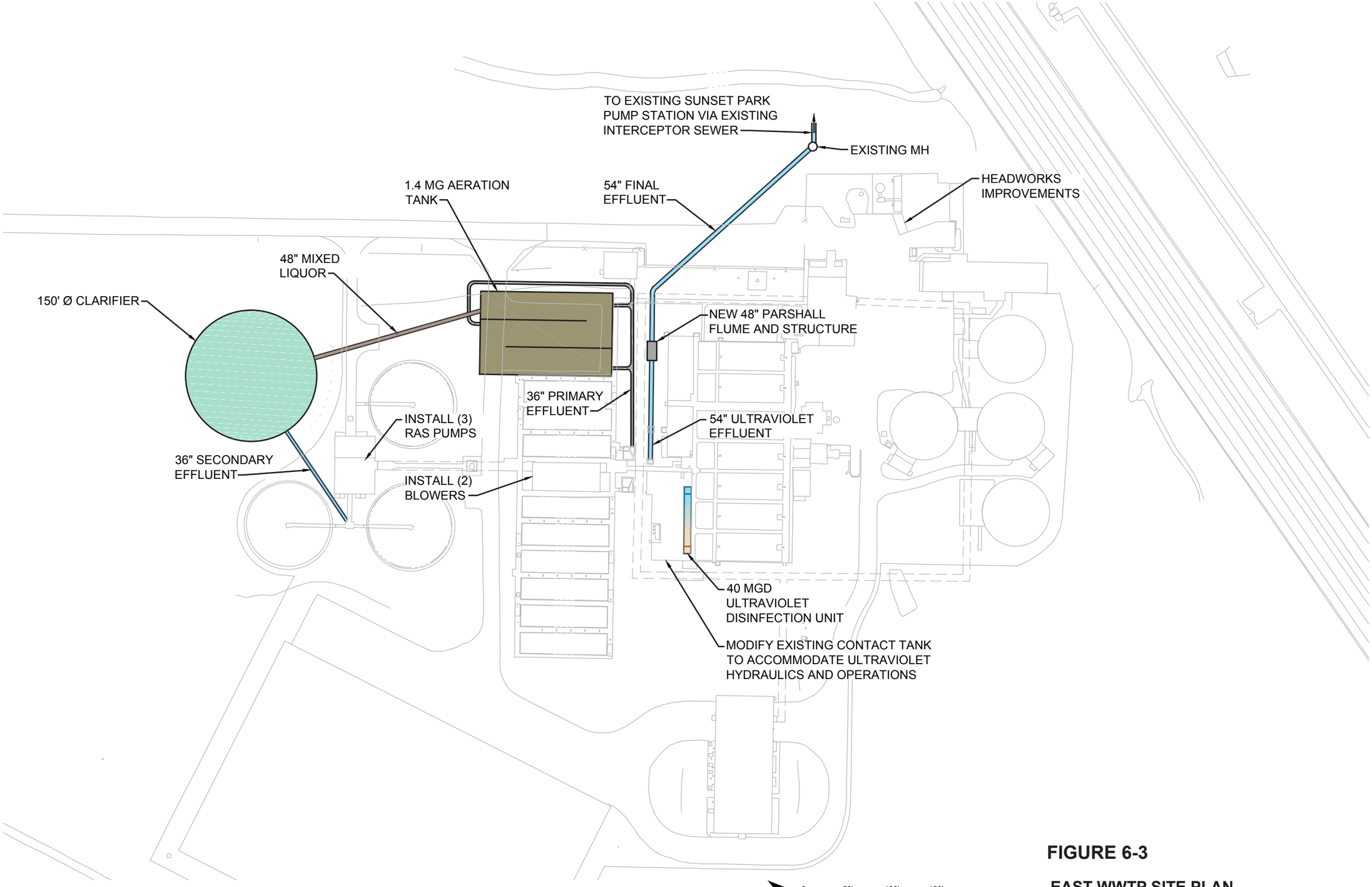


FIGURE 6-3

EAST WWTP SITE PLAN
40 MGD Expansion
January 15, 2016

6.4.1 West 1-60 (Parallel PCI Relief)

Major features included in this alternative:

- West WWTP at 60 mgd
- New 7th Avenue Lift Station with a total pumping capacity of 170 mgd
- Parallel relief sewer from Diamond Avenue CSO to the 7th Avenue Lift Station via Heidelbach, Colombia, and Fulton
- Consolidation sewers:
  - Send flow from the 6th Avenue, Dresden, and Maryland CSOs to the Delaware CSO Storage Facility
  - Send the Franklin, Fulton, and 9th Avenue CSOs to the 7th Avenue Lift Station and CSO Control Facility

Project details for each CSO, or CSO grouping, are summarized in Figure 6-4. CSO-by-CSO details are provided in the subsections below.

6.4.1.1 Diamond/Baker

- Construct and utilize storage as equalization for sending flows to the parallel relief; storage is proposed to be located within the existing ponding area and north of Diamond Avenue, depending on quantity of storage required.
- Due to sewer depth, pump captured CSO into storage.
  - Diamond flow is diverted from the 90-inch into the storage/pumping facility via a new diversion structure located between the existing diversion structure and the levee/outfall gate control structure.
  - Baker flow is lifted into the existing 72-inch (this pipe flows north to the existing Diamond Avenue levee pump station) via a new lift station located upstream of the levee gate.
  - Tie the 72-inch into the storage/pumping facility.
- Begin pumping to the parallel relief sewer when storage is half full.
- Pump stored flow into the parallel relief sewer when the West WWTP flow is less than its peak design capacity.

6.4.1.2 Oakley

- Construct a gravity in, gravity out storage basin on the abandoned Sonic property near the diversion structure.
- Divert flow out of the diversion structure and into storage.
- Discharge stored flow into the PCI when the West WWTP flow is less than is peak design capacity.
- CSO volumes that exceed the storage volume would discharge from the storage tank through a high level overflow/bypass that would connect to the existing outfall.

6.4.1.3 6th Avenue/Dresden/Maryland/Delaware

- Construct a consolidation sewer that captures CSO from 6th Avenue, Dresden, and Maryland and conveys it to the Delaware Street CSO Storage Facility.
- Flow from the consolidation sewer and from the two Delaware diversion structures would need to be pumped into the storage facility due to sewer depths.
- Pump stored flow into the PCI when the West WWTP flow is less than its peak design capacity.

6.4.1.4 Franklin/7th Avenue East/Fulton/9th Avenue

- Construct consolidation sewers that capture CSO from Franklin and from 9th Avenue and convey it to the proposed new 7th Avenue Lift Station.
- Flows from Fulton Avenue would be conveyed to the new 7th Avenue Lift Station through the existing pipe that captures this flow.
- Construct a new 7th Avenue Lift Station adjacent to the City's greenway trailhead on the property that lies just west of the Fulton Avenue levee pump station and just south of the Lloyd Expressway.
  - 60 mgd of pumping capacity would be constructed to pump DWF and a portion of WWF to the West WWTP.
  - 110 mgd of pumping capacity would be constructed to pump WWF into an above-ground storage facility (will likely be split into two tanks).
- Construct a parallel relief sewer to the Howell Park CSO Storage Facility and send flow into it when storage is completely full.
- Drain storage tanks back into the parallel relief sewer by gravity and send stored flow to the West WWTP when its flow is less than its peak design capacity.

6.4.1.5 St Joseph

- Increase the underflow pipe size and install flap gate to prevent backflow from the BAI.
- Raise diversion structure weir to push more flow into the BAI and reduce CSO activations.
- Construct buried storage adjacent to the diversion structure and St Joseph levee pump station.

6.4.1.6 West WWTP/CSO 123

- Construct new West WWTP headworks facility with capability to pump 60 mgd
- Construct gravity in, gravity out storage basin in Howell Park to serve as equalization for the West WWTP



CSO	Name	Receiving Water	WWTP Service Area
006	Fulton Avenue Pumping Station	Ohio River	West
009	7th Avenue West	Ohio River	West
012	Maryland Street – West Bank	Pigeon Creek	West
013	Delaware Street	Pigeon Creek	West
014	Dresden Street	Pigeon Creek	West
015	7th Avenue East	Ohio River	West
016	Franklin Street	Pigeon Creek	West
017	6th Avenue	Pigeon Creek	West
018	Oakley Street	Pigeon Creek	West
020	9th Avenue	Ohio River	West
022	St. Joseph Avenue	Ohio River	West
123	West Plan CSO	Ohio River	West
024	Baker Street	Pigeon Creek	West
025	Diamond Avenue	Pigeon Creek	West

Legend

East Service Area

- Separate Sewer Area
- Combined Sewer Area

West Service Area

- Separate Sewer Area
- Combined Sewer Area

- Wastewater Treatment Plant
- CSO
- Storage Basin
- High Rate Treatment Unit
- City Limits

Activation Points	Delaware CSO Control Facility		7th Ave CSO Control Facility		Oakley CSO Control Facility		Diamond Ave CSO Control Facility		St. Joseph CSO Control Facility		Howell Park Control Facility		Total System Storage (MG)	Total System Satellite Treatment (MGD)
	Storage (MG)	Satellite Treatment (MGD)	Storage (MG)	Satellite Treatment (MGD)	Storage (MG)	Satellite Treatment (MGD)	Storage (MG)	Satellite Treatment (MGD)	Storage (MG)	Satellite Treatment (MGD)	Storage (MG)	Satellite Treatment (MGD)		
0	4.8		5.1		0.6		16.8				44.3		71.6	
1	4.8		5.1		0.6		16.8				44.3		71.6	
3	4.3		5.1		0.6		13.1				35.8		58.9	
4	3.4		5.1		0.6		8.1				36.4		53.6	
7	1.1		5.1		0.6		5				36.6		58.4	
8	1.1		5.1		0.6		5				28.2		40	
12	0.9		5.1		0.6		2				24.2		32.8	

North

FIGURE 6-4
West 1-60 Relief Sewer
Long Term Control Plan
May 31, 2013

6.5 Deep Storage/Conveyance Tunnel Alternatives

West and East tunnel alternatives were evaluated in conjunction with WWTP expansion in order to minimize or eliminate collection system storage basins and treatment units. The alternatives evaluation included a review of area geology in order to assess potential construction methods, and based upon the anticipated construction method and project needs, costs were developed for each level of control required per Appendix C, Section I, Paragraph 3 of the Decree. In addition to the information below, additional detail regarding assessment of tunnel alternatives may be found in Appendix F.

6.5.1 Project Area Geology

A preliminary evaluation of project area geologic conditions was provided in the *Preliminary Letter of Opinion, Conceptual Deep CSO Storage Facilities, Evansville, Indiana*, prepared by NTH Consultants for CH2M HILL, and dated July 6, 2012. A brief description of the project area geology, based on the NTH report and additional information from the Indiana Geological Survey, is presented in the paragraphs following.

The City of Evansville is located within the Ohio River floodplain, more specifically within the Wabash Lowland Physiographic Region. Topographically, the area is relatively flat, with ground elevations generally ranging from about 380 ft to 400 ft above mean sea level (AMSL). Lower ground elevations are observed at some locations along the Ohio River and Pigeon Creek. Higher elevations are observed primarily to the north and west of the city in upland areas bordering the floodplain.

The Ohio River Valley is essentially a pre-glacial valley that has been filled largely with glaciofluvial outwash deposits comprised largely of sand and gravel with variable amounts of cobbles. In proximity to the river, the outwash is overlain by recent alluvial floodplain and levee deposits comprised of fine-grained sand, silt and clay with minor amounts of gravel. Bordering the alluvial areas, the surficial soils include glacial lake and terrace deposits generally comprised of fine-grained sand, silt and clay. These deposits underlie much of the city, including the area to the north of the river along Pigeon Creek. As a consequence of the changing and active nature of fluvial environments, the soil stratigraphy of the area is complex and the soils are variable both laterally and vertically in the subsurface.

The available information indicates that the bedrock surface in the area varies from about elevation 250 ft to 300 ft AMSL, with lower elevations to the south and higher elevations to the north and west. Coupled with topographic relief, the result is that soil thickness is generally in the range of about 80 to 100 ft. However, it is as much as 120 ft thick in the vicinity of junction of Pigeon Creek with the Ohio River and up to 130 ft to the south of the downtown area on the east side of the bow in the river. Soil thickness as little as about 45 ft is observed where Pigeon Creek turns sharply to the east to the north of the Ohio River.

The bedrock underlying the Evansville area is sedimentary rock of Middle to Upper Pennsylvanian age. Although not identified in the previously mentioned NTH Consultants report, based on available information, it appears that the rock in the depth range of interest belongs to the lower part of the McLeansboro Group and the Carbondale Group. The formations that comprise these groups are described as being mainly shale and sandstone, with a number of named interbeds of coal and limestone.

The lower formations of the McLeansboro are the Patoka and Shelburn Formations. The Patoka is a southward-thickening unit of shale, sandstone, clay, limestone, and coal. Shale and sandstone make up more than 85 percent of formation. Thickness ranges from 100 ft in northern Sullivan County (north of Evansville), to 310 ft in southwestern Posey County, which is the county immediately west of Vanderburgh County where Evansville is located. Readily available online documents provide no description of the Shelburne Formation. The underlying Carbondale Group is dominantly gray shale with prominent local sandstone, and within the Illinois Basin is as much as 225 to 300 ft thick (Kosanke et al., 1960).

6.5.2 Tunnel Construction Considerations

The storage / transmission tunnels would require inside diameters in the range of 17 to 25 ft. Excavated diameters would then be in the range of 19 to 27 ft. In particular, the West Basin alternative would comprise a length of approximately 25,000 LF and inside diameter of 17 to 20 ft, depending upon level of control. Conceptually, the alignment would extend from the approximate location where Pigeon Creek crosses Diamond Avenue, westward to the approximate location of CSO 14 on Pigeon Creek, then southward more or less parallel to the Creek to where the Creek enters the Ohio River, and then west to about St. Joseph Avenue.

6.5.2.1 Vertical Alignment

The current evaluation has considered the potential for the storage/transmission tunnel to be either a soft-ground or rock tunnel. For either case, typical practice is to have two (2) excavated-diameters of cover above the tunnel crown. For a soft-ground tunnel, the tunnel should ideally be constructed at a depth at least two tunnel diameters below the ground surface, and for a rock tunnel, the tunnel should ideally be constructed at a depth at least two diameters below the bedrock surface. In addition, for a soft-ground tunnel, adequate clearance above the bedrock surface that respects the potential range of relief that might be observed, is also required. With site-specific knowledge, smaller clearance distances could potentially be accommodated, but at this early stage of evaluation, typical clearance distances are warranted for planning.

It was noted above that the soil thickness where Pigeon Creek bends to the east is in the range of about 45 ft. This small thickness, while potentially limited in aerial extent, creates uncertainty that precludes a soft-ground tunnel of the diameter range for the required level of control for the upstream approximately one-half of the conceptual West Basin alignment. There are essentially then two vertical alignment alternatives:

1. A vertical alignment that includes soft-ground, mixed-face and rock segments, and
2. An all-rock tunnel alignment.

The first alternative is problematic, and it is more costly and carries significantly more risk than the rock tunnel alternative. Mixed-face tunneling requires simultaneous excavation of materials with significantly different properties. This has the potential to create difficulties in maintaining both vertical and horizontal alignment, and would create a significant potential for lost ground, with consequent surface settlements, in the granular soils overlying the bedrock. These problems may be exacerbated by variable relief on the bedrock surface. In addition, once fully into rock, the tunneling is likely to carry significant risk. This is because the upper rock tends to be more weathered and fractured than the rock at some depth below the bedrock surface, which increases the risk of instability problems and unmanageable groundwater inflows.

For the rock tunnel alternative, the available information indicates the bedrock surface is more or less flat to gently sloping in the range of Elev. 250 to 300 ft, as noted above. For a West Basin alternative, it appears that the bedrock surface along the alignment is in the range of about Elev. 280 to 300 ft, so bedrock surface elevation is unlikely to impact tunnel grade in a significant way. For an East Basin alternative, the bedrock surface declines from near Elev. 300 ft to below 250 ft, and that would affect tunnel depth and grade.

6.5.2.2 Horizontal Alignment

The primary drivers for tunnel horizontal alignment are:

- Available right-of-way or other publicly owned lands for tunnel alignment routing,
- Availability of land area for shafts and tunnel construction staging,
- Locations of existing CSOs and distances to potential drop shaft locations,
- Availability of land area for drop shafts, and
- Surrounding land uses and potential impacts on residences, businesses and traffic.

For any tunnel, the main construction shafts need to be located directly over the tunnel. At a minimum, a primary launch or mining shaft at the downstream end of the tunnel and an exit or recovery shaft at the upstream end of the tunnel are required. Both shafts should be maintained as long-term access shafts. For the range of excavated diameters being considered, the West Basin tunnel could be excavated in a single tunnel drive from the launch shaft to the recovery shaft. However, some consideration should also be given to locating a construction shaft somewhere near the middle of the alignment that could also be maintained as a long-term access shaft.

Land area for staging is required at both the launch and recovery shaft, although a larger area is required at the launch shaft. Ideally, an area in the range of 2 to 5 acres is required at the launch shaft. A smaller area in the range of ½ to 1 acre is required at the recovery shaft location. Although the drop shafts would be smaller in diameter than the tunnel construction shafts, land requirements at drop shaft locations are likely similar to requirements for the recovery shaft. The reason is that additional facilities are generally required at those locations, such as trash racks (screening), approach channel and tangential inlet.

Larger diameter rock and soft-ground tunnels can be excavated continuously provided that the alignment incorporates horizontal curves of appropriate radius. In general, a minimum radius of 1,000 ft is appropriate, although a somewhat smaller radius can be achieved if necessary to accommodate right-of-way or other property restrictions.

At a high level it appears that the noted constraints can be met for a West Basin tunnel alternative. There would be more challenge for an East Basin tunnel given that the alignment would traverse the riverfront area of the downtown.

It should also be noted that a vertical alignment that places the tunnel in soil or mixed face at drop shaft locations would likely require the shafts to be located directly over the tunnel. This is because a conventional deaeration chamber / connecting adit arrangement such as would be constructed in rock, is a difficult, costly and risky proposition in soil, particularly given the anticipated granular soils in the project area. This would also require a larger diameter shaft that would incorporate deaeration into the shaft. Although such an arrangement is being implemented for the DC Water CSO System, which is being constructed in soft ground, the

hydraulics for this arrangement have only been tested via software and physical modeling, not through real-world application.

6.5.2.3 Construction Methodologies

All of the shafts on the project would extend through soils including silts, sands and gravels. These would be unstable below the groundwater table, so all shafts would require construction methodologies incorporating positive ground support in advance of excavation and positive groundwater cutoff. Methodologies that provide these features include ground freezing, slurry diaphragm walls, secant pile walls, and potentially sheet pile walls. Such methods require specialist subcontractors and tend to be more expensive to implement than more conventional shaft excavation and support methods such as soldier piles and lagging, ribs and lagging, ribs and liner plates and similar methods. The viability of any of them for any specific shaft would depend on site-specific conditions, including the specific sequence and properties of soils, depth to rock and depth to groundwater.

For the portions of shafts in rock, it should be possible to use conventional drill-and-blast excavation methodology. Initial support can be installed as excavation proceeds, and is likely to use conventional methodologies such as rock dowels, wire mesh and shotcrete.

For reasons similar to those noted above for shafts, tunnels in soft ground or mixed face would require use of a pressurized-face tunnel boring machine (TBM). This could be a slurry-shield (STBM), Mixshield (a form of STBM) or earth pressure balance (EPBM) machine. A precast concrete segmental lining would be constructed immediately behind the TBM to provide initial and final support to the tunnel excavation as it proceeds. Any type of open- or non-pressurized-face TBM would be unsuitable.

By contrast, a rock tunnel would likely use a conventional, open-face, main-beam gripper machine. Some form of initial support would need to be installed immediately behind the TBM, and the type would be determined on the basis of site-specific information. This could range from a system of rock bolts and wire mesh to a ribs and lagging support system. The design would need to address the potential for:

1. The shale layers in the rock mass to degrade as a result of slaking or swelling behavior.
2. Significant groundwater inflows during tunneling.
3. Methane occurrence.

The definition of these issues and the determination of appropriate measures to mitigate the risks posed by them would depend on collection of site-specific subsurface information.

6.5.3 West System Tunnel Alternative Features

In general, the West tunnel alternative consisted of West WWTP expansion and a storage/transmission tunnel to replace the Pigeon Creek Relief Sewer and minimize or eliminate collection system storage basins and treatment units.

Major features of this alternative include:

- West WWTP at 60 mgd capacity
- New 7th Avenue Lift Station with a total pumping capacity of 45 mgd
- Deep storage/conveyance tunnel extending from the West WWTP to Diamond Avenue.
- Drop shafts at Diamond, Delaware, 7th Avenue, and Howell Park sites

- Consolidation sewers which:
  - Direct flow from the 6th Avenue, Dresden, and Maryland CSOs to the Delaware CSO Storage Facility
  - Direct the Franklin, Fulton, and 9th Avenue CSOs to the 7th Avenue Lift Station and CSO Control Facility
  - Utilize the existing Broadway Avenue Interceptor to convey St Joseph flows directly to the West WWTP

Project details for the tunnel associated modifications at each CSO are summarized in Figure 6-5. Details of the tunnel associated modifications at each CSO are as follows:

6.5.3.1 Diamond/Baker

- Construct a drop shaft at Diamond Avenue (CSO 025) within the existing EVLAD pump station ponding area:
  - Diamond Avenue (CSO 025) flow is diverted from the 90-inch into the tunnel drop shaft via a new diversion structure that would be located between the existing diversion structure and the levee/outfall gate control structure.
  - Baker Street (CSO 024) flow is lifted into the existing 72-inch (this pipe flows north to the existing Diamond Avenue levee pump station) via a new lift station located upstream of the levee gate.
  - Tie the existing 72-inch into the new Diamond Avenue drop shaft.

6.5.3.2 Oakley

- Construct a gravity in, gravity out storage basin on the abandoned Sonic property near the diversion structure.
- Divert flow out of the Oakly diversion structure and into the new storage basin.
- Discharge stored flow into the PCI when the West WWTP flow is less than peak design capacity and when capacity exists within PCI.
- CSO volumes that exceed the storage volume would discharge from the storage tank through a high level overflow/bypass that would connect to the existing Oakley Street (CSO 018) outfall.

6.5.3.3 6th Avenue/Dresden/Maryland/Delaware

- Construct a drop shaft under the existing baseball diamond in Lamasco Park.
- Construct a consolidation sewer that captures combined flows from 6th Avenue (CSO 017), Dresden (CSO 014), Maryland (CSO 012), and the two Delaware diversion structures (CSO 013) and conveys it to the new drop shaft.

6.5.3.4 Franklin/7th Avenue East/Fulton/9th Avenue

- Construct a new 7th Avenue Lift Station adjacent to the City's greenway trailhead on the property that lies just west of the Fulton Avenue levee pump station and just south of the Lloyd Expressway.
  - 45 mgd of pumping capacity would be constructed to pump DWF and a portion of WWF to the West WWTP.

- Construct a drop shaft adjacent to the new 7th Avenue Lift Station.
- Construct consolidation sewers that capture CSO from Franklin (CSO 016) and from 9th Avenue (CSO 020) and convey it to the proposed new 7th Avenue Lift Station.
- Flows from Fulton Avenue (CSO 006) would be conveyed to the 7th Avenue drop shaft through the existing pipe that conveys this flow.

6.5.3.5 St. Joseph Avenue (CSO 022)

- Increase the underflow pipe size at CSO 022, and install a flap gate to prevent backflow from the BAI.
- Raise the diversion structure weir to push more flow into the BAI and reduce activations at St. Joseph Avenue (CSO 022).

6.5.3.6 West WWTP/CSO 123

- Construct a new West WWTP headworks facility with 60 mgd capacity.
- Construct a new tunnel pump station to pump flows from the tunnel into the West WWTP when influent flows are less than 60 mgd.
- Tie the Broadway Avenue Interceptor into the new tunnel pump station and send flows in excess of 60 mgd to the tunnel for storage/equalization.

6.5.4 East System Tunnel Alternative Features

In general, the East tunnel alternative consisted of East WWTP expansion and a storage/ transmission tunnel to replace the Riverside Interceptor and eliminate downtown storage basins.

Major features of this alternative are presented in Figure 6-6 and include:

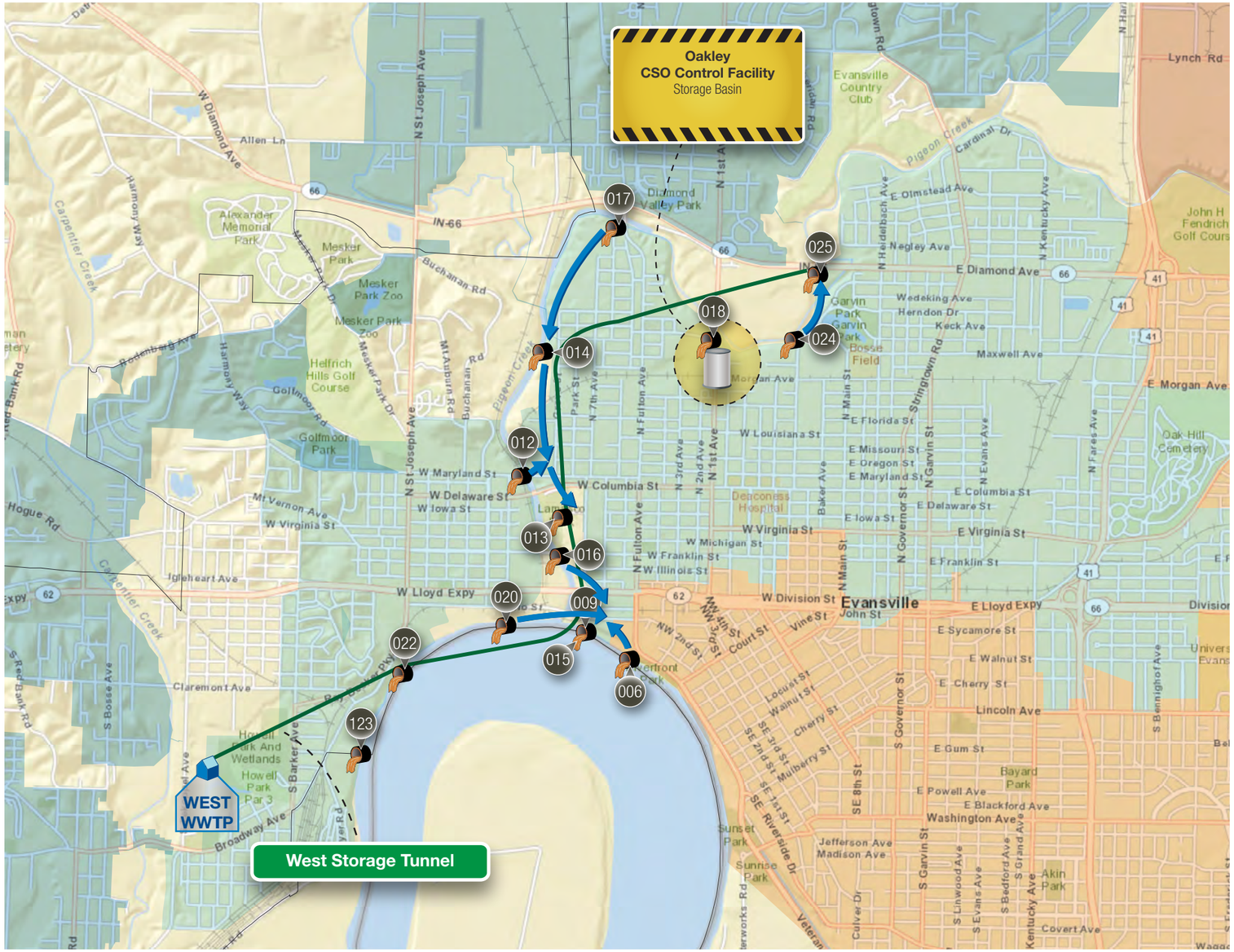
- East WWTP at 40 mgd capacity
- Deep storage/conveyance tunnel extending from the East WWTP to Dress Plaza (CSO 010).
- Drop shafts at Dress Plaza and Oak/Riverside
- Consolidation sewers that Convey flow from Chestnut to Oak/Riverside

6.6 Cost-Performance Assessment

6.6.1 West Alternative Cost-Performance

Alternative costs were calculated using CH2M HILL's PACC tool for each level of control evaluated. Figure 6-7 presents alternative costs based on annual number of activations, and Figure 6-8 presents costs based on percent capture for the West System. Similarly, Figures 6-9 and 6-10 present East System costs versus level of control.

The West 1-45 storage and HRT option is the most cost effective West System alternative on both a capital cost and life-cycle cost basis, for any level of control evaluated. For the East System, the East 3-68 storage/HRT/wetland option is the most cost effective for any particular level of control. The Utility reviewed storage, treatment, and corridor routing needs for constructability in more detail than completed during the alternative screening evaluation to validate the feasibility of each alternative. Results of this evaluation are provided in Appendix C.



CSO	Name	Receiving Water	WWTP Service Area
006	Fulton Avenue Pumping Station	Ohio River	West
009	7th Avenue West	Ohio River	West
012	Maryland Street – West Bank	Pigeon Creek	West
013	Delaware Street	Pigeon Creek	West
014	Dresden Street	Pigeon Creek	West
015	7th Avenue East	Ohio River	West
016	Franklin Street	Pigeon Creek	West
017	6th Avenue	Pigeon Creek	West
018	Oakley Street	Pigeon Creek	West
020	9th Avenue	Ohio River	West
022	St. Joseph Avenue	Ohio River	West
123	West Plan CSO	Ohio River	West
024	Baker Street	Pigeon Creek	West
025	Diamond Avenue	Pigeon Creek	West

Legend

East Service Area

- Separate Sewer Area
- Combined Sewer Area

West Service Area

- Separate Sewer Area
- Combined Sewer Area
- Tunnel Alignment

- Wastewater Treatment Plant
- CSO
- Storage Basin
- High Rate Treatment Unit
- City Limits

Activation Points	Oakley CSO Control Facility		St. Joseph CSO Control Facility			PCI Tunnel Control Facility		Total System Storage (MG)	Total System Satellite Treatment (MGD)
	Storage (MG)	Satellite Treatment (MGD)	Storage (MG)	Satellite Treatment (MGD)	Diameter (FT)	Storage (MG)	Satellite Treatment (MGD)		
4	0.6		0.6		20	58.7		59.9	
12	0.6		0.6		17	42.4		43.6	

North

FIGURE 6-5
West Tunnel
Long Term Control Plan
May 31, 2013



CSO	Name	Receiving Water	WWTP Service Area
001	Kentucky Avenue	Bee Slough	East
002	Cass Avenue	Bee Slough	East
103	Junction Box Prior to WWTP Headworks	Ohio River	East
004	Adams	Bee Slough	East
008	Chestnut Street	Ohio River	East
010	Dress Plaza	Ohio River	East
011	Weinbach Lift Station (Oakhill Road)	Pigeon Creek	East
038	Oak / Riverside	Ohio River	East

Legend

East Service Area
- Separate Sewer Area
- Combined Sewer Area

West Service Area
- Separate Sewer Area
- Combined Sewer Area
- Tunnel Alignment

- Wastewater Treatment Plant
- CSO
- Storage Basin
- High Rate Treatment Unit
- City Limits
- Wetlands

Activation Points	Kentucky CSO Control Facility		Cass Ave CSO Control Facility		Downtown Tunnel CSO Control Facility			Oakhill CSO Control Facility		Total System Storage (MG)	Total System Satellite Treatment (MGD)
	Storage (MG)	Wetlands Treatment (MG)	Storage (MG)	Satellite Treatment (MGD)	Diameter (FT)	Storage (MG)	Satellite Treatment (MGD)	Storage (MG)	Satellite Treatment (MGD)		
0		42		226	25	25.1		12		37.1	226
3		42		226	16.5	10.69		6.83		6.1	226
7		42		226	14.5	8.46		2.97		11.43	226
12		42		226	11.5	5.33		0.77		17.52	226

North

FIGURE 6-6
East Tunnel
Long Term Control Plan
May 31, 2013

renewEVANSVILLE

Figure 6-7 West Alternatives Cost Performance - Number of Activations

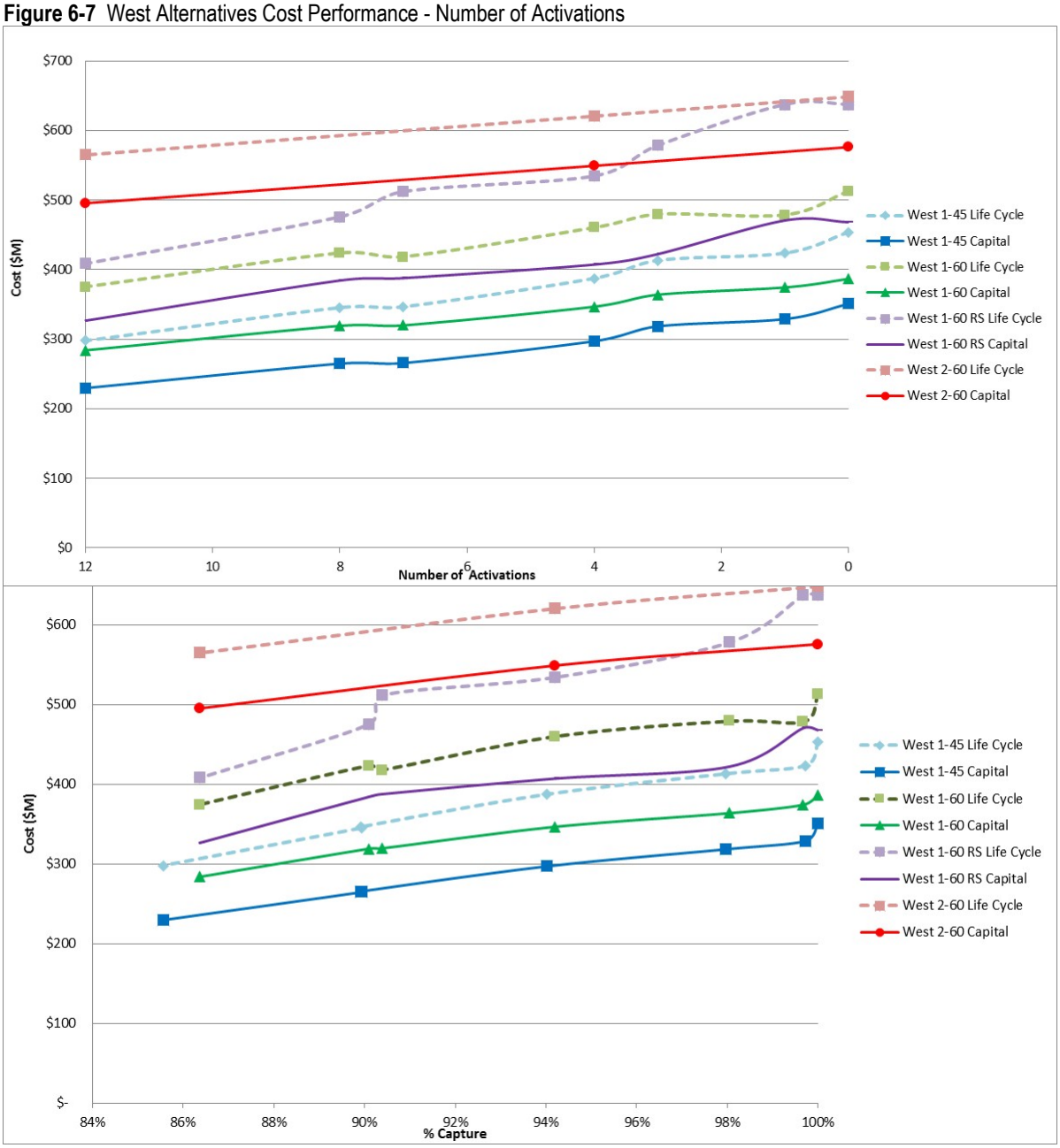
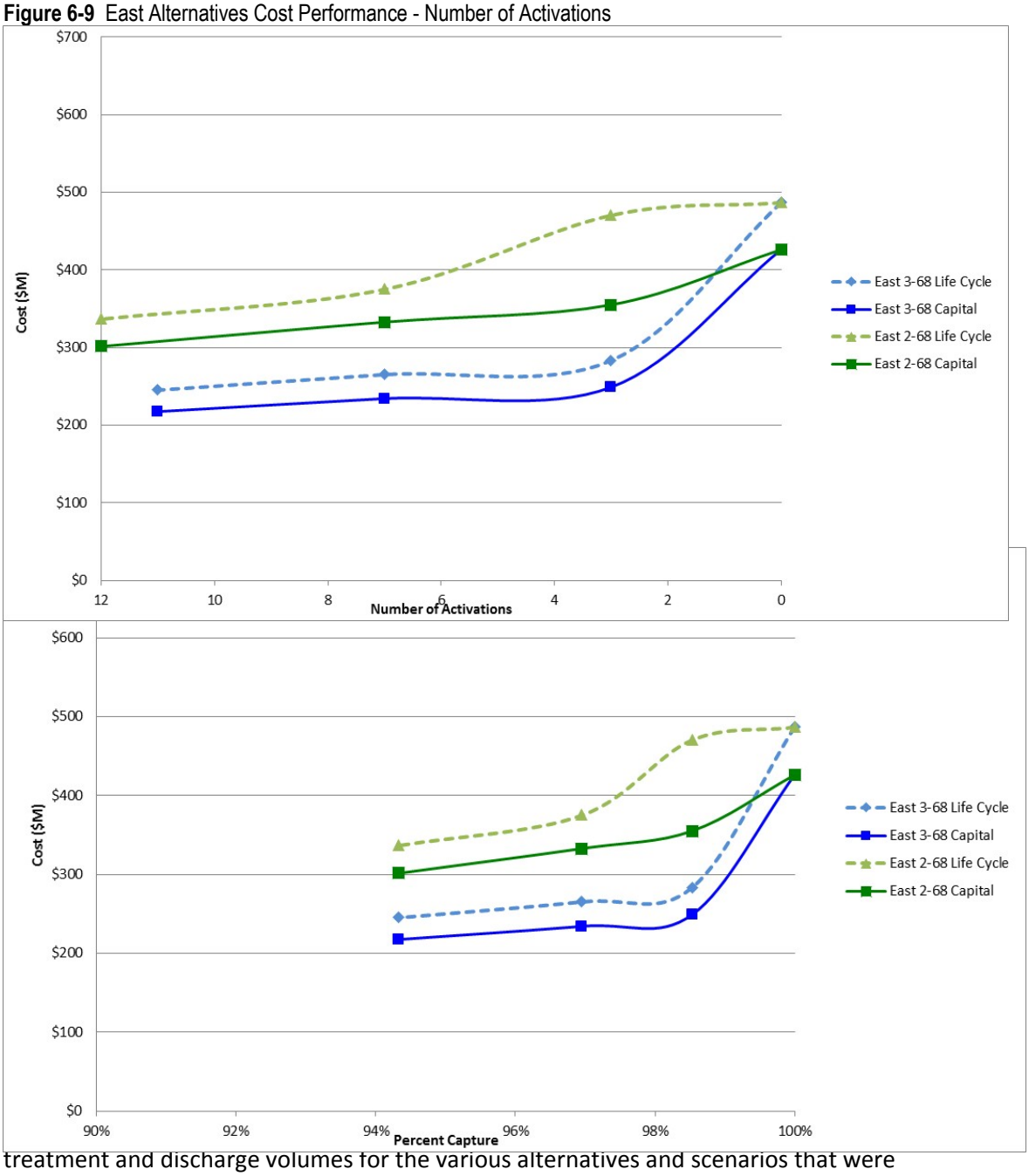


Figure 6-9 East Alternatives Cost Performance - Number of Activations



treatment and discharge volumes for the various alternatives and scenarios that were evaluated.

SECTION 7

Water Quality Modeling Assessment of CSO Control Measures

As part of the IOCP planning and prior to selection of a preferred control solution, the Utility utilized a water quality model of Pigeon Creek and the Ohio River to evaluate the in-stream bacterial *E. Coli* water quality benefits from each of the controls considered. Model development was described in the *Stream Reach Characterization and Evaluation Report* (CH2M HILL and LimnoTech, 2011). The report also determined that *E. Coli* was the only pollutant of concern needing be addressed by this LTCP.

7.1 Water Quality Assessment Overview

This section presents results of two water quality modeling analyses:

- Evaluation of one of three main control alternatives over the Typical Year at each of the levels of control required by the Decree (0, 1, 3, 4, 7, 8, and 12 activations or overflows per year [OF/yr]). The CSO controls simulated in these alternatives were the off-line storage/HRT controls. Eight CSO control scenarios were simulated in the water quality model, with control levels ranging from "no control" baseline to capture and treatment of all CSO volume (e.g., 0 activations).
- Evaluation of the in-stream water quality impact for different performance assumptions of the Bee Slough treatment wetland solution for a Typical Year storm when the capacity of the wetland is exceeded, resulting in partial treatment of a portion of the CSO flow routed into the wetland. Three scenarios that reflected full, partial, and no treatment of CSO discharges that currently discharge into Bee Slough were simulated for a 1.75-inch storm event that occurred in August 2000.

This section also describes updates that have been made to the water quality model since it was used to develop the Draft IOCP in July 2012. The model updates reflect additional water quality monitoring conducted by the Utility during the 2012 recreation season, as well as changes to applicable water quality standards between July 2012 and April 2013.

Compliance with current water quality standards was the primary factor used to evaluate results. This comparison was considered in two contexts: (1) assuming other, non-CSO sources are controlled (CSO Only) and (2) assuming no control of other, non-CSO sources. Because the Utility can only control the sources under their jurisdiction, the first approach illustrates where their individual cost-performance knee occurs. The second approach provides a more realistic representation of the limits of water quality improvement resulting from CSO control, given the levels of pollutants from sources outside the Utility's jurisdiction.

7.1.1 Typical Year Control Alternative Analysis

Model results were compared to applicable water quality standards and to water quality benefit metrics for each control alternative. Results indicate that compliance with water quality standards can be achieved in Pigeon Creek and the Ohio River at 12 OF/yr, assuming other sources are controlled (shown as the red line in Figures 7-1 and 7-2, respectively). Even if the background sources are not controlled, the model results indicate that there is little to no

additional water quality benefit (defined as additional days of recreation) at control levels greater than 12 OF/yr (shown as the blue line in Figures 1 and 2 for Pigeon Creek and the Ohio River, respectively).

Figure 7-1 Percent of Days Meeting Recreation Standard Criteria (235 CFU/100 ml) in Pigeon Creek at River Mile 0.5, Downstream of All CSOs.

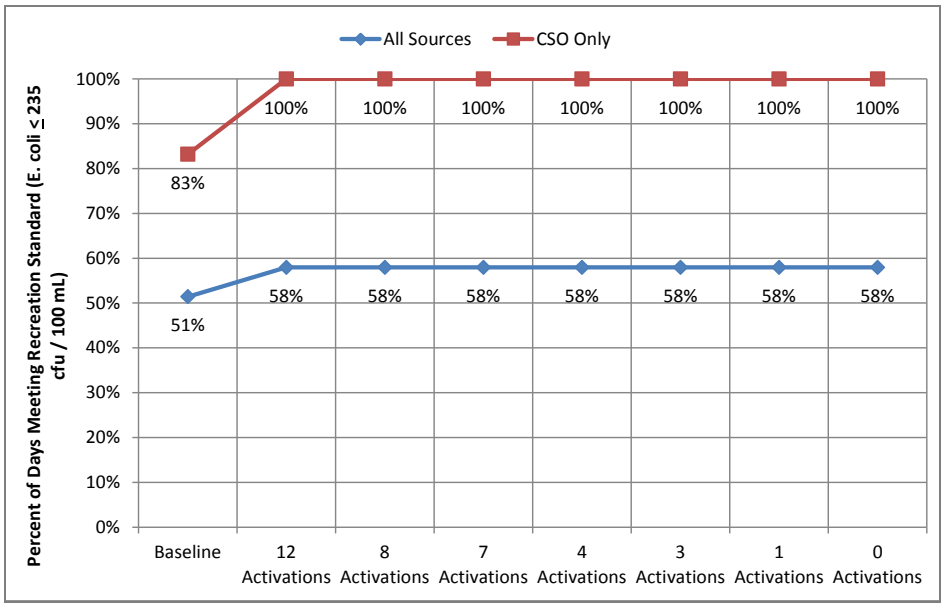
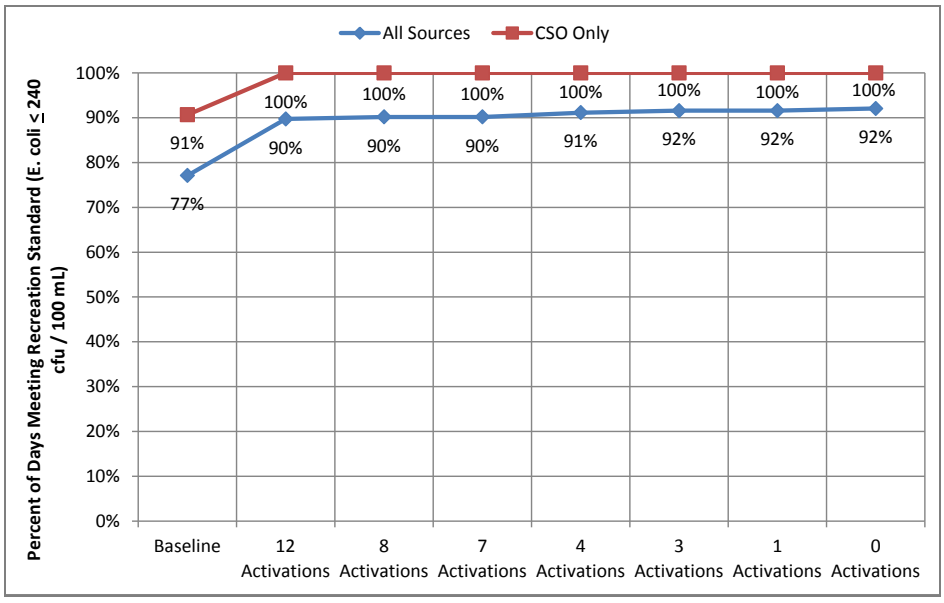


Figure 7-2 Percent of Days Meeting Recreation Standard Criteria (240 CFU/100 ml) in Ohio River at River Mile 794.5, Downstream of All CSOs and WWTPs



Recreational water quality criteria have been proposed by the EPA that allow up to 10 percent of days within a 30-day period to exceed the safe recreation level. When compared to that criterion, CSO control at 12 OF/yr is needed to ensure that CSOs alone do not cause exceedances of the numeric criteria.

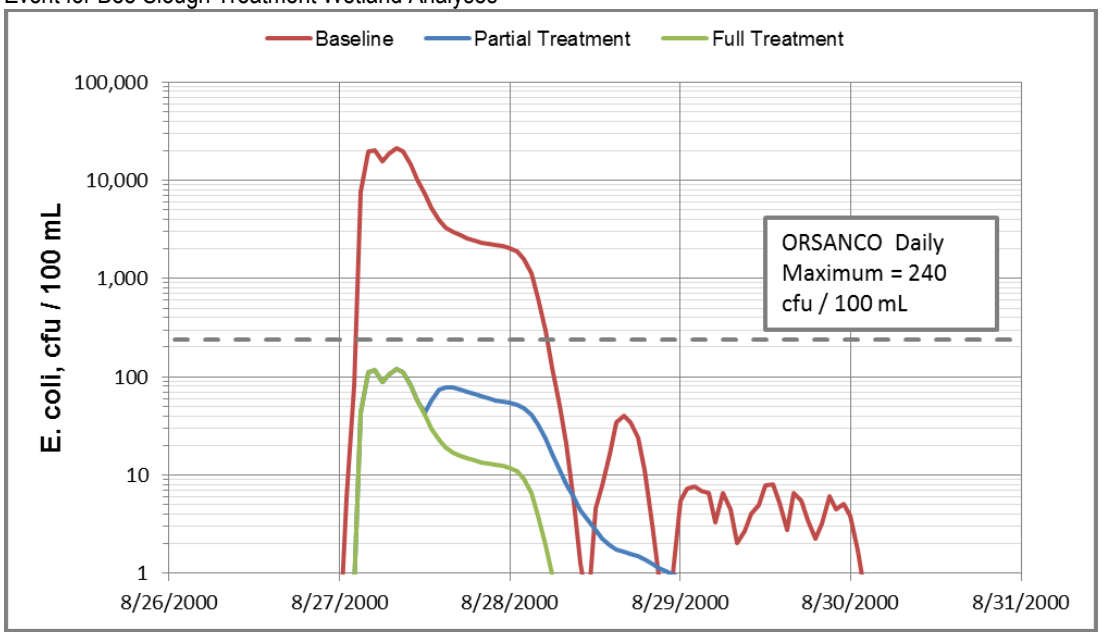
The water quality model results indicate that the maximum level of attainment to all of the criteria considered in each waterway is the same for all of the control alternatives (e.g., 12 OF/yr, 8 OF/yr, etc.). These results suggest that additional controls to further reduce CSO activations would provide little to no improvement in water quality. Further, by reducing the number of CSO activations to 12 OF/yr, the relative importance of other sources increases such that the loads from these other sources become the controlling factor in complying with the water quality standards.

7.1.2 Bee Slough Treatment Wetland Analysis

During the 1.75-inch storm event, approximately 52 MG from the CSO discharges were routed into the treatment wetland system. Modeling of the wetland configuration indicated that approximately 20 percent of the volume (10 MG) would exceed the wetland capacity. This excess volume was modeled with the water quality model assuming a reduced detention time in the wetland and half the contact time in the chlorine contact disinfection tank, corresponding to a partial treatment scenario. A full treatment scenario was also modeled assuming full 48-hour detention time in the wetland and with the design contact time of 15 minutes in the chlorine contact tank. These results were compared to a pre-IOCP baseline scenario assuming no control or treatment of the volume from the CSOs discharging to Bee Slough.

Results were evaluated for the Ohio River grid cells immediately adjacent to the Indiana shoreline, or right descending bank, as this part of the of the river would be the most affected by pollutant loads from the Utility's CSOs. Water quality model results indicated that under both the partial and full treatment scenarios, in-stream Ohio River *E. Coli* levels from the wetland control peaked at approximately 100 CFU/100 ml during this storm event, well below the "safe" recreation *E. Coli* level of 235 CFU/100 ml (Figure 7-3).

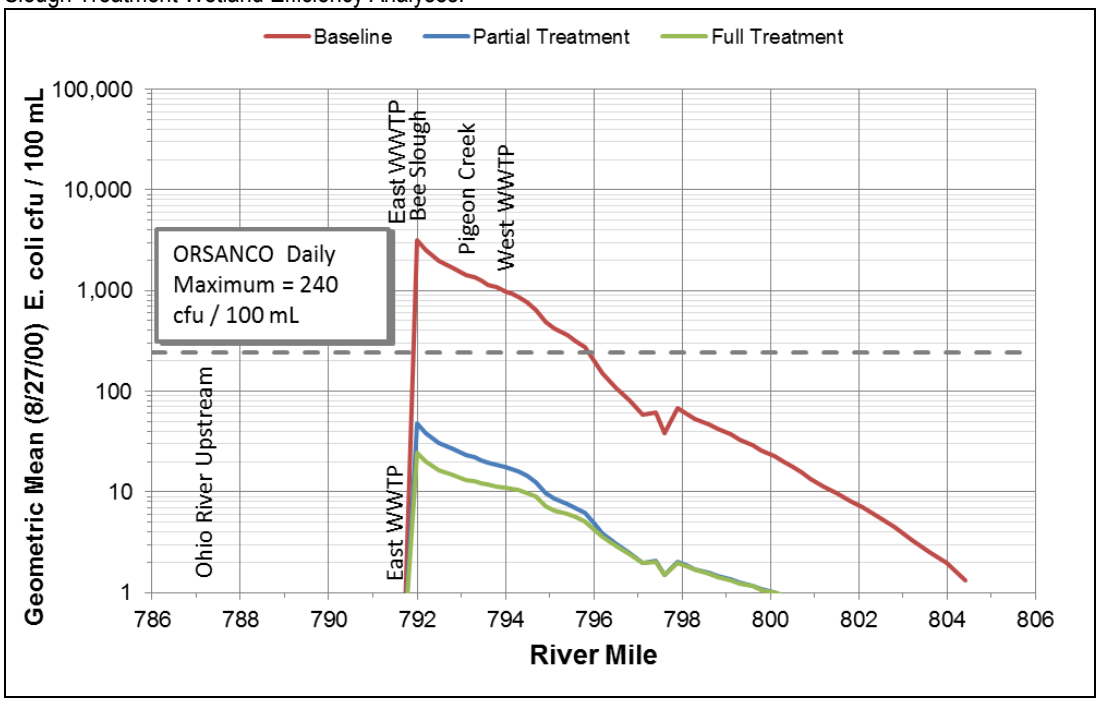
Figure 7-3 Temporal Profile of Near Shore Ohio River *E. Coli* Levels at RM 792.2 During August 27, 2000 Storm Event for Bee Slough Treatment Wetland Analyses



In-stream daily average *E. Coli* levels on the first day of the storm (when *E. Coli* loads are the largest) were approximately 50 CFU/100 ml under the partial treatment scenario and 25 CFU/100 ml under the full treatment scenario (Figure 7-4). Model results indicate that the

wetland design provides sufficient treatment so that discharges have minimal impact on Ohio River water quality conditions.

Figure 7-4 Downriver Profile of Near Shore Ohio River *E. Coli* Levels During August 27, 2000 Storm Event for Bee Slough Treatment Wetland Efficiency Analyses.



7.2 Water Quality Model Updates

The water quality model is described in detail in the Stream Reach Characterization and Evaluation Report (Evansville Water & Sewer Utility, 2011). The data and methods used to develop and calibrate the river model were used to develop the flow and bacteria density inputs for non-CSO sources (e.g. upstream and tributary sources) to the model with the updates described in this section. Consistent with the model development and calibration, the Ohio River portion of the model does not include flows or pollutant loads from tributaries or land-side sources on the Kentucky side of the river.

After the Draft IOCP was submitted in July 2012, the water quality model was updated to reflect additional water quality monitoring conducted by the Utility during the 2012 recreation season as well as changes to applicable water quality standards between July 2012 and April 2013. Other updates were made to the model inputs to reflect new rainfall sources and updates to the East and West CSS models. Table 7-1 presents a summary of the updates made to the water quality model.

Table 7-1 Water Quality Model Updates Since July 2012

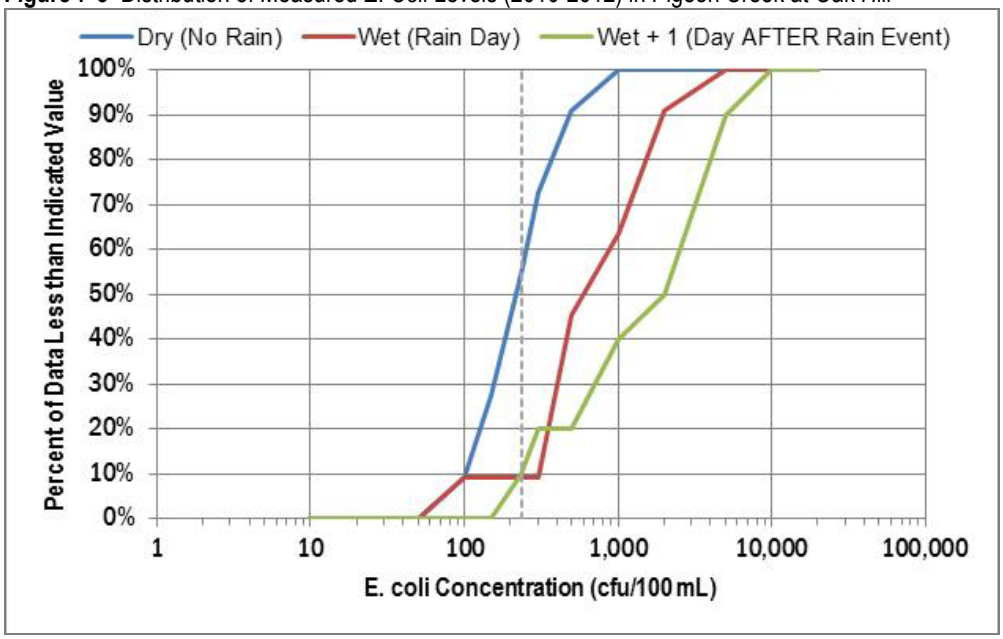
Model Input	Description of Update
Typical Year (2000) Rainfall	Using same rainfall as the infrastructure modelers. This rainfall time series differs from actual year 2000 rainfall used in the modeling for the draft IOCP by removing a February event and adding an October event.
Upstream Pigeon Creek flow	Updated to reflect new rainfall used to drive flow inputs
Tributary runoff flows	Updated to reflect new rainfall used to drive flow inputs
Upstream Pigeon Creek *E. Coli* levels	Updated to reflect Utility monitoring data from 2012 recreation season
West CSO flows	Updated to reflect results from re-calibrated West CSS model
Water quality standards	Updated to reflect 2012 Ohio River Valley Sanitation Commission (ORSANCO) Pollution Control Standards (PCS). Added EPA Recreational Water Quality Criteria (RWQC) released in November 2012 as additional standard criteria

7.2.1 Upstream Pigeon Creek *E. Coli* Levels

Between June and October 2012, the Utility conducted weekly sampling in Pigeon Creek at the Oak Hill sampling location, which corresponds to the upstream boundary of the water quality model approximately 8 miles upstream on Pigeon Creek. This location is upstream of all of the Utility's CSOs. This program was the first time that the creek's water quality was sampled on a routine basis and the program data nearly doubled the *E. Coli* dataset used to develop the upstream *E. Coli* inputs for Pigeon Creek. Samples were collected during a variety of dry and wet weather conditions, which were noted in the field notes. Results from the sampling, shown graphically in Figure 7-5, yielded two important findings:

1. *E. Coli* levels are often higher than the water quality standard criterion of 235 CFU/100 ml during dry weather. As Figure 7-5 illustrates (blue line), dry weather *E. Coli* levels entering the City exceed water quality standards approximately 50 percent of the time. This variability was incorporated into the Existing Conditions scenario.
2. Upstream wet weather loads tend to take at least a day to reach the City. As Figure 7-5 illustrates, the highest densities were measured the day AFTER a rain event (e.g., green line). This lag was incorporated into the control alternatives scenarios.

Figure 7-5 Distribution of Measured *E. Coli* Levels (2010-2012) in Pigeon Creek at Oak Hill



The monitoring data collected in Pigeon Creek indicate that upstream sources contribute significant bacteria loads to the lower portion of the creek flowing through the City. Although the Utility's 2012 data nearly doubled the upstream dataset, the relationship between the upstream loads and rainfall cannot be well characterized. Because the magnitude of upstream source loads is significant, compliance with water quality standards is sensitive to how this load is specified in the model. For the water quality modeling analyses described in this section, the upstream boundary was specified using a post--total maximum daily load (TMDL) implementation dry weather *E. Coli* density of 50 CFU/100 ml so that the model results would reflect wet weather impacts. During wet weather, the upstream *E. Coli* level was ramped up to a representative peak density of 5,000 CFU/100 ml using a lag time of 18 hours, derived from wet weather sampling data, then ramped down to the dry weather density using a -1.0 day-1 recession rate and event flow conditions.

7.2.2 Water Quality Standard Criteria Updates

To evaluate in-stream benefits of potential CSO controls, the water quality model results were compared to applicable water quality standard criteria in the draft IOCP. This approach was also used in the evaluation of control alternatives for the final IOCP; however, the water quality standards for the Ohio River have been updated to reflect the 2012 ORSANCO PCS, which were finalized in October 2012. Table 7-2 presents a comparison of the previous and current ORSANCO PCS criteria.

Table 7-2 Comparison of ORSANCO's 2011 and 2012 *E. Coli* Pollution Control Standards.

Description	2011 *E. Coli* PCS	2012 *E. Coli* PCS
Geometric Mean (GM)	30-day GM <= 130 CFU/100 ml	90-day GM <= 130 CFU/100 ml
Maximum	No sample can exceed 240 CFU/100 ml	No more than 25% of samples can exceed 240 CFU/100 ml in a 90-day period
Recreation Season	May – October	April – October

In November 2012, EPA published their final RWQC, which was a requirement under the Beaches Environmental Assessment and Coastal Health (BEACH) Act settlement between EPA and the National Resources Defense Council (NRDC) (EPA, 2012). These criteria are intended to replace EPA's 1986 criteria, which have been used as the basis for Indiana's current recreational use water quality standards. The model results were also compared to the RWQC *E. Coli* criteria, since the States will be required or encouraged to adopt them in the near future. The *E. Coli* criteria are:

- 30-day Maximum: No more than 10 percent of samples can exceed 410 CFU/100 ml in a 30-day period.
- 30-day Geometric Mean: 30-day geometric mean < 130 CFU/100 ml

Although the model results were compared to multiple measures of water quality benefit, comparison to current water quality standards were the primary factor used to evaluate the most appropriate level of control.

7.3 CSO Control Alternatives Water Quality Modeling

Because the Utility's wastewater system is divided into East and West basins, with each having their own WWTP, the Utility has developed and calibrated collection system models of each basin to simulate collection and transport of sanitary sewage and stormwater runoff to the WWTP and overflow locations. These models were applied in a continuous simulation application for a Typical Year of rainfall (2000) to produce hourly estimates of CSO volume from each of the Utility's outfalls under current existing conditions. To evaluate the performance of proposed control alternatives, the models were modified to account for population growth, sewered area expansion, and increases in WWTP peak capacities to 45 mgd (West WWTP) and 40 mgd (East WWTP) over the 20-year implementation period (e.g. 2032) specified in the Utility's Consent Decree. The scenarios evaluated under this 2032 set of conditions included a "No control" Baseline, and control alternative scenarios spanning wet weather activations at 12, 8, 7, 4, 3, 1 and 0 OF/yr (Table 7-3). The CSOs in each scenario were simulated with the offline storage/HRT control alternative.

Table 7-3 Summary of CSO Control Scenarios Evaluated with Water Quality Model

Scenario ID	West Scenario ID	West Number of Activations	East Scenario ID	East Number of Activations	Total Number of CSO Events
No Control (Baseline)	Future Baseline	40	Baseline	42	42
12 OF/Yr	45mgd_Act12	12	7A	10	12
8 OF/Yr	45mgd_Act12	8	7B	6	8
7 OF/Yr	45mgd_Act12	7	7B	6	7
4 OF/Yr	45mgd_Act12	4	7C	2	4
3 OF/Yr	45mgd_Act12	3	7C	2	3
1 OF/Yr	45mgd_Act12	1	6	1	2
0 OF/Yr	1008	0	7D	0	0

Note:
Activations for each scenario were counted using a 24-hour interevent duration and a minimum CSO volume from either system of 0.1 MG.

The water quality model of the Ohio River and lower Pigeon Creek was used to evaluate the in-stream *E. Coli* bacteria water quality benefits from each control scenario for the Typical Year period. Water quality model results in each model grid cell were compared to applicable water quality standards to:

- Identify the level of control needed to ensure that CSOs do not cause these standards to be exceeded;
- Quantify the potential benefit of CSO control within the context of other pollutant sources in the watershed; and,
- Characterize the cost versus performance of each control alternative at the locations in each waterbody most impacted by CSO pollutant loads.

Model results from the recreation season (April through October) were compared to the applicable water quality standards to protect recreation uses (Table 7-4).

Table 7-4 Summary of *E. Coli* Water Quality Standards for Pigeon Creek and Ohio River

Waterbody	Agency	Criteria Type	Evaluation Period	Numeric Value (CFU/100 ml)	Allowable Percent Exceedance[a]	Rolling Frequency (days)	Number of Evaluation Periods[b]
Ohio River	ORSANCO	Geometric Mean	90 days	130	n/a	30	5
		Maximum	90 days	240	25%	30	5
Pigeon Creek	IDEM	Geometric Mean	30 days	125	n/a	1	184
		Single Sample Maximum	1 day	235	0%	n/a	214

[a] For ORSANCO's maximum criterion, no more than 25 percent of the values evaluated within the 90 day period can exceed 240 CFU/100 ml.

For IDEM single sample maximum criteria, no daily values can exceed 235 CFU/100 ml. However, for ORSANCO, no more than 25 percent of daily values within a 90-day period can exceed 240 CFU/100 ml.

For the geometric mean criteria, all values within the 30-day or 90-day period for Pigeon Creek and the Ohio River, respectively, are used to calculate the geometric mean (GM) and the resulting GM value cannot exceed the numeric value shown in the table.

[b] The 30-day geometric mean and maximum criteria were evaluated for multiple 30-day periods by rolling forward one day starting on April 30 and ending on October 31, which results in 184 evaluation periods (note there are 214 days in Indiana and ORSANCO's recreation season). The 90-day geometric mean and maximum criteria were evaluated for multiple 90-day periods by rolling forward 30 days (approximately monthly) starting on April 30 and ending on October 31, which results in 5 evaluation periods.

Additional water quality benefit measures used to evaluate the model results are summarized in Table 7-5. Additional days of recreation are a useful factor to quantify improvements to the public and other stakeholders. The EPA RWQC were used to provide a common basis of comparison between the two waterbodies while the monthly geometric mean densities are useful as a comparison to typical compliance sampling and evaluation methods.

Table 7-5 Summary of *E. Coli* Water Quality Benefit Measures for Pigeon Creek and Ohio River

WQ Benefit	Criteria Type	Evaluation Period	Numeric Value (CFU/100 ml)	Allowable Percent Exceedance	Rolling Frequency (days)	Number of Evaluation Periods
Days of Recreation[a]	Ohio River	1 day	240	0%	n/a	214
	Pigeon Creek	1 day	235	0%	n/a	214
Monthly geometric mean density	Geometric Mean	Monthly	130	n/a	n/a	7
EPA RWQC[b,c]	Geometric Mean	30 days	130	n/a	1	184
	Maximum	30 days	235	10%	1	184

[a] The Days of Recreation measure for Pigeon Creek is the same as the Single Sample Maximum water quality standard for Pigeon Creek in Table 7-4.

[b] The 30-day geometric mean and maximum criteria were evaluated for multiple 30-day periods by rolling forward one day starting on April 30 and ending on October 31.

[c] For the EPA RWQC, no more than 10 percent of daily values within a 30-day period can exceed 235 CFU/100 ml. For the geometric mean criteria, all values within the 30-day period are used to calculate the GM and the resulting GM value cannot exceed the numeric value shown in the table.

7.3.1 Water Quality Modeling Results

Results from the CSO Control Alternatives are presented in the following subsections:

1. Bounding Analysis: The model was applied assuming no control of CSOs and complete elimination of CSOs. These two simulations bracket the range of potential improvements of the control alternatives. The effect of the CSOs alone on water quality were also evaluated by applying the model in a "CSO Only" baseline scenario.
2. Control Scenario Results: This analysis is similar to the bounding analysis with the addition of the results from each of the intermediate control alternative simulations.
3. Cost-performance Assessment: This analysis compares water quality benefit for each alternative to the associated cost of the controls in the alternative to identify the level of control that corresponds to the "knee of the curve" or most cost-effective solution.

Model outputs were compared to current water quality standards and to other measures of water quality benefit, such as additional days of recreation. Compliance with water quality standards is evaluated in two contexts: (1) assuming other, non-CSO sources are controlled (CSO Only) and (2) assuming no control of other, non-CSO sources. Because the Utility can only control the sources under their jurisdiction, the first approach illustrates where their individual cost-performance knee occurs. The second approach provides a more realistic representation of the limits of water quality improvement resulting from CSO control, given the levels of pollutants from sources outside the Utility's jurisdiction.

7.3.1.1 Bounding Analysis

The first step in evaluating the control alternatives was to define the range of possible improvements in water quality using a bounding analysis approach. For this analysis, different combinations of bacteria sources were isolated and evaluated with the water quality model over the Typical Year. The scenarios included a "No control" Baseline (Baseline) that included CSO and other (upstream and tributary) sources, a CSO Only version of the Baseline that only included CSO loads, and a 0 CSO Activations (No CSO) version of the Baseline that only included loads from upstream and tributary sources. These scenarios were simulated with the water quality model and compliance

with applicable water quality standards in each waterbody was tallied. Results are shown in Figures 6 and 7 for the Ohio River, and Figures 8 and 9 for Pigeon Creek. Results for the Ohio River are shown for the grid cells immediately adjacent to the Indiana shoreline, or right descending bank, as this part of the river will be the most affected by pollutant loads from the Utility's CSOs.

Figure 7-6 Compliance with ORSANCO 90-day Maximum Criterion (240 CFU/100 ml) Along the Right Descending Bank of the Ohio River

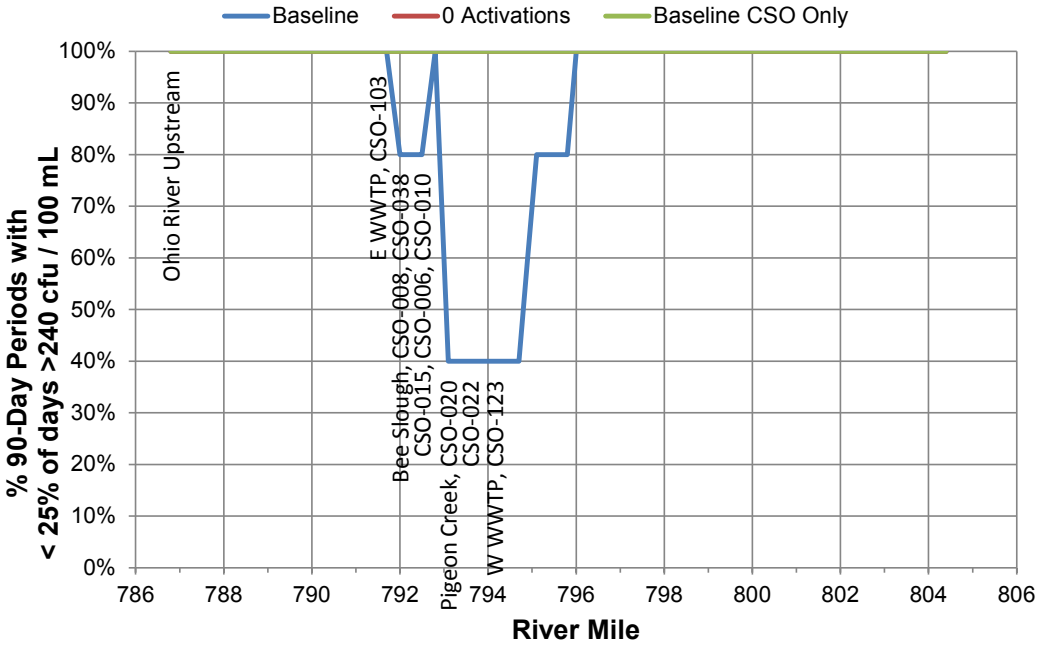
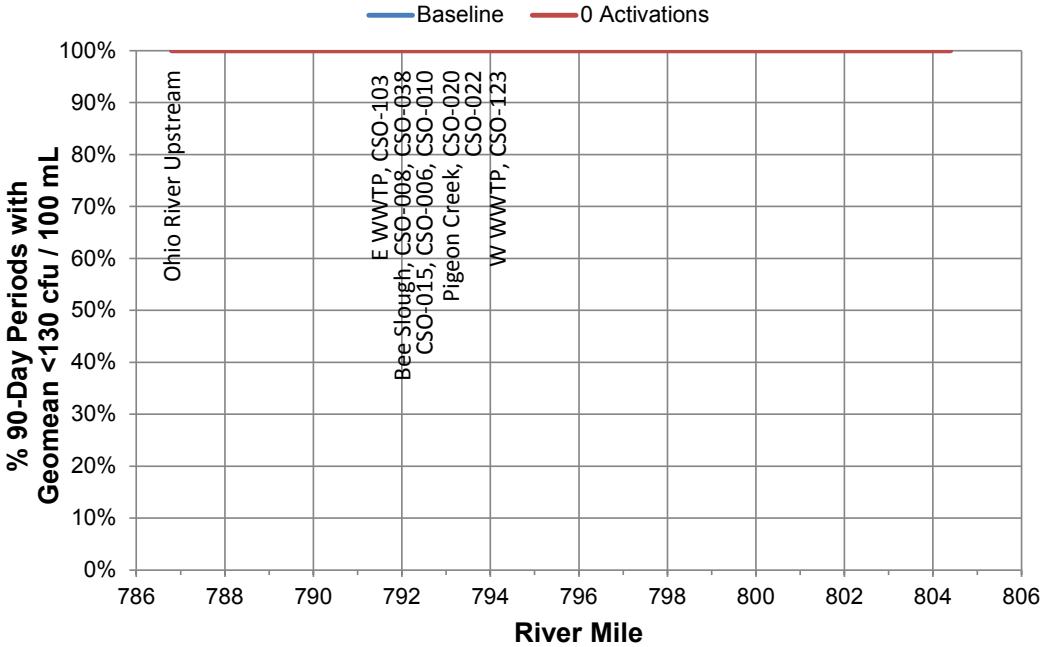


Figure 7-7 Compliance with ORSANCO 90-day Geometric Mean Criterion (130 CFU/100 ml) Along the Right Descending Bank of the Ohio River.*



(*Because CSOs are intermittent sources that discharge infrequently during any given 30-day period, the calculation of a geometric mean is confounded by the large number of 0 values used in the calculation that correspond to days when the CSOs are not discharging. Therefore, results for the CSO Only scenario were not included in this figure.)

Figure 7-8 Compliance with Indiana Single Sample Maximum Criterion (235 CFU/100 ml) in Pigeon Creek.

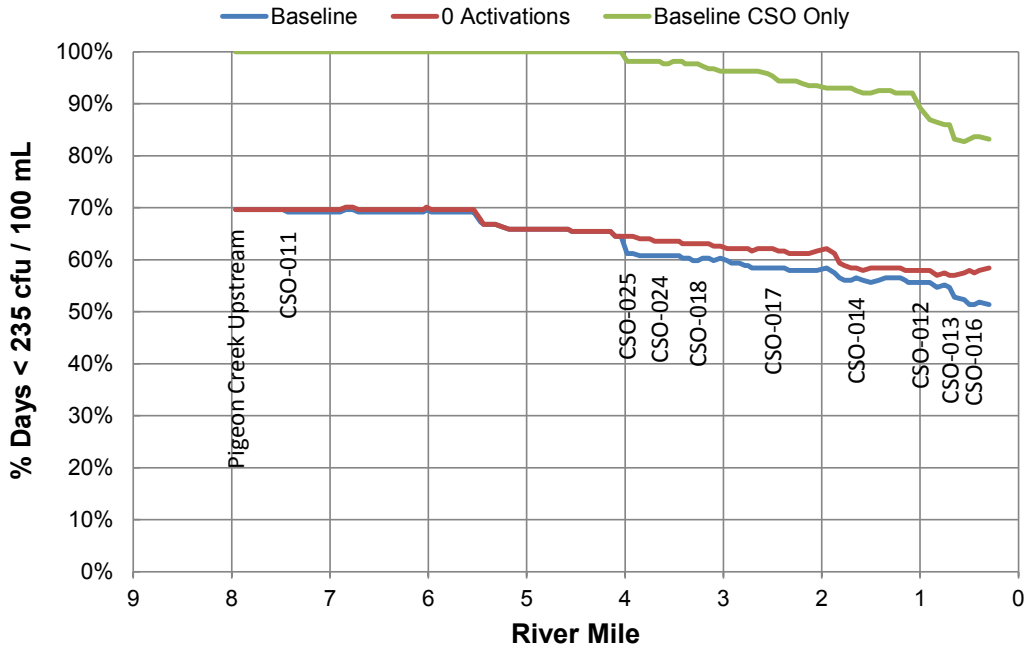
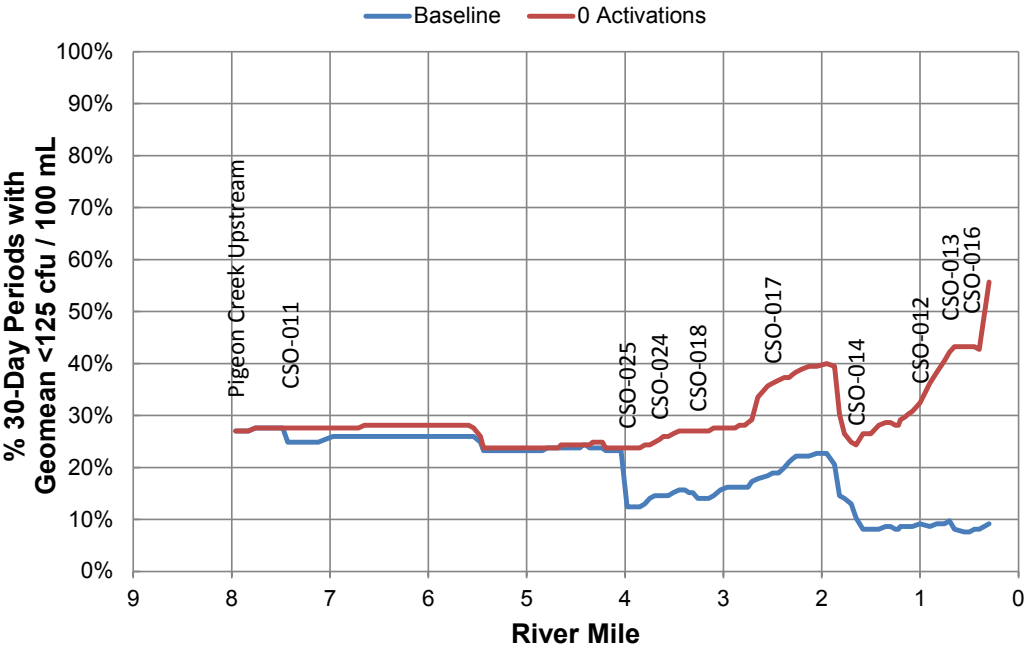


Figure 7-9 Compliance with Indiana Geometric Mean Criterion (125 CFU/100 ml) in Pigeon Creek.



(*Because CSOs are intermittent sources that discharge infrequently during any given 30-day period, the calculation of a geometric mean is confounded by the large number of 0 values used in the calculation that correspond to days when the CSOs are not discharging. Therefore, results for the CSO Only scenario were not included in this figure.)

Inspection of the No Control Baseline results (blue line in each figure) indicates:

- The Ohio River meets the 90-day geometric mean criterion without any additional CSO control (Figure 7-7).

- Pigeon Creek is more sensitive to the geometric mean criterion (less than 30 percent of the 30-day periods in the recreation season meet this criterion (Figure 7-9) while 50-70 percent of the days meet the single sample maximum criterion (Figure 7-8).
- The Ohio River is more sensitive to the 90-day maximum criterion (Figure 7-6) because compliance tends to be worse downstream with this criterion than with the 90-day geometric mean criterion (Figure 7-7); however, there are a limited number of evaluation periods because the criteria period spans nearly half of the recreation season.

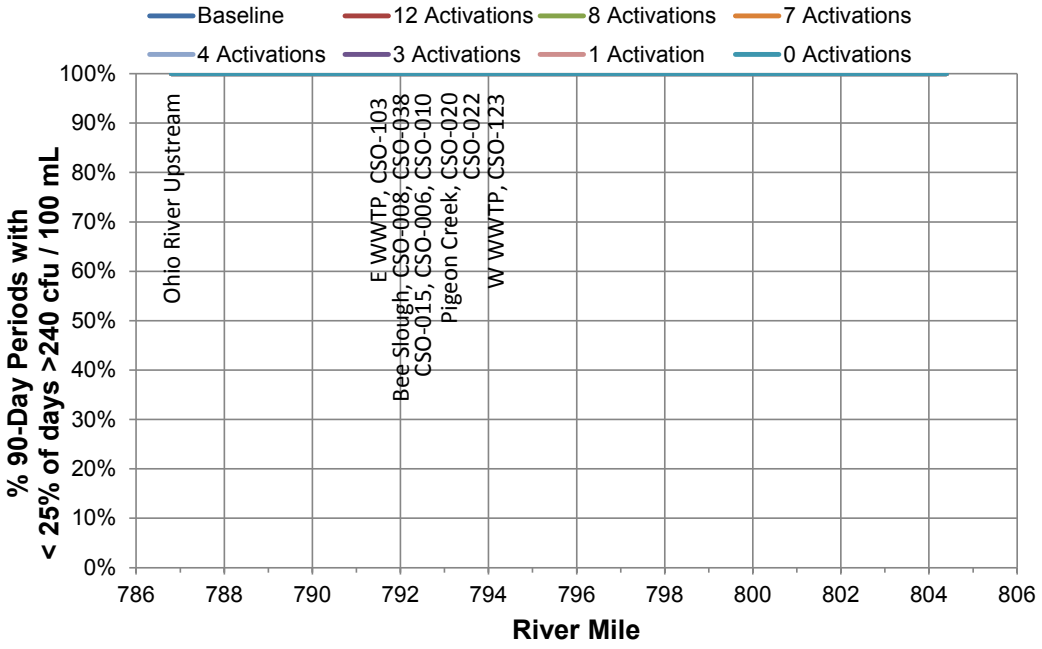
Key points from evaluating the No CSO (0 activations) and CSO Only analyses (red line and green line, respectively) include:

- Water quality in the Ohio River improves by roughly the same amount if CSOs are eliminated OR if upstream sources are controlled.
- In Pigeon Creek, water quality is affected by bacteria loads from the Utility's CSOs as well as upstream sources. However, as Figure 7-8 illustrates, the difference between the Baseline scenario results (blue line) and the CSO Only (green line) and No CSO (red line) scenarios suggests that more benefit (e.g. more river miles of improvement, higher compliance rate with water quality standards) can be achieved from reducing loads from upstream sources.
- More improvement in compliance with the geometric mean criterion than with the single sample maximum criterion can be achieved in Pigeon Creek if CSOs were eliminated. This suggests that compliance with the single sample maximum criterion is more dependent on non-CSO loads than compliance with the geometric mean criterion.
- The incremental benefit in water quality from CSO elimination, assuming other sources remain at current loads is, at best, 15 additional days of compliance with the single sample maximum criterion in Pigeon Creek and 3 additional 90-day periods of compliance with the 90-day maximum criterion in the Ohio River (of five 90-day periods evaluated using a 30-day or approximately monthly rolling frequency).

7.3.1.2 Control Scenario Results

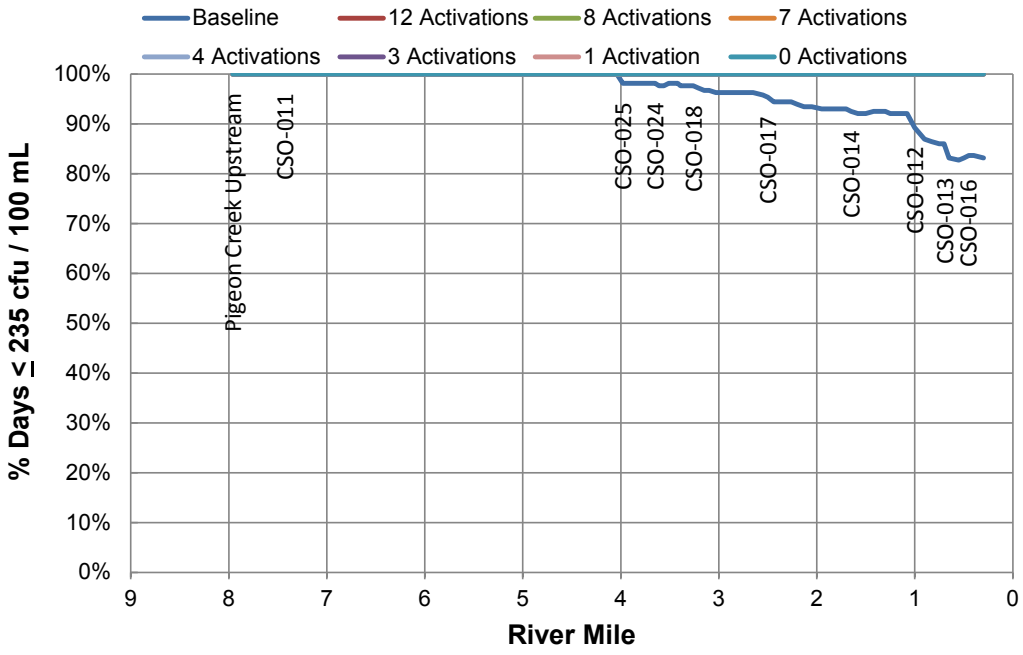
The Baseline and control alternative scenarios were simulated in the model so that the effect of the Utility's CSOs alone on in-stream water quality could be evaluated in addition to the overall in-stream water quality resulting from the impact of all pollutant sources. The "CSO only" water quality results were compared to each waterbody's maximum criterion. Results are shown in Figure 7-10 (Ohio River) and Figure 7-11 (Pigeon Creek) for the Baseline and the seven control levels spanning the range of activations considered in the set of alternatives.

Figure 7-10 Compliance with ORSANCO 90-day Maximum Criterion in Ohio River Right Descending Bank*



*Assuming loads from other, non-CSO sources are controlled.

Figure 7-11 Compliance with Indiana's Single Sample Maximum Criterion in Pigeon Creek*



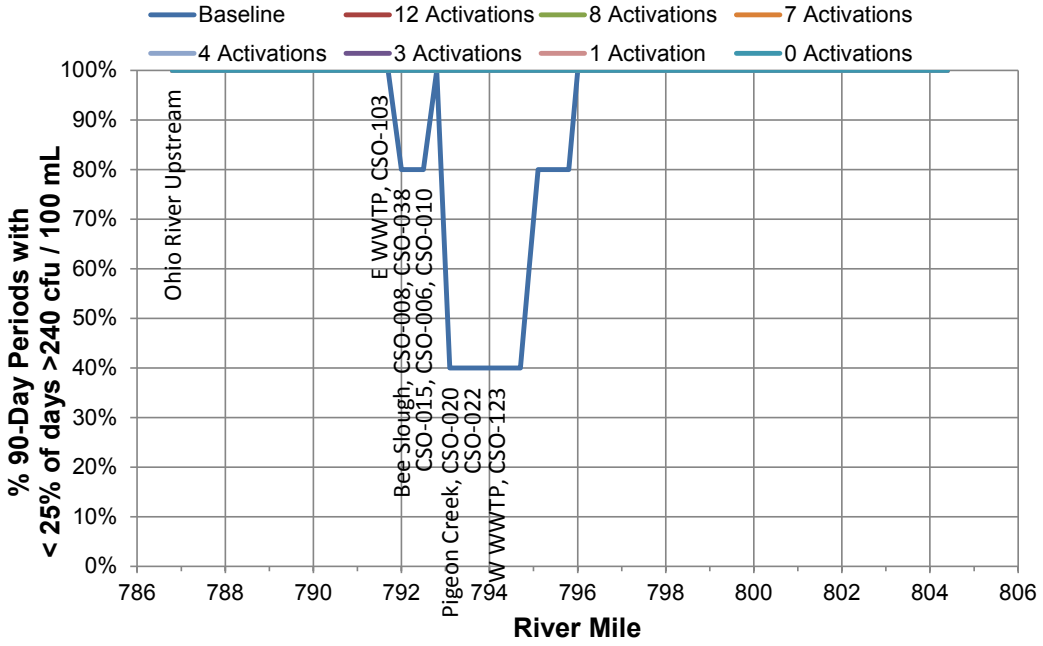
*Assuming loads from other, non-CSO sources are controlled.

Results indicate that CSO loads alone do not impact compliance with either ORSANCO water quality standards for the Ohio River. Results indicate that CSO loads alone significantly affect compliance with water quality standards in the lower four (4) miles of Pigeon Creek under the Baseline scenario. At 12 OF/yr, both waterbodies comply with the respective maximum criteria

100 percent of the time. Going to higher levels of control (e.g., 8 OF/yr, 7 OF/yr, 4 OF/yr, 3 OF/yr, 1 OF/yr) naturally also results in full compliance but at higher cost.

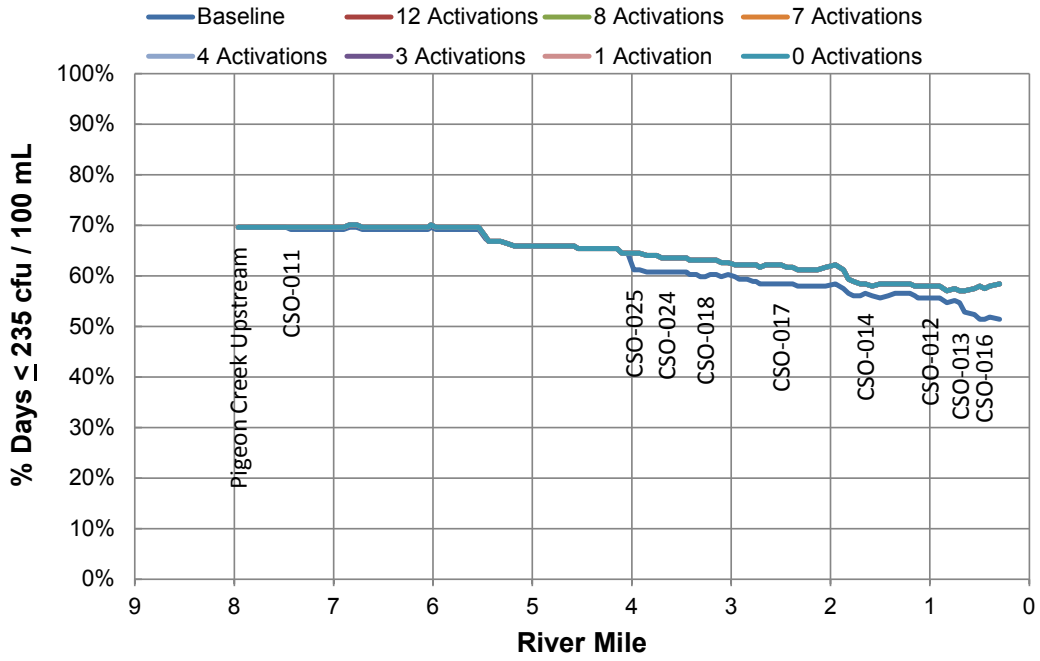
Results for the model simulations that assumed no control of background sources indicate that the maximum level of attainment of the maximum criteria in each waterway is the same for all of the control alternatives (e.g., 12 OF/yr, 8 OF/yr, etc.), as shown in Figure 7-12 for the Ohio River and Figure 7-13 for Pigeon Creek. These results suggest that reducing the number of CSO activations to 12 OF/yr increases the relative importance of other sources such that the loads from these other sources become the controlling factor in complying with the water quality standards.

Figure 7-12 Compliance with ORSANCO 90-day Maximum Criterion in Ohio River Right Descending Bank*



*Assuming loads from other, non-CSO sources are NOT controlled.

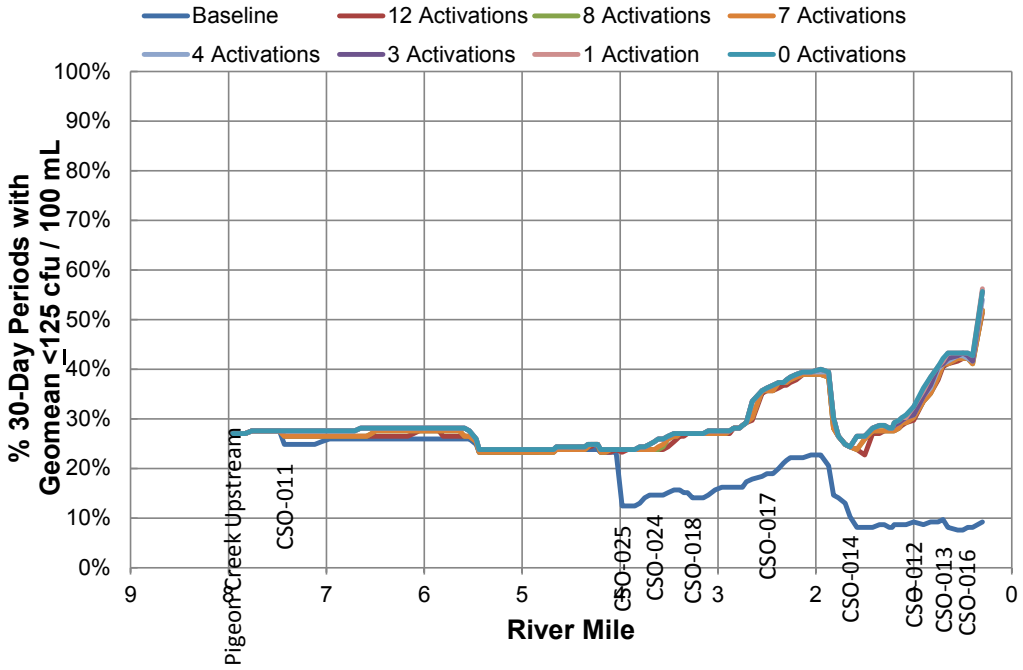
Figure 7-13 Compliance with Indiana's Single Sample Maximum Criterion in Pigeon Creek*



**Assuming loads from other, non-CSO sources are NOT controlled.*

Figure 7-14 shows compliance with Indiana's 30-day geometric mean water quality standard criterion in Pigeon Creek for each of the control alternatives. The largest improvement occurs between the baseline no control scenario and the 12 OF/Yr scenario. At higher control levels, some areas of the creek show minor improvements (<2 percent) in compliance. However, as with the compliance results for the maximum criteria, when CSO activations are reduced to 12 or fewer per year, the loads from other sources appear to be the more controlling factor in complying with the water quality standards than CSO discharges.

Figure 7-14 Compliance with Indiana's Single Sample Maximum Criterion in Pigeon Creek*



*Assuming loads from other, non-CSO sources are NOT controlled.

Model results were also compared to other water quality benefit metrics for each control alternative. Days of compliance with "safe" recreation levels is a measure of benefit that is useful for communicating results to the public and other non-technical stakeholders. Daily average model results indicate that these safe levels can be achieved on all days in Pigeon Creek and the Ohio River at 12 OF/yr, assuming other sources are controlled (shown as the red line in Figure 7-15 and 16, respectively). Even if the background sources are not controlled, the model results indicate that there is little to no additional water quality benefit (defined as additional days of recreation) at control levels greater than 12 OF/yr (shown as the blue line in Figures 7-15 and 7-16 for Pigeon Creek and the Ohio River, respectively).

Figure 7-15 Percent of Days Meeting Recreation Standard Criteria (235 CFU/100 ml) in Pigeon Creek Downstream of All CSOs

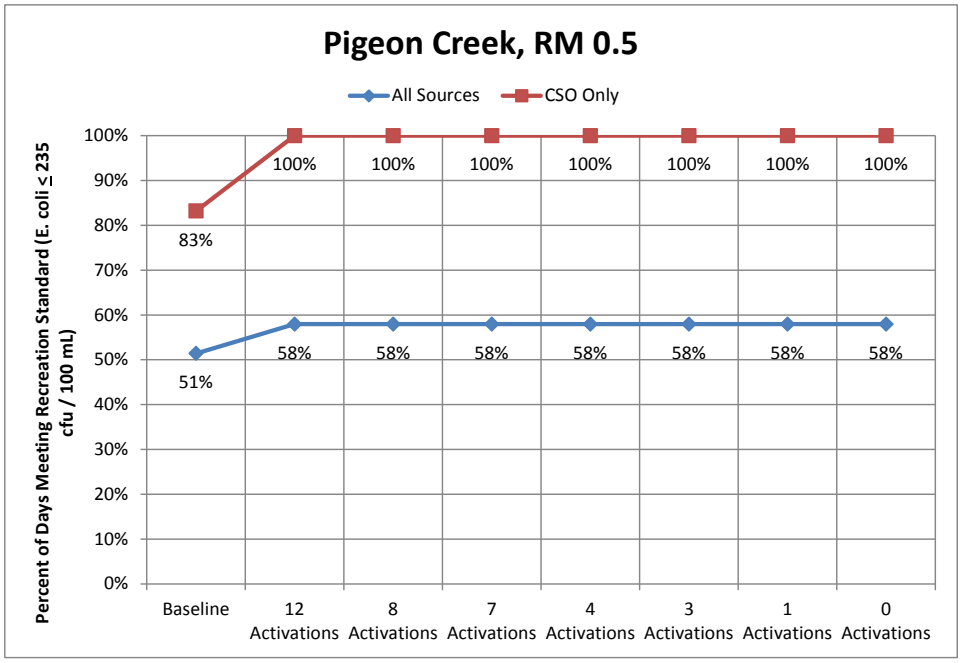
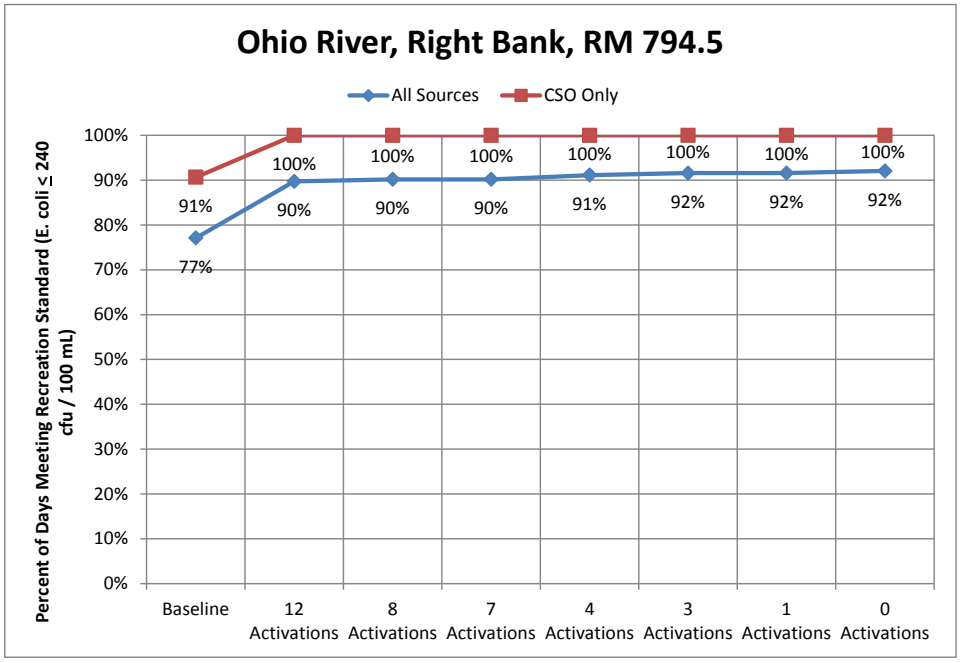


Figure 7-16 Percent of Days Meeting Recreation Standard Criteria (240 CFU/100 ml) in Ohio River Downstream of All CSOs and WWTPs.



Monthly geometric mean results for each control scenario are summarized in Table 7-6 for the Ohio River and Table 7-7 for Pigeon Creek. This measure of water quality benefit approximates a sampling strategy used to evaluate compliance with the numeric value of the geometric mean criteria and watershed impairment assessments required under the 305(b) portion of the CWA. Model results were compared to a typical 30-day geometric mean numeric criterion of 130 CFU/100 ml to determine whether there is a specific level of control that results in more months of compliance. These results were based on the model configuration that assumed

background sources were not controlled. Results are shown for the Ohio River at river mile 794.5, downstream of all of the Utility's CSOs. Results are shown for Pigeon Creek at river mile 0.5, downstream of all of the Utility's CSOs.

Table 7-6 Summary of Monthly *E. Coli* Geometric Mean Densities (CFU/100 ml) in the Ohio River at River Mile 794.5

Scenario ID	April	May	June	July	August	September	October
No Control (Baseline)	141	87	114	56	143	47	27
12 OF/Yr	130	57	64	38	65	20	19
8 OF/Yr	130	57	63	38	63	20	18
7 OF/Yr	130	57	63	38	63	20	18
4 OF/Yr	130	57	62	37	60	19	18
3 OF/Yr	130	57	62	37	60	19	18
1 OF/Yr	130	57	61	37	60	19	18
0 OF/Yr	130	57	60	37	60	19	18

Table 7-7 Summary of Monthly *E. Coli* Geometric Mean Densities (CFU/100 ml) in the Pigeon Creek at River Mile 0.5

Scenario ID	April	May	June	July	August	September	October
No Control (Baseline)	324	441	177	128	267	193	88
12 OF/Yr	120	257	135	105	196	148	78
8 OF/Yr	120	257	135	105	195	149	77
7 OF/Yr	120	257	135	105	195	149	77
4 OF/Yr	120	257	134	104	190	148	77
3 OF/Yr	120	257	133	104	190	145	77
1 OF/Yr	120	257	131	104	190	144	77
0 OF/Yr	120	257	130	104	190	144	77

Comparison of the values in the two tables shows that the Ohio River water quality is very good, with *E. Coli* densities most months well below the typical 130 CFU/100 ml numeric criterion. For all of the CSO control activation scenarios, none of the monthly geometric mean values exceed 130 CFU/100 ml. There is a measurable ($\geq$1 CFU/100 ml) change in the monthly geometric mean density for only a few months and scenarios. The month of June had the highest rainfall of all of the months in the recreation season and shows the most sensitivity to increasing levels of control, with the monthly geometric mean going from 64 CFU/100 ml at 12 OF/yr to 60 CFU/100 ml at 0 OF/yr.

In contrast, monthly geometric mean densities in Pigeon Creek exceed the 130 CFU/100 ml numeric for five of the seven months evaluated for the Baseline (No control) scenario. Only one more month (April) had a monthly geometric mean density less than 130 CFU/100 ml at CSO

activation levels between 12 OF/yr and 1 OF/yr. At 0 OF/yr, the month of June is right at the numeric criterion. Inspection of the change in monthly densities at the different control levels show that differences are fairly small, typically less than 5 CFU/100 ml, between the control scenarios. ***These results suggest that there is little to no additional water quality improvement that results from increasing the level of CSO control beyond 12 OF/yr.***

7.3.1.3 Cost-Performance Analysis

The performance of each control alternative was evaluated by comparing the water quality benefit to the cost for each control scenario. The costs are summarized in Table 7-8. The model results of days compliance with "safe" recreation levels (235 CFU/100 ml) was used as the performance or benefit basis for the Pigeon Creek graph and the ORSANCO maximum PCS criterion of 240 CFU/100 ml was used as the performance for the Ohio River graph. The Pigeon Creek water quality performance metric is also the Indiana's single sample maximum. Because CSOs are intermittent sources that discharge infrequently during any 30- or 90-day period, comparison to current ORSANCO PCS criteria or to geometric mean criteria are confounded by the large number of zero values used in these calculations that correspond to days when the CSOs are not discharging. Therefore, the single sample maximum criteria are more appropriate for evaluating the effects of CSOs in a cost-performance analysis. Results are shown for model results with all sources active and with background sources controlled.

Table 7-8 Summary of Control Alternative Costs in Millions of Dollars

Scenario ID	West Scenario ID	West Capital Cost ($M)	East Scenario ID	East Capital Cost ($M)	Total Capital Cost ($M)
No Control (Baseline)	Future Baseline	$0	Baseline	$0	$0
12 OF/Yr	45mgd_Act12	$229.7	3-68-12	$217.5	$447.2
8 OF/Yr	45mgd_Act8	$264.8	3-68-7	$234.2	$499.0
7 OF/Yr	45mgd_Act7	$265.8	3-68-7	$234.2	$500.0
4 OF/Yr	45mgd_Act4	$297.1	3-68-3	$248.9	$546.0
3 OF/Yr	45mgd_Act3	$318.5	3-68-3	$248.9	$567.4
1 OF/Yr	45mgd_Act1	$329.0	3-68-0	$426.2	$755.2
0 OF/Yr	45mgd_Act0	$350.7	3-68-0	$426.2	$776.9

Results are shown in Figure 7-17 near the mouth of Pigeon Creek and Figure 7-18 at river mile 794.5 in the Ohio River, just downstream of the EWSU West WWTP. The cost-performance graphs were used to identify the most cost-effective level of control, which is at 12 OF/yr in both waterbodies.

Figure 7-17 Pigeon Creek Water Quality Standard Compliance versus Scenario Cost at River Mile 0.5.

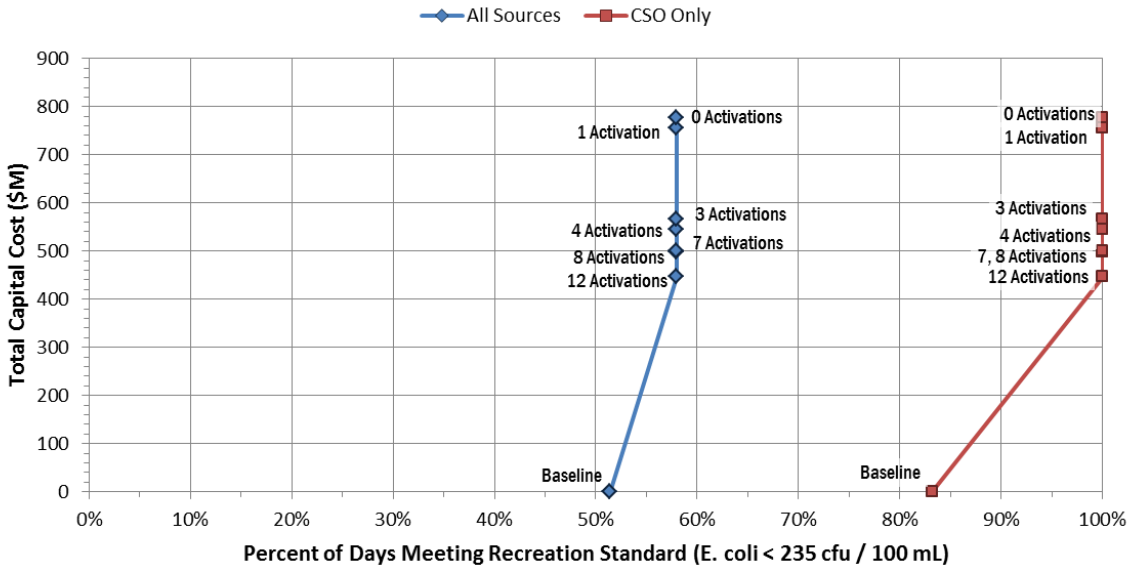
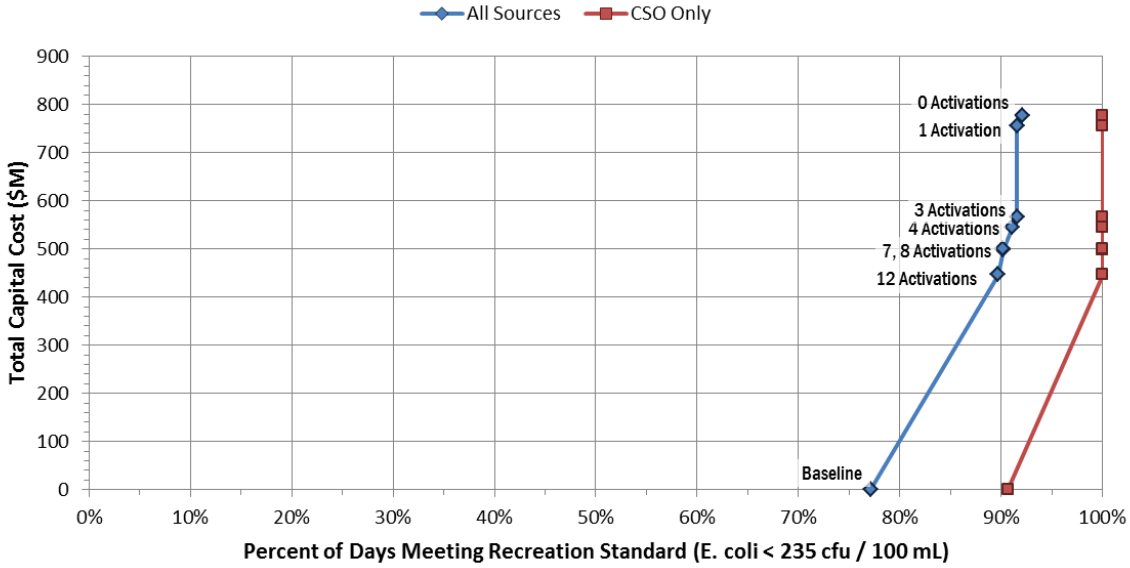


Figure 7-18 Ohio River Compliance with Maximum Criterion versus Scenario Cost at River Mile 794.5.



7.4 Bee Slough Treatment Wetland Modeling Analysis

The Bee Slough has been identified as a priority area by the Utility, based on stakeholder input and the potential public health risk posed by untreated CSO discharges into the open channel of the slough. The IOCP preferred alternative addresses the volume from the CSOs discharging to the slough by routing that flow into a treatment wetland, then into a chlorine contact tank for disinfection prior to discharge into the Ohio River. The wetland has a 43-MG capacity while the chlorine contact tank is sized to provide a 15-minute contact time for disinfection. There are seven storms in the Typical Year where the CSO volume exceeds the 43-MG capacity. Although all of the discharge volume from the CSOs would be routed through the wetland-disinfection treatment process, some of the volume during these seven storms would not receive full treatment as designed. The purpose of this water quality modeling analysis was to evaluate the

relative impact on the Ohio River resulting from different treatment levels applied to the excess CSO volume.

Of the seven storms considered for this analysis, the August 27 event was selected for this analysis for the following reasons:

1. This is one of the top three storms during the recreation season;
2. This storm has a critical combination of conditions – a large rainfall (1.75 inches) over a short period of time (9 hours) – that provide the most stress on the wetland/disinfection control solution;
3. August is a period when people are likely to be using the river for recreation;
4. Ohio River and tributary flows tend to be lower in late summer than during other parts of the recreation season and so has less dilution than during other periods in the recreation season.

During this storm event, 52 MG of CSO discharge was simulated with the collection system model. A model of the wetland indicated that approximately 10 MG of this CSO discharge exceeded the capacity of the wetland and would receive partial treatment, such as reduced contact time in the disinfection portion of the control. Three scenarios were simulated with the model:

1. No treatment of the Bee Slough CSO volume (Baseline)
2. Partial treatment of the excess flow
3. Full treatment of all of the flow

To set the full and partially treated effluent densities, literature sources were used to identify appropriate treatment efficiencies in both the wetland and the chlorine contact tank. Bacteria removal rates cited in the literature for treatment wetlands range from 25 percent - 75 percent, though higher and lower rates have also been reported. The median removal rate from a literature review was 65 percent (LimnoTech, 2011). For this analysis, a more conservative removal rate of 50 percent was assumed for the wetland portion of the control. Disinfection efficiency in the chlorine contact time were calculated the following equation (Metcalf and Eddy):

$$N/N_o = [1+(0.23)(Cr)(t)]^{-3}$$

where

N = effluent density, CFU/100 ml
N_o = influent density, CFU/100 ml
Cr = Disinfectant (Cl-) concentration, 1 mg/L
t = contact time, minutes

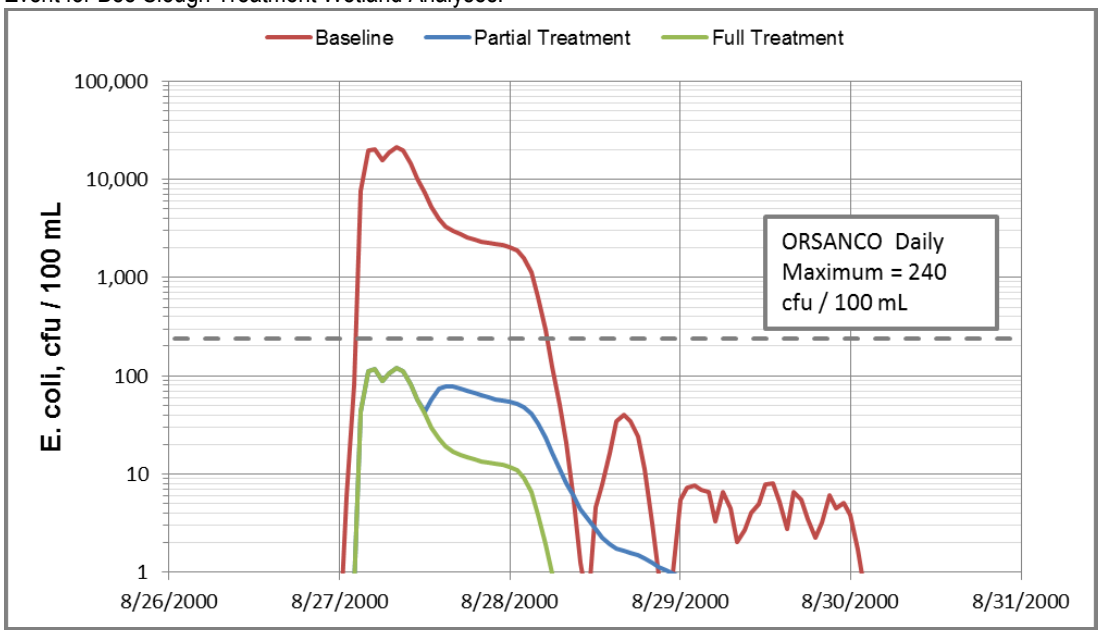
Table 7-9 presents a summary of the assumptions used in each scenario and the resulting effluent densities.

Table 7-9 Summary of Bee Slough Treatment Wetland Sensitivity Analyses.

Scenario	Influent *E. Coli* Density (CFU/100 ml)	Wetland Removal Treatment Efficiency (%)	Disinfection Contact Time (min)	Effluent *E. Coli* Density (CFU/100 ml)
Baseline (No control)	1,200,000	na	na	1,200,000
Partial Treatment	1,200,000	50%	7.5	30,000
Full Treatment	1,200,000	50%	15	6,800

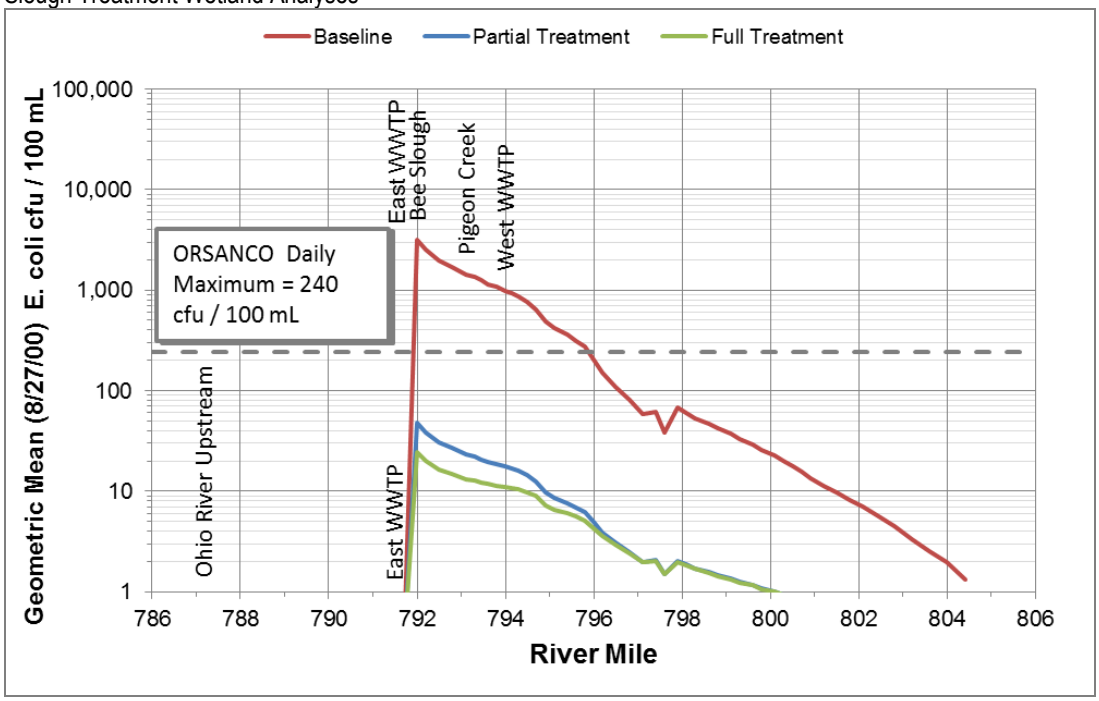
Model results indicate that the wetland design provides sufficient treatment to have minimal impact on Ohio River water quality conditions. Under both the partial and full treatment scenarios, in-stream Ohio River *E. Coli* levels from the wetland control peaked at approximately 100 CFU/100 ml during this storm event, well below the "safe" recreation *E. Coli* level of 235 CFU/100 ml (Figure 7-19).

Figure 7-19 Temporal Profile of Near Shore Ohio River *E. Coli* Levels at RM 792.2 During August 27, 2000 Storm Event for Bee Slough Treatment Wetland Analyses.



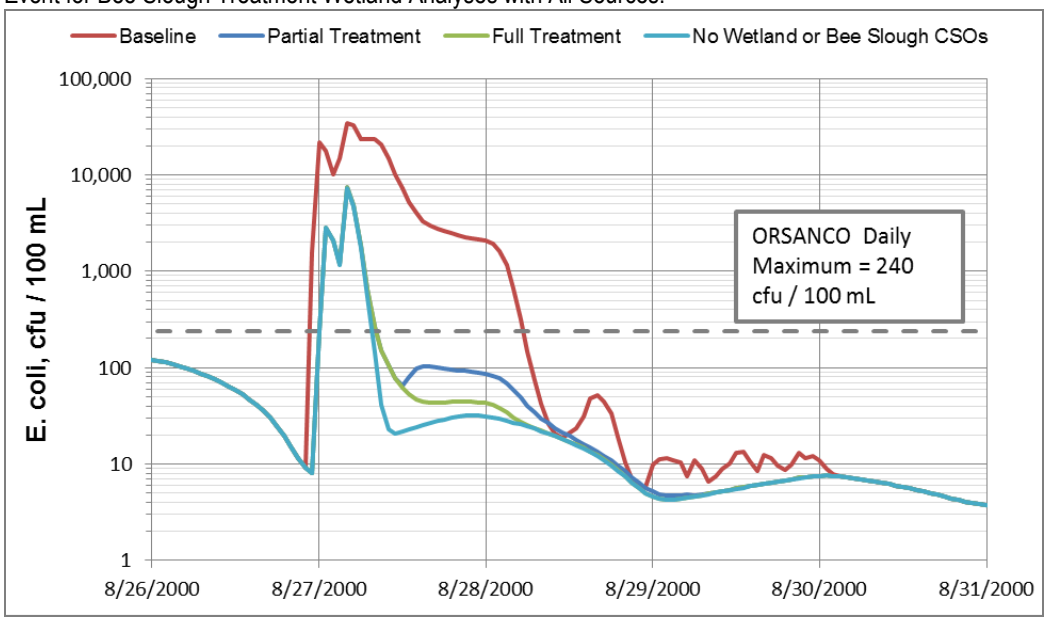
In-stream daily average *E. Coli* levels were approximately 50 CFU/100 ml under the partial treatment scenario and 25 CFU/100 ml under the full treatment scenario (Figure 7-20).

Figure 7-20 Downriver Profile of Near Shore Ohio River *E. Coli* Levels During August 27, 2000 Storm Event for Bee Slough Treatment Wetland Analyses



The wetland treatment sensitivity analysis was also simulated with the water quality model assuming that upstream and tributary sources were not controlled and the CSOs not discharging to Bee Slough were controlled to 12 OF/yr. For this storm event, many of the CSOs overflowed, including the four "downtown" CSOs near Bee Slough (CSOs 103, 038 and 008). A hypothetical "No wetland/no Bee Slough" scenario was also run as part of this analysis to provide a bound of water quality impact from these other sources. Model results are shown in Figure 7-21 for the Ohio River just downstream of Bee Slough at river mile 792.2.

Figure 7-21 Temporal Profile of Near Shore Ohio River *E. Coli* Levels at RM 792.2 During August 27, 2000 Storm Event for Bee Slough Treatment Wetland Analyses with All Sources.



The downtown CSOs have a short intense impact on the river at the start of the storm that lasts approximately 8 hours. During this period, *E. Coli* densities in the Ohio River are elevated, exceeding 1,000 CFU/100 ml. The additional load from the wetland during this period, roughly 100 CFU/100 ml (Figure 7-19), is masked by the load from those CSOs. However, the limited impact from the wetland is also due in part to the fact that the wetland attenuates the peak flow rates by retaining and releasing the CSO volume over a longer period, as shown in the later part of the day on 8/27 and 8/28. The treatment achieved in the wetland results in in-stream densities of ~100 CFU/100 ml. The *E. Coli* levels in both the full and partial treatment scenario results are more similar in magnitude to the "no wetland/no bee slough" scenario than the baseline scenario, which suggests that the wetland control solution would provide sufficient treatment, even if a portion of the CSO volume during the storm events where the wetland capacity is exceeded does not receive the full design treatment.

7.5 Conclusions

The objectives of the water quality modeling analysis of the control alternatives were to:

- Identify the level of control needed to ensure that CSOs do not cause water quality standards to be exceeded;
- Quantify the potential benefit of CSO control within the context of other pollutant sources in the watershed; and,
- Characterize the cost versus performance of each control alternative at the locations in each waterbody most impacted by CSO pollutant loads.

The results of the water quality modeling analysis can be summarized in the following conclusions:

- Controlling CSOs to fewer than 12 activations per year results in very little to no water quality improvement;
- Reductions in upstream and tributary sources are needed in Pigeon Creek to improve compliance with water quality standards;
- The Ohio River will comply with the 90-day geometric mean criterion in the 2012 ORSANCO Pollution Control Standards;
- The wetland control solution for the Bee Slough CSOs, even with partial treatment of large storms, has minimal impact on in-stream water quality in the Ohio River.

The Utility's Recommended Plan to reduce CSO activations from approximately 50 days to 12 days in a Typical Year provides the most cost effective approach to improve water quality for *E. Coli* bacteria. The results of the water quality model analysis reveal that both the Ohio River and Pigeon Creek are impaired waterways when the reach Evansville. The water quality model shows that reduction of CSO discharges to 12 days of activation increases the number of days Pigeon Creek and the Ohio River meet the water quality standard for *E. Coli* from 112 days to 125 days during the 180-day recreational season. Reducing the days of CSO activation to less than 12 overflows in a Typical Year provides no (zero) additional days of water quality compliance for *E. Coli* on either water way.

7.6 Demonstration of Compliance with Water Quality Standards and Use Attainability Analysis

7.6.1 Compliance with Water Quality Standards.

Both the Ohio River and Pigeon Creek are currently designated for whole body recreational contact. To protect that use of the Ohio River, ORSANCO has established two *E. Coli* criteria: a 90 day geometric mean of 130 CFU/100ml and a 90 day maximum of 240 CFU/100ml (allowing no more than 25 percent of the samples to exceed that maximum). For Pigeon Creek, the State of Indiana also has established two *E. Coli* criteria to protect recreational use: a 30 day geometric mean of 125 CFU/100ml and a single day maximum of 235 CFU/100ml (see Table 7-4).

The CSO Control Policy (EPA, 1994) and EPA's LTCP Guidance (1995) provide for cities to demonstrate compliance with water quality standards by evaluating whether water quality standards are met, considering only the impact of the CSO discharge itself, as follows.

To be a successful demonstration, the permittee should demonstrate each of the following:

> i. The planned control program is adequate to meet WQS and protect designated uses, unless WQS or uses cannot be met as a result of natural background conditions *or pollution sources other than CSOs*;
>
> ii. The CSO discharges remaining after implementation of the planned control program will not preclude the attainment of WQS or the receiving waters' designated uses or contribute to their impairment.
>
> ***
>
> iii. The planned control program will provide the maximum pollution reduction benefits reasonably attainable;
>
> iv. The planned control program is designed to allow cost effective expansion or cost effective retrofitting if additional controls are subsequently determined to be necessary to meet WQS or designated uses.[1]

The LTCP Guidance describes the general approach to evaluating alternatives, first defining water quality and CSO control goals:

- Defining a CSO control goal based on a water quality goal means identifying a level of CSO control which will allow attainment of the water quality goal, *assuming non-CSO sources of pollution are also controlled to an appropriate level*.[2]

[1] Under the CSO Control Policy, the LTCP also is presumed to meet water quality standards because it will result in capture of 92 percent of the flows. "The elimination or the capture for treatment of no less than 85 percent by volume of the combined sewage collected in the CSS during precipitation events on a system-wide annual average basis" is a basis for presuming compliance. 59 Fed. Reg. at 18692.

[2] Combined Sewer Overflows: Guidance for Long-Term Control Plan (LTCP Guidance) (EPA 832-B-95-002, Sep. 1995), at 3-21 (emphasis added).

The IDEM Long Term Control Plan and Use Attainability Analysis Guidance (2001) (hereinafter IDEM LTCP and UAA Guidance) is similar:

- The planned control program is adequate to meet water quality standards and protect designated uses, unless water quality standards or uses cannot be met as a result of natural background conditions *or pollution sources other than CSOs*. The EPA CSO Control Policy reiterates the fact that NPDES permits must require attainment of water quality standards, but recognizes that in many receiving water segments, sources other than CSOs might be contributing substantially to non-attainment of water quality standards. In these cases, even complete elimination of CSOs might not result in attainment of water quality standards.

- The CSO discharges remaining after implementation of the planned control program will not preclude the attainment of water quality standards or the receiving waters' designated uses or contribute to their impairment. Where water quality standards and designated uses are not met in part because of natural background conditions or pollution sources other than CSOs, a total maximum daily load, including a wasteload allocation, a load allocation or other means should be used to apportion pollutant loads. This is intended to ensure the selected level of CSO control would be sufficient to allow attainment of water quality standards if other sources causing nonattainment were controlled.[3]

The water quality analysis above in this section demonstrates that, assuming control of other sources, the LTCP will allow both the Ohio River and Pigeon Creek to meet ambient water quality standards to protect recreational uses, including Indiana's single daily maximum (applied instream rather than to the discharge itself).[4]

With respect to the Indiana single day maximum criterion, IDEM must translate it into an effluent limitation and, in performing the translation, IDEM must consider the appropriate upstream concentration of a substance (327 IAC 5-2-11.1(g)).[5] In determining the appropriate effluent limitation, IDEM also must apply a mixing zone.[6] EPA Guidance recognizes that states have this discretion.[7]

7.6.2 Use Attainability Analysis

If IDEM interprets its water quality standards to require compliance with the Indiana single-day maximum criterion for *E. Coli* in the CSO discharge itself, and not instream outside a mixing zone, Evansville requests that the wet weather limited use subcategory be applied to Pigeon Creek for 1 day for the approximately 7 miles from the first CSO (CSO-011) down to 1/2 mile

[3] Indiana Department of Environmental Management Nonrule Policy Document, "Long Term Control Plan Use Attainability Analysis Guidance" (Water-003-NRD) (Dec. 14, 2001), at 27 (emphasis added).

[4] Figure 7-1 shows that under the IOCP, 100 percent of days meet the 235 CFU/100 ml criterion in Pigeon Creek at River Mile 0.5, downstream of all CSOs. Figure 7-2 shows that under the IOCP, 100 percent of days meet the 240 CFU/100 ml criterion in Ohio River at River Mile 794.5, downstream of all CSOs and the WWTPs.

[5] *Carmel Water - Wastewater Utilities, Objections to Issuance of NDPES Permit*, 1999 OEA 13 (98-W-J-1976).

[6] EPA regulations allow states to adopt mixing zones [40 CFR 131.13 and 40 CFR §122.44(d)(1)(ii)]. Indiana regulations provide for a mixing zone [327 IAC §2-1-4]. ("All surface water quality standards in this rule, except those provided in section 6(a)(1) of this rule, are to be applied at a point outside of the mixing zone to allow for a reasonable admixture of waste effluents with the receiving waters."). Inside the mixing zone, Indiana's narrative (327 IAC 2-1-6) prohibits discharges that "Will settle to form putrescent or otherwise objectionable deposits." Evansville's CSO discharges meet this standard.

[7] EPA (2001), at 5 (describing how states may apply bacteria water quality criteria "at the beach or at the point of contact rather than at the end-of-pipe or at the edge of the mixing zones"). EPA cannot ban such a mixing zone through guidance. *Iowa League of Cities* v. EPA, 711 F.3d 844 (8th Cir. 2013).

from the mouth of Pigeon Creek (river mile 0.5)[8]. Additional measures to further reduce or eliminate CSOs to meet applicable water quality standards are not economically feasible for the City.

Once applicable, the new use subcategory would require Evansville to comply with the conditions included in its LTCP during wet-weather periods. This will allow the City to continue its efforts to improve water quality in Pigeon Creek without violating water quality standards. This section contains the information necessary for the state and EPA to approve a use attainability analysis (UAA) supporting application of the wet-weather limited use subcategory.

7.6.2.1 Regulatory Factors Necessary to Support a UAA

UAAs are developed to support changes in designated uses [40 CFR. §131.10(j)]. Federal regulations set forth the conditions that must be satisfied in order to apply a use subcategory such as the one proposed here [40 CFR. §131.10(g)]:

> States may remove a designated use which is not an existing use, as defined in §131.3, or establish sub-categories of a use if the State can demonstrate that attaining the designated use is not feasible because:
>
> (1) Naturally occurring pollutant concentrations prevent the attainment of the use; or
>
> (2) Natural, ephemeral, intermittent or low flow conditions or water levels prevent the attainment of the use, unless these conditions may be compensated for by the discharge of sufficient volume of effluent discharges without violating State water quality conservation requirements to enable uses to be met; or
>
> (3) Human caused conditions or sources of pollution prevent the attainment of the use and cannot be remedied or would cause more environmental damage to correct than to leave in place; or
>
> (4) Dams, diversions or other types of hydrologic modifications preclude the attainment of the use, and it is not feasible to restore the water body to its original condition or to operate such modification in a way that would result in the attainment of the
>
> use; or
>
> (5) Physical conditions related to the natural features of the water body, such as the lack of a proper substrate, cover, flow, depth, pools, riffles, and the like, unrelated to water quality, preclude attainment of aquatic life protection uses; or
>
> (6) Controls more stringent than those required by sections 301(b) and 306 of the Act would result in substantial and widespread economic and social impact.

As discussed in more detail below, the City will rely primarily on "Factor 6," concerning social and economic impacts. IDEM has indicated that this factor "will be the primary mechanism for suspending a recreational designated use." (IDEM LTCP and UAA Guidance, at 46).

[8] The modeling shows that the impacts, in fact, last only a few hours.

7.6.2.2 Socioeconomic Analysis

The LTCP represents the maximum level of control that is economically feasible for the City to achieve. Controls more stringent than those proposed here would result in substantial and widespread economic and social impacts that would be adverse to the City, its citizens, and the goals of the LTCP. As a result, attainment of the designated recreational use during wet-weather events is not feasible, and application of the wet-weather limited use subcategory is justified.

7.6.2.2.1 Financial Capability Assessment

Section 4 of Volume 1 of this IOCP contains the financial capability assessment, which analyzes the level of capital and operational expenses that the City can feasibly undertake during the LTCP implementation period. As detailed in the financial capability section, the City is proposing to spend capital investment dollars in an amount and over a period of time that would keep the cost per household for city residents at approximately 2 percent of the median household income (MHI) for those residents, which, according to the guidelines provided by IDEM and EPA, represents the border between imposing a medium or high burden on residential households. Based on this analysis, an IOCP of $540 with an implementation period of 28 years is at the limit of affordability for the citizens of the City.

With an IOCP of $540 million, the City projects that it could achieve a maximum of 12 overflows per year. Although the current projection keeps the cost per household at the 2 percent MHI level, there are few guarantees that the current cost estimates will remain accurate through the LTCP implementation period. These costs likely will be affected by inflation and by other market forces. For example, there remains significant uncertainty regarding the ultimate costs of the project given long-term uncertainty regarding inflation, especially as driven by energy prices, as well as potential spikes in construction costs.

Although the Recommended Plan calls for $540 million ($447.2 million for the LTCP alone) to achieve 12 overflows per year, various other alternatives were also explored in the process of preparing the LTCP. These other options demonstrate the significant financial burden associated with each additional reduction in overflows. Figure 7-17 provides the "knee of the curve analysis" for the control options for meeting the daily maximum *E. Coli* standard in Pigeon Creek. As demonstrated in that figure**, additional control does not achieve additional days of meeting that standard**. Assuming other sources are controlled, Pigeon Creek meets this standard 100 percent of the time at 12 overflows a year, as well as at higher (and more costly) levels of control. There is no additional water quality benefit for eliminating all CSOs at a cost of nearly $800 million (LTCP only). As demonstrated in Appendix C of Volume 1 of the IOCP, the recommended plan cost will cause rates to rise to 2.02 percent of the MHI of the City of Evansville and 1.95 percent of the MHI of the District. Impacts to both the City and the District can be considered "substantial" because they are closer to substantial impacts than not (EPA, 1995).

7.6.2.2.2 Additional Financial Information

Considering all of the costs related to the IOCP, imposition of more stringent CSO controls would result in substantial and widespread social and economic impacts on the City.

The City is at the lower end of the national spectrum in MHI and at the high end relative to poverty among its residents.

- With an MHI of only $35,900 in 2011, the City's MHI was only 71 percent of the 2011 national MHI.
- Thirty-four percent of the households in the City earned less than $25,000 per year in 2011 and 20 percent earned less than $15,000 per year.

While Evansville's residents are hard-working and unemployment is currently (September 2014) at about 6 percent, just below the current national average of 6.1 percent, the majority of those jobs are low paying.

- In 2011, 19.2 percent of the population was living below the poverty level, and 14.5 percent of the households in the City were receiving Food Stamps and Supplemental Nutrition Assistance Program benefits.

When compared to the 2011 national average (15.3 percent below the poverty level and 13 percent receiving Food Stamps and Supplemental Nutrition Assistance Program benefits), it becomes apparent that a high percentage of residents live below the poverty line and are already highly burdened by the cost of wastewater services.

As further demonstrated in Figure 4-4 of Volume 1, Section 4 of this IOCP, for 34 percent of the Utility's customers, the impact of IOCP implementation will be extremely burdensome. When monthly bills for City residents on average are approximately 2 percent of MHI, these customers will be paying 3.1 percent of MHI or more.

The City has seen inflation average of 2.34 percent from between 1990 and 2010, while the growth in MHI has averaged 0.6 percent per year. While the City hopes these divergent economic trends do not continue, it would be negligent to ignore these past trends in a projection. The growth in MHI in the Evansville area in the recent years has been negatively affected by the globalization of the economy, which has resulted in the loss of higher paying factory jobs and in changing demographics. For example, in 2014, Evansville lost 217 jobs when Whirlpool decided to close its Evansville refrigeration product development center.[9] Projections for Evansville show that the number of people 65 and older (retirees) will double between 2000 and 2030. The number of retirees in Evansville is expected to be 16 percent of the population by 2030. These factors are likely to continue to suppress the growth in MHI and make Evansville economically vulnerable.

Congress recently spoke to the issue of what constitutes economic hardship in a community. The Water Resources Reform and Development Act Resources (Public Law No. 113-121) added subsection (i) to section 603 of the Clean Water Act. This new subsection identifies factors for when a community is facing significant hardship. These factors include whether the area is considered economically distressed under section 301 of the Public Works and Economic Development Act of 1965 (42 U.S.C. 3161). That Act evaluates whether a community or area within a larger political boundary has a per capita income at 80 percent, or less than the national average, or unemployment 1 percent, or more greater than national average, or actual or threatened severe unemployment or economic adjustment, based on information provided by the community. Under that standard, Evansville is economically distressed based on the fact that its per capita income is below 80 percent of the national average.

[9] At one time Whirlpool was a major Evansville employer, with nearly 10,000 local workers. In 2010, Whirlpool moved its refrigerator production to Mexico, eliminating 1,200 local jobs.

7.6.2.3 Agency Guidance Concerning Social and Economic Impacts

7.6.2.3.1 EPA Substantial Impacts Analysis

EPA prescribes a five-step analysis to determine whether the economic impacts of meeting a water quality standard are substantial, as follows (EPA, 1995):

1. Verify project costs and calculate the annual cost of the pollution control project;
2. Calculate the total annualized pollution control costs per household;
3. Calculate and evaluate municipal preliminary screener score;
4. Apply the secondary test (IDEM, 2001); and
5. Assess where the community falls in the Substantial Impacts Matrix (i.e., the matrix established based on EPA studies across environmental programs which identified the appropriate levels of significance for comparison) (IDEM, 2001).

The Financial Capability Analysis submitted to EPA in February 2013 demonstrates that the anticipated impacts of the IOCP will be substantial.[10] The impacts of complete elimination of CSO discharges to Pigeon Creek would cause even greater impacts. These additional controls would increase the cost of the IOCP by over $225 million and increase the annual cost per household from $884 to $991, increasing the residential indicator from 2.46 to 2.76 for the City and from 2.17 to 2.43 for the District.[11].

7.6.2.3.2 EPA Widespread Impacts Analysis

Because both the IOCP and complete elimination of CSO discharges to Pigeon Creek will cause substantial economic impacts on Evansville, it is appropriate and necessary to evaluate whether those impacts also will be widespread. No standardized test exists for this determination; however, EPA guidance suggests that defining the geographic area affected by CSO compliance alternatives and assessing potential indicators of widespread impact is adequate. Potential indicators evaluated here include increases in unemployment, losses to the local economy, changes in household income, decreases in tax revenues, indirect effects on other businesses, and increases in sewer fees (EPA, 1995).

The geographic area affected by the selected CSO treatment method for Evansville is the entire City of Evansville, plus parts of Vanderburgh County. All citizens pay for water pollution control costs through monthly water bills. Industrial users must pay additional costs, depending on pollutant contributions to the system. This extends the affected geographic area to neighboring municipalities, whose citizens may travel to work at Evansville's industrial entities.

Using EPA's recommended socioeconomic indicators, the City has determined that there will be widespread impacts within the community under its selected alternative. Those impacts will be greater if elimination of CSO discharges to Pigeon Creek are required, and include the following:

- Changes in household income: Evansville's MHI is 29 percent below the U.S. average.
- Overall net debt per capita: Evansville already scores weakly in the Secondary Test for financial impact; increasing the financial burdens on households will only exacerbate that weakness.

[10] This FCA is based on 2011 median household incomes and other information available at that time.

[11] The cost per household is less than reported in the February 2013 FCA because the final IOCP was $540 million and that FCA was based on a cost of $606 million.

- Indirect effects on local businesses: Evansville is aggressively seeking to bring development into the City. However, one of the key factors in attracting potential investors to the area will be the cost of the utilities that will serve potential new facilities. Continued upward pressure on the utility rates to achieve CSO reductions above the City's selected alternative could push prospective investors away. In addition, the increased utility costs anticipated to result from this LTCP may provide incentives for existing local businesses to look elsewhere in order save costs. Increases in utility rates beyond what is already identified to fund a $540 million IOCP could motivate the existing and prospective businesses to explore other locations, worsening the City's economic position.

Not only do these factors alone identify widespread impact, but cumulatively, all of these factors will be compounded as money moves through the local economy (*i.e.*, some portion of the lost income would have been spent in the economy for goods and services; which impacts salaries of employees) (EPA, 1995) Thus, the above factors, compounded with the "multiplier effect" in the economy, mean that every incremental increase in costs will have an even greater impact on the total Evansville economy. In light of these considerations, requiring Evansville to eliminate all CSO discharges to Pigeon Creek would have widespread social and economic impacts.

7.6.2.3.3 IDEM Combined Substantial and Widespread Impacts Analysis

The City believes that the factors set forth in the EPA guidance discussed above show that substantial and widespread socioeconomic impacts would result if it is required to eliminate CSO discharges to Pigeon Creek. In addition, "substantial and widespread economic impact" is demonstrated under Indiana guidance. Indiana offers three tests for determining "substantial and widespread economic and social impact" within the context of a UAA:

1. Wastewater cost per household indicator (WW_{CPHI}) test
2. Total water quality (TWQ) cost test; or
3. Change in socioeconomic indicators test

The WW_{CPHI} test is similar to the Residential Indicator used by EPA, in that it compares the MHI to the total existing and expected LTCP wastewater treatment costs, in order to determine the annual wastewater burden per household. The baseline WW_{CPHI} and Socioeconomic Indicator Matrix (SEIM) scores are plotted on the graph in Figure 7-22**.** Anything above the designated baseline carries substantial and widespread socioeconomic impact that would justify a change in water quality standards. If the WW_{CPHI} test is satisfied, the second and third tests are not necessary (IDEM, 2001).

Based on the $540 million IOCP and Evansville's February 2013 FCA,, for the City of Evansville, WW_{CPHI} is 2.46 percent, which is calculated as the annualized IOCP cost and existing wastewater costs per household ($884), divided by the annualized MHI ($35,900). For the District it would be 2.17 percent, based on a District MHI of $40,800.

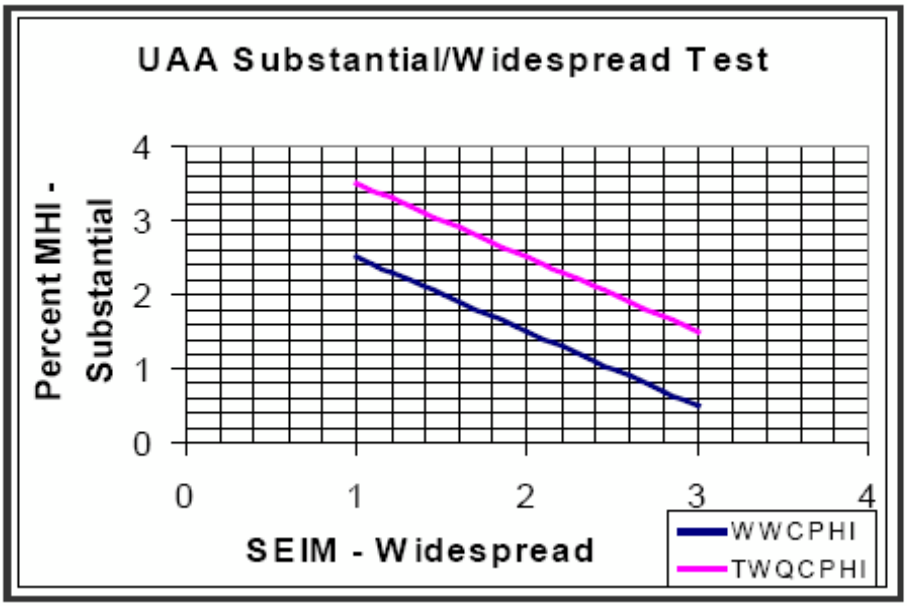
The SEIM calculation considers factors similar to the financial capability indicators calculated in Section 7 of this LTCP (Table 7-10).

Table 7-10 S-E Indicators Matrix Worksheet from IDEM Guidance

S-E Indicator Matrix	Municipality Value	Weak, Mid-Range, or Strong	Municipality Score
Median Household Income	-31% Evansville only; -21% District	Weak or Mid-Range	3 or 2
Tax Collection Rate (%)	88.84	Weak	3
Bond Rating	AA-/A1	Strong	1
Overall Net Debt Per Capita	$1,943	Mid-Range	2
Average Unemployment Rate	-.1%	Mid-Range	2
S-E Indicator Matrix Total			11 or 10
S-E Indicator (Total / 5)			2 or 2.2

The test is satisfied if the intersection of the City's Percent MHI and SEIM score lies above the lower WW_{CPHI} line in Figure 7-22 below. Because the intersection of 2.46 percent of Evansville's MHI or 2.17 percent of the District's MHI and 2. 0 or 2.2 SEIM score does lie above the WW_{CPHI} line, IDEM's substantial and widespread test is satisfied, and a UAA to apply the wet weather limited use subcategory is justified and should be approved (IDEM, 2001).

Figure 7-22 WWCPHI and TWQ Test Substantial and Widespread Socioeconomic Impacts Baseline



Overall, the proposed LTCP has been prepared by giving thoughtful consideration to water quality needs and the socioeconomic condition of the City of Evansville.

7.6.2.3.3.1 Wet-weather Limited Use Subcategory

The City believes that water quality standards will be met. However, if IDEM takes the position that current water quality standards for *E. Coli* established to support recreational uses will not be supported during wet-weather events that result in CSO discharges, the City requests application of Indiana's wet-weather limited use subcategory to Pigeon Creek during those periods.

7.6.2.3.3.2 Indiana Statutory Requirements

Indiana has established a wet-weather limited use subcategory, which can be implemented after completion of LTCP activities (Indiana Code [IC]13-18-3-2.5):

> (a) A CSO wet weather limited use subcategory is established for waters affected by receiving combined sewer overflows, as specified in the long term control plan. The CSO wet weather limited use subcategory applies to a specific water body after implementation of an approved long term control plan for the combined sewer system whose overflow discharges affect those waters is implemented and the conditions of subsection (b) are satisfied. The following requirements apply to the CSO wet weather limited use subcategory:
>
> > (1) The water quality based requirements associated with the CSO wet weather limited use subcategory that apply to waters affected by wet weather combined sewer overflows are determined by an approved long term control plan for the combined sewer system. The water quality based requirements remain in effect during the time and to the physical extent that the recreational use designation that applied to the waters immediately before the application to the waters of the CSO wet weather limited use subcategory is not attained, but for not more than four (4) days after the date the overflow discharge ends.
> >
> > (2) At all times other than those described in subdivision (1), the water quality criteria associated with the appropriate recreational use designation that applied to the waters immediately before the application to the waters of the CSO wet weather limited use subcategory apply unless there is a change in the use designation as a result of a use attainability analysis.
>
> (b) The CSO wet weather limited use subcategory applies if:
>
> > (1) the department has approved a long term control plan for the NPDES permit holder for the combined sewer system;
> >
> > (2) the approved long term control plan:
> >
> > > (A) is incorporated into:
> > >
> > > > (i) the NPDES permit holder's NPDES permit; or
> > > >
> > > > (ii) an order of the commissioner under IC 13-14-2-6;
> > >
> > > (B) satisfies the requirements of section 2.3 of this chapter;
> > >
> > > and
> > >
> > > (C) specifies the water quality based requirements that apply to combined sewer overflows during and immediately following wet weather events, as provided in subsection (a)(1);
> >
> > (3) the NPDES permit holder has implemented the approved long term control plan; and
> >
> > (4) subject to subsection (c), 40 CFR 131.10, 40 CFR 131.20, and 40 CFR 131.21 are satisfied.
>
> (c) For purposes of subsection (b)(4), 40 CFR 131.10 may be satisfied by including appropriate data and information in the long term control plan.

(d) The department shall implement the CSO wet weather limited use subcategory and associated water quality based requirements under this section when the subcategory and requirements are approved by the United States Environmental Protection Agency. The department shall seek approval of the United States Environmental Protection Agency in a timely manner.

(e) The NPDES permit holder shall monitor its discharges and the water quality in the affected receiving stream periodically as provided in the long term control plan. The NPDES permit holder shall provide all such information to the department.

(f) In conjunction with a review of its long term control plan under section 2.4 of this chapter, the NPDES permit holder shall review approved by the department to determine whether the conclusion of the use attainability analysis is still valid. The NPDES permit holder shall provide the results of the review to the department.

Indiana has also established the requirements necessary to change the designated use of a water to the wet-weather limited use subcategory discussed above (IC 13-18-3-2.3):

(a) This subsection applies if a use attainability analysis is performed and approved to change the designated use of a water body receiving wet weather discharges from combined sewer overflows from the recreational use designation that applied to the waters immediately before the application to the waters of the CSO wet weather subcategory established in section 2.5 of this chapter to that subcategory. Upon implementation of the approved long term control plan, the plan fulfills the water quality goals of the state with respect to wet weather discharges that are a result of overflows from the combined sewer system addressed by the plan.

(b) A long term control plan must meet the requirements of:

(1) Section 402(q) of the federal Clean Water Act (33 U.S.C.1342(q)); and

(2) 59 FR 18688.

(c) An approved long term control plan shall be incorporated into: (1) the NPDES permit holder's NPDES permit; or

(2) an order of the commissioner under IC 13-14-2-6.

(d) If a use attainability analysis is performed, the department shall:

(1) review a use attainability analysis submitted under this chapter concurrently with a long term control plan submitted under this chapter; and

(2) use the approved long term control plan to satisfy the requirements of the use attainability analysis.

As described above, although the City believes that water quality standards will be met through implementation of the IOCP, Evansville is seeking application of this wet-weather limited use subcategory if IDEM determines that Pigeon Creek will be adversely affected by storm events sufficient to cause CSOs. Consistent with the statutory requirements, this wet-weather limited use would apply only to the 12 CSO events remaining in a Typical Year after implementation of the IOCP during a wet-weather event.

7.6.2.3.3.3 Downstream Extent and Duration of Wet Weather Limited Use Subcategory

Because the water quality modeling indicates that Pigeon Creek will meet the *E. Coli* standards following implementation of the LTCP, assuming other sources are controlled, Evansville would need a wet-weather limited use designation for 1 day for the approximately 7 miles from the first CSO (CSO-011) to River Mile 0.5, above the mouth of Pigeon Creek.

SECTION 8

Recommended Long Term Control Plan for CSO Control – May 31, 2013

This section describes the Utility's Recommended Plan for meeting CWA objectives for reducing sewer overflows that was submitted to IDEM and EPA on May 31, 2013 and was subsequently rejected by the agencies. The Recommended Plan is superseded by the Final Negotiated Plan set forth in Section 9 below. The Utility submitted the Recommended Plan because it believed it addresses the community's highest priorities and balances the overall plan benefits with the Utility's financial capability to schedule and achieve the highest benefits as expeditiously as possible. It represents the best level of control possible for the available public investment. This plan is based on the alternatives evaluation described in Section 3, the financial impacts and affordability considerations discussed in Section 4, and the input received from the CAC in 2012 and 2013. Summaries of the recommended projects are provided in this section, and specific and detailed information on each of the projects can be found in the technical documents integrated by this IOCP (specifically, the LTCP, SSRMP, and WWTP Facility Plan).

8.1 Overview of the Recommended IOCP

The City's Recommended IOCP will dramatically reduce the number of CSOs that occur in the City. When complete, the IOCP will protect water quality and reduce CSOs from approximately 50 activations to 12 during a Typical Year and increase the combined sewer system's percent capture from 35 percent today to 92 percent. EPA's CSO Control Policy seeks to have cities reduce overflows to 0 to 12 activationsper year and increase percent capture to 75 to 100 percent. The CWA requires protection of water quality. Therefore, the proposed LTCP portion of the IOCP meets the regulatory thresholds put forth by EPA and the CWA. It is worth noting that the complete elimination CSOs is cost prohibitive and simply not practical, so residual CSOs will occur during some large storm events.

8.2 Recommended LTCP Projects

The recommended plan focuses on these major initiatives:

- Remedy the odor and aesthetic problems in Bee Slough through the control and treatment of CSO discharges into Bee Slough and the redirection of East WWTP treated effluent from Bee Slough to the Ohio River during high river conditions.
- Reduce the inflow of stormwater into the sewer systems through the construction of green infrastructure projects, partial sewer separation projects that include green infrastructure elements, and through I/I reduction projects in the separate sanitary sewer system.
- Increase treatment of captured wet-weather flows at the East WWTP by reactivating and utilizing the primary effluent bypass, eliminating any remaining hydraulic bottlenecks within the treatment processes, and changing wet-weather operations to operate the primary and secondary treatment processes in parallel to treat up to 68 mgd during wet-weather.

- Increase treatment of captured wet-weather flows at the West WWTP by constructing a new, expanded Headworks Facility, eliminating remaining hydraulic bottlenecks within the treatment processes, and constructing flow equalization facilities.
- Replace the 7th Avenue Lift Station to increase its pumping capacity and increase its reliability through the installation of redundant equipment and a backup power source, and construct a CSO storage and treatment facility at this location to capture and treat CSO discharges from the 7th Avenue East, Fulton Street, Franklin Street, and 9th Street CSOs.
- Increase capture of combined wet-weather flows by raising overflow weirs in the diversion structures throughout the entire system; by cleaning the Pigeon Creek Interceptor; and by implementing real-time control strategies to optimize the operation of the Pigeon Creek Interceptor and flood control system, the 7th Avenue Lift Station, and the West WWTP.
- Control CSO discharges to Pigeon Creek through construction of CSO storage facilities at the Diamond Avenue, Oakley Street, Delaware Street, and Oak Hill CSOs.
- Control CSO discharges to the Ohio River through construction of two CSO storage facilities in the downtown area to capture and control CSO discharges from the Dress Plaza, Chestnut Street, and Oak/Riverside CSOs.
- Optimize the Ohio Street and Broadway Avenue Interceptors to increase capture and treatment of CSO discharges from the St. Joseph Avenue CSO.
- Enhance the Utility's precipitation, flow, and overflow monitoring systems to continuously track system performance and the results of the implementing the proposed overflow control and inflow reduction projects.

Implementation of the IOCP will not negatively affect environmental justice populations. Although projects in the IOCP are spread throughout the community, much of the early work will occur near and focus on remedying Bee Slough, which is adjacent to economically disadvantaged neighborhoods. Additionally, the Renew Evansville Citizens Advisory Committee has not identified any environmental justice issues.

8.3 Green Infrastructure Program

Evansville is committed to aggressively pursuing green, sustainable projects to direct stormwater out of the sewer system. To that end, the Utility performed a rigorous investigation of a range of potential green infrastructure programs and projects throughout the combined sewer area (see Appendix D). A particular focus of the evaluation included evaluating GI opportunities in the City's downtown area, as well as efforts to augment the sewer separation approaches previously discussed. The investigation examined opportunities to incorporate green infrastructure into a variety of public infrastructure improvements in conjunction with other planning initiatives for redevelopment and beautification of the City's downtown.

To promote implementation of GI projects for the benefit of the community as well as the stormwater capture/overflow reduction potential, the Utility is committing to being a project participant on many non-Utility projects that will include a GI component. Several project opportunities were identified for the Utility to work toward implementing in the near future in conjunction with other City departments. The majority of the GI opportunities currently identified are linked to downtown redevelopment, and the associated roadway and facility improvements being performed by other City departments. As the Utility will be a project

participant, rather than in direct control of initiating and completing the various projects, the list of GI projects to be implemented will likely vary with time. The potential changes in the specific GI project list will not prevent the Utility from meeting the planned system-wide level of control, as the Utility's adaptive management approach (Section 8.6) will allow the Utility to implement green and gray infrastructure to a greater or lesser extent than planned, and "right size" the projects in order to achieve the Utility's level of control commitment.

8.3.1 Identified GI Project Opportunities

Based upon the GI analysis described in Appendix D, and in conjunction with other City departments, the Utility has identified a program of green infrastructure improvements that that leverage available funding across multiple City departments and are consistent with City planning objectives. The list of projects identified in Table 8-1 are projects currently identified as green opportunities, several of which have already been funded by various City departments, most as a component of other non-Utility projects. Based upon these identified opportunities and the anticipated stormwater capture, the Utility is committed to a minimum expenditure of $16 million on green infrastructure projects over the life of the IOCP.

The Utility will likely not be in direct control of the projects with a GI component, and the lead agency could make changes to the projects providing the GI opportunities. As a result, the Utility cannot commit to the effectiveness of individual GI projects in terms of CSO volume and frequency reduction as part of the IOCP. Modeled estimates of the stormwater capture were developed, and cost per gallon estimates were used to identify the listed opportunities. Ongoing flow monitoring and hydraulic monitoring refinements, per the adaptive management plan, will allow the Utility to evaluate actual GI project effectiveness. The Utility's overall commitment to GI and the system wide level of control also provide the Utility the greatest flexibility to use GI as a tool to cost effectively meet the Utility's overall system-wide level of control commitments.

The list of green infrastructure projects and project types presented in Table 8-1 and Section 8.3.2 should be considered a representation of the types of sustainable, green projects Evansville plans to pursue. Based upon funding availability for other, non-green components of the projects, the project list may be revised over time, i.e., other projects may be identified that supersede the listed projects, and projects on the list may not be constructed. As previously noted, changes to the project list will not prevent the Utility from meeting the IOCP commitments due to the Utility's adaptive management strategy.

All projects will meet all local, state, and federal requirements based on technology and site conditions. Detailed specifications, specific maintenance procedures, and any evaluation that may be necessary regarding the final fate of water infiltrated will be addressed at the time detailed designs are developed. Maintenance of constructed GI projects will likely be performed by either the Utility or other appropriate City department (e.g., the Parks Department for some facilities) similar to other maintenance activities that fall within the Nine Minimum Controls requirements.

8.3.2 Green Infrastructure Project Types

Within the downtown area and nearby residential neighborhoods, green infrastructure includes street improvements to replace all or a portion of the conventional pavement with porous pavement and other streetscape green technologies.

In addition, there are large public parking lots and some City parks that present opportunities to include green infrastructure to intercept, divert, and/or capture stormwater runoff before it can enter the CSS. In addition to porous pavement, the green street concept includes, porous sub-grade material and underdrain systems intended to both convey and detain stormwater runoff. The outlet for this green street concept is a dry well that redirects stormwater discharges to a buried layer of pervious sand and gravel. In areas of the City where the infiltration capacity of the surrounding soils is lower, the green infrastructure improvements would discharge residual flows through an underdrain back to the CSS. Portions of the City are underlain with the porous Ohio River sand aquifer, which has the potential to accommodate infiltration approaches.

Green infrastructure improvements optimize the performance of the proposed sewer separation and provide inherent water quality benefits to those projects. In addition, the green street concept with a dry well is capable of significant reductions in stormwater runoff volume to the CSS in areas where there is no suitable storm system outfall. In the downtown areas of the City and in the adjacent historic neighborhoods, green infrastructure improvements provide an opportunity to meet the overall IOCP objectives while also providing other intrinsic value to the community. The Utility will continue to interact with City departments, private industry, and neighborhoods on a regular basis to identify opportunities where green infrastructure can be incorporated into projects that would reduce CSOs and provide other benefits. In addition, the green street concept is expected to create additional incentive for the community to expand on its redevelopment and street enhancement programs. The Utility's program to implement green infrastructure will include a scoring system that values each potential project based on cost and other benefit factors that determine prioritization.

8.4 CSO Control Measures for the Recommended Plan – May 31, 2013

The CSO projects proposed in the plan are shown in Figure 8-1 and summarized in the following sections. Each project described below has been planned and sized to capture CSO discharges and reduce CSO activations that occur under Typical Year, future flow conditions. Where satellite treatment is proposed, the facilities have been planned and sized to achieve the equivalent of primary treatment and to disinfect the treated effluent to *E. Coli* concentrations of less than 235 CFU/mL.

The projects included in the recommended IOCP and described below have been planned and prioritized in accordance with the project scoring and prioritization methodology described in Appendix G.

8.4.1 Control Measure 1 – Bee Slough Restoration and CSO Treatment

This control measure addresses CSOs 001, 002, and 004. The recommended plan to remedy the odor and aesthetic problems in Bee Slough is shown on Figure 8-2 and includes the design and construction of the following projects:

- Drainage pipelines between the concrete channel and the East WWTP Headworks Facility to provide the ability to send standing water in Bee Slough to the WWTP for treatment.
- A pump station to pump treated effluent from the East WWTP to the Ohio River during periods of high river levels (instead of allowing it to back up and collect in Bee Slough when the K-4 Levee Pump Station is being utilized).

Evansville Water and Sewer Utility
Attachment - Green Infrastructure Planning and Recommendations
Representative Green Infrastructure Projects
City of Evansville, IN
May 29, 2013

	Project Name:	General Information						Project Dimensions		Implementation Costs		Hydrologic Performance		Comments
		CSS Sub-basin	Implementation Year(s)	Project Type	Project Description	Project Location	Other Partnering Agencies	Length (ft.)	Area (ac.)	Total Estimated Cost	EWSU Cost Contribution	Preliminary Estimate of Stormwater Capture (MG/Yr)	GI Cost per Gallon of Stormwater Capture	
1	Bi-centennial Park	Sycamore	2013	Urban Park (Infiltration Practices)	Downtown park w/embedded GI; pervious pavement with dry well to access infiltration layer	Bounded by Vine, Third, Sycamore and Second Streets	DMD, DPR	--	2.3	--	$400,000	1.01	$0.39	Assumes both projects will occur simultaneously and allow the park improvements to provide the dry well that the streetscape improvements will discharge to. The green street costs and hydrologic performance are taken from the worksheet for Area E-2. Costs for GI within the park were provided by Ratio Architects, which exceeded $800K. The EWSU cost contribution provided ($400K) is based on an assessment of a more reasonable contribution for GI that will have a direct benefit to the CSS. The hydrologic performance of the GI within the park is based on the multiplier for a medium density residential area, to account for the lower percentage of impervious area associated with a typical park.
	Third Street	Sycamore	2014	Urban Roadway (CompleteGreen Street)	Urban green street improvement adjacent to Bi-centennial Park; pervious pavers in parking lane with connections to dry well(s) in adjacent park to access infiltration layer	Between Vine and Sycamore Streets		369	--	$1,190,025	$178,504	0.51	$0.35	
2	Vine Street	Court and Sycamore	2013	Urban Roadway (Complete Green Street)	Urban green street improvement; pervious pavers in parking lane with dry well to access infiltration layer	Between 2nd Street and MLK Jr. Boulevard	BPW	2596	--	$5,612,175	$841,826	2.61	$0.32	It is likely this entire project will occur over multiple phases, with the first phase occuring in conjunction with the Bi-centennial Park project. The assumption related to the EWSU cost contribution is that the project occurs as part of an overall streetscape (complete street) improvement project.
3	YMCA-EVBA Parking Lot	Sycamore	2014	Parking Lot Rehabilitation (Infiltation Practices)	Reconstruction of two adjacent parking lots owned by YMCA and DMD (soon EVBA); to include GI retrofits of bio-retention and/or pervious pavement with dry well to access infiltration layer	Corner of MLK Jr. Boulevard and Vine Street	EVBA (YMCA?)	--	1.9	--	$126,760	1.75	$0.07	The EWSU cost contribution reflects GI improvements only that would occur as part of a larger parking lot improvement project. The total cost of all parking lot improvements has not been determined.
4	Civic Center Building (the old jail) at 1 NW MLK Jr. Boulevard	Sycamore	2013	Building Retrofit (Green Roof)	Retrofit of existing rooftop to include pallets/trays of planted material	Corner of MLK Jr. Boulevard and Sycamore Street	EVBA	--	0.2	N/A	$250,470	0.10	$2.39	Project area assumes 0.23 acres of 0.7 acre rooftop area will be treated with 'extensive' green roof feature, using the modular (tray) system, at $25/sq. ft.; EWSU will provide 100% of costs associated with green roof, not including structural retrofits. Preliminary estimate of SW capture utilizes the multiplier for downtown/high impervious area, but assumes the roof is capable of capturing 1/2 of the volume compared to the green street application - this is based on information suggesting 0.7 to 0.75 inches rainfall capture for a modular (extensive) green roof, compared to the 1.5 inches for the green street application.
5	Downtown Hotel at 202 SE Sixth Street	Locust/Chestnut	2013	`	Private/public partnership to re-develop parcel adjacent to arena as a hotel; incentives for green infrastructure	Corner of Sixth and Walnut Streets	DMD, APC	--	2.1	N/A	$383,460	1.92	$0.20	Prelim. estimate of SW capture applies the multiplier associated with a downtown/highly impervious area; EWSU will contribute $0.10 per annual gallon of stormwater runoff eliminated from the CSS.
6	Sycamore Street Parking Garage	Sycamore Basin	2016	Building Retrofit (Cistern)	Retrofit existing parking garage to re-direct drainage to a cistern; sized to capture 2" of runoff; for re-use or controlled release to CSS	Along Sycamore Street between Fifth and Sixth Streets	EVBA	--	0.9	N/A	$150,000	0.82	$0.18	Required storage volume of cistern is approx. 49,000 gallons, based on total footprint area and 2" rainfall capture. Estimated cost is based on five 10,000 gallon above-ground tanks with the plumbing necessary to connnect the existing drains to the tanks, including the overflows; plumbing will also be necessary to allow these tanks to be discharged to City trucks for water re-use. Prelim. estimate of SW capture applies the multiplier associated with a downtown/highly impervious area.
7	Locust Street Parking Garage	Locust Basin	2016	Building Retrofit (Cistern)	Retrofit existing parking garage to re-direct drainage to a cistern; sized to capture 2" of runoff; for re-use or controlled release to CSS	Along Locust Street between Fourth and Fifth Streets	EVBA	--	0.9	N/A	$150,000	0.82	$0.18	Required storage volume of cistern is approx. 49,000 gallons, based on total footprint area and 2" rainfall capture. Estimated cost is based on five 10,000 gallon above-ground tanks with the plumbing necessary to connnect the existing drains to the tanks, including the overflows; plumbing will also be necessary to allow these tanks to be discharged to City trucks for water re-use. Prelim. estimate of SW capture applies the multiplier associated with a downtown/highly impervious area.
8	Walnut Street Parking Garage	Locust/Chestnut Basin	2016	Building Retrofit (Cistern)	Retrofit existing parking garage to re-direct drainage to a cistern; sized to capture 2" of runoff; for re-use or controlled release to CSS	Along Walnut Street between Third and Fourth Streets	EVBA	--	0.9	N/A	$150,000	0.82	$0.18	Required storage volume of cistern is approx. 49,000 gallons, based on total footprint area and 2" rainfall capture. Estimated cost is based on five 10,000 gallon above-ground tanks with the plumbing necessary to connnect the existing drains to the tanks, including the overflows; plumbing will also be necessary to allow these tanks to be discharged to City trucks for water re-use. Prelim. estimate of SW capture applies the multiplier associated with a downtown/highly impervious area.
9	Greenway Trail at U.S. 41	Diamond Ave. and Bee Slough-Cass Ave.	2014	Bikeway Project (Infiltration Practices)	Bio-retention basins installed along bikeway and in U.S. 41 west ditch; re-direct drainage from south bound lanes to bio-basins	Along west side of U.S. 41 (Gilbert Ave.) between Covert Avenue and Walnut Street	DPR	6700	15.4	$3,000,000	$1,005,000	6.78	$0.15	The computed area associated with this project assumes an average 100' wide project corridor that extends to the U.S. 41 median, the prelim. estimate of SW capture applies the multiplier associated with a residential GI application; the total estimated cost was provided by DLZ (?) and the EWSU cost contribution utilizes the multipliers associated with a parking lot.
10	Arts District Revitalization (W. Washington Avenue)	Adams & Sunset	2016	Urban Roadway (Complete Green Street)	Streetscape project with raingardens and/or pervious pavement; connect to dry well in adjacent parking lot rehab for access to infiltration layer	Between SE Second Street and Parrett Street intersections	DMD	276	--	$353,280	$88,320	0.37	$0.24	Assumes both projects will coccur simultaneously and allow the parking lot improvements to provide the dry well that the streetscape GI will discharge to. The cost and hydrologic performance of GI for the streetscape and parking lot are taken from the separate worksheets for area E-1 and Public Parking Lots; the total cost of GI may exceed this value, but GI is an integral part of these projects and will replace conventional storm sewer system (there is no storm system at this intersection), so it is assumed DMD will cover some of those costs. The total cost of all parking lot improvements has not been determined.
	DMD Parking Lot (adjacent to W. Washington Avenue)	Adams & Sunset	2016	Parking Lot Rehabilitation (Infiltation Practices)	Reconstruction of parking lot in conjunction with streetscape project; to include GI retrofits of bio-retention and/or pervious pavement with dry well to access infiltration layer	At intersection of W. Washington Avenue and SE Second Street	DMD	--	0.21	--	$27,443	0.19	$0.15	
11	Greenway Trail along S. Governor and Garvin Streets	Chestnut	2014	Urban Roadways (Complete Green Street)	Upgrade roadways in conjunction with greenway trail through downtown areas	S. Governor and Garvin Streets between E. Walnut Street and the Lloyd Expressway	DPR, BPW	2451	--	$3,524,480	$881,120	3.78	$0.23	The dimensions, costs and hyrologic performance inlucde the sgements of both roads extending up to Division Street (just north of the Lloyd). The assumption is that the project includes complete complete green streets (bikeway lanes and pervious pavement).
12	Riverside Drive at Veterans	Oak & Riverside	2013	Parking Area/Sidewalk	Install bio-retention basins along sidewalk on cul-de-sac portion of Riverside Drive) between Oak and Mulberry Streets	Large parking area between Oak and Mulberry Streets (east of Riverside Drive)	DMD, BPW	--	0.34	--	$44,431	0.31	$0.15	GI Cost and Hydrologic Performance are based on same assumptions as used for the application of bio-retention basins to a parking lot, except that a cost mulitplier of 2.0 has been applied due to some uncertainty about the full extent of the improvements.
	SE Riverside Drive	Oak & Riverside	2019	Urban Roadway (Complete Green Street)	Urban green street improvement; pervious pavers in parking lane with dry well to access infiltration layer	Between Park Place (Mulberry Street) and south of Chandler Avenue	DMD, BPW	478	--	$1,169,370	$292,343	1.23	$0.24	Costs and hydrologic performance are based on results in the 'CSS Area E-1' tab for the length of SE Riverside between Park Place and Chandler Ave., multiplied by 1.35 to account for additional road length south of Chandler Ave. [478'/355' = 1.35].
13	Arts District Revitalization (SE Second Street)	Adams & Sunset	2019	Urban Roadways (Complete Green Street)	Urban green street improvement; pervious pavers in parking lane only or from curb-to-curb depending on total pavement width and traffic loads; with dry well to access infiltration layer	Between Blackford Avenue and Madison Avenue Intersections	DMD, BPW	1140	--	$1,732,800	$433,200	1.76	$0.25	For street segments not listed in the Area E-1 worksheet, GI costs are based on length measurements from the ARC Reader Tool, pavement widths from the Area E-1 worksheet (for that same street), and cost multipliers for residential streets; hydrologic performance computations also utilize information from Area E-1 worksheet to determine R/W width and utilize the multipliers for stormwater capture associated with a residential green street.
	Arts District Revitalization (Parrett Street)		2019			Between Blackford Avenue and Madison Avenue Intersections		1200	--	$1,488,000	$372,000	1.94	$0.19	
	Arts District Revitalization (Putnam Street)		2018			Between Washington Avenue and Madison Avenue Intersections		892	--	$1,177,440	$294,360	1.38	$0.21	
	Arts District Revitalization (SE Sixth Street)		2017			Between Powell Avenue and Washington Avenue Intersections		663	--	$861,120	$215,280	1.07	$0.20	
	Arts District Revitalization (Madison Avenue)		2017			Between Parrett Street and Putnam Street Intersections		632	--	$706,200	$176,550	0.80	$0.22	
	Arts District Revitalization (Jefferson Avenue)		2017			Between Parrett Street and Putnam Street Intersections		616	--	$739,200	$184,800	0.90	$0.20	
	Arts District Revitalization (E. Blackford Avenue)		2018			Between SE Second Street and SE Sixth Street Intersections		1030	--	$988,800	$247,200	1.30	$0.19	
	Arts District Revitalization (Washington Avenue)		2018			Between SE Eighth Street and Parrett Street		970	--	$1,241,600	$310,400	1.30	$0.24	
	Arts District Revitalization (Adams Avenue)		2019			Between Putnam Street and SE Riverside Drive		1590	--	$2,162,400	$540,600	2.29	$0.24	
14	Jacobsville Area Revitalization (W. Indiana Street)	Court	2015	Urban Roadway (CompleteGreen Street)	Urban green street improvement; pervious pavers in parking lane with dry well to access infiltration layer	Between N. Main Street and Read Street	DMD, BPW	1318	--	$3,228,075	$484,211	1.75	$0.28	W. Inidiana Street is one of the few high scoring streets in the Jacobsville planning area; the master planning effort is still underway and other recommendations may be made.
15	Green Infrastructure Enhancement Fund	E1, E2, E4	2015 - 2032	Miscellaneous Private Re-development Opportunities	Cost share incentive for implementation of on-site GI where there are benefits to CSO reduction	---	APC, BPW	--	--	--	$10,000,000	50	$0.20	EWSU Cost Contribution Assumes up to $500,000 in cost share opportuniites over the next 20 years. Prelim. Estimate of SW removal is based on $0.10 contribution per annual gallon of redirection or re-use.
							Totals =	22921	25.20	$29,174,965	$18,228,277	88		

- A wetland treatment system and associated pump station and disinfection system to capture and treat discharges from the Kentucky Avenue CSO. The wetland treatment system will treat captured overflows to the equivalent of primary treatment; effluent will be disinfected prior to discharge. The wetland effluent will be discharged to either Bee Slough or the East WWTP outfall depending on Ohio River stage and the flow rate through the East WWTP. During low river stage, the Utility's preference will be to discharge through the East WWTP outfall to keep treated flow out of Bee Slough and minimize the occurrence of standing water in Bee Slough. This will also reduce the possibility of recirculating treated flow through the East WWTP if the Bee Slough drains are being utilized. In the event that wetland effluent is discharged in Bee Slough, it would discharge into Bee Slough approximately 3,500 LF upstream of its confluence with the Ohio River.
- Pipes and drains that interconnect the wetland pump station, disinfection facility, and East WWTP to maximize the use of the East WWTP for treating captured CSO, and to allow for recirculation of water through the wetland treatment system in order to increase wetland treatment performance. Evansville conducted several analyses of wetland and WWTP operations, including a projection of anticipated effluent quality for each event in the Typical Year. The results of these analyses are provided in Appendix G.
- A combined storage/treatment facility (VTU) for capture, treatment, and disinfection of CSO discharges from the Cass Avenue CSO, and a pipeline that captures CSO discharges from the Adams Street CSO and sends the captured flow to this facility. The VTU will treat captured overflows to the equivalent of primary treatment and effluent will be disinfected prior to discharge.

The project will be subject to review and approval by and coordination with the USACE and could be subject to changes based on USACE's review and approval process. As proposed, the Bee Slough Remediation Projects are expected to treat 100 percent of the overflows in the Typical Year.

Additionally, as described in Section 5.6.3.4, hydraulic monitoring and water quality sampling will be conducted at multiple locations within the wetland treatment system to track performance and health and to establish a basis for operational adjustment, as needed.

8.4.2 Control Measure 2 – East WWTP Improvement Projects

This control measure addresses CSO 103. In early 2012, the Utility completed installation of a second fine screen and fourth pump in the Headworks Facility, which expanded the headworks capacity from 20 to 40 mgd. Since that time, the Utility has completed WWTP stress testing and determined that up to 50 mgd can be treated by the primary treatment process and up to 28 mgd can be treated by the secondary process. The existing disinfection process has the capability of treating up to 32 mgd.

The recommended plan would first upgrade and expand the existing disinfection tanks to increase disinfection capacity to 68 mgd and reactivate existing piping to allow flows treated by the primary treatment process that exceed the secondary treatment process capacity to bypass the secondary treatment units. The Utility will take the opportunity of this upgrade to the capacity of the disinfection facilities to convert from the use of gaseous chlorine (which poses safety and health risks), to sodium hypochlorite, a safer disinfecting chemical. Those modifications would allow the Utility to treat up to 40 mgd through the primary treatment and disinfection processes, and 28 mgd through the secondary treatment process during and after

wet-weather events. This means that up to an additional 12 mgd of wet-weather flow can be treated by the WWTP during each storm event rather than being discharged from the collection system without any treatment. Upon completion of the wetland pump station and piping that connects it to the WWTP, the Utility will adjust wet-weather operations to treat up to 68 mgd through the East WWTP by running the primary and secondary treatment processes in parallel and disinfecting the combined flow before discharge to the Ohio River. A No Feasible Alternatives Analysis for peak wet weather diversion was conducted and is presented in Section 5.3 of the WWTP Facility Plan (Volume 4 of the IOCP).

The plan also includes the modification of the CSO 103 diversion structure weir (the East WWTP bypass point) to completely divert wet-weather flows into the East WWTP for treatment during the Typical Year, and to eliminate CSO 103. Figure 8-3 shows the planned improvements.

8.4.3 Control Measure 3 – West WWTP Improvement Projects

This control measure addresses CSO 123. The stress tests completed during summer 2012 determined that the West WWTP can treat up to 40 mgd through the primary treatment process and that the secondary treatment process has the capability to treat up to 45 mgd. The tests also determined that the existing disinfection process has the capability of treating up to 56 mgd. Historically, the Utility has limited headworks pumping to less than 40 mgd due to the primary process's maximum capacity, and engineering analysis has determined that it is unlikely that the existing headworks has the ability to pump flows much higher than 40 mgd. A further complication is that pumping at these higher flow rates negatively affects the influent sewer system hydraulics, because of the need to maintain high, flooded wetwell levels that are outside the bounds of the facility's design conditions. This situation, in combination with the single fine screen in the Headworks Facility, with only a coarse bar screen for backup, warrants a replacement Headworks Facility that is purpose-built for these conditions, that contains the appropriate redundancy in equipment, and that has provisions for maintaining consistent influent sewer levels during wet-weather events.

The IOCP would construct a new Headworks Facility designed and constructed to reliably treat up to the 45 mgd peak secondary treatment capacity. This higher flow rate would be achieved through construction of a pipe that would allow up to 7 mgd of wet-weather flow to be sent directly to the secondary process during events when flow is greater than the 40 mgd primary clarifier capacity. The plan also includes conversion of the disinfection process to hypochlorite.

Proposed IOCP Projects

renewEVANSVILLE

CSO Inventory

CSO	NAME	RECEIVING WATER	WWTP SERVICE AREA
001	Kentucky Avenue	Bee Slough	East
002	Cass Avenue	Bee Slough	East
103	Junction Box Prior to WWTP Headworks	Ohio River	East
004	Adams	Bee Slough	East
006	Fulton Avenue Pumping Station	Ohio River	West
008	Chestnut Street	Ohio River	East
009	7th Avenue West	Ohio River	West
010	Dress Plaza	Ohio River	East
011	Weinbach Lift Station (Oakhill Road)	Pigeon Creek	East
012	Maryland Street - West Bank	Pigeon Creek	West
013	Delaware Street	Pigeon Creek	West
014	Dresden Street	Pigeon Creek	West
015	7th Avenue East	Ohio River	West
016	Franklin Street	Pigeon Creek	West
017	6th Avenue	Pigeon Creek	West
018	Oakley Street	Pigeon Creek	West
020	9th Avenue	Ohio River	West
022	St. Joseph Avenue	Ohio River	West
123	West Plant CSO	Ohio River	West
024	Baker Street	Pigeon Creek	West
025	Diamond Avenue	Pigeon Creek	West
038	Oak / Riverside	Ohio River	East

Mill Road SSO Group

Oakley
CSO Control Facility
Storage Basin

Diamond Ave & Baker
CSO Control Facility
Relief from Baker to Diamond Ave
Storage Basin at Diamond Ave

Bergdolt Road SSO

Delaware, Maryland,
Dresden & 6th Avenue
CSO Control Facility
Relief sewer from 6th Ave, Dresden,
and Maryland to Storage Basin
at Delaware

St. Joesph
CSO Control Facility
System Optimization

Dress Plaza
CSO Control Facility
Storage Basin

Chestnut & Oak-Riverside
CSO Control Facility
Relief sewer from Chestnut to
storage basin at Oak-Riverside

Oakhill
CSO Control Facility
Storage Basin

Lincoln Avenue SSO Group

Tekoppel Avenue SSO

WEST
WWTP

Franklin, 9th Ave,
Fulton, and 7th Ave
CSO Control Facility
Relief sewer from Franklin, 9th Ave,
Fulton, to Storage Basin and
treatment unit at 7th Ave

EAST
WWTP

Howell Park
CSO Control Facility
Storage Basin

Bee Slough
See Proposed Plan figures

017 025 018 024 014 012 013 016 020 009 015 006 010 008 038 103 004 002 001 022 123 011

Map Legend

East Service Area
- Separate Sewer Area
- Combined Sewer Area

West Service Area
- Separate Sewer Area
- Combined Sewer Area

- Wastewater Treatment Plant
- Priority SSO Location
- CSO
- Storage Basin
- High Rate Treatment Unit
- Sewer Rehab Projects
- City Limits

Figure 8-1

Recommended Plan
Integrated Overflow Control Plan
May 31, 2013

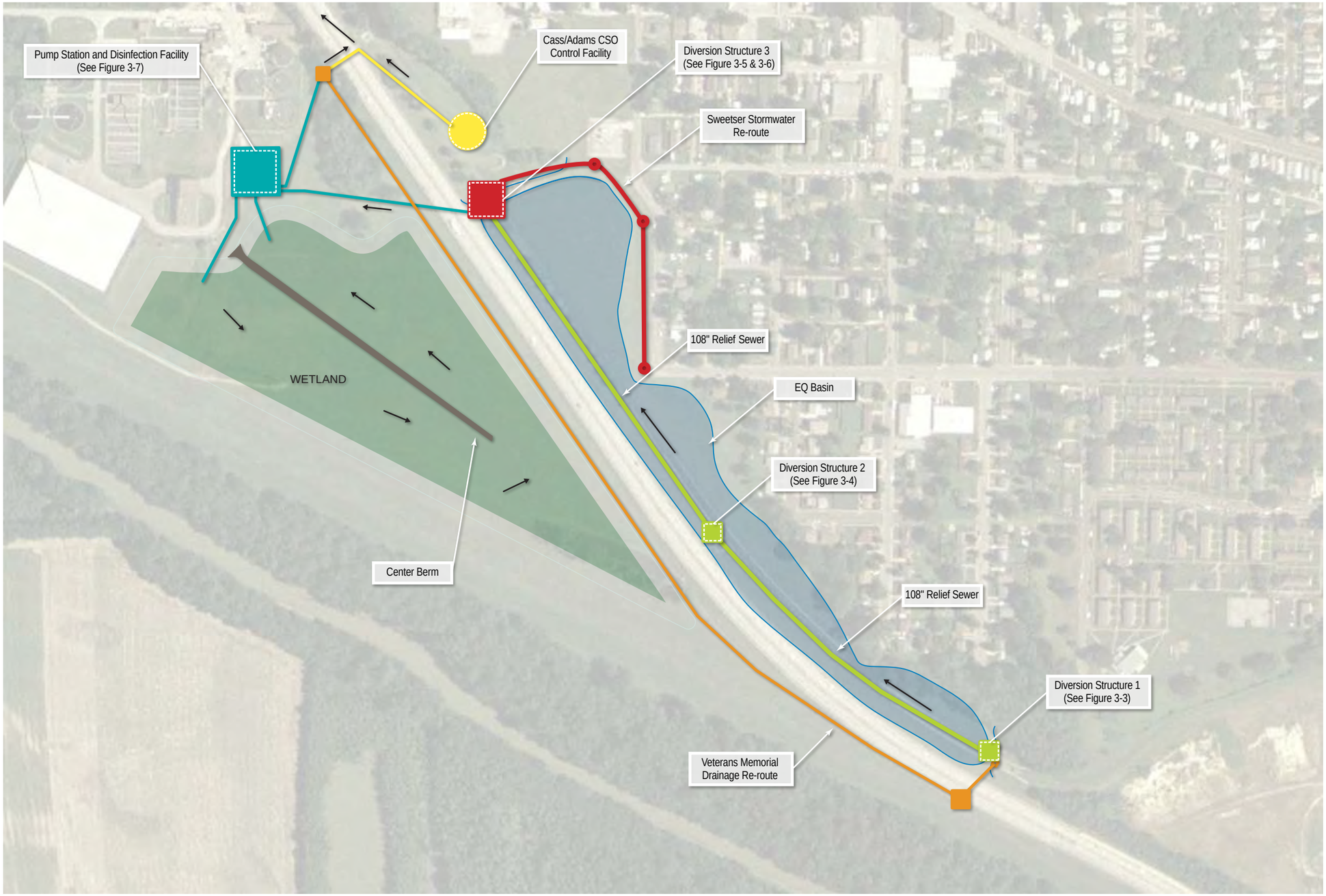
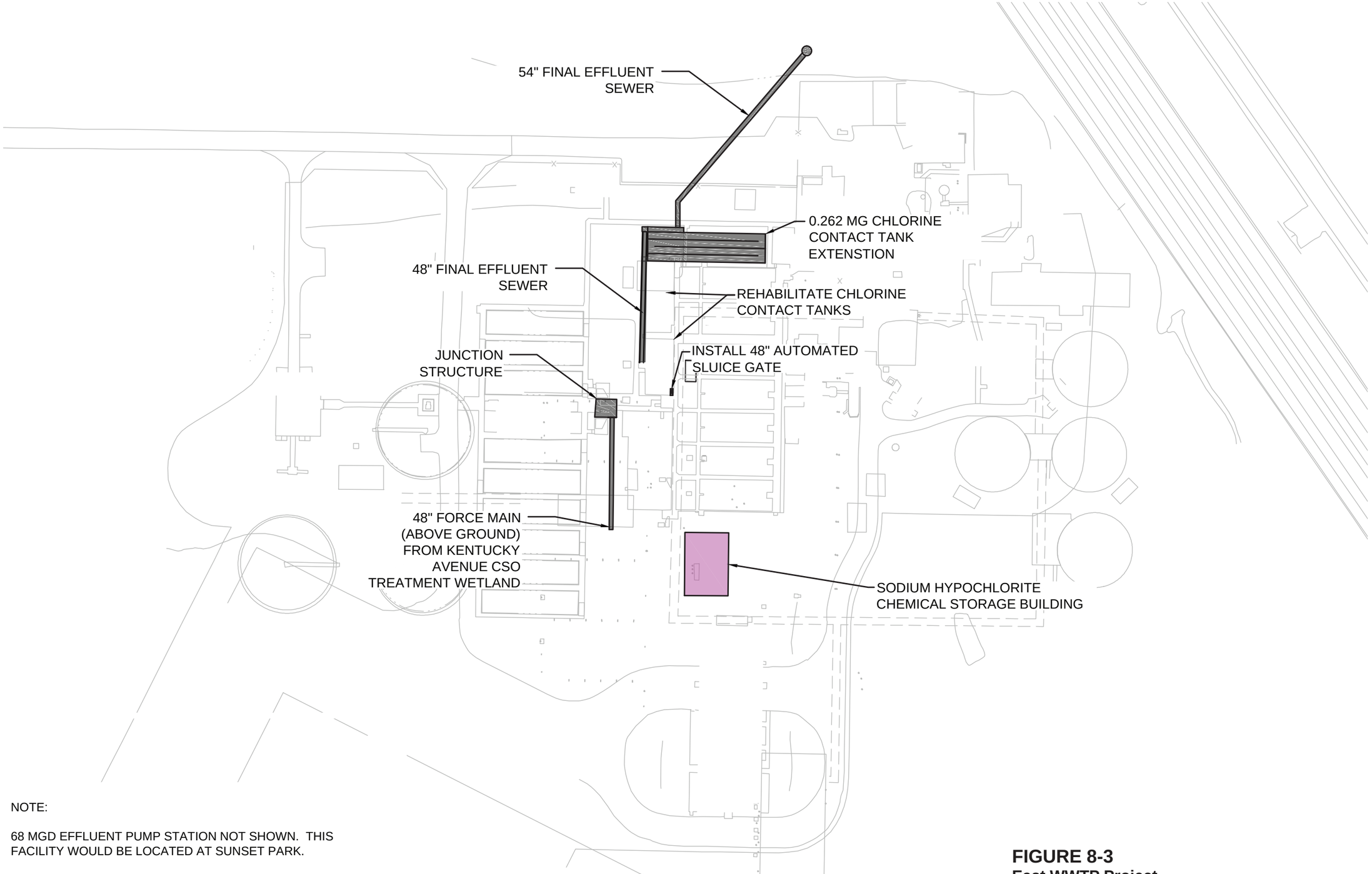


FIGURE 8-2
Bee Slough Remediation
Integrated Overflow Control Plan
May 31, 2013



NOTE:

68 MGD EFFLUENT PUMP STATION NOT SHOWN. THIS FACILITY WOULD BE LOCATED AT SUNSET PARK.

FIGURE 8-3
East WWTP Project
Integrated Overflow Control Plan
May 31, 2013

Figure 8-4 shows the planned improvements.

8.4.4 Control Measure 4 – Pigeon Creek Interceptor Optimization and Real-Time Control Projects

This control measure addresses CSOs 012, 013, 014, 016, 017, 018, 024, and 025. The Utility has already started the process of optimizing the Pigeon Creek Interceptor system and maximizing its capability to capture and treat more wet-weather flow. Historically, operation of the levee pump stations and wet-weather flow control gates has focused on preventing flooding on the City side of the flood protection system, and this focus on flood prevention has generally taken priority over CSO control. Consequently, those operating rules have been universally applied to flow control gate operations and the Utility believes that opportunities exist to adjust operations to capture additional wet-weather flow without causing flooding. Therefore, in May 2012, the Utility launched a project to collect and analyze flow and precipitation data in the Pigeon Creek Interceptor in conjunction with levee gate and pump station operational data to better understand the in-system conditions in the interceptor during rain events. This project includes the development of a real-time decision support system to facilitate and direct operational decisions with the goal of capturing more wet-weather flow in the system without causing surface flooding or backups into homes or businesses. It also includes a task to identify potential opportunities to store wet-weather flow in the trunk sewer tributary to the Pigeon Creek Interceptor, and with the same requirement that no surface flooding or backups occur as a result.

Another key piece of data used to develop this project was the condition of the Pigeon Creek Interceptor. During summer 2011, the Utility commissioned an inspection of this critical piece of sewer infrastructure using sonar and other state-of-the-art inspection technologies to identify sediment levels in the pipeline, structural defects that may present a risk for pipe failure and other structural attributes that may impede flow. As a result of this inspection, the Utility will be moving forward with a major cleaning project to remove the sediment in the pipe.

Future phases of this project may include making modifications to the diversion structures, including flow control and better integrating flood protection infrastructure with CSO capture strategies. In addition, after cleaning the interceptor, the Utility will continue to make refinements to the West system hydraulic model in order to right-size IOCP Phase 2 CSO control projects.

8.4.5 Control Measure 5 – 7th Avenue, Franklin Street, Fulton Avenue, 9th Avenue, and St Joseph Avenue CSO Control Projects

This control measure addresses CSOs 006, 009, 015, 016, 020, and 022. The 7th Avenue Lift Station plays a vitally important role in transferring millions of gallons of wastewater to the West WWTP. Currently the station has no onsite backup power system and only a single screen with no redundancy. This lack of backup equipment poses a high risk for large sewer overflows in the event of a power interruption or problem with the screen. To reliably capture and pump wet-weather flows in the future, the Utility determined through its analyses of this facility that it needs to be replaced. The recommended plan would replace the 7th Avenue Lift Station, and it would be designed and constructed to ultimately have a firm pumping capacity of 135 mgd, with 45 mgd being pumped to the West WWTP and 90 mgd being pumped to an onsite storage and ballasted flocculation HRT (Actiflo) treatment facility. Screening, grit removal, and backup power would be included as well.

In addition to the lift station, storage, and treatment facilities, Control Measure 5 includes:

- Construction of relief sewers from the Fulton Avenue, 9th Avenue, and Franklin Street CSOs to the proposed 7th Avenue Lift Station.
- Raising the St. Joseph Avenue CSO regulator weir to capture more wet-weather flow and send it to the West WWTP for treatment.

8.4.6 Control Measure 6 – Diamond Avenue/Baker Street Sewer Separation and CSO Control Projects

This control measure addresses CSOs 024 and 025. One of the key features of IOCP Phase 1 is the Utility's focus on reducing stormwater runoff into the CSS at key locations to reduce the size and cost of "end of pipe" CSO control facilities. The City's 2007 Stormwater Master Plan identified several partial sewer separation projects in the Diamond Avenue subbasin that direct street drainage into the 90-inch storm sewer that runs east to west along Diamond Avenue. The Diamond Avenue Phase I through IV separation projects are included in Control Measure 6. Figure 8-5 shows the projects' boundaries. Each of the projects will include green infrastructure components to provide water quality treatment for the stormwater-borne pollutants. These projects will free up significant capacity in the CSS to convey, store, and treat additional combined flows from other subareas.

In addition to the sewer separation projects, control of the CSOs from the Diamond Avenue and Baker Street CSOs will be accomplished by constructing an underground CSO storage facility beneath the Diamond Avenue levee pump station ponding area and pumping CSO flow from the Baker Street CSO to the storage facility. Stored CSO will be pumped into the Pigeon Creek Interceptor and routed to the West WWTP for treatment.

8.4.7 Control Measure 7 – Oakley Street CSO Storage Facility

This control measure addresses CSO 018. CSO flow from the Oakley Street CSO will be captured in an underground CSO storage facility near the Oakley Street CSO diversion structure. Stored CSO will be drained by gravity into the Pigeon Creek Interceptor and routed to the West WWTP for treatment.

8.4.8 Control Measure 8 – Oak Hill Sewer Separation and CSO Storage Facility

This control measure addresses CSO 011. This control measure includes the Akin Park, State Hospital, Boeke Road Outfall, Weinbach and Keck sewer separation projects from the 2007 Stormwater Master Plan and an underground CSO storage facility that will be located near the Oak Hill CSO outfall. Stored CSO will be pumped into the adjacent sewer collection system and routed to the East WWTP for treatment. The areas to be separated are described and presented within the 2007 Stormwater Master Plan (Appendix I).

8.4.9 Control Measure 9 – Downtown CSO (Oak/Riverside, Chestnut, and Dress Plaza) Control Projects

This control measure addresses CSOs 008, 010, and 038. Control Measure 9 includes construction of two underground storage facilities in the downtown area. One facility will capture wet-weather flows in the Dress Plaza CSS basin and the other will be located within the Oak/Riverside CSS basin; flows from the Chestnut CSS basin will be routed to it via a proposed relief sewer. Stored CSO will be pumped into the adjacent collection system and routed through the Riverside Interceptor to be treated at the East WWTP.

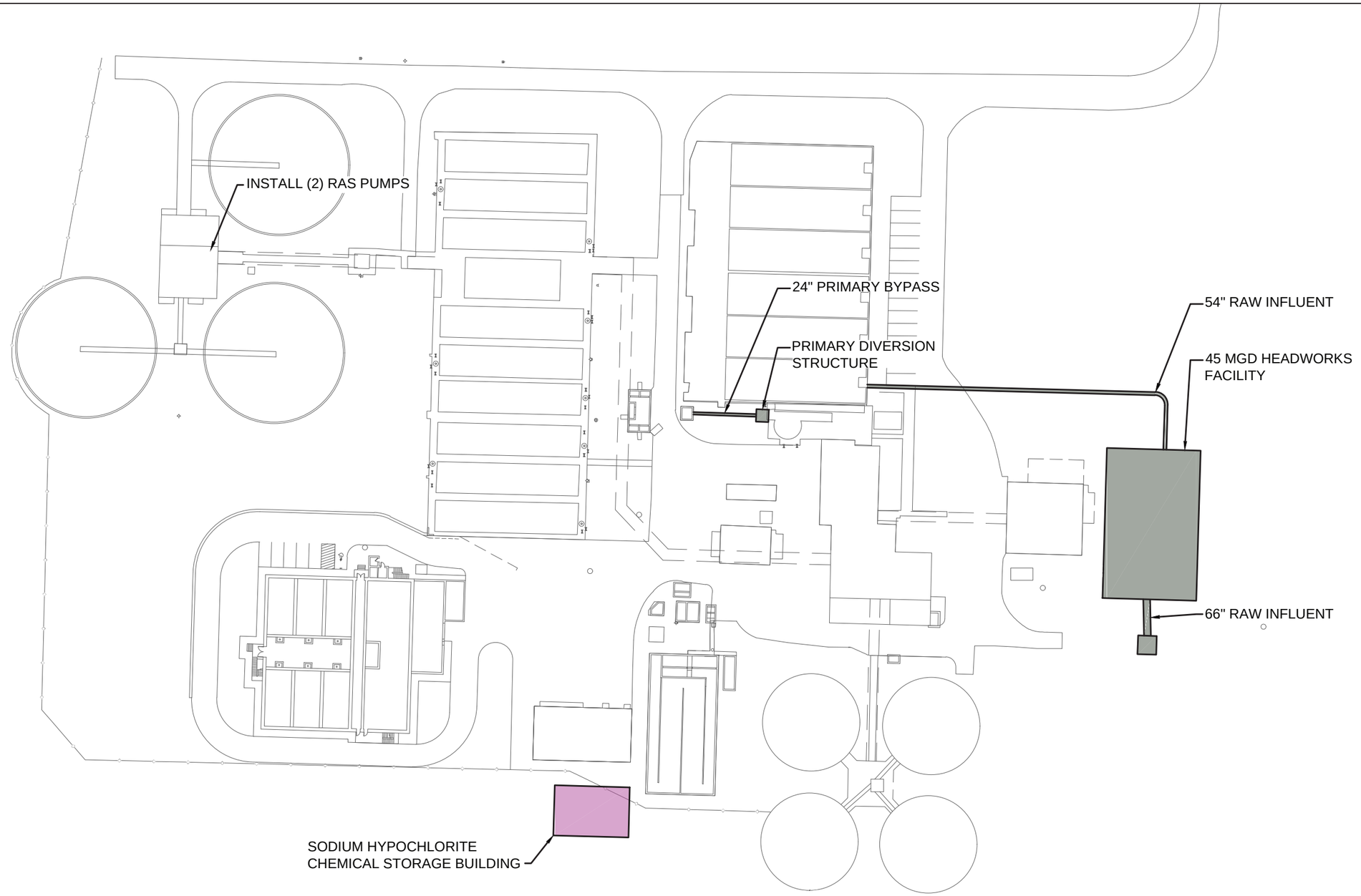
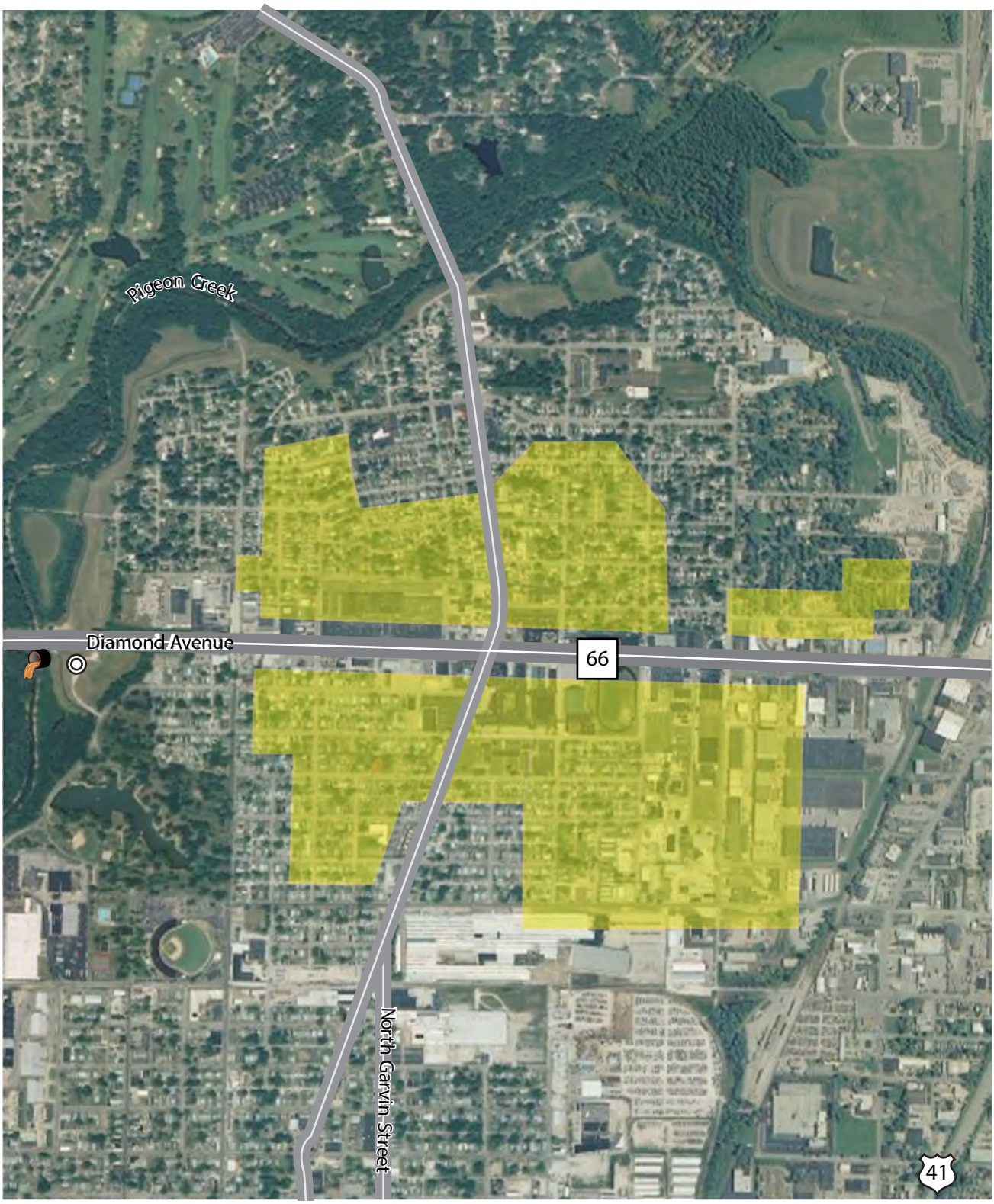


FIGURE 8-4
West WWTP Project
Integrated Overflow Control Plan
May 31, 2013



Legend

CSO

Storm Sewer Project Limits

Levee Pump Station

1,000 Feet

North

Figure 8-5
Diamond Avenue Storm Sewer Separation Project Boundaries
Integrated Overflow Control Plan
May 31, 2013

The green infrastructure program described above will be primarily focused in the downtown area in order to reduce the size and cost of Control Measure 9 or to attempt to eliminate the storage projects altogether.

8.4.10 Control Measure 10 – 6th Avenue, Dresden Street, Maryland Street, and Delaware Street CSO Control Projects

This control measure addresses CSOs 012, 013, 014, and 017. In this control measure, a CSO storage facility will be constructed near the Delaware Street CSO outfall. A relief sewer system will capture CSO from the Maryland Street, Dresden Street, and 6th Avenue CSOs and route it to the proposed Delaware Street CSO Storage Facility. Stored flow from the CSOs will be pumped into the Pigeon Creek Interceptor and routed to the West WWTP for treatment.

8.5 Capital Costs and Implementation Schedule of the Recommended Plan

Table 8-2 sets forth the overall, 28-year LTCP schedule. Figure 8-6 represents a time benefit graph depicting the capital expenditures over time relative to the benefits achieved.

Table 8-3 provides planning-level opinions of probable capital costs for the Phase 1 LTCP projects and the implementation schedule. It includes the key dates required by the Decree: the bid date, commencement of construction, and achievement of full operation.

8.6 Adaptive Management Implementation Approach

As previously described, the Utility is taking an adaptive management approach to the IOCP. This approach to implementing the IOCP is being used because the projects proposed to be conducted in the early years of the IOCP will reduce stormwater inflow into the sewer systems or redirect stormwater inflow out of the sewer systems. This will reduce the size and cost of new overflow control infrastructure projects proposed for both the CSS and SSS in later years. Additionally, the uncertainty inherent in any computer model used to size projects needs to be refined and recalibrated over time to ensure the right-sizing of projects.

The proposed IOCP projects have been sized using planning-level computer models and other engineering analysis tools that were calibrated based on the condition of the existing system and using data that was largely collected during 2011. 2011 has been documented as the wettest year in the City's history since precipitation data began being recorded in the 1890s. This created significant challenges in sewer system model development and other technical assessments conducted to develop the IOCP. Analysis and project development using planning-level models and approaches is inherently conservative and under normal circumstances presents opportunities for project and cost refinement during plan implementation. However, refinement opportunities generally require actual performance data gathered through time and after system optimization and I/I reduction. In the Utility's case, the complexity and

Table 8-2 28-Year LTCP Schedule

Control Measure/Plan	Project	Addresses	Planning Level Opinions of Probable Capital Costs	Bid Date	Commencement of Construction	Achievement of Full Operation
Green Infrastructure	All	CSS Basins	16,816,830	1/1/2018	1/12019	5/31/2035
1	Bee Slough Restoration and CSO Treatment	001, 002, 004	140,985,000	1/1/2019	1/1/2020	5/31/2035
2	East WWTP Improvement Projects	103	21,183,000	1/1/2019	1/1/2020	1/1/2023
3	West WWTP Improvement Projects	123	43,590,000	1/1/2021	1/1/2021	1/1/2028
4	Pigeon Creek Interceptor Optimization and RTC Projects	012, 013, 014, 016, 017, 018, 024, 025	4,000,000	1/1/2018	1/1/2019	1/1/2023
5	7th Avenue, Franklin Street, Fulton Avenue, 9th Avenue, and St. Joseph Avenue CSO Control Projects	006, 009, 015, 016, 020, 022	109,112,000	1/1/2025	1/1/2026	5/31/3035
6	Diamond Avenue/Baker Street Sewer Separation and CSO Control Projects	024, 025	49,163,000	1/1/2030	1/1/2031	1/1/2034
7	Oakley Street CSO Storage Facility	18	3,872,000	1/1/2034	1/1/2034	7/1/2035
8	Oak Hill Sewer Separationand CSO Control Projects	11	14,164,000	1/1/2025	1/1/2026	7/1/2035
9	Downtown CSO (Oak/Riverside, Chestnut, and Dress Plaza) Control Projects	008, 010, 038	52,405,000	1/1/2037	1/1/2038	1/1/2043
10	6th Avenue, Dresden Street, Maryland Street, and Delaware Street CSO Control Projects	012, 013, 014, 017	40,711,000	1/1/2040	1/1/2041	5/31/2043
	Proposed IOCP Cost		**496,001,830**			

Notes

1. Refer to the LTCP, SSRMP, and WWTP Facility Plan for specific project details and development of cost opinions.
2. The proposed bid, commencement of construction, and achievement of full operation dates are subject to change based on state and federal (including USACE) permitting and approval.
3. These summary tables present only capital cost since it is the key scheduling component of cost. Project O&M costs and Life Cycle cost are presented with project details in the appendixes to the LTCP.

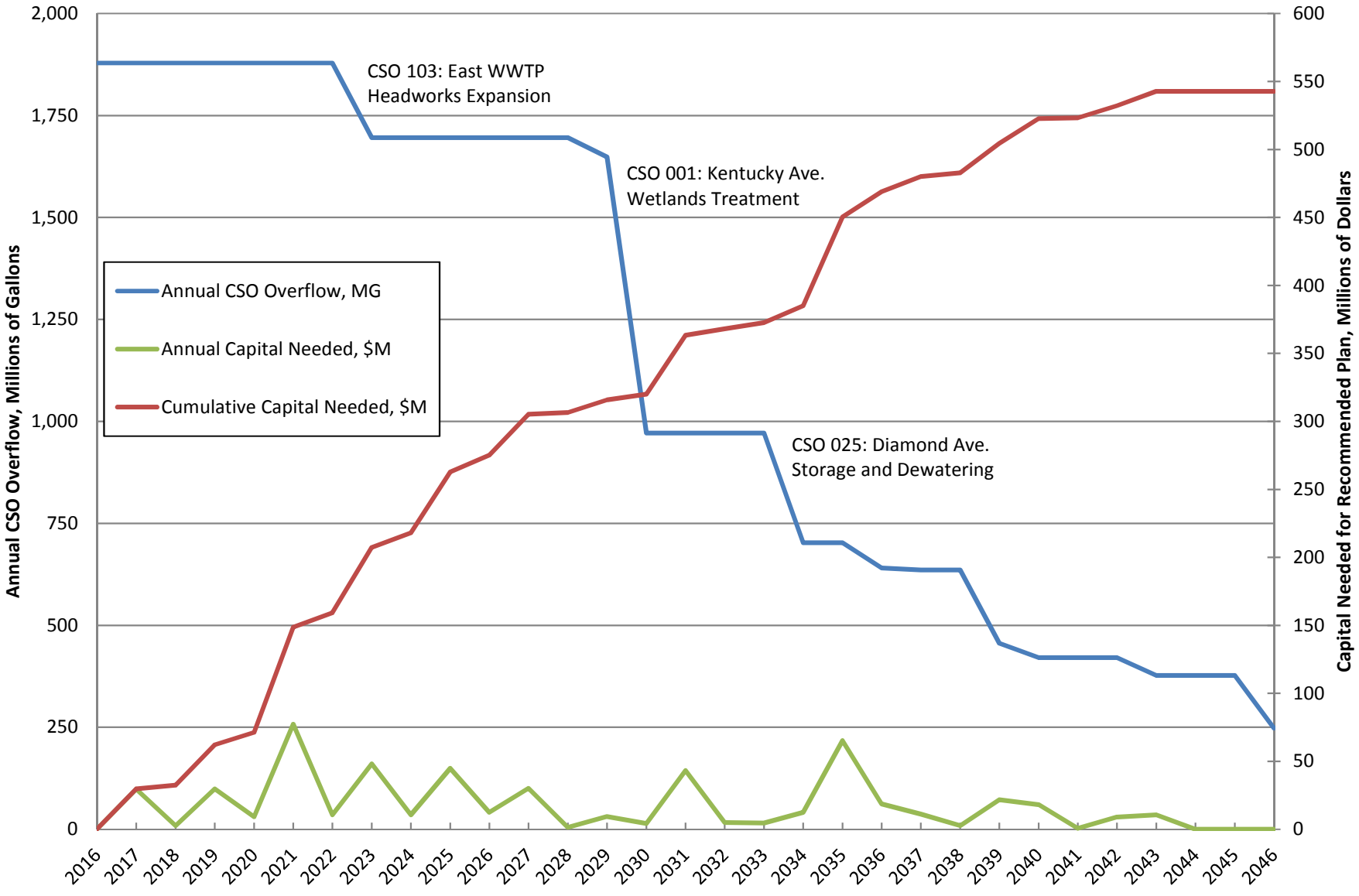
Table 8-3 20-year only LTCP Schedule - May 31, 2035 Completion

Control Measure/Plan	Project	Addresses	Planning Level Opinions of Probable Capital Costs	Bid Date	Commencement of Construction	Achievement of Full Operation
Green Infrastructure	All	CSS Basins	16,816,830	1/1/2018	1/12019	5/31/2035
1	Bee Slough Restoration and CSO Treatment	001, 002, 004	140,985,000	1/1/2019	1/1/2020	5/31/2035
2	East WWTP Improvement Projects	103	21,183,000	1/1/2019	1/1/2020	1/1/2023
3	West WWTP Improvement Projects	123	43,590,000	1/1/2021	1/1/2021	1/1/2028
4	Pigeon Creek Interceptor Optimization and RTC Projects	012, 013, 014, 016, 017, 018, 024, 025	4,000,000	1/1/2018	1/1/2019	1/1/2023
5	7th Avenue, Franklin Street, Fulton Avenue, 9th Avenue, and St. Joseph Avenue CSO Control Projects	006, 009, 015, 016, 020, 022	68,853,705	1/1/2025	1/1/2026	5/31/3035
6	Diamond Avenue/Baker Street Sewer Separation and CSO Control Projects	024, 025	31,883,000	1/1/2030	1/1/2031	1/1/2034
7	Oakley Street CSO Storage Facility	018	3,872,000	1/1/2034	6/1/2034	5/31/2035
8	Oak Hill Sewer Separationand CSO Control Projects	011	8,441,000	1/1/2025	1/1/2026	5/31/2035
9	Downtown CSO (Oak/Riverside, Chestnut, and Dress Plaza) Control Projects	008, 010, 038	0			
10	6th Avenue, Dresden Street, Maryland Street, and Delaware Street CSO Control Projects	012, 013, 014, 017	0			
	Proposed IOCP Cost		**339,624,535**			

Notes

1. Refer to the LTCP, SSRMP, and WWTP Facility Plan for specific project details and development of cost opinions.
2. The proposed bid, commencement of construction, and achievement of full operation dates are subject to change based on state and federal (including USACE) permitting and approval.
3. These summary tables present only capital cost since it is the key scheduling component of cost. Project O&M costs and Life Cycle cost are presented with project details in the appendixes to the LTCP.

Figure 8-6 Time-Benefit Graph
Recommended Plan, 2016–2046



interdependency of the CSS operation in relation to the operation of the flood protection system have made model calibration more difficult, and the extremely wet year introduced significant additional challenges and uncertainty. This uncertainty forces additional conservatism in predicting overflow volumes and flow rates, which may translate into higher projected costs for overflow control facilities. The Utility requested and was granted an additional 6 months to collect additional flow data during a drier period and to refine the computer models used for planning the IOCP projects, which resulted in more computer model certainty, a more cost-effective plan, and better projected performance. However, an adaptive approach is still warranted to achieve the best performance at the lowest life-cycle cost across the entire IOCP.

The proposed adaptive approach to IOCP implementation recognizes the conservatism and uncertainty inherent in this process. It also recognizes that system conditions and future facility sizing will change. Changes will occur as a result of (1) implementing specific optimization or real-time control projects and (2) constructing green infrastructure projects, overflow control facilities, reducing I/I, and redirecting stormwater inflow out of the sewer systems. The adaptive management approach can be summarized as follows:

- Monitor and analyze dry- and wet-weather flow data before and after individual IOCP projects are implemented.
- Refine and/or recalibrate the hydraulic models on an ongoing basis and after individual IOCP projects are implemented.
- Conduct value engineering and verify infrastructure sizing during advanced facility planning and preliminary design efforts for storage, pumping, and conveyance projects to ensure that the individual projects meet the planned performance objectives and support the IOCP overall performance objectives.

The specific IOCP projects and schedule are provided in Volume 1 of the IOCP.

8.7 Post-Construction Monitoring Program

As previously stated, the Utility is committed to continuous improvement and adaptive management to appropriately size future CSO improvements and to address the most pressing problems first. Consequently, the Utility has begun to enhance the monitoring of precipitation, in-system flows and overflows from the system, and a key component of the recommended Phase 1 plan is to conduct a post-construction monitoring program to determine and report on the performance of the projects and the resulting benefits. A more detailed discussion of the Post-Construction Monitoring Program is set forth in Section 9.

8.8 The Recommended IOCP Provides the Best Benefit for the City's Large Infrastructure Investment

Evansville's Recommended IOCP dramatically reduces CSO discharges and addresses SSOs in an aggressive manner while attempting to keep sewer rates in check.

In Evansville, approximately 2 billion gallons of combined wastewater and stormwater leave the sewer system through 22 outfalls in a Typical Year, and overflows can occur with as little as 0.1 inch of rainfall. Evansville experiences approximately 50 days of CSOs in a Typical Year. A comparison of other cities reveals that Evansville has a CSO problem that is comparable to larger cities that have more customers over which to spread the cost of system improvements.

Nevertheless, Evansville's Recommended IOCP will comply with the CWA and federal mandates and can be implemented under a schedule that balances necessary infrastructure improvements with Evansville citizens' ability to afford a large capital program. The Recommended IOCP will greatly reduce the days of CSO activations to 12 events during a Typical Year and dramatically increase the percentage of flow capture from 35 to 92 percent. These targets meet or exceed EPA's CSO control policy for addressing CSOs. Evansville's approach to funding the plan (see Section 4), is to not allow sewer rates to exceed 2 percent of MHI for in-city customers. This approach allows Evansville to achieve this high level of CSO control over 28 years.

The Utility's Recommended Plan to reduce CSO activations from approximately 50 days to 12 days in a Typical Year also provides the most cost effective approach to improve water quality for *E. Coli* bacteria. The results of the water quality model analysis reveal that both the Ohio River and Pigeon Creek are impaired waterways when they reach Evansville. The water quality model shows that reduction of CSO discharges to 12 days of activation increases the number of days Pigeon Creek and the Ohio River meet the water quality standard for *E. Coli* from 112 days to 125 days during the 180-day recreational season. Reducing the days of CSO activation to less than 12 overflows in a Typical Year provides no (zero) additional days of water quality compliance for *E. Coli* in either water way.

Lastly, tackling the significant challenges posed by a decades-long capital program to address sewer overflows through an adaptive management approach allows Evansville to continually evaluate infrastructure improvements and sewer system characteristics to adjust and modify projects in later years of the Recommended IOCP to ensure infrastructure projects are appropriately sized and designed to meet intended goals. Such an approach allows the Utility to reap the benefits of green infrastructure and advances in technology that are almost certain to occur over the next 20-plus years.

8.9 Implementation Options for the Recommended Plan

As described in Section 4 of Volume 1, at least a 28-year implementation schedule for the Recommended IOCP is necessary, based on the City's financial capability to fund a large program and the impact such a program will have on wastewater rates. Given the passage of time since the original IOCP was submitted on May 31, 2013, without approval and the time likely necessary to reach approval, the City has pushed the dates in the 28-year schedule back 3 years in this resubmission to ensure appropriate time to raise funds as necessary, bond for projects, engage engineering consultants, design, and gain permit approval of projects. A detailed, 28-year schedule is set forth below in Table 8-4. If state and federal regulators refuse to allow the City the appropriate time to implement both phases of the IOCP over this 28-year time frame, the alternative option at this point, based upon affordability and potential Decree requirements, is for the City to commit to and implement Phase 1 of the recommended IOCP. When originally submitted in May 31, 2013, Phase 1 of the plan had a completion date of May 31, 2032, per the proposed plan completion date set forth in the Consent Decree. As is discussed above, given the passage of time since submission of the original plan on May 31, 2013, and that the City's plan is still not approved, the City has extended the completion date of phase 1 by three years to May 31, 2035.

Table 8-4 28-Year Recommended IOCP Schedule

Control Measure/Plan	Project	Addresses	Planning Level Opinions of Probable Capital Costs	Bid Date	Commencement of Construction	Achievement of Full Operation
Green Infrastructure	All	CSS Basins	16,816,830	1/1/2018	1/2019	5/31/2035
1	Bee Slough Restoration and CSO Treatment	001, 002, 004	140,985,000	1/1/2019	1/1/2020	5/31/2035
2	East WWTP Improvement Projects	103	21,183,000	1/1/2019	1/1/2020	1/1/2023
3	West WWTP Improvement Projects	123	43,590,000	1/1/2021	1/1/2022	1/1/2028
4	Pigeon Creek Interceptor Optimization and RTC Projects	012, 013, 014, 016, 017, 018, 024, 025	4,000,000	1/1/2018	1/1/2019	1/1/2023
5	7th Avenue, Franklin Street, Fulton Avenue, 9th Avenue, and St Joseph AvenueCSO Control Projects	006, 009, 015, 016, 020, 022	109,112,000	1/1/2025	1/1/2026	1/1/2038
6	Diamond Avenue/Baker Street Sewer Separation and CSO Control Projects	All CSOs	49,163,000	1/1/2030	1/1/2031	7/1/2039
7	Oakley Street CSO Storage Facility	018	3,872,000	1/1/2034	1/1/2035	7/1/2036
8	Oak Hill Sewer Separation and CSO Storage Facility	011	14,164,000	1/1/2025	1/1/2026	7/1/2039
9	Downtown CSO (Oak/Riverside, Chestnut, and Dress Plaza) Control Projects	008, 010, 038	52,405,000	1/1/2037	1/1/2038	1/1/2043
10	6th Avenue, Dresden Street, Maryland Street, and Delaware Street CSO Control Projects	012, 013, 014, 017	40,711,000	1/1/2040	1/1/2041	5/31/2043

Table 8-4 28-Year Recommended IOCP Schedule

Control Measure/Plan	Project	Addresses	Planning Level Opinions of Probable Capital Costs	Bid Date	Commencement of Construction	Achievement of Full Operation
SSRMP	North Park Rehabilitation Projects	Mill Road SSOs	10,529,000	1/1/2018	1/1/2019	1/1/2023
SSRMP	North Park Capacity Projects	Mill Road SSOs	4,247,000	1/1/2030	1/1/2031	5/31/2035
SSRMP	Lloyd Expressway Rehabilitation Projects	Lincoln Avenue SSOs	2,442,000	1/1/2021	1/1/2022	1/1/2025
SSRMP	Lloyd Expressway Capacity Projects	Lincoln Avenue SSOs	2,961,000	1/1/2024	1/1/2025	1/1/2027
SSRMP	NW/SW Rehabilitation Projects	Tekoppel Avenue SSOs	3,614,000	1/1/2022	1/1/2023	1/1/2027
SSRMP	NW/SW Capacity Projects	Tekoppel Avenue SSOs	3,054,000	1/1/2026	1/1/2027	1/1/2028
SSRMP	E-11 Rehabilitation Projects	Bergdolt Road SSOs	3,251,000	1/1/2022	1/1/2023	1/1/2026
SSRMP	E-11 Capacity Projects	Bergdolt Road SSOs	10,760,000	1/1/2027	1/1/2028	1/1/2030
SSRMP	SSS Rehabilitation Projects	SSS Basins	3,423,000	1/1/2024	1/1/2025	5/31/2035
	Proposed IOCP Cost		**540,282,830**			

Notes

1. Refer to the LTCP, SSRMP, and WWTP Facility Plan for specific project details and development of cost opinions.
2. The proposed bid, commencement of construction, and achievement of full operation dates are subject to change based on state and federal (including USACE) permitting and approval.
3. This summary table present sonly capital cost because it is the key scheduling component of cost. Project O&M and Life Cycle costs are presented with project details in the appendixes to the LTCP.
4. Costs in 2012 dollars.

Phase 1 over the first 20 years is planned to achieve system-wide capture of approximately 65 percent of all wet-weather flows entering the CSS (compared to 35 percent capture in the Typical Year existing condition), with approximately 35 activations still occurring during the Typical Year. Implementing both phases of the IOCP over at least 28 years would result system-wide capture of 92 percent of all wet-weather flows entering the CSS, with 12 CSO activations occurring during the Typical Year.

Table 8-5 lists the projects that would be constructed in a 20-year-only IOCP. Note that the projects in a 20-year only IOCP are slightly different than the projects proposed in the first 20 years of a 28-year IOCP, because of the timing of funding availability and construction schedules.

Table 8-5 sets forth schedule of projects for a 20-year IOCP.

Table 8-5 20-year only Recommended IOCP Schedule - May 31, 2035 Completion

Control Measure/Plan	Project	Addresses	Planning Level Opinions of Probable Capital Costs	Bid Date	Commencement of Construction	Achievement of Full Operation
Green Infrastructure	All	CSS Basins	16,816,830	1/1/2018	1/1/2019	5/31/2035
1	Bee Slough Restoration and CSO Treatment	001, 002, 004	140,985,000	1/1/2019	1/1/2020	5/31/2035
2	East WWTP Improvement Projects	103	21,183,000	1/1/2019	1/1/2020	1/1/2023
3	West WWTP Improvement Projects	123	43,590,000	1/1/2021	1/1/2022	1/1/2028
4	Pigeon Creek Interceptor Optimization and RTC Projects	012, 013, 014, 016, 017, 018, 024, 025	4,000,000	1/1/2018	1/1/2019	1/1/2023
5	7th Avenue, Franklin Street, Fulton Avenue, 9th Avenue, and St Joseph Avenue CSO Control Projects	006, 009, 015, 016, 020, 022	68,853,705	1/1/2025	1/1/2026	5/31/2035
6	Diamond Avenue/Baker Street Sewer Separation andCSO Control Projects	All CSOs	31,883,000	1/1/2030	1/1/2031	1/1/2034
7	Oakley Street CSO Storage Facility	018	3,872,000	1/1/2034	6/1/2034	5/31/2035
8	Oak Hill Sewer Separation and CSO Storage Facility	011	8,441,000	1/1/2025	1/1/2026	5/31/2035
9	Downtown CSO (Oak/Riverside, Chestnut, and Dress Plaza) Control Projects	008, 010, 038	0			
10	6th Avenue, Dresden Street, Maryland Street, and Delaware Street CSO Control	012, 013, 014, 017	0			

Table 8-5 20-year only Recommended IOCP Schedule - May 31, 2035 Completion

Control Measure/Plan	Project	Addresses	Planning Level Opinions of Probable Capital Costs	Bid Date	Commencement of Construction	Achievement of Full Operation
	Projects					
SSRMP	North Park Rehabilitation Projects	Mill Road SSOs	10,529,000	1/1/2018	1/1/2019	1/12023
SSRMP	North Park Capacity Projects	Mill Road SSOs	4,247,000	1/1/2030	1/1/2031	5/31/2035
SSRMP	Lloyd Expressway Rehabilitation Projects	Lincoln Avenue SSOs	2,442,000	1/1/2021	1/1/2022	1/1/2025
SSRMP	Lloyd Expressway Capacity Projects	Lincoln Avenue SSOs	2,961,000	1/1/2024	1/1/2025	1/1/2027
SSRMP	NW/SW Rehabilitation Projects	Tekoppel Avenue SSOs	3,614,000	1/1/2022	1/1/2023	1/1/2027
SSRMP	NW/SW Capacity Projects	Tekoppel Avenue SSOs	3,054,000	1/1/2025	1/1/2027	1/1/2028
SSRMP	E-11 Rehabilitation Projects	Bergdolt Road SSOs	3,251,000	1/1/2022	1/1/2023	1/1/2026
SSRMP	E-11 Capacity Projects	Bergdolt Road SSOs	10,760,000	1/1/2027	1/1/2028	1/1/2030
SSRMP	SSS Rehabilitation Projects	SSS Basins	3,423,000	1/1/2024	1/1/2025	5/31/2035
	Proposed IOCP Cost		**383,905,535**			

Notes

1. Refer to the LTCP, SSRMP, and WWTP Facility Plan for specific project details and development of cost opinions.
2. The proposed bid, commencement of construction, and achievement of full operation dates are subject to change based on state and federal (including USACE) permitting and approval.
3. These summary tables present only capital cost since it is the key scheduling component of cost. Project O&M costs and Life Cycle cost are presented with project details in the appendixes to the LTCP.
4. Costs in 2012 dollars.

SECTION 9

Final Negotiated Long Term Control Plan for CSO Control – January 15, 2016

This section describes the Utility's Negotiated Plan reached via agreement with EPA and IDEM for meeting CWA objectives for reducing sewer overflows. This plan supersedes the Recommended Plan. Like the Recommended Plan, the Negotiated Plan addresses the community's highest priorities and balances the overall plan benefits with the Utility's financial capability to schedule and achieve the highest benefits as expeditiously as possible. It represents the best level of control possible for the available public investment. This plan is based on the alternatives evaluation described in Section 3, the financial impacts and affordability considerations discussed in Section 4, and the input received from the CAC in 2012 and 2013. Summaries of the recommended projects are provided in this section, and specific and detailed information on each of the projects can be found in the technical documents integrated by this IOCP (specifically, the LTCP, SSRMP, and WWTP Facility Plan).

9.1 Overview of the Negotiated IOCP

The City's IOCP will address and dramatically reduce the number of CSOs that occur in the City and eliminate chronic, recurring SSO locations. The total cost of the IOCP is projected at $729 million over 25 years.

When complete, the Negotiated IOCP will protect water quality, and reduce CSOs from approximately 50 activations to 4 activations during a Typical Year, and will increase the combined sewer system's capture of combined sewage by volume from 35 percent today to 98 percent when implementation is complete. EPA's CSO Control Policy seeks to have cities reduce overflows to 0 to 12 activations per year and increase percent capture to 75 to 100 percent. The CWA requires protection of water quality. Therefore, the proposed LTCP portion of the ICOP meets the regulatory thresholds set forth by EPA and the CWA. It is worth noting that the complete elimination CSOs is cost prohibitive and simply not practical, so residual CSOs will occur during some large storm events.

9.2 Negotiated IOCP Projects for CSO Control

The negotiated plan focuses on these major initiatives:

- Remedy the odor and aesthetic problems in Bee Slough through the control and treatment of CSO discharges into Bee Slough and the redirection of East WWTP treated effluent from Bee Slough to the Ohio River during high river conditions.
- Reduce the inflow of stormwater into the sewer systems through the construction of green infrastructure projects, partial sewer separation projects that include green infrastructure elements, and through I/I reduction projects in the separate sanitary sewer system.
- Increase treatment of captured wet-weather flows at the East WWTP by expanding the secondary treatment process capacity to 40 mgd to match the capacity of the existing primary treatment process.

- Increase treatment of captured wet-weather flows at the West WWTP by constructing a new, expanded Headworks Facility, eliminating remaining hydraulic bottlenecks within the treatment processes, and constructing flow equalization facilities. One change from the Recommended Plan is the Utility will not use the 5-mgd bypass around the primary clarifiers. Rather, the plan includes raising primary clarifier weirs and constructing curb walls for the primary clarifier influent channel. Replace the 7th Avenue Lift Station to increase its pumping capacity and increase its reliability through the installation of redundant equipment and a backup power source, and construct a CSO storage and treatment facility at this location to capture and treat CSO discharges from the 7th Avenue East, Fulton Street, Franklin Street, and 9th Street CSOs.
- Increase capture of combined wet-weather flows by raising overflow weirs in the diversion structures throughout the entire system; by cleaning the Pigeon Creek Interceptor; and by implementing real-time control strategies to optimize the operation of the Pigeon Creek Interceptor and flood control system, the 7th Avenue Lift Station, and the West WWTP.
- Control CSO discharges to Pigeon Creek through construction of CSO storage facilities at the Diamond Avenue, Oakley Street, Delaware Street, and Oak Hill CSOs.
- Control CSO discharges to the Ohio River through construction of two CSO storage facilities in the downtown area to capture and control CSO discharges from the Dress Plaza, Chestnut Street, and Oak/Riverside CSOs.
- Optimize the Ohio Street and Broadway Avenue Interceptors to increase capture and treatment of CSO discharges from the St. Joseph Avenue CSO.
- Enhance the Utility's precipitation, flow, and overflow monitoring systems to continuously track system performance and the results of the implementing the proposed overflow control and inflow reduction projects.
- Elimination of CSO 009 and CSO 122. Existing controls and equipment will be removed or rendered inoperable, and structures will be encased in concrete as appropriate to prevent any future use.

9.3 Green Infrastructure Program

The Utility has completed an investigation of a range of potential green infrastructure programs and projects throughout the combined sewer area, with a particular focus on the City's downtown and efforts to augment the sewer separation approaches discussed previously. The investigation examined opportunities to incorporate green infrastructure into a variety of public infrastructure improvements and in keeping with other planning initiatives for redevelopment and beautification of the City's downtown. As a result, the Utility has identified a program of green infrastructure improvements that are consistent with other City planning objectives and that leverage available funding across multiple City departments. Within the downtown area and nearby residential neighborhoods, green infrastructure includes street improvements to replace all or a portion of the conventional pavement with porous pavement and other streetscape green technologies. In addition, there are large public parking lots and some City parks that present opportunities to include green infrastructure to intercept, divert, and/or capture stormwater runoff before it can enter the CSS. In addition to porous pavement, the green street concept includes porous sub-grade material and underdrain systems intended to

both convey and detain stormwater runoff. The outlet for this green street concept is a dry well that redirects stormwater discharges to a buried layer of pervious sand and gravel. In areas of the City where the infiltration capacity of the surrounding soils is lower, the green infrastructure improvements would discharge residual flows through an underdrain back to the CSS. Portions of the City are underlain with the porous Ohio River sand aquifer, which has the potential to accommodate infiltration approaches.

Green infrastructure improvements optimize the performance of the proposed sewer separation and provide inherent water quality benefits to those projects. In addition, the green street concept with a dry well is capable of significant reductions in stormwater runoff volume to the CSS in areas where there is no suitable storm system outfall. In the downtown areas of the City and in the adjacent historic neighborhoods, green infrastructure improvements provide an opportunity to meet the overall IOCP objectives while also providing other intrinsic value to the community. The Utility has established a green infrastructure participation program and will continue to interact with City departments, private industry, and neighborhoods on a regular basis to identify opportunities where green infrastructure can be incorporated into projects that would reduce CSOs and provide other benefits. In addition, the green street concept is expected to create additional incentive for the community to expand on its redevelopment and street enhancement programs. The Utility's program to implement green infrastructure will include a scoring system that values each potential project based on cost and other benefit factors that determine prioritization.

To date, the Utility has moved forward with green infrastructure projects at Professional Plaza and the YMCA/Evansville Building Authority parking lot that will remove 4.5 MG of rainwater from the combined sewer system in downtown Evansville.

9.4 Negotiated Plan CSO Control Measures

The CSO projects proposed in the plan are shown in Figure 9-1 and summarized in the following sections.

9.4.1 Control Measure 1 – Bee Slough Restoration and CSO Treatment

The plan to remedy the odor and aesthetic problems in Bee Slough is shown on Figure 9-2 and includes the design and construction of the following projects:

- Drainage pipelines between the concrete channel and the East WWTP Headworks Facility to provide the ability to send standing water in Bee Slough to the WWTP for treatment.
- A pump station to pump treated effluent from the East WWTP to the Ohio River during periods of high river levels (instead of allowing it to back up and collect in Bee Slough when the K-4 Levee Pump Station is being utilized).
- A wetland treatment system and associated pump station and disinfection system to capture and treat discharges from the Kentucky Avenue CSO. Effluent from the wetland treatment system will meet the all of the Performance Criteria in Appendix G of the Consent Decree, and effluent monitoring will be performed per Appendix H of the Consent Decree.
- Pipes and drains that interconnect the wetland pump station, disinfection facility, and East WWTP to maximize the use of the East WWTP for treating captured CSO, and to allow for

recirculation of water through the wetland treatment system to increase wetland treatment performance.

- A combined storage/treatment facility (VTU) for capture, treatment, and disinfection of CSO discharges from the Cass Avenue CSO, and a pipeline that captures CSO discharges from the Adams Street CSO and sends the captured flow to this facility. Effluent from the VTU will meet performance criteria identified in Appendix G of the Decree.

The project will be subject to review and approval by and coordination with USACE and could be subject to changes based on their review and approval process. As proposed, the Bee Slough Remediation Projects are expected to treat 100 percent of the overflows in the Typical Year. Per EPA's request, included in the technical memorandum in Appendix J are updated modeling results from the Bee Slough wetland solution that include instances where the wetland flow level exceeds 4 feet of depth. To date, the Bee Slough advanced facility plan and geotechnical soil boring data collection regarding this control measure are complete, and the Utility has begun preliminary design of the relief sewer from CSO 004 to CSO 002.

9.4.2 Control Measure 2 – East WWTP Improvement Projects

In early 2012, the Utility completed installation of a second fine screen and fourth pump in the Headworks Facility, which expanded the headworks capacity from 20 to 40 mgd. Since that time, the Utility has completed WWTP stress testing and determined that up to 50 mgd can be treated by the primary treatment process and up to 28 mgd can be treated by the secondary process. The existing disinfection process has the capability of treating up to 32 mgd.

The IOCP would upgrade and expand the secondary treatment process capacity to 40 mgd. This was a change from the Recommended Plan for the East WWTP, which included expansion of treatment capacity to 40 mgd by means of PE Bypass infrastructure. The negotiated plan does not involve utilizing PE Bypass infrastructure. The Utility will take the opportunity during this upgrade to convert from the use of gaseous chlorine (which poses safety and health risks), to sodium hypochlorite, a safer disinfecting chemical.

The plan also includes the modification of the CSO 103 diversion structure weir (the East WWTP bypass point) to completely divert wet-weather flows into the East WWTP for treatment during the Typical Year. Figure 9-3 shows the planned improvements.

9.4.3 Control Measure 3 – West WWTP Improvement Projects

The stress tests completed during summer 2012 determined that the West WWTP can treat up to 40 mgd through the primary treatment process and that the secondary treatment process has the capability to treat up to 45 mgd. The tests also determined that the existing disinfection process has the capability of treating up to 56 mgd. Historically, the Utility has limited headworks pumping to less than 40 mgd due to the primary process's maximum capacity, and engineering analysis has determined that it is unlikely that the existing headworks has the ability to pump flows much higher than 40 mgd. A further complication is that pumping at these higher flow rates negatively affects the influent sewer system hydraulics, because of the need to maintain high, flooded wetwell levels that are outside the bounds of the facility's design conditions. This situation, in combination with the single fine screen in the Headworks Facility, with only a coarse bar screen for backup, warrants a replacement Headworks Facility that is purpose-built for these conditions, that contains the appropriate redundancy in equipment, and that has provisions for maintaining consistent influent sewer levels during wet-weather events.

Proposed IOCP Projects

renewEVANSVILLE

CSO Inventory

CSO	NAME	RECEIVING WATER	WWTP SERVICE AREA
001	Kentucky Avenue	Bee Slough	East
002	Cass Avenue	Bee Slough	East
103	Junction Box Prior to WWTP Headworks	Ohio River	East
004	Adams	Bee Slough	East
006	Fulton Avenue Pumping Station	Ohio River	West
008	Chestnut Street	Ohio River	East
009	7th Avenue West	Ohio River	West
010	Dress Plaza	Ohio River	East
011	Weinbach Lift Station (Oakhill Road)	Pigeon Creek	East
012	Maryland Street - West Bank	Pigeon Creek	West
013	Delaware Street	Pigeon Creek	West
014	Dresden Street	Pigeon Creek	West
015	7th Avenue East	Ohio River	West
016	Franklin Street	Pigeon Creek	West
017	6th Avenue	Pigeon Creek	West
018	Oakley Street	Pigeon Creek	West
020	9th Avenue	Ohio River	West
022	St. Joseph Avenue	Ohio River	West
123	West Plant CSO	Ohio River	West
024	Baker Street	Pigeon Creek	West
025	Diamond Avenue	Pigeon Creek	West
038	Oak / Riverside	Ohio River	East

Map Legend

East Service Area
- Separate Sewer Area
- Combined Sewer Area

West Service Area
- Separate Sewer Area
- Combined Sewer Area

- Wastewater Treatment Plant
- Priority SSO Location
- CSO
- Storage Basin
- High Rate Treatment Unit
- Sewer Rehab Projects
- City Limits

Mill Road SSO Group

Oakley CSO Control Facility
Storage Basin

Relief from Baker to Diamond Ave
Storage Basin and Treatment at Diamond Ave.

Bergdolt Road SSO

Delaware, Maryland, Dresden & 6th Avenue CSO Control Facility
Relief sewer from 6th Ave, Dresden, and Maryland to Storage Basin at Delaware

St. Joesph CSO Control Facility
System Optimization

Dress Plaza CSO Control Facility
Storage Basin

Oakhill CSO Control Facility
Storage Basin

Chestnut & Oak-Riverside CSO Control Facility
Relief sewer from Chestnut to storage basin at Oak-Riverside

Lincoln Avenue SSO Group

Tekoppel Avenue SSO

WEST WWTP

Franklin, 9th Ave, Fulton, and 7th Ave CSO Control Facility
Relief sewer from Franklin, 9th Ave, Fulton, to Storage Basin and treatment unit at 7th Ave

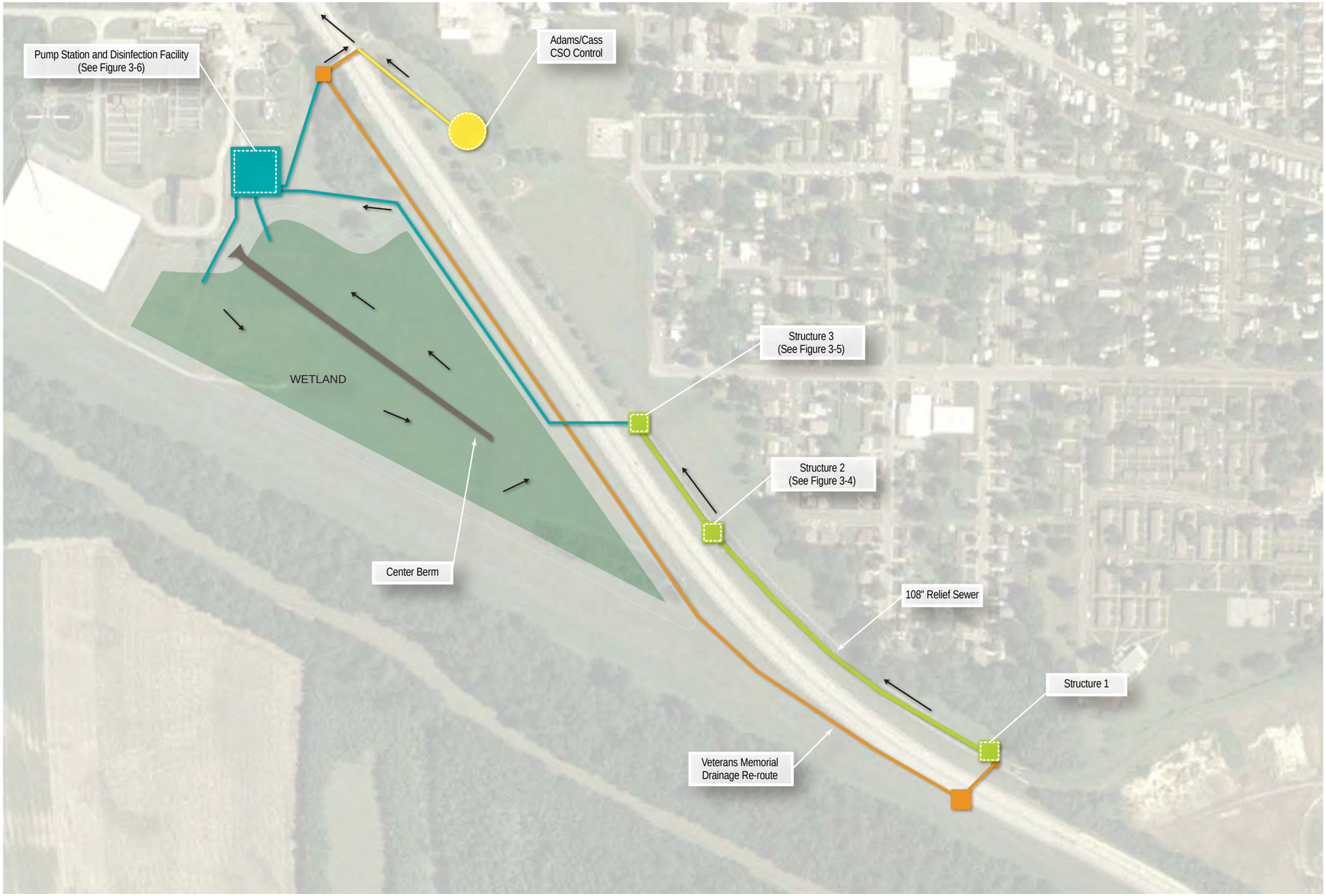
EAST WWTP

Howell Park CSO Control Facility
Storage Basin

Bee Slough
See Proposed Plan figures

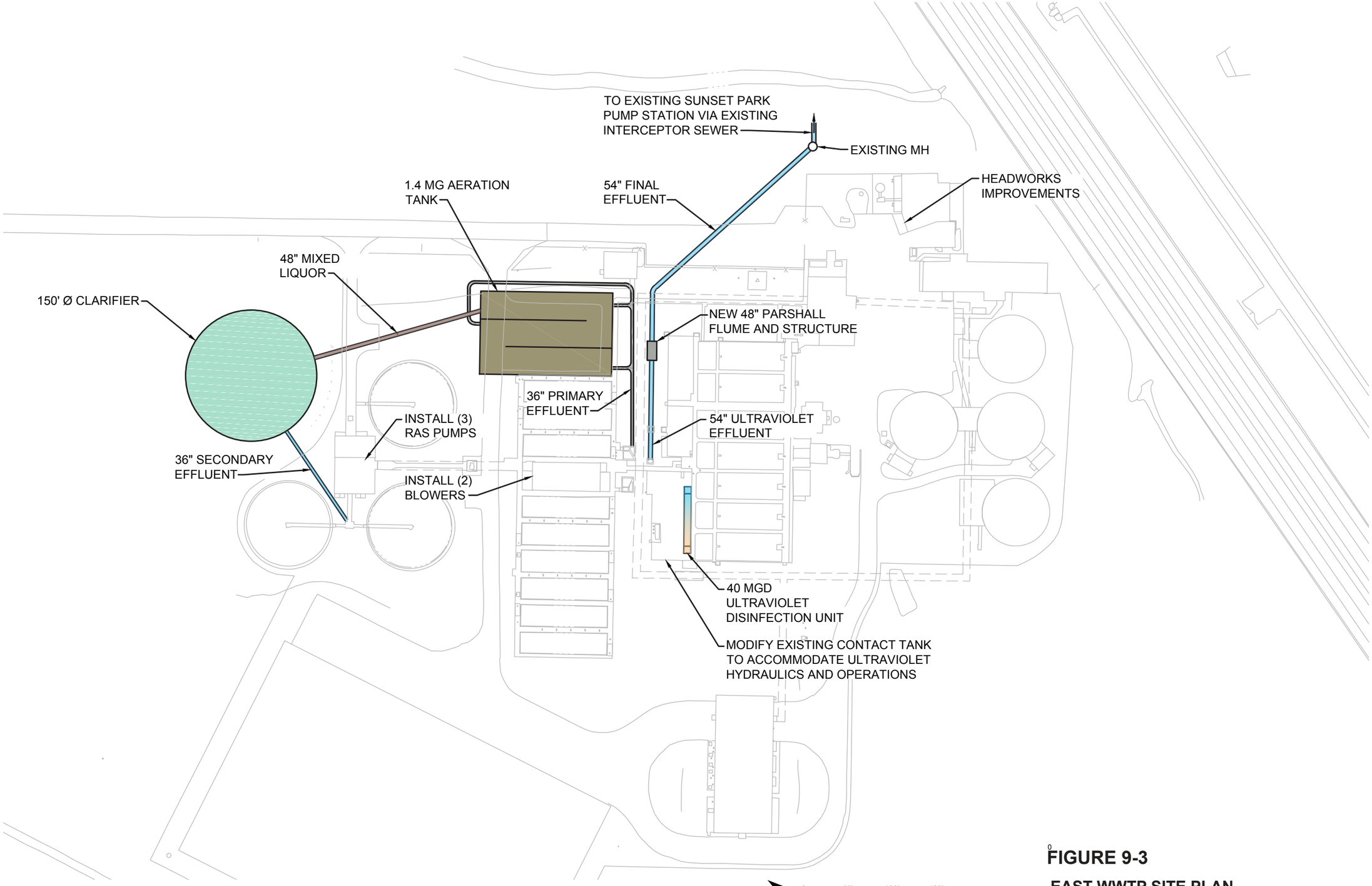
Figure 9-1

Negotiated Plan
Integrated Overflow Control Plan
January 15, 2016



North

FIGURE 9-2
Bee Slough Control Measure Overview
Integrated Overflow Control Plan
January 15, 2016



0

FIGURE 9-3

EAST WWTP SITE PLAN

40 MGD Expansion

January 15, 2016

The IOCP would construct a new Headworks Facility designed and constructed to reliably treat up to the 45 mgd peak secondary treatment capacity. One change from the Recommended Plan for the West WWTP is the elimination of the primary treatment bypass. Consequently, the Utility agreed to raise the primary clarifier weirs and construct curb walls for the primary clarifier influent channel. The Negotiated Plan therefore includes these changes along with upgrades originally recommended to bring treatment capacity to 45 mgd: the new headworks facility, conversion to liquid chlorine for disinfection, and upgrades to the existing RAS system. The plan also includes conversion of the disinfection process to hypochlorite.

Figure 9-4 shows the planned improvements.

9.4.4 Control Measure 4 – Pigeon Creek Interceptor Optimization and Real-Time Control Projects

The Utility has already started the process of optimizing the Pigeon Creek Interceptor system and maximizing its capability to capture and treat more wet-weather flow. Historically, operation of the levee pump stations and wet-weather flow control gates has focused on preventing flooding on the City side of the flood protection system, and this focus on flood prevention has generally taken priority over CSO control. Consequently, those operating rules have been universally applied to flow control gate operations and the Utility believes that opportunities exist to adjust operations to capture additional wet-weather flow without causing flooding. Therefore, in May 2012, the Utility launched a project to collect and analyze flow and precipitation data in the Pigeon Creek Interceptor in conjunction with levee gate and pump station operational data to better understand the in-system conditions in the interceptor during rain events. This project includes the development of a real-time decision support system to facilitate and direct operational decisions with the goal of capturing more wet-weather flow in the system without causing surface flooding or backups into homes or businesses. It also includes a task to identify potential opportunities to store wet-weather flow in the trunk sewer tributary to the Pigeon Creek Interceptor, and with the same requirement that no surface flooding or backups occur as a result.

Other key information used to develop this project was the condition of the Pigeon Creek Interceptor. During summer 2011, the Utility commissioned an inspection of this critical piece of sewer infrastructure using sonar and other state-of-the-art inspection technologies to identify sediment levels in the pipeline, structural defects that may present a risk for pipe failure, and other structural attributes that may impede flow. As a result of this inspection, the Utility will be moving forward with a major cleaning project to remove the sediment in the pipe.

Future phases of this project may include making modifications to the diversion structures, including flow control and better integrating flood protection infrastructure with CSO capture strategies. In addition, after cleaning the interceptor, the Utility will continue to make refinements to the West system hydraulic model to right-size IOCP Phase 2 CSO control projects.

9.4.5 Control Measure 5 – 7th Avenue, Franklin Street, Fulton Avenue, 9th Avenue, and St Joseph Avenue CSO Control Projects

The 7th Avenue Lift Station plays a vitally important role in transferring millions of gallons of wastewater to the West WWTP. Currently, the station has no onsite backup power system and only a single screen with no redundancy. This lack of backup equipment poses a high risk for large sewer overflows in the event of a power interruption or problem with the screen. To reliably capture and pump wet-weather flows in the future, the Utility determined through its

analyses of this facility that it needs to be replaced. The recommended plan would replace the 7th Avenue Lift Station, and it would be designed and constructed to ultimately have a firm pumping capacity that will allow the Utility to pump 45 mgd to the West WWTP and to pump wet-weather flow to an onsite storage and high-rate treatment facility. Effluent from the treatment system will meet the all of the Performance Criteria in Appendix G of the Consent Decree, and effluent monitoring will be performed per Appendix H of the Consent Decree. Screening, grit removal, and backup power would be included as well.

In addition to the lift station, storage, and treatment facilities, Control Measure 5 includes:

- Construction of relief sewers from the Fulton Avenue, 9th Avenue, and Franklin Street CSOs to the proposed 7th Avenue Lift Station.
- Raising the St Joseph Avenue CSO regulator weir to capture more wet-weather flow and send it to the West WWTP for treatment.

9.4.6 Control Measure 6 – Diamond Avenue/Baker Street Sewer Separation and CSO Control Projects

One of the key features of IOCP is the Utility's focus on reducing stormwater runoff into the CSS at key locations to reduce the size and cost of "end of pipe" CSO control facilities. The City's 2007 Stormwater Master Plan (Clark Dietz, Inc. 2007) identified several partial sewer separation projects in the Diamond Avenue subbasin that direct street drainage into the 90-inch storm sewer that runs east to west along Diamond Avenue. Figure 9-5 shows the projects' boundaries. Each of the projects will include green infrastructure components to provide water quality treatment for the stormwater-borne pollutants. These projects will free up significant capacity in the CSS to convey, store, and treat additional combined flows from other subareas.

In addition to the sewer separation projects, control of the CSOs from the Diamond Avenue and Baker Street CSOs will be accomplished by constructing an underground CSO storage facility beneath the Diamond Avenue levee pump station equalization basin and pumping CSO flow from the Baker Street CSO to the storage facility. CSO flows that exceed the capacity of the storage facilities will be treated at a high-rate treatment facility, disinfected, and discharged to Pigeon Creek. Effluent from the treatment facility will achieve the equivalent of primary treatment and will be disinfected to meet or exceed water quality standards as identified in Appendix G of the Decree. Stored CSO will be pumped into the Pigeon Creek Interceptor and routed to the West WWTP for treatment.

9.4.7 Control Measure 7 – Oakley Street CSO Storage Facility

CSO flow from the Oakley Street CSO will be captured in an underground CSO storage facility near the Oakley Street CSO diversion structure. Stored CSO will be drained by gravity into the Pigeon Creek Interceptor and routed to the West WWTP for treatment.

9.4.8 Control Measure 8 – Oak Hill Sewer Separation and CSO Storage Facility

This control measure includes the Akin Park, State Hospital, Boeke Road Outfall, Weinbach and Keck sewer separation projects from the 2007 Stormwater Master Plan (Clark Dietz, Inc., 2007) and an underground CSO storage facility that will be located near the Oak Hill CSO outfall. Stored CSO will be pumped into the adjacent sewer collection system and routed to the East WWTP for treatment. The areas to be separated are described and presented within the 2007 Stormwater Master Plan.

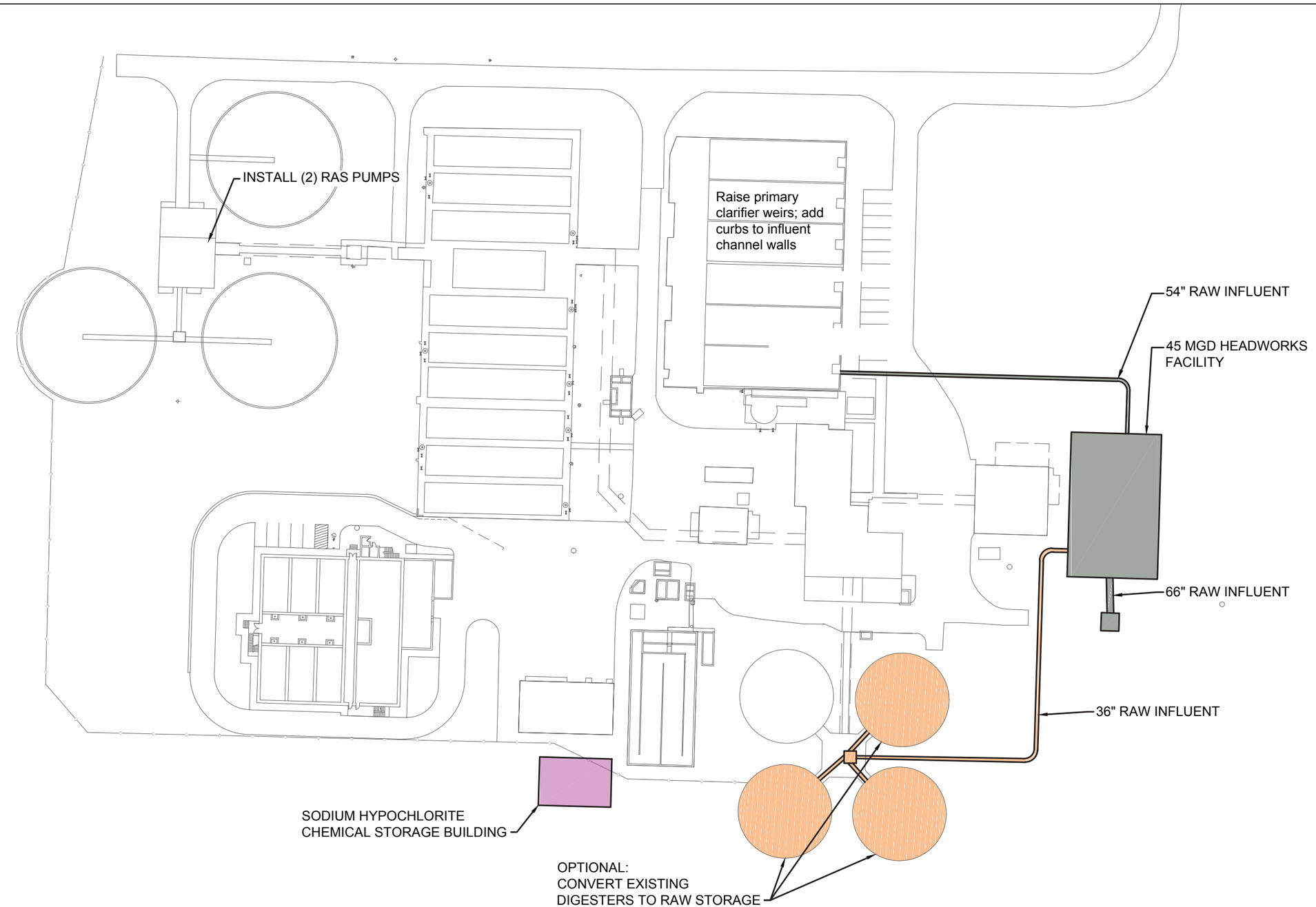
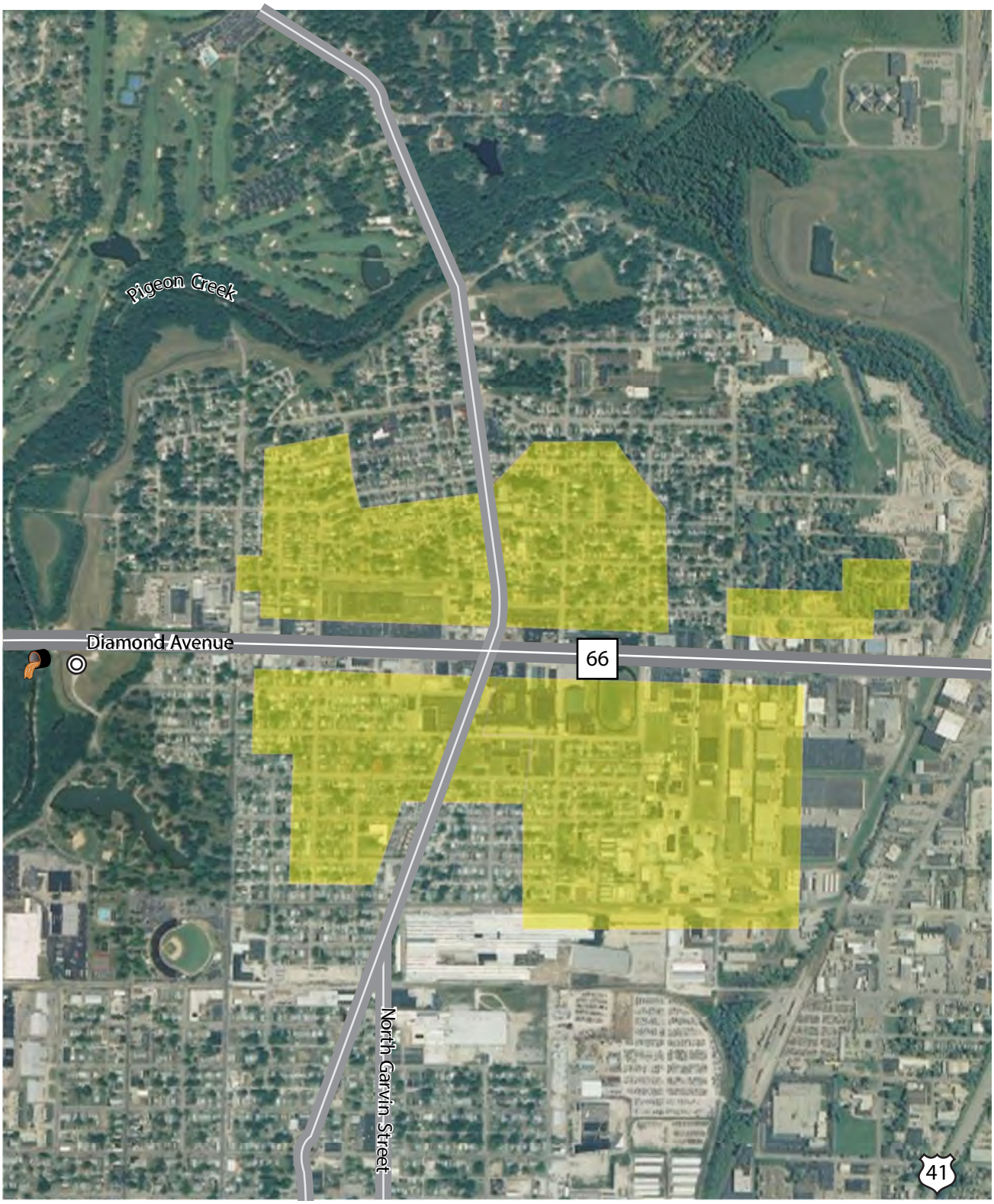


FIGURE 9-4
WEST WWTP SITE PLAN
45 MGD Expansion
January 15, 2016



Legend

CSO

Storm Sewer Project Limits

Levee Pump Station

1,000 Feet

North

Figure 9-5
Diamond Avenue Storm Sewer Separation Project Boundaries Integrated Overflow Control Plan
January 15, 2016

9.4.9 Control Measure 9 – Downtown CSO (Oak/Riverside, Chestnut, and Dress Plaza) Control Projects

Control Measure 9 includes construction of two underground storage facilities in the downtown area. One facility will capture wet-weather flows in the Dress Plaza CSS basin and the other will be located within the Oak/Riverside CSS basin; flows from the Chestnut CSS basin will be routed to it via a proposed relief sewer. Stored CSO will be pumped into the adjacent collection system and routed through the Riverside Interceptor to be treated at the East WWTP.

The green infrastructure program described above will be primarily focused in the downtown area to reduce the size and cost of Control Measure 9 or to attempt to eliminate the storage projects altogether.

9.4.10 Control Measure 10 – 6th Avenue, Dresden Street, Maryland Street, and Delaware Street CSO Control Projects

In this control measure, a CSO storage facility will be constructed near the Delaware Street CSO outfall. A relief sewer system will capture CSO from the Maryland Street, Dresden Street, and 6th Avenue CSOs and route it to the proposed Delaware Street CSO Storage Facility. Stored flow from the CSOs will be pumped into the Pigeon Creek Interceptor and routed to the West WWTP for treatment.

9.4.10.1 Capital Costs and Implementation Schedule

Table 9-1 provides planning-level opinions of probable capital costs for the IOCP projects and the 25-year implementation schedule. It includes the key dates required by the Decree: the bid date, commencement of construction, and achievement of full operation. Figure 9-6 represents a time benefit graph depicting the capital expenditures over time relative to the benefits achieved.

9.5 Adaptive Management Implementation Approach

As previously described, the Utility is taking an adaptive management approach to the IOCP. This approach to implementing the IOCP is being used because the projects proposed to be conducted in the early years of the IOCP will reduce stormwater inflow into the sewer systems or redirect stormwater inflow out of the sewer systems. This will reduce the size and cost of new overflow control infrastructure projects proposed in later years. Additionally, the uncertainty inherent in any computer model used to size projects needs to be refined and recalibrated over time to ensure the right-sizing of projects.

Table 9-1: Negotiated 25-year IOCP Remedial Measures, Design Criteria, Performance Criteria, and Implementation Schedule

Control Measure/Plan	Project	Outfall Number or Overflow	Name	Description	Narrative Description of Proposed Design and Performance Criteria		Implementation Schedule			Planning Level Opinions of Probable Capital Cost
					Design Criteria	Performance Criteria	Bid Date	Commencement of Construction	Achievement of Full Operation	
Green Infrastructure	**All**	**CSS Basins**					**1/1/2016**	**1/1/2017**	**12/31/2039**	**$ 18,036,000**
1	Bee Slough Restoration and CSO Treatment	001	Kentucky Ave	Wetlands treatment system	Constructed wetland treatment with a minimum storage volume of 42 million gallons. This volume is for the storage basin only, and excludes conveyance sewers and dewatering sewers. Conveyance pump station with minimum sustained design capacity of 198 MG per day. Relief sewer with a minimum diameter of 108 inches. The hydraulic loading rates for all projects shall not exceed any manufacture's recommendation.	0 CSOs and 0 gallons of residual overflow volume under Typical Year conditions. Treated discharges shall meet a 50% TSS reduction by mass standard, with a flow weighted basis and 12-month rolling average reported each month. See Appendix H for monitoring and reporting requirements.	1/1/2021	1/1/2022	1/1/2025	$ 151,206,000
		002	Cass Ave	Vertical Treatment Unit (VTU)	Satellite vertical treatment unit that meets the performance criteria, including disinfection, with a minimum sustained design capacity of 226 MG per day. The hydraulic loading rate shall not exceed the manufacture's recommendation.	0 CSOs and 0 gallons of residual overflow volume under Typical Year conditions. Treated discharges shall meet a 50% TSS reduction by mass with a flow weighted basis and 12-month rolling average reported each month. See Appendix H for monitoring and reporting requirements.	1/1/2030	1/1/2031	1/1/2033	
		004	Adams	Relief sewer to Cass Ave CSO control facility	Relief sewer to the Cass Avenue Vertical Treatment with a minimum diameter of 72 inches.	0 CSOs and 0 gallons of residual overflow volume under Typical Year conditions.	1/1/2030*	1/1/2031*	1/1/2033*	
		001, 002, 004	Bee Slough	Bee Slough Drainage Pipeline	Drainage pipelines between the concrete channel and the East WWTP Headworks Facility to provide the ability to send standing water in Bee Slough to the WWTP for treatment.	0 CSOs and 0 gallons of residual overflow volume under Typical Year conditions. Maximize flow to the East WWTP after wet weather events.			1/1/2018	
		103	East WWTP	Effluent Pump Station	Conveyance pump station with minimum sustained design capacity of 68 MG per day.	Eliminate CSO overflow point. All East WWTP effluent pumped to the Ohio River and not to Bee Slough during high river levels.	1/1/2019	1/1/2020	1/1/2023	
		001, 002, 004	Bee Slough	Akin Park Partial sewer separation	Partial sewer separation projects in sewerage tributary to Bee Slough/East WWTP.	No SSOs pursuant to Consent Decree paragraph 12, subject to Consent Decree paragraph 69.			1/1/2020	
2	East WWTP Improvement Projects	103	East WWTP	Expand peak Treatment Capacity	Expand secondary treatment system to achieve a minimum sustained capacity of 40 MG per day through the entire East WWTP.	0 CSOs and 0 gallons of residual overflow volume under Typical Year conditions. No bypasses of any portion of East WWTP.	1/1/2019	1/1/2020	1/1/2023	$ 40,001,000

Table 9-1: Negotiated 25-year IOCP Remedial Measures, Design Criteria, Performance Criteria, and Implementation Schedule

Control Measure/Plan	Project	Outfall Number or Overflow	Name	Description	Narrative Description of Proposed Design and Performance Criteria		Implementation Schedule			Planning Level Opinions of Probable Capital Cost
					Design Criteria	Performance Criteria	Bid Date	Commencement of Construction	Achievement of Full Operation	
3	West WWTP Improvement Projects	123	West WWTP	Expand peak primary treatment capacity; Storage Basin in Howell Park with overflow, Gravity in and out of Storage	Expand West WWTP headworks and primary treatment to achieve a minimum sustained capacity of 45 MG per day through the entire West WWTP.	0 CSOs and 0 gallons of residual overflow volume under Typical Year conditions.	1/1/2019	1/1/2020	1/1/2023	$ 46,750,000
		123	Howell Park Storage	Construct storage basin at Howell Park	Storage basin with a minimum storage volume of 6.1 million gallons. This volume is for the storage basin only, and excludes conveyance sewers and dewatering sewers.	0 CSOs and 0 gallons of residual overflow volume under Typical Year conditions.	1/1/2019*	1/1/2020*	1/1/2023*	
4	Pigeon Creek Interceptor Optimization and RTC Projects	012, 013, 014, 016, 017, 018, 024, 025	PCI	Complete cleaning and inspection of the PCI	Full interceptor capacity available to convey dry and wet weather flow to the West WWTP	Convey total capacity of the interceptor to the WWTP and maximize wet weather storage capacity within the interceptor.	1/1/2017	1/1/2018	1/1/2022	$ 4,290,000
5	7th Avenue, Franklin Street, Fulton Avenue, 9th Avenue, and St. Joseph Avenue CSO Control Projects	006	Fulton Avenue Pump Station	Send to 7th Ave East. Use existing pipe	Eliminate CSO overflow point	Eliminate CSO overflow point. All wastewater will be conveyed to new 7th Avenue Pump Station using existing pipe.			1/1/2036	$ 121,880,000
		009	7th Avenue West	Eliminated	Eliminate CSO overflow point	Eliminate CSO overflow point. All wastewater will be conveyed to new 7th Avenue Pump Station using existing pipe.			1/1/2036	
		015	7th Avenue East	Construct new 7th Ave Lift station for wet and dry weather flows.	Conveyance pump station with minimum sustained design capacity of 135 MG per day.	Ability to pump 45 MGD to the West WWTP and 90 MGD to onsite storage and high-rate treatment facility.		1/1/2026	1/1/2038*	
				Above ground storage basin	Storage basin with a minimum storage volume of 5.1 million gallons. This volume is for the storage basin only, and excludes conveyance sewers and dewatering sewers.	After construction of the high-rate treatment unit, no more than four CSOs, and a total of 7 MG of residual overflow volume under Typical Year conditions. Treated discharges must not exceed a TSS concentration of 40 mg/L averaged over the last seven discharge events. The compliance sampling done at the proposed high-rate treatment unit will be representative and reported as a seven-discharge rolling average over the seven most recent discharge events. See Appendix H for monitoring and reporting requirements.		1/1/2028	1/1/2038*	
				Satellite high rate treatment facility	Satellite high rate treatment unit that meets the performance criteria, including disinfection, with a minimum sustained design capacity of 72 MG per day. The hydraulic loading rate shall not exceed the manufacture's recommendation.		1/1/2035	1/1/2036	1/1/2038	
		016	Franklin Street	Relief sewer to 7th Avenue CSO Control Facility	Relief sewer with a minimum diameter of 72 inches.	No more than two CSOs, and a total of 2 MG of residual overflow volume under Typical Year conditions.	1/1/2035	1/1/2036	1/1/2038*	
		020	9th Avenue	Relief sewer to 7th Avenue CSO Control Facility	Relief sewer with a minimum diameter of 48 inches.	0 CSOs and 0 gallons of residual overflow volume under Typical Year conditions.	1/1/2035*	1/1/2036	1/1/2038*	
		022	St. Joseph Avenue	Increase underflow pipe size and build weir	Raise CSO regulatory weir and increase underflow sewer diameter to 36 inches.	0 CSOs and 0 gallons of residual overflow volume under Typical Year conditions.	1/1/2026	1/1/2027	1/1/2028	

Table 9-1: Negotiated 25-year IOCP Remedial Measures, Design Criteria, Performance Criteria, and Implementation Schedule

Control Measure/Plan	Project	Outfall Number or Overflow	Name	Description	Narrative Description of Proposed Design and Performance Criteria		Implementation Schedule			Planning Level Opinions of Probable Capital Cost
					Design Criteria	Performance Criteria	Bid Date	Commencement of Construction	Achievement of Full Operation	
6	Diamond Avenue/Baker Street Sewer Separation and CSO Control Projects	024	Baker	Relief pump station to Diamond Avenue CSO Control Facility	Conveyance pump station with minimum sustained design capacity of 100 MG per day.	No more than four CSOs, and a total of 12 MG of residual overflow volume under Typical Year conditions.	1/1/2025	1/1/2026	7/1/2038	$ 108,605,000
		025	Diamond Avenue	Storage basin with dewatering pump station.	Storage basin with a minimum storage volume of 8.1 million gallons. This volume is for the storage basin only, and excludes conveyance sewers and dewatering sewers. Dewatering pump station with minimum sustained design capacity of 4 MG per day.	After construction of the treatment unit, no more than 4 CSOs, and a total of 40 MG of residual overflow volume will occur under Typical Year conditions. Treated discharges must not exceed a TSS concentration of 40 mg/L averaged over the last seven discharge events. The compliance sampling done at the proposed high-rate treatment unit will be representative and reported as a 7-Discharge Rolling Average over the seven most recent discharge events. See Appendix H for monitoring and reporting requirements.	1/1/2028	1/1/2029	1/1/2032*	
				Conveyance Pump Station	Pump station to conveyance wastewater to Diamond Avenue storage basin/treatment facility with minimum sustained design capacity of 150 MG per day.		1/1/2028*	1/1/2029	1/1/2032*	
				Satellite high rate treatment facility	Satellite high rate treatment unit that meets the performance criteria, including disinfection, with a minimum sustained design capacity of 20 MG per day. The hydraulic loading rate shall not exceed the manufacture's recommendation.		1/1/2028*	1/1/2029	1/1/2032	
				Diamond Avenue partial sewer separation	Partial sewer separation within the Diamond Avenue subbasin, as described in Evansville's 2007 Stormwater Master Plan and in Figure 9-5 of the July 31, 2015 IOCP.	No SSOs pursuant to Consent Decree paragraph 12, subject to Consent Decree paragraph 69.			1/1/2026	
7	Oakley Street CSO Storage Facility	018	Oakley Street	Storage basin with gravity influent & effluent	Storage basin with a minimum storage volume of 0.6 million gallons. This volume is for the storage basin only, and excludes conveyance sewers and dewatering sewers	0 CSOs and 0 gallons of residual overflow volume under Typical Year conditions.	1/1/2034	1/1/2035	7/1/2036	$ 4,153,000
8	Oak Hill Sewer Separation and CSO Control Projects		Oak Hill	Partial sewer separation	Partial sewer separation projects, including the State Hospital, Boeke Road Outfall, Weinbach and Keck projects, as identified within Evansville's 2007 Stormwater Master Plan.	No SSOs pursuant to Consent Decree paragraph 12, subject to Consent Decree paragraph 69.			1/1/2025	$ 33,695,000
		011	Oak Hill	Storage basin with dewatering pump station	Storage basin with a minimum storage volume of 6.4 million gallons. This volume is for the storage basin only, and excludes conveyance sewers and dewatering sewers. dewatering pump station with minimum sustained design capacity of 4.6 MG per day.	No more than three CSOs, and a total of 5 MG of residual overflow volume under Typical Year conditions.	1/1/2035	1/1/2036	7/1/2037	

Table 9-1: Negotiated 25-year IOCP Remedial Measures, Design Criteria, Performance Criteria, and Implementation Schedule

Control Measure/Plan	Project	Outfall Number or Overflow	Name	Description	Narrative Description of Proposed Design and Performance Criteria		Implementation Schedule			Planning Level Opinions of Probable Capital Cost
					Design Criteria	Performance Criteria	Bid Date	Commencement of Construction	Achievement of Full Operation	
9	Downtown CSO (Oak/Riverside, Chestnut, and Dress Plaza) Control Projects	008	Chestnut	Relief sewer to Oak-Riverside Storage facility	Relief sewer with a minimum diameter of 84 inches.	No more than 3 CSOs, and a total of 13 MG of residual overflow volume under Typical Year conditions.	1/1/2037	1/1/2038	1/1/2039	$ 71,416,000
		038	Oak and Riverside	Storage basin with dewatering pump station	Storage basin with a minimum storage volume of 7.5 million gallons. This volume is for the storage basin only, and excludes conveyance sewers and dewatering sewers. Dewatering pump station with minimum sustained design capacity of 3.8 MG per day. Relief sewer with a minimum diameter of 48 inches.	0 CSOs and 0 gallons of residual overflow volume under Typical Year conditions.	1/1/2037	1/1/2038	12/31/2039	
		010	Dress Plaza	Storage basin with dewatering pump station	Storage basin with a minimum storage volume of 3.2 million gallons. This volume is for the storage basin only and excludes conveyance sewers and dewatering sewers. Dewatering pump station with minimum sustained design capacity of 2.1 MG per day. Relief sewer with a minimum diameter of 60 inches.	No more than three CSOs, and a total of 7 MG of residual overflow volume under Typical Year conditions.	1/1/2035	1/1/2036	1/1/2037	
10	6th Avenue, Dresden Street, Maryland Street, and Delaware Street CSO Control Projects	012	Maryland Street	Relocate diversion structure and sanitary connection to the upstream. Relief Sewer to Delaware CSO Control Facility.	Relief sewer with a minimum diameter of 72 inches.	No more than two CSOs, and a total of 1 MG of residual overflow volume under Typical Year conditions.	1/1/2036	1/1/2038	5/31/2040	$ 55,254,000
		13	Delaware Street	Storage basin with dewatering pump station, conveyance pump station, and relief sewer.	Storage basin with a minimum storage volume of 3.5 million gallons. This volume is for the storage basin only and excludes conveyance sewers and dewatering sewers. Dewatering pump station with minimum sustained design capacity of 1.8 MG per day. Conveyance pump station with minimum sustained design capacity of 70 MG per day. Relief sewer with minimum diameter of 84 inches.	No more than two CSOs, and a total of 3 MG of residual overflow volume under Typical Year conditions.	1/1/2036	1/1/2038	5/31/2040	
		014	Dresden Street	Relief sewer to Delaware Street CSO Control Facility	Relief sewer with a minimum diameter of 60 inches.	No more than two CSOs, and a total of 1 MG of residual overflow volume under Typical Year conditions.	1/1/2036	1/1/2038	5/31/2040	
		017	6th Avenue	Relief sewer to Delaware Street CSO Control Facility	Relief sewer with a minimum diameter of 24 inches.	No more than one CSOs, and 1 MG of residual overflow volume under Typical Year conditions.	1/1/2036	1/1/2038	5/31/2040	

Notes:

This summary table represents only capital costs in 2015 dollars using ENRCCI of 8903. Refer to the LTCP, SSRMP, and Facility Plan (Volumes 2 through 4) for specific project details and development of cost opinions. Project O&M and Life Cycle costs for the LTCP projects are presented in the appendixes to the LTCP, Volume 2.

Table 9-1: Negotiated 25-year IOCP Remedial Measures, Design Criteria, Performance Criteria, and Implementation Schedule

Control Measure/Plan	Project	Outfall Number or Overflow	Name	Description	Narrative Description of Proposed Design and Performance Criteria		Implementation Schedule			
					Design Criteria	Performance Criteria	Bid Date	Commencement of Construction	Achievement of Full Operation	Planning Level Opinions of Probable Capital Cost

1. Performance criteria is based on Evansville's typical precipitation year. Evansville should have no more than four CSO activations within the combined sewer collection system during the typical precipitation year.
2. Crossed-out boxes in the Implementation Schedule indicated smaller projects where full completion dates were earlier than the larger projects within the same control measure.
3. Dates with an asterisk denote dates in the Implementation Schedule that were taken from a larger project in the same control measure.
4. Effluent from the 7th Avenue Remote Treatment Unit, Diamond Avenue Remote Treatment Unit, the Constructed Wetland, and the VTU shall not exceed the following *E. Coli* criteria from April 1 through October 31: (A) 125 colony forming units per one hundred (100) milliliters as a geometric mean provided that 5 grab samples or more are collected over a 30-day period and (B) 235 colony forming units per 100 milliliters daily maximum. Daily maximum shall be the geometric mean of all samples on any discharge day provided that three (3) or more grab samples are collected. If less than three grab samples are taken then the arithmetic mean shall be reported instead. The goal of the effluent monitoring program is to collect at least three grab samples during each discharge event, and the samples shall be collected at shorter intervals at the onset of the event, if Evansville estimates that the event duration may be less than 6 hours.
5. Discharges from the wetland treatment system, VTU, 7th Avenue East satellite high rate treatment system, and Diamond Avenue high rate treatment system in compliance with the applicable Design and Performance Criteria and applicable NPDES permit requirements are not considered a "CSO" prohibited by the Consent Decree, as amended, for purposes of determining compliance with the number of CSOs specified by the Performance Criteria applicable to each such system.
6. Per Evansville's 2015 Combined Sewer Overflow Operation Plan (CSOOP) Update, CSOs 009 and 123 are not utilized. Evansville shall physically eliminate both of these CSOs by October 31, 2016, and reflect the elimination of these outfalls in its 2016 CSOOP Update.

Table 9-1: Negotiated 25-year LTCP Remedial Measures, Design Criteria, Performance Criteria, and Implementation Schedule

					Narrative Description of Proposed Design and Performance Criteria		Implementation Schedule			
Control Measure/Plan	**Project**	**Outfall Number or Overflow**	**Name**	**Description**	**Design Criteria**	**Performance Criteria**	**Bid Date**	**Commencement of Construction**	**Achievement of Full Operation**	Planning Level Opinions of Probable Capital Cost
Green Infrastructure	All	CSS Basins					1/1/2016	1/1/2017	12/31/2039	$ 18,036,000
1	Bee Slough Restoration and CSO Treatment	001	Kentucky Ave	Wetlands treatment system	Constructed wetland treatment with a minimum storage volume of 42 million gallons. This volume is for the storage basin only, and excludes conveyance sewers and dewatering sewers. Conveyance pump station with minimum sustained design capacity of 198 million gallons per day. Relief sewer with a minimum diameter of 108 inches. The hydraulic loading rates for all projects shall not exceed any manufacture's recommendation.	0 CSOs and 0 gallons of residual overflow volume under Typical Year conditions. Treated discharges shall meet a 50% TSS reduction by mass standard, with a flow weighted basis and 12-Month Rolling Average reported each month. See Appendix H for monitoring and reporting requirements.	1/1/2021	1/1/2022	1/1/2025	$ 151,206,000
		002	Cass Ave	Vertical treatment unit (VTU)	Satellite vertical treatment unit that meets the performance criteria, including disinfection, with a minimum sustained design capacity of 226 million gallons per day. The hydraulic loading rate shall not exceed the manufacture's recommendation.	0 CSOs and 0 gallons of residual overflow volume under Typical Year conditions. Treated discharges shall meet a 50% TSS reduction by mass with a flow weighted basis and 12-Month Rolling Average reported each month. See Appendix H for monitoring and reporting requirements.	1/1/2030	1/1/2031	1/1/2033	
		004	Adams	Relief sewer to Cass Ave CSO control facility	Relief sewer to the Cass Avenue Vertical Treatment with a minimum diameter of 72 inches.	0 CSOs and 0 gallons of residual overflow volume under Typical Year conditions.	1/1/2030*	1/1/2031*	1/1/2033*	
		001, 002, 004	Bee Slough	Bee Slough Drainage Pipeline	Drainage pipelines between the concrete channel and the East WWTP Headworks Facility to provide the ability to send standing water in Bee Slough to the WWTP for treatment.	0 CSOs and 0 gallons of residual overflow volume under Typical Year conditions. Maximize flow to the East WWTP after wet weather events.			1/1/2018	
		103	East WWTP	Effluent Pump Station	Conveyance pump station with minimum sustained design capacity of 68 million gallons per day.	Eliminate CSO overflow point. All East WWTP effluent pumped to the Ohio River and not to Bee Slough during high river levels.	1/1/2019	1/1/2020	1/1/2023	
		001, 002, 004	Bee Slough	Akin Park Partial sewer separation	Partial sewer separation projects in sewerage tributary to Bee Slough/East WWTP.	No SSOs pursuant to Consent Decree paragraph 12, subject to Consent Decree paragraph 69.			1/1/2020	
2	East WWTP Improvement Projects	103	East WWTP	Expand peak Treatment Capacity	Expand secondary treatment system to achieve a minimum sustained capacity of 40 million gallons per day through the entire East WWTP.	0 CSOs and 0 gallons of residual overflow volume under Typical Year conditions. No bypasses of any portion of East WWTP.	1/1/2019	1/1/2020	1/1/2023	$ 60,174,000
3	West WWTP Improvement Projects	123	West WWTP	Expand peak primary treatment capacity; Storage Basin in Howell Park with overflow, Gravity in and out of Storage	Expand West WWTP headworks and primary treatment to achieve a minimum sustained capacity of 45 million gallons per day through the entire West WWTP.	0 CSOs and 0 gallons of residual overflow volume under Typical Year conditions.	1/1/2019	1/1/2020	1/1/2023	$ 46,750,000
		123	Howell Park Storage	Construct storage basin at Howell Park	Storage basin with a minimum storage volume of 6.1 MG. This volume is for the storage basin only, and excludes conveyance sewers and dewatering sewers.	0 CSOs and 0 gallons of residual overflow volume under Typical Year conditions.	1/1/2019*	1/1/2020*	1/1/2023*	
4	Pigeon Creek Interceptor Optimization and RTC Projects	012, 013, 014, 016, 017, 018, 024, 025	PCI	Complete cleaning and inspection of the PCI	Full interceptor capacity available to convey dry and wet weather flow to the West WWTP	Convey total capacity of the interceptor to the WWTP and maximize wet weather storage capacity within the interceptor.	1/1/2017	1/1/2018	1/1/2022	$ 4,290,000

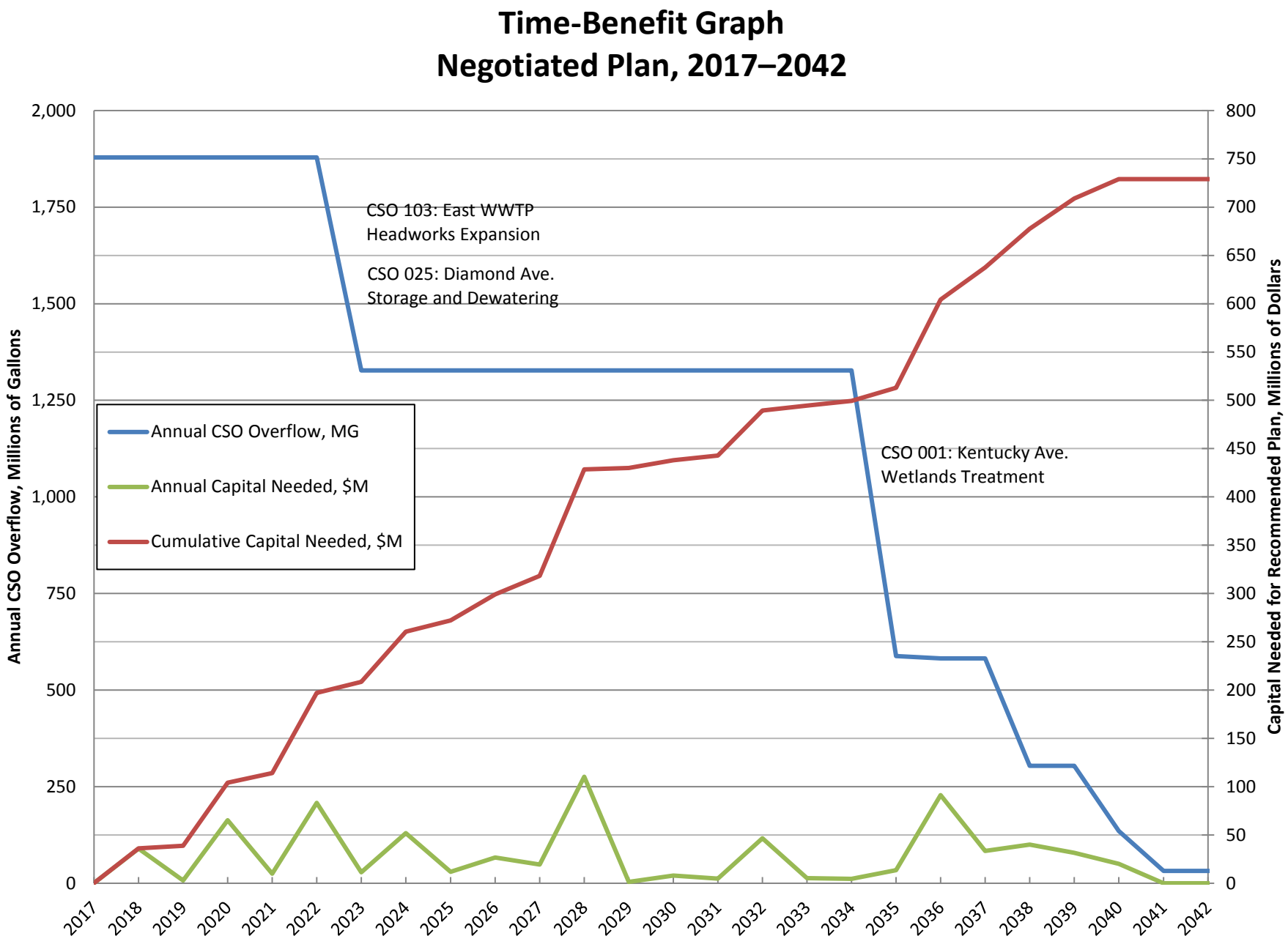

Time-Benefit Graph
Negotiated Plan, 2017–2042
Annual CSO Overflow, Millions of Gallons
Capital Needed for Recommended Plan, Millions of Dollars
2,000
1,750
1,500
1,250
1,000
750
500
250
0
800
750
700
650
600
550
500
450
400
350
300
250
200
150
100
50
0
2017
2018
2019
2020
2021
2022
2023
2024
2025
2026
2027
2028
2029
2030
2031
2032
2033
2034
2035
2036
2037
2038
2039
2040
2041
2042
Annual CSO Overflow, MG
Annual Capital Needed, $M
Cumulative Capital Needed, $M
CSO 103: East WWTP
Headworks Expansion
CSO 025: Diamond Ave.
Storage and Dewatering
CSO 001: Kentucky Ave.
Wetlands Treatment

Figure 9-6

SECTION 10

Post-Construction Monitoring Program

A Post-construction Monitoring Program (PCMP) is a requirement of the CSO Policy and provisions of the Decree. Appendix C, Section 1, Paragraph 10 of the CD states:

> **Post-Construction Monitoring: The IOCP shall include a post-construction monitoring program which shall be used to assess the effectiveness of the selected and completed SSO, CSO and Bypass Discharge Control Measures. The post-construction monitoring program must be adequate to: (1) measure compliance with water quality standards and protection of designated uses; (2) ascertain whether the projects are meeting the Performance Criteria established in the approved IOCP, and (3) to evaluate the impacts of any residual Discharges on water quality in the receiving streams. This post-construction monitoring program shall be consistent with the CSO Policy.**

The Utility is committed to continuous improvement and adaptive management in order to appropriately size future CSO and other IOCP improvements and to address the most pressing problems first. Consequently, the Utility has begun to enhance the monitoring of precipitation; in-system flows, and overflows from the system consistent with evaluating system performance and meeting future information needs for the PCMP.

The CSO Control Policy and the Decree both require that the LTCP include a plan for post-construction monitoring to ascertain whether the projects are meeting the Performance Criteria established in the approved IOCP.

The specific performance criteria for the Negotiated Plan is set forth in Table 9-1 (Negotiated 25-year LTCP Remedial Measures, Design Criteria, Performance Criteria, and Implementation Schedule) and Appendix K (Monitoring, Reporting and Compliance Criteria for Remote Treatment Facilities). A water quality analysis that shows residual CSO discharges to the Ohio River and Pigeon Creek are not attributing to water quality standards exceedances for bacteria will also be required.

Ongoing performance monitoring will play a key role in the phased implementation and adaptive management of the LTCP to cost-effectively achieve the stated CWA objectives. The iterative method for completing the proposed level of CSO control will rely on the results of ongoing performance monitoring to determine the effectiveness of each phase of the LTCP. The results may then be used to adapt LTCP implementation in later years to achieve the overall goals of the program. This will help ensure that the program provides the greatest benefits for the public investments.

The PCMP will be conducted after all system improvements are completed. Dates for PCM activities as set forth in the Third Amendment of the Consent Decree require:

- One full year of PCMP monitoring that begins on May 31, 2040, following implementation of the IOCP
- Complete Post-Construction Monitoring on May 31, 2041
- Submit Post-Construction Monitoring Report by May 31, 2042

This PCMP is focused on meeting these criteria and the need to measure compliance with water quality standards and protection of designated uses.

The "CSO Post-Construction Compliance Monitoring Guidance," published by the EPA in May 2012 was used for guidance in developing the Post-Construction Compliance Monitoring Program (PCCMP). The LTCP projects and PCCMP follow the "demonstrative approach" to comply with the CWA.

10.1 Current Monitoring

The Utility currently monitors the performance of both its CSS and SSS assets, in addition to collecting rainfall amounts, stream flows, and other environmental data. The Utility also employed an extensive flow monitoring program to collect data from several locations during wet and dry weather for the development of a hydraulic model of the collection systems. Collectively, these data are not only used in concert with daily operations and maintenance activities, but also have been used in the initial characterization and evaluation of the CSS and the receiving waters. These baseline results will be used as the basis for evaluating future LTCP implementation projects for successful performance and compliance with CWA objectives.

Current monitoring activities are done by the Utility and others. The Utility currently utilizes the monitoring information from the following on an ongoing basis:

- Rain gauges/rainfall monitoring
- CSO discharge flow monitoring
- Collection system in-system flow monitoring
- Stream flow and water quality monitoring
- Level sensors at lift stations
- USGS river level data
- ORSANCO water quality and stream flow data

As the LTCP projects are implemented, the Utility will continue to use these methods and others that have proven effective with historical and current monitoring efforts to determine the effectiveness of the CSO controls. This ongoing performance monitoring will include a comparison of both pre- and post-construction conditions. Performance monitoring may also help account for other related municipal programs such as downspout disconnection and GI initiatives to determine the effectiveness of those program efforts with regard to CSO abatement and control to meet the system wide performance criteria.

It is important to note that ongoing monitoring in these programs may change over time based upon decisions made by the Utility and others. The Utility will comply at all times with monitoring requirements in the NPDES permits and the CD.

The Utility monitors several parameters on an ongoing basis.

10.1.1 Rainfall Monitoring

The Utility currently utilizes 5 rain gauges located throughout the City. The Utility will continue to collect rainfall data so that this information can be simultaneously evaluated with the other sets of data to help determine the timing and impact of wet weather on the collection system assets and the effectiveness of the LTCP program elements as they are implemented to achieve

the CWA objectives. Rainfall monitoring technologies may change as well as locations and number of sites, but quality and quantity of information will meet PCMP requirements.

The Utility currently has ISCO 675 rain gauges at the following locations:

- West WWTP
- Lorain Park Pump Station
- Stockwell Lift Station
- Willow Lift Station, and
- Baker

The ISCO 675 gauges, along with Flowlink software, are capable of measuring rainfall intensity.

As part of the Utility's monitoring and real time controls initiative with EmNet in the west collection system, seven Global Water RG200 rain gauges that measure both rainfall accumulation and rainfall intensity are in place at the follow locations:

- Perry Heights Middle School
- Allens Lane Distribution Building
- Maryland CSO
- 7th Ave Lift Station
- East Plant
- Police Department substation at Columbia & Governor
- Weinbach Lift Station

The RG200 gauges include cellular units that allow real time viewing of rainfall data using the EmNet monitoring portal webpage.

The Utility also has access to and uses the rainfall data gathered by the USGS rain gauge at Court and Riverside and the NOAA rain gauge at the Evansville Airport.

10.1.2 CSO Flow Monitoring

The Utility monitors discharges from each of its 22 CSO outfalls using area-velocity flow monitors. These monitors are installed in the CSO outfalls, or in influent and effluent sewers adjacent to the structures, to calculate discharge volumes. This monitoring system was installed in 2006 and has been recording data since that time. The monitors are connected to a wireless canopy network which allows the Utility to receive real-time flow information. The real-time status of all CSOs is also available for online viewing through the City's website.

CSO overflow monitoring is currently administered in accordance with the Utility's NPDES permit and reported on the NPDES CSO Monthly Discharge Monitoring Reports (CSO DMRs) and submitted to IDEM on a monthly basis. On this form, each CSO overflow event is recorded by date, time and duration, as well as volume. The amount of precipitation, if any, is also recorded for each day regardless of whether a CSO event occurred. In addition to meeting NPDES reporting requirements, these overflow data are also available for use by the PCCMP.

To determine the effectiveness of the CSO controls proposed in the LTCP, flow monitoring data will continue to be collected from the CSO discharge points to calculate the overflow volumes during wet weather events. These data will be compared to the baseline CSO flow data throughout the LTCP implementation period to help determine the effectiveness of the CSO

controls as they are implemented, typically using hydraulic models. The overflow data will be tabulated along with the rainfall data and analyzed as needed.

The following typical data is available from this monitoring:

- Rainfall and overflow relationships for each CSO
- Number of overflow activations for each CSO point, allowing before/after comparisons of each CSO control measure implemented
- Estimated volume of CSO for each CSO, allowing performance of each CSO control measure implemented to be monitored and calculated

10.1.3 In-System Flow Monitoring

The Utility currently owns 27 in-system flow monitors located throughout the SSS, to measure flows being input to the CSS from the various sanitary sewer sub-basins.

Additionally, a series of flow studies were conducted in 2010 and 2011 that included the installation of temporary flow monitors throughout the CSS and SSS systems, and along the PCI. The data collected during these study periods were summarized by the *Initial System Characterization including Separate Sanitary Sewer Hydraulic Model Developme*nt (CH2M HILL, 2011a) report, utilized for hydraulic model calibrations, and subsequently used in the development of the LTCP project alternatives.

In addition to the in-system flow monitors located in the sewer systems, the Utility has flow monitoring equipment at pump stations, mechanical regulators and other flow control devices, and at the WWTPs.

The Utility will continue to collect in-system flow data so that this information can be simultaneously evaluated with the other sets of data to help determine the timing and impact of wet weather on the collection system assets and the effectiveness of the LTCP program elements as they are implemented to achieve the CWA objectives.

Monitors may be relocated and additional temporary monitoring done as needed to assess system performance and complete the PCMP monitoring.

10.1.4 Stream Flow and Water Quality Monitoring

When the capacity of the CSS is exceeded, primarily during wet weather, CSOs discharge into the receiving waters of either Pigeon Creek or the Ohio River. Historically, for the Ohio River, stream flow and river stage level data has been collected by the USGS and the USACE and water quality data have been collected by the ORSANCO (and its state and utility partners). For Pigeon Creek, water quality sampling has been employed periodically by the IDEM, the Indiana Department of Natural Resources (IDNR), and the Vanderburgh Soil and Water Conservations District (SWCD).

In addition to these data resources, the Utility recently completed an update of its previous SRCERs, which reviewed and consolidated past and present SRCER information in one report document. Additional sampling and data analyses were also performed to fill data gaps that had been identified during a data quality review process that was conducted as part of the update. This included field measurements and the collection of water quality samples at five locations on Pigeon Creek and five CSO discharge locations within the City of Evansville to further characterize CSO impacts on Pigeon Creek and the Ohio River. The information was also used in the

development of the Pigeon Creek water quality model. These additional data and a summary of findings are provided by the 2011 SRCER Update (CH2M HILL and Limno Tech, 2011).

The Utility will continue to conduct periodic stream sampling so that this information can be simultaneously evaluated with the other sets of data to help determine the effectiveness of the LTCP program elements as they are implemented to achieve the CWA objectives.

10.2 Post-Construction Compliance Monitoring Objectives

The primary purpose of a PCMP for compliance monitoring is to evaluate whether residual CSO discharges contribute to water quality exceedances. The objectives of the PCMP include the following:

- **Assessment and Documentation of Baseline Conditions** - The Utility has conducted several studies to document the existing conditions of the SSS and CSS, wet weather flow conditions, CSO activity, and stream reach characterization. The establishment of these baseline conditions is integral to the determination of system performance and the water quality benefits being implemented by future CSO and other IOCP controls.
- **Execution of Post-Construction Monitoring and Analyses** - The Utility will compare the baseline condition data to post-construction data normalized to Typical Year levels to evaluate the collective performance of system wide improvements.
- **Remote Storage and Treatment Performance Criteria –** The compliance criteria for the remote storage and treatment facilities described in the IOCP are described in detail Appendix K.
- **Storm Events for Compliance Monitoring –** The Utility has evaluated rainfall data in the Typical Year and based upon anticipated performance of the Negotiated LTCP, has selected storm events by which compliance with the overflow and volume performance criteria may be measured, 4 overflows and 98 percent capture respectively. Data will be collected and evaluated for at least two events near, but below the level of control and at least one event that exceeds the level of control. Table 10-1 lists events from the typical year that are near the level of control of four activations per year. The events were determined from hydraulic model simulations of the 4-activation and 12-activation alternatives.

  Prior wet weather events and existing wet weather conditions in the wastewater system can significantly affect the performance of the treatment plants and the capacity of the collection system. Data for events that occur within three days of the end of a prior rainfall event should be analyzed to determine if conditions were satisfactory for optimal performance of the LTCP control measures. If the conditions are determined to be unsatisfactory, the flow data should not be a basis for determining compliance.

  Similarly, backwater from receiving water bodies has an impact on the validity of measured flow data. Data for events that occur when the river stage is above 18 feet be analyzed to determine if the conditions were satisfactory for appropriate data collection and system performance. If the conditions are determined to be unsatisfactory, the flow data should not be a basis for determining compliance.

Table 10-1 Storm Events for Compliance Monitoring

Storm Event	Rainfall Depth (in)	Rainfall Duration (hr)	Average Rainfall Intensity (in/hr)	Peak Rainfall Intensity (in/hr)
Greater than LOC (Smallest modeled event in 4-activation alternative)				
8/27/2000	1.74	9	0.19	1.09
Near the LOC (5th largest modeled event in 12-activation alternative)				
9/25/2000	1.55	17	0.09	0.53
Below the LOC (Smaller modeled events in 12-activation alternative)				
10/13/2000	2.15	26	0.08	0.34
2/13/2000	1.43	11	0.13	0.33

10.3 Reporting Results to Regulatory Agencies

The Utility will provide reports on the performance of the LTCP projects to regulatory agencies and to the public as required by the CD.

Generally, the CSO controls proposed by the LTCP will be implemented using one of two methods: 1) storage and treatment at either the East Side WWTP or the West Side WWTP or 2) storage with wet weather treatment at various satellite facilities. Treated wet weather flow will either be discharged to the Ohio River or Pigeon Creek. Once the capacities of these proposed facilities are exceeded, residual overflows will also be discharged to either Pigeon Creek or the Ohio River. Frequency of activations and volume of CSO will be dramatically reduced by the LTCP.

Post-construction monitoring for LTCP control measures involving frequency of activations and volume of CSO will generally include monitoring of flow rates and volumes of combined sewage that are discharged and/or captured in the storage facilities. The stored volume will be sent to one of the WWTPs for treatment once capacity is available.

Performance monitoring for LTCP control measures involving wet weather storage and treatment at satellite treatment facilities will include monitoring and reporting of flow and pollutants for the treated effluent per Appendix K.

Once the capacity of these facilities is exceeded, untreated overflows discharging to the receiving streams will be measured for flow and volume.

Additionally, as is set forth in Section 5.6.3.4, hydraulic monitoring and water quality sampling will be conducted at multiple locations within the wetland treatment system to track performance and health and to establish a basis for operational adjustment, as needed.

Monitoring locations must be strategically selected to ensure that post-construction compliance monitoring is representative of the impacts of the CSO control projects as they are implemented. Current monitoring locations will be used where validated. Other monitoring locations will be considered at those points along Pigeon Creek and the Ohio River on which baseline conditions were established either through historical data collection by outside agencies or through SRCER activities.

The performance criteria specified in Appendix G of the Consent Decree will be the basis for evaluating the effectiveness of the selected and completed CSO, SSO, and Bypass Discharge Control Measures with the Post-Construction Monitoring Program. The water quality sampling in Pigeon Creek is designed to provide information on decreases in *E. Coli* levels in the creek resulting from the CSO controls and to inform a water quality analysis that shows residual CSO discharges are not attributing to bacterial water quality standard exceedances. As noted in the SRCER, bacteria loads from upstream sources alone can result in exceedances of *E. Coli* water quality standards. However, the load from upstream sources tends to reach the Evansville area 12 to 24 hours after the start of rainfall, whereas CSO discharges tend to affect stream conditions within the first 6 to 8 hours of the storm. Therefore, Evansville plans to collect water quality samples in Pigeon Creek within 1 to 8 hours of the start of rainfall and between 12 to 24 hours after the start of rainfall. This frequency will allow CSO impacts, if any, to be characterized from the first set of samples, and the impact from upstream sources to be characterized from the second set of samples. Table 10-2 has been updated to reflect the City's intent for water quality sampling in Pigeon Creek. The current monitoring locations proposed for the Utility's PCCMP, including monitoring parameters and protocols are summarized in Table 10-2. A map of the locations are depicted in Figure 10-1. These may change based on NPDES permit requirements, changed outfall conditions due to new projects, new information , and/or technology changes.

Figure 10-1 Proposed PCM Sampling Locations

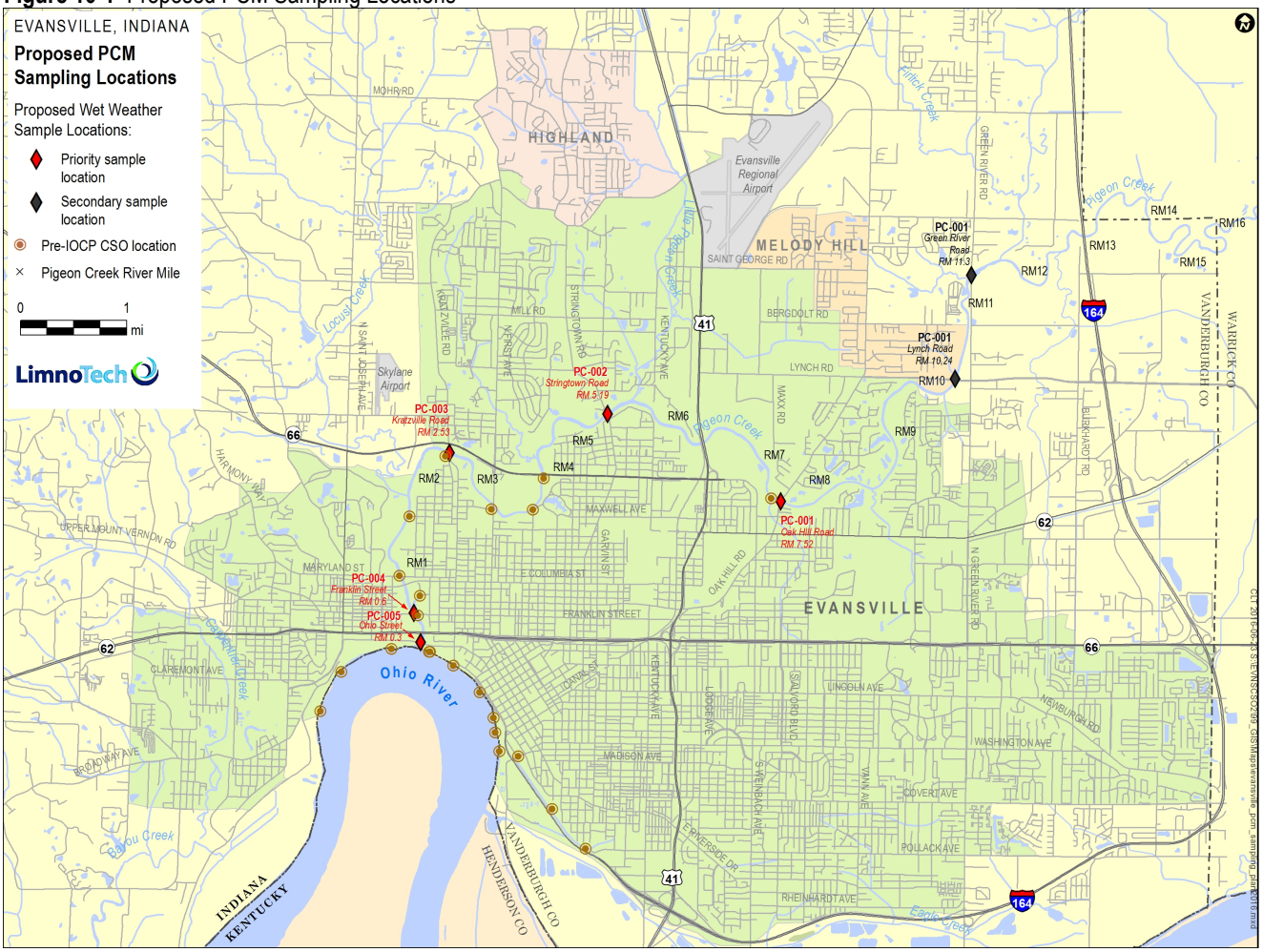


Table 10-2 LTCP Post-Construction Compliance Monitoring Locations

Site ID	Location	Receiving Stream	Rationale for Monitoring	Current Monitoring Parameters		Current Monitoring Frequency	Current Monitoring Protocols
				Discharge	Water Quality		
CSO 001	Kentucky Avenue	Bee Slough	Required per NPDES permit.	x		Continuous	Flow, velocity, duration, volume
CSO 002	Cass Avenue	Bee Slough	Required per NPDES permit.	x		Continuous	Flow, velocity, duration, volume
CSO 004	Adams Street	Bee Slough	Required per NPDES permit.	x		Continuous	Flow, velocity, duration, volume
CSO 006	Fulton Avenue PS	Ohio River	Required per NPDES permit.	x		Continuous	Flow, velocity, duration, volume
CSO 008	Chestnut Street	Ohio River	Required per NPDES permit.	x		Continuous	Flow, velocity, duration, volume
CSO 009	7th Avenue West	Ohio River	Required per NPDES permit.	x		Continuous	Flow, velocity, duration, volume
CSO 010	Dress Plaza	Ohio River	Required per NPDES permit.	x		Continuous	Flow, velocity, duration, volume
CSO 011	Oakhill Road	Pigeon Creek	Required per NPDES permit.	x		Continuous	Flow, velocity, duration, volume
CSO 012	Maryland Street	Pigeon Creek	Required per NPDES permit.	x		Continuous	Flow, velocity, duration, volume

Table 10-2 LTCP Post-Construction Compliance Monitoring Locations

Site ID	Location	Receiving Stream	Rationale for Monitoring	Current Monitoring Parameters		Current Monitoring Frequency	Current Monitoring Protocols
				Discharge	Water Quality		
CSO 013	Delaware Street	Pigeon Creek	Required per NPDES permit.	x		Continuous	Flow, velocity, duration, volume
CSO 014	Dresden Street	Pigeon Creek	Required per NPDES permit.	x		Continuous	Flow, velocity, duration, volume
CSO 015	7th Avenue East	Ohio River	Required per NPDES permit.	x		Continuous	Flow, velocity, duration, volume
CSO 016	Franklin Street	Pigeon Creek	Required per NPDES permit.	x		Continuous	Flow, velocity, duration, volume
CSO 017	6th Avenue	Pigeon Creek	Required per NPDES permit.	x		Continuous	Flow, velocity, duration, volume
CSO 018	Oakley Street	Pigeon Creek	Required per NPDES permit.	x		Continuous	Flow, velocity, duration, volume
CSO 020	9th Avenue	Ohio River	Required per NPDES permit.	x		Continuous	Flow, velocity, duration, volume
CSO 022	St. Joseph Avenue	Ohio River	Required per NPDES permit.	x		Continuous	Flow, velocity, duration, volume
CSO 024	Baker Street	Pigeon Creek	Required per NPDES permit.	x		Continuous	Flow, velocity, duration, volume

Table 10-2 LTCP Post-Construction Compliance Monitoring Locations

Site ID	Location	Receiving Stream	Rationale for Monitoring	Current Monitoring Parameters		Current Monitoring Frequency	Current Monitoring Protocols
				Discharge	Water Quality		
CSO 025	Diamond Avenue	Pigeon Creek	Required per NPDES permit.	x		Continuous	Flow, velocity, duration, volume
CSO 026	Read Street	Pigeon Creek	Required per NPDES permit.	x		Continuous	Flow, velocity, duration, volume
CSO 038	Oak/Riverside	Ohio River	Required per NPDES permit.	x		Continuous	Flow, velocity, duration, volume
CSO 103	East WWTP Bypass	Ohio River	Required per NPDES permit.	x		Continuous	Flow, velocity, duration, volume
CSO 123	West Plant CSO	Ohio River	Required per NPDES permit.	x		Continuous	Flow, velocity, duration, volume
PC-001	Oakhill Road	Pigeon Creek	Baseline established during Pigeon Creek SRCER Update.		x	Within hour 1-8 and 12-24 after rain event	*E. Coli*, $CBOD_5$, TSS, NH_4-N, pH, DO
PC-002	Stringtown Road	Pigeon Creek	Baseline established during Pigeon Creek SRCER Update.		x	Within hour 1-8 and 12-24 after rain event	*E. Coli*, $CBOD_5$, TSS, NH_4-N, pH, DO
PC-003	Kratzville Road	Pigeon Creek	Baseline established during Pigeon Creek SRCER Update.		x	Within hour 1-8 and 12-24 after rain event	*E. Coli*, $CBOD_5$, TSS, NH_4-N, pH, DO
PC-004	Franklin Street	Pigeon Creek	Baseline established during Pigeon Creek SRCER Update.		x	Within hour 1-8 and 12-24 after rain event	*E. Coli*, $CBOD_5$, TSS, NH_4-N, pH, DO

Table 10-2 LTCP Post-Construction Compliance Monitoring Locations

Site ID	Location	Receiving Stream	Rationale for Monitoring	Current Monitoring Parameters		Current Monitoring Frequency	Current Monitoring Protocols
				Discharge	Water Quality		
PC-005	Ohio Street	Pigeon Creek	Baseline established during Pigeon Creek SRCER Update.		x	Within hour 1-8 and 12-24 after rain event	*E. Coli*, $CBOD_5$, TSS, NH_4-N, pH, DO
In-System Monitors (SSS)	Various	N/A	Measure success of sewer rehabilitation, I/I removal projects; Measure service area growth.	x		Continuous	Flow, velocity
Wet-Weather Storage Facilities	Various	Pigeon Creek/ Ohio River	Measure wet weather storage facility performance by measuring volume temporarily stored, released for treatment.	x		Periodically, after each use	Flow, volume
Wet-Weather Treatment Facilities	Various	Pigeon Creek/ Ohio River	Measure performance of wet weather treatment facilities by measuring water quality of discharges.	x	x	Periodically, after each use	*E. Coli*, $CBOD_5$, TSS, NH_4-N, pH, DO
USGS 03322000	Ohio River at Evansville, IN	Ohio River	Historical USGS Gaging Station.	x		Continuous	Stage
ORSANCO	River Mile 791.5	Ohio River	Historical ORSANCO Gaging Station.	x	x	Continuous	*E. Coli*
ORSANCO	River Mile 793.7	Ohio River	Historical ORSANCO Gaging Station.	x	x	Continuous	*E. Coli*

10.4 Sampling Requirements and Procedures for Remote Treatment Facilities

The Utility will provide post-construction sampling and monitoring requirements for specific pollutants that apply to the proposed four remote treatment locations identified in Appendix G to the Consent Decree, specifically:

- Seventh Avenue Lift Station Remote Treatment Unit;
- Diamond Avenue Remote Treatment Unit;
- Vertical Treatment Unit (VTU) at the East Wastewater Treatment Plant (WWTP)
- Constructed Wetland Treatment System (Constructed Wetland) at the East WWTP.

The Utility will include in its final Post-Construction Monitoring Report any previously reported sampling results from these four proposed remote treatment units to determine compliance with the applicable Performance Criteria.

10.4.1 Seventh Avenue and Diamond Avenue Monitoring Requirements

10.4.1.1 Sampling Requirements

The Utility will conduct effluent sampling when the unit is discharging. The Utility will sample each Remote Treatment Units' effluent discharge at representative locations and such locations will be recorded in the Monthly Report required under Section E of this Appendix K. The Utility will analyze samples for TSS, $CBOD_5$, pH, and *E. Coli*. The Utility will also sample for residual chlorine if the Utility choses to disinfect CSO effluent using chlorine. The Utility will also sample for any additional parameters identified in the NPDES permit.

The Utility will use an automatic sampler that collects samples at defined intervals or will take grab samples. The Utility will collect each sample, whether automatic or grab, that must be representative of the discharge. The Utility will initiate sampling within 30 minutes from the beginning of the discharge event, and will continue at intervals determined by the Utility but no less than every 2 hours during the event. The Utility will take and analyze composite samples for TSS and $CBOD_5$. The Utility must sample for *E. Coli* daily when discharging. If the Utility choses to disinfect using chlorine, the Utility will perform and analyze a grab sample of residual chlorine each time a separate grab sample of E coli is performed. The Utility is not required to sample the wet weather treatment component influent for *E. Coli* or residual chlorine. The Utility will perform a representative pH grab sample for each wet weather treatment component discharge event. The Utility will conform all sampling to the requirements in 40 CFR 136.

The Utility will calculate the effluent TSS concentration 7-Discharge Rolling Average for each outfall at the Seventh Avenue Lift Station Remote Treatment Unit and the Diamond Avenue Remote Treatment Unit, and report the 7-Discharge Rolling Average in the Monthly Report to EPA/IDEM. The 7-Discharge Rolling Average calculation will be: (x1+x2+x3+x4+x5+x6+x7)/7, where x=the representative effluent TSS concentration samples during the most recent discharge and 1=the first discharge event, 2=the second discharge event, and so on. If there is no discharge in a month from either of the Remote Treatment Units, the Utility will report "No Discharge" on the Monthly Report for that month. In the next month in which a discharge occurs, the 7-Discharge Rolling Average will be calculated using the representative effluent TSS

concentrations from each of the 7 most recent discharge events regardless of whether the discharges occurred in contiguous months.

10.4.1.2 Monthly Report Requirements for the Remote Treatment Units

In addition to the requirements in Section E of this Appendix H, the Utility will include in each Monthly Report results for TSS, $CBOD_5$, *E. Coli*, pH, and, if applicable, residual chlorine for the Remote Treatment Units for each activation/discharge event. The Utility will report TSS, BOD5, and residual chlorine as concentrations (mg/L). The Utility will report *E. Coli* as cfu/100 mL (or equivalent, such as MPN/100 ml) and pH as s.u. In addition, the Utility will include in each Monthly Report:

- The corresponding precipitation information for each discharge event
- The results of each individual *E. Coli* grab sample taken
- The monthly geometric mean for all of the *E. Coli* samples taken in the previous month when at least 5 samples were collected
- The time when each *E. Coli* sample was taken and the estimated flow being discharged from the Remote Treatment Units
- Identify any dry weather discharges that occurred from the Remote Treatment Units within the previous month (include the start and end time of the dry weather discharge and the estimated total volume discharged).
- Identify any discharge the does not meet the performance criteria for the Remote Treatment Units that occurred during the previous month.
- Identify the start and end time and the total volume discharged from outfall CSO 005 for each day when the CSO discharged in the previous month.
- Identify the flow in MGD discharged from the 7th Avenue Lift Station Remote Treatment Unit for each calendar day the CSO discharged.
- Identify the start and end time and the total volume discharged from outfall CSO 025 for each day when the CSO discharged in the previous month.
- Identify the flow in MGD discharged from the Diamond Avenue Remote Treatment Unit for each calendar day the CSO discharged.

10.4.1.3 Continuous Operation of the Remote Treatment Units/Prohibition Against Dry Weather Discharges

No CSOs will occur at Seventh Avenue East (CSO 005) when the Seventh Avenue Remote Treatment Unit is operating at or below its design maximum flow of 72 million gallons per day. No CSOs will occur at Diamond Avenue (CSO 025) when the Diamond Avenue Remote Treatment Unit is operating at or below its design maximum flow of 20 million gallons per day. The bypass provisions of 40 CFR 122.41(m) will apply to each bypass at the Remote Treatment Units. Each Remote Treatment Unit is prohibited from discharging during dry weather conditions.

The sampling for the Remote Treatment Units must begin upon the Achievement of Full Operation date. The Utility will perform all sampling for the Remote Treatment Units at a point representative of the Remote Treatment Units' effluent, before admixture with any other flow.

The Utility will monitor the other flow, including but not limited to a CSO, before combining with effluent from the Remote Treatment Units. The Utility will report this measured other flow within the Monthly Report, including the start and end time and the total volume discharged, when either of the Remote Treatment Units are discharging.

10.4.2 Constructed Wetland Monitoring and Water Quality Sampling Procedure

10.4.2.1 Sampling Requirements

The Utility will conduct influent and effluent sampling when the Constructed Wetland is filling or discharging, respectively. The Utility will measure inflow and outflow from the Constructed Wetland at a representative location and recorded in 15-minute intervals to determine rates of filling/emptying of the Constructed Wetland during and after events. The Utility will average the inflow and outflow information on an hourly basis to correspond with samples being taken. In addition, The Utility will log Constructed Wetland water levels using an ultrasonic transducer or similar method, at a representative location, to track and record the depth of the Constructed Wetland and duration of storm events before, during, and after storm events.

The Utility will sample Constructed Wetland influent and effluent at representative Constructed Wetland inflow and outflow locations. The Utility will analyze samples for TSS, $CBOD_5$, residual chlorine, pH, and *E. Coli*. All sampling conducted must be representative of the Constructed Wetland's influent and effluent. The Utility will use an automatic sampler that collects samples at defined intervals or will take grab samples. The Utility will collect each sample, whether automatic or grab, during representative inflow into or representative discharges from the Constructed Wetland. The Utility will initiate influent sampling within 30 minutes from the beginning of filling of the Constructed Wetland. The Utility will continue influent sampling at intervals determined by The Utility but no less than every hour during the filling of the Constructed Wetland.

The Utility will initiate effluent sampling within 30 minutes after the beginning of a discharge from the Constructed Wetland. The Utility will continue effluent sampling at intervals determined by the Utility but no less than every hour during discharge. The Utility will analyze composite samples taken for TSS and $CBOD_5$. The Utility must sample for *E. Coli* daily when discharging. If the Utility chooses to disinfect using chlorine, the Utility will take and analyze a grab sample of residual chlorine each time a separate grab sample of *E. Coli* is taken. The Utility will perform a representative pH grab sample for each Constructed Wetland discharge event. The Utility will conform all sampling to the requirements in 40 CFR Part 136.

The Utility will calculate the TSS percent reduction by mass for each discharge day using the corresponding day's TSS influent and effluent sampling results and corresponding Constructed Wetland inflow and outflow volumes. The typical calculation for TSS percent reduction for a single discharge event would be: re = 1 – (te×ve)/ (ti×vi) = TSS percent removal, where:

- r_e = TSS percent removal for event e
- t_e = average of the TSS effluent concentrations
- v_e = total effluent volume
- t_i = the average of the TSS influent concentrations
- v_i = total influent volume

The flow weighted percent removal will be calculated by multiplying the computed TSS percent removal by the total volume for each discharge event. A sample 12-Month Rolling Average for flow weight TSS percent removal would be:

((r1×v1)+(r2×v2)+(r3×v3)…)/(v1+v2+v3…) = the flow weighted TSS percent removed running total, where:

- r = percent of mass removed
- v = total effluent volume discharged from the Constructed Wetland during each event
- $_1$ = the first discharge event, $_2$ = the second discharge event, and so on and so forth

If there is no discharge in a month from the Constructed Wetland, the Utility will report "No Discharge" on the Monthly Report.

10.4.2.2 Monthly Report Requirements for the Constructed Wetland

In addition to the requirements of Section E of this Appendix H, the Utility will include in the Monthly Report all sample results for TSS, $CBOD_5$, pH, *E. Coli* and, if applicable, residual chlorine for the Constructed Wetland. The Utility will report TSS, $CBOD_5$, and residual chlorine as concentrations (mg/L). The Utility will report *E. Coli* as cfu/100 mL (or equivalent) and pH as s.u. In addition, the Utility will include in the Monthly Report of the last month of the PCM monitoring period, the calculation of the 12-Month Rolling Average for TSS. The Utility will compare that value to the Performance Criterion of 50 percent TSS removal stated in Appendix G, and state in this Monthly Report whether the rolling 12-month period(s) 50 percent TSS removal performance criterion requirement was not met. In addition, the Utility will also include in each Monthly Report:

- The Constructed Wetland maximum water elevation for each wetland discharge event;
- The results of each individual *E. Coli* grab sample taken;
- The monthly geometric mean for all of the *E. Coli* samples taken in the previous month;
- The date and time each *E. Coli* grab sample was taken and the estimated flow being discharged from the Constructed Wetland;
- Corresponding precipitation information for each discharge event;
- Any dry weather discharges that occurred from the Constructed Wetland within the previous month (include the start and end time of the dry weather discharge and the total volume discharged); and
- The start and end time and the total volume discharged from outfall CSO 001 for each day when the CSO discharged in the previous month.
- The flow in MGD discharged from the Wetland for each calendar day CSO 001 discharged.

10.4.2.3 Continuous Operation of the Constructed Wetland

When the Constructed Wetland is not operating at greater than its design maximum flow of 198 million gallons per day, no CSOs will occur at Kentucky Avenue (CSO 001). The bypass provisions within 40 CFR 122.41(m) will apply to any bypasses of the Constructed Wetland. The Utility will not fill the wetland when the East WWTP is receiving flows less than 40 MGD, except as necessary to maintain water levels to support vegetation. During this exception, the Utility

will only use effluent treated with full secondary treatment at the East WWTP, and each such instance during a month in which the Utility fills the wetland will be documented in the Monthly Report. The Utility will conduct TSS sampling of the East WWTP effluent, regardless of the duration of the inflow, used to support the Constructed Wetland's vegetation and will include this sampled TSS concentration and the applicable inflow volume in the TSS percent removal calculation.

The Utility will begin monitoring the flow weighted TSS percent removal at the Constructed Wetland by no later than January 1, 2025, or after achievement of full operation of the Constructed Wetland, whichever is earlier. One full year of PCMP monitoring will be conducted, consistent with the requirements in Appendix G of the Consent Decree.

The Utility will perform all sampling for the Constructed Wetland at a point representative of the Constructed Wetland's effluent, before combining with any other flow. The Utility will monitor the other flow, including but not limited to WWTP discharge or a CSO, before combining with effluent from the Constructed Wetland. The Utility will report this measured other flow within the Monthly Report, including the start and end time and the total volume discharged, when the Constructed Wetland is discharging.

10.4.3 Vertical Treatment Unit (VTU) Monitoring Procedure

10.4.3.1 Sampling Requirements

The Utility will conduct influent and effluent sampling when the VTU is discharging. The Utility will measure the VTU's effluent discharge volume at a representative location and log the discharge event in 15-minute intervals to determine rates of emptying of the system during and after wet weather events. The Utility will average outflow data on an hourly basis to correspond with samples being taken.

The Utility will monitor, and include in the Monthly Report required under Section E of this Appendix H, the total volume (gallons) of wastewater captured and pumped to Evansville's East WWTP. The Utility will sample VTU influent and effluent at representative inflow and outflow locations. The Utility will analyze samples for TSS, $CBOD_5$, residual chlorine, pH, and *E. Coli*.

The Utility will use an automatic sampler that collects samples at defined intervals or will take grab samples. The Utility will collect each sample, whether automatic or grab, during representative inflow into or representative discharges from the VTU. The Utility will initiate sampling within 30 minutes from the beginning of the filling of the VTU for influent sampling and within 30 minutes after the discharge event begins for effluent sampling. The Utility will continue at intervals determined by the Utility but no less than every hour during the event. The Utility will composite samples taken for TSS, $CBOD_5$, and must sample for *E. Coli* daily when discharging. If the Utility choose to disinfect using chlorine, the Utility will perform and analyze a grab sample of residual chlorine each time a separate grab sample of *E. Coli* is performed. The Utility will perform a representative pH grab sample for each VTU discharge event. The Utility will conform all sampling to the requirements in 40 CFR Part 136.

The Utility will calculate the TSS percent reduction for the VTU using the appropriate TSS influent and effluent sampling results for each discharge event. The typical calculation for TSS percent reduction for a single discharge event is: $re = 1 – (t_e \times v_e)/ (t_i \times v_e)$ = TSS percent removal, where:

- r_e = TSS percent removal for event e
- t_e = average of the TSS effluent concentrations
- v_e = total effluent volume
- t_i = the average of the TSS influent concentrations

The Utility will calculate the flow weighted percent removal by multiplying the computed TSS percent removal by the total volume. A sample 12-Month Rolling Average for flow weighted TSS percent removal would be: ((r1×v1)+(r2×v2)+(r3×v3)…)/(v1+v2+v3…) = the flow weighted TSS percent removed running total, Where:

- r = percent of mass removed
- v = volume discharged in each event
- 1 = the first discharge event, 2 = the second discharge event, and so on and so forth

If there is no discharge in a month from the VTU, the Utility will report "No Discharge" for that month on the Monthly Report. The Utility will include in the Monthly Report of the last month of the PCM monitoring period, the calculation of the 12-Month Rolling Average for TSS. The Utility will compare that value to the Performance Criterion of 50 percent TSS removal stated in Appendix G, and state in this Monthly Report whether the rolling 12-month period(s) 50 percent TSS removal performance criterion requirement was not met.

10.4.3.2 Monthly Report Requirements for the VTU

In addition to the requirements of Section E of this Appendix H, the Utility will include the results for TSS, $CBOD_5$, *E. Coli*, pH, and, if applicable, residual chlorine for the VTU in the Monthly Report required under Section E of this Appendix H. The Utility will report TSS, $CBOD_5$, and residual chlorine as concentrations (mg/L). The Utility will report *E. Coli* as cfu/100 mL and pH as s.u. In addition, The Utility will include in the Monthly Report of the last month of the PCM monitoring period, the calculation of the 12-Month Rolling Average for TSS. The Utility will compare that value to the Performance Criterion of 50 percent TSS removal stated in Appendix G, and state in this Monthly Report whether the rolling 12-month period(s) 50 percent TSS removal performance criterion requirement was not met. In addition, the Utility will also include in each Monthly Report:

- The results of each individual *E. Coli* grab sample taken;
- The monthly geometric mean for all of the *E. Coli* samples taken in the previous month;
- The date and time each *E. Coli* grab sample was taken and the estimated flow being discharged from the VTU;
- Corresponding precipitation information for each discharge event;
- Any dry weather discharges that occurred from the VTU within the previous month (include the start and end time of the dry weather discharge and the total volume discharged);
- The start and end time and the total volume discharged from outfall CSO 002 and CSO 004 for each day either of the CSOs discharged in the previous month; and,

- The flow in MGD discharged from the VTU for each calendar day whenever either CSO 002 or CSO 004 discharge.

10.4.3.3 Continuous Operation of the VTU During Discharges/Prohibition on Dry Weather Discharges

No CSOs will occur at Cass Avenue (CSO 002) or at Adams Avenue (CSO 004) when the VTU is operating at or below its design maximum flow of 226 million gallons per day. The provisions of 40 C.F.R. § 122.41(m) apply to all bypasses at the VTU. The VTU is prohibited from discharging during dry weather conditions.

The Utility will operate the VTU in order to maximize the amount of wastewater captured and pumped back to the Utility's East WWTP. The amount of wastewater pumped back to the East WWTP will not be included in TSS percent removal calculation for the VTU. The Utility will begin monitoring and sampling influent and effluent at the VTU, and begin calculating the flow weighted percent removal, on January 1, 2033, or after achievement of full operation, whichever is earlier. One full year of PCMP monitoring will be conducted, consistent with the requirements in Appendix G of the Consent Decree.

The Utility will perform all sampling for the VTU at a point representative of the VTU's effluent, before admixture with any other flow. The Utility will monitor the other flow, including but not limited to WWTP discharge or a CSO, before combining with effluent from the VTU. The Utility will report this other measured flow within the Monthly Report, including the start and end time and the total volume discharged, when the VTU is discharging.

10.5 Quality Assurance and Quality Control

Quality control (QC) procedures ensure that consistent and accurate data are measured and reported by the PCCMP. Quality control procedures for the PCMP include the following:

- Documentation of receiving streamflow monitoring and field measurement activities. Assurances that flow data generated are valid and representative, including streamflow discharge estimates.

- Documentation of CSO outfall monitoring activities, including installation activities, calibration records, field-testing equipment and maintenance, and data downloads. Assurances that flow data generated are valid and representative.

- Documentation of field sampling activities, including sampling dates, times, sample identification numbers, equipment calibration, monitoring results, weather conditions, and any other pertinent observations in support of the sample collection.

- Completion of tracking forms, chain-of-custody forms, and sampling equipment maintenance records.

- Documentation of laboratory analysis activities, including sample checking, analytical methods and protocols, use of reference samples and duplicates, sample archiving, data verification and coding, equipment calibration, and maintenance and data downloads.

- Documentation of rainfall monitoring activities including equipment calibration and maintenance records, precipitation records, and data downloads. Assurances that precipitation data generated are valid and representative.

- Documentation of data retrieval, management, and analysis activities, including data entry practices and data validation (e.g., entry range limits, duplicate entry checking), data tracking, data formatting, data analysis, and data reporting.

- QC reviews of all internal and external deliverables.

A number of factors can impact data accuracy including but not limited to high river stage, preceding wet weather events, high antecedent moisture conditions, debris, and poor quality data collection. Evansville will only utilize satisfactory data for determining compliance with the Consent Decree. As such, a quality assurance / quality control procedure will be used for determining whether data is satisfactory. Evansville will include within its final report the data used in determining compliance and results from its control procedure with a clear basis for why any data was not utilized in determining compliance.

10.6 Post-Construction Compliance Monitoring Report

The PCMP will be conducted after all system improvements are completed and a report will be submitted as follows per the schedule outlined in the Negotiated Plan described in Section 9 and the Third Amendment to the Consent Decree:

- Begin one full year of post-construction monitoring: May 31, 2040
- Complete one year of post-construction monitoring: May 31, 2041
- Submit Post-Construction Monitoring Report: May 31, 2042

Prior to the start of the Final PCMP, Evansville is committed to using data gathered in the PCMP process to calibrate and validate its SWMM model. Flow measurement will be collected over a 5-month period from April to August of the relevant year with up to 16 flow meters placed at the discretion of the City of Evansville. Results will be available after December of the relevant year. Evansville will run the calibrated and validated SWMM model with the typical year precipitation data to determine if the results show that Evansville has met or exceeded the Performance Criteria in Appendix G of the Consent Decree. Evansville will include the typical year precipitation results in the final report submitted to EPA and IDEM and in accordance with the schedule summarized in Table 10-3.

Table 10-3 SWMM Model Validation Reporting Schedule

Control Measure	CSOs Affected	Calibration Year	Validation Year	Reporting Year
1, 2	001, 002, 004, 103	2033	2034	2035
3, 4	123, 012, 013, 014, 016, 017, 018, 024, 025	2023	2024	2025
5	006, 009, 015, 016, 020, 022	2038	2039	2040
6, 7	024, 025, 018	2038	2040	2041
8	011	2037	2038	2039
9, GI	008. 038, 010	2039	2040	2041
10	012, 013, 014, 017	2040	2041	2042
SSRMP		2035	2036	2037

The PCM dates in the CD will have to be modified by the parties to align with the Negotiated Plan and the dates above. If the results of the PCCMP do not demonstrate compliance with the activation, volume reduction goals and recreational use goals as shown in Table 10-4, within one hundred eighty (180) Days of receiving notice that compliance has not been demonstrated, (or a different time period agreed to) the Utility will submit to a Supplemental Compliance Plan which describes the additional improvements and/or other remedial measures that the Utility will take to achieve compliance, and a proposed schedule for taking such actions. Upon approval the Utility will implement the Supplemental Compliance Plan in accordance with the schedule specified in the approved Plan and the requirements of the Decree. Alternatively, if the results of the PCMP do not demonstrate compliance with applicable water quality standards, the Utility reserves it right to pursue a modification of applicable standards through a use attainability analysis, as noted in Section B.4 and Section E.6. of Appendix C.

Table 10-4 Negotiated Plan

Facility	Name	Anticipated Number of Untreated CSO Discharges in the Typical Year	Anticipated Volume of Untreated CSO Discharges in the Typical Year
All	Clean PCI, Sewer Separation, Green Infrastructure		
CSO 001	Kentucky Ave	0	0
CSO 002	Cass Ave	0	0
CSO 004	Adams	0	0
CSO 006	Fulton Avenue Pump Station	0	0
CSO 008	Chestnut	3	13
CSO 010	Dress Plaza	3	7
CSO 011	Oak Hill	3	5
CSO 012	Maryland Street	2	1
CSO 013	Delaware Street	2	3
CSO 014	Dresden Street	2	1
CSO 015	7th Avenue East	4	7
CSO 016	Franklin Street	2	2
CSO 017	6th Avenue	1	1
CSO 018	Oakley Street	0	0
CSO 020	9th Avenue	0	0
CSO 022	St. Joseph Avenue	0	0
CSO 024	Baker	4	12
CSO 025	Diamond Avenue	4	40
CSO 038	Oak and Riverside	0	0
CSO 103	East WWTP	0	0
WWTP	WWTP Projects		
	Compliance Metrics - Normalized to Typical Year Conditions:	**4**	**73**

10.6.1 Final Post-Construction Compliance Monitoring Report

On or before May 31, 2042, Evansville will submit to EPA and IDEM a final Post-Construction Monitoring Report, which will:

- Demonstrate that Evansville completed all of the requirements of the Post-Construction Monitoring Plan;
- Provide the information required by section 10 of Volume 2, the LTCP;
- Evaluate whether each CSO and SSO Control Measure implemented pursuant to Appendix G of the Consent Decree meets the Performance Criteria described in the Consent Decree Appendix G, Table G-1, and is performing as designed;
- Evaluate how well Evansville's system is performing as a whole, following completion of all CSO and SSO Control Measures, and will include an assessment of whether the CSO and SSO Control Measures implemented pursuant to the Consent Decree Appendix G, as constructed, operated, or otherwise implemented, have achieved the Performance Criteria of no more than four CSO Events during the Typical Year, and zero SSO events with a 10-Year level of SSO control;
- Summarize the data collected during the entirety of the 12-month post-construction monitoring period and include any new data relevant to the evaluation that Evansville did not previously submit to EPA or IDEM;
- Evaluate whether Evansville's remaining CSO Discharges, if any, comply with all applicable requirements in Appendix G, and determine the water quality impacts, if any, of any remaining CSO discharges and CSS releases to receiving streams;
- If model or monitoring results of the CSOs and SSOs show that Evansville's CSO or SSO Control Measures did not meet Performance Criteria, including the Performance Criteria of no more than four CSO Events during the Typical Year; and zero SSO events with a 10-Year level of SSO control; Evansville will identify and describe in detail deficiencies or performance-limiting factors in system design, process, operations, and maintenance that may have limited the ability of the CSO or SSO Control Measures to achieve their intended performance. Thereafter, Evansville will identify and describe in detail all necessary corrective measures, alternative operating strategies, structural modifications, and additional facilities and processes necessary to meet the Performance Criteria.

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APPENDIX A

Applicable Technologies by CSO

TABLE A-1
Site Specific CSO Technology Screening
CSO 025 (Diamond Avenue) - West Basin

Technology Classification	Potential Technologies Considered	Suitable (Y/N)	Comments
Inflow Reduction	Stormwater Management/Green Infrastructure	N	Large sewer basin, soil conditions throughout catchment area not ideal for GI
	Industrial Pretreatment/Other Source Controls	N	Utility's pretreatment program provides source control to the extent possible
	Partial Sewer Separation	Y	
Sewer System Modification	Flow Redirection	N	Large sewer catchment is most upstream in West system, and opportunities for flow redirection are not available
	Infiltration Reduction	N	Applicable to SSRMP
	Interceptor Sewer Construction	Y	
	Relief Sewer Construction	Y	
	Outfall Consolidation	Y	CSO 025 and 024 will be consolidated at this location
	Pump Station Modifications	NA	
	Static Flow Control	Y	
	Variable Flow Control	Y	
	Real-Time Flow Control	Y	
Storage	Open Basins and Tanks	Y	Levee Authority already stores flow in an open basin in this locaiton
	Closed Storage Tanks	Y	Closed storage would help prevent odor and aesthetic problems at the park
	Storage Conduits	Y	90" combined
	Storage Tunnels	Y	
	Existing Tunnels or Conduits (Abandoned)	NA	
Physical/ Chemical Satellite Treatment	Floatables Control (Screening)	Y	
	Swirl Concentrators and Vortex Separators	Y	
	Sedimentation	Y	Actiflow
	Compressed Media Filtration	Y	
	High Rate Treatment/Ballasted Flocculation	Y	
	Disinfection/Dechlorination	Y	
	Increased Treatment Capacities at Existing Facilities	Y	
	Constructed Treatment Wetlands	N	Insufficient land available nearby

TABLE A-2
Site Specific CSO Technology Screening
CSO 024 (Baker Street) - West Basin

Technology Classification	Potential Technologies Considered	Suitable (Y/N)	Comments
Inflow Reduction	Stormwater Management/Green Infrastructure	N	Large sewer basin, soil conditions throughout catchment area not ideal for GI
	Industrial Pretreatment/Other Source Controls	N	Utility's pretreatment program provides source control to the extent possible
	Partial Sewer Separation	N	
Sewer System Modification	Flow Redirection	N	Large sewer catchment is most upstream in West system, and opportunities for flow redirection are not available
	Infiltration Reduction	N	Applicable to SSRMP
	Interceptor Sewer Construction	Y	
	Relief Sewer Construction	Y	
	Outfall Consolidation	Y	CSO 025 and 024 will be consolidated at this location
	Pump Station Modifications	Y	Pump flow to CSO 025
	Static Flow Control	Y	
	Variable Flow Control	N	Potential may exist in the future to utilize existing sewers for storage; not evaluated in 2013 LTCP
	Real-Time Flow Control	Y	
Storage	Open Basins and Tanks	N	Not an ideal location for open storage
	Closed Storage Tanks	Y	Space is limited but there is some possible storage available in nearby parking lot
	Storage Conduits	N	Potential may exist in the future to utilize existing sewers for storage; not evaluated in 2013 LTCP
	Storage Tunnels	Y	
	Existing Tunnels or Conduits (Abandoned)	NA	
Physical/ Chemical Satellite Treatment	Floatables Control (Screening)	Y	
	Swirl Concentrators and Vortex Separators	N	Insufficient land available; existing infracture can be utilized to consolidate the Baker Street CSO with the Diamond Avenue CSO control measure
	Sedimentation	N	Insufficient land available; existing infracture can be utilized to consolidate the Baker Street CSO with the Diamond Avenue CSO control measure
	Compressed Media Filtration	N	Insufficient land available; existing infracture can be utilized to consolidate the Baker Street CSO with the Diamond Avenue CSO control measure
	High Rate Treatment/Ballasted Flocculation	N	Insufficient land available; existing infracture can be utilized to consolidate the Baker Street CSO with the Diamond Avenue CSO control measure
	Disinfection/Dechlorination	N	Insufficient land available; existing infracture can be utilized to consolidate the Baker Street CSO with the Diamond Avenue CSO control measure
	Increased Treatment Capacities at Existing Facilities	Y	
	Constructed Treatment Wetlands	N	Insufficient land available nearby

TABLE A-3
Site Specific CSO Technology Screening
CSO 018 (Oakley Street) - West Basin

Technology Classification	Potential Technologies Considered	Suitable (Y/N)	Comments
Inflow Reduction	Stormwater Management/Green Infrastructure	N	Soil conditions throughout catchment area not ideal for GI
	Industrial Pretreatment/Other Source Controls	N	Utility's pretreatment program provides source control to the extent possible
	Partial Sewer Separation	N	
Sewer System Modification	Flow Redirection	Y	
	Infiltration Reduction	N	Applicable to SSRMP
	Interceptor Sewer Construction	Y	
	Relief Sewer Construction	Y	
	Outfall Consolidation	N	Low volume CSO located far from other CSO outfalls
	Pump Station Modifications	NA	
	Static Flow Control	Y	
	Variable Flow Control	N	Potential may exist in the future to utilize existing sewers for storage; not evaluated in 2013 LTCP
	Real-Time Flow Control	Y	
Storage	Open Basins and Tanks	Y	
	Closed Storage Tanks	Y	
	Storage Conduits	N	Potential may exist in the future to utilize existing sewers for storage; not evaluated in 2013 LTCP
	Storage Tunnels	Y	
	Existing Tunnels or Conduits (Abandoned)	NA	
Physical/ Chemical Satellite Treatment	Floatables Control (Screening)	Y	
	Swirl Concentrators and Vortex Separators	N	Low volume CSO; not cost effective compared to other technologies
	Sedimentation	N	Low volume CSO; not cost effective compared to other technologies
	Compressed Media Filtration	N	Low volume CSO; not cost effective compared to other technologies
	High Rate Treatment/Ballasted Flocculation	N	Low volume CSO; not cost effective compared to other technologies
	Disinfection/Dechlorination	N	Low volume CSO; not cost effective compared to other technologies
	Increased Treatment Capacities at Existing Facilities	Y	
	Constructed Treatment Wetlands	N	Insufficient land available nearby

TABLE A-4
Site Specific CSO Technology Screening
CSO 017 (Sixth Avenue) - West Basin

Technology Classification	Potential Technologies Considered	Suitable (Y/N)	Comments
Inflow Reduction	Stormwater Management/Green Infrastructure	N	Soil conditions throughout catchment area not ideal for GI
	Industrial Pretreatment/Other Source Controls	N	Utility's existing pretreatment program provides source control to the extent possible, additional source controls not considered as part of LTCP
	Partial Sewer Separation	Y	
Sewer System Modification	Flow Redirection	Y	
	Infiltration Reduction	N	Appropriate for addressing separate sanitary sewer overflows
	Interceptor Sewer Construction	Y	
	Relief Sewer Construction	Y	
	Outfall Consolidation	N	Storage not available at this location, therefore directing flow to another location considered
	Pump Station Modifications	NA	Levee pump station cannot be used for CSO pumping
	Static Flow Control	Y	
	Variable Flow Control	N	Potential may exist in the future to utilize existing sewers for storage; not evaluated in 2013 LTCP
	Real-Time Flow Control	Y	
Storage	Open Basins and Tanks	N	Immediately adjacent to earthen levee and residential neighborhood. Insufficient land available for storage.
	Closed Storage Tanks	N	Immediately adjacent to earthen levee and residential neighborhood. Insufficient land available for storage.
	Storage Conduits	Y	
	Storage Tunnels	Y	
	Existing Tunnels or Conduits (Abandoned)	NA	
Physical/ Chemical Satellite Treatment	Floatables Control (Screening)	Y	
	Swirl Concentrators and Vortex Separators	N	Low volume CSO; not cost effective compared to other technologies
	Sedimentation	N	Low volume CSO; not cost effective compared to other technologies
	Compressed Media Filtration	N	Low volume CSO; not cost effective compared to other technologies
	High Rate Treatment/Ballasted Flocculation	N	Low volume CSO; not cost effective compared to other technologies
	Disinfection/Dechlorination	N	Low volume CSO; not cost effective compared to other technologies
	Increased Treatment Capacities at Existing Facilities	Y	
	Constructed Treatment Wetlands	N	Insufficient land available nearby, therefore wetland treatment for this CSO is not viable.

TABLE A-5
Site Specific CSO Technology Screening
CSO 014 (Dresden Street) - West Basin

Technology Classification	Potential Technologies Considered	Suitable (Y/N)	Comments
Inflow Reduction	Stormwater Management/Green Infrastructure	N	Large sewer basin, soil conditions throughout catchment area not ideal for GI
	Industrial Pretreatment/Other Source Controls	N	Utility's pretreatment program provides source control to the extent possible
	Partial Sewer Separation	N	
Sewer System Modification	Flow Redirection	Y	
	Infiltration Reduction	N	Applicable to SSRMP
	Interceptor Sewer Construction	Y	
	Relief Sewer Construction	Y	
	Outfall Consolidation	Y	Cosidered routing flow to Maryland CSO
	Pump Station Modifications	NA	Levee pump station cannot be used for CSO pumping
	Static Flow Control	Y	
	Variable Flow Control	N	Potential may exist in the future to utilize existing sewers for storage; not evaluated in 2013 LTCP
	Real-Time Flow Control	Y	
Storage	Open Basins and Tanks	Y	Space is very limited and adjacent to levee in a residential area. Only small amounts of storage were evaluated.
	Closed Storage Tanks	Y	Space is very limited and adjacent to levee in a residential area. Only small amounts of storage were evaluated.
	Storage Conduits	Y	
	Storage Tunnels	Y	
	Existing Tunnels or Conduits (Abandoned)	NA	
Physical/ Chemical Satellite Treatment	Floatables Control (Screening)	Y	
	Swirl Concentrators and Vortex Separators	N	Insufficient land available nearby
	Sedimentation	N	Insufficient land available nearby
	Compressed Media Filtration	N	Insufficient land available nearby
	High Rate Treatment/Ballasted Flocculation	N	Insufficient land available nearby
	Disinfection/Dechlorination	N	Insufficient land available nearby
	Increased Treatment Capacities at Existing Facilities	Y	
	Constructed Treatment Wetlands	N	Insufficient land available nearby

TABLE A-6
Site Specific CSO Technology Screening
CSO 012 (Maryland Street) - West Basin

Technology Classification	Potential Technologies Considered	Suitable (Y/N)	Comments
Inflow Reduction	Stormwater Management/Green Infrastructure	Y	Large sewer basin, soil conditions throughout catchment area not ideal for GI
	Industrial Pretreatment/Other Source Controls	N	Utility's pretreatment program provides source control to the extent possible
	Partial Sewer Separation	Y	
Sewer System Modification	Flow Redirection	Y	
	Infiltration Reduction	N	Applicable to SSRMP
	Interceptor Sewer Construction	Y	
	Relief Sewer Construction	Y	
	Outfall Consolidation	Y	
	Pump Station Modifications	NA	
	Static Flow Control	Y	
	Variable Flow Control	N	Potential may exist in the future to utilize existing sewers for storage; not evaluated in 2013 LTCP
	Real-Time Flow Control	Y	
Storage	Open Basins and Tanks	Y	Land not availabe at CSO location but storage is possible across the creek. Closed storage is prefered in park location
	Closed Storage Tanks	Y	Land not availabe at CSO location but storage is possible across the creek
	Storage Conduits	Y	
	Storage Tunnels	Y	
	Existing Tunnels or Conduits (Abandoned)	NA	
Physical/ Chemical Satellite Treatment	Floatables Control (Screening)	Y	Buried under ball field
	Swirl Concentrators and Vortex Separators	Y	Buried under ball field
	Sedimentation	Y	Buried under ball field
	Compressed Media Filtration	Y	Buried under ball field
	High Rate Treatment/Ballasted Flocculation	Y	Buried under ball field
	Disinfection/Dechlorination	Y	Buried under ball field
	Increased Treatment Capacities at Existing Facilities	Y	
	Constructed Treatment Wetlands	N	Insufficient land available nearby

TABLE A-7
Site Specific CSO Technology Screening
CSO 013 (Delaware) - West Basin

Technology Classification	Potential Technologies Considered	Suitable (Y/N)	Comments
Inflow Reduction	Stormwater Management/Green Infrastructure	N	Soil conditions throughout catchment area not ideal for GI
	Industrial Pretreatment/Other Source Controls	N	Utility's pretreatment program provides source control to the extent possible
	Partial Sewer Separation	Y	
Sewer System Modification	Flow Redirection	N	Potential may exist in the future; not evaluated in 2013 LTCP
	Infiltration Reduction	N	Applicable to SSRMP
	Interceptor Sewer Construction	Y	
	Relief Sewer Construction	Y	
	Outfall Consolidation	Y	
	Pump Station Modifications	NA	
	Static Flow Control	Y	
	Variable Flow Control	N	Potential may exist in the future to utilize existing sewers for storage; not evaluated in 2013 LTCP
	Real-Time Flow Control	Y	
Storage	Open Basins and Tanks	Y	Land not availabe at CSO location but storage is possible across the creek. Closed storage is prefered in park location
	Closed Storage Tanks	Y	Land not availabe at CSO location but storage is possible across the creek
	Storage Conduits	N	Land is available adjacent to outfall for storage
	Storage Tunnels	Y	
	Existing Tunnels or Conduits (Abandoned)	NA	
Physical/ Chemical Satellite Treatment	Floatables Control (Screening)	Y	Buried under ball field
	Swirl Concentrators and Vortex Separators	Y	Buried under ball field
	Sedimentation	Y	Buried under ball field
	Compressed Media Filtration	Y	Buried under ball field
	High Rate Treatment/Ballasted Flocculation	Y	Buried under ball field
	Disinfection/Dechlorination	Y	Buried under ball field
	Increased Treatment Capacities at Existing Facilities	Y	
	Constructed Treatment Wetlands	N	Insufficient land available nearby

TABLE A-8
Site Specific CSO Technology Screening
CSO 016 (Franklin Street) - West Basin

Technology Classification	Potential Technologies Considered	Suitable (Y/N)	Comments
Inflow Reduction	Stormwater Management/Green Infrastructure	N	Soil conditions throughout catchment area not ideal for GI
	Industrial Pretreatment/Other Source Controls	N	Utility's pretreatment program provides source control to the extent possible
	Partial Sewer Separation	Y	
Sewer System Modification	Flow Redirection	N	
	Infiltration Reduction	N	Applicable to SSRMP
	Interceptor Sewer Construction	Y	
	Relief Sewer Construction	Y	
	Outfall Consolidation	N	Rerouted to Delaware or 7th Avenue CSO
	Pump Station Modifications	NA	
	Static Flow Control	Y	
	Variable Flow Control	N	Potential may exist in the future to utilize existing sewers for storage; not evaluated in 2013 LTCP
	Real-Time Flow Control	Y	
Storage	Open Basins and Tanks	N	Not sufficient space
	Closed Storage Tanks	N	Not sufficient space
	Storage Conduits	N	Potential may exist in the future to utilize existing sewers for storage; not evaluated in 2013 LTCP
	Storage Tunnels	Y	
	Existing Tunnels or Conduits (Abandoned)	NA	
Physical/ Chemical Satellite Treatment	Floatables Control (Screening)	Y	
	Swirl Concentrators and Vortex Separators	N	Not sufficient space
	Sedimentation	N	Not sufficient space
	Compressed Media Filtration	N	Not sufficient space
	High Rate Treatment/Ballasted Flocculation	N	Not sufficient space
	Disinfection/Dechlorination	N	Not sufficient space
	Increased Treatment Capacities at Existing Facilities	Y	
	Constructed Treatment Wetlands	N	Insufficient land available nearby

TABLE A-9
Site Specific CSO Technology Screening
CSO 009 (7th Avenue West) - West Basin

Technology Classification	Potential Technologies Considered	Suitable (Y/N)	Comments
Inflow Reduction	Stormwater Management/Green Infrastructure	N	CSO is no longer activated
	Industrial Pretreatment/Other Source Controls	N	CSO is no longer activated
	Partial Sewer Separation	N	CSO is no longer activated
Sewer System Modification	Flow Redirection	N	CSO is no longer activated
	Infiltration Reduction	N	CSO is no longer activated
	Interceptor Sewer Construction	N	CSO is no longer activated
	Relief Sewer Construction	N	CSO is no longer activated
	Outfall Consolidation	N	CSO is no longer activated
	Pump Station Modifications	N	CSO is no longer activated
	Static Flow Control	N	CSO is no longer activated
	Variable Flow Control	N	CSO is no longer activated
	Real-Time Flow Control	N	CSO is no longer activated
Storage	Open Basins and Tanks	N	CSO is no longer activated
	Closed Storage Tanks	N	CSO is no longer activated
	Storage Conduits	N	CSO is no longer activated
	Storage Tunnels	N	CSO is no longer activated
	Existing Tunnels or Conduits (Abandoned)	N	CSO is no longer activated
Physical/ Chemical Satellite Treatment	Floatables Control (Screening)	N	CSO is no longer activated
	Swirl Concentrators and Vortex Separators	N	CSO is no longer activated
	Sedimentation	N	CSO is no longer activated
	Compressed Media Filtration	N	CSO is no longer activated
	High Rate Treatment/Ballasted Flocculation	N	CSO is no longer activated
	Disinfection/Dechlorination	N	CSO is no longer activated
	Increased Treatment Capacities at Existing Facilities	N	CSO is no longer activated
	Constructed Treatment Wetlands	N	CSO is no longer activated

TABLE A-10
Site Specific CSO Technology Screening
CSO 015 (7th Avenue East) - West Basin

Technology Classification	Potential Technologies Considered	Suitable (Y/N)	Comments
Inflow Reduction	Stormwater Management/Green Infrastructure	N	Soil conditions throughout catchment area not ideal for GI
	Industrial Pretreatment/Other Source Controls	N	Utility's pretreatment program provides source control to the extent possible
	Partial Sewer Separation	N	
Sewer System Modification	Flow Redirection	N	Opportunities for flow redirection are not available
	Infiltration Reduction	N	Applicable to SSRMP
	Interceptor Sewer Construction	Y	
	Relief Sewer Construction	Y	
	Outfall Consolidation	Y	
	Pump Station Modifications	Y	
	Static Flow Control	Y	
	Variable Flow Control	N	Potential may exist in the future to utilize existing sewers for storage; not evaluated in 2013 LTCP
	Real-Time Flow Control	Y	
Storage	Open Basins and Tanks	Y	
	Closed Storage Tanks	Y	
	Storage Conduits	N	Congested urban area adjacent to 7th Ave LS; large CSO at this location and available location are adequate for storage and treatment
	Storage Tunnels	Y	
	Existing Tunnels or Conduits (Abandoned)	NA	
Physical/ Chemical Satellite Treatment	Floatables Control (Screening)	Y	
	Swirl Concentrators and Vortex Separators	Y	
	Sedimentation	Y	
	Compressed Media Filtration	Y	
	High Rate Treatment/Ballasted Flocculation	Y	
	Disinfection/Dechlorination	Y	
	Increased Treatment Capacities at Existing Facilities	Y	
	Constructed Treatment Wetlands	N	Insufficient land available nearby

TABLE A-11
Site Specific CSO Technology Screening
CSO 006 (Fulton Avenue Pump Station) - West Basin

Technology Classification	Potential Technologies Considered	Suitable (Y/N)	Comments
Inflow Reduction	Stormwater Management/Green Infrastructure	N	Soil conditions throughout catchment area not ideal for GI
	Industrial Pretreatment/Other Source Controls	N	Utility's pretreatment program provides source control to the extent possible
	Partial Sewer Separation	N	
Sewer System Modification	Flow Redirection	N	Opportunities for flow redirection are not available
	Infiltration Reduction	N	Applicable to SSRMP
	Interceptor Sewer Construction	Y	
	Relief Sewer Construction	Y	
	Outfall Consolidation	Y	
	Pump Station Modifications	NA	
	Static Flow Control	Y	
	Variable Flow Control	N	Potential may exist in the future to utilize existing sewers for storage; not evaluated in 2013 LTCP
	Real-Time Flow Control	Y	
Storage	Open Basins and Tanks	Y	
	Closed Storage Tanks	Y	
	Storage Conduits	N	Congested urban area adjacent to 7th Ave LS; large CSO at this location and available location are adequate for storage and treatment
	Storage Tunnels	Y	
	Existing Tunnels or Conduits (Abandoned)	NA	
Physical/ Chemical Satellite Treatment	Floatables Control (Screening)	Y	
	Swirl Concentrators and Vortex Separators	N	Existing infrasturcture allow for cost-effective consolidation with 7th Ave LS and CSOs
	Sedimentation	N	Existing infrasturcture allow for cost-effective consolidation with 7th Ave LS and CSOs
	Compressed Media Filtration	N	Existing infrasturcture allow for cost-effective consolidation with 7th Ave LS and CSOs
	High Rate Treatment/Ballasted Flocculation	N	Existing infrasturcture allow for cost-effective consolidation with 7th Ave LS and CSOs
	Disinfection/Dechlorination	N	Existing infrasturcture allow for cost-effective consolidation with 7th Ave LS and CSOs
	Increased Treatment Capacities at Existing Facilities	Y	
	Constructed Treatment Wetlands	N	Insufficient land available nearby

TABLE A-12
Site Specific CSO Technology Screening
CSO 020 (9th Avenue) - West Basin

Technology Classification	Potential Technologies Considered	Suitable (Y/N)	Comments
Inflow Reduction	Stormwater Management/Green Infrastructure	N	Soil conditions throughout catchment area not ideal for GI
	Industrial Pretreatment/Other Source Controls	N	Utility's pretreatment program provides source control to the extent possible
	Partial Sewer Separation	N	
Sewer System Modification	Flow Redirection	N	Opportunities for flow redirection are not available
	Infiltration Reduction	N	Applicable to SSRMP
	Interceptor Sewer Construction	Y	
	Relief Sewer Construction	Y	
	Outfall Consolidation	Y	
	Pump Station Modifications	NA	
	Static Flow Control	Y	
	Variable Flow Control	N	Potential may exist in the future to utilize existing sewers for storage; not evaluated in 2013 LTCP
	Real-Time Flow Control	Y	
Storage	Open Basins and Tanks	Y	
	Closed Storage Tanks	Y	
	Storage Conduits	N	Congested urban area adjacent to 7th Ave LS; large CSO at this location and available location are adequate for storage and treatment
	Storage Tunnels	Y	
	Existing Tunnels or Conduits (Abandoned)	NA	
Physical/ Chemical Satellite Treatment	Floatables Control (Screening)	Y	
	Swirl Concentrators and Vortex Separators	N	No land adjacent to CSO outfall; ability to consolidate with 7th Ave LS and CSO control
	Sedimentation	N	No land adjacent to CSO outfall; ability to consolidate with 7th Ave LS and CSO control
	Compressed Media Filtration	N	No land adjacent to CSO outfall; ability to consolidate with 7th Ave LS and CSO control
	High Rate Treatment/Ballasted Flocculation	N	No land adjacent to CSO outfall; ability to consolidate with 7th Ave LS and CSO control
	Disinfection/Dechlorination	N	No land adjacent to CSO outfall; ability to consolidate with 7th Ave LS and CSO control
	Increased Treatment Capacities at Existing Facilities	Y	
	Constructed Treatment Wetlands	N	Insufficient land available nearby

TABLE A-13
Site Specific CSO Technology Screening
CSO 022 (St. Joseph Avenue) - West Basin

Technology Classification	Potential Technologies Considered	Suitable (Y/N)	Comments
Inflow Reduction	Stormwater Management/Green Infrastructure	Y	
	Industrial Pretreatment/Other Source Controls	N	Utility's pretreatment program provides source control to the extent possible
	Partial Sewer Separation	Y	
Sewer System Modification	Flow Redirection	Y	Opportunities for flow redirection are not available
	Infiltration Reduction	N	Applicable to SSRMP
	Interceptor Sewer Construction	N	Large diameter interceptor exists and serves this CSO
	Relief Sewer Construction	Y	
	Outfall Consolidation	Y	
	Pump Station Modifications	NA	
	Static Flow Control	Y	
	Variable Flow Control	N	Potential may exist in the future to utilize existing sewers for storage; not evaluated in 2013 LTCP
	Real-Time Flow Control	Y	
Storage	Open Basins and Tanks	Y	
	Closed Storage Tanks	Y	
	Storage Conduits	N	Potential may exist in the future to utilize existing sewers for storage; not evaluated in 2013 LTCP
	Storage Tunnels	Y	
	Existing Tunnels or Conduits (Abandoned)	Y	
Physical/ Chemical Satellite Treatment	Floatables Control (Screening)	Y	
	Swirl Concentrators and Vortex Separators	N	Insufficient land available nearby
	Sedimentation	N	Insufficient land available nearby
	Compressed Media Filtration	N	Insufficient land available nearby
	High Rate Treatment/Ballasted Flocculation	N	Insufficient land available nearby
	Disinfection/Dechlorination	N	Insufficient land available nearby
	Increased Treatment Capacities at Existing Facilities	Y	
	Constructed Treatment Wetlands	N	Insufficient land available nearby

TABLE A-14
Site Specific CSO Technology Screening
CSO 123 (West Plant) - West Basin

Technology Classification	Potential Technologies Considered	Suitable (Y/N)	Comments
Inflow Reduction	Stormwater Management/Green Infrastructure	N	Soil conditions throughout catchment area not ideal for GI
	Industrial Pretreatment/Other Source Controls	N	Utility's pretreatment program provides source control to the extent possible
	Partial Sewer Separation	N	
Sewer System Modification	Flow Redirection	N	Opportunities for flow redirection are not available
	Infiltration Reduction	N	Applicable to SSRMP
	Interceptor Sewer Construction		
	Relief Sewer Construction		
	Outfall Consolidation		
	Pump Station Modifications	NA	
	Static Flow Control		
	Variable Flow Control		
	Real-Time Flow Control		
Storage	Open Basins and Tanks	Y	
	Closed Storage Tanks	Y	
	Storage Conduits	Y	
	Storage Tunnels	Y	
	Existing Tunnels or Conduits (Abandoned)	NA	
Physical/ Chemical Satellite Treatment	Floatables Control (Screening)		
	Swirl Concentrators and Vortex Separators		
	Sedimentation		
	Compressed Media Filtration		
	High Rate Treatment/Ballasted Flocculation		
	Disinfection/Dechlorination		
	Increased Treatment Capacities at Existing Facilities	Y	
	Constructed Treatment Wetlands	N	Insufficient land available nearby

TABLE A-15
Site Specific CSO Technology Screening
CSO 011 (Oakhill Road) - East Basin

Technology Classification	Potential Technologies Considered	Suitable (Y/N)	Comments
Inflow Reduction	Stormwater Management/Green Infrastructure	N	Soil conditions throughout catchment area not ideal for GI
	Industrial Pretreatment/Other Source Controls	N	Utility's pretreatment program provides source control to the extent possible
	Partial Sewer Separation	Y	
Sewer System Modification	Flow Redirection	N	Opportunities for flow redirection are not available
	Infiltration Reduction	N	Applicable to SSRMP
	Interceptor Sewer Construction	N	Remote CSO in a congested urban area located far from the WWTP
	Relief Sewer Construction	N	Remote CSO in a congested urban area located far from the WWTP
	Outfall Consolidation	N	Remote CSO in a congested urban area located far from the WWTP
	Pump Station Modifications	Y	
	Static Flow Control	Y	
	Variable Flow Control	N	Potential may exist in the future to utilize existing sewers for storage; not evaluated in 2013 LTCP
	Real-Time Flow Control	N	
Storage	Open Basins and Tanks	Y	
	Closed Storage Tanks	Y	
	Storage Conduits	N	Remote CSO in a congested urban area located far from the WWTP
	Storage Tunnels	N	Remote CSO in a congested urban area located far from the WWTP
	Existing Tunnels or Conduits (Abandoned)	NA	
Physical/ Chemical Satellite Treatment	Floatables Control (Screening)	Y	
	Swirl Concentrators and Vortex Separators	Y	
	Sedimentation	Y	
	Compressed Media Filtration	Y	
	High Rate Treatment/Ballasted Flocculation	Y	
	Disinfection/Dechlorination	Y	
	Increased Treatment Capacities at Existing Facilities	Y	
	Constructed Treatment Wetlands	N	Insufficient land available nearby

TABLE A-16
Site Specific CSO Technology Screening
CSO 010 (Dress Plaza) - East Basin

Technology Classification	Potential Technologies Considered	Suitable (Y/N)	Comments
Inflow Reduction	Stormwater Management/Green Infrastructure	Y	
	Industrial Pretreatment/Other Source Controls	N	Utility's pretreatment program provides source control to the extent possible
	Partial Sewer Separation	N	
Sewer System Modification	Flow Redirection	N	Opportunities for flow redirection are not available
	Infiltration Reduction	N	Applicable to SSRMP
	Interceptor Sewer Construction	N	
	Relief Sewer Construction	Y	
	Outfall Consolidation	N	
	Pump Station Modifications	NA	
	Static Flow Control	Y	
	Variable Flow Control	N	Potential may exist in the future to utilize existing sewers for storage; not evaluated in 2013 LTCP
	Real-Time Flow Control	N	
Storage	Open Basins and Tanks	N	Not a good choice congested area
	Closed Storage Tanks	Y	
	Storage Conduits	N	
	Storage Tunnels	Y	
	Existing Tunnels or Conduits (Abandoned)	NA	
Physical/ Chemical Satellite Treatment	Floatables Control (Screening)	Y	
	Swirl Concentrators and Vortex Separators	N	Congested public area
	Sedimentation	N	Congested public area
	Compressed Media Filtration	N	Congested public area
	High Rate Treatment/Ballasted Flocculation	N	Congested public area
	Disinfection/Dechlorination	N	Congested public area
	Increased Treatment Capacities at Existing Facilities	Y	
	Constructed Treatment Wetlands	N	Insufficient land available nearby

TABLE A-17
Site Specific CSO Technology Screening
CSO 008 (Chestnut Street) - East Basin

Technology Classification	Potential Technologies Considered	Suitable (Y/N)	Comments
Inflow Reduction	Stormwater Management/Green Infrastructure	Y	
	Industrial Pretreatment/Other Source Controls	N	Utility's pretreatment program provides source control to the extent possible
	Partial Sewer Separation	N	
Sewer System Modification	Flow Redirection	N	Opportunities for flow redirection are not available
	Infiltration Reduction	N	Applicable to SSRMP
	Interceptor Sewer Construction	N	
	Relief Sewer Construction	Y	
	Outfall Consolidation	N	
	Pump Station Modifications	NA	
	Static Flow Control	Y	
	Variable Flow Control	N	Potential may exist in the future to utilize existing sewers for storage; not evaluated in 2013 LTCP
	Real-Time Flow Control	N	
Storage	Open Basins and Tanks	N	Not a good choice congested area
	Closed Storage Tanks	Y	Limited locations available and conveyance will be required
	Storage Conduits	N	
	Storage Tunnels	Y	
	Existing Tunnels or Conduits (Abandoned)	NA	
Physical/ Chemical Satellite Treatment	Floatables Control (Screening)	Y	
	Swirl Concentrators and Vortex Separators	N	Congested public area
	Sedimentation	N	Congested public area
	Compressed Media Filtration	N	Congested public area
	High Rate Treatment/Ballasted Flocculation	N	Congested public area
	Disinfection/Dechlorination	N	Congested public area
	Increased Treatment Capacities at Existing Facilities	Y	
	Constructed Treatment Wetlands	N	Insufficient land available nearby

TABLE A-18
Site Specific CSO Technology Screening
CSO 038 (Oak/Riverside) - East Basin

Technology Classification	Potential Technologies Considered	Suitable (Y/N)	Comments
Inflow Reduction	Stormwater Management/Green Infrastructure	Y	
	Industrial Pretreatment/Other Source Controls	N	Utility's pretreatment program provides source control to the extent possible
	Partial Sewer Separation	N	
Sewer System Modification	Flow Redirection	Y	Opportunities for flow redirection are not available
	Infiltration Reduction	N	Applicable to SSRMP
	Interceptor Sewer Construction	N	
	Relief Sewer Construction	Y	
	Outfall Consolidation	N	
	Pump Station Modifications	NA	
	Static Flow Control	Y	
	Variable Flow Control	N	Potential may exist in the future to utilize existing sewers for storage; not evaluated in 2013 LTCP
	Real-Time Flow Control	N	
Storage	Open Basins and Tanks	N	Not a good choice congested area
	Closed Storage Tanks	Y	Limited locations available and conveyance will be required
	Storage Conduits	N	
	Storage Tunnels	Y	
	Existing Tunnels or Conduits (Abandoned)	NA	
Physical/ Chemical Satellite Treatment	Floatables Control (Screening)	Y	
	Swirl Concentrators and Vortex Separators	N	Congested public area
	Sedimentation	N	Congested public area
	Compressed Media Filtration	N	Congested public area
	High Rate Treatment/Ballasted Flocculation	N	Congested public area
	Disinfection/Dechlorination	N	Congested public area
	Increased Treatment Capacities at Existing Facilities	Y	
	Constructed Treatment Wetlands	N	Insufficient land available nearby

TABLE A-19
Site Specific CSO Technology Screening
CSO 103 (East Plant) - East Basin

Technology Classification	Potential Technologies Considered	Suitable (Y/N)	Comments
Inflow Reduction	Stormwater Management/Green Infrastructure	Y	
	Industrial Pretreatment/Other Source Controls	N	Utility's pretreatment program provides source control to the extent possible
	Partial Sewer Separation	N	
Sewer System Modification	Flow Redirection	N	Opportunities for flow redirection are not available
	Infiltration Reduction	N	Applicable to SSRMP
	Interceptor Sewer Construction	N	
	Relief Sewer Construction	N	
	Outfall Consolidation	Y	Evaluated closing CSO 103 which combines flow with CSO 002
	Pump Station Modifications	NA	
	Static Flow Control	N	
	Variable Flow Control	N	
	Real-Time Flow Control	N	
Storage	Open Basins and Tanks	N	
	Closed Storage Tanks	N	
	Storage Conduits	N	
	Storage Tunnels	N	
	Existing Tunnels or Conduits (Abandoned)	NA	
Physical/ Chemical Satellite Treatment	Floatables Control (Screening)	N	
	Swirl Concentrators and Vortex Separators	N	
	Sedimentation	N	
	Compressed Media Filtration	N	
	High Rate Treatment/Ballasted Flocculation	N	
	Disinfection/Dechlorination	N	
	Increased Treatment Capacities at Existing Facilities	Y	Minimal effect
	Constructed Treatment Wetlands	N	Insufficient land available nearby

TABLE A-20
Site Specific CSO Technology Screening
CSO 004 (Adams) - East Basin

Technology Classification	Potential Technologies Considered	Suitable (Y/N)	Comments
Inflow Reduction	Stormwater Management/Green Infrastructure	Y	
	Industrial Pretreatment/Other Source Controls	N	Utility's pretreatment program provides source control to the extent possible
	Partial Sewer Separation	Y	
Sewer System Modification	Flow Redirection	Y	Opportunities for flow redirection are not available
	Infiltration Reduction	N	Applicable to SSRMP
	Interceptor Sewer Construction	N	
	Relief Sewer Construction	Y	
	Outfall Consolidation	Y	Considered combining with CSO 002 and CSO 001
	Pump Station Modifications	NA	
	Static Flow Control	Y	
	Variable Flow Control	N	Potential may exist in the future to utilize existing sewers for storage; not evaluated in 2013 LTCP
	Real-Time Flow Control	N	
Storage	Open Basins and Tanks	N	Residential area
	Closed Storage Tanks	Y	
	Storage Conduits	N	
	Storage Tunnels	Y	
	Existing Tunnels or Conduits (Abandoned)	NA	
Physical/ Chemical Satellite Treatment	Floatables Control (Screening)	Y	
	Swirl Concentrators and Vortex Separators	Y	Considered after combining with other CSO's
	Sedimentation	Y	Considered after combining with other CSO's
	Compressed Media Filtration	Y	Considered after combining with other CSO's
	High Rate Treatment/Ballasted Flocculation	Y	Considered after combining with other CSO's
	Disinfection/Dechlorination	Y	Considered after combining with other CSO's
	Increased Treatment Capacities at Existing Facilities	Y	
	Constructed Treatment Wetlands	Y	Pumping required

TABLE A-21
Site Specific CSO Technology Screening
CSO 002 (Cass Avenue) - East Basin

Technology Classification	Potential Technologies Considered	Suitable (Y/N)	Comments
Inflow Reduction	Stormwater Management/Green Infrastructure	Y	
	Industrial Pretreatment/Other Source Controls	N	Utility's pretreatment program provides source control to the extent possible
	Partial Sewer Separation	N	
Sewer System Modification	Flow Redirection	N	Opportunities for flow redirection are not available
	Infiltration Reduction	N	Applicable to SSRMP
	Interceptor Sewer Construction	N	
	Relief Sewer Construction	N	
	Outfall Consolidation	Y	Considered combining with CSO 004 and CSO 001
	Pump Station Modifications	NA	
	Static Flow Control	Y	
	Variable Flow Control	N	Potential may exist in the future to utilize existing sewers for storage; not evaluated in 2013 LTCP
	Real-Time Flow Control	N	
Storage	Open Basins and Tanks	N	
	Closed Storage Tanks	Y	Evaluated many different volumes and storage types
	Storage Conduits	N	
	Storage Tunnels	N	Cost prohibitive; outfall is in close proximity to East WWTP and tunnel is not practical
	Existing Tunnels or Conduits (Abandoned)	NA	
Physical/ Chemical Satellite Treatment	Floatables Control (Screening)	Y	
	Swirl Concentrators and Vortex Separators	Y	
	Sedimentation	Y	
	Compressed Media Filtration	Y	
	High Rate Treatment/Ballasted Flocculation	Y	
	Disinfection/Dechlorination	Y	
	Increased Treatment Capacities at Existing Facilities	Y	Minimal effect
	Constructed Treatment Wetlands	Y	Pumping required

TABLE A-22
Site Specific CSO Technology Screening
CSO 001 (Kentucky Avenue) - East Basin

Technology Classification	Potential Technologies Considered	Suitable (Y/N)	Comments
Inflow Reduction	Stormwater Management/Green Infrastructure	Y	
	Industrial Pretreatment/Other Source Controls	N	Utility's pretreatment program provides source control to the extent possible
	Partial Sewer Separation	N	
Sewer System Modification	Flow Redirection	N	Opportunities for flow redirection are not available
	Infiltration Reduction	N	Applicable to SSRMP
	Interceptor Sewer Construction	N	Relief infrastcutre exists to convey flow to the WWTP
	Relief Sewer Construction	N	Relief infrastcutre exists to convey flow to the WWTP
	Outfall Consolidation	Y	
	Pump Station Modifications	NA	
	Static Flow Control	Y	
	Variable Flow Control	N	Potential may exist in the future to utilize existing sewers for storage; not evaluated in 2013 LTCP
	Real-Time Flow Control	N	Potential may exist in the future to utilize existing sewers for storage; not evaluated in 2013 LTCP
Storage	Open Basins and Tanks	N	
	Closed Storage Tanks	Y	
	Storage Conduits	Y	
	Storage Tunnels	N	Cost prohibitive and not practical due to the presence of existing relief infrastructure to route flow to the WWTP
	Existing Tunnels or Conduits (Abandoned)	NA	
Physical/ Chemical Satellite Treatment	Floatables Control (Screening)	N	Outfall discharges in close proximity to the East WWTP
	Swirl Concentrators and Vortex Separators	N	Outfall discharges in close proximity to the East WWTP
	Sedimentation	N	Outfall discharges in close proximity to the East WWTP
	Compressed Media Filtration	N	Outfall discharges in close proximity to the East WWTP
	High Rate Treatment/Ballasted Flocculation	N	Outfall discharges in close proximity to the East WWTP
	Disinfection/Dechlorination	N	Outfall discharges in close proximity to the East WWTP
	Increased Treatment Capacities at Existing Facilities	Y	Minimal effect
	Constructed Treatment Wetlands	Y	Evaluated many differennt wetland scenarios

APPENDIX B

West System Optimization Screening Data

Table B-1

Optimization Model Runs (Scenario ID)/ Alternatives - 1 yr 3 hr design event

Scenario ID	Life Cycle Cost	Percent Reduction	WWTP Upgrade	WWTP Storage	Diamond Ave Storage	Diamond Ave HRT	Storage at School	HRT_7thLS_Treatment	7th St HRT	Force Main to WRP	Pump to Force Main	7th St LS Increase Pumping	CSO 012 Storage	CSO 012 HRT	CSO 012 Siphon	CSO 013 Storage	CSO 013 HRT	Consolidate CSO 014 to CSO 012	Consolidate CSO 016 to 7th St LS	Consolidate CSO 016 to CSO 013	PCI Relief (N/S)	PCI Relief (E/W)	CSO 019 Storage	Separation (CSO 020/022)	Separation (CSO 013/016)	Separation (CSO 017)	Separation (CSO 025)	GSI (Basin 012)	GSI (Basin 020 and 022)
4141	$30,184,300	8.1%	-	-	-	-	9 mgal	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
4142	$53,669,100	14.1%	-	-	-	-	17 mgal	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
4143	$117,828,500	50.7%	-	-	10 mgal	20MGD	12 mgal	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
4144	$96,037,025	48.2%	-	-	5 mgal	10MGD	15 mgal	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
4145	$37,409,812	7.2%	-	-	-	-	-	-	-	-	-	-	-	-	-	4 mgal	5MGD	-	-	-	-	-	-	-	-	-	-	-	-
4146	$42,795,413	7.2%	-	-	-	-	-	-	-	-	-	-	-	-	-	3 mgal	10MGD	-	-	-	-	-	-	-	-	-	-	-	-
4147	$67,912,215	11.5%	-	-	-	-	-	-	-	-	-	-	-	-	-	5 mgal	20MGD	-	-	6' Pipe	-	-	-	-	-	-	-	-	-
4148	$48,184,172	10.7%	-	-	-	-	-	-	-	-	-	-	-	-	-	4 mgal	10MGD	-	-	4' Pipe	-	-	-	-	-	-	-	-	-
4149	$39,586,545	5.0%	-	-	-	-	-	-	-	-	-	-	4 mgal	5 MGD	5' Pipe	-	-	-	-	-	-	-	-	-	-	-	-	-	-
4150	$41,348,329	5.0%	-	-	-	-	-	-	-	-	-	-	4 mgal	5 MGD	12' Pipe	-	-	-	-	-	-	-	-	-	-	-	-	-	-
4152	$41,850,473	4.6%	-	-	-	-	-	3 mgal	5MGD	-	-	-	-	-	-	-	-	-	4' Pipe	-	-	-	-	-	-	-	-	-	-
4153	$43,195,252	4.8%	-	-	-	-	-	3 mgal	5MGD	-	-	-	-	-	-	-	-	-	6' Pipe	-	-	-	-	-	-	-	-	-	-
4154	$99,650,025	46.8%	-	-	15 mgal	10MGD	6 mgal	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
4155	$159,014,400	53.2%	-	-	20 mgal	20MGD	15 mgal	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
4156	$184,749,525	52.9%	-	-	35 mgal	30MGD	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
4157	$101,908,225	49.2%	-	-	5 mgal	10MGD	17 mgal	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
4158	$39,586,545	5.0%	-	-	-	-	-	-	-	-	-	-	4 mgal	5 MGD	5' Pipe	-	-	-	-	-	-	-	-	-	-	-	-	-	-
4159	$41,348,329	5.0%	-	-	-	-	-	-	-	-	-	-	4 mgal	5 MGD	12' Pipe	-	-	-	-	-	-	-	-	-	-	-	-	-	-
4160	$38,649,930	4.9%	-	-	-	-	-	-	-	-	-	-	3 mgal	5 MGD	12' Pipe	-	-	-	-	-	-	-	-	-	-	-	-	-	-
4161	$49,660,612	4.8%	-	-	-	-	-	-	-	-	-	-	4 mgal	5 MGD	-	-	-	6' Pipe	-	-	-	-	-	-	-	-	-	-	-
4162	$46,813,012	4.2%	-	-	-	-	-	-	-	-	-	-	4 mgal	5 MGD	-	-	-	4' Pipe	-	-	-	-	-	-	-	-	-	-	-
4163	$59,569,895	9.7%	-	-	-	-	-	-	-	-	-	-	7 mgal	5 MGD	8' Pipe	-	-	5' Pipe	-	-	-	-	-	-	-	-	-	-	-
4164	$56,730,754	9.4%	-	-	-	-	-	-	-	-	-	-	6 mgal	5 MGD	8' Pipe	-	-	5' Pipe	-	-	-	-	-	-	-	-	-	-	-
4165	$51,735,058	8.1%	-	-	-	-	-	-	-	-	-	-	5 mgal	5 MGD	5' Pipe	-	-	4' Pipe	-	-	-	-	-	-	-	-	-	-	-
4234	$254,592,628	14.8%	80 MGD	-	-	-	-	-	-	36" FM	30MGD	-	-	-	-	-	-	-	-	-	7' Pipe	7' Pipe	-	-	-	-	-	-	-
4236	$313,857,375	20.7%	80 MGD	16 mgal	-	-	-	-	-	36" FM	30MGD	-	-	-	-	-	-	-	-	-	7' Pipe	7' Pipe	-	-	-	-	-	-	-
4238	$469,551,356	60.1%	80 MGD	16 mgal	5 mgal	10MGD	15 mgal	3 mgal	10MGD	36" FM	30MGD	-	-	-	-	-	-	-	-	-	7' Pipe	7' Pipe	-	-	-	-	-	-	-
4239	$78,758,141	12.0%	-	-	-	-	-	-	-	-	-	-	4 mgal	5 MGD	12' Pipe	4 mgal	5MGD	-	-	-	-	-	-	-	-	-	-	-	-
4240	$413,242,997	40.8%	80 MGD	16 mgal	-	-	-	-	-	36" FM	30MGD	-	7 mgal	5 MGD	12' Pipe	4 mgal	5MGD	6' Pipe	-	-	7' Pipe	7' Pipe	-	-	-	-	-	-	-
4241	$172,650,428	55.4%	-	-	10 mgal	20MGD	17 mgal	2 mgal	10MGD	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
4242	$156,667,212	43.8%	-	-	10 mgal	30MGD	-	3 mgal	20MGD	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
4243	$171,010,753	55.5%	-	-	25 mgal	20MGD	-	2 mgal	10MGD	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
4244	$352,495,079	75.4%	-	16 mgal	20 mgal	30MGD	-	5 mgal	20MGD	-	-	-	4 mgal	5 MGD	12' Pipe	4 mgal	5MGD	-	-	-	-	-	-	-	-	-	-	-	-
4245	$122,692,470	10.8%	-	16 mgal	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	Higher	Higher
4246	$545,427,303	76.9%	80 MGD	16 mgal	25 mgal	70MGD	-	-	-	36" FM	30MGD	-	4 mgal	5 MGD	12' Pipe	4 mgal	5MGD	-	-	-	-	-	-	-	-	-	-	-	-	-
4247	$775,400,748	82.0%	80 MGD	16 mgal	25 mgal	50MGD	-	6 mgal	40MGD	36" FM	30MGD	20MGD	4 mgal	5 MGD	12' Pipe	4 mgal	5MGD	-	-	-	6' Pipe	6' Pipe	-	-	-	-	-	Higher	Higher
4248	$27,641,517	4.8%	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	Yes	Yes	Yes	Yes	-	-
4251	$29,074,332	4.3%	-	-	-	-	-	-	-	30" FM	20MGD	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
4252	$42,691,074	6.0%	-	-	-	-	-	-	-	36" FM	30MGD	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
4253	$56,150,212	7.6%	-	-	-	-	-	-	-	42" FM	40MGD	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
4254	$57,851,712	7.6%	-	-	-	-	-	-	-	42" FM	40MGD	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
4259	$215,025,728	5.6%	80 MGD	20 mgal	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
4260	$164,934,507	9.5%	60 MGD	20 mgal	-	-	-	-	-	30" FM	20MGD	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
4261	$48,239,125	25.3%	-	-	5 mgal	10MGD	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
4262	$78,837,400	34.1%	-	-	10 mgal	20MGD	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
4263	$110,608,525	42.6%	-	-	15 mgal	30MGD	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
4264	$143,552,500	50.4%	-	-	20 mgal	40MGD	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
4265	$95,048,500	44.9%	-	-	20 mgal	10MGD	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
4266	$192,056,500	51.9%	-	-	20 mgal	70MGD	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
4267	$12,570,700	2.5%	-	-	-	-	3 mgal	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
4268	$21,377,500	5.4%	-	-	-	-	6 mgal	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
4269	$30,184,300	8.1%	-	-	-	-	9 mgal	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
4270	$38,991,100	10.3%	-	-	-	-	12 mgal	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
4271	$47,797,900	12.5%	-	-	-	-	15 mgal	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
4272	$53,669,100	14.1%	-	-	-	-	17 mgal	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
4273	$32,059,928	2.5%	-	-	-	-	-	2 mgal	5MGD	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
4274	$45,493,812	5.4%	-	-	-	-	-	3 mgal	10MGD	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
4275	$67,199,352	9.1%	-	-	-	-	-	4 mgal	20MGD	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
4276	$17,745,812	2.9%	-	-	-	-	-	3 mgal	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
4277	$23,283,352	4.6%	-	-	-	-	-	4 mgal	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
4278	$40,143,928	3.7%	-	-	-	-	-	2 mgal	10MGD	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
4279	$45,617,500	4.5%	-	-	-	-	-	-	20MGD	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
4280	$33,761,428	2.5%	-	-	-	-	-	2 mgal	5MGD	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
4287	$35,998,445	4.8%	-	-	-	-	-	-	-	-	-	-	2 mgal	5 MGD	12' Pipe	-	-	-	-	-	-	-	-	-	-	-	-	-	-
4288	$41,348,329	5.0%	-	-	-	-	-	-	-	-	-	-	4 mgal	5 MGD	12' Pipe	-	-	-	-	-	-	-	-	-	-	-	-	-	-
4289	$51,953,929	7.6%	-	-	-	-	-	-	-	-	-	-	4 mgal	5 MGD	12' Pipe	-	-	5' Pipe	-	-	-	-	-	-	-	-	-	-	-
4290	$53,599,129	7.4%	-	-	-	-	-	-	-	-	-	-	4 mgal	5 MGD	12' Pipe	-	-	6' Pipe	-	-	-	-	-	-	-	-	-	-	-
4291	$60,330,610	9.8%	-	-	-	-	-	-	-	-	-	-	7 mgal	5 MGD	12' Pipe	-	-	5' Pipe	-	-	-	-	-	-	-	-	-	-	-
4292	$61,975,810	9.8%	-	-	-	-	-	-	-	-	-	-	7 mgal	5 MGD	12' Pipe	-	-	6' Pipe	-	-	-	-	-	-	-	-	-	-	-
4293	$32,059,928	7.0%	-	-	-	-	-	-	-	-	-	-	-	-	-	2 mgal	5MGD	-	-	-	-	-	-	-	-	-	-	-	-
4294	$37,409,812	7.2%	-	-	-	-	-	-	-	-	-	-	-	-	-	4 mgal	5MGD	-	-	-	-	-	-	-	-	-	-	-	-
4295	$40,155,125	7.2%	-	-	-	-	-	-	-	-	-	-	-	-	-	5 mgal	5MGD	-	-	-	-	-	-	-	-	-	-	-	-
4296	$34,711,413	7.2%	-	-	-	-	-	-	-	-	-	-	-	-	-	3 mgal	5MGD	-	-	-	-	-	-	-	-	-	-	-	-
4297	$32,059,928	7.0%	-	-	-	-	-	-	-	-	-	-	-	-	-	2 mgal	5MGD	-	-	-	-	-	-	-	-	-	-	-	-
4298	$42,845,485	10.6%	-	-	-	-	-	-	-	-	-	-	-	-	-	5 mgal	5MGD	-	-	4' Pipe	-	-	-	-	-	-	-	-	-
4299	$43,189,505	10.6%	-	-	-	-	-	-	-	-	-	-	-	-	-	5 mgal	5MGD	-	-	5' Pipe	-	-	-	-	-	-	-	-	-
4300	$48,820,873	11.5%	-	-	-	-	-	-	-	-	-	-	-	-	-	7 mgal	5MGD	-	-	5' Pipe	-	-	-	-	-	-	-	-	-
4301	$51,273,505	11.5%	-	-	-	-	-	-	-	-	-	-	-	-	-	5 mgal	10MGD	-	-	5' Pipe	-	-	-	-	-	-	-	-	-
4302	$45,981,732	11.5%	-	-	-	-	-	-	-	-	-	-	-	-	-	6 mgal	5MGD	-	-	5' Pipe	-	-	-	-	-	-	-	-	-

Table B-1

Optimization Model Runs (Scenario ID)/ Alternatives - 1 yr 3 hr design event

Scenario ID	Life Cycle Cost	Percent Reduction	WWTP Upgrade	WWTP Storage	Diamond Ave Storage	Diamond Ave HRT	Storage at School	HRT_7thLS_Treatment	7th St HRT	Force Main to WRP	Pump to Force Main	7th St LS Increase Pumping	CSO 012 Storage	CSO 012 HRT	CSO 012 Siphon	CSO 013 Storage	CSO 013 HRT	Consolidate CSO 014 to CSO 012	Consolidate CSO 016 to 7th St LS	Consolidate CSO 016 to CSO 013	PCI Relief (N/S)	PCI Relief (E/W)	CSO 019 Storage	Separation (CSO 020/022)	Separation (CSO 013/016)	Separation (CSO 017)	Separation (CSO 025)	GSI (Basin 012)	GSI (Basin 020 and 022)
4303	$135,221,155	9.9%	-	8 mgal	-	-	-	-	-	-	-	-	2 mgal	5 MGD	-	2 mgal	5MGD	-	-	-	-	-	-	-	-	-	-	-	-
4304	$146,546,014	15.0%	-	16 mgal	-	-	-	-	-	-	-	-	4 mgal	5 MGD	-	4 mgal	5MGD	-	-	-	-	-	-	-	-	-	-	-	-
4305	$146,546,014	15.0%	-	16 mgal	-	-	-	-	-	-	-	-	4 mgal	5 MGD	-	4 mgal	5MGD	-	-	-	-	-	-	-	-	-	-	-	-
4306	$371,235,249	69.5%	-	12 mgal	20 mgal	40MGD	-	5 mgal	30MGD	-	-	-	3 mgal	5 MGD	-	3 mgal	5MGD	-	-	-	-	-	-	-	-	-	-	-	-
4307	$27,641,517	4.8%	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	Yes	Yes	Yes	Yes	-	-
4308	$63,427,723	5.7%	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	Higher	Higher
4320	$25,244,018	2.2%	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	Medium	Medium
4321	$87,485,214	9.8%	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	Yes	Yes	Yes	Higher	Higher
4322	$149,254,117	22.0%	-	-	-	-	-	5 mgal	30MGD	-	-	-	-	-	-	-	-	-	-	-	6' Pipe	6' Pipe	-	-	-	-	-	-	-
4323	$115,148,993	14.2%	-	-	-	-	-	3 mgal	10MGD	-	-	-	-	-	-	-	-	-	-	-	7' Pipe	7' Pipe	-	-	-	-	-	-	-
4324	$91,671,308	12.7%	-	-	-	-	-	3 mgal	10MGD	-	-	-	-	-	-	-	-	-	-	-	4' Pipe	4' Pipe	-	-	-	-	-	-	-
4325	$258,558,154	17.4%	80 MGD	-	-	-	-	-	-	42" FM	40MGD	-	-	-	-	-	-	-	-	-	6' Pipe	6' Pipe	-	-	-	-	-	-	-
4326	$305,058,917	19.2%	80 MGD	12 mgal	-	-	-	-	-	42" FM	40MGD	-	-	-	-	-	-	-	-	-	6' Pipe	6' Pipe	-	-	-	-	-	-	-
4327	$76,350,910	2.3%	60 MGD	-	-	-	-	-	-	-	-	30MGD	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
4328	$63,080,820	0.1%	60 MGD	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
4329	$142,246,373	0.4%	80 MGD	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
4833	$308,220,770	69.7%	-	-	30 mgal	30MGD	9 mgal	4 mgal	-	-	-	-	3 mgal	5 MGD	8' Pipe	4 mgal	-	5' Pipe	-	-	-	-	-	-	Yes	Yes	Yes	-	-
4834	$275,961,780	64.2%	-	-	5 mgal	20MGD	15 mgal	4 mgal	20MGD	-	-	-	6 mgal	5 MGD	5' Pipe	-	10MGD	6' Pipe	-	4' Pipe	-	-	-	-	Yes	-	-	-	-
4835	$275,630,002	55.9%	-	-	5 mgal	40MGD	3 mgal	4 mgal	30MGD	-	-	-	2 mgal	5 MGD	12' Pipe	-	20MGD	-	-	5' Pipe	-	-	-	-	-	-	-	-	-
4836	$238,084,503	49.6%	-	-	10 mgal	10MGD	3 mgal	2 mgal	10MGD	-	-	-	-	-	5' Pipe	5 mgal	30MGD	5' Pipe	-	-	-	-	-	Yes	Yes	Yes	Yes	-	-
4837	$329,635,307	71.7%	-	-	35 mgal	40MGD	-	3 mgal	20MGD	-	-	-	5 mgal	5 MGD	5' Pipe	2 mgal	-	-	-	-	-	-	-	Yes	Yes	-	-	-	-
4838	$253,800,188	66.8%	-	-	15 mgal	10MGD	12 mgal	4 mgal	-	-	-	-	3 mgal	5 MGD	-	4 mgal	20MGD	5' Pipe	-	4' Pipe	-	-	-	Yes	-	-	-	-	-
4839	$260,142,438	59.0%	-	-	10 mgal	10MGD	15 mgal	2 mgal	10MGD	-	-	-	6 mgal	5 MGD	5' Pipe	5 mgal	20MGD	-	-	-	-	-	-	-	-	-	-	-	-
4840	$299,488,358	65.7%	-	-	5 mgal	40MGD	17 mgal	2 mgal	10MGD	-	-	-	4 mgal	5 MGD	12' Pipe	1 mgal	10MGD	4' Pipe	-	4' Pipe	-	-	-	-	-	-	Yes	-	-
4841	$265,113,516	65.8%	-	-	20 mgal	10MGD	3 mgal	4 mgal	10MGD	-	-	-	-	-	12' Pipe	2 mgal	30MGD	4' Pipe	-	4' Pipe	-	-	-	-	-	-	Yes	-	-
4842	$207,476,667	33.0%	-	-	-	20MGD	3 mgal	5 mgal	-	-	-	-	4 mgal	5 MGD	8' Pipe	5 mgal	20MGD	6' Pipe	-	5' Pipe	-	-	-	-	-	-	-	-	-
4843	$423,355,308	72.6%	-	-	30 mgal	30MGD	15 mgal	4 mgal	20MGD	-	-	-	5 mgal	5 MGD	-	2 mgal	30MGD	-	-	4' Pipe	-	-	-	Yes	Yes	-	Yes	-	-
4844	$129,924,457	23.5%	-	-	-	10MGD	-	2 mgal	-	-	-	-	7 mgal	5 MGD	5' Pipe	-	-	6' Pipe	-	4' Pipe	-	-	-	Yes	Yes	-	Yes	-	-
4845	$309,491,009	69.4%	-	-	20 mgal	10MGD	9 mgal	5 mgal	30MGD	-	-	-	7 mgal	5 MGD	12' Pipe	5 mgal	5MGD	-	-	-	-	-	-	Yes	-	-	-	-	-
4846	$338,417,708	74.3%	-	-	35 mgal	10MGD	15 mgal	3 mgal	30MGD	-	-	-	1 mgal	5 MGD	-	2 mgal	-	6' Pipe	-	4' Pipe	-	-	-	Yes	-	-	-	-	-
4847	$362,047,277	75.3%	-	-	20 mgal	30MGD	12 mgal	2 mgal	10MGD	-	-	-	3 mgal	5 MGD	12' Pipe	4 mgal	30MGD	6' Pipe	-	6' Pipe	-	-	-	-	Yes	-	Yes	-	-
4848	$357,681,126	68.6%	-	-	35 mgal	40MGD	15 mgal	-	-	-	-	-	3 mgal	5 MGD	12' Pipe	4 mgal	5MGD	5' Pipe	-	-	-	-	-	Yes	-	Yes	Yes	-	-
4849	$334,209,622	71.1%	-	-	25 mgal	10MGD	9 mgal	2 mgal	30MGD	-	-	-	6 mgal	5 MGD	-	6 mgal	10MGD	-	-	5' Pipe	-	-	-	Yes	-	-	Yes	-	-
4850	$135,917,655	23.2%	-	-	-	-	9 mgal	-	5MGD	-	-	-	1 mgal	5 MGD	5' Pipe	6 mgal	-	4' Pipe	-	5' Pipe	-	-	-	-	-	Yes	Yes	-	-
4851	$292,200,382	63.0%	-	-	5 mgal	40MGD	15 mgal	4 mgal	-	-	-	-	4 mgal	5 MGD	12' Pipe	2 mgal	30MGD	-	-	6' Pipe	-	-	-	-	Yes	-	-	-	-
4852	$283,861,535	61.2%	-	-	10 mgal	30MGD	12 mgal	3 mgal	10MGD	-	-	-	3 mgal	5 MGD	5' Pipe	-	10MGD	4' Pipe	-	4' Pipe	-	-	-	Yes	Yes	Yes	Yes	-	-
4853	$268,795,833	66.9%	-	-	25 mgal	30MGD	12 mgal	4 mgal	-	-	-	-	-	-	12' Pipe	-	5MGD	6' Pipe	-	5' Pipe	-	-	-	Yes	-	Yes	Yes	-	-
4854	$209,665,190	67.0%	-	-	35 mgal	-	-	3 mgal	10MGD	-	-	-	-	-	12' Pipe	3 mgal	-	-	-	6' Pipe	-	-	-	-	-	Yes	Yes	-	-
4855	$374,323,504	78.2%	-	-	30 mgal	20MGD	12 mgal	5 mgal	-	-	-	-	6 mgal	5 MGD	5' Pipe	6 mgal	30MGD	5' Pipe	-	4' Pipe	-	-	-	-	-	-	Yes	-	-
4856	$246,945,844	68.0%	-	-	5 mgal	-	12 mgal	4 mgal	20MGD	-	-	-	7 mgal	5 MGD	12' Pipe	4 mgal	5MGD	5' Pipe	-	4' Pipe	-	-	-	Yes	-	-	Yes	-	-
4857	$311,771,896	68.0%	-	-	20 mgal	30MGD	12 mgal	2 mgal	10MGD	-	-	-	6 mgal	5 MGD	-	1 mgal	5MGD	6' Pipe	-	-	-	-	-	Yes	-	Yes	Yes	-	-
4858	$296,565,040	69.3%	-	-	5 mgal	20MGD	12 mgal	5 mgal	20MGD	-	-	-	5 mgal	5 MGD	12' Pipe	4 mgal	10MGD	5' Pipe	-	5' Pipe	-	-	-	-	-	Yes	Yes	-	-
4859	$145,015,341	48.8%	-	-	5 mgal	-	3 mgal	3 mgal	5MGD	-	-	-	2 mgal	5 MGD	-	1 mgal	-	4' Pipe	-	4' Pipe	-	-	-	Yes	-	Yes	Yes	-	-
4860	$192,894,734	49.0%	-	-	5 mgal	-	3 mgal	2 mgal	20MGD	-	-	-	2 mgal	5 MGD	8' Pipe	7 mgal	5MGD	4' Pipe	-	-	-	-	-	Yes	Yes	Yes	-	-	-
4861	$279,105,198	68.4%	-	-	25 mgal	10MGD	3 mgal	3 mgal	5MGD	-	-	-	4 mgal	5 MGD	8' Pipe	7 mgal	20MGD	-	-	5' Pipe	-	-	-	-	-	Yes	-	-	-
4862	$296,287,759	56.8%	-	-	15 mgal	40MGD	3 mgal	3 mgal	10MGD	-	-	-	3 mgal	5 MGD	-	5 mgal	20MGD	-	-	-	-	-	-	Yes	Yes	-	-	-	-
4863	$339,071,897	76.7%	-	-	30 mgal	-	6 mgal	4 mgal	30MGD	-	-	-	4 mgal	5 MGD	-	6 mgal	10MGD	6' Pipe	-	6' Pipe	-	-	-	-	Yes	Yes	Yes	-	-
4864	$153,473,365	57.6%	-	-	20 mgal	-	3 mgal	4 mgal	-	-	-	-	-	-	-	-	5MGD	5' Pipe	-	5' Pipe	-	-	-	-	-	Yes	Yes	-	-
4865	$234,432,497	56.3%	-	-	5 mgal	20MGD	3 mgal	3 mgal	5MGD	-	-	-	6 mgal	5 MGD	8' Pipe	7 mgal	10MGD	-	-	5' Pipe	-	-	-	-	-	Yes	Yes	-	-
4866	$250,576,904	69.4%	-	-	25 mgal	30MGD	6 mgal	5 mgal	-	-	-	-	-	-	-	5 mgal	10MGD	-	-	5' Pipe	-	-	-	Yes	-	-	-	-	-
4867	$265,452,391	64.1%	-	-	25 mgal	30MGD	3 mgal	-	5MGD	-	-	-	4 mgal	5 MGD	8' Pipe	6 mgal	5MGD	-	-	-	-	-	-	Yes	-	Yes	-	-	-
4868	$380,923,714	71.4%	-	-	35 mgal	10MGD	12 mgal	5 mgal	20MGD	-	-	-	2 mgal	5 MGD	-	3 mgal	30MGD	4' Pipe	-	-	-	-	-	-	-	-	-	-	-
4869	$274,852,313	61.4%	-	-	20 mgal	30MGD	-	4 mgal	5MGD	-	-	-	2 mgal	5 MGD	5' Pipe	1 mgal	5MGD	6' Pipe	-	-	-	-	-	Yes	Yes	-	Yes	-	-
4870	$218,720,255	66.8%	-	-	30 mgal	-	6 mgal	2 mgal	5MGD	-	-	-	3 mgal	5 MGD	8' Pipe	2 mgal	-	-	-	-	-	-	-	Yes	Yes	-	-	-	-
4871	$198,149,221	34.1%	-	-	-	-	17 mgal	2 mgal	5MGD	-	-	-	5 mgal	5 MGD	12' Pipe	3 mgal	10MGD	4' Pipe	-	5' Pipe	-	-	-	Yes	Yes	Yes	-	-	-
4872	$261,908,451	69.9%	-	-	30 mgal	10MGD	-	-	-	-	-	-	4 mgal	5 MGD	8' Pipe	5 mgal	20MGD	6' Pipe	-	5' Pipe	-	-	-	-	Yes	Yes	-	-	-
4873	$184,939,047	59.3%	-	-	20 mgal	-	6 mgal	-	5MGD	-	-	-	7 mgal	5 MGD	8' Pipe	6 mgal	-	-	-	-	-	-	-	Yes	-	Yes	-	-	-
4874	$338,505,686	74.3%	-	-	20 mgal	10MGD	9 mgal	4 mgal	20MGD	-	-	-	5 mgal	5 MGD	5' Pipe	4 mgal	30MGD	6' Pipe	-	5' Pipe	-	-	-	Yes	Yes	-	-	-	-
4875	$296,259,483	47.4%	-	-	-	30MGD	9 mgal	4 mgal	30MGD	-	-	-	6 mgal	5 MGD	8' Pipe	2 mgal	10MGD	6' Pipe	-	6' Pipe	-	-	-	Yes	-	Yes	Yes	-	-
4876	$278,670,855	56.9%	-	-	15 mgal	20MGD	-	-	20MGD	-	-	-	3 mgal	5 MGD	5' Pipe	6 mgal	30MGD	6' Pipe	-	-	-	-	-	-	Yes	Yes	-	-	-
4877	$279,808,504	66.6%	-	-	10 mgal	30MGD	17 mgal	2 mgal	30MGD	-	-	-	-	-	12' Pipe	5 mgal	5MGD	4' Pipe	-	4' Pipe	-	-	-	-	-	Yes	-	-	-
4878	$160,832,631	20.7%	-	-	-	20MGD	6 mgal	3 mgal	5MGD	-	-	-	2 mgal	5 MGD	12' Pipe	-	5MGD	-	-	-	-	-	-	-	-	Yes	-	-	-
4879	$287,365,215	61.8%	-	-	20 mgal	10MGD	-	2 mgal	10MGD	-	-	-	2 mgal	5 MGD	12' Pipe	5 mgal	30MGD	5' Pipe	-	-	-	-	-	-	Yes	-	Yes	-	-
4880	$253,843,705	64.6%	-	-	15 mgal	20MGD	6 mgal	4 mgal	10MGD	-	-	-	5 mgal	5 MGD	-	2 mgal	-	4' Pipe	-	6' Pipe	-	-	-	Yes	-	-	Yes	-	-
4881	$223,626,371	54.3%	-	-	10 mgal	10MGD	6 mgal	2 mgal	5MGD	-	-	-	7 mgal	5 MGD	5' Pipe	-	5MGD	6' Pipe	-	-	-	-	-	Yes	Yes	Yes	Yes	-	-
4882	$325,472,602	73.2%	-	-	20 mgal	20MGD	6 mgal	4 mgal	5MGD	-	-	-	5 mgal	5 MGD	8' Pipe	6 mgal	20MGD	5' Pipe	-	5' Pipe	-	-	-	-	Yes	Yes	Yes	-	-
4883	$328,223,791	74.3%	-	-	30 mgal	10MGD	3 mgal	3 mgal	5MGD	-	-	-	3 mgal	5 MGD	8' Pipe	7 mgal	20MGD	4' Pipe	-	5' Pipe	-	-	-	-	Yes	Yes	Yes	-	-
4884	$352,455,068	75.5%	-	-	25 mgal	30MGD	12 mgal	4 mgal	5MGD	-	-	-	3 mgal	5 MGD	8' Pipe	5 mgal	10MGD	5' Pipe	-	4' Pipe	-	-	-	-	Yes	Yes	Yes	-	-
4885	$297,197,842	53.1%	-	-	-	40MGD	17 mgal	4 mgal	20MGD	-	-	-	5 mgal	5 MGD	8' Pipe	4 mgal	-	6' Pipe	-	4' Pipe	-	-	-	-	Yes	Yes	Yes	-	-
4886	$309,828,549	74.8%	-	-	20 mgal	20MGD	9 mgal	3 mgal	10MGD	-	-	-	4 mgal	5 MGD	8' Pipe	6 mgal	5MGD	5' Pipe	-	5' Pipe	-	-	-	-	Yes	Yes	Yes	-	-
4887	$290,696,067	72.5%	-	-	20 mgal	20MGD	9 mgal	2 mgal	5MGD	-	-	-	4 mgal	5 MGD	8' Pipe	4 mgal	10MGD	4' Pipe	-	5' Pipe	-	-	-	-	-	Yes	Yes	-	-
4888	$329,276,513	73.7%	-	-	25 mgal	30MGD	6 mgal	4 mgal	5MGD	-	-	-	3 mgal	5 MGD	5' Pipe	3 mgal	10MGD	6' Pipe	-	4' Pipe	-	-	-	-	Yes	-	Yes	-	-
4889	$275,941,969	61.1%	-	-	15 mgal	30MGD	3 mgal	4 mgal	5MGD	-	-	-	2 mgal	5 MGD	5' Pipe	2 mgal	5MGD	6' Pipe	-	4' Pipe	-	-	-	Yes	Yes	-	Yes	-	-
4890	$261,590,116	60.0%	-	-	10 mgal	30MGD	3 mgal	4 mgal	5MGD	-	-	-	1 mgal	5 MGD	8' Pipe	2 mgal	10MGD	5' Pipe	-	4' Pipe	-	-	-	-	Yes	-	Yes	-	-
4891	$285,207,625	64.4%	-	-	5 mgal	30MGD	9 mgal	4 mgal	10MGD	-	-	-	5 mgal	5 MGD	5' Pipe	3 mgal	10MGD	5' Pipe	-	4' Pipe	-	-	-	-	Yes	-	Yes	-	-
4892	$294,979,314	73.9%	-	-	20 mgal	20MGD	9 mgal	4 mgal	10MGD	-	-	-	5 mgal	5 MGD	5' Pipe	4 mgal	5MGD	5' Pipe	-	4' Pipe	-	-	-	-	Yes	Yes	-	-	-
4893	$288,927,391	38.6%	-	-	-	20MGD	15 mgal	2 mgal	20MGD	-	-	-	6 mgal	5 MGD	-	5 mgal	30MGD	4' Pipe	-	4' Pipe	-	-	-	Yes	-	-	-	-	-
4894	$327,156,612	75.8%	-	-	15 mgal	20MGD	15 mgal	2 mgal	30MGD	-	-	-	3 mgal	5 MGD	8' Pipe	5 mgal	5MGD	4' Pipe	-	4' Pipe	-	-	-	Yes	-	Yes	Yes	-	-
4895	$341,564,455	74.5%	-	-	30 mgal	20MGD	9 mgal	4 mgal	10MGD	-	-	-	3 mgal	5 MGD	-	3 mgal	5MGD	5' Pipe	-	4' Pipe	-	-	-	Yes	Yes	Yes	Yes	-	-

Table B-1

Optimization Model Runs (Scenario ID)/ Alternatives - 1 yr 3 hr design event

Scenario ID	Life Cycle Cost	Percent Reduction	WWTP Upgrade	WWTP Storage	Diamond Ave Storage	Diamond Ave HRT	Storage at School	HRT_7thLS_Treatment	7th St HRT	Force Main to WRP	Pump to Force Main	7th St LS Increase Pumping	CSO 012 Storage	CSO 012 HRT	CSO 012 Siphon	CSO 013 Storage	CSO 013 HRT	Consolidate CSO 014 to CSO 012	Consolidate CSO 016 to 7th St LS	Consolidate CSO 016 to CSO 013	PCI Relief (N/S)	PCI Relief (E/W)	CSO 019 Storage	Separation (CSO 020/022)	Separation (CSO 013/016)	Separation (CSO 017)	Separation (CSO 025)	GSI (Basin 012)	GSI (Basin 020 and 022)
4896	$292,271,663	68.4%	-	-	15 mgal	10MGD	6 mgal	3 mgal	30MGD	-	-	-	2 mgal	5 MGD	8' Pipe	5 mgal	5MGD	5' Pipe	-	5' Pipe	-	-	-	-	Yes	Yes	Yes	-	-
4897	$350,355,965	75.4%	-	-	30 mgal	20MGD	12 mgal	4 mgal	10MGD	-	-	-	2 mgal	5 MGD	8' Pipe	4 mgal	5MGD	5' Pipe	-	5' Pipe	-	-	-	-	Yes	Yes	Yes	-	-
4898	$372,667,780	70.1%	-	-	30 mgal	20MGD	17 mgal	-	30MGD	-	-	-	1 mgal	5 MGD	5' Pipe	3 mgal	5MGD	6' Pipe	-	4' Pipe	-	-	-	Yes	Yes	Yes	Yes	-	-
4899	$337,043,573	73.6%	-	-	15 mgal	30MGD	17 mgal	-	30MGD	-	-	-	1 mgal	5 MGD	8' Pipe	4 mgal	5MGD	5' Pipe	-	4' Pipe	-	-	-	Yes	Yes	Yes	Yes	-	-
4900	$319,284,069	71.5%	-	-	15 mgal	30MGD	9 mgal	3 mgal	20MGD	-	-	-	2 mgal	5 MGD	8' Pipe	5 mgal	5MGD	4' Pipe	-	4' Pipe	-	-	-	Yes	Yes	Yes	Yes	-	-
4901	$272,638,520	66.1%	-	-	25 mgal	10MGD	3 mgal	4 mgal	5MGD	-	-	-	-	-	5' Pipe	3 mgal	20MGD	5' Pipe	-	5' Pipe	-	-	-	Yes	Yes	Yes	Yes	-	-
4902	$219,094,235	57.7%	-	-	15 mgal	10MGD	3 mgal	4 mgal	5MGD	-	-	-	-	-	5' Pipe	2 mgal	10MGD	5' Pipe	-	5' Pipe	-	-	-	Yes	Yes	Yes	Yes	-	-
4903	$225,181,639	59.1%	-	-	20 mgal	10MGD	3 mgal	4 mgal	5MGD	-	-	-	-	-	5' Pipe	1 mgal	5MGD	5' Pipe	-	5' Pipe	-	-	-	Yes	Yes	Yes	Yes	-	-
4904	$246,624,352	68.9%	-	-	20 mgal	-	9 mgal	3 mgal	5MGD	-	-	-	3 mgal	5 MGD	8' Pipe	2 mgal	5MGD	4' Pipe	-	5' Pipe	-	-	-	Yes	Yes	Yes	Yes	-	-
4905	$218,604,054	59.0%	-	-	20 mgal	20MGD	-	2 mgal	10MGD	-	-	-	6 mgal	5 MGD	5' Pipe	1 mgal	-	-	-	-	-	-	-	Yes	Yes	-	-	-	-
4906	$236,461,272	56.7%	-	-	5 mgal	30MGD	9 mgal	3 mgal	-	-	-	-	4 mgal	5 MGD	8' Pipe	1 mgal	20MGD	-	-	5' Pipe	-	-	-	Yes	Yes	-	-	-	-
4907	$219,180,268	58.4%	-	-	5 mgal	10MGD	3 mgal	2 mgal	5MGD	-	-	-	7 mgal	5 MGD	5' Pipe	4 mgal	5MGD	5' Pipe	-	4' Pipe	-	-	-	Yes	Yes	Yes	Yes	-	-
4908	$219,813,698	55.5%	-	-	5 mgal	20MGD	6 mgal	2 mgal	-	-	-	-	6 mgal	5 MGD	5' Pipe	1 mgal	10MGD	4' Pipe	-	4' Pipe	-	-	-	Yes	Yes	-	Yes	-	-
4909	$302,474,257	74.6%	-	-	20 mgal	30MGD	9 mgal	4 mgal	-	-	-	-	3 mgal	5 MGD	8' Pipe	3 mgal	10MGD	5' Pipe	-	4' Pipe	-	-	-	Yes	Yes	Yes	Yes	-	-
4910	$306,421,333	76.0%	-	-	30 mgal	20MGD	-	3 mgal	20MGD	-	-	-	2 mgal	5 MGD	12' Pipe	4 mgal	5MGD	4' Pipe	-	5' Pipe	-	-	-	Yes	Yes	-	-	-	-
4911	$276,685,844	68.1%	-	-	10 mgal	20MGD	6 mgal	4 mgal	20MGD	-	-	-	4 mgal	5 MGD	8' Pipe	3 mgal	5MGD	4' Pipe	-	5' Pipe	-	-	-	Yes	-	-	Yes	-	-
4912	$283,021,760	69.1%	-	-	15 mgal	20MGD	6 mgal	4 mgal	10MGD	-	-	-	5 mgal	5 MGD	5' Pipe	2 mgal	5MGD	4' Pipe	-	5' Pipe	-	-	-	Yes	Yes	Yes	Yes	-	-
4913	$283,021,760	69.1%	-	-	15 mgal	20MGD	6 mgal	4 mgal	10MGD	-	-	-	5 mgal	5 MGD	5' Pipe	2 mgal	5MGD	4' Pipe	-	5' Pipe	-	-	-	Yes	Yes	Yes	Yes	-	-
4914	$283,021,760	69.1%	-	-	15 mgal	20MGD	6 mgal	4 mgal	10MGD	-	-	-	5 mgal	5 MGD	5' Pipe	2 mgal	5MGD	4' Pipe	-	5' Pipe	-	-	-	Yes	Yes	Yes	Yes	-	-
4915	$344,208,712	75.9%	-	-	25 mgal	30MGD	12 mgal	4 mgal	5MGD	-	-	-	4 mgal	5 MGD	5' Pipe	3 mgal	5MGD	5' Pipe	-	4' Pipe	-	-	-	Yes	Yes	Yes	Yes	-	-
4916	$214,272,172	58.9%	-	-	20 mgal	10MGD	-	4 mgal	10MGD	-	-	-	2 mgal	5 MGD	8' Pipe	-	10MGD	-	-	6' Pipe	-	-	-	-	-	-	-	-	-
4917	$241,272,934	57.9%	-	-	15 mgal	20MGD	3 mgal	2 mgal	10MGD	-	-	-	2 mgal	5 MGD	8' Pipe	7 mgal	5MGD	-	-	-	-	-	-	Yes	Yes	Yes	-	-	-
4918	$260,017,728	61.4%	-	-	10 mgal	10MGD	6 mgal	3 mgal	20MGD	-	-	-	3 mgal	5 MGD	5' Pipe	6 mgal	10MGD	5' Pipe	-	4' Pipe	-	-	-	Yes	Yes	Yes	-	-	-
4919	$272,638,530	68.3%	-	-	20 mgal	10MGD	9 mgal	2 mgal	10MGD	-	-	-	1 mgal	5 MGD	8' Pipe	5 mgal	10MGD	5' Pipe	-	4' Pipe	-	-	-	Yes	Yes	Yes	-	-	-
4920	$270,138,257	72.9%	-	-	20 mgal	10MGD	9 mgal	4 mgal	10MGD	-	-	-	3 mgal	5 MGD	8' Pipe	3 mgal	-	5' Pipe	-	4' Pipe	-	-	-	Yes	Yes	Yes	Yes	-	-
4921	$220,493,953	54.5%	-	-	5 mgal	10MGD	3 mgal	2 mgal	20MGD	-	-	-	2 mgal	5 MGD	8' Pipe	6 mgal	5MGD	4' Pipe	-	4' Pipe	-	-	-	Yes	Yes	Yes	-	-	-
4922	$207,824,378	55.3%	-	-	10 mgal	10MGD	6 mgal	3 mgal	5MGD	-	-	-	2 mgal	5 MGD	5' Pipe	2 mgal	-	4' Pipe	-	4' Pipe	-	-	-	Yes	Yes	Yes	Yes	-	-
4923	$223,427,503	58.9%	-	-	15 mgal	10MGD	6 mgal	3 mgal	5MGD	-	-	-	2 mgal	5 MGD	5' Pipe	2 mgal	-	4' Pipe	-	4' Pipe	-	-	-	Yes	Yes	Yes	Yes	-	-
4924	$296,393,144	65.0%	-	-	20 mgal	40MGD	-	2 mgal	10MGD	-	-	-	2 mgal	5 MGD	12' Pipe	4 mgal	10MGD	5' Pipe	-	-	-	-	-	Yes	-	Yes	Yes	-	-
4925	$234,689,549	58.2%	-	-	10 mgal	20MGD	3 mgal	4 mgal	5MGD	-	-	-	2 mgal	5 MGD	8' Pipe	2 mgal	5MGD	4' Pipe	-	5' Pipe	-	-	-	Yes	-	Yes	Yes	-	-
4926	$198,239,938	58.2%	-	-	5 mgal	-	6 mgal	3 mgal	10MGD	-	-	-	6 mgal	5 MGD	8' Pipe	2 mgal	5MGD	4' Pipe	-	4' Pipe	-	-	-	Yes	-	Yes	Yes	-	-
4927	$194,604,074	48.8%	-	-	5 mgal	10MGD	3 mgal	3 mgal	5MGD	-	-	-	2 mgal	5 MGD	5' Pipe	1 mgal	5MGD	4' Pipe	-	4' Pipe	-	-	-	Yes	-	Yes	Yes	-	-
4928	$234,688,963	61.1%	-	-	10 mgal	10MGD	6 mgal	2 mgal	5MGD	-	-	-	4 mgal	5 MGD	5' Pipe	3 mgal	5MGD	6' Pipe	-	4' Pipe	-	-	-	Yes	Yes	Yes	Yes	-	-
4929	$228,257,337	56.9%	-	-	10 mgal	10MGD	6 mgal	3 mgal	5MGD	-	-	-	2 mgal	5 MGD	5' Pipe	3 mgal	5MGD	4' Pipe	-	4' Pipe	-	-	-	-	Yes	Yes	Yes	-	-
4930	$285,807,154	60.1%	-	-	10 mgal	40MGD	-	2 mgal	20MGD	-	-	-	6 mgal	5 MGD	5' Pipe	5 mgal	20MGD	-	-	6' Pipe	-	-	-	Yes	-	-	-	-	-
4931	$237,527,315	57.7%	-	-	5 mgal	20MGD	-	2 mgal	10MGD	-	-	-	7 mgal	5 MGD	5' Pipe	3 mgal	10MGD	5' Pipe	-	5' Pipe	-	-	-	Yes	Yes	-	Yes	-	-
4932	$203,841,010	53.2%	-	-	5 mgal	10MGD	-	2 mgal	5MGD	-	-	-	7 mgal	5 MGD	5' Pipe	2 mgal	5MGD	6' Pipe	-	4' Pipe	-	-	-	Yes	Yes	-	Yes	-	-
4933	$206,403,844	53.4%	-	-	10 mgal	10MGD	3 mgal	3 mgal	5MGD	-	-	-	6 mgal	5 MGD	-	1 mgal	-	4' Pipe	-	5' Pipe	-	-	-	Yes	Yes	-	Yes	-	-
4934	$191,125,247	52.2%	-	-	10 mgal	10MGD	3 mgal	3 mgal	5MGD	-	-	-	3 mgal	5 MGD	-	1 mgal	-	4' Pipe	-	5' Pipe	-	-	-	Yes	-	-	Yes	-	-
4935	$253,072,314	66.0%	-	-	25 mgal	-	3 mgal	5 mgal	-	-	-	-	1 mgal	5 MGD	5' Pipe	3 mgal	30MGD	4' Pipe	-	5' Pipe	-	-	-	-	Yes	-	-	-	-
4936	$224,090,364	58.1%	-	-	15 mgal	10MGD	3 mgal	3 mgal	5MGD	-	-	-	2 mgal	5 MGD	5' Pipe	4 mgal	10MGD	5' Pipe	-	5' Pipe	-	-	-	-	-	Yes	-	-	-
4937	$284,404,421	66.3%	-	-	25 mgal	20MGD	3 mgal	4 mgal	5MGD	-	-	-	1 mgal	5 MGD	5' Pipe	1 mgal	5MGD	5' Pipe	-	5' Pipe	-	-	-	-	Yes	-	Yes	-	-
4938	$216,911,661	47.8%	-	-	5 mgal	20MGD	3 mgal	3 mgal	5MGD	-	-	-	1 mgal	5 MGD	5' Pipe	1 mgal	5MGD	4' Pipe	-	4' Pipe	-	-	-	Yes	Yes	Yes	Yes	-	-
4939	$234,218,955	56.8%	-	-	20 mgal	10MGD	3 mgal	4 mgal	5MGD	-	-	-	1 mgal	5 MGD	5' Pipe	-	5MGD	5' Pipe	-	5' Pipe	-	-	-	-	-	Yes	Yes	-	-
4940	$249,099,456	59.8%	-	-	20 mgal	10MGD	3 mgal	3 mgal	5MGD	-	-	-	1 mgal	5 MGD	5' Pipe	1 mgal	5MGD	5' Pipe	-	5' Pipe	-	-	-	Yes	Yes	Yes	Yes	-	-
4941	$203,348,232	49.9%	-	-	5 mgal	10MGD	3 mgal	3 mgal	5MGD	-	-	-	2 mgal	5 MGD	5' Pipe	1 mgal	5MGD	4' Pipe	-	4' Pipe	-	-	-	Yes	Yes	Yes	Yes	-	-
4942	$221,208,417	34.4%	-	-	-	10MGD	9 mgal	2 mgal	10MGD	-	-	-	5 mgal	5 MGD	-	5 mgal	10MGD	4' Pipe	-	5' Pipe	-	-	-	Yes	-	Yes	Yes	-	-
4943	$201,773,438	34.0%	-	-	-	10MGD	9 mgal	2 mgal	5MGD	-	-	-	3 mgal	5 MGD	5' Pipe	5 mgal	5MGD	4' Pipe	-	5' Pipe	-	-	-	Yes	-	Yes	Yes	-	-
4944	$267,263,211	61.8%	-	-	10 mgal	20MGD	12 mgal	3 mgal	5MGD	-	-	-	1 mgal	5 MGD	5' Pipe	4 mgal	5MGD	5' Pipe	-	5' Pipe	-	-	-	Yes	Yes	Yes	Yes	-	-
4945	$218,036,592	51.1%	-	-	5 mgal	10MGD	6 mgal	2 mgal	5MGD	-	-	-	1 mgal	5 MGD	5' Pipe	6 mgal	5MGD	4' Pipe	-	5' Pipe	-	-	-	Yes	Yes	Yes	Yes	-	-
4946	$282,232,494	68.7%	-	-	20 mgal	20MGD	6 mgal	2 mgal	5MGD	-	-	-	7 mgal	5 MGD	8' Pipe	4 mgal	5MGD	5' Pipe	-	-	-	-	-	Yes	-	Yes	Yes	-	-
4947	$270,399,634	67.4%	-	-	20 mgal	10MGD	6 mgal	2 mgal	5MGD	-	-	-	7 mgal	5 MGD	8' Pipe	6 mgal	5MGD	4' Pipe	-	-	-	-	-	Yes	-	Yes	Yes	-	-
4948	$240,009,267	64.1%	-	-	15 mgal	20MGD	6 mgal	3 mgal	5MGD	-	-	-	4 mgal	5 MGD	5' Pipe	5 mgal	5MGD	-	-	4' Pipe	-	-	-	Yes	-	Yes	-	-	-
4949	$270,399,634	67.4%	-	-	20 mgal	10MGD	6 mgal	2 mgal	5MGD	-	-	-	7 mgal	5 MGD	8' Pipe	6 mgal	5MGD	4' Pipe	-	-	-	-	-	Yes	-	Yes	Yes	-	-
4950	$287,370,141	70.7%	-	-	20 mgal	20MGD	9 mgal	3 mgal	20MGD	-	-	-	3 mgal	5 MGD	8' Pipe	2 mgal	10MGD	-	-	4' Pipe	-	-	-	Yes	-	-	-	-	-
4951	$232,793,457	63.7%	-	-	20 mgal	10MGD	6 mgal	2 mgal	10MGD	-	-	-	3 mgal	5 MGD	8' Pipe	2 mgal	5MGD	-	-	4' Pipe	-	-	-	Yes	-	-	-	-	-
4952	$287,942,998	70.3%	-	-	20 mgal	20MGD	9 mgal	3 mgal	5MGD	-	-	-	3 mgal	5 MGD	8' Pipe	2 mgal	5MGD	5' Pipe	-	-	-	-	-	Yes	Yes	-	Yes	-	-
4953	$222,578,207	51.5%	-	-	10 mgal	20MGD	-	3 mgal	5MGD	-	-	-	2 mgal	5 MGD	5' Pipe	1 mgal	5MGD	5' Pipe	-	4' Pipe	-	-	-	Yes	Yes	Yes	Yes	-	-
4954	$242,658,282	66.2%	-	-	25 mgal	10MGD	6 mgal	2 mgal	5MGD	-	-	-	3 mgal	5 MGD	8' Pipe	2 mgal	5MGD	-	-	4' Pipe	-	-	-	Yes	-	-	-	-	-
4955	$202,919,091	50.9%	-	-	10 mgal	10MGD	3 mgal	2 mgal	5MGD	-	-	-	2 mgal	5 MGD	5' Pipe	1 mgal	5MGD	4' Pipe	-	4' Pipe	-	-	-	Yes	-	-	Yes	-	-
4956	$260,041,076	62.5%	-	-	10 mgal	20MGD	6 mgal	2 mgal	10MGD	-	-	-	5 mgal	5 MGD	5' Pipe	3 mgal	5MGD	5' Pipe	-	4' Pipe	-	-	-	Yes	Yes	Yes	Yes	-	-
4957	$224,433,853	60.1%	-	-	5 mgal	10MGD	3 mgal	3 mgal	10MGD	-	-	-	6 mgal	5 MGD	5' Pipe	4 mgal	5MGD	5' Pipe	-	4' Pipe	-	-	-	Yes	-	Yes	Yes	-	-
4958	$218,042,627	58.1%	-	-	5 mgal	10MGD	3 mgal	2 mgal	5MGD	-	-	-	6 mgal	5 MGD	5' Pipe	4 mgal	5MGD	5' Pipe	-	4' Pipe	-	-	-	Yes	Yes	Yes	Yes	-	-
4959	$224,330,791	57.8%	-	-	10 mgal	10MGD	3 mgal	3 mgal	5MGD	-	-	-	4 mgal	5 MGD	5' Pipe	1 mgal	5MGD	5' Pipe	-	4' Pipe	-	-	-	Yes	Yes	Yes	Yes	-	-
4960	$216,688,288	53.6%	-	-	5 mgal	10MGD	3 mgal	3 mgal	10MGD	-	-	-	2 mgal	5 MGD	5' Pipe	3 mgal	5MGD	4' Pipe	-	4' Pipe	-	-	-	Yes	Yes	Yes	Yes	-	-
4961	$205,952,803	51.4%	-	-	5 mgal	10MGD	3 mgal	3 mgal	5MGD	-	-	-	2 mgal	5 MGD	5' Pipe	2 mgal	5MGD	4' Pipe	-	4' Pipe	-	-	-	Yes	Yes	Yes	Yes	-	-
4962	$178,112,086	49.0%	-	-	5 mgal	10MGD	3 mgal	3 mgal	5MGD	-	-	-	2 mgal	5 MGD	8' Pipe	-	5MGD	-	-	4' Pipe	-	-	-	Yes	-	Yes	Yes	-	-
4963	$194,925,017	50.6%	-	-	5 mgal	10MGD	3 mgal	3 mgal	5MGD	-	-	-	2 mgal	5 MGD	8' Pipe	1 mgal	5MGD	5' Pipe	-	4' Pipe	-	-	-	-	-	Yes	Yes	-	-
4964	$203,348,232	49.9%	-	-	5 mgal	10MGD	3 mgal	3 mgal	5MGD	-	-	-	2 mgal	5 MGD	5' Pipe	1 mgal	5MGD	4' Pipe	-	4' Pipe	-	-	-	Yes	Yes	Yes	Yes	-	-
4965	$203,348,232	49.9%	-	-	5 mgal	10MGD	3 mgal	3 mgal	5MGD	-	-	-	2 mgal	5 MGD	5' Pipe	1 mgal	5MGD	4' Pipe	-	4' Pipe	-	-	-	Yes	Yes	Yes	Yes	-	-
4966	$227,684,760	57.1%	-	-	10 mgal	10MGD	6 mgal	4 mgal	5MGD	-	-	-	2 mgal	5 MGD	5' Pipe	2 mgal	5MGD	4' Pipe	-	4' Pipe	-	-	-	Yes	-	Yes	Yes	-	-
4967	$210,848,030	50.8%	-	-	5 mgal	10MGD	3 mgal	3 mgal	5MGD	-	-	-	2 mgal	5 MGD	5' Pipe	3 mgal	10MGD	5' Pipe	-	4' Pipe	-	-	-	Yes	-	Yes	Yes	-	-
4968	$210,848,030	50.8%	-	-	5 mgal	10MGD	3 mgal	3 mgal	5MGD	-	-	-	2 mgal	5 MGD	5' Pipe	3 mgal	10MGD	5' Pipe	-	4' Pipe	-	-	-	Yes	-	Yes	Yes	-	-
4969	$221,261,410	44.2%	-	-	5 mgal	30MGD	-	2 mgal	5MGD	-	-	-	2 mgal	5 MGD	12' Pipe	-	30MGD	-	-	5' Pipe	-	-	-	-	Yes	Yes	-	-	-
4970	$222,655,017	53.3%	-	-	5 mgal	20MGD	6 mgal	2 mgal	5MGD	-	-	-	2 mgal	5 MGD	8' Pipe	1 mgal	10MGD	-	-	4' Pipe	-	-	-	Yes	Yes	Yes	Yes	-	-
4971	$204,550,632	49.7%	-	-	5 mgal	10MGD	3 mgal	3 mgal	5MGD	-	-	-	2 mgal	5 MGD	5' Pipe	1 mgal	5MGD	5' Pipe	-	4' Pipe	-	-	-	Yes	Yes	Yes	Yes	-	-
4972	$194,649,666	56.4%	-	-	15 mgal	-	3 mgal	4 mgal	-	-	-	-	1 mgal	5 MGD	5' Pipe	2 mgal	10MGD	4' Pipe	-	5' Pipe	-	-	-	-	Yes	Yes	Yes	-	-
4973	$268,699,852	66.5%	-	-	20 mgal	10MGD	6 mgal	4 mgal	5MGD	-	-	-	3 mgal	5 MGD	5' Pipe	1 mgal	5MGD	5' Pipe	-	5' Pipe	-	-	-	Yes	Yes	Yes	Yes	-	-
4974	$208,236,557	60.2%	-	-	10 mgal	10MGD	3 mgal	4 mgal	5MGD	-	-	-	4 mgal	5 MGD	5' Pipe	1 mgal	-	4' Pipe	-	4' Pipe	-	-	-	Yes	Yes	-	Yes	-	-

Table B-1

Optimization Model Runs (Scenario ID)/ Alternatives - 1 yr 3 hr design event

Scenario ID	Life Cycle Cost	Percent Reduction	WWTP Upgrade	WWTP Storage	Diamond Ave Storage	Diamond Ave HRT	Storage at School	HRT_7thLS_Treatment	7th St HRT	Force Main to WRP	Pump to Force Main	7th St LS Increase Pumping	CSO 012 Storage	CSO 012 HRT	CSO 012 Siphon	CSO 013 Storage	CSO 013 HRT	Consolidate CSO 014 to CSO 012	Consolidate CSO 016 to 7th St LS	Consolidate CSO 016 to CSO 013	PCI Relief (N/S)	PCI Relief (E/W)	CSO 019 Storage	Separation (CSO 020/022)	Separation (CSO 013/016)	Separation (CSO 017)	Separation (CSO 025)	GSI (Basin 012)	GSI (Basin 020 and 022)
4975	$227,914,463	56.9%	-	-	15 mgal	10MGD	3 mgal	4 mgal	5MGD	-	-	-	1 mgal	5 MGD	5' Pipe	1 mgal	5MGD	4' Pipe	-	5' Pipe	-	-	-	Yes	-	Yes	Yes	-	-
4976	$189,254,190	47.5%	-	-	5 mgal	10MGD	3 mgal	2 mgal	5MGD	-	-	-	2 mgal	5 MGD	5' Pipe	1 mgal	5MGD	4' Pipe	-	4' Pipe	-	-	-	Yes	-	Yes	Yes	-	-
4977	$207,632,178	50.9%	-	-	10 mgal	10MGD	3 mgal	3 mgal	5MGD	-	-	-	1 mgal	5 MGD	5' Pipe	1 mgal	5MGD	5' Pipe	-	4' Pipe	-	-	-	Yes	-	Yes	Yes	-	-
4978	$189,254,190	47.5%	-	-	5 mgal	10MGD	3 mgal	2 mgal	5MGD	-	-	-	2 mgal	5 MGD	5' Pipe	1 mgal	5MGD	4' Pipe	-	4' Pipe	-	-	-	Yes	-	Yes	Yes	-	-
4979	$227,100,917	60.3%	-	-	5 mgal	10MGD	6 mgal	3 mgal	10MGD	-	-	-	3 mgal	5 MGD	8' Pipe	6 mgal	5MGD	4' Pipe	-	5' Pipe	-	-	-	-	-	Yes	Yes	-	-
4980	$271,263,150	67.2%	-	-	25 mgal	10MGD	9 mgal	-	5MGD	-	-	-	2 mgal	5 MGD	5' Pipe	6 mgal	10MGD	5' Pipe	-	5' Pipe	-	-	-	-	Yes	Yes	-	-	-
4981	$239,516,694	59.9%	-	-	20 mgal	10MGD	3 mgal	2 mgal	5MGD	-	-	-	2 mgal	5 MGD	5' Pipe	3 mgal	10MGD	5' Pipe	-	4' Pipe	-	-	-	-	Yes	Yes	-	-	-
4982	$240,614,881	56.6%	-	-	10 mgal	10MGD	12 mgal	2 mgal	5MGD	-	-	-	1 mgal	5 MGD	5' Pipe	4 mgal	5MGD	4' Pipe	-	4' Pipe	-	-	-	-	Yes	Yes	Yes	-	-
4983	$211,316,319	50.5%	-	-	5 mgal	10MGD	6 mgal	2 mgal	5MGD	-	-	-	1 mgal	5 MGD	5' Pipe	5 mgal	5MGD	4' Pipe	-	4' Pipe	-	-	-	-	Yes	Yes	Yes	-	-
4984	$255,701,497	63.6%	-	-	15 mgal	20MGD	9 mgal	2 mgal	10MGD	-	-	-	1 mgal	5 MGD	8' Pipe	5 mgal	5MGD	4' Pipe	-	4' Pipe	-	-	-	Yes	-	Yes	-	-	-
4985	$250,165,354	68.9%	-	-	20 mgal	10MGD	6 mgal	2 mgal	5MGD	-	-	-	4 mgal	5 MGD	8' Pipe	6 mgal	5MGD	4' Pipe	-	4' Pipe	-	-	-	Yes	-	Yes	-	-	-
4986	$252,910,667	68.8%	-	-	20 mgal	10MGD	6 mgal	2 mgal	5MGD	-	-	-	5 mgal	5 MGD	8' Pipe	6 mgal	5MGD	4' Pipe	-	4' Pipe	-	-	-	Yes	-	Yes	-	-	-
4987	$218,643,390	57.2%	-	-	10 mgal	10MGD	3 mgal	3 mgal	5MGD	-	-	-	3 mgal	5 MGD	5' Pipe	3 mgal	5MGD	4' Pipe	-	4' Pipe	-	-	-	Yes	-	Yes	Yes	-	-
4988	$300,100,100	67.1%	-	-	20 mgal	20MGD	6 mgal	2 mgal	10MGD	-	-	-	2 mgal	5 MGD	12' Pipe	7 mgal	30MGD	-	-	4' Pipe	-	-	-	-	-	Yes	-	-	-
4989	$251,591,467	65.8%	-	-	20 mgal	10MGD	6 mgal	2 mgal	5MGD	-	-	-	5 mgal	5 MGD	8' Pipe	6 mgal	10MGD	-	-	4' Pipe	-	-	-	Yes	-	Yes	-	-	-
4990	$339,878,919	77.5%	-	-	25 mgal	20MGD	9 mgal	3 mgal	10MGD	-	-	-	6 mgal	5 MGD	8' Pipe	5 mgal	10MGD	4' Pipe	-	4' Pipe	-	-	-	Yes	Yes	-	Yes	-	-
4991	$258,956,594	67.5%	-	-	15 mgal	10MGD	6 mgal	2 mgal	5MGD	-	-	-	7 mgal	5 MGD	5' Pipe	4 mgal	5MGD	5' Pipe	-	4' Pipe	-	-	-	Yes	Yes	-	Yes	-	-
4992	$225,787,915	56.5%	-	-	10 mgal	10MGD	3 mgal	2 mgal	5MGD	-	-	-	5 mgal	5 MGD	5' Pipe	4 mgal	5MGD	4' Pipe	-	-	-	-	-	Yes	Yes	Yes	Yes	-	-
4993	$264,933,926	64.0%	-	-	10 mgal	10MGD	9 mgal	3 mgal	10MGD	-	-	-	5 mgal	5 MGD	-	4 mgal	10MGD	5' Pipe	-	4' Pipe	-	-	-	Yes	Yes	Yes	Yes	-	-
4994	$234,436,987	59.9%	-	-	10 mgal	10MGD	6 mgal	3 mgal	10MGD	-	-	-	2 mgal	5 MGD	-	2 mgal	10MGD	4' Pipe	-	4' Pipe	-	-	-	Yes	-	Yes	Yes	-	-
4995	$300,382,742	61.3%	-	-	10 mgal	30MGD	17 mgal	2 mgal	5MGD	-	-	-	2 mgal	5 MGD	8' Pipe	6 mgal	20MGD	4' Pipe	-	-	-	-	-	-	Yes	Yes	-	-	-
4996	$329,604,402	72.6%	-	-	30 mgal	20MGD	9 mgal	3 mgal	10MGD	-	-	-	4 mgal	5 MGD	8' Pipe	1 mgal	5MGD	5' Pipe	-	4' Pipe	-	-	-	Yes	-	Yes	Yes	-	-
4997	$224,061,886	60.6%	-	-	15 mgal	20MGD	6 mgal	3 mgal	5MGD	-	-	-	-	-	8' Pipe	2 mgal	5MGD	5' Pipe	-	4' Pipe	-	-	-	Yes	-	Yes	Yes	-	-
4998	$245,747,158	63.5%	-	-	15 mgal	10MGD	6 mgal	2 mgal	5MGD	-	-	-	3 mgal	5 MGD	8' Pipe	3 mgal	5MGD	4' Pipe	-	4' Pipe	-	-	-	Yes	Yes	Yes	Yes	-	-
4999	$277,820,473	70.8%	-	-	25 mgal	10MGD	6 mgal	2 mgal	5MGD	-	-	-	3 mgal	5 MGD	8' Pipe	2 mgal	5MGD	4' Pipe	-	4' Pipe	-	-	-	Yes	Yes	Yes	Yes	-	-
5000	$220,383,078	55.4%	-	-	10 mgal	10MGD	3 mgal	3 mgal	5MGD	-	-	-	2 mgal	5 MGD	5' Pipe	2 mgal	5MGD	4' Pipe	-	4' Pipe	-	-	-	Yes	Yes	Yes	Yes	-	-
5001	$257,220,163	64.5%	-	-	20 mgal	10MGD	6 mgal	2 mgal	5MGD	-	-	-	2 mgal	5 MGD	8' Pipe	2 mgal	5MGD	4' Pipe	-	4' Pipe	-	-	-	Yes	Yes	Yes	Yes	-	-
5002	$208,131,278	50.4%	-	-	10 mgal	10MGD	3 mgal	3 mgal	5MGD	-	-	-	1 mgal	5 MGD	5' Pipe	1 mgal	5MGD	4' Pipe	-	4' Pipe	-	-	-	Yes	-	Yes	Yes	-	-
5003	$220,383,078	58.4%	-	-	10 mgal	10MGD	3 mgal	2 mgal	5MGD	-	-	-	4 mgal	5 MGD	5' Pipe	2 mgal	5MGD	4' Pipe	-	4' Pipe	-	-	-	Yes	Yes	Yes	Yes	-	-
5004	$198,837,307	53.3%	-	-	10 mgal	-	6 mgal	3 mgal	5MGD	-	-	-	2 mgal	5 MGD	5' Pipe	1 mgal	5MGD	4' Pipe	-	4' Pipe	-	-	-	Yes	Yes	Yes	Yes	-	-
5005	$205,999,717	51.2%	-	-	5 mgal	10MGD	3 mgal	3 mgal	5MGD	-	-	-	3 mgal	5 MGD	5' Pipe	1 mgal	5MGD	4' Pipe	-	4' Pipe	-	-	-	Yes	Yes	Yes	Yes	-	-
5006	$203,348,232	49.9%	-	-	5 mgal	10MGD	3 mgal	3 mgal	5MGD	-	-	-	2 mgal	5 MGD	5' Pipe	1 mgal	5MGD	4' Pipe	-	4' Pipe	-	-	-	Yes	Yes	Yes	Yes	-	-
5007	$274,076,410	60.2%	-	-	5 mgal	20MGD	9 mgal	2 mgal	20MGD	-	-	-	5 mgal	5 MGD	8' Pipe	3 mgal	10MGD	4' Pipe	-	-	-	-	-	Yes	Yes	Yes	Yes	-	-
5008	$230,238,369	59.6%	-	-	5 mgal	10MGD	6 mgal	3 mgal	10MGD	-	-	-	5 mgal	5 MGD	8' Pipe	2 mgal	5MGD	4' Pipe	-	4' Pipe	-	-	-	Yes	Yes	Yes	Yes	-	-
5009	$250,214,910	66.2%	-	-	10 mgal	10MGD	6 mgal	4 mgal	10MGD	-	-	-	5 mgal	5 MGD	8' Pipe	4 mgal	5MGD	4' Pipe	-	4' Pipe	-	-	-	Yes	-	Yes	Yes	-	-
5010	$227,689,438	59.1%	-	-	5 mgal	10MGD	6 mgal	3 mgal	10MGD	-	-	-	6 mgal	5 MGD	8' Pipe	2 mgal	5MGD	4' Pipe	-	4' Pipe	-	-	-	Yes	-	Yes	Yes	-	-
5011	$237,861,021	58.5%	-	-	15 mgal	10MGD	3 mgal	4 mgal	5MGD	-	-	-	1 mgal	5 MGD	5' Pipe	1 mgal	5MGD	5' Pipe	-	5' Pipe	-	-	-	Yes	Yes	Yes	Yes	-	-
5012	$190,777,532	46.4%	-	-	5 mgal	10MGD	-	3 mgal	5MGD	-	-	-	2 mgal	5 MGD	5' Pipe	1 mgal	5MGD	4' Pipe	-	4' Pipe	-	-	-	Yes	Yes	Yes	Yes	-	-
5013	$235,932,455	67.8%	-	-	30 mgal	-	6 mgal	3 mgal	5MGD	-	-	-	-	-	8' Pipe	2 mgal	10MGD	4' Pipe	-	5' Pipe	-	-	-	-	-	Yes	Yes	-	-
5014	$200,602,594	64.5%	-	-	20 mgal	-	3 mgal	3 mgal	5MGD	-	-	-	3 mgal	5 MGD	8' Pipe	2 mgal	-	4' Pipe	-	5' Pipe	-	-	-	Yes	-	Yes	Yes	-	-
5015	$261,897,376	63.2%	-	-	20 mgal	10MGD	6 mgal	4 mgal	5MGD	-	-	-	1 mgal	5 MGD	5' Pipe	1 mgal	5MGD	4' Pipe	-	4' Pipe	-	-	-	Yes	Yes	Yes	Yes	-	-
5016	$203,348,232	49.9%	-	-	5 mgal	10MGD	3 mgal	3 mgal	5MGD	-	-	-	2 mgal	5 MGD	5' Pipe	1 mgal	5MGD	4' Pipe	-	4' Pipe	-	-	-	Yes	Yes	Yes	Yes	-	-
5017	$299,374,032	61.3%	-	-	30 mgal	20MGD	9 mgal	2 mgal	-	-	-	-	-	-	5' Pipe	4 mgal	30MGD	6' Pipe	-	-	-	-	-	-	-	-	Yes	-	-
5018	$192,109,097	54.1%	-	-	15 mgal	10MGD	6 mgal	4 mgal	-	-	-	-	-	-	5' Pipe	2 mgal	10MGD	5' Pipe	-	-	-	-	-	-	-	-	Yes	-	-
5019	$310,930,164	72.4%	-	-	20 mgal	20MGD	6 mgal	3 mgal	20MGD	-	-	-	5 mgal	5 MGD	8' Pipe	2 mgal	5MGD	5' Pipe	-	5' Pipe	-	-	-	Yes	Yes	Yes	Yes	-	-
5020	$303,324,648	72.2%	-	-	30 mgal	10MGD	6 mgal	2 mgal	10MGD	-	-	-	3 mgal	5 MGD	8' Pipe	2 mgal	5MGD	4' Pipe	-	4' Pipe	-	-	-	Yes	Yes	Yes	Yes	-	-
5021	$295,240,648	71.0%	-	-	30 mgal	10MGD	6 mgal	2 mgal	5MGD	-	-	-	3 mgal	5 MGD	8' Pipe	2 mgal	5MGD	4' Pipe	-	4' Pipe	-	-	-	Yes	Yes	Yes	Yes	-	-
5022	$295,240,648	71.0%	-	-	30 mgal	10MGD	6 mgal	2 mgal	5MGD	-	-	-	3 mgal	5 MGD	8' Pipe	2 mgal	5MGD	4' Pipe	-	4' Pipe	-	-	-	Yes	Yes	Yes	Yes	-	-
5023	$278,342,600	66.5%	-	-	15 mgal	20MGD	6 mgal	3 mgal	5MGD	-	-	-	5 mgal	5 MGD	5' Pipe	2 mgal	10MGD	5' Pipe	-	4' Pipe	-	-	-	Yes	Yes	Yes	Yes	-	-
5024	$228,768,218	60.1%	-	-	10 mgal	10MGD	3 mgal	2 mgal	5MGD	-	-	-	6 mgal	5 MGD	5' Pipe	2 mgal	5MGD	6' Pipe	-	4' Pipe	-	-	-	Yes	Yes	Yes	Yes	-	-
5025	$204,456,804	53.1%	-	-	5 mgal	10MGD	3 mgal	2 mgal	5MGD	-	-	-	3 mgal	5 MGD	5' Pipe	2 mgal	5MGD	5' Pipe	-	4' Pipe	-	-	-	Yes	Yes	Yes	Yes	-	-
5026	$217,177,084	56.5%	-	-	5 mgal	10MGD	3 mgal	2 mgal	5MGD	-	-	-	7 mgal	5 MGD	5' Pipe	2 mgal	5MGD	6' Pipe	-	4' Pipe	-	-	-	Yes	Yes	Yes	Yes	-	-
5027	$233,921,987	62.5%	-	-	10 mgal	10MGD	3 mgal	4 mgal	5MGD	-	-	-	4 mgal	5 MGD	5' Pipe	3 mgal	5MGD	4' Pipe	-	4' Pipe	-	-	-	Yes	Yes	Yes	Yes	-	-
5028	$231,270,502	61.5%	-	-	10 mgal	10MGD	3 mgal	4 mgal	5MGD	-	-	-	4 mgal	5 MGD	5' Pipe	2 mgal	5MGD	4' Pipe	-	4' Pipe	-	-	-	Yes	Yes	Yes	Yes	-	-
5029	$231,270,502	61.5%	-	-	10 mgal	10MGD	3 mgal	4 mgal	5MGD	-	-	-	4 mgal	5 MGD	5' Pipe	2 mgal	5MGD	4' Pipe	-	4' Pipe	-	-	-	Yes	Yes	Yes	Yes	-	-
5030	$228,665,931	60.4%	-	-	10 mgal	10MGD	3 mgal	4 mgal	5MGD	-	-	-	4 mgal	5 MGD	5' Pipe	1 mgal	5MGD	4' Pipe	-	4' Pipe	-	-	-	Yes	Yes	Yes	Yes	-	-
5031	$224,079,388	54.3%	-	-	10 mgal	10MGD	3 mgal	2 mgal	5MGD	-	-	-	2 mgal	5 MGD	8' Pipe	3 mgal	10MGD	4' Pipe	-	-	-	-	-	Yes	Yes	Yes	Yes	-	-
5032	$219,548,932	57.4%	-	-	10 mgal	10MGD	-	3 mgal	5MGD	-	-	-	2 mgal	5 MGD	8' Pipe	3 mgal	10MGD	4' Pipe	-	4' Pipe	-	-	-	Yes	Yes	Yes	Yes	-	-
5033	$303,365,188	62.8%	-	-	5 mgal	20MGD	15 mgal	2 mgal	30MGD	-	-	-	3 mgal	5 MGD	-	5 mgal	10MGD	4' Pipe	-	5' Pipe	-	-	-	-	Yes	-	Yes	-	-
5034	$230,423,655	57.9%	-	-	5 mgal	10MGD	9 mgal	3 mgal	10MGD	-	-	-	2 mgal	5 MGD	-	3 mgal	5MGD	4' Pipe	-	4' Pipe	-	-	-	Yes	Yes	Yes	Yes	-	-
5035	$230,423,655	57.9%	-	-	5 mgal	10MGD	9 mgal	3 mgal	10MGD	-	-	-	2 mgal	5 MGD	-	3 mgal	5MGD	4' Pipe	-	4' Pipe	-	-	-	Yes	Yes	Yes	Yes	-	-
5036	$223,034,563	56.3%	-	-	10 mgal	10MGD	3 mgal	3 mgal	5MGD	-	-	-	2 mgal	5 MGD	5' Pipe	3 mgal	5MGD	4' Pipe	-	4' Pipe	-	-	-	Yes	Yes	Yes	Yes	-	-
5037	$212,582,870	54.6%	-	-	5 mgal	10MGD	6 mgal	3 mgal	5MGD	-	-	-	2 mgal	5 MGD	-	2 mgal	5MGD	4' Pipe	-	4' Pipe	-	-	-	Yes	Yes	Yes	Yes	-	-
5038	$198,957,059	50.3%	-	-	5 mgal	10MGD	3 mgal	3 mgal	5MGD	-	-	-	3 mgal	5 MGD	5' Pipe	1 mgal	5MGD	4' Pipe	-	4' Pipe	-	-	-	Yes	-	Yes	Yes	-	-
5039	$196,305,574	48.3%	-	-	5 mgal	10MGD	3 mgal	3 mgal	5MGD	-	-	-	2 mgal	5 MGD	5' Pipe	1 mgal	5MGD	4' Pipe	-	4' Pipe	-	-	-	Yes	-	Yes	Yes	-	-
5040	$196,305,574	48.3%	-	-	5 mgal	10MGD	3 mgal	3 mgal	5MGD	-	-	-	2 mgal	5 MGD	5' Pipe	1 mgal	5MGD	4' Pipe	-	4' Pipe	-	-	-	Yes	-	Yes	Yes	-	-
5041	$196,305,574	48.3%	-	-	5 mgal	10MGD	3 mgal	3 mgal	5MGD	-	-	-	2 mgal	5 MGD	5' Pipe	1 mgal	5MGD	4' Pipe	-	4' Pipe	-	-	-	Yes	-	Yes	Yes	-	-
5042	$208,139,383	60.1%	-	-	15 mgal	-	9 mgal	3 mgal	10MGD	-	-	-	5 mgal	5 MGD	8' Pipe	-	5MGD	-	-	4' Pipe	-	-	-	-	-	-	Yes	-	-
5043	$195,443,033	58.4%	-	-	10 mgal	-	6 mgal	3 mgal	5MGD	-	-	-	4 mgal	5 MGD	5' Pipe	1 mgal	5MGD	4' Pipe	-	4' Pipe	-	-	-	Yes	-	Yes	Yes	-	-
5044	$243,369,772	61.6%	-	-	15 mgal	10MGD	3 mgal	3 mgal	10MGD	-	-	-	2 mgal	5 MGD	8' Pipe	2 mgal	5MGD	4' Pipe	-	4' Pipe	-	-	-	Yes	Yes	Yes	Yes	-	-
5045	$224,883,807	56.6%	-	-	10 mgal	10MGD	6 mgal	3 mgal	5MGD	-	-	-	2 mgal	5 MGD	5' Pipe	1 mgal	5MGD	4' Pipe	-	4' Pipe	-	-	-	Yes	Yes	Yes	Yes	-	-
5046	$220,383,078	55.4%	-	-	10 mgal	10MGD	3 mgal	3 mgal	5MGD	-	-	-	2 mgal	5 MGD	5' Pipe	2 mgal	5MGD	4' Pipe	-	4' Pipe	-	-	-	Yes	Yes	Yes	Yes	-	-
5047	$226,585,307	54.7%	-	-	10 mgal	10MGD	6 mgal	3 mgal	5MGD	-	-	-	2 mgal	5 MGD	5' Pipe	1 mgal	5MGD	4' Pipe	-	4' Pipe	-	-	-	Yes	Yes	Yes	Yes	-	-
5048	$201,646,732	49.5%	-	-	5 mgal	10MGD	3 mgal	3 mgal	5MGD	-	-	-	2 mgal	5 MGD	5' Pipe	1 mgal	5MGD	4' Pipe	-	4' Pipe	-	-	-	Yes	Yes	Yes	Yes	-	-
5049	$247,250,318	62.9%	-	-	20 mgal	10MGD	3 mgal	4 mgal	5MGD	-	-	-	1 mgal	5 MGD	5' Pipe	1 mgal	5MGD	5' Pipe	-	4' Pipe	-	-	-	Yes	-	Yes	Yes	-	-
5050	$196,305,574	48.3%	-	-	5 mgal	10MGD	3 mgal	3 mgal	5MGD	-	-	-	2 mgal	5 MGD	5' Pipe	1 mgal	5MGD	4' Pipe	-	4' Pipe	-	-	-	Yes	-	Yes	Yes	-	-
5051	$262,247,431	67.8%	-	-	20 mgal	10MGD	3 mgal	4 mgal	5MGD	-	-	-	4 mgal	5 MGD	5' Pipe	1 mgal	5MGD	5' Pipe	-	4' Pipe	-	-	-	Yes	Yes	Yes	Yes	-	-
5052	$215,438,056	57.1%	-	-	5 mgal	10MGD	3 mgal	4 mgal	5MGD	-	-	-	4 mgal	5 MGD	5' Pipe	1 mgal	5MGD	5' Pipe	-	4' Pipe	-	-	-	Yes	Yes	Yes	Yes	-	-
5053	$277,229,432	66.7%	-	-	5 mgal	10MGD	9 mgal	5 mgal	5MGD	-	-	-	6 mgal	5 MGD	12' Pipe	3 mgal	20MGD	6' Pipe	-	4' Pipe	-	-	-	Yes	Yes	Yes	Yes	-	-

Table B-1

Optimization Model Runs (Scenario ID)/ Alternatives - 1 yr 3 hr design event

Scenario ID	Life Cycle Cost	Percent Reduction	WWTP Upgrade	WWTP Storage	Diamond Ave Storage	Diamond Ave HRT	Storage at School	HRT_7thLS_Treatment	7th St HRT	Force Main to WRP	Pump to Force Main	7th St LS Increase Pumping	CSO 012 Storage	CSO 012 HRT	CSO 012 Siphon	CSO 013 Storage	CSO 013 HRT	Consolidate CSO 014 to CSO 012	Consolidate CSO 016 to 7th St LS	Consolidate CSO 016 to CSO 013	PCI Relief (N/S)	PCI Relief (E/W)	CSO 019 Storage	Separation (CSO 020/022)	Separation (CSO 013/016)	Separation (CSO 017)	Separation (CSO 025)	GSI (Basin 012)	GSI (Basin 020 and 022)
5054	$274,851,952	68.7%	-	-	20 mgal	10MGD	6 mgal	3 mgal	5MGD	-	-	-	3 mgal	5 MGD	8' Pipe	2 mgal	10MGD	5' Pipe	-	5' Pipe	-	-	-	Yes	Yes	Yes	Yes	-	-
5055	$257,241,567	62.0%	-	-	20 mgal	10MGD	3 mgal	4 mgal	5MGD	-	-	-	2 mgal	5 MGD	5' Pipe	1 mgal	5MGD	5' Pipe	-	5' Pipe	-	-	-	Yes	Yes	Yes	Yes	-	-
5056	$217,256,008	57.4%	-	-	5 mgal	10MGD	6 mgal	2 mgal	5MGD	-	-	-	4 mgal	5 MGD	5' Pipe	3 mgal	5MGD	5' Pipe	-	5' Pipe	-	-	-	Yes	Yes	Yes	Yes	-	-
5057	$235,462,536	55.5%	-	-	5 mgal	10MGD	12 mgal	2 mgal	5MGD	-	-	-	2 mgal	5 MGD	5' Pipe	5 mgal	5MGD	4' Pipe	-	5' Pipe	-	-	-	Yes	Yes	Yes	Yes	-	-
5058	$198,901,419	49.9%	-	-	5 mgal	10MGD	3 mgal	2 mgal	5MGD	-	-	-	2 mgal	5 MGD	5' Pipe	2 mgal	5MGD	4' Pipe	-	4' Pipe	-	-	-	Yes	Yes	Yes	Yes	-	-
5059	$221,305,852	52.8%	-	-	5 mgal	10MGD	9 mgal	2 mgal	5MGD	-	-	-	1 mgal	5 MGD	5' Pipe	4 mgal	5MGD	4' Pipe	-	5' Pipe	-	-	-	Yes	Yes	Yes	Yes	-	-
5060	$203,348,232	49.9%	-	-	5 mgal	10MGD	3 mgal	3 mgal	5MGD	-	-	-	2 mgal	5 MGD	5' Pipe	1 mgal	5MGD	4' Pipe	-	4' Pipe	-	-	-	Yes	Yes	Yes	Yes	-	-
5061	$212,499,052	50.0%	-	-	5 mgal	10MGD	6 mgal	2 mgal	5MGD	-	-	-	1 mgal	5 MGD	5' Pipe	4 mgal	5MGD	4' Pipe	-	5' Pipe	-	-	-	Yes	Yes	Yes	Yes	-	-
5062	$203,348,232	49.9%	-	-	5 mgal	10MGD	3 mgal	3 mgal	5MGD	-	-	-	2 mgal	5 MGD	5' Pipe	1 mgal	5MGD	4' Pipe	-	4' Pipe	-	-	-	Yes	Yes	Yes	Yes	-	-
5063	$274,707,577	70.2%	-	-	25 mgal	10MGD	3 mgal	3 mgal	5MGD	-	-	-	3 mgal	5 MGD	8' Pipe	2 mgal	5MGD	4' Pipe	-	5' Pipe	-	-	-	Yes	Yes	Yes	Yes	-	-
5064	$203,348,232	49.9%	-	-	5 mgal	10MGD	3 mgal	3 mgal	5MGD	-	-	-	2 mgal	5 MGD	5' Pipe	1 mgal	5MGD	4' Pipe	-	4' Pipe	-	-	-	Yes	Yes	Yes	Yes	-	-
5065	$245,520,317	64.4%	-	-	15 mgal	10MGD	3 mgal	4 mgal	5MGD	-	-	-	3 mgal	5 MGD	8' Pipe	2 mgal	5MGD	4' Pipe	-	5' Pipe	-	-	-	Yes	Yes	Yes	Yes	-	-
5066	$211,255,773	54.4%	-	-	5 mgal	10MGD	3 mgal	3 mgal	5MGD	-	-	-	3 mgal	5 MGD	5' Pipe	3 mgal	5MGD	4' Pipe	-	4' Pipe	-	-	-	Yes	Yes	Yes	Yes	-	-
5067	$325,048,188	70.3%	-	-	15 mgal	20MGD	15 mgal	4 mgal	5MGD	-	-	-	6 mgal	5 MGD	5' Pipe	6 mgal	30MGD	5' Pipe	-	-	-	-	-	-	-	Yes	-	-	-	-
5068	$278,061,009	71.1%	-	-	20 mgal	10MGD	9 mgal	3 mgal	5MGD	-	-	-	3 mgal	5 MGD	5' Pipe	4 mgal	10MGD	4' Pipe	-	5' Pipe	-	-	-	Yes	-	Yes	Yes	-	-
5069	$255,820,325	64.2%	-	-	20 mgal	10MGD	6 mgal	3 mgal	5MGD	-	-	-	3 mgal	5 MGD	5' Pipe	2 mgal	5MGD	4' Pipe	-	5' Pipe	-	-	-	Yes	-	Yes	Yes	-	-
5070	$256,508,560	65.1%	-	-	20 mgal	10MGD	3 mgal	2 mgal	5MGD	-	-	-	2 mgal	5 MGD	8' Pipe	5 mgal	5MGD	4' Pipe	-	4' Pipe	-	-	-	Yes	Yes	Yes	Yes	-	-
5071	$205,952,803	51.4%	-	-	5 mgal	10MGD	3 mgal	3 mgal	5MGD	-	-	-	2 mgal	5 MGD	5' Pipe	2 mgal	5MGD	4' Pipe	-	4' Pipe	-	-	-	Yes	Yes	Yes	Yes	-	-
5072	$285,146,156	73.8%	-	-	20 mgal	10MGD	9 mgal	2 mgal	5MGD	-	-	-	7 mgal	5 MGD	5' Pipe	5 mgal	5MGD	4' Pipe	-	4' Pipe	-	-	-	Yes	Yes	Yes	Yes	-	-
5073	$209,601,187	56.0%	-	-	5 mgal	10MGD	3 mgal	3 mgal	5MGD	-	-	-	4 mgal	5 MGD	5' Pipe	2 mgal	5MGD	4' Pipe	-	4' Pipe	-	-	-	Yes	Yes	Yes	Yes	-	-
5074	$265,315,360	67.3%	-	-	20 mgal	10MGD	6 mgal	2 mgal	5MGD	-	-	-	2 mgal	5 MGD	8' Pipe	5 mgal	5MGD	4' Pipe	-	4' Pipe	-	-	-	Yes	Yes	Yes	Yes	-	-
5075	$203,348,232	49.9%	-	-	5 mgal	10MGD	3 mgal	3 mgal	5MGD	-	-	-	2 mgal	5 MGD	5' Pipe	1 mgal	5MGD	4' Pipe	-	4' Pipe	-	-	-	Yes	Yes	Yes	Yes	-	-
5076	$232,662,669	60.4%	-	-	5 mgal	10MGD	9 mgal	2 mgal	5MGD	-	-	-	5 mgal	5 MGD	8' Pipe	4 mgal	5MGD	4' Pipe	-	4' Pipe	-	-	-	Yes	Yes	Yes	Yes	-	-
5100	$105,771,894	6.2%	60 MGD	-	-	-	-	-	-	36" FM	30MGD	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
5101	$184,937,447	6.2%	80 MGD	-	-	-	-	-	-	36" FM	30MGD	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
5102	$231,438,210	8.5%	80 MGD	12 mgal	-	-	-	-	-	36" FM	30MGD	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
5103	$400,163,798	76.2%	-	12 mgal	20 mgal	40MGD	-	5 mgal	30MGD	-	-	-	2 mgal	5 MGD	12' Pipe	3 mgal	5MGD	-	-	-	-	-	-	Yes	Yes	Yes	Yes	-	-
5104	$417,195,426	76.2%	-	12 mgal	20 mgal	40MGD	-	5 mgal	30MGD	-	-	-	3 mgal	5 MGD	12' Pipe	3 mgal	5MGD	-	-	-	-	-	-	Yes	Yes	Yes	Yes	-	-
5105	$442,492,609	79.2%	-	12 mgal	20 mgal	40MGD	-	5 mgal	30MGD	30" FM	20MGD	-	3 mgal	5 MGD	12' Pipe	3 mgal	5MGD	5' Pipe	-	-	-	-	-	Yes	Yes	Yes	Yes	-	-
5106	$570,197,471	73.9%	80 MGD	12 mgal	20 mgal	40MGD	-	5 mgal	30MGD	30" FM	20MGD	-	3 mgal	5 MGD	-	3 mgal	5MGD	-	-	-	-	-	-	Yes	Yes	Yes	Yes	-	-
5107	$622,279,746	75.0%	80 MGD	12 mgal	20 mgal	40MGD	-	5 mgal	30MGD	30" FM	20MGD	-	3 mgal	5 MGD	-	3 mgal	5MGD	-	-	-	5' Pipe	5' Pipe	-	Yes	Yes	Yes	Yes	-	-
5108	$636,659,889	75.0%	80 MGD	12 mgal	20 mgal	40MGD	-	5 mgal	30MGD	30" FM	20MGD	-	3 mgal	5 MGD	-	3 mgal	5MGD	-	-	-	5' Pipe	5' Pipe	-	Yes	Yes	Yes	Yes	-	-
5109	$646,120,231	74.4%	80 MGD	12 mgal	20 mgal	40MGD	-	5 mgal	30MGD	30" FM	20MGD	20MGD	3 mgal	5 MGD	-	3 mgal	5MGD	-	-	-	5' Pipe	5' Pipe	-	Yes	Yes	Yes	Yes	-	-
5110	$117,828,500	50.7%	-	-	10 mgal	20MGD	12 mgal	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
5111	$59,482,225	40.8%	-	-	5 mgal	-	12 mgal	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
5112	$101,660,500	49.8%	-	-	10 mgal	10MGD	12 mgal	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
5113	$92,853,700	44.7%	-	-	10 mgal	10MGD	9 mgal	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
5114	$135,421,928	52.2%	-	-	10 mgal	10MGD	12 mgal	2 mgal	5MGD	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
5115	$140,049,012	50.2%	-	-	10 mgal	10MGD	9 mgal	3 mgal	10MGD	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
5116	$80,299,053	27.7%	-	-	5 mgal	10MGD	-	2 mgal	5MGD	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
5117	$129,302,017	52.5%	-	-	10 mgal	10MGD	12 mgal	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	Yes	Yes	Yes	Yes	-	-
5118	$101,611,608	35.4%	-	-	10 mgal	10MGD	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	Higher	Medium
5119	$152,526,684	53.2%	-	4 mgal	10 mgal	10MGD	12 mgal	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	Yes	Yes	Yes	Yes	-	-
5120	$109,170,163	34.3%	-	12 mgal	10 mgal	10MGD	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
5121	$135,448,755	37.5%	-	20 mgal	10 mgal	10MGD	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
5122	$251,416,536	37.0%	80 MGD	12 mgal	10 mgal	10MGD	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
5123	$419,596,403	69.8%	-	-	20 mgal	-	12 mgal	-	20MGD	36" FM	30MGD	30MGD	2 mgal	5 MGD	5' Pipe	6 mgal	30MGD	5' Pipe	6' Pipe	4' Pipe	6' Pipe	5' Pipe	-	Yes	-	-	Yes	-	-
5124	$419,596,403	69.8%	-	-	20 mgal	-	12 mgal	-	20MGD	36" FM	30MGD	30MGD	2 mgal	5 MGD	5' Pipe	6 mgal	30MGD	5' Pipe	6' Pipe	4' Pipe	6' Pipe	5' Pipe	-	Yes	-	-	Yes	-	-
5125	$424,139,219	72.7%	-	8 mgal	20 mgal	30MGD	9 mgal	5 mgal	10MGD	-	-	10MGD	2 mgal	5 MGD	-	5 mgal	5MGD	4' Pipe	4' Pipe	-	5' Pipe	4' Pipe	-	Yes	Yes	Yes	-	-	-
5126	$424,139,219	72.7%	-	8 mgal	20 mgal	30MGD	9 mgal	5 mgal	10MGD	-	-	10MGD	2 mgal	5 MGD	-	5 mgal	5MGD	4' Pipe	4' Pipe	-	5' Pipe	4' Pipe	-	Yes	Yes	Yes	-	-	-
5127	$424,139,219	72.7%	-	8 mgal	20 mgal	30MGD	9 mgal	5 mgal	10MGD	-	-	10MGD	2 mgal	5 MGD	-	5 mgal	5MGD	4' Pipe	4' Pipe	-	5' Pipe	4' Pipe	-	Yes	Yes	Yes	-	-	-
5128	$424,139,219	72.7%	-	8 mgal	20 mgal	30MGD	9 mgal	5 mgal	10MGD	-	-	10MGD	2 mgal	5 MGD	-	5 mgal	5MGD	4' Pipe	4' Pipe	-	5' Pipe	4' Pipe	-	Yes	Yes	Yes	-	-	-
5129	$424,139,219	72.7%	-	8 mgal	20 mgal	30MGD	9 mgal	5 mgal	10MGD	-	-	10MGD	2 mgal	5 MGD	-	5 mgal	5MGD	4' Pipe	4' Pipe	-	5' Pipe	4' Pipe	-	Yes	Yes	Yes	-	-	-
5130	$458,095,552	73.9%	-	-	35 mgal	10MGD	-	2 mgal	30MGD	30" FM	20MGD	10MGD	4 mgal	5 MGD	5' Pipe	1 mgal	5MGD	4' Pipe	4' Pipe	5' Pipe	6' Pipe	6' Pipe	-	Yes	Yes	-	Yes	-	-
5131	$476,306,062	78.0%	-	16 mgal	25 mgal	20MGD	9 mgal	5 mgal	30MGD	-	-	-	3 mgal	5 MGD	5' Pipe	6 mgal	20MGD	-	4' Pipe	5' Pipe	5' Pipe	6' Pipe	-	-	-	-	-	-	-
5132	$356,707,944	71.5%	-	4 mgal	25 mgal	-	3 mgal	4 mgal	5MGD	42" FM	40MGD	-	-	-	12' Pipe	1 mgal	10MGD	-	4' Pipe	5' Pipe	-	5' Pipe	-	-	-	Yes	-	Yes	-	-
5133	$471,746,536	71.0%	-	12 mgal	25 mgal	20MGD	6 mgal	2 mgal	20MGD	36" FM	30MGD	20MGD	-	-	5' Pipe	7 mgal	10MGD	6' Pipe	6' Pipe	4' Pipe	5' Pipe	4' Pipe	-	-	-	Yes	Yes	-	-
5134	$366,767,215	71.0%	-	-	15 mgal	10MGD	6 mgal	2 mgal	5MGD	36" FM	30MGD	30MGD	4 mgal	5 MGD	5' Pipe	2 mgal	5MGD	5' Pipe	5' Pipe	6' Pipe	-	5' Pipe	-	-	Yes	-	Yes	-	-
5135	$417,521,324	73.7%	-	20 mgal	15 mgal	20MGD	12 mgal	-	20MGD	-	-	10MGD	3 mgal	5 MGD	5' Pipe	1 mgal	10MGD	4' Pipe	6' Pipe	6' Pipe	6' Pipe	-	-	Yes	-	-	Yes	-	-
5136	$349,260,841	66.6%	-	-	20 mgal	-	3 mgal	2 mgal	20MGD	36" FM	30MGD	30MGD	6 mgal	5 MGD	12' Pipe	7 mgal	10MGD	-	4' Pipe	-	4' Pipe	-	-	Yes	Yes	Yes	-	-	-
5137	$367,630,735	71.7%	-	-	25 mgal	30MGD	9 mgal	-	5MGD	30" FM	20MGD	30MGD	-	-	12' Pipe	2 mgal	10MGD	6' Pipe	6' Pipe	-	5' Pipe	-	-	-	Yes	Yes	-	Yes	-	-
5138	$402,622,297	71.0%	-	20 mgal	10 mgal	-	3 mgal	2 mgal	5MGD	-	-	20MGD	6 mgal	5 MGD	12' Pipe	3 mgal	30MGD	6' Pipe	5' Pipe	6' Pipe	-	6' Pipe	-	Yes	-	-	Yes	-	-
5139	$319,074,570	64.7%	-	12 mgal	5 mgal	40MGD	9 mgal	2 mgal	-	-	-	-	5 mgal	5 MGD	8' Pipe	7 mgal	-	-	4' Pipe	6' Pipe	4' Pipe	5' Pipe	-	Yes	-	Yes	-	-	-
5140	$396,160,316	72.5%	-	16 mgal	25 mgal	10MGD	-	3 mgal	10MGD	-	-	10MGD	4 mgal	5 MGD	5' Pipe	-	10MGD	-	6' Pipe	5' Pipe	6' Pipe	5' Pipe	-	Yes	-	Yes	Yes	-	-
5141	$350,144,916	70.0%	-	4 mgal	10 mgal	20MGD	6 mgal	4 mgal	20MGD	-	-	-	4 mgal	5 MGD	8' Pipe	4 mgal	30MGD	4' Pipe	4' Pipe	4' Pipe	-	-	-	Yes	-	-	-	-	-
5142	$351,476,914	71.3%	-	-	15 mgal	40MGD	9 mgal	5 mgal	5MGD	-	-	10MGD	7 mgal	5 MGD	-	2 mgal	5MGD	5' Pipe	6' Pipe	4' Pipe	5' Pipe	-	-	-	Yes	-	Yes	-	-
5143	$397,412,571	72.0%	-	8 mgal	15 mgal	40MGD	-	5 mgal	20MGD	-	-	-	-	-	12' Pipe	1 mgal	30MGD	5' Pipe	5' Pipe	5' Pipe	5' Pipe	4' Pipe	-	Yes	-	Yes	Yes	-	-
5144	$515,955,695	75.5%	-	4 mgal	25 mgal	30MGD	17 mgal	4 mgal	-	42" FM	40MGD	20MGD	7 mgal	5 MGD	12' Pipe	6 mgal	10MGD	-	-	5' Pipe	4' Pipe	6' Pipe	-	-	Yes	Yes	Yes	-	-
5145	$256,607,036	51.5%	-	8 mgal	5 mgal	10MGD	6 mgal	-	5MGD	30" FM	20MGD	20MGD	1 mgal	5 MGD	-	-	20MGD	4' Pipe	4' Pipe	6' Pipe	-	-	-	Yes	-	-	-	-	-
5146	$413,202,661	79.7%	-	16 mgal	35 mgal	-	15 mgal	-	10MGD	42" FM	40MGD	20MGD	1 mgal	5 MGD	-	4 mgal	-	6' Pipe	5' Pipe	4' Pipe	-	-	-	-	-	-	-	-	-
5147	$471,195,242	72.2%	-	16 mgal	15 mgal	30MGD	6 mgal	5 mgal	20MGD	30" FM	20MGD	10MGD	1 mgal	5 MGD	8' Pipe	-	30MGD	5' Pipe	6' Pipe	6' Pipe	5' Pipe	4' Pipe	-	Yes	Yes	Yes	-	-	-
5148	$607,159,445	77.4%	-	16 mgal	30 mgal	30MGD	15 mgal	3 mgal	10MGD	42" FM	40MGD	-	3 mgal	5 MGD	12' Pipe	5 mgal	30MGD	-	-	5' Pipe	6' Pipe	6' Pipe	-	Yes	Yes	Yes	Yes	-	-
5149	$449,741,308	73.1%	-	4 mgal	20 mgal	40MGD	3 mgal	3 mgal	20MGD	-	-	-	2 mgal	5 MGD	8' Pipe	1 mgal	30MGD	4' Pipe	-	4' Pipe	6' Pipe	5' Pipe	-	Yes	Yes	-	-	-	-
5150	$466,128,334	67.8%	-	20 mgal	30 mgal	40MGD	6 mgal	-	20MGD	-	-	-	1 mgal	5 MGD	5' Pipe	-	10MGD	5' Pipe	-	4' Pipe	-	6' Pipe	-	Yes	Yes	Yes	Yes	-	-
5151	$322,751,699	60.5%	-	16 mgal	5 mgal	30MGD	6 mgal	-	-	-	-	20MGD	5 mgal	5 MGD	5' Pipe	-	10MGD	5' Pipe	4' Pipe	5' Pipe	5' Pipe	-	-	Yes	-	-	Yes	-	-
5152	$460,638,474	67.4%	-	12 mgal	25 mgal	30MGD	12 mgal	-	20MGD	36" FM	30MGD	30MGD	-	-	5' Pipe	3 mgal	5MGD	5' Pipe	4' Pipe	-	5' Pipe	6' Pipe	-	-	-	-	-	-	-
5153	$303,350,808	46.7%	-	-	-	10MGD	17 mgal	-	5MGD	42" FM	40MGD	10MGD	3 mgal	5 MGD	8' Pipe	-	-	5' Pipe	6' Pipe	4' Pipe	-	5' Pipe	-	Yes	-	-	Yes	-	-
5154	$496,278,128	71.2%	-	16 mgal	5 mgal	10MGD	17 mgal	3 mgal	30MGD	42" FM	40MGD	30MGD	5 mgal	5 MGD	5' Pipe	1 mgal	20MGD	4' Pipe	5' Pipe	-	6' Pipe	4' Pipe	-	Yes	-	-	-	-	-
5155	$524,509,558	80.1%	-	20 mgal	20 mgal	20MGD	15 mgal	-	5MGD	42" FM	40MGD	-	6 mgal	5 MGD	8' Pipe	6 mgal	20MGD	4' Pipe	5' Pipe	-	5' Pipe	5' Pipe	-	Yes	Yes	Yes	-	-	-

Table B-1

Optimization Model Runs (Scenario ID)/ Alternatives - 1 yr 3 hr design event

Scenario ID	Life Cycle Cost	Percent Reduction	WWTP Upgrade	WWTP Storage	Diamond Ave Storage	Diamond Ave HRT	Storage at School	HRT_7thLS_Treatment	7th St HRT	Force Main to WRP	Pump to Force Main	7th St LS Increase Pumping	CSO 012 Storage	CSO 012 HRT	CSO 012 Siphon	CSO 013 Storage	CSO 013 HRT	Consolidate CSO 014 to CSO 012	Consolidate CSO 016 to 7th St LS	Consolidate CSO 016 to CSO 013	PCI Relief (N/S)	PCI Relief (E/W)	CSO 019 Storage	Separation (CSO 020/022)	Separation (CSO 013/016)	Separation (CSO 017)	Separation (CSO 025)	GSI (Basin 012)	GSI (Basin 020 and 022)
5156	$506,550,613	72.4%	-	-	30 mgal	20MGD	15 mgal	2 mgal	20MGD	36" FM	30MGD	10MGD	7 mgal	5 MGD	5' Pipe	-	30MGD	-	6' Pipe	6' Pipe	5' Pipe	4' Pipe	-	-	-	-	Yes	-	-
5157	$414,439,687	66.5%	-	20 mgal	5 mgal	20MGD	3 mgal	2 mgal	5MGD	30" FM	20MGD	-	4 mgal	5 MGD	5' Pipe	3 mgal	5MGD	4' Pipe	6' Pipe	5' Pipe	6' Pipe	6' Pipe	-	Yes	Yes	-	Yes	-	-
5158	$419,058,650	72.9%	-	12 mgal	30 mgal	10MGD	3 mgal	5 mgal	30MGD	30" FM	20MGD	10MGD	3 mgal	5 MGD	5' Pipe	1 mgal	5MGD	4' Pipe	4' Pipe	-	6' Pipe	-	-	-	-	Yes	-	-	-
5159	$247,060,013	55.4%	-	16 mgal	5 mgal	10MGD	-	3 mgal	-	-	-	-	3 mgal	5 MGD	5' Pipe	2 mgal	10MGD	-	-	4' Pipe	-	-	-	Yes	-	-	Yes	-	-
5160	$373,416,770	73.9%	-	20 mgal	25 mgal	20MGD	3 mgal	3 mgal	-	-	-	30MGD	-	-	-	1 mgal	20MGD	5' Pipe	6' Pipe	5' Pipe	4' Pipe	6' Pipe	-	-	-	-	-	-	-
5161	$399,144,693	73.0%	-	12 mgal	35 mgal	-	9 mgal	4 mgal	20MGD	-	-	-	4 mgal	5 MGD	8' Pipe	-	-	-	4' Pipe	5' Pipe	4' Pipe	5' Pipe	-	-	Yes	-	-	-	-
5162	$321,668,765	74.2%	-	4 mgal	25 mgal	10MGD	3 mgal	-	5MGD	-	-	-	5 mgal	5 MGD	12' Pipe	7 mgal	-	5' Pipe	6' Pipe	4' Pipe	6' Pipe	4' Pipe	-	Yes	Yes	-	-	-	-
5163	$407,371,783	80.3%	-	20 mgal	25 mgal	-	-	5 mgal	-	36" FM	30MGD	-	7 mgal	5 MGD	5' Pipe	3 mgal	10MGD	6' Pipe	4' Pipe	5' Pipe	-	5' Pipe	-	-	-	Yes	-	-	-
5164	$416,609,219	62.9%	-	4 mgal	5 mgal	20MGD	6 mgal	2 mgal	5MGD	36" FM	30MGD	10MGD	5 mgal	5 MGD	-	7 mgal	30MGD	4' Pipe	5' Pipe	6' Pipe	4' Pipe	6' Pipe	-	Yes	-	Yes	-	-	-
5165	$443,140,177	71.2%	-	4 mgal	20 mgal	30MGD	3 mgal	-	30MGD	30" FM	20MGD	30MGD	5 mgal	5 MGD	-	5 mgal	5MGD	5' Pipe	6' Pipe	-	4' Pipe	5' Pipe	-	-	Yes	-	-	-	-
5166	$382,191,841	67.3%	-	12 mgal	10 mgal	10MGD	9 mgal	5 mgal	5MGD	36" FM	30MGD	10MGD	5 mgal	5 MGD	5' Pipe	3 mgal	5MGD	-	4' Pipe	-	6' Pipe	6' Pipe	-	Yes	-	Yes	-	-	-
5167	$421,558,251	70.4%	-	-	10 mgal	30MGD	17 mgal	5 mgal	5MGD	30" FM	20MGD	30MGD	6 mgal	5 MGD	5' Pipe	-	30MGD	4' Pipe	5' Pipe	4' Pipe	6' Pipe	5' Pipe	-	Yes	-	Yes	-	-	-
5168	$289,744,630	67.7%	-	4 mgal	10 mgal	-	12 mgal	-	5MGD	-	-	-	6 mgal	5 MGD	12' Pipe	2 mgal	5MGD	5' Pipe	-	-	4' Pipe	4' Pipe	-	-	-	-	Yes	-	-
5169	$453,825,213	83.5%	-	8 mgal	25 mgal	10MGD	9 mgal	5 mgal	10MGD	30" FM	20MGD	-	7 mgal	5 MGD	5' Pipe	2 mgal	20MGD	6' Pipe	4' Pipe	6' Pipe	4' Pipe	-	-	-	Yes	Yes	Yes	-	-
5170	$405,038,500	67.3%	-	8 mgal	5 mgal	40MGD	12 mgal	4 mgal	10MGD	42" FM	40MGD	-	-	-	8' Pipe	-	5MGD	6' Pipe	5' Pipe	6' Pipe	4' Pipe	6' Pipe	-	-	Yes	-	-	-	-
5171	$367,412,291	43.3%	-	16 mgal	-	20MGD	3 mgal	2 mgal	5MGD	30" FM	20MGD	20MGD	1 mgal	5 MGD	8' Pipe	1 mgal	10MGD	-	4' Pipe	6' Pipe	5' Pipe	5' Pipe	-	Yes	Yes	-	Yes	-	-
5172	$409,534,009	45.1%	-	4 mgal	-	30MGD	-	5 mgal	30MGD	42" FM	40MGD	30MGD	2 mgal	5 MGD	12' Pipe	5 mgal	10MGD	5' Pipe	4' Pipe	-	5' Pipe	6' Pipe	-	Yes	Yes	Yes	-	-	-
5173	$452,107,066	72.7%	-	20 mgal	10 mgal	10MGD	12 mgal	-	5MGD	42" FM	40MGD	-	4 mgal	5 MGD	-	4 mgal	30MGD	6' Pipe	6' Pipe	5' Pipe	-	4' Pipe	-	Yes	Yes	-	Yes	-	-
5174	$547,913,430	76.5%	-	8 mgal	30 mgal	40MGD	17 mgal	2 mgal	20MGD	36" FM	30MGD	-	5 mgal	5 MGD	8' Pipe	5 mgal	5MGD	4' Pipe	5' Pipe	5' Pipe	6' Pipe	5' Pipe	-	-	-	-	-	-	-
5175	$444,243,861	80.1%	-	20 mgal	35 mgal	10MGD	15 mgal	-	30MGD	-	-	-	6 mgal	5 MGD	8' Pipe	-	-	5' Pipe	6' Pipe	4' Pipe	5' Pipe	-	-	Yes	-	-	-	-	-
5176	$451,889,541	74.0%	-	16 mgal	35 mgal	-	-	4 mgal	-	30" FM	20MGD	-	7 mgal	5 MGD	-	5 mgal	10MGD	4' Pipe	-	6' Pipe	5' Pipe	6' Pipe	-	Yes	Yes	Yes	Yes	-	-
5177	$308,479,516	58.7%	-	4 mgal	10 mgal	10MGD	6 mgal	2 mgal	5MGD	30" FM	20MGD	20MGD	2 mgal	5 MGD	5' Pipe	3 mgal	5MGD	-	4' Pipe	6' Pipe	-	5' Pipe	-	-	-	Yes	Yes	-	-
5178	$380,000,776	46.3%	-	4 mgal	-	30MGD	17 mgal	5 mgal	-	30" FM	20MGD	10MGD	7 mgal	5 MGD	-	2 mgal	20MGD	4' Pipe	5' Pipe	-	6' Pipe	-	-	-	-	-	Yes	Yes	-	-
5179	$395,161,235	70.8%	-	12 mgal	20 mgal	20MGD	6 mgal	4 mgal	-	-	-	20MGD	3 mgal	5 MGD	5' Pipe	-	10MGD	5' Pipe	5' Pipe	5' Pipe	5' Pipe	4' Pipe	-	Yes	Yes	Yes	Yes	-	-
5180	$412,948,922	75.2%	-	16 mgal	15 mgal	30MGD	3 mgal	3 mgal	20MGD	-	-	20MGD	5 mgal	5 MGD	5' Pipe	1 mgal	10MGD	4' Pipe	4' Pipe	4' Pipe	5' Pipe	-	-	Yes	-	Yes	Yes	-	-
5181	$365,140,113	63.3%	-	12 mgal	15 mgal	10MGD	3 mgal	4 mgal	10MGD	-	-	20MGD	3 mgal	5 MGD	5' Pipe	1 mgal	20MGD	5' Pipe	5' Pipe	-	5' Pipe	-	-	-	-	Yes	Yes	-	-
5182	$320,887,501	63.8%	-	-	15 mgal	30MGD	6 mgal	-	5MGD	-	-	20MGD	1 mgal	5 MGD	8' Pipe	1 mgal	10MGD	5' Pipe	5' Pipe	5' Pipe	5' Pipe	-	-	Yes	Yes	-	Yes	-	-
5183	$344,005,717	67.3%	-	16 mgal	10 mgal	10MGD	3 mgal	3 mgal	5MGD	-	-	20MGD	5 mgal	5 MGD	5' Pipe	1 mgal	10MGD	5' Pipe	4' Pipe	5' Pipe	5' Pipe	-	-	Yes	-	Yes	Yes	-	-
5184	$393,582,302	70.4%	-	16 mgal	15 mgal	20MGD	6 mgal	3 mgal	10MGD	30" FM	20MGD	20MGD	-	-	5' Pipe	2 mgal	10MGD	4' Pipe	4' Pipe	4' Pipe	4' Pipe	5' Pipe	-	Yes	-	-	-	-	-
5185	$426,502,895	77.3%	-	16 mgal	15 mgal	10MGD	6 mgal	3 mgal	20MGD	30" FM	20MGD	-	3 mgal	5 MGD	5' Pipe	3 mgal	10MGD	-	4' Pipe	4' Pipe	4' Pipe	5' Pipe	-	-	-	-	-	Yes	-	-
5186	$348,822,462	67.5%	-	16 mgal	10 mgal	10MGD	3 mgal	3 mgal	10MGD	-	-	-	3 mgal	5 MGD	5' Pipe	2 mgal	10MGD	-	4' Pipe	4' Pipe	4' Pipe	4' Pipe	-	-	-	-	-	Yes	-	-
5187	$410,497,425	75.8%	-	8 mgal	20 mgal	20MGD	6 mgal	4 mgal	10MGD	-	-	10MGD	3 mgal	5 MGD	5' Pipe	2 mgal	10MGD	4' Pipe	4' Pipe	5' Pipe	5' Pipe	4' Pipe	-	Yes	-	Yes	Yes	-	-
5188	$348,907,433	65.8%	-	12 mgal	10 mgal	10MGD	3 mgal	3 mgal	5MGD	-	-	10MGD	3 mgal	5 MGD	5' Pipe	2 mgal	10MGD	4' Pipe	4' Pipe	4' Pipe	4' Pipe	4' Pipe	-	Yes	-	Yes	Yes	-	-
5189	$354,126,234	77.3%	-	8 mgal	20 mgal	-	9 mgal	2 mgal	5MGD	30" FM	20MGD	10MGD	4 mgal	5 MGD	8' Pipe	5 mgal	-	5' Pipe	4' Pipe	5' Pipe	4' Pipe	5' Pipe	-	Yes	-	Yes	-	-	-
5190	$389,230,243	72.9%	-	12 mgal	20 mgal	30MGD	12 mgal	2 mgal	-	-	-	20MGD	2 mgal	5 MGD	8' Pipe	4 mgal	10MGD	4' Pipe	5' Pipe	6' Pipe	4' Pipe	5' Pipe	-	Yes	-	Yes	-	-	-
5191	$399,626,111	73.6%	-	16 mgal	15 mgal	20MGD	6 mgal	4 mgal	-	-	-	20MGD	2 mgal	5 MGD	5' Pipe	1 mgal	10MGD	5' Pipe	5' Pipe	5' Pipe	4' Pipe	5' Pipe	-	Yes	Yes	Yes	Yes	-	-
5192	$414,794,928	73.8%	-	12 mgal	15 mgal	20MGD	9 mgal	3 mgal	5MGD	30" FM	20MGD	-	1 mgal	5 MGD	8' Pipe	3 mgal	5MGD	-	4' Pipe	5' Pipe	4' Pipe	5' Pipe	-	Yes	Yes	-	Yes	-	-
5193	$431,617,357	76.1%	-	12 mgal	15 mgal	20MGD	9 mgal	4 mgal	5MGD	30" FM	20MGD	10MGD	1 mgal	5 MGD	8' Pipe	1 mgal	10MGD	5' Pipe	5' Pipe	5' Pipe	4' Pipe	4' Pipe	-	-	Yes	Yes	Yes	-	-
5194	$352,943,924	58.4%	-	8 mgal	5 mgal	20MGD	12 mgal	-	-	-	-	20MGD	2 mgal	5 MGD	5' Pipe	3 mgal	10MGD	5' Pipe	6' Pipe	-	4' Pipe	5' Pipe	-	Yes	-	Yes	-	-	-
5195	$389,786,824	75.2%	-	12 mgal	10 mgal	30MGD	9 mgal	3 mgal	-	-	-	10MGD	5 mgal	5 MGD	5' Pipe	2 mgal	5MGD	4' Pipe	4' Pipe	6' Pipe	4' Pipe	5' Pipe	-	Yes	Yes	Yes	Yes	-	-
5196	$390,287,747	69.8%	-	8 mgal	20 mgal	20MGD	6 mgal	4 mgal	-	-	-	20MGD	2 mgal	5 MGD	5' Pipe	1 mgal	10MGD	5' Pipe	5' Pipe	5' Pipe	5' Pipe	4' Pipe	-	Yes	Yes	Yes	Yes	-	-
5197	$547,902,209	76.1%	-	20 mgal	20 mgal	40MGD	15 mgal	3 mgal	20MGD	30" FM	20MGD	10MGD	3 mgal	5 MGD	8' Pipe	2 mgal	10MGD	-	4' Pipe	-	5' Pipe	6' Pipe	-	-	Yes	Yes	Yes	-	-
5198	$398,600,184	73.3%	-	8 mgal	15 mgal	10MGD	9 mgal	2 mgal	10MGD	30" FM	20MGD	20MGD	6 mgal	5 MGD	8' Pipe	3 mgal	10MGD	5' Pipe	4' Pipe	-	5' Pipe	4' Pipe	-	Yes	-	-	-	-	-
5199	$370,836,680	70.0%	-	8 mgal	10 mgal	20MGD	12 mgal	3 mgal	10MGD	-	-	10MGD	4 mgal	5 MGD	12' Pipe	-	10MGD	5' Pipe	5' Pipe	5' Pipe	4' Pipe	4' Pipe	-	Yes	Yes	Yes	-	-	-
5200	$335,188,727	70.1%	-	4 mgal	10 mgal	10MGD	15 mgal	2 mgal	5MGD	-	-	10MGD	6 mgal	5 MGD	8' Pipe	2 mgal	5MGD	5' Pipe	4' Pipe	-	4' Pipe	4' Pipe	-	Yes	-	-	-	-	-
5201	$345,796,524	78.4%	-	8 mgal	20 mgal	-	12 mgal	3 mgal	10MGD	-	-	-	6 mgal	5 MGD	12' Pipe	4 mgal	-	5' Pipe	4' Pipe	4' Pipe	4' Pipe	4' Pipe	-	-	-	Yes	-	-	-
5202	$471,932,057	77.7%	-	8 mgal	25 mgal	20MGD	9 mgal	2 mgal	5MGD	30" FM	20MGD	-	5 mgal	5 MGD	12' Pipe	6 mgal	10MGD	5' Pipe	-	4' Pipe	6' Pipe	5' Pipe	-	Yes	Yes	Yes	Yes	-	-
5203	$402,762,937	76.5%	-	4 mgal	25 mgal	10MGD	6 mgal	2 mgal	5MGD	-	-	-	5 mgal	5 MGD	12' Pipe	7 mgal	5MGD	5' Pipe	5' Pipe	4' Pipe	6' Pipe	4' Pipe	-	Yes	Yes	Yes	Yes	-	-
5204	$399,570,220	74.8%	-	12 mgal	15 mgal	20MGD	6 mgal	3 mgal	5MGD	-	-	10MGD	3 mgal	5 MGD	8' Pipe	3 mgal	10MGD	5' Pipe	-	5' Pipe	5' Pipe	4' Pipe	-	Yes	Yes	Yes	Yes	-	-
5205	$367,270,654	53.0%	-	12 mgal	-	10MGD	9 mgal	4 mgal	10MGD	30" FM	20MGD	30MGD	5 mgal	5 MGD	8' Pipe	2 mgal	5MGD	5' Pipe	6' Pipe	4' Pipe	5' Pipe	6' Pipe	-	-	-	-	Yes	-	-
5206	$376,803,411	74.7%	-	8 mgal	20 mgal	10MGD	6 mgal	3 mgal	5MGD	-	-	20MGD	5 mgal	5 MGD	12' Pipe	2 mgal	5MGD	5' Pipe	6' Pipe	4' Pipe	6' Pipe	5' Pipe	-	Yes	Yes	-	Yes	-	-
5207	$352,349,862	69.2%	-	4 mgal	15 mgal	10MGD	3 mgal	3 mgal	10MGD	-	-	-	5 mgal	5 MGD	8' Pipe	6 mgal	10MGD	4' Pipe	5' Pipe	4' Pipe	5' Pipe	4' Pipe	-	Yes	Yes	-	-	-	-
5208	$459,104,523	76.4%	-	4 mgal	15 mgal	40MGD	12 mgal	4 mgal	10MGD	-	-	10MGD	5 mgal	5 MGD	5' Pipe	1 mgal	20MGD	4' Pipe	4' Pipe	4' Pipe	5' Pipe	4' Pipe	-	Yes	Yes	-	Yes	-	-
5209	$438,822,091	72.9%	-	12 mgal	20 mgal	30MGD	3 mgal	4 mgal	10MGD	-	-	20MGD	2 mgal	5 MGD	5' Pipe	1 mgal	10MGD	5' Pipe	5' Pipe	4' Pipe	5' Pipe	4' Pipe	-	Yes	Yes	Yes	Yes	-	-
5210	$415,054,586	74.2%	-	4 mgal	30 mgal	20MGD	17 mgal	4 mgal	-	36" FM	30MGD	-	6 mgal	5 MGD	-	2 mgal	5MGD	4' Pipe	4' Pipe	5' Pipe	6' Pipe	-	-	-	Yes	-	-	-	-
5211	$409,559,721	74.7%	-	4 mgal	15 mgal	30MGD	15 mgal	5 mgal	5MGD	30" FM	20MGD	20MGD	7 mgal	5 MGD	-	2 mgal	5MGD	5' Pipe	4' Pipe	4' Pipe	5' Pipe	-	-	-	Yes	-	Yes	-	-
5212	$398,786,822	75.6%	-	16 mgal	15 mgal	20MGD	9 mgal	3 mgal	10MGD	-	-	10MGD	5 mgal	5 MGD	5' Pipe	1 mgal	5MGD	5' Pipe	6' Pipe	5' Pipe	5' Pipe	-	-	Yes	Yes	-	Yes	-	-
5213	$384,432,936	73.6%	-	4 mgal	15 mgal	40MGD	12 mgal	5 mgal	5MGD	-	-	10MGD	7 mgal	5 MGD	-	2 mgal	5MGD	5' Pipe	5' Pipe	4' Pipe	5' Pipe	-	-	-	Yes	-	Yes	-	-
5214	$446,752,998	75.9%	-	12 mgal	20 mgal	20MGD	9 mgal	3 mgal	5MGD	-	-	20MGD	5 mgal	5 MGD	-	1 mgal	20MGD	5' Pipe	4' Pipe	5' Pipe	5' Pipe	4' Pipe	-	Yes	Yes	Yes	Yes	-	-
5215	$389,964,887	49.3%	-	12 mgal	-	20MGD	17 mgal	2 mgal	-	-	-	30MGD	4 mgal	5 MGD	5' Pipe	7 mgal	30MGD	-	5' Pipe	-	5' Pipe	4' Pipe	-	-	-	Yes	Yes	-	-
5216	$429,023,252	71.1%	-	20 mgal	15 mgal	20MGD	3 mgal	-	10MGD	30" FM	20MGD	-	2 mgal	5 MGD	5' Pipe	2 mgal	5MGD	4' Pipe	5' Pipe	5' Pipe	5' Pipe	6' Pipe	-	Yes	Yes	Yes	Yes	-	-
5217	$429,681,184	71.8%	-	12 mgal	5 mgal	20MGD	9 mgal	3 mgal	5MGD	30" FM	20MGD	10MGD	6 mgal	5 MGD	8' Pipe	4 mgal	10MGD	4' Pipe	6' Pipe	5' Pipe	6' Pipe	5' Pipe	-	Yes	Yes	Yes	Yes	-	-
5218	$404,913,624	66.4%	-	12 mgal	5 mgal	20MGD	6 mgal	2 mgal	5MGD	30" FM	20MGD	10MGD	4 mgal	5 MGD	5' Pipe	3 mgal	5MGD	4' Pipe	6' Pipe	5' Pipe	6' Pipe	6' Pipe	-	Yes	Yes	Yes	Yes	-	-
5219	$434,985,220	72.2%	-	20 mgal	10 mgal	20MGD	3 mgal	3 mgal	5MGD	30" FM	20MGD	-	4 mgal	5 MGD	5' Pipe	3 mgal	5MGD	4' Pipe	6' Pipe	5' Pipe	6' Pipe	6' Pipe	-	Yes	Yes	Yes	Yes	-	-
5220	$414,730,764	72.9%	-	12 mgal	15 mgal	20MGD	9 mgal	3 mgal	5MGD	-	-	20MGD	3 mgal	5 MGD	5' Pipe	1 mgal	10MGD	5' Pipe	5' Pipe	5' Pipe	5' Pipe	5' Pipe	-	Yes	Yes	Yes	Yes	-	-
5221	$374,779,288	73.6%	-	-	5 mgal	10MGD	17 mgal	3 mgal	30MGD	-	-	-	4 mgal	5 MGD	5' Pipe	3 mgal	20MGD	5' Pipe	-	6' Pipe	-	6' Pipe	-	Yes	Yes	Yes	-	-	-
5222	$418,215,785	80.1%	-	16 mgal	20 mgal	20MGD	3 mgal	3 mgal	-	-	-	20MGD	6 mgal	5 MGD	5' Pipe	3 mgal	10MGD	5' Pipe	4' Pipe	5' Pipe	5' Pipe	5' Pipe	-	Yes	Yes	Yes	Yes	-	-
5223	$398,098,502	72.2%	-	16 mgal	10 mgal	30MGD	6 mgal	2 mgal	-	-	-	20MGD	5 mgal	5 MGD	5' Pipe	2 mgal	10MGD	5' Pipe	4' Pipe	5' Pipe	5' Pipe	4' Pipe	-	Yes	Yes	Yes	Yes	-	-
5224	$382,537,374	72.9%	-	16 mgal	15 mgal	10MGD	9 mgal	2 mgal	5MGD	-	-	10MGD	4 mgal	5 MGD	5' Pipe	-	10MGD	5' Pipe	5' Pipe	5' Pipe	5' Pipe	4' Pipe	-	Yes	-	Yes	Yes	-	-
5225	$365,987,916	66.8%	-	16 mgal	10 mgal	10MGD	6 mgal	2 mgal	5MGD	-	-	20MGD	5 mgal	5 MGD	5' Pipe	-	10MGD	5' Pipe	4' Pipe	5' Pipe	5' Pipe	4' Pipe	-	Yes	-	Yes	Yes	-	-
5226	$337,435,558	69.6%	-	8 mgal	10 mgal	10MGD	9 mgal	3 mgal	-	-	-	10MGD	4 mgal	5 MGD	8' Pipe	2 mgal	5MGD	5' Pipe	4' Pipe	4' Pipe	4' Pipe	4' Pipe	-	Yes	Yes	Yes	Yes	-	-
5227	$354,589,296	72.5%	-	8 mgal	15 mgal	10MGD	9 mgal	3 mgal	5MGD	-	-	10MGD	4 mgal	5 MGD	8' Pipe	2 mgal	5MGD	5' Pipe	5' Pipe	4' Pipe	5' Pipe	4' Pipe	-	Yes	Yes	Yes	Yes	-	-
5228	$358,368,199	70.6%	-	8 mgal	10 mgal	10MGD	9 mgal	3 mgal	5MGD	-	-	10MGD	4 mgal	5 MGD	8' Pipe	2 mgal	5MGD	5' Pipe	4' Pipe	4' Pipe	4' Pipe	4' Pipe	-	Yes	Yes	Yes	Yes	-	-
5229	$352,708,385	71.3%	-	8 mgal	10 mgal	10MGD	9 mgal	3 mgal	5MGD	-	-	10MGD	4 mgal	5 MGD	8' Pipe	3 mgal	5MGD	5' Pipe	4' Pipe	4' Pipe	4' Pipe	4' Pipe	-	Yes	-	Yes	Yes	-	-
5230	$360,833,459	68.8%	-	12 mgal	15 mgal	10MGD	6 mgal	2 mgal	5MGD	-	-	10MGD	3 mgal	5 MGD	5' Pipe	3 mgal	5MGD	4' Pipe	4' Pipe	4' Pipe	4' Pipe	4' Pipe	-	Yes	-	Yes	Yes	-	-
5231	$412,573,815	40.0%	-	12 mgal	-	20MGD	6 mgal	4 mgal	30MGD	42" FM	40MGD	-	7 mgal	5 MGD	-	7 mgal	-	6' Pipe	6' Pipe	-	6' Pipe	-	-	-	Yes	Yes	Yes	-	-
5232	$446,177,327	78.7%	-	4 mgal	15 mgal	20MGD	17 mgal	3 mgal	-	42" FM	40MGD	10MGD	4 mgal	5 MGD	8' Pipe	5 mgal	5MGD	5' Pipe	-	4' Pipe	4' Pipe	5' Pipe	-	Yes	Yes	Yes	Yes	-	-
5233	$420,818,733	70.2%	-	16 mgal	5 mgal	10MGD	12 mgal	-	5MGD	42" FM	40MGD	10MGD	3 mgal	5 MGD	8' Pipe	3 mgal	10MGD	5' Pipe	6' Pipe	4' Pipe	-	5' Pipe	-	Yes	Yes	-	Yes	-	-
5234	$430,451,383	74.1%	-	4 mgal	10 mgal	10MGD	17 mgal	2 mgal	10MGD	42" FM	40MGD	10MGD	2 mgal	5 MGD	8' Pipe	3 mgal	5MGD	5' Pipe	4' Pipe	4' Pipe	4' Pipe	5' Pipe	-	Yes	Yes	Yes	Yes	-	-

Table B-1

Optimization Model Runs (Scenario ID)/ Alternatives - 1 yr 3 hr design event

Scenario ID	Life Cycle Cost	Percent Reduction	WWTP Upgrade	WWTP Storage	Diamond Ave Storage	Diamond Ave HRT	Storage at School	HRT_7thLS_Treatment	7th St HRT	Force Main to WRP	Pump to Force Main	7th St LS Increase Pumping	CSO 012 Storage	CSO 012 HRT	CSO 012 Siphon	CSO 013 Storage	CSO 013 HRT	Consolidate CSO 014 to CSO 012	Consolidate CSO 016 to 7th St LS	Consolidate CSO 016 to CSO 013	PCI Relief (N/S)	PCI Relief (E/W)	CSO 019 Storage	Separation (CSO 020/022)	Separation (CSO 013/016)	Separation (CSO 017)	Separation (CSO 025)	GSI (Basin 012)	GSI (Basin 020 and 022)
5235	$408,504,942	72.3%	-	4 mgal	5 mgal	10MGD	17 mgal	2 mgal	5MGD	42" FM	40MGD	10MGD	3 mgal	5 MGD	8' Pipe	2 mgal	5MGD	5' Pipe	5' Pipe	4' Pipe	4' Pipe	5' Pipe	-	Yes	Yes	Yes	Yes	-	-
5236	$389,204,647	69.7%	-	12 mgal	5 mgal	10MGD	9 mgal	3 mgal	5MGD	30" FM	20MGD	10MGD	4 mgal	5 MGD	5' Pipe	2 mgal	10MGD	4' Pipe	4' Pipe	4' Pipe	4' Pipe	4' Pipe	-	Yes	Yes	Yes	Yes	-	-
5237	$383,684,161	74.8%	-	8 mgal	20 mgal	10MGD	3 mgal	2 mgal	10MGD	-	-	20MGD	5 mgal	5 MGD	12' Pipe	7 mgal	5MGD	5' Pipe	5' Pipe	4' Pipe	5' Pipe	4' Pipe	-	Yes	Yes	Yes	-	-	-
5238	$383,962,479	75.6%	-	4 mgal	25 mgal	10MGD	3 mgal	2 mgal	5MGD	-	-	10MGD	5 mgal	5 MGD	12' Pipe	7 mgal	5MGD	5' Pipe	6' Pipe	4' Pipe	6' Pipe	4' Pipe	-	Yes	Yes	Yes	-	-	-
5239	$383,962,479	75.6%	-	4 mgal	25 mgal	10MGD	3 mgal	2 mgal	5MGD	-	-	10MGD	5 mgal	5 MGD	12' Pipe	7 mgal	5MGD	5' Pipe	6' Pipe	4' Pipe	6' Pipe	4' Pipe	-	Yes	Yes	Yes	-	-	-
5240	$383,962,479	75.6%	-	4 mgal	25 mgal	10MGD	3 mgal	2 mgal	5MGD	-	-	10MGD	5 mgal	5 MGD	12' Pipe	7 mgal	5MGD	5' Pipe	6' Pipe	4' Pipe	6' Pipe	4' Pipe	-	Yes	Yes	Yes	-	-	-
5241	$435,153,617	76.4%	-	4 mgal	15 mgal	20MGD	9 mgal	2 mgal	10MGD	36" FM	30MGD	20MGD	4 mgal	5 MGD	5' Pipe	4 mgal	5MGD	5' Pipe	5' Pipe	5' Pipe	5' Pipe	5' Pipe	-	-	Yes	-	Yes	-	-
5242	$400,442,999	73.9%	-	4 mgal	15 mgal	10MGD	6 mgal	2 mgal	5MGD	36" FM	30MGD	30MGD	4 mgal	5 MGD	5' Pipe	2 mgal	5MGD	5' Pipe	5' Pipe	6' Pipe	4' Pipe	5' Pipe	-	-	Yes	-	Yes	-	-
5243	$412,653,336	74.9%	-	8 mgal	20 mgal	10MGD	3 mgal	2 mgal	5MGD	36" FM	30MGD	30MGD	4 mgal	5 MGD	5' Pipe	2 mgal	5MGD	-	5' Pipe	6' Pipe	4' Pipe	5' Pipe	-	Yes	Yes	-	Yes	-	-
5244	$348,295,286	64.3%	-	16 mgal	5 mgal	10MGD	3 mgal	4 mgal	5MGD	-	-	10MGD	3 mgal	5 MGD	5' Pipe	2 mgal	10MGD	-	4' Pipe	5' Pipe	4' Pipe	4' Pipe	-	Yes	Yes	-	Yes	-	-
5245	$409,654,214	77.0%	-	12 mgal	20 mgal	20MGD	17 mgal	5 mgal	20MGD	-	-	20MGD	1 mgal	5 MGD	5' Pipe	4 mgal	-	6' Pipe	6' Pipe	5' Pipe	4' Pipe	-	-	Yes	-	-	-	-	-
5246	$387,677,175	72.5%	-	8 mgal	10 mgal	10MGD	9 mgal	3 mgal	10MGD	30" FM	20MGD	30MGD	4 mgal	5 MGD	5' Pipe	3 mgal	-	5' Pipe	5' Pipe	6' Pipe	4' Pipe	4' Pipe	-	Yes	Yes	-	Yes	-	-
5247	$368,057,313	66.2%	-	8 mgal	10 mgal	10MGD	3 mgal	2 mgal	5MGD	30" FM	20MGD	20MGD	3 mgal	5 MGD	5' Pipe	4 mgal	5MGD	4' Pipe	4' Pipe	6' Pipe	4' Pipe	5' Pipe	-	Yes	-	Yes	Yes	-	-
5248	$355,835,866	61.3%	-	4 mgal	10 mgal	10MGD	3 mgal	2 mgal	5MGD	30" FM	20MGD	20MGD	2 mgal	5 MGD	5' Pipe	2 mgal	5MGD	4' Pipe	4' Pipe	6' Pipe	4' Pipe	5' Pipe	-	Yes	Yes	Yes	Yes	-	-
5249	$383,555,979	64.8%	-	4 mgal	10 mgal	20MGD	6 mgal	3 mgal	5MGD	30" FM	20MGD	20MGD	2 mgal	5 MGD	5' Pipe	1 mgal	5MGD	4' Pipe	4' Pipe	6' Pipe	4' Pipe	5' Pipe	-	Yes	Yes	Yes	Yes	-	-
5250	$337,686,193	64.3%	-	12 mgal	10 mgal	20MGD	3 mgal	2 mgal	5MGD	-	-	10MGD	3 mgal	5 MGD	5' Pipe	2 mgal	10MGD	4' Pipe	4' Pipe	4' Pipe	4' Pipe	-	-	Yes	Yes	-	Yes	-	-
5251	$345,483,845	42.7%	-	-	-	40MGD	15 mgal	2 mgal	20MGD	-	-	10MGD	1 mgal	5 MGD	5' Pipe	-	20MGD	6' Pipe	4' Pipe	-	4' Pipe	-	-	Yes	Yes	-	Yes	-	-
5252	$389,331,044	62.2%	-	4 mgal	10 mgal	20MGD	9 mgal	2 mgal	10MGD	30" FM	20MGD	20MGD	2 mgal	5 MGD	5' Pipe	-	10MGD	5' Pipe	4' Pipe	-	4' Pipe	5' Pipe	-	Yes	Yes	Yes	Yes	-	-
5253	$412,150,997	73.1%	-	12 mgal	10 mgal	40MGD	6 mgal	3 mgal	10MGD	-	-	-	4 mgal	5 MGD	8' Pipe	4 mgal	20MGD	4' Pipe	4' Pipe	5' Pipe	4' Pipe	4' Pipe	-	Yes	-	Yes	Yes	-	-
5254	$392,092,315	72.2%	-	12 mgal	5 mgal	40MGD	9 mgal	2 mgal	5MGD	-	-	-	6 mgal	5 MGD	8' Pipe	6 mgal	10MGD	4' Pipe	4' Pipe	6' Pipe	4' Pipe	5' Pipe	-	Yes	-	Yes	Yes	-	-
5255	$363,090,107	61.8%	-	12 mgal	5 mgal	30MGD	3 mgal	3 mgal	5MGD	-	-	-	3 mgal	5 MGD	5' Pipe	2 mgal	10MGD	4' Pipe	4' Pipe	4' Pipe	4' Pipe	4' Pipe	-	Yes	-	Yes	Yes	-	-
5256	$396,498,996	71.8%	-	12 mgal	5 mgal	40MGD	9 mgal	2 mgal	5MGD	-	-	-	5 mgal	5 MGD	8' Pipe	3 mgal	5MGD	4' Pipe	4' Pipe	5' Pipe	4' Pipe	5' Pipe	-	Yes	-	Yes	Yes	-	-
5257	$370,545,247	67.5%	-	12 mgal	5 mgal	20MGD	6 mgal	2 mgal	5MGD	-	-	10MGD	4 mgal	5 MGD	8' Pipe	4 mgal	10MGD	5' Pipe	4' Pipe	6' Pipe	4' Pipe	5' Pipe	-	Yes	-	Yes	Yes	-	-
5258	$393,432,237	64.3%	-	16 mgal	5 mgal	20MGD	3 mgal	3 mgal	5MGD	30" FM	20MGD	10MGD	3 mgal	5 MGD	8' Pipe	2 mgal	10MGD	5' Pipe	4' Pipe	5' Pipe	-	5' Pipe	-	Yes	-	-	Yes	-	-
5259	$532,854,924	80.3%	-	12 mgal	25 mgal	40MGD	15 mgal	4 mgal	5MGD	30" FM	20MGD	10MGD	4 mgal	5 MGD	12' Pipe	7 mgal	10MGD	5' Pipe	6' Pipe	6' Pipe	5' Pipe	5' Pipe	-	Yes	Yes	Yes	-	-	-
5260	$345,340,943	58.2%	-	12 mgal	5 mgal	10MGD	3 mgal	3 mgal	5MGD	-	-	10MGD	2 mgal	5 MGD	5' Pipe	2 mgal	10MGD	4' Pipe	5' Pipe	4' Pipe	5' Pipe	5' Pipe	-	Yes	Yes	Yes	Yes	-	-
5261	$341,519,816	61.5%	-	12 mgal	5 mgal	10MGD	3 mgal	3 mgal	5MGD	-	-	10MGD	3 mgal	5 MGD	5' Pipe	2 mgal	10MGD	4' Pipe	4' Pipe	4' Pipe	4' Pipe	4' Pipe	-	Yes	Yes	Yes	Yes	-	-
5262	$354,283,800	64.3%	-	16 mgal	5 mgal	10MGD	3 mgal	3 mgal	5MGD	-	-	10MGD	3 mgal	5 MGD	5' Pipe	2 mgal	10MGD	4' Pipe	4' Pipe	4' Pipe	4' Pipe	4' Pipe	-	Yes	Yes	Yes	Yes	-	-
5263	$396,574,154	64.1%	-	16 mgal	5 mgal	-	3 mgal	3 mgal	10MGD	30" FM	20MGD	20MGD	6 mgal	5 MGD	-	7 mgal	30MGD	5' Pipe	-	4' Pipe	4' Pipe	4' Pipe	-	Yes	Yes	-	-	-	-
5264	$372,163,709	63.0%	-	16 mgal	5 mgal	10MGD	3 mgal	3 mgal	5MGD	-	-	10MGD	5 mgal	5 MGD	-	4 mgal	20MGD	4' Pipe	-	4' Pipe	4' Pipe	4' Pipe	-	Yes	Yes	-	Yes	-	-
5265	$348,377,333	65.2%	-	16 mgal	5 mgal	10MGD	3 mgal	3 mgal	5MGD	-	-	10MGD	3 mgal	5 MGD	8' Pipe	2 mgal	10MGD	4' Pipe	-	4' Pipe	4' Pipe	4' Pipe	-	Yes	Yes	-	Yes	-	-
5266	$370,866,321	70.0%	-	12 mgal	10 mgal	10MGD	9 mgal	3 mgal	5MGD	-	-	10MGD	5 mgal	5 MGD	8' Pipe	1 mgal	5MGD	5' Pipe	4' Pipe	5' Pipe	4' Pipe	4' Pipe	-	Yes	Yes	Yes	Yes	-	-
5267	$364,703,958	74.6%	-	8 mgal	10 mgal	10MGD	12 mgal	3 mgal	5MGD	-	-	10MGD	4 mgal	5 MGD	8' Pipe	2 mgal	5MGD	4' Pipe	4' Pipe	4' Pipe	4' Pipe	4' Pipe	-	Yes	Yes	Yes	Yes	-	-
5268	$348,292,758	68.7%	-	8 mgal	10 mgal	10MGD	6 mgal	3 mgal	5MGD	-	-	10MGD	4 mgal	5 MGD	8' Pipe	2 mgal	5MGD	5' Pipe	4' Pipe	4' Pipe	4' Pipe	4' Pipe	-	Yes	Yes	Yes	Yes	-	-
5269	$348,292,758	68.7%	-	8 mgal	10 mgal	10MGD	6 mgal	3 mgal	5MGD	-	-	10MGD	4 mgal	5 MGD	8' Pipe	2 mgal	5MGD	5' Pipe	4' Pipe	4' Pipe	4' Pipe	4' Pipe	-	Yes	Yes	Yes	Yes	-	-
5270	$341,519,816	61.5%	-	12 mgal	5 mgal	10MGD	3 mgal	3 mgal	5MGD	-	-	10MGD	3 mgal	5 MGD	5' Pipe	2 mgal	10MGD	4' Pipe	4' Pipe	4' Pipe	4' Pipe	4' Pipe	-	Yes	Yes	Yes	Yes	-	-
5271	$347,550,828	71.2%	-	-	10 mgal	20MGD	17 mgal	-	5MGD	30" FM	20MGD	30MGD	2 mgal	5 MGD	12' Pipe	4 mgal	-	5' Pipe	4' Pipe	4' Pipe	-	4' Pipe	-	Yes	-	Yes	Yes	-	-
5272	$370,294,973	74.5%	-	8 mgal	15 mgal	10MGD	9 mgal	2 mgal	10MGD	-	-	10MGD	4 mgal	5 MGD	8' Pipe	4 mgal	5MGD	5' Pipe	5' Pipe	4' Pipe	4' Pipe	4' Pipe	-	-	-	Yes	Yes	-	-
5273	$395,231,362	74.9%	-	16 mgal	15 mgal	10MGD	3 mgal	3 mgal	10MGD	-	-	10MGD	4 mgal	5 MGD	5' Pipe	4 mgal	10MGD	5' Pipe	4' Pipe	4' Pipe	4' Pipe	4' Pipe	-	Yes	-	Yes	Yes	-	-
5274	$391,027,081	55.3%	-	-	-	30MGD	17 mgal	5 mgal	10MGD	36" FM	30MGD	-	3 mgal	5 MGD	12' Pipe	3 mgal	20MGD	5' Pipe	-	6' Pipe	6' Pipe	-	-	Yes	-	Yes	Yes	-	-
5275	$384,810,595	74.5%	-	4 mgal	10 mgal	20MGD	9 mgal	3 mgal	5MGD	30" FM	20MGD	-	3 mgal	5 MGD	12' Pipe	2 mgal	10MGD	5' Pipe	-	5' Pipe	5' Pipe	5' Pipe	-	Yes	-	Yes	Yes	-	-
5276	$334,136,091	72.1%	-	4 mgal	10 mgal	10MGD	12 mgal	2 mgal	5MGD	-	-	-	5 mgal	5 MGD	12' Pipe	2 mgal	5MGD	5' Pipe	-	4' Pipe	4' Pipe	4' Pipe	-	Yes	-	Yes	Yes	-	-
5277	$336,925,712	73.4%	-	4 mgal	10 mgal	10MGD	12 mgal	2 mgal	5MGD	-	-	-	6 mgal	5 MGD	12' Pipe	2 mgal	5MGD	5' Pipe	-	4' Pipe	4' Pipe	4' Pipe	-	Yes	-	Yes	Yes	-	-
5278	$370,068,069	69.4%	-	8 mgal	5 mgal	10MGD	12 mgal	2 mgal	5MGD	30" FM	20MGD	10MGD	3 mgal	5 MGD	8' Pipe	1 mgal	5MGD	5' Pipe	5' Pipe	4' Pipe	4' Pipe	5' Pipe	-	Yes	-	Yes	Yes	-	-
5279	$373,199,020	69.1%	-	4 mgal	5 mgal	10MGD	12 mgal	2 mgal	5MGD	36" FM	30MGD	10MGD	3 mgal	5 MGD	8' Pipe	1 mgal	5MGD	5' Pipe	6' Pipe	4' Pipe	4' Pipe	5' Pipe	-	Yes	-	Yes	Yes	-	-
5280	$400,794,893	71.1%	-	8 mgal	5 mgal	20MGD	12 mgal	2 mgal	10MGD	30" FM	20MGD	10MGD	3 mgal	5 MGD	8' Pipe	1 mgal	5MGD	5' Pipe	4' Pipe	4' Pipe	4' Pipe	5' Pipe	-	Yes	Yes	Yes	Yes	-	-
5281	$356,325,340	66.3%	-	16 mgal	5 mgal	20MGD	3 mgal	4 mgal	-	-	-	10MGD	3 mgal	5 MGD	5' Pipe	2 mgal	10MGD	4' Pipe	4' Pipe	4' Pipe	4' Pipe	4' Pipe	-	Yes	Yes	Yes	Yes	-	-
5282	$430,654,718	77.8%	-	-	25 mgal	30MGD	6 mgal	3 mgal	20MGD	30" FM	20MGD	-	5 mgal	5 MGD	-	4 mgal	20MGD	5' Pipe	4' Pipe	5' Pipe	6' Pipe	-	-	Yes	-	Yes	-	-	-
5283	$414,328,357	75.9%	-	-	15 mgal	20MGD	9 mgal	2 mgal	10MGD	36" FM	30MGD	20MGD	4 mgal	5 MGD	8' Pipe	2 mgal	10MGD	5' Pipe	5' Pipe	4' Pipe	5' Pipe	5' Pipe	-	Yes	-	Yes	Yes	-	-
5284	$413,029,519	74.1%	-	4 mgal	15 mgal	20MGD	6 mgal	3 mgal	10MGD	30" FM	20MGD	20MGD	2 mgal	5 MGD	8' Pipe	3 mgal	5MGD	4' Pipe	4' Pipe	5' Pipe	4' Pipe	5' Pipe	-	Yes	Yes	Yes	Yes	-	-
5285	$355,365,156	61.2%	-	4 mgal	10 mgal	10MGD	3 mgal	2 mgal	5MGD	30" FM	20MGD	20MGD	2 mgal	5 MGD	5' Pipe	2 mgal	5MGD	4' Pipe	4' Pipe	5' Pipe	4' Pipe	5' Pipe	-	Yes	Yes	Yes	Yes	-	-
5286	$391,261,631	68.8%	-	8 mgal	15 mgal	10MGD	6 mgal	2 mgal	5MGD	30" FM	20MGD	20MGD	2 mgal	5 MGD	5' Pipe	2 mgal	5MGD	4' Pipe	5' Pipe	4' Pipe	4' Pipe	5' Pipe	-	Yes	Yes	Yes	Yes	-	-
5287	$351,049,854	61.6%	-	4 mgal	5 mgal	10MGD	12 mgal	2 mgal	10MGD	-	-	10MGD	2 mgal	5 MGD	5' Pipe	2 mgal	10MGD	4' Pipe	4' Pipe	5' Pipe	5' Pipe	5' Pipe	-	Yes	Yes	Yes	Yes	-	-
5288	$326,540,607	58.9%	-	4 mgal	5 mgal	10MGD	9 mgal	3 mgal	10MGD	-	-	-	2 mgal	5 MGD	5' Pipe	2 mgal	10MGD	4' Pipe	-	5' Pipe	-	5' Pipe	-	Yes	Yes	Yes	Yes	-	-
5289	$381,903,834	62.6%	-	4 mgal	10 mgal	10MGD	6 mgal	2 mgal	5MGD	30" FM	20MGD	20MGD	2 mgal	5 MGD	5' Pipe	1 mgal	20MGD	4' Pipe	4' Pipe	6' Pipe	4' Pipe	4' Pipe	-	Yes	Yes	-	Yes	-	-
5290	$376,131,724	59.6%	-	8 mgal	5 mgal	10MGD	6 mgal	2 mgal	5MGD	30" FM	20MGD	20MGD	1 mgal	5 MGD	5' Pipe	1 mgal	20MGD	4' Pipe	4' Pipe	6' Pipe	4' Pipe	4' Pipe	-	Yes	Yes	-	Yes	-	-
5291	$338,446,977	58.4%	-	12 mgal	5 mgal	10MGD	3 mgal	3 mgal	5MGD	-	-	10MGD	2 mgal	5 MGD	5' Pipe	2 mgal	10MGD	4' Pipe	4' Pipe	5' Pipe	4' Pipe	4' Pipe	-	Yes	Yes	-	Yes	-	-
5292	$322,082,592	54.3%	-	8 mgal	5 mgal	10MGD	3 mgal	2 mgal	5MGD	-	-	20MGD	1 mgal	5 MGD	5' Pipe	1 mgal	10MGD	4' Pipe	4' Pipe	6' Pipe	4' Pipe	4' Pipe	-	Yes	Yes	-	Yes	-	-
5293	$380,941,666	57.1%	-	8 mgal	5 mgal	10MGD	3 mgal	2 mgal	5MGD	36" FM	30MGD	20MGD	1 mgal	5 MGD	5' Pipe	1 mgal	20MGD	4' Pipe	4' Pipe	6' Pipe	4' Pipe	4' Pipe	-	Yes	Yes	-	Yes	-	-
5294	$347,757,623	59.1%	-	16 mgal	5 mgal	10MGD	3 mgal	3 mgal	5MGD	-	-	10MGD	1 mgal	5 MGD	5' Pipe	1 mgal	10MGD	4' Pipe	4' Pipe	5' Pipe	4' Pipe	4' Pipe	-	Yes	Yes	-	Yes	-	-
5295	$381,075,822	72.4%	-	-	35 mgal	-	12 mgal	2 mgal	5MGD	-	-	20MGD	7 mgal	5 MGD	12' Pipe	4 mgal	-	4' Pipe	-	6' Pipe	5' Pipe	6' Pipe	-	-	-	-	Yes	-	-
5296	$399,127,698	70.7%	-	-	10 mgal	20MGD	9 mgal	3 mgal	5MGD	36" FM	30MGD	30MGD	3 mgal	5 MGD	5' Pipe	1 mgal	10MGD	5' Pipe	5' Pipe	5' Pipe	5' Pipe	5' Pipe	-	Yes	Yes	Yes	Yes	-	-
5297	$385,208,725	76.2%	-	-	15 mgal	10MGD	6 mgal	2 mgal	5MGD	36" FM	30MGD	30MGD	5 mgal	5 MGD	5' Pipe	3 mgal	5MGD	5' Pipe	5' Pipe	6' Pipe	4' Pipe	5' Pipe	-	Yes	Yes	Yes	Yes	-	-
5298	$367,004,095	70.3%	-	4 mgal	10 mgal	10MGD	6 mgal	2 mgal	5MGD	36" FM	30MGD	30MGD	4 mgal	5 MGD	5' Pipe	2 mgal	-	5' Pipe	5' Pipe	6' Pipe	4' Pipe	5' Pipe	-	Yes	Yes	-	Yes	-	-
5299	$345,752,049	70.2%	-	4 mgal	15 mgal	10MGD	6 mgal	2 mgal	5MGD	-	-	20MGD	3 mgal	5 MGD	8' Pipe	4 mgal	5MGD	5' Pipe	5' Pipe	5' Pipe	5' Pipe	5' Pipe	-	Yes	Yes	Yes	-	-	-
5300	$373,594,157	64.1%	-	16 mgal	5 mgal	10MGD	6 mgal	3 mgal	5MGD	30" FM	20MGD	10MGD	3 mgal	5 MGD	5' Pipe	2 mgal	5MGD	-	4' Pipe	4' Pipe	5' Pipe	5' Pipe	-	Yes	-	Yes	Yes	-	-
5301	$351,192,041	64.7%	-	16 mgal	5 mgal	10MGD	6 mgal	3 mgal	5MGD	-	-	10MGD	3 mgal	5 MGD	5' Pipe	2 mgal	10MGD	-	4' Pipe	5' Pipe	5' Pipe	5' Pipe	-	Yes	-	Yes	Yes	-	-
5302	$334,476,193	73.8%	-	4 mgal	20 mgal	10MGD	6 mgal	2 mgal	5MGD	-	-	10MGD	4 mgal	5 MGD	8' Pipe	2 mgal	-	4' Pipe	-	5' Pipe	4' Pipe	5' Pipe	-	Yes	-	-	Yes	-	-
5303	$336,136,442	63.5%	-	16 mgal	5 mgal	10MGD	3 mgal	3 mgal	5MGD	-	-	10MGD	3 mgal	5 MGD	5' Pipe	2 mgal	10MGD	-	4' Pipe	4' Pipe	4' Pipe	4' Pipe	-	Yes	-	Yes	Yes	-	-
5304	$336,136,442	63.5%	-	16 mgal	5 mgal	10MGD	3 mgal	3 mgal	5MGD	-	-	10MGD	3 mgal	5 MGD	5' Pipe	2 mgal	10MGD	-	4' Pipe	4' Pipe	4' Pipe	4' Pipe	-	Yes	-	Yes	Yes	-	-
5305	$321,638,419	43.2%	-	20 mgal	-	30MGD	3 mgal	-	-	-	-	-	6 mgal	5 MGD	-	5 mgal	5MGD	4' Pipe	4' Pipe	6' Pipe	5' Pipe	6' Pipe	-	-	-	Yes	Yes	-	-
5306	$349,305,843	68.0%	-	12 mgal	10 mgal	20MGD	3 mgal	3 mgal	-	-	-	-	3 mgal	5 MGD	8' Pipe	3 mgal	10MGD	4' Pipe	4' Pipe	5' Pipe	4' Pipe	5' Pipe	-	Yes	-	Yes	Yes	-	-
5307	$364,756,666	72.7%	-	16 mgal	10 mgal	20MGD	3 mgal	3 mgal	-	-	-	-	5 mgal	5 MGD	5' Pipe	3 mgal	10MGD	4' Pipe	4' Pipe	5' Pipe	4' Pipe	5' Pipe	-	Yes	-	Yes	Yes	-	-
5308	$561,587,066	77.8%	-	4 mgal	30 mgal	20MGD	12 mgal	5 mgal	30MGD	42" FM	40MGD	10MGD	2 mgal	5 MGD	12' Pipe	1 mgal	30MGD	4' Pipe	-	4' Pipe	6' Pipe	6' Pipe	-	-	-	-	-	-	-
5309	$386,981,148	72.3%	-	8 mgal	10 mgal	30MGD	9 mgal	3 mgal	5MGD	-	-	-	4 mgal	5 MGD	8' Pipe	2 mgal	5MGD	5' Pipe	4' Pipe	4' Pipe	4' Pipe	4' Pipe	-	Yes	Yes	Yes	Yes	-	-
5310	$368,492,891	66.3%	-	16 mgal	5 mgal	20MGD	6 mgal	3 mgal	5MGD	-	-	-	3 mgal	5 MGD	5' Pipe	2 mgal	10MGD	4' Pipe	4' Pipe	4' Pipe	4' Pipe	4' Pipe	-	Yes	-	Yes	Yes	-	-
5311	$424,982,365	73.8%	-	4 mgal	25 mgal	20MGD	3 mgal	2 mgal	10MGD	36" FM	30MGD	30MGD	2 mgal	5 MGD	5' Pipe	3 mgal	-	4' Pipe	4' Pipe	5' Pipe	4' Pipe	4' Pipe	-	Yes	Yes	Yes	Yes	-	-
5312	$361,815,883	71.3%	-	8 mgal	15 mgal	10MGD	3 mgal	3 mgal	5MGD	-	-	20MGD	5 mgal	5 MGD	8' Pipe	2 mgal	5MGD	5' Pipe	4' Pipe	4' Pipe	4' Pipe	4' Pipe	-	Yes	Yes	Yes	Yes	-	-
5313	$374,650,458	74.0%	-	12 mgal	10 mgal	10MGD	9 mgal	4 mgal	5MGD	-	-	10MGD	4 mgal	5 MGD	8' Pipe	2 mgal	5MGD	5' Pipe	4' Pipe	4' Pipe	4' Pipe	4' Pipe	-	Yes	Yes	Yes	Yes	-	-

Table B-1

Optimization Model Runs (Scenario ID)/ Alternatives - 1 yr 3 hr design event

Scenario ID	Life Cycle Cost	Percent Reduction	WWTP Upgrade	WWTP Storage	Diamond Ave Storage	Diamond Ave HRT	Storage at School	HRT_7thLS_Treatment	7th St HRT	Force Main to WRP	Pump to Force Main	7th St LS Increase Pumping	CSO 012 Storage	CSO 012 HRT	CSO 012 Siphon	CSO 013 Storage	CSO 013 HRT	Consolidate CSO 014 to CSO 012	Consolidate CSO 016 to 7th St LS	Consolidate CSO 016 to CSO 013	PCI Relief (N/S)	PCI Relief (E/W)	CSO 019 Storage	Separation (CSO 020/022)	Separation (CSO 013/016)	Separation (CSO 017)	Separation (CSO 025)	GSI (Basin 012)	GSI (Basin 020 and 022)
5314	$357,099,558	71.4%	-	8 mgal	10 mgal	10MGD	9 mgal	3 mgal	5MGD	-	-	10MGD	4 mgal	5 MGD	8' Pipe	2 mgal	5MGD	5' Pipe	4' Pipe	4' Pipe	4' Pipe	4' Pipe	-	Yes	Yes	Yes	Yes	-	-
5315	$379,258,600	65.5%	-	16 mgal	5 mgal	10MGD	6 mgal	3 mgal	5MGD	-	-	10MGD	3 mgal	5 MGD	5' Pipe	2 mgal	20MGD	4' Pipe	4' Pipe	4' Pipe	4' Pipe	4' Pipe	-	Yes	Yes	Yes	Yes	-	-
5316	$426,482,477	74.9%	-	16 mgal	30 mgal	20MGD	6 mgal	5 mgal	-	-	-	20MGD	4 mgal	5 MGD	-	6 mgal	20MGD	5' Pipe	5' Pipe	-	5' Pipe	-	-	-	-	Yes	Yes	-	-
5317	$399,729,175	79.3%	-	8 mgal	15 mgal	20MGD	9 mgal	3 mgal	5MGD	-	-	10MGD	6 mgal	5 MGD	12' Pipe	4 mgal	5MGD	5' Pipe	5' Pipe	5' Pipe	4' Pipe	4' Pipe	-	Yes	Yes	Yes	Yes	-	-
5318	$391,005,729	75.9%	-	4 mgal	15 mgal	20MGD	12 mgal	3 mgal	5MGD	30" FM	20MGD	-	2 mgal	5 MGD	12' Pipe	3 mgal	5MGD	5' Pipe	4' Pipe	5' Pipe	4' Pipe	5' Pipe	-	-	Yes	-	-	-	-
5319	$362,697,293	74.8%	-	4 mgal	10 mgal	10MGD	15 mgal	2 mgal	5MGD	-	-	10MGD	6 mgal	5 MGD	12' Pipe	2 mgal	5MGD	5' Pipe	4' Pipe	4' Pipe	4' Pipe	4' Pipe	-	Yes	Yes	Yes	Yes	-	-
5320	$376,820,444	71.5%	-	16 mgal	10 mgal	10MGD	6 mgal	3 mgal	5MGD	-	-	10MGD	3 mgal	5 MGD	8' Pipe	2 mgal	10MGD	4' Pipe	4' Pipe	4' Pipe	4' Pipe	4' Pipe	-	Yes	Yes	Yes	Yes	-	-
5321	$407,932,122	65.8%	-	4 mgal	5 mgal	30MGD	9 mgal	2 mgal	10MGD	36" FM	30MGD	20MGD	7 mgal	5 MGD	5' Pipe	1 mgal	10MGD	5' Pipe	-	-	5' Pipe	4' Pipe	-	Yes	Yes	Yes	-	-	-
5322	$356,189,355	67.4%	-	4 mgal	10 mgal	20MGD	9 mgal	2 mgal	5MGD	-	-	10MGD	5 mgal	5 MGD	8' Pipe	3 mgal	5MGD	5' Pipe	-	-	4' Pipe	4' Pipe	-	Yes	Yes	Yes	Yes	-	-
5323	$362,147,825	54.6%	-	8 mgal	-	10MGD	17 mgal	2 mgal	-	30" FM	20MGD	20MGD	3 mgal	5 MGD	8' Pipe	4 mgal	10MGD	5' Pipe	6' Pipe	5' Pipe	4' Pipe	5' Pipe	-	-	-	Yes	Yes	-	-
5324	$366,406,440	54.2%	-	4 mgal	-	10MGD	17 mgal	2 mgal	5MGD	36" FM	30MGD	10MGD	3 mgal	5 MGD	8' Pipe	2 mgal	5MGD	5' Pipe	6' Pipe	4' Pipe	4' Pipe	5' Pipe	-	-	-	Yes	Yes	-	-
5325	$332,062,050	63.1%	-	12 mgal	5 mgal	10MGD	9 mgal	3 mgal	-	-	-	10MGD	3 mgal	5 MGD	5' Pipe	3 mgal	10MGD	4' Pipe	5' Pipe	4' Pipe	4' Pipe	4' Pipe	-	-	-	Yes	Yes	-	-
5326	$360,276,712	66.5%	-	8 mgal	5 mgal	10MGD	12 mgal	2 mgal	5MGD	30" FM	20MGD	10MGD	3 mgal	5 MGD	8' Pipe	-	5MGD	5' Pipe	5' Pipe	4' Pipe	4' Pipe	5' Pipe	-	Yes	-	Yes	Yes	-	-
5327	$372,214,463	68.7%	-	4 mgal	5 mgal	10MGD	15 mgal	2 mgal	5MGD	36" FM	30MGD	10MGD	3 mgal	5 MGD	8' Pipe	-	5MGD	5' Pipe	6' Pipe	4' Pipe	4' Pipe	5' Pipe	-	Yes	-	Yes	Yes	-	-
5328	$345,359,371	64.5%	-	16 mgal	5 mgal	10MGD	6 mgal	3 mgal	5MGD	-	-	10MGD	3 mgal	5 MGD	5' Pipe	1 mgal	5MGD	4' Pipe	4' Pipe	4' Pipe	4' Pipe	4' Pipe	-	Yes	-	Yes	Yes	-	-
5329	$396,523,784	74.2%	-	12 mgal	20 mgal	10MGD	3 mgal	2 mgal	5MGD	-	-	-	5 mgal	5 MGD	8' Pipe	5 mgal	5MGD	5' Pipe	6' Pipe	4' Pipe	6' Pipe	5' Pipe	-	Yes	Yes	-	Yes	-	-
5330	$383,681,764	73.5%	-	8 mgal	20 mgal	10MGD	3 mgal	2 mgal	5MGD	-	-	-	5 mgal	5 MGD	8' Pipe	6 mgal	5MGD	5' Pipe	6' Pipe	4' Pipe	6' Pipe	4' Pipe	-	Yes	Yes	-	Yes	-	-
5331	$391,128,568	76.4%	-	4 mgal	25 mgal	10MGD	3 mgal	2 mgal	5MGD	-	-	-	5 mgal	5 MGD	12' Pipe	6 mgal	5MGD	5' Pipe	6' Pipe	4' Pipe	6' Pipe	4' Pipe	-	Yes	Yes	-	Yes	-	-
5332	$389,820,944	67.1%	-	12 mgal	10 mgal	10MGD	3 mgal	4 mgal	5MGD	30" FM	20MGD	-	3 mgal	5 MGD	5' Pipe	3 mgal	10MGD	4' Pipe	5' Pipe	4' Pipe	5' Pipe	4' Pipe	-	Yes	Yes	-	Yes	-	-
5333	$454,946,849	75.1%	-	20 mgal	35 mgal	20MGD	-	-	-	30" FM	20MGD	10MGD	1 mgal	5 MGD	5' Pipe	6 mgal	5MGD	-	5' Pipe	5' Pipe	-	6' Pipe	-	Yes	Yes	-	Yes	-	-
5334	$427,669,740	76.2%	-	12 mgal	30 mgal	10MGD	6 mgal	-	5MGD	-	-	10MGD	4 mgal	5 MGD	5' Pipe	6 mgal	5MGD	4' Pipe	5' Pipe	4' Pipe	5' Pipe	5' Pipe	-	Yes	Yes	-	Yes	-	-
5335	$346,081,508	59.8%	-	4 mgal	10 mgal	10MGD	6 mgal	2 mgal	5MGD	-	-	20MGD	2 mgal	5 MGD	5' Pipe	1 mgal	20MGD	4' Pipe	4' Pipe	5' Pipe	4' Pipe	4' Pipe	-	Yes	-	Yes	Yes	-	-
5336	$329,517,372	54.2%	-	4 mgal	5 mgal	10MGD	6 mgal	2 mgal	5MGD	-	-	20MGD	1 mgal	5 MGD	5' Pipe	1 mgal	20MGD	4' Pipe	4' Pipe	6' Pipe	4' Pipe	4' Pipe	-	Yes	-	Yes	Yes	-	-
5337	$329,517,372	54.2%	-	4 mgal	5 mgal	10MGD	6 mgal	2 mgal	5MGD	-	-	20MGD	1 mgal	5 MGD	5' Pipe	1 mgal	20MGD	4' Pipe	4' Pipe	6' Pipe	4' Pipe	4' Pipe	-	Yes	-	Yes	Yes	-	-
5338	$383,471,182	59.2%	-	8 mgal	5 mgal	10MGD	6 mgal	2 mgal	5MGD	36" FM	30MGD	20MGD	1 mgal	5 MGD	5' Pipe	1 mgal	20MGD	4' Pipe	4' Pipe	6' Pipe	4' Pipe	4' Pipe	-	Yes	-	Yes	Yes	-	-
5339	$319,781,021	62.0%	-	4 mgal	5 mgal	10MGD	3 mgal	4 mgal	5MGD	-	-	10MGD	4 mgal	5 MGD	5' Pipe	2 mgal	10MGD	4' Pipe	4' Pipe	5' Pipe	4' Pipe	4' Pipe	-	Yes	-	Yes	Yes	-	-
5340	$460,401,787	77.3%	-	12 mgal	35 mgal	-	-	-	10MGD	36" FM	30MGD	10MGD	7 mgal	5 MGD	5' Pipe	-	30MGD	6' Pipe	4' Pipe	5' Pipe	5' Pipe	4' Pipe	-	Yes	Yes	Yes	-	-	-
5341	$405,276,588	78.6%	-	12 mgal	20 mgal	10MGD	9 mgal	2 mgal	10MGD	-	-	-	4 mgal	5 MGD	5' Pipe	4 mgal	5MGD	5' Pipe	5' Pipe	5' Pipe	4' Pipe	4' Pipe	-	Yes	Yes	Yes	Yes	-	-
5342	$402,269,638	75.7%	-	8 mgal	15 mgal	10MGD	6 mgal	2 mgal	5MGD	30" FM	20MGD	20MGD	5 mgal	5 MGD	5' Pipe	3 mgal	5MGD	5' Pipe	5' Pipe	6' Pipe	4' Pipe	5' Pipe	-	Yes	Yes	Yes	Yes	-	-
5343	$419,977,268	73.5%	-	4 mgal	20 mgal	10MGD	6 mgal	2 mgal	5MGD	36" FM	30MGD	20MGD	5 mgal	5 MGD	-	4 mgal	20MGD	4' Pipe	5' Pipe	6' Pipe	4' Pipe	5' Pipe	-	Yes	-	Yes	-	-	-
5344	$412,663,507	76.1%	-	4 mgal	15 mgal	10MGD	6 mgal	2 mgal	5MGD	36" FM	30MGD	30MGD	5 mgal	5 MGD	5' Pipe	2 mgal	10MGD	4' Pipe	5' Pipe	6' Pipe	4' Pipe	5' Pipe	-	Yes	Yes	Yes	Yes	-	-
5345	$394,925,809	72.9%	-	12 mgal	15 mgal	10MGD	3 mgal	3 mgal	5MGD	30" FM	20MGD	10MGD	4 mgal	5 MGD	5' Pipe	2 mgal	10MGD	4' Pipe	4' Pipe	5' Pipe	4' Pipe	4' Pipe	-	Yes	-	Yes	Yes	-	-
5346	$455,085,781	69.2%	-	16 mgal	25 mgal	30MGD	15 mgal	5 mgal	-	30" FM	20MGD	30MGD	1 mgal	5 MGD	5' Pipe	2 mgal	5MGD	4' Pipe	-	5' Pipe	6' Pipe	5' Pipe	-	-	-	-	-	-	-
5347	$361,389,100	64.7%	-	16 mgal	5 mgal	10MGD	6 mgal	3 mgal	5MGD	-	-	10MGD	3 mgal	5 MGD	5' Pipe	2 mgal	10MGD	4' Pipe	4' Pipe	4' Pipe	4' Pipe	4' Pipe	-	Yes	Yes	Yes	Yes	-	-
5348	$352,582,300	64.0%	-	16 mgal	5 mgal	10MGD	3 mgal	3 mgal	5MGD	-	-	10MGD	3 mgal	5 MGD	5' Pipe	2 mgal	10MGD	4' Pipe	4' Pipe	4' Pipe	4' Pipe	4' Pipe	-	Yes	Yes	Yes	Yes	-	-
5349	$352,582,300	64.0%	-	16 mgal	5 mgal	10MGD	3 mgal	3 mgal	5MGD	-	-	10MGD	3 mgal	5 MGD	5' Pipe	2 mgal	10MGD	4' Pipe	4' Pipe	4' Pipe	4' Pipe	4' Pipe	-	Yes	Yes	Yes	Yes	-	-
5350	$352,582,300	64.0%	-	16 mgal	5 mgal	10MGD	3 mgal	3 mgal	5MGD	-	-	10MGD	3 mgal	5 MGD	5' Pipe	2 mgal	10MGD	4' Pipe	4' Pipe	4' Pipe	4' Pipe	4' Pipe	-	Yes	Yes	Yes	Yes	-	-
5351	$352,582,300	64.0%	-	16 mgal	5 mgal	10MGD	3 mgal	3 mgal	5MGD	-	-	10MGD	3 mgal	5 MGD	5' Pipe	2 mgal	10MGD	4' Pipe	4' Pipe	4' Pipe	4' Pipe	4' Pipe	-	Yes	Yes	Yes	Yes	-	-
5352	$402,512,757	74.9%	-	12 mgal	10 mgal	10MGD	9 mgal	3 mgal	5MGD	30" FM	20MGD	20MGD	4 mgal	5 MGD	8' Pipe	2 mgal	5MGD	5' Pipe	4' Pipe	5' Pipe	4' Pipe	4' Pipe	-	Yes	Yes	Yes	Yes	-	-
5353	$320,218,004	58.3%	-	12 mgal	5 mgal	10MGD	3 mgal	4 mgal	5MGD	-	-	20MGD	2 mgal	5 MGD	5' Pipe	2 mgal	-	4' Pipe	4' Pipe	5' Pipe	4' Pipe	4' Pipe	-	Yes	Yes	-	Yes	-	-
5354	$345,594,359	67.6%	-	8 mgal	10 mgal	10MGD	6 mgal	3 mgal	5MGD	-	-	10MGD	3 mgal	5 MGD	8' Pipe	2 mgal	5MGD	4' Pipe	4' Pipe	4' Pipe	4' Pipe	4' Pipe	-	Yes	Yes	Yes	Yes	-	-
5355	$350,869,523	60.1%	-	16 mgal	5 mgal	10MGD	3 mgal	3 mgal	5MGD	-	-	10MGD	2 mgal	5 MGD	5' Pipe	2 mgal	10MGD	4' Pipe	4' Pipe	4' Pipe	4' Pipe	4' Pipe	-	Yes	Yes	-	Yes	-	-
5356	$336,259,197	65.8%	-	4 mgal	10 mgal	30MGD	9 mgal	2 mgal	-	42" FM	40MGD	30MGD	-	-	-	-	-	5' Pipe	-	5' Pipe	-	6' Pipe	-	Yes	-	Yes	Yes	-	-
5357	$338,350,442	64.8%	-	8 mgal	5 mgal	10MGD	6 mgal	3 mgal	5MGD	-	-	10MGD	4 mgal	5 MGD	8' Pipe	3 mgal	5MGD	5' Pipe	5' Pipe	4' Pipe	4' Pipe	4' Pipe	-	Yes	Yes	Yes	Yes	-	-
5358	$345,607,595	63.5%	-	12 mgal	5 mgal	10MGD	6 mgal	3 mgal	5MGD	-	-	10MGD	3 mgal	5 MGD	5' Pipe	2 mgal	10MGD	4' Pipe	5' Pipe	4' Pipe	4' Pipe	4' Pipe	-	Yes	-	Yes	Yes	-	-
5359	$405,279,989	73.9%	-	16 mgal	10 mgal	30MGD	17 mgal	-	-	-	-	20MGD	6 mgal	5 MGD	5' Pipe	1 mgal	5MGD	5' Pipe	6' Pipe	6' Pipe	-	6' Pipe	-	Yes	-	Yes	Yes	-	-
5360	$371,203,453	70.5%	-	8 mgal	10 mgal	20MGD	12 mgal	3 mgal	-	-	-	10MGD	3 mgal	5 MGD	5' Pipe	3 mgal	5MGD	5' Pipe	5' Pipe	5' Pipe	5' Pipe	5' Pipe	-	Yes	Yes	Yes	Yes	-	-
5361	$380,179,997	64.6%	-	16 mgal	5 mgal	20MGD	9 mgal	3 mgal	-	-	-	10MGD	3 mgal	5 MGD	5' Pipe	2 mgal	20MGD	4' Pipe	5' Pipe	5' Pipe	-	5' Pipe	-	Yes	-	Yes	Yes	-	-
5362	$334,386,867	67.1%	-	4 mgal	10 mgal	10MGD	12 mgal	-	5MGD	-	-	10MGD	3 mgal	5 MGD	8' Pipe	2 mgal	10MGD	5' Pipe	5' Pipe	-	4' Pipe	4' Pipe	-	Yes	-	Yes	Yes	-	-
5363	$313,930,235	59.3%	-	8 mgal	5 mgal	10MGD	6 mgal	3 mgal	-	-	-	10MGD	3 mgal	5 MGD	5' Pipe	2 mgal	10MGD	4' Pipe	5' Pipe	4' Pipe	4' Pipe	4' Pipe	-	Yes	-	Yes	Yes	-	-
5364	$348,592,914	66.6%	-	4 mgal	5 mgal	10MGD	9 mgal	3 mgal	5MGD	-	-	10MGD	4 mgal	5 MGD	5' Pipe	2 mgal	20MGD	4' Pipe	5' Pipe	5' Pipe	4' Pipe	4' Pipe	-	Yes	-	Yes	Yes	-	-
5365	$355,079,965	63.8%	-	12 mgal	5 mgal	10MGD	9 mgal	4 mgal	5MGD	-	-	10MGD	3 mgal	5 MGD	5' Pipe	2 mgal	20MGD	4' Pipe	4' Pipe	4' Pipe	4' Pipe	4' Pipe	-	Yes	-	-	-	-	-
5366	$505,613,875	76.2%	-	12 mgal	30 mgal	-	17 mgal	2 mgal	20MGD	42" FM	40MGD	10MGD	1 mgal	5 MGD	-	2 mgal	5MGD	4' Pipe	4' Pipe	4' Pipe	6' Pipe	5' Pipe	-	Yes	Yes	Yes	Yes	-	-
5367	$415,805,024	73.0%	-	8 mgal	15 mgal	10MGD	9 mgal	4 mgal	10MGD	30" FM	20MGD	10MGD	3 mgal	5 MGD	5' Pipe	2 mgal	5MGD	4' Pipe	4' Pipe	4' Pipe	5' Pipe	4' Pipe	-	Yes	Yes	Yes	Yes	-	-
5368	$346,983,168	65.2%	-	8 mgal	10 mgal	10MGD	6 mgal	3 mgal	5MGD	-	-	10MGD	3 mgal	5 MGD	5' Pipe	2 mgal	5MGD	4' Pipe	5' Pipe	4' Pipe	4' Pipe	4' Pipe	-	Yes	Yes	Yes	Yes	-	-
5369	$473,751,485	78.5%	-	12 mgal	15 mgal	20MGD	17 mgal	3 mgal	10MGD	36" FM	30MGD	20MGD	4 mgal	5 MGD	5' Pipe	1 mgal	5MGD	5' Pipe	5' Pipe	4' Pipe	5' Pipe	5' Pipe	-	Yes	-	-	Yes	-	-
5370	$394,985,820	74.1%	-	16 mgal	20 mgal	20MGD	9 mgal	4 mgal	-	-	-	20MGD	3 mgal	5 MGD	5' Pipe	2 mgal	10MGD	4' Pipe	-	4' Pipe	5' Pipe	4' Pipe	-	-	-	-	-	-	-
5371	$366,686,523	71.2%	-	8 mgal	10 mgal	10MGD	15 mgal	3 mgal	-	36" FM	30MGD	10MGD	3 mgal	5 MGD	8' Pipe	1 mgal	5MGD	5' Pipe	5' Pipe	4' Pipe	4' Pipe	4' Pipe	-	-	-	-	-	-	-
5372	$377,060,809	70.2%	-	4 mgal	5 mgal	10MGD	12 mgal	2 mgal	5MGD	36" FM	30MGD	10MGD	3 mgal	5 MGD	8' Pipe	2 mgal	5MGD	5' Pipe	-	4' Pipe	4' Pipe	5' Pipe	-	Yes	Yes	Yes	Yes	-	-
5373	$362,053,954	64.7%	-	12 mgal	5 mgal	10MGD	6 mgal	3 mgal	5MGD	-	-	10MGD	3 mgal	5 MGD	5' Pipe	2 mgal	20MGD	4' Pipe	-	4' Pipe	4' Pipe	4' Pipe	-	Yes	Yes	Yes	Yes	-	-
5374	$398,243,635	70.8%	-	8 mgal	5 mgal	10MGD	12 mgal	2 mgal	5MGD	36" FM	30MGD	10MGD	3 mgal	5 MGD	8' Pipe	1 mgal	10MGD	5' Pipe	4' Pipe	4' Pipe	4' Pipe	5' Pipe	-	Yes	Yes	Yes	Yes	-	-
5375	$349,843,138	62.8%	-	16 mgal	5 mgal	10MGD	3 mgal	3 mgal	5MGD	-	-	10MGD	3 mgal	5 MGD	5' Pipe	2 mgal	10MGD	4' Pipe	-	4' Pipe	4' Pipe	4' Pipe	-	Yes	Yes	Yes	Yes	-	-
5376	$335,555,128	74.2%	-	4 mgal	15 mgal	20MGD	9 mgal	2 mgal	-	-	-	-	7 mgal	5 MGD	5' Pipe	3 mgal	-	5' Pipe	4' Pipe	-	4' Pipe	6' Pipe	-	Yes	-	-	Yes	-	-
5377	$379,776,144	72.2%	-	4 mgal	20 mgal	20MGD	6 mgal	3 mgal	5MGD	-	-	10MGD	5 mgal	5 MGD	8' Pipe	5 mgal	5MGD	5' Pipe	6' Pipe	4' Pipe	6' Pipe	5' Pipe	-	-	Yes	-	Yes	-	-
5378	$353,908,326	70.6%	-	4 mgal	20 mgal	10MGD	3 mgal	2 mgal	5MGD	-	-	10MGD	5 mgal	5 MGD	8' Pipe	6 mgal	5MGD	5' Pipe	6' Pipe	4' Pipe	6' Pipe	4' Pipe	-	Yes	Yes	-	Yes	-	-
5379	$353,790,658	73.6%	-	4 mgal	25 mgal	10MGD	6 mgal	2 mgal	5MGD	-	-	-	4 mgal	5 MGD	12' Pipe	6 mgal	-	5' Pipe	5' Pipe	4' Pipe	5' Pipe	4' Pipe	-	-	Yes	-	-	-	-
5380	$343,264,272	67.0%	-	12 mgal	10 mgal	10MGD	6 mgal	3 mgal	5MGD	-	-	-	3 mgal	5 MGD	8' Pipe	2 mgal	10MGD	4' Pipe	4' Pipe	4' Pipe	4' Pipe	4' Pipe	-	Yes	Yes	-	-	-	-
5381	$328,505,471	37.0%	-	20 mgal	-	10MGD	-	5 mgal	20MGD	-	-	30MGD	-	-	8' Pipe	7 mgal	5MGD	-	4' Pipe	-	4' Pipe	6' Pipe	-	Yes	Yes	Yes	-	-	-
5382	$361,574,995	64.5%	-	12 mgal	10 mgal	10MGD	3 mgal	3 mgal	10MGD	-	-	20MGD	1 mgal	5 MGD	12' Pipe	7 mgal	5MGD	4' Pipe	4' Pipe	4' Pipe	5' Pipe	5' Pipe	-	Yes	Yes	Yes	-	-	-
5383	$374,688,663	60.9%	-	8 mgal	10 mgal	10MGD	6 mgal	2 mgal	5MGD	30" FM	20MGD	20MGD	1 mgal	5 MGD	5' Pipe	1 mgal	10MGD	4' Pipe	4' Pipe	5' Pipe	4' Pipe	4' Pipe	-	Yes	Yes	Yes	Yes	-	-
5384	$360,630,075	67.2%	-	16 mgal	10 mgal	10MGD	3 mgal	3 mgal	5MGD	-	-	10MGD	3 mgal	5 MGD	5' Pipe	2 mgal	5MGD	4' Pipe	4' Pipe	4' Pipe	4' Pipe	4' Pipe	-	Yes	Yes	Yes	Yes	-	-
5385	$487,799,105	76.7%	-	-	35 mgal	-	12 mgal	3 mgal	30MGD	42" FM	40MGD	30MGD	1 mgal	5 MGD	8' Pipe	1 mgal	30MGD	6' Pipe	-	6' Pipe	5' Pipe	-	-	-	-	-	Yes	-	-
5386	$385,401,582	69.5%	-	8 mgal	20 mgal	-	9 mgal	2 mgal	10MGD	36" FM	30MGD	20MGD	1 mgal	5 MGD	5' Pipe	1 mgal	20MGD	5' Pipe	-	6' Pipe	4' Pipe	-	-	Yes	-	-	Yes	-	-
5387	$336,154,208	59.0%	-	8 mgal	10 mgal	20MGD	6 mgal	2 mgal	5MGD	-	-	20MGD	1 mgal	5 MGD	5' Pipe	1 mgal	20MGD	4' Pipe	-	6' Pipe	4' Pipe	-	-	Yes	-	-	Yes	-	-
5388	$339,638,759	55.1%	-	8 mgal	5 mgal	10MGD	6 mgal	2 mgal	5MGD	30" FM	20MGD	20MGD	1 mgal	5 MGD	5' Pipe	1 mgal	20MGD	4' Pipe	5' Pipe	6' Pipe	4' Pipe	-	-	Yes	-	-	Yes	-	-
5389	$304,946,887	62.7%	-	12 mgal	5 mgal	10MGD	3 mgal	3 mgal	5MGD	-	-	10MGD	4 mgal	5 MGD	5' Pipe	3 mgal	10MGD	4' Pipe	-	5' Pipe	4' Pipe	-	-	Yes	-	-	Yes	-	-
5390	$412,097,670	74.6%	-	8 mgal	25 mgal	10MGD	6 mgal	3 mgal	5MGD	30" FM	20MGD	20MGD	2 mgal	5 MGD	-	3 mgal	10MGD	4' Pipe	4' Pipe	5' Pipe	4' Pipe	5' Pipe	-	-	Yes	Yes	Yes	-	-
5391	$353,146,960	70.7%	-	4 mgal	15 mgal	10MGD	6 mgal	2 mgal	5MGD	30" FM	20MGD	20MGD	2 mgal	5 MGD	-	3 mgal	5MGD	4' Pipe	4' Pipe	6' Pipe	4' Pipe	5' Pipe	-	-	Yes	Yes	Yes	-	-
5392	$339,720,568	64.1%	-	4 mgal	10 mgal	10MGD	6 mgal	2 mgal	5MGD	30" FM	20MGD	20MGD	2 mgal	5 MGD	5' Pipe	3 mgal	5MGD	4' Pipe	4' Pipe	6' Pipe	4' Pipe	5' Pipe	-	-	Yes	Yes	Yes	-	-

Table B-1

Optimization Model Runs (Scenario ID)/ Alternatives - 1 yr 3 hr design event

Scenario ID	Life Cycle Cost	Percent Reduction	WWTP Upgrade	WWTP Storage	Diamond Ave Storage	Diamond Ave HRT	Storage at School	HRT_7thLS_Treatment	7th St HRT	Force Main to WRP	Pump to Force Main	7th St LS Increase Pumping	CSO 012 Storage	CSO 012 HRT	CSO 012 Siphon	CSO 013 Storage	CSO 013 HRT	Consolidate CSO 014 to CSO 012	Consolidate CSO 016 to 7th St LS	Consolidate CSO 016 to CSO 013	PCI Relief (N/S)	PCI Relief (E/W)	CSO 019 Storage	Separation (CSO 020/022)	Separation (CSO 013/016)	Separation (CSO 017)	Separation (CSO 025)	GSI (Basin 012)	GSI (Basin 020 and 022)
5393	$339,720,568	64.1%	-	4 mgal	10 mgal	10MGD	6 mgal	2 mgal	5MGD	30" FM	20MGD	20MGD	2 mgal	5 MGD	5' Pipe	3 mgal	5MGD	4' Pipe	4' Pipe	6' Pipe	4' Pipe	5' Pipe	-	-	Yes	Yes	Yes	-	-
5394	$341,562,772	67.2%	-	12 mgal	10 mgal	10MGD	6 mgal	3 mgal	5MGD	-	-	-	3 mgal	5 MGD	8' Pipe	2 mgal	10MGD	4' Pipe	4' Pipe	4' Pipe	4' Pipe	4' Pipe	-	Yes	Yes	-	-	-	-
5395	$346,340,653	62.6%	-	16 mgal	5 mgal	10MGD	3 mgal	3 mgal	5MGD	-	-	-	3 mgal	5 MGD	5' Pipe	2 mgal	10MGD	4' Pipe	4' Pipe	4' Pipe	4' Pipe	4' Pipe	-	Yes	Yes	-	Yes	-	-
5396	$317,327,210	58.0%	-	12 mgal	5 mgal	10MGD	3 mgal	3 mgal	5MGD	-	-	-	3 mgal	5 MGD	5' Pipe	2 mgal	10MGD	4' Pipe	4' Pipe	4' Pipe	4' Pipe	4' Pipe	-	Yes	Yes	-	-	-	-
5397	$346,340,653	62.6%	-	16 mgal	5 mgal	10MGD	3 mgal	3 mgal	5MGD	-	-	-	3 mgal	5 MGD	5' Pipe	2 mgal	10MGD	4' Pipe	4' Pipe	4' Pipe	4' Pipe	4' Pipe	-	Yes	Yes	-	Yes	-	-
5398	$330,091,194	61.5%	-	16 mgal	5 mgal	10MGD	3 mgal	3 mgal	5MGD	-	-	-	3 mgal	5 MGD	5' Pipe	2 mgal	10MGD	4' Pipe	4' Pipe	4' Pipe	4' Pipe	4' Pipe	-	Yes	Yes	-	-	-	-
5399	$501,652,294	82.5%	-	16 mgal	30 mgal	30MGD	3 mgal	3 mgal	5MGD	42" FM	40MGD	10MGD	5 mgal	5 MGD	5' Pipe	7 mgal	30MGD	4' Pipe	-	4' Pipe	-	-	-	-	-	-	-	-	-
5400	$379,181,626	74.5%	-	16 mgal	15 mgal	20MGD	3 mgal	3 mgal	5MGD	30" FM	20MGD	10MGD	4 mgal	5 MGD	5' Pipe	4 mgal	10MGD	4' Pipe	-	4' Pipe	-	-	-	Yes	-	-	Yes	-	-
5401	$335,124,903	68.4%	-	4 mgal	10 mgal	10MGD	9 mgal	4 mgal	5MGD	-	-	10MGD	4 mgal	5 MGD	8' Pipe	2 mgal	5MGD	5' Pipe	4' Pipe	4' Pipe	4' Pipe	4' Pipe	-	Yes	Yes	Yes	-	-	-
5402	$341,059,394	67.3%	-	8 mgal	5 mgal	20MGD	9 mgal	3 mgal	-	-	-	10MGD	3 mgal	5 MGD	8' Pipe	4 mgal	5MGD	5' Pipe	4' Pipe	4' Pipe	4' Pipe	4' Pipe	-	Yes	Yes	-	Yes	-	-
5403	$317,314,613	62.8%	-	16 mgal	5 mgal	20MGD	3 mgal	3 mgal	-	-	-	10MGD	3 mgal	5 MGD	5' Pipe	3 mgal	10MGD	4' Pipe	4' Pipe	4' Pipe	4' Pipe	-	-	Yes	-	-	Yes	-	-
5404	$451,187,094	81.6%	-	20 mgal	15 mgal	20MGD	15 mgal	3 mgal	10MGD	-	-	10MGD	6 mgal	5 MGD	8' Pipe	6 mgal	5MGD	5' Pipe	-	4' Pipe	6' Pipe	6' Pipe	-	-	-	-	-	-	-
5405	$385,858,207	75.0%	-	12 mgal	10 mgal	10MGD	9 mgal	3 mgal	5MGD	-	-	10MGD	5 mgal	5 MGD	8' Pipe	5 mgal	5MGD	5' Pipe	4' Pipe	4' Pipe	5' Pipe	5' Pipe	-	Yes	Yes	Yes	Yes	-	-
5406	$359,751,043	72.2%	-	8 mgal	10 mgal	10MGD	9 mgal	3 mgal	5MGD	-	-	10MGD	4 mgal	5 MGD	8' Pipe	3 mgal	5MGD	5' Pipe	4' Pipe	4' Pipe	4' Pipe	4' Pipe	-	Yes	Yes	Yes	Yes	-	-
5407	$333,026,402	60.2%	-	8 mgal	5 mgal	10MGD	6 mgal	3 mgal	5MGD	-	-	10MGD	3 mgal	5 MGD	5' Pipe	2 mgal	10MGD	4' Pipe	4' Pipe	4' Pipe	4' Pipe	4' Pipe	-	Yes	-	Yes	Yes	-	-
5408	$333,026,402	60.2%	-	8 mgal	5 mgal	10MGD	6 mgal	3 mgal	5MGD	-	-	10MGD	3 mgal	5 MGD	5' Pipe	2 mgal	10MGD	4' Pipe	4' Pipe	4' Pipe	4' Pipe	4' Pipe	-	Yes	-	Yes	Yes	-	-
5409	$333,026,402	60.2%	-	8 mgal	5 mgal	10MGD	6 mgal	3 mgal	5MGD	-	-	10MGD	3 mgal	5 MGD	5' Pipe	2 mgal	10MGD	4' Pipe	4' Pipe	4' Pipe	4' Pipe	4' Pipe	-	Yes	-	Yes	Yes	-	-
5410	$333,594,235	61.7%	-	8 mgal	5 mgal	10MGD	6 mgal	3 mgal	5MGD	-	-	10MGD	3 mgal	5 MGD	5' Pipe	2 mgal	10MGD	4' Pipe	5' Pipe	4' Pipe	4' Pipe	4' Pipe	-	Yes	-	Yes	Yes	-	-
5411	$347,241,142	62.5%	-	16 mgal	5 mgal	10MGD	3 mgal	3 mgal	5MGD	-	-	10MGD	3 mgal	5 MGD	5' Pipe	2 mgal	10MGD	4' Pipe	4' Pipe	4' Pipe	4' Pipe	4' Pipe	-	Yes	-	Yes	Yes	-	-
5412	$404,718,798	62.3%	-	16 mgal	10 mgal	20MGD	-	-	-	36" FM	30MGD	10MGD	4 mgal	5 MGD	12' Pipe	6 mgal	30MGD	6' Pipe	-	-	-	6' Pipe	-	-	-	-	-	-	-
5413	$391,567,782	76.1%	-	8 mgal	25 mgal	10MGD	9 mgal	-	5MGD	-	-	10MGD	4 mgal	5 MGD	8' Pipe	3 mgal	5MGD	5' Pipe	4' Pipe	4' Pipe	4' Pipe	4' Pipe	-	Yes	Yes	-	Yes	-	-
5414	$358,033,816	76.0%	-	4 mgal	15 mgal	10MGD	12 mgal	-	5MGD	-	-	10MGD	6 mgal	5 MGD	12' Pipe	2 mgal	5MGD	5' Pipe	4' Pipe	4' Pipe	4' Pipe	4' Pipe	-	Yes	Yes	-	Yes	-	-
5415	$353,748,386	71.2%	-	12 mgal	5 mgal	10MGD	12 mgal	2 mgal	5MGD	-	-	10MGD	4 mgal	5 MGD	8' Pipe	3 mgal	5MGD	5' Pipe	4' Pipe	4' Pipe	4' Pipe	4' Pipe	-	Yes	-	Yes	Yes	-	-
5416	$342,430,691	72.7%	-	4 mgal	10 mgal	10MGD	12 mgal	-	5MGD	-	-	10MGD	6 mgal	5 MGD	12' Pipe	2 mgal	5MGD	5' Pipe	4' Pipe	4' Pipe	4' Pipe	4' Pipe	-	Yes	Yes	-	Yes	-	-
5417	$413,101,507	78.3%	-	8 mgal	15 mgal	10MGD	9 mgal	2 mgal	5MGD	30" FM	20MGD	10MGD	4 mgal	5 MGD	8' Pipe	6 mgal	5MGD	4' Pipe	5' Pipe	4' Pipe	5' Pipe	5' Pipe	-	Yes	Yes	Yes	Yes	-	-
5418	$360,786,692	67.6%	-	16 mgal	5 mgal	10MGD	3 mgal	3 mgal	5MGD	-	-	10MGD	4 mgal	5 MGD	8' Pipe	6 mgal	5MGD	4' Pipe	4' Pipe	4' Pipe	4' Pipe	4' Pipe	-	Yes	Yes	Yes	Yes	-	-
5419	$451,659,116	78.5%	-	16 mgal	20 mgal	10MGD	12 mgal	2 mgal	-	36" FM	30MGD	10MGD	2 mgal	5 MGD	8' Pipe	4 mgal	30MGD	4' Pipe	4' Pipe	5' Pipe	-	4' Pipe	-	-	-	Yes	-	-	-
5420	$361,657,864	71.5%	-	8 mgal	20 mgal	10MGD	6 mgal	2 mgal	-	-	-	10MGD	2 mgal	5 MGD	8' Pipe	2 mgal	10MGD	4' Pipe	4' Pipe	5' Pipe	4' Pipe	5' Pipe	-	Yes	Yes	-	Yes	-	-
5421	$365,283,656	74.6%	-	4 mgal	20 mgal	10MGD	9 mgal	2 mgal	5MGD	-	-	-	3 mgal	5 MGD	8' Pipe	3 mgal	5MGD	4' Pipe	4' Pipe	5' Pipe	4' Pipe	4' Pipe	-	Yes	Yes	-	Yes	-	-
5422	$341,340,886	64.2%	-	8 mgal	10 mgal	10MGD	3 mgal	3 mgal	5MGD	-	-	-	3 mgal	5 MGD	5' Pipe	4 mgal	10MGD	4' Pipe	4' Pipe	4' Pipe	4' Pipe	4' Pipe	-	Yes	Yes	-	Yes	-	-
5423	$421,203,119	47.6%	-	16 mgal	-	40MGD	12 mgal	2 mgal	30MGD	-	-	30MGD	7 mgal	5 MGD	-	2 mgal	10MGD	4' Pipe	6' Pipe	-	5' Pipe	-	-	-	-	Yes	Yes	-	-
5424	$413,125,144	77.8%	-	12 mgal	20 mgal	20MGD	6 mgal	2 mgal	10MGD	-	-	20MGD	4 mgal	5 MGD	8' Pipe	2 mgal	5MGD	4' Pipe	5' Pipe	5' Pipe	4' Pipe	5' Pipe	-	Yes	-	Yes	Yes	-	-
5425	$400,111,457	75.1%	-	8 mgal	20 mgal	10MGD	6 mgal	2 mgal	10MGD	-	-	10MGD	5 mgal	5 MGD	8' Pipe	2 mgal	10MGD	5' Pipe	5' Pipe	4' Pipe	5' Pipe	4' Pipe	-	Yes	Yes	Yes	Yes	-	-
5426	$333,650,653	59.4%	-	16 mgal	5 mgal	10MGD	6 mgal	3 mgal	-	-	-	10MGD	3 mgal	5 MGD	5' Pipe	2 mgal	10MGD	4' Pipe	4' Pipe	4' Pipe	-	4' Pipe	-	Yes	-	Yes	Yes	-	-
5427	$383,615,851	74.5%	-	4 mgal	25 mgal	10MGD	3 mgal	2 mgal	5MGD	-	-	10MGD	3 mgal	5 MGD	8' Pipe	5 mgal	5MGD	4' Pipe	5' Pipe	5' Pipe	5' Pipe	4' Pipe	-	Yes	Yes	Yes	Yes	-	-
5428	$335,535,640	60.5%	-	12 mgal	5 mgal	10MGD	3 mgal	3 mgal	5MGD	-	-	10MGD	3 mgal	5 MGD	5' Pipe	2 mgal	5MGD	4' Pipe	4' Pipe	5' Pipe	4' Pipe	4' Pipe	-	Yes	Yes	Yes	Yes	-	-
5429	$301,105,331	68.8%	-	-	5 mgal	-	17 mgal	2 mgal	-	30" FM	20MGD	20MGD	6 mgal	5 MGD	8' Pipe	2 mgal	20MGD	5' Pipe	4' Pipe	4' Pipe	4' Pipe	-	-	-	-	Yes	Yes	-	-
5430	$349,796,720	69.1%	-	4 mgal	5 mgal	10MGD	17 mgal	2 mgal	-	-	-	20MGD	5 mgal	5 MGD	8' Pipe	2 mgal	20MGD	5' Pipe	4' Pipe	4' Pipe	4' Pipe	4' Pipe	-	-	-	-	Yes	Yes	-	-
5431	$345,293,894	63.9%	-	16 mgal	5 mgal	10MGD	9 mgal	3 mgal	-	-	-	10MGD	3 mgal	5 MGD	5' Pipe	3 mgal	20MGD	4' Pipe	4' Pipe	4' Pipe	4' Pipe	4' Pipe	-	Yes	-	-	-	-	-
5432	$551,171,016	84.0%	-	20 mgal	35 mgal	40MGD	12 mgal	2 mgal	20MGD	36" FM	30MGD	20MGD	3 mgal	5 MGD	12' Pipe	2 mgal	-	4' Pipe	6' Pipe	4' Pipe	5' Pipe	-	-	-	-	Yes	Yes	-	-
5433	$458,482,975	81.5%	-	12 mgal	20 mgal	30MGD	15 mgal	2 mgal	10MGD	30" FM	20MGD	20MGD	5 mgal	5 MGD	8' Pipe	2 mgal	10MGD	4' Pipe	5' Pipe	4' Pipe	4' Pipe	-	-	-	-	Yes	Yes	-	-
5434	$310,841,640	55.7%	-	-	5 mgal	10MGD	9 mgal	-	5MGD	30" FM	20MGD	20MGD	1 mgal	5 MGD	8' Pipe	2 mgal	10MGD	4' Pipe	4' Pipe	5' Pipe	-	4' Pipe	-	Yes	-	Yes	Yes	-	-
5435	$414,520,242	75.2%	-	8 mgal	20 mgal	20MGD	9 mgal	-	5MGD	-	-	10MGD	4 mgal	5 MGD	5' Pipe	2 mgal	20MGD	5' Pipe	4' Pipe	5' Pipe	4' Pipe	4' Pipe	-	Yes	Yes	Yes	Yes	-	-
5436	$375,682,265	68.9%	-	4 mgal	10 mgal	10MGD	9 mgal	-	5MGD	36" FM	30MGD	10MGD	2 mgal	5 MGD	8' Pipe	2 mgal	10MGD	4' Pipe	4' Pipe	5' Pipe	4' Pipe	4' Pipe	-	Yes	Yes	Yes	Yes	-	-
5437	$349,012,164	61.4%	-	4 mgal	5 mgal	10MGD	9 mgal	-	5MGD	30" FM	20MGD	20MGD	1 mgal	5 MGD	8' Pipe	2 mgal	10MGD	4' Pipe	4' Pipe	5' Pipe	4' Pipe	4' Pipe	-	Yes	Yes	Yes	Yes	-	-
5438	$72,708,653	14.3%	-	-	-	-	-	-	-	-	-	-	6 mgal	5 MGD	5' Pipe	2 mgal	-	4' Pipe	6' Pipe	-	-	-	-	-	-	-	-	-	-
5439	$66,183,450	10.6%	-	-	-	-	-	-	-	-	-	-	1 mgal	5 MGD	-	7 mgal	-	5' Pipe	-	-	-	-	-	-	-	-	-	-	-
5440	$75,337,902	13.6%	-	-	-	-	-	-	-	-	-	-	2 mgal	5 MGD	8' Pipe	4 mgal	5MGD	-	-	4' Pipe	-	-	-	-	-	-	-	-	-
5441	$134,701,308	13.5%	-	-	-	-	-	-	-	-	-	-	3 mgal	5 MGD	8' Pipe	7 mgal	30MGD	5' Pipe	-	-	-	-	-	-	-	-	-	-	-
5442	$106,154,591	16.5%	-	-	-	-	-	-	-	-	-	-	5 mgal	5 MGD	5' Pipe	7 mgal	5MGD	6' Pipe	6' Pipe	-	-	-	-	-	-	-	-	-	-
5443	$138,708,743	17.2%	-	-	-	-	-	-	-	-	-	-	6 mgal	5 MGD	12' Pipe	3 mgal	30MGD	6' Pipe	4' Pipe	-	-	-	-	-	-	-	-	-	-
5444	$122,943,876	15.6%	-	-	-	-	-	-	-	-	-	-	2 mgal	5 MGD	8' Pipe	5 mgal	30MGD	-	4' Pipe	4' Pipe	-	-	-	-	-	-	-	-	-
5445	$116,493,432	16.3%	-	-	-	-	-	-	-	-	-	-	6 mgal	5 MGD	12' Pipe	4 mgal	20MGD	-	4' Pipe	6' Pipe	-	-	-	-	-	-	-	-	-
5446	$92,003,851	12.5%	-	-	-	-	-	-	-	-	-	-	1 mgal	5 MGD	12' Pipe	1 mgal	10MGD	6' Pipe	6' Pipe	5' Pipe	-	-	-	-	-	-	-	-	-
5447	$122,968,884	18.8%	-	-	-	-	-	-	-	-	-	-	7 mgal	5 MGD	5' Pipe	2 mgal	20MGD	4' Pipe	6' Pipe	6' Pipe	-	-	-	-	-	-	-	-	-
5448	$49,159,534	9.3%	-	-	-	-	-	-	-	-	-	-	6 mgal	5 MGD	8' Pipe	-	-	-	-	5' Pipe	-	-	-	-	-	-	-	-	-
5449	$63,052,787	8.2%	-	-	-	-	-	-	-	-	-	-	-	-	5' Pipe	3 mgal	10MGD	5' Pipe	4' Pipe	5' Pipe	-	-	-	-	-	-	-	-	-
5450	$95,660,881	14.0%	-	-	-	-	-	-	-	-	-	-	7 mgal	5 MGD	5' Pipe	-	10MGD	6' Pipe	5' Pipe	4' Pipe	-	-	-	-	-	-	-	-	-
5451	$41,307,883	10.9%	-	-	-	-	-	-	-	-	-	-	-	-	12' Pipe	5 mgal	-	4' Pipe	4' Pipe	5' Pipe	-	-	-	-	-	-	-	-	-
5452	$81,899,167	17.7%	-	-	-	-	-	-	-	-	-	-	6 mgal	5 MGD	8' Pipe	3 mgal	-	6' Pipe	6' Pipe	4' Pipe	-	-	-	-	-	-	-	-	-
5453	$93,844,095	9.5%	-	-	-	-	-	-	-	-	-	-	1 mgal	5 MGD	12' Pipe	-	20MGD	4' Pipe	4' Pipe	4' Pipe	-	-	-	-	-	-	-	-	-
5454	$116,416,708	16.1%	-	-	-	-	-	-	-	-	-	-	2 mgal	5 MGD	-	5 mgal	20MGD	6' Pipe	5' Pipe	4' Pipe	-	-	-	-	-	-	-	-	-
5455	$80,728,231	11.4%	-	-	-	-	-	-	-	-	-	-	1 mgal	5 MGD	12' Pipe	1 mgal	5MGD	4' Pipe	6' Pipe	4' Pipe	-	-	-	-	-	-	-	-	-
5456	$97,494,655	16.3%	-	-	-	-	-	-	-	-	-	-	5 mgal	5 MGD	12' Pipe	3 mgal	10MGD	5' Pipe	-	-	-	-	-	-	-	-	-	-	-
5457	$113,244,303	15.6%	-	-	-	-	-	-	-	-	-	-	1 mgal	5 MGD	-	5 mgal	20MGD	6' Pipe	4' Pipe	4' Pipe	-	-	-	-	-	-	-	-	-
5458	$91,733,582	13.5%	-	-	-	-	-	-	-	-	-	-	2 mgal	5 MGD	-	3 mgal	10MGD	4' Pipe	4' Pipe	5' Pipe	-	-	-	-	-	-	-	-	-
5459	$99,949,284	18.6%	-	-	-	-	-	-	-	-	-	-	5 mgal	5 MGD	12' Pipe	6 mgal	5MGD	4' Pipe	-	6' Pipe	-	-	-	-	-	-	-	-	-
5460	$77,597,008	16.2%	-	-	-	-	-	-	-	-	-	-	1 mgal	5 MGD	12' Pipe	7 mgal	-	5' Pipe	4' Pipe	5' Pipe	-	-	-	-	-	-	-	-	-
5461	$80,597,987	17.5%	-	-	-	-	-	-	-	-	-	-	3 mgal	5 MGD	8' Pipe	6 mgal	-	5' Pipe	6' Pipe	5' Pipe	-	-	-	-	-	-	-	-	-
5462	$108,899,958	11.8%	-	-	-	-	-	-	-	-	-	-	3 mgal	5 MGD	5' Pipe	1 mgal	20MGD	5' Pipe	5' Pipe	4' Pipe	-	-	-	-	-	-	-	-	-
5463	$113,635,627	20.9%	-	-	-	-	-	-	-	-	-	-	7 mgal	5 MGD	8' Pipe	6 mgal	10MGD	5' Pipe	-	5' Pipe	-	-	-	-	-	-	-	-	-
5464	$131,914,459	16.3%	-	-	-	-	-	-	-	-	-	-	7 mgal	5 MGD	5' Pipe	3 mgal	30MGD	-	6' Pipe	5' Pipe	-	-	-	-	-	-	-	-	-
5465	$76,546,116	13.0%	-	-	-	-	-	-	-	-	-	-	6 mgal	5 MGD	-	3 mgal	-	5' Pipe	4' Pipe	6' Pipe	-	-	-	-	-	-	-	-	-
5466	$96,157,240	16.4%	-	-	-	-	-	-	-	-	-	-	5 mgal	5 MGD	8' Pipe	2 mgal	5MGD	6' Pipe	5' Pipe	6' Pipe	-	-	-	-	-	-	-	-	-
5467	$78,275,240	14.7%	-	-	-	-	-	-	-	-	-	-	7 mgal	5 MGD	8' Pipe	5 mgal	-	-	6' Pipe	5' Pipe	-	-	-	-	-	-	-	-	-
5468	$49,405,012	7.8%	-	-	-	-	-	-	-	-	-	-	1 mgal	5 MGD	-	-	-	6' Pipe	5' Pipe	4' Pipe	-	-	-	-	-	-	-	-	-
5469	$142,601,782	19.3%	-	-	-	-	-	-	-	-	-	-	5 mgal	5 MGD	8' Pipe	5 mgal	30MGD	4' Pipe	6' Pipe	6' Pipe	-	-	-	-	-	-	-	-	-
5470	$125,255,623	16.3%	-	-	-	-	-	-	-	-	-	-	1 mgal	5 MGD	12' Pipe	2 mgal	30MGD	6' Pipe	4' Pipe	4' Pipe	-	-	-	-	-	-	-	-	-
5471	$97,052,032	17.6%	-	-	-	-	-	-	-	-	-	-	4 mgal	5 MGD	12' Pipe	3 mgal	10MGD	4' Pipe	-	6' Pipe	-	-	-	-	-	-	-	-	-

Table B-1

Optimization Model Runs (Scenario ID)/ Alternatives - 1 yr 3 hr design event

Scenario ID	Life Cycle Cost	Percent Reduction	WWTP Upgrade	WWTP Storage	Diamond Ave Storage	Diamond Ave HRT	Storage at School	HRT_7thLS_Treatment	7th St HRT	Force Main to WRP	Pump to Force Main	7th St LS Increase Pumping	CSO 012 Storage	CSO 012 HRT	CSO 012 Siphon	CSO 013 Storage	CSO 013 HRT	Consolidate CSO 014 to CSO 012	Consolidate CSO 016 to 7th St LS	Consolidate CSO 016 to CSO 013	PCI Relief (N/S)	PCI Relief (E/W)	CSO 019 Storage	Separation (CSO 020/022)	Separation (CSO 013/016)	Separation (CSO 017)	Separation (CSO 025)	GSI (Basin 012)	GSI (Basin 020 and 022)
5472	$141,966,517	15.1%	-	-	-	-	-	-	-	-	-	-	4 mgal	5 MGD	12' Pipe	7 mgal	30MGD	4' Pipe	5' Pipe	-	-	-	-	-	-	-	-	-	-
5473	$120,365,054	16.1%	-	-	-	-	-	-	-	-	-	-	6 mgal	5 MGD	-	4 mgal	20MGD	6' Pipe	-	6' Pipe	-	-	-	-	-	-	-	-	-
5474	$101,782,627	11.3%	-	-	-	-	-	-	-	-	-	-	1 mgal	5 MGD	5' Pipe	6 mgal	10MGD	5' Pipe	5' Pipe	6' Pipe	-	-	-	-	-	-	-	-	-
5475	$87,613,678	13.4%	-	-	-	-	-	-	-	-	-	-	3 mgal	5 MGD	12' Pipe	2 mgal	10MGD	-	6' Pipe	5' Pipe	-	-	-	-	-	-	-	-	-
5476	$95,300,711	15.6%	-	-	-	-	-	-	-	-	-	-	5 mgal	5 MGD	5' Pipe	4 mgal	10MGD	-	4' Pipe	5' Pipe	-	-	-	-	-	-	-	-	-
5477	$96,874,003	17.9%	-	-	-	-	-	-	-	-	-	-	7 mgal	5 MGD	12' Pipe	3 mgal	5MGD	4' Pipe	-	5' Pipe	-	-	-	-	-	-	-	-	-
5478	$76,672,428	-0.6%	-	-	-	-	-	-	-	-	-	-	-	-	5' Pipe	-	30MGD	4' Pipe	5' Pipe	-	-	-	-	-	-	-	-	-	-
5479	$126,288,169	20.8%	-	-	-	-	-	-	-	-	-	-	6 mgal	5 MGD	8' Pipe	5 mgal	20MGD	6' Pipe	-	6' Pipe	-	-	-	-	-	-	-	-	-
5480	$101,314,664	17.9%	-	-	-	-	-	-	-	-	-	-	7 mgal	5 MGD	12' Pipe	3 mgal	5MGD	4' Pipe	4' Pipe	5' Pipe	-	-	-	-	-	-	-	-	-
5481	$128,543,302	12.7%	-	-	-	-	-	-	-	-	-	-	1 mgal	5 MGD	5' Pipe	4 mgal	30MGD	5' Pipe	6' Pipe	4' Pipe	-	-	-	-	-	-	-	-	-
5482	$115,520,031	13.4%	-	-	-	-	-	-	-	-	-	-	1 mgal	5 MGD	12' Pipe	1 mgal	30MGD	6' Pipe	-	-	-	-	-	-	-	-	-	-	-
5483	$111,559,667	14.9%	-	-	-	-	-	-	-	-	-	-	3 mgal	5 MGD	12' Pipe	1 mgal	30MGD	-	-	5' Pipe	-	-	-	-	-	-	-	-	-
5484	$73,766,085	9.7%	-	-	-	-	-	-	-	-	-	-	2 mgal	5 MGD	-	1 mgal	5MGD	6' Pipe	-	-	-	-	-	-	-	-	-	-	-
5485	$90,751,260	8.0%	-	-	-	-	-	-	-	-	-	-	3 mgal	5 MGD	-	6 mgal	10MGD	-	5' Pipe	-	-	-	-	-	-	-	-	-	-
5486	$111,979,281	15.8%	-	-	-	-	-	-	-	-	-	-	3 mgal	5 MGD	-	3 mgal	20MGD	5' Pipe	5' Pipe	4' Pipe	-	-	-	-	-	-	-	-	-
5487	$120,032,961	18.3%	-	-	-	-	-	-	-	-	-	-	5 mgal	5 MGD	8' Pipe	3 mgal	20MGD	5' Pipe	4' Pipe	4' Pipe	-	-	-	-	-	-	-	-	-
5488	$79,059,951	16.6%	-	-	-	-	-	-	-	-	-	-	7 mgal	5 MGD	5' Pipe	5 mgal	-	5' Pipe	-	-	-	-	-	-	-	-	-	-	-
5489	$95,248,682	16.3%	-	-	-	-	-	-	-	-	-	-	4 mgal	5 MGD	8' Pipe	3 mgal	5MGD	6' Pipe	5' Pipe	4' Pipe	-	-	-	-	-	-	-	-	-
5490	$121,038,342	19.0%	-	-	-	-	-	-	-	-	-	-	4 mgal	5 MGD	12' Pipe	3 mgal	20MGD	6' Pipe	6' Pipe	4' Pipe	-	-	-	-	-	-	-	-	-
5491	$104,870,342	17.4%	-	-	-	-	-	-	-	-	-	-	4 mgal	5 MGD	12' Pipe	3 mgal	10MGD	6' Pipe	6' Pipe	4' Pipe	-	-	-	-	-	-	-	-	-
5492	$137,104,055	19.2%	-	-	-	-	-	-	-	-	-	-	3 mgal	5 MGD	12' Pipe	5 mgal	30MGD	4' Pipe	6' Pipe	4' Pipe	-	-	-	-	-	-	-	-	-
5493	$119,393,142	19.3%	-	-	-	-	-	-	-	-	-	-	3 mgal	5 MGD	12' Pipe	4 mgal	20MGD	5' Pipe	6' Pipe	4' Pipe	-	-	-	-	-	-	-	-	-
5494	$107,569,042	18.4%	-	-	-	-	-	-	-	-	-	-	6 mgal	5 MGD	8' Pipe	3 mgal	10MGD	5' Pipe	5' Pipe	5' Pipe	-	-	-	-	-	-	-	-	-
5495	$99,485,042	17.5%	-	-	-	-	-	-	-	-	-	-	6 mgal	5 MGD	8' Pipe	3 mgal	5MGD	5' Pipe	5' Pipe	5' Pipe	-	-	-	-	-	-	-	-	-
5496	$101,563,167	18.2%	-	-	-	-	-	-	-	-	-	-	6 mgal	5 MGD	8' Pipe	3 mgal	5MGD	6' Pipe	6' Pipe	4' Pipe	-	-	-	-	-	-	-	-	-
5497	$106,562,757	18.0%	-	-	-	-	-	-	-	-	-	-	6 mgal	5 MGD	8' Pipe	2 mgal	10MGD	6' Pipe	5' Pipe	5' Pipe	-	-	-	-	-	-	-	-	-
5498	$112,105,513	19.2%	-	-	-	-	-	-	-	-	-	-	4 mgal	5 MGD	5' Pipe	7 mgal	10MGD	5' Pipe	5' Pipe	5' Pipe	-	-	-	-	-	-	-	-	-
5499	$98,103,795	14.1%	-	-	-	-	-	-	-	-	-	-	2 mgal	5 MGD	5' Pipe	7 mgal	5MGD	5' Pipe	4' Pipe	5' Pipe	-	-	-	-	-	-	-	-	-
5500	$96,500,293	14.7%	-	-	-	-	-	-	-	-	-	-	1 mgal	5 MGD	8' Pipe	7 mgal	5MGD	5' Pipe	4' Pipe	5' Pipe	-	-	-	-	-	-	-	-	-
5501	$89,452,161	14.4%	-	-	-	-	-	-	-	-	-	-	1 mgal	5 MGD	12' Pipe	4 mgal	5MGD	5' Pipe	5' Pipe	5' Pipe	-	-	-	-	-	-	-	-	-
5502	$95,774,377	14.2%	-	-	-	-	-	-	-	-	-	-	4 mgal	5 MGD	5' Pipe	1 mgal	10MGD	5' Pipe	5' Pipe	5' Pipe	-	-	-	-	-	-	-	-	-
5503	$92,200,425	13.7%	-	-	-	-	-	-	-	-	-	-	1 mgal	5 MGD	-	3 mgal	10MGD	6' Pipe	5' Pipe	4' Pipe	-	-	-	-	-	-	-	-	-
5504	$84,647,958	10.5%	-	-	-	-	-	-	-	-	-	-	3 mgal	5 MGD	5' Pipe	1 mgal	5MGD	5' Pipe	5' Pipe	4' Pipe	-	-	-	-	-	-	-	-	-
5505	$81,464,940	11.6%	-	-	-	-	-	-	-	-	-	-	1 mgal	5 MGD	-	2 mgal	5MGD	6' Pipe	5' Pipe	4' Pipe	-	-	-	-	-	-	-	-	-
5506	$95,903,952	14.0%	-	-	-	-	-	-	-	-	-	-	2 mgal	5 MGD	12' Pipe	4 mgal	10MGD	4' Pipe	5' Pipe	-	-	-	-	-	-	-	-	-	-
5507	$105,518,200	14.3%	-	-	-	-	-	-	-	-	-	-	5 mgal	5 MGD	8' Pipe	4 mgal	10MGD	6' Pipe	4' Pipe	-	-	-	-	-	-	-	-	-	-
5508	$98,907,648	16.2%	-	-	-	-	-	-	-	-	-	-	3 mgal	5 MGD	8' Pipe	3 mgal	10MGD	4' Pipe	6' Pipe	5' Pipe	-	-	-	-	-	-	-	-	-
5509	$89,879,142	11.4%	-	-	-	-	-	-	-	-	-	-	2 mgal	5 MGD	8' Pipe	1 mgal	10MGD	4' Pipe	5' Pipe	4' Pipe	-	-	-	-	-	-	-	-	-
5510	$88,975,438	15.7%	-	-	-	-	-	-	-	-	-	-	3 mgal	5 MGD	12' Pipe	3 mgal	5MGD	5' Pipe	5' Pipe	-	-	-	-	-	-	-	-	-	-
5511	$82,199,943	14.3%	-	-	-	-	-	-	-	-	-	-	3 mgal	5 MGD	8' Pipe	2 mgal	5MGD	6' Pipe	-	-	-	-	-	-	-	-	-	-	-
5512	$91,557,253	13.0%	-	-	-	-	-	-	-	-	-	-	3 mgal	5 MGD	5' Pipe	4 mgal	5MGD	6' Pipe	5' Pipe	-	-	-	-	-	-	-	-	-	-
5513	$85,639,535	9.3%	-	-	-	-	-	-	-	-	-	-	2 mgal	5 MGD	5' Pipe	3 mgal	5MGD	6' Pipe	4' Pipe	-	-	-	-	-	-	-	-	-	-
5514	$53,618,482	6.3%	-	-	-	-	-	-	-	-	-	-	-	-	5' Pipe	2 mgal	5MGD	6' Pipe	4' Pipe	4' Pipe	-	-	-	-	-	-	-	-	-	-
5515	$106,218,737	18.0%	-	-	-	-	-	-	-	-	-	-	6 mgal	5 MGD	8' Pipe	2 mgal	10MGD	6' Pipe	5' Pipe	4' Pipe	-	-	-	-	-	-	-	-	-	-
5516	$105,209,209	16.8%	-	-	-	-	-	-	-	-	-	-	7 mgal	5 MGD	5' Pipe	2 mgal	10MGD	4' Pipe	5' Pipe	4' Pipe	-	-	-	-	-	-	-	-	-	-
5517	$102,331,613	17.3%	-	-	-	-	-	-	-	-	-	-	4 mgal	5 MGD	5' Pipe	3 mgal	10MGD	6' Pipe	5' Pipe	4' Pipe	-	-	-	-	-	-	-	-	-	-
5518	$103,807,038	16.4%	-	-	-	-	-	-	-	-	-	-	7 mgal	5 MGD	5' Pipe	1 mgal	10MGD	5' Pipe	5' Pipe	4' Pipe	-	-	-	-	-	-	-	-	-	-
5519	$119,539,137	18.0%	-	-	-	-	-	-	-	-	-	-	6 mgal	5 MGD	8' Pipe	2 mgal	20MGD	4' Pipe	5' Pipe	4' Pipe	-	-	-	-	-	-	-	-	-	-
5520	$97,639,527	17.6%	-	-	-	-	-	-	-	-	-	-	2 mgal	5 MGD	12' Pipe	6 mgal	5MGD	4' Pipe	6' Pipe	6' Pipe	-	-	-	-	-	-	-	-	-	-
5521	$116,802,283	18.4%	-	-	-	-	-	-	-	-	-	-	3 mgal	5 MGD	8' Pipe	3 mgal	20MGD	6' Pipe	5' Pipe	4' Pipe	-	-	-	-	-	-	-	-	-	-
5522	$106,422,015	15.9%	-	-	-	-	-	-	-	-	-	-	5 mgal	5 MGD	8' Pipe	3 mgal	10MGD	6' Pipe	5' Pipe	5' Pipe	-	-	-	-	-	-	-	-	-	-
5523	$84,040,081	11.4%	-	-	-	-	-	-	-	-	-	-	6 mgal	5 MGD	12' Pipe	1 mgal	5MGD	-	5' Pipe	4' Pipe	-	-	-	-	-	-	-	-	-	-
5524	$119,393,142	19.3%	-	-	-	-	-	-	-	-	-	-	3 mgal	5 MGD	12' Pipe	4 mgal	20MGD	5' Pipe	6' Pipe	4' Pipe	-	-	-	-	-	-	-	-	-	-
5525	$122,138,455	20.2%	-	-	-	-	-	-	-	-	-	-	5 mgal	5 MGD	12' Pipe	3 mgal	20MGD	5' Pipe	6' Pipe	4' Pipe	-	-	-	-	-	-	-	-	-	-
5526	$130,225,660	16.3%	-	-	-	-	-	-	-	-	-	-	3 mgal	5 MGD	5' Pipe	7 mgal	30MGD	-	4' Pipe	4' Pipe	-	-	-	-	-	-	-	-	-	-
5527	$117,287,648	17.5%	-	-	-	-	-	-	-	-	-	-	3 mgal	5 MGD	8' Pipe	4 mgal	20MGD	5' Pipe	4' Pipe	4' Pipe	-	-	-	-	-	-	-	-	-	-
5528	$120,261,397	19.0%	-	-	-	-	-	-	-	-	-	-	4 mgal	5 MGD	12' Pipe	3 mgal	20MGD	6' Pipe	5' Pipe	4' Pipe	-	-	-	-	-	-	-	-	-	-
5529	$118,486,211	19.2%	-	-	-	-	-	-	-	-	-	-	5 mgal	5 MGD	12' Pipe	2 mgal	20MGD	5' Pipe	4' Pipe	5' Pipe	-	-	-	-	-	-	-	-	-	-
5530	$101,021,983	17.7%	-	-	-	-	-	-	-	-	-	-	4 mgal	5 MGD	12' Pipe	3 mgal	10MGD	4' Pipe	4' Pipe	5' Pipe	-	-	-	-	-	-	-	-	-	-
5531	$121,278,438	19.6%	-	-	-	-	-	-	-	-	-	-	6 mgal	5 MGD	12' Pipe	2 mgal	20MGD	5' Pipe	4' Pipe	5' Pipe	-	-	-	-	-	-	-	-	-	-
5532	$118,616,197	18.7%	-	-	-	-	-	-	-	-	-	-	4 mgal	5 MGD	12' Pipe	3 mgal	20MGD	5' Pipe	5' Pipe	4' Pipe	-	-	-	-	-	-	-	-	-	-
5533	$136,673,796	16.1%	-	-	-	-	-	-	-	-	-	-	3 mgal	5 MGD	-	7 mgal	30MGD	6' Pipe	-	6' Pipe	-	-	-	-	-	-	-	-	-	-
5534	$103,729,578	16.1%	-	-	-	-	-	-	-	-	-	-	4 mgal	5 MGD	-	5 mgal	10MGD	5' Pipe	4' Pipe	5' Pipe	-	-	-	-	-	-	-	-	-	-
5535	$117,631,668	18.6%	-	-	-	-	-	-	-	-	-	-	4 mgal	5 MGD	8' Pipe	3 mgal	20MGD	5' Pipe	4' Pipe	5' Pipe	-	-	-	-	-	-	-	-	-	-
5536	$103,818,047	17.7%	-	-	-	-	-	-	-	-	-	-	4 mgal	5 MGD	8' Pipe	4 mgal	10MGD	5' Pipe	4' Pipe	4' Pipe	-	-	-	-	-	-	-	-	-	-
5537	$80,633,136	5.6%	-	-	-	-	-	-	-	-	-	-	2 mgal	5 MGD	5' Pipe	-	10MGD	5' Pipe	5' Pipe	5' Pipe	-	-	-	-	-	-	-	-	-	-
5538	$69,600,545	5.4%	-	-	-	-	-	-	-	-	-	-	1 mgal	5 MGD	5' Pipe	-	5MGD	5' Pipe	5' Pipe	4' Pipe	-	-	-	-	-	-	-	-	-	-
5539	$71,245,745	6.2%	-	-	-	-	-	-	-	-	-	-	1 mgal	5 MGD	5' Pipe	-	5MGD	6' Pipe	5' Pipe	4' Pipe	-	-	-	-	-	-	-	-	-	-
5540	$71,245,745	6.2%	-	-	-	-	-	-	-	-	-	-	1 mgal	5 MGD	5' Pipe	-	5MGD	6' Pipe	5' Pipe	4' Pipe	-	-	-	-	-	-	-	-	-	-
5541	$102,107,799	16.7%	-	-	-	-	-	-	-	-	-	-	3 mgal	5 MGD	5' Pipe	4 mgal	10MGD	6' Pipe	4' Pipe	5' Pipe	-	-	-	-	-	-	-	-	-	-
5542	$88,329,895	10.7%	-	-	-	-	-	-	-	-	-	-	2 mgal	5 MGD	5' Pipe	3 mgal	5MGD	6' Pipe	4' Pipe	4' Pipe	-	-	-	-	-	-	-	-	-	-
5543	$90,384,163	15.3%	-	-	-	-	-	-	-	-	-	-	4 mgal	5 MGD	8' Pipe	2 mgal	5MGD	5' Pipe	4' Pipe	4' Pipe	-	-	-	-	-	-	-	-	-	-
5544	$83,073,839	8.9%	-	-	-	-	-	-	-	-	-	-	1 mgal	5 MGD	5' Pipe	2 mgal	5MGD	6' Pipe	4' Pipe	4' Pipe	-	-	-	-	-	-	-	-	-	-
5545	$89,749,597	15.2%	-	-	-	-	-	-	-	-	-	-	4 mgal	5 MGD	8' Pipe	2 mgal	5MGD	4' Pipe	5' Pipe	4' Pipe	-	-	-	-	-	-	-	-	-	-
5546	$99,035,997	15.8%	-	-	-	-	-	-	-	-	-	-	4 mgal	5 MGD	8' Pipe	2 mgal	10MGD	5' Pipe	5' Pipe	4' Pipe	-	-	-	-	-	-	-	-	-	-
5547	$90,951,997	15.3%	-	-	-	-	-	-	-	-	-	-	4 mgal	5 MGD	8' Pipe	2 mgal	5MGD	5' Pipe	5' Pipe	4' Pipe	-	-	-	-	-	-	-	-	-	-
5548	$89,749,597	15.2%	-	-	-	-	-	-	-	-	-	-	4 mgal	5 MGD	8' Pipe	2 mgal	5MGD	4' Pipe	5' Pipe	4' Pipe	-	-	-	-	-	-	-	-	-	-
5549	$96,885,696	18.4%	-	-	-	-	-	-	-	-	-	-	3 mgal	5 MGD	12' Pipe	5 mgal	5MGD	5' Pipe	4' Pipe	5' Pipe	-	-	-	-	-	-	-	-	-	-
5550	$96,885,696	18.4%	-	-	-	-	-	-	-	-	-	-	3 mgal	5 MGD	12' Pipe	5 mgal	5MGD	5' Pipe	4' Pipe	5' Pipe	-	-	-	-	-	-	-	-	-	-

Table B-1

Optimization Model Runs (Scenario ID)/ Alternatives - 1 yr 3 hr design event

Scenario ID	Life Cycle Cost	Percent Reduction	WWTP Upgrade	WWTP Storage	Diamond Ave Storage	Diamond Ave HRT	Storage at School	HRT_7thLS_Treatment	7th St HRT	Force Main to WRP	Pump to Force Main	7th St LS Increase Pumping	CSO 012 Storage	CSO 012 HRT	CSO 012 Siphon	CSO 013 Storage	CSO 013 HRT	Consolidate CSO 014 to CSO 012	Consolidate CSO 016 to 7th St LS	Consolidate CSO 016 to CSO 013	PCI Relief (N/S)	PCI Relief (E/W)	CSO 019 Storage	Separation (CSO 020/022)	Separation (CSO 013/016)	Separation (CSO 017)	Separation (CSO 025)	GSI (Basin 012)	GSI (Basin 020 and 022)
5551	$97,026,438	18.0%	-	-	-	-	-	-	-	-	-	-	2 mgal	5 MGD	12' Pipe	6 mgal	5MGD	5' Pipe	4' Pipe	5' Pipe	-	-	-	-	-	-	-	-	-
5552	$125,705,109	20.7%	-	-	-	-	-	-	-	-	-	-	5 mgal	5 MGD	12' Pipe	4 mgal	20MGD	6' Pipe	5' Pipe	4' Pipe	-	-	-	-	-	-	-	-	-
5553	$82,952,366	17.9%	-	-	-	-	-	-	-	-	-	-	6 mgal	5 MGD	8' Pipe	4 mgal	-	5' Pipe	6' Pipe	4' Pipe	-	-	-	-	-	-	-	-	-
5554	$97,026,438	18.0%	-	-	-	-	-	-	-	-	-	-	2 mgal	5 MGD	12' Pipe	6 mgal	5MGD	5' Pipe	4' Pipe	5' Pipe	-	-	-	-	-	-	-	-	-
5555	$122,959,796	19.3%	-	-	-	-	-	-	-	-	-	-	4 mgal	5 MGD	12' Pipe	4 mgal	20MGD	6' Pipe	5' Pipe	4' Pipe	-	-	-	-	-	-	-	-	-
5556	$77,274,171	16.3%	-	-	-	-	-	-	-	-	-	-	5 mgal	5 MGD	5' Pipe	7 mgal	-	-	6' Pipe	5' Pipe	-	-	-	-	-	-	-	-	-
5557	$94,724,447	16.1%	-	-	-	-	-	-	-	-	-	-	4 mgal	5 MGD	8' Pipe	3 mgal	5MGD	5' Pipe	6' Pipe	5' Pipe	-	-	-	-	-	-	-	-	-
5558	$101,563,167	18.2%	-	-	-	-	-	-	-	-	-	-	6 mgal	5 MGD	8' Pipe	3 mgal	5MGD	6' Pipe	6' Pipe	4' Pipe	-	-	-	-	-	-	-	-	-
5559	$93,327,228	15.9%	-	-	-	-	-	-	-	-	-	-	3 mgal	5 MGD	8' Pipe	3 mgal	5MGD	6' Pipe	6' Pipe	4' Pipe	-	-	-	-	-	-	-	-	-
5560	$101,563,167	18.2%	-	-	-	-	-	-	-	-	-	-	6 mgal	5 MGD	8' Pipe	3 mgal	5MGD	6' Pipe	6' Pipe	4' Pipe	-	-	-	-	-	-	-	-	-
5561	$121,038,342	19.0%	-	-	-	-	-	-	-	-	-	-	4 mgal	5 MGD	12' Pipe	3 mgal	20MGD	6' Pipe	6' Pipe	4' Pipe	-	-	-	-	-	-	-	-	-
5562	$80,387,571	18.5%	-	-	-	-	-	-	-	-	-	-	4 mgal	5 MGD	12' Pipe	6 mgal	-	6' Pipe	-	6' Pipe	-	-	-	-	-	-	-	-	-
5563	$98,770,940	16.0%	-	-	-	-	-	-	-	-	-	-	5 mgal	5 MGD	8' Pipe	3 mgal	5MGD	6' Pipe	6' Pipe	4' Pipe	-	-	-	-	-	-	-	-	-
5564	$94,087,943	16.5%	-	-	-	-	-	-	-	-	-	-	3 mgal	5 MGD	12' Pipe	3 mgal	5MGD	6' Pipe	6' Pipe	4' Pipe	-	-	-	-	-	-	-	-	-
5565	$118,339,943	19.0%	-	-	-	-	-	-	-	-	-	-	3 mgal	5 MGD	12' Pipe	3 mgal	20MGD	6' Pipe	6' Pipe	4' Pipe	-	-	-	-	-	-	-	-	-
5566	$121,132,170	19.4%	-	-	-	-	-	-	-	-	-	-	5 mgal	5 MGD	12' Pipe	2 mgal	20MGD	6' Pipe	6' Pipe	4' Pipe	-	-	-	-	-	-	-	-	-
5567	$93,299,381	12.7%	-	-	-	-	-	-	-	-	-	-	1 mgal	5 MGD	12' Pipe	4 mgal	10MGD	4' Pipe	5' Pipe	-	-	-	-	-	-	-	-	-	-
5568	$99,715,277	16.6%	-	-	-	-	-	-	-	-	-	-	4 mgal	5 MGD	12' Pipe	2 mgal	10MGD	4' Pipe	6' Pipe	5' Pipe	-	-	-	-	-	-	-	-	-
5569	$119,393,142	18.7%	-	-	-	-	-	-	-	-	-	-	4 mgal	5 MGD	12' Pipe	3 mgal	20MGD	5' Pipe	6' Pipe	4' Pipe	-	-	-	-	-	-	-	-	-
5570	$118,190,742	18.2%	-	-	-	-	-	-	-	-	-	-	4 mgal	5 MGD	12' Pipe	3 mgal	20MGD	4' Pipe	6' Pipe	4' Pipe	-	-	-	-	-	-	-	-	-
5571	$138,359,240	16.3%	-	-	-	-	-	-	-	-	-	-	5 mgal	5 MGD	8' Pipe	7 mgal	30MGD	-	6' Pipe	5' Pipe	-	-	-	-	-	-	-	-	-
5572	$124,836,854	19.0%	-	-	-	-	-	-	-	-	-	-	4 mgal	5 MGD	12' Pipe	5 mgal	20MGD	5' Pipe	6' Pipe	4' Pipe	-	-	-	-	-	-	-	-	-
5573	$118,142,191	19.1%	-	-	-	-	-	-	-	-	-	-	5 mgal	5 MGD	12' Pipe	2 mgal	20MGD	5' Pipe	4' Pipe	4' Pipe	-	-	-	-	-	-	-	-	-
5574	$120,261,397	19.0%	-	-	-	-	-	-	-	-	-	-	4 mgal	5 MGD	12' Pipe	3 mgal	20MGD	6' Pipe	5' Pipe	4' Pipe	-	-	-	-	-	-	-	-	-
5575	$131,537,196	16.1%	-	-	-	-	-	-	-	-	-	-	7 mgal	5 MGD	-	6 mgal	20MGD	5' Pipe	4' Pipe	6' Pipe	-	-	-	-	-	-	-	-	-
5576	$117,631,668	18.6%	-	-	-	-	-	-	-	-	-	-	4 mgal	5 MGD	8' Pipe	3 mgal	20MGD	5' Pipe	4' Pipe	5' Pipe	-	-	-	-	-	-	-	-	-
5577	$121,278,438	19.6%	-	-	-	-	-	-	-	-	-	-	6 mgal	5 MGD	12' Pipe	2 mgal	20MGD	5' Pipe	4' Pipe	5' Pipe	-	-	-	-	-	-	-	-	-
5578	$120,261,397	19.0%	-	-	-	-	-	-	-	-	-	-	4 mgal	5 MGD	12' Pipe	3 mgal	20MGD	6' Pipe	5' Pipe	4' Pipe	-	-	-	-	-	-	-	-	-
5579	$67,296,098	11.3%	-	-	-	-	-	-	-	-	-	-	3 mgal	5 MGD	-	5 mgal	-	4' Pipe	-	4' Pipe	-	-	-	-	-	-	-	-	-
5580	$104,776,815	16.7%	-	-	-	-	-	-	-	-	-	-	5 mgal	5 MGD	8' Pipe	3 mgal	10MGD	5' Pipe	5' Pipe	5' Pipe	-	-	-	-	-	-	-	-	-
5581	$103,332,682	17.2%	-	-	-	-	-	-	-	-	-	-	4 mgal	5 MGD	8' Pipe	3 mgal	10MGD	6' Pipe	5' Pipe	4' Pipe	-	-	-	-	-	-	-	-	-
5582	$73,129,710	12.5%	-	-	-	-	-	-	-	-	-	-	-	-	8' Pipe	2 mgal	20MGD	5' Pipe	-	5' Pipe	-	-	-	-	-	-	-	-	-
5583	$78,117,780	7.9%	-	-	-	-	-	-	-	-	-	-	1 mgal	5 MGD	8' Pipe	-	10MGD	5' Pipe	4' Pipe	4' Pipe	-	-	-	-	-	-	-	-	-
5584	$113,360,141	16.1%	-	-	-	-	-	-	-	-	-	-	4 mgal	5 MGD	12' Pipe	1 mgal	20MGD	5' Pipe	5' Pipe	4' Pipe	-	-	-	-	-	-	-	-	-
5585	$118,932,855	7.9%	-	-	-	-	-	-	-	-	-	-	5 mgal	5 MGD	-	-	30MGD	4' Pipe	6' Pipe	6' Pipe	-	-	-	-	-	-	-	-	-
5586	$83,806,287	9.1%	-	-	-	-	-	-	-	-	-	-	4 mgal	5 MGD	-	-	10MGD	5' Pipe	5' Pipe	5' Pipe	-	-	-	-	-	-	-	-	-
5587	$118,976,447	18.4%	-	-	-	-	-	-	-	-	-	-	3 mgal	5 MGD	8' Pipe	4 mgal	20MGD	5' Pipe	6' Pipe	5' Pipe	-	-	-	-	-	-	-	-	-
5588	$87,382,213	10.4%	-	-	-	-	-	-	-	-	-	-	-	-	-	3 mgal	30MGD	6' Pipe	-	-	-	-	-	-	-	-	-	-	-
5589	$60,093,583	11.5%	-	-	-	-	-	-	-	-	-	-	-	-	-	2 mgal	10MGD	6' Pipe	5' Pipe	4' Pipe	-	-	-	-	-	-	-	-	-
5590	$79,391,902	7.8%	-	-	-	-	-	-	-	-	-	-	1 mgal	5 MGD	5' Pipe	1 mgal	5MGD	5' Pipe	5' Pipe	4' Pipe	-	-	-	-	-	-	-	-	-
5591	$98,381,695	18.8%	-	-	-	-	-	-	-	-	-	-	4 mgal	5 MGD	12' Pipe	5 mgal	5MGD	4' Pipe	4' Pipe	5' Pipe	-	-	-	-	-	-	-	-	-
5592	$93,031,811	16.8%	-	-	-	-	-	-	-	-	-	-	2 mgal	5 MGD	12' Pipe	5 mgal	5MGD	4' Pipe	4' Pipe	5' Pipe	-	-	-	-	-	-	-	-	-
5593	$90,427,240	15.5%	-	-	-	-	-	-	-	-	-	-	1 mgal	5 MGD	12' Pipe	5 mgal	5MGD	4' Pipe	4' Pipe	5' Pipe	-	-	-	-	-	-	-	-	-
5594	$120,112,196	18.6%	-	-	-	-	-	-	-	-	-	-	4 mgal	5 MGD	12' Pipe	4 mgal	20MGD	4' Pipe	5' Pipe	4' Pipe	-	-	-	-	-	-	-	-	-
5595	$136,297,743	17.3%	-	-	-	-	-	-	-	-	-	-	6 mgal	5 MGD	5' Pipe	2 mgal	30MGD	4' Pipe	6' Pipe	6' Pipe	-	-	-	-	-	-	-	-	-
5596	$103,574,415	18.1%	-	-	-	-	-	-	-	-	-	-	3 mgal	5 MGD	8' Pipe	5 mgal	10MGD	4' Pipe	5' Pipe	5' Pipe	-	-	-	-	-	-	-	-	-
5597	$85,519,381	13.6%	-	-	-	-	-	-	-	-	-	-	5 mgal	5 MGD	8' Pipe	3 mgal	5MGD	-	4' Pipe	5' Pipe	-	-	-	-	-	-	-	-	-
5598	$117,484,980	16.5%	-	-	-	-	-	-	-	-	-	-	5 mgal	5 MGD	8' Pipe	3 mgal	20MGD	4' Pipe	6' Pipe	-	-	-	-	-	-	-	-	-	-
5599	$76,979,543	17.0%	-	-	-	-	-	-	-	-	-	-	6 mgal	5 MGD	12' Pipe	3 mgal	-	5' Pipe	4' Pipe	-	-	-	-	-	-	-	-	-	-
5600	$80,831,159	11.4%	-	-	-	-	-	-	-	-	-	-	5 mgal	5 MGD	8' Pipe	1 mgal	5MGD	-	5' Pipe	5' Pipe	-	-	-	-	-	-	-	-	-
5601	$80,263,325	11.4%	-	-	-	-	-	-	-	-	-	-	5 mgal	5 MGD	8' Pipe	1 mgal	5MGD	-	4' Pipe	5' Pipe	-	-	-	-	-	-	-	-	-
5602	$80,263,325	11.4%	-	-	-	-	-	-	-	-	-	-	5 mgal	5 MGD	8' Pipe	1 mgal	5MGD	-	4' Pipe	5' Pipe	-	-	-	-	-	-	-	-	-
5603	$94,802,045	17.1%	-	-	-	-	-	-	-	-	-	-	2 mgal	5 MGD	12' Pipe	5 mgal	5MGD	5' Pipe	5' Pipe	5' Pipe	-	-	-	-	-	-	-	-	-
5604	$94,421,867	16.3%	-	-	-	-	-	-	-	-	-	-	1 mgal	5 MGD	12' Pipe	6 mgal	5MGD	5' Pipe	4' Pipe	5' Pipe	-	-	-	-	-	-	-	-	-
5605	$121,038,342	19.0%	-	-	-	-	-	-	-	-	-	-	4 mgal	5 MGD	12' Pipe	3 mgal	20MGD	6' Pipe	6' Pipe	4' Pipe	-	-	-	-	-	-	-	-	-
5606	$71,494,478	13.0%	-	-	-	-	-	-	-	-	-	-	7 mgal	5 MGD	5' Pipe	4 mgal	-	-	6' Pipe	-	-	-	-	-	-	-	-	-	-
5607	$92,056,732	16.0%	-	-	-	-	-	-	-	-	-	-	2 mgal	5 MGD	12' Pipe	4 mgal	5MGD	5' Pipe	5' Pipe	5' Pipe	-	-	-	-	-	-	-	-	-
5608	$96,786,342	16.5%	-	-	-	-	-	-	-	-	-	-	4 mgal	5 MGD	12' Pipe	3 mgal	5MGD	6' Pipe	6' Pipe	4' Pipe	-	-	-	-	-	-	-	-	-
5609	$46,114,442	3.3%	-	-	-	-	-	-	-	-	-	-	-	-	8' Pipe	-	10MGD	4' Pipe	6' Pipe	-	-	-	-	-	-	-	-	-	-
5610	$59,652,784	11.5%	-	-	-	-	-	-	-	-	-	-	-	-	12' Pipe	4 mgal	5MGD	5' Pipe	5' Pipe	4' Pipe	-	-	-	-	-	-	-	-	-
5611	$96,525,594	15.6%	-	-	-	-	-	-	-	-	-	-	5 mgal	5 MGD	8' Pipe	4 mgal	10MGD	-	5' Pipe	4' Pipe	-	-	-	-	-	-	-	-	-
5612	$95,287,137	15.2%	-	-	-	-	-	-	-	-	-	-	6 mgal	5 MGD	8' Pipe	2 mgal	5MGD	4' Pipe	5' Pipe	4' Pipe	-	-	-	-	-	-	-	-	-
5613	$115,934,028	17.2%	-	-	-	-	-	-	-	-	-	-	3 mgal	5 MGD	8' Pipe	3 mgal	20MGD	5' Pipe	6' Pipe	4' Pipe	-	-	-	-	-	-	-	-	-
5614	$81,040,969	7.6%	-	-	-	-	-	-	-	-	-	-	2 mgal	5 MGD	5' Pipe	1 mgal	5MGD	4' Pipe	4' Pipe	6' Pipe	-	-	-	-	-	-	-	-	-
5615	$99,391,214	16.7%	-	-	-	-	-	-	-	-	-	-	5 mgal	5 MGD	8' Pipe	4 mgal	5MGD	5' Pipe	5' Pipe	5' Pipe	-	-	-	-	-	-	-	-	-
5616	$101,563,167	18.2%	-	-	-	-	-	-	-	-	-	-	6 mgal	5 MGD	8' Pipe	3 mgal	5MGD	6' Pipe	6' Pipe	4' Pipe	-	-	-	-	-	-	-	-	-
5617	$104,109,627	17.2%	-	-	-	-	-	-	-	-	-	-	4 mgal	5 MGD	8' Pipe	3 mgal	10MGD	6' Pipe	6' Pipe	4' Pipe	-	-	-	-	-	-	-	-	-
5618	$120,277,627	18.8%	-	-	-	-	-	-	-	-	-	-	4 mgal	5 MGD	8' Pipe	3 mgal	20MGD	6' Pipe	6' Pipe	4' Pipe	-	-	-	-	-	-	-	-	-
5619	$50,851,825	5.5%	-	-	-	-	-	-	-	-	-	-	2 mgal	5 MGD	8' Pipe	-	-	5' Pipe	5' Pipe	-	-	-	-	-	-	-	-	-	-
5620	$101,262,027	17.4%	-	-	-	-	-	-	-	-	-	-	4 mgal	5 MGD	8' Pipe	3 mgal	10MGD	4' Pipe	6' Pipe	4' Pipe	-	-	-	-	-	-	-	-	-
5621	$99,812,942	15.8%	-	-	-	-	-	-	-	-	-	-	4 mgal	5 MGD	8' Pipe	2 mgal	10MGD	5' Pipe	6' Pipe	4' Pipe	-	-	-	-	-	-	-	-	-
5622	$130,718,414	20.6%	-	-	-	-	-	-	-	-	-	-	5 mgal	5 MGD	12' Pipe	6 mgal	20MGD	5' Pipe	6' Pipe	5' Pipe	-	-	-	-	-	-	-	-	-
5623	$126,482,054	19.3%	-	-	-	-	-	-	-	-	-	-	4 mgal	5 MGD	12' Pipe	5 mgal	20MGD	6' Pipe	6' Pipe	4' Pipe	-	-	-	-	-	-	-	-	-
5624	$121,038,342	19.0%	-	-	-	-	-	-	-	-	-	-	4 mgal	5 MGD	12' Pipe	3 mgal	20MGD	6' Pipe	6' Pipe	4' Pipe	-	-	-	-	-	-	-	-	-
5625	$94,578,561	15.2%	-	-	-	-	-	-	-	-	-	-	5 mgal	5 MGD	8' Pipe	3 mgal	5MGD	4' Pipe	4' Pipe	4' Pipe	-	-	-	-	-	-	-	-	-
5626	$112,063,913	17.8%	-	-	-	-	-	-	-	-	-	-	3 mgal	5 MGD	12' Pipe	2 mgal	20MGD	4' Pipe	5' Pipe	4' Pipe	-	-	-	-	-	-	-	-	-
5627	$106,240,023	14.8%	-	-	-	-	-	-	-	-	-	-	1 mgal	5 MGD	12' Pipe	2 mgal	20MGD	4' Pipe	4' Pipe	4' Pipe	-	-	-	-	-	-	-	-	-
5628	$111,840,099	17.5%	-	-	-	-	-	-	-	-	-	-	3 mgal	5 MGD	12' Pipe	2 mgal	20MGD	4' Pipe	4' Pipe	5' Pipe	-	-	-	-	-	-	-	-	-
5629	$115,964,712	18.0%	-	-	-	-	-	-	-	-	-	-	2 mgal	5 MGD	12' Pipe	4 mgal	20MGD	5' Pipe	5' Pipe	4' Pipe	-	-	-	-	-	-	-	-	-

Table B-1

Optimization Model Runs (Scenario ID)/ Alternatives - 1 yr 3 hr design event

Scenario ID	Life Cycle Cost	Percent Reduction	WWTP Upgrade	WWTP Storage	Diamond Ave Storage	Diamond Ave HRT	Storage at School	HRT_7thLS_Treatment	7th St HRT	Force Main to WRP	Pump to Force Main	7th St LS Increase Pumping	CSO 012 Storage	CSO 012 HRT	CSO 012 Siphon	CSO 013 Storage	CSO 013 HRT	Consolidate CSO 014 to CSO 012	Consolidate CSO 016 to 7th St LS	Consolidate CSO 016 to CSO 013	PCI Relief (N/S)	PCI Relief (E/W)	CSO 019 Storage	Separation (CSO 020/022)	Separation (CSO 013/016)	Separation (CSO 017)	Separation (CSO 025)	GSI (Basin 012)	GSI (Basin 020 and 022)
5630	$93,350,391	10.0%	-	-	-	-	-	-	-	-	-	-	-	-	5' Pipe	2 mgal	30MGD	4' Pipe	6' Pipe	6' Pipe	-	-	-	-	-	-	-	-	-
5631	$98,378,948	16.1%	-	-	-	-	-	-	-	-	-	-	4 mgal	5 MGD	5' Pipe	2 mgal	10MGD	5' Pipe	5' Pipe	5' Pipe	-	-	-	-	-	-	-	-	-
5632	$117,725,496	17.2%	-	-	-	-	-	-	-	-	-	-	5 mgal	5 MGD	8' Pipe	2 mgal	20MGD	5' Pipe	4' Pipe	5' Pipe	-	-	-	-	-	-	-	-	-
5633	$119,500,682	18.8%	-	-	-	-	-	-	-	-	-	-	4 mgal	5 MGD	8' Pipe	3 mgal	20MGD	6' Pipe	5' Pipe	4' Pipe	-	-	-	-	-	-	-	-	-
5634	$95,485,162	17.3%	-	-	-	-	-	-	-	-	-	-	3 mgal	5 MGD	12' Pipe	4 mgal	5MGD	5' Pipe	6' Pipe	5' Pipe	-	-	-	-	-	-	-	-	-
5635	$97,572,119	18.0%	-	-	-	-	-	-	-	-	-	-	6 mgal	5 MGD	5' Pipe	3 mgal	5MGD	5' Pipe	4' Pipe	4' Pipe	-	-	-	-	-	-	-	-	-
5636	$97,916,139	17.7%	-	-	-	-	-	-	-	-	-	-	6 mgal	5 MGD	5' Pipe	3 mgal	5MGD	5' Pipe	4' Pipe	5' Pipe	-	-	-	-	-	-	-	-	-
5637	$98,386,849	18.0%	-	-	-	-	-	-	-	-	-	-	6 mgal	5 MGD	5' Pipe	3 mgal	5MGD	5' Pipe	4' Pipe	6' Pipe	-	-	-	-	-	-	-	-	-
5638	$114,589,249	17.2%	-	-	-	-	-	-	-	-	-	-	3 mgal	5 MGD	8' Pipe	3 mgal	20MGD	5' Pipe	4' Pipe	4' Pipe	-	-	-	-	-	-	-	-	-
5639	$53,736,218	11.7%	-	-	-	-	-	-	-	-	-	-	3 mgal	5 MGD	12' Pipe	2 mgal	-	-	-	4' Pipe	-	-	-	-	-	-	-	-	-
5640	$85,576,123	14.2%	-	-	-	-	-	-	-	-	-	-	4 mgal	5 MGD	5' Pipe	1 mgal	5MGD	4' Pipe	4' Pipe	4' Pipe	-	-	-	-	-	-	-	-	-
5641	$114,020,502	16.8%	-	-	-	-	-	-	-	-	-	-	4 mgal	5 MGD	5' Pipe	1 mgal	20MGD	6' Pipe	6' Pipe	4' Pipe	-	-	-	-	-	-	-	-	-
5642	$115,468,932	7.3%	-	-	-	-	-	-	-	-	-	-	6 mgal	5 MGD	-	-	30MGD	4' Pipe	-	5' Pipe	-	-	-	-	-	-	-	-	-
5643	$87,395,218	14.0%	-	-	-	-	-	-	-	-	-	-	3 mgal	5 MGD	8' Pipe	2 mgal	5MGD	4' Pipe	5' Pipe	5' Pipe	-	-	-	-	-	-	-	-	-
5644	$115,917,798	19.0%	-	-	-	-	-	-	-	-	-	-	3 mgal	5 MGD	12' Pipe	3 mgal	20MGD	5' Pipe	5' Pipe	4' Pipe	-	-	-	-	-	-	-	-	-
5645	$112,246,264	19.1%	-	-	-	-	-	-	-	-	-	-	3 mgal	5 MGD	12' Pipe	7 mgal	10MGD	6' Pipe	4' Pipe	5' Pipe	-	-	-	-	-	-	-	-	-
5646	$99,485,042	18.4%	-	-	-	-	-	-	-	-	-	-	3 mgal	5 MGD	8' Pipe	6 mgal	5MGD	5' Pipe	5' Pipe	5' Pipe	-	-	-	-	-	-	-	-	-
5647	$125,705,109	20.7%	-	-	-	-	-	-	-	-	-	-	5 mgal	5 MGD	12' Pipe	4 mgal	20MGD	6' Pipe	5' Pipe	4' Pipe	-	-	-	-	-	-	-	-	-
5648	$79,997,841	5.2%	-	-	-	-	-	-	-	-	-	-	-	-	5' Pipe	1 mgal	30MGD	-	4' Pipe	6' Pipe	-	-	-	-	-	-	-	-	-
5649	$102,031,502	17.6%	-	-	-	-	-	-	-	-	-	-	3 mgal	5 MGD	8' Pipe	4 mgal	10MGD	5' Pipe	5' Pipe	5' Pipe	-	-	-	-	-	-	-	-	-
5650	$97,469,760	17.6%	-	-	-	-	-	-	-	-	-	-	3 mgal	5 MGD	8' Pipe	5 mgal	5MGD	5' Pipe	6' Pipe	5' Pipe	-	-	-	-	-	-	-	-	-
5651	$104,349,723	17.3%	-	-	-	-	-	-	-	-	-	-	6 mgal	5 MGD	8' Pipe	2 mgal	10MGD	5' Pipe	4' Pipe	5' Pipe	-	-	-	-	-	-	-	-	-
5652	$121,038,342	19.0%	-	-	-	-	-	-	-	-	-	-	4 mgal	5 MGD	12' Pipe	3 mgal	20MGD	6' Pipe	6' Pipe	4' Pipe	-	-	-	-	-	-	-	-	-
5653	$112,273,091	15.2%	-	-	-	-	-	-	-	-	-	-	2 mgal	5 MGD	-	4 mgal	20MGD	5' Pipe	4' Pipe	6' Pipe	-	-	-	-	-	-	-	-	-
5654	$100,355,096	14.6%	-	-	-	-	-	-	-	-	-	-	5 mgal	5 MGD	8' Pipe	2 mgal	10MGD	4' Pipe	4' Pipe	5' Pipe	-	-	-	-	-	-	-	-	-
5655	$89,666,525	12.5%	-	-	-	-	-	-	-	-	-	-	5 mgal	5 MGD	8' Pipe	1 mgal	5MGD	4' Pipe	4' Pipe	5' Pipe	-	-	-	-	-	-	-	-	-
5656	$89,666,525	12.5%	-	-	-	-	-	-	-	-	-	-	5 mgal	5 MGD	8' Pipe	1 mgal	5MGD	4' Pipe	4' Pipe	5' Pipe	-	-	-	-	-	-	-	-	-
5657	$121,314,596	19.0%	-	-	-	-	-	-	-	-	-	-	4 mgal	5 MGD	12' Pipe	4 mgal	20MGD	5' Pipe	5' Pipe	4' Pipe	-	-	-	-	-	-	-	-	-
5658	$79,200,946	9.1%	-	-	-	-	-	-	-	-	-	-	5 mgal	5 MGD	-	-	5MGD	6' Pipe	4' Pipe	4' Pipe	-	-	-	-	-	-	-	-	-
5659	$105,162,826	17.7%	-	-	-	-	-	-	-	-	-	-	4 mgal	5 MGD	8' Pipe	4 mgal	10MGD	5' Pipe	6' Pipe	4' Pipe	-	-	-	-	-	-	-	-	-
5660	$99,824,139	16.7%	-	-	-	-	-	-	-	-	-	-	5 mgal	5 MGD	8' Pipe	4 mgal	5MGD	5' Pipe	6' Pipe	4' Pipe	-	-	-	-	-	-	-	-	-
5661	$99,824,139	16.7%	-	-	-	-	-	-	-	-	-	-	5 mgal	5 MGD	8' Pipe	4 mgal	5MGD	5' Pipe	6' Pipe	4' Pipe	-	-	-	-	-	-	-	-	-
5662	$102,616,366	18.5%	-	-	-	-	-	-	-	-	-	-	6 mgal	5 MGD	8' Pipe	4 mgal	5MGD	5' Pipe	6' Pipe	4' Pipe	-	-	-	-	-	-	-	-	-
5663	$99,520,458	16.3%	-	-	-	-	-	-	-	-	-	-	3 mgal	5 MGD	12' Pipe	2 mgal	10MGD	6' Pipe	6' Pipe	4' Pipe	-	-	-	-	-	-	-	-	-
5664	$87,774,828	12.3%	-	-	-	-	-	-	-	-	-	-	5 mgal	5 MGD	-	3 mgal	5MGD	4' Pipe	-	6' Pipe	-	-	-	-	-	-	-	-	-
5665	$94,732,978	17.3%	-	-	-	-	-	-	-	-	-	-	4 mgal	5 MGD	5' Pipe	4 mgal	5MGD	5' Pipe	4' Pipe	4' Pipe	-	-	-	-	-	-	-	-	-
5666	$93,718,234	13.2%	-	-	-	-	-	-	-	-	-	-	2 mgal	5 MGD	5' Pipe	6 mgal	5MGD	4' Pipe	4' Pipe	4' Pipe	-	-	-	-	-	-	-	-	-
5667	$116,849,197	17.7%	-	-	-	-	-	-	-	-	-	-	4 mgal	5 MGD	8' Pipe	2 mgal	20MGD	6' Pipe	5' Pipe	4' Pipe	-	-	-	-	-	-	-	-	-
5668	$76,562,538	10.8%	-	-	-	-	-	-	-	-	-	-	3 mgal	5 MGD	5' Pipe	6 mgal	-	5' Pipe	6' Pipe	-	-	-	-	-	-	-	-	-	-
5669	$87,593,918	14.9%	-	-	-	-	-	-	-	-	-	-	3 mgal	5 MGD	5' Pipe	4 mgal	5MGD	5' Pipe	-	4' Pipe	-	-	-	-	-	-	-	-	-
5670	$120,355,225	19.4%	-	-	-	-	-	-	-	-	-	-	5 mgal	5 MGD	12' Pipe	2 mgal	20MGD	6' Pipe	5' Pipe	4' Pipe	-	-	-	-	-	-	-	-	-
5671	$51,141,328	10.3%	-	-	-	-	-	-	-	-	-	-	-	-	-	2 mgal	5MGD	5' Pipe	6' Pipe	4' Pipe	-	-	-	-	-	-	-	-	-
5672	$95,099,481	17.4%	-	-	-	-	-	-	-	-	-	-	4 mgal	5 MGD	8' Pipe	4 mgal	5MGD	4' Pipe	5' Pipe	4' Pipe	-	-	-	-	-	-	-	-	-
5673	$99,371,257	15.3%	-	-	-	-	-	-	-	-	-	-	4 mgal	5 MGD	12' Pipe	2 mgal	10MGD	4' Pipe	6' Pipe	4' Pipe	-	-	-	-	-	-	-	-	-
5674	$69,425,917	16.6%	-	-	-	-	-	-	-	-	-	-	4 mgal	5 MGD	5' Pipe	4 mgal	-	4' Pipe	-	4' Pipe	-	-	-	-	-	-	-	-	-
5675	$114,927,743	15.9%	-	-	-	-	-	-	-	-	-	-	2 mgal	5 MGD	8' Pipe	3 mgal	20MGD	6' Pipe	6' Pipe	4' Pipe	-	-	-	-	-	-	-	-	-
5676	$122,976,026	19.1%	-	-	-	-	-	-	-	-	-	-	4 mgal	5 MGD	8' Pipe	4 mgal	20MGD	6' Pipe	6' Pipe	4' Pipe	-	-	-	-	-	-	-	-	-
5677	$127,619,979	10.7%	-	-	-	-	-	-	-	-	-	-	1 mgal	5 MGD	8' Pipe	5 mgal	30MGD	4' Pipe	5' Pipe	-	-	-	-	-	-	-	-	-	-
5678	$111,303,198	15.9%	-	-	-	-	-	-	-	-	-	-	2 mgal	5 MGD	8' Pipe	3 mgal	20MGD	4' Pipe	5' Pipe	4' Pipe	-	-	-	-	-	-	-	-	-
5679	$119,393,142	18.7%	-	-	-	-	-	-	-	-	-	-	4 mgal	5 MGD	12' Pipe	3 mgal	20MGD	5' Pipe	6' Pipe	4' Pipe	-	-	-	-	-	-	-	-	-
5680	$115,917,798	19.0%	-	-	-	-	-	-	-	-	-	-	3 mgal	5 MGD	12' Pipe	3 mgal	20MGD	5' Pipe	5' Pipe	4' Pipe	-	-	-	-	-	-	-	-	-
5681	$121,038,342	19.0%	-	-	-	-	-	-	-	-	-	-	4 mgal	5 MGD	12' Pipe	3 mgal	20MGD	6' Pipe	6' Pipe	4' Pipe	-	-	-	-	-	-	-	-	-
5682	$121,038,342	19.0%	-	-	-	-	-	-	-	-	-	-	4 mgal	5 MGD	12' Pipe	3 mgal	20MGD	6' Pipe	6' Pipe	4' Pipe	-	-	-	-	-	-	-	-	-
5683	$123,465,782	16.3%	-	-	-	-	-	-	-	-	-	-	1 mgal	5 MGD	12' Pipe	1 mgal	30MGD	6' Pipe	4' Pipe	6' Pipe	-	-	-	-	-	-	-	-	-
5684	$93,577,492	14.9%	-	-	-	-	-	-	-	-	-	-	3 mgal	5 MGD	5' Pipe	5 mgal	5MGD	4' Pipe	4' Pipe	4' Pipe	-	-	-	-	-	-	-	-	-
5685	$119,393,142	18.7%	-	-	-	-	-	-	-	-	-	-	4 mgal	5 MGD	12' Pipe	3 mgal	20MGD	5' Pipe	6' Pipe	4' Pipe	-	-	-	-	-	-	-	-	-
5686	$96,891,503	15.2%	-	-	-	-	-	-	-	-	-	-	2 mgal	5 MGD	8' Pipe	3 mgal	20MGD	-	-	4' Pipe	-	-	-	-	-	-	-	-	-
5687	$91,777,119	13.9%	-	-	-	-	-	-	-	-	-	-	3 mgal	5 MGD	5' Pipe	3 mgal	10MGD	4' Pipe	-	4' Pipe	-	-	-	-	-	-	-	-	-
5688	$89,136,831	14.9%	-	-	-	-	-	-	-	-	-	-	3 mgal	5 MGD	5' Pipe	5 mgal	5MGD	4' Pipe	-	4' Pipe	-	-	-	-	-	-	-	-	-
5689	$89,136,831	14.9%	-	-	-	-	-	-	-	-	-	-	3 mgal	5 MGD	5' Pipe	5 mgal	5MGD	4' Pipe	-	4' Pipe	-	-	-	-	-	-	-	-	-
5690	$83,641,673	8.6%	-	-	-	-	-	-	-	-	-	-	2 mgal	5 MGD	5' Pipe	1 mgal	5MGD	6' Pipe	5' Pipe	4' Pipe	-	-	-	-	-	-	-	-	-
5691	$81,037,102	9.4%	-	-	-	-	-	-	-	-	-	-	1 mgal	5 MGD	5' Pipe	1 mgal	5MGD	6' Pipe	5' Pipe	4' Pipe	-	-	-	-	-	-	-	-	-
5692	$81,037,102	9.4%	-	-	-	-	-	-	-	-	-	-	1 mgal	5 MGD	5' Pipe	1 mgal	5MGD	6' Pipe	5' Pipe	4' Pipe	-	-	-	-	-	-	-	-	-
5693	$81,037,102	9.4%	-	-	-	-	-	-	-	-	-	-	1 mgal	5 MGD	5' Pipe	1 mgal	5MGD	6' Pipe	5' Pipe	4' Pipe	-	-	-	-	-	-	-	-	-
5694	$93,921,512	14.3%	-	-	-	-	-	-	-	-	-	-	3 mgal	5 MGD	5' Pipe	5 mgal	5MGD	4' Pipe	4' Pipe	5' Pipe	-	-	-	-	-	-	-	-	-
5695	$114,933,269	18.1%	-	-	-	-	-	-	-	-	-	-	3 mgal	5 MGD	8' Pipe	3 mgal	20MGD	5' Pipe	4' Pipe	5' Pipe	-	-	-	-	-	-	-	-	-
5696	$128,769,083	16.3%	-	-	-	-	-	-	-	-	-	-	3 mgal	5 MGD	5' Pipe	6 mgal	30MGD	-	5' Pipe	6' Pipe	-	-	-	-	-	-	-	-	-
5697	$97,609,783	15.3%	-	-	-	-	-	-	-	-	-	-	2 mgal	5 MGD	8' Pipe	4 mgal	10MGD	4' Pipe	4' Pipe	5' Pipe	-	-	-	-	-	-	-	-	-
5698	$87,681,927	14.5%	-	-	-	-	-	-	-	-	-	-	1 mgal	5 MGD	12' Pipe	4 mgal	5MGD	4' Pipe	4' Pipe	5' Pipe	-	-	-	-	-	-	-	-	-
5699	$90,524,905	14.2%	-	-	-	-	-	-	-	-	-	-	1 mgal	5 MGD	8' Pipe	5 mgal	5MGD	5' Pipe	4' Pipe	4' Pipe	-	-	-	-	-	-	-	-	-
5700	$111,546,227	15.6%	-	-	-	-	-	-	-	-	-	-	1 mgal	5 MGD	8' Pipe	3 mgal	20MGD	6' Pipe	5' Pipe	4' Pipe	-	-	-	-	-	-	-	-	-
5701	$148,523,155	20.7%	-	-	-	-	-	-	-	-	-	-	7 mgal	5 MGD	12' Pipe	5 mgal	30MGD	4' Pipe	6' Pipe	5' Pipe	-	-	-	-	-	-	-	-	-
5702	$90,080,473	11.1%	-	-	-	-	-	-	-	-	-	-	1 mgal	5 MGD	5' Pipe	2 mgal	10MGD	5' Pipe	5' Pipe	4' Pipe	-	-	-	-	-	-	-	-	-
5703	$80,392,971	10.4%	-	-	-	-	-	-	-	-	-	-	1 mgal	5 MGD	8' Pipe	1 mgal	5MGD	5' Pipe	5' Pipe	4' Pipe	-	-	-	-	-	-	-	-	-
5704	$81,795,142	11.2%	-	-	-	-	-	-	-	-	-	-	2 mgal	5 MGD	8' Pipe	1 mgal	5MGD	4' Pipe	5' Pipe	4' Pipe	-	-	-	-	-	-	-	-	-
5705	$82,997,542	10.7%	-	-	-	-	-	-	-	-	-	-	2 mgal	5 MGD	8' Pipe	1 mgal	5MGD	5' Pipe	5' Pipe	4' Pipe	-	-	-	-	-	-	-	-	-
5706	$97,714,808	18.1%	-	-	-	-	-	-	-	-	-	-	3 mgal	5 MGD	8' Pipe	6 mgal	5MGD	4' Pipe	4' Pipe	5' Pipe	-	-	-	-	-	-	-	-	-
5707	$122,959,796	19.3%	-	-	-	-	-	-	-	-	-	-	4 mgal	5 MGD	12' Pipe	4 mgal	20MGD	6' Pipe	5' Pipe	4' Pipe	-	-	-	-	-	-	-	-	-
5708	$62,019,110	13.7%	-	-	-	-	-	-	-	-	-	-	-	-	12' Pipe	3 mgal	10MGD	6' Pipe	-	5' Pipe	-	-	-	-	-	-	-	-	-

Table B-1

Optimization Model Runs (Scenario ID)/ Alternatives - 1 yr 3 hr design event

Scenario ID	Life Cycle Cost	Percent Reduction	WWTP Upgrade	WWTP Storage	Diamond Ave Storage	Diamond Ave HRT	Storage at School	HRT_7thLS_Treatment	7th St HRT	Force Main to WRP	Pump to Force Main	7th St LS Increase Pumping	CSO 012 Storage	CSO 012 HRT	CSO 012 Siphon	CSO 013 Storage	CSO 013 HRT	Consolidate CSO 014 to CSO 012	Consolidate CSO 016 to 7th St LS	Consolidate CSO 016 to CSO 013	PCI Relief (N/S)	PCI Relief (E/W)	CSO 019 Storage	Separation (CSO 020/022)	Separation (CSO 013/016)	Separation (CSO 017)	Separation (CSO 025)	GSI (Basin 012)	GSI (Basin 020 and 022)
5709	$86,287,522	14.8%	-	-	-	-	-	-	-	-	-	-	4 mgal	5 MGD	8' Pipe	2 mgal	5MGD	5' Pipe	-	5' Pipe	-	-	-	-	-	-	-	-	-
5710	$88,018,091	14.1%	-	-	-	-	-	-	-	-	-	-	6 mgal	5 MGD	8' Pipe	1 mgal	5MGD	4' Pipe	-	5' Pipe	-	-	-	-	-	-	-	-	-
5711	$117,609,912	18.0%	-	-	-	-	-	-	-	-	-	-	4 mgal	5 MGD	12' Pipe	2 mgal	20MGD	6' Pipe	5' Pipe	4' Pipe	-	-	-	-	-	-	-	-	-
5712	$84,422,346	6.7%	-	-	-	-	-	-	-	-	-	-	-	-	5' Pipe	6 mgal	20MGD	5' Pipe	4' Pipe	-	-	-	-	-	-	-	-	-	-
5713	$102,959,667	18.6%	-	-	-	-	-	-	-	-	-	-	4 mgal	5 MGD	8' Pipe	4 mgal	10MGD	4' Pipe	4' Pipe	5' Pipe	-	-	-	-	-	-	-	-	-
5714	$103,525,143	15.3%	-	-	-	-	-	-	-	-	-	-	3 mgal	5 MGD	12' Pipe	6 mgal	10MGD	4' Pipe	4' Pipe	-	-	-	-	-	-	-	-	-	-
5715	$87,205,204	15.3%	-	-	-	-	-	-	-	-	-	-	3 mgal	5 MGD	12' Pipe	3 mgal	5MGD	4' Pipe	4' Pipe	-	-	-	-	-	-	-	-	-	-
5716	$88,446,479	15.0%	-	-	-	-	-	-	-	-	-	-	3 mgal	5 MGD	12' Pipe	2 mgal	5MGD	5' Pipe	4' Pipe	4' Pipe	-	-	-	-	-	-	-	-	-
5717	$87,244,079	14.9%	-	-	-	-	-	-	-	-	-	-	3 mgal	5 MGD	12' Pipe	2 mgal	5MGD	4' Pipe	4' Pipe	4' Pipe	-	-	-	-	-	-	-	-	-
5718	$116,802,283	18.4%	-	-	-	-	-	-	-	-	-	-	3 mgal	5 MGD	8' Pipe	3 mgal	20MGD	6' Pipe	5' Pipe	4' Pipe	-	-	-	-	-	-	-	-	-
5719	$113,676,792	16.7%	-	-	-	-	-	-	-	-	-	-	4 mgal	5 MGD	8' Pipe	1 mgal	20MGD	6' Pipe	4' Pipe	4' Pipe	-	-	-	-	-	-	-	-	-
5720	$95,264,798	14.5%	-	-	-	-	-	-	-	-	-	-	7 mgal	5 MGD	8' Pipe	3 mgal	10MGD	-	-	6' Pipe	-	-	-	-	-	-	-	-	-
5721	$118,199,502	18.6%	-	-	-	-	-	-	-	-	-	-	4 mgal	5 MGD	8' Pipe	3 mgal	20MGD	5' Pipe	5' Pipe	5' Pipe	-	-	-	-	-	-	-	-	-
5722	$124,497,757	20.6%	-	-	-	-	-	-	-	-	-	-	6 mgal	5 MGD	12' Pipe	3 mgal	20MGD	5' Pipe	5' Pipe	5' Pipe	-	-	-	-	-	-	-	-	-
5723	$61,118,246	10.3%	-	-	-	-	-	-	-	-	-	-	1 mgal	5 MGD	8' Pipe	1 mgal	-	4' Pipe	6' Pipe	6' Pipe	-	-	-	-	-	-	-	-	-
5724	$104,964,170	17.8%	-	-	-	-	-	-	-	-	-	-	5 mgal	5 MGD	12' Pipe	2 mgal	10MGD	6' Pipe	6' Pipe	4' Pipe	-	-	-	-	-	-	-	-	-
5725	$89,030,543	13.4%	-	-	-	-	-	-	-	-	-	-	3 mgal	5 MGD	8' Pipe	2 mgal	5MGD	5' Pipe	6' Pipe	4' Pipe	-	-	-	-	-	-	-	-	-
5726	$84,015,986	11.5%	-	-	-	-	-	-	-	-	-	-	2 mgal	5 MGD	-	2 mgal	5MGD	5' Pipe	6' Pipe	6' Pipe	-	-	-	-	-	-	-	-	-
5727	$120,715,475	16.5%	-	-	-	-	-	-	-	-	-	-	5 mgal	5 MGD	8' Pipe	2 mgal	20MGD	6' Pipe	6' Pipe	5' Pipe	-	-	-	-	-	-	-	-	-
5728	$118,486,211	19.2%	-	-	-	-	-	-	-	-	-	-	5 mgal	5 MGD	12' Pipe	2 mgal	20MGD	5' Pipe	4' Pipe	5' Pipe	-	-	-	-	-	-	-	-	-
5729	$115,396,878	17.7%	-	-	-	-	-	-	-	-	-	-	4 mgal	5 MGD	12' Pipe	2 mgal	20MGD	5' Pipe	4' Pipe	4' Pipe	-	-	-	-	-	-	-	-	-
5730	$94,205,909	12.6%	-	-	-	-	-	-	-	-	-	-	-	-	12' Pipe	4 mgal	30MGD	4' Pipe	-	5' Pipe	-	-	-	-	-	-	-	-	-
5731	$118,392,383	19.7%	-	-	-	-	-	-	-	-	-	-	4 mgal	5 MGD	12' Pipe	3 mgal	20MGD	5' Pipe	4' Pipe	5' Pipe	-	-	-	-	-	-	-	-	-
5732	$115,740,898	18.6%	-	-	-	-	-	-	-	-	-	-	4 mgal	5 MGD	12' Pipe	2 mgal	20MGD	5' Pipe	4' Pipe	5' Pipe	-	-	-	-	-	-	-	-	-
5733	$118,616,197	18.7%	-	-	-	-	-	-	-	-	-	-	4 mgal	5 MGD	12' Pipe	3 mgal	20MGD	5' Pipe	5' Pipe	4' Pipe	-	-	-	-	-	-	-	-	-
5734	$128,173,857	16.3%	-	-	-	-	-	-	-	-	-	-	5 mgal	5 MGD	12' Pipe	5 mgal	30MGD	-	-	6' Pipe	-	-	-	-	-	-	-	-	-
5735	$104,335,130	16.0%	-	-	-	-	-	-	-	-	-	-	5 mgal	5 MGD	12' Pipe	3 mgal	10MGD	4' Pipe	5' Pipe	5' Pipe	-	-	-	-	-	-	-	-	-
5736	$95,331,313	13.5%	-	-	-	-	-	-	-	-	-	-	2 mgal	5 MGD	8' Pipe	2 mgal	10MGD	6' Pipe	5' Pipe	4' Pipe	-	-	-	-	-	-	-	-	-
5737	$81,037,102	9.4%	-	-	-	-	-	-	-	-	-	-	1 mgal	5 MGD	5' Pipe	1 mgal	5MGD	6' Pipe	5' Pipe	4' Pipe	-	-	-	-	-	-	-	-	-
5738	$81,037,102	9.4%	-	-	-	-	-	-	-	-	-	-	1 mgal	5 MGD	5' Pipe	1 mgal	5MGD	6' Pipe	5' Pipe	4' Pipe	-	-	-	-	-	-	-	-	-
5739	$81,037,102	9.4%	-	-	-	-	-	-	-	-	-	-	1 mgal	5 MGD	5' Pipe	1 mgal	5MGD	6' Pipe	5' Pipe	4' Pipe	-	-	-	-	-	-	-	-	-
5740	$93,031,811	16.8%	-	-	-	-	-	-	-	-	-	-	2 mgal	5 MGD	12' Pipe	5 mgal	5MGD	4' Pipe	4' Pipe	5' Pipe	-	-	-	-	-	-	-	-	-
5741	$120,261,397	19.0%	-	-	-	-	-	-	-	-	-	-	4 mgal	5 MGD	12' Pipe	3 mgal	20MGD	6' Pipe	5' Pipe	4' Pipe	-	-	-	-	-	-	-	-	-
5742	$105,021,553	17.3%	-	-	-	-	-	-	-	-	-	-	6 mgal	5 MGD	5' Pipe	3 mgal	10MGD	4' Pipe	5' Pipe	4' Pipe	-	-	-	-	-	-	-	-	-
5743	$92,177,268	16.1%	-	-	-	-	-	-	-	-	-	-	3 mgal	5 MGD	8' Pipe	4 mgal	5MGD	4' Pipe	4' Pipe	5' Pipe	-	-	-	-	-	-	-	-	-
5744	$93,031,811	16.8%	-	-	-	-	-	-	-	-	-	-	2 mgal	5 MGD	12' Pipe	5 mgal	5MGD	4' Pipe	4' Pipe	5' Pipe	-	-	-	-	-	-	-	-	-
5745	$90,427,240	15.5%	-	-	-	-	-	-	-	-	-	-	1 mgal	5 MGD	12' Pipe	5 mgal	5MGD	4' Pipe	4' Pipe	5' Pipe	-	-	-	-	-	-	-	-	-
5746	$89,383,094	14.9%	-	-	-	-	-	-	-	-	-	-	4 mgal	5 MGD	5' Pipe	2 mgal	5MGD	5' Pipe	4' Pipe	4' Pipe	-	-	-	-	-	-	-	-	-
5747	$97,916,139	17.7%	-	-	-	-	-	-	-	-	-	-	6 mgal	5 MGD	5' Pipe	3 mgal	5MGD	5' Pipe	4' Pipe	5' Pipe	-	-	-	-	-	-	-	-	-
5748	$97,916,139	17.7%	-	-	-	-	-	-	-	-	-	-	6 mgal	5 MGD	5' Pipe	3 mgal	5MGD	5' Pipe	4' Pipe	5' Pipe	-	-	-	-	-	-	-	-	-
5749	$98,386,849	18.0%	-	-	-	-	-	-	-	-	-	-	6 mgal	5 MGD	5' Pipe	3 mgal	5MGD	5' Pipe	4' Pipe	6' Pipe	-	-	-	-	-	-	-	-	-
5750	$114,589,249	17.2%	-	-	-	-	-	-	-	-	-	-	3 mgal	5 MGD	8' Pipe	3 mgal	20MGD	5' Pipe	4' Pipe	4' Pipe	-	-	-	-	-	-	-	-	-
5751	$123,240,653	11.8%	-	-	-	-	-	-	-	-	-	-	5 mgal	5 MGD	-	2 mgal	30MGD	5' Pipe	-	-	-	-	-	-	-	-	-	-	-
5752	$99,059,587	18.1%	-	-	-	-	-	-	-	-	-	-	3 mgal	5 MGD	8' Pipe	6 mgal	5MGD	4' Pipe	6' Pipe	5' Pipe	-	-	-	-	-	-	-	-	-
5753	$98,183,561	18.0%	-	-	-	-	-	-	-	-	-	-	4 mgal	5 MGD	12' Pipe	4 mgal	5MGD	5' Pipe	6' Pipe	5' Pipe	-	-	-	-	-	-	-	-	-
5754	$100,261,987	18.4%	-	-	-	-	-	-	-	-	-	-	3 mgal	5 MGD	8' Pipe	6 mgal	5MGD	5' Pipe	6' Pipe	5' Pipe	-	-	-	-	-	-	-	-	-
5755	$119,393,142	18.7%	-	-	-	-	-	-	-	-	-	-	4 mgal	5 MGD	12' Pipe	3 mgal	20MGD	5' Pipe	6' Pipe	4' Pipe	-	-	-	-	-	-	-	-	-
5756	$115,262,007	16.3%	-	-	-	-	-	-	-	-	-	-	4 mgal	5 MGD	8' Pipe	6 mgal	20MGD	-	4' Pipe	5' Pipe	-	-	-	-	-	-	-	-	-
5757	$103,715,157	16.1%	-	-	-	-	-	-	-	-	-	-	2 mgal	5 MGD	8' Pipe	6 mgal	10MGD	4' Pipe	5' Pipe	5' Pipe	-	-	-	-	-	-	-	-	-
5758	$97,610,502	16.5%	-	-	-	-	-	-	-	-	-	-	2 mgal	5 MGD	8' Pipe	6 mgal	5MGD	5' Pipe	6' Pipe	5' Pipe	-	-	-	-	-	-	-	-	-
5759	$91,712,712	16.3%	-	-	-	-	-	-	-	-	-	-	4 mgal	5 MGD	12' Pipe	2 mgal	5MGD	5' Pipe	5' Pipe	4' Pipe	-	-	-	-	-	-	-	-	-
5760	$96,874,499	16.3%	-	-	-	-	-	-	-	-	-	-	3 mgal	5 MGD	12' Pipe	2 mgal	10MGD	5' Pipe	4' Pipe	5' Pipe	-	-	-	-	-	-	-	-	-
5761	$87,244,079	14.9%	-	-	-	-	-	-	-	-	-	-	3 mgal	5 MGD	12' Pipe	2 mgal	5MGD	4' Pipe	4' Pipe	4' Pipe	-	-	-	-	-	-	-	-	-
5762	$87,244,079	14.9%	-	-	-	-	-	-	-	-	-	-	3 mgal	5 MGD	12' Pipe	2 mgal	5MGD	4' Pipe	4' Pipe	4' Pipe	-	-	-	-	-	-	-	-	-
5763	$104,109,627	17.2%	-	-	-	-	-	-	-	-	-	-	4 mgal	5 MGD	8' Pipe	3 mgal	10MGD	6' Pipe	6' Pipe	4' Pipe	-	-	-	-	-	-	-	-	-
5764	$100,634,283	16.8%	-	-	-	-	-	-	-	-	-	-	3 mgal	5 MGD	8' Pipe	3 mgal	10MGD	6' Pipe	5' Pipe	4' Pipe	-	-	-	-	-	-	-	-	-
5765	$111,840,702	16.2%	-	-	-	-	-	-	-	-	-	-	2 mgal	5 MGD	8' Pipe	4 mgal	20MGD	6' Pipe	-	4' Pipe	-	-	-	-	-	-	-	-	-
5766	$123,006,710	20.5%	-	-	-	-	-	-	-	-	-	-	5 mgal	5 MGD	12' Pipe	3 mgal	20MGD	6' Pipe	5' Pipe	4' Pipe	-	-	-	-	-	-	-	-	-
5767	$117,562,998	19.0%	-	-	-	-	-	-	-	-	-	-	3 mgal	5 MGD	12' Pipe	3 mgal	20MGD	6' Pipe	5' Pipe	4' Pipe	-	-	-	-	-	-	-	-	-
5768	$121,038,342	19.0%	-	-	-	-	-	-	-	-	-	-	4 mgal	5 MGD	12' Pipe	3 mgal	20MGD	6' Pipe	6' Pipe	4' Pipe	-	-	-	-	-	-	-	-	-
5769	$123,783,655	20.5%	-	-	-	-	-	-	-	-	-	-	5 mgal	5 MGD	12' Pipe	3 mgal	20MGD	6' Pipe	6' Pipe	4' Pipe	-	-	-	-	-	-	-	-	-
5770	$146,519,638	21.0%	-	-	-	-	-	-	-	-	-	-	7 mgal	5 MGD	5' Pipe	4 mgal	30MGD	6' Pipe	6' Pipe	4' Pipe	-	-	-	-	-	-	-	-	-
5771	$104,203,455	15.8%	-	-	-	-	-	-	-	-	-	-	5 mgal	5 MGD	8' Pipe	2 mgal	10MGD	6' Pipe	6' Pipe	4' Pipe	-	-	-	-	-	-	-	-	-
5772	$115,740,898	18.6%	-	-	-	-	-	-	-	-	-	-	4 mgal	5 MGD	12' Pipe	2 mgal	20MGD	5' Pipe	4' Pipe	5' Pipe	-	-	-	-	-	-	-	-	-
5773	$99,520,458	16.3%	-	-	-	-	-	-	-	-	-	-	3 mgal	5 MGD	12' Pipe	2 mgal	10MGD	6' Pipe	6' Pipe	4' Pipe	-	-	-	-	-	-	-	-	-
5774	$113,814,559	16.3%	-	-	-	-	-	-	-	-	-	-	5 mgal	5 MGD	8' Pipe	4 mgal	20MGD	-	6' Pipe	5' Pipe	-	-	-	-	-	-	-	-	-
5775	$118,293,330	17.2%	-	-	-	-	-	-	-	-	-	-	5 mgal	5 MGD	8' Pipe	2 mgal	20MGD	5' Pipe	5' Pipe	5' Pipe	-	-	-	-	-	-	-	-	-
5776	$118,486,211	19.2%	-	-	-	-	-	-	-	-	-	-	5 mgal	5 MGD	12' Pipe	2 mgal	20MGD	5' Pipe	4' Pipe	5' Pipe	-	-	-	-	-	-	-	-	-
5777	$118,486,211	19.2%	-	-	-	-	-	-	-	-	-	-	5 mgal	5 MGD	12' Pipe	2 mgal	20MGD	5' Pipe	4' Pipe	5' Pipe	-	-	-	-	-	-	-	-	-
5778	$120,261,397	19.0%	-	-	-	-	-	-	-	-	-	-	4 mgal	5 MGD	12' Pipe	3 mgal	20MGD	6' Pipe	5' Pipe	4' Pipe	-	-	-	-	-	-	-	-	-
5779	$132,452,820	18.6%	-	-	-	-	-	-	-	-	-	-	5 mgal	5 MGD	8' Pipe	7 mgal	20MGD	5' Pipe	6' Pipe	4' Pipe	-	-	-	-	-	-	-	-	-
5780	$59,097,911	5.8%	-	-	-	-	-	-	-	-	-	-	-	-	5' Pipe	1 mgal	10MGD	6' Pipe	4' Pipe	4' Pipe	-	-	-	-	-	-	-	-	-
5781	$81,037,102	9.4%	-	-	-	-	-	-	-	-	-	-	1 mgal	5 MGD	5' Pipe	1 mgal	5MGD	6' Pipe	5' Pipe	4' Pipe	-	-	-	-	-	-	-	-	-
5782	$81,996,473	9.1%	-	-	-	-	-	-	-	-	-	-	2 mgal	5 MGD	5' Pipe	1 mgal	5MGD	5' Pipe	5' Pipe	4' Pipe	-	-	-	-	-	-	-	-	-
5783	$118,190,742	18.2%	-	-	-	-	-	-	-	-	-	-	4 mgal	5 MGD	12' Pipe	3 mgal	20MGD	4' Pipe	6' Pipe	4' Pipe	-	-	-	-	-	-	-	-	-
5784	$93,224,961	15.5%	-	-	-	-	-	-	-	-	-	-	6 mgal	5 MGD	5' Pipe	5 mgal	5MGD	-	4' Pipe	6' Pipe	-	-	-	-	-	-	-	-	-
5785	$90,248,034	14.4%	-	-	-	-	-	-	-	-	-	-	3 mgal	5 MGD	5' Pipe	3 mgal	5MGD	5' Pipe	5' Pipe	5' Pipe	-	-	-	-	-	-	-	-	-
5786	$99,824,139	16.7%	-	-	-	-	-	-	-	-	-	-	5 mgal	5 MGD	8' Pipe	4 mgal	5MGD	5' Pipe	6' Pipe	4' Pipe	-	-	-	-	-	-	-	-	-
5787	$101,563,167	18.2%	-	-	-	-	-	-	-	-	-	-	6 mgal	5 MGD	8' Pipe	3 mgal	5MGD	6' Pipe	6' Pipe	4' Pipe	-	-	-	-	-	-	-	-	-

Table B-1

Optimization Model Runs (Scenario ID)/ Alternatives - 1 yr 3 hr design event

Scenario ID	Life Cycle Cost	Percent Reduction	WWTP Upgrade	WWTP Storage	Diamond Ave Storage	Diamond Ave HRT	Storage at School	HRT_7thLS_Treatment	7th St HRT	Force Main to WRP	Pump to Force Main	7th St LS Increase Pumping	CSO 012 Storage	CSO 012 HRT	CSO 012 Siphon	CSO 013 Storage	CSO 013 HRT	Consolidate CSO 014 to CSO 012	Consolidate CSO 016 to 7th St LS	Consolidate CSO 016 to CSO 013	PCI Relief (N/S)	PCI Relief (E/W)	CSO 019 Storage	Separation (CSO 020/022)	Separation (CSO 013/016)	Separation (CSO 017)	Separation (CSO 025)	GSI (Basin 012)	GSI (Basin 020 and 022)
5788	$101,563,167	18.2%	-	-	-	-	-	-	-	-	-	-	6 mgal	5 MGD	8' Pipe	3 mgal	5MGD	6' Pipe	6' Pipe	4' Pipe	-	-	-	-	-	-	-	-	-
5789	$101,563,167	18.2%	-	-	-	-	-	-	-	-	-	-	6 mgal	5 MGD	8' Pipe	3 mgal	5MGD	6' Pipe	6' Pipe	4' Pipe	-	-	-	-	-	-	-	-	-
5790	$85,261,357	13.2%	-	-	-	-	-	-	-	-	-	-	1 mgal	5 MGD	8' Pipe	3 mgal	5MGD	4' Pipe	5' Pipe	6' Pipe	-	-	-	-	-	-	-	-	-
5791	$94,364,197	16.2%	-	-	-	-	-	-	-	-	-	-	4 mgal	5 MGD	12' Pipe	3 mgal	5MGD	5' Pipe	5' Pipe	4' Pipe	-	-	-	-	-	-	-	-	-
5792	$128,706,438	21.0%	-	-	-	-	-	-	-	-	-	-	7 mgal	5 MGD	5' Pipe	4 mgal	20MGD	5' Pipe	6' Pipe	4' Pipe	-	-	-	-	-	-	-	-	-
5793	$98,954,562	16.3%	-	-	-	-	-	-	-	-	-	-	4 mgal	5 MGD	8' Pipe	2 mgal	10MGD	4' Pipe	6' Pipe	5' Pipe	-	-	-	-	-	-	-	-	-
5794	$86,038,302	13.4%	-	-	-	-	-	-	-	-	-	-	3 mgal	5 MGD	8' Pipe	1 mgal	5MGD	4' Pipe	6' Pipe	6' Pipe	-	-	-	-	-	-	-	-	-
5795	$83,386,817	10.5%	-	-	-	-	-	-	-	-	-	-	2 mgal	5 MGD	8' Pipe	1 mgal	5MGD	4' Pipe	6' Pipe	6' Pipe	-	-	-	-	-	-	-	-	-
5796	$119,737,162	19.7%	-	-	-	-	-	-	-	-	-	-	4 mgal	5 MGD	12' Pipe	3 mgal	20MGD	5' Pipe	6' Pipe	5' Pipe	-	-	-	-	-	-	-	-	-
5797	$71,777,984	15.6%	-	-	-	-	-	-	-	-	-	-	3 mgal	5 MGD	12' Pipe	3 mgal	-	5' Pipe	4' Pipe	5' Pipe	-	-	-	-	-	-	-	-	-
5798	$94,418,212	15.9%	-	-	-	-	-	-	-	-	-	-	4 mgal	5 MGD	8' Pipe	3 mgal	5MGD	5' Pipe	5' Pipe	6' Pipe	-	-	-	-	-	-	-	-	-
5799	$116,694,743	19.0%	-	-	-	-	-	-	-	-	-	-	3 mgal	5 MGD	12' Pipe	3 mgal	20MGD	5' Pipe	6' Pipe	4' Pipe	-	-	-	-	-	-	-	-	-
5800	$84,840,289	15.6%	-	-	-	-	-	-	-	-	-	-	1 mgal	5 MGD	-	6 mgal	5MGD	4' Pipe	-	5' Pipe	-	-	-	-	-	-	-	-	-
5801	$89,470,176	12.9%	-	-	-	-	-	-	-	-	-	-	4 mgal	5 MGD	-	3 mgal	5MGD	4' Pipe	4' Pipe	6' Pipe	-	-	-	-	-	-	-	-	-
5802	$116,854,413	19.0%	-	-	-	-	-	-	-	-	-	-	4 mgal	5 MGD	5' Pipe	3 mgal	20MGD	5' Pipe	5' Pipe	4' Pipe	-	-	-	-	-	-	-	-	-
5803	$93,880,750	13.4%	-	-	-	-	-	-	-	-	-	-	-	-	8' Pipe	2 mgal	30MGD	4' Pipe	6' Pipe	5' Pipe	-	-	-	-	-	-	-	-	-
5804	$104,199,542	18.4%	-	-	-	-	-	-	-	-	-	-	4 mgal	5 MGD	5' Pipe	4 mgal	10MGD	5' Pipe	5' Pipe	6' Pipe	-	-	-	-	-	-	-	-	-
5805	$98,386,849	18.0%	-	-	-	-	-	-	-	-	-	-	6 mgal	5 MGD	5' Pipe	3 mgal	5MGD	5' Pipe	4' Pipe	6' Pipe	-	-	-	-	-	-	-	-	-
5806	$91,766,951	14.2%	-	-	-	-	-	-	-	-	-	-	4 mgal	5 MGD	8' Pipe	1 mgal	10MGD	5' Pipe	-	5' Pipe	-	-	-	-	-	-	-	-	-
5807	$88,018,091	14.1%	-	-	-	-	-	-	-	-	-	-	6 mgal	5 MGD	8' Pipe	1 mgal	5MGD	4' Pipe	-	5' Pipe	-	-	-	-	-	-	-	-	-
5808	$88,018,091	14.1%	-	-	-	-	-	-	-	-	-	-	6 mgal	5 MGD	8' Pipe	1 mgal	5MGD	4' Pipe	-	5' Pipe	-	-	-	-	-	-	-	-	-
5809	$88,018,091	14.1%	-	-	-	-	-	-	-	-	-	-	6 mgal	5 MGD	8' Pipe	1 mgal	5MGD	4' Pipe	-	5' Pipe	-	-	-	-	-	-	-	-	-
5810	$99,749,798	17.4%	-	-	-	-	-	-	-	-	-	-	3 mgal	5 MGD	12' Pipe	3 mgal	10MGD	5' Pipe	5' Pipe	4' Pipe	-	-	-	-	-	-	-	-	-
5811	$83,164,318	15.3%	-	-	-	-	-	-	-	-	-	-	5 mgal	5 MGD	-	6 mgal	-	6' Pipe	4' Pipe	5' Pipe	-	-	-	-	-	-	-	-	-
5812	$88,451,666	16.1%	-	-	-	-	-	-	-	-	-	-	6 mgal	5 MGD	-	7 mgal	-	6' Pipe	4' Pipe	4' Pipe	-	-	-	-	-	-	-	-	-
5813	$112,415,470	14.3%	-	-	-	-	-	-	-	-	-	-	4 mgal	5 MGD	-	2 mgal	20MGD	4' Pipe	6' Pipe	6' Pipe	-	-	-	-	-	-	-	-	-
5814	$146,248,552	20.7%	-	-	-	-	-	-	-	-	-	-	7 mgal	5 MGD	12' Pipe	4 mgal	30MGD	4' Pipe	6' Pipe	6' Pipe	-	-	-	-	-	-	-	-	-
5815	$100,369,151	14.3%	-	-	-	-	-	-	-	-	-	-	5 mgal	5 MGD	5' Pipe	7 mgal	5MGD	6' Pipe	-	-	-	-	-	-	-	-	-	-	-
5816	$89,124,371	13.7%	-	-	-	-	-	-	-	-	-	-	4 mgal	5 MGD	8' Pipe	1 mgal	5MGD	5' Pipe	6' Pipe	4' Pipe	-	-	-	-	-	-	-	-	-
5817	$90,656,087	11.0%	-	-	-	-	-	-	-	-	-	-	1 mgal	5 MGD	8' Pipe	2 mgal	10MGD	4' Pipe	6' Pipe	4' Pipe	-	-	-	-	-	-	-	-	-
5818	$89,922,871	13.4%	-	-	-	-	-	-	-	-	-	-	4 mgal	5 MGD	12' Pipe	1 mgal	5MGD	5' Pipe	5' Pipe	6' Pipe	-	-	-	-	-	-	-	-	-
5819	$135,720,955	16.0%	-	-	-	-	-	-	-	-	-	-	2 mgal	5 MGD	-	6 mgal	30MGD	6' Pipe	5' Pipe	5' Pipe	-	-	-	-	-	-	-	-	-
5820	$132,608,653	19.8%	-	-	-	-	-	-	-	-	-	-	7 mgal	5 MGD	5' Pipe	6 mgal	20MGD	4' Pipe	5' Pipe	5' Pipe	-	-	-	-	-	-	-	-	-
5821	$118,100,082	14.9%	-	-	-	-	-	-	-	-	-	-	3 mgal	5 MGD	12' Pipe	6 mgal	20MGD	6' Pipe	-	-	-	-	-	-	-	-	-	-	-
5822	$74,172,249	12.2%	-	-	-	-	-	-	-	-	-	-	-	-	12' Pipe	6 mgal	20MGD	-	-	5' Pipe	-	-	-	-	-	-	-	-	-
5823	$76,838,681	12.1%	-	-	-	-	-	-	-	-	-	-	-	-	8' Pipe	2 mgal	20MGD	4' Pipe	4' Pipe	6' Pipe	-	-	-	-	-	-	-	-	-
5824	$139,604,037	19.6%	-	-	-	-	-	-	-	-	-	-	7 mgal	5 MGD	8' Pipe	1 mgal	30MGD	6' Pipe	5' Pipe	6' Pipe	-	-	-	-	-	-	-	-	-
5825	$88,541,442	18.7%	-	-	-	-	-	-	-	-	-	-	7 mgal	5 MGD	12' Pipe	4 mgal	-	6' Pipe	6' Pipe	5' Pipe	-	-	-	-	-	-	-	-	-
5826	$71,006,452	11.2%	-	-	-	-	-	-	-	-	-	-	1 mgal	5 MGD	8' Pipe	7 mgal	-	6' Pipe	-	-	-	-	-	-	-	-	-	-	-
5827	$115,158,409	18.1%	-	-	-	-	-	-	-	-	-	-	2 mgal	5 MGD	12' Pipe	3 mgal	20MGD	6' Pipe	4' Pipe	6' Pipe	-	-	-	-	-	-	-	-	-
5828	$142,379,317	20.5%	-	-	-	-	-	-	-	-	-	-	6 mgal	5 MGD	5' Pipe	4 mgal	30MGD	5' Pipe	6' Pipe	5' Pipe	-	-	-	-	-	-	-	-	-
5829	$73,680,090	9.1%	-	-	-	-	-	-	-	-	-	-	3 mgal	5 MGD	8' Pipe	-	10MGD	-	5' Pipe	5' Pipe	-	-	-	-	-	-	-	-	-
5830	$96,420,128	12.3%	-	-	-	-	-	-	-	-	-	-	1 mgal	5 MGD	8' Pipe	2 mgal	20MGD	-	4' Pipe	5' Pipe	-	-	-	-	-	-	-	-	-
5831	$101,380,870	15.3%	-	-	-	-	-	-	-	-	-	-	5 mgal	5 MGD	-	5 mgal	5MGD	6' Pipe	6' Pipe	5' Pipe	-	-	-	-	-	-	-	-	-
5832	$102,503,150	16.5%	-	-	-	-	-	-	-	-	-	-	5 mgal	5 MGD	12' Pipe	3 mgal	10MGD	5' Pipe	5' Pipe	-	-	-	-	-	-	-	-	-	-
5833	$81,980,177	16.2%	-	-	-	-	-	-	-	-	-	-	2 mgal	5 MGD	12' Pipe	6 mgal	5MGD	-	-	5' Pipe	-	-	-	-	-	-	-	-	-
5834	$131,234,955	15.7%	-	-	-	-	-	-	-	-	-	-	4 mgal	5 MGD	-	3 mgal	30MGD	4' Pipe	6' Pipe	6' Pipe	-	-	-	-	-	-	-	-	-
5835	$126,782,046	16.4%	-	-	-	-	-	-	-	-	-	-	7 mgal	5 MGD	5' Pipe	5 mgal	20MGD	4' Pipe	5' Pipe	-	-	-	-	-	-	-	-	-	-
5836	$116,471,038	15.1%	-	-	-	-	-	-	-	-	-	-	1 mgal	5 MGD	12' Pipe	3 mgal	30MGD	-	4' Pipe	6' Pipe	-	-	-	-	-	-	-	-	-
5837	$75,985,076	9.8%	-	-	-	-	-	-	-	-	-	-	-	-	8' Pipe	3 mgal	20MGD	4' Pipe	4' Pipe	-	-	-	-	-	-	-	-	-	-
5838	$92,815,237	12.9%	-	-	-	-	-	-	-	-	-	-	2 mgal	5 MGD	12' Pipe	6 mgal	10MGD	-	6' Pipe	-	-	-	-	-	-	-	-	-	-
5839	$109,170,942	17.4%	-	-	-	-	-	-	-	-	-	-	7 mgal	5 MGD	8' Pipe	6 mgal	5MGD	6' Pipe	5' Pipe	-	-	-	-	-	-	-	-	-	-
5840	$128,684,365	11.8%	-	-	-	-	-	-	-	-	-	-	6 mgal	5 MGD	-	3 mgal	30MGD	5' Pipe	-	-	-	-	-	-	-	-	-	-	-
5841	$106,330,174	16.8%	-	-	-	-	-	-	-	-	-	-	7 mgal	5 MGD	5' Pipe	2 mgal	10MGD	4' Pipe	6' Pipe	5' Pipe	-	-	-	-	-	-	-	-	-
5842	$124,938,721	15.8%	-	-	-	-	-	-	-	-	-	-	4 mgal	5 MGD	12' Pipe	6 mgal	20MGD	5' Pipe	6' Pipe	-	-	-	-	-	-	-	-	-	-
5843	$72,421,844	14.4%	-	-	-	-	-	-	-	-	-	-	-	-	-	7 mgal	10MGD	5' Pipe	4' Pipe	6' Pipe	-	-	-	-	-	-	-	-	-
5844	$102,578,126	16.2%	-	-	-	-	-	-	-	-	-	-	4 mgal	5 MGD	-	7 mgal	5MGD	6' Pipe	4' Pipe	4' Pipe	-	-	-	-	-	-	-	-	-
5845	$94,887,692	16.3%	-	-	-	-	-	-	-	-	-	-	4 mgal	5 MGD	8' Pipe	7 mgal	5MGD	-	5' Pipe	6' Pipe	-	-	-	-	-	-	-	-	-
5846	$125,659,539	17.2%	-	-	-	-	-	-	-	-	-	-	3 mgal	5 MGD	5' Pipe	3 mgal	30MGD	5' Pipe	-	5' Pipe	-	-	-	-	-	-	-	-	-
5847	$123,887,952	19.1%	-	-	-	-	-	-	-	-	-	-	4 mgal	5 MGD	5' Pipe	6 mgal	20MGD	4' Pipe	5' Pipe	4' Pipe	-	-	-	-	-	-	-	-	-
5848	$97,760,966	13.3%	-	-	-	-	-	-	-	-	-	-	2 mgal	5 MGD	5' Pipe	5 mgal	10MGD	6' Pipe	-	5' Pipe	-	-	-	-	-	-	-	-	-
5849	$76,540,216	17.2%	-	-	-	-	-	-	-	-	-	-	4 mgal	5 MGD	12' Pipe	4 mgal	-	4' Pipe	5' Pipe	5' Pipe	-	-	-	-	-	-	-	-	-
5850	$89,864,622	14.5%	-	-	-	-	-	-	-	-	-	-	1 mgal	5 MGD	5' Pipe	6 mgal	5MGD	6' Pipe	-	5' Pipe	-	-	-	-	-	-	-	-	-
5851	$81,509,922	18.3%	-	-	-	-	-	-	-	-	-	-	6 mgal	5 MGD	12' Pipe	4 mgal	-	4' Pipe	4' Pipe	5' Pipe	-	-	-	-	-	-	-	-	-
5852	$58,872,948	9.7%	-	-	-	-	-	-	-	-	-	-	2 mgal	5 MGD	8' Pipe	1 mgal	-	4' Pipe	4' Pipe	-	-	-	-	-	-	-	-	-	-
5853	$119,356,840	13.2%	-	-	-	-	-	-	-	-	-	-	3 mgal	5 MGD	-	6 mgal	20MGD	4' Pipe	5' Pipe	5' Pipe	-	-	-	-	-	-	-	-	-
5854	$112,859,695	9.9%	-	-	-	-	-	-	-	-	-	-	1 mgal	5 MGD	12' Pipe	-	30MGD	6' Pipe	4' Pipe	4' Pipe	-	-	-	-	-	-	-	-	-
5855	$62,387,766	12.7%	-	-	-	-	-	-	-	-	-	-	5 mgal	5 MGD	5' Pipe	3 mgal	-	-	5' Pipe	-	-	-	-	-	-	-	-	-	-
5856	$149,265,261	17.8%	-	-	-	-	-	-	-	-	-	-	5 mgal	5 MGD	8' Pipe	7 mgal	30MGD	6' Pipe	4' Pipe	5' Pipe	-	-	-	-	-	-	-	-	-
5857	$94,435,380	15.2%	-	-	-	-	-	-	-	-	-	-	3 mgal	5 MGD	8' Pipe	5 mgal	5MGD	5' Pipe	6' Pipe	-	-	-	-	-	-	-	-	-	-
5858	$60,969,136	7.5%	-	-	-	-	-	-	-	-	-	-	-	-	5' Pipe	2 mgal	10MGD	5' Pipe	5' Pipe	5' Pipe	-	-	-	-	-	-	-	-	-
5859	$109,190,567	7.8%	-	-	-	-	-	-	-	-	-	-	3 mgal	5 MGD	-	7 mgal	20MGD	-	4' Pipe	-	-	-	-	-	-	-	-	-	-
5860	$79,453,386	11.0%	-	-	-	-	-	-	-	-	-	-	-	-	-	5 mgal	20MGD	5' Pipe	4' Pipe	-	-	-	-	-	-	-	-	-	-
5861	$88,876,471	15.1%	-	-	-	-	-	-	-	-	-	-	1 mgal	5 MGD	8' Pipe	6 mgal	5MGD	5' Pipe	-	4' Pipe	-	-	-	-	-	-	-	-	-
5862	$105,885,473	15.9%	-	-	-	-	-	-	-	-	-	-	1 mgal	5 MGD	8' Pipe	7 mgal	10MGD	6' Pipe	4' Pipe	4' Pipe	-	-	-	-	-	-	-	-	-
5863	$97,508,792	15.1%	-	-	-	-	-	-	-	-	-	-	1 mgal	5 MGD	8' Pipe	4 mgal	10MGD	6' Pipe	4' Pipe	4' Pipe	-	-	-	-	-	-	-	-	-
5864	$97,801,473	15.9%	-	-	-	-	-	-	-	-	-	-	1 mgal	5 MGD	8' Pipe	7 mgal	5MGD	6' Pipe	4' Pipe	4' Pipe	-	-	-	-	-	-	-	-	-
5865	$102,125,330	16.5%	-	-	-	-	-	-	-	-	-	-	2 mgal	5 MGD	8' Pipe	5 mgal	10MGD	5' Pipe	5' Pipe	5' Pipe	-	-	-	-	-	-	-	-	-
5866	$93,503,816	13.9%	-	-	-	-	-	-	-	-	-	-	2 mgal	5 MGD	-	3 mgal	10MGD	5' Pipe	5' Pipe	5' Pipe	-	-	-	-	-	-	-	-	-

Table B-1

Optimization Model Runs (Scenario ID)/ Alternatives - 1 yr 3 hr design event

Scenario ID	Life Cycle Cost	Percent Reduction	WWTP Upgrade	WWTP Storage	Diamond Ave Storage	Diamond Ave HRT	Storage at School	HRT_7thLS_Treatment	7th St HRT	Force Main to WRP	Pump to Force Main	7th St LS Increase Pumping	CSO 012 Storage	CSO 012 HRT	CSO 012 Siphon	CSO 013 Storage	CSO 013 HRT	Consolidate CSO 014 to CSO 012	Consolidate CSO 016 to 7th St LS	Consolidate CSO 016 to CSO 013	PCI Relief (N/S)	PCI Relief (E/W)	CSO 019 Storage	Separation (CSO 020/022)	Separation (CSO 013/016)	Separation (CSO 017)	Separation (CSO 025)	GSI (Basin 012)	GSI (Basin 020 and 022)
5867	$96,113,784	14.6%	-	-	-	-	-	-	-	-	-	-	2 mgal	5 MGD	8' Pipe	3 mgal	10MGD	5' Pipe	4' Pipe	5' Pipe	-	-	-	-	-	-	-	-	-
5868	$95,680,549	12.2%	-	-	-	-	-	-	-	-	-	-	2 mgal	5 MGD	5' Pipe	3 mgal	10MGD	5' Pipe	5' Pipe	5' Pipe	-	-	-	-	-	-	-	-	-
5869	$111,568,621	19.1%	-	-	-	-	-	-	-	-	-	-	4 mgal	5 MGD	8' Pipe	6 mgal	10MGD	6' Pipe	5' Pipe	4' Pipe	-	-	-	-	-	-	-	-	-
5870	$106,077,995	18.7%	-	-	-	-	-	-	-	-	-	-	3 mgal	5 MGD	8' Pipe	5 mgal	10MGD	6' Pipe	5' Pipe	4' Pipe	-	-	-	-	-	-	-	-	-
5871	$107,475,214	18.9%	-	-	-	-	-	-	-	-	-	-	4 mgal	5 MGD	8' Pipe	5 mgal	10MGD	5' Pipe	5' Pipe	5' Pipe	-	-	-	-	-	-	-	-	-
5872	$103,676,702	17.6%	-	-	-	-	-	-	-	-	-	-	3 mgal	5 MGD	8' Pipe	4 mgal	10MGD	6' Pipe	5' Pipe	5' Pipe	-	-	-	-	-	-	-	-	-
5873	$89,727,114	12.2%	-	-	-	-	-	-	-	-	-	-	2 mgal	5 MGD	5' Pipe	4 mgal	5MGD	5' Pipe	4' Pipe	5' Pipe	-	-	-	-	-	-	-	-	-
5874	$98,952,925	14.7%	-	-	-	-	-	-	-	-	-	-	1 mgal	5 MGD	8' Pipe	5 mgal	10MGD	5' Pipe	4' Pipe	5' Pipe	-	-	-	-	-	-	-	-	-
5875	$87,937,938	15.3%	-	-	-	-	-	-	-	-	-	-	3 mgal	5 MGD	5' Pipe	4 mgal	5MGD	5' Pipe	-	5' Pipe	-	-	-	-	-	-	-	-	-
5876	$87,028,715	11.3%	-	-	-	-	-	-	-	-	-	-	2 mgal	5 MGD	5' Pipe	3 mgal	5MGD	5' Pipe	4' Pipe	5' Pipe	-	-	-	-	-	-	-	-	-
5877	$101,021,983	17.7%	-	-	-	-	-	-	-	-	-	-	4 mgal	5 MGD	12' Pipe	3 mgal	10MGD	4' Pipe	4' Pipe	5' Pipe	-	-	-	-	-	-	-	-	-
5878	$101,021,983	17.7%	-	-	-	-	-	-	-	-	-	-	4 mgal	5 MGD	12' Pipe	3 mgal	10MGD	4' Pipe	4' Pipe	5' Pipe	-	-	-	-	-	-	-	-	-
5879	$98,381,695	16.0%	-	-	-	-	-	-	-	-	-	-	5 mgal	5 MGD	12' Pipe	4 mgal	5MGD	4' Pipe	4' Pipe	5' Pipe	-	-	-	-	-	-	-	-	-
5880	$98,381,695	16.0%	-	-	-	-	-	-	-	-	-	-	5 mgal	5 MGD	12' Pipe	4 mgal	5MGD	4' Pipe	4' Pipe	5' Pipe	-	-	-	-	-	-	-	-	-
5881	$96,207,612	14.2%	-	-	-	-	-	-	-	-	-	-	4 mgal	5 MGD	8' Pipe	1 mgal	10MGD	5' Pipe	4' Pipe	5' Pipe	-	-	-	-	-	-	-	-	-
5882	$85,563,238	12.9%	-	-	-	-	-	-	-	-	-	-	2 mgal	5 MGD	8' Pipe	3 mgal	5MGD	5' Pipe	5' Pipe	-	-	-	-	-	-	-	-	-	-
5883	$83,878,793	12.5%	-	-	-	-	-	-	-	-	-	-	3 mgal	5 MGD	8' Pipe	1 mgal	5MGD	4' Pipe	4' Pipe	4' Pipe	-	-	-	-	-	-	-	-	-
5884	$89,525,783	14.1%	-	-	-	-	-	-	-	-	-	-	2 mgal	5 MGD	8' Pipe	4 mgal	5MGD	4' Pipe	4' Pipe	5' Pipe	-	-	-	-	-	-	-	-	-
5885	$101,890,957	18.3%	-	-	-	-	-	-	-	-	-	-	6 mgal	5 MGD	12' Pipe	3 mgal	5MGD	6' Pipe	5' Pipe	5' Pipe	-	-	-	-	-	-	-	-	-
5886	$107,475,214	17.8%	-	-	-	-	-	-	-	-	-	-	5 mgal	5 MGD	8' Pipe	4 mgal	10MGD	5' Pipe	5' Pipe	5' Pipe	-	-	-	-	-	-	-	-	-
5887	$104,605,586	19.0%	-	-	-	-	-	-	-	-	-	-	6 mgal	5 MGD	8' Pipe	4 mgal	5MGD	6' Pipe	6' Pipe	5' Pipe	-	-	-	-	-	-	-	-	-
5888	$107,444,727	19.2%	-	-	-	-	-	-	-	-	-	-	7 mgal	5 MGD	8' Pipe	4 mgal	5MGD	6' Pipe	6' Pipe	5' Pipe	-	-	-	-	-	-	-	-	-
5889	$108,021,092	20.9%	-	-	-	-	-	-	-	-	-	-	6 mgal	5 MGD	5' Pipe	6 mgal	5MGD	6' Pipe	5' Pipe	4' Pipe	-	-	-	-	-	-	-	-	-
5890	$84,187,026	9.2%	-	-	-	-	-	-	-	-	-	-	7 mgal	5 MGD	5' Pipe	-	10MGD	-	6' Pipe	4' Pipe	-	-	-	-	-	-	-	-	-
5891	$85,034,279	12.6%	-	-	-	-	-	-	-	-	-	-	2 mgal	5 MGD	8' Pipe	2 mgal	5MGD	5' Pipe	4' Pipe	4' Pipe	-	-	-	-	-	-	-	-	-
5892	$90,384,163	15.3%	-	-	-	-	-	-	-	-	-	-	4 mgal	5 MGD	8' Pipe	2 mgal	5MGD	5' Pipe	4' Pipe	4' Pipe	-	-	-	-	-	-	-	-	-
5893	$81,227,308	11.2%	-	-	-	-	-	-	-	-	-	-	2 mgal	5 MGD	8' Pipe	1 mgal	5MGD	4' Pipe	4' Pipe	4' Pipe	-	-	-	-	-	-	-	-	-
5894	$81,227,308	11.2%	-	-	-	-	-	-	-	-	-	-	2 mgal	5 MGD	8' Pipe	1 mgal	5MGD	4' Pipe	4' Pipe	4' Pipe	-	-	-	-	-	-	-	-	-
5895	$96,204,216	17.7%	-	-	-	-	-	-	-	-	-	-	4 mgal	5 MGD	12' Pipe	4 mgal	5MGD	4' Pipe	5' Pipe	5' Pipe	-	-	-	-	-	-	-	-	-
5896	$84,991,978	8.9%	-	-	-	-	-	-	-	-	-	-	1 mgal	5 MGD	5' Pipe	3 mgal	5MGD	5' Pipe	5' Pipe	5' Pipe	-	-	-	-	-	-	-	-	-
5897	$96,204,216	17.7%	-	-	-	-	-	-	-	-	-	-	4 mgal	5 MGD	12' Pipe	4 mgal	5MGD	4' Pipe	5' Pipe	5' Pipe	-	-	-	-	-	-	-	-	-
5898	$96,204,216	17.7%	-	-	-	-	-	-	-	-	-	-	4 mgal	5 MGD	12' Pipe	4 mgal	5MGD	4' Pipe	5' Pipe	5' Pipe	-	-	-	-	-	-	-	-	-
5899	$94,098,412	17.1%	-	-	-	-	-	-	-	-	-	-	4 mgal	5 MGD	5' Pipe	4 mgal	5MGD	4' Pipe	5' Pipe	4' Pipe	-	-	-	-	-	-	-	-	-
5900	$88,709,653	15.5%	-	-	-	-	-	-	-	-	-	-	4 mgal	5 MGD	5' Pipe	3 mgal	5MGD	4' Pipe	5' Pipe	-	-	-	-	-	-	-	-	-	-
5901	$88,709,653	15.5%	-	-	-	-	-	-	-	-	-	-	4 mgal	5 MGD	5' Pipe	3 mgal	5MGD	4' Pipe	5' Pipe	-	-	-	-	-	-	-	-	-	-
5902	$94,247,193	15.3%	-	-	-	-	-	-	-	-	-	-	6 mgal	5 MGD	5' Pipe	3 mgal	5MGD	4' Pipe	5' Pipe	-	-	-	-	-	-	-	-	-	-
5903	$81,141,519	11.7%	-	-	-	-	-	-	-	-	-	-	2 mgal	5 MGD	8' Pipe	2 mgal	5MGD	4' Pipe	4' Pipe	-	-	-	-	-	-	-	-	-	-
5904	$90,681,269	15.6%	-	-	-	-	-	-	-	-	-	-	3 mgal	5 MGD	8' Pipe	3 mgal	5MGD	5' Pipe	4' Pipe	5' Pipe	-	-	-	-	-	-	-	-	-
5905	$88,029,784	14.2%	-	-	-	-	-	-	-	-	-	-	3 mgal	5 MGD	8' Pipe	2 mgal	5MGD	5' Pipe	4' Pipe	5' Pipe	-	-	-	-	-	-	-	-	-
5906	$88,029,784	13.7%	-	-	-	-	-	-	-	-	-	-	2 mgal	5 MGD	8' Pipe	3 mgal	5MGD	5' Pipe	4' Pipe	5' Pipe	-	-	-	-	-	-	-	-	-
5907	$88,029,784	14.2%	-	-	-	-	-	-	-	-	-	-	3 mgal	5 MGD	8' Pipe	2 mgal	5MGD	5' Pipe	5' Pipe	4' Pipe	-	-	-	-	-	-	-	-	-
5908	$101,813,359	15.9%	-	-	-	-	-	-	-	-	-	-	5 mgal	5 MGD	8' Pipe	4 mgal	5MGD	6' Pipe	6' Pipe	5' Pipe	-	-	-	-	-	-	-	-	-
5909	$99,239,472	18.0%	-	-	-	-	-	-	-	-	-	-	2 mgal	5 MGD	12' Pipe	6 mgal	5MGD	6' Pipe	5' Pipe	5' Pipe	-	-	-	-	-	-	-	-	-
5910	$87,779,592	13.2%	-	-	-	-	-	-	-	-	-	-	1 mgal	5 MGD	8' Pipe	4 mgal	5MGD	5' Pipe	4' Pipe	4' Pipe	-	-	-	-	-	-	-	-	-
5911	$105,366,301	19.2%	-	-	-	-	-	-	-	-	-	-	6 mgal	5 MGD	12' Pipe	4 mgal	5MGD	6' Pipe	6' Pipe	5' Pipe	-	-	-	-	-	-	-	-	-
5912	$108,205,442	19.3%	-	-	-	-	-	-	-	-	-	-	7 mgal	5 MGD	12' Pipe	4 mgal	5MGD	6' Pipe	6' Pipe	5' Pipe	-	-	-	-	-	-	-	-	-
5913	$88,253,598	13.4%	-	-	-	-	-	-	-	-	-	-	3 mgal	5 MGD	8' Pipe	2 mgal	5MGD	5' Pipe	5' Pipe	4' Pipe	-	-	-	-	-	-	-	-	-
5914	$102,960,543	13.3%	-	-	-	-	-	-	-	-	-	-	2 mgal	5 MGD	8' Pipe	6 mgal	10MGD	6' Pipe	4' Pipe	-	-	-	-	-	-	-	-	-	-
5915	$91,877,004	11.8%	-	-	-	-	-	-	-	-	-	-	2 mgal	5 MGD	8' Pipe	3 mgal	10MGD	4' Pipe	4' Pipe	-	-	-	-	-	-	-	-	-	-
5916	$96,301,881	16.6%	-	-	-	-	-	-	-	-	-	-	4 mgal	5 MGD	8' Pipe	4 mgal	5MGD	5' Pipe	5' Pipe	4' Pipe	-	-	-	-	-	-	-	-	-
5917	$87,834,545	12.1%	-	-	-	-	-	-	-	-	-	-	1 mgal	5 MGD	8' Pipe	5 mgal	5MGD	5' Pipe	4' Pipe	-	-	-	-	-	-	-	-	-	-
5918	$92,271,972	12.1%	-	-	-	-	-	-	-	-	-	-	1 mgal	5 MGD	8' Pipe	6 mgal	5MGD	6' Pipe	4' Pipe	-	-	-	-	-	-	-	-	-	-
5919	$86,491,403	11.8%	-	-	-	-	-	-	-	-	-	-	2 mgal	5 MGD	8' Pipe	4 mgal	5MGD	4' Pipe	4' Pipe	-	-	-	-	-	-	-	-	-	-
5920	$104,661,031	18.5%	-	-	-	-	-	-	-	-	-	-	5 mgal	5 MGD	5' Pipe	6 mgal	5MGD	6' Pipe	4' Pipe	4' Pipe	-	-	-	-	-	-	-	-	-
5921	$110,292,399	20.9%	-	-	-	-	-	-	-	-	-	-	6 mgal	5 MGD	5' Pipe	7 mgal	5MGD	6' Pipe	4' Pipe	4' Pipe	-	-	-	-	-	-	-	-	-
5922	$90,337,249	14.7%	-	-	-	-	-	-	-	-	-	-	3 mgal	5 MGD	8' Pipe	3 mgal	5MGD	5' Pipe	4' Pipe	4' Pipe	-	-	-	-	-	-	-	-	-
5923	$99,123,491	18.3%	-	-	-	-	-	-	-	-	-	-	4 mgal	5 MGD	5' Pipe	5 mgal	5MGD	6' Pipe	4' Pipe	4' Pipe	-	-	-	-	-	-	-	-	-
5924	$86,483,364	13.4%	-	-	-	-	-	-	-	-	-	-	2 mgal	5 MGD	8' Pipe	3 mgal	5MGD	4' Pipe	4' Pipe	4' Pipe	-	-	-	-	-	-	-	-	-
5925	$99,404,975	13.5%	-	-	-	-	-	-	-	-	-	-	2 mgal	5 MGD	5' Pipe	7 mgal	5MGD	6' Pipe	4' Pipe	4' Pipe	-	-	-	-	-	-	-	-	-
5926	$82,042,703	13.4%	-	-	-	-	-	-	-	-	-	-	2 mgal	5 MGD	8' Pipe	3 mgal	5MGD	4' Pipe	-	4' Pipe	-	-	-	-	-	-	-	-	-
5948	$44,648,852	5.9%	-	-	-	-	-	4 mgal	5MGD	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
5949	$52,732,852	7.2%	-	-	-	-	-	4 mgal	10MGD	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
5950	$75,007,280	11.6%	-	-	-	-	-	4 mgal	5MGD	-	-	-	-	-	-	2 mgal	5MGD	-	-	-	-	-	-	-	-	-	-	-	-
5951	$40,143,928	7.2%	-	-	-	-	-	-	-	-	-	-	-	-	-	2 mgal	10MGD	-	-	-	-	-	-	-	-	-	-	-	-
5952	$34,711,413	7.2%	-	-	-	-	-	-	-	-	-	-	-	-	-	3 mgal	5MGD	-	-	-	-	-	-	-	-	-	-	-	-
5953	$34,750,288	7.0%	-	-	-	-	-	-	-	-	-	-	-	-	-	2 mgal	5MGD	-	-	4' Pipe	-	-	-	-	-	-	-	-	-
5954	$35,094,308	7.3%	-	-	-	-	-	-	-	-	-	-	-	-	-	2 mgal	5MGD	-	-	5' Pipe	-	-	-	-	-	-	-	-	-
5955	$35,565,018	7.5%	-	-	-	-	-	-	-	-	-	-	-	-	-	2 mgal	5MGD	-	-	6' Pipe	-	-	-	-	-	-	-	-	-
5956	$15,000,000	0.1%	45 MGD	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
5957	$63,080,820	0.1%	60 MGD	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
5958	$142,246,373	0.4%	80 MGD	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
5959	$151,706,715	1.9%	80 MGD	-	-	-	-	-	-	-	-	20MGD	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
5960	$159,168,606	3.3%	80 MGD	-	-	-	-	-	-	-	-	40MGD	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
5965	$37,745,793	8.7%	-	-	-	-	-	-	-	-	-	-	-	-	-	3 mgal	5MGD	-	-	5' Pipe	-	-	-	-	-	-	-	-	-
5966	$40,444,192	9.5%	-	-	-	-	-	-	-	-	-	-	-	-	-	4 mgal	5MGD	-	-	5' Pipe	-	-	-	-	-	-	-	-	-
5967	$45,829,793	9.6%	-	-	-	-	-	-	-	-	-	-	-	-	-	3 mgal	10MGD	-	-	5' Pipe	-	-	-	-	-	-	-	-	-
5968	$61,997,793	11.2%	-	-	-	-	-	-	-	-	-	-	-	-	-	3 mgal	20MGD	-	-	5' Pipe	-	-	-	-	-	-	-	-	-
5969	$37,409,812	4.1%	-	-	-	-	-	3 mgal	5MGD	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
5970	$42,947,352	5.8%	-	-	-	-	-	4 mgal	5MGD	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Table B-1

Optimization Model Runs (Scenario ID)/ Alternatives - 1 yr 3 hr design event

Scenario ID	Life Cycle Cost	Percent Reduction	WWTP Upgrade	WWTP Storage	Diamond Ave Storage	Diamond Ave HRT	Storage at School	HRT_7thLS_Treatment	7th St HRT	Force Main to WRP	Pump to Force Main	7th St LS Increase Pumping	CSO 012 Storage	CSO 012 HRT	CSO 012 Siphon	CSO 013 Storage	CSO 013 HRT	Consolidate CSO 014 to CSO 012	Consolidate CSO 016 to 7th St LS	Consolidate CSO 016 to CSO 013	PCI Relief (N/S)	PCI Relief (E/W)	CSO 019 Storage	Separation (CSO 020/022)	Separation (CSO 013/016)	Separation (CSO 017)	Separation (CSO 025)	GSI (Basin 012)	GSI (Basin 020 and 022)
5971	$24,984,852	4.5%	-	-	-	-	-	4 mgal	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
5972	$48,732,792	6.5%	-	-	-	-	-	4 mgal	5MGD	-	-	-	-	-	-	-	-	-	6' Pipe	-	-	-	-	-	-	-	-	-	-
5973	$54,457,988	8.2%	-	-	-	-	-	5 mgal	5MGD	-	-	-	-	-	-	-	-	-	6' Pipe	-	-	-	-	-	-	-	-	-	-
5974	$95,086,859	37.3%	-	-	10 mgal	20MGD	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	Yes	-	-
5975	$94,521,984	41.7%	-	-	15 mgal	10MGD	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	Yes	-	-
5976	$106,478,917	38.5%	-	-	10 mgal	20MGD	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	Yes	Yes	Yes	Yes	-	-
6007	$27,845,725	0.1%	45 MGD	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
6008	$33,324,580	0.8%	45 MGD	-	-	-	-	-	-	-	-	10MGD	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
6009	$83,391,544	15.3%	-	-	-	-	-	4 mgal	5MGD	-	-	-	-	-	-	4 mgal	5MGD	-	-	5' Pipe	-	-	-	-	-	-	-	-	-
6010	$80,693,145	14.2%	-	-	-	-	-	4 mgal	5MGD	-	-	-	-	-	-	3 mgal	5MGD	-	-	5' Pipe	-	-	-	-	-	-	-	-	-
6011	$132,267,777	50.4%	-	-	15 mgal	10MGD	-	-	-	-	-	-	-	-	-	3 mgal	5MGD	-	-	5' Pipe	-	-	-	-	-	-	Yes	-	-
6017	$157,252,629	54.8%	-	-	15 mgal	10MGD	-	4 mgal	-	-	-	-	-	-	-	3 mgal	5MGD	-	-	5' Pipe	-	-	-	-	-	-	Yes	-	-
6018	$190,577,209	55.1%	45 MGD	-	15 mgal	10MGD	-	4 mgal	-	-	-	10MGD	-	-	-	3 mgal	5MGD	-	-	5' Pipe	-	-	-	-	-	-	Yes	-	-

Table B-2

Optimization Model Runs (Scenario ID)/ Alternatives - CSO Volumes for Each Alternative - 1 year 3 hr Design Event

Scenario ID	CSO 006	CSO 012	CSO 013	CSO 014	CSO 015	CSO 016	CSO 017	CSO 018	CSO 020	CSO 022	CSO 123 (Treated Effluent)	CSO 024	CSO 025	Total (No CSO 123)	Percent Reduction
4140	0.299	3.124	4.82	3.151	3.86	2.893	0.553	2.413	2.307	6.939	7.622	0.837	34.897	66.093	N/A
4141	0.3	3.123	4.776	3.151	3.848	2.893	0.553	2.413	2.307	6.944	7.621	0.729	29.735	60.772	8%
4142	0.303	3.123	4.74	3.15	3.844	2.893	0.553	2.413	2.307	6.944	7.622	0.619	25.876	56.765	14%
4143	0.299	3.124	4.839	3.152	3.863	2.893	0.553	2.413	2.307	6.945	7.621	2.163	0	32.551	51%
4144	0.303	3.124	4.873	3.152	3.88	2.893	0.553	2.413	2.307	6.944	7.622	3.379	0.39	34.211	48%
4145	0.299	3.124	0.091	3.151	3.847	2.893	0.553	2.413	2.307	6.939	7.622	0.836	34.891	61.344	7%
4146	0.299	3.124	0.091	3.151	3.847	2.893	0.553	2.413	2.307	6.939	7.622	0.836	34.891	61.344	7%
4147	0.298	3.124	0.093	3.151	3.868	0	0.553	2.413	2.307	6.942	7.611	0.837	34.898	58.484	12%
4148	0.298	3.124	0.652	3.151	3.871	0.001	0.553	2.413	2.307	6.943	7.614	0.837	34.901	59.051	11%
4149	0.299	0	4.716	3.151	3.814	2.893	0.553	2.413	2.307	6.935	7.613	0.835	34.902	62.818	5%
4150	0.299	0	4.714	3.151	3.815	2.893	0.553	2.413	2.307	6.936	7.613	0.836	34.883	62.8	5%
4152	0.3	3.123	4.412	3.151	3.037	1.549	0.553	2.413	2.307	6.619	7.589	0.823	34.792	63.079	5%
4153	0.3	3.123	4.391	3.151	2.992	1.47	0.553	2.413	2.307	6.601	7.584	0.823	34.798	62.922	5%
4154	0.299	3.124	4.85	3.152	3.866	2.893	0.553	2.413	2.307	6.945	7.621	2.151	2.606	35.159	47%
4155	0.303	3.123	4.747	3.15	3.841	2.893	0.553	2.413	2.307	6.94	7.622	0.654	0	30.924	53%
4156	0.299	3.124	4.804	3.151	3.851	2.893	0.553	2.413	2.307	6.94	7.622	0.809	0	31.144	53%
4157	0.303	3.124	4.863	3.152	3.877	2.893	0.553	2.413	2.307	6.944	7.622	3.161	0	33.59	49%
4158	0.299	0	4.716	3.151	3.814	2.893	0.553	2.413	2.307	6.935	7.613	0.835	34.902	62.818	5%
4159	0.299	0	4.714	3.151	3.815	2.893	0.553	2.413	2.307	6.936	7.613	0.836	34.883	62.8	5%
4160	0.299	0	4.739	3.151	3.821	2.893	0.553	2.413	2.307	6.937	7.613	0.836	34.89	62.839	5%
4161	0.298	3.123	4.709	0.192	3.795	2.893	0.553	2.413	2.307	6.937	7.621	0.832	34.859	62.911	5%
4162	0.299	3.124	4.818	0.396	3.826	2.893	0.553	2.413	2.307	6.94	7.621	0.836	34.891	63.296	4%
4163	0.304	0	4.64	0.192	3.772	2.893	0.553	2.413	2.307	6.938	7.613	0.831	34.852	59.695	10%
4164	0.304	0.005	4.772	0.192	3.807	2.893	0.553	2.413	2.307	6.941	7.613	0.834	34.883	59.904	9%
4165	0.298	0.381	4.803	0.651	3.806	2.893	0.553	2.413	2.307	6.938	7.613	0.835	34.886	60.764	8%
4234	0.299	3.139	6.381	3.156	5.11	2.893	0.564	2.413	2.313	6.946	13.075	0.717	22.354	56.285	15%
4236	0.299	3.136	6.163	3.155	5.053	2.893	0.564	2.413	2.312	3.314	12.689	0.724	22.368	52.394	21%
4238	0.299	3.133	5.377	3.152	3.931	2.893	0.553	0.416	2.308	3.314	12.512	0.972	0	26.348	60%
4239	0.299	0	0.089	3.151	3.803	2.893	0.553	2.413	2.307	6.935	7.613	0.835	34.883	58.161	12%
4240	0.3	0	0.089	0.192	4.832	2.893	0.559	2.413	2.309	3.314	12.654	0.691	21.539	39.131	41%
4241	0.299	3.121	4.228	3.15	2.454	2.893	0.553	2.413	2.307	6.596	7.589	1.461	0	29.475	55%
4242	0.299	3.12	3.759	3.151	0.988	2.893	0.553	2.413	2.307	6.17	7.59	3.726	7.781	37.16	44%
4243	0.302	3.122	4.379	3.15	2.226	2.893	0.553	2.413	2.307	6.652	7.585	1.423	0	29.42	55%
4244	0.297	0	0.044	3.149	0	2.893	0.553	0.416	2.307	3.314	6.142	1.924	1.376	16.273	75%
4245	0.299	1.917	4.806	3.151	3.822	2.893	0.553	2.413	1.555	1.792	6.141	0.837	34.905	58.943	11%
4246	0.299	0	0.067	3.149	1.412	2.893	0.553	0.416	2.307	3.314	12.655	0.831	0	15.241	77%
4247	0.299	0	0.04	3.149	0.668	2.893	0.553	0.416	1.555	1.689	12.311	0.608	0	11.87	82%
4248	0.299	2.973	4.692	3.151	3.82	2.723	0.545	2.413	2.288	6.654	7.614	0.812	32.521	62.891	5%
4249	0.304	3.124	4.799	3.151	3.825	2.893	0.553	2.413	2.307	6.091	6.825	0.837	34.897	65.194	1%
4250	0.304	3.124	4.799	3.151	3.825	2.893	0.553	2.413	2.307	3.846	6.139	0.837	34.896	62.948	5%
4251	0.299	3.121	4.154	3.15	1.956	2.893	0.553	2.413	2.307	6.764	7.737	0.827	34.823	63.26	4%
4252	0.303	3.117	3.742	3.15	1.451	2.893	0.553	2.413	2.307	6.583	7.817	0.821	34.78	62.113	6%

Table B-2

Optimization Model Runs (Scenario ID)/ Alternatives - CSO Volumes for Each Alternative - 1 year 3 hr Design Event

Scenario ID	CSO 006	CSO 012	CSO 013	CSO 014	CSO 015	CSO 016	CSO 017	CSO 018	CSO 020	CSO 022	CSO 123 (Treated Effluent)	CSO 024	CSO 025	Total (No CSO 123)	Percent Reduction
4253	0.302	3.111	3.446	3.149	1.106	2.893	0.553	2.413	2.307	6.283	7.885	0.813	34.72	61.096	8%
4254	0.298	3.111	3.442	3.149	1.094	2.893	0.553	2.413	2.307	6.278	7.878	0.813	34.718	61.069	8%
4255	0.304	3.124	4.8	3.151	3.829	2.893	0.553	2.413	2.307	6.507	7.292	0.837	34.897	65.615	1%
4256	0.303	3.124	4.797	3.151	3.825	2.893	0.553	2.413	2.307	5.409	6.362	0.836	34.894	64.505	2%
4257	0.302	3.124	4.799	3.151	3.822	2.893	0.553	2.413	2.307	3.314	6.139	0.837	34.922	62.437	6%
4258	0.302	3.124	4.799	3.151	3.822	2.893	0.553	2.413	2.307	3.314	6.139	0.837	34.922	62.437	6%
4259	0.3	3.124	4.8	3.151	3.814	2.893	0.553	2.413	2.307	3.314	9.932	0.837	34.909	62.415	6%
4260	0.3	3.121	4.154	3.15	1.935	2.893	0.553	2.413	2.307	3.314	9.864	0.827	34.819	59.786	10%
4261	0.299	3.125	4.948	3.153	3.9	2.893	0.555	2.413	2.307	6.944	7.622	5.097	13.751	49.385	25%
4262	0.299	3.125	4.923	3.153	3.889	2.893	0.554	2.413	2.307	6.944	7.622	3.919	9.137	43.556	34%
4263	0.299	3.124	4.896	3.152	3.88	2.893	0.553	2.413	2.307	6.943	7.623	2.878	4.577	37.915	43%
4264	0.299	3.124	4.859	3.151	3.868	2.893	0.553	2.413	2.307	6.941	7.622	1.903	0.46	32.771	50%
4265	0.299	3.124	4.875	3.152	3.873	2.893	0.553	2.413	2.307	6.942	7.622	2.288	3.729	36.448	45%
4266	0.299	3.124	4.838	3.151	3.861	2.893	0.553	2.413	2.307	6.941	7.622	1.41	0	31.79	52%
4267	0.298	3.124	4.806	3.151	3.851	2.893	0.553	2.413	2.307	6.94	7.622	0.81	33.278	64.424	3%
4268	0.299	3.124	4.792	3.151	3.848	2.893	0.553	2.413	2.307	6.941	7.623	0.772	31.41	62.503	5%
4269	0.3	3.123	4.776	3.151	3.848	2.893	0.553	2.413	2.307	6.944	7.621	0.729	29.735	60.772	8%
4270	0.298	3.123	4.756	3.15	3.834	2.893	0.553	2.413	2.307	6.943	7.622	0.677	28.314	59.261	10%
4271	0.303	3.123	4.744	3.15	3.844	2.893	0.553	2.413	2.307	6.939	7.622	0.638	26.905	57.812	13%
4272	0.303	3.123	4.74	3.15	3.844	2.893	0.553	2.413	2.307	6.944	7.622	0.619	25.876	56.765	14%
4273	0.3	3.122	4.402	3.15	3.003	2.893	0.553	2.413	2.307	6.693	7.589	0.826	34.811	64.473	2%
4274	0.3	3.121	3.99	3.15	1.877	2.893	0.553	2.413	2.307	6.362	7.584	0.82	34.766	62.552	5%
4275	0.302	3.118	3.316	3.149	0.554	2.893	0.553	2.413	2.307	5.926	7.588	0.815	34.736	60.082	9%
4276	0.3	3.122	4.338	3.15	2.916	2.893	0.553	2.413	2.307	6.599	7.587	0.822	34.796	64.209	3%
4277	0.3	3.122	4.066	3.15	2.3	2.893	0.553	2.413	2.307	6.381	7.589	0.819	34.764	63.068	5%
4278	0.299	3.121	4.241	3.15	2.465	2.893	0.553	2.413	2.307	6.598	7.588	0.824	34.803	63.667	4%
4279	0.3	3.121	4.318	3.15	1.657	2.893	0.553	2.413	2.307	6.765	7.595	0.829	34.844	63.15	4%
4280	0.297	3.122	4.451	3.15	2.896	2.893	0.553	2.413	2.307	6.718	7.586	0.827	34.834	64.461	2%
4281	0.299	3.124	4.82	3.151	3.86	2.893	0.553	2.413	2.307	6.939	7.622	0.837	34.897	66.093	0%
4282	0.299	3.124	4.82	3.151	3.86	2.893	0.553	2.413	2.307	6.939	7.622	0.837	34.897	66.093	0%
4283	0.298	3.124	4.815	3.151	3.856	2.893	0.553	1.423	2.307	6.941	7.622	0.835	34.875	65.071	2%
4284	0.298	3.124	4.815	3.151	3.856	2.893	0.553	0.416	2.307	6.941	7.622	0.835	34.884	64.073	3%
4285	0.304	3.124	4.799	3.151	3.825	2.893	0.553	2.413	2.307	6.091	6.825	0.837	34.897	65.194	1%
4286	0.304	3.124	4.799	3.151	3.825	2.893	0.553	2.413	2.307	3.846	6.139	0.837	34.896	62.948	5%
4287	0.299	0.013	4.81	3.151	3.843	2.893	0.553	2.413	2.307	6.939	7.613	0.836	34.894	62.951	5%
4288	0.299	0	4.714	3.151	3.815	2.893	0.553	2.413	2.307	6.936	7.613	0.836	34.883	62.8	5%
4289	0.299	0.504	4.79	0.814	3.8	2.893	0.553	2.413	2.307	6.942	7.612	0.835	34.887	61.037	8%
4290	0.299	0.418	4.78	1.085	3.798	2.893	0.553	2.413	2.307	6.942	7.613	0.835	34.887	61.21	7%
4291	0.299	0	4.603	0.192	3.75	2.893	0.553	2.413	2.307	6.937	7.613	0.831	34.849	59.627	10%
4292	0.299	0	4.602	0.192	3.75	2.893	0.553	2.413	2.307	6.937	7.613	0.831	34.851	59.628	10%
4293	0.299	3.124	0.226	3.151	3.847	2.893	0.553	2.413	2.307	6.939	7.622	0.836	34.891	61.479	7%
4294	0.299	3.124	0.091	3.151	3.847	2.893	0.553	2.413	2.307	6.939	7.622	0.836	34.891	61.344	7%
4295	0.299	3.124	0.091	3.151	3.847	2.893	0.553	2.413	2.307	6.939	7.622	0.836	34.891	61.344	7%

Table B-2

Optimization Model Runs (Scenario ID)/ Alternatives - CSO Volumes for Each Alternative - 1 year 3 hr Design Event

Scenario ID	CSO 006	CSO 012	CSO 013	CSO 014	CSO 015	CSO 016	CSO 017	CSO 018	CSO 020	CSO 022	CSO 123 (Treated Effluent)	CSO 024	CSO 025	Total (No CSO 123)	Percent Reduction
4296	0.299	3.124	0.091	3.151	3.847	2.893	0.553	2.413	2.307	6.939	7.622	0.836	34.891	61.344	7%
4297	0.299	3.124	0.226	3.151	3.847	2.893	0.553	2.413	2.307	6.939	7.622	0.836	34.891	61.479	7%
4298	0.298	3.124	0.696	3.151	3.871	0.001	0.553	2.413	2.307	6.943	7.614	0.837	34.901	59.095	11%
4299	0.299	3.124	0.699	3.151	3.871	0	0.553	2.413	2.307	6.941	7.619	0.838	34.917	59.113	11%
4300	0.299	3.124	0.093	3.151	3.871	0	0.553	2.413	2.307	6.941	7.619	0.838	34.917	58.507	11%
4301	0.299	3.124	0.093	3.151	3.871	0	0.553	2.413	2.307	6.941	7.619	0.838	34.917	58.507	11%
4302	0.299	3.124	0.103	3.151	3.871	0	0.553	2.413	2.307	6.941	7.619	0.838	34.917	58.517	11%
4303	0.303	3.123	0.204	3.151	3.81	2.893	0.553	1.423	2.307	6.09	6.825	0.835	34.876	59.568	10%
4304	0.303	3.123	0.09	3.151	3.81	2.893	0.553	0.416	2.307	3.85	6.139	0.835	34.881	56.212	15%
4305	0.303	3.123	0.09	3.151	3.81	2.893	0.553	0.416	2.307	3.85	6.139	0.835	34.881	56.212	15%
4306	0.298	3.109	0.044	3.149	0	2.893	0.553	0.908	2.307	4.797	6.178	1.744	0.379	20.181	69%
4307	0.299	2.973	4.692	3.151	3.82	2.723	0.545	2.413	2.288	6.654	7.614	0.812	32.521	62.891	5%
4308	0.299	1.917	4.807	3.151	3.818	2.893	0.553	2.413	1.555	5.186	7.596	0.837	34.896	62.325	6%
4320	0.299	2.645	4.809	3.151	3.832	2.893	0.553	2.413	2.007	6.301	7.611	0.837	34.905	64.645	2%
4321	0.3	1.917	4.684	3.151	3.794	2.723	0.545	2.413	1.555	5.185	7.599	0.813	32.553	59.633	10%
4322	0.299	3.12	3.48	3.149	2.705	2.893	0.553	2.413	2.307	6.129	7.591	0.678	23.842	51.568	22%
4323	0.299	3.146	6.642	3.159	5.121	2.893	0.562	2.413	2.323	6.821	7.592	0.719	22.638	56.736	14%
4324	0.3	3.114	3.191	3.149	2.686	2.893	0.553	2.413	2.307	6.472	7.588	0.709	29.9	57.687	13%
4325	0.299	3.121	4.206	3.149	3.912	2.893	0.555	2.413	2.307	6.695	13.053	0.714	24.357	54.621	17%
4326	0.3	3.121	4.259	3.149	3.937	2.893	0.555	2.413	2.307	5.128	12.56	0.723	24.616	53.401	19%
4327	0.299	3.121	4.297	3.15	2.276	2.893	0.553	2.413	2.307	7.601	10.187	0.828	34.828	64.566	2%
4328	0.3	3.124	4.815	3.151	3.851	2.893	0.553	2.413	2.307	6.829	10.165	0.837	34.922	65.995	0%
4329	0.3	3.124	4.817	3.151	3.844	2.893	0.553	2.413	2.307	6.692	13.044	0.837	34.9	65.831	0%
5100	0.298	3.117	3.738	3.15	1.432	2.893	0.553	2.413	2.307	6.506	10.22	0.822	34.79	62.019	6%
5101	0.3	3.117	3.737	3.15	1.433	2.893	0.553	2.413	2.307	6.456	13.048	0.822	34.784	61.965	6%
5102	0.3	3.117	3.735	3.15	1.428	2.893	0.553	2.413	2.307	4.955	12.694	0.821	34.779	60.451	9%
5103	0.299	0	0.039	3.149	0	2.723	0.545	0.908	2.288	4.437	6.17	1.369	0	15.757	76%
5104	0.299	0	0.039	3.149	0	2.723	0.545	0.908	2.288	4.432	6.168	1.357	0	15.74	76%
5105	0.299	0.639	0.039	0.854	0	2.723	0.545	0.908	2.288	4.122	6.295	1.323	0	13.74	79%
5106	0.299	2.952	0.039	3.149	0	2.723	0.545	0.908	2.288	3.021	12.501	1.316	0	17.24	74%
5107	0.3	2.96	0.034	3.149	0	2.723	0.545	0.908	2.288	3.022	12.493	0.588	0	16.517	75%
5108	0.3	2.96	0.034	3.149	0	2.723	0.545	0.908	2.288	3.022	12.492	0.594	0	16.523	75%
5109	0.3	2.958	0.034	3.149	0	2.723	0.545	0.908	2.288	3.387	12.493	0.601	0	16.893	74%
5110	0.299	3.124	4.839	3.152	3.863	2.893	0.553	2.413	2.307	6.945	7.621	2.163	0	32.551	51%
5111	0.299	3.124	4.892	3.153	3.88	2.893	0.554	2.413	2.307	6.948	7.622	3.851	4.827	39.141	41%
5112	0.299	3.124	4.846	3.152	3.865	2.893	0.553	2.413	2.307	6.945	7.621	2.345	0.445	33.187	50%
5113	0.3	3.124	4.863	3.152	3.876	2.893	0.553	2.413	2.307	6.946	7.622	2.675	3.444	36.546	45%
5114	0.298	3.123	4.478	3.151	2.905	2.893	0.553	2.413	2.307	6.715	7.586	2.305	0.419	31.56	52%
5115	0.299	3.122	4.197	3.151	1.529	2.893	0.553	2.413	2.307	6.47	7.589	2.61	3.364	32.908	50%
5116	0.3	3.123	4.535	3.152	3.046	2.893	0.554	2.413	2.307	6.697	7.589	5.036	13.715	47.771	28%
5117	0.298	2.973	4.705	3.151	3.825	2.723	0.545	2.413	2.288	6.65	7.614	1.84	0	31.411	52%
5118	0.3	1.918	4.915	3.153	3.866	2.893	0.554	2.413	2.007	6.173	7.612	4.022	10.471	42.685	35%
5119	0.303	2.973	4.688	3.151	3.805	2.723	0.545	2.413	2.288	6.195	7.29	1.834	0	30.918	53%

Table B-2

Optimization Model Runs (Scenario ID)/ Alternatives - CSO Volumes for Each Alternative - 1 year 3 hr Design Event

Scenario ID	CSO 006	CSO 012	CSO 013	CSO 014	CSO 015	CSO 016	CSO 017	CSO 018	CSO 020	CSO 022	CSO 123 (Treated Effluent)	CSO 024	CSO 025	Total (No CSO 123)	Percent Reduction
5120	0.304	3.125	4.902	3.153	3.859	2.893	0.554	2.413	2.307	5.409	6.363	4.017	10.459	43.395	34%
5121	0.303	3.125	4.904	3.153	3.857	2.893	0.554	2.413	2.307	3.314	6.139	4.021	10.461	41.305	38%
5122	0.3	3.125	4.905	3.153	3.847	2.893	0.554	2.413	2.307	3.664	12.534	4.019	10.451	41.631	37%
5948	0.303	3.121	4.034	3.15	1.508	2.893	0.553	2.413	2.307	6.366	7.59	0.818	34.752	62.218	6%
5949	0.299	3.121	3.927	3.15	0.833	2.893	0.553	2.413	2.307	6.286	7.595	0.817	34.751	61.35	7%
5950	0.3	3.121	0.046	3.15	1.799	2.893	0.553	2.413	2.307	6.253	7.59	0.818	34.76	58.413	12%
5951	0.299	3.124	0.091	3.151	3.847	2.893	0.553	2.413	2.307	6.939	7.622	0.836	34.891	61.344	7%
5952	0.299	3.124	0.091	3.151	3.847	2.893	0.553	2.413	2.307	6.939	7.622	0.836	34.891	61.344	7%
5953	0.298	3.124	3.082	3.151	3.873	0.001	0.553	2.413	2.307	6.943	7.614	0.837	34.899	61.481	7%
5954	0.299	3.124	2.855	3.151	3.873	0	0.553	2.413	2.307	6.941	7.619	0.838	34.915	61.269	7%
5955	0.298	3.124	2.78	3.151	3.87	0	0.553	2.413	2.307	6.942	7.611	0.837	34.893	61.168	7%
5956	0.3	3.124	4.822	3.151	3.854	2.893	0.553	2.413	2.307	6.896	8.6	0.837	34.896	66.046	0%
5957	0.3	3.124	4.815	3.151	3.851	2.893	0.553	2.413	2.307	6.829	10.165	0.837	34.922	65.995	0%
5958	0.3	3.124	4.817	3.151	3.844	2.893	0.553	2.413	2.307	6.692	13.044	0.837	34.9	65.831	0%
5959	0.3	3.122	4.421	3.15	2.678	2.893	0.553	2.413	2.307	7.323	13.055	0.83	34.84	64.83	2%
5960	0.3	3.12	4.102	3.15	1.889	2.893	0.553	2.413	2.307	7.525	13.055	0.826	34.805	63.883	3%
5965	0.304	3.124	1.963	3.151	3.882	0	0.553	2.413	2.307	6.898	8.598	0.838	34.922	60.355	9%
5966	0.304	3.124	1.399	3.151	3.882	0	0.553	2.413	2.307	6.898	8.598	0.838	34.922	59.791	10%
5967	0.304	3.124	1.375	3.151	3.882	0	0.553	2.413	2.307	6.898	8.598	0.838	34.922	59.767	10%
5968	0.304	3.124	0.327	3.151	3.882	0	0.553	2.413	2.307	6.898	8.598	0.838	34.922	58.719	11%
5969	0.299	3.121	4.145	3.15	2.409	2.893	0.553	2.413	2.307	6.475	7.588	0.821	34.785	63.371	4%
5970	0.3	3.121	3.876	3.15	1.802	2.893	0.553	2.413	2.307	6.254	7.59	0.818	34.758	62.245	6%
5971	0.299	3.122	4.214	3.15	2.035	2.893	0.553	2.413	2.307	6.478	7.586	0.821	34.803	63.088	5%
5972	0.299	3.122	4.108	3.15	2.381	1.47	0.553	2.413	2.307	6.392	7.588	0.82	34.765	61.78	7%
5973	0.299	3.121	3.844	3.15	1.751	1.47	0.553	2.413	2.307	6.202	7.591	0.818	34.754	60.682	8%
5974	0.299	3.125	4.906	3.153	3.882	2.893	0.554	2.413	2.307	6.945	7.615	3.598	7.372	41.447	37%
5975	0.299	3.124	4.882	3.152	3.874	2.893	0.553	2.413	2.307	6.945	7.616	2.757	5.317	38.516	42%
5976	0.298	2.974	4.794	3.153	3.853	2.723	0.546	2.413	2.288	6.659	7.614	3.591	7.346	40.638	39%
6007	0.3	3.124	4.822	3.151	3.854	2.893	0.553	2.413	2.307	6.896	8.6	0.837	34.896	66.046	0%
6008	0.3	3.123	4.585	3.151	3.277	2.893	0.553	2.413	2.307	7.279	8.616	0.832	34.864	65.577	1%
6009	0.3	3.121	0.493	3.15	1.821	0	0.553	2.413	2.307	6.266	7.588	0.819	34.757	56	15%
6010	0.3	3.121	1.194	3.15	1.821	0	0.553	2.413	2.307	6.266	7.588	0.819	34.757	56.701	14%
6011	0.299	3.124	2.015	3.152	3.887	0	0.553	2.413	2.307	6.945	7.613	2.757	5.301	32.753	50%
6017	0.299	3.123	1.523	3.151	2.074	0	0.553	2.413	2.307	6.484	7.588	2.696	5.223	29.846	55%
6018	0.299	3.122	1.414	3.151	1.562	0	0.553	2.413	2.307	6.898	8.572	2.695	5.239	29.653	55%
4833	0.301	1.232	0.042	1.248	2.213	2.723	0.545	2.413	2.307	6.343	7.591	0.657	0	20.024	70%
4834	0.299	0.032	3.54	0.193	0.007	0	0.553	2.413	2.307	6.087	7.588	8.26	0	23.691	64%
4835	0.299	0.001	2.977	3.151	0.551	0	0.553	2.433	2.307	5.643	7.589	11.214	0	29.129	56%
4836	0.299	6.017	0.065	1.114	2.169	2.723	0.545	2.424	2.288	6.283	7.589	9.407	0	33.334	50%
4837	0.3	0	0.043	3.15	0.467	2.723	0.553	2.413	2.288	5.948	7.586	0.789	0	18.674	72%
4838	0.302	2.971	0.047	0.192	2.277	0.001	0.553	2.413	2.288	6.007	7.584	4.871	0	21.922	67%
4839	0.302	0	0.065	3.151	2.422	2.893	0.553	2.413	2.307	6.584	7.594	6.403	0	27.093	59%
4840	0.299	0.278	2.677	0.563	2.202	0.001	0.553	2.413	2.307	6.638	7.582	4.737	0	22.668	66%

Table B-2

Optimization Model Runs (Scenario ID)/ Alternatives - CSO Volumes for Each Alternative - 1 year 3 hr Design Event

Scenario ID	CSO 006	CSO 012	CSO 013	CSO 014	CSO 015	CSO 016	CSO 017	CSO 018	CSO 020	CSO 022	CSO 123 (Treated Effluent)	CSO 024	CSO 025	Total (No CSO 123)	Percent Reduction
4841	0.299	2.557	0.045	2.667	0.799	0.001	0.553	2.413	2.307	6.274	7.59	4.658	0	22.573	66%
4842	0.299	0.634	0.045	0.546	1.334	0	0.553	2.413	2.307	6.276	7.587	0.793	29.057	44.257	33%
4843	0.298	2.969	0.039	3.149	0.024	0	0.553	2.413	2.288	5.755	7.587	0.598	0	18.086	73%
4844	0.299	0	4.296	0.192	3.394	0	0.553	2.413	2.288	6.458	7.587	0.804	29.868	50.565	23%
4845	0.298	0	0.044	3.149	0	2.893	0.553	2.413	2.288	5.122	7.586	3.456	0	20.216	69%
4846	0.299	2.966	1.321	0.385	0.613	0.001	0.553	2.413	2.288	5.564	7.587	0.612	0	17.015	74%
4847	0.297	0.658	0.06	0.411	2.365	0	0.553	2.413	2.307	6.573	7.591	0.71	0	16.347	75%
4848	0.299	0.6	0.086	0.659	3.744	2.893	0.545	2.413	2.288	6.643	7.611	0.614	0	20.784	69%
4849	0.303	2.968	0.059	3.149	0.579	0	0.553	2.413	2.288	6.003	7.588	0.761	0	19.076	71%
4850	0.298	4.579	0.602	1.814	3.031	0	0.545	2.413	2.307	6.899	7.6	0.689	27.598	50.775	23%
4851	0.3	0	0.044	3.151	2.27	0	0.553	2.413	2.307	6.368	7.588	7.051	0	24.457	63%
4852	0.297	2.262	3.884	1.322	1.82	0	0.545	2.413	2.288	5.983	7.584	4.85	0	25.664	61%
4853	0.299	2.312	4.163	1.133	1.99	0	0.545	2.413	2.288	6.103	7.576	0.631	0	21.877	67%
4854	0.299	2.53	1.571	3.15	1.85	0	0.545	2.413	2.307	6.366	7.586	0.773	0	21.804	67%
4855	0.297	0.137	0.045	0.295	1.618	0.001	0.553	2.413	2.307	6.139	7.59	0.627	0	14.432	78%
4856	0.298	0	0.045	0.192	0.549	0.001	0.553	2.413	2.288	5.551	7.587	9.281	0	21.171	68%
4857	0.295	2.97	0.244	0.192	2.357	2.893	0.545	2.413	2.288	6.229	7.585	0.704	0	21.13	68%
4858	0.296	0.078	0.045	0.251	0.545	0	0.545	2.413	2.307	5.613	7.588	8.166	0	20.259	69%
4859	0.3	2.973	3.354	0.41	2.558	0.001	0.546	2.449	2.288	6.126	7.588	11.617	1.195	33.817	49%
4860	0.299	2.078	0.058	1.351	1.106	2.723	0.546	2.451	2.288	6.151	7.591	11.973	2.715	33.739	49%
4861	0.299	0	0.062	3.15	2.163	0	0.545	2.413	2.307	6.542	7.589	3.407	0	20.888	68%
4862	0.299	2.972	0.051	3.151	1.514	2.723	0.553	2.413	2.288	6.104	7.584	6.492	0	28.56	57%
4863	0.298	3.113	0.039	0.192	0	0	0.545	2.413	2.307	5.817	7.581	0.708	0	15.432	77%
4864	0.3	3.122	4.145	1.143	2.308	0	0.545	2.413	2.307	6.373	7.585	5.337	0	27.993	58%
4865	0.3	0	0.055	3.153	2.429	0	0.545	2.441	2.307	6.476	7.59	11.182	0	28.888	56%
4866	0.299	2.97	0.046	3.15	1.686	0	0.553	2.413	2.288	5.804	7.586	1.006	0	20.215	69%
4867	0.299	0	0.083	3.15	3.335	2.893	0.545	2.413	2.288	6.575	7.606	2.118	0	23.699	64%
4868	0.298	3.113	0.044	0.501	0.54	2.893	0.553	2.413	2.307	5.589	7.584	0.638	0	18.889	71%
4869	0.299	3.883	0.089	1.319	1.437	2.723	0.553	2.413	2.288	5.973	7.584	4.565	0	25.542	61%
4870	0.299	0	0.236	3.15	2.919	2.723	0.553	2.413	2.288	6.336	7.583	1.024	0	21.941	67%
4871	0.298	0.212	0.652	1.621	2.77	0	0.545	2.413	2.288	6.361	7.584	0.609	25.763	43.532	34%
4872	0.3	0.686	0.084	0.599	3.791	0	0.545	2.413	2.307	6.929	7.61	2.217	0	19.871	70%
4873	0.299	0	0.083	3.151	3.343	2.893	0.545	2.413	2.288	6.575	7.606	5.332	0	26.922	59%
4874	0.299	0.387	0.04	1.398	0.549	0	0.553	2.413	2.288	5.543	7.587	3.51	0	16.98	74%
4875	0.295	0	0.483	0.192	0.545	0	0.545	2.413	2.288	5.22	7.587	0.663	22.102	34.746	47%
4876	0.301	1.9	0.067	0.919	1.887	2.723	0.545	2.423	2.307	6.693	7.588	8.699	0	28.464	57%
4877	0.299	2.704	0.057	2.764	0.534	0.001	0.545	2.413	2.307	6.35	7.589	4.108	0	22.082	67%
4878	0.299	0.003	4.222	3.15	2.176	2.893	0.545	2.413	2.307	6.531	7.59	0.76	27.133	52.432	21%
4879	0.298	1.191	0.065	1.141	2.137	2.723	0.553	2.413	2.307	6.624	7.584	5.765	0	25.217	62%
4880	0.299	2.971	2.026	0.8	0.819	0	0.553	2.413	2.288	5.92	7.582	5.336	0	23.425	65%
4881	0.299	0	4.177	0.192	2.887	2.723	0.545	2.414	2.288	6.319	7.583	8.376	0	30.22	54%
4882	0.3	0.432	0.042	1.132	1.415	0	0.545	2.413	2.307	6.347	7.587	2.806	0	17.739	73%
4883	0.299	1.034	0.056	0.921	2.113	0	0.545	2.413	2.307	6.523	7.589	0.787	0	16.998	74%

Table B-2

Optimization Model Runs (Scenario ID)/ Alternatives - CSO Volumes for Each Alternative - 1 year 3 hr Design Event

Scenario ID	CSO 006	CSO 012	CSO 013	CSO 014	CSO 015	CSO 016	CSO 017	CSO 018	CSO 020	CSO 022	CSO 123 (Treated Effluent)	CSO 024	CSO 025	Total (No CSO 123)	Percent Reduction
4884	0.298	1.089	0.042	1.109	1.404	0	0.545	2.413	2.307	6.348	7.584	0.628	0	16.183	76%
4885	0.3	0.29	0.352	1.058	0.549	0	0.545	2.413	2.307	5.901	7.586	0.582	16.729	31.026	53%
4886	0.299	0.727	0.05	0.856	1.445	0	0.545	2.413	2.307	6.456	7.592	1.535	0	16.633	75%
4887	0.299	0.541	0.253	0.736	2.822	0	0.545	2.413	2.307	6.699	7.584	1.569	0	18.184	72%
4888	0.299	2.331	0.257	0.777	1.408	0	0.553	2.413	2.307	6.345	7.584	0.725	0	17.415	74%
4889	0.3	3.623	1.695	1.436	1.438	0	0.553	2.413	2.288	5.985	7.583	6.003	0	25.734	61%
4890	0.298	2.166	1.088	1.327	1.468	0	0.553	2.416	2.307	6.347	7.585	8.496	0	26.466	60%
4891	0.297	0.595	0.245	1.301	0.81	0	0.553	2.413	2.307	6.271	7.589	8.741	0	23.533	64%
4892	0.299	0.614	0.224	1.04	0.771	0	0.545	2.413	2.307	6.267	7.588	2.801	0	17.281	74%
4893	0.299	2.97	0.065	1.22	1.202	0.001	0.553	2.413	2.288	6.169	7.581	0.625	22.761	40.566	39%
4894	0.299	0.97	0.057	1.145	0.534	0.001	0.545	2.413	2.288	5.982	7.579	1.738	0	15.972	76%
4895	0.299	2.97	0.832	0.192	0.758	0	0.545	2.413	2.288	5.913	7.585	0.653	0	16.863	74%
4896	0.298	1.984	0.04	1.261	0	0	0.545	2.413	2.307	6.114	7.584	5.925	0	20.887	68%
4897	0.298	1.78	0.209	1.021	0.761	0	0.545	2.413	2.307	6.267	7.586	0.627	0	16.228	75%
4898	0.299	4.066	1.038	1.311	1	0	0.545	2.413	2.288	6.211	7.582	0.586	0	19.757	70%
4899	0.298	2.205	0.438	1.128	1.005	0	0.545	2.413	2.288	6.213	7.582	0.907	0	17.44	74%
4900	0.299	2.026	0.043	1.436	0.51	0	0.545	2.413	2.288	5.946	7.586	3.319	0	18.825	72%
4901	0.299	6.086	0.043	1.067	1.432	0	0.545	2.413	2.288	5.989	7.586	2.256	0	22.418	66%
4902	0.299	5.856	1.078	0.934	1.463	0	0.545	2.414	2.288	5.989	7.585	7.099	0	27.965	58%
4903	0.299	5.943	2.229	1.206	1.443	0	0.545	2.413	2.288	5.989	7.586	4.669	0	27.024	59%
4904	0.299	0.903	1.819	0.993	2.115	0	0.545	2.413	2.288	6.167	7.587	3.021	0	20.563	69%
4905	0.3	0	0.954	3.151	2.137	2.723	0.553	2.413	2.288	6.293	7.584	6.256	0	27.068	59%
4906	0.299	0	0.988	3.152	2.901	0	0.553	2.418	2.288	6.238	7.585	9.788	0	28.625	57%
4907	0.299	0	0.713	0.192	2.935	0	0.545	2.441	2.288	6.332	7.589	11.383	0.399	27.527	58%
4908	0.302	0.354	2.385	0.781	3.486	0	0.554	2.431	2.288	6.473	7.586	10.364	0	29.418	55%
4909	0.298	0.921	0.256	0.81	2.236	0	0.545	2.413	2.288	5.992	7.586	1.001	0	16.76	75%
4910	0.3	0.988	0.087	0.949	1.007	0	0.553	2.413	2.288	5.798	7.59	1.451	0	15.834	76%
4911	0.299	0.446	1.002	0.456	0.019	0	0.553	2.413	2.288	5.736	7.591	7.853	0	21.065	68%
4912	0.297	0.379	1.605	0.822	0.787	0	0.545	2.413	2.288	5.905	7.586	5.358	0	20.399	69%
4913	0.297	0.379	1.605	0.822	0.787	0	0.545	2.413	2.288	5.905	7.586	5.358	0	20.399	69%
4914	0.297	0.379	1.605	0.822	0.787	0	0.545	2.413	2.288	5.905	7.586	5.358	0	20.399	69%
4915	0.3	0.728	1.003	0.623	1.402	0	0.545	2.413	2.288	5.987	7.584	0.628	0	15.917	76%
4916	0.299	0.417	4.054	3.151	0.867	0	0.553	2.413	2.307	6.293	7.587	6.784	0	27.138	59%
4917	0.299	0.283	0.066	3.152	2.18	2.723	0.545	2.415	2.288	6.294	7.585	7.582	0	27.827	58%
4918	0.299	2.978	0.044	1.14	0.533	0	0.545	2.423	2.288	5.951	7.586	9.316	0	25.517	61%
4919	0.299	2.243	0.066	1.073	2.153	0	0.545	2.413	2.288	6.291	7.585	3.578	0	20.949	68%
4920	0.298	0.931	1.149	1.152	1.207	0	0.545	2.413	2.288	5.761	7.586	2.157	0	17.901	73%
4921	0.299	2.054	0.06	1.611	1.206	0	0.546	2.45	2.288	6.16	7.584	11.764	1.622	30.06	55%
4922	0.3	3.531	2.096	1.514	2.376	0	0.545	2.417	2.288	6.092	7.582	8.374	0	29.533	55%
4923	0.3	3.92	2.051	1.273	2.359	0	0.545	2.413	2.288	6.091	7.584	5.919	0	27.159	59%
4924	0.299	1.001	0.066	1.044	2.398	2.893	0.545	2.413	2.288	6.217	7.588	3.976	0	23.14	65%
4925	0.3	2.003	1.781	1.645	1.8	0	0.545	2.421	2.288	5.872	7.587	8.955	0	27.61	58%
4926	0.3	0.21	1.965	0.956	1.898	0.001	0.545	2.439	2.288	5.992	7.581	11.065	0	27.659	58%

Table B-2

Optimization Model Runs (Scenario ID)/ Alternatives - CSO Volumes for Each Alternative - 1 year 3 hr Design Event

Scenario ID	CSO 006	CSO 012	CSO 013	CSO 014	CSO 015	CSO 016	CSO 017	CSO 018	CSO 020	CSO 022	CSO 123 (Treated Effluent)	CSO 024	CSO 025	Total (No CSO 123)	Percent Reduction
4927	0.3	3.666	2.594	1.697	2.43	0.001	0.545	2.447	2.288	6.104	7.585	11.376	0.401	33.849	49%
4928	0.299	0.669	1.496	0.399	2.828	0	0.545	2.417	2.288	6.361	7.587	8.393	0	25.695	61%
4929	0.298	3.466	1.309	1.069	2.159	0	0.545	2.417	2.307	6.524	7.586	8.374	0	28.468	57%
4930	0.299	0	0.067	3.153	1.234	0	0.553	2.432	2.288	6.177	7.586	10.161	0	26.364	60%
4931	0.299	0	0.667	0.192	2.163	0	0.554	2.446	2.288	6.29	7.586	11.894	1.136	27.929	58%
4932	0.3	0	2.041	0.192	2.814	0	0.555	2.447	2.288	6.361	7.585	12.012	1.907	30.917	53%
4933	0.298	2.973	3.252	1.191	2.265	0	0.553	2.423	2.288	6.182	7.588	9.383	0	30.808	53%
4934	0.3	2.973	3.404	1.736	2.315	0	0.553	2.424	2.288	6.191	7.584	9.388	0	31.572	52%
4935	0.299	3.989	0.041	1.037	1.635	0	0.553	2.413	2.307	6.139	7.588	4.044	0	22.457	66%
4936	0.299	3.881	0.153	1.378	2.191	0	0.545	2.417	2.307	6.533	7.588	8.016	0	27.72	58%
4937	0.299	3.742	2.178	1.436	1.418	0	0.553	2.413	2.307	6.349	7.588	1.588	0	22.283	66%
4938	0.299	4.801	2.788	1.809	2.194	0	0.546	2.443	2.288	6.172	7.586	11.181	0	34.521	48%
4939	0.299	4.852	4.073	1.59	1.455	0	0.545	2.413	2.307	6.353	7.587	4.664	0	28.551	57%
4940	0.299	3.716	2.809	1.512	2.133	0	0.545	2.413	2.288	6.169	7.586	4.682	0	26.566	60%
4941	0.299	3.141	2.814	1.434	2.198	0	0.545	2.447	2.288	6.172	7.587	11.379	0.394	33.111	50%
4942	0.299	2.971	0.072	0.78	2.162	0	0.545	2.413	2.288	6.305	7.584	0.689	24.849	43.373	34%
4943	0.299	2.212	0.276	0.912	2.797	0	0.545	2.413	2.288	6.363	7.586	0.69	24.859	43.654	34%
4944	0.299	3.566	0.534	1.737	2.119	0	0.545	2.413	2.288	6.166	7.586	5.594	0	25.261	62%
4945	0.299	4.663	0.069	2.092	2.85	0	0.545	2.432	2.288	6.363	7.583	10.704	0	32.305	51%
4946	0.299	0	0.068	0.192	2.872	2.893	0.545	2.413	2.288	6.322	7.584	2.817	0	20.709	69%
4947	0.299	0.009	0.068	0.247	2.92	2.893	0.545	2.413	2.288	6.326	7.584	3.55	0	21.558	67%
4948	0.3	0	0.074	3.151	2.396	0.001	0.545	2.413	2.288	6.114	7.584	6.425	0	23.707	64%
4949	0.299	0.009	0.068	0.247	2.92	2.893	0.545	2.413	2.288	6.326	7.584	3.55	0	21.558	67%
4950	0.3	0	0.992	3.15	1.034	0.001	0.553	2.413	2.288	5.817	7.586	2.804	0	19.352	71%
4951	0.298	0	1.984	3.15	2.432	0.001	0.553	2.413	2.288	6.248	7.581	4.628	0	23.995	64%
4952	0.297	0.922	0.053	0.592	2.101	2.723	0.553	2.413	2.288	6.155	7.585	1.542	0	19.639	70%
4953	0.304	3.804	2.938	1.276	2.193	0	0.545	2.433	2.288	6.171	7.587	10.103	0	32.055	52%
4954	0.299	0	2.073	3.15	2.962	0.001	0.553	2.413	2.288	6.349	7.587	2.25	0	22.338	66%
4955	0.299	3.129	3.301	1.708	2.984	0.001	0.553	2.425	2.288	6.341	7.584	9.392	0	32.421	51%
4956	0.299	0.616	1.404	0.89	2.158	0	0.545	2.414	2.288	6.29	7.586	7.89	0	24.794	62%
4957	0.299	0.125	0.841	0.381	1.556	0.001	0.545	2.446	2.288	6.102	7.582	11.374	0.395	26.353	60%
4958	0.299	0.019	0.851	0.192	2.86	0	0.545	2.447	2.288	6.364	7.587	11.393	0.404	27.662	58%
4959	0.3	0.79	2.86	0.946	2.169	0	0.545	2.424	2.288	6.17	7.586	9.384	0	27.876	58%
4960	0.299	2.99	1.305	1.386	1.534	0	0.545	2.447	2.288	6.096	7.585	11.376	0.391	30.657	54%
4961	0.299	2.627	1.992	1.778	2.194	0	0.545	2.447	2.288	6.172	7.586	11.377	0.4	32.119	51%
4962	0.3	0.276	4.469	3.154	2.269	0.001	0.546	2.447	2.288	6.192	7.579	11.388	0.404	33.734	49%
4963	0.299	2.158	3.116	1.261	2.221	0.001	0.545	2.447	2.307	6.532	7.585	11.377	0.397	32.661	51%
4964	0.299	3.141	2.814	1.434	2.198	0	0.545	2.447	2.288	6.172	7.587	11.379	0.394	33.111	50%
4965	0.299	3.141	2.814	1.434	2.198	0	0.545	2.447	2.288	6.172	7.587	11.379	0.394	33.111	50%
4966	0.299	3.814	1.905	1.262	1.476	0.001	0.545	2.416	2.288	5.992	7.586	8.371	0	28.369	57%
4967	0.298	4.354	0.88	1.567	2.208	0.001	0.545	2.447	2.288	6.175	7.577	11.377	0.399	32.539	51%
4968	0.298	4.354	0.88	1.567	2.208	0.001	0.545	2.447	2.288	6.175	7.577	11.377	0.399	32.539	51%
4969	0.298	0.008	4.598	3.155	2.955	0	0.547	2.457	2.307	6.713	7.588	12.103	1.755	36.896	44%

Table B-2

Optimization Model Runs (Scenario ID)/ Alternatives - CSO Volumes for Each Alternative - 1 year 3 hr Design Event

Scenario ID	CSO 006	CSO 012	CSO 013	CSO 014	CSO 015	CSO 016	CSO 017	CSO 018	CSO 020	CSO 022	CSO 123 (Treated Effluent)	CSO 024	CSO 025	Total (No CSO 123)	Percent Reduction
4970	0.299	0.284	2.277	3.153	2.892	0	0.545	2.428	2.288	6.376	7.587	10.354	0	30.896	53%
4971	0.299	3.23	2.873	1.442	2.195	0	0.545	2.447	2.288	6.172	7.587	11.379	0.394	33.264	50%
4972	0.3	5.007	1.077	0.896	2.277	0	0.545	2.416	2.307	6.356	7.586	7.649	0	28.83	56%
4973	0.298	2.454	2.162	1.062	1.414	0	0.545	2.413	2.288	5.985	7.586	3.517	0	22.138	67%
4974	0.299	0.579	2.581	0.682	1.559	0	0.553	2.424	2.288	5.991	7.583	9.367	0	26.323	60%
4975	0.3	4.521	2.264	1.382	1.788	0	0.545	2.413	2.288	5.88	7.587	7.093	0	28.474	57%
4976	0.3	3.775	3.04	1.129	3.008	0.001	0.546	2.448	2.288	6.343	7.585	11.39	0.41	34.678	48%
4977	0.3	3.977	2.885	2.181	2.404	0.001	0.545	2.424	2.288	6.102	7.586	9.374	0	32.481	51%
4978	0.3	3.775	3.04	1.129	3.008	0.001	0.546	2.448	2.288	6.343	7.585	11.39	0.41	34.678	48%
4979	0.3	1.009	0.056	0.916	1.551	0	0.545	2.432	2.307	6.463	7.591	10.678	0	26.257	60%
4980	0.299	3.547	0.082	1.251	3.012	0	0.545	2.413	2.307	6.897	7.601	1.319	0	21.672	67%
4981	0.299	3.166	0.727	1.816	2.83	0	0.545	2.413	2.307	6.697	7.588	5.716	0	26.516	60%
4982	0.299	4.691	0.737	1.959	2.82	0	0.545	2.413	2.307	6.695	7.587	6.241	0	28.707	57%
4983	0.299	4.386	0.163	2.313	2.867	0	0.545	2.433	2.307	6.697	7.587	10.7	0	32.71	51%
4984	0.298	2.573	0.232	1.846	2.176	0.001	0.545	2.413	2.288	6.296	7.586	5.415	0	24.083	64%
4985	0.299	0.459	0.076	0.626	2.833	0.001	0.545	2.413	2.288	6.367	7.589	4.657	0	20.564	69%
4986	0.299	0.298	0.075	0.847	2.833	0.001	0.545	2.413	2.288	6.366	7.588	4.651	0	20.616	69%
4987	0.297	2.418	1.578	0.976	2.189	0.001	0.545	2.424	2.288	6.175	7.579	9.392	0	28.283	57%
4988	0.296	0.005	0.073	3.15	2.226	0.001	0.545	2.413	2.307	6.651	7.585	4.064	0	21.731	67%
4989	0.299	0	0.076	3.15	2.832	0.001	0.545	2.413	2.288	6.378	7.589	4.65	0	22.632	66%
4990	0.299	0.2	0.05	0.863	1.451	0	0.553	2.413	2.288	6.094	7.586	0.674	0	14.885	77%
4991	0.299	0	0.643	0.192	2.759	0	0.553	2.413	2.288	6.36	7.584	5.953	0	21.46	68%
4992	0.299	0.496	0.068	1.289	2.842	2.723	0.545	2.424	2.288	6.353	7.583	9.403	0	28.73	57%
4993	0.303	2.97	0.045	0.192	1.829	0	0.545	2.413	2.288	5.994	7.586	7.243	0	23.822	64%
4994	0.3	2.972	1.352	0.325	1.9	0.001	0.545	2.417	2.288	6.002	7.589	8.376	0	26.478	60%
4995	0.298	2.153	0.063	1.36	2.926	2.723	0.545	2.413	2.307	6.663	7.586	4.145	0	25.596	61%
4996	0.296	0.603	2.668	1.04	1.472	0.001	0.545	2.413	2.288	6.099	7.581	0.658	0	18.083	73%
4997	0.303	3.468	2.071	1.209	2.177	0.001	0.545	2.413	2.288	6.175	7.578	5.387	0	26.037	61%
4998	0.3	0.919	1.466	1.024	2.813	0	0.545	2.413	2.288	6.361	7.587	5.974	0	24.103	64%
4999	0.3	0.906	1.962	0.563	2.783	0	0.545	2.413	2.288	6.361	7.586	1.181	0	19.302	71%
5000	0.299	2.969	1.935	1.287	2.172	0	0.545	2.424	2.288	6.169	7.585	9.378	0	29.466	55%
5001	0.3	1.985	1.977	1.273	2.793	0	0.545	2.413	2.288	6.361	7.586	3.559	0	23.494	64%
5002	0.299	4.203	3.13	2.158	2.19	0.001	0.545	2.424	2.288	6.174	7.579	9.384	0	32.796	50%
5003	0.299	0.596	2.115	0.64	2.851	0	0.545	2.425	2.288	6.362	7.586	9.402	0	27.523	58%
5004	0.3	3.994	2.437	1.625	2.16	0	0.545	2.42	2.288	6.168	7.587	8.961	0	30.898	53%
5005	0.299	2.407	2.949	1.196	2.2	0	0.545	2.447	2.288	6.172	7.586	11.38	0.398	32.281	51%
5006	0.299	3.141	2.814	1.434	2.198	0	0.545	2.447	2.288	6.172	7.587	11.379	0.394	33.111	50%
5007	0.302	0.333	0.049	0.956	1.446	2.723	0.545	2.415	2.288	6.03	7.582	9.231	0	26.318	60%
5008	0.3	0.277	1.775	0.569	1.878	0	0.545	2.432	2.288	5.985	7.585	10.669	0	26.718	60%
5009	0.3	0.277	0.573	0.84	0.838	0.001	0.545	2.417	2.288	5.911	7.58	8.367	0	22.357	66%
5010	0.3	0.207	2.079	0.869	1.555	0.001	0.545	2.432	2.288	6.101	7.581	10.679	0	27.056	59%
5011	0.296	3.78	2.259	1.294	1.456	0	0.545	2.413	2.288	5.987	7.586	7.096	0	27.414	59%
5012	0.304	3.526	2.763	1.264	2.215	0	0.546	2.454	2.288	6.173	7.586	12.004	1.912	35.449	46%

Table B-2

Optimization Model Runs (Scenario ID)/ Alternatives - CSO Volumes for Each Alternative - 1 year 3 hr Design Event

Scenario ID	CSO 006	CSO 012	CSO 013	CSO 014	CSO 015	CSO 016	CSO 017	CSO 018	CSO 020	CSO 022	CSO 123 (Treated Effluent)	CSO 024	CSO 025	Total (No CSO 123)	Percent Reduction
5013	0.3	3.727	1.406	1.031	2.378	0	0.545	2.413	2.307	6.461	7.59	0.728	0	21.296	68%
5014	0.3	0.905	2.241	0.977	2.384	0	0.545	2.413	2.288	6.099	7.591	5.336	0	23.488	64%
5015	0.3	4.635	2.184	0.996	1.423	0	0.545	2.413	2.288	5.985	7.584	3.526	0	24.295	63%
5016	0.299	3.141	2.814	1.434	2.198	0	0.545	2.447	2.288	6.172	7.587	11.379	0.394	33.111	50%
5017	0.3	5.013	0.075	1.136	3.439	2.893	0.553	2.413	2.307	6.787	7.587	0.666	0	25.582	61%
5018	0.3	6.09	0.047	1.232	2.261	2.893	0.553	2.413	2.307	6.352	7.588	5.913	0	30.361	54%
5019	0.3	0.365	1.301	1.486	0.989	0	0.545	2.413	2.288	5.793	7.584	2.789	0	18.269	72%
5020	0.299	0.887	1.779	0.871	2.375	0	0.545	2.413	2.288	6.222	7.586	0.695	0	18.374	72%
5021	0.299	0.904	1.904	0.853	2.912	0	0.545	2.413	2.288	6.33	7.589	0.697	0	19.145	71%
5022	0.299	0.904	1.904	0.853	2.912	0	0.545	2.413	2.288	6.33	7.589	0.697	0	19.145	71%
5023	0.3	0.555	1.225	1.158	2.131	0	0.545	2.413	2.288	6.167	7.585	5.376	0	22.158	66%
5024	0.299	0	2.035	0.192	2.818	0	0.545	2.423	2.288	6.36	7.587	9.396	0	26.356	60%
5025	0.299	1.506	2.149	0.731	2.863	0	0.546	2.447	2.288	6.364	7.586	11.39	0.412	30.995	53%
5026	0.299	0	2.011	0.192	2.797	0	0.545	2.441	2.288	6.361	7.587	11.388	0.397	28.719	57%
5027	0.296	0.571	1.157	0.666	1.481	0	0.545	2.424	2.288	5.988	7.584	9.366	0	24.782	63%
5028	0.296	0.571	1.793	0.666	1.481	0	0.545	2.424	2.288	5.988	7.584	9.366	0	25.418	62%
5029	0.296	0.571	1.793	0.666	1.481	0	0.545	2.424	2.288	5.988	7.584	9.366	0	25.418	62%
5030	0.296	0.657	2.304	0.84	1.481	0	0.545	2.424	2.288	5.988	7.584	9.372	0	26.195	60%
5031	0.299	1.974	0.068	1.278	2.834	2.723	0.545	2.425	2.288	6.351	7.582	9.395	0	30.18	54%
5032	0.3	1.993	0.609	1.213	2.195	0	0.545	2.44	2.288	6.171	7.587	10.387	0	28.141	57%
5033	0.3	3.118	0.045	1.487	1.028	0	0.553	2.413	2.307	6.194	7.59	7.114	0	24.559	63%
5034	0.303	2.972	1.119	0.575	1.885	0	0.545	2.417	2.288	5.998	7.586	9.738	0	27.84	58%
5035	0.303	2.972	1.119	0.575	1.885	0	0.545	2.417	2.288	5.998	7.586	9.738	0	27.84	58%
5036	0.299	2.969	1.338	1.287	2.172	0	0.545	2.424	2.288	6.169	7.585	9.378	0	28.869	56%
5037	0.299	2.973	2	0.381	2.215	0	0.545	2.432	2.288	6.18	7.589	10.684	0	29.997	55%
5038	0.298	3.025	3.067	1.019	2.217	0.001	0.545	2.447	2.288	6.176	7.577	11.379	0.395	32.857	50%
5039	0.298	3.843	3.175	1.419	2.215	0.001	0.545	2.447	2.288	6.176	7.577	11.378	0.399	34.184	48%
5040	0.298	3.843	3.175	1.419	2.215	0.001	0.545	2.447	2.288	6.176	7.577	11.378	0.399	34.184	48%
5041	0.298	3.843	3.175	1.419	2.215	0.001	0.545	2.447	2.288	6.176	7.577	11.378	0.399	34.184	48%
5042	0.3	0	3.952	3.15	1.848	0.001	0.553	2.413	2.307	6.364	7.585	5.498	0	26.386	60%
5043	0.299	0.792	2.757	0.905	2.408	0.001	0.545	2.421	2.288	6.1	7.586	8.961	0	27.477	58%
5044	0.3	2.004	1.677	1.241	1.836	0	0.545	2.413	2.288	5.985	7.585	7.089	0	25.378	62%
5045	0.3	2.817	2.336	1.166	2.379	0	0.545	2.416	2.288	6.092	7.583	8.371	0	28.71	57%
5046	0.299	2.969	1.935	1.287	2.172	0	0.545	2.424	2.288	6.169	7.585	9.378	0	29.466	55%
5047	0.3	3.883	2.426	1.418	2.155	0	0.545	2.416	2.288	6.168	7.586	8.371	0	29.97	55%
5048	0.3	3.677	2.428	1.434	2.408	0	0.545	2.447	2.288	6.096	7.583	11.375	0.405	33.403	49%
5049	0.299	3.29	2.38	1.195	1.458	0.001	0.545	2.413	2.288	5.992	7.587	4.669	0	24.53	63%
5050	0.298	3.843	3.175	1.419	2.215	0.001	0.545	2.447	2.288	6.176	7.577	11.378	0.399	34.184	48%
5051	0.296	0.786	2.208	0.678	1.436	0	0.545	2.413	2.288	5.984	7.584	4.661	0	21.295	68%
5052	0.296	0.655	2.358	0.547	1.501	0	0.545	2.447	2.288	5.988	7.584	11.371	0.389	28.385	57%
5053	0.298	0	0.039	0.192	0.781	0	0.545	2.415	2.288	5.796	7.583	9.673	0	22.027	67%
5054	0.3	0.929	1.211	1.19	2.114	0	0.545	2.413	2.288	6.166	7.586	3.536	0	20.692	69%
5055	0.296	4.014	2.183	1.301	1.428	0	0.545	2.413	2.288	5.985	7.585	4.663	0	25.116	62%

Table B-2

Optimization Model Runs (Scenario ID)/ Alternatives - CSO Volumes for Each Alternative - 1 year 3 hr Design Event

Scenario ID	CSO 006	CSO 012	CSO 013	CSO 014	CSO 015	CSO 016	CSO 017	CSO 018	CSO 020	CSO 022	CSO 123 (Treated Effluent)	CSO 024	CSO 025	Total (No CSO 123)	Percent Reduction
5056	0.298	0.641	1.521	0.418	2.974	0	0.545	2.433	2.288	6.335	7.582	10.7	0	28.153	57%
5057	0.299	3.974	0.124	1.876	2.82	0	0.545	2.413	2.288	6.361	7.583	8.734	0	29.434	55%
5058	0.299	2.803	2.105	1.495	2.982	0	0.546	2.447	2.288	6.335	7.588	11.385	0.406	33.091	50%
5059	0.299	3.978	0.801	1.884	2.834	0	0.545	2.419	2.288	6.362	7.584	9.768	0	31.178	53%
5060	0.299	3.141	2.814	1.434	2.198	0	0.545	2.447	2.288	6.172	7.587	11.379	0.394	33.111	50%
5061	0.299	4.663	0.829	2.092	2.85	0	0.545	2.432	2.288	6.363	7.583	10.704	0	33.065	50%
5062	0.299	3.141	2.814	1.434	2.198	0	0.545	2.447	2.288	6.172	7.587	11.379	0.394	33.111	50%
5063	0.298	0.901	1.834	0.878	2.121	0	0.545	2.413	2.288	6.168	7.586	2.262	0	19.708	70%
5064	0.299	3.141	2.814	1.434	2.198	0	0.545	2.447	2.288	6.172	7.587	11.379	0.394	33.111	50%
5065	0.298	0.895	1.734	0.82	1.454	0	0.545	2.413	2.288	5.986	7.586	7.098	0	23.531	64%
5066	0.299	1.919	1.404	1.079	2.198	0	0.545	2.447	2.288	6.172	7.587	11.382	0.415	30.148	54%
5067	0.299	0	0.045	0.192	1.737	2.893	0.545	2.413	2.307	6.225	7.594	2.973	0	19.629	70%
5068	0.298	1.823	0.054	1.078	2.36	0	0.545	2.413	2.288	6.096	7.59	2.174	0	19.129	71%
5069	0.3	3.168	1.913	1.041	2.366	0	0.545	2.413	2.288	6.097	7.591	3.53	0	23.661	64%
5070	0.299	1.969	0.103	1.575	2.803	0	0.545	2.413	2.288	6.365	7.588	4.697	0	23.057	65%
5071	0.299	2.627	1.992	1.778	2.194	0	0.545	2.447	2.288	6.172	7.586	11.377	0.4	32.119	51%
5072	0.299	0.001	0.067	0.245	2.916	0	0.545	2.413	2.288	6.328	7.588	2.212	0	17.314	74%
5073	0.3	0.58	1.939	0.682	2.418	0	0.545	2.447	2.288	6.097	7.584	11.377	0.399	29.072	56%
5074	0.3	1.985	0.09	1.273	2.793	0	0.545	2.413	2.288	6.361	7.586	3.559	0	21.607	67%
5075	0.299	3.141	2.814	1.434	2.198	0	0.545	2.447	2.288	6.172	7.587	11.379	0.394	33.111	50%
5076	0.299	0.289	0.827	0.521	2.844	0	0.545	2.42	2.288	6.363	7.586	9.749	0	26.145	60%
5123	0.3	4.027	0.045	1.786	0.723	0	0.553	2.413	2.288	7.369	7.751	0.478	0	19.982	70%
5124	0.3	4.027	0.045	1.786	0.723	0	0.553	2.413	2.288	7.369	7.751	0.478	0	19.982	70%
5125	0.299	2.963	0.032	0.817	1.901	1.451	0.545	1.423	2.288	5.767	6.745	0.563	0	18.049	73%
5126	0.299	2.963	0.032	0.817	1.901	1.451	0.545	1.423	2.288	5.767	6.745	0.563	0	18.049	73%
5127	0.299	2.963	0.032	0.817	1.901	1.451	0.545	1.423	2.288	5.767	6.745	0.563	0	18.049	73%
5128	0.299	2.963	0.032	0.817	1.901	1.451	0.545	1.423	2.288	5.767	6.745	0.563	0	18.049	73%
5129	0.299	2.963	0.032	0.817	1.901	1.451	0.545	1.423	2.288	5.767	6.745	0.563	0	18.049	73%
5130	0.304	0.625	1.763	0.689	2.059	0	0.553	1.771	2.288	6.603	7.656	0.622	0	17.277	74%
5131	0.3	0	0.043	3.149	1.851	0	0.553	2.413	2.307	3.316	6.145	0.599	0	14.531	78%
5132	0.302	2.555	1.886	3.182	0	0	0.571	1.424	2.307	5.71	7.39	0.904	0	18.841	71%
5133	0.299	6.111	0.038	0.973	0.954	0	0.545	1.771	2.307	5.633	6.573	0.539	0	19.17	71%
5134	0.3	0.704	2.105	0.283	0.189	0	0.609	1.455	2.307	7.57	7.743	3.62	0	19.142	71%
5135	0.299	2.967	0.984	1.346	1.663	0	0.553	1.771	2.288	3.022	6.142	2.462	0	17.355	74%
5136	0.303	0	0.036	3.149	0.076	1.451	0.545	0.908	2.288	7.279	7.734	6.041	0	22.076	67%
5137	0.299	2.282	0.035	1.241	1.635	1.377	0.553	0.908	2.288	7.471	7.73	0.595	0	18.684	72%
5138	0.302	0	0.1	0.192	2.249	0	0.761	1.967	2.288	3.025	6.144	8.273	0	19.157	71%
5139	0.297	0	0.072	3.153	3.839	0	0.545	2.413	2.288	4.956	6.308	5.767	0	23.33	65%
5140	0.3	0	3.472	3.149	3.514	0	0.545	0.908	2.288	3.421	6.141	0.59	0	18.187	72%
5141	0.3	0.458	0.045	0.626	0.549	0	0.553	0.911	2.288	5.267	7.232	8.804	0	19.801	70%
5142	0.302	3.107	0.308	0.192	1.205	0	0.553	2.413	2.307	6.488	7.59	2.068	0	18.943	71%
5143	0.299	2.29	0.036	1.024	1.082	0	0.545	2.413	2.288	5.246	6.718	3.31	0	18.533	72%
5144	0.299	0	0.044	3.152	0.87	0	0.546	1.423	2.307	7.028	7.39	0.545	0	16.214	75%

Table B-2

Optimization Model Runs (Scenario ID)/ Alternatives - CSO Volumes for Each Alternative - 1 year 3 hr Design Event

Scenario ID	CSO 006	CSO 012	CSO 013	CSO 014	CSO 015	CSO 016	CSO 017	CSO 018	CSO 020	CSO 022	CSO 123 (Treated Effluent)	CSO 024	CSO 025	Total (No CSO 123)	Percent Reduction
5145	0.3	2.966	3.601	1.056	1.172	0	0.553	2.439	2.288	6.286	6.976	11.3	0.106	32.067	51%
5146	0.299	3.103	0.22	0.475	0.628	0	0.553	0.908	2.307	4.321	6.307	0.595	0	13.409	80%
5147	0.299	2.135	2.451	1.267	0.582	0	0.545	2.413	2.288	3.627	6.142	2.737	0	18.344	72%
5148	0.303	0	0.044	3.149	2.423	0	0.545	1.423	2.288	4.255	6.193	0.486	0	14.916	77%
5149	0.299	2.063	0.037	1.212	3.009	0	0.553	1.771	2.288	5.948	7.23	0.613	0	17.793	73%
5150	0.299	3.215	5.514	0.692	2.376	0	0.639	2.447	2.288	3.022	6.138	0.82	0	21.312	68%
5151	0.299	0.61	3.01	1.024	2.989	0	0.553	1.423	2.288	4.224	6.137	9.658	0	26.078	61%
5152	0.297	6.28	0.06	1.26	1.783	1.548	0.553	0.908	2.307	5.986	6.694	0.56	0	21.542	67%
5153	0.299	1.001	3.941	1.104	0.902	0	0.567	1.775	2.288	6.397	7.832	0.624	16.307	35.205	47%
5154	0.3	0.519	0.032	2.136	0.667	1.502	0.553	1.423	2.288	4.479	6.252	5.123	0	19.022	71%
5155	0.3	0.183	0.054	0.738	1.901	1.407	0.545	1.771	2.288	3.482	6.144	0.49	0	13.159	80%
5156	0.298	0	2.875	3.149	0.245	0	0.553	1.423	2.307	6.935	7.716	0.468	0	18.253	72%
5157	0.299	0.598	2.106	0.512	4.3	0	0.554	1.773	2.288	3.022	6.141	6.659	0	22.111	67%
5158	0.299	2.941	0.03	1.353	0.481	1.548	0.545	2.413	2.307	5.17	6.351	0.855	0	17.942	73%
5159	0.3	0	1.724	3.154	2.969	0.001	0.555	1.456	2.288	3.103	6.148	12.008	1.915	29.473	55%
5160	0.3	3.117	0.858	0.902	2.716	0	0.56	2.413	2.307	3.332	6.141	0.723	0	17.228	74%
5161	0.298	0	3.017	3.149	1.044	0	0.553	1.771	2.307	5.125	6.223	0.575	0	17.839	73%
5162	0.299	0.017	0.055	0.192	4.016	0	0.553	2.413	2.288	6.288	7.258	0.915	0	17.036	74%
5163	0.3	0	0.851	0.192	0.58	0	0.616	1.81	2.307	3.314	6.144	3.083	0	13.053	80%
5164	0.303	2.967	0.057	0.749	1.614	0	0.558	1.792	2.288	6.446	7.38	7.76	0	24.534	63%
5165	0.3	3.109	0.051	0.192	1.226	1.376	0.553	1.771	2.307	7.272	7.356	0.893	0	19.05	71%
5166	0.3	0	0.041	3.149	3.139	1.549	0.545	2.413	2.288	5.176	6.52	2.988	0	21.588	67%
5167	0.3	0.311	2.843	1.305	1.967	0	0.545	2.413	2.288	6.918	7.653	0.698	0	19.588	70%
5168	0.3	0	0.061	0.192	3.384	2.893	0.553	0.908	2.307	6.471	7.284	4.305	0	21.374	68%
5169	0.299	0	0.03	0.192	0	0	0.545	1.423	2.307	5.456	6.807	0.64	0	10.892	84%
5170	0.299	3.54	2.964	1.133	0.756	0	0.556	1.423	2.307	5.541	6.939	3.116	0	21.635	67%
5171	0.3	1.411	1.134	3.149	2.296	0	0.553	1.771	2.288	4.404	6.143	0.614	19.523	37.443	43%
5172	0.3	1.01	0.041	1.054	0.655	1.451	0.545	2.413	2.288	6.515	7.364	0.698	19.306	36.276	45%
5173	0.299	2.972	0.085	0.192	1.07	0	0.623	2.456	2.288	3.283	6.146	4.777	0	18.045	73%
5174	0.3	0.373	0.04	1.821	2.081	0	0.553	1.771	2.307	5.809	6.915	0.451	0	15.506	77%
5175	0.298	0.044	2.776	0.526	1.689	0	0.553	1.423	2.288	3.021	6.138	0.563	0	13.181	80%
5176	0.3	2.97	0.045	1.633	3.208	0	0.545	1.771	2.288	3.756	6.139	0.659	0	17.175	74%
5177	0.3	0.711	2.174	3.219	0.695	0	0.66	2.511	2.307	7.173	7.35	7.535	0	27.285	59%
5178	0.299	3.107	0.03	1.536	0.591	1.502	0.545	0.908	2.307	6.572	7.304	0.523	17.557	35.477	46%
5179	0.299	2.44	2.973	1.362	2.211	0	0.545	1.423	2.288	5.101	6.373	0.651	0	19.293	71%
5180	0.299	0.332	0.725	0.583	0.932	0	0.545	1.423	2.288	3.589	6.142	5.667	0	16.383	75%
5181	0.299	3.645	0.031	1.203	1.117	1.502	0.545	1.423	2.307	5.423	6.371	6.794	0	24.289	63%
5182	0.299	2.54	0.937	1.713	2.347	0	0.553	1.422	2.288	7.339	7.615	4.499	0	23.937	64%
5183	0.3	0.635	0.957	1.016	1.539	0	0.545	1.423	2.288	3.795	6.145	9.112	0	21.61	67%
5184	0.3	5.644	0.604	0.931	1.078	0	0.553	1.423	2.288	4.184	6.142	2.591	0	19.596	70%
5185	0.299	0	0.044	3.149	1.037	0	0.553	1.771	2.307	3.948	6.145	1.907	0	15.015	77%
5186	0.3	0	0.632	3.149	2.602	0	0.553	1.423	2.307	3.377	6.139	7.145	0	21.488	67%
5187	0.299	1.596	0.504	1.149	1.826	0	0.545	1.423	2.288	5.772	6.743	0.623	0	16.025	76%

Table B-2

Optimization Model Runs (Scenario ID)/ Alternatives - CSO Volumes for Each Alternative - 1 year 3 hr Design Event

Scenario ID	CSO 006	CSO 012	CSO 013	CSO 014	CSO 015	CSO 016	CSO 017	CSO 018	CSO 020	CSO 022	CSO 123 (Treated Effluent)	CSO 024	CSO 025	Total (No CSO 123)	Percent Reduction
5188	0.3	2.004	0.682	0.855	2.327	0	0.545	1.423	2.288	4.996	6.325	7.19	0	22.61	66%
5189	0.299	0.64	0.105	0.894	1.818	0	0.545	1.423	2.288	5.988	6.898	1.017	0	15.017	77%
5190	0.299	1.901	0.063	1.53	3.057	0	0.545	2.413	2.288	5.257	6.426	0.553	0	17.906	73%
5191	0.299	3.565	1.142	1.441	1.548	0	0.545	1.423	2.288	3.756	6.146	1.427	0	17.434	74%
5192	0.3	1.453	0.463	3.149	1.428	0	0.553	1.771	2.288	5.052	6.429	0.848	0	17.305	74%
5193	0.299	2.255	0.915	1.025	0.24	0	0.545	1.423	2.307	5.44	6.459	1.326	0	15.775	76%
5194	0.299	3.135	0.061	1.667	3.369	2.466	0.545	1.771	2.288	6.224	6.89	5.647	0	27.472	58%
5195	0.299	0.265	1.169	0.524	2.811	0	0.545	1.771	2.288	5.021	6.337	1.698	0	16.391	75%
5196	0.299	3.886	1.031	1.596	2.282	0	0.545	1.423	2.288	5.954	6.799	0.634	0	19.938	70%
5197	0.3	0	0.045	3.149	2.415	1.451	0.545	1.771	2.307	3.314	6.146	0.517	0	15.814	76%
5198	0.298	0.057	0.048	0.55	2.032	1.549	0.553	0.908	2.288	6.182	6.936	3.185	0	17.65	73%
5199	0.3	0.27	2.939	0.341	2.087	0	0.545	1.423	2.288	5.81	6.751	3.817	0	19.82	70%
5200	0.298	0.07	0.064	0.448	3.512	1.549	0.553	0.908	2.288	6.554	7.258	3.519	0	19.763	70%
5201	0.298	0	0.273	0.192	2.275	0	0.553	1.423	2.307	5.925	6.736	1.039	0	14.285	78%
5202	0.3	0	0.047	0.192	3.343	0	0.545	1.771	2.288	5.75	6.888	0.521	0	14.757	78%
5203	0.298	0.017	0.043	0.192	3.606	0	0.545	1.771	2.288	6.216	7.236	0.564	0	15.54	76%
5204	0.299	0.94	0.041	0.947	2.866	0	0.545	1.423	2.288	5.007	6.335	2.281	0	16.637	75%
5205	0.3	0.452	1.289	1.044	0.654	0	0.553	2.413	2.307	5.629	6.529	0.56	15.845	31.046	53%
5206	0.299	0.053	1.223	0.197	3.149	0	0.553	2.413	2.288	6.002	6.811	0.545	0	16.722	75%
5207	0.298	0.254	0.036	0.743	3.089	0	0.553	1.423	2.288	5.874	7.237	5.796	0	20.354	69%
5208	0.3	0.504	0.211	1.439	1.813	0	0.553	1.771	2.288	6.189	7.23	0.497	0	15.565	76%
5209	0.299	3.439	0.889	1.37	1.443	0	0.545	1.771	2.288	5.066	6.349	0.775	0	17.885	73%
5210	0.3	3.107	0.345	1.203	0.292	0	0.553	2.413	2.307	6.017	7.36	0.537	0	17.074	74%
5211	0.298	3.099	0.228	0.192	0	0	0.553	2.413	2.307	6.723	7.289	0.891	0	16.704	75%
5212	0.302	0.564	1.002	1.166	1.376	0	0.553	1.771	2.288	3.377	6.148	3.733	0	16.132	76%
5213	0.299	3.108	0.361	0.192	0.835	0	0.553	2.413	2.307	6.367	7.235	1.038	0	17.473	74%
5214	0.299	2.962	0.304	0.192	2.288	0	0.545	1.423	2.288	5.132	6.388	0.512	0	15.945	76%
5215	0.299	0	0.057	3.149	3.245	1.503	0.545	1.422	2.307	5.771	6.476	0.455	14.761	33.514	49%
5216	0.3	3.256	1.511	1.637	3.52	0	0.545	1.771	2.288	3.021	6.142	1.281	0	19.13	71%
5217	0.298	0.205	0.036	0.76	2.807	0	0.545	1.423	2.288	5.161	6.478	5.09	0	18.613	72%
5218	0.3	0.629	1.833	0.513	3.851	0	0.545	1.771	2.288	5.252	6.52	5.211	0	22.193	66%
5219	0.3	0.645	1.617	0.494	3.897	0	0.545	1.771	2.288	3.021	6.15	3.775	0	18.353	72%
5220	0.3	2.309	1.29	1.048	2.876	0	0.545	1.423	2.288	5.136	6.387	0.692	0	17.907	73%
5221	0.297	0.628	0.066	0.261	0.727	0	0.674	1.494	2.288	5.626	7.583	5.381	0	17.442	74%
5222	0.299	0.15	0.053	0.347	3.495	0	0.545	1.423	2.288	3.847	6.143	0.708	0	13.155	80%
5223	0.299	0.576	0.51	1.131	3.217	0	0.545	1.423	2.288	4.004	6.145	4.396	0	18.389	72%
5224	0.299	0.678	3.291	0.661	3.4	0	0.545	1.422	2.288	3.56	6.14	1.772	0	17.916	73%
5225	0.296	0.552	3.235	0.944	2.879	0	0.545	1.423	2.288	3.941	6.155	5.82	0	21.923	67%
5226	0.299	0.633	0.985	1.193	2.732	0	0.545	0.908	2.288	5.889	6.774	4.59	0	20.062	70%
5227	0.3	0.606	0.94	0.705	2.683	0	0.545	2.413	2.288	5.862	6.764	1.832	0	18.174	73%
5228	0.299	0.554	0.892	0.851	2.24	0	0.545	1.423	2.288	5.86	6.757	4.5	0	19.452	71%
5229	0.299	0.618	0.548	0.978	2.301	0	0.545	0.908	2.288	5.865	6.768	4.609	0	18.959	71%
5230	0.299	3.007	0.617	1.192	2.972	0	0.545	1.423	2.288	5.04	6.355	3.232	0	20.615	69%

Table B-2

Optimization Model Runs (Scenario ID)/ Alternatives - CSO Volumes for Each Alternative - 1 year 3 hr Design Event

Scenario ID	CSO 006	CSO 012	CSO 013	CSO 014	CSO 015	CSO 016	CSO 017	CSO 018	CSO 020	CSO 022	CSO 123 (Treated Effluent)	CSO 024	CSO 025	Total (No CSO 123)	Percent Reduction
5231	0.3	3.096	0.026	0.192	0.478	1.376	0.545	1.771	2.307	4.795	6.467	0.612	24.143	39.641	40%
5232	0.299	0.538	0.042	0.675	1.081	0	0.545	1.771	2.288	6.343	7.407	0.477	0	14.059	79%
5233	0.301	0.956	0.591	1.123	0.888	0	0.635	1.835	2.288	4.573	6.308	6.494	0	19.684	70%
5234	0.3	1.95	0.2	1.704	0.999	0	0.545	1.771	2.288	6.314	7.413	1.045	0	17.116	74%
5235	0.3	0.978	0.765	1.145	1.094	0	0.545	1.771	2.288	6.356	7.425	3.068	0	18.31	72%
5236	0.298	0.694	0.298	0.686	1.3	0	0.545	1.423	2.288	5.135	6.457	7.336	0	20.003	70%
5237	0.3	0.081	0.044	0.304	2.523	0	0.545	1.422	2.288	6.038	6.816	3.133	0	16.678	75%
5238	0.3	0.083	0.042	0.327	3.353	0	0.545	1.771	2.288	6.543	7.24	0.9	0	16.152	76%
5239	0.3	0.083	0.042	0.327	3.353	0	0.545	1.771	2.288	6.543	7.24	0.9	0	16.152	76%
5240	0.3	0.083	0.042	0.327	3.353	0	0.545	1.771	2.288	6.543	7.24	0.9	0	16.152	76%
5241	0.3	0.774	0.041	0.584	1.467	0	0.553	1.771	2.307	7.158	7.37	0.654	0	15.609	76%
5242	0.299	0.932	0.867	0.804	0.369	0	0.553	1.771	2.307	7.338	7.408	2.026	0	17.266	74%
5243	0.299	0	0.863	3.149	0.339	0	0.553	1.771	2.288	6.377	7.052	0.973	0	16.612	75%
5244	0.3	0	0.335	3.149	2.255	0	0.553	1.425	2.288	3.333	6.147	9.96	0	23.598	64%
5245	0.297	3.328	0.035	0.95	0.52	0	0.553	1.771	2.288	4.818	6.266	0.637	0	15.197	77%
5246	0.3	0.844	0.464	1.256	0.027	0	0.553	1.771	2.288	6.147	6.919	4.51	0	18.16	73%
5247	0.299	2.251	0.122	1.284	1.015	0	0.545	1.771	2.288	6.197	6.944	6.599	0	22.371	66%
5248	0.298	3.76	1.031	1.474	1.009	0	0.545	1.771	2.288	6.917	7.345	6.454	0	25.547	61%
5249	0.298	3.964	1.462	1.497	0.636	0	0.545	1.771	2.288	6.831	7.314	3.963	0	23.255	65%
5250	0.299	2.411	0.354	1.06	1.397	0	0.553	1.423	2.288	5.041	6.348	8.762	0	23.588	64%
5251	0.297	2.562	2.766	1.278	1.043	1.451	0.553	0.908	2.288	6.704	7.583	0.557	17.455	37.862	43%
5252	0.3	4.024	3.158	1.041	1.403	1.451	0.545	1.423	2.288	6.904	7.347	2.468	0	25.005	62%
5253	0.3	0.478	0.047	0.673	2.333	0	0.545	2.413	2.288	4.856	6.251	3.821	0	17.754	73%
5254	0.299	0.206	0.06	0.66	2.982	0	0.545	2.413	2.288	4.91	6.283	4.009	0	18.372	72%
5255	0.299	1.964	0.788	1.092	2.742	0	0.545	1.771	2.288	4.875	6.262	8.878	0	25.242	62%
5256	0.298	0.129	0.966	0.454	3.23	0	0.545	1.771	2.288	4.914	6.285	4.041	0	18.636	72%
5257	0.299	0.532	0.061	0.431	3.245	0	0.545	1.773	2.288	5.058	6.358	7.263	0	21.495	67%
5258	0.299	0.934	2.203	0.833	0.964	0	0.72	1.568	2.288	3.982	6.143	9.793	0	23.584	64%
5259	0.3	0.416	0.036	0.935	2	0	0.545	0.909	2.288	5.081	6.442	0.489	0	12.999	80%
5260	0.3	3.158	1.147	1.434	3.336	0	0.545	1.423	2.288	5.01	6.332	8.993	0	27.634	58%
5261	0.299	1.905	0.521	0.96	2.49	0	0.545	1.423	2.288	4.997	6.316	10.004	0	25.432	62%
5262	0.299	1.693	0.5	1.015	2.444	0	0.545	1.423	2.288	3.442	6.133	9.919	0	23.568	64%
5263	0.3	2.961	0.038	0.192	1.039	0	0.553	0.908	2.288	4.193	6.141	11.161	0.081	23.714	64%
5264	0.3	2.965	0.042	0.742	2.812	0	0.553	1.423	2.288	3.435	6.147	9.897	0	24.457	63%
5265	0.3	0.911	0.473	1.089	2.743	0	0.553	1.423	2.288	3.422	6.141	9.816	0	23.018	65%
5266	0.299	0.379	1.383	1.764	2.276	0	0.545	1.423	2.288	4.995	6.328	4.456	0	19.808	70%
5267	0.3	0.472	0.848	0.933	1.524	0	0.545	0.908	2.288	5.858	6.756	3.109	0	16.785	75%
5268	0.3	0.497	0.952	0.909	2.432	0	0.545	0.908	2.288	5.862	6.758	6.005	0	20.698	69%
5269	0.3	0.497	0.952	0.909	2.432	0	0.545	0.908	2.288	5.862	6.758	6.005	0	20.698	69%
5270	0.299	1.905	0.521	0.96	2.49	0	0.545	1.423	2.288	4.997	6.316	10.004	0	25.432	62%
5271	0.304	1.05	1.471	0.94	1.23	0	0.573	1.773	2.288	7.406	7.716	2.001	0	19.036	71%
5272	0.3	0.681	0.049	0.944	2.448	0	0.545	1.423	2.307	6.215	6.782	1.924	0	16.836	75%
5273	0.299	0.681	0.043	0.786	2.136	0	0.545	1.771	2.288	3.362	6.14	4.703	0	16.614	75%

Table B-2

Optimization Model Runs (Scenario ID)/ Alternatives - CSO Volumes for Each Alternative - 1 year 3 hr Design Event

Scenario ID	CSO 006	CSO 012	CSO 013	CSO 014	CSO 015	CSO 016	CSO 017	CSO 018	CSO 020	CSO 022	CSO 123 (Treated Effluent)	CSO 024	CSO 025	Total (No CSO 123)	Percent Reduction
5274	0.299	0.612	0.03	0.62	0.483	0	0.545	1.423	2.288	5.382	7.681	0.499	17.38	29.561	55%
5275	0.3	0.608	0.7	0.622	2.935	0	0.545	0.908	2.288	5.876	7.307	2.062	0	16.844	75%
5276	0.3	0.081	1.191	0.324	3.414	0.001	0.545	0.908	2.288	6.122	7.237	3.281	0	18.455	72%
5277	0.3	0	1.084	0.192	2.894	0.001	0.545	0.908	2.288	6.056	7.237	3.325	0	17.593	73%
5278	0.3	0.912	1.672	0.514	1.336	0	0.545	1.771	2.288	6.011	6.906	4.843	0	20.192	69%
5279	0.299	0.935	1.613	0.904	0.727	0	0.545	1.771	2.288	6.469	7.386	4.896	0	20.447	69%
5280	0.3	0.882	1.507	0.526	0.977	0	0.545	1.771	2.288	5.977	6.892	4.309	0	19.082	71%
5281	0.298	1.926	0.425	1.034	1.829	0	0.545	1.423	2.288	3.394	6.137	9.129	0	22.291	66%
5282	0.296	2.951	0.03	0.192	0	0	0.545	1.771	2.288	5.8	7.653	0.79	0	14.663	78%
5283	0.3	0.632	0.718	0.92	0.87	0	0.545	1.771	2.288	7.209	7.73	0.693	0	15.946	76%
5284	0.299	2.021	0.342	1.547	0.303	0	0.545	1.771	2.288	6.789	7.312	1.243	0	17.148	74%
5285	0.297	3.512	1.025	1.826	1.026	0	0.545	1.771	2.288	6.915	7.348	6.468	0	25.673	61%
5286	0.298	3.849	0.977	1.761	0.901	0	0.545	1.771	2.288	6.19	6.942	2.041	0	20.621	69%
5287	0.3	3.465	0.676	1.671	3.635	0	0.545	1.771	2.288	6.5	7.235	4.555	0	25.406	62%
5288	0.3	3.617	2.05	1.203	2.3	0	0.626	1.489	2.288	5.764	7.232	7.559	0	27.196	59%
5289	0.3	3.588	0.401	2.04	0.786	0	0.553	1.771	2.288	6.909	7.348	6.11	0	24.746	63%
5290	0.3	3.865	0.399	1.974	0.743	0	0.553	1.771	2.288	6.193	6.946	8.614	0	26.7	60%
5291	0.304	3.836	0.468	1.545	2.376	0	0.553	1.423	2.288	4.996	6.323	9.696	0	27.485	58%
5292	0.3	3.933	1.274	2.185	2.015	0	0.553	1.771	2.288	6.072	6.834	9.785	0	30.176	54%
5293	0.299	4.598	0.381	2.022	0.36	0	0.553	1.771	2.288	6.275	7.017	9.799	0	28.346	57%
5294	0.299	4.199	1.16	0.925	2.432	0	0.553	1.777	2.288	3.447	6.14	9.943	0	27.023	59%
5295	0.3	0	1.305	0.268	4.053	0	0.554	1.423	2.307	7.493	7.601	0.541	0	18.244	72%
5296	0.299	2.76	1.089	0.844	0.558	0	0.545	1.423	2.288	7.261	7.72	2.275	0	19.342	71%
5297	0.3	0.495	0.348	0.777	0.395	0	0.545	1.422	2.288	7.368	7.738	1.779	0	15.717	76%
5298	0.299	0.732	1.193	0.731	0.369	0	0.553	1.423	2.288	7.042	7.407	4.983	0	19.613	70%
5299	0.299	0.93	0.07	0.614	3.481	0	0.545	1.423	2.288	6.866	7.268	3.194	0	19.71	70%
5300	0.299	0	1.236	3.149	2.797	0	0.545	1.772	2.288	4.018	6.144	7.632	0	23.736	64%
5301	0.299	0	1.105	3.149	3.566	0	0.545	1.423	2.288	3.46	6.142	7.518	0	23.353	65%
5302	0.3	0.446	1.574	0.272	3.3	0	0.553	1.423	2.288	6.535	7.257	0.635	0	17.326	74%
5303	0.301	0	0.658	3.149	2.652	0	0.545	1.423	2.288	3.419	6.141	9.686	0	24.121	64%
5304	0.301	0	0.658	3.149	2.652	0	0.545	1.423	2.288	3.419	6.141	9.686	0	24.121	64%
5305	0.299	3.129	1.204	1.229	4.911	0	0.552	2.413	2.307	3.314	6.147	0.718	17.458	37.534	43%
5306	0.3	0.912	0.381	0.709	3.324	0	0.545	1.771	2.288	4.902	6.277	6.047	0	21.179	68%
5307	0.298	0.231	0.42	0.416	3.263	0	0.545	1.424	2.288	3.154	6.141	6.009	0	18.048	73%
5308	0.3	1.139	0.039	1.561	0.74	0.001	0.553	1.423	2.307	6.1	7.36	0.512	0	14.675	78%
5309	0.3	0.626	0.953	0.713	2.599	0	0.545	1.771	2.288	5.634	6.725	2.868	0	18.297	72%
5310	0.303	1.799	0.731	0.908	2.697	0	0.545	1.771	2.288	3.094	6.142	8.159	0	22.295	66%
5311	0.304	3.173	0.501	1.367	0.136	0	0.545	1.422	2.288	7.013	7.396	0.581	0	17.33	74%
5312	0.3	0.406	0.855	1.157	1.785	0	0.545	0.908	2.288	6.002	6.796	4.738	0	18.984	71%
5313	0.3	0.653	0.783	0.879	1.444	0	0.545	0.908	2.288	4.961	6.304	4.398	0	17.159	74%
5314	0.299	0.612	0.873	0.815	2.225	0	0.545	0.908	2.288	5.857	6.758	4.478	0	18.9	71%
5315	0.3	2.962	0.043	1.043	1.874	0	0.545	1.425	2.288	3.437	6.134	8.907	0	22.824	65%
5316	0.299	3.11	0.031	0.192	1.472	1.502	0.545	2.413	2.307	4.064	6.142	0.629	0	16.564	75%

Table B-2

Optimization Model Runs (Scenario ID)/ Alternatives - CSO Volumes for Each Alternative - 1 year 3 hr Design Event

Scenario ID	CSO 006	CSO 012	CSO 013	CSO 014	CSO 015	CSO 016	CSO 017	CSO 018	CSO 020	CSO 022	CSO 123 (Treated Effluent)	CSO 024	CSO 025	Total (No CSO 123)	Percent Reduction
5317	0.303	0	0.04	0.192	2.422	0	0.545	0.908	2.288	5.836	6.762	1.178	0	13.712	79%
5318	0.3	1.196	0.372	0.948	1.891	0	0.553	1.423	2.307	6.117	7.316	0.848	0	15.955	76%
5319	0.298	0	0.934	0.192	2.938	0	0.545	0.908	2.288	6.501	7.245	2.073	0	16.677	75%
5320	0.299	0.922	0.409	0.826	2.599	0	0.545	1.423	2.288	3.405	6.133	6.136	0	18.852	71%
5321	0.299	0	0.039	0.192	0.513	2.723	0.545	1.771	2.288	6.901	7.386	7.309	0	22.58	66%
5322	0.3	0.357	0.05	1.054	2.268	2.723	0.545	1.423	2.288	6.516	7.25	4.029	0	21.553	67%
5323	0.3	1.146	0.057	1.2	1.276	0	0.545	1.771	2.307	6.575	6.964	0.501	14.327	30.005	55%
5324	0.3	1.252	1.045	1.034	0.732	0	0.545	1.771	2.307	6.782	7.384	0.483	14.041	30.292	54%
5325	0.298	2.903	0.108	1.384	2.724	0	0.545	1.423	2.307	5.353	6.344	7.315	0	24.36	63%
5326	0.3	0.906	3.343	0.762	1.384	0	0.545	1.771	2.288	6.011	6.906	4.809	0	22.119	67%
5327	0.3	1.004	3.211	0.982	0.724	0	0.545	1.771	2.288	6.468	7.384	3.419	0	20.712	69%
5328	0.3	1.645	1.622	1.137	2.402	0	0.545	1.423	2.288	3.449	6.143	8.67	0	23.481	64%
5329	0.303	0.381	0.055	1.907	4.031	0	0.553	1.771	2.288	4.938	6.295	0.845	0	17.072	74%
5330	0.299	0.387	0.042	1.175	3.491	0	0.553	1.771	2.288	5.737	6.753	1.752	0	17.495	74%
5331	0.299	0.081	0.042	0.297	3.466	0	0.553	1.771	2.288	6.194	7.229	0.579	0	15.57	76%
5332	0.299	2.571	0.033	0.909	1.588	0	0.553	1.423	2.288	4.991	6.395	7.106	0	21.761	67%
5333	0.302	2.529	0.407	3.224	1.965	0	0.686	0.924	2.288	3.193	6.145	0.922	0	16.44	75%
5334	0.299	0.687	0.061	0.735	3.921	0	0.553	1.423	2.288	5.175	6.403	0.584	0	15.726	76%
5335	0.298	3.97	0.682	1.718	2.455	0	0.545	1.771	2.288	6.855	7.268	6.011	0	26.593	60%
5336	0.3	4.352	0.698	2.296	2.477	0	0.545	1.771	2.288	6.854	7.262	8.715	0	30.296	54%
5337	0.3	4.352	0.698	2.296	2.477	0	0.545	1.771	2.288	6.854	7.262	8.715	0	30.296	54%
5338	0.298	3.842	0.611	2.194	0.367	0	0.545	1.771	2.288	6.275	7.009	8.764	0	26.955	59%
5339	0.299	0.764	0.623	1.062	1.889	0	0.545	1.424	2.288	6.257	7.23	9.939	0	25.09	62%
5340	0.3	0	2.93	0.192	0.867	0	0.545	1.771	2.288	5.445	6.633	0.639	0	14.977	77%
5341	0.298	0.675	0.049	0.63	2.712	0	0.545	1.423	2.288	4.886	6.269	0.613	0	14.119	79%
5342	0.3	0.493	0.457	1.348	0.969	0	0.545	1.423	2.288	6.188	6.942	2.029	0	16.04	76%
5343	0.299	2.96	0.05	0.811	1.239	0	0.545	1.423	2.288	6.859	7.385	1.053	0	17.527	73%
5344	0.298	0.408	0.525	0.923	0.392	0	0.545	1.423	2.288	7.045	7.406	1.972	0	15.819	76%
5345	0.3	0.797	0.536	0.94	1.285	0	0.545	1.423	2.288	5.136	6.471	4.645	0	17.895	73%
5346	0.304	4.399	0.798	2.336	2.157	0	0.553	2.413	2.307	4.628	6.142	0.462	0	20.357	69%
5347	0.301	2.444	0.416	1.099	2.639	0	0.545	1.423	2.288	3.409	6.133	8.747	0	23.311	65%
5348	0.3	1.999	0.523	1.07	2.289	0	0.545	1.424	2.288	3.402	6.134	9.958	0	23.798	64%
5349	0.3	1.999	0.523	1.07	2.289	0	0.545	1.424	2.288	3.402	6.134	9.958	0	23.798	64%
5350	0.3	1.999	0.523	1.07	2.289	0	0.545	1.424	2.288	3.402	6.134	9.958	0	23.798	64%
5351	0.3	1.999	0.523	1.07	2.289	0	0.545	1.424	2.288	3.402	6.134	9.958	0	23.798	64%
5352	0.299	0.643	0.776	0.876	0.417	0	0.545	0.908	2.288	5.275	6.526	4.534	0	16.561	75%
5353	0.3	3.937	1.118	1.599	1.41	0	0.553	1.423	2.288	5.082	6.361	9.854	0	27.564	58%
5354	0.3	0.943	0.915	1.131	2.347	0	0.545	0.908	2.288	5.86	6.758	6.184	0	21.421	68%
5355	0.299	3.732	0.496	1.717	2.45	0	0.553	1.423	2.288	3.451	6.144	9.974	0	26.383	60%
5356	0.3	2.974	4.546	0.254	0.12	0	0.656	1.468	2.288	6.972	7.482	3.018	0	22.596	66%
5357	0.3	0.617	0.392	0.711	2.356	0	0.545	1.423	2.288	5.859	6.757	8.774	0	23.265	65%
5358	0.3	1.531	0.713	1.026	2.352	0	0.545	1.771	2.288	4.994	6.325	8.596	0	24.116	64%
5359	0.299	0.136	3.756	0.299	2.956	0	0.606	1.789	2.288	4.247	6.149	0.867	0	17.243	74%

Table B-2

Optimization Model Runs (Scenario ID)/ Alternatives - CSO Volumes for Each Alternative - 1 year 3 hr Design Event

Scenario ID	CSO 006	CSO 012	CSO 013	CSO 014	CSO 015	CSO 016	CSO 017	CSO 018	CSO 020	CSO 022	CSO 123 (Treated Effluent)	CSO 024	CSO 025	Total (No CSO 123)	Percent Reduction
5360	0.3	2.256	0.683	0.988	3.399	0	0.545	1.771	2.288	5.895	6.777	1.359	0	19.484	71%
5361	0.299	2.108	1.41	0.956	2.592	0	0.697	1.891	2.288	3.51	6.143	7.647	0	23.398	65%
5362	0.3	1.011	0.063	1.302	3.227	1.502	0.545	1.423	2.288	6.609	7.287	3.485	0	21.755	67%
5363	0.304	2.491	0.793	1.108	2.807	0	0.545	1.771	2.288	5.884	6.776	8.939	0	26.93	59%
5364	0.299	0.63	0.049	0.548	2.356	0	0.545	1.423	2.288	6.408	7.235	7.5	0	22.046	67%
5365	0.299	2.26	0.041	1.256	2.189	0	0.553	1.422	2.288	4.943	6.297	8.707	0	23.958	64%
5366	0.3	2.959	0.642	0.468	1.393	0	0.545	1.423	2.288	5.291	6.596	0.447	0	15.756	76%
5367	0.298	3.039	0.658	1.153	0.476	0	0.545	1.771	2.288	5.835	6.83	1.793	0	17.856	73%
5368	0.3	1.839	0.936	1.082	2.256	0	0.545	1.771	2.288	5.863	6.756	6.101	0	22.981	65%
5369	0.3	0.639	1.337	0.695	1.201	0	0.553	1.423	2.288	5.288	6.563	0.46	0	14.184	79%
5370	0.299	2.809	0.527	1.319	2.759	0.001	0.553	1.771	2.307	4.095	6.149	0.69	0	17.13	74%
5371	0.301	1.062	1.326	0.77	1.182	0	0.553	1.771	2.307	6.283	6.948	3.465	0	19.02	71%
5372	0.3	0.918	0.978	0.77	0.798	0	0.545	1.771	2.288	6.494	7.396	4.86	0	19.722	70%
5373	0.299	1.603	0.045	0.867	2.489	0	0.545	1.423	2.288	5.004	6.328	8.772	0	23.335	65%
5374	0.3	0.929	1.201	0.631	0.753	0	0.545	1.771	2.288	6.043	6.984	4.845	0	19.306	71%
5375	0.3	2.6	0.52	1.149	2.497	0	0.545	1.423	2.288	3.461	6.14	9.805	0	24.588	63%
5376	0.299	0	0.086	0.192	4.159	1.549	0.56	0.908	2.288	6.258	7.248	0.758	0	17.057	74%
5377	0.3	0.435	0.037	1.271	3.736	0	0.553	2.413	2.307	6.737	7.241	0.554	0	18.343	72%
5378	0.297	0.354	0.041	1.76	3.406	0	0.553	2.413	2.288	6.547	7.241	1.782	0	19.441	71%
5379	0.299	0.511	0.05	1.007	3.733	0	0.553	1.771	2.307	6.535	7.24	0.673	0	17.439	74%
5380	0.303	0.914	0.506	0.931	2.8	0	0.553	1.423	2.288	4.876	6.265	7.244	0	21.838	67%
5381	0.301	3.59	0.046	3.159	0.921	1.451	0.56	1.423	2.288	3.028	6.147	0.818	24.022	41.607	37%
5382	0.3	1.636	0.043	1.549	2.772	0	0.545	1.771	2.288	5.122	6.376	7.461	0	23.487	64%
5383	0.299	4.476	1.035	2.382	0.725	0	0.545	1.771	2.288	6.191	6.945	6.13	0	25.842	61%
5384	0.299	2.174	0.96	0.785	2.381	0	0.545	1.422	2.288	3.476	6.133	7.35	0	21.68	67%
5385	0.298	2.198	0.031	1.458	0.5	0	0.553	1.423	2.307	6.091	7.704	0.527	0	15.386	77%
5386	0.3	3.858	0.264	1.505	0.777	0	0.553	1.771	2.288	6.198	6.987	2.644	0	20.158	70%
5387	0.304	3.88	0.447	2.205	1.923	0	0.553	1.771	2.288	6.073	6.831	7.645	0	27.089	59%
5388	0.3	4.386	0.337	2.368	1.076	0	0.553	1.771	2.288	6.153	6.928	10.465	0	29.697	55%
5389	0.3	0.693	0.038	0.651	2.184	0	0.553	1.423	2.288	4.982	6.321	11.256	0.279	24.647	63%
5390	0.299	3.113	0.046	0.405	0.604	0	0.545	2.413	2.307	6.443	6.91	0.589	0	16.764	75%
5391	0.299	3.112	0.376	0.415	0.815	0	0.545	2.413	2.307	7.207	7.353	1.865	0	19.354	71%
5392	0.299	3.205	0.477	1.454	1.04	0	0.545	2.413	2.307	7.215	7.348	4.772	0	23.727	64%
5393	0.299	3.205	0.477	1.454	1.04	0	0.545	2.413	2.307	7.215	7.348	4.772	0	23.727	64%
5394	0.3	0.904	0.477	0.608	2.99	0	0.553	1.423	2.288	4.861	6.255	7.277	0	21.681	67%
5395	0.3	2.452	0.493	1.196	2.997	0	0.553	1.424	2.288	3.08	6.143	9.91	0	24.693	63%
5396	0.3	2.57	0.599	1.217	3.116	0	0.554	1.424	2.288	4.864	6.257	10.83	0	27.762	58%
5397	0.3	2.452	0.493	1.196	2.997	0	0.553	1.424	2.288	3.08	6.143	9.91	0	24.693	63%
5398	0.303	2.476	0.555	1.025	2.909	0	0.553	1.425	2.288	3.066	6.146	10.819	0	25.419	62%
5399	0.3	0.425	0.048	0.683	0	0.001	0.553	1.771	2.307	4.734	6.23	0.772	0	11.594	82%
5400	0.3	0.618	0.054	0.737	0.266	0.001	0.553	1.423	2.288	4.05	6.147	6.558	0	16.848	75%
5401	0.3	0.64	0.835	1.212	1.75	0	0.545	0.908	2.288	6.248	7.233	6.147	0	20.873	68%
5402	0.3	0.947	0.045	1.139	2.709	0	0.553	0.908	2.288	5.887	6.772	6.848	0	21.624	67%

Table B-2

Optimization Model Runs (Scenario ID)/ Alternatives - CSO Volumes for Each Alternative - 1 year 3 hr Design Event

Scenario ID	CSO 006	CSO 012	CSO 013	CSO 014	CSO 015	CSO 016	CSO 017	CSO 018	CSO 020	CSO 022	CSO 123 (Treated Effluent)	CSO 024	CSO 025	Total (No CSO 123)	Percent Reduction
5403	0.3	2.674	0.042	1.096	1.658	0	0.553	1.423	2.288	3.485	6.145	11.039	0	24.558	63%
5404	0.298	0.118	0.059	0.314	3.79	0.001	0.553	0.908	2.307	3.314	6.14	0.525	0	12.187	82%
5405	0.298	0.364	0.045	0.571	3.208	0	0.545	0.908	2.288	5.006	6.328	3.306	0	16.539	75%
5406	0.299	0.612	0.323	0.815	2.225	0	0.545	0.908	2.288	5.857	6.758	4.478	0	18.35	72%
5407	0.302	2.759	0.665	1.277	2.314	0	0.545	1.771	2.288	5.861	6.766	8.556	0	26.338	60%
5408	0.302	2.759	0.665	1.277	2.314	0	0.545	1.771	2.288	5.861	6.766	8.556	0	26.338	60%
5409	0.302	2.759	0.665	1.277	2.314	0	0.545	1.771	2.288	5.861	6.766	8.556	0	26.338	60%
5410	0.3	1.591	0.732	0.992	2.407	0	0.545	1.771	2.288	5.861	6.768	8.833	0	25.32	62%
5411	0.299	2.614	0.774	0.866	2.512	0	0.545	1.423	2.288	3.449	6.142	9.999	0	24.769	63%
5412	0.304	0.375	0.109	0.421	1.422	2.893	0.796	1.988	2.307	5.028	6.3	9.305	0	24.948	62%
5413	0.297	0.632	0.468	1.221	2.864	0	0.553	0.908	2.288	6.004	6.833	0.534	0	15.769	76%
5414	0.3	0	0.964	0.192	2.896	0	0.553	0.908	2.288	6.594	7.289	1.149	0	15.844	76%
5415	0.297	0.645	0.593	0.921	1.57	0	0.545	0.908	2.288	5.046	6.358	6.205	0	19.018	71%
5416	0.3	0	0.983	0.192	2.945	0	0.553	0.908	2.288	6.595	7.289	3.293	0	18.057	73%
5417	0.299	0.459	0.051	0.582	1.302	0	0.545	1.771	2.288	6.014	6.911	1.047	0	14.358	78%
5418	0.3	0.468	0.044	0.579	2.423	0	0.545	1.423	2.288	3.442	6.133	9.926	0	21.438	68%
5419	0.298	1.989	0.095	1.11	0.726	0	0.598	0.919	2.307	4.83	6.22	1.315	0	14.187	79%
5420	0.299	2.014	0.826	1.347	3.418	0	0.553	1.423	2.288	5.953	6.811	0.69	0	18.811	72%
5421	0.299	0.954	0.448	0.938	3.219	0	0.553	1.423	2.288	6.091	7.239	0.56	0	16.773	75%
5422	0.3	2.037	0.041	1.234	2.924	0	0.553	1.423	2.288	5.61	6.729	7.234	0	23.644	64%
5423	0.299	3.103	0.035	1.662	0.388	1.47	0.545	0.908	2.307	4.367	6.152	0.567	18.954	34.605	48%
5424	0.299	0.476	1.21	0.631	2.019	0	0.545	1.423	2.288	5.17	6.399	0.605	0	14.666	78%
5425	0.3	0.353	0.505	0.966	2.858	0	0.545	1.771	2.288	5.896	6.78	0.944	0	16.426	75%
5426	0.3	2.198	2.825	0.903	2.651	0	0.712	1.556	2.288	3.518	6.149	9.868	0	26.819	59%
5427	0.3	0.916	0.046	0.703	3.149	0	0.545	1.771	2.288	6.53	7.251	0.584	0	16.832	75%
5428	0.298	1.857	0.961	1.064	2.43	0	0.545	1.771	2.288	4.996	6.329	9.884	0	26.094	61%
5429	0.299	0.004	0.039	0.192	1.264	0	0.545	0.908	2.307	7.504	7.692	7.558	0	20.62	69%
5430	0.3	0.423	0.081	0.941	3.046	0	0.545	1.423	2.307	7.178	7.286	4.154	0	20.398	69%
5431	0.299	3.015	0.047	1.304	2.906	0	0.553	1.423	2.288	3.467	6.145	8.583	0	23.885	64%
5432	0.299	0.645	0.727	0.574	0	0	0.545	1.423	2.307	3.533	6.145	0.554	0	10.607	84%
5433	0.299	0.365	0.404	1.042	0.159	0	0.545	0.908	2.307	5.657	6.551	0.55	0	12.236	81%
5434	0.299	2.712	2.271	1.725	1.413	0	0.658	1.865	2.288	7.209	7.713	8.85	0	29.29	56%
5435	0.303	0.822	0.055	1.244	2.827	0	0.545	1.771	2.288	6.009	6.842	0.525	0	16.389	75%
5436	0.302	1.876	0.462	1.28	0.751	0	0.545	1.771	2.288	6.527	7.448	4.722	0	20.524	69%
5437	0.303	2.631	0.497	2.251	0.839	0	0.545	1.771	2.288	6.993	7.402	7.419	0	25.537	61%
5438	0.298	0.433	0.78	1.199	3.789	2.244	0.553	2.413	2.307	6.942	7.613	0.834	34.878	56.67	14%
5439	0.299	3.124	0.089	0.961	3.811	2.893	0.553	2.413	2.307	6.938	7.621	0.835	34.891	59.114	11%
5440	0.299	0.44	1.389	3.151	3.856	0.001	0.553	2.413	2.307	6.937	7.615	0.837	34.909	57.092	14%
5441	0.3	1.223	0.089	0.926	3.794	2.893	0.553	2.413	2.307	6.939	7.612	0.834	34.884	57.155	14%
5442	0.298	0.399	0.088	0.445	3.787	2.244	0.553	2.413	2.307	6.94	7.614	0.834	34.88	55.188	16%
5443	0.298	0	0.088	0.192	3.747	2.506	0.553	2.413	2.307	6.934	7.612	0.831	34.848	54.717	17%
5444	0.299	0.44	0.092	3.151	3.856	0	0.553	2.413	2.307	6.937	7.615	0.837	34.909	55.794	16%
5445	0.299	0	0.092	3.151	3.826	0	0.553	2.413	2.307	6.933	7.62	0.836	34.901	55.311	16%

Table B-2

Optimization Model Runs (Scenario ID)/ Alternatives - CSO Volumes for Each Alternative - 1 year 3 hr Design Event

Scenario ID	CSO 006	CSO 012	CSO 013	CSO 014	CSO 015	CSO 016	CSO 017	CSO 018	CSO 020	CSO 022	CSO 123 (Treated Effluent)	CSO 024	CSO 025	Total (No CSO 123)	Percent Reduction
5446	0.299	1.482	3.212	1.082	3.83	0	0.554	2.413	2.307	6.934	7.615	0.836	34.903	57.852	12%
5447	0.299	0.138	0.98	0.472	3.82	0	0.553	2.413	2.307	6.938	7.619	0.836	34.889	53.645	19%
5448	0.299	0	4.744	3.151	3.836	0	0.553	2.413	2.307	6.935	7.615	0.837	34.898	59.973	9%
5449	0.299	6.001	1.374	1.232	3.834	0	0.554	2.413	2.307	6.935	7.616	0.837	34.917	60.703	8%
5450	0.303	0	4.659	0.192	3.795	0	0.553	2.413	2.307	6.929	7.614	0.832	34.848	56.831	14%
5451	0.3	2.711	1.21	2.888	3.823	0	0.553	2.413	2.307	6.935	7.614	0.836	34.917	58.893	11%
5452	0.299	0	2.183	0.192	3.802	0	0.553	2.413	2.307	6.932	7.615	0.835	34.89	54.406	18%
5453	0.299	1.951	4.825	0.947	3.837	0	0.553	2.413	2.307	6.94	7.614	0.837	34.919	59.828	9%
5454	0.299	3.124	0.092	0.192	3.835	0	0.553	2.413	2.307	6.935	7.612	0.836	34.886	55.472	16%
5455	0.3	1.959	3.327	1.202	3.827	0	0.553	2.413	2.307	6.936	7.615	0.836	34.917	58.577	11%
5456	0.299	0.088	0.088	0.256	3.788	2.893	0.553	2.413	2.307	6.941	7.612	0.835	34.889	55.35	16%
5457	0.299	3.124	0.092	0.479	3.838	0	0.553	2.413	2.307	6.936	7.612	0.836	34.896	55.773	16%
5458	0.298	3.124	1.384	0.528	3.847	0	0.554	2.413	2.307	6.94	7.619	0.838	34.927	57.16	14%
5459	0.303	0.286	0.093	1.36	3.821	0	0.553	2.413	2.307	6.935	7.619	0.835	34.886	53.792	19%
5460	0.299	1.773	0.163	1.378	3.82	0	0.553	2.413	2.307	6.933	7.614	0.835	34.892	55.366	16%
5461	0.298	1.041	0.713	0.712	3.819	0	0.553	2.413	2.307	6.938	7.615	0.836	34.905	54.535	17%
5462	0.297	3.3	1.713	1.239	3.811	0	0.553	2.413	2.307	6.933	7.614	0.835	34.881	58.282	12%
5463	0.298	0	0.09	0.192	3.776	0	0.553	2.413	2.307	6.933	7.615	0.832	34.865	52.259	21%
5464	0.298	0	0.092	3.151	3.827	0	0.553	2.413	2.307	6.936	7.615	0.836	34.892	55.305	16%
5465	0.296	3.123	2.169	0.192	3.807	0	0.553	2.413	2.307	6.935	7.61	0.833	34.87	57.498	13%
5466	0.299	0.304	2.466	0.444	3.816	0	0.553	2.413	2.307	6.935	7.619	0.835	34.889	55.261	16%
5467	0.299	0	1.152	3.151	3.824	0	0.553	2.413	2.307	6.934	7.615	0.836	34.895	56.364	15%
5468	0.299	3.124	4.837	0.883	3.85	0	0.553	2.413	2.307	6.937	7.613	0.837	34.905	60.945	8%
5469	0.299	0.352	0.091	0.845	3.821	0	0.553	2.413	2.307	6.936	7.619	0.836	34.892	53.345	19%
5470	0.3	1.508	0.322	1.391	3.826	0	0.554	2.413	2.307	6.936	7.615	0.837	34.916	55.31	16%
5471	0.303	0.28	1.375	0.69	3.834	0	0.554	2.413	2.307	6.937	7.62	0.837	34.903	54.433	18%
5472	0.298	0.406	0.089	1.217	3.797	2.381	0.554	2.413	2.307	6.943	7.613	0.836	34.894	56.135	15%
5473	0.297	3.123	0.092	0.192	3.805	0	0.553	2.413	2.307	6.935	7.61	0.833	34.873	55.423	16%
5474	0.299	4.614	0.091	1.853	3.815	0	0.553	2.413	2.307	6.936	7.619	0.835	34.878	58.594	11%
5475	0.299	0	2.028	3.151	3.834	0	0.553	2.413	2.307	6.941	7.615	0.836	34.883	57.245	13%
5476	0.298	0	0.578	3.151	3.827	0	0.553	2.413	2.307	6.936	7.615	0.836	34.892	55.791	16%
5477	0.299	0	1.923	0.267	3.814	0	0.553	2.413	2.307	6.932	7.615	0.836	34.897	54.241	18%
5478	0.303	6.145	4.834	0.995	3.839	2.381	0.554	2.413	2.307	6.944	7.612	0.837	34.908	66.46	-1%
5479	0.299	0.004	0.09	0.192	3.806	0	0.553	2.413	2.307	6.934	7.62	0.834	34.881	52.313	21%
5480	0.299	0	1.923	0.267	3.814	0	0.553	2.413	2.307	6.932	7.615	0.836	34.897	54.241	18%
5481	0.303	4.272	0.092	1.237	3.834	0	0.554	2.413	2.307	6.935	7.614	0.837	34.892	57.676	13%
5482	0.299	1.493	0.089	0.696	3.796	2.893	0.554	2.413	2.307	6.942	7.613	0.836	34.895	57.213	13%
5483	0.299	0	1.006	3.151	3.834	0	0.553	2.413	2.307	6.941	7.615	0.836	34.886	56.226	15%
5484	0.299	3.123	0.91	0.723	3.808	2.893	0.553	2.413	2.307	6.938	7.621	0.835	34.885	59.687	10%
5485	0.298	3.124	0.091	3.151	3.845	2.381	0.553	2.413	2.307	6.938	7.623	0.837	34.892	60.83	8%
5486	0.299	3.123	0.285	0.192	3.815	0	0.553	2.413	2.307	6.934	7.613	0.833	34.866	55.62	16%
5487	0.299	0.471	0.284	1.189	3.817	0	0.554	2.413	2.307	6.934	7.615	0.836	34.905	54.009	18%
5488	0.298	0	0.088	0.192	3.754	2.893	0.553	2.413	2.307	6.936	7.614	0.831	34.846	55.111	17%

Table B-2

Optimization Model Runs (Scenario ID)/ Alternatives - CSO Volumes for Each Alternative - 1 year 3 hr Design Event

Scenario ID	CSO 006	CSO 012	CSO 013	CSO 014	CSO 015	CSO 016	CSO 017	CSO 018	CSO 020	CSO 022	CSO 123 (Treated Effluent)	CSO 024	CSO 025	Total (No CSO 123)	Percent Reduction
5489	0.299	0.662	1.938	0.662	3.819	0	0.553	2.413	2.307	6.934	7.616	0.836	34.911	55.334	16%
5490	0.3	0.414	0.284	0.754	3.82	0	0.553	2.413	2.307	6.935	7.614	0.836	34.908	53.524	19%
5491	0.3	0.414	1.33	0.754	3.82	0	0.553	2.413	2.307	6.935	7.614	0.836	34.908	54.57	17%
5492	0.3	0.658	0.092	0.59	3.826	0	0.553	2.413	2.307	6.936	7.615	0.837	34.922	53.434	19%
5493	0.3	0.721	0.091	0.418	3.824	0	0.553	2.413	2.307	6.936	7.614	0.837	34.918	53.318	19%
5494	0.298	0.131	1.306	0.467	3.809	0	0.553	2.413	2.307	6.937	7.616	0.835	34.898	53.954	18%
5495	0.298	0.131	1.91	0.467	3.809	0	0.553	2.413	2.307	6.937	7.616	0.835	34.898	54.558	17%
5496	0.299	0	1.877	0.192	3.8	0	0.553	2.413	2.307	6.932	7.615	0.834	34.889	54.096	18%
5497	0.298	0	2.005	0.192	3.798	0	0.553	2.413	2.307	6.935	7.615	0.834	34.885	54.22	18%
5498	0.299	0.773	0.091	0.453	3.821	0	0.553	2.413	2.307	6.938	7.615	0.836	34.903	53.387	19%
5499	0.299	3.261	0.092	1.352	3.817	0	0.553	2.413	2.307	6.937	7.615	0.836	34.896	56.763	14%
5500	0.298	2.623	0.092	1.607	3.818	0	0.553	2.413	2.307	6.933	7.614	0.836	34.9	56.38	15%
5501	0.299	1.773	1.37	1.378	3.82	0	0.553	2.413	2.307	6.933	7.614	0.835	34.892	56.573	14%
5502	0.299	0.731	3.216	0.682	3.824	0	0.553	2.413	2.307	6.938	7.615	0.836	34.901	56.7	14%
5503	0.299	3.124	1.349	0.479	3.838	0	0.553	2.413	2.307	6.936	7.612	0.836	34.896	57.03	14%
5504	0.297	2.47	3.44	1.224	3.82	0	0.553	2.413	2.307	6.934	7.614	0.835	34.885	59.178	10%
5505	0.299	3.124	2.733	0.479	3.839	0	0.553	2.413	2.307	6.936	7.613	0.836	34.896	58.415	12%
5506	0.298	1.115	0.089	1.216	3.79	2.381	0.553	2.413	2.307	6.941	7.612	0.835	34.885	56.823	14%
5507	0.3	0.356	0.088	1.644	3.793	2.506	0.553	2.413	2.307	6.939	7.613	0.834	34.881	56.614	14%
5508	0.299	1.127	1.346	0.856	3.82	0	0.553	2.413	2.307	6.937	7.615	0.836	34.902	55.396	16%
5509	0.299	2.075	3.129	1.29	3.822	0	0.553	2.413	2.307	6.934	7.615	0.836	34.909	58.567	11%
5510	0.298	0.705	0.088	0.533	3.788	2.381	0.553	2.413	2.307	6.939	7.612	0.835	34.888	55.728	16%
5511	0.3	0.971	0.201	0.553	3.798	2.893	0.553	2.413	2.307	6.939	7.613	0.835	34.887	56.65	14%
5512	0.298	2.259	0.089	0.796	3.788	2.38	0.553	2.413	2.307	6.939	7.613	0.834	34.877	57.533	13%
5513	0.298	4.036	0.089	1.327	3.785	2.506	0.553	2.413	2.307	6.939	7.613	0.834	34.874	59.961	9%
5514	0.299	5.802	2.878	1.165	3.836	0	0.554	2.413	2.307	6.934	7.614	0.837	34.904	61.929	6%
5515	0.299	0	2.003	0.192	3.8	0	0.553	2.413	2.307	6.932	7.615	0.834	34.889	54.222	18%
5516	0.296	0.171	2.06	0.738	3.814	0	0.553	2.413	2.307	6.934	7.615	0.836	34.894	55.016	17%
5517	0.297	0.802	1.332	0.473	3.818	0	0.553	2.413	2.307	6.934	7.614	0.835	34.885	54.649	17%
5518	0.297	0	3.118	0.192	3.786	0	0.553	2.413	2.307	6.93	7.614	0.832	34.849	55.277	16%
5519	0.299	0.258	0.99	0.89	3.819	0	0.554	2.413	2.307	6.934	7.616	0.837	34.915	54.216	18%
5520	0.304	1.34	0.095	0.949	3.825	0	0.553	2.413	2.307	6.935	7.619	0.836	34.888	54.445	18%
5521	0.299	0.991	0.289	0.598	3.819	0	0.553	2.413	2.307	6.934	7.615	0.836	34.908	53.947	18%
5522	0.298	0.332	1.319	1.849	3.811	0	0.553	2.413	2.307	6.937	7.615	0.835	34.898	55.552	16%
5523	0.3	0	3.338	3.151	3.835	0	0.553	2.413	2.307	6.938	7.616	0.836	34.9	58.571	11%
5524	0.3	0.721	0.091	0.418	3.824	0	0.553	2.413	2.307	6.936	7.614	0.837	34.918	53.318	19%
5525	0.299	0.099	0.276	0.287	3.821	0	0.553	2.413	2.307	6.936	7.615	0.836	34.916	52.743	20%
5526	0.299	0	0.092	3.151	3.853	0	0.553	2.413	2.307	6.941	7.615	0.837	34.9	55.346	16%
5527	0.299	1.283	0.091	1.104	3.818	0	0.553	2.413	2.307	6.934	7.615	0.836	34.909	54.547	17%
5528	0.3	0.414	0.284	0.754	3.82	0	0.553	2.413	2.307	6.935	7.614	0.836	34.908	53.524	19%
5529	0.3	0.088	0.975	0.264	3.82	0	0.553	2.413	2.307	6.933	7.614	0.836	34.895	53.384	19%
5530	0.299	0.277	1.375	0.629	3.83	0	0.554	2.413	2.307	6.935	7.615	0.837	34.911	54.367	18%
5531	0.3	0	0.941	0.192	3.795	0	0.553	2.413	2.307	6.93	7.615	0.833	34.871	53.135	20%

Table B-2

Optimization Model Runs (Scenario ID)/ Alternatives - CSO Volumes for Each Alternative - 1 year 3 hr Design Event

Scenario ID	CSO 006	CSO 012	CSO 013	CSO 014	CSO 015	CSO 016	CSO 017	CSO 018	CSO 020	CSO 022	CSO 123 (Treated Effluent)	CSO 024	CSO 025	Total (No CSO 123)	Percent Reduction
5532	0.299	0.5	0.291	0.838	3.822	0	0.554	2.413	2.307	6.937	7.616	0.836	34.915	53.712	19%
5533	0.297	3.123	0.092	0.192	3.805	0	0.553	2.413	2.307	6.935	7.611	0.833	34.872	55.422	16%
5534	0.298	3.123	0.092	0.192	3.811	0	0.553	2.413	2.307	6.939	7.618	0.833	34.879	55.44	16%
5535	0.299	0.696	0.291	0.777	3.819	0	0.553	2.413	2.307	6.937	7.614	0.836	34.902	53.83	19%
5536	0.299	0.722	0.617	0.973	3.82	0	0.553	2.413	2.307	6.934	7.615	0.836	34.911	54.385	18%
5537	0.299	4.095	4.805	1.404	3.828	0	0.553	2.413	2.307	6.934	7.615	0.836	34.895	62.369	6%
5538	0.301	3.766	4.811	1.901	3.841	0	0.553	2.413	2.307	6.938	7.615	0.836	34.889	62.556	5%
5539	0.303	4.052	4.842	0.967	3.85	0	0.554	2.413	2.307	6.939	7.615	0.837	34.904	61.968	6%
5540	0.303	4.052	4.842	0.967	3.85	0	0.554	2.413	2.307	6.939	7.615	0.837	34.904	61.968	6%
5541	0.299	1.447	0.613	0.92	3.817	0	0.553	2.413	2.307	6.937	7.616	0.836	34.899	55.041	17%
5542	0.297	4.147	1.947	0.887	3.82	0	0.554	2.413	2.307	6.934	7.614	0.836	34.89	59.032	11%
5543	0.299	0.705	2.477	0.755	3.821	0	0.553	2.413	2.307	6.934	7.615	0.836	34.911	56.011	15%
5544	0.297	4.214	2.62	1.351	3.823	0	0.554	2.413	2.307	6.938	7.615	0.836	34.89	60.243	9%
5545	0.299	0.545	2.823	0.614	3.827	0	0.553	2.413	2.307	6.935	7.616	0.837	34.916	56.069	15%
5546	0.299	0.709	2.064	0.82	3.82	0	0.553	2.413	2.307	6.934	7.615	0.836	34.911	55.666	16%
5547	0.299	0.705	2.477	0.755	3.821	0	0.553	2.413	2.307	6.934	7.615	0.836	34.911	56.011	15%
5548	0.299	0.545	2.823	0.614	3.827	0	0.553	2.413	2.307	6.935	7.616	0.837	34.916	56.069	15%
5549	0.299	0.71	0.675	0.511	3.823	0	0.553	2.413	2.307	6.934	7.615	0.836	34.899	53.96	18%
5550	0.299	0.71	0.675	0.511	3.823	0	0.553	2.413	2.307	6.934	7.615	0.836	34.899	53.96	18%
5551	0.299	1.126	0.095	0.939	3.821	0	0.553	2.413	2.307	6.933	7.615	0.836	34.898	54.22	18%
5552	0.3	0.032	0.09	0.192	3.817	0	0.553	2.413	2.307	6.935	7.615	0.836	34.908	52.383	21%
5553	0.299	0.122	1.701	0.377	3.811	0	0.553	2.413	2.307	6.933	7.615	0.835	34.903	54.254	18%
5554	0.299	1.126	0.095	0.939	3.821	0	0.553	2.413	2.307	6.933	7.615	0.836	34.898	54.22	18%
5555	0.3	0.414	0.09	0.754	3.82	0	0.553	2.413	2.307	6.935	7.614	0.836	34.908	53.33	19%
5556	0.298	0	0.132	3.151	3.827	0	0.553	2.413	2.307	6.936	7.615	0.836	34.892	55.345	16%
5557	0.299	0.696	1.94	0.777	3.819	0	0.553	2.413	2.307	6.937	7.614	0.836	34.902	55.479	16%
5558	0.299	0	1.877	0.192	3.8	0	0.553	2.413	2.307	6.932	7.615	0.834	34.889	54.096	18%
5559	0.299	0.991	1.939	0.598	3.819	0	0.553	2.413	2.307	6.934	7.615	0.836	34.908	55.597	16%
5560	0.299	0	1.877	0.192	3.8	0	0.553	2.413	2.307	6.932	7.615	0.834	34.889	54.096	18%
5561	0.3	0.414	0.284	0.754	3.82	0	0.553	2.413	2.307	6.935	7.614	0.836	34.908	53.524	19%
5562	0.303	0.415	0.707	0.651	3.826	0	0.554	2.413	2.307	6.935	7.619	0.835	34.89	53.836	19%
5563	0.299	0.3	1.928	1.228	3.815	0	0.553	2.413	2.307	6.933	7.615	0.836	34.903	55.515	16%
5564	0.3	0.65	1.942	0.53	3.822	0	0.553	2.413	2.307	6.936	7.614	0.836	34.915	55.204	16%
5565	0.3	0.65	0.29	0.53	3.822	0	0.553	2.413	2.307	6.936	7.614	0.836	34.915	53.552	19%
5566	0.3	0.032	0.958	0.192	3.817	0	0.553	2.413	2.307	6.935	7.615	0.836	34.908	53.251	19%
5567	0.298	1.955	0.089	1.223	3.791	2.381	0.553	2.413	2.307	6.936	7.613	0.835	34.886	57.667	13%
5568	0.299	0.276	2.103	0.654	3.83	0	0.554	2.413	2.307	6.935	7.615	0.837	34.912	55.12	17%
5569	0.299	0.5	0.291	0.838	3.822	0	0.554	2.413	2.307	6.937	7.616	0.836	34.915	53.712	19%
5570	0.3	0.443	0.308	1.199	3.828	0	0.554	2.413	2.307	6.936	7.615	0.837	34.922	54.047	18%
5571	0.299	0	0.092	3.151	3.824	0	0.553	2.413	2.307	6.934	7.615	0.836	34.895	55.304	16%
5572	0.299	0.5	0.09	0.838	3.822	0	0.554	2.413	2.307	6.937	7.616	0.836	34.915	53.511	19%
5573	0.299	0.099	0.971	0.287	3.821	0	0.553	2.413	2.307	6.936	7.615	0.836	34.916	53.438	19%
5574	0.3	0.414	0.284	0.754	3.82	0	0.553	2.413	2.307	6.935	7.614	0.836	34.908	53.524	19%

Table B-2

Optimization Model Runs (Scenario ID)/ Alternatives - CSO Volumes for Each Alternative - 1 year 3 hr Design Event

Scenario ID	CSO 006	CSO 012	CSO 013	CSO 014	CSO 015	CSO 016	CSO 017	CSO 018	CSO 020	CSO 022	CSO 123 (Treated Effluent)	CSO 024	CSO 025	Total (No CSO 123)	Percent Reduction
5575	0.296	3.123	0.092	0.192	3.807	0	0.553	2.413	2.307	6.935	7.611	0.833	34.871	55.422	16%
5576	0.299	0.696	0.291	0.777	3.819	0	0.553	2.413	2.307	6.937	7.614	0.836	34.902	53.83	19%
5577	0.3	0	0.941	0.192	3.795	0	0.553	2.413	2.307	6.93	7.615	0.833	34.871	53.135	20%
5578	0.3	0.414	0.284	0.754	3.82	0	0.553	2.413	2.307	6.935	7.614	0.836	34.908	53.524	19%
5579	0.299	3.124	1.219	2.218	3.836	0.001	0.553	2.413	2.307	6.936	7.612	0.836	34.892	58.634	11%
5580	0.298	0.459	1.33	1.208	3.815	0	0.553	2.413	2.307	6.937	7.614	0.836	34.899	55.055	17%
5581	0.299	0.662	1.333	0.662	3.819	0	0.553	2.413	2.307	6.934	7.616	0.836	34.911	54.729	17%
5582	0.299	3.648	1.027	1.073	3.839	0	0.554	2.413	2.307	6.935	7.614	0.838	34.911	57.844	12%
5583	0.299	2.62	4.822	1.356	3.83	0	0.553	2.413	2.307	6.938	7.616	0.836	34.913	60.887	8%
5584	0.299	0.515	1.718	1.147	3.821	0	0.554	2.413	2.307	6.936	7.615	0.836	34.914	55.46	16%
5585	0.299	3.124	4.837	0.791	3.85	0	0.553	2.413	2.307	6.939	7.611	0.837	34.91	60.86	8%
5586	0.298	3.123	4.738	0.192	3.824	0	0.553	2.413	2.307	6.936	7.618	0.834	34.879	60.097	9%
5587	0.298	1.041	0.091	0.712	3.819	0	0.553	2.413	2.307	6.938	7.615	0.836	34.905	53.913	18%
5588	0.298	3.124	0.09	1.065	3.816	2.893	0.554	2.413	2.307	6.94	7.621	0.837	34.888	59.225	10%
5589	0.298	3.124	2.108	1.117	3.845	0	0.554	2.413	2.307	6.937	7.612	0.838	34.921	58.462	12%
5590	0.303	4.346	3.288	1.235	3.837	0	0.554	2.413	2.307	6.935	7.615	0.837	34.89	60.945	8%
5591	0.299	0.277	0.7	0.629	3.83	0	0.554	2.413	2.307	6.935	7.615	0.837	34.911	53.692	19%
5592	0.299	1.187	0.669	1.072	3.821	0	0.553	2.413	2.307	6.934	7.615	0.836	34.897	54.988	17%
5593	0.299	1.948	0.668	1.164	3.822	0	0.553	2.413	2.307	6.936	7.614	0.835	34.89	55.835	16%
5594	0.3	0.443	0.091	1.199	3.828	0	0.554	2.413	2.307	6.936	7.615	0.837	34.922	53.83	19%
5595	0.299	0.399	0.307	1.884	3.815	0	0.554	2.413	2.307	6.937	7.619	0.835	34.88	54.63	17%
5596	0.299	1.127	0.092	0.856	3.82	0	0.553	2.413	2.307	6.937	7.615	0.836	34.902	54.142	18%
5597	0.299	0	1.871	3.151	3.824	0	0.553	2.413	2.307	6.934	7.615	0.836	34.895	57.083	14%
5598	0.3	0.295	0.089	0.546	3.801	2.244	0.553	2.413	2.307	6.942	7.613	0.835	34.893	55.218	16%
5599	0.298	0	0.105	0.301	3.765	2.506	0.553	2.413	2.307	6.936	7.613	0.832	34.865	54.881	17%
5600	0.299	0	3.361	3.151	3.828	0	0.553	2.413	2.307	6.934	7.615	0.836	34.895	58.577	11%
5601	0.299	0	3.361	3.151	3.828	0	0.553	2.413	2.307	6.934	7.615	0.836	34.895	58.577	11%
5602	0.299	0	3.361	3.151	3.828	0	0.553	2.413	2.307	6.934	7.615	0.836	34.895	58.577	11%
5603	0.299	1.126	0.671	0.939	3.821	0	0.553	2.413	2.307	6.933	7.615	0.836	34.898	54.796	17%
5604	0.299	1.773	0.094	1.378	3.82	0	0.553	2.413	2.307	6.933	7.614	0.835	34.892	55.297	16%
5605	0.3	0.414	0.284	0.754	3.82	0	0.553	2.413	2.307	6.935	7.614	0.836	34.908	53.524	19%
5606	0.298	0	0.089	3.151	3.8	2.244	0.553	2.413	2.307	6.935	7.614	0.835	34.899	57.524	13%
5607	0.299	1.126	1.376	0.939	3.821	0	0.553	2.413	2.307	6.933	7.615	0.836	34.898	55.501	16%
5608	0.3	0.414	1.935	0.754	3.82	0	0.553	2.413	2.307	6.935	7.614	0.836	34.908	55.175	17%
5609	0.299	3.732	4.834	1.037	3.832	2.245	0.554	2.413	2.307	6.939	7.613	0.837	34.908	63.937	3%
5610	0.299	2.576	1.365	2.508	3.821	0	0.553	2.413	2.307	6.936	7.615	0.835	34.909	58.522	11%
5611	0.298	0	0.574	3.151	3.829	0	0.553	2.413	2.307	6.934	7.615	0.836	34.899	55.794	16%
5612	0.299	0.259	2.588	1.111	3.82	0	0.554	2.413	2.307	6.934	7.616	0.837	34.915	56.037	15%
5613	0.299	1.283	0.289	1.104	3.818	0	0.553	2.413	2.307	6.934	7.615	0.836	34.909	54.745	17%
5614	0.299	4.168	3.384	1.464	3.82	0	0.553	2.413	2.307	6.935	7.62	0.835	34.883	61.061	8%
5615	0.298	0.459	1.361	1.208	3.815	0	0.553	2.413	2.307	6.937	7.614	0.836	34.899	55.086	17%
5616	0.299	0	1.877	0.192	3.8	0	0.553	2.413	2.307	6.932	7.615	0.834	34.889	54.096	18%
5617	0.299	0.662	1.333	0.662	3.819	0	0.553	2.413	2.307	6.934	7.616	0.836	34.911	54.729	17%

Table B-2

Optimization Model Runs (Scenario ID)/ Alternatives - CSO Volumes for Each Alternative - 1 year 3 hr Design Event

Scenario ID	CSO 006	CSO 012	CSO 013	CSO 014	CSO 015	CSO 016	CSO 017	CSO 018	CSO 020	CSO 022	CSO 123 (Treated Effluent)	CSO 024	CSO 025	Total (No CSO 123)	Percent Reduction
5618	0.299	0.662	0.286	0.662	3.819	0	0.553	2.413	2.307	6.934	7.616	0.836	34.911	53.682	19%
5619	0.3	2.043	4.788	1.219	3.809	2.381	0.553	2.413	2.307	6.942	7.613	0.835	34.89	62.48	5%
5620	0.299	0.542	1.356	0.6	3.825	0	0.553	2.413	2.307	6.935	7.615	0.837	34.915	54.582	17%
5621	0.299	0.709	2.064	0.82	3.82	0	0.553	2.413	2.307	6.934	7.615	0.836	34.911	55.666	16%
5622	0.3	0.088	0.091	0.264	3.82	0	0.553	2.413	2.307	6.933	7.614	0.836	34.895	52.5	21%
5623	0.3	0.414	0.09	0.754	3.82	0	0.553	2.413	2.307	6.935	7.614	0.836	34.908	53.33	19%
5624	0.3	0.414	0.284	0.754	3.82	0	0.553	2.413	2.307	6.935	7.614	0.836	34.908	53.524	19%
5625	0.299	0.399	1.951	1.633	3.822	0	0.554	2.413	2.307	6.934	7.615	0.837	34.913	56.062	15%
5626	0.3	0.658	1.001	0.59	3.826	0	0.553	2.413	2.307	6.936	7.615	0.837	34.922	54.343	18%
5627	0.3	1.954	0.989	1.306	3.823	0	0.553	2.413	2.307	6.936	7.615	0.836	34.911	56.328	15%
5628	0.299	0.655	1.004	0.812	3.824	0	0.553	2.413	2.307	6.933	7.614	0.836	34.899	54.535	17%
5629	0.3	1.104	0.092	0.933	3.822	0	0.553	2.413	2.307	6.936	7.615	0.836	34.916	54.212	18%
5630	0.3	6.107	0.346	0.938	3.848	0	0.554	2.413	2.307	6.937	7.619	0.838	34.912	59.5	10%
5631	0.299	0.705	2.07	0.62	3.821	0	0.553	2.413	2.307	6.937	7.615	0.836	34.899	55.46	16%
5632	0.298	0.459	0.98	1.208	3.815	0	0.553	2.413	2.307	6.937	7.614	0.836	34.899	54.705	17%
5633	0.299	0.662	0.286	0.662	3.819	0	0.553	2.413	2.307	6.934	7.616	0.836	34.911	53.682	19%
5634	0.299	0.71	1.381	0.511	3.823	0	0.553	2.413	2.307	6.934	7.615	0.836	34.899	54.666	17%
5635	0.297	0.036	1.931	0.192	3.817	0	0.553	2.413	2.307	6.934	7.615	0.835	34.885	54.2	18%
5636	0.299	0.131	1.927	0.292	3.815	0	0.553	2.413	2.307	6.937	7.615	0.836	34.896	54.406	18%
5637	0.298	0.037	1.933	0.192	3.815	0	0.553	2.413	2.307	6.934	7.619	0.836	34.884	54.202	18%
5638	0.299	1.283	0.289	1.104	3.818	0	0.553	2.413	2.307	6.934	7.615	0.836	34.909	54.745	17%
5639	0.3	0	3.12	3.151	3.841	0.001	0.553	2.413	2.307	6.938	7.616	0.836	34.897	58.357	12%
5640	0.296	0.666	3.319	0.653	3.827	0	0.553	2.413	2.307	6.935	7.615	0.836	34.894	56.699	14%
5641	0.297	0.736	1.713	0.47	3.819	0	0.553	2.413	2.307	6.934	7.615	0.835	34.886	54.963	17%
5642	0.298	3.124	4.831	1.221	3.847	0	0.553	2.413	2.307	6.939	7.618	0.837	34.909	61.279	7%
5643	0.299	1.038	2.761	0.935	3.821	0	0.553	2.413	2.307	6.938	7.615	0.836	34.906	56.807	14%
5644	0.3	0.721	0.295	0.418	3.824	0	0.553	2.413	2.307	6.936	7.614	0.837	34.918	53.522	19%
5645	0.299	0.673	0.091	0.64	3.82	0	0.553	2.413	2.307	6.933	7.614	0.835	34.889	53.453	19%
5646	0.298	1.041	0.094	0.712	3.819	0	0.553	2.413	2.307	6.938	7.615	0.836	34.905	53.916	18%
5647	0.3	0.032	0.09	0.192	3.817	0	0.553	2.413	2.307	6.935	7.615	0.836	34.908	52.383	21%
5648	0.299	6.364	1.043	3.151	3.862	0	0.553	2.413	2.307	6.94	7.62	0.837	34.909	62.678	5%
5649	0.298	1.041	0.621	0.712	3.819	0	0.553	2.413	2.307	6.938	7.615	0.836	34.905	54.443	18%
5650	0.298	1.041	0.665	0.712	3.819	0	0.553	2.413	2.307	6.938	7.615	0.836	34.905	54.487	18%
5651	0.298	0.131	2.033	0.467	3.809	0	0.553	2.413	2.307	6.937	7.616	0.835	34.898	54.681	17%
5652	0.3	0.414	0.284	0.754	3.82	0	0.553	2.413	2.307	6.935	7.614	0.836	34.908	53.524	19%
5653	0.296	3.124	0.092	0.777	3.831	0	0.553	2.413	2.307	6.938	7.61	0.837	34.905	56.073	15%
5654	0.299	0.389	2.074	1.925	3.819	0	0.554	2.413	2.307	6.938	7.615	0.836	34.906	56.46	15%
5655	0.299	0.387	3.525	1.81	3.825	0	0.554	2.413	2.307	6.938	7.615	0.836	34.905	57.799	13%
5656	0.299	0.387	3.525	1.81	3.825	0	0.554	2.413	2.307	6.938	7.615	0.836	34.905	57.799	13%
5657	0.299	0.5	0.09	0.838	3.822	0	0.554	2.413	2.307	6.937	7.616	0.836	34.915	53.511	19%
5658	0.299	3.123	4.739	0.192	3.824	0	0.553	2.413	2.307	6.934	7.613	0.833	34.87	60.087	9%
5659	0.299	0.722	0.617	0.973	3.82	0	0.553	2.413	2.307	6.934	7.615	0.836	34.911	54.385	18%
5660	0.299	0.471	1.359	1.189	3.817	0	0.554	2.413	2.307	6.934	7.615	0.836	34.905	55.084	17%

Table B-2

Optimization Model Runs (Scenario ID)/ Alternatives - CSO Volumes for Each Alternative - 1 year 3 hr Design Event

Scenario ID	CSO 006	CSO 012	CSO 013	CSO 014	CSO 015	CSO 016	CSO 017	CSO 018	CSO 020	CSO 022	CSO 123 (Treated Effluent)	CSO 024	CSO 025	Total (No CSO 123)	Percent Reduction
5661	0.299	0.471	1.359	1.189	3.817	0	0.554	2.413	2.307	6.934	7.615	0.836	34.905	55.084	17%
5662	0.299	0.122	1.339	0.377	3.811	0	0.553	2.413	2.307	6.933	7.615	0.835	34.903	53.892	18%
5663	0.3	0.647	2.065	0.508	3.822	0	0.553	2.413	2.307	6.936	7.614	0.836	34.914	55.301	16%
5664	0.297	3.124	1.952	0.795	3.835	0	0.553	2.413	2.307	6.937	7.61	0.837	34.902	57.952	12%
5665	0.297	0.765	1.373	0.456	3.818	0	0.553	2.413	2.307	6.935	7.615	0.836	34.89	54.643	17%
5666	0.297	3.755	0.093	1.474	3.816	0	0.553	2.413	2.307	6.934	7.615	0.835	34.885	57.362	13%
5667	0.299	0.662	0.982	0.662	3.819	0	0.553	2.413	2.307	6.934	7.616	0.836	34.911	54.378	18%
5668	0.298	3.583	0.089	0.997	3.786	2.244	0.553	2.413	2.307	6.939	7.613	0.834	34.88	58.923	11%
5669	0.297	1.871	1.363	0.995	3.814	0.001	0.553	2.413	2.307	6.934	7.614	0.835	34.884	56.267	15%
5670	0.3	0.032	0.958	0.192	3.817	0	0.553	2.413	2.307	6.935	7.615	0.836	34.908	53.251	19%
5671	0.299	3.124	2.841	1.188	3.85	0	0.554	2.413	2.307	6.937	7.612	0.838	34.909	59.26	10%
5672	0.299	0.542	1.386	0.6	3.825	0	0.553	2.413	2.307	6.935	7.615	0.837	34.915	54.612	17%
5673	0.3	0.444	2.085	1.355	3.827	0	0.554	2.413	2.307	6.937	7.615	0.837	34.92	55.979	15%
5674	0.296	0.697	1.74	0.645	3.823	0.001	0.553	2.413	2.307	6.935	7.615	0.836	34.892	55.138	17%
5675	0.299	1.971	0.289	1.23	3.819	0	0.553	2.413	2.307	6.934	7.616	0.836	34.91	55.561	16%
5676	0.299	0.662	0.09	0.662	3.819	0	0.553	2.413	2.307	6.934	7.616	0.836	34.911	53.486	19%
5677	0.298	2.746	0.089	1.808	3.793	2.381	0.553	2.413	2.307	6.939	7.613	0.834	34.881	59.042	11%
5678	0.299	2.02	0.29	1.207	3.819	0	0.553	2.413	2.307	6.934	7.615	0.836	34.906	55.584	16%
5679	0.299	0.5	0.291	0.838	3.822	0	0.554	2.413	2.307	6.937	7.616	0.836	34.915	53.712	19%
5680	0.3	0.721	0.295	0.418	3.824	0	0.553	2.413	2.307	6.936	7.614	0.837	34.918	53.522	19%
5681	0.3	0.414	0.284	0.754	3.82	0	0.553	2.413	2.307	6.935	7.614	0.836	34.908	53.524	19%
5682	0.3	0.414	0.284	0.754	3.82	0	0.553	2.413	2.307	6.935	7.614	0.836	34.908	53.524	19%
5683	0.303	1.519	1.025	0.731	3.834	0	0.554	2.413	2.307	6.935	7.619	0.836	34.891	55.348	16%
5684	0.296	2.167	0.658	1.36	3.812	0	0.553	2.413	2.307	6.934	7.615	0.835	34.888	56.223	15%
5685	0.299	0.5	0.291	0.838	3.822	0	0.554	2.413	2.307	6.937	7.616	0.836	34.915	53.712	19%
5686	0.299	0.44	0.315	3.151	3.856	0.001	0.553	2.413	2.307	6.937	7.615	0.837	34.909	56.018	15%
5687	0.296	2.167	1.334	1.36	3.812	0.001	0.553	2.413	2.307	6.934	7.615	0.835	34.888	56.9	14%
5688	0.296	2.167	0.658	1.36	3.812	0.001	0.553	2.413	2.307	6.934	7.615	0.835	34.888	56.224	15%
5689	0.296	2.167	0.658	1.36	3.812	0.001	0.553	2.413	2.307	6.934	7.615	0.835	34.888	56.224	15%
5690	0.297	3.897	3.319	1.156	3.818	0	0.553	2.413	2.307	6.934	7.615	0.835	34.883	60.412	9%
5691	0.297	3.491	3.482	0.845	3.83	0	0.554	2.413	2.307	6.938	7.614	0.837	34.895	59.889	9%
5692	0.297	3.491	3.482	0.845	3.83	0	0.554	2.413	2.307	6.938	7.614	0.837	34.895	59.889	9%
5693	0.297	3.491	3.482	0.845	3.83	0	0.554	2.413	2.307	6.938	7.614	0.837	34.895	59.889	9%
5694	0.3	3.001	0.665	0.935	3.818	0	0.553	2.413	2.307	6.937	7.615	0.836	34.897	56.662	14%
5695	0.298	1.041	0.292	0.712	3.819	0	0.553	2.413	2.307	6.938	7.615	0.836	34.905	54.114	18%
5696	0.299	0	0.092	3.151	3.849	0	0.553	2.413	2.307	6.934	7.62	0.836	34.894	55.328	16%
5697	0.299	2.052	0.618	1.271	3.818	0	0.553	2.413	2.307	6.938	7.615	0.836	34.904	56.009	15%
5698	0.299	1.948	1.374	1.164	3.822	0	0.553	2.413	2.307	6.936	7.614	0.835	34.89	56.541	14%
5699	0.299	2.404	0.682	1.514	3.825	0	0.554	2.413	2.307	6.934	7.615	0.837	34.914	56.683	14%
5700	0.299	2.21	0.309	1.18	3.825	0	0.554	2.413	2.307	6.935	7.615	0.837	34.912	55.781	16%
5701	0.299	0	0.091	0.267	3.814	0	0.553	2.413	2.307	6.932	7.615	0.836	34.897	52.409	21%
5702	0.303	3.334	2.081	1.251	3.834	0	0.554	2.413	2.307	6.935	7.615	0.837	34.895	58.744	11%
5703	0.299	2.427	3.403	1.301	3.829	0	0.554	2.413	2.307	6.934	7.616	0.837	34.914	59.218	10%

Table B-2

Optimization Model Runs (Scenario ID)/ Alternatives - CSO Volumes for Each Alternative - 1 year 3 hr Design Event

Scenario ID	CSO 006	CSO 012	CSO 013	CSO 014	CSO 015	CSO 016	CSO 017	CSO 018	CSO 020	CSO 022	CSO 123 (Treated Effluent)	CSO 024	CSO 025	Total (No CSO 123)	Percent Reduction
5704	0.299	2.097	3.371	1.172	3.824	0	0.553	2.413	2.307	6.934	7.616	0.836	34.909	58.715	11%
5705	0.299	2.034	3.359	1.527	3.822	0	0.553	2.413	2.307	6.934	7.616	0.836	34.908	58.992	11%
5706	0.299	1.127	0.095	0.856	3.82	0	0.553	2.413	2.307	6.937	7.615	0.836	34.902	54.145	18%
5707	0.3	0.414	0.09	0.754	3.82	0	0.553	2.413	2.307	6.935	7.614	0.836	34.908	53.33	19%
5708	0.299	2.315	1.37	1.262	3.827	0	0.554	2.413	2.307	6.935	7.614	0.837	34.904	57.023	14%
5709	0.299	0.683	2.8	0.757	3.82	0	0.553	2.413	2.307	6.938	7.615	0.836	34.904	56.31	15%
5710	0.298	0.249	3.274	1.196	3.821	0	0.554	2.413	2.307	6.938	7.615	0.836	34.908	56.794	14%
5711	0.3	0.414	0.98	0.754	3.82	0	0.553	2.413	2.307	6.935	7.614	0.836	34.908	54.22	18%
5712	0.298	6.038	0.09	1.004	3.81	2.505	0.554	2.413	2.307	6.936	7.612	0.836	34.898	61.689	7%
5713	0.298	0.546	0.638	0.565	3.824	0	0.553	2.413	2.307	6.938	7.615	0.837	34.91	53.829	19%
5714	0.298	0.657	0.089	0.689	3.793	2.506	0.553	2.413	2.307	6.939	7.612	0.835	34.889	55.968	15%
5715	0.298	0.657	0.089	0.689	3.793	2.506	0.553	2.413	2.307	6.939	7.612	0.835	34.889	55.968	15%
5716	0.3	0.715	2.845	0.546	3.825	0	0.553	2.413	2.307	6.936	7.614	0.836	34.915	56.191	15%
5717	0.3	0.662	2.852	0.642	3.828	0	0.553	2.413	2.307	6.937	7.615	0.837	34.92	56.251	15%
5718	0.299	0.991	0.289	0.598	3.819	0	0.553	2.413	2.307	6.934	7.615	0.836	34.908	53.947	18%
5719	0.299	0.665	1.713	0.629	3.819	0	0.553	2.413	2.307	6.934	7.616	0.836	34.912	55.08	17%
5720	0.299	0	1.297	3.151	3.826	0	0.553	2.413	2.307	6.932	7.62	0.836	34.892	56.506	15%
5721	0.299	0.696	0.291	0.777	3.819	0	0.553	2.413	2.307	6.937	7.614	0.836	34.902	53.83	19%
5722	0.3	0	0.253	0.192	3.795	0	0.553	2.413	2.307	6.93	7.615	0.833	34.871	52.447	21%
5723	0.299	2.099	3.68	1.332	3.917	0	0.554	2.413	2.307	6.942	7.619	0.837	34.899	59.279	10%
5724	0.3	0.032	2.04	0.192	3.817	0	0.553	2.413	2.307	6.935	7.615	0.836	34.908	54.333	18%
5725	0.299	1.264	2.848	1.038	3.82	0	0.553	2.413	2.307	6.934	7.616	0.836	34.91	57.222	13%
5726	0.296	3.124	2.482	0.808	3.832	0	0.553	2.413	2.307	6.938	7.611	0.837	34.906	58.496	11%
5727	0.298	0.332	0.975	1.849	3.811	0	0.553	2.413	2.307	6.937	7.615	0.835	34.898	55.208	16%
5728	0.3	0.088	0.975	0.264	3.82	0	0.553	2.413	2.307	6.933	7.614	0.836	34.895	53.384	19%
5729	0.299	0.5	0.988	0.838	3.822	0	0.554	2.413	2.307	6.937	7.616	0.836	34.915	54.409	18%
5730	0.3	2.711	0.091	2.888	3.823	0	0.553	2.413	2.307	6.935	7.614	0.836	34.917	57.774	13%
5731	0.3	0.359	0.299	0.364	3.825	0	0.554	2.413	2.307	6.934	7.615	0.836	34.903	53.094	20%
5732	0.3	0.359	0.997	0.364	3.825	0	0.554	2.413	2.307	6.934	7.615	0.836	34.903	53.792	19%
5733	0.299	0.5	0.291	0.838	3.822	0	0.554	2.413	2.307	6.937	7.616	0.836	34.915	53.712	19%
5734	0.299	0	0.092	3.151	3.826	0	0.553	2.413	2.307	6.933	7.62	0.836	34.901	55.311	16%
5735	0.299	0.277	1.329	1.847	3.815	0	0.553	2.413	2.307	6.933	7.615	0.835	34.891	55.499	16%
5736	0.299	1.966	2.062	1.09	3.819	0	0.553	2.413	2.307	6.934	7.616	0.836	34.907	57.186	13%
5737	0.297	3.491	3.482	0.845	3.83	0	0.554	2.413	2.307	6.938	7.614	0.837	34.895	59.889	9%
5738	0.297	3.491	3.482	0.845	3.83	0	0.554	2.413	2.307	6.938	7.614	0.837	34.895	59.889	9%
5739	0.297	3.491	3.482	0.845	3.83	0	0.554	2.413	2.307	6.938	7.614	0.837	34.895	59.889	9%
5740	0.299	1.187	0.669	1.072	3.821	0	0.553	2.413	2.307	6.934	7.615	0.836	34.897	54.988	17%
5741	0.3	0.414	0.284	0.754	3.82	0	0.553	2.413	2.307	6.935	7.614	0.836	34.908	53.524	19%
5742	0.296	0.408	1.336	0.889	3.815	0	0.553	2.413	2.307	6.935	7.615	0.836	34.892	54.68	17%
5743	0.299	1.127	1.376	0.856	3.82	0	0.553	2.413	2.307	6.937	7.615	0.836	34.902	55.426	16%
5744	0.299	1.187	0.669	1.072	3.821	0	0.553	2.413	2.307	6.934	7.615	0.836	34.897	54.988	17%
5745	0.299	1.948	0.668	1.164	3.822	0	0.553	2.413	2.307	6.936	7.614	0.835	34.89	55.835	16%
5746	0.297	0.835	2.733	0.616	3.818	0	0.553	2.413	2.307	6.935	7.615	0.836	34.888	56.231	15%

Table B-2

Optimization Model Runs (Scenario ID)/ Alternatives - CSO Volumes for Each Alternative - 1 year 3 hr Design Event

Scenario ID	CSO 006	CSO 012	CSO 013	CSO 014	CSO 015	CSO 016	CSO 017	CSO 018	CSO 020	CSO 022	CSO 123 (Treated Effluent)	CSO 024	CSO 025	Total (No CSO 123)	Percent Reduction
5747	0.299	0.131	1.927	0.292	3.815	0	0.553	2.413	2.307	6.937	7.615	0.836	34.896	54.406	18%
5748	0.299	0.131	1.927	0.292	3.815	0	0.553	2.413	2.307	6.937	7.615	0.836	34.896	54.406	18%
5749	0.298	0.037	1.933	0.192	3.815	0	0.553	2.413	2.307	6.934	7.619	0.836	34.884	54.202	18%
5750	0.299	1.283	0.289	1.104	3.818	0	0.553	2.413	2.307	6.934	7.615	0.836	34.909	54.745	17%
5751	0.299	3.123	0.089	0.192	3.786	2.893	0.553	2.413	2.307	6.935	7.621	0.832	34.851	58.273	12%
5752	0.299	1.127	0.095	0.856	3.82	0	0.553	2.413	2.307	6.937	7.615	0.836	34.902	54.145	18%
5753	0.3	0.359	1.385	0.364	3.825	0	0.554	2.413	2.307	6.934	7.615	0.836	34.903	54.18	18%
5754	0.298	1.041	0.094	0.712	3.819	0	0.553	2.413	2.307	6.938	7.615	0.836	34.905	53.916	18%
5755	0.299	0.5	0.291	0.838	3.822	0	0.554	2.413	2.307	6.937	7.616	0.836	34.915	53.712	19%
5756	0.299	0	0.092	3.151	3.824	0	0.553	2.413	2.307	6.934	7.615	0.836	34.895	55.304	16%
5757	0.299	2.052	0.092	1.271	3.818	0	0.553	2.413	2.307	6.938	7.615	0.836	34.904	55.483	16%
5758	0.299	1.982	0.094	1.029	3.818	0	0.553	2.413	2.307	6.937	7.614	0.836	34.899	55.167	17%
5759	0.299	0.361	2.485	0.371	3.825	0	0.554	2.413	2.307	6.936	7.614	0.837	34.918	55.306	16%
5760	0.299	0.71	2.077	0.498	3.823	0	0.553	2.413	2.307	6.934	7.615	0.836	34.898	55.348	16%
5761	0.3	0.662	2.852	0.642	3.828	0	0.553	2.413	2.307	6.937	7.615	0.837	34.92	56.251	15%
5762	0.3	0.662	2.852	0.642	3.828	0	0.553	2.413	2.307	6.937	7.615	0.837	34.92	56.251	15%
5763	0.299	0.662	1.333	0.662	3.819	0	0.553	2.413	2.307	6.934	7.616	0.836	34.911	54.729	17%
5764	0.299	0.991	1.336	0.598	3.819	0	0.553	2.413	2.307	6.934	7.615	0.836	34.908	54.994	17%
5765	0.299	1.971	0.091	1.23	3.819	0.001	0.553	2.413	2.307	6.934	7.616	0.836	34.91	55.364	16%
5766	0.3	0.032	0.266	0.192	3.817	0	0.553	2.413	2.307	6.935	7.615	0.836	34.908	52.559	20%
5767	0.3	0.65	0.29	0.53	3.822	0	0.553	2.413	2.307	6.936	7.614	0.836	34.915	53.552	19%
5768	0.3	0.414	0.284	0.754	3.82	0	0.553	2.413	2.307	6.935	7.614	0.836	34.908	53.524	19%
5769	0.3	0.032	0.266	0.192	3.817	0	0.553	2.413	2.307	6.935	7.615	0.836	34.908	52.559	20%
5770	0.297	0	0.09	0.192	3.775	0	0.553	2.413	2.307	6.929	7.615	0.831	34.849	52.236	21%
5771	0.299	0.3	2.051	1.228	3.815	0	0.553	2.413	2.307	6.933	7.615	0.836	34.903	55.638	16%
5772	0.3	0.359	0.997	0.364	3.825	0	0.554	2.413	2.307	6.934	7.615	0.836	34.903	53.792	19%
5773	0.3	0.647	2.065	0.508	3.822	0	0.553	2.413	2.307	6.936	7.614	0.836	34.914	55.301	16%
5774	0.299	0	0.092	3.151	3.824	0	0.553	2.413	2.307	6.934	7.615	0.836	34.895	55.304	16%
5775	0.298	0.459	0.98	1.208	3.815	0	0.553	2.413	2.307	6.937	7.614	0.836	34.899	54.705	17%
5776	0.3	0.088	0.975	0.264	3.82	0	0.553	2.413	2.307	6.933	7.614	0.836	34.895	53.384	19%
5777	0.3	0.088	0.975	0.264	3.82	0	0.553	2.413	2.307	6.933	7.614	0.836	34.895	53.384	19%
5778	0.3	0.414	0.284	0.754	3.82	0	0.553	2.413	2.307	6.935	7.614	0.836	34.908	53.524	19%
5779	0.299	0.471	0.09	1.189	3.817	0	0.554	2.413	2.307	6.934	7.615	0.836	34.905	53.815	19%
5780	0.299	5.99	3.16	1.01	3.839	0	0.554	2.413	2.307	6.935	7.615	0.837	34.908	62.252	6%
5781	0.297	3.491	3.482	0.845	3.83	0	0.554	2.413	2.307	6.938	7.614	0.837	34.895	59.889	9%
5782	0.297	3.756	3.372	0.927	3.821	0	0.553	2.413	2.307	6.935	7.615	0.835	34.888	60.104	9%
5783	0.3	0.443	0.308	1.199	3.828	0	0.554	2.413	2.307	6.936	7.615	0.837	34.922	54.047	18%
5784	0.299	0	0.617	3.151	3.825	0	0.553	2.413	2.307	6.932	7.62	0.836	34.89	55.823	16%
5785	0.299	1.775	1.938	0.782	3.818	0	0.553	2.413	2.307	6.937	7.615	0.836	34.894	56.552	14%
5786	0.299	0.471	1.359	1.189	3.817	0	0.554	2.413	2.307	6.934	7.615	0.836	34.905	55.084	17%
5787	0.299	0	1.877	0.192	3.8	0	0.553	2.413	2.307	6.932	7.615	0.834	34.889	54.096	18%
5788	0.299	0	1.877	0.192	3.8	0	0.553	2.413	2.307	6.932	7.615	0.834	34.889	54.096	18%
5789	0.299	0	1.877	0.192	3.8	0	0.553	2.413	2.307	6.932	7.615	0.834	34.889	54.096	18%

Table B-2

Optimization Model Runs (Scenario ID)/ Alternatives - CSO Volumes for Each Alternative - 1 year 3 hr Design Event

Scenario ID	CSO 006	CSO 012	CSO 013	CSO 014	CSO 015	CSO 016	CSO 017	CSO 018	CSO 020	CSO 022	CSO 123 (Treated Effluent)	CSO 024	CSO 025	Total (No CSO 123)	Percent Reduction
5790	0.298	2.125	1.962	1.195	3.825	0	0.554	2.413	2.307	6.933	7.62	0.837	34.9	57.349	13%
5791	0.299	0.5	1.944	0.838	3.822	0	0.554	2.413	2.307	6.937	7.616	0.836	34.915	55.365	16%
5792	0.297	0	0.09	0.192	3.782	0	0.553	2.413	2.307	6.93	7.614	0.832	34.849	52.245	21%
5793	0.298	0.546	2.086	0.597	3.824	0	0.553	2.413	2.307	6.938	7.615	0.837	34.908	55.307	16%
5794	0.299	1.009	3.429	0.712	3.825	0	0.553	2.413	2.307	6.936	7.62	0.836	34.892	57.211	13%
5795	0.299	2.107	3.404	1.607	3.822	0	0.553	2.413	2.307	6.935	7.619	0.835	34.883	59.165	10%
5796	0.3	0.359	0.299	0.364	3.825	0	0.554	2.413	2.307	6.934	7.615	0.836	34.903	53.094	20%
5797	0.299	0.707	2.251	0.738	3.823	0	0.553	2.413	2.307	6.933	7.615	0.836	34.898	55.758	16%
5798	0.299	0.708	1.941	0.903	3.816	0	0.553	2.413	2.307	6.936	7.62	0.835	34.891	55.602	16%
5799	0.3	0.721	0.295	0.418	3.824	0	0.553	2.413	2.307	6.936	7.614	0.837	34.918	53.522	19%
5800	0.299	3.124	0.098	0.487	3.834	0	0.553	2.413	2.307	6.939	7.618	0.837	34.911	55.802	16%
5801	0.297	3.124	1.962	0.402	3.838	0	0.553	2.413	2.307	6.938	7.61	0.837	34.906	57.577	13%
5802	0.297	0.765	0.292	0.456	3.818	0	0.553	2.413	2.307	6.935	7.615	0.836	34.89	53.562	19%
5803	0.3	3.717	0.342	1.1	3.847	0	0.554	2.413	2.307	6.936	7.615	0.838	34.901	57.255	13%
5804	0.299	0.738	0.627	0.502	3.819	0	0.553	2.413	2.307	6.934	7.618	0.836	34.885	53.913	18%
5805	0.298	0.037	1.933	0.192	3.815	0	0.553	2.413	2.307	6.934	7.619	0.836	34.884	54.202	18%
5806	0.299	0.703	3.026	0.88	3.821	0	0.553	2.413	2.307	6.938	7.615	0.836	34.902	56.678	14%
5807	0.298	0.249	3.274	1.196	3.821	0	0.554	2.413	2.307	6.938	7.615	0.836	34.908	56.794	14%
5808	0.298	0.249	3.274	1.196	3.821	0	0.554	2.413	2.307	6.938	7.615	0.836	34.908	56.794	14%
5809	0.298	0.249	3.274	1.196	3.821	0	0.554	2.413	2.307	6.938	7.615	0.836	34.908	56.794	14%
5810	0.3	0.721	1.344	0.418	3.824	0	0.553	2.413	2.307	6.936	7.614	0.837	34.918	54.571	17%
5811	0.298	3.123	0.648	0.192	3.811	0	0.553	2.413	2.307	6.939	7.617	0.833	34.878	55.995	15%
5812	0.299	3.123	0.128	0.192	3.814	0	0.553	2.413	2.307	6.933	7.613	0.833	34.859	55.454	16%
5813	0.297	3.124	1.009	0.402	3.838	0	0.553	2.413	2.307	6.938	7.61	0.837	34.906	56.624	14%
5814	0.303	0	0.091	0.265	3.821	0	0.553	2.413	2.307	6.934	7.619	0.836	34.894	52.417	21%
5815	0.298	0.54	0.088	1.108	3.786	2.893	0.553	2.413	2.307	6.939	7.613	0.834	34.878	56.637	14%
5816	0.299	0.707	3.46	0.78	3.824	0	0.553	2.413	2.307	6.934	7.615	0.836	34.91	57.023	14%
5817	0.299	2.792	2.06	1.879	3.821	0	0.553	2.413	2.307	6.934	7.615	0.836	34.906	58.8	11%
5818	0.304	0.525	3.424	1.203	3.827	0	0.554	2.413	2.307	6.936	7.62	0.835	34.892	57.22	13%
5819	0.298	3.124	0.092	0.192	3.835	0	0.553	2.413	2.307	6.942	7.618	0.836	34.911	55.503	16%
5820	0.3	0.163	0.091	0.667	3.823	0	0.553	2.413	2.307	6.937	7.615	0.836	34.903	52.993	20%
5821	0.299	0.675	0.088	0.559	3.788	2.893	0.553	2.413	2.307	6.941	7.612	0.835	34.882	56.233	15%
5822	0.303	2.657	0.093	3.151	3.867	0	0.553	2.413	2.307	6.939	7.615	0.837	34.897	58.017	12%
5823	0.302	3.72	1.037	1.227	3.852	0	0.554	2.413	2.307	6.936	7.62	0.838	34.91	58.096	12%
5824	0.299	0	0.97	0.192	3.772	0	0.553	2.413	2.307	6.93	7.619	0.831	34.85	53.117	20%
5825	0.299	0	1.567	0.192	3.77	0	0.553	2.413	2.307	6.928	7.615	0.831	34.856	53.716	19%
5826	0.301	2.235	0.089	1.435	3.802	2.893	0.554	2.413	2.307	6.94	7.612	0.835	34.89	58.694	11%
5827	0.304	1.017	0.291	0.788	3.828	0	0.553	2.413	2.307	6.935	7.62	0.836	34.891	54.163	18%
5828	0.299	0.131	0.09	0.292	3.815	0	0.553	2.413	2.307	6.937	7.615	0.836	34.896	52.569	20%
5829	0.299	0	4.812	3.151	3.856	0	0.553	2.413	2.307	6.936	7.615	0.837	34.901	60.065	9%
5830	0.299	1.724	1.018	3.151	3.856	0	0.553	2.413	2.307	6.936	7.614	0.837	34.897	57.991	12%
5831	0.298	3.123	0.61	0.192	3.811	0	0.553	2.413	2.307	6.939	7.617	0.833	34.878	55.957	15%
5832	0.298	0.198	0.088	0.495	3.787	2.381	0.553	2.413	2.307	6.939	7.613	0.835	34.886	55.18	17%

Table B-2

Optimization Model Runs (Scenario ID)/ Alternatives - CSO Volumes for Each Alternative - 1 year 3 hr Design Event

Scenario ID	CSO 006	CSO 012	CSO 013	CSO 014	CSO 015	CSO 016	CSO 017	CSO 018	CSO 020	CSO 022	CSO 123 (Treated Effluent)	CSO 024	CSO 025	Total (No CSO 123)	Percent Reduction
5833	0.299	0.013	0.098	3.151	3.855	0	0.553	2.413	2.307	6.943	7.615	0.837	34.89	55.359	16%
5834	0.297	3.124	0.092	0.402	3.838	0	0.553	2.413	2.307	6.938	7.61	0.837	34.906	55.707	16%
5835	0.298	0.147	0.088	0.643	3.79	2.38	0.553	2.413	2.307	6.942	7.613	0.835	34.885	55.281	16%
5836	0.299	0.761	0.093	3.151	3.855	0	0.553	2.413	2.307	6.936	7.619	0.837	34.898	56.103	15%
5837	0.299	3.721	0.091	1.196	3.819	2.505	0.554	2.413	2.307	6.938	7.613	0.837	34.908	59.588	10%
5838	0.299	0.012	0.09	3.151	3.831	2.244	0.553	2.413	2.307	6.939	7.613	0.836	34.891	57.566	13%
5839	0.3	0	0.088	0.192	3.749	2.381	0.553	2.413	2.307	6.934	7.612	0.83	34.846	54.593	17%
5840	0.299	3.123	0.089	0.192	3.786	2.893	0.553	2.413	2.307	6.935	7.621	0.832	34.851	58.273	12%
5841	0.3	0.166	2.067	0.69	3.822	0	0.553	2.413	2.307	6.937	7.614	0.836	34.901	54.992	17%
5842	0.298	0.509	0.088	0.826	3.786	2.244	0.553	2.413	2.307	6.939	7.612	0.835	34.885	55.683	16%
5843	0.301	3.124	0.093	1.234	3.854	0	0.554	2.413	2.307	6.939	7.61	0.838	34.915	56.572	14%
5844	0.299	3.123	0.092	0.192	3.814	0	0.553	2.413	2.307	6.933	7.613	0.833	34.859	55.418	16%
5845	0.299	0	0.092	3.151	3.826	0	0.553	2.413	2.307	6.932	7.62	0.836	34.892	55.301	16%
5846	0.299	1.775	0.091	0.782	3.818	0	0.553	2.413	2.307	6.937	7.615	0.836	34.894	54.705	17%
5847	0.296	0.697	0.092	0.645	3.823	0	0.553	2.413	2.307	6.935	7.615	0.836	34.892	53.489	19%
5848	0.299	4.122	0.092	1.033	3.82	0	0.554	2.413	2.307	6.937	7.615	0.837	34.902	57.316	13%
5849	0.299	0.277	1.762	0.629	3.83	0	0.554	2.413	2.307	6.935	7.615	0.837	34.911	54.754	17%
5850	0.299	3.169	0.099	1.169	3.825	0	0.554	2.413	2.307	6.934	7.615	0.837	34.906	56.512	14%
5851	0.299	0.003	1.739	0.215	3.823	0	0.553	2.413	2.307	6.934	7.615	0.837	34.905	54.028	18%
5852	0.3	2.124	1.471	1.523	3.795	2.506	0.553	2.413	2.307	6.939	7.613	0.834	34.885	59.65	10%
5853	0.298	3.124	0.092	2.05	3.834	0	0.554	2.413	2.307	6.938	7.617	0.837	34.909	57.356	13%
5854	0.299	1.577	4.841	0.994	3.84	0	0.554	2.413	2.307	6.938	7.615	0.837	34.924	59.524	10%
5855	0.298	0	0.112	3.151	3.8	2.381	0.553	2.413	2.307	6.934	7.613	0.835	34.897	57.681	13%
5856	0.298	0.332	0.09	1.849	3.811	0	0.553	2.413	2.307	6.937	7.615	0.835	34.898	54.323	18%
5857	0.3	1.069	0.089	0.645	3.797	2.245	0.553	2.413	2.307	6.941	7.612	0.835	34.885	56.079	15%
5858	0.299	5.994	2.104	0.954	3.836	0	0.554	2.413	2.307	6.935	7.615	0.838	34.916	61.15	7%
5859	0.298	3.124	0.091	3.151	3.845	2.506	0.553	2.413	2.307	6.94	7.622	0.837	34.894	60.959	8%
5860	0.299	3.124	0.09	1.003	3.82	2.506	0.554	2.413	2.307	6.939	7.621	0.837	34.899	58.791	11%
5861	0.299	2.404	0.097	1.514	3.825	0.001	0.554	2.413	2.307	6.934	7.615	0.837	34.914	56.099	15%
5862	0.299	2.21	0.092	1.18	3.825	0	0.554	2.413	2.307	6.935	7.615	0.837	34.912	55.564	16%
5863	0.299	2.21	0.638	1.18	3.825	0	0.554	2.413	2.307	6.935	7.615	0.837	34.912	56.11	15%
5864	0.299	2.21	0.092	1.18	3.825	0	0.554	2.413	2.307	6.935	7.615	0.837	34.912	55.564	16%
5865	0.299	1.982	0.092	1.029	3.818	0	0.553	2.413	2.307	6.937	7.614	0.836	34.899	55.165	17%
5866	0.298	3.124	1.354	0.362	3.836	0	0.553	2.413	2.307	6.942	7.618	0.837	34.913	56.939	14%
5867	0.299	1.982	1.339	1.029	3.818	0	0.553	2.413	2.307	6.937	7.614	0.836	34.899	56.412	15%
5868	0.299	3.261	1.332	1.352	3.817	0	0.553	2.413	2.307	6.937	7.615	0.836	34.896	58.003	12%
5869	0.299	0.662	0.09	0.662	3.819	0	0.553	2.413	2.307	6.934	7.616	0.836	34.911	53.486	19%
5870	0.299	0.991	0.091	0.598	3.819	0	0.553	2.413	2.307	6.934	7.615	0.836	34.908	53.749	19%
5871	0.299	0.696	0.091	0.777	3.819	0	0.553	2.413	2.307	6.937	7.614	0.836	34.902	53.63	19%
5872	0.298	0.966	0.617	0.797	3.818	0	0.553	2.413	2.307	6.938	7.615	0.836	34.902	54.445	18%
5873	0.299	3.261	1.362	1.352	3.817	0	0.553	2.413	2.307	6.937	7.615	0.836	34.896	58.033	12%
5874	0.298	2.623	0.092	1.607	3.818	0	0.553	2.413	2.307	6.933	7.614	0.836	34.9	56.38	15%
5875	0.299	1.775	1.368	0.782	3.818	0	0.553	2.413	2.307	6.937	7.615	0.836	34.894	55.982	15%

Table B-2

Optimization Model Runs (Scenario ID)/ Alternatives - CSO Volumes for Each Alternative - 1 year 3 hr Design Event

Scenario ID	CSO 006	CSO 012	CSO 013	CSO 014	CSO 015	CSO 016	CSO 017	CSO 018	CSO 020	CSO 022	CSO 123 (Treated Effluent)	CSO 024	CSO 025	Total (No CSO 123)	Percent Reduction
5876	0.299	3.261	1.931	1.352	3.817	0	0.553	2.413	2.307	6.937	7.615	0.836	34.896	58.602	11%
5877	0.299	0.277	1.375	0.629	3.83	0	0.554	2.413	2.307	6.935	7.615	0.837	34.911	54.367	18%
5878	0.299	0.277	1.375	0.629	3.83	0	0.554	2.413	2.307	6.935	7.615	0.837	34.911	54.367	18%
5879	0.299	0.277	1.357	1.847	3.815	0	0.553	2.413	2.307	6.933	7.615	0.835	34.891	55.527	16%
5880	0.299	0.277	1.357	1.847	3.815	0	0.553	2.413	2.307	6.933	7.615	0.835	34.891	55.527	16%
5881	0.299	0.703	3.026	0.88	3.821	0	0.553	2.413	2.307	6.938	7.615	0.836	34.902	56.678	14%
5882	0.3	2.031	0.089	1.053	3.798	2.381	0.553	2.413	2.307	6.941	7.612	0.835	34.881	57.582	13%
5883	0.299	1.193	3.306	1.295	3.822	0	0.553	2.413	2.307	6.934	7.615	0.836	34.906	57.864	12%
5884	0.299	2.052	1.369	1.271	3.818	0	0.553	2.413	2.307	6.938	7.615	0.836	34.904	56.76	14%
5885	0.299	0	1.814	0.192	3.781	0	0.553	2.413	2.307	6.929	7.615	0.832	34.859	53.979	18%
5886	0.298	0.459	0.61	1.208	3.815	0	0.553	2.413	2.307	6.937	7.614	0.836	34.899	54.335	18%
5887	0.298	0	1.309	0.192	3.798	0	0.553	2.413	2.307	6.935	7.615	0.834	34.885	53.524	19%
5888	0.298	0	1.225	0.192	3.771	0	0.553	2.413	2.307	6.933	7.616	0.832	34.864	53.388	19%
5889	0.297	0	0.09	0.192	3.804	0	0.553	2.413	2.307	6.932	7.614	0.834	34.871	52.293	21%
5890	0.299	0	4.747	3.151	3.838	0	0.553	2.413	2.307	6.935	7.615	0.837	34.9	59.98	9%
5891	0.299	1.951	2.611	1.138	3.82	0	0.553	2.413	2.307	6.934	7.615	0.836	34.905	57.767	13%
5892	0.299	0.705	2.477	0.755	3.821	0	0.553	2.413	2.307	6.934	7.615	0.836	34.911	56.011	15%
5893	0.299	2.097	3.371	1.172	3.824	0	0.553	2.413	2.307	6.934	7.616	0.836	34.909	58.715	11%
5894	0.299	2.097	3.371	1.172	3.824	0	0.553	2.413	2.307	6.934	7.616	0.836	34.909	58.715	11%
5895	0.299	0.277	1.405	0.629	3.83	0	0.554	2.413	2.307	6.935	7.615	0.837	34.911	54.397	18%
5896	0.299	4.364	1.927	1.842	3.816	0	0.553	2.413	2.307	6.933	7.615	0.836	34.895	60.185	9%
5897	0.299	0.277	1.405	0.629	3.83	0	0.554	2.413	2.307	6.935	7.615	0.837	34.911	54.397	18%
5898	0.299	0.277	1.405	0.629	3.83	0	0.554	2.413	2.307	6.935	7.615	0.837	34.911	54.397	18%
5899	0.296	0.697	1.382	0.645	3.823	0	0.553	2.413	2.307	6.935	7.615	0.836	34.892	54.779	17%
5900	0.298	0.669	0.089	0.673	3.794	2.38	0.553	2.413	2.307	6.942	7.613	0.835	34.883	55.836	16%
5901	0.298	0.669	0.089	0.673	3.794	2.38	0.553	2.413	2.307	6.942	7.613	0.835	34.883	55.836	16%
5902	0.298	0.416	0.088	1.089	3.789	2.38	0.553	2.413	2.307	6.942	7.614	0.835	34.882	55.992	15%
5903	0.3	2.124	0.199	1.523	3.795	2.506	0.553	2.413	2.307	6.939	7.613	0.834	34.885	58.378	12%
5904	0.298	1.041	1.941	0.712	3.819	0	0.553	2.413	2.307	6.938	7.615	0.836	34.905	55.763	16%
5905	0.298	1.057	2.806	0.743	3.82	0	0.553	2.413	2.307	6.937	7.615	0.836	34.905	56.675	14%
5906	0.299	1.982	1.938	1.029	3.818	0	0.553	2.413	2.307	6.937	7.614	0.836	34.899	57.011	14%
5907	0.298	1.057	2.806	0.743	3.82	0	0.553	2.413	2.307	6.937	7.615	0.836	34.905	56.675	14%
5908	0.298	0.332	1.348	1.849	3.811	0	0.553	2.413	2.307	6.937	7.615	0.835	34.898	55.581	16%
5909	0.299	1.07	0.094	1.005	3.82	0	0.553	2.413	2.307	6.933	7.615	0.835	34.89	54.219	18%
5910	0.299	2.404	1.387	1.514	3.825	0	0.554	2.413	2.307	6.934	7.615	0.837	34.914	57.388	13%
5911	0.299	0	1.252	0.192	3.781	0	0.553	2.413	2.307	6.929	7.615	0.832	34.859	53.417	19%
5912	0.299	0	1.219	0.192	3.77	0	0.553	2.413	2.307	6.928	7.615	0.831	34.856	53.368	19%
5913	0.299	1.264	2.848	1.038	3.82	0	0.553	2.413	2.307	6.934	7.616	0.836	34.91	57.222	13%
5914	0.3	1.897	0.089	0.807	3.799	2.506	0.553	2.413	2.307	6.939	7.612	0.835	34.886	57.331	13%
5915	0.3	2.124	0.089	1.523	3.795	2.506	0.553	2.413	2.307	6.939	7.613	0.834	34.885	58.268	12%
5916	0.299	0.722	1.368	0.973	3.82	0	0.553	2.413	2.307	6.934	7.615	0.836	34.911	55.136	17%
5917	0.301	2.358	0.089	1.081	3.805	2.506	0.554	2.413	2.307	6.936	7.612	0.835	34.891	58.076	12%
5918	0.3	2.223	0.089	1.248	3.801	2.506	0.554	2.413	2.307	6.943	7.613	0.835	34.895	58.114	12%

Table B-2

Optimization Model Runs (Scenario ID)/ Alternatives - CSO Volumes for Each Alternative - 1 year 3 hr Design Event

Scenario ID	CSO 006	CSO 012	CSO 013	CSO 014	CSO 015	CSO 016	CSO 017	CSO 018	CSO 020	CSO 022	CSO 123 (Treated Effluent)	CSO 024	CSO 025	Total (No CSO 123)	Percent Reduction
5919	0.3	2.124	0.089	1.523	3.795	2.506	0.553	2.413	2.307	6.939	7.613	0.834	34.885	58.268	12%
5920	0.297	0.532	0.091	1.23	3.815	0	0.553	2.413	2.307	6.934	7.614	0.835	34.879	53.886	18%
5921	0.297	0	0.09	0.192	3.804	0	0.553	2.413	2.307	6.932	7.614	0.834	34.871	52.293	21%
5922	0.299	1.283	1.937	1.104	3.818	0	0.553	2.413	2.307	6.934	7.615	0.836	34.909	56.393	15%
5923	0.297	0.802	0.656	0.473	3.818	0	0.553	2.413	2.307	6.934	7.614	0.835	34.885	53.973	18%
5924	0.299	2.02	1.936	1.207	3.819	0	0.553	2.413	2.307	6.934	7.615	0.836	34.906	57.23	13%
5925	0.297	4.147	0.092	0.887	3.82	0	0.554	2.413	2.307	6.934	7.614	0.836	34.89	57.177	13%
5926	0.299	2.02	1.936	1.207	3.819	0.001	0.553	2.413	2.307	6.934	7.615	0.836	34.906	57.231	13%

Table B-3

Summary of Cost-Effective Solutions across Range of Investment Levels - Typical Year

						Diamond Ave. Facilities			7th Ave. Facilities		CSO 013 Facilities			
Scenario ID	Life-cycle Cost	Percent CSO Reduction	Cost Per Gallon	West Plant Improvement	7th Avenue Lift Station Improvement	Vertical Storage[a]	Shallow Storage	HRT	Storage	HRT	Storage	HRT	Separation	Other
6013	$33,324,580	34	$0.03	45 mgd	10 mgd									
5995	$37,409,812	29	$0.04						3 MG	5 mgd				
5929	$48,239,125	34	$0.05			5 MG		10 mgd						
5931	$78,837,400	41	$0.07			10 MG		20 mgd						
6005	$159,168,606	49	$0.11	80 mgd	40 mgd									
5937	$135,421,928	65	$0.07			10 MG	12 MG	20 mgd	2 MG[b]	5 mgd				
6020	$190,577,209	75	$0.09	45 mgd	10 mgd	15 MG		10 mgd	4 MG		3 MG	5 mgd	Diamond	5-ft Sewer CSO 016 to Delaware HRT
5943	$285,146,156	81	$0.12			20 MG	9 MG	10 mgd	2 MG	5 mgd		5 mgd	All projects	7 MG at CSO 012 w/ 5 MG HRT, 4-ft consolidation sewer CSO 014 to CSO 012 and CSO 016 to 013

[a]All storage options at Diamond Ave. include real time control to force flow to storage until a depth of 35 ft is reached at Node349, indicating interceptor levels indicate capacity is available to convey flow to treatment.

[b]Includes conveyance from Ohio St to the proposed 7th Ave. Storage facilities

Comparison of Alternative to Optimization Runs - Typical Year

						Diamond Ave. Facilities			7th Ave. Facilities		CSO 013 Facilities			
Scenario ID				West Plant Improvement	7th Avenue Lift Station Improvement	Vertical Storage	Shallow Storage	HRT	Storage	HRT	Storage	HRT	Separation	Other
1005				80 MGD		21 MG		20 MGD	14 MG	10 MGD	6 MG	5 MGD	Diamond	
1007				80 MGD		21 MG		20 MGD	26 MG	20 MGD	6 MG	5 MGD	Diamond	
1008				80 MGD		21 MG		20 MGD	26 MG	30 MGD	6 MG	5 MGD	Diamond	
1009				80 MGD		21 MG		20 MGD	26 MG	30 MGD	6 MG	5 MGD	Diamond	
1012				80 MGD		13 MG		20 MGD	13 MG	30 MGD	13 MG	10 MGD	Diamond	
1020				45 MGD	45 MGD		5 MG	10 MGD	26 MG	30 MGD	5 MG		Diamond	7th Avenue has an addtiona 90 MGD wet weter pumping capacity
1021				45 MGD	35 MGD		5 MG	10 MGD					Diamond	7th Avenue has an addtiona 90 MGD wet
1023				45 MGD	45 MGD		2 MG	10 MGD	5 MG	45 MGD			Diamond	7th Avenue has an addtiona 90 MGD wet weter pumping capacity
1030				45 MGD	45 MGD	10 MG		10 MGD	5 MG	45 MGD	5 MG	10 MGD	Diamond	7th Avenue has an addtiona 90 MGD wet weter pumping capacity
1043				45 MGD	45 MGD	15 MG		10 MGD	5 MG	45 MGD	5 MG	10 MGD	Diamond	7th Avenue has an addtiona 90 MGD wet weter pumping capacity

APPENDIX C

Site Specific CSO Control Evaluation

CSO Alternative Ground Truth Checklist

Date Completed: May 30, 2013
CSO # and Name: CSO 008 - Chestnut
Created by: Andy Sucharitakul

Storage Facilities - n/a

- □ Verify the Volume of storage and type of storage selected - n/a
- □ Quantify the footprint required for the selected storage - n/a
- □ Select a specific site for storage
  - Ĭ Yes ☐ No Does the site have space available for the selected storage - n/a
  - Who currently owns property?
    - ☐ City ☐ Levee Authority ☐ Utility √ Other
  - List any concerns

High Rate Treatment – n/a

- ☐ Verify the type of treatment selected – n/a
- ☐ Quantify the footprint required for the selected treatment – n/a
- ☐ Select a specific site for treatment – n/a
  - ☐ Yes ☐ No Does the site have space available for the selected treatment – n/a
  - Who currently owns property?
    - ☐ City ☐ Levee Authority ☐ Utility ☐ Other _____
  - List any concerns

Conveyance

- √ Were conveyance and connections to existing facilities considered
  - List any concerns
    - No issues identified.

Items that need further evaluation prior to design

1. Flow will be conveyed to Oak/Riverside storage location. Conflicts will need to be verified.

CSO Alternative Ground Truth Checklist

Date Completed: May 30, 2013
CSO # and Name: CSO 010 – Dress Plaza
Created by: Andy Sucharitakul

Storage Facilities

- √ Verify the Volume of storage and type of storage selected (1.68 MG Buried Tank)
- √ Quantify the footprint required for the selected storage (25,000 ft^2)
- √ Select a specific site for storage
  - √Yes ☐ No Does the site have space available for the selected storage(69,000 ft^2 avail)
  - Who currently owns property?
  - √ City ☐ Levee Authority ☐ Utility ☐ Other
  - Bicentennial Park located on the southeast corner of 2nd and Vine
  - List any concerns
  - No concerns at this stage. Modelers verified location

High Rate Treatment – n/a

- ☐ Verify the type of treatment selected – n/a
- ☐ Quantify the footprint required for the selected treatment – n/a
- ☐ Select a specific site for treatment – n/a
  - ☐ Yes ☐ No Does the site have space available for the selected treatment – n/a
  - Who currently owns property?
  - ☐ City ☐ Levee Authority ☐ Utility ☐ Other _____
  - List any concerns
  - _____

Conveyance

- √ Were conveyance and connections to existing facilities considered
  - List any concerns
  - Storage locations were verified with modelers. Conveyance is short and no issues identified.

Items that need further evaluation prior to design

1. EWSU will need to verify with the Parks department that a storage tank will work with the plans for the future park.

CSO Alternative Ground Truth Checklist

Date Completed: May 30, 2013
CSO # and Name: CSO 038 – Oak and Riverside
Created by: Andy Sucharitakul

Storage Facilities

- √ Verify the Volume of storage and type of storage selected (3.65 MG Buried Tank)
- √ Quantify the footprint required for the selected storage (50,000 ft^2)
- √ Select a specific site for storage
  - √ Yes ☐ No Does the site have space available for the selected storage(89,000 ft^2 avail)
  - Who currently owns property?
  - ☐ City ☐ Levee Authority ☐ Utility √ Other
  - Two sites were identified. One located at 408 SE Third St is owned by Select Medical Property Ventures LLC and the other lot adjacent to the south located at 500 SE Third St is owned by Walker Building Development LLC. Both sites are open parking lots with approximately 89,000 ft^2 available space.
  - List any concerns
  - No concerns at this stage. Modelers verified location

High Rate Treatment – n/a

- ☐ Verify the type of treatment selected – n/a
- ☐ Quantify the footprint required for the selected treatment – n/a
- ☐ Select a specific site for treatment – n/a
  - ☐ Yes ☐ No Does the site have space available for the selected treatment – n/a
  - Who currently owns property?
  - ☐ City ☐ Levee Authority ☐ Utility ☐ Other _____
  - List any concerns
  - _____

Conveyance

- √ Were conveyance and connections to existing facilities considered
  - List any concerns
  - Storage locations were verified with modelers. Conveyance is short and no issues identified.

Items that need further evaluation prior to design

1. EWSU will need to verify if either property is available for purchase at a reasonable price.



DOWNTOWN CSO

CSO CONTROL FACILITY
CONCEPTUAL PLAN

CH2MHILL.

CSO Alternative Ground Truth Checklist

Date Completed: May 30, 2013
CSO # and Name: CSO 011 – Oakhill
Created by: Andy Sucharitakul

Storage Facilities

- √ Verify the Volume of storage and type of storage selected (0.77 MG Buried Tank)
- √ Quantify the footprint required for the selected storage (11,000 ft^2)
- √ Select a specific site for storage
  - ✓Yes ☐ No Does the site have space available for the selected storage(63,000 ft^2 avail)
  - Who currently owns property?
  - ☐ City ☐ Levee Authority ☐ Utility √ Other
  - The location is multiple parcels that are owned by two different private owners. Team Automotive LLC and Bruce Shepherd own separate parcels identified for storage locations.
  - List any concerns
  - No concerns at this stage. Modelers verified location

High Rate Treatment – n/a

- ☐ Verify the type of treatment selected – n/a
- ☐ Quantify the footprint required for the selected treatment – n/a
- ☐ Select a specific site for treatment – n/a
  - ☐ Yes ☐ No Does the site have space available for the selected treatment – n/a
  - Who currently owns property?
  - ☐ City ☐ Levee Authority ☐ Utility ☐ Other _____
  - List any concerns
  - _____

Conveyance

- √ Were conveyance and connections to existing facilities considered
  - List any concerns
  - Storage locations were verified with modelers. Conveyance is short and no issues identified.

Items that need further evaluation prior to design

1. EWSU will need to verify if the owners will consider selling.



WEINBACH LIFT STATION / OAKHILL

CSO CONTROL FACILITY
CONCEPTUAL PLAN

CH2MHILL.

CSO Alternative Ground Truth Checklist

Date Completed: May 30, 2013
CSO # and Name: CSO 013 – Delaware
Created by: Andy Sucharitakul

Storage Facilities

- √ Verify the Volume of storage and type of storage selected
  (0.9 MG Vertical Tank + Pump Station)
- √ Quantify the footprint required for the selected storage
  (Assuming the Diameter is 100 ft storage and and some space for the pump station 25,000 ft^2)
- √ Select a specific site for storage
  - √ Yes ☐ No Does the site have space available for the selected storage
    (300,000 ft^2 available for storage and treatment)
  - Who currently owns property?
    √ City ☐ Levee Authority ☐ Utility ☐ Other
    City of Evansville, Lamasco Park
  - List any concerns
    The property north of Columbia St. is also an option but the figures developed show the Lamasco park site. Either location has plenty of space.

High Rate Treatment n/a

- ☐ Verify the type of treatment selected n/a
- ☐ Quantify the footprint required for the selected treatment n/a
- ☐ Select a specific site for treatment
  - ☐ Yes ☐ No Does the site have space available for the selected treatment
  - Who currently owns property?
    ☐ City ☐ Levee Authority ☐ Utility ☐ Other _____
  - List any concerns

Conveyance

- √ Were conveyance and connections to existing facilities considered
  List any concerns
  No issues identified

Items that need further evaluation prior to design

1. EWSU will need to verify which site is preferred and either purchase from Cytex or verify that the City Parks department is not opposed to putting storage and treatment under the park.



DELAWARE

CSO CONTROL FACILITY
CONCEPTUAL PLAN

CH2MHILL.

CSO Alternative Ground Truth Checklist

Date Completed: May 30, 2013
CSO # and Name: CSO 012 – Maryland
Created by: Andy Sucharitakul

Storage Facilities n/a

- ☐ Verify the Volume of storage and type of storage selected n/a
- ☐ Quantify the footprint required for the selected storage n/a
- ☐ Select a specific site for storage
  - ☐ Yes ☐ No Does the site have space available for the selected storage
  - Who currently owns property?
  - ☐ City ☐ Levee Authority ☐ Utility ☐ Other
  - List any concerns

High Rate Treatment n/a

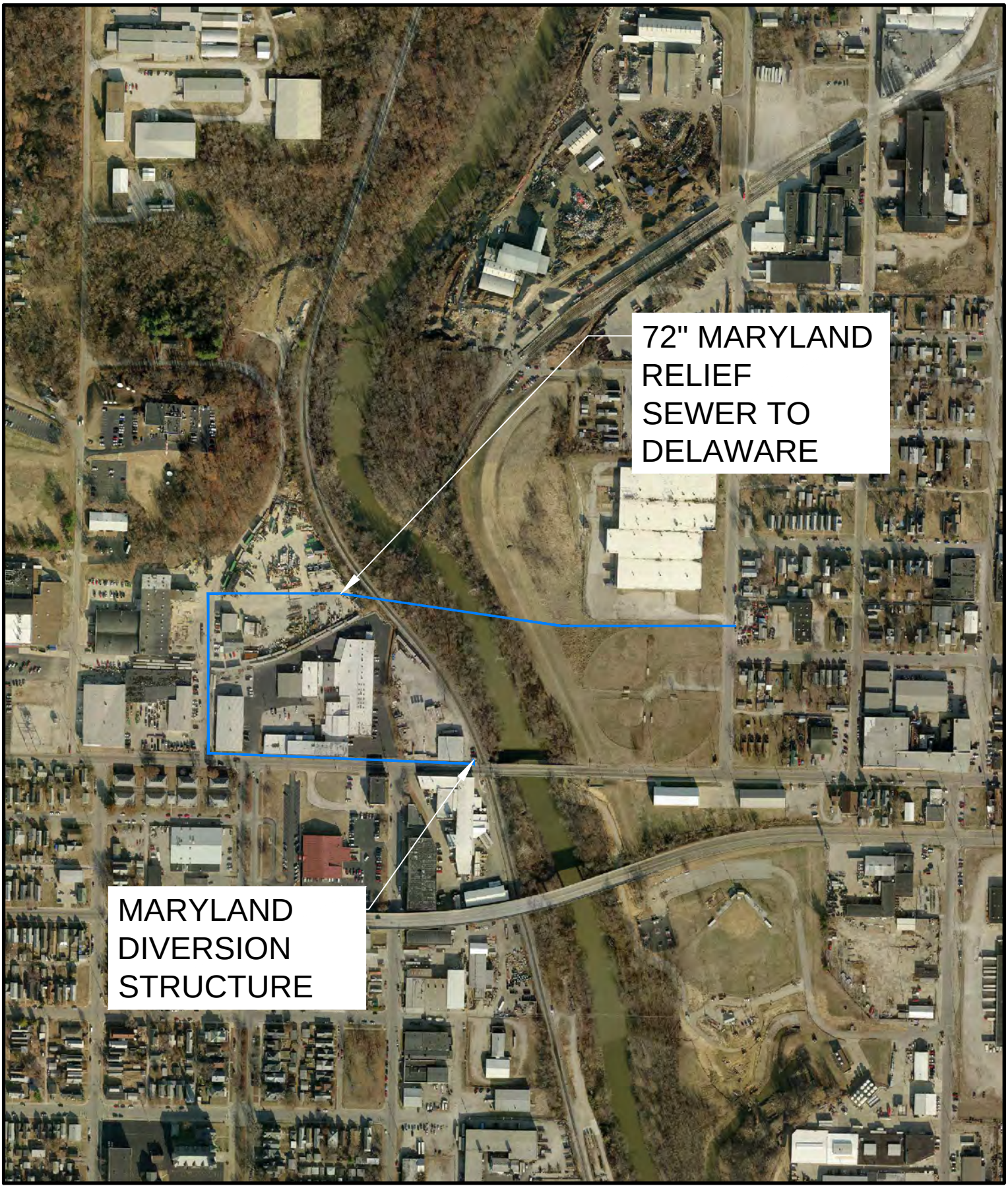
- ☐ Verify the type of treatment selected n/a
- ☐ Quantify the footprint required for the selected treatment n/a
- ☐ Select a specific site for treatment
  - ☐ Yes ☐ No Does the site have space available for the selected treatment
  - Who currently owns property?
  - ☐ City ☐ Levee Authority ☐ Utility ☐ Other _____
  - List any concerns

Conveyance

- √ Were conveyance and connections to existing facilities considered
  - List any concerns
  - Conveyance is deep and will have to cross levee system and pigeon creek. Coordination with USACE and Levee Authority will be required.

Items that need further evaluation prior to design

1. Easements will need to be obtained and verify conflicts. Coordinate with USACE.



MARYLAND

CSO RELIEF SEWER

CONCEPTUAL PLAN

CSO Alternative Ground Truth Checklist

Date Completed: May 30, 2013
CSO # and Name: CSO 014 - Dresden
Created by: Andy Sucharitakul

Storage Facilities n/a

- ☐ Verify the Volume of storage and type of storage selected n/a
- ☐ Quantify the footprint required for the selected storage n/a
- ☐ Select a specific site for storage
  - ☐ Yes ☐ No Does the site have space available for the selected storage
  - Who currently owns property?
  - ☐ City ☐ Levee Authority ☐ Utility √ Other
  - List any concerns

High Rate Treatment – n/a

- ☐ Verify the type of treatment selected – n/a
- ☐ Quantify the footprint required for the selected treatment – n/a
- ☐ Select a specific site for treatment – n/a
  - ☐ Yes ☐ No Does the site have space available for the selected treatment – n/a
  - Who currently owns property?
  - ☐ City ☐ Levee Authority ☐ Utility ☐ Other _____
  - List any concerns
  - _____

Conveyance

- √ Were conveyance and connections to existing facilities considered
  - List any concerns
  - No issues identified.

Items that need further evaluation prior to design

1. Check for conflicts.



DRESDEN

CSO RELIEF SEWER
CONCEPTUAL PLAN

CSO Alternative Ground Truth Checklist

Date Completed: May 30, 2013
CSO # and Name: CSO 016 - Franklin
Created by: Andy Sucharitakul

Storage Facilities – n/a

- ☐ Verify the Volume of storage and type of storage selected – n/a
- ☐ Quantify the footprint required for the selected storage – n/a
- ☐ Select a specific site for storage – n/a
  - ☐ Yes ☐ No Does the site have space available for the selected storage
  - Who currently owns property?
  - ☐ City ☐ Levee Authority ☐ Utility √ Other
  - List any concerns

High Rate Treatment – n/a

- ☐ Verify the type of treatment selected – n/a
- ☐ Quantify the footprint required for the selected treatment – n/a
- ☐ Select a specific site for treatment – n/a
  - ☐ Yes ☐ No Does the site have space available for the selected treatment – n/a
  - Who currently owns property?
  - ☐ City ☐ Levee Authority ☐ Utility ☐ Other _____
  - List any concerns
  - _____

Conveyance

- √ Were conveyance and connections to existing facilities considered
  - List any concerns
  - No issues identified.

Items that need further evaluation prior to design

1. Conveyance from Franklin CSO doesn't appear to be an issue. Conflicts will have to be addressed later in design.



FRANKLIN

CSO RELIEF SEWER
CONCEPTUAL PLAN

CSO Alternative Ground Truth Checklist

Date Completed: May 30, 2013
CSO # and Name: CSO 017 -6th Ave
Created by: Andy Sucharitakul

Storage Facilities – n/a

- ☐ Verify the Volume of storage and type of storage selected – n/a
- ☐ Quantify the footprint required for the selected storage – n/a
- ☐ Select a specific site for storage – n/a
  - ☐ Yes ☐ No Does the site have space available for the selected storage
  - Who currently owns property?
  - ☐ City ☐ Levee Authority ☐ Utility √ Other
  - List any concerns

High Rate Treatment – n/a

- ☐ Verify the type of treatment selected – n/a
- ☐ Quantify the footprint required for the selected treatment – n/a
- ☐ Select a specific site for treatment – n/a
  - ☐ Yes ☐ No Does the site have space available for the selected treatment – n/a
  - Who currently owns property?
  - ☐ City ☐ Levee Authority ☐ Utility ☐ Other _____
  - List any concerns
  - _____

Conveyance

- √ Were conveyance and connections to existing facilities considered
  - List any concerns
  - No issues identified.

Items that need further evaluation prior to design

1. Conveyance from 6th Ave CSO doesn't appear to be an issue. Conflicts will have to be addressed later in design.



6TH AVENUE

RELIEF SEWER
CONCEPTUAL PLAN

CSO Alternative Ground Truth Checklist

Date Completed: May 30, 2013
CSO # and Name: CSO 018 - Oakley
Created by: Andy Sucharitakul

Storage Facilities

- √ Verify the Volume of storage and type of storage selected (0.6 MG Buried Tank)
- √ Quantify the footprint required for the selected storage (10,000 ft^2)
- √ Select a specific site for storage
  - √ Yes ☐ No Does the site have space available for the selected storage (36,400 ft^2)
  - Who currently owns property?
  - ☐ City ☐ Levee Authority ☐ Utility √ Other NFA LLC
  - List any concerns

High Rate Treatment – n/a

- ☐ Verify the type of treatment selected – n/a
- ☐ Quantify the footprint required for the selected treatment – n/a
- ☐ Select a specific site for treatment – n/a
  - ☐ Yes ☐ No Does the site have space available for the selected treatment – n/a
  - Who currently owns property?
  - ☐ City ☐ Levee Authority ☐ Utility ☐ Other _____
  - List any concerns
  - _____

Conveyance

- √ Were conveyance and connections to existing facilities considered
  - List any concerns
  - No issues identified.

Items that need further evaluation prior to design

1. EWSU will need to verify if the property is available for purchase.



OAKLEY

CSO CONTROL FACILITY
CONCEPTUAL PLAN

CSO Alternative Ground Truth Checklist

Date Completed: May 30, 2013
CSO # and Name: CSO 020 – 9th Ave
Created by: Andy Sucharitakul

Storage Facilities – n/a

- ☐ Verify the Volume of storage and type of storage selected – n/a
- ☐ Quantify the footprint required for the selected storage – n/a
- ☐ Select a specific site for storage – n/a
  - ☐ Yes ☐ No Does the site have space available for the selected storage
  - Who currently owns property?
  - ☐ City ☐ Levee Authority ☐ Utility √ Other
  - List any concerns

High Rate Treatment – n/a

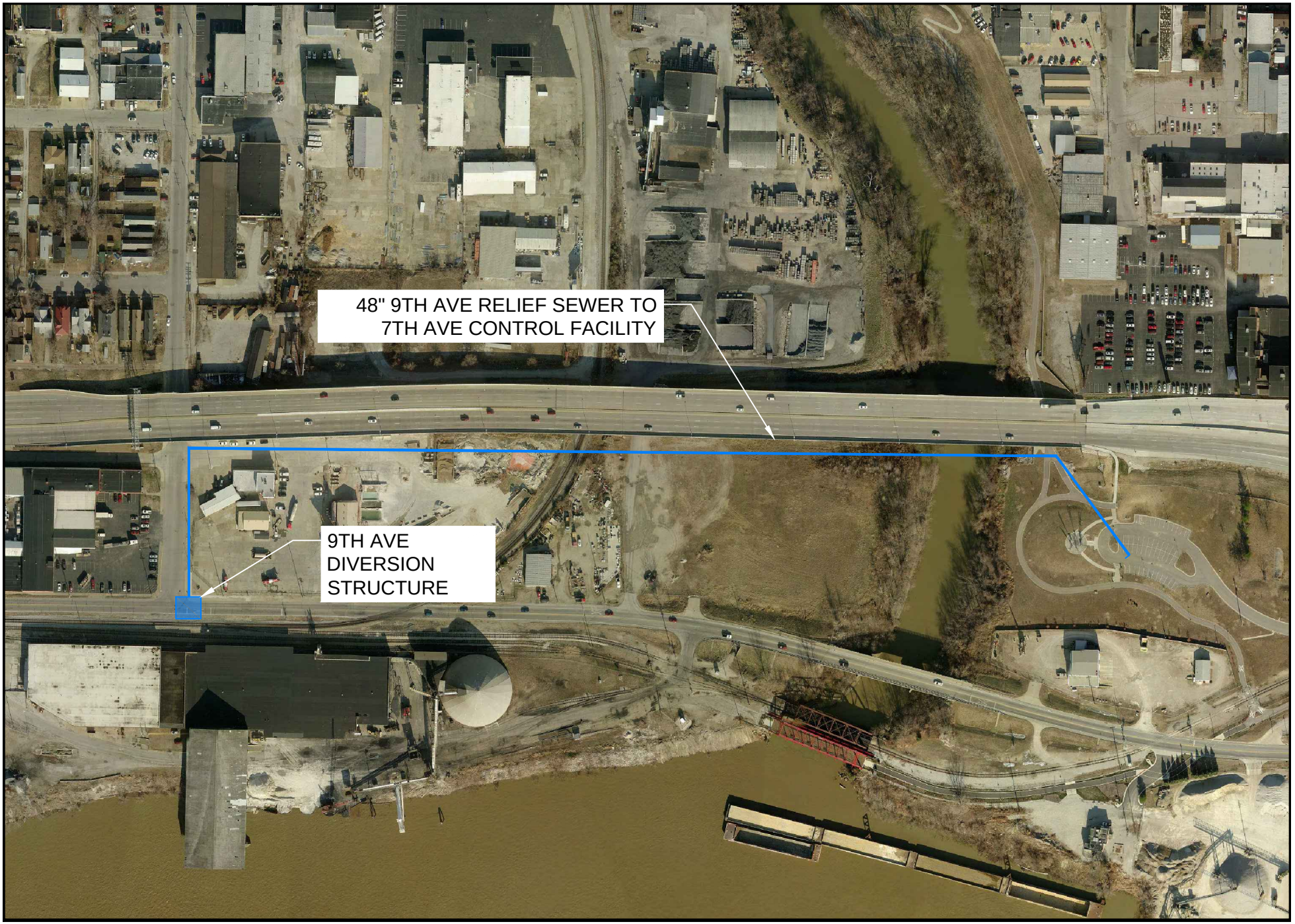
- ☐ Verify the type of treatment selected – n/a
- ☐ Quantify the footprint required for the selected treatment – n/a
- ☐ Select a specific site for treatment – n/a
  - ☐ Yes ☐ No Does the site have space available for the selected treatment – n/a
  - Who currently owns property?
  - ☐ City ☐ Levee Authority ☐ Utility ☐ Other _____
  - List any concerns
  - _____

Conveyance

- √ Were conveyance and connections to existing facilities considered
  - List any concerns
  - No issues identified.

Items that need further evaluation prior to design

1. Conveyance from 9th Ave CSO doesn't appear to be an issue. Conflicts will have to be addressed later in design.



9TH AVE CSO RELIEF SEWER
CONCEPTUAL PLAN

CSO Alternative Ground Truth Checklist

Date Completed: May 30, 2013
CSO # and Name: CSO 025 – Diamond
Created by: Andy Sucharitakul

Storage Facilities

- √ Verify the Volume of storage and type of storage selected
  (2 MG Vertical Tank at Diamond)
- √ Quantify the footprint required for the selected storage
  (Assuming the Diameter is 100 ft then 10,000 ft is needed)
- √ Select a specific site for storage
  - √ Yes ☐ No Does the site have space available for the selected storage
    (200,000 ft^2 available for storage)
    Who currently owns property?
    √ City √ Levee Authority ☐ Utility ☐ Other
    Evansville Vanderburgh Levee Authority District
    List any concerns
    This site is used for ponding area for the Levee Pumping station. Coordination with the USACE and the local Levee Authority will be required.

High Rate Treatment – n/a

- ☐ Verify the type of treatment selected – n/a
- ☐ Quantify the footprint required for the selected treatment – n/a
- ☐ Select a specific site for treatment
  - ☐ Yes ☐ No Does the site have space available for the selected treatment
    Who currently owns property?
    ☐ City ☐ Levee Authority ☐ Utility ☐ Other _____
    List any concerns

Conveyance

- √ Were conveyance and connections to existing facilities considered
  List any concerns
  Coordination with USACE and Levee Authority will be required.

Items that need further evaluation prior to design

1. Coordination with the USACE and local Levee Authority will be required.



DIAMOND AVENUE

CSO CONTROL FACILITY
CONCEPTUAL PLAN

CSO Alternative Ground Truth Checklist

Date Completed: May 30, 2013
CSO # and Name: CSO 024 - Baker
Created by: Andy Sucharitakul

Storage Facilities – n/a

- ☐ Verify the Volume of storage and type of storage selected – n/a
- ☐ Quantify the footprint required for the selected storage – n/a
- ☐ Select a specific site for storage – n/a
  - ☐ Yes ☐ No Does the site have space available for the selected storage
  - Who currently owns property?
  - ☐ City ☐ Levee Authority ☐ Utility √ Other
  - List any concerns

High Rate Treatment – n/a

- ☐ Verify the type of treatment selected – n/a
- ☐ Quantify the footprint required for the selected treatment – n/a
- ☐ Select a specific site for treatment – n/a
  - ☐ Yes ☐ No Does the site have space available for the selected treatment – n/a
  - Who currently owns property?
  - ☐ City ☐ Levee Authority ☐ Utility ☐ Other _____
  - List any concerns

Pump Station

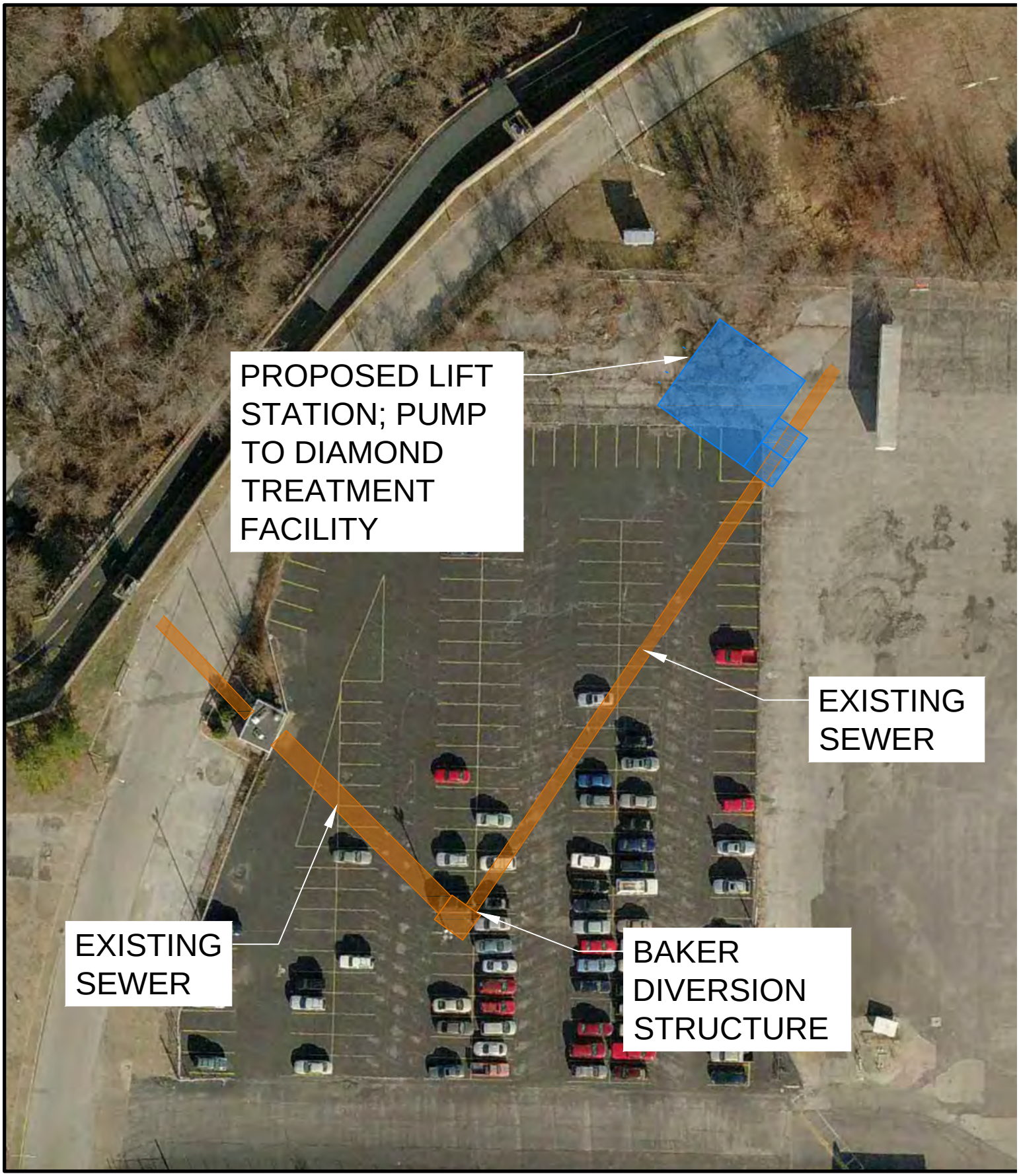
- √ Verify the type of pump station selected - Submersible
- √ Quantify the footprint required for the selected pump station – 1600 ft^2
- √ Select a specific site for pump station – Large parking lot plenty of space available
  - √ Yes ☐ No Does the site have space available for the selected treatment
  - Who currently owns property?
  - ☐ City ☐ Levee Authority ☐ Utility √ Other AQ Real Estate LLC
  - List any concerns

Conveyance

- √ Were conveyance and connections to existing facilities considered
  - List any concerns
  - No issues identified.

Items that need further evaluation prior to design

1. Conveyance from doesn't appear to be an issue. Utility will need to verify property is available for purchase.



BAKER

CSO CONTROL FACILITY
CONCEPTUAL PLAN

APPENDIX D

Green Infrastructure Planning and Recommendations

renew EVANSVILLE

Investing in clean water resources

Appendix D
Green Infrastructure Planning and Recommendations

Submitted

May 29, 2013



Prepared for

EVANSVILLE WATER & SEWER UTILITY

City-County Administration Building
1 Martin Luther King Blvd
Evansville, IN 47708

Prepared by

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SUBMITTAL AUTHORIZATION

Approved By:  May 29, 2013

Date

I certify under penalty of law that I have examined and am familiar with the information submitted in this document and all attachments and that this document and its attachments were prepared under my direction or supervision in a manner designed to ensure that qualified and knowledgeable personnel properly gather and present the information contained therein. I further certify, based on my inquiry of those individuals immediately responsible for obtaining the information, that I believe that the information is true, accurate, and complete. I am aware that there are significant penalties for submitting false information, including the possibility of fines and imprisonment.

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Acronyms and Abbreviations

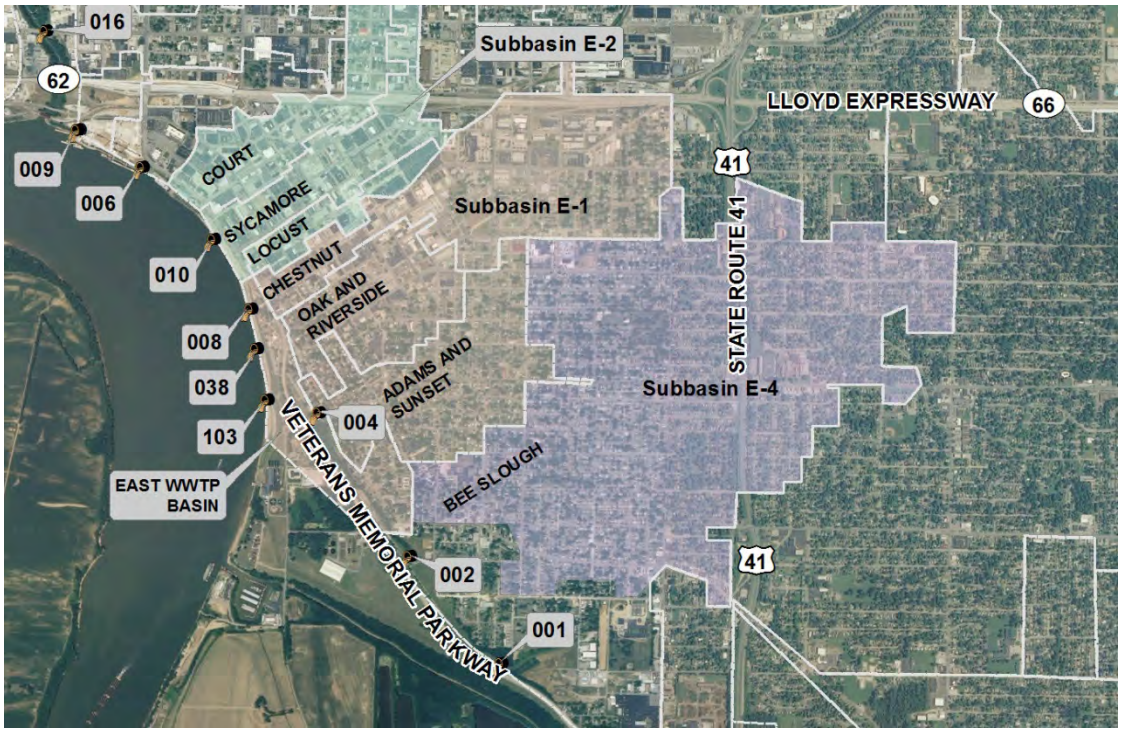
3P	Public-Private Partnership
APC	Evansville-Vanderburgh County Area Plan Commission
BMP	Best Management Practices
CSS	Combined Sewer System
EWSU	Evansville Water and Sewer Utility
GI	Green Infrastructure
GIS	Geographic Information System
IDNR	Indiana Department of Natural Resources
IOCP	Integrated Overflow Control Plan
LID	Low-impact Development
LiDAR	Light Detection and Ranging
MS4	Municipal Separate Storm Sewer System
NPDES	National Pollutant Discharge Elimination System
RIPR	Relative Infiltration Potential Rating
SSURGO	Soil Survey Geographic (database)
SWMM	Storm Water Management Model
TBL	Triple Bottom Line
USEPA	U.S. Environmental Protection Agency
USGS	U.S. Geological Survey
WinSLAMM	Source Loading and Management Model for Windows
WWTP	Wastewater Treatment Plant

SECTION 1

Introduction

The designated planning area for Green Sustainable Infrastructure within the City of Evansville includes CSO areas identified as sub-basins E-1, E-2 and E-4. Figure 1 depicts these areas within the City, as well as the corresponding combined sewer system (CSS) model sub-catchments and the associated CSO outfalls to the Ohio River. The entire green infrastructure (GI) planning area is tributary to the East wastewater treatment plant (WWTP) operated by EWSU. There was a separate inflow redirection (sewer separation) opportunity with the inclusion of GI features that was investigated in the western CSS basin; however, the benefits and costs associated with those improvements were outweighed by other gray improvements that are necessary to achieve the goal for CSO abatement in that portion of the CSS. For that reason, there is no presentation of the western GI investigation and results in this document.

FIGURE 1: Designated Green Infrastructure Planning Area



The study of GI within the described planning area includes conceptually identifying both opportunities and constraints for infiltration-based stormwater practices and inflow re-direction. The infiltration-based practices are intended to manage stormwater runoff at the source, prior to being intercepted by the CSS. Inflow re-direction consists of a separate storm sewer system devised to intercept stormwater runoff currently discharging to the CSS and directing that runoff to an existing or proposed stormwater outfall. The study also includes an analysis of the existing surface and subsurface conditions of the affected CSO sub-catchments and identification of relative soils infiltration rates. This study does not consider the implementation of low impact development (LID) techniques in areas of the CSS outside of sub-

basins E-1, E-2 and E-4 as other gray infrastructure improvements have been identified to meet the requirements for mitigating the occurrence of CSO.

EWSU has already begun implementing a plan for large-scale inflow re-direction projects in the form of storm sewer improvements to eliminate significant areas from the CSS within sub-basin E-4. In addition to considering the possibility of GI projects to mitigate CSO's in the areas described above, specific gray improvements have already been identified to ensure the overall goals of the City's IOCP met. These improvements include changes to the underflow pipe that conveys flows from the identified sub-basins to the WWTP and storage tanks to temporarily hold excess flow in strategic areas of downtown Evansville. In addition, the IOCP identifies a wetland project along Bee Slough to capture and treat CSO's from the upstream area.

The overall goal of effort is to determine sustainable methods for diminishing the inflow of stormwater runoff to the CSS, and reduce the extent and cost of infrastructure improvements to otherwise store, transport and treat that flow, while also considering the socio-economic impacts to the community related to revitalizing urban and residential areas of the City through the application of integrated GI features.

1.1 Background

With the relatively recent understanding, acceptance, and utilization of progressive stormwater management techniques, the United States Environmental Protection Agency (USEPA) has defined LID as "…an approach to land development (or re-development) that works with nature to manage stormwater as close to its source as possible. LID employs principles such as preserving and re-creating natural landscape features, minimizing effective imperviousness to create functional and appealing site drainage that treats stormwater as a resource rather than a waste product. There are many practices that have been used to adhere to these principles such as bio-retention facilities, rain gardens, vegetated rooftops, rain barrels, and permeable pavement ("Low Impact Development (LID)".

LID has been characterized as a sustainable stormwater practice by the Water Environment Research Foundation (WERF), American Society of Civil Engineers (ASCE) and others within the stormwater management industry. More importantly is the realization sustainable stormwater best management practices can be applied to reduce the potential for combined sewer overflows (CSO). In recognition of a stormwater-based initiative for CSO reduction, WERF published guidance on the use of 'decentralized' stormwater practices to reduce CSOs. The USEPA has provided similar guidance and has promoted the use of LID techniques to reduce the direct impact of stormwater runoff on a combined sewer system. Most recently, the USEPA has published guidelines on the development of an Integrated Planning approach to holistically address water quality related to both point and non-point sources, whereby sustainable stormwater practices can be applied to both separate and combined sewer systems to address current and likely future regulatory requirements related to the various National Pollutant Discharge Elimination System (NPDES) programs.

Spear-headed by EWSU, the City of Evansville has pursued a GI initiative through both internal and external initiatives by forming a Green Opportunities Group comprised of Deputy Directors of the various municipal departments to discuss their individual Capital Improvement Programs and opportunities for GI inclusion. Through this collaboration, the City has implemented street, sidewalk and parking lot improvement projects with GI features intended to reduce the impact of stormwater runoff on the CSS. In addition, there is a Smart Growth Committee comprised of

representatives of the City and other public/private stakeholders who regularly meet to discuss sustainability initiatives and how they can be applied to various activities occurring throughout the community. This committee has been designated as a potential clearinghouse for the future consideration of changes to City codes, policies and guidelines to facilitate the application of GI projects in both public infrastructure and private development projects.

The City is a Municipal Separate Storm Sewer System (MS4) community operating under the NPDES program. Within this program, the City has begun initiating various regulatory and non-regulatory initiatives to promote water quality. The Evansville-Vanderburgh County Area Plan Commission (APC) is in the process of updating the Comprehensive Plan for the City and surrounding areas. The draft updated plan includes recommendations for the consideration of sustainability as a component of future municipal programs, with a reference to the use of GI as a component of public infrastructure improvement projects and, more specifically, the use of GI as a measure to address CSOs.

All of this information provides a solid foundation for the consideration of GI to meet the goals of the City's IOCP as well as providing other tangible benefits to the community.

1.2 Project Goals and Objectives

The primary goals of developing a GI program within the City of Evansville are listed below. These goals reflect the priority needs of EWSU related to the development of the IOCP, as well as considering current planning and design guidelines for the integration of GI into municipal programs and capital projects.

1. Focus on ultra-urban areas of the City where gray solutions are complicated by existing infrastructure, as well as nearby high density residential areas.
2. Develop GI schemes that fit into the lay-out of other desired infrastructure improvements, such as:
    - Green complete streets
    - Parking lot rehabilitation
    - Rainwater harvesting
    - City park improvements
    - Downtown re-development projects
3. Promote collaboration between City Departments to include GI within future capital projects to reduce the cost burden on EWSU in the realization of stormwater capture and CSO reduction.

The reference to downtown re-development projects as a component of the City's GI program suggests a public/private partnership (3P) that will promote the use GI through both regulatory requirements and financial incentives that can be directly implemented as an element of the IOCP. Similar to the collaboration between City departments to promote GI inclusions, the 3P approach allows EWSU to leverage their funds against those of another entity to achieve the desired outcome of reducing the impact of stormwater runoff on the CSS.

The objective of the GI program investigation is to identify and conceptually locate applicable GI features within the designated CSS sub-catchment areas for consideration within the system-wide SWMM model to determine a reduction in overall volume and frequency of occurrence at the various CSO outfalls. The SWMM model will determine the benefits of GI in tandem with other gray improvements that will also be necessary to achieve the goal for CSO abatement as established by the IOCP.

The effort to achieve the stated goals and objectives includes a sequential process of existing conditions data collection, preliminary analysis of surface and sub-surface conditions to determine physical opportunities and constraints, and the preparation of recommended GI techniques and how they can be integrated into public and private infrastructure improvements. Data critical to the GI recommendations for the study areas include: soils conditions, land use/land cover, topography, rainfall, existing infrastructure with the public right-of-way and property ownership.

The result of these efforts is a GIS-based compilation of data and mapping information with an integrated database analysis of GI opportunities and constraints to score and rank potential GI projects throughout the designated planning area. The scoring of GI project opportunities considers overlapping planning initiatives within the designated CSS sub-basins that generally support public infrastructure improvements consistent with the preferred GI features, such as green complete streets. High-scoring GI project opportunities can be considered in tandem with the City's planned Capital Improvement Program to determine where GI inclusion would have the most benefit to the CSS and the community as a whole.

1.3 Existing Data

It is not the intent of this summary to provide a detailed discussion of the data collection and compilation process. Various entities within the City of Evansville and Vanderburgh County, as well as the State of Indiana, maintain GIS data relevant to the GI investigation. The necessary data includes local utility information, well logs, national soils data, regional geologic data, flood hazard data, LiDAR-based topography, land use/land cover and property ownership, among other things. This information has been synthesized into a database for purposes of mapping and analysis.

1.4 Modeling of GI

The modeling of GI opportunities has occurred in several forms. The SWMM model of the CSS has been used to analyze GI initially on an area-wide basis and then to analyze only specific projects for consideration within the IOCP. Supporting these efforts has been a separate analysis of typical GI applications using the WinSLAMM model to determine the expected hydrologic response, which provided targets for stormwater runoff capture volumes within the SWMM analysis of GI. The WinSLAMM results have been applied to the compiled database of all GI opportunities within the designated planning area to allow for an estimate of stormwater capture volumes on an area-wide and project-by-project basis.

SECTION 2

Identification of GI Opportunities

The investigation of GI opportunities occurred initially on an area-wide basis to throughout the designated planning area, including sub-basins E-1, E-2 and E-4. The evaluation considered various factors that would influence whether the application of GI features is practical in various settings, primarily focusing on the surrounding physical infrastructure to determine whether it posed an opportunity or constraint to the use of GI. The nature of this investigation was to focus on the application of GI within publicly owned property, which primarily consists of roadways and parking lots, and also includes parking structures (multi-level garages) and City parks. The focus on improving public infrastructure with GI is obvious in that it provides for the opportunity to combine the City's various Capital Improvement Programs with the goals of the IOCP in the downtown areas of the City. Complementing this approach is the understanding that the City could and should adopt other program elements to both require and incentivize the use of GI in private re-development areas, also within the downtown areas of the City where an alternative CSO mitigation approach is being sought.

2.1 Evaluation of Infiltration Potential

The ability for infiltration is a fundamental component of GI performance relative to reducing the impact of stormwater runoff on the CSS. Simply capturing runoff with GI will not be sufficient if the runoff is then routed directly to the CSS. Any GI feature can be designed to have an inherent water quality capability; however, the nature of the in-situ soils where GI is being placed will have the biggest impact on whether infiltration can occur and reduce the volume of stormwater runoff conveyed to the CSS. For a large-scale planning effort, it is not practical to perform an extensive field assessment of soils to determine permeability. For this reason, this investigation considered readily available published documentation and technical data related to soils throughout the designated planning area. The sources of available information are listed below.

1. The USDA-NRCS soil survey data for Vanderburgh County, describing the composition and permeability of soils extending 60-inches below the surface.
2. Geologic reports prepared by the State of Indiana Department of Natural Resources (IDNR), 1977, and the U.S. Geological Survey (USGS), 2009, both for the southwestern region of the State of Indiana. These reports include maps of the region depicting and qualifying the nature of the deeper geology within and surrounding the City of Evansville.
3. Well logs obtained from IDNR describing both the nature of the soils encountered at various depths below ground and the depth at which groundwater was encountered.

As part of the identification of GI opportunities, the acquired soils information and well log data were compiled into the GIS mapping and database prepared for this investigation. Using the compiled information, an analysis of infiltration potential was completed for the designated planning area. The purpose of the analysis is to examine potential infiltration of soil layers to assist in identifying optimum locations to install GI features. Infiltration of stormwater into the ground is a natural process that has the potential for supplying groundwater aquifers, base flow to streams, and reducing the volume of runoff to the CSS. The urban landscape interrupts the

natural hydrologic process and reduces the amount of infiltration while increasing surface runoff directly to receiving sewers and streams. Infiltration potential and engineered infiltration practices are being evaluated to encourage the integration of such practices into future infrastructure improvements within the designated planning area.

The evaluation of infiltration potential is not meant to quantify the actual permeability rate at any specific site. Further site specific investigations are required to determine the permeability of existing soils and underlying geology, as well to identify potential risk factors associated with recharging the shallow or deeper groundwater systems.

2.1.1 Relative Infiltration Potential Rating (RIPR) Analysis

The Relative Infiltration Potential Rating (RIPR) system is a GIS-based method that uses readily-available soils information to create a general overview of infiltration potential based on both spatial and horizontal variations in soil characteristics, providing a tool that lends itself to mathematical analysis and visual mapping of infiltration potential on an area- wide scale. Infiltration potential within this investigation considers the relative beneficial impact of implementing engineered infiltration practices based on soil characteristics in the first five feet (60-inches) beneath the surface. The natural (existing) conditions analysis will illustrate areas of "high" potential which are considered priority areas for infiltration-based BMPs. In the engineered conditions analysis, areas that may have scored "low" or "moderate" under the natural condition due to a limiting soil layer may score as "high" potential when an engineered infiltration practice is designed to extend beyond the limiting layer to a higher infiltration potential soil horizon.

The RIPR infiltration rating system is based on a published method originally developed for Dane County, Wisconsin, in cooperation with the Wisconsin Department of Natural Resources and the University of Wisconsin, Madison ("Infiltration Map Project"). The method uses a scoring system of four soil criteria to create a map of relative infiltration potential. The criteria are: saturated hydraulic conductivity, depth to water table, depth to bedrock, and surface slope. This rating method is also similar to, but more detailed than, the NRCS criteria for the assignment of Hydrologic Soil Groups (A, B, C, and D).

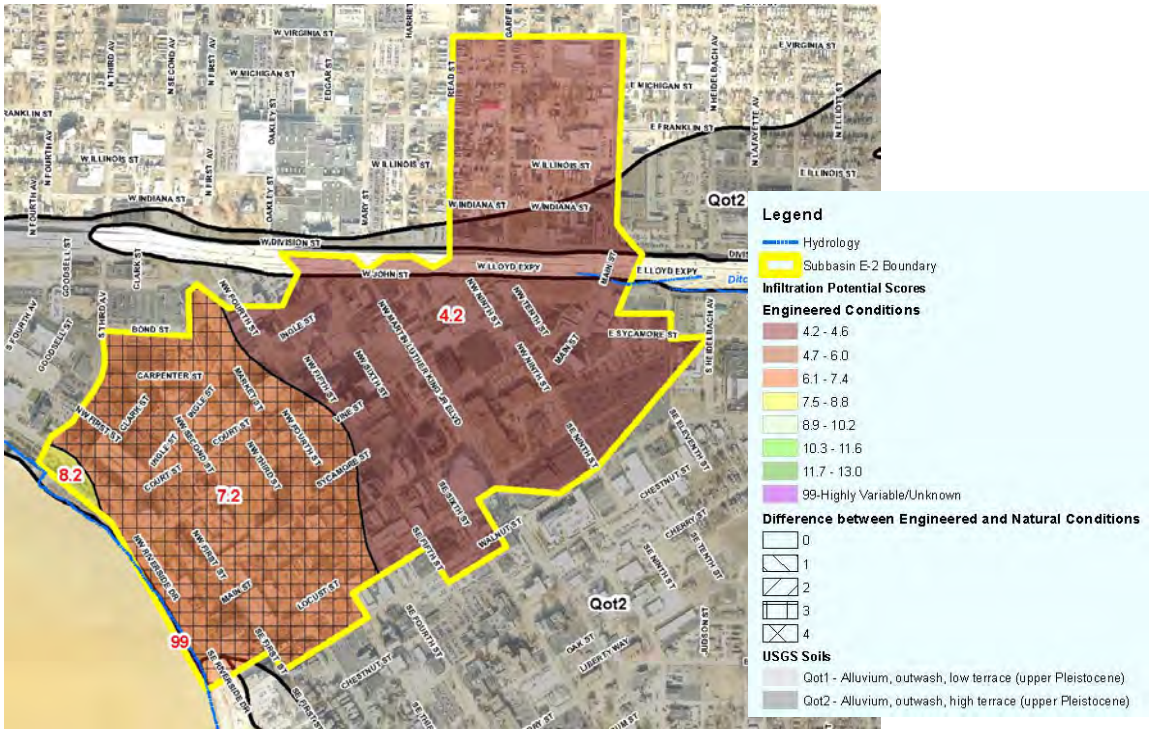
The Soil Survey Geographic (SSURGO) database is the digitized version of soil surveys published by the NRCS on a county-by-county basis. Three of the four infiltration potential criteria (saturated hydraulic conductivity, depth to water table, and depth to bedrock) come from SSURGO data. The fourth (slope) comes from available topographic data for Vanderburgh County. SSURGO data contains soil permeability values for individual layers or horizons at varying depths for each soil type, listed as saturated hydraulic conductivity.

This analysis has been applied to two different conditions: 1) existing conditions; and 2) engineered conditions as described in this chapter. The comparison of these two conditions is what is referred to as the 'relative infiltration potential'. The scoring system applied to this analysis assigns a relative value for each of the four criteria for every soil type in the identified sub-catchment. In the case of saturated hydraulic conductivity, the soil layer with the lowest value for each soil type is considered the limiting soil layer and is used in the infiltration potential scoring. The individual scores from the four criteria are totaled to give a single score that rates relative infiltration potential for each soil type. Saturated hydraulic conductivity is considered the best indicator of potential infiltration and is therefore weighted the highest (values up to 6). Depth to water and depth to bedrock are considered medium indicators and

are given values up to 2.5. Slope is considered a lesser indicator and is given values up to 2.0. The higher the resultant score, the higher the infiltration potential.

Within the designated planning areas, slopes are consistently flat and have been excluded from the analysis. In addition, depth to bedrock is fairly deep; therefore, this criterion has little effect on the scoring and is also not considered in the analysis. The RIPR analysis is executed entirely within the GIS environment, allowing for the easy creation of overlay mapping depicting the relative infiltration potential throughout the designated planning area. Figure 2 is an example of this mapping and the corresponding scoring.

FIGURE 2: Mapping of RIPR Results



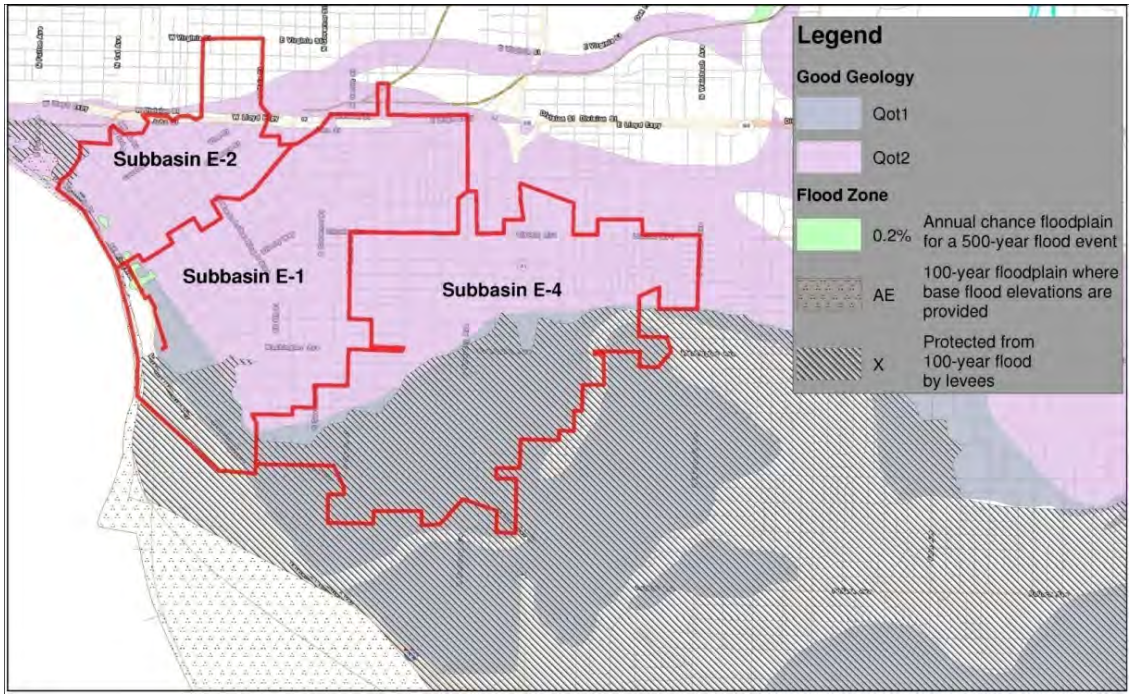
2.1.2 Geologic Data for the Planning Area

Probably one of the most profound sources of information related to the analysis of infiltration potential is the geologic data published first by IDNR and then by the USGS. The mapping provided with the USGS report identifies two areas of alluvium outwash that extend through a majority of the designated planning area, referred to as Qot1 and Qot2, both with properties associated with higher permeability soils. More specifically, Qot2 consists of fine to coarse grained sands and gravels buried beneath 10 to 15 feet of depositional material comprised of silts and clays. The thickness of the alluvium material is estimated to be as much as 170 feet.

Figure 3 depicts the areas of this alluvium material relative the designated planning area (CSS sub-basins E-1, E-2 and E-4). The IDNR well logs seem to corroborate this information in that the logs within the denoted alluvium zone consistently report sand and gravel first encountered at depths less than 20 feet below the surface, while the logs north of the planning area suggest more cohesive and less permeable soils even at depths greater than 20 feet. The published data does not suggest numerical infiltration rates for this area of what is being referred to as the

'good geology'; however, by its nature it is anticipated to be very conducive to engineered infiltration practices that extend deep enough to get through the less permeable overburden.

FIGURE 3: Geologic Overlay within the Planning Area



Given the proximity of the Ohio River to this planning area and the direct connection to the mapped sand and gravel layer, it is understood that there is both a seasonal and flood-related high groundwater table associated with the area of good geology. For that reason, the portion of the planning area that sits below the 100-year flood elevation of the river (also depicted on Figure 3) has been excluded from consideration of GI applications.

2.2 Selected GI Technologies

Several GI features are applicable to urban and residential land uses, each with their own attributes and design considerations. As part of this investigation, there was not a formal screening of various GI applications on a location-by-location basis, rather there was a focus on identifying a GI practice that would optimize the potential for intercepting stormwater runoff and reducing the volume of stormwater discharging to the CSS. Given this consideration, the chosen GI technologies would require a considerable surface area and be unobtrusive within the limits of the public infrastructure that it would be applied to, such as roadways and parking lots. Based on these considerations, this investigation focused on the application of pervious pavement within the public right-of-way, including alleyways, and bio-retention/infiltration basins within parking lots. Additionally, there was a consideration of cisterns as part of a City-wide rainwater harvesting program that could also be focused on the downtown areas of the community where there is a concentration of larger buildings and impervious surfaces.

This investigation also included a consideration of City-acquired property as part of the land bank program, and whether the application of GI on a neighborhood-by-neighborhood basis could also benefit the CSS. In the long-term, there would appear to be opportunities to take

advantage of abandoned/vacant lands for this purpose, regardless of the direct impact toward reducing CSO's; however, due to the uncertainties associated with this application, the presentation of GI within this document does not specifically include the conversion of land bank property to a GI use.

As a component of the City's GI program and a complement to the selected GI features, encouraging downspout disconnection and residential rain gardens would broaden the community's knowledge and appreciation for sustainable stormwater practices and could have a measurable effect on reducing CSO's if implemented on a large scale. While not a specific consideration within this investigation, the City has already made progress toward implementing these lot-by-lot practices, primarily through their MS4 (NPDES) compliance program.



Pervious concrete applied to parking areas only – photo provided by EMH&T

2.2.1 Pervious Pavement

Pervious pavement has been used for both partial and full width street replacement projects in communities throughout the country. Partial width replacement typically consists of applying the pervious pavement within parking lanes along the curb line, while maintaining conventional pavement in the travel lanes. In this case, the pervious pavement is still capturing stormwater runoff from all areas within the roadway right-of-way, and any underground utilities required along the corridor can be embedded within the conventional pavement portion of the roadway. This approach allows for pervious pavement to be applied even on busier downtown streets where a full width pervious application is less desirable. Depending on the pavement material used, this approach can also become an integral component of a streetscape improvement that only enhances the City of Evansville's Complete Streets Policy. For the purpose of this investigation, the assumed pavement material is permeable pavers, in part due to the enhanced appearance but also in consideration of short- and long-term operation and maintenance issues.



Permeable clay brick pavers applied to full pavement width – photo provided by EMH&T

Full width replacement consists of applying the pervious pavement uniformly from curb to curb. This approach is much less common and would typically only apply to low traffic/low speed roadways. Full width replacement with pervious pavement can be cost competitive with conventional pavement when the street repair requires full depth replacement, by reducing storm sewer infrastructure (i.e., pipes and catch basins/manholes) and providing water quality credits to reduce or eliminate the requirement for separate water quality BMPs. It is assumed for the purpose of this investigation that this application would be permeable brick pavers, and not porous asphalt or

concrete. Furthermore, clay brick pavers have certain advantages over concrete pavers due to their strength, durability, and aesthetic qualities. Clay brick pavers can have a compressive strength of 10,000 psi, making them suitable for most low-traffic pavement design standards. However, as opposed to concrete brick pavers, clay pavers currently are not able to be installed using a machine and must be hand-laid, increasing the cost of most typical applications.

The use of full width permeable pavers allows for the inclusion of an extended bed of porous subgrade material with the associated void spaces providing storage capacity for stormwater runoff captured by the GI practice. The application of full width permeable pavers is more conducive to the residential portions of the designated planning area, particularly the Evansville Historic Arts District that overlays CSS sub-basin E-1, as depicted on Figure 9. The historic nature of this expansive residential area, and the existence of brick streets (many of them covered by a thin layer of asphalt overlay), lends itself to street reconstruction using the permeable pavement application. In addition, the GI approach to street reconstruction would provide benefits related to stormwater management as many of the neighborhoods are underserved by the existing storm sewer system, with inlets spaced far apart and in poor condition.



Pervious concrete application in parking stalls – photo provided by EMH&T

Pervious pavement can also be applied to sidewalks and within parking lots, and has various applications within a re-development setting. The City of Evansville has already applied pervious concrete to several sidewalk replacement projects and there are many examples throughout the country of pervious material being applied to the parking stall portions of a parking lot. Most pervious pavement applications incorporate an underdrain system to ensure the porous sub-grade material is well drained and the pavement does not become damaged due to a saturated condition or freeze/thaw conditions. For the application of GI within the City of Evansville, an underdrain system is anticipated for these reasons; however, it is also anticipated that the underdrain system will not discharge to the CSS but will instead be directed to a dry well system embedded in the GI application to take advantage of a high permeability layer of sand and gravel underlying a majority of the designated planning area (described in Section 2.1).



A Chicago Alley (before) – photo provided by Janet Attarian

Finally, pervious pavement has been applied in alley settings, with a very good example being the City of Chicago's Green Alley program, where alleys are rebuilt with light-colored pervious pavement to solve drainage issues, decrease the heat island affect, reduce combined sewer overflows, and enhance the value of the surrounding properties (Attarian, n.p.). The analysis of GI opportunities within the City of Evansville considered the application of pervious pavement in alleyways throughout the designated planning area. There are numerous alleys within the City with very poor pavement and many without any pavement at all. With the

anticipation of future improvements to these alleys, the City could adopt a design standard that incorporates pervious pavement where it would not potentially compromise the combined or sanitary sewer systems by increasing the potential for inflow and infiltration. The pavement material typically used in green alleys is either pervious concrete or permeable interlocking concrete pavers. Pervious concrete is typically used in the center of the alley inside of the wheel tracks to avoid the potential for structural failures attributed to excess loading, such as garbage trucks using the alley for trash collection purposes. Pervious concrete can also be used as a full width application if excessive loading is not a concern. As with pervious pavement applications associated with roadway reconstruction, stormwater runoff would be intercepted and captured in the porous sub-grade material, where it can then be conveyed to the CSS or re-directed to a dry well feature discharging to the good geology that is evident throughout the majority of the designated planning area.



A Chicago Alley (after) – photo provided by Janet Attarian

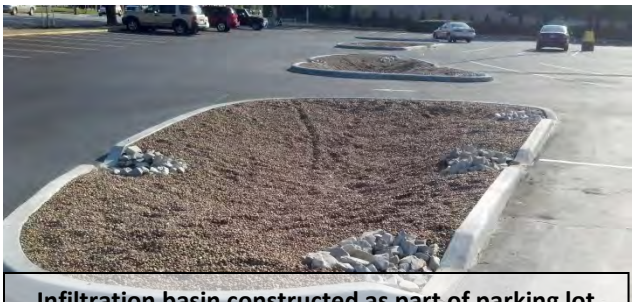
2.2.2 Bio-retention and Infiltration Basins



Bio-retention basin in urban roadway corridor – photo provided by EMH&T

Bio-retention basins are a common green infrastructure technology consisting of a stone aggregate storage reservoir overlain by a layer of very sandy and permeable growing media, covered with mulch and planted with various native grasses, flowers, and/or trees and shrubs. The surface is typically allowed to pond to a depth of 6-inches before overflowing into a drain or catch basin. Bio-retention is an important water quality BMP and may also serve as an infiltration practice if located in suitable in-situ soils. This GI practice can be applied in a roadway setting as either a bump-out (also referred to as a curb extension) feature or a bump –in (located behind the curb line) feature. Figure 4 is a schematic rendering of a bump-out bio-retention application integrated into a City street, which would also serve as a traffic-calming element within a residential neighborhood. Bio-retention basins are also very suitable for application in a parking lot setting in that they can be integrated into depressed islands or along the perimeter of a parking lot. Roadway applications are often limited by the roadway pavement width and available clearance within the right-of- way outside of the curb line. However, when properly designed and implemented, they can provide a substantial amenity to both residential and commercial roadway corridors.

Infiltration basins are a simplified variation of a bio-retention basin and can take on different forms in terms of appearance and function; however, their principal purpose is to intercept and capture stormwater runoff through a highly permeable surface media and either store or convey this flow to a suitable outlet. The goal of this investigation is to apply GI in a manner that reduces the volume of stormwater runoff to the CSS. As such, it is assumed bio-retention/infiltration basins will be applied in conjunction with the use of dry wells to re-direct stormwater runoff to the good geology. The City and EWSU have already realized success in the

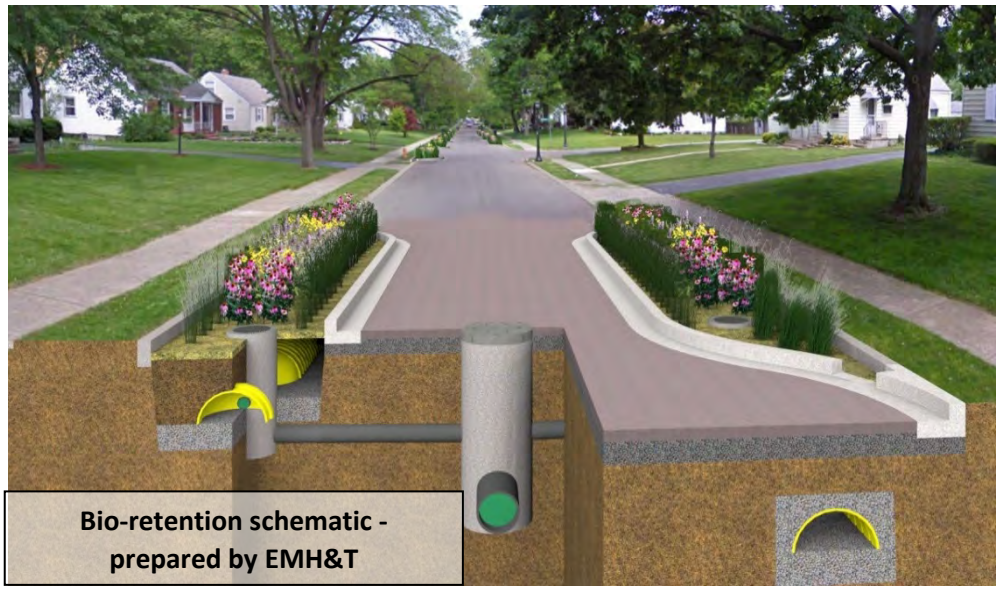


Infiltration basin constructed as part of parking lot improvements; Evansville, IN - photo provided by EMH&T

application of infiltration basins to remove stormwater runoff from the CSS, with the application of this GI feature to a portion of the large municipal parking lot located behind the City's Civic Center building, which also took advantage of the good geology to infiltrate stormwater to the maximum extent possible. Although no formal monitoring data is yet available for this project, observations during significant rainfall events have shown the infiltration practices are performing as anticipated.

Bio-retention basins and other infiltration practices are often highly suitable for application within a variety of private development settings, but are most commonly used in conjunction with non-residential (e.g., commercial) development. The City of Evansville is seeking to develop an overall GI program that includes refined codes and policies that promote the use of GI applications within new and re-development projects. In combination with potential financial incentives, it is anticipated there will be many opportunities for public-private partnerships (3P) to implement GI where it would benefit the CSS. In the global investigation of GI opportunities for CSO reduction, it has been assumed that bio-retention/infiltration basins will be principally applied to parking lot improvement projects; however, the final presentation of representative GI projects includes a potential 3P project that is currently in the planning stages for development. In addition, the list of projects includes a GI fund for future investment in GI as part of both capital improvement projects and 3P projects.

FIGURE 4: Schematic of a Bump-out Bio-retention Application



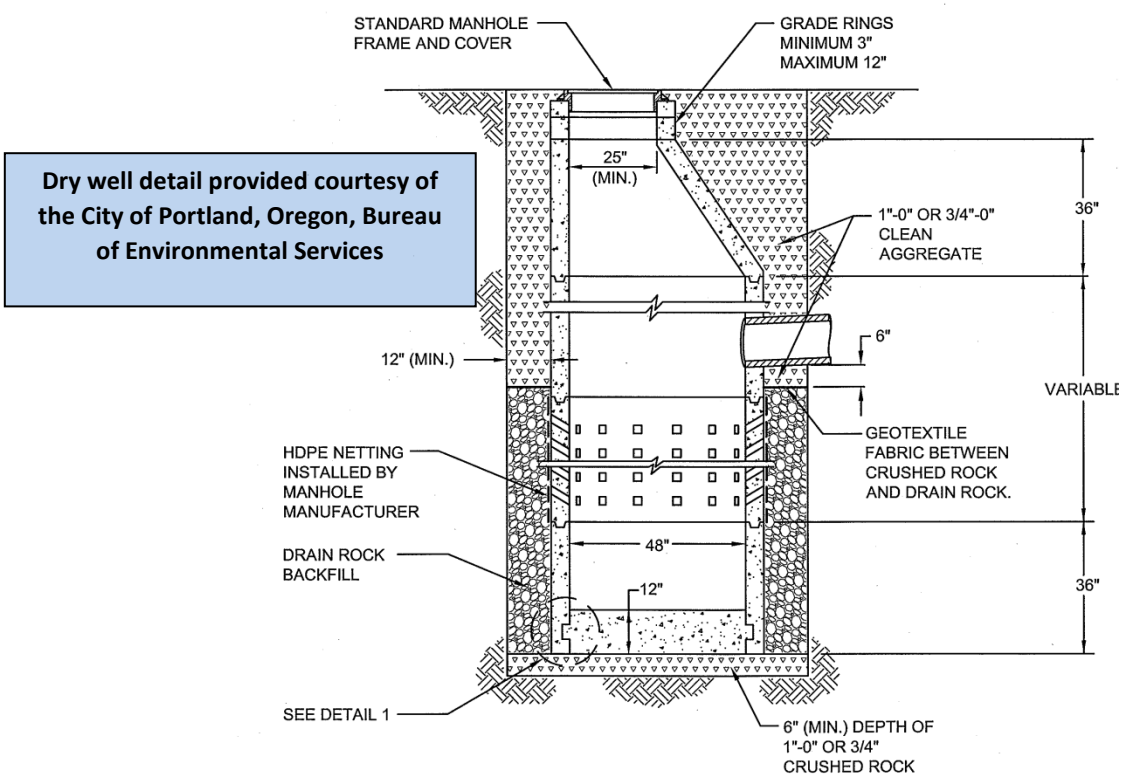
Bio-retention schematic - prepared by EMH&T

2.2.3 Dry Wells

The application of dry wells has already been referenced with respect to the use of other GI features, such as pervious pavement and bio-retention/infiltration. Their function within an overall GI application is to optimize the infiltration potential and reduce the volume of stormwater runoff to the CSS. Without these features, or some other application to access the good geology underlying areas of the City, the use of GI features could have very little impact toward reducing CSO's. As part of the design process associated with any future GI project, it will be required to perform a sub-surface investigation to confirm the presence of the good geology and the depth below the surface. Where highly permeable soils are present at shallow depths, it is possible that the GI feature would not require a dry well application; however, the available published data suggests the depth below the surface is likely to be in excess of 10 to 15 feet and a dry well application will be advisable to fully realize the infiltration potential of the project.

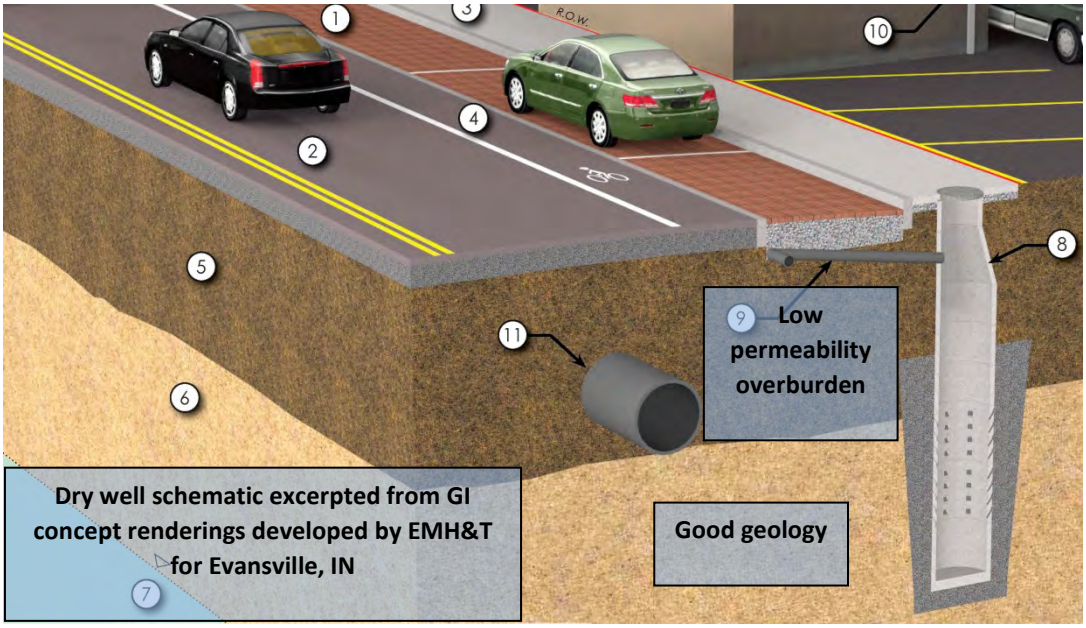
Dry wells are not a new application in the context of GI projects and there is adequate standard design and specification information available to support the engineering of future projects within the City. A dry well does not need to be a reinforced concrete structure, but that is advisable when there is the expectation for multiple outfall connections and the feature is to be embedded within other published infrastructure improvements, such as a green complete street. Figure 5 is a schematic detail of a pre-cast dry well and illustrates the material surrounding the installation. The intent of this application is to allow stormwater runoff captured by a surface GI feature to be re-directed to a layer of highly permeable soils. As such, the dry well is filled and back-filled with stone material with sufficient void space to promote the movement of water from the well to the surrounding permeable soil layer.

FIGURE 5: Dry Well Detail



The use of dry wells to promote infiltration of stormwater runoff poses a potential threat to groundwater contamination. A dry well should only be used when there is adequate pre-treatment of the runoff before it would reach the dry well and be discharged to the good geology. Without this pre-treatment, the project risks both an impact to groundwater and the possibility of clogging due to excess deposition of sediments and other pollutants. The application of GI features on the surface to both capture and filter stormwater runoff before it reaches the dry well is generally considered an acceptable form of pre-treatment, but will require some specific design considerations to protect the integrity of the project and minimize the potential for groundwater contamination. Figure 6 provides a simplistic view of the inclusion of a dry well into a GI practice – a green street with permeable pavement. The additional design considerations in this case may include the use of a geotextile filter fabric and/or a sand filter layer to intercept the fine materials that would pass through the porous sub-grade material. The University of New Hampshire has published guidance on the types and gradations of material to be used to ensure both infiltration and filtration of stormwater runoff for specific GI practices.

FIGURE 6: Schematic View of a Dry Well Application



2.3 Visualization of GI Features

A key aspect of increasing awareness of GI opportunities within the City was the ability to illustrate the potential visual impact of these features on the current landscape of the City. Although the City has completed several recent public infrastructure improvements that include GI, the scale of the projects being considered as part of the IOCP required the development of schematic images (renderings) that are based on actual areas within the City where GI could be integrated into other capital projects, such as roadways and parking lots. These examples of GI have been used with City staff and other stakeholders to generate enthusiasm for the use of GI in future projects and to begin the discussion of how the City's overall GI program can be used to facilitate the use of GI in both public and private projects.

The development of the GI renderings also factored significantly into the initial screening of GI opportunities that is described in Section 2.4. By realizing the general layout of GI as it would affect existing public infrastructure, a screening process could be developed relative to existing roadway corridors and other public property. The figures provided on the following pages consider the various GI features that have been the focus of the investigation in the City of Evansville, including the application of a green complete street in an ultra-urban setting and improvements to a public parking lot. Other concept renderings were provided but not presented here related to the application of GI along residential streets and derelict property acquired through the City's land bank program. There was also a concept rendering developed for incorporating an infiltration practice into a public street without the benefit of a green complete street improvement project.

FIGURE 7A: GI Rendering of Vine Street Corridor (Existing Conditions)



FIGURE 7B: GI Rendering of Vine Street Corridor (with GI)

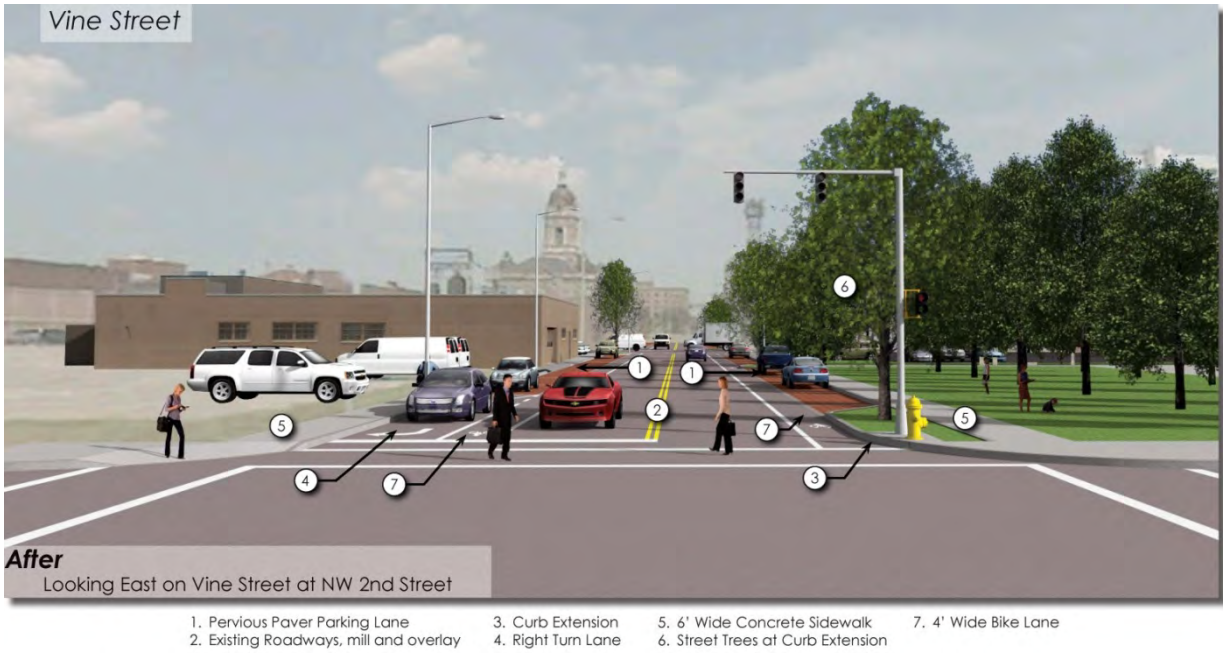


FIGURE 7B (cont.): GI Rendering of Vine Street Corridor (with GI)

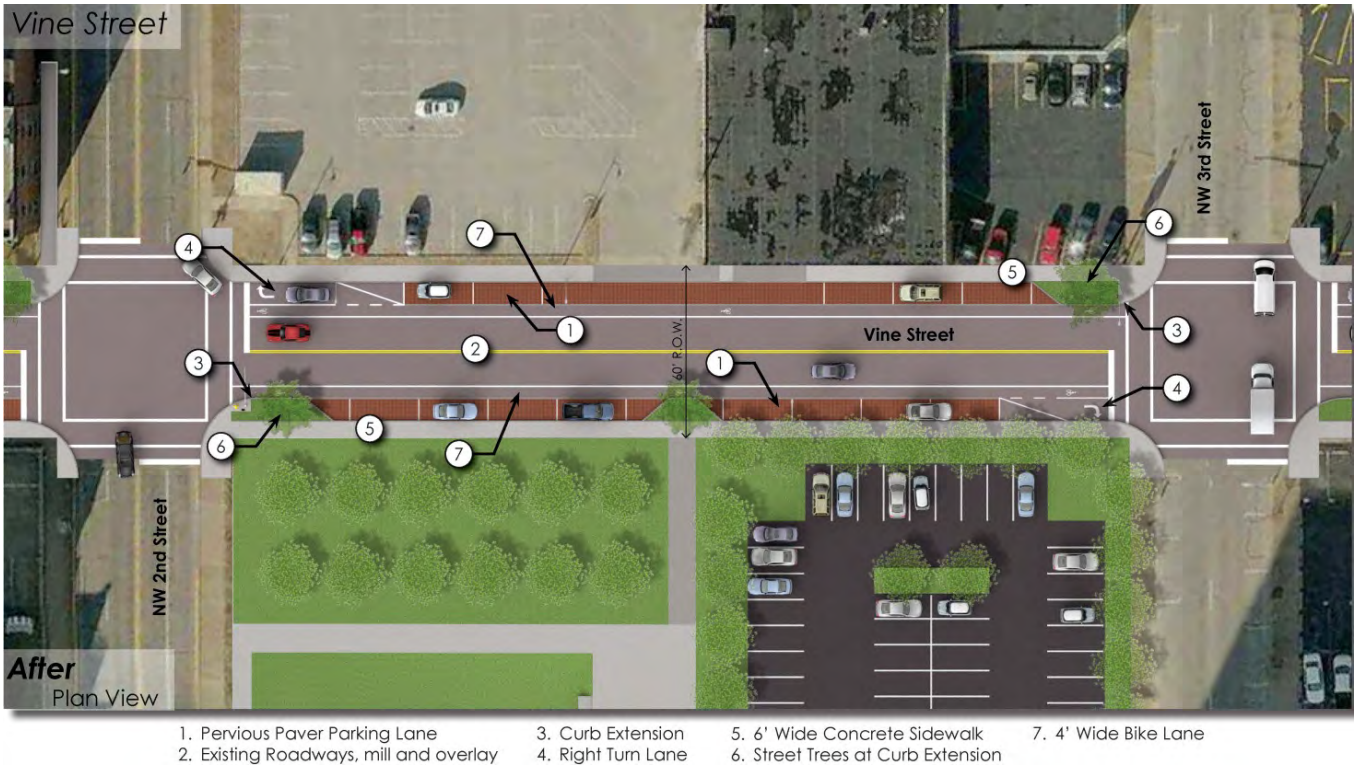
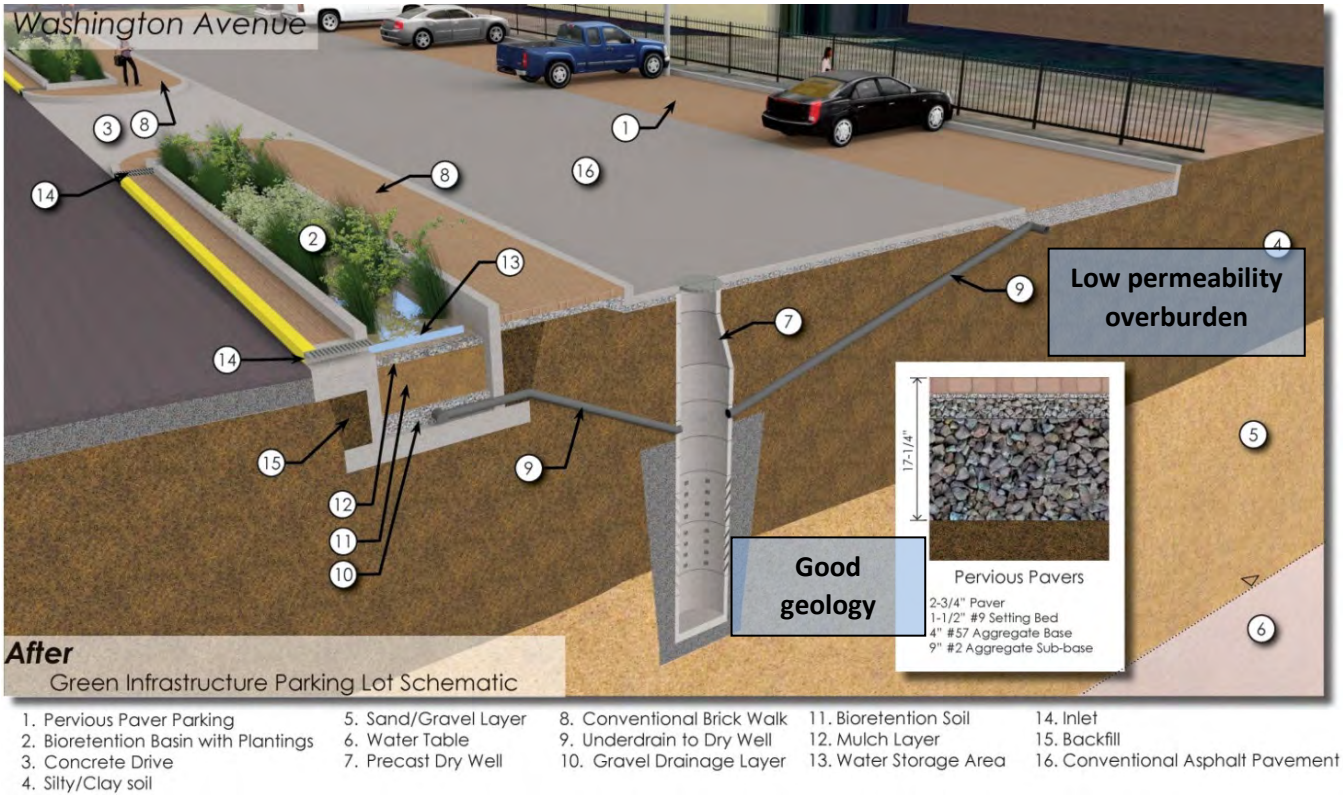


FIGURE 8A: GI Rendering of Washington Avenue Parking Lot (Existing Conditions)



FIGURE 8B: GI Rendering of Washington Avenue Parking Lot (with GI)

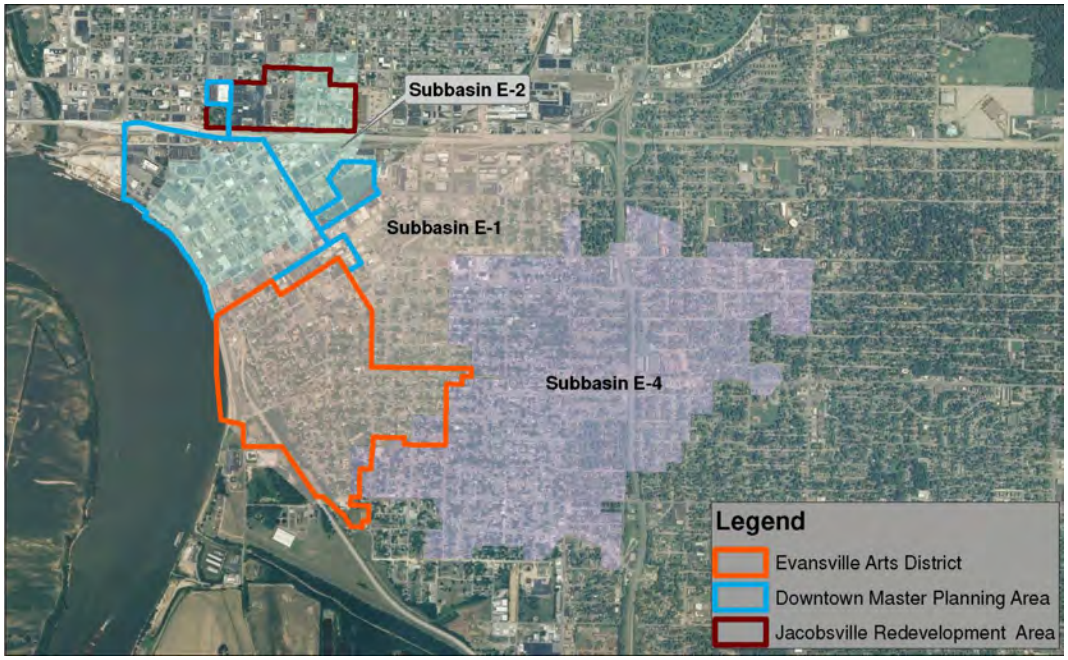


2.4 Screening GI Opportunities

The designated planning area for GI, consisting of CSS sub-basins E-1, E-2 and E-4, covers a large area of the City's downtown and adjacent high-density residential neighborhoods. Previous discussions have alluded to various factors that are either opportunities or constraints for the implementation of GI projects. A notable opportunity is the presence of the good geology underlying a significant portion of the planning area, while a notable constraint is the portion of the planning are determined to be below the 100-year flood elevation of the Ohio River. Both of these overlay designations are provided on Figure 3. Also relevant to the investigation of GI opportunities is the presence of several large, overlapping planning areas, which are designated on Figure 9. The planning areas affect ultra-urban areas (Downtown Master Plan), residential areas (Evansville/Historic Arts District) and a unique neighborhood re-development opportunity just north of the Lloyd Expressway (Jacobsville Re-development Area).

All of these planning efforts focus on the opportunities to improve public infrastructure as an enhancement to the immediately surrounding properties and the community as a whole, essentially promoting revitalization and growth. The conclusions of these planning efforts represent the opportunity to develop a master plan of capital improvements to address roadways and other public spaces, while also considering a sustainability initiative that addresses obvious limitations in the public utilities that serve those areas. The use of GI in these areas can serve to improve stormwater management and reduce the burden on the CSS as a component of the re-development process.

FIGURE 9: Overlapping Planning Areas Impacting GI Opportunities



Another notable overlapping planning effort is the City's Stormwater Master Plan, which was updated in 2007. This plan identified numerous storm system improvement projects, with many of those projects intended to re-direct stormwater runoff from the CSS. These projects represent a significant improvement toward reducing CSO's within the community. Incorporating GI into those areas of sewer separation would provide no real additional benefit to the CSS and the areas served by the storm system improvement projects were not considered for implementation of GI as part of this investigation. There are numerous other factors that have been considering in screening opportunities for the future implementation GI throughout the designated planning area. Figure 10 illustrates those factors and their individual scores. The 'green' denoted items are considered beneficial to the application of GI, with positive scores ranging from 0 to 3, while the 'red' denoted items are constraints with negative scores ranging from -1 to -5. The selection of these evaluation criteria and the relative was reviewed within the City's Green Opportunities Group to ensure it was consistent with the City's priorities for selecting beneficial GI opportunities.

Each public street segment within the planning area was evaluated against these criteria and an automated scoring system was created in a database environment that was joined with the GIS mapping established for the investigation of GI. Alleyways were also evaluated against a limited number of these scoring criteria. The result of this effort was a cumulative GI score for each street and alleyway segment, which could then be mapped to create a demonstration of which streets and alleys would be most conducive to the application of GI as it was visualized for the City of Evansville. Streets with a cumulative score of 8 or higher were considered good opportunities for GI features, while lower scoring streets would need to be evaluated on a case-by-case basis to determine the obvious constraints and how they could be overcome. Figure 11 is a graphic excerpted from the final mapping of the GI screening process illustrating the designation of low to high scoring green street opportunities throughout the planning area, as well as a City park and public parking lot also representing opportunities for GI.

FIGURE 10: Scoring Factors for Screening GI Opportunities

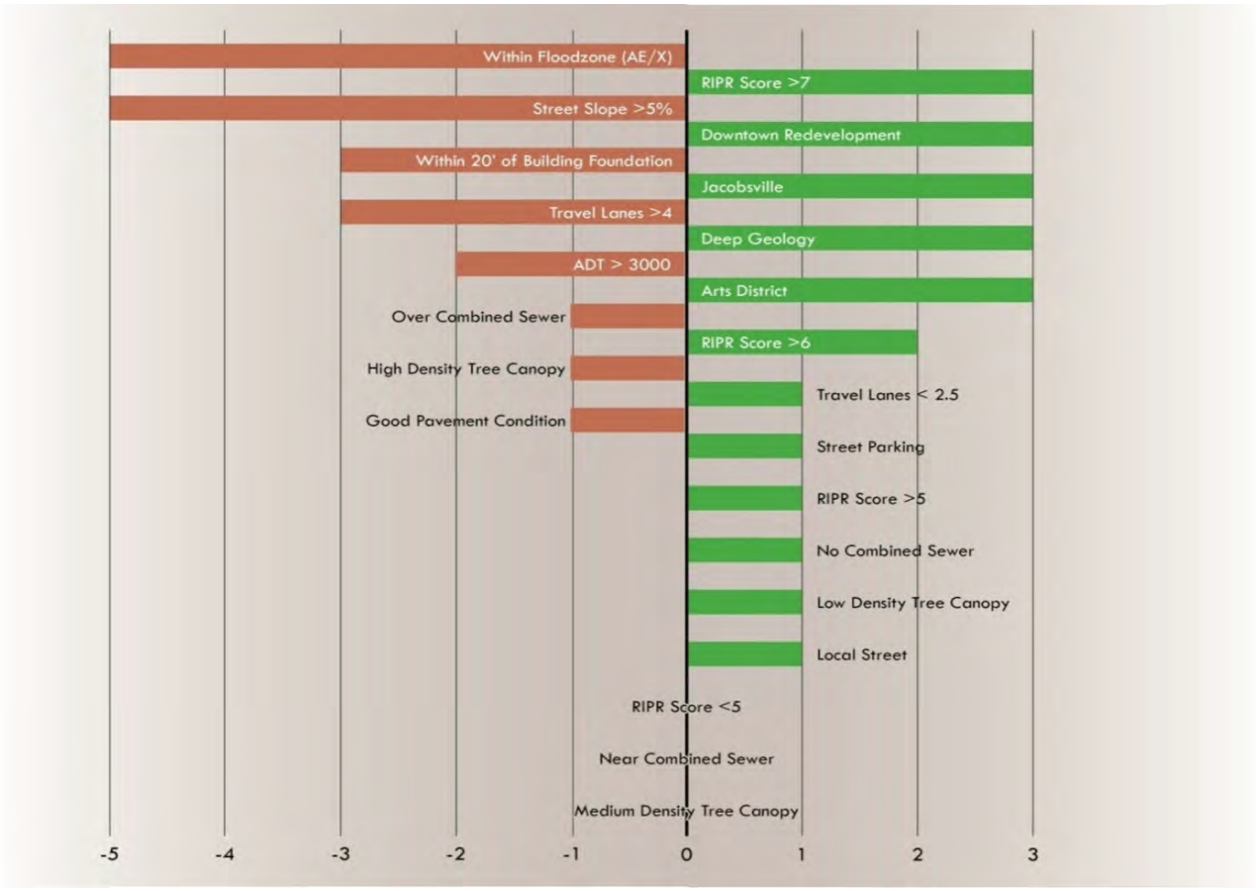


FIGURE 11: Mapping Representation of Scored GI Opportunities



2.5 Selection of Representative Green Infrastructure Projects

The results of the area-wide assessment of GI opportunities were presented to the various project stakeholders, most notably the City's Green Opportunities Group. As this group is instrumental in planning and implementing capital improvement projects throughout the City, they were asked to consider the highest scoring green streets, as well as identified parking lot retrofit opportunities, in the context of their individual municipal programs. This coordination occurred in a group setting and also in one-on-one meetings with individual departments to determine which GI opportunities potentially overlapped with other planned public infrastructure improvement projects. One of the selected projects is associated with the Jacobsville Re-development Area, which is an on-going planning initiative within the City. As part of this investigation, there was direct coordination with the Jacobsville planning consultant and the associated City staff to select a roadway corridor that was identified for a streetscape improvement and could include GI features to capture and reduce stormwater runoff to the CSS.

As a result of this coordination, a list of projects has been devised representing the best current opportunity for EWSU to collaborate with other City departments to implement projects with GI inclusion. There are a total of 14 representative GI projects provided in Table 1. A more detailed accounting of these projects is presented in a table provided as an Attachment to this document. The current list of potential projects covers the spectrum of GI opportunities that were considered throughout this investigation, summarized below.

1. Green complete streets in the downtown area (urban revitalization).
2. Green streets in the City's Arts District (historic neighborhood revitalization).
3. Two public parking lots previously identified for improvement.
4. A downtown City park and a greenways trail, both currently in the planning stage.
5. A green roof retrofit and three parking structure rainwater harvesting projects.
6. One 3P project opportunity currently in an advanced planning stage.

Some of the projects listed in Table 1 are actually a conglomeration of several projects, which is illustrated in more detail in the table provided as an Attachment. For example, the project listed as #13, is actually nine separate roadway segments in the City's Historic Arts District that may be constructed separately or in groups, depending on available funding. Similarly, project #10 includes a roadway segment and an adjacent public parking lot that should be constructed simultaneously but could be separated into individual projects. For a majority of these projects, there is a specific City department who would partner with EWSU to achieve the goal of stormwater capture and runoff volume reduction to the CSS.

The preliminary estimate of stormwater volume capture represented in the table reflects the model analysis of GI described in Section 3. The total project costs for many of the GI projects are based on unit values assigned to the various categories of GI, such as street and parking lot improvements. In other cases, such as rainwater harvesting and the green roof opportunity, a more deliberate effort was made to estimate a potential project cost. In these last two cases, the total project cost is also the cost to ESWU for the implementation of GI, as there are no other significant project costs beyond the chosen green feature. For the other projects, the EWSU cost contribution represents an estimated factor for GI inclusion as a percentage of the total project cost.

TABLE 1: Summary of Representative GI Projects

	Project Name	CSS Sub-area	Project Type	Total Project Cost	EWSU Contribution	Preliminary Estimate of SW Capture (MG/Yr)	GI Cost per Gallon of SW Capture
1	Bi-centennial Park[1]	Sycamore (E-2)	Infiltration Practices	$1.19M	$579,000	1.52	$0.38
2	Vine Street	Court/ Sycamore (E-2)	Green Complete Street	$5.61M	$842,000	2.61	$0.32
3	YMCA Parking Lot[2]	Sycamore (E-2)	Infiltration Practices	Unknown	$127,000	1.75	$0.07
4	Civic Center Building	Sycamore (E-2)	Green Roof	--	$250,000	0.10	$2.39
5	Downtown Hotel (3P)	Locust/Chestnut (E-2/E-1)	Infiltration Practices[3]	---	$383,000	1.92	$0.20
6	Sycamore Street Parking Structure	Sycamore (E-2)	Rainwater Harvesting[4]	---	$150,000	0.82	$0.18
7	Locust Street Parking Structure	Locust (E-2)	Rainwater Harvesting	---	$150,000	0.82	$0.18
8	Walnut Street Parking Structure	Locust/Chestnut (E-2/E-1)	Rainwater Harvesting	---	$150,000	0.82	$0.18
9	Greenways Trail at U.S. 41	Bee Slough (E-4)	Infiltration Practices	$3.0M	$1.0M	6.78	$0.15
10	Washington Ave. and Parking Lot	Adams & Sunset (E-1)	Green Street and Infiltration Practices	$353,000	$116,000	0.56	$0.21
11	Greenway Trail along Governor/ Garvin Streets	Chestnut (E-1)	Green Complete Street	$3.52M	$881,000	3.78	$0.23
12	Riverside Drive	Oak & Riverside (E-1)	Green Complete Street[5]	$1.17M	$337,000	1.54	$0.22
13	Arts District Revitalization[6]	Adams & Sunset (E-1)	Green Streets	$11.10M	$2.77M	12.76	$0.22
14	Jacobsville Area Revitilization[7]	Court (E-2)	Green Complete Street	$3.23M	$484,000	1.75	$0.28
15	GI Enhancement Fund[8]	E-1/E-2	__	__	$10.0M	50	$0.20
				Totals =	**$18.23M**	**88**	**$0.21**

[1] Includes assumed green complete street application to the adjacent portion of Third Street; total cost provided is for Third Street only (total cost for park improvements is unknown)
[2] Includes the adjacent public parking lot owned by the Evansville Building Authority
[3] May include green complete street along adjacent roadways
[4] Cistern application within and/or on outside of structure
[5] Includes infiltration practices applied to adjacent parking area
[6] Nine individual street improvement projects
[7] Assumed to be reconstruction of W. Indiana Street
[8] Applied to future public infrastructure improvement projects and 3P opportunities

In addition to the 14 listed projects, there is an identified GI enhancement fund that the Utility expects to apply to future identified public infrastructure improvement projects as well as 3P

opportunities. The value of that fund and the anticipated benefits are based on the premise of a cost-share arrangement that would enable EWSU to spend approximately $.20 per gallon of stormwater runoff captured and removed from the CSS through the application of GI. It is generally understood that individual projects may be removed from this list and replaced by others; however, the intent and goal of implementing GI to reduce CSO volume and frequency of occurrence will not change.

SECTION 3

Model Analysis of GI Benefits

The modeling of GI opportunities in the designated planning area was performed in two different steps. The initial step evaluated all of the high-scoring GI opportunities throughout the planning area, while the second step isolated a limited number of GI projects for consideration within the IOCP document. For the modeling process, it was important to provide a thorough analysis of the potential hydrologic response of implementing GI projects, while also working with the environment of the established SWMM model of the CSS to determine the direct benefits toward the reduction of CSO volume and frequency of occurrence. Meanwhile, it is understood this is a planning level analysis of GI applied over a large area of the City. A more refined analysis of the impacts of GI on the CSS will be necessary as individual projects are designed and implemented. Furthermore, a post-construction monitoring program instituted by the City can validate and refine the modeling of GI practices to reflect actual observed stormwater runoff volume reduction. The post-construction monitoring and refined modeling process can be used to continually evaluate the planning and implementation of both green and gray infrastructure improvements to optimize the City's investment in projects that will have the most benefit on the CSS and the community as a whole.

3.1 Modeling of GI Applied Throughout the Designated Planning Area

There are numerous modeling platforms available to model both the hydrologic and hydraulic components of GI applied on a site-by-site or watershed basis. The USEPA's SWMM platform has been recently updated to include an LID component that allows the user to code specific GI practices on a local or regional basis. However, WinSLAMM (Source Loading and Management Model for Windows), which is in the USEPA's published toolbox for modeling GI applications, was the selected GI modeling platform for this particular project. The results of the WinSLAMM model of GI have been incorporated into the system-wide SWMM analysis of the CSS. A brief description of the WinSLAMM model is as follows:

> "WinSLAMM (Source Loading and Management Model for Windows) was developed to evaluate nonpoint source pollutant loadings in urban areas using small storm hydrology. The model determines the runoff from a series of normal rainfall events and calculates the pollutant loading from each individual source area created by these rainfall events. The user is able to apply a series of stormwater control practices, such as infiltration/ bio-filtration, street sweeping, wet detention ponds, grass swales, porous pavement, catch basins, or various proprietary devices to determine how effectively these practices remove pollutants. Since its origination in the 1970's, the program's use has extended across North America and overseas. WinSLAMM is based largely upon Dr. Robert Pitt's research and studies conducted in the United States and Canada and by research studies conducted through the WDNR and the USGS (PV & Associates)."

3.1.1 WinSLAMM Model Overview

WinSLAMM is a continuous event model that uses empirical data derived from actual field observations to determine runoff volumes, peak flow rates, and pollutant loads and is often used as a watershed planning tool, as well as to design site-specific BMPs. The input data required for the model include detailed land use/land cover data and a continuous rainfall data set. WinSLAMM uses the input data coupled with or without selected GI technologies to calculate a hydrologic response, representing a volume of stormwater runoff associated with the modeled conditions. A vast array of output data formats are available including continuous hydrograph data sets that can be imported into SWMM to determine how green infrastructure may reduce the frequency and volume of CSO events.

3.1.2 Rainfall Data

The WinSLAMM model uses continuous rainfall data to create storms and applies a standard rainfall distribution to each storm event. Standard hourly rainfall data is converted by WinSLAMM to a program specific ".ran" file. WinSLAMM takes the hourly rainfall total depth data and groups them into storms with the minimum time between storms being three hours. Each storm is defined as having a start time, end time, and total depth. For this investigation, the typical annual rainfall data set from the City's system-wide model of the CSS was utilized and converted to the WinSLAMM format.

3.1.3 3.1.3 Source Areas and Land Uses

Source areas for stormwater runoff are described in WinSLAMM as commercial, residential, institutional, industrial, Other Urban, and Freeways. Each source area has a list of land uses that can be populated with data reflecting the physical characteristics affecting stormwater runoff. Defining different source areas is essential to the development of an accurate WinSLAMM analysis, as specific BMPs can be easily applied to individual source areas instead of the entire watershed area. For the designated planning area, specific ultra-urban and residential neighborhoods were extracted from sub-basins E-1 and E-4 for simulation within the WinSLAMM platform, to determine the potential change in stormwater runoff between existing and with GI conditions.

A detailed land use/land cover area takeoff was performed for the selected neighborhoods to correspond with the WinSLAMM residential and commercial input spreadsheets, which includes rooftops, sidewalks, alleys, streets, driveways, small and large open space (landscaped) areas, and other pervious areas. Where appropriate, the measured area was represented in the model as either hydraulically connected or disconnected. Impervious areas with a flow path that is not interrupted by a vegetative area are considered directly connected impervious area. Impervious areas which flow through vegetated areas are referred to as disconnected. For example, a roof discharging onto a driveway that flows to the street, to a catch basin, to a storm sewer pipe and then to the CSS is considered directly connected impervious area.

3.1.4 WinSLAMM Results

The WinSLAMM analysis was used to evaluate variations of the two principle GI applications – green streets using permeable pavers and parking lots with embedded infiltration practices. The focus of the analysis was on the use of dry wells to accomplish the full extent of the desired infiltration. The analysis evaluated different percentages of the GI application relative to the entire runoff areas within the template ultra-urban and high density residential land use settings. The WinSLAMM analysis initially considered that no areas outside of the public right-of-

way would be intercepted by the GI application; however, the City's on-going downspout disconnection program and other factors supported the use of a unit multiplier to increase the stormwater volume capture estimated by the WinSLAMM analysis.

The results of the WinSLAMM analysis related to stormwater capture have been converted to a 'per acre' value so they can be applied to any potential GI project. One other outcome of this analysis was the determination of the rainfall depth each type of GI application could expect to intercept (reported as 'initial abstraction'), above which the generated runoff would exceed the capacity of the GI feature and discharge to the CSS. Table 2 is a summary of the results of the GI analysis, including the unit multiplier used to account for capture areas beyond the right-of-way.

The analysis to determine the number/density of dry wells required to achieve the desired infiltration was performed outside of the WinSLAMM environment. There is published guidance on the method of estimating dry well capacity (Massman, 2004) that was applied within this investigation, which considers the size of the dry well barrel, the saturated hydraulic conductivity of the surrounding in-situ soils, and the depth to groundwater beneath the bottom of the drywell.

TABLE 2: Summary Results from WinSLAMM Analysis of GI Applications

Land Use/Land Cover	Primary CSS Sub-basin	Estimated Stormwater Capture Volume (MG/Yr/Ac)	Multiplier to Account for Areas Beyond the R/W	Initial Abstraction (inches)
Ultra-Urban Neighborhood[1]	E-2	.913	1.1	1.5
High-density Residential Neighborhood[2]	E-1/E-4	.441	2.5[4]	1.5
Parking Lots[3]	E-1, E-2, E-4	.90	N/A	2.0

[1] Green complete street application with partial width permeable pavers and dry wells

[2] Green street application with full-width permeable pavers and dry wells

[3] Infiltration practices (similar runoff conditions as ultra-urban)

[4] Assumes a fairly aggressive downspout disconnection program

3.1.5 SWMM Analysis

The WinSLAMM model results determining initial abstraction of the selected GI applications were used in an area-wide analysis of the impact of GI on reducing CSOs, using the established SWMM model of the CSS. Only the high-scoring green streets (screening score of 8 or higher) and public parking lots were used in this model evaluation. To simulate the full extent of potential GI in the model, the TR-55 (Runoff Curve Number - RCN) method was used to determine target results for stormwater runoff volume reduction for all GI opportunities. Model execution using the RCN method is limited to single storm event runs. Therefore, several significant rainfall events were extracted from the City's continuous rainfall data set for execution within the SWMM environment. Each storm event was run separately using a RCN for the impacted sub-catchments that represented the calculated initial rainfall abstraction from the WinSLAMM analysis. There were several other modeling steps necessary to account for the

area-application of GI within the larger model sub-catchments which are not described as part of this discussion.

The single event model runs established the volume and general shape of the runoff hydrographs from the various model sub-catchments, reflecting the area-wide application of GI. To convert these results to a continuous rainfall model run, the single event models were again executed but this time using the Green-Ampt equation for calculating infiltration. Various hydrologic parameters were adjusted to achieve general agreement with the results of the RCN method models. Once the Green-Ampt model was 'calibrated' to the results of the RCN model, the full typical year rainfall data set was executed in the SWMM model to not only determine the hydrologic response of the area-wide application of GI but to also determine the impact on reducing CSOs. The results of this modeling are not included as part of this discussion as the extent of GI represented by this effort was well beyond what was anticipated as part of the IOCP; however, the effort did illustrate an effective process for considering various GI applications over a large planning area and gave the City some idea of what could be achieved through a long-term aggressive GI program.

3.2 Modeling of the Final List of Representative GI Projects

The next phase of the modeling process considered only the 14 projects described in Section 2.5, to determine the extent of the potential stormwater capture volume and the impact toward reducing CSOs within the designated planning area. This modeling was simplified from the effort associated with the area-wide consideration of GI applications. GIS shapefiles were created for each of the designated projects. These shapefiles accounted for the expectation of intercepting some areas outside of the public right-of-way (for green streets projects). For each GI project there is an anticipated value for stormwater runoff volume reduction volume that is presented in Table 1.

The project-specific shapefiles were then applied to the GIS mapping of the CSS sub-catchments to determine how much area within each sub-catchment was affected by a calculated reduction in stormwater runoff volume. Figure 12 demonstrates a portion of the representative GI projects overlaid on the model sub-catchments. Considering that the GI Enhancement Fund (#15) was not part of this analysis, the total target stormwater runoff volume reduction for the other 14 projects is 38 MG/Yr. Various hydrologic parameters in the SWMM model were then adjusted to achieve the target annual runoff volume reduction on a sub-catchment level and across all of the areas impacted by the application of GI. The following is a more specific discussion of the steps taken to account for the 14 GI projects in the CSS model.

3.2.1 CSS Model Adjustment to Account for GI

The steps listed below were executed in sequence to account for the 14 representative GI projects in the input parameters of the current SWMM model of the CSS.

- Overlaid GI project areas on the CSS model sub-catchments and determined which CSO outfalls will be impacted by the GI projects.
- Established the percentage of each GI project in each sub-catchment.
- Determined the stormwater runoff reduction goal for each sub-catchment based on the specific GI projects and their area impact within the various model sub-catchments.
- Reduced infiltration parameters (impervious factors) in each impacted model sub-catchment to achieve the runoff reduction goals.

3.2.2 CSS Model Execution with Typical Year Rainfall (and GI Inclusion)

The steps listed below were executed in sequence to execute the SWMM model and determine the hydrologic and hydraulic impact of the 14 representative GI projects. The chosen CSS model for the inclusion of these GI projects already included a baseline of gray improvements described elsewhere in this document. The results of this GI modeling are accounted for in Table 3.

- Executed the 12-activation alternative model for the typical year with the adjusted parameters to account for GI inclusion.
- Identified revised CSO volumes to each outfall and computed cumulative overflow reductions with GI, and identified the number of overflow events with GI.
- Computed percentage reductions for stormwater runoff and CSO volumes.

FIGURE 12: Overlay of Representative GI Projects on CSS Sub-catchments



TABLE 3: Summary of GI Model Results (Representative Projects)

Calculated Values	CSO Name			
	002/004 (Cass/Adams)	038 (Oak & Riverside)	008 (Chestnut)	010 (Dress Plaza)
Baseline Model Condition (12 Activation Condition)				
Runoff Volume (MG/Yr)	223.4	29.8	160.7	147.8
Overflow Volume (MG/Yr)	103.4	1.2	37.8	19.2
Overflow Activations	14	5	11	10
Proposed Condition (with GI)				
Runoff Volume (MG/Yr)	203.9	28.3	155.1	138.0
Overflow Volume (MG/Yr)	92.7	1.2	35.8	15.6
Overflow Activations	14	5	11	9
Comparison of Baseline and With GI Conditions				
Runoff Volume Reduction (MG/Yr)	19.5	1.5	5.5	9.8
Runoff Volume % Reduction	9%	5%	3%	7%
CSO Volume Reduction (MG/Yr)	10.7	0.1	2.0	3.6
CSO Volume % Reduction	10%	6%	5%	19%

SECTION 4

Future Implementation of GI Program

The implementation of the City's GI program remains the biggest challenge to successfully realizing the benefits of utilizing sustainable practices toward reducing stormwater impacts to the CSS. EWSU has already taken significant steps, in collaboration with other project stakeholders, to formulate an approach to promoting GI within both public infrastructure and private improvement projects. These measures seek to develop a process whereby most, if not all, capital improvement projects are considered for inclusion of GI, particularly those in the downtown CSS area where there is a specific target for stormwater runoff volume reduction. These measures include consideration of both requirements and incentives for GI inclusion in private development areas, again focusing on the priority areas for runoff volume reduction. The City's Green Opportunities Group will continue to play an important role within the City to support EWSU in executing the identified representative GI projects and continuing to develop additional capital improvement projects with GI inclusion. The Smart Growth Committee will play a key role in refining the City's current policies and practices related to stormwater management and the consideration of sustainable GI practices, particularly with regard to private site development projects.

4.1 Implementation of the Representative Projects

Most of the 14 identified projects represent opportunities for GI inclusion in capital improvements that are currently being promoted through various City departments, with the key project advocates being the City's Department of Parks and Recreations and the Department of Metropolitan Development. In these cases, EWSU will provide financial and likely some design support in the implementation of GI features within the context of a larger project. In other cases, EWSU will take the lead role in implementing a GI-based retrofit to existing public infrastructure. Regardless, it is going to be critically important that the various collaborating City departments continue to participate in the Green Opportunities Group to ensure these projects, and any future projects are being adequately considered for GI inclusion.

While some of the identified projects are already in the planning stages and are likely to be implemented, there are others which may not be performed within the anticipated timeframes. It is understood that projects may be re-programmed or replaced by other similar projects, but with the intent of meeting or exceeding the goals for stormwater capture under the context of CSO mitigation within the designated planning area. The impact of GI projects in reducing runoff volume to the CSS and the resulting decrease in CSO's will determine to what extent the planned gray improvements can be down-sized, or right-sized, to account for the green improvements. The City's adaptive management program, including long-term flow monitoring and efforts to refine the CSS modeling, will allow future decisions to be made with the benefit of real-world data.

4.2 Applying the Triple Bottom Line Process

The triple bottom line (TBL) process is a common metric applied to the evaluation of GI projects in comparison to more conventional gray improvements. The metric assigns values to monetary and non-monetary attributes of these projects to determine the most beneficial alternative. The

non-monetary attributes are related to social and environmental benefits that are likely to be more prominent in a GI approach, thereby providing justification for selecting green over gray when both will at least achieve the underlying goals of the project, such as CSO mitigation. Many CSO communities and others who have established robust GI programs have some form of the TBL process in place to select and prioritize improvements in their communities. There is a fairly standard platform for this scoring process, which consists of: 1) a document establishing and defining the scoring criteria; and 2) a score sheet that assigns values for individual criteria and tallies a cumulative score for a specific project. The nature of this process is to allow for some subjectivity in assessing individual criteria but with boundaries to ensure an appropriate amount of objectivity in evaluating and comparing projects.

To establish a TBL process for the City of Evansville, there was a vetting process with key project stakeholders to determine which criteria would be the most applicable to the evaluation of green and gray projects in the community, as well as to determine the relative importance of these criteria. This effort resulted in a TBL document customized for application to projects within the IOCP, or any capital improvement project considering the use of GI as a stormwater management application. The initial goal of refining the TBL process for the City was to apply the scoring to the representative GI projects and determine a priority for future implementation. In other words, use the TBL process to evaluate green versus green. In reality the prioritization of the listed GI projects will depend heavily on other factors unrelated to many of the established scoring criteria. As such, the projects listed in Table 1 have not been subjected to a TBL evaluation.

In addition, within the City of Evansville, an adaptive management program will determine the potential for GI improvements replacing or reducing gray infrastructure in the downtown areas of the City, based on the success of future GI projects toward reducing CSO volume and frequency. In essence, the City's philosophy is to consider GI features on public infrastructure improvement projects as those opportunities arise, with the goal of achieving the intrinsic value of CSO mitigation. The Utility will promote the cost-share opportunity for GI inclusion with both public infrastructure and 3P projects which can eventually generate some competition for these funds between individual projects. In cases where the Utility is faced with multiple opportunities for GI implementation and with the potential for limited available funding, then the TBL process can be applied to select preferred projects based on their benefits across the spectrum of the established scoring criteria.

4.3 Design and Modeling Considerations for Future GI Projects

Future design efforts related to the implementation of GI projects should take into account the best available modeling applications, including SWMM-LID and WinSLAMM. There are other GI-based modeling applications; however, the tools used to determine the hydrologic response of a GI feature should be compatible with the overall CSS model. The noted model platforms are not entirely intuitive and project designers should be careful in performing the required analysis to ensure the calculated results are reasonable and predictable. Under-designing GI features will compromise the ability of the project to meet the intended goals of stormwater runoff capture and volume reduction, while over-designing these features will add unnecessary project costs. The modeling and design of GI projects, specifically using the features identified as part of this investigation, requires a keen understanding of underlying soil permeability. Shallow depth BMP's can be effective infiltration practices if the in-situ soils are demonstrated to have the required permeability. If not, then the design process should determine whether the underlying

good geology is present at a reasonable depth below the surface. If the determined depth is excessive at the project location then the performance of the GI features in terms of infiltration may be compromised by a seasonally high groundwater table. In either case, the appropriate soils investigation is required, including using recommended methods for determining the saturated hydraulic conductivity of the native soils. In addition, if dry wells are to be utilized as a means to accomplish the desired stormwater runoff infiltration, then using the published guidance on analyzing their capacity is required to ensure the appropriate size and density of dry wells is incorporated into the project design.

Designing pervious pavement, specifically permeable pavers, requires the inclusion of detailed specifications regarding the various materials required to achieve the desired stormwater capture and to ensure the project is structurally adequate. For both permeable pavers and other infiltration practices that may be utilized on a project-by-project basis, it is recommended that the City adopt specific design standards to ensure uniformity and facilitate the engineering plan review process. Individual projects may require specific design and construction considerations, but the implementation of most GI features should adhere to established practices and reflect a well-documented engineering analysis.

4.4 Revising Current Codes, Policies and Guidelines

The APC is finalizing a revised area-wide Comprehensive Plan that outlines several regulatory and non-regulatory changes within City programs that would promote sustainability. In addition, EWSU's investigation of a City-wide GI program included a fairly extensive evaluation of the City's current practices related to codes, policies and guidelines. In each case, there are recommended changes that would have an impact on how individual projects are conceived and implemented, with an emphasis on promoting the use of GI to meet certain stormwater management requirements. Although regulatory mandates are effective at creating a change toward sustainability in projects, there is also a benefit to providing incentives to encourage and reward projects for meeting a higher standard, which fosters an atmosphere of cooperation between individual City departments and between the City and private interests. The tools for creating a multi-faceted GI program are well-established and documented by the USEPA. As mentioned earlier, the City's Smart Growth Committee is anticipated to be a partner in the effort to refine the City's regulatory practices to promote the use of and create uniform guidance for the application of GI features.

The implementation of a GI program presents unique challenges in every different community, and the City of Evansville is considering these challenges in tandem with the emerging requirements of the IOCP, which will place a significant financial burden on the City as an institution, as well as the residents and business owners who will share in the costs of overhauling significant components of the City's utility infrastructure. However, the past and on-going area-wide planning efforts throughout the urbanized areas of the City also show a commitment to community revitalization that is essential to the realization of the GI program goals and objectives. Putting this program into motion and maintaining the proper momentum will require diligence by key municipal staff and other stakeholders. A sustainability (or green) 'champion' within the City's staff, with the ability to influence both political and policy decisions and to promote continued collaboration amongst the multiple City departments, will be a key factor in the success of the GI program.

APPENDIX E

Hydraulic and Operations Analysis of the Bee Slough Control Measure

Updated Hydraulic and Operations Analysis of the Bee Slough Control Measure

PREPARED FOR: Evansville Water and Sewer Utility

COPY TO: File

PREPARED BY: Paul Amico/CH2M HILL
Chris Andres/CH2M HILL
Suibing Liu/CH2M HILL

DATE: May 20, 2015

Overview

After Evansville and EPA reached agreement on the East Wastewater Treatment Plant (WWTP) capacity and operational approach (secondary treatment process expanded to 40 million gallons per day (mgd) and no PE bypasses), EPA requested one additional model analysis of Bee Slough, the East WWTP, and the proposed treatment wetland to better understand how the wetland and WWTP would perform together to treat wet-weather flows in the Typical Year.

The purpose of this technical memorandum (TM) is to document the modeling approach, and present key findings.

Modeling Approach

This section describes the modeling approach.

Data Sources

Table 1 describes the data utilized and how each was used.

TABLE 1
Data for Wetland Model Development

Data Item	Description
TM-Hydraulic and Operations Analysis of the Bee Slough Control Measure, April 18, 2014	The previous wetland model description and results
Previous wetland models developed in April 2014	Model files for Hydraulic and Operations Analysis of the Bee Slough Control Measure

Model Network and Layout

The general model network and layout was summarized in the TM-Hydraulic and Operations Analysis of the Bee Slough Control Measure, April 18, 2014 (attached to this memorandum). For this updated analysis, only one model run was performed. The following list the major updates applied to the model:

- The East WWTP plant capacity is 40 mgd for both primary and secondary processes
- There is no PE bypass
- There is no bypass pumping/flow from the East WWTP to the wetland; and
- There is no bypass pumping/flow from the wetland to the East WWTP

The updated model schematics are illustrated in Figure 1. Figure 2 shows the updated model network and layout.

Key Findings

This section presents the key findings of the modeling results, as it relates to the performance of the East WWTP, wetland, and VTU. Detailed data from the modeling analysis can be found in the digital excel spreadsheet (*TBL-2015-05-29-UpdatedWetlandSimulationResults_ToEPA*) submitted along with this TM. In summary, the following observations were made from the modeling effort:

1. The wetland was utilized 30 times and treated approximately 483 MG in the Typical Year. The average maximum depth was approximately 2.4 feet. The wetland volume was exceeded twice once (Events 1 and 21), by approximately 30.3 and 1.3 MG, respectively. In addition, there were five instances where the wetland did not completely drain prior to the start of the next storm event. However, this did not negatively impact wetland performance (i.e. the wetland volume was not exceeded). Attachment 1 displays a breakdown of wetland performance by storm event.
2. Table 2 displays a breakdown of wetland operating levels in the Typical Year. Approximately 36 (77 percent) events fill the wetland to a depth of 4 feet or less. The wetland capacity is maximized twice in the Typical Year, which is the same events mentioned in Item 1 above.
3. Table 3 displays a summary of VTU performance during the Typical Year. The VTU captures approximately 226 MG of overflow. Analysis shows that that the majority of storm events result in small influent volumes to the VTU that do not exceed the VTU capacity. In these instances, captured volume is stored and drained to the WWTP headworks. While few storms result in treated discharge from the VTU, the associated volumes are relatively large; approximately 181 MG of treated effluent is discharged into Bee Slough.

TABLE 2
Breakdown of Wetland Operating Level

Max Depth (FT)	Frequency
<1	19
1-2	7
2-4	10
4-6	7
6-8	2
>8[a]	2

[a] Depth greater than 8 feet indicates wetland capacity is exceeded. "Exceeded" means that a portion the volume of influent would receive less than 48 hours detention time in the wetland.

TABLE 3
VTU Performance

	Volume (MG)	Percent of Total Volume	Number of Occurrences
Drain to WWTP[a]	47	20%	33
Overflow/Effluent to Bee Slough Channel[b]	181	80%	13
Total Volume	**226**		

[a] When the captured volume does not exceed the VTU volume, the VTU unit acts as a storage tank. Flow is not discharged to Bee Slough. Rather, it is drained to the WWTP headworks.

[b] When the captured volume exceeds the VTU volume, treated flow is discharged from the VTU into Bee Slough

ATTACHMENT 1[A,B]

Wetland Performance, by Storm Event

Event	Date	Duration (HR)	Max Depth (FT)	Max Inflow (MGD)	Avg Flow (MGD)	Treated Volume (MG)	Wetland Operated?	Completely Drained?	Volume Exceeded (MG)
1	1/2/2000 19:00	140	13.8	183.6	14.7	85.6	Yes	YES	30.3
2	1/17/2000 20:00	76	0.1	0.0	0.0	0.0	No	YES	0
3	2/13/2000 9:00	82	4.9	117.9	7.6	25.8	Yes	YES	0
4	2/23/2000 22:00	67	2.5	76.5	3.1	8.6	Yes	YES	0
5	2/26/2000 17:00	62	2.5	76.6	4.2	11.0	Yes	YES	0
6	3/3/2000 13:00	188	0.1	0.0	0.0	0.0	No	YES	0
7	3/11/2000 9:00	84	1.0	51.8	0.6	2.1	Yes	YES	0
8	3/16/2000 3:00	75	3.5	115.2	5.1	15.9	Yes	NO	0
9	3/19/2000 6:00	73	2.0	90.3	3.1	9.4	Yes	YES	0
10	3/27/2000 1:00	72	0.1	0.0	0.0	0.0	No	YES	0
11	4/2/2000 6:00	133	0.0	0.0	0.0	0.0	No	YES	0
12	4/7/2000 19:00	100	3.0	62.3	2.6	10.9	Yes	YES	0
13	4/24/2000 9:00	58	0.1	0.0	0.0	0.0	No	YES	0
14	5/3/2000 13:00	82	0.0	0.0	0.0	0.0	No	YES	0
15	5/9/2000 20:00	80	0.0	0.0	0.0	0.0	No	YES	0
16	5/13/2000 4:05	138	0.0	0.0	0.0	0.0	No	YES	0
17	5/18/2000 22:00	90	1.9	44.0	1.1	4.3	Yes	YES	0
18	5/23/2000 0:00	60	0.1	0.0	0.0	0.0	No	YES	0
19	5/26/2000 11:50	85	0.0	0.0	0.0	0.0	No	YES	0
20	6/14/2000 18:00	51	1.7	42.9	1.6	3.5	Yes	NO	0
21	6/16/2000 21:00	99	8.2	196.6	14.1	58.2	Yes	YES	1.3
22	6/21/2000 0:00	91	1.8	77.9	1.2	4.7	Yes	YES	0
23	6/24/2000 19:00	35	0.1	0.0	0.0	0.0	No	YES	0
24	6/26/2000 6:00	105	5.8	155.8	7.6	33.1	Yes	YES	0
25	7/5/2000 4:00	82	1.0	29.7	0.6	2.0	Yes	YES	0

ATTACHMENT 1[A,B]

Wetland Performance, by Storm Event

Event	Date	Duration (HR)	Max Depth (FT)	Max Inflow (MGD)	Avg Flow (MGD)	Treated Volume (MG)	Wetland Operated?	Completely Drained?	Volume Exceeded (MG)
26	7/19/2000 0:00	101	3.9	165.7	3.8	16.2	Yes	YES	0
27	7/29/2000 11:00	81	0.1	0.0	0.0	0.0	No	YES	0
28	8/3/2000 19:00	81	0.0	0.0	0.0	0.0	No	YES	0
29	8/7/2000 4:00	5	0.0	0.0	0.0	0.0	No	YES	0
30	8/7/2000 11:00	82	0.0	0.0	0.0	0.0	No	YES	0
31	8/18/2000 2:00	92	2.3	50.3	1.6	6.1	Yes	YES	0
32	8/23/2000 9:00	89	5.4	154.4	7.6	28.3	Yes	YES	0
33	8/27/2000 2:00	91	6.5	166.6	10.3	39.0	Yes	YES	0
34	9/9/2000 12:00	64	1.1	64.9	1.5	4.0	Yes	NO	0
35	9/12/2000 4:00	74	5.5	174.0	10.3	31.7	Yes	YES	0
36	9/20/2000 18:00	90	1.9	79.0	1.3	5.0	Yes	YES	0
37	9/25/2000 7:00	81	6.2	192.5	10.4	35.2	Yes	YES	0
38	10/5/2000 21:15	184	0.1	0.0	0.0	0.0	No	YES	0
39	10/13/2000 16:00	89	5.3	94.7	6.9	25.6	Yes	YES	0
40	10/17/2000 9:00	479	0.1	0.9	0.0	0.1	Yes	YES	0
41	11/6/2000 9:00	60	1.0	16.6	0.7	1.8	Yes	NO	0
42	11/8/2000 21:00	76	3.7	137.8	6.3	20.0	Yes	YES	0
43	11/13/2000 5:00	282	0.1	0.0	0.0	0.0	No	YES	0
44	11/24/2000 23:00	91	2.3	93.1	1.7	6.6	Yes	YES	0
45	12/11/2000 8:00	50	4.7	132.9	7.4	15.4	Yes	NO	0
46	12/13/2000 10:00	58	4.1	25.7	4.2	10.3	Yes	YES	0
47	12/16/2000 2:00	98	3.1	94.2	2.8	11.6	Yes	YES	0

[a] Highlighting denotes that the wetland capacity was exceeded. "Exceeded" means that a portion of the influent would simply receive less than 48 hours detention time in the wetland. All wetland effluent receives disinfection.

[b] Red font and underlining denotes that the wetland was unable to completely drain prior to the start of the next event.

Figure 1

East Wetland/WWTP Treatment, No Bypass between Plant and Wetland

Model Schematics

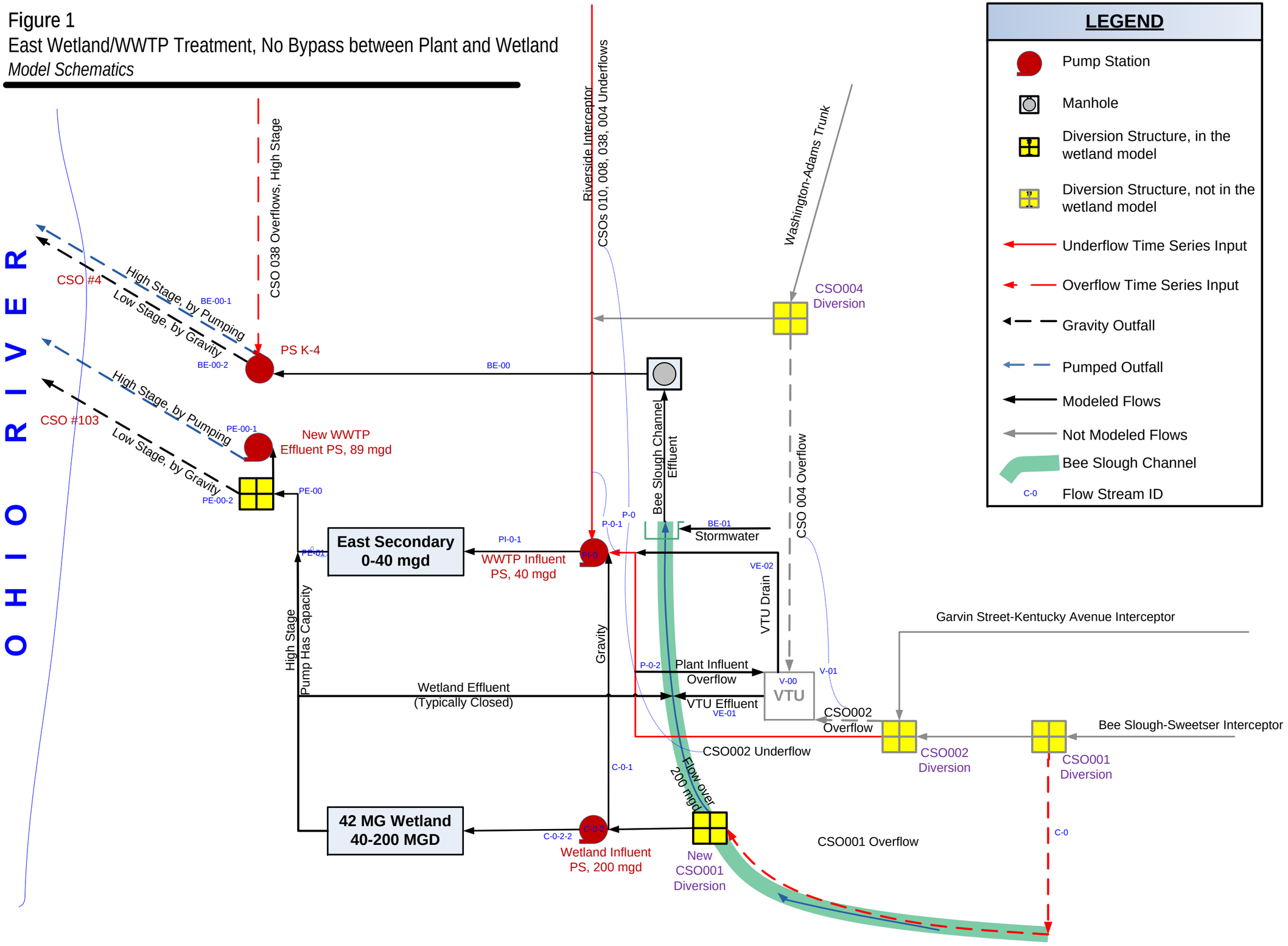


Figure 2
Model Network and Layout
Model Schematics



APPENDIX F

System-wide Tunnel Screening Analysis Technical Memorandum

System-wide Tunnel Screening Analysis

COPY TO: File

PREPARED BY: Kisch Elsenbroek
Lynn Wile

DATE: November 30, 2012

PROJECT NUMBER: 424722

This technical memorandum summarizes the system-wide tunnel evaluation completed as part of the Evansville Water and Sewer Utility (EWSU) Long-term Control Plan (LTCP) and Integrated Overflow Control Plan (IOCP) development.

Evaluation Methodology

The project team reviewed system-wide tunnel storage in conjunction with the conveyance, storage, and treatment alternatives considered as part of the LTCP alternatives analysis. The tunnel alternative evaluation assumed that a tunnel would serve both the West and East Service Areas to capture flows from EWSU combined sewer overflow (CSO) structures.

The system-wide tunnel storage system evaluation consisted of the following steps:

- Developed conceptual tunnel alignment (Figure 1) and determined the corresponding tunnel length.
- Determined the tunnel storage volume that would be provided by pipe diameters ranging from 12 feet to 25 feet.
- Determined the storage requirement for a tunnel project that would achieve a level of control similar to that of the recommended alternative (approximately 90 percent capture and 15 activations) summarized in the Draft LTCP (CH2M HILL, 2012a).
- Calculated the capital cost estimate for the tunnel project.

Capital costs were calculated using CH2M HILL's Program Alternative Cost Calculator (PACC) tool, as described in the IOCP Development Cost Estimating Guidelines (CH2M HILL, 2012b). The PACC tool was used to develop the numerous cost estimates prepared as part of the alternatives analysis; as a result, the tunnel costing method, unit costs, and markups were consistent with those used for other alternatives.

Assumptions

Key assumptions for evaluation of the tunnel alternative were as follows:

- The tunnel would capture flows from all CSO structures, with the exception of CSO 011 (Oakhill/Weinbach).
- Treatment for all combined sewage stored in the tunnel would be provided at the East Wastewater Treatment Plant (WWTP).
- Expanding the East WWTP to a capacity of 60 million gallons per day (MGD) may be required to dewater and treat flow conveyed by, and stored in, the tunnel within a 2-day period.

Level of Control

Based on the 34,000-linear-foot (LF) alignment presented in Figure 1, a 25-foot-diameter tunnel would provide a storage volume of approximately 125 million gallons (MG).

During a typical year, the tunnel alternative estimated level of control is:

- 94% capture
- 15 system activations per year

Similar performance would be expected from either the system-wide tunnel alternative or the recommended plan summarized in the Draft LTCP (CH2M HILL, 2012a).

Cost

For a soft-ground tunnel, the tunnel should be constructed at a depth at least two tunnel diameters below the ground surface, and one tunnel diameter above bedrock. Bedrock in the Evansville area is approximately 80 feet below ground, so a soft ground tunnel would be limited to a maximum diameter of approximately 20 feet. As a result, the capital cost was calculated based on a deep bedrock tunnel:

- 34,000 LF of 25–foot-diameter tunnel
- Estimated depth of 200 feet
- Installed in bedrock
- 4 launch shafts
- 10 receiving shafts
- 10 drop shafts
- 60-MGD dry well/ wet well style dewatering pump station
- Estimate of near-surface work to direct CSO overflow into the tunnel

The tunnel project cost estimate, excluding the necessary treatment plant expansion, exceeds $682 million. The cost breakdown is provided in Appendix A.

For comparison purposes, the tunnel project cost and the cost for the Draft LTCP-recommended projects associated with CSO storage and treatment (Control Measures 1, 11, 12, 13, 14, 15, 16, 17, 18, and 19) (CH2M HILL, 2012a, Table 3-21 [attached]) are presented in Table 1.

TABLE 1
CSO Storage/Treatment Project Comparison

System Alternative	% Capture	Activations	Estimated Capital Cost
Tunnel	94	15	$682,300,000[a,b]
Recommended LTCP Storage/Treatment Projects	90	15	$480,200,000[c]

[a] Excludes the cost to expand the East WWTP to treat tunnel flows. Cost differential will be greater than noted.
[b] Cost breakdown provided in Appendix A
[c] LTCP costs originally presented in the Draft LTCP (CH2M HILL, 2012a) and are summarized in attached Table 3-21

In addition to the costs noted above, each alternative would also include the following projects detailed in the attached table:

- Partial Sewer Separation (Control Measures 7 and 10)
- Green Infrastructure (Control Measure 8)
- Existing 7th Avenue Lift Station Upgrade (Control Measure 4)
- Pigeon Creek Interceptor Optimization and Real-Time Control (RTC) (Control Measure 5)
- CSO Diversion Structure Weir Optimization (Control Measure 6)
- Sanitary Sewer System (SSS) Rehabilitation (Control Measure 9)
- SSS Investigation (Control Measure 20)
- West WWTP headworks expansion for more consistent treatment performance (Control Measure 3)

Additional Risk Factors

In addition to the higher costs that would be associated with a tunnel alternative, the physical landscape and existing development of Evansville may present construction difficulties that are not reflected in the cost estimate. The following factors are considered potential additional risk factors associated with the tunnel alternative:

- The tunnel alignment is located close to the Ohio River and earthen levee.
- The proposed tunnel alignment parallels and crosses the levee multiple times.
- Numerous old coal mines are present in the area of the tunnel.
- Evansville is located in the New Madrid & Wabash Valley Seismic Zones.
- Geology has not been fully evaluated.
- Contaminated soils could be encountered.
- Space for access points (such as drop shafts) is limited due to existing development, and easement acquisition may be necessary.
- Haul distances were not determined, as dump site locations were not verified.
- Odor control at each drop shaft location in urban and residential areas was not evaluated.
- Diversion structure locations and condition of the existing system at connecting locations not determined
- Construction of consolidation sewers in somewhat restricted areas would be difficult.
- Groundwater influence from the river may complicate tunnel construction.
- Actual depths required for connector sewers may need to be lower than estimated to address crossing conditions at creeks, freeways, and railroads, and also to address hydraulic conditions that would be determined during early detail design stages.

Conclusions

The tunnel alternative is estimated to cost over $200 million more than the recommended alternative presented in the Draft LTCP. With the addition of the East WWTP expansion costs, the tunnel alternative cost would be significantly higher than the cost of the LTCP-recommended plan. As a result of the significantly higher tunnel alternative cost and the additional risk factors noted above, the tunnel alternative was eliminated from further consideration.

References Cited

CH2M HILL. 2012a. *DRAFT Long-Term Control Plan.* July 31.
CH2M HILL. 2012b. *IOCP Development Cost Estimating Guidelines.* May 25.

Table 3-21 CIP Summary for Alternative 1030/7A

Control Measure		Alternative 1030 / 7A	
		Description	**Project Capital Cost**
1	Bee Slough Restoration and CSO Treatment	Convey flow from CSO 001 to a new 100mgd CSO pump station. where it is directed to wetlands adjacent to the East WWTP and disinfection by UV. Convey flow from CSO 002 and CSO 004 into a vertical treatment unit for treatment and disinfection prior to discharge.	$126,832,000
2	East WWTP Improvement Projects	Rehab existing chlorine contact tank to increase treatment capacity to 40 MGD and convert to sodium hypochlorite disinfection	$2,160,000
3	West WWTP Improvement Projects	Construct new primary treatment bypass structure and pipe. West WWTP Secondary Processes. Convert disinfection system to liquid chlorine. Replace existing headworks to expand capacity to 45 MGD	$22,170,000
4	7th Avenue Lift Station Upgrade Project	Add back up power and redundant screening to existing 7th Ave Lift Station	$13,000,000
5	Pigeon Creek Interceptor Optimization and RTC Projects	Automated control of overflow gates to optimize in system storage. New Pigeon Creek relief sewer. Clean existing Pigeon Creek Interceptor.	$10,000,000
6	CSO Diversion Structure Weir Optimization Projects	Raise weirs in system to optimize in system storage. Increase St. Joe underflow pipe to 36".	$2,064,000
7	Diamond Avenue Partial Sewer Separation Projects	Replace existing piping to separate storm and sanitary systems.	$15,600,000
8	Phase 1 Green Infrastructure Projects	Construct gray improvements to interceptors along Riverside Dr.; 100% capture of CSO 011	$11,000,000
9	SSS Rehabilitation Projects	Point repairs, inflow reduction projects, CIPP, manhole rehabilitation, and post construction flow monitoring.	$24,412,000
10	Partial Sewer Separation Projects	Replace existing piping to separate storm and sanitary systems in Akin Park, State Hospital Lake Pump Station, Weinbach & Booked, and Weinbach & Keck.	$12,402,000
11	Downtown CSOs (Oak/Riverside, Chestnut, and Dress Plaza) Control Projects	3.55 MG Vertical Storage facility with odor control. Lift station for storage and conveyance line. 2.19 MG Storage Facility with odor control. Lift station and conveyance for storage. Underground Storage facility with odor control. Conveyance line to storage and lift station for draining.	$41,172,000
12	7th Avenue Lift Station/Fulton Avenue CSO Control Projects	Expand LS to 45 MGD for 7th Ave LS and Fulton Avenue CSO; replace force main between 7th Ave LS and Broadway Interceptor	$79,373,000
13	9th Avenue CSO Control Project	20 MGD lift station with force main discharge to Broadway interceptor downstream of St. Joe (CSO 022)	$7,755,000
14	West WWTP Flow Equalization	5 MG Storage. With gravity pipes in and out.	$17,028,000
15	Oak Hill CSO Control Projects	Construct 2.87 MG Storage Facility with dewatering lift station and odor control	$12,797,000
16	Diamond Avenue/Baker Street CSO Control Projects	10 MG storage facility (two 5 MG vertical storage units) and 10 MGD High Rate treatment (Actiflo type unit). 50 MGD pump station into storage and 5 MGD pump station at Baker.	$65,270,000
17	Oakley Street/6th Avenue CSO Control Projects	1 MG Below Ground Storage Facility	$9,280,000
18	Dresden/Maryland/Delaware CSO Control Projects	Redirect Maryland and tunnel under pigeon creek. 3 MG storage tank with 50 MGD lift station and 10 MGD Height Rate Treatment (Actiflo Type) located on Cytex property for Maryland; 0.5 MG Above Ground Storage with 2 MGD pump station at Dresden; 5 MG of Vertical Storage with a separate 50 MGD lift station. 10 MGD HRT (Actiflo type) facility Open Cut Sewer used for gravity connections from existing diversion structures to lift station. at Delaware	$112,627,000
19	Franklin Street CSO Relief Sewer	Convey flow to 7th Ave lift station	$8,089,000
20	SSS Investigation Projects	Complete manhole inspection, smoke testing, clean and CCTV sewers, and compete flow monitoring.	$12,716,970
		Total Alternative Capital Cost	**$605,748,000**
		System Percent Capture	90%
		System Activations	15

LEGEND

- Drop Shafts
- Tunnel Alternative
- CSO
- Wastewater Treatment Plant
- Trunk/Interceptor Sewer
- Hydrography
- Combined Sewer Boundary

N

0 1,500 3,000

Feet

FIGURE 1
Evansville Tunnel Alternative
Long-Term Control Plan

LEGEND

- Drop Shafts
- Tunnel Alternative
- VanderburghMines
- W CSO
- 3 Wastewater Treatment Plant
- Trunk/Interceptor Sewer
- Hydrography
- Combined Sewer Boundary

N

0 1,500 3,000

Feet

FIGURE 2
Evansville Tunnel Alternative
Long-Term Control Plan

Appendix A
Tunnel Project Cost Breakdown

Program Alternative Cost Calculator

CSO CONTROL PROGRAM

Project Cost Summary Sheet

Version 2012

Project ID: ***East West Tunnel***

Description: System wide tunnel to collect flows for all CSO except Oakhill/Weinbach. Estimate includes rough assumption of work related to connecting the CSOs to the drop shafts.

Prepared By: Kisch Elsenbroek, P.E. CH2M HILL Estimate Date: 11/13/2012

Checked By: Matt Thomas, P.E. CH2M HILL Printed Date: 11/27/2012

Cost Estimate Description		Totals
Estimated Open Cut Sewer Construction Cost	$	10,030,000
Estimated Tunneling Construction Cost	$	411,282,000
Estimated Building Separation Cost	$	-
Estimated Off-line Storage Facilities Construction Cost	$	-
Estimated Rehabilitation Cost	$	-
Estimated Pump Station Cost	$	36,221,000
Estimated Flow Control Structure	$	-
Estimated Bioretention Cost	$	-
Estimated Green Infrastructure (by Volume)	$	-
Estimated Green Infrastructure (by Area)	$	-
Estimated Force Main Cost	$	112,000
Estimated High Rate Treatment Cost	$	-
Estimated Screening Cost	$	-
Misc. Extra Cost Description:	$	-
Total Estimated Construction Cost =	**$**	**457,645,000**

Real Estate Costs Description			Totals
Easement Cost	# of Properties =	10	$ 175,965
Property Acquisition			$ 2,400,000
Misc. Extra Cost Description:			$ -
Total Additional Costs =			**$ 2,576,000**

Multipliers Description	Multiplier
Right-of-Way Costs	1%
Planning & Preliminary Design	4%
Design Services	10%
Administrative Costs	3%
Miscellaneous - PTI, test bore, ECI Inspector, R/W	2%
Capitalized Interest	3.3%
Field Engineering & Inspection	10%
Project Contingencies	15%
Total Multipliers =	**48%**

	PROJECT CAPITAL COST ESTIMATE =	$ 682,278,000
Data File ENRCCI in use 8301	**Project 25 Year Present Worth Estimate =**	$ 508,717,000

ENRCCI overwrite by Estimator 8301

PROJECT CAPITAL COST ESTIMATE =	**$**	**682,278,000**
Project 25 Year Present Worth Estimate =	**$**	**508,717,000**
Project Annual O&M =	**$**	**72,764**
Construction Cost Estimate =	**$**	**460,221,000**

Program Alternative Cost Calculator

CSO CONTROL PROGRAM

Project Values Summary Sheet

Value Description	Totals
Length of Open Cut Sewer Conveyance (Feet)	12,900
Length of Tunnel Sewer Conveyance (Feet)	36,900
Off-line Storage Annual Volume Stored (Million Gallons)	0
Off-line Storage Estimated # of Annual Occurrence	0
Flow Control Structure Annual Volume Stored (Million Gallons)	0
Flow Control Structure Estimated # of Annual Occurrence	0
Bioretention Structure Annual Volume Stored (Million Gallons)	0
Bioretention Structure Estimated # of Annual Occurrence	0
Green Infrastructure (by Volume) Total Volume (Gallons)	0
Green Infrastructure (by Area) (Square Feet)	0
Length of I/I Removal Lining (Feet)	0
Annual Volume of Pumping (Million Gallons)	21,900
Estimated Total Dynamic Head of Pumping (Feet)	0
Length of Force Main Conveyance (Feet)	100
Annual Volume of High Rate Treatment (Million Gallons)	0
High Rate Treatment Estimated # of Annual Occurrences	0
Screening Estimated # of Annual Occurrences	0
Screening Annual Volume Disinfected	0
Length of Sanitary Sewer Open Cut	50

OPEN CUT SEWER CONSTRUCTION VALUE ENTRY SHEET

Project ID: ***East West Tunnel***

Estimate Date: 11/13/2012

Printed Date: 11/27/2012

Prepared By: Kisch Elsenbroek, P.E. CH2M HILL

Costs here represent ENRCCI = 8301

(To Include in cost Insert Y or y for Yes)

Segment ID	*Pipe Size (in)	Length of Pipe in Street (ft)	Length of Pipe out of Street (ft)	**Average Depth (ft)	# of San. Service Laterals	# of Aband'd Inlets	# of New Inlets	# of Water Services Replaced	Street Width (ft)	# of Manholes	# of Junction Boxes	# of Existing MH Surface Rehabs	Small Medium or Large Creek Crossing (S,M, or L)	Sanitary Sewer Construction	In Rock	Dewatering Required	Maintenance of Flow	Brownfields	Clearing and Grubbing	Traffic Maintenance Required	Urban Alignment	Total Cost Per Segment
Kentucky to Dro	108	0	1400	15	0	0	0	0	0	0	1	0		N	N	y	y	N	y	N	N	$ 2,032,135
														N	N	y	y	N	y	y	N	$ -
														N	N	y	y	N	y	y	N	$ -
Fulton to Drop	48	1500	0	12	0	0	0	0	10	0	0	0		N	N	y	N	N	N	y	N	$ 933,776
9th to Drop	54	2000	0	15	0	0	0	0	10	0	0	0		N	N	y	y	N	N	y	N	$ 1,672,628
Franklin to Dro	60	1200	0	10	0	0	0	0	10	0	0	0		N	N	y	y	N	N	y	N	$ 819,750
														N	N	y	y	N	N	y	N	$ -
														N	N	y	y	N	N	y	N	$ -
Dresden to Dro	60	100	0	20	0	0	0	0	10	0	0	0		N	N	y	y	N	N	y	N	$ 117,555
6th to Drop	42	4500	0	10	0	0	0	0	10	0	0	0		N	N	y	y	N	N	y	N	$ 2,417,829
Oakley to Drop	60	2000	0	13	0	0	0	0	10	0	0	0		N	N	y	y	N	N	y	N	$ 1,631,922
Baker to Drop	66	100	0	25	0	0	0	0	10	0	0	0		N	N	y	y	N	N	y	N	$ 163,090
Diamond to Dro	90	100	0	30	0	0	0	0	10	0	0	0		N	N	y	y	N	y	N	N	$ 240,916
-	0	0	0	0	0	0	0	0	0	0	0	0		N	N	N	N	N	N	N	N	$ -
-	0	0	0	0	0	0	0	0	0	0	0	0		N	N	N	N	N	N	N	N	$ -
-	0	0	0	0	0	0	0	0	0	0	0	0		N	N	N	N	N	N	N	N	$ -
-	0	0	0	0	0	0	0	0	0	0	0	0		N	N	N	N	N	N	N	N	$ -
-	0	0	0	0	0	0	0	0	0	0	0	0		N	N	N	N	N	N	N	N	$ -
-	0	0	0	0	0	0	0	0	0	0	0	0		N	N	N	N	N	N	N	N	$ -
-	0	0	0	0	0	0	0	0	0	0	0	0		N	N	N	N	N	N	N	N	$ -
-	0	0	0	0	0	0	0	0	0	0	0	0		N	N	N	N	N	N	N	N	$ -
-	0	0	0	0	0	0	0	0	0	0	0	0		N	N	N	N	N	N	N	N	$ -
-	0	0	0	0	0	0	0	0	0	0	0	0		N	N	N	N	N	N	N	N	$ -
-	0	0	0	0	0	0	0	0	0	0	0	0		N	N	N	N	N	N	N	N	$ -
-	0	0	0	0	0	0	0	0	0	0	0	0		N	N	N	N	N	N	N	N	$ -
-	0	0	0	0	0	0	0	0	0	0	0	0		N	N	N	N	N	N	N	N	$ -
-	0	0	0	0	0	0	0	0	0	0	0	0		N	N	N	N	N	N	N	N	$ -
-	0	0	0	0	0	0	0	0	0	0	0	0		N	N	N	N	N	N	N	N	$ -
-	0	0	0	0	0	0	0	0	0	0	0	0		N	N	N	N	N	N	N	N	$ -
-	0	0	0	0	0	0	0	0	0	0	0	0		N	N	N	N	N	N	N	N	$ -
-	0	0	0	0	0	0	0	0	0	0	0	0		N	N	N	N	N	N	N	N	$ -
-	0	0	0	0	0	0	0	0	0	0	0	0		N	N	N	N	N	N	N	N	$ -
-	0	0	0	0	0	0	0	0	0	0	0	0		N	N	N	N	N	N	N	N	$ -
-	0	0	0	0	0	0	0	0	0	0	0	0		N	N	N	N	N	N	N	N	$ -
-	0	0	0	0	0	0	0	0	0	0	0	0		N	N	N	N	N	N	N	N	$ -
-	0	0	0	0	0	0	0	0	0	0	0	0		N	N	N	N	N	N	N	N	$ -
-	0	0	0	0	0	0	0	0	0	0	0	0		N	N	N	N	N	N	N	N	$ -
-	0	0	0	0	0	0	0	0	0	0	0	0		N	N	N	N	N	N	N	N	$ -

Project ID: ***East West Tunnel***

Estimate Date: 11/13/2012

Printed Date: 11/27/2012

Prepared By: Kisch Elsenbroek, P.E. CH2M HILL

Costs here represent ENRCCI = 8301

(To Include in cost Insert Y or y for Yes)

Segment ID	*Pipe Size (in)	Length of Pipe in Street (ft)	Length of Pipe out of Street (ft)	**Average Depth (ft)	# of San. Service Laterals	# of Aband'd Inlets	# of New Inlets	# of Water Services Replaced	Street Width (ft)	# of Manholes	# of Junction Boxes	# of Existing MH Surface Rehabs	Small Medium or Large Creek Crossing (S,M, or L)	Sanitary Sewer Construction	In Rock	Dewatering Required	Maintenance of Flow	Brownfields	Clearing and Grubbing	Traffic Maintenance Required	Urban Alignment	Total Cost Per Segment
-	0	0	0	0	0	0	0	0	0	0	0	0		N	N	N	N	N	N	N	N	$ -
-	0	0	0	0	0	0	0	0	0	0	0	0		N	N	N	N	N	N	N	N	$ -
-	0	0	0	0	0	0	0	0	0	0	0	0		N	N	N	N	N	N	N	N	$ -
-	0	0	0	0	0	0	0	0	0	0	0	0		N	N	N	N	N	N	N	N	$ -
-	0	0	0	0	0	0	0	0	0	0	0	0		N	N	N	N	N	N	N	N	$ -
-	0	0	0	0	0	0	0	0	0	0	0	0		N	N	N	N	N	N	N	N	$ -
-	0	0	0	0	0	0	0	0	0	0	0	0		N	N	N	N	N	N	N	N	$ -
-	0	0	0	0	0	0	0	0	0	0	0	0		N	N	N	N	N	N	N	N	$ -
-	0	0	0	0	0	0	0	0	0	0	0	0		N	N	N	N	N	N	N	N	$ -
-	0	0	0	0	0	0	0	0	0	0	0	0		N	N	N	N	N	N	N	N	$ -
-	0	0	0	0	0	0	0	0	0	0	0	0		N	N	N	N	N	N	N	N	$ -
-	0	0	0	0	0	0	0	0	0	0	0	0		N	N	N	N	N	N	N	N	$ -
-	0	0	0	0	0	0	0	0	0	0	0	0		N	N	N	N	N	N	N	N	$ -
-	0	0	0	0	0	0	0	0	0	0	0	0		N	N	N	N	N	N	N	N	$ -
-	0	0	0	0	0	0	0	0	0	0	0	0		N	N	N	N	N	N	N	N	$ -
-	0	0	0	0	0	0	0	0	0	0	0	0		N	N	N	N	N	N	N	N	$ -

Total Cost for Construction = $ 10,029,602

Check to Exclude x **Sm Job Multiplier =** 0%

12,900 **= Total Length of Open Cut Job**

0 **= Total Length of Sanitary Sewer**

Estimated Total Sewer Construction Cost = $ 10,029,602

* - Use standard pipe sizes with maximum pipe size of 144 inches

** - Minimum depth is 5 feet. For depths that are greater than 25 feet use Tunneling worksheet

TUNNELING VALUE ENTRY SHEET

Project ID: ***East West Tunnel***

Estimate Date: 11/13/2012

Printed Date: 11/27/2012

Prepared By: Kisch Elsenbroek, P.E. CH2M HILL

Costs here represenrt ENRCCI = 8301

Segment ID	*Pipe Size (in)	Length of Pipe (ft)	Average Depth (ft)	# of Launching Shafts (Tunneling)	# of Receiving Shafts (Tunneling)	# of Access Shafts (TBM)	# of Small (Q<12 MGD) Deep Tunnel Dropshaft Complexes (TBM)	# of Large (Q>12 MGD) Deep Tunnel Dropshaft Complexes (TBM)	Auger Bore (6" - 54") **	Microtunneling (21" - 84")	TBM Tunneling (42"-384")	Rock, Mixed-face (Bore Only)	Excl. Shafts (Bore Only)	Grade > 2% (Bore only)	Mixed-face (Tunnelings)	Pit or Shaft in St. (Trfc. Maint.)	Dewatering Required	R/R or Freeway Crossing	Brownfields	Urban Alignment	Total Cost Per Segment
Cass to Adams	300	3,100	200	1	0	0	0	1			x						x	x			$ 38,738,664
Cass to Kentucky	300	1,100	200	0	0	0	0	1			x						x	x			$ 20,473,174
Adams to Dress Plaza	300	4,200	200	0	0	0	0	1			x					x	x	x			$ 45,336,911
Dress Plaza to 7th Ave	300	2,800	200	0	0	0	0	1			x					x	x	x			$ 34,190,680
7th Ave to Delaware	300	3,000	200	0	0	0	0	1			x						x	x			$ 35,466,335
Maryland to delaware	300	1,700	200	1	0	0	0	1			x						x	x			$ 27,691,073
Delaware to Dresden	300	3,500	200	0	0	0	0	1			x						x	x			$ 39,411,903
Dresdent to Baker	300	6,100	200	0	0	0	0	1			x					x	x	x			$ 60,463,939
Baker to Diamond	300	2,100	200	1	0	0	0	1			x						x	x			$ 30,847,527
7th to St. Joe	300	4,400	200	1	0	0	0	1			x					x	x	x			$ 49,434,617
to Retreival shaft	300	1,000	200	0	0	0	0	1			x					x	x	x			$ 19,859,811
-	0	0	0	0	0	0	0	0													$ -
-	0	0	0	0	0	0	0	0													$ -
Chestnut to Adams	96	2500	30		0	0	0	0			x						x				$ 6,227,749
Dress to Drop	84	400	30		0	0	0	0		x							x				$ 910,363
Delaware to Drop	60	100	35		0	0	0	0		x							x				$ 171,957
Marylnad to Drop	84	800	30		0	0	0	0		x							x				$ 1,820,725
Diamond to Drop	90	100	30		0	0	0	0			x						x				$ 236,263
-	0	0	0	0	0	0	0	0													$ -
-	0	0	0	0	0	0	0	0													$ -
-	0	0	0	0	0	0	0	0													$ -
-	0	0	0	0	0	0	0	0													$ -
-	0	0	0	0	0	0	0	0													$ -
-	0	0	0	0	0	0	0	0													$ -
-	0	0	0	0	0	0	0	0													$ -

Total Cost for Construction = $ 411,281,691

36,900 **= Total Length of Tunnel Job**

Check to Exclude ☐ **Small Job Multiplier =** 0%

Estimated Total Tunneling construction Cost = $ 411,281,691

* - Use standard pipe sizes

** - Auger Bore maximum depth of 25 feet

PUMP STATIONS VALUE ENTRY SHEET

Project ID: ***East West Tunnel***

Estimate Date: 11/13/2012

Printed Date: 11/27/2012

Prepared By: Kisch Elsenbroek, P.E. CH2M HILL

Costs here represent ENRCCI = 8301

Facility ID	**Estimated Depth (ft)	Estimated Total Head (ft)	*Estimated Peak Flow Rate (MGD)	Dry Well/Wet Well PS	Submersible PS	***In Rock	Odor Control	Grinders Required	Number of Grit Pits Included	Dewatering Required	Brownfields	Exclude Structure (-%)	Total Cost Per Facility	
-	225	0	60.000	x			x					0%	$ 36,221,286	
-	0	0	0.000									0%	$ -	Must Select One PS Element
-	0	0	0.000									0%	$ -	Must Select One PS Element
-	0	0	0.000									0%	$ -	Must Select One PS Element
-	0	0	0.000									0%	$ -	Must Select One PS Element
-	0	0	0.000									0%	$ -	Must Select One PS Element
-	0	0	0.000									0%	$ -	Must Select One PS Element
-	0	0	0.000									0%	$ -	Must Select One PS Element
-	0	0	0.000									0%	$ -	Must Select One PS Element
-	0	0	0.000									0%	$ -	Must Select One PS Element
-	0	0	0.000									0%	$ -	Must Select One PS Element

Enter Description if Exclude Structure -% used:

Estimated Total DW/WW Pump Station Construction Cost = $ 36,221,286

Estimated Total Submersible Pump Station Construction Cost = $ -

Estimated Total Pump Station Construction Cost = $ 36,221,286

* - Pump station cost curve limits out at 200 MGD. If over 200 MGD use multiple pump stations and do not check box any extras or reenter the same depth.
** - Cost per linear foot increases at depths of 20, 50, 100 and 150 feet.
*** - Being in rock is beneficial at depths greater than 50 feet. In Rock should not be checked at these depths.

FORCE MAIN CONSTRUCTION VALUE ENTRY SHEET

Project ID: ***East West Tunnel***

Estimate Date: 11/13/2012

Printed Date: 11/27/2012

Prepared By: Kisch Elsenbroek, P.E. CH2M HILL

Segment ID	*Pipe Size (in)	Length of Pipe in Street (ft)	Length of Pipe out of Street (ft)	Average Depth (ft)	# of Utility crossings	Street Width (ft)	# of Manholes	# of Air Release Valves	Small Medium or Large Creek Crossing (S,M, or L)	Dewatering Required	Brownfields	Clearing and Grubbing	Traffic Maintenance Required	Total Cost Per Segment
A	54	0	100	10	0	0	0	0		x				$ 112,333
B	0	0	0	0	0	0	0	0						$ -
C	0	0	0	0	0	0	0	0						$ -
D	0	0	0	0	0	0	0	0						$ -
E	0	0	0	0	0	0	0	0						$ -
F	0	0	0	0	0	0	0	0						$ -
G	0	0	0	0	0	0	0	0						$ -
H	0	0	0	0	0	0	0	0						$ -
I	0	0	0	0	0	0	0	0						$ -
J	0	0	0	0	0	0	0	0						$ -
K	0	0	0	0	0	0	0	0						$ -
L	0	0	0	0	0	0	0	0						$ -
M	0	0	0	0	0	0	0	0						$ -
N	0	0	0	0	0	0	0	0						$ -
O	0	0	0	0	0	0	0	0						$ -
P	0	0	0	0	0	0	0	0						$ -
Q	0	0	0	0	0	0	0	0						$ -
R	0	0	0	0	0	0	0	0						$ -
S	0	0	0	0	0	0	0	0						$ -
T	0	0	0	0	0	0	0	0						$ -
U	0	0	0	0	0	0	0	0						$ -
V	0	0	0	0	0	0	0	0						$ -
W	0	0	0	0	0	0	0	0						$ -
B	0	0	0	0	0	0	0	0						$ -
C	0	0	0	0	0	0	0	0						$ -
D	0	0	0	0	0	0	0	0						$ -
E	0	0	0	0	0	0	0	0						$ -
F	0	0	0	0	0	0	0	0						$ -
G	0	0	0	0	0	0	0	0						$ -
H	0	0	0	0	0	0	0	0						$ -
I	0	0	0	0	0	0	0	0						$ -
J	0	0	0	0	0	0	0	0						$ -
K	0	0	0	0	0	0	0	0						$ -
L	0	0	0	0	0	0	0	0						$ -
M	0	0	0	0	0	0	0	0						$ -
N	0	0	0	0	0	0	0	0						$ -
O	0	0	0	0	0	0	0	0						$ -
P	0	0	0	0	0	0	0	0						$ -
Q	0	0	0	0	0	0	0	0						$ -
R	0	0	0	0	0	0	0	0						$ -
S	0	0	0	0	0	0	0	0						$ -
T	0	0	0	0	0	0	0	0						$ -
U	0	0	0	0	0	0	0	0						$ -
V	0	0	0	0	0	0	0	0						$ -
W	0	0	0	0	0	0	0	0						$ -
X	0	0	0	0	0	0	0	0						$ -
Y	0	0	0	0	0	0	0	0						$ -

*Note - pipe diamteres range from 6" to 120". If a larger forcemain than 48" may be required it is recommended that the estimator cost out dual forcemains of smaller diameter.

100 **= Total Length of Force Mair**

Estimated Total Force Main Construction Cost = $ 112,333

APPENDIX G

Alternative Benefit Scoring Technical Memorandum

Alternative Benefit Scoring

PREPARED FOR: Evansville Water & Sewer Utility

PREPARED BY: Lynn Wile/CH2M HILL

DATE: Revised June 13, 2013

This technical memorandum (TM) summarizes the benefit scoring evaluation for the West and East System alternatives evaluated as part of the Integrated Overflow Control Plan (IOCP) detailed alternatives evaluation. The scoring criteria and methodology were previously described in the *CSO Alternative Screening Report* (CH2M HILL, 2012) and are summarized within this TM.

Summary of Alternatives

As part of the IOCP evaluation, several alternatives were selected for a more detailed evaluation following the alternative screening evaluation. The alternative screening resulted in identification of the following alternatives for further evaluation:

- **West Storage/HRT** (West 1-45) – An alternative that includes distributed storage, two HRT facilities, additional PCI conveyance, and West WWTP expansion
- **West Parallel PCI Relief** (West 1-60) – An alternative similar to the storage/HRT alternative, but with PCI conveyance sized in a manner to eliminate the distributed storage and HRT facilities
- **West Tunnel** – An alternative consisting of West WWTP expansion and a storage/transmission tunnel to replace the Pigeon Creek Relief Sewer and minimize or eliminate collection system storage basins and treatment units
- **East Storage/WWTP** (East 1) – An alternative providing secondary treatment at the East WWTP, storage basins for downtown CSOs (038, 008, 010, and 011), and a combination of storage and treatment for the Bee Slough CSOs (001, 002, and 004)
- **East Storage/HRT/Wetlands** (East 3) – An alternative providing secondary treatment at the East WWTP, storage basins for downtown CSOs (038, 010, and 011), wetland treatment for CSO 001, and storage and HRT for the other Bee Slough CSOs (002 and 004)
- **East Tunnel** – An alternative providing secondary treatment at the East WWTP, but with a storage/transmission tunnel to minimize or eliminate collection system storage basins and treatment units

The detailed assessment of the above listed alternatives included an evaluation of the technical feasibility and applicability of each project identified for each CSO outfall or groupings of outfalls. The listed alternatives were refined through additional modeling and site-specific analysis to develop a range of sizes to achieve the following system wide levels of control, as required per Appendix C, Section I, Paragraph 3:

- Number of annual untreated Typical Year discharges: 0, 1, 3, 4, 7, 8, and 12
- Percent capture for treatment: 100%, 90%, 85%, 80%, and 75%;

Benefit metrics were developed for the CSO technology screening, and subsequent alternatives evaluation, to objectively assess the benefits of the CSO controls. Benefit scoring was completed based on the merits of each particular alternative, regardless of the level of control provided.

Development of Benefit Metrics

Four primary screening categories were identified to evaluate the ability of the CSO technologies to meet the goals and objectives of the public and the Utility, as well as to address the requirements of the National CSO Policy (EPA, 1994) and the Consent Decree:

- **Performance Factors**—Gauge the effectiveness of the CSO technologies in reducing water quantities (discharged at the CSO structures, conveyed through the sewer system, or treated at the WWTPs). Performance factors are also used to evaluate the ability of a technology to improve water quality.
- **Implementation and Operation Factors**—Evaluate the ease of permitting, constructing, and operating the specific CSO technologies.
- **Safety Factors**—Assess the risks and potential safety hazards to Utility staff and public.
- **Community Impacts**—Evaluate the potential social and environmental effects on the community or neighborhoods of the various CSO technologies.

Benefit Screening Criteria

Specific benefit evaluation criteria were identified within each category. The criteria were selected by the Utility during a workshop held on January 11, 2012. These criteria, and a description regarding the application and consideration of each, are provided in Table 1.

Benefits of CSO control anticipated by the public represented in the Citizens Advisory Committee (CAC) were combined with the requirements of the National CSO Policy (EPA, 1994) and the Consent Decree to define the criteria used in control screening and throughout the alternatives evaluation. These criteria are summarized in Table 1.

Table 1 **Benefit Screening Evaluation Criteria**

Category/Criteria		Criteria Considerations
Performance Factors	Reduces combined sewer overflow volume	If the technology were to be implemented, could it reduce CSO volumes?
	Reduces runoff volume	Would this technology help reduce runoff volume for a service area where it may be implemented?
	Reduces frequency of untreated discharges	Would this technology reduce the number of CSO, SSO, or CSS releases?
	Reduces wet weather flows in system	Would this technology prevent wet weather flows from entering the sewer system?
	Reduces suspended solids	Would implementation of this technology reduce the suspended solids being released into the water bodies?
	Reduces bacteria	Would this technology reduce the amount of bacteria that enter the water bodies?

	Reduces floatables/trash	Would Does this technology keep floatables and trash from entering the waterways?
Implementation and Operation Factors	Enhances Nine Minimum Controls	Would this alternative contribute to achieving the Nine Minimum Controls?
	Maximize use of existing infrastructure Reliability	Would the proposed technology have the ability to use available capacity that exists within the collection or treatment system? Is this technology tested in other similar situations? Is the equipment mechanically reliable?
	Flexibility (possibility of future expansion)	Would future expansion of the technology be possible?
	Land requirements	How much land does this require?
	Constructability	How difficult is the construction of this technology?
	Simplicity of operation and maintenance	Will operations require more staff or additional certifications or equipment? How often does it need to be maintained?
	Implementation time	How long from start until technology is fully functional?
	Synergy with other needs	Can this project be conducted with another department? Does it correspond to another city goal? Is there a project currently on the shelf using this technology?
Safety	Human health & safety (basement backups, street flooding, etc.)	Would this technology decrease the potential for exposure to raw sewage? Are there risks to the public or Utility staff due to potential exposure to chemicals? Does this technology pose unique risks to Utility personnel or the public?
	Emergency response time (street flooding, etc.)	Would this technology potentially improve emergency response time to a certain area by reducing street flooding?
Community Impacts	Protection of historical and cultural resources	Would the area the technology is being built in, or have an impact upon, have an effect on historic landmarks?
	Protection of environmental resources	Would this technology help the environment when implemented (flora, fauna, and water)?
	Short-term (noise, truck traffic, siting, etc.)	Would this technology have construction impacts that would disrupt a neighborhood?
	Long-term (open space creation, recreational opportunities, aesthetic improvements, etc.)	Could this technology be combined with community improvements, in order to make the community a better place than before it was implemented?

Benefit Criteria Weighting

Each of the screening categories and criteria were weighted based on the goals and objectives of the LTCP. The Utility and public place a high value upon public safety and neighborhood impacts, and it was determined that public safety and community improvements associated with the LTCP may best be achieved by:

- Reducing WWFs that contribute to SSOs, CSS releases, and flooding (street and basement)
- Reducing the quantity and volume of CSO discharges to achieve water quality improvements in Pigeon Creek and the Ohio River, thus reducing health concerns and increasing the duration for safe recreational use
- Selecting technologies that improve water quality, either through effective treatment or overall reduction of CSO discharges

Efficient and effective implementation, performance, and operation of the technologies selected will be essential to achieving public safety and community improvements; therefore, the Performance and Implementation and Operation categories were weighted most heavily for benefit evaluation. This approach allows the Utility to meet the CD requirement to place the highest priority on controlling overflows to sensitive areas, achieve the IOCP objectives outlined above, and attain the resulting benefits to public safety and the community. The weighting assigned to the four categories is summarized in Table 2 and is described in more detail below.

TABLE 2
Criteria Category Weighting

Category	Weighting
Performance Factors	40%
Implementation and Operation Factors	30%
Safety	10%
Community Impacts	20%

Performance Factors

As described above, reducing the frequency and volume of untreated discharges are priorities to be addressed by the CSO control technologies. Reduction of bacteria is also desired, but that criterion was assigned a lower weighting based on the reasoning that reductions in CSO volume and frequency will result in water quality improvements. The weightings of the performance factors criteria are provided in Table 3.

TABLE 3
Performance Factors Criteria Weighting

Criteria	Weighting
Reduces combined sewer overflow volume	25%
Reduces runoff volume	15%
Reduces frequency of untreated discharges	25%
Reduces wet weather flows in system	15%
Reduces suspended solids	5%
Reduces bacteria	10%
Reduces floatables/trash	5%

Implementation and Operation

Table 4 summarizes the implementation and operation performance factors and assigned weighting. The ability to effectively implement and operate the technologies ultimately selected would greatly affect the ability of the Utility to achieve the performance goals noted above. As a result, the following were assigned the greatest weight within this category: maximize use of existing infrastructure, simplicity of operation and maintenance, enhances Nine Minimum Controls, reliability, and synergy. Synergy relates to the ability of the Utility to implement a project in conjunction with one or more other projects to be completed by other City department(s), serve a dual purpose (such as enhance park or recreation space while achieving source controls), or be executed at the same time as another project to minimize construction disruptions.

TABLE 4
Implementation and Operation Factors Criteria Weighting

Criteria	Weight
Enhances Nine Minimum Controls	15%
Maximize use of existing infrastructure	20%
Reliability	15%
Flexibility (possibility of future expansion)	5%
Land requirements	5%
Constructability	5%
Simplicity of operation and maintenance	20%
Implementation time	5%
Synergy (with other needs, projects, departments)	15%

Safety

Safety was also considered for each technology, as presented in Table 5. The human health and safety criterion refers to the potential risks or safety hazards to the public or Utility personnel posed by a technology, as well as the improvements that a technology may achieve by reducing basement backups and street flooding. Additionally, the Utility has included emergency response time improvements to factor in the ability of a technology to improve emergency response time in areas where severe street flooding is an issue.

TABLE 5
Safety Factors Criteria Weighting

Criteria	Weight
Human health & safety (basement backups, street flooding, etc.)	75%
Emergency response time Improvements (street flooding, etc.)	25%

Community Impacts

As previously noted, community impacts are very important to the Utility. In addition to the desired reduction of overflow volumes and water quality improvements that will benefit the community, the community may also be affected by short- and long-term construction impacts. Table 6 presents weighting assigned to community impact performance factors. The Utility weighed long-term impacts more heavily, as they pose the greatest potential for lasting community benefits or detriment.

TABLE 6
Community Impacts Criteria Weighting

Criteria	Weight
Protection of historical and cultural resources	25%
Protection of environmental resources	40%
Short-term (noise, truck traffic, siting, etc.)	10%
Long-term (open space creation, recreational opportunities, aesthetic improvements, etc.)	25%

Benefit Scoring Methodology

A scoring process was developed to assess the effectiveness of the CSO control measures. Each technology was assessed with respect to the criteria summarized above, and a score was assigned for each criterion. Technology-specific criterion scores were assigned using a scale of 0 through 4, with 0 indicating an adverse impact by the technology with respect to the criterion, and 4 indicating a very good or positive impact (Table 7).

TABLE 7
Scoring System

Description	Score
Very good/positive	4
Good/positive	3
Neutral	2
Poor/adverse	1
Very poor/adverse	0

Weighted criterion scores were calculated by multiplying the criterion score by the weighting factors assigned to the criterion and associated category. The total weighted benefit score was calculated by summing the weighted criteria scores for each control measure.

Alternative Benefit Scoring

Benefit scores were assigned to each alternative for each scoring criterion, as presented in Table 8. Reasoning behind the assigned scores is as follows:

Performance Factors

- **Reduces combined sewer overflow volume** - Equal scores were assigned to this performance factor. Each alternative can be designed for any particular level of control, and the alternatives would be equally effective when compared against each other for any particular level of control.
- **Reduces runoff volume** – The alternatives are primarily focused on reducing runoff volume, however, the East alternatives include green infrastructure (GI) projects which will help reduce runoff volume from reaching the combined sewer system. As a result, the East alternatives were scored slightly higher than the West alternatives since GI will be included in any selected East alternative.
- **Reduces frequency of untreated discharges** - Equal scores were assigned to this performance factor. Each alternative can be designed for any particular level of control, and the alternatives would be equally effective when compared against each other for any particular level of control.

- **Reduces wet weather flows in system** – East alternatives include GI projects which will help reduce wet weather flows entering the CSS. East alternatives were, therefore, scored slightly higher than the West alternatives.
- **Reduces suspended solids** – Each of the alternatives will reduce solids, therefore, each of the alternatives received a neutral score.
- **Reduces bacteria** – All options will be disinfected. During the March 20, 2013 Technical Meeting with EPA, EPA stated that they prefer secondary treatment due to studies that suggest solids may be disinfected at the surface, but contain live pathogens within. Alternatives providing secondary treatment were scored higher than high rate treatment (HRT) or wetland options based on EPA's concern regarding disinfection.
- **Reduces floatables/trash –** Each alternative includes screening at each CSO. As a result, each alternative was scored equally.

Implementation and Operation Factors

- **Enhances Nine Minimum Controls** – Each of the alternatives will enhance Nine Minimum Controls. With the exception of maximizing use of the collection system for storage, enhancement of other Nine Minimum Controls would be similar. The PCI relief, tunnel, and wetland options scored slightly higher than options with on-site storage due to their ability to maximize use of the collection system for storage.
- **Maximize use of existing infrastructure** – Each of the alternatives involves construction of a significant amount of new infrastructure. A neutral score was, therefore, assigned to each alternative.
- **Reliability** – HRT and wetland alternatives were scored slightly lower than alternatives which treated all flow at the West or East WWTP.
- **Flexibility (possibility of future expansion)** – Conveyance and wetland alternatives scored lower than storage and HRT alternatives, as additional capacity for a tunnel, PCI relief, or wetland alternative could not be simply achieved. Expansion of alternatives via storage and/or HRT would be a possibility, if needed.
- **Land requirements** - PCI relief and tunnels would require more easement acquisition, therefore, these alternatives scored lower than the others. Although the wetland requires a large amount of land for implementation, the land would not be developed for other uses and does not entail significant land acquisition activities. Wetland and storage/HRT options were scored equally.
- **Constructability** – PCI relief would result in the most disruption to the community due to the length of conveyance improvements along roadways. Additionally, the length of construction along roadway right of way presents constructability and maintenance of traffic issues not posed by the other alternatives. Construction in the Bee Slough area may be more challenging than construction of storage and HRT facilities, therefore, storage and HRT facilities scored better than the wetland, PCI relief, or tunnel alternatives.
- **Simplicity of operation and maintenance** – Operation and maintenance needs will be similar for each alternative, therefore, each are scored equally.
- **Implementation time** – Alternatives consisting of PCI relief or a tunnel were scored poorly, because benefits won't be achieved until full system-wide construction is completed. Storage, HRT, and wetland alternatives scored better, because benefits would be achieved as soon as individual projects are constructed.
- **Synergy (with other needs, projects, departments)** – Each of the control measures associated with the various alternatives were developed based on the Utility's need and were not developed based on other project or department needs. The East system green infrastructure projects may be implemented with other departments as opportunities and cost sharing alternatives are identified and some synergy may be achieved, however, each alternative received a neutral score, as synergy is not the primary driver of any alternative.

Safety Factors

- **Human health & safety (basement backups, street flooding, etc.) –** Each alternative will reduce flooding and backups similarly for any particular level of control, therefore, each alternative was scored equally.
- **Emergency response time improvements (street flooding, etc.)** - Each alternative will result in similar emergency response time improvements based on the street flooding reductions associated with any particular level of control, therefore, each alternative was scored equally.

Community Impact Factors

- **Protection of historical and cultural resources** – Impacts to historic and cultural resources are not anticipated. Additionally, if any were to be identified, similar protection could be provided for any particular level of control. As a result, each alternative was scored equally.
- **Protection of environmental resources** – Flows to receiving waters and other water bodies will be reduced with implementation of the control measures, therefore, protection of environmental resources will result. Each alternative will reduce flooding, backups, and runoff or overflows to surface waters similarly for any particular level of control, therefore, each alternative was scored equally.
- **Short-term (noise, truck traffic, siting, etc.)** – Construction impacts and disruption to the community will occur throughout the community for an extended period of time. The impacts and disruption will vary depending upon the alternative selected, however, each received the lowest possible score due to the widespread nature of all activities, as well as the extended duration of all construction activities.
- **Long-term (open space creation, recreational opportunities, aesthetic improvements, etc.)** – Long term aesthetic improvements, recreational opportunities, and space creation will occur with the construction of the Bee Slough wetland. The project is intended to turn a community nuisance into a community amenity, therefore, alternatives including the Bee Slough wetlands were scored higher than other alternatives.

Sensitivity Analysis

Alternatives were equally scored for several criteria, therefore, weighting of the equally scored criteria was applied to other remaining criteria to assess the sensitivity of the benefit scoring results. Additionally, category weighting was adjusted, as the Safety category weighting was reduced to zero due to equal scoring for each of the Safety criteria.

- **Performance Factors** – Several of the Performance Factors criteria scored equally for each alternative, therefore, sensitivity analysis weighting and scoring for this category was limited to the reduces runoff volume, reduces wet weather flows in system, and reduces bacteria criteria. The reduces bacteria criterion was weighted most heavily, as reduction of bacteria was discussed with EPA during the March 20, 2013 Technical Meeting.
- **Implementation and Operation Factors** – Weighting for three of the nine Implementation and Operation Factors was reduced to zero and applied to the remaining factors. Weighting of the Implementation time criterion was increased from the original weighting due to the Decree requirements to implement the IOCP in as expeditious a manner as possible.
- **Safety** - Scoring for the Safety category was equal for each alternative, therefore, weighting originally applied to the Safety category was applied to the Community Impacts category.
- **Community Impacts** – With the exception of the Long-term (open space creation, recreational opportunities, aesthetic improvements, etc.) criterion, the other Community Impacts scored equally for each alternative. All Community Impacts weighting was, therefore, applied to the remaining criterion. The category weighting was increased to reflect the elimination of the Safety category weighting.

Summary and Conclusions

The West storage and HRT alternative (West 1-45) and the East 3 (Storage/HRT/wetland) alternatives received the highest benefit scores using the original benefit metrics, as well as the different scenarios evaluated as part of the sensitivity analysis.

TABLE 8
Alternative Benefit Scoring

Screening Category:			Performance Factors							Implementation and Operation Factors									Safety		Community Impacts				Performance Score	Implementation and Operation	Safety	Community Impacts	Total	Rank
Screening Category Weight:			40%							30%									10%		20%									
Screening Criterion Weight:			25%	15%	25%	15%	5%	10%	5%	15%	20%	15%	5%	5%	5%	15%	5%	15%	75%	25%	25%	40%	10%	25%						
Maximum Criterion Score (of the 4 point total technology score):			0.4	0.24	0.4	0.24	0.08	0.16	0.08	0.18	0.24	0.18	0.06	0.06	0.06	0.18	0.06	0.18	0.3	0.1	0.2	0.32	0.08	0.2						
Score Description 4 Very Good 3 Good 2 Neutral 1 Poor 0 Adverse			Reduces combined sewer overflow volume	Reduces runoff volume	Reduces frequency of untreated discharges	Reduces wet weather flows in system	Reduces suspended solids	Reduces bacteria	Reduces floatables/trash	Enhances Nine Minimum Controls	Maximizes use of existing infrastructure	Reliability	Flexibility (possibility of future expansion)	Land requirements	Constructability	Simplicity of operation and maintenance	Implementation time	Synergy with other needs/projects	Human health & safety (exposure, basement backups, street flooding, etc.)	Emergency Response Time (street flooding, etc.)	Protection of historical and cultural resources	Protection of environmental resources	Short-term (noise, truck traffic, siting, etc.)	Long-term (open space creation, recreational opportunities, aesthetic improvements, etc.)						
Alternative	**Technologies**	**Fatally Flawed**																												
West 1-45	Storage/HRT		4	2	4	2	3	3	4	3	2	3	4	2	3	2	3	2	4	3	2	3	1	2	1.30	0.75	0.38	0.46	2.89	1
West 1-60	Parallel PCI Relief		4	2	4	2	3	4	4	4	2	4	0	0	0	2	1	2	4	3	2	3	1	2	1.34	0.68	0.38	0.46	2.85	3
West Tunnel	West Tunnel		4	2	4	2	3	4	4	4	2	4	0	1	1	2	1	2	4	3	2	3	1	2	1.34	0.71	0.38	0.46	2.88	2
East 1	Storage/HRT		4	3	4	3	3	4	4	3	2	3	4	2	3	2	3	2	4	3	2	3	1	2	1.46	0.75	0.38	0.46	3.05	4
East 3-40	Storage/HRT/Wetland		4	3	4	3	3	3	4	4	2	3	1	2	2	2	3	2	4	3	2	3	1	4	1.42	0.74	0.38	0.56	3.09	1
East 3-68	Storage/HRT/Wetland		4	3	4	3	3	3	4	4	2	3	1	2	2	2	3	2	4	3	2	3	1	4	1.42	0.74	0.38	0.56	3.09	1
East Tunnel	East 3-40 with downtown storage replaced by tunnel		4	3	4	3	3	3	4	4	2	4	0	1	1	2	1	2	4	3	2	3	1	4	1.42	0.71	0.38	0.56	3.06	3

TABLE 9

Alternative Benefit Scoring - Sensitivity Analysis 1

Weighting of criteria with equal scores reduced to zero (shown by yellow highlighting), and overall weighting adjusted to total 100%

Reduces bacteria more heavily weighted than reduces runoff volume and reduces wet weather flows in system.

Screening Category:			Performance Factors							Implementation and Operation Factors									Safety		Community Impacts							
Screening Category Weight:			35%							35%									0%		30%							
Screening Criterion Weight:			0%	30%	0%	30%	0%	40%	0%	25%	0%	25%	10%	10%	10%	0%	20%	0%	0%	0%	0%	0%	0%	100%				
Maximum Criterion Score (of the 4 point total technology score):			0	0.42	0	0.42	0	0.56	0	0.35	0	0.35	0.14	0.14	0.14	0	0.28	0	0	0	0	0	0	1.2				
Score Description 4 Very Good 3 Good 2 Neutral 1 Poor 0 Adverse			Reduces combined sewer overflow volume	Reduces runoff volume	Reduces frequency of untreated discharges	Reduces wet weather flows in system	Reduces suspended solids	Reduces bacteria	Reduces floatables/trash	Enhances Nine Minimum Controls	Maximizes use of existing infrastructure	Reliability	Flexibility (possibility of future expansion)	Land requirements	Constructability	Simplicity of operation and maintenance	Implementation time	Synergy with other needs/projects	Human health & safety (exposure, basement backups, street flooding, etc.)	Emergency Response Time (street flooding, etc.)	Protection of historical and cultural resources	Protection of environmental resources	Short-term (noise, truck traffic, siting, etc.)	Long-term (open space creation, recreational opportunities, aesthetic improvements, etc.)	Performance Score	Implementation and Operation	Safety	Community Impacts	Total	Rank
Alternative	**Technologies**	**Fatally Flawed**																										
West 1-45	Storage/HRT		4	2	4	2	3	3	4	3	2	3	4	2	3	2	3	2	4	3	2	3	1	2	0.84	1.05	0.00	0.60	2.49	1
West 1-60	Parallel PCI Relief		4	2	4	2	3	4	4	4	2	4	0	0	0	2	1	2	4	3	2	3	1	2	0.98	0.77	0.00	0.60	2.35	3
West Tunnel	West Tunnel		4	2	4	2	3	4	4	4	2	4	0	1	1	2	1	2	4	3	2	3	1	2	0.98	0.84	0.00	0.60	2.42	2
East 1	Storage/HRT		4	3	4	3	3	4	4	3	2	3	4	2	3	2	3	2	4	3	2	3	1	2	1.19	1.05	0.00	0.60	2.84	4
East 3-40	Storage/HRT/Wetland		4	3	4	3	3	3	4	4	2	3	1	2	2	2	3	2	4	3	2	3	1	4	1.05	1.00	0.00	1.20	3.25	1
East 3-68	Storage/HRT/Wetland		4	3	4	3	3	3	4	4	2	3	1	2	2	2	3	2	4	3	2	3	1	4	1.05	1.00	0.00	1.20	3.25	1
East Tunnel	East 3-40 with downtown storage replaced by tunnel		4	3	4	3	3	3	4	4	2	4	0	1	1	2	1	2	4	3	2	3	1	4	1.05	0.84	0.00	1.20	3.09	3

TABLE 10

Alternative Benefit Scoring - Sensitivity Analysis 2

Weighting of criteria with equal scores reduced to zero (shown by yellow highlighting), and overall weighting adjusted to total 100%

Reduces bacteria more heavily weighted than reduces runoff volume and reduces wet weather flows in system.

Heaviest weighting assigned to Implementation and Operation Factors that has greatest scoring differentiation between alternatives

Screening Category:			Performance Factors							Implementation and Operation Factors									Safety		Community Impacts							
Screening Category Weight:			20%							50%									0%		30%							
Screening Criterion Weight:			0%	30%	0%	30%	0%	40%	0%	25%	0%	25%	10%	10%	10%	0%	20%	0%	0%	0%	0%	0%	0%	0%	100%						
Maximum Criterion Score (of the 4 point total technology score):			0	0.24	0	0.24	0	0.32	0	0.5	0	0.5	0.2	0.2	0.2	0	0.4	0	0	0	0	0	0	0	1.2						
Score Description 4 Very Good 3 Good 2 Neutral 1 Poor 0 Adverse			Reduces combined sewer overflow volume	Reduces runoff volume	Reduces frequency of untreated discharges	Reduces wet weather flows in system	Reduces suspended solids	Reduces bacteria	Reduces floatables/trash	Enhances Nine Minimum Controls	Maximizes use of existing infrastructure	Reliability	Flexibility (possibility of future expansion)	Land requirements	Constructability	Simplicity of operation and maintenance	Implementation time	Synergy with other needs/projects	Human health & safety (exposure, basement backups, street flooding, etc.)	Emergency Response Time (street flooding, etc.)	Protection of historical and cultural resources	Protection of environmental resources	Short-term (noise, truck traffic, siting, etc.)	Long-term (open space creation, recreational opportunities, aesthetic improvements, etc.)	Performance Score	Implementation and Operation	Safety	Community Impacts	Total	Rank
Alternative	Technologies	Fatally Flawed																											
West 1-45	Storage/HRT		4	2	4	2	3	3	4	3	2	3	4	2	3	2	3	2	4	3	2	3	1	2	0.48	1.50	0.00	0.60	2.58	1
West 1-60	Parallel PCI Relief		4	2	4	2	3	4	4	4	2	4	0	0	0	2	1	2	4	3	2	3	1	2	0.56	1.10	0.00	0.60	2.26	3
West Tunnel	West Tunnel		4	2	4	2	3	4	4	4	2	4	0	1	1	2	1	2	4	3	2	3	1	2	0.56	1.20	0.00	0.60	2.36	2
East 1	Storage/HRT		4	3	4	3	3	4	4	3	2	3	4	2	3	2	3	2	4	3	2	3	1	2	0.68	1.50	0.00	0.60	2.78	4
East 3-40	Storage/HRT/Wetland		4	3	4	3	3	3	4	4	2	3	1	2	2	2	3	2	4	3	2	3	1	4	0.60	1.43	0.00	1.20	3.23	1
East 3-68	Storage/HRT/Wetland		4	3	4	3	3	3	4	4	2	3	1	2	2	2	3	2	4	3	2	3	1	4	0.60	1.43	0.00	1.20	3.23	1
East Tunnel	East 3-40 with downtown storage replaced by tunnel		4	3	4	3	3	3	4	4	2	4	0	1	1	2	1	2	4	3	2	3	1	4	0.60	1.20	0.00	1.20	3.00	3

APPENDIX H

Cost Performance Databases

(to be provided in electronic format only)

APPENDIX I

2007 Stormwater Master Plan

(to be provided in electronic format only)

APPENDIX J

Updated Bee Slough Wetland Modeling Data

Preliminary Modeling Results, Bee Slough Wetland

PREPARED FOR: Project File

COPY TO: Project team

PREPARED BY: Jim Bays/TPA

DATE: January 13, 2016

PROJECT NUMBER: 424722.03.30.99.10

Introduction

As one alternative under evaluation in the Long Term Control Plan for the City of Evansville Combined Sewer Overflow (CSO), the use of a constructed treatment wetland has been proposed as a method of storing and treating CSO flow from Outlet 001. Constructed treatment wetlands are shallow basins, planted with wetland vegetation adapted to inundated conditions, and designed to improve water quality. While the use of engineered constructed wetlands are a well-established treatment technology in the United States and world-wide, their use for CSO treatment has received interest only relatively recently, given the potential for passive operation, and is currently being investigated or implemented at locations within the Midwestern and northeastern United States.

As part of the Alternatives Evaluation, this technical memorandum presents a preliminary assessment of the anticipated water quality improvement in CSO flow during storm events. Storm water volume data modeled as part of the standard "typical year" used for alternatives evaluation were combined with available storm event water quality data to establish a modeling baseline. A spreadsheet-based model was used to estimate improvement in biochemical oxygen demand (BOD), total suspended solids (TSS) and ammonia-nitrogen (NH4N).

This memorandum updates a previous memorandum prepared on March 17 2013 with the results of the updated hydraulic modeling summarized by CH2M in a memorandum issued on May 20 2015. This update adjusted the following:

- Number of times the wetland would have been operated in a Typical Year
- The associated average flow and estimated operating depth of the wetland when operated.
- Wetland water quality performance when operated.

Methods

Wetland performance was estimated by applying the first-order area-based P-k-C* treatment wetland model (Kadlec and Wallace 2009). Calibrated to extensive data sets assembled by Robert Kadlec, the model predicts treatment wetland performance as a function of wetland area, inflow rate and parameter concentration, and ambient temperature for selected parameters. The following data assumptions were used as inputs to the model:

- Area: 20 acres.
- Flow rate: The wetland was operated for a total of 30 storm events during the typical year, with total volumes ranging from 0.11 to 85.6 million gallons. Storm events were characterized by four modeled inundation depth categories: <1 foot, 1-3 feet, 3-6 feet and 6-8 feet. Total storm event volumes during the typical year used for alternatives evaluation were divided by their respective durations in million gallons per day. Flow rates from the minimum and maximum storm events in each category, based on volume, were used as inputs.
- Inflow concentration: BOD = 75 mg/L, TSS = 116 mg/L, and NH4N = 8 mg/L.

- Removal rate constants: BOD = 41 m/yr, TSS = 200 m/yr and NH4N = 15 m/yr. The BOD value represents recommended median values recommended by Kadlec and Wallace (2009) for wastewaters with similar inflow wastewater concentrations. The NH4N value is the median of the calibration data set summarized in Kadlec and Wallace (2009). The TSS value represents a professional judgment on the expected settling characteristics of the CSO flows, and is conservative, in that stormwater removal rates typically exceed this value by an order of magnitude. Model BOD rate constants for pond systems were reviewed and compared to the treatment wetland rate constants and were found to be very similar and not sufficiently different to warrant their use for this preliminary analysis.
- Temperature: An ambient air temperature of 10°C was assumed, with the intention of representing average cold weather conditions. A temperature adjustment factor of 1.05 was applied to the NH4N analysis, to represent the normal decreased ammonia nitrification rates during cold weather, consistent with recommendations of Kadlec and Wallace (2009).

A summary of modeled storm event characteristics are attached to this memorandum as Appendix A.

Results

Table 1 summarizes the results of the modeling analysis. The following data are provided:

- Storm volume (million gallons, or MG): Estimated volume of storm event, based on hydraulic models. All of this volume was assumed to be pumped into the constructed wetland. Four categories are proposed based upon a review of the modeled storm depth and volume characteristics: 0-2, 2-11, 10-33, and 35-86 MG.
- Wetland Depth (feet): Estimated depth of inundation in the wetland during the event.
- Storms (Typical Year): Number of storms in this depth category. A total of 30 storms are estimated during the typical year, of which 16 yield enough flow to fill the wetland to a depth of 3 feet or less, and 15 yield enough flow to fill to a depth of 6 or 8 feet.
- Outflow (mg/L): Estimated average concentration of BOD, TSS, and NH4N in the wetland outflow during the storm event, predicted for the smallest and largest storm events in this category.
- Mass Load (kg/ha*d): Estimated average area loading of each parameter to the wetland over the course of the storm. These data are used as a basis to compare modeled performance with that measured at existing wetlands based on published information.

Modeled BOD concentrations ranged from 6.1 mg/L to 57 mg/L across the model scenarios from lowest to greatest volume storm. An average minimum of 28 mg/L and an average maximum of 50 mg/L were estimated, weighted by storm frequency category. This represents average concentration reductions of 62% for lower-volume storms, and 34% for greater volume storms, respectively.

Modeled TSS concentrations ranged from 31 to 73 mg/L from lowest to greatest volume storm. An average minimum of 41 mg/L and an average maximum of 52 mg/L were estimated, weighted by storm frequency category. This represents average concentration reductions of 65% and 55% respectively.

Modeled ammonia concentrations ranged from 0.0 mg/L to 7.7 mg/L from the lowest to greatest volume storm. An average minimum of 4.6 mg/L to an average maximum of 6.4 mg/L were estimated, weighted by storm frequency category. This represents average concentration reductions of 43% and 20%, respectively.

Figure 1 presents a loading coordinate graph adapted from Kadlec and Wallace (2009), and associated data, for BOD. This figure shows the distribution of average outflow BOD concentrations arrayed against the average daily loading rate for over 200 operational treatment wetlands. These types of figures usefully show the general expected range of wetland performance under different loading rates, subdivided by inflow concentration categories. Superimposed upon these literature values, the results for the Bee Slough constructed wetland are shown for a series of analyses with inflow rates ranging from 0.5 mgd to 12 mgd, representing the range of

hydraulic loadings anticipated for the typical year. The model outputs are plotted as a curve overlaid on the distribution of data points.

The key finding of this comparison is that even with the modeled high hydraulic loadings to the wetland, the performance of the wetland tracks the literature experience, and falls central to the cluster of points characterized by a BOD concentration range of 30-100 mg/L. This data range does not specifically represent the relative error anticipated for the Bee Slough wetland, but it does represent the general performance ranges on the loading gradient. The general range of distribution around the central tendency in the data set reflects a distribution of removal rate constants (Kadlec and Wallace 2009). The rate constants selected for the Evansville analysis were median values derived from this published summary. As a result, projected outflow concentrations could be greater or less than depicted in Figure 1. The maximum depths of inundation modeled for higher hydraulic loading rates at the peak of the storm hydrograph (Table 1) likely exceed the range of depths intrinsic to the wetland model data calibration range. As a result, removal rate constants may differ than those selected for the higher loading rates. In the case of these relatively few, highest-loaded storm events, treatment performance is expected to be limited and dominated by the high hydraulic loading. As noted in the comparison of average event concentrations modeled above, the performance of the wetland is best represented as a distribution of concentrations, with average to high concentration reductions for low volume storms, and average to low reductions in concentrations for high volume storms. Finally, the overlay of the model results directly shows that the proposed Bee Slough Wetland will receive loadings and expect to perform similar to wetlands receiving and treating primary wastewater or a rich secondary. The range of BOD loading and performance expectations does not exceed the loading and performance ranges of other treatment wetlands.

Figure 2 presents the same figure for TSS, showing a similar overlay on a figure adapted from Kadlec and Wallace (2009). The modeled data fall centrally in distribution to other wetland systems receiving similar TSS loading. A slightly different pattern is shown, where the outflow concentrations approach a limit of 31 mg/L, similar to values presented in Table 1. This is an outcome limited by a key assumption of the TSS analysis, where outflow background concentrations are predicted as a function of inflow concentrations, as detailed in Kadlec and Wallace (2009). With the same inflow concentration for all model flow comparisons, the minimum modeled outflow will be limited to the predicted background concentration. Experience indicates that actual concentrations will likely vary to lower concentrations than shown here, given the variable range of concentrations anticipated in the inflow.

In the original figure, Kadlec and Wallace make the point that existing EPA design and guidance manuals clearly track the overall trend in performance but were derived from within a relatively narrow range of the loading gradient. The proposed Bee Slough Wetlands would in effect be sized similarly to the performance of wetlands designed using EPA design criteria.

Figure 3 presents the similar loading coordinate plot for ammonia, superimposed on the Kadlec and Wallace data base. For the purpose of this analysis, the inflow total kjeldahl nitrogen (TKN) was assumed to be practicably all ammonia-nitrogen. As with the other plots, the anticipated performance of the Bee Slough spans a range of concentrations central to the distribution of wetlands, and within the range of concentrations (3-20 mg/L) that bracket the inflow concentration of 7.9 mg/L.

An important observation in all of these graphs is that the expected trend in performance is lateral, and not on a 1:1 diagonal. That is, concentration changes for a specific wetland do not readily translate on a diagonal pattern through the central tendency of the entire data set, but instead are greatly influenced by the starting concentration, and are generally arrayed from right to left at a relatively slight slope. This is consistent with observations provided in Kadlec and Wallace (2009; e.g. Fig. 17-7).

Conclusions

The proposed 20-acre Bee Slough Wetland is anticipated to provide a range of improvements to CSO flows, with concentration reductions averaging over ranges of 34-62% BOD, 55-65% TSS and 20-43% NH4N, depending upon storm volume. These reductions are well within the range of reductions anticipated from prior experience with wetlands, and are consistent with expectations of loading and inflow concentration criteria established by the

treatment wetland literature. This range of reductions is consistent with the expected range of removals associated with primary wastewater treatment of ≤45%, ≤65% and ≤20% (Kadlec and Knight, 1996; Table 18-2). Predicted concentrations of BOD5, TSS and NH4N were 6-57 mg/L, 31-73 mg/L and 0.0-7.7 mg/L, respectively, which were well below values typically associated with wastewater receiving primary treatment and overlapping in range with values associated with secondary treatment (e.g., 10-45 mg/L BOD5, 35-75 mg/L TSS and <1-20 mg/L NH4N; see Table 18-2 in Kadlec and Knight, 1996). The hydraulic analysis completed in 2015 showed a lower number of wetland operations. Water quality results showed slight differences for all parameters but agreed closely with previous analyses.

Based upon these analyses, and associated assumptions, the wetland will achieve, at a minimum, a quality equivalent to or better than primary treated effluent. Consistent effort by the Utility to target secondary treatment will allow the wetland system to discharge the highest effluent quality.

References

Kadlec, R.H. and R.L. Knight. 1996.Treatment Wetlands. CRC Press, Boca Raton, FL.
Kadlec, R.H. and S. Wallace. 2009. Treatment Wetlands 2nd Ed. CRC Press, Boca Raton, FL.

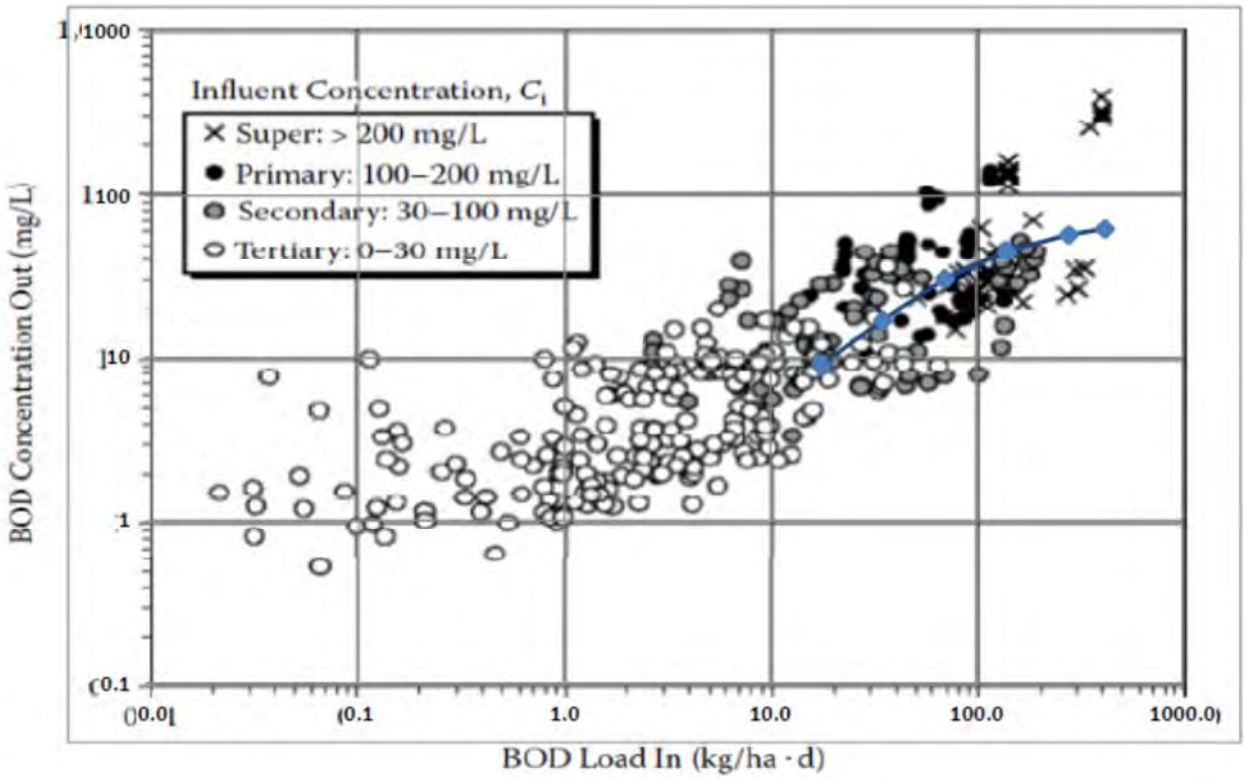
Table 1
Wetland Modeling Summary
Source: This study

Storm Volume (MG)	Wetland Depth (feet)	Storms (Typical Year)	Parameter	Outflow (mg/L)		Mass Load (kg/ha*d)	
				Low	High	Min	Max
0.1 – 2	<1	4	BOD	6.1	42	0.4	25
			TSS	31	31	0.5	39
			NH4N	0.0	3.6	0.04	2.7
4-11	1-3	11	BOD	25	47	40	149
			TSS	32	43	62	231
			NH4N	5	6.9	4.3	16
10-33	3-6	11	BOD	31	53	100	360
			TSS	37	63	154	557
			NH4N	6	7.5	11	38
35-856	6-8	4	BOD	51	57	362	514
			TSS	63	73	558	796
			NH4N	7.5	7.7	38.5	55
	Total	30	BOD	28	50	126	262
	Inter-event Average (d)	12	TSS	41	52	194	406
			NH4N	4.6	6.4	13	28

Figure 1

Predicted BOD Outflow Concentration as a Function of Loading

Figure source: Kadlec and Wallace (2009)

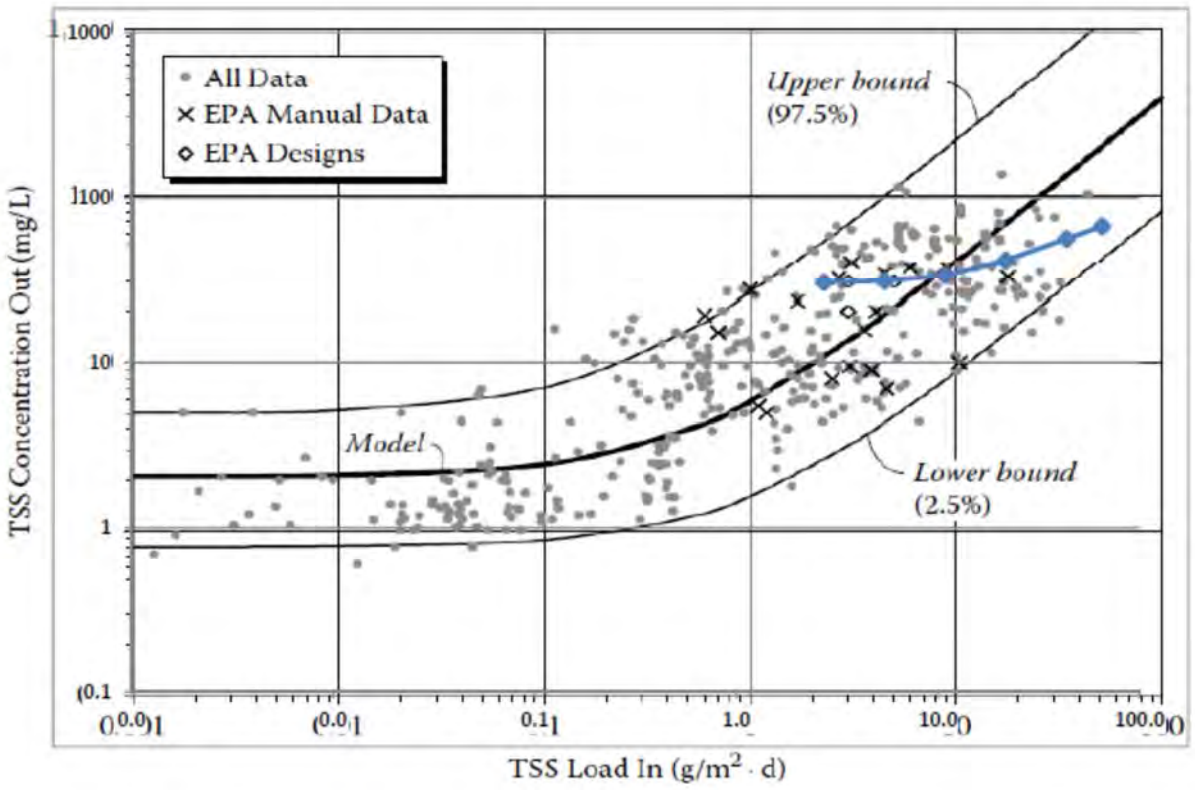


Flow	Con-centration	Mass (kg/d)	Areal Load (kg/ha*d)	Co	HLR (cm/d)
0.5	75	142	17.5	9	2.3
1	75	284	35.1	17	4.7
2	75	568	70.1	30.5	9.3
4	75	1136	140.2	45.5	18.7
8	75	2271	280.5	57.6	37.4
12	75	3407	420.7	62.7	56.1

Figure 2

Predicted TSS Concentration as a Function of Loading

Figure source: Kadlec and Wallace (2009)

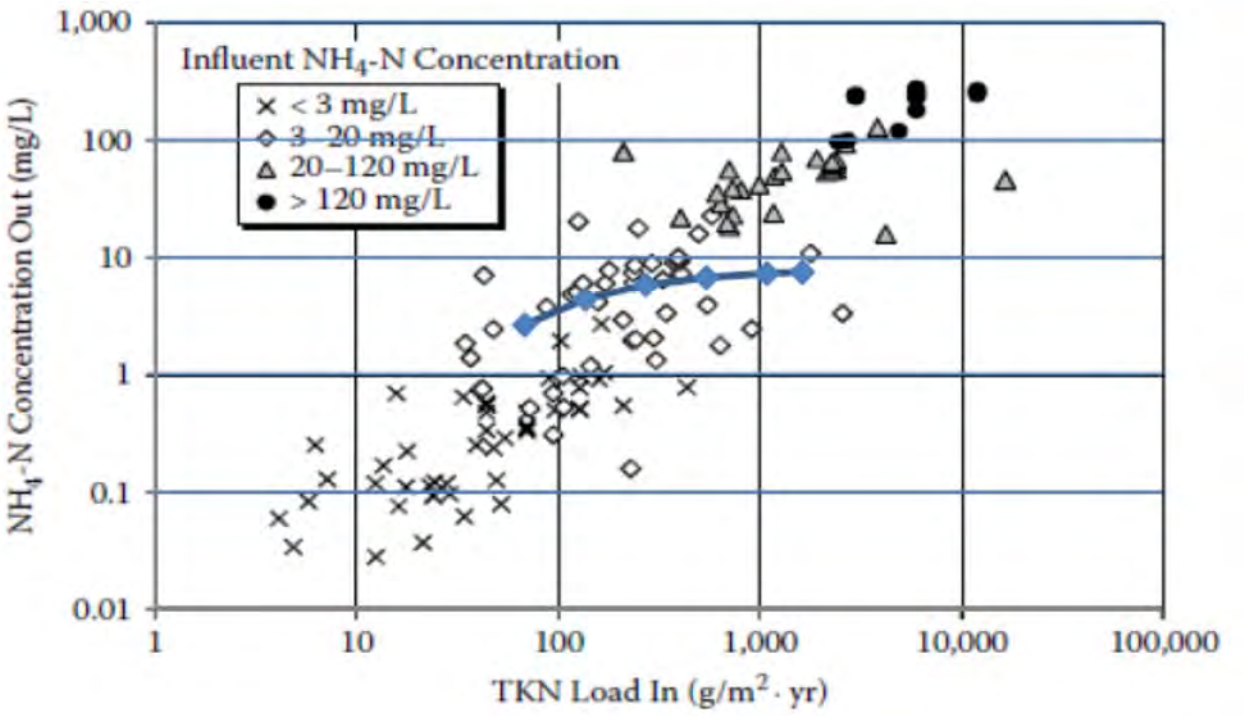


Flow	Concen-tration	Mass (g/d)	Areal Load (g/m2*d)	Co	HLR (cm/d)
0.5	116	219530	2.7	30.7	2.3
1	116	439060	5.4	31.3	4.7
2	116	878120	10.8	33.9	9.3
4	116	1756240	21.7	41.7	18.7
8	116	3512480	43.4	56.5	37.4
12	116	5268720	65.1	67.3	56.1

Figure 3

Predicted Ammonia-Nitrogen Concentrations as a Function of Loading

Figure source: Kadlec and Wallace (2009)



Flow	Concentration	Mass (g/d)	Mass (g/yr)	Areal Load (g/m2*yr)	Co	HLR (cm/d)
0.5	8	15,140	5,526,100	68	2.62	2.3
1	8	30,280	11,052,200	137	4.34	4.7
2	8	60,560	22,104,400	273	5.77	9.3
4	8	121,120	44,208,800	546	6.73	18.7
8	8	242,240	88,417,600	1092	7.28	37.4
12	8	363,360	132,626,400	1639	7.49	56.1

Appendix A

Storm Event Characteristics, Evansville CSO

Model data source: CH2MHILL (2013)

Event	Date	Duration (HR)	Max Depth (FT)	Max Inflow (MGD)	Avg Flow (MGD)	Treated Volume (MG)	Wetland Operated?	Completely Drained?	Volume Exceeded (MG)
1	1/2/2000 19:00	140	13.8	183.6	14.7	85.6	Yes	YES	30.3
2	1/17/2000 20:00	76	0.1	0.0	0.0	0.0	No	YES	0
3	2/13/2000 9:00	82	4.9	117.9	7.6	25.8	Yes	YES	0
4	2/23/2000 22:00	67	2.5	76.5	3.1	8.6	Yes	YES	0
5	2/26/2000 17:00	62	2.5	76.6	4.2	11.0	Yes	YES	0
6	3/3/2000 13:00	188	0.1	0.0	0.0	0.0	No	YES	0
7	3/11/2000 9:00	84	1.0	51.8	0.6	2.1	Yes	YES	0
8	3/16/2000 3:00	75	3.5	115.2	5.1	15.9	Yes	NO	0
9	3/19/2000 6:00	73	2.0	90.3	3.1	9.4	Yes	YES	0
10	3/27/2000 1:00	72	0.1	0.0	0.0	0.0	No	YES	0
11	4/2/2000 6:00	133	0.0	0.0	0.0	0.0	No	YES	0
12	4/7/2000 19:00	100	3.0	62.3	2.6	10.9	Yes	YES	0
13	4/24/2000 9:00	58	0.1	0.0	0.0	0.0	No	YES	0
14	5/3/2000 13:00	82	0.0	0.0	0.0	0.0	No	YES	0
15	5/9/2000 20:00	80	0.0	0.0	0.0	0.0	No	YES	0
16	5/13/2000 4:05	138	0.0	0.0	0.0	0.0	No	YES	0
17	5/18/2000 22:00	90	1.9	44.0	1.1	4.3	Yes	YES	0
18	5/23/2000 0:00	60	0.1	0.0	0.0	0.0	No	YES	0
19	5/26/2000 11:50	85	0.0	0.0	0.0	0.0	No	YES	0
20	6/14/2000 18:00	51	1.7	42.9	1.6	3.5	Yes	NO	0
21	6/16/2000 21:00	99	8.2	196.6	14.1	58.2	Yes	YES	1.3
22	6/21/2000 0:00	91	1.8	77.9	1.2	4.7	Yes	YES	0
23	6/24/2000 19:00	35	0.1	0.0	0.0	0.0	No	YES	0
24	6/26/2000 6:00	105	5.8	155.8	7.6	33.1	Yes	YES	0
25	7/5/2000 4:00	82	1.0	29.7	0.6	2.0	Yes	YES	0
26	7/19/2000 0:00	101	3.9	165.7	3.8	16.2	Yes	YES	0
27	7/29/2000 11:00	81	0.1	0.0	0.0	0.0	No	YES	0
28	8/3/2000 19:00	81	0.0	0.0	0.0	0.0	No	YES	0
29	8/7/2000 4:00	5	0.0	0.0	0.0	0.0	No	YES	0
30	8/7/2000 11:00	82	0.0	0.0	0.0	0.0	No	YES	0
31	8/18/2000 2:00	92	2.3	50.3	1.6	6.1	Yes	YES	0
32	8/23/2000 9:00	89	5.4	154.4	7.6	28.3	Yes	YES	0
33	8/27/2000 2:00	91	6.5	166.6	10.3	39.0	Yes	YES	0
34	9/9/2000 12:00	64	1.1	64.9	1.5	4.0	Yes	NO	0
35	9/12/2000 4:00	74	5.5	174.0	10.3	31.7	Yes	YES	0
36	9/20/2000 18:00	90	1.9	79.0	1.3	5.0	Yes	YES	0

Event	Date	Duration (HR)	Max Depth (FT)	Max Inflow (MGD)	Avg Flow (MGD)	Treated Volume (MG)	Wetland Operated?	Completely Drained?	Volume Exceeded (MG)
37	9/25/2000 7:00	81	6.2	192.5	10.4	35.2	Yes	YES	0
38	10/5/2000 21:15	184	0.1	0.0	0.0	0.0	No	YES	0
39	10/13/2000 16:00	89	5.3	94.7	6.9	25.6	Yes	YES	0
40	10/17/2000 9:00	479	0.1	0.9	0.0	0.1	Yes	YES	0
41	11/6/2000 9:00	60	1.0	16.6	0.7	1.8	Yes	NO	0
42	11/8/2000 21:00	76	3.7	137.8	6.3	20.0	Yes	YES	0
43	11/13/2000 5:00	282	0.1	0.0	0.0	0.0	No	YES	0
44	11/24/2000 23:00	91	2.3	93.1	1.7	6.6	Yes	YES	0
45	12/11/2000 8:00	50	4.7	132.9	7.4	15.4	Yes	NO	0
46	12/13/2000 10:00	58	4.1	25.7	4.2	10.3	Yes	YES	0
47	12/16/2000 2:00	98	3.1	94.2	2.8	11.6	Yes	YES	0

[a] Highlighting denotes that the wetland capacity was exceeded. "Exceeded" means that a portion of the influent would simply receive less than 48 hours detention time in the wetland. All wetland effluent receives disinfection.

[b] Red font and underlining denotes that the wetland was unable to completely drain prior to the start of the next event.

APPENDIX K

Monitoring, Reporting, and Compliance Criteria for Remote Treatment Facilities (Consent Decree Appendix H)

CONSENT DECREE APPENDIX H: Monitoring and Reporting Requirements for Remote Treatment Controls Identified in Appendix G.

This Appendix H states the post-construction monitoring requirements for specific pollutants that apply to the proposed four remote treatment locations identified in Appendix G to this Consent Decree, specifically:

- Seventh Avenue Lift Station Remote Treatment Unit;
- Diamond Avenue Remote Treatment Unit;
- Vertical Treatment Unit ("VTU") at the East Wastewater Treatment Plant ("WWTP"); and
- Constructed Wetland Treatment System ("Constructed Wetland") at the East WWTP.

The post-construction monitoring requirements stated in this Appendix H are in addition to those requirements in Defendant's IOCP Post-Construction Monitoring Plan to be prepared in accordance with Appendix C of this Consent Decree and subject to approval by Plaintiffs pursuant to Section XV of the Consent Decree (Review and Approval Procedures). The post-construction monitoring requirements in this Appendix H shall be incorporated by reference in Defendants' IOCP Post-Construction Monitoring Plan. The IOCP Post-Construction Monitoring Plan, including the requirements of this Appendix H, shall be used to determine compliance with the Consent Decree and to determine whether a Supplemental Compliance Plan is required pursuant to Paragraph 49 of the Decree.

A. Definitions

- *7-Discharge Rolling Average* shall mean an event-based monthly calculation for samples from an individual treatment unit reported each month in Defendants' Monthly Report, and shall be calculated by adding the TSS results from the most recent seven discharges and dividing by 7.

- *12-Month Event-Based Rolling Average* shall mean the volume weighted, event based monthly calculation for samples from an individual treatment unit that multiplies the TSS percent removal by the total effluent volume for each event in the most recent 12-month consecutive period and adds the events during the 12-month consecutive period together, before dividing by the total effluent volume from all of the events during the entire 12-month consecutive period.

- *composite sample* shall mean a sample prepared by physically combining two or more samples from the same sampling point, having some specific relationship and processed to ensure homogeneity.

- *continuous monitoring* shall mean the uninterrupted collection of data from a specific sampling point throughout the discharge event.

- *geometric mean* shall mean the antilogarithm of the mean of the logarithms of all the values in a set.

- *grab sample* shall mean a single sample which is collected at one point in time and place.

- *Monthly Report* shall mean the report required under Section E of this Appendix H.

- *precipitation event* shall mean an occurrence of rain, snow, sleet, hail, or other form of precipitation.

- *sample or sampling* shall mean the process of obtaining a representative portion of the material of concern.

B. Seventh Avenue and Diamond Avenue Monitoring Requirements

1. Sampling Requirements

Defendants shall conduct effluent sampling when the unit is discharging. Defendants shall sample each Remote Treatment Units' effluent discharge at representative locations and such locations shall be recorded in the Monthly Report required under Section E of this Appendix H. Defendants shall analyze samples for TSS, $CBOD_5$, pH, and E. coli. Defendants shall also sample for residual chlorine if Defendants choose to disinfect CSO effluent using chlorine. Defendants shall also sample for any additional parameters identified in the NPDES permit.

Defendants shall use an automatic sampler that collects samples at defined intervals or shall take grab samples. Defendants shall collect each sample, whether automatic or grab, that must be representative of the discharge. Defendants shall initiate sampling within 30 minutes from the beginning of the discharge event, and shall continue at intervals determined by Defendants but no less than every 2 hours during the event. Defendants shall take and analyze composite samples for TSS and $CBOD_5$. Defendants must sample for E. coli daily when discharging. If Defendants choose to disinfect using chlorine, Defendants shall perform and analyze a grab sample of residual chlorine each time a separate grab sample of E coli is performed. Defendants are not required to sample the wet weather treatment component influent for E. coli or residual chlorine. Defendants shall perform a representative pH grab sample for each wet weather treatment component discharge event. Defendants shall conform all sampling to the requirements in 40 CFR 136.

Defendants shall calculate the effluent TSS concentration 7-Discharge Rolling Average for each outfall at the Seventh Avenue Lift Station Remote Treatment Unit and the Diamond Avenue Remote Treatment Unit, and report the 7-Discharge Rolling Average in the Monthly Report to EPA/IDEM. The 7-Discharge Rolling Average calculation will be:
$(x_1+x_2+x_3+x_4+x_5+x_6+x_7)/7$

Where:

x = the representative effluent TSS concentration sampled during the most recent discharge
$_1$ = the first discharge event, $_2$ = the second discharge event, and so on.

If, for example, 10 remote treatment discharges occur in a single month, then 10 7-Discharge Rolling Averages would be included in the monthly report (*i.e.* the newest discharge result would be added, the oldest discharge result would be dropped off in the calculation and so on). If there is no discharge in a month from either of the Remote Treatment Units, Defendants shall report "No Discharge" on the Monthly Report for that month. In the next month in which a discharge occurs, the 7-Discharge Rolling Average shall be calculated using the representative effluent TSS concentrations from each of the 7 most recent discharge events regardless of whether the discharges occurred in contiguous months.

2. Monthly Report Requirements for the Remote Treatment Units

In addition to the requirements in Section E of this Appendix H, Defendants shall include in each Monthly Report results for TSS, $CBOD_5$, E. coli, pH, and, if applicable, residual chlorine for the Remote Treatment Units for each activation/discharge event. Defendants shall report TSS, $CBOD_5$, and residual chlorine as concentrations (mg/L). Defendant shall report E. coli as cfu/100 mL and pH as s.u. In addition, Defendants shall include in each Monthly Report:

- The corresponding precipitation information for each discharge event
- The results of each individual E. coli grab sample taken
- The monthly geometric mean for all of the E. coli samples taken in the previous month
- The time when each E. coli sample was taken and the estimated flow being discharged from the Remote Treatment Units
- Identify any dry weather discharges that occurred from the Remote Treatment Units within the previous month (include the start and end time of the dry weather discharge and the total volume discharged).
- Identify any discharge the does not meet the performance criteria for the Remote Treatment Units that occurred during the previous month.
- Identify the start and end time and the total volume discharged from outfall CSO 005 for each day when the CSO discharged in the previous month. Identify the flow in MGD discharged from the 7th Avenue Lift Station Remote Treatment Unit for each calendar day the CSO discharged.
- Identify the start and end time and the total volume discharged from outfall CSO 025 for each day when the CSO discharged in the previous month. Identify the flow in MGD discharged from the Diamond Avenue Remote Treatment Unit for each calendar day the CSO discharged.

3. Continuous Operation of the Remote Treatment Units/ Prohibition Against Dry Weather Discharges

No CSOs shall occur at Seventh Avenue East (CSO 015) when the Seventh Avenue Remote Treatment Unit is operating at or below its design maximum flow of 72 million gallons per day. No CSOs shall occur at Diamond Avenue (CSO 025) when the Diamond Avenue Remote Treatment Unit is operating at or below its design maximum flow of 20 million gallons per day. The bypass provisions of 40 CFR 122.41(m) shall apply to each bypass at the Remote Treatment Units. Each Remote Treatment Unit is prohibited from discharging during dry weather conditions.

The sampling for the Remote Treatment Units must begin upon the Remote Treatment Units upon the Achievement of Full Operation date identified in Appendix G.

Defendants shall perform all sampling for the Remote Treatment Units at a point representative of the Remote Treatment Units' effluent, before admixture with any other flow. Defendants shall monitor the other flow, including but not limited to a CSO, before combining with effluent from the Remote Treatment Units. Defendants shall report this measured other flow within the Monthly Report, including the start and end time and the total volume discharged, when either of the Remote Treatment Units are discharging.

C. Constructed Wetland Monitoring and Water Quality Sampling Procedure

1. Sampling Requirements

Defendants shall conduct influent and effluent sampling when the Constructed Wetland is filling or discharging. Defendants shall measure inflow and outflow from the Constructed Wetland at a representative location and recorded in 15 minutes intervals to determine rates of filling/emptying of the Constructed Wetland during and after events. Defendants shall average the inflow and outflow information on hourly basis to correspond with samples being taken. In addition, Defendants shall log Constructed Wetland water levels using an ultrasonic transducer or similar method, at a representative location, to track and record the depth of the Constructed Wetland and duration of storm events before, during, and after storm events.

Defendants shall sample Constructed Wetland influent and effluent at representative Constructed Wetland inflow and outflow locations. Defendants shall analyze samples for TSS, CBOD5, residual chlorine, pH, and E. coli. All sampling conducted must be representative of the Constructed Wetland's influent and effluent.

Defendants shall use an automatic sampler that collects samples at defined intervals or shall take grab samples. Defendants shall collect each sample, whether automatic or grab, during representative inflow into or representative discharges from the Constructed Wetland. Defendants shall initiate influent sampling within 30 minutes from the beginning of filling of the Constructed Wetland. Defendant shall continue influent sampling at intervals determined by Defendants but no less than every hour during the filling of the Constructed Wetland

Defendants shall initiate effluent sampling within 30 minutes after the beginning of a discharge from the Constructed Wetland. Defendant shall continue effluent sampling at intervals determined by Defendants but no less than every hour during discharge. Defendants shall analyze composite samples taken for TSS and $CBOD_5$. Defendants must sample for E. coli daily when discharging. If Defendants choose to disinfect using chlorine, Defendants shall take and analyze a grab sample of residual chlorine each time a separate grab sample of E. coli is taken. Defendants shall perform a representative pH grab sample for each Constructed Wetland discharge event. Defendants shall conform all sampling to the requirements in 40 CFR Part 136.

Defendants shall calculate the TSS percent reduction by mass for each discharge day using the corresponding day's TSS influent and effluent sampling results and corresponding Constructed Wetland inflow and outflow volumes. The typical calculation for TSS percent reduction for a single discharge event would be:

$r_e = 1 - (t_e \times v_e)/ (t_i \times v_i)$ = TSS percent removal

Where:

- r_e = TSS percent removal for event e
- t_e = average of the TSS effluent concentrations
- v_e = total effluent volume
- t_i = the average of the TSS influent concentrations
- v_i = total influent volume

The flow weighted percent removal shall be calculated by multiplying the computed TSS percent removal by the total volume for each discharge event. A sample 12-Month Rolling Average for flow weight TSS percent removal would be:

$((r_1 \times v_1)+(r_2 \times v_2)+(r_3 \times v_3)\ldots)/(v_1+v_2+v_3\ldots)$ = the flow weighted TSS percent removed running total

Where:

- r = percent of mass removed
- v = total effluent volume discharged from the Constructed Wetland during each event
- $_1$ = the first discharge event, $_2$ = the second discharge event, and so on and so forth

After the 13th month of operation, the results used in the TSS percent removal from the 1st month of operation would drop off the 12-Month Rolling Average. This process will continue for each subsequent month in which newest month's results would be added and the oldest month's discharge results would be dropped off in the calculation and so on. If there is no discharge in a month from the Constructed Wetland, Defendants shall report "No Discharge" on the Monthly Report.

2. Monthly Report Requirements for the Constructed Wetland

In addition to the requirements of Section E of this Appendix H, Defendants shall include in the Monthly Report all sample results for TSS, $CBOD_5$, pH, E. coli and, if applicable, residual chlorine for the Constructed Wetland. Defendants shall report TSS, $CBOD_5$, and residual chlorine as concentrations (mg/L). Defendants shall report E. coli as cfu/100 mL and pH as s.u.

In addition, Defendants shall include in the Monthly Report the calculation of the 12-Month Rolling Average for TSS. Defendants shall compare that value to the Performance Criterion of 50% TSS removal stated in Appendix G, and state in each Monthly Report each instance in which that requirement was not met during that month. In addition, Defendants shall also include in each Monthly Report:

- The Constructed Wetland maximum water elevation for each wetland discharge event;
- The results of each individual E. coli grab sample taken;
- The monthly geometric mean for all of the E. coli samples taken in the previous month;
- The date and time each E. coli grab sample was taken and the estimated flow being discharged from the Constructed Wetland;
- Corresponding precipitation information for each discharge event;
- Any dry weather discharges that occurred from the Constructed Wetland within the previous month (include the start and end time of the dry weather discharge and the total volume discharged); and
- The start and end time and the total volume discharged from outfall CSO 001 for each day when the CSO discharged in the previous month.
- The flow in MGD discharged from the Wetland for each calendar day CSO 001 discharged.

3. Continuous Operation of the Constructed Wetland

When the Constructed Wetland is not operating at greater than its design maximum flow of 198 million gallons per day, no CSOs shall occur at Kentucky Avenue (CSO 001). The bypass provisions within 40 CFR 122.41(m) shall apply to any bypasses of the Constructed Wetland. Defendants shall not fill the wetland when the East WWTP is receiving flows less than 40 MGD, except as necessary to maintain water levels to support vegetation. During this exception, Defendant shall only use effluent treated with full secondary treatment at the East WWTP, and each such instance during a month in which Defendant fills the wetland shall be documented in the Monthly Report. Defendant shall conduct TSS sampling of the East WWTP effluent, regardless of the duration of the inflow, used to support the Constructed Wetland's vegetation and shall include this sampled TSS concentration and the applicable inflow volume in the TSS percent removal calculation.

Defendants shall begin monitoring the flow weighted TSS percent removal at the Constructed Wetland by no later than January 1, 2025 or after achievement of full operation, whichever is earlier.

Defendants shall perform all sampling for the Constructed Wetland at a point representative of the Constructed Wetland's effluent, before admixture with any other flow. Defendant shall monitor the other flow, including but not limited to WWTP discharge or a CSO, before combining with effluent from the Constructed Wetland. Defendants shall report this measured other flow within the Monthly Report, including the start and end time and the total volume discharged, when the Constructed Wetland is discharging.

D. Vertical Treatment Unit (VTU) Monitoring Procedure

1. Sampling Requirements

Defendants shall conduct influent and effluent sampling when the VTU is discharging. Defendants shall measure the VTU's effluent discharge volume at a representative location and log the discharge event in 15 minutes intervals to determine rates of emptying of the system during and after wet weather events. Defendants shall average outflow data on an hourly basis to correspond with samples being taken.

Defendants shall monitor, and include in the Monthly Report required under Section E of this Appendix H, the total volume (gallons) of wastewater captured and pumped to Evansville's East WWTP. Defendants shall sample VTU influent and effluent at representative inflow and outflow locations. Defendants shall analyze samples for TSS, $CBOD_5$, residual chlorine, pH, and E. coli.

Defendants shall use an automatic sampler that collects samples at defined intervals or shall take grab samples. Defendants shall collect each sample, whether automatic or grab, during representative inflow into or representative discharges from the VTU. Defendants shall initiate sampling within 30 minutes from the beginning of the filling of the VTU for influent sampling and within 30 minutes after the discharge event begins for effluent sampling. Defendants shall continue at intervals determined by Defendants but no less than every hour during the event. Defendants shall composite samples taken for TSS and $CBOD_5$. Defendants must sample for E. coli daily when discharging. If Defendants choose to disinfect using chlorine, Defendants shall perform and analyze a grab sample of residual chlorine each time a separate grab sample of E. coli is performed. Defendants shall perform a representative pH grab sample for each VTU discharge event. Defendants shall conform all sampling to the requirements in 40 CFR Part 136.

Defendants shall calculate the TSS percent reduction for the VTU using the appropriate TSS influent and effluent sampling results for each discharge event. The typical calculation for TSS percent reduction for a single discharge event is:

$$r_e = 1 - (t_e \times v_e) / (t_i \times v_e) = \text{TSS percent removal}$$

Where:

- r_e = TSS percent removal for event e
- t_e = average of the TSS effluent concentrations
- v_e = total effluent volume

- t_i = the average of the TSS influent concentrations

Defendants shall calculate the flow weighted percent removal by multiplying the computed TSS percent removal by the total volume. A sample 12-Month Rolling Average for flow weighted TSS percent removal would be:

$((r_1 \times v_1)+(r_2 \times v_2)+(r_3 \times v_3)\ldots)/(v_1+v_2+v_3\ldots)$ = the flow weighted TSS percent removed running total

Where:

- r = percent of mass removed
- v = volume discharged in each event
- $_1$ = the first discharge event, $_2$ = the second discharge event, and so on and so forth

After the 13th month of operation, the results used in the TSS percent removal from the 1st months of operation would drop off the rolling 12-Month Rolling Average. This process will continue for each subsequent month, in which newest month's results would be added and the oldest discharge results would be dropped off in the calculation and so on. If there is no discharge in a month from the VTU, Defendants shall report "No Discharge" for that month on the Monthly Report.

Defendants shall include the calculation of the 12-Month Rolling Average in the Monthly Report submitted to EPA and IDEM. Defendants shall compare this value to the requirement for 50% TSS removal and identify in its reports when that requirement is not met.

2. Monthly Report Requirements for the VTU

In addition to the requirements of Section E of this Appendix H, Defendants shall include the results for TSS, $CBOD_5$, E. coli, pH, and, if applicable, residual chlorine for the VTU in the Monthly Report required under Section E of this Appendix H. Defendants shall report TSS, $CBOD_5$, and residual chlorine as concentrations (mg/L). Defendants shall report E. coli as cfu/100 mL and pH as s.u.

In addition, Defendants shall include in the Monthly Report the calculation of the VTU's 12-Month Rolling Average for TSS percent reduction. Defendants shall compare that value to the Performance Criterion of 50% TSS removal stated in Appendix G, and state in each Monthly Report each instance in which that requirement was not met during that month. In addition, Defendants shall also include in each Monthly Report:

- The results of each individual E. coli grab sample taken;
- The monthly geometric mean for all of the E. coli samples taken in the previous month;
- The date and time each E. coli grab sample was taken and the estimated flow being discharged from the VTU;
- Corresponding precipitation information for each discharge event;

- Any dry weather discharges that occurred from the VTU within the previous month (include the start and end time of the dry weather discharge and the total volume discharged);
- The start and end time and the total volume discharged from outfall CSO 002 and CSO 004 for each day either of the CSOs discharged in the previous month; and.
- The flow in MGD discharged from the VTU for each calendar day whenever either CSO 002 or CSO 004 discharge.

3. Continuous Operation of the VTU During Discharges/Prohibition on Dry Weather Discharges

No CSOs shall occur at Cass Avenue (CSO 002) or at Adams Avenue (CSO 004) when the VTU is operating at or below its design maximum flow of 226 million gallons per day. The provisions of 40 C.F.R. § 122.41(m) apply to all bypasses at the VTU. The VTU is prohibited from discharging during dry weather conditions.

Defendants shall operate the VTU in order to maximize the amount of wastewater captured and pumped back to Defendants' East WWTP. The amount of wastewater pumped back to the East WWTP will not be included in TSS percent removal calculation for the VTU.

Defendants shall begin monitoring and sampling influent and effluent at the VTU, and begin calculating the flow weighted percent removal, on January 1, 2033 or after achievement of full operation, whichever is earlier.

Defendant shall perform all sampling for the VTU at a point representative of the VTU's effluent, before admixture with any other flow. Defendants shall monitor the other flow, including but not limited to WWTP discharge or a CSO, before combining with effluent from the VTU. Defendants shall report this other measured flow within the Monthly Report, including the start and end time and the total volume discharged, when the VTU is discharging.

E. Requirements for Monthly Reports

Defendants shall submit a Monthly Report to the addresses for EPA and IDEM identified in Paragraph 98 of the Consent Decree. The Monthly Report shall be submitted on the 28th day of each month until termination of the Consent Decree, beginning on January 1, 2025 or after achievement of full operation of the Constructed Wetland, whichever is earlier. In addition to the foregoing requirements in this Appendix H, and for each measurement or sample provided within the Monthly Report, Defendants shall record and maintain records of all the monitoring or sampling information, including the following:

- The exact place, date, and time of sampling/measurement
- The names and titles of the person(s) who performed the sampling/measurement
- The date and times the analyses were performed
- The names and titles of the person(s) who performed the analyses
- The analytical techniques or methods used

- All relevant calibration records pertaining to the analyses performed
- The results of all analyses and measurements performed

In addition, Defendants shall report precipitation events in each Monthly Report, including the amount of precipitation, the duration of the event, and the type of precipitation. If excessive snowmelt was a condition that caused a CSO discharge from the Remote Treatment Units, Constructed Wetland, or VTU, Defendants must include in the Monthly Report an estimate of the amount of snow in inches melted that caused the discharges.

If Defendants fill the Constructed Wetland as permitted by Section C.3 of this Appendix H for the purpose of maintaining water levels to support vegetation and the intended wastewater treatment function of the wetland, then Defendants shall report in the Monthly Report for that month the volume of treated effluent discharged to the wetland and the date and duration of discharge.

The following influent and effluent sampling requirements in Table 1, below, shall apply to the Seventh Avenue Lift Station Remote Treatment Unit, the Diamond Avenue Remote Treatment Unit, the VTU, and the Constructed Wetland, and shall be included in each Monthly Report.

Table 1

Evansville Proposed Sampling Requirements		
	Influent (units)	Effluent (units)
Total Suspended Solids	mg/L	mg/L
CBOD5	mg/L	mg/L
pH	s.u.	s.u.
E. coli	cfu/100 mL	cfu/100 mL
Residual Chlorine	mg/L	mg/L

Defendants shall retain this information and any additional calibration, record of analyses preformed, maintenance of instrumentation and recording from continuous monitoring instrumentation for at least 5 years after the termination of the Consent Decree in accordance with Paragraph 109 in the Consent Decree.