REPORT
MARCH 2024

Alternatives Analysis Report

Prepared for:

Capital Region Water

Contents

Figures

Tables

Appendices

Acronyms and Abbreviations

AWTF	Advance wastewater treatment facility
BOD	Biochemical oxygen demand
BOD5	Five day biochemical oxygen demand
CBH_2OPP	City Beautiful H_2O Program Plan
CFU	Colony forming units
CHP	Combined heat and power
CRW	Capital Region Water
CSO	Combined sewer overflow
DO	Dissolved oxygen
DOJ	Department of Justice
EC	Enhanced conveyance
E. coli	Escherichia coli
EFDC	Environmental Fluid Dynamics Code
EPA	Environmental Protection Agency
E&S	Erosion and sedimentation
FCA	Financial Capability Assessment
FEMA	Federal Emergency Management Agency
FSI	Front Street Interceptor
FT	Feet
GPM	Gallons per minute
GSI	Green stormwater infrastructure
H&H	Hydrologic and hydraulic

HRC	High rate clarification
HRF	High rate filtration
I/I	Infiltration and inflow
LID	Low impact development
LoC	Level of control
LSRK	Lower Susquehanna Riverkeeper
LTCP	Long Term Control Plan
MCM	Minimum control measure
MGD	Million gallons per day
mg/L	Milligrams per liter
mL	Milliliter
MPCD	Modified Partial Consent Decree
MPN	Most probable number
MS4	Municipal separate storm sewer system
MTA	Mixed technology alternative
NA	Not applicable
NMCs	Nine minimum controls
NPDES	National Pollutant Discharge Elimination System
O&M	Operation and maintenance
PADEP	Pennsylvania Department of Environmental Protection
PCI	Paxton Creek Interceptor
RDII	Rainfall dependent infiltration and inflow
R&R	Renewal and replacement
RTB	Retention treatment basin
RTC	Real time control
SCADA	Supervisory control and data acquisition
S&D	Screening and disinfection
SST	Satellite sewage treatment
SWMM	Stormwater Management Model
TBL	Triple bottom line

TBM	Tunnel boring machine
TMDL	Total maximum daily load
TN	Total nitrogen
TP	Total phosphorus
TSS	Total suspended solids
TS	Tunnel storage
USACE	United States Army Corps of Engineers
USGS	United States Geological Survey
WAS	Waste activated sludge
WASP	Water Quality Analysis Simulation Program
WQMP	Water Quality Monitoring Plan

Executive Summary

Synopsis

Capital Region Water (CRW) is developing an *Updated City Beautiful H_2O Program Plan* (CBH_2OPP), which formulates a long-term, integrated approach for wastewater and stormwater management in the City of Harrisburg. Key objectives of the CBH_2OPP are to control combined sewer overflow (CSO) discharges, reduce collection system backups onto streets and into basements, improve the health of local waterways, protect public health and safety, and achieve compliance with the Clean Water Act. This *Alternatives Analysis Report*, which is a critical component of the CBH_2OPP, provides a comprehensive evaluation encompassing technical and economic analyses to identify the Recommended Plan.

The Recommended Plan consists of a suite of proposed CSO controls, including a centralized retention treatment basin, enhanced conveyance capacity, satellite storage tanks, green stormwater infrastructure, and sewer separation in small catchment areas. The Recommended Plan, estimated at $450 million (total present value lifecycle cost, including capital, operation and maintenance, and renewal and replacement costs) with a 40-year implementation period, aims to keep the program within affordability constraints to minimize undue financial strain on low-income households to the extent possible. This plan provides substantial reductions in CSO discharge volume. Overall, the Recommended Plan embodies a balanced approach that prioritizes both environmental stewardship and fiscal responsibility, making it the ideal choice to advance CRW's objectives effectively and efficiently.

Approach

CRW employed a multi-faceted strategy for the alternatives analysis by utilizing the demonstration approach of the CSO Control Policy combined with integrated planning and adaptive management, while also focusing on maximizing the environmental, economic, and social benefits. The development of the alternatives analysis and the Updated CBH_2OPP are directed by a Modified Partial Consent Decree (MPCD) involving CRW and the City of Harrisburg, along with the U.S. Department of Justice (DOJ), the U.S. Environmental Protection Agency (EPA), and the Pennsylvania Department of Environmental Protection (PADEP).

To analyze a range of alternatives and demonstrate how those alternatives fulfill the water-quality based requirements of the CSO Policy, CRW developed models of the combined and separate sewer systems and the two receiving waters, the Susquehanna River and Paxton Creek. The calibrated hydrologic and hydraulic (H&H) model of the CRW system simulates the operation of the CRW system under wet and dry weather conditions; and quantifies CSO volume, frequency, duration, and pollutant loads resulting from each of the analyzed alternatives. The results from the H&H simulations provide inputs into the respective water quality models to quantify the impacts of pollutant load reductions in the receiving waters and determine whether current water quality standards are attained by the control alternatives.

Public engagement and participation is a crucial component of the Updated CBH2OPP. A newly convened steering committee, along with the public, will have the opportunity to influence revisions and updates to the Recommended Plan. Capital Region Water has identified several events to educate, engage, and involve stakeholders before final submission in December 2024. Multiple events will provide opportunities for formal feedback, starting on April 24th and ending in August. Monthly Steering Committee Meetings, Community Ambassador Meetings, litter clean-up events, and neighborhood association meetings will also involve stakeholder engagement.

Creating an Effective Foundation

Over the last decade, CRW has implemented multiple programs and completed an extensive set of rehabilitation and enhancement projects to restore the resilience and reliability of the sewer system. CRW proactively committed to a critical set of upcoming projects (documented in Appendix B of MPCD), which are scheduled for completion by December 31, 2032. CRW is also a partner in the planning of the Paxton Creek Greenway, a project that provides a comprehensive means to control flooding and restore the creek's natural ecological function. Completion of these committed initiatives leads to substantial decreases in the total annual overflow volume and the annual overflow frequencies at individual CSO outfalls. These foundational initiatives serve as the initial building blocks to which each of the alternative control technologies are added and evaluated for developing this *Alternatives Analysis Report*.

Analyzing Alternative Control Technologies

CRW conducted a CSO control technology screening process, whereby a comprehensive list of control technologies was developed and evaluated. Control technologies determined to be technically infeasible for implementation in the CRW combined sewer system were excluded from further analysis. For example, street storage would result in frequent clogging of control orifices, so this technology was not included in further analysis. Several control technologies, including green stormwater infrastructure and catch basin modifications, are currently part of CRW’s ongoing system operation. A wide range of control technologies were determined to be feasible and advanced to the next round of analysis.

Six distinct, feasible control technologies, as listed below, were each applied throughout the CRW system model to determine the cost of implementation and facility sizes to provide a range of CSO control. The control technologies fall into two main categories: centralized (or systemwide) and decentralized (or local) technologies.

- **Enhanced Conveyance and Increased AWTF Capacities**. These centralized technologies focus on increasing the conveyance capacities of the interceptor system and pump stations and increasing conveyance and/ or treatment capacity at the advanced wastewater treatment facility (AWTF).
- **Tunnel Storage**. Under these centralized technologies, excess wet weather flows that exceed existing conveyance system capacities are conveyed to a tunnel system, stored temporarily, and dewatered to the AWTF after the storm passes and conveyance and treatment capacities become available.
- **Green Stormwater Infrastructure (GSI)**. These decentralized technologies retain stormwater runoff near where it originates, reduce the volume and/or peak flow of stormwater runoff and associated pollutant loads before it enters the combined sewer collection system, and reduce the risk of street flooding and basement backups.

- **Satellite Storage**. These decentralized technologies convey excess wet weather flows that exceed existing system capacities to a network of strategically placed satellite storage tanks, where they are stored temporarily and subsequently dewatered and conveyed to the AWTF after the storm passes and conveyance and treatment capacities become available.
- **Satellite Treatment**. These decentralized technologies reduce the pollutant loads to receiving waters by treating wet weather flows before discharging to the receiving waters. Specific technologies can address different pollutant constituents.
- **Sewer Separation**. Sewer separation requires new sewers to be constructed to convey sanitary and stormwater flows separately, and can be implemented systemwide or targeted to a local scale. This prevents stormwater runoff from comingling with sanitary wastewater. Stormwater would be conveyed to the receiving waters and wastewater would be conveyed to the AWTF for treatment and discharge.

Each control technology was evaluated based on, but not limited to, the following key parameters: ability to meet current water quality criteria, flexibility/ adaptability, facility footprint feasibility, applicability to satellite locations, operation and maintenance, compatibility with other technologies, degree of collection system benefits, and cost effectiveness. The most effective control technologies for large-scale implementation were determined to be targeted enhanced conveyance, green stormwater infrastructure, satellite storage, satellite treatment with retention treatment basins, satellite treatment with screening/disinfection, and tunnel storage.

Assembling Mixed Technology Alternatives for Enhanced Results

Due to the complexity of the CRW system and the multiple objectives for the controls, it was necessary to combine a mixture of technologies. Therefore, the most effective control technologies were integrated to develop a suite of mixed technology alternatives (MTAs) for further analysis.

CRW intends to maximize green stormwater infrastructure (GSI) throughout the system due to its cost-effectiveness and additional community benefits. GSI facilities manages stormwater runoff at the source They reduce the volume, peak flow, and pollutant loads before the runoff enters the combined sewer system. This reduces the volume reaching the AWTF, thereby reducing the treatment burden on the facility. GSI implementation lowers the risk of surface flooding and basement backups within the collection system. GSI is particularly cost-effective at decreasing overflow volume because it can work synergistically with other gray technologies, such as satellite storage, by reducing the end-of-pipe volumes, thereby minimizing the required facility sizes and costs. Implementing GSI also yields additional benefits that add value to the community, including groundwater recharge, quality of life improvements, smog, and heat mitigation, reducing respiratory and heat-related illnesses, and creating additional jobs.

Eight mixed technology alternatives were developed, each incorporating an appropriately wide range of technological solutions and levels of control (LoCs). The single control technology components included in each MTA are identified in **Table ES-1**. The development of MTAs used several principles, such as evaluating a wide range of wet weather control technologies, combining the best-performing technologies, considering various degrees of catchment/outfall consolidation, and the advancement of Paxton Creek Greenway for additional sewer separation and gray infrastructure placement. GSI is a preferred technology for managing flows and pollutants and reducing surface flooding and basement backups, so all MTAs incorporate GSI implementation.

Table ES-1. Components of Mixed Technology Alternatives

Single Technology	Mixed Technology Alternatives							
	1	2	3	4A	4B	5	6	7
Green Stormwater Infrastructure	✓	✓	✓	✓	✓	✓	✓	✓
Satellite Storage	✓	✓	✓	✓	✓	✓	✓	✓
Targeted Sewer Separation	✓	✓	✓	✓	✓	✓	✓	✓
Enhanced Conveyance	✓						✓	
Tunnel Storage						✓		
Screening and Disinfection			✓	✓				
Retention Treatment Basin			✓	✓			✓	

All these alternatives encompass the required projects outlined in MPCD Appendix B, alongside GSI measures designed to manage runoff from approximately 294 acres of impervious area. Below is a brief description of the MTAs.

- **MTA-1: Enhanced Conveyance and Treatment**. Includes hydraulic and process improvements of the interceptors, pump stations, and advanced wastewater treatment facility (AWTF) to increase the peak wet weather capacity for primary treatment and disinfection.
- **MTA-2: Satellite Storage with Limited Consolidation**. Utilizes satellite storage, with limited catchment consolidation, as the primary means of controlling wet weather discharges.
- **MTA-3: Satellite Storage and Treatment with Limited Consolidation**. Utilizes a combination of satellite treatment and storage facilities to control wet weather discharges.
- **MTA-4A: Satellite Storage and Treatment with Maximized Consolidation**. Utilizes a combination of satellite treatment and storage as the primary means of controlling wet weather discharges and consolidates adjacent CSO regulator structures to limit the number of required facilities.
- **MTA-4B: Satellite Storage with Maximized Consolidation**. Utilizes consolidated satellite storage as the primary means of controlling wet weather discharges and consolidates adjacent CSO regulator structures to limit the number of required facilities.
- **MTA-5: Tunnel Based Storage**. Utilizes tunnel storage as the primary means of controlling wet weather discharges.
- **MTA-6: Maximize Conveyance and Treatment**. Utilizes a 70 MGD retention treatment basin, interceptor system enhancements, and limited satellite storage.
- **MTA-7: Paxton Creek Storage Conduit**. Potential “add-on” that can be used in conjunction with the other alternatives listed above. In this concept, individual satellite storage facilities along the Paxton Creek Interceptor are replaced by a single linear conduit storage facility.

Present value lifecycle cost estimates for each MTA level of control were utilized to prepare cost-performance (or knee-of-the-curve) plots for comparing the alternative plans.

CRW evaluated each MTA based upon, but not limited to, the following criteria: ability to meet current water quality standards, flexibility/ adaptability, facility footprint feasibility, operation and maintenance, hydraulic improvements, uncertainty, O&M requirements, complexity, near-term water quality benefits, cost-effectiveness, number of projects, and public acceptability. The evaluation indicated that certain MTAs stand out as more favorable than others. Among these, MTA-4B and MTA-6 emerged as particularly advantageous, offering an effectual blend of control technologies to address water quality standards.

Additionally, MTA-7 is a complementary option to either MTA-4B or MTA-6. MTA-7 proposes a single linear conduit storage facility along Paxton Creek. This approach could be used to substitute individual satellite storage facilities for enhanced installation and operational efficiency and effectiveness.

Focus on Water Quality

The primary objective of this alternatives analysis is to identify a preferred alternative that can provide a sufficient LoC to meet current water quality standards for bacteria. Water quality models, conforming to the Water Quality Modeling Plan (WQMP), were created for both the Susquehanna River and Paxton Creek. The water bodies were analyzed separately, and the results are depicted separately within the report, because they have different assimilative capacities and will require distinct levels of control.

CRW completed monitoring/data collection during a wet weather event in 2023, to develop the preliminary water quality models. CRW plans to perform further monitoring/data collection to develop a fully calibrated water quality model in 2024. For each MTA, the CSO volumes and pollutant loads from the H&H model were input into the water quality models to assess compliance with current water quality standards.

Given that water quality monitoring is ongoing, CRW is presenting the findings as a range of what is required to meet current water quality standards. The upper and lower limits correspond to a range of assumed wastewater bacteria levels. For the Susquehanna River, each MTA requires a LoC range between 10 to 16 overflows per year (during the Typical Year precipitation) to meet current water quality standards. For Paxton Creek, each MTA requires a LoC range of 2 to 10 overflows (except for MTA-7 which requires a range of 2 to 5 overflows) during the Typical Year to meet current water quality standards.

Selecting the Preferred Alternative

An assessment of the mixed technology alternatives was conducted, and based on this assessment, MTA-6 was chosen as the preferred alternative. It was also decided that satellite storage facilities along Paxton Creek could potentially be substituted with linear storage using an adaptive management approach during final design efforts. The detailed feasibility analysis, design and implementation phases will incorporate an adaptive management approach, allowing for some adjustments to the sizing and location of selected technologies to pursue collaborative advantages that may be available. The following factors proved to be key advantages of MTA-6.

- Conveyance and treatment capacities would be increased, providing operational flexibility, resilience to climate change, and adaptability to evolving regulatory standards.
- Procurement of an adjacent property to AWTF for the retention treatment basin (RTB) would also provide other future expansion opportunities for an otherwise landlocked AWTF site.
- The RTB will allow for some of the combined sewage volume to be retained in the associated storage that will be released to AWTF for full secondary treatment when capacity becomes available.
- With the increase in interceptor conveyance capacity, CSO regulators can be modified to convey more flow into the interceptors, which allows the number and sizes of satellite storage facilities to be reduced.
- The retention treatment basin is adjacent to the existing AWTF, so required onsite staffing during wet weather events would be efficient.
- Supervisory Control and Data Acquisition (SCADA) and real-time control (RTC) technologies will be utilized to manage the complexity associated with providing the required operational flexibility and to optimize available conveyance and treatment capacities.
- Delivers a larger net environmental benefit by achieving lower systemwide CSO volumes across all levels of control.

Refining the Proposed Alternative

Refinements to MTA-6 were made based on additional analyses to identify a more cost-effective size for the retention treatment basin and to identify the best balance of GSI facilities and storage tank volumes. The Financial Capability Assessment (FCA) results also helped refine the proposed alternative.

CRW completed an FCA with an economic model. The results indicated that if CRW were to implement additional water pollution control capital investments, along with other system investment needs, totaling $400 million (in 2024 dollars), and implemented over a 20-year period, this would place an excessively high economic burden on low-income households. The economic model developed for the FCA was applied to the sequence of capital, life-cycle operation and maintenance (O&M), and renewal and replacement (R&R) costs associated with the preferred alternative MTA-6. The economic model showed that the implementation of MTA-6 within a 20-year period to meet current water quality standards on both the Susquehanna River and Paxton Creek would place an excessively high economic burden on households within CRW's city retail service area.

Therefore, refinements to MTA-6 were made which aimed to meet current water quality standards along the Susquehanna River and minimize CSO discharges to Paxton Creek without placing an excessively high financial burden on the community. CRW evaluated varying levels of GSI implementation to maximize community benefits, such as reducing localized flooding and basement backups, while considering affordability constraints. Additionally, a more effective balance of gray infrastructure was achieved by reducing the size of the RTB, which then slightly increased the number and size of storage tanks.

CRW's Recommended Plan, based on MTA-6 with modifications, features a 30 MGD retention treatment basin and runoff from approximately 200 acres of impervious area managed by GSI. This plan targets approximately 10 overflows per year along the Susquehanna River, conservatively meeting current water quality standards according to the preliminary water quality model, and 16 overflows per year along Paxton Creek, significantly reducing CSO discharges and pollutant loads. Compliance with the Clean Water Act for Paxton Creek will be pursued through a Use Attainability Analysis (UAA).

Elements Comprising the Recommended Plan

Implementing the Recommended Plan encompasses several key components aimed at mitigating CSO discharges and enhancing water quality of the receiving waters. These include the project components listed below. These facilities that comprise the Recommended Plan are depicted on a map in **Figure ES-2.**

- CSO-048 stormwater diversion system (a MPCD Appendix B project).
- Rehabilitation and expansion of the Spring Creek Pump Station (a MPCD Appendix B project).

  Construction of an approximately 30 MGD Retention Treatment Basin (RTB) adjacent to the existing AWTF.
- Replacement and capacity expansion of Paxton Creek Interceptor (a MPCD Appendix B project).

  Further extension of the Paxton Creek Interceptor (approximately 3,700 linear feet to the new RTB).
- Satellite storage tanks strategically placed along both the Susquehanna River (3 storage tanks) and Paxton Creek (3 storage tanks).
- A network of supporting consolidation sewers and flow diversion structures to regulate wet weather flow and convey it to the proposed satellite storage facilities.
- Green stormwater infrastructure facilities to manage stormwater runoff from approximately 200 acres of impervious area.
- Sewer separation initiatives along Paxton Creek (approximately 17 acres, MPCD Appendix B projects).
- Upgrades to regulator structures to increase wet weather capture and prevent river intrusion into the interceptors.

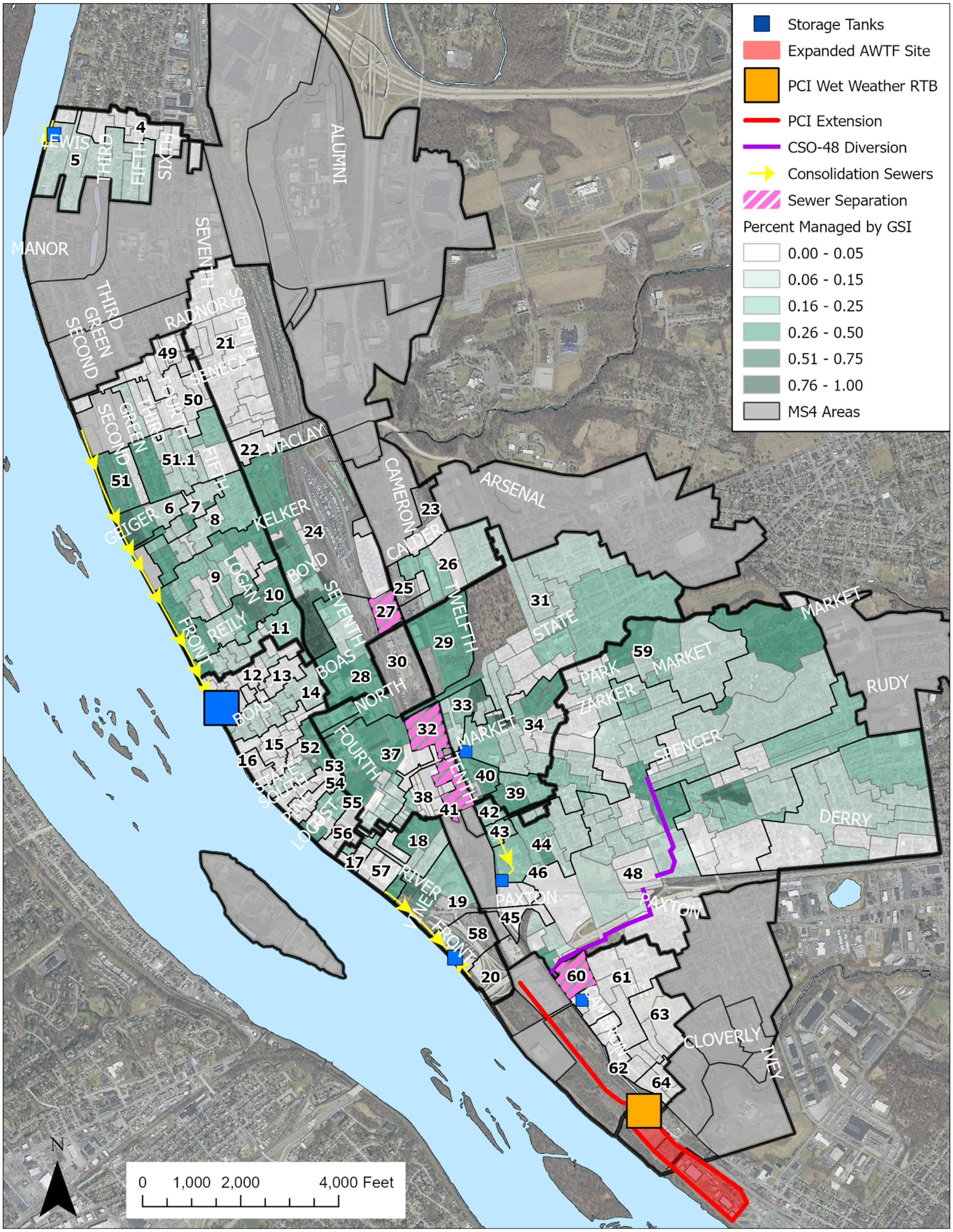

Figure ES- 1: Map of CSO Control Facilities for Recommended Plan

Recommended Plan Performance

Based on the preliminary water quality model, the Recommended Plan is projected to achieve an annual CSO frequency of approximately 10 overflows in the typical year for the outfalls contributing to the Susquehanna River, down from a maximum of 95 overflows in Pre-Plan conditions. Similarly, Paxton Creek annual CSOs are projected to be reduced to approximately 16 overflows, compared to a maximum of 90 previously. CSO volumes to the Susquehanna River are projected to be reduced by approximately 90%, from 280 MG to approximately 29 MG, and CSO volumes to the Paxton Creek are projected to be reduced by approximately 84% from 513 MG to approximately 83 MG. Moreover, the plan achieves water quality compliance for the Susquehanna River, under typical year precipitation while considerable progress is made in Paxton Creek.

Conclusion

The Recommended Plan, with its enhanced conveyance and treatment capacities, offers a robust solution capable of adapting to evolving environmental regulations and climatic conditions. In coordination with the Recommended Plan, the Paxton Creek Greenway provides the opportunity to replace and increase the size of the Paxton Creek Interceptor and maximize additional benefits to improve water quality. Moreover, the Recommended Plan's reduced reliance on satellite storage tanks, compared to other alternative options, minimizes visual impact on the community. The Recommended Plan is technically feasible, cost-effective, resilient, and sustainable.

1.0 Overview of the Approach for Preparing this Alternatives Analysis

Capital Region Water (CRW) is a municipal authority that improves, maintains, and operates the water, wastewater, and stormwater infrastructure for the City of Harrisburg. CRW has proactively implemented many projects and programs focused on the following key priorities:

- Serve as a steward of the Harrisburg area’s water systems
- Provide community focused solutions
- Protect public health and the environment
- Implement fiscally responsible practices

Located along the east shore of the Susquehanna River, CRW provides service to over 20,966 customer accounts in the City of Harrisburg. CRW also provides wastewater conveyance and treatment services to six satellite communities as wholesale customers. CRW assumed ownership and operation and maintenance responsibilities for the wastewater and stormwater collection and conveyance systems in late 2013, which followed decades of deferred maintenance by the City of Harrisburg. About 60 percent of Harrisburg’s wastewater and stormwater collection systems are comprised of combined sewers, some of which were built over a century ago. The remaining 40% of the City system, and the systems for the six satellite community customers, are served by separate sanitary and stormwater systems.

CRW’s cornerstone program to provide environmentally conscious wastewater and stormwater management is the City Beautiful H_2O Program Plan (CBH_2OPP). The CBH_2OPP provides an assessment of the existing conditions, evaluates multiple strategies for asset renewal and environmental compliance, and ultimately selects the suite of projects that will most effectively benefit the community, improve water quality, and fulfill regulatory requirements.

1.1 Regulatory Context

Capital Region Water (CRW) is developing an Updated City Beautiful H_2O Program Plan to control combined sewer overflow (CSO) discharges and backups onto streets and into basements, improve the health of local waterways, and protect public health and safety. Capital Region Water (CRW) is party to a Modified Partial Consent Decree (MPCD)[1] with the U.S. Department of Justice (DOJ), the U.S. Environmental Protection Agency (EPA), and the Pennsylvania Department of Environmental Protection (PADEP). The finalized MPCD was entered August 25, 2023. The MPCD is consistent with the objectives set by the federal Clean Water Act (CWA),[2] the Combined Sewer Overflow (CSO) Control Policy,[3] federal and commonwealth regulations for pollutant discharges from municipal separate storm sewer systems[4]

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[1] Modification to Partial Consent Decree, United States of America and Commonwealth of PA Dept. of Environmental Protection, Plaintiffs, v. Capital Region Water and the City of Harrisburg, PA, Defendants, effective August 25, 2023.

[2] Clean Water Act, 33 U.S.C., § 1251, Oct 18, 1972

[3] EPA Combined Sewer Overflow Policy, April 11, 1994

[4] 40 CFR § 122.26, 122.30-122.37

(MS4s), as well as state laws and regulations. Its objective is to improve water quality in receiving waters as necessary to achieve their designated waterway uses (e.g., drinking water, recreation, aquatic life, and others) and protect public health, safety, and welfare.

Section V, Paragraph 13 of the MPCD establishes the requirement for CRW to develop a revised and updated Long Term Control Plan:

> *By no later than December 31, 2024, CRW shall complete and submit a revised and updated Long Term Control Plan ("LTCP") to Plaintiffs for review and approval in accordance with the requirements of Section VI (Review and Approval of Deliverables). The updated LTCP shall conform to the requirements of the EPA's CSO Policy; EPA's "Guidance for Long-Term Control Plan," EPA 832-B-95-002, September 1995; EPA's "Greening CSO Plans: Planning and Modeling Green Infrastructure for Combined Sewer Overflow (CSO) Control," EPA 832-R-14-001, March 2014; and EPA's Integrated Municipal Stormwater and Wastewater Planning Approach Framework Memorandum, dated June 5, 2012. The updated LTCP shall include schedules, deadlines and timetables for remedial measures designed to meet the following goals:*
>
> - *Bring all CSO discharge points into compliance with the technology-based and water quality-based requirements of the CWA; and*
> - *Minimize the impacts of CSOs on water quality, aquatic biota, and human health.*

Paragraph 19 of the MPCD establishes the requirement for CRW to develop an Alternatives Evaluation:

> *As part of the LTCP, pursuant to Paragraph 13 above, by March 31, 2024, CRW shall submit an Alternatives Evaluation that complies with the requirements of the CSO Control Policy Section II.C.4, and that is consistent with EPA's "Guidance for Long-Term Control Plan," EPA 832-B-95-002, September 1995. The Alternatives Evaluation shall consist of: (1) the identification of feasible CSO control technologies, (2) a detailed evaluation of an appropriately wide range of specific CSO control alternatives and sizes of those alternatives, and (3) selection of an appropriate suite of proposed CSO controls to achieve compliance with the Clean Water Act. CRW shall specifically evaluate the feasibility of eliminating or relocating all CSO Outfalls that discharge to Sensitive Areas and shall give a high priority to the control of CSO Outfalls that discharge to Priority Areas, and those that have the highest frequency or greatest volume of discharge of wastewater.*

Paragraph 15 of the MPCD establishes the following pollutants of concern for the receiving waters:

- **Paxton Creek:** Bacteria, Dissolved Oxygen, Biochemical Oxygen Demand ("BOD"), Total Suspended Solids ("TSS"), Nitrogen, and Phosphorus
- **Susquehanna River:** Bacteria, TSS, Nitrogen, and Phosphorus

As a result, the review of CSO abatement technologies will concentrate on technologies suitable for addressing these pollutants of concern.

Paragraph 16 of the MPCD requires the submission of a Water Quality Modeling Plan (WQMP) and the subsequent implementation of the approved plan. The WQMP identifies the modeling software and configuration and the sampling activities used to calibrate and validate the model. The plan requires the model to evaluate Typical Year instream conditions for each pollutant of concern. The model is used to evaluate the receiving water quality improvements associated with proposed alternative control facilities and to help inform the selection of the recommended CSO control alternative.

Paragraph 10 of the MPCD requires CRW to create a program to identify and prioritize remedial work. The priority in which this remedial work is completed was determined through CRW's assessment of risk of failure and consequence of failure of the defects identified. Appendix B of the MPCD fulfills this requirement and contains a list of required remediation and CSO control projects along with project descriptions and implementation schedules for the start and completion of construction. The projects within Appendix B are intended to further enhance system resiliency and reliability and significantly increase CSO capture.

This *Alternatives Analysis Report* meets each of the requirements specified in the MPCD and within the CSO Control Policy.

- **Section 2** describes the identification and screening of a wide range of potential technologies used for the control of CSO discharges and the assessment of alternative control measures relevant to and feasible for the CRW system.
- **Section 3** documents completed and committed sewer system rehabilitation, repair, enhancement, and CSO control projects to bring the CRW system to a fully functioning and resilient operating condition that can support an approvable LTCP.
- **Section 4** describes the evaluation of the selected site-specific individual control technologies for controlling wet weather discharges and the associated pollutants of concern. A detailed examination of single technology screening evaluations is described, where individual control technologies were evaluated for their applicability and effectiveness in controlling wet weather flow and CSO discharges in the CRW system.
- **Section 5** describes the water quality monitoring and modeling activities to quantify existing pollutant loads and instream conditions and the impacts of CSO control alternatives on instream water quality. The section also describes the metrics used to assess the instream impacts of CSO discharges and presents metrics for each of the CSO alternatives.
- **Section 6** describes the eight mixed technology alternatives formulated and evaluated to provide the range of levels of control, including alternatives sufficient for achieving water quality compliance. This includes specific facility locations and the extents of alternative facility sizes, and capacities. The multiple factors used to evaluate the alternatives are also outlined.
- **Section 7** is the conclusion of the *Alternatives Analysis Report*, which includes a "selection of an appropriate suite of proposed CSO controls to achieve compliance with the Clean Water Act," per the MPCD, and establishes the basis for a fully detailed LTCP (due December 31, 2024). The preferred alternative and the Recommended Plan are presented while synthesizing the findings and recommendations derived from the preceding sections. This section encapsulates the culmination of the analysis, offering a cohesive solution tailored to meet the defined environmental, social, and economic objectives.

1.2 Relationship to Other Documents

This *Alternatives Analysis Report* was prepared within the context of other required Plans concurrently developed and implemented.

Long Term Control Plan (LTCP): CRW submitted a LTCP to EPA and PADEP on April 1, 2018. The LTCP is called the City Beautiful H_2O Program Plan (CBH_2OPP) and is based upon an integrated approach that included combined sewer system and separate sanitary/MS4 system compliance objectives and asset renewal components. The asset renewal components are required to get the CSO system to a baseline operating condition and operate it as designed. In coordination with EPA and PADEP, CRW developed a 10-year plan to address system renewal from the 2018 LTCP, and by December 31, 2024, will submit an updated CBH_2OPP that meets the requirements of the MPCD. The updated CBH_2OPP will be consistent with the requirements of the EPA's CSO Policy as documented in EPA's 1995 Guidance for Long-Term Control Plan.[5] As explained in Section 1.4, the updated CBH_2OPP will be an integrated plan, including combined sewer system compliance objectives, separate sanitary/MS4 system compliance objectives, and asset renewal components. Projects will be selected using a triple bottom line framework to best prioritize capital investments to achieve the greatest human health and environmental benefits. The CBH_2OPP will implement the demonstration approach under the National CSO Policy, and will demonstrate that its plan, and the range of alternative control measures developed and evaluated under this Alternative Analysis, are adequate to meet the current water quality-based requirements of the CWA. The updated CBH_2OPP will include a schedule for remedial measures designed to bring all CSO discharge points into compliance with the technology-based and water quality-based requirements of the CWA and minimize the impacts of CSOs on water quality, aquatic biota, and human health.

Water Quality Modeling Plan: On June 10, 2022, CRW submitted a Water Quality (WQ) Modeling Plan to EPA and PADEP. The Plan was revised and resubmitted in February 2023 in response to review comments from the regulatory agencies. An Addendum to the Plan was submitted in May 2023toreflect changes in the modeling approach. The Addendum was approved by EPA and PADEP in August 2023. The Plan documents the available data for each receiving water, including water quality, bathymetry, channel geometry, and river flow and stage data. The Plan documents the existing WQ monitoring data that has been previously collected, the additional data to be collected to strengthen model calibration and validation, and the model calibration and validation activities. The Plan also documents the specific WQ models, their configuration, and the modeling approach to be utilized.

Public Notification Plan: On September 22, 2023, CRW submitted a Public Notification Plan that documented how and when CRW will notify the public about CSO events, including the design, location, and planned installation date of any signs, placards, monitors, or other public notification system. In response, EPA provided a comment letter on November 2, 2023. CRW provided a response and clarification to all matters presented in EPA's comment letter by way of a response letter on November 21, 2023. Implementation of the Public Notification Plan and related procedures will be documented in the Semi-Annual Reports submitted under the MPCD.

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[5] EPA 832-B-95-002, September 1995

Sensitive Areas/Priority Areas Report: On September 22, 2023, CRW submitted a report that addresses the topics of sensitive areas and priority areas in the receiving waters of the CRW service area. Neither the Susquehanna River nor Paxton Creek are designated as an Outstanding National Resource Water or a National Marine Sanctuary. Public water intakes, public access points and primary contact recreation, and waters with threatened or endangered species were investigated for the report. Water quality information and the flow characteristics of the two waterways were also investigated to support the analysis of sensitive and priority areas. Because of public access points for recreation along the Capital Area Greenbelt, CRW will develop a CSO LTCP implementation schedule that gives higher priority to controlling CSOs to the Susquehanna River. CRW will also evaluate, in developing its LTCP, whether there are any individual outfalls along the receiving waters that would require more attention than others in evaluating control options and/or implementation schedules. On January 4, 2024, EPA provided conditional approval of the Sensitive Areas Plan, pending the results of water quality modeling showing the extent of the CSO plume into the Susquehanna River.

Financial Capability Analysis: The schedule for implementing the recommended alternative identified within the updated 2024 CBH_2OPP will be guided by affordability constraints defined by a Financial Capability Assessment (FCA). The FCA was submitted on February 24, 2024, per the requirements of the MPCD. Financial capability is one of many factors the EPA considers when developing schedules for the implementation of long-term CWA control plans. After control facilities have been selected, the updated FCA will be used to aid in assessing the CRW service area's financial capability as a part of negotiating implementation schedules for the LTCP.

1.3 Relationship to Completed and Planned Projects

The alternative control facilities evaluated under this *Alternatives Analysis Report* are built upon the critical foundation of two categories of improvement and remediation projects to the CRW system.

- Projects that were previously completed between 2013 and 2023.
- Projects required to be completed in accordance with the implementation schedule within MPCD Appendix B (with various milestone dates through December 31, 2032).

CRW assumed ownership and operation and maintenance (O&M) responsibilities for the City of Harrisburg's wastewater and stormwater collection and conveyance systems in 2013. The sewer system infrastructure reflected the consequences of decades of deferred maintenance by the City. Since 2013, CRW has implemented a balanced, affordable approach to address the problems, characterize system component conditions, prioritize needs, and develop and implement remediation measures to restore and protect the reliability and resiliency of the CRW system.

Previously completed projects since 2013 provided primarily system resiliency and reliability. Additional projects required under Appendix B of the MPCD are intended to further enhance system resiliency and reliability and significantly increase CSO capture. With the completion of the Appendix B projects by 2032, average systemwide combined sewage capture within the CRW system is expected to increase from 53% to approximately 83% to 84% and the total annual overflow volume, under typical year precipitation conditions, is expected to decrease from 280 to 144 million gallons (MG) along the Susquehanna River and from 513 to 186 MG along Paxton Creek. Each Appendix B project has a designated completion schedule between now and December 31, 2032. More detailed descriptions of the completed projects and the Appendix B projects, and the resulting benefits they provided or will provide when complete, are provided in Section 3 of this report, *Committed Projects – The First Level of Control Point*.

1.4 Compliance Approach and Strategy

This *Alternatives Analysis Report* is based on the following compliance approaches and strategies. These approaches and strategies will also be used for the December 2024 CBH_2OPP submittal.

Demonstrative Approach: CRW is implementing the demonstration approach under the federal CSO Policy and will demonstrate that its plan, and the range of alternative control measures developed and evaluated under this alternatives analysis, are adequate to meet the water quality-based requirements of the policy. CRW has successfully created a calibrated hydrologic and hydraulic (H&H) model of the CRW system that is used to generate annual CSO discharge statistics (overflow volume, frequency, and duration) for each CSO outfall within the CRW system. The H&H model employs a continuous simulation approach utilizing the EPA Stormwater Management Model (SWMM). The H&H Model will be applied using a Typical Year precipitation time-series that statistically represents the long-term precipitation record for the CRW service area. CRW has also developed WQ models for the receiving waters, the Susquehanna River and Paxton Creek. For the Susquehanna, a two-dimensional (2-D) WQ model was developed using EPA's Environmental Fluid Dynamics Code (EFDC). The EFDC model simulates both the longitudinal (along the river) and transverse (across the channel) hydrodynamics and the mixing, transport and fate of pollutant loads from upstream sources and each CSO outfall. For the much smaller, narrower, and shallower Paxton Creek, a 1-D model was developed using EPA's Water Quality Analysis Simulation Program (WASP). The WASP model simulates the hydrodynamics and the mixing, transport, and fate of pollutant loads from upstream sources and CSO and stormwater flows along the creek. The H&H model is used to quantify the reductions in CSO volume, frequency, duration, and pollutant loads resulting from each of the analyzed control alternatives. The results from the H&H model are input into the WQ models to forecast and quantify the degree to which the alternative control facilities meet water quality criteria in each receiving water. Section 5 documents the completed activities for water quality modeling and how the models are used to support the associated alternative analyses.

Integrated Planning Approach: CRW is implementing an integrated planning approach under the 2019 Water Infrastructure and Improvement Act.[6] The integrated planning approach includes combined sewer system compliance objectives, separate sanitary/MS4 system compliance objectives, and asset renewal components in a triple bottom line framework to best prioritize capital investments and to achieve the greatest human health and environmental benefits. This approach can also lead to more sustainable and comprehensive solutions, such as green infrastructure, that protect human health, improve water quality, manage stormwater as a resource, and provide multiple economic benefits and quality of life attributes that enhance the vitality of communities. The major advantage in using an integrated planning approach to develop a LTCP is that it would prevent CRW from utilizing and expending all its available capital resources on CSO control when investing on other non-CSO projects would provide greater environmental and human health benefits.

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[6] Water Infrastructure and Improvement Act (WIIA) (H.R. 7279), January 14, 2019

Adaptive Management Approach: Implementation of the recommended wet weather control alternative identified within the updated 2024 CBH2OPP will rely upon an adaptive management process. This adaptive management approach will require flexibility and periodic program assessments throughout the implementation period. As the projects in the recommended LTCP evolve from a conceptual planning level to the preliminary and final design processes, the specific location, configuration, and size of the facilities are likely to change. Adaptations are expected throughout this period to meet compliance goals and optimize and enhance the program to maximize benefits and minimize implementation costs. An adaptive management approach is a part of, and consistent with, an integrated planning framework. The MPCD includes semiannual and annual progress reporting requirements and continuous updates on the adaptation of the implementation program will be provided to EPA and PADEP through this reporting process.

Triple Bottom Line Approach: There are numerous ways to manage stormwater runoff and CSO discharges in urban areas. These include traditional engineering approaches that rely largely on traditional (“gray”) infrastructure and more “natural” and environmentally friendly approaches that rely more on “green infrastructure” and Low Impact Development (LID) techniques. These approaches help divert, store, and promote infiltration of stormwater to help restore and enhance natural systems rather than overload traditional wastewater and stormwater collection and treatment facilities. CRW will emphasize the Triple Bottom Line (TBL) implications of the green and traditional infrastructure approaches in terms of their respective ability to provide environmental, economic, social, and other values. CRW’s CBH$_2$OPP will include green stormwater infrastructure (GSI) elements to manage stormwater runoff in a way that maximizes triple bottom line benefits as is consistent with EPA’s 2014 document *Greening CSO Plans, Planning and Modeling Green Infrastructure for Combined Sewer Overflow (CSO) Control*.[7]

Approach for the Implementation Schedule: The schedule for implementing the recommended alternative identified within the updated 2024 CBH$_2$OPP will be guided by multiple affordability factors and constraints, including those defined by a Financial Capability Assessment (FCA). The FCA includes information on sewer rate setting, a definition of the service population of the City of Harrisburg and the entire CRW service area, and household income information on the service population. Financial capability is one of many factors EPA considers when developing schedules for the implementation of long-term CWA control plans. After control facilities have been selected, the information contained within the FCA will be used to aid in assessing CRW’s financial capability as a part of negotiating implementation schedules under both permits and enforcement agreements. These activities are intended to keep rates affordable, particularly for the most economically vulnerable ratepayers.

1.5 Public Engagement and Participation

The public engagement and participation component of the Recommended Plan selection process is a crucial component of the Long-term Control Plan. CRW’s public participation strategy builds upon ongoing programming, outreach, and communications designed to intentionally engage various audiences and stakeholders as described and documented in the Public Notification Plan, Nine Minimum

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[7] EPA 832-R-14-001, March 2014

Control (NMC) Plan, and semi-annual reports. A newly convened steering committee will act as advisors and, in conjunction with the public, will have the ability to influence the revisions and updates to the long-term control plan ahead of its final submission in December of 2024. Capital Region Water has identified a number of specific events through a robust events calendar, aimed at reaching diverse audiences and stakeholders. Four significant events hosted by CRW will be dedicated to educating, engaging, and involving the public and major stakeholders. Each session will provide an opportunity for formal feedback through various electronic and in-person channels. The first session will occur on April 24th, during the regular monthly Board of Directors meeting, marking the official launch of the formal feedback period. The following events will take place in May, July, and August, culminating in the August Board of Directors meeting as the conclusion of the formal feedback period. Additionally, other events have been identified as valuable opportunities for public engagement and participation. Monthly Steering Committee Meetings, Bi-monthly Community Ambassador Meetings, several litter clean-up events, and neighborhood association meetings will be attended to involve and educate all stakeholders for the successful execution of this plan.

2.0 Control Technologies and Screening

2.1 Overview of Control Technologies and Screening

This section describes the potential combined sewer overflow (CSO) control technologies, along with municipal separate stormwater sewer system (MS4) control technologies and other wet weather control measures, that were considered and evaluated by Capital Region Water (CRW) for creating this *Alternatives Analysis Report*. All three categories of control technologies were evaluated because of the regulatory approaches selected by CRW and described in report Section 1. The development and evaluation of alternative control measures is based upon an integrated planning approach that offers an opportunity for a municipality or sewer authority to propose to meet multiple CWA requirements to best prioritize capital investments and to achieve the greatest human health and environmental benefits. Integrated planning allows CRW to identify efficiencies from separate wastewater and stormwater programs and sequence investments so that the highest priority projects come first. Integrated planning also allows CRW to use more sustainable and comprehensive solutions, such as green infrastructure, that improve water quality and provide multiple triple-bottom-line benefits that enhance community vitality.

The technologies included in this initial screening evaluation are grouped into the following categories:

- **Decentralized Source Controls**: Technologies, operating strategies, and policies that affect the quantity and quality of runoff that enters CRW’s combined sewer system.
- **Conveyance/Collection System Controls**: Modifications within the conveyance and collection systems that affect CSO flows and loads after the introduction of runoff.
- **Storage Technologies**: In-line and off-line storage for wet weather flows that are detained and released once treatment and conveyance capacity have been restored.
- **Treatment Technologies**: Technologies to reduce pollutant loads to the receiving waters.
- **Receiving Water Technologies**: Methods for removing pollutants after they have been discharged to the receiving waters.

2.2 Identification of Feasible CSO Controls

2.2.1 Decentralized Source Controls

Green Stormwater Infrastructure (GSI): Green infrastructure includes specific sets of source controls that use natural processes such as infiltration, evapotranspiration, and filtration as well as engineered structural controls such as storage and controlled release, to reduce the volume of stormwater runoff entering the sewer system. Examples include bioretention, dry wells, subsurface infiltration, green roofs, porous pavement, rain barrels, rain gardens, vegetated swales, infiltration trenches, and street trees. he technologies are designed to manage runoff from small- to moderate-sized storms and can provide significant reductions in CSO frequency, volume, and pollutant loads. GSI not only provides benefits with meeting clean water regulatory obligations but also yields additional benefits that add value to the community, including beautifying neighborhoods, improving air quality, reducing respiratory and heat-related illnesses, and creating additional jobs.

Inflow and Infiltration Reduction: A variety of control measures can be utilized to reduce the inflow of stormwater and/or pollutants from upstream separate sewer systems that discharge into a downstream combined sewer. These include but are not limited to illicit connection controls such as roof leader disconnections, sump pump disconnections, and foundation drain disconnections. These measures also include catch basin and storm inlet modifications and maintenance, street storage (catch basin inlet control), stream and surface swales diversion (disconnecting surface streams and swales from the combined sewer collection system and rerouting the flow), and groundwater infiltration reductions.

Construction-Phase Controls: The Dauphin County Conservation District (District) enforces construction-phase erosion and sediment (E&S) control within the CRW service area in accordance with PADEP requirements. These measures reduce the load of total suspended solids to the combined sewer and receiving waters. CRW staff review and approve E&S plans submitted by developers. Site inspections are conducted during construction, and fines are levied, if necessary, to ensure compliance.

Post-Construction Controls: CRW conducts construction inspections and enforces stormwater management rules and regulations for new development and redevelopment. Post-construction controls are most effective for CSO and MS4 control where they focus on restoring a more natural balance between stormwater runoff and infiltration, reducing pollutant loads, and controlling runoff rates at levels that minimize stream bank erosion. CRW has successfully developed and implemented a green infrastructure program to better define design criteria and potential enhanced regulations that address the impairment of a surface water body in Harrisburg. Site designers can provide the level of performance required using a variety of controls such as disconnection of impervious cover, bioretention, subsurface storage and infiltration, green roofs, swales, and increased tree canopy.

Pollution Prevention/Good Housekeeping: Many types of good housekeeping practices can reduce pollution in local waterways. Pollutants from commercial and industrial facilities can be managed by proper handling (loading, unloading, and storage) of hazardous materials, industrial pretreatment requirements and stormwater pollution prevention measures, spill prevention and responses, oil/water separators, vehicle and equipment management, and employee training. Additional means for municipal entities to prevent pollution include street sweeping programs, on-lot septic system management, household hazardous waste collection, responsible bridge/roadway maintenance, record keeping and reporting, and litter and illegal dumping enforcement.

2.2.2 Conveyance and Collection System Controls

Sewer Separation: This is a control method whereby a combined sewer system is divided into separate pipe systems for sanitary and stormwater flows. The scope of work could be limited to sewers within the public right-of-way, or it could extend to private property and service laterals. Sewer separation can be accomplished by constructing new sanitary sewers, including private connections to existing structures; the existing combined sewers become the new separate storm sewers. Sewer separation can also be accomplished by leaving the previously combined sewers as sanitary sewers and constructing new storm sewers, commonly referred to “stormwater redirection”. Sewer separation can involve both public and private inflow removal or can involve only the public inflow sources, such as a catch basin in the public right-of-way.

Sewer separation can be complete separation of all the combined sewers within a catchment area or can be partial separation. Partial separation is often implemented because certain areas of a contributing catchment area may be easier to separate than others. The goal is to target the level and extent of sewer separation where the cost per acre is not excessively high. However, it is important to note that sewer separation redirects stormwater pollutants from a combined sewer to a separate sewer system, and in an overall water quality standards attainment framework, there is still a need to address pollutant loads from the newly created stormwater discharges.

RDII Reduction: For sewershed areas served by separate sewer systems, rainfall dependent infiltration and inflow (RDII) reduction programs may reduce the peak flow and volume of wet weather flow conveyed to downstream combined sewer systems. These programs use targeted flow monitoring and smoke testing to identify specific area where excessive quantities of RDII enter the sewer system. Sewer pipe reaches that are identified as sources of RDII are then rehabilitated by replacing the defective pipes or using a trenchless rehabilitation technology.

Utilization of Existing System for Storage: Use of the collection system for storage has long been recognized as a potentially cost-effective means to mitigate the occurrence and impacts of CSOs. An approach that can be implemented to gain additional in-system storage is to raise the overflow elevation by physically modifying the crest elevation of the diversion weir within the CSO regulator structure (e.g., raising an overflow weir). However, this approach must be implemented cautiously, since raising the overflow elevation also raises the hydraulic grade line in the combined trunk sewer during storm flows, and therefore increases the risk of basement and other structural flooding within the upstream sewer system due to backup or surcharge problems.

Real-Time Control: Real-time controls (RTCs) are controlled CSO outfall and regulator gate facilities that use level monitors to control the position of the connector pipe gate and tide gate at regulator structure locations to maximize the utilization of in-system storage and control facilities in the combined sewer system. The use of RTC can allow the capture and delivery to the treatment works of flow at the maximum rate at which it can be treated. This approach is attractive in terms of optimizing the use of the existing sewer system and implementing control facilities to capture combined wastewater and minimize CSOs.

Pump Station Expansion: Pump station upgrades and/or expansion, or construction of a new pump station, could significantly increase the conveyance capacity of the conveyance system, increase CSO capture, and minimize CSO discharges. This technology is only suitable if the downstream Advanced Wastewater Treatment Facility (AWTF) has the capacity to accept the additional wet weather flow.

Outfall and Regulator Consolidation: Where several outfalls are near each other, CRW can investigate whether to consolidate their flows to a single location for storage and/or treatment. Consolidation can provide more cost-effective control of CSOs, minimizing the number of sites necessary for abatement facilities. In waterfront areas where redevelopment is taking place and new public amenities are being created, elimination of outfalls through consolidation can remove an impediment to public use and enjoyment of the waterfront.

Parallel Interceptors: Parallel interceptors and/or relief trunk sewers provide increased transmission capacity to bring flows to the Advanced Water Treatment Facility (AWTF).

Remove Flow Bottlenecks: CRW's collection and conveyance system includes some localized instances where existing infrastructure does not have the capacity to convey the full flow from upstream. Examples include inverted siphons and pipes of smaller diameter than upstream pipes. In these cases, localized replacement may be a cost-effective way to increase transmission capacity to the AWTF.

Diversion of Trunk Flow Directly to AWTF (via Interceptor): For a limited number of small sewershed areas close to the AWTF, it may be possible to divert all wet weather trunk flow to the interceptor and AWTF without the wet weather flow diversion that is provided by a CSO regulator structure at the downstream end of a catchment area served by combined sewers.

2.2.3 Storage Technologies

In-Line Storage in Interceptor or Trunk Sewer: In-line storage can be developed in two ways: (1) construction of new tanks or oversized conduits to provide storage capacity or (2) construction of a flow regulator to optimize storage capacity in existing conduits. The new tanks or oversized conduits are designed to allow dry weather flow to pass through, while flows above design peaks are restricted, causing the tank or oversized conduit to fill. A flow regulator on an existing conduit functions under the same principle, with the existing conduit providing the storage volume. Developing in-line storage in existing conduits is typically less costly than other, more capital-intensive technologies, such as offline storage, and is attractive because it can provide the most effective utilization of existing facilities. The applicability of in-line storage, particularly the use of existing conduits for storage, is very site-specific, depending on existing conduit sizes and the risk of flooding due to an elevated hydraulic grade line.

Earthen Basins: Generally, there are three types of earthen basins used in stormwater management design: Detention, Wet-Weather Retention, and Infiltration. Basins may or may not be supplemented with some form of underdrain and emergency overflow structure to manage flow into the combined system. Detention basins are large areas of depression within a pervious location that remains dry except during wet-weather events. The detention basins capture wet-weather runoff during storm events and detain the runoff to attenuate peak flows into the combined system. Wet-weather retention basins always have a small pond of water and generally are vegetated. The retention pond allows for greater nutrient and solids removal than that of the detention basin. Infiltration basins are constructed with a more intricate underdrain system to facilitate nutrient and total suspended solids removal and infiltration and groundwater recharge of captured stormwater. Earthen basins may be implemented in a variety of sizes and locations to help meet stormwater management needs for large or small drainage areas. The flexibility of earthen basins allows for them to be used in conjunction with other stormwater management practices to reduce CSOs into receiving waters.

Offline Above or Below Grade Closed Storage Tanks: Off-line or tank storage control technologies are designed to capture a prescribed volume of overflow, with no provisions for flow-through operation. Volumes exceeding the design capacity bypass the tank storage. The volume stored is sufficient to allow capture of all smaller storms and some fraction of larger storms. The tanks have influent screening and automatic flushing systems to assist in the post-event tank cleaning. For above grade tanks, wet weather flow is pumped into the storage facility and subsequently emptied by gravity when downstream conveyance and treatment capacities become available. For below grade tanks, wet weather flow enters the storage facility via gravity. Dewatering pumps are provided to transport the contents of the tank and the collected solids to the interceptor system following the overflow event when treatment capacity becomes available.

Tunnel Storage: These systems are used to minimize sewer overflows into the local waterways by capturing, storing, and conveying large volumes of wet weather flow that would otherwise result in CSO and/or SSO discharges. The captured wet weather flow is stored in the tunnel until there is capacity at the treatment facility to accept pumped sewage from the tunnel system. The tunnel is dewatered and the combined sewage treated either at the AWTF or through another technology before being discharged to the receiving waters. Tunnels can accommodate large overflow volumes with little or no disruption to the surrounding land surface area and capture all smaller storms and some fraction of larger storms.

Instream Storage: The instream storage method involves using floating pontoons and flexible curtains to create a storage facility within the receiving water. CSO flows fill the facility by displacing the receiving water that normally occupies the storage facility. The CSO flows are then pumped to the collection system following a storm. The technology has been used for CSO control in Brooklyn, New York. This alternative involves permanently installing the floating pontoons in the receiving water near the CSO outlets. The feasibility of this technology, therefore, depends in part on whether the structure would be a hindrance to navigation and whether or not the hydraulic and hydrologic characteristics of the receiving water (channel depths and velocities) would allow CSO discharges to be stored.

2.2.4 Treatment Technologies

Netting: Two types of netting systems can be used to collect floatables in a CSS: in-line netting and floating units. In-line netting can be installed at strategic locations throughout the CSS. The nets would be installed in underground concrete vaults containing one or more nylon mesh bags and a metal frame and guide system to support the nets. The mesh netting is sized according to the volume and types of floatables targeted for capture. The CSO flow carries the floatables into the nets for capture, and bags are replaced after every storm event. Floating units consist of an in-water containment area that funnels CSO flow through a series of large nylon mesh nets. Mesh size depends on the volume and type of floatables expected at the site. This system is passive and relies on the energy of the overflow to carry the floatables to the nets. However, nets must be located some distance from the outfall, often 15 meters (50 feet) or more, to allow floatable materials entrained in the turbulent CSO flow to rise to the flow surface and be captured. The nets are single use, and after an overflow, the nets are typically removed and taken to a disposal area.

Screening: Screens and trash racks consist of a series of vertical and horizontal bars or wires that trap floatables while allowing water to pass through the openings between the bars or wires. Screens can be installed at select points within a CSS to capture floatables and prevent their discharge in CSOs. Screens used for CSO control include mechanically cleaned permanent screens, static screens, traveling screens, or drum screens. Screens can also be divided into the following three categories according to the size of floatable material they are designed to capture.

- Bar screens: > 2.5-centimeter (1 inch) openings
- Coarse screens: 0.5-to-2.5-centimeter (0.25 to 1 inch) openings
- Fine screens: 0.01-to-0.5-centimeter (0.004 to 0.25 inch) openings

The screens most commonly used to control CSOs are trash racks (a type of bar screen primarily used as an end-of-pipe control) and coarse screens.

Swirl Concentrator: Swirl concentrators provide flow regulation and solids separation by inducing a swirling motion within a structural vessel. Solids are concentrated and removed through an underdrain, while clarified effluent passes over a weir at the top of the vessel. Types of swirl devices include the EPA swirl concentrator, which conceptually is designed to act as an in-line regulator device. In addition to flow routing or diversion, it removes heavy solids and floatables from the overflow. Each type of swirl unit has a different configuration of depth/diameter ratio, baffles, pipe arrangements, and other details designed to maximize performance.

Vortex Separation: Commercial vortex separators are based on the same general concept as the EPA swirl concentrator but include several design modifications intended to improve solids separation. The commercial designs have been applied as offline treatment units. Vortex separators placed at discharge points are intended for inorganic solids separation and removal prior to discharging. Separation is facilitated by a swirling motion similar to a centrifuge and the solids are settled out at the bottom of the unit. Vortex separators are available for both in-line and offline treatment, and are available in varying sizes and designs based on the peak flow design event and on-site configuration requirements.

Retention Treatment Basins: Retention treatment basins (RTBs) are satellite high-rate treatment facilities designed to provide screening, settling, skimming (with a fixed baffle) and disinfection of combined sewer flows before discharge to a receiving water. Since RTBs are empty between wet-weather events, they also provide storage, which can completely capture combined sewer flows from small wet weather events for later dewatering and conveyance to the AWTF for treatment. RTBs can be designed with a variety of screen types, disinfection methods and basin geometries. The surface loading rates can also vary but are typically higher than rates used for design of primary clarifiers. RTBs can be constructed above or below grade but typically require at least an above grade process/control building. If pumping of the combined sewer flow is required, the pump station may be integral to the RTB facility or constructed as a separate structure. An advantage of RTBs is that they are relatively simple to operate and maintain. A disadvantage for above ground facilities is that the large footprint of the structure occupies waterfront land that could otherwise provide public amenities. For below grade facilities, public amenities such as athletic courts and/or playgrounds are often constructed above the facility and adjacent to the process/control building.

High-Rate Clarification: High-rate clarification (HRC) processes have surface overflow rates greater than 20 gallons per minute per square foot (gpm/ft^2). Both the DensaDeg® and Actiflo® processes utilize ballasted flocculation to achieve these overflow rates.

DensaDeg® Ballasted Flocculation recirculates settled sludge as the ballast to achieve total suspended solids (TSS) removal at a standard design surface overflow rate of 40 gpm/ft^2 for wet-weather flow. The process consists of a rapid mix zone, reactor zone, and a clarifier/thickening zone. Polymer is added as a flocculating agent as the wastewater flows to the reactor zone, which is equipped with an axial flow impeller/draft tube arrangement. The water and flocculated sludge enter the clarification zone where most of the solids settle. Suspended solids removal in excess of 90% of influent concentrations can be achieved consistently, and chemical oxygen demand (COD) and biological oxygen demand (BOD) removal are often better than 60% depending on influent characteristics. Optimal treatment is typically achieved approximately 30 to 45 minutes after start-up. The start-up time is necessary to build up adequate sludge.

Actiflo® Ballasted Flocculation utilizes microsand as the ballast to achieve excellent TSS removal at a standard design surface overflow rate of 60 gpm/ft^2 for wet-weather flow. The process consists of a coagulation zone, injection zone, maturation zone, and clarification zone. Wastewater enters the coagulation chamber along with a coagulant for flash mixing. Microsand interacts with the destabilized particles and the polymer. The polymer promotes the formation of strong flocs around the microsand. The Actiflo® process provides high removal efficiencies at variable influent flows and loads.

Biologically and Chemically Enhanced High-Rate Clarification (Bio HRC) is a relatively new process that incorporates a short duration biological contact tank upstream of chemically enhanced clarification (CEC) to achieve rapid uptake of soluble organic matter that would not be removed by only CEC. In this process, activated sludge from a plant's secondary process (RAS or WAS) is routed to a short-duration (5-10 minutes) contact basin where it blends with excess wet weather flows to achieve rapid uptake of soluble organic matter into the biomass. This mixture of biomass and influent wastewater is then treated through chemically enhanced primary treatment (CEPT) or HRC. The nonproprietary technology is called Bio CEPT, and the current proprietary technology is BioActiflo®.

High-Rate Filtration: High-rate filtration systems utilize proprietary filter media for CSO treatment with high filtration rates of approximately 20 to 40 gpm/ft^2. These systems occupy less space than standard filtration systems or sedimentation tanks. Examples of high-rate filtration technologies include the Metawater® pinwheel filter medium, Schreiber LLC® Fuzzy Filter compressible synthetic medium, WWETCO FlexFilter, and AquaStorm™ disk configuration filter.

The AquaStorm™ Filter Process utilizes a disk configuration and an outside-in flow path, which allows for three zones of solids removal. These zones are especially critical in wet weather applications due to the high solids typically associated with the first flush after wet weather events. The top zone is the "floatable zone" where surface materials such as fats, oils, and grease are allowed to collect on the water surface. The middle zone is the "filtration zone," where solids are removed through filtration. This buildup of solids on the media creates hydraulic resistance to flow through the media and causes the water level in the tank to rise. Once a predetermined liquid level or time setting is attained, the disks begin to rotate and the backwash pump starts, which draws filtered water from the inside of the disk through the media and removes solids from the filter media's surface. The bottom or "solids zone" permits heavier solids to settle to the bottom of the tank for intermittent removal. The solids are stored and later evacuated from the hopper through collection laterals using the solids/backwash pump.

Expansion of Primary Treatment Capacity: Expanding primary treatment capacity at an AWTF can be beneficial when the NPDES permit allows flows that exceed the secondary treatment capacity to be discharged after receiving primary treatment and disinfection. This process protects the biological secondary treatment system from washout, which could result in discharge of non-compliant effluent to the environment, thus better protecting the receiving stream. Expansion of the primary treatment capacity of the AWTF must consider the average daily flow, the peak instantaneous flow, and the maximum daily average flow that could potentially be delivered to the plant. Using this information, the feasibility of expanding the plant to apply primary treatment to all wet weather flow being delivered must be evaluated regarding spatial limitations of the plant expansion footprint, costing, and a list of design options.

Satellite Sewage (Biological) Treatment (SST): This is a method whereby satellite facilities provide biological treatment for excess wet weather flows in separate sanitary sewer portions of the system. Examples of satellite sewage treatment include conventional activated sludge process, sequencing batch reactor process, and trickling filter process. SST facilities can be considered where sufficient average daily flow is available to sustain a biological treatment facility. Therefore, intermittent operation of an SST facility only during wet weather is not feasible. When evaluating a potential SST site, it is necessary to identify the existing base flow that can be diverted on a continuous basis to the SST.

Satellite Advanced Treatment: This technology consists of a higher level of satellite sewage treatment for use on smaller tributary streams where treatment beyond the secondary level is required due to a total maximum daily load (TMDL) requirement or other water quality factors.

Disinfection: This process destroys or inactivates microorganisms in overflows. Various disinfection technologies are available both with and without chlorine compounds. Some of the more common technologies include gaseous chlorine, liquid sodium hypochlorite, chlorine dioxide, ultraviolet radiation, and ozone. For disinfection of CSOs, liquid sodium hypochlorite is the most common of the above technologies.

Dechlorination: A potential disadvantage of chlorine-based disinfection systems is that the residual chlorine concentration can have a toxic effect on the receiving waters, due either to the free chlorine residual itself or to the reaction of the chlorine with organic compounds present in the effluent. With the relatively short contact times available at many CSO control facilities, disinfection residuals can be of particular concern and can require consideration of dechlorination alternatives. Two of the more common means for dechlorinating treated effluent are application of gaseous sulfur dioxide or liquid sodium bisulfite solution.

2.2.5 Receiving Water Technologies

Side Stream Aeration: This option consists of adding air directly to a receiving waterway to increase dissolved oxygen (DO) concentrations. For side stream aeration, flow is diverted to an offline aeration facility and re-diverted back to the stream or river.

Instream Aeration: Instream aeration is a technology developed to add oxygen to the water column where slow, stagnant conditions occur along streams. Air can be added directly to a receiving waterway using a diffusion system to increase DO concentration for the improvement of fish habitat and water quality.

Plunge Pool Removal: When stormwater and combined sewer outfalls discharge directly to the stream channel, they may create deep, poorly mixed pools. Because these pools are typically near the bank and not in the main flow, they can become poorly mixed during low flow. These pools often have increased odors and reduce the aesthetic quality of the stream. Biological activity in the sediment and water column can reduce DO to low levels, and this low-DO water can be flushed out and affect downstream areas during wet weather. The depression of DO is a function of pollutant loads from the outfalls, stream baseflow, and the physical condition of the channel. When DO is in an acceptable range in the well-mixed portion of the channel but not in nearby plunge pools, elimination of the plunge pools can be expected to improve DO levels in the main channel.

Stream Restoration: Restoration involves returning a stream or river to a natural shape and condition, reducing nutrient levels through natural processes. Restoration projects take many forms and encompass many goals, but three of the most common are to improve water quality, create effective riparian buffers along stream corridors, and reconnect stream channels with their overbanks to provide spaces for water to flow rainstorm events. When riparian buffers, beneficial strips of native trees, shrubs and grasses are restored along stream corridors and urban runoff pollution is reduced resulting in a cleaner receiving water. Restoration projects restore the natural ecological function of the creek, mitigate the creek’s hydraulically and ecologically impaired condition, and help reduce sediment and nutrient loads to the waterway.

Constructed Wetlands Along Stream Corridors: Wetlands intercept and filter stormwater runoff from urban, residential, and agricultural surfaces prior to reaching waterways and remove pollutants through physical, chemical, and biological processes. Wetland restoration is the manipulation of a former or degraded wetland's physical, chemical, or biological characteristics to return its natural functions. Riparian wetlands protect streambanks from erosion because the roots of wetland plants hold soil in place and can reduce velocity of stream or river currents. They could be recreated concurrently with channel realignment, bank restoration, and planting of more diverse native vegetation, including hydrophytic species adapted to saturated soil conditions.

Reforestation: Reforestation that occurs adjacent to the channel will provide wetland habitat and other associated benefits. Although priority reforestation areas consist of floodplains, steep slopes, and wetlands, smaller areas such as public rights-of-way, parks, schools, and neighborhoods also provide reforestation opportunities. Benefits of reforestation are numerous: cooler temperatures, rainfall interception, reduced runoff, reduced sediment load, reduced discharge velocities, increased groundwater recharge, increased species diversity and habitat, and improved air quality and aesthetics.

2.3 Screening Results

Potential CSO control technologies, along with MS4 control technologies and other wet weather control measures, were considered and evaluated by CRW for creating this *Alternatives Analysis Report*. These alternative control technologies were evaluated and assessed for their ability to control wet weather flow and resolve existing problems regarding CSOs, SSOs, Unauthorized Releases (as defined in the MPCD), MS4 discharges, and significant structural deterioration of infrastructure. The alternative control technologies were also evaluated within the context of the regulatory approaches selected by CRW to provide wet weather control. This *Alternatives Analysis Report* and the upcoming CBH_2OPP are based on the demonstration approach under the EPA CSO Control Policy and will clearly identify control technologies and facilities that are adequate to meet the water quality requirements of the Clean Water Act. The alternatives evaluation and CBH_2OPP are also based upon an integrated planning approach to meet multiple CWA requirements for both wastewater and stormwater to best prioritize capital investments and achieve human health and water quality objectives. Some technologies are minimum controls satisfying the technology-based requirements of the CWA while others provide more significant levels of control. Minimum controls are defined by CRW's Nine Minimum Control (NMC) Plan,[8] which defines CRW's approach to meeting the technology-based minimum controls of the CSO Control Policy, as well as the six minimum control measures (MCMs) required by CRW's separate storm sewer system (MS4) permit.

CRW is already practicing and implementing many of the source controls, conveyance/collection system controls, and receiving water technologies through ongoing implementation of their NMC Plan, Operation and Maintenance Manual, and MS4 Permit requirements. This *Alternatives Analysis Report* accounts for the ongoing implementation of these controls and technologies, and further evaluation of their efficacy and applicability to CRW was deemed unnecessary. The costs associated with these ongoing improvements are already incorporated into CRW's annual budgeting process and were not double-counted as alternative control measure costs. Further details are provided below.

Decentralized Source Controls: The MPCD defines Source Controls as "measures that reduce the volume, peak flow, or pollutant load of runoff, either before it enters the separate sanitary, storm, and combined Collection System or is re-directed to an MS4, including measures that mimic natural hydrologic processes. Source Controls shall include, inter alia, Green Infrastructure, as defined in this Consent Decree." They typically consist of minimum controls per Nine Minimum Controls (NMCs), Minimum Control Measures (MCMs), and decentralized controls. Most of the source controls are part of CRW's ongoing implementation of GSI projects, except for dry wells, green roofs, street storage, and stream diversion. CRW is evaluating alternatives with additional green stormwater infrastructure. Street storage is not applicable in the CRW system. This is because the required levels of stormwater runoff control for the CRW service area would require control orifice sizes that are small and would be prone to frequent clogging. Stream diversions are not applicable in the CRW system due to limited surface water bodies and concentrated development with the City. All of the other alternative source control measures described in Section 2.2.1 were considered suitable and applicable for the CRW service area.

Conveyance/Collection System Controls: Conveyance System Controls are not defined in the MPCD, but alternative technologies are evaluated under this technology evaluation. The MPCD defines Collection System Controls as "measures that reduce the volume, peak flow, or pollutant load of flows within the Collection System." Alternative conveyance and collection system controls are also evaluated under this technology analysis. Many suitable conveyance/collection system control technologies are also aligned with the committed projects listed in MPCD Appendix B (and described in Section 3 of this report). Several of these controls are part of CRW's ongoing O&M implementation program, including utilization

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[8] CRW *Nine Minimum Control Plan, Version 3.0*, August 2017, available at **https://capitalregionwater.com/cbh2o/**

of the existing system for storage, inspection, cleaning, maintenance, rehabilitation, and asset management. Alternative controls to consider and evaluate will also include a combination of further modifications to CSO regulator structures and connector pipes, flow diversion facilities to direct wet weather flow to control facilities, required rehabilitation for significant defects, and solutions for localized flooding and basement backup areas. As sewer rehabilitation projects are identified, opportunities for additional levels of stormwater/CSO control will be identified and assessed for potential project elements such as oversizing the damaged pipe reach to provide additional storage, adding supplemental green stormwater infrastructure to the project for stormwater runoff control, etc.

The satellite suburban communities served by CRW are already implementing RDII reduction programs and their success is confirmed by the analysis of CRW monitoring data at the points of municipal connection to the CRW interceptor system. CRW is coordinating with PennDOT engineers as part of the PennDOT I83 expansion project to construct a system of stormwater diversion pipes to route the stormwater flow from the three large catchments, totaling 478 acres in area, around the downstream combined trunk sewer. These 478 acres are served by separate sanitary and storm sewer systems that ultimately convey and discharge stormwater runoff to the downstream combined trunk sewer. Therefore, additional RDII reduction programs were excluded from further analysis. Except for RDII reduction and diversion of trunk flow directly to AWTF which was found to not be feasible, all the alternative conveyance and collection system control technologies described in Section 2.2.2 were considered suitable and applicable for the CRW service area.

Storage Technologies: The MPCD defines Storage Technologies as “structural measures that detain flows within the Conveyance and/or Conveyance System and reduce peak flows prior to treatment at the AWTF.” CRW has decided to implement an integrated planning approach under the 2019 Water Infrastructure and Improvement Act.[9] The integrated planning approach includes combined sewer system compliance objectives, separate sanitary/MS4 system compliance objectives, and asset renewal components in a triple bottom line framework to best prioritize capital investments and achieve our human health and water quality objectives. Therefore, storage technologies for stormwater management were evaluated along with wastewater storage technologies. Instream storage was considered not applicable to the CRW service area. Along the Susquehanna River, the Capital Area Green Belt extends along the northern shoreline and is an established recreational and aesthetic amenity to the community. The use of floating pontoons and flexible curtains to create a CSO storage facility within the receiving water would be incompatible with this important amenity. The channel hydrology and hydraulics along the Paxton Creek channel are incompatible with the implementation of instream storage. All the other alternative wastewater and stormwater storage technologies described in Section 2.2.3 were considered suitable and applicable for the CRW service area.

Treatment Technologies: The MPCD defines Treatment Technologies as “structural measures and/or physical chemical processes that reduce the pollutant load in a CSO prior to discharge to its Receiving Water.” The Biologically and Chemically Enhanced High-Rate Clarification (Bio HRC) technology was deemed as unsuitable for the CRW service area, because the process requires active biomass and can only be implemented adjacent to an AWTF and not at a remote CSO discharge point. Satellite Sewage

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[9] Water Infrastructure and Improvement Act (WIIA) (H.R. 7279), January 14, 2019

Treatment (SST), a method whereby satellite facilities provide biological treatment for excess wet weather flows in separate sanitary sewer portions of the system, and Satellite Advanced Treatment was considered not applicable to the CRW service area as CRW does not need additional continuous dry and wet weather treatment or additional advanced treatment within its separate sewered areas. Swirl concentrators and vortex separation were also deemed unsuitable as CSO treatment technologies because there is a limited installation history and because of the required complexity of operation. However, it could be an acceptable treatment technology for stormwater. Netting was eliminated as a control technology because it is incompatible with CRW's selected approach for controlling solids and floatables. CRW has implemented a decentralized approach of utilizing catch basin baffles and replacing and reconfiguring inlet grates to trap solids and floatable materials up in the collection system, rather than utilizing and end-of-pipe approach. The implementation of this control approach is a requirement of the MPCD. All the other alternative source control measures described in Section 2.2.4 were considered suitable and applicable for the CRW service area.

Receiving Water Technologies: Receiving Water Technologies are not defined in the MPCD. Side stream aeration and instream aeration technologies are not directly applicable to the Susquehanna River because dissolved oxygen impairments are not present but would be potentially applicable for Paxton Creek. All the other alternative receiving water control measures were considered suitable and applicable for the CRW service area. Several receiving water technologies, including stream restoration, stream cleanup and maintenance, and constructed wetlands, are included in CRW's ongoing implementation of its MS4 permit requirements. Alternatives for the rehabilitation/replacement of the Paxton Creek Interceptor also include plans for the Paxton Creek channel. The Paxton Creek Restoration Master Plan provides a comprehensive strategy to restore the natural ecological function of the creek, mitigate the creek's ecologically Impaired condition, and help meet the sediment and nutrient reduction requirements of Paxton Creek total maximum daily load (TMDL) allocations.

2.4 Control Technology Evaluation Summary

Table 2.4-1 identifies the specific control technologies that were considered and evaluated for the CRW service area. The range and scope of control technologies that were evaluated fully meet the requirements of the National CSO Control Policy and the MPCD. Each control technology is classified as one or more of the following types based on the analysis presented in Section 2.3.

- Ongoing Implementation: Suitable and applicable technologies that CRW is already implementing and will continue to implement. Further evaluation is not required, as the application of these technologies will continue.
- Included in Alternatives Analysis: Suitable and applicable technologies that will be evaluated further within one or more evaluated alternatives (described in Sections 4 and 6), including cost development.
- Screened Out from Further Analysis: Technologies determined to not be applicable to the CRW service area.

Table 2.4-1 Wet Weather Control Alternatives Evaluated for CRW's Service Area

Control Technology	Ongoing Implemen-tation	Included in Alternative Analysis	Screened Out from Further Analysis	Comments
Decentralized Source Controls				
Green Stormwater Infrastructure				
Bioretention / rain gardens	X	X		Alternatives Analysis does not distinguish between specific types of green stormwater infrastructure
Dry wells		X		
Grassed swales	X	X		
Rain barrels	X	X		
Infiltration trenches	X	X		
Green roofs		X		
Porous/permeable pavement	X	X		
Inflow and Infiltration Reduction				
Catch basin modifications	X			
Catch basin and storm inlet maintenance	X			
Illicit connection control	X			Addressed as they are identified by CRW O&M staff
Roof leader disconnection	X			
Sump pump disconnections	X			
Street storage (catch basin inlet control)			X	Required control orifice sizes would frequently clog
Stream and surface swale diversion		X		Included in the CSO-048 storm sewer diversion project (MPCD Appendix B)
Groundwater infiltration reduction	X			
Construction-Phase Controls (MCMs)				
Construction-phase E&S controls	X			
Inspections and enforcement measures	X			
Post-Construction Controls (MCMs)				
Post-construction stormwater control	X			
Post-construction inspection/enforcement	X			
Tree canopy enhancements	X			
Pollution Prevention/Good Housekeeping (NMCs/MCMs)				
Loading, unloading, and storage of materials	X			
Spill prevention and response	X			
Street sweeping programs	X			
Vehicle and equipment management	X			
Industrial facility inspection/enforcement	X			
Employee training	X			
Record keeping and reporting	X			

Control Technology	Ongoing Implemen-tation	Included in Alternative Analysis	Screened Out from Further Analysis	Comments
Responsible landscaping practices	X			
Responsible bridge/roadway maintenance	X			
Require industrial pretreatment	X			
On-lot disposal (septic system) management	X			
Household hazardous waste collection	X			
Oil/water separator/water quality inlets	X			
Industrial stormwater pollution prevention	X			
Litter and illegal dumping enforcement	X			
Conveyance/Collection System Controls				
Sewer separation		X		
RDII removal projects	X		X	Already implemented by Suburban communities
Utilization of existing system for storage	X	X		
Real-time control	X	X		Included as a component of other control technologies
Pump station expansion	X	X		
Outfall and regulator consolidation		X		Included as a component of other control technologies
Parallel interceptors		X		
Remove local flow bottlenecks		X		
Diversion of trunk flow directly to AWTF (via interceptor)			X	Not applicable or feasible
Storage Technologies				
In-line storage		X		
Earthen basins (for stormwater only)		X		Included in CSO-048 storm sewer diversion project (MPCD Appendix. B), but not considered for storing combined sewage
Offline above/below grade storage tanks		X		
Tunnel storage		X		
Instream storage			X	Not applicable within Paxton Creek or the Susquehanna River
Treatment Technologies				
Netting			X	Incompatible with CRW's decentralized approach to controlling floatables
Screening		X		
Swirl concentrator			X	Not suitable for CSO control (more appropriate for separate stormwater)
Vortex separation			X	
Retention treatment basins		X		

Control Technology	Ongoing Implemen-tation	Included in Alternative Analysis	Screened Out from Further Analysis	Comments
High-rate clarification		X		
Bio High-rate clarification			X	Requires activated sludge from AWTF (not feasible for satellite treatment opportunities)
High-rate filtration		X		
Expansion of primary treatment capacity		X		
Satellite sewage (biological) treatment			X	Not necessary for CRW system
Satellite advanced treatment			X	Provides higher level of treatment than necessary
Disinfection		X		Components of all treatment technologies
Dechlorination		X		
Receiving Water Technologies				
Side stream aeration		X	X	Not applicable to Susquehanna River, but is applicable to Paxton Creek
Instream aeration			X	
Plunge pool removal	X			Implemented where applicable
Stream restoration	X			Included in the Paxton Creek Restoration Master Plan
Constructed wetlands along stream corridors	X			Included as part of stream restoration projects
Reforestation	X			

3.0 Committed Projects – The First Level of Control Point

The alternative control facilities evaluated under this *Alternatives Analysis Report* are built upon the critical foundation of two categories of projects:

- Previously completed remediation projects between 2013 and 2023, and
- Projects required to be completed in accordance with the implementation schedule within Modified Partial Consent Decree (MPCD) Appendix B, with various milestone dates through December 31, 2032.

When Capital Region Water (CRW) assumed ownership and operation and maintenance (O&M) responsibilities for the wastewater and stormwater collection, conveyance, and treatment systems in 2013, the sewer system infrastructure reflected the consequences of decades of deferred maintenance by the City of Harrisburg. Since 2013, CRW has implemented a balanced, affordable approach to characterizing system component conditions, prioritizing needs, and developing and implementing remediation measures to restore the reliability and resiliency of the CRW systems. Appendix B of the MPCD stipulates a list of additional required projects intended to further enhance the combined sewer system resiliency and reliability and significantly increase CSO capture.

This report section describes the remediation projects that were completed between 2013 and 2023 in the combined sewer system, and the additional projects required to be implemented under MPCD Appendix B. Projects completed between 2013 and 2023 include CRW's ongoing Nine Minimum Control (NMC) measures that are documented within its approved NMC Plan.[10] Project descriptions are grouped into five system types:

- Improvements to the advanced wastewater treatment facility (AWTF)
- Improvements to the conveyance system
- The Paxton Creek Restoration Master Plan
- Improvements to the collection system
- Stormwater diversion in CSO-048

The CSO control alternatives evaluation incorporates the expected benefits from these projects. The first control point for the technology evaluations documented in Section 4 reflects the level of control (LoC) achieved by the projects that are either already completed or are required to be completed in accordance with the implementation schedule in MPCD Appendix B.

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[10] Nine Minimum Control Plan, Capital Region Water, Wastewater Division, August 2014, and subsequently updated annually.

3.1 Improvements to the AWTF

Improvements to the AWTF through 2023: Evaluations completed by CRW revealed that most treatment processes were in fair physical condition but required capital replacement investments and additional O&M expenditures. Improvements and upgrades were executed at the AWTF to address equipment failures and structural/operational deficiencies attributed to decades of deferred maintenance.

- In March 2014, CRW began upgrading its AWTF with biological nutrient removal to comply with the Chesapeake Bay Tributary Strategy and meet associated new NPDES permit discharge requirements. This $50 million project at the AWTF consisted of adding biological nutrient removal technology to the existing processes to achieve nitrogen and ammonia removal requirements. The process involved adding side stream treatment (nitrification) for the filtrate from the sludge dewatering process that, when returned to the main treatment process, will bolster performance. Multiple tanks and processes were modified to complete integration of the new process. The project was completed in 2016.

Headworks Screening project was completed in 2018 (the AWTF previously had no screening facilities).

Rehabilitation of the existing primary clarifiers, including installation of baffles and other improvements to enhance hydraulic capacity and treatment efficiency, was completed 2020-2023.

- Other deficiencies have been corrected within the anaerobic digester, waste activated sludge (WAS) thickening, trucked in/hauled waste, co-generation, dewatering, and gravity thickener facilities. These remediation projects were considered to be a high priority to preserve/enhance existing capacity and minimize the risk of potential system failure.
- Improvements to the anaerobic and primary digester facilities were completed in December 2022.

Additional Improvements to the AWTF with Appendix B Projects:

- The installation of a Combined Heat and Power (CHP) energy system is scheduled for completion by March 2024 and will produce power, capture the excess heat which would have otherwise been wasted, emit less carbon, and reduce emissions of greenhouse gases and other air pollutants.
- Improvements to the waste activated sludge (WAS) thickening facilities, to increase solids content and reduce the volume of free water, are also scheduled for completion by March 2024.
- Ongoing improvements are currently underway for the primary clarifiers, including replacing drive, chain, flight, and pump equipment along with structural rehabilitation and enhanced baffling. The work is scheduled for completion by December 2024.
- Continuing improvements and enhancements to the secondary digester facilities and additional dewatering improvements are scheduled for completion by December 2027.
- Continuing general equipment renewals and replacements are also included in the Appendix B project list and are scheduled for completion between December 2025 and December 2032.

3.2 Improvements to the Conveyance System

Improvements to the Conveyance System through 2023: CRW completed systemwide inspections of the interceptors that identified structural and operational deficiencies attributed to decades of deferred maintenance.

- The interceptor system inspections prompted implementation of a comprehensive cleaning program in 2016 and 2017 where 1,500 tons of debris were removed. The pipes were re-inspected to confirm cleaning effectiveness and implement structural condition assessments.
- Rehabilitation of the Front Street Interceptor is currently underway. This will minimize the risk of a major system failure by restoring structural integrity.
- The Front Street Pump Station was rehabilitated to restore reliability and was expanded to increase the hydraulic capacity to 60 million gallons per day (MGD).
- Structural modifications were made to selected CSO regulator structures (all Hemlock Street Interceptor CSOs and CSOs 021, 022, 024, and 032) to increase the annual capture of wet weather flows; reduce the frequency, volume, and duration of CSO discharges to receiving waters; and reduce creek backflow into the interceptors.

Figure 3.2-1: Front Street Pump Station Rehabilitation

Additional Improvements to the Conveyance System with Appendix B Projects:

- The structural and hydraulic capacity rehabilitation of the Front Street Interceptor is scheduled for completion, under MPCD Appendix B, by July 2024.
- The preliminary design process for the Paxton Creek Interceptor replacement is underway. The MPCD allows the flexibility for CRW to choose between a segmented slip lining rehabilitation approach or replacement of the interceptor pipe. CRW has decided to replace the interceptor pipe in conjunction with implementing the Paxton Creek Restoration Master Plan described below. Construction of the interceptor replacement is scheduled for completion by June 2030.
- Under Appendix B, rehabilitation of the Spring Creek Interceptor and the rehabilitation and expansion of the

Figure 3.2-2: Front Street Interceptor Rehabilitation

Spring Creek Pump Station to restore reliability and increase the hydraulic capacity to 20 MGD are scheduled for completion by December 2028.

- Rehabilitation and enhancement of additional CSO regulator structures are scheduled for completion by September 2030. This will include rehabilitation of outfall pipes and flap gates to prevent river/creek intrusion and modifications to the control orifices and diversion dam crest heights to increase wet weather capture.

3.3 Paxton Creek Greenway

The Paxton Creek Greenway provides a comprehensive means to control flooding, restore the natural ecological function of the creek, and mitigate the creek's ecologically impaired condition. Successful implementation of the Paxton Creek Greenway requires significant buy-in and financial contributions from multiple stakeholder partners. Alternatives for the rehabilitation and/or replacement of the Paxton Creek Interceptor take into consideration of potential plans for the Paxton Creek channel. With the implementation of the Paxton Creek Greenway and the sharing of implementation costs with other critical stakeholders, CRW has elected to replace the Paxton Creek Interceptor rather than rehabilitate it with cured-in-place pipe (CIPP)or segmented slip-lining. The Paxton Creek Greenway includes stream restoration which can provide cost-effective sediment and nutrient reductions compared to land-based stormwater management in urban areas.

As shown in **Figure 3.3-1**, implementation of the Paxton Creek Greenway would create a linear urban green space along the Paxton Creek corridor to its confluence with the Susquehanna River, offering recreational benefits, community connectivity, and redevelopment opportunities. Implementation would also address flood control, reduce sediment and nutrient pollution, and restore habitat. The new green corridor would also replace the existing concrete channel (which is narrow and deep due to the configuration of vertical retaining walls) with a widened and naturalized channel that would reestablish the connection with the overbanks. This may also increase the available space for decentralized satellite control facilities along the new interceptor.

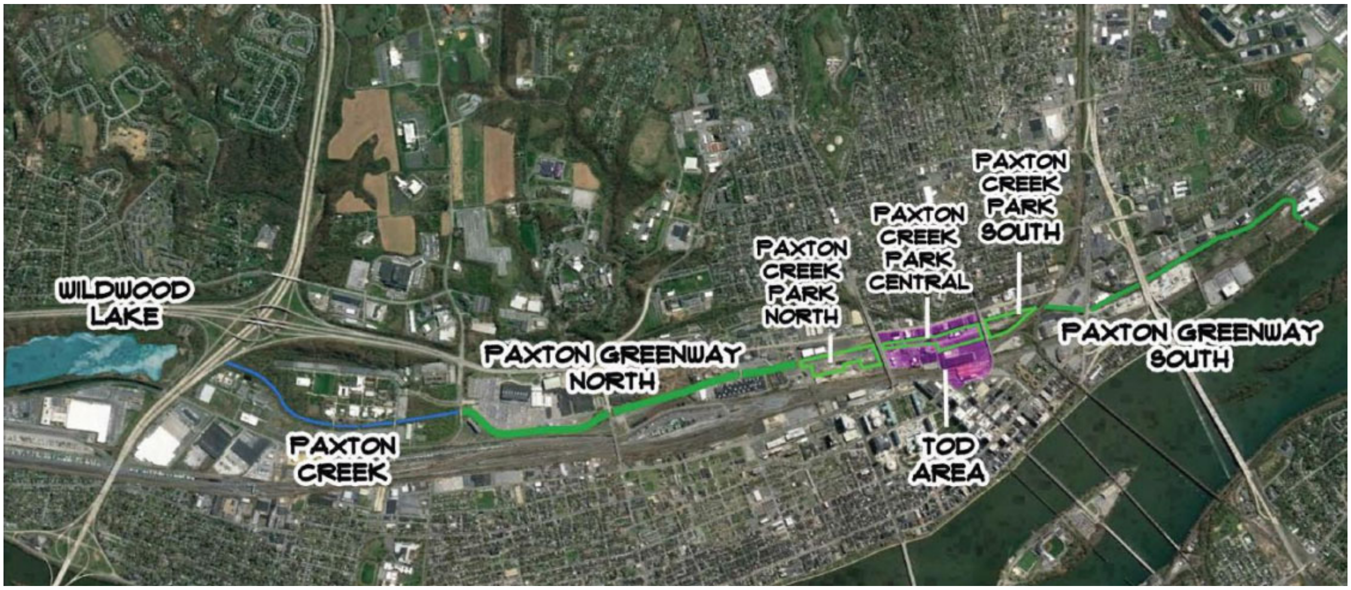

Figure 3.3-1: Proposed Configuration of the Paxton Creek Greenway

3.4 Improvements to the Collection System

Improvements to the Collection System through 2023:

- In 2015 and 2016, CRW completed a rapid assessment of the collection system based on pole camera inspections from every manhole, and subsequently developed and completed a comprehensive closed caption television (CCTV) inspection program.
- Asset renewal needs were identified and a condition assessment, combining an asset's probability of failure and consequence of failure to determine the core risk, was conducted to establish priorities.
- Since 2013, when CRW assumed ownership and O&M responsibilities for the combined, wastewater, and stormwater collection systems, approximately 41,700 linear feet of defective sewer pipe has been rehabilitated or replaced to protect the reliability and resiliency of the collection system.
- CRW has also successfully implemented a systemwide stormwater inlet and catch basin cleaning and repair program, completed in 2021, to address inlets that were blocked with debris and those that required complete reconstruction when cleaned. In addition, catch basin inlet grates and/or curb openings are being replaced and/or sewer hood functionality is being improved to keep litter and other floatable materials out of the collection system and meet the requirements of Nine Minimum Control (NMC) number 6, control of solids and floatable materials.

Additional Improvements to the Collection System with Appendix B Projects:

- Under its collection system renewal program, CRW is planning and developing three additional phases of future projects to rehabilitate or replace sewer defects identified during CCTV inspections and prioritized under the asset management program. Under MPCD Appendix B, the three additional rehabilitation phases are scheduled to be completed by December 31, 2025, December 31, 2030, and December 31, 2032.
- Under Appendix B, CRW will separate the existing combined sewer collection systems for four small catchment areas totaling 12.7 acres in area. These separation projects are scheduled for completion by December 31, 2025. Appendix B projects also include the rehabilitation and enhancement of selected CSO regulator structure control orifices and dam heights, flap gates, and outfall pipes to increase wet weather capture and prevent creek and river intrusion into the CRW system.
- Appendix B projects also include the installation of green stormwater infrastructure (GSI) facilities to manage stormwater runoff before it enters the combined collection system. By June 2025, 50 acres of impervious area will be managed by new GSI facilities and by December 2030, an additional 50 acres will be managed.

Figure 3.4-1: YMCA Green Stormwater Infrastructure Project

3.5 Stormwater Diversion in CSO-048

At the upstream end of the CSO-048 sewershed are three large catchments, totaling 478 acres in area, served by separate sanitary and storm sewer systems that ultimately convey and discharge stormwater runoff to the downstream combined trunk sewer. CRW is coordinating with PennDOT engineers as part of the PennDOT I83 expansion project to construct a system of stormwater diversion pipes to route the stormwater flow from the three large catchments around the combined trunk sewer. CRW intends to provide treatment for suspended solids and nutrients through a large sedimentation pond before the diverted stormwater would be discharged into Paxton Creek. During Typical Year rainfall, the completed system of stormwater diversion pipes would divert approximately 170 million gallons of stormwater around the combined collection system. The initial Phase 1 project is scheduled for completion under MPCD Appendix B by the Summer of 2025, and the complete project is scheduled to be fully implemented by December 31, 2032.

3.6 Appendix B Projects

A summary of the required Appendix B projects is provided in **Table 3.6-1**. The estimated total present value project lifecycle cost for the Appendix B projects is $217 million.

Table 3.6-1. Committed Project List

Appendix B Reference Number	System Type	Project Description
Completed Appendix B Projects		
-	AWTF	Biological Nutrient Removal Upgrade
-	AWTF	Headworks Screening
-	AWTF	Primary Clarifiers Rehabilitation
-	Conveyance	Interceptor Cleaning
-	Collection	Inlet and Catch Basin Cleaning/Repair Program
-	Collection	CCTV Inspection Program
-	Conveyance	Front Street Pump Station Upgrade
5a	AWTF	Anaerobic digester roof repair and primary digester facilities
2b	Conveyance	Modifications to selected CSO structures after finishing Front Street Pump Station
3	Conveyance	Front Street Interceptor
Currently Active Appendix B projects		
1	Stormwater Diversion	Storm Sewer Diversion in CSO-048
2a	Collection	Small sewer separation of catchments
4	AWTF	AWTF Primary Clarifier Improvements
5b	AWTF	Cogeneration (CHP) to RNG/WAS thickening/HSW receiving
6b	Collection	Decentralized Green/Gray Controls - Phase 4 (21 acres)
6c	Collection	Decentralized Green/Gray Controls - Phase 5 (9 acres)
9	Conveyance	Rehabilitation and Enhancement of CSO Regulator Structures
Upcoming Appendix B Projects		
5c	AWTF	Gravity thickeners
5d	AWTF	Secondary digester conversion
5e	AWTF	Dewatering improvements
5f	AWTF	General AWTF equipment renewal and replacement
7	Collection	Collection System Renewal
8	Conveyance	Paxton Creek Interceptor
10	Conveyance	Spring Creek Pump Station and Interceptor
6d	Collection	Decentralized Green/Gray Controls - Phase 6 (50 acres)
6e	Collection	Decentralized Green/Gray Controls - Phase 7

3.7 Benefits of the Completed Appendix B Projects

The completed and planned activities and projects summarized above will provide the initial level of control (LoC) for each of the alternative control facilities evaluated under this *Alternatives Analysis Report*.

Pre-Plan Conditions: When CRW assumed ownership and O&M responsibilities for the wastewater and stormwater collection and conveyance systems in 2013, average systemwide capture within the CRW system was approximately 53%, and the total annual overflow volume under typical year precipitation conditions was 796 million gallons. Corresponding annual overflow frequencies at each of the individual CSO outfall pipes ranged from 6 to 95 overflow frequencies. These 2013 CSO discharge statistics are shown graphically on **Figures 3.7-1** and **3.7-2**.

Completed Appendix B ("First Control Point"): With the completion of the initial rehabilitation projects and the remaining Appendix B projects by 2032, average systemwide capture within the CRW system is expected to increase from 53% to approximately 83 to 84% and the total annual overflow volume, under typical year precipitation conditions, is expected to decrease from 280 to 144 million gallons (MG) along the Susquehanna River and from 513 to 186 MG along Paxton Creek. The corresponding annual overflow frequencies at each of the individual CSO outfall pipes are expected to decrease to a range from 6 to 60 overflow frequencies (systemwide average of 27 overflows). The CSO discharge statistics associated with the 2032 completion of the Appendix B Projects are shown graphically on **Figures 3.7-3** and **3.7-4.**

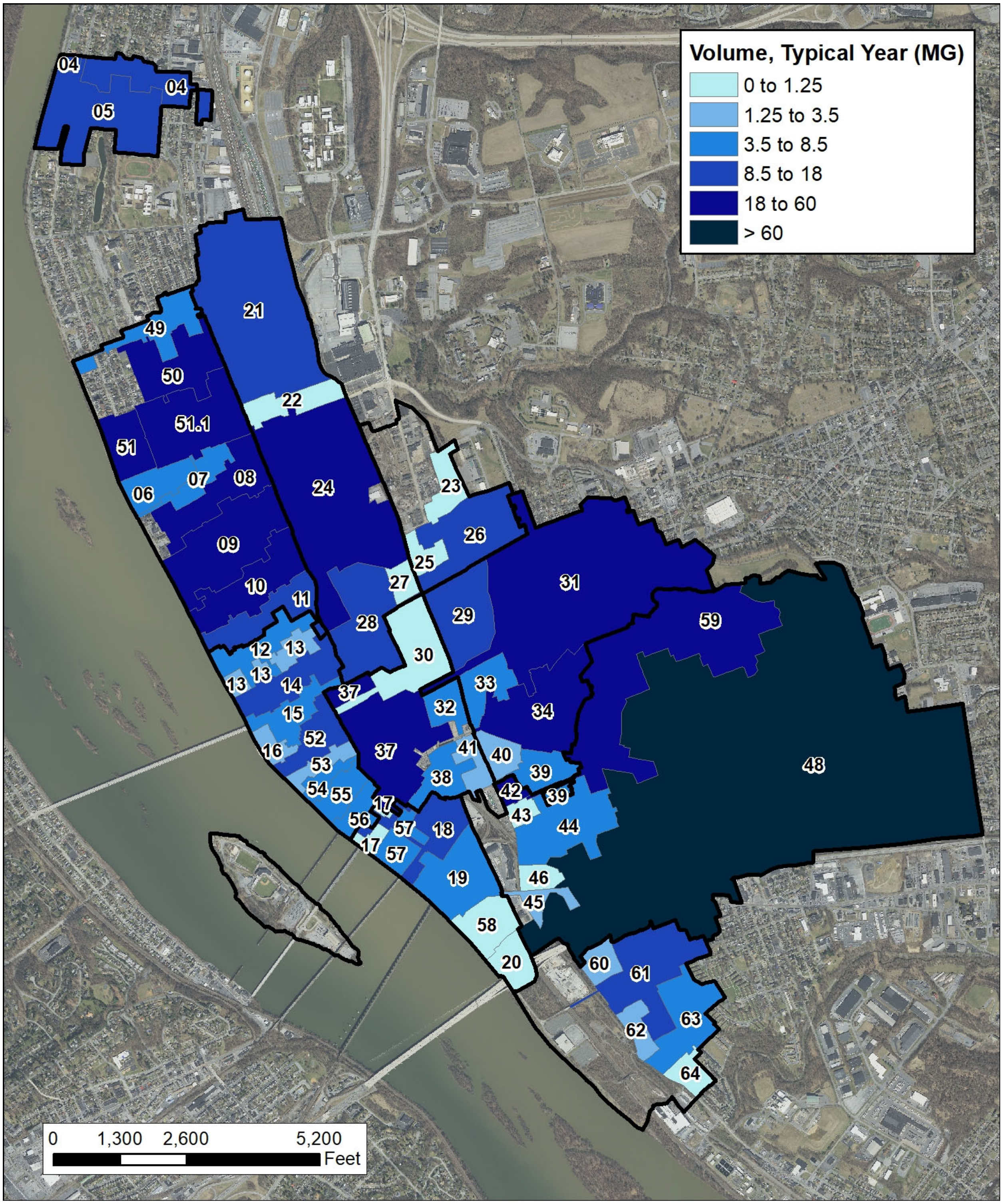

Figure 3.7-1: Typical Year Annual CSO Discharge Volumes under Pre-Plan Conditions

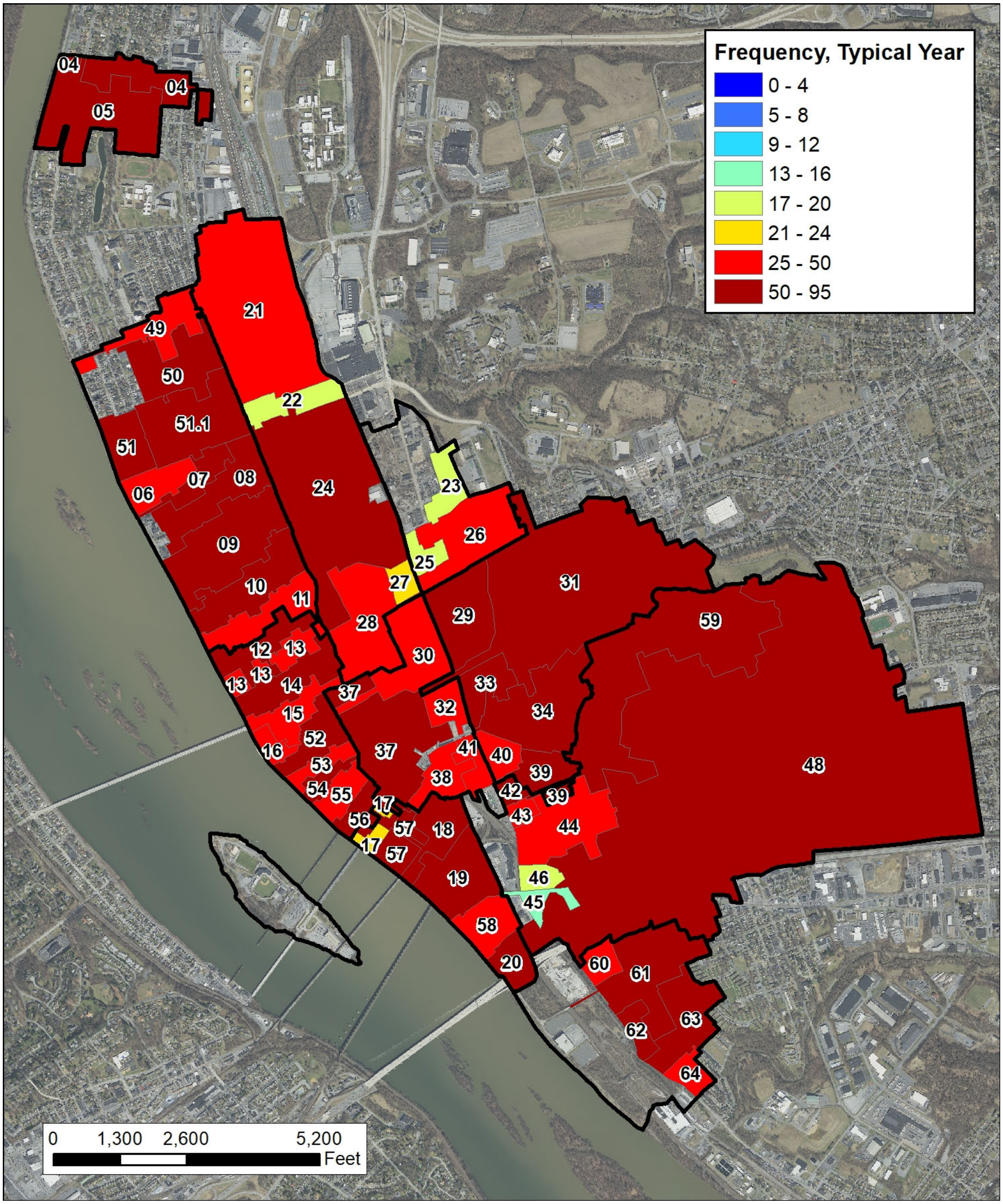

Figure 3.7-2: Typical Year Annual CSO Discharge Frequency under Pre-Plan Conditions

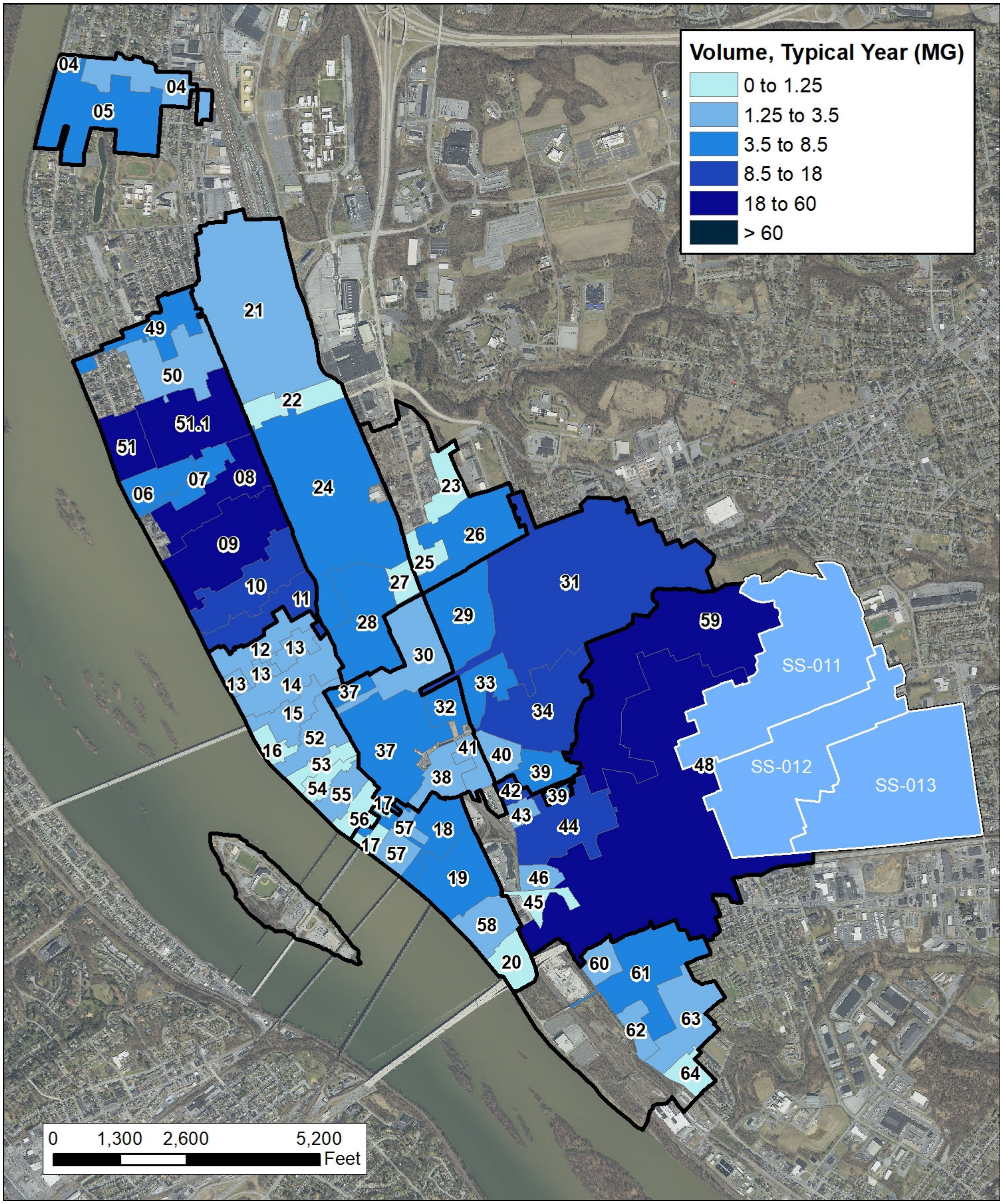

Figure 3.7-3: Typical Year Annual CSO Discharge Volumes under 2032 Conditions

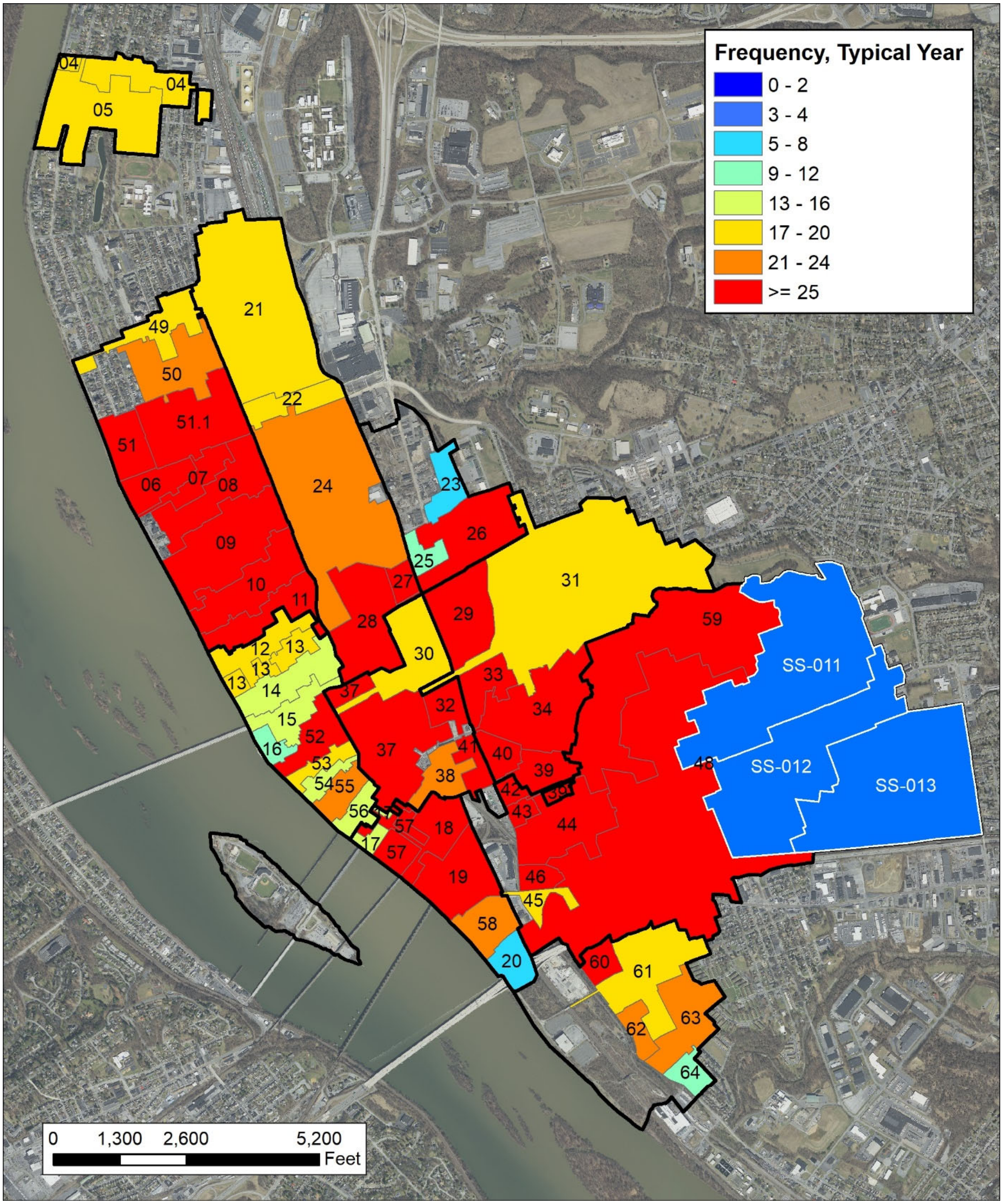

Figure 3.7-4: Typical Year Annual CSO Discharge Frequency under 2032 Conditions

Pre-Plan Conditions: CRW assumed ownership and O&M responsibilities for the wastewater and stormwater collection and conveyance systems in 2013. These 2013 CSO discharge statistics are shown graphically as stacked bar charts in **Figures 3.7-5** and **3.7-6**. Separate figures are provided for the Susquehanna River and Paxton Creek. The total height of the bars indicates the total typical year CSO frequency at each individual CSO outfall. The intensity of the colors indicates the relative volumes of the individual CSO discharges. For example, on CSO-10, eight of the annual CSO discharges have volumes greater than 1 MG, 16 of the annual discharges have volumes from 0.5 to 1.0 MG, and so on. Comparing the preplan and post Appendix B figures provides a visual representation of the CSO reductions provided.

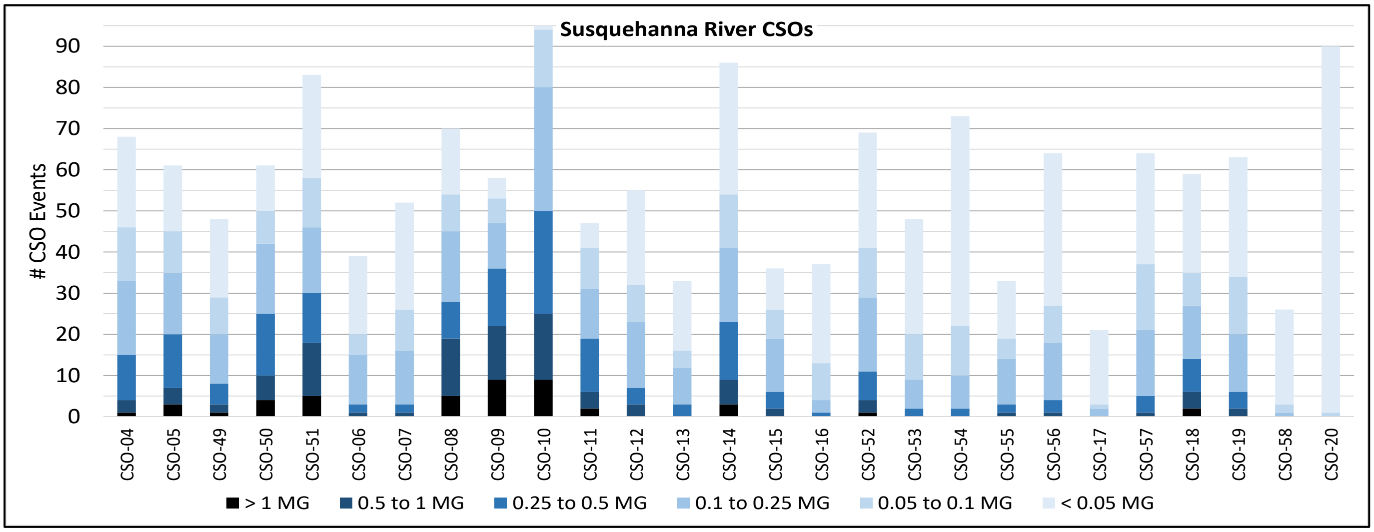

Figure 3.7-5: Frequency and Volume Stacked Bar Charts of Susquehanna CSOs under Pre-Plan Conditions

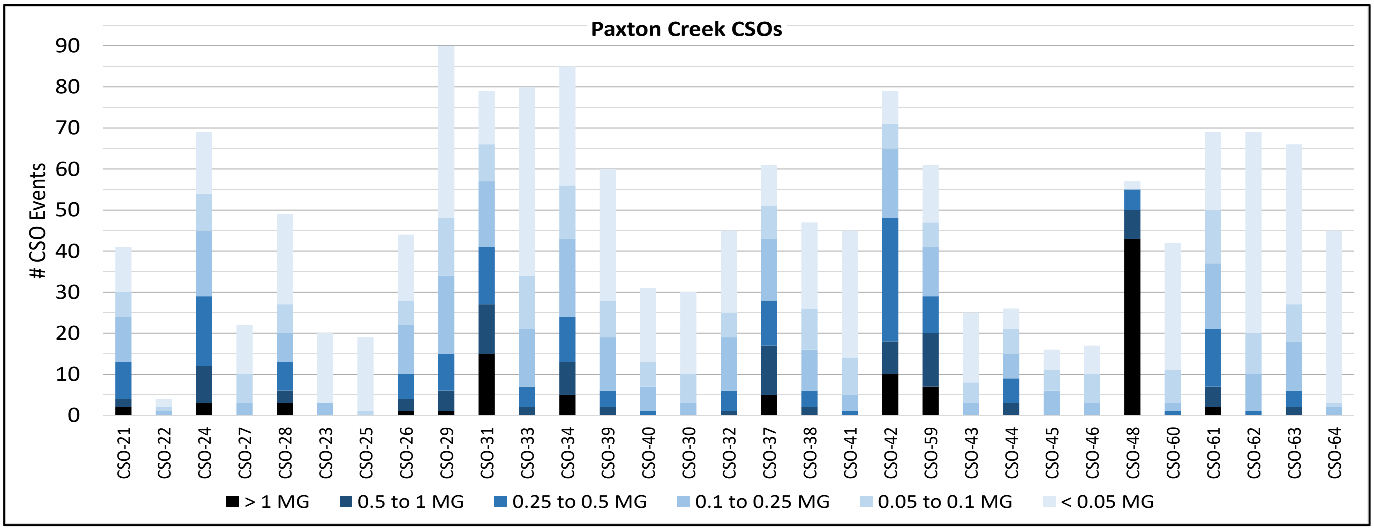

Figure 3.7-6: Frequency and Volume Stacked Bar Charts of Paxton CSOs under Pre-Plan Conditions

Completed Appendix B ("First Control Point"): With the completion of the initial rehabilitation projects and the remaining Appendix B projects by 2032, the total annual overflow volume, under typical year precipitation conditions, is expected to decrease from 796 to 331 million gallons. The corresponding annual overflow frequencies at each of the individual CSO outfall pipes are expected to decrease to a range from 6 to 60 overflow frequencies. The CSO discharge statistics associated with the 2032 completion of the Appendix B Projects are shown graphically on **Figures 3.7-7** and **3.7-8**. The height of the empty bars indicates the reduction in typical year CSO frequency at each individual CSO outfall. The intensity of the colors indicates the relative volumes of the individual CSO discharges. For example, on CSO-10, with Appendix B improvements, only one of the annual CSO discharges have volumes greater than 1 MG, and 4 of the annual discharges have volumes from 0.5 to 1.0 MG, and so on. Comparing the preplan and post Appendix B figures provides a visual representation of the CSO reductions provided.

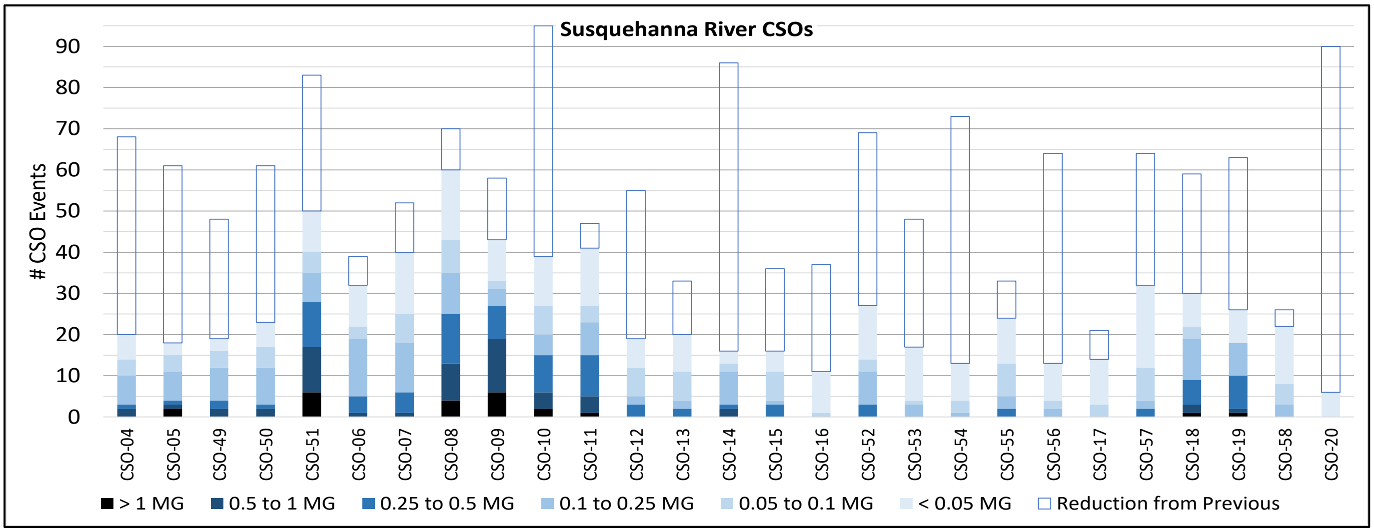

Figure 3.7-7: Frequency and Volume Stacked Bar Charts of Susquehanna CSOs under Appendix B Conditions

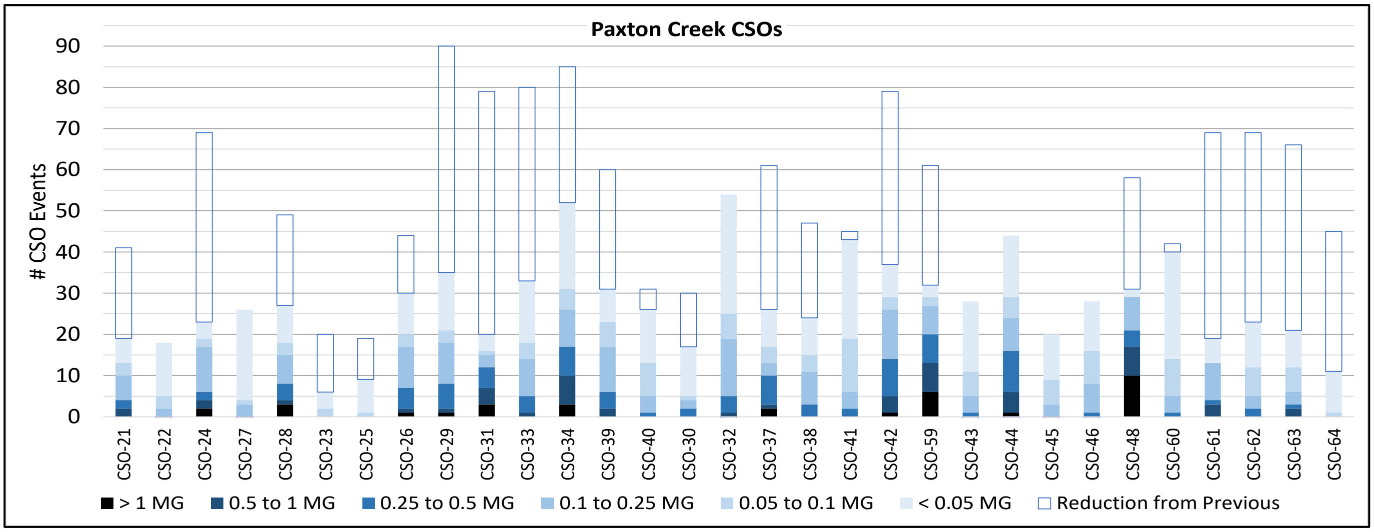

Figure 3.7-8: Frequency and Volume Stacked Bar Charts of Paxton CSOs under Appendix B Conditions

4.0 Single Technology Screening Evaluations

4.1 Single Technology Screening Approach

To prepare this *Alternatives Analysis Report*, Capital Region Water (CRW) evaluated a wide range of CSO control technologies and sizes and evaluated a wide range of levels of control (LoC) at each combined sewer overflow (CSO) outfall. While CRW has selected to utilize an integrated planning approach for its Long-Term Control Plan (City Beautiful H_2O Program Plan), this single technology screening evaluation is focused on CSO control technologies.

Section 2 of this report described the potential CSO control technologies, along with municipal separate stormwater sewer system (MS4) control technologies and other wet weather control measures, that were evaluated by CRW for this report. The evaluated range of control technologies fully meet the requirements of the National CSO Control Policy and the Modified Partial Consent Decree (MPCD). **Section 2** also documented the initial screening process applied to the full set of control technologies.

This **Section 4** of the report documents additional screening evaluations of control technologies that in Section 2 were determined to be applicable for the CRW combined sewer system. The findings from these single technology screening evaluations identify the best control technologies to utilize in the development and assessment of the mixed technology alternatives to meet water quality criteria along the receiving waters, documented in report **Section 6**.

It is important to note that while the technology evaluations within this section include cost-performance results, they are only for screening evaluations and are not complete control "alternatives". The complete control alternatives and associated cost-performance results are described in **Section 6**.

Control technologies evaluated under this report section can generally be classified into two categories.

Centralized or Systemwide Technologies increase the conveyance and/or treatment capacity of the system.

- Enhanced Conveyance and Increased AWTF Capacities (**Section 4.2**)
- Tunnel Storage (**Section 4.3**)

Decentralized or Local Technologies are applied to individual catchments (or groups of consolidated catchments) to reduce the quantity of (and improve the quantity of) runoff entering the conveyance system.

- Green Stormwater Infrastructure (**Section 4.4**)
- Satellite Storage (**Section 4.5**)
- Satellite Treatment (**Section 4.6**)
- Sewer Separation (**Section 4.7**)

Within each of the control technology sub-sections listed above, the following information is provided:

- **Technology Overview** - Brief descriptions of the technology and the control facilities that were evaluated.
- **Levels of Control Descriptions** - Brief description of each LoC along the evaluated control range, starting from Pre-Plan conditions (when CRW assumed operation and maintenance (O&M) responsibilities for the wastewater and stormwater collection and conveyance systems in 2013), and extending though a LoC where there are no CSO discharges during the typical year.
- **Site-Specific Feasibility and Applicability** – Brief discussion of site-specific constraints.
- **Basis of Cost Estimates**- Brief description of the cost estimates that were developed for each control technology that was evaluated.
- **Cost-Performance Summary** - Summary table showing the cost and the typical year CSO discharge frequency and volume for each LoC within the evaluated range; "knee-of-the curve" cost-performance plots for the present value lifecycle cost versus the typical year CSO frequency and the typical year CSO volume.

Section 4.8 summarizes the findings from the completed single technology evaluations. It also explains how these findings were utilized to inform the development of the mixed technology alternatives documented in Section 6. **Section 4.8.1** summarizes the criteria used to screen the technologies. The screening criteria includes comparisons of cost effectiveness between the technologies, the ability to meet water quality criteria, site-specific constraints, how the technologies can be used in combination with other technologies and impacts on the collection system. Finally, **Section 4.8.2** documents the results of the single technology screening evaluations and explains how these technologies will be incorporated into the mixed technology alternatives presented in Section 6.

Baseline Assumptions ("First Control Point"): As explained within Sections 1.3 and 3, the control technologies evaluated under this alternative analysis report are built upon the foundation of projects that were either previously completed or are required to be completed in accordance with the implementation schedule within MPCD Appendix B. Projects completed between 2013 and 2023 include CRW's ongoing Nine Minimum Control (NMC) measures that are documented within its approved NMC Plan. The alternative analysis incorporates the expected benefits from these projects.

H&H Modeling: For each technology, CRW's calibrated hydrologic and hydraulic (H&H) model was used to determine the number and sizes of facilities required to meet each LoC. The H&H model also provides CSO statistics (overflow volume, frequency, and duration) for each LoC at each CSO outfall. CRW's H&H model has been documented in previously submitted MPCD deliverables, including the *Sewer System H&H Model Report* (April 2016); *Combined Sewer System Characterization Report, Version 2.0* (February 2018); and *Separate Sanitary Sewer Capacity Assessment Report, Version 2.0* (February 2018). For this *Alternatives Analysis Report*, additional model updates were made to address additional MPCD requirements and to evaluate the control technologies more comprehensively.

Cost Effectiveness Comparisons: The single technology evaluations facilitate a direct comparison of the relative cost effectiveness of each technology. Cost-performance curves plot the cost of the required control facilities against each associated LoC. The "knee of the curve," is identified as the point where the incremental change in cost per performance increases rapidly. Two knee-of-the-curve plots were generated, one for CSO frequency during the typical year and a second for systemwide overflow volume during the typical year. The targeted overflow LoCs are 24, 20, 16, 12, 8, 4, and 0 overflows/year.

4.2 Enhanced Conveyance and Increased AWTF Capacities

Enhanced conveyance and increased AWTF capacities (Enhanced Conveyance) involves incrementally and systematically increasing the conveyance capacity of CRW’s interceptor sewers and pump stations and increasing the treatment capacity of the AWTF to provide a range of LoCs. The locations and configurations of the improvements are provided in **Figure 4.2-1**.

Unlike the other technologies evaluated (that provide the same LoC at each CSO outfall) this technology provides varying LoCs among different CSO regulator structures and outfalls. This is because increasing the conveyance capacity unevenly affects individual CSO outfalls. Therefore, for equal comparison among other technologies, each LoC explained below is assumed equivalent to the closest systemwide performance achieved for the other technology evaluations (e.g., 24, 20, 16, 12, 8, 4, or 0 overflows).

4.2.1 Levels of Control Descriptions

Pre-Plan Conditions: Pre-Plan conditions reflect the performance of the CRW system, under typical year precipitation, when CRW assumed operation and maintenance (O&M) responsibilities for the wastewater and stormwater collection and conveyance systems in 2013.

First Control Point: The first control point under each single technology reflects the LoC achieved by the projects that are either already completed or are required to be completed in accordance with the implementation schedule within MPCD Appendix B. The specific projects are described in Sections 1.3 and 3.

Second Control Point: The second control point under this technology would include all the first control point improvements and the following additional improvements.

- Expansion of the Front Street and Spring Creek pump stations to achieve a combined total hydraulic capacity of 120 MGD. This includes expansion of the buildings, wet well volumes and the peak pumping capacities.
- Improvements and treatment capacity expansions at the AWTF to provide a total peak capacity of 120 MGD. This includes the permitted bypassing of secondary treatment facilities.
- Modifications to selected regulator structures and connector pipes to the interceptor. These modifications increase wet weather flow to the interceptor and the AWTF, leading to a decrease in CSO volume and frequency.

Third Control Point: The third control point under this technology would include all the previous improvements and the following additional improvements.

- New parallel interceptors along the Paxton Creek, Front Street, and Hemlock Street Interceptors installed along the same alignment as the existing interceptors. These parallel interceptors provide a total hydraulic conveyance capacity of 180 MGD.

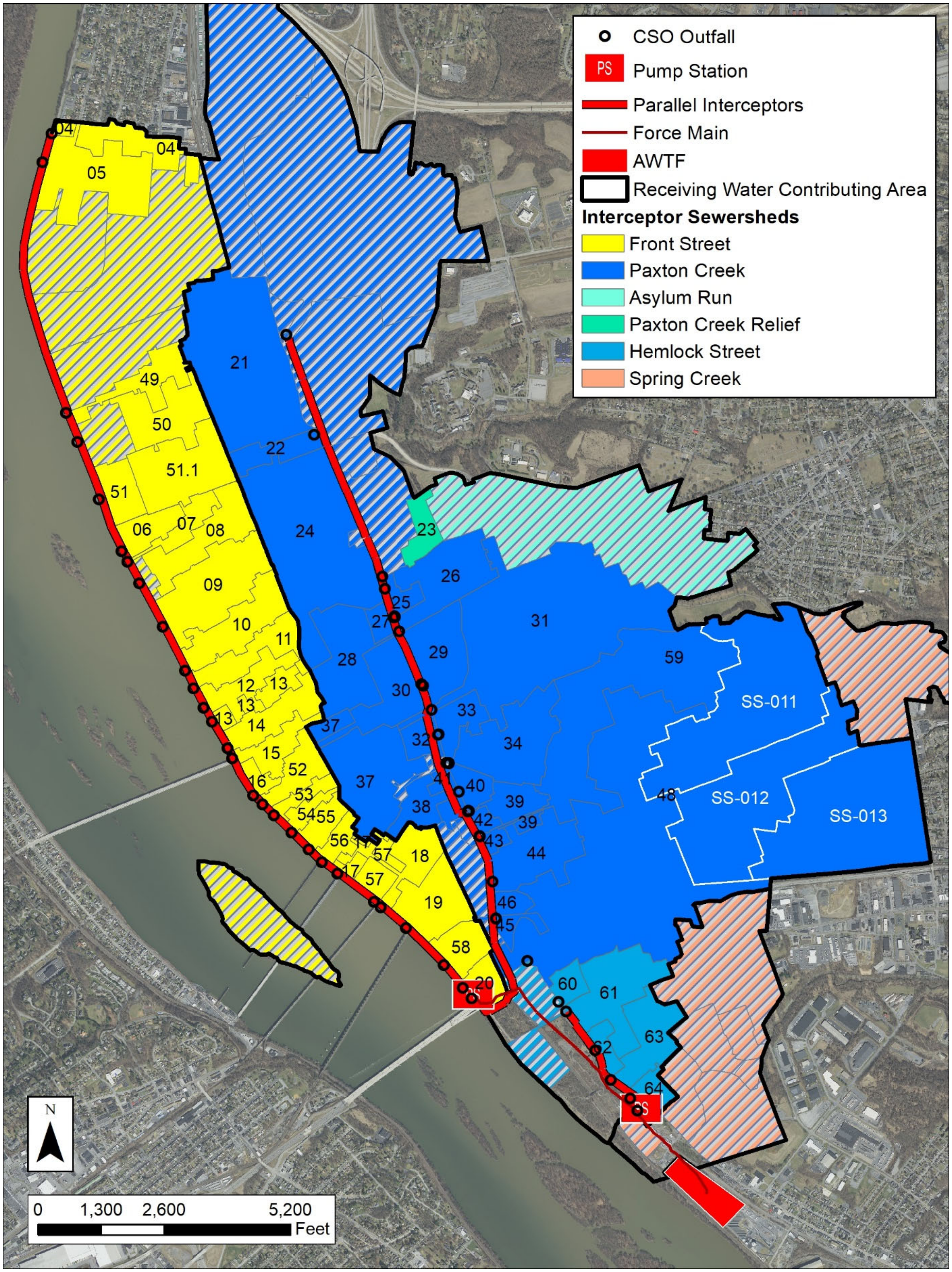

Figure 4.2-1: Location of Facilities for Enhanced Conveyance and Increased AWTF Capacities

- Further expansion of the Front Street and Spring Creek Pump Stations and the AWTF to achieve a total peak hydraulic capacity and a primary treatment and disinfection capacity of 180 MGD.

Fourth Control Point: The fourth control point would include all the previous improvements and the following additional improvements.

- Increase the hydraulic capacity of the new parallel interceptors along the Paxton Creek, Front Street, and Hemlock Street Interceptors to provide a total peak conveyance capacity of 240 MGD.
- Further expansion of the Front Street and Spring Creek Pump Stations and the AWTF to achieve a total peak hydraulic capacity and a primary treatment and disinfection capacity of 240 MGD.

Fifth Control Point: The fifth control point would include all the previous improvements and the following additional improvements.

- Increase the hydraulic capacity of the new parallel interceptors along the Paxton Creek, Front Street, and Hemlock Street Interceptors to provide a total peak conveyance capacity of 400 MGD.
- Further expansion of the Front Street and Spring Creek Pump Stations and the AWTF to achieve a total peak hydraulic capacity and a primary treatment and disinfection capacity of 400 MGD.

Sixth Control Point: The sixth control point would include all the previous control point improvements and the following additional improvements.

- Increase the hydraulic capacity of the new parallel interceptors along the Paxton Creek, Front Street, and Hemlock Street Interceptors to provide a total peak conveyance capacity of 550 MGD.
- Further expansion of the Front Street and Spring Creek Pump Stations and the AWTF to achieve a total peak hydraulic capacity and a primary treatment and disinfection capacity of 550 MGD.

Seventh Control Point: The seventh control point would include all the previous improvements and the following additional improvements.

- Further increase the hydraulic capacity of the new parallel interceptors along the Paxton Creek, Front Street, and Hemlock Street Interceptors to provide a total peak conveyance capacity of 700 MGD.
- Further expansion of the Front Street and Spring Creek Pump Stations and the AWTF to achieve a total peak hydraulic capacity and a primary treatment and disinfection capacity of 700 MGD.

Eighth Control Point: The eighth control point would include all the previous improvements and the following additional improvements.

- Further increase the hydraulic capacity of the new parallel interceptors along the Paxton Creek, Front Street, and Hemlock Street Interceptors to provide a total conveyance peak capacity of 1,200 MGD.

- Further expansion of the Front Street and Spring Creek Pump Stations and the AWTF to achieve a total peak hydraulic capacity and a primary treatment and disinfection capacity of 1,200 MGD.

4.2.2 Basis of Cost Estimates

The construction cost opinion for each pumping station and AWTF expansion was developed from construction cost data based on the peak flow, which was subsequently adjusted to the location and escalated to present day. The construction cost opinion for each interceptor expansion was developed from construction cost data based on the diameter and depth, which was subsequently adjusted to the location and escalated to present day. To develop the present value lifecycle cost, annual operation and maintenance was estimated as 1.0% of the construction cost. At the end of the 20-year planning period, it was assumed that the pumping stations and treatment facilities would require replacement or rehabilitation of 20% of the capital cost. For more detailed information on the basis of cost estimates, refer to **Appendix 1** – Basis of Costs.

4.2.3 Site-Specific Feasibility and Applicability Findings

The Enhanced Conveyance technology entails a range of siting constraints depending on the LoC. For lower LoCs, expanding the Paxton Creek Interceptor and expanding the Front Street Pump Station may be manageable, but the higher LoCs, which include additional parallel interceptors and an expanded AWTF, present significant siting constraints. The Paxton Creek Interceptor is scheduled for replacement; however, expanding the Paxton Creek Interceptor without increasing the capacities of the downstream facilities (Front Street Pump Station, force mains, and AWTF) does not significantly impact CSO control.

4.2.4 Cost-Performance Summary

Table 4.2-1 provides the typical year CSO statistics and present value cost estimate associated with each LoC. Typical year CSO volume is the systemwide total of individual CSO outfalls, and typical year CSO frequency range represents the range of frequencies for individual CSO outfalls. As mentioned above, for this technology, control points two through seven result in varied frequencies among individual outfalls. For comparison purposes, these are assumed to be equivalent to the other overflow targets utilized for other technologies (e.g., 24, 20, 16, 12, 8, 4, and 0 overflows).

Cost-Performance Curves: Cost-performance curve plots were generated for each evaluated control technology. The cost-performance curves show the range of levels of control (LoCs) provided, their associated reductions in the frequency and volume of CSO discharges, and demonstrate which technologies are most cost-effective. The “knee of the curve,” is identified as the point where the incremental change in cost per performance increases rapidly. Two cost-performance plots were generated for each control technology. In the first plot, the horizontal axis shows the CSO frequency during typical year precipitation. In the second plot, the horizontal axis shows the systemwide overflow volume during the typical year. The vertical axis for both plots shows the present value lifecycle cost for each LoC. For this single technology screening evaluation, except for the Enhanced Conveyance and Increased AWTF Capacities technology, each CSO outfall has at least the same LoC along the range of overflows per typical year analyzed. The corresponding target overflows are 24, 20, 16, 12, 8, 4, and 0 overflows/year.

Table 4.2-1: LoCs and Costs for Enhanced Conveyance and Increased AWTF Capacities

Control Point	Facilities	System Capacity (MGD)	Estimated Cost ($ Million)	Typical Year CSO Volume (MG)	Typical Year CSO Frequency Range
Pre-Plan	NA	80	NA	796	6 to 95
1 (App. B)	FSPS Upgrade; PCI Replacement	80	217	331	6 to 60
2	Expanded PS	120	306	299	0 to 60 (Equivalent to 24)
3	Expanded PS, Interceptors, AWTF	180	495	269	0 to 30 (Equivalent to 20)
4	Expanded PS, Interceptors, AWTF	240	686	239	0 to 15 (Equivalent to 16)
5	Expanded PS, Interceptors, AWTF	400	1,065	59	0 to 10 (Equivalent to 12)
6	Expanded PS, Interceptors, AWTF	550	1,253	44	0 to 7 (Equivalent to 8)
7	Expanded PS, Interceptors, AWTF	700	1,447	29	0 to 4 (Equivalent to 4)
8	Expanded PS, Interceptors, AWTF	1,200	2,117	0	0

Figure 4.2-2 is the cost-performance plot of CSO frequency versus present value costs. The plotted frequencies depict a representative frequency for comparison to the other technologies.

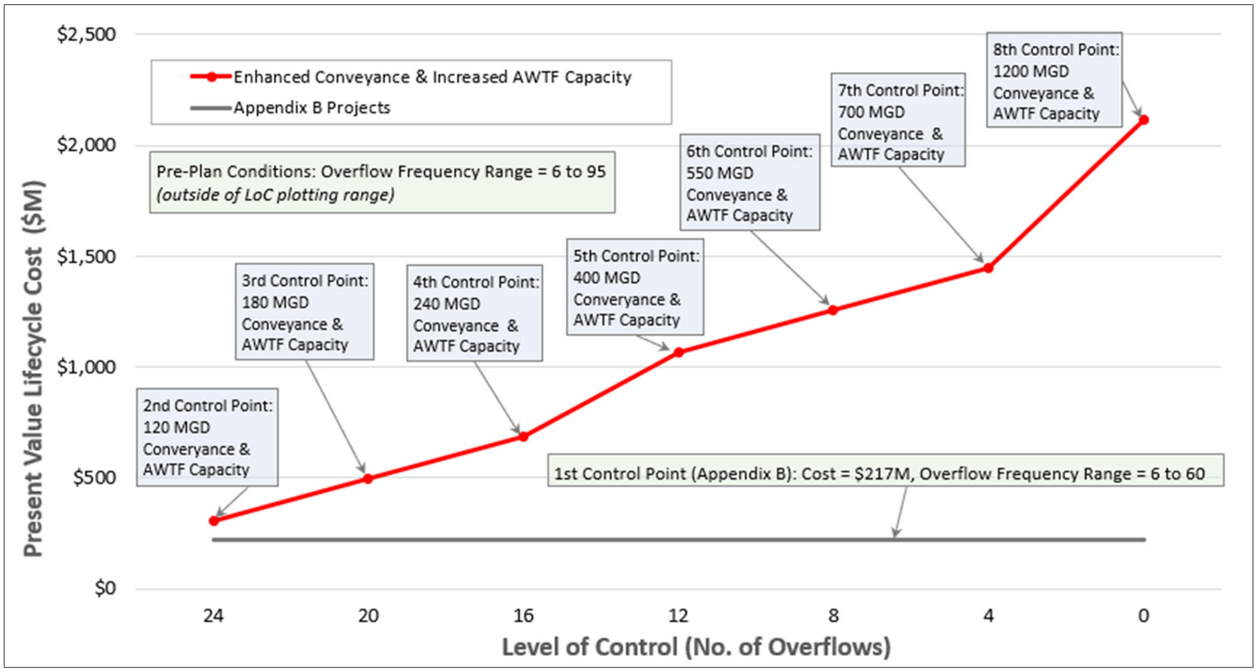

Figure 4.2-2: Typical Year CSO Frequency vs. Cost-Performance Curve for Enhanced Conveyance and Increased AWTF Capacity

Figure 4.2-3 is the cost-performance plot of systemwide overflow volume versus present value costs.

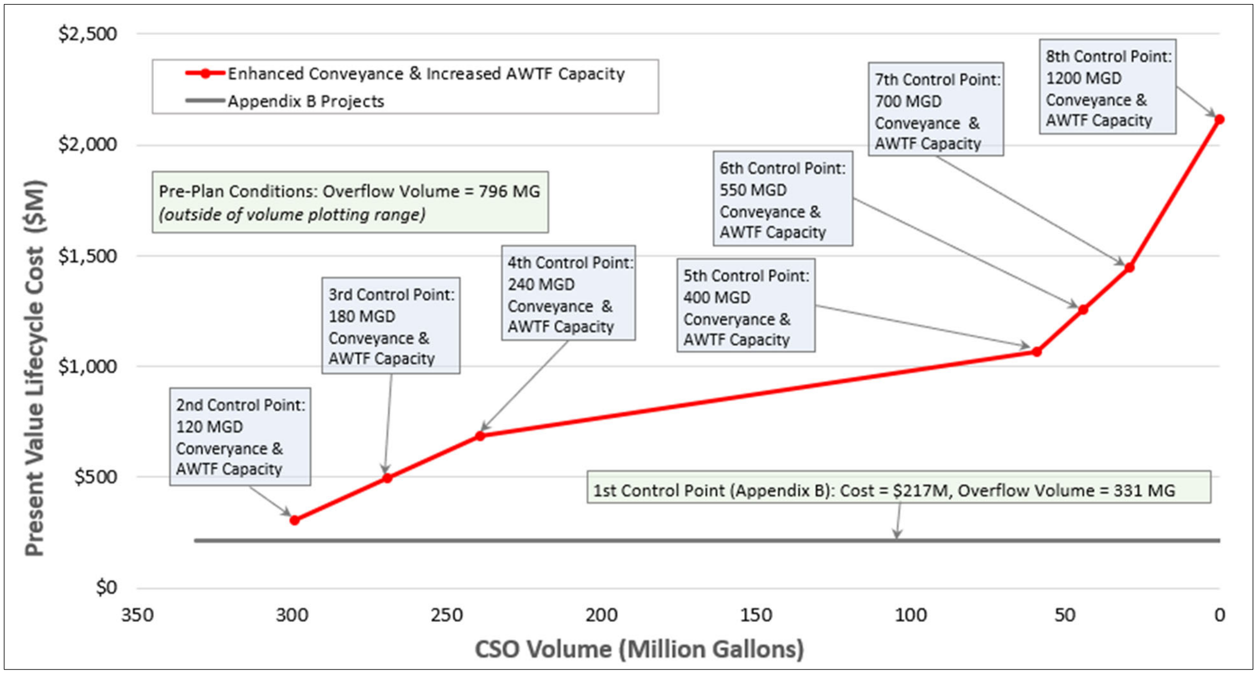

Figure 4.2-3: Typical Year CSO Volume vs. Cost-Performance Curve for Enhanced Conveyance and Increased AWTF Capacity

4.3 Tunnel Storage

A new tunnel storage system would be built with alignments parallel to the existing Front Street, Paxton Creek, and Hemlock Street interceptors and with invert elevations below the existing interceptor profiles. In this control technology, excess wet weather flows that exceed existing conveyance system capacities are conveyed to a tunnel system, stored temporarily, and dewatered to the AWTF after the storm passes and treatment capacity becomes available. The locations and configurations of the improvements are provided in **Figure 4.3-1.**

A simplifying assumption for the assessment is that the tunnel storage system extends a total length of approximately 45,000 feet, the entire length of the CRW interceptor sewers, so that excess wet weather flow from every CSO regulator structure can be conveyed to the tunnel. Each LoC was achieved by increasing the diameter and corresponding storage volume of the tunnel. It was assumed tunnels with diameters 6 feet and smaller would be constructed using micro-tunneling, and tunnels with diameters greater than 6 feet would be constructed using a tunnel boring machine (TBM).

A dewatering pump station would empty the tunnel system after a storm event is over and capacity becomes available at the existing AWTF. Ten drop shaft structures to convey the wet weather flow to the tunnel were assumed for costing purposes. Flow diversion structures and consolidation sewers were included to convey the diverted flow to the drop shaft structures.

4.3.1 Levels of Control Descriptions

Pre-Plan Conditions: Pre-Plan conditions reflect the performance of the CRW system, under typical year precipitation, when CRW assumed operation and maintenance (O&M) responsibilities for the wastewater and stormwater collection and conveyance systems in 2013.

First Control Point: The first control point under each single technology reflects the LoC achieved by the projects that are either already completed or are required to be completed in accordance with the implementation schedule within MPCD Appendix B. The specific projects are described in Sections 1.3 and 3.

Second Control Point: The second control point would provide a systemwide LoC whereby every outfall would have no more than 20 CSOs per year during typical year precipitation. The storage volume required to achieve this LoC is approximately 1.38 million gallons (MG), which corresponds to a tunnel diameter of 2.3 feet.

Third Control Point: The third control point would provide a systemwide LoC whereby every outfall would have no more than 16 CSOs per year during typical year precipitation. The storage volume required to achieve this LoC is approximately 2.1 MG, which corresponds to a tunnel diameter of 2.8 feet.

Fourth Control Point: The fourth control point would provide a systemwide LoC whereby every outfall would have no more than 10 CSOs per year during typical year precipitation. The storage volume required to achieve this LoC is approximately 4.5 MG, which corresponds to a tunnel diameter of approximately 4 feet.

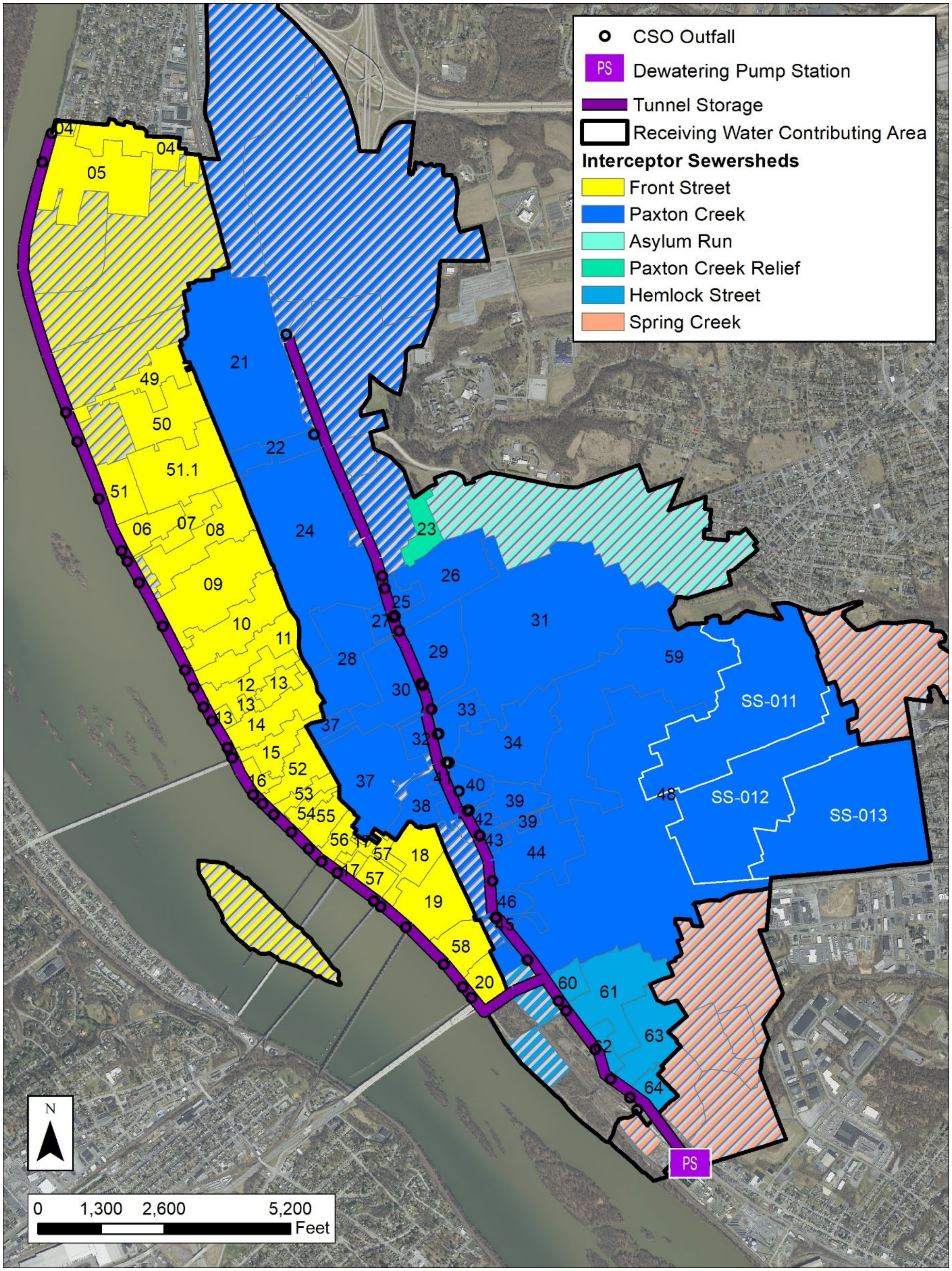

Figure 4.3-1: Location of Facilities for Tunnel Storage

Fifth Control Point: The fifth control point would provide a systemwide LoC whereby every outfall would have no more than 5 CSOs per year during typical year precipitation. The storage volume required to achieve this LoC is approximately 6.8 MG, which corresponds to a tunnel diameter of approximately 5 feet.

Sixth Control Point: The sixth control point would provide a systemwide LoC whereby every outfall would have no more than 2 CSOs per year during typical year precipitation. The storage volume required to achieve this LoC is approximately 9.8 MG, which corresponds to a tunnel diameter of approximately 6 feet.

Seventh Control Point: The seventh control point would provide a systemwide LoC whereby every outfall would have no more than 0 CSOs per year during typical year precipitation. The storage volume required to achieve this LoC is approximately 15 MG, which corresponds to a tunnel diameter of approximately 7.5 feet.

Eighth Control Point: The eighth control point would provide a systemwide LoC whereby every outfall would have no overflows during typical year precipitation. The storage volume required to achieve this LoC is approximately 54 MG, which corresponds to a tunnel diameter of approximately 14 feet.

4.3.2 Basis of Cost Estimates

The construction cost opinion for each tunnel was developed from construction cost data based on the length, diameter, and depth, which was subsequently adjusted to the location and escalated to the present day. In addition to the tunnel construction, the following elements were included: consolidation sewers, diversion chambers, drop shaft, maintenance/ventilation shafts, and a dewatering pumping station.

To develop the present value lifecycle cost, annual operation and maintenance was estimated as 0.50% of the construction cost. At the end of the 20-year planning period, it was assumed that the storage facilities would require replacement or rehabilitation of 10% of the capital cost. The present value cost also includes the cost of wastewater treatment at the AWTF for the typical year storage volume.

The costs for pipes up to 6 ft in diameter within this technology evaluation were based on installation using micro-tunneling, but the actual installation decisions would be made during final design. For pipes lager than 6 ft, it was assumed that the installation would be achieved utilizing a tunnel boring machine.

4.3.3 Site-Specific Feasibility and Applicability Findings

Tunnel storage does not require a significant above-ground footprint, except for the placement of drop shafts and maintenance/vent shafts. Also, a dewatering pump station is required, but this can be near the AWTF.

4.3.4 Cost-Performance Summary

Table 4.3-1 provides the typical year CSO statistics and present value cost estimate associated with each LoC. Typical year CSO volume is the systemwide total of individual CSO outfalls, and typical year CSO frequency represents the range of frequencies for individual CSO outfalls (Pre-Plan and Appendix B) or the target frequency corresponding to the LoC (control points two through eight).

Table 4.3-1: LoCs and Costs for Tunnel Storage

Control Point	Tunnel Diameter (ft)	Tunnel Storage Volume (MG)	Estimated Cost ($ Million)	Typical Year CSO Volume (MG)	Typical Year CSO Frequency
Pre-Plan	NA	NA	NA	796	6 to 95
1 (App. B)	NA	NA	217	331	6 to 60
2	2.3	1.4	562	239	24
3	2.8	2.1	598	223	20
4	4.1	4.5	643	180	16
5	5.1	6.8	794	146	12
6	6.1	9.8	906	114	8
7	7.5	15	1,057	83	4
8	14.2	54	1,269	0	0

Figure 4.3-2 is the cost-performance plot of CSO frequency versus present value costs. For this technology screening evaluation, except for the Pre-Plan and Appendix B conditions, each of the control points along the curve would provide a consistent systemwide LoC whereby every outfall would have no more than the frequencies indicated in the CSO frequency column in the above table.

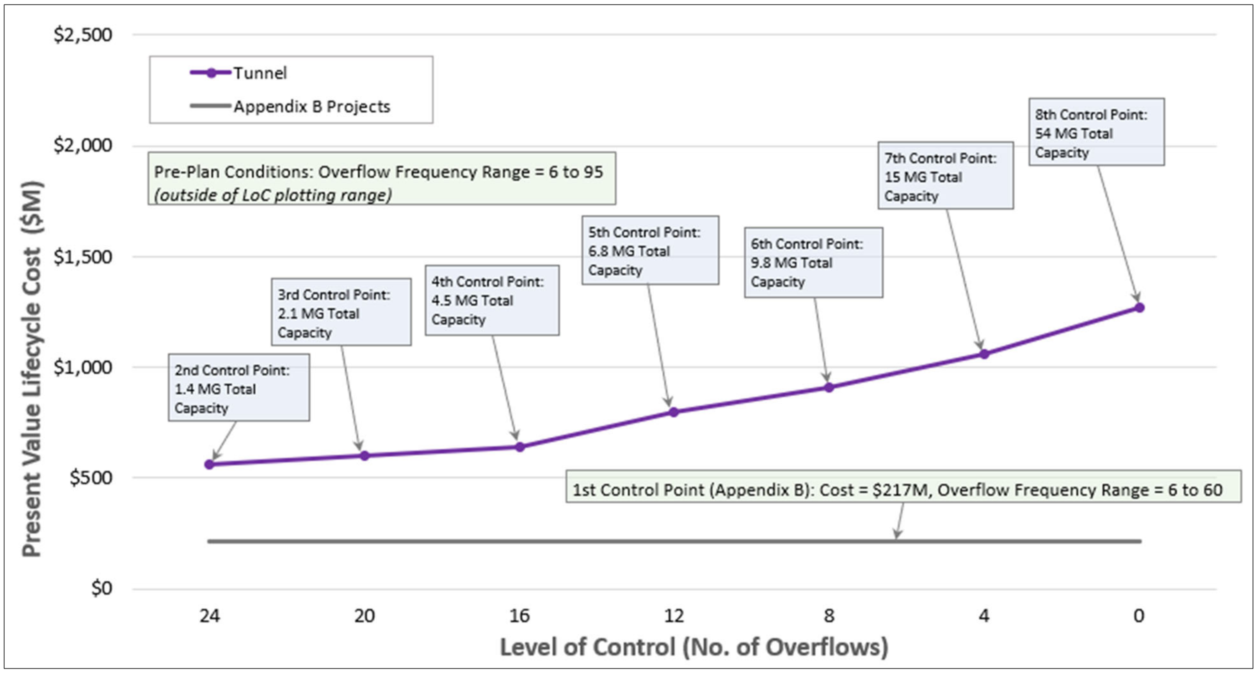

Figure 4.3-2: Typical Year CSO Frequency vs. Cost-Performance Curve for Tunnel Storage

Figure 4.3-3 is the cost-performance plot of systemwide overflow volume versus present value costs.

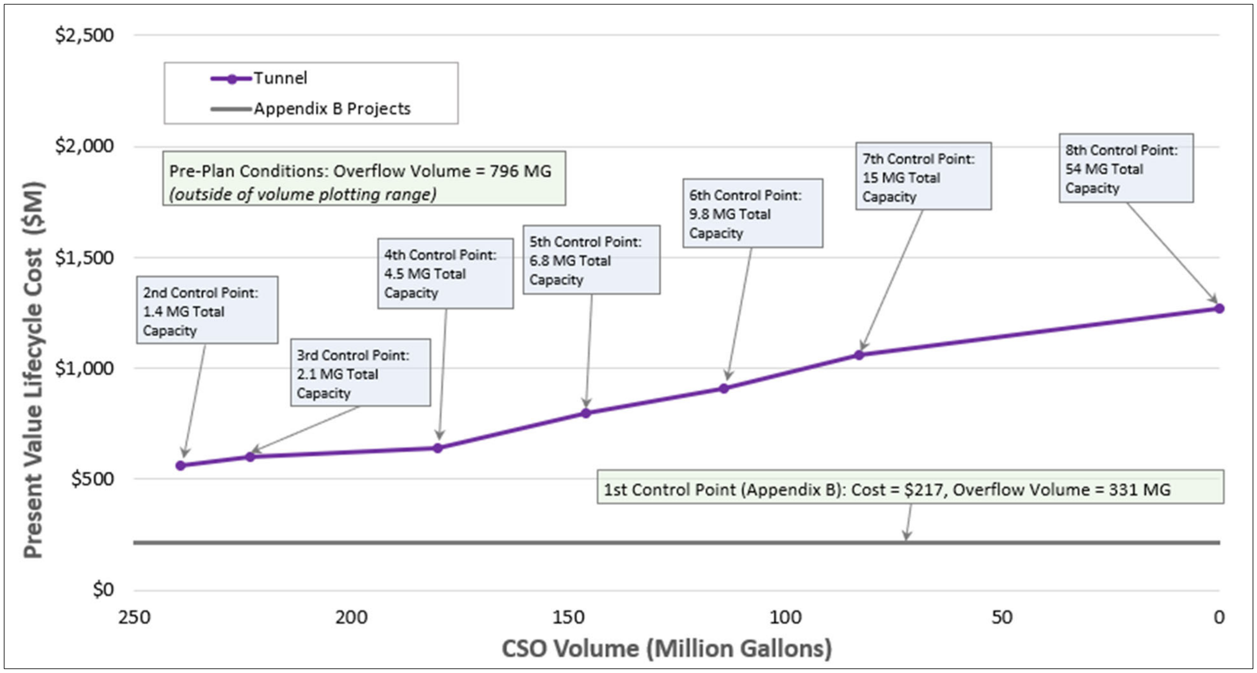

Figure 4.3-3: Typical Year CSO Volume vs. Cost-Performance Curve for Tunnel Storage

4.4 Decentralized Green Stormwater Infrastructure

Green Stormwater Infrastructure (GSI) retains or detains stormwater runoff near where it originates and reduces the volume and/or peak flow from stormwater runoff before it enters the combined sewer collection system. In retention systems, such as a rain garden, the runoff is routed to a permeable surface and allowed to infiltrate back into the ground. By preventing this stormwater from ever entering the collection system, the volume of overflow and associated pollutant/nutrient loads discharging to the receiving waters is reduced. In detention systems, runoff is routed to a storage unit and subsequently returned to the combined sewer collection system, ideally after conveyance and treatment capacities are available to receive this flow. By attenuating these flows, the conveyance system can accept a greater percentage of the overall runoff volume over a longer period, resulting in a net reduction of CSO volume and pollutant loads to the receiving waters.

GSI practices not only effectively manage stormwater but offers valuable co-benefits. These benefits extend beyond water quality and volume control. The GSI program and projects provide positive outcomes:

- ***Beautifying Neighborhoods:*** GSI enhances urban aesthetics by incorporating green spaces, trees, and vegetation.
- ***Avoiding Flood Damages:*** GSI prevents basement backups and flooding, reducing property damage and protecting communities.
- ***Improving Air Quality:*** Vegetation in GSI systems filters pollutants, leading to cleaner urban environments, including carbon sequestration.
- ***Urban Heat Island Stress Reduction:*** GSI features help manage heat island effects in cities, benefiting residents during hot weather.
- ***Enhanced Recreational Opportunities:*** GSI installations create spaces for recreation, connecting residents with nature.
- ***Reducing Illnesses:*** GSI mitigates air quality and heat-related illnesses by providing shade and cooling.
- ***Creating Jobs:*** GSI design, installation, and maintenance generate additional employment opportunities.

In summary, GSI practices contribute to healthier, resilient, and vibrant communities.

There are several categories of GSI facilities, described briefly below. For this single technology screening evaluation, it was assumed that all these categories could be used, and that the most appropriate GSI technologies would be applied to the individual catchment areas being managed.

Rain Gardens: A rain garden consists of a shallow depressed area designed to collect stormwater runoff from surrounding surfaces. The collected water infiltrates into the ground, evaporates back into the atmosphere, or is transpired by the vegetation. To increase water absorption and promote infiltration, rain garden designs typically include an upper layer of amended soil with high porosity. Plant selection and maintenance are critical to the long-term viability of a rain garden.

Right-of-Way Bioswales: The typical right-of-way bioswale is between 3 and 5 feet wide by 10 to 20 feet long. They are constructed along the existing sidewalk, with curb cuts to allow street runoff traveling along the gutter to enter the bioswale on the upstream side. Excess flow either returns to the street on the downstream side or is conveyed to the combined sewer via an underdrain system. On the surface, the right-of-way bioswale looks and functions much like a rain garden, however, a raingarden is generally less than a foot deep, and a right-of-way bioswale is approximately 4 ½ feet deep. The upper portion is made up of an engineered soil designed to allow for rapid infiltration. The lower portion of the bioswale is a stone base to provide storage. A picture of a typical bioswale is provided in **Figure 4.4-1**.

Enhanced Tree Pits: Enhanced tree pits can appear like a standard city tree pit; however, they use an underground system designed to infiltrate runoff. The underground system includes engineered soil capable of rapidly infiltrating water, crushed stone for storage, and an underdrain system. Although they can be built individually, they become more effective when they are installed as a connected multi-unit linear system. A picture of a typical tree pit is provided in **Figure 4.4-1**.

Figure 4.4.1: Typical Examples of Enhanced Tree Pits and Right-of-Way Bioswales

Green Roofs: A green roof generally consists of a vegetated layer on top of a lightweight soil medium, below which lies an underdrain system and waterproof membrane. A portion of the precipitation that falls on the vegetated surface is retained in the soil medium and eventually released back to the atmosphere through evaporation and taken up through transpiration. The underdrain system acts as an additional detention system before the excess water is eventually discharged through the buildings downspouts to the ground or directly into the combined sewer system.

Downspout Disconnection: In many urban areas, downspouts are connected directly into the combined sewer system. Disconnecting these downspouts provides opportunity for rooftop runoff to be infiltrated or intercepted before entering the combined sewer system. For buildings with exterior downspouts, disconnection can be as simple as cutting the existing downspout, installing an elbow, and routing the downspout to a pervious surface or storage unit, such as a rain barrel. For buildings with interior downspouts the process can be more complicated and may not be practical.

Permeable Pavements: The term Permeable Pavements refers to several distinct surfaces, each of which are intended to provide increased infiltration and a reduction in stormwater runoff as compared with traditional paving methods. Stormwater migrates through the pavement void spaces down into an underlying stone bed, and either infiltrates to the natural soil or enters an underdrain system. The major types of permeable pavements include porous asphalt, porous concrete, and permeable interlocking concrete pavers.

For this technology screening evaluation, specific locations for GSI facilities were not needed. Within each catchment area tributary to a CSO regulator, the quantity of impervious area managed was increased by the model as necessary to achieve each LoC. The specific facility categories and locations within the catchment areas would be decided during detailed design under adaptive management principles. Therefore, no facility location map figure is provided for the GSI control technology.

4.4.1 Levels of Control Descriptions

Pre-Plan Conditions: Pre-Plan conditions reflect the performance of the CRW system, under typical year precipitation, when CRW assumed operation and maintenance (O&M) responsibilities for the wastewater and stormwater collection and conveyance systems in 2013.

First Control Point: The first control point under each single technology reflects the LoC achieved by the projects that are either already completed or are required to be completed in accordance with the implementation schedule within MPCD Appendix B. The specific projects are described in Sections 1.3 and 3. This includes 100 acres of impervious area managed by GSI facilities.

Second Control Point: The second control point would provide a systemwide LoC whereby every outfall would have no more than 24 overflows per year during typical year precipitation. To achieve this LoC, runoff from 236 acres of impervious area would need to be managed by GSI facilities.

Third Control Point: The third control point would provide a systemwide LoC whereby every outfall would have no more than 20 overflows per year during typical year precipitation. To achieve this LoC, runoff from 347 acres of impervious area would need to be managed by GSI facilities.

Fourth Control Point: The fourth control point would provide a systemwide LoC whereby every outfall would have no more than 16 overflows per year during typical year precipitation. To achieve this LoC, runoff from 539 acres of impervious area would need to be managed by GSI facilities.

Fifth Control Point: The fifth control point would provide a systemwide LoC whereby every outfall would have no more than 12 overflows per year during typical year precipitation. To achieve this LoC, runoff from 767 acres of impervious area would need to be managed by GSI facilities.

Sixth Control Point: The sixth control point would provide a systemwide LoC whereby every outfall would have no more than 8 overflows per year during typical year precipitation. To achieve this LoC, runoff from 932 acres of impervious area would need to be managed by GSI facilities.

Seventh Control Point: The seventh control point would provide a systemwide LoC whereby every outfall would have no more than 4 overflows per year during typical year precipitation. To achieve this LoC, runoff from 1,109 acres of impervious area would need to be managed by GSI facilities.

Eighth Control Point: The eighth control point would provide a systemwide LoC whereby every outfall would have no overflows during typical year precipitation. To achieve this LoC, runoff from 1,283 acres of impervious area would need to be managed by GSI facilities. For context, this LoC would require approximately 25% of the City of Harrisburg to be manages by GSI facilities.

4.4.2 Basis of Cost Estimates

The construction cost opinion for green stormwater infrastructure was based upon $250,000 per acre of impervious area managed, which includes a 25% construction contingency; this is the planning value that CRW utilizes for the ongoing GSI implementation. This value was utilized for areas ranked as a 5, 6, or 7 in CRW's *Community Greening Plan* (January 2017), because these areas provide the best opportunities for GSI implementation. As discussed in Section 4.4.3, some areas are more difficult to implement GSI, so additional cost multipliers were applied for these areas.

To develop the present value lifecycle cost, annual operation and maintenance costs were estimated as $8,000 per acre of impervious area managed. At the end of the 20-year planning period, it was assumed that GSI facilities would not require replacement or rehabilitation beyond annual operation and maintenance. Since GSI will remove stormwater from the combined sewer system, a credit for wastewater treatment at the AWTF was also applied for the volume of stormwater removed in the typical year.

4.4.3 Site-Specific Feasibility and Applicability Findings

GSI is advantageous in that it can be incorporated throughout the collection system. Additionally, GSI facilities are often integrated with the existing infrastructure to provide additional community benefits (e.ge. parks, green streets). GSI affords flexibility in the placement of facilities, which is consistent with an Adaptive Management approach (i.e., if a specific GSI project cannot be constructed, another project with comparable managed area / storage volume can be constructed at another location within the catchment).

However, there are limits to how much GSI can be implemented within individual catchments. This is based on the types of properties (public vs. private), topography, soil conditions, utility conflicts, and other factors. As part of CRW's *Community Greening Plan*, an opportunity analysis was conducted to rank the ease of GSI implementation for all streets and parcels within the City of Harrisburg. Additionally, CRW performed more comprehensive assessments to identify potential GSI projects within select planning areas, including Uptown, Lower Front Street, and Lower Paxton Creek. These analyses are the basis for identifying which catchments have more or less GSI opportunities.

4.4.4 Cost-Performance Summary

Table 4.4-1 provides the typical year CSO statistics and present value cost estimate associated with each LoC. Typical year CSO volume is the systemwide total of individual CSO outfalls, and typical year CSO frequency represents the range of frequencies for individual CSO outfalls (Pre-Plan and Appendix B) or the target frequency corresponding to the LoC (control points two through eight).

Table 4.4-1: LoCs and Costs for Decentralized Green Stormwater Infrastructure

Control Point	Managed Impervious Acres	Estimated Cost ($ Million)	Typical Year CSO Volume (MG)	Typical Year CSO Frequency
Pre-Plan	0	NA	796	6 to 95
1 (App. B)	100*	217**	331	6 to 60
2	236	350	210	24
3	347	417	176	20
4	539	552	125	16
5	767	735	75	12
6	932	884	47	8
7	1,109	1,071	30	4
8	1,283	1,259	17	0

*Appendix B includes 100 acres of GSI (approximately 40 acres have already been completed).
**Appendix B costs also include other non-GSI committed projects.

Figure 4.4-2 is the cost-performance plot of CSO frequency versus present value costs. For this technology screening evaluation, except for the Pre-Plan and Appendix B conditions, each of the LoC points along the curve would provide a consistent systemwide LoC whereby every outfall would have no more than the frequencies indicated in the CSO frequency column in the above table. Since GSI will remove stormwater from the combined sewer system, a credit for wastewater treatment at the AWTF was applied for the volume of stormwater removed in the typical year.

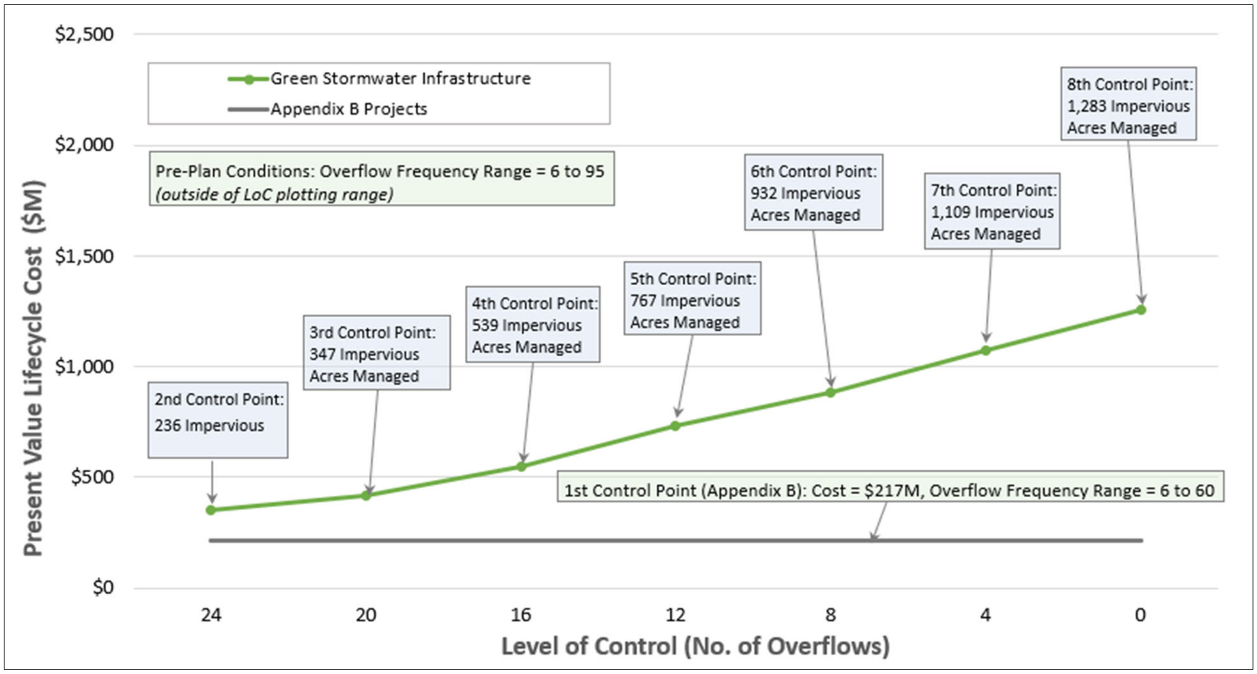

Figure 4.4-2: Typical Year CSO Frequency vs. Cost-Performance Curve For Decentralized Green Stormwater Infrastructure

Figure 4.4-3 is the cost-performance plot of systemwide overflow volume versus present value costs.

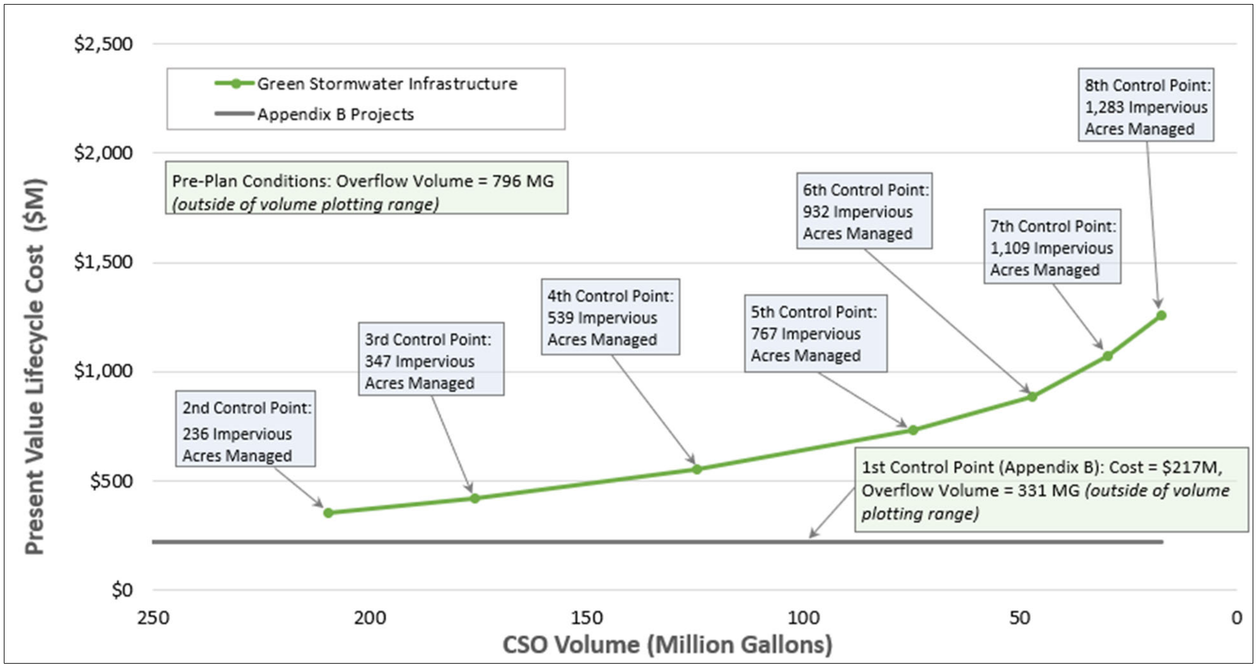

Figure 4.4-3: Typical Year CSO Volume vs. Cost-Performance Curve for Decentralized Green Stormwater Infrastructure

4.5 Decentralized Satellite Storage

With this satellite storage, excess wet weather flows that exceed existing system capacities are conveyed to a network of satellite storage tanks placed at strategic locations scattered throughout the combined sewer system. The appropriate volume of combined sewage is stored temporarily and subsequently dewatered and conveyed to the AWTF after the storm passes and treatment capacity becomes available.

For this technology it is assumed that all the satellite storage tanks are constructed underground and function as gravity-in/pumped-out facilities. To control the accumulation of solids and debris, the storage systems are assumed to be equipped with automated flushing mechanisms. New flow diversion structures would regulate the quantity of wet weather flow conveyed to the interceptor system and divert the excess wet weather flow to the storage tanks. For adjacent catchments, consolidation sewers are constructed to convey the diverted wet weather flow to a shared storage facility (discussed further in **Section 4.5.3**). It is assumed that supervisory control and data acquisition (SCADA) systems would connect the remote storage facilities with the Front Street and Spring Creek pump stations and the AWTF, and that Real Time Control systems would optimize the dewatering of the storage vaults. The locations and configurations of the facilities are provided in **Figure 4.5-1**.

4.5.1 Levels of Control Descriptions

Pre-Plan Conditions: Pre-Plan conditions reflect the performance of the CRW system, under typical year precipitation, when CRW assumed operation and maintenance (O&M) responsibilities for the wastewater and stormwater collection and conveyance systems in 2013.

First Control Point: The first control point under each single technology reflects the LoC achieved by the projects that are either already completed or are required to be completed in accordance with the implementation schedule within MPCD Appendix B.

Second Control Point: The second control point would provide a systemwide LoC whereby every outfall would have no more than 24 overflows per year during typical year precipitation. The total systemwide storage volume for all the control facilities required to achieve this LoC is approximately 1.25 MG.

Third Control Point: The third control point would provide a systemwide LOC whereby every outfall would have no more than 20 CSOs per year during typical year precipitation. The total systemwide storage volume for all the control facilities required to achieve this LoC is approximately 1.96 MG.

Fourth Control Point: The fourth control point would provide a systemwide LoC whereby every outfall would have no more than 16 CSOs per year during typical year precipitation. The total systemwide storage volume for all the control facilities required to achieve this LoC is approximately 4.21 MG.

Fifth Control Point: The fifth control point would provide a systemwide LoC whereby every outfall would have no more than 12 CSOs per year during typical year precipitation. The total systemwide storage volume for all the control facilities required to achieve this LoC is approximately 6.53 MG.

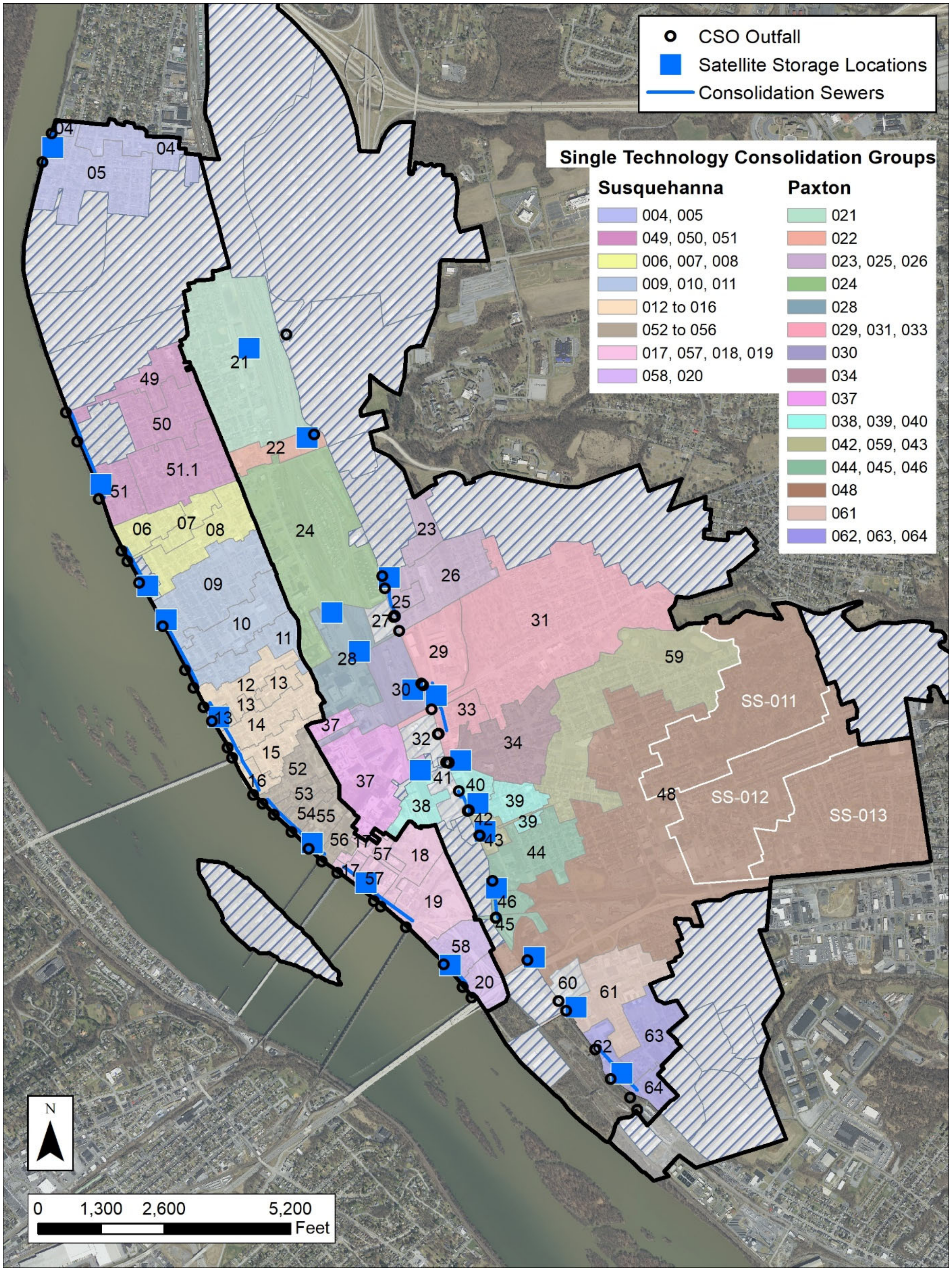

Figure 4.5-1: Potential Location of Control Facilities for Decentralized Satellite Storage

Sixth Control Point: The sixth control point would provide a systemwide LoC whereby every outfall would have no more than 8 CSOs per year during typical year precipitation. The total systemwide storage volume for all the control facilities required to achieve this LoC is approximately 9.46 MG.

Seventh Control Point: The seventh control point would provide a systemwide LoC whereby every outfall would have no more than 4 CSOs per year during typical year precipitation. The total systemwide storage volume for all the control facilities required to achieve this LoC is approximately 14.31 MG.

Eighth Control Point: The eighth control point would provide a systemwide LoC whereby every outfall would have no overflows during typical year precipitation. The total systemwide storage volume for all the control facilities required to achieve this LoC is approximately 52.02 MG.

4.5.2 Basis of Cost Estimates

The construction cost opinion for each underground storage tank was developed from construction cost data based on the volume of storage, which was subsequently adjusted to the location and escalated to present day. In addition to the storage tank construction, the following elements were included for each tank: consolidation sewers, diversion chambers, influent and effluent sewers, and a dewatering pumping station. In limited locations, the pumping station was excluded because the hydraulics will allow for a gravity-in, gravity-out configuration.

To develop the present value lifecycle cost, annual operation and maintenance was estimated as 0.25% of the construction cost. At the end of the 20-year planning period, it was assumed that the storage facilities would require replacement or rehabilitation of 10% of the capital cost. The present value cost also includes the cost of wastewater treatment at the AWTF for the typical year storage volume.

4.5.3 Site-Specific Feasibility and Applicability Findings

For both satellite storage and satellite treatment technologies, it was necessary to develop assumptions regarding the consolidation of catchments. Consolidation consists of constructing new consolidation sewers to “connect” excess flows from multiple adjacent catchments that discharges to a common facility. In general, consolidating flows is cost-effective because it results in fewer facilities. Also, CRW’s combined sewer system includes catchments with small volumes impractical to manage with individual gray facilities. However, longer consolidation sewers may present additional challenges (e.g., utility conflicts, prohibitive sewer depths). For example, CSOs 21, 22, and 24 are adjacent to each other, but because of the orientation of these catchments, they would require much longer consolidation sewers compared to other catchments. For comparison purposes, a modest degree of consolidation was assumed, and this assumption was maintained for all storage/treatment technology LoCs. Additional degrees of consolidation are further evaluated in Section 6.

The availability of space to place facilities is also a factor in determining consolidation groupings and the facility location for each grouping. The available space is limited to open spaces (e.g., parks, parking lots, vacant lots) within approximately one block from the CSO regulators. Additionally, the Paxton Creek Restoration Master Plan (refer to Section 3) may include additional opportunities for the placement of gray facilities. **Figure 4.5-4** shows the available space within the CRW combined sewer system.

An analysis was conducted to verify that proposed control facilities would fit into the sites. The range of facility sizes associated with each of the analyzed levels of control, ranging from 20 overflows to 0 overflows per year under Typical Year precipitation conditions, was superimposed over each potential site to verify the site had sufficient dimensions. **Figure 4.5-4** also shows the consolidation groups that were used for conducting the single technology evaluations. Adjacent catchment areas would be linked with consolidation sewers to reduce the number of required control facilities.

For this evaluation, the default assumption is that storage tanks would have a side water depth of about 15 feet. Then, the required footprint is calculated accordingly. If the footprint does not fit within the available space, the tank depth is increased to achieve the required volume. However, storage tanks deeper than 20 feet become more expensive to construct and maintain. In general, the storage tank footprints fit well within the available space for most LoCs, but for higher LoCs (2 and 0 overflows), some consolidation groups within the Uptown, Middle Paxton Creek East, and Lower Paxton Creek planning areas would require storage tank depths up to 30 feet deep.

4.5.4 Cost-Performance Summary

Table 4.5-1 provides the typical year CSO statistics and present value cost estimate associated with each LoC. Typical year CSO volume is the systemwide total of individual CSO outfalls, and typical year CSO frequency represents the range of frequencies for individual CSO outfalls (Pre-Plan and Appendix B) or the target frequency corresponding to the LoC (control points two through eight).

Figure 4.5-2 is the cost-performance plot of CSO frequency versus present value costs. For this technology screening evaluation, except for the Pre-Plan and Appendix B conditions, each of the LoC points along the curve would provide a consistent systemwide LoC whereby every outfall would have no more than the frequencies indicated in the CSO frequency column in the above table.

Table 4.5-1: LoCs and Costs for Decentralized Satellite Storage

Control Point	Number of Facilities	Total Storage Capacity (MG)	Estimated Cost ($ Million)	Typical Year CSO Volume (MG)	Typical Year CSO Frequency
Pre-Plan	NA	NA	NA	796	6 to 95
1 (App. B)	NA	NA	217	331	6 to 60
2	10	1.25	328	234	24
3	15	1.96	372	219	20
4	20	4.21	443	174	16
5	22	6.53	505	141	12
6	22	9.46	561	115	8
7	22	14.31	663	87	4
8	23	52.02	1,218	13	0

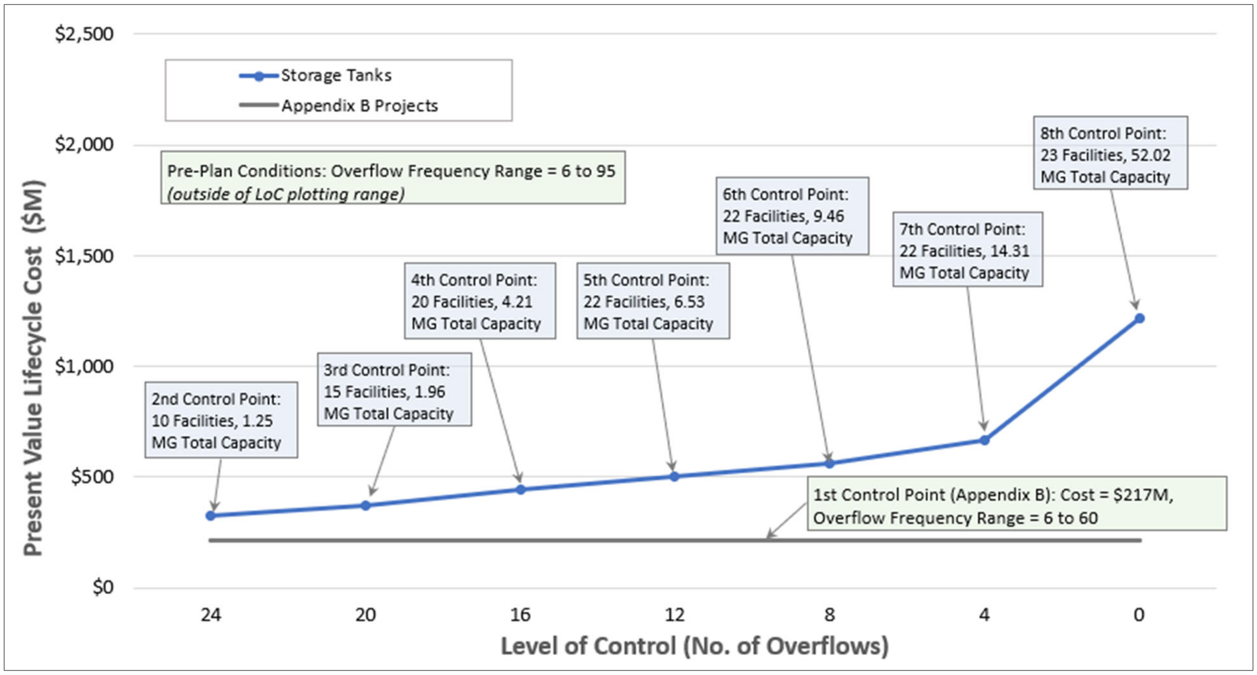

Figure 4.5-2: Typical Year Annual CSO Frequency vs. Cost-Performance Curve for Decentralized Satellite Storage

Figure 4.5-3 is the cost-performance plot of systemwide overflow volume versus present value costs.

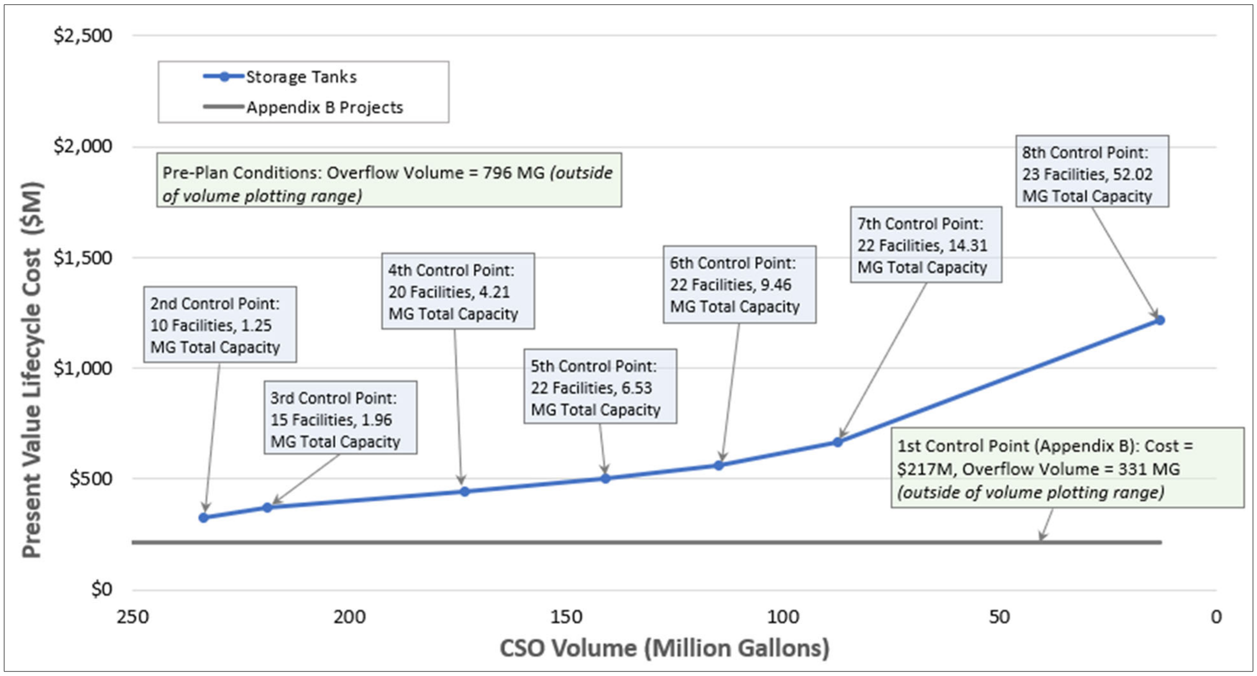

Figure 4.5-3: Typical Year CSO Volume vs. Cost-Performance Curve for Decentralized Satellite Storage

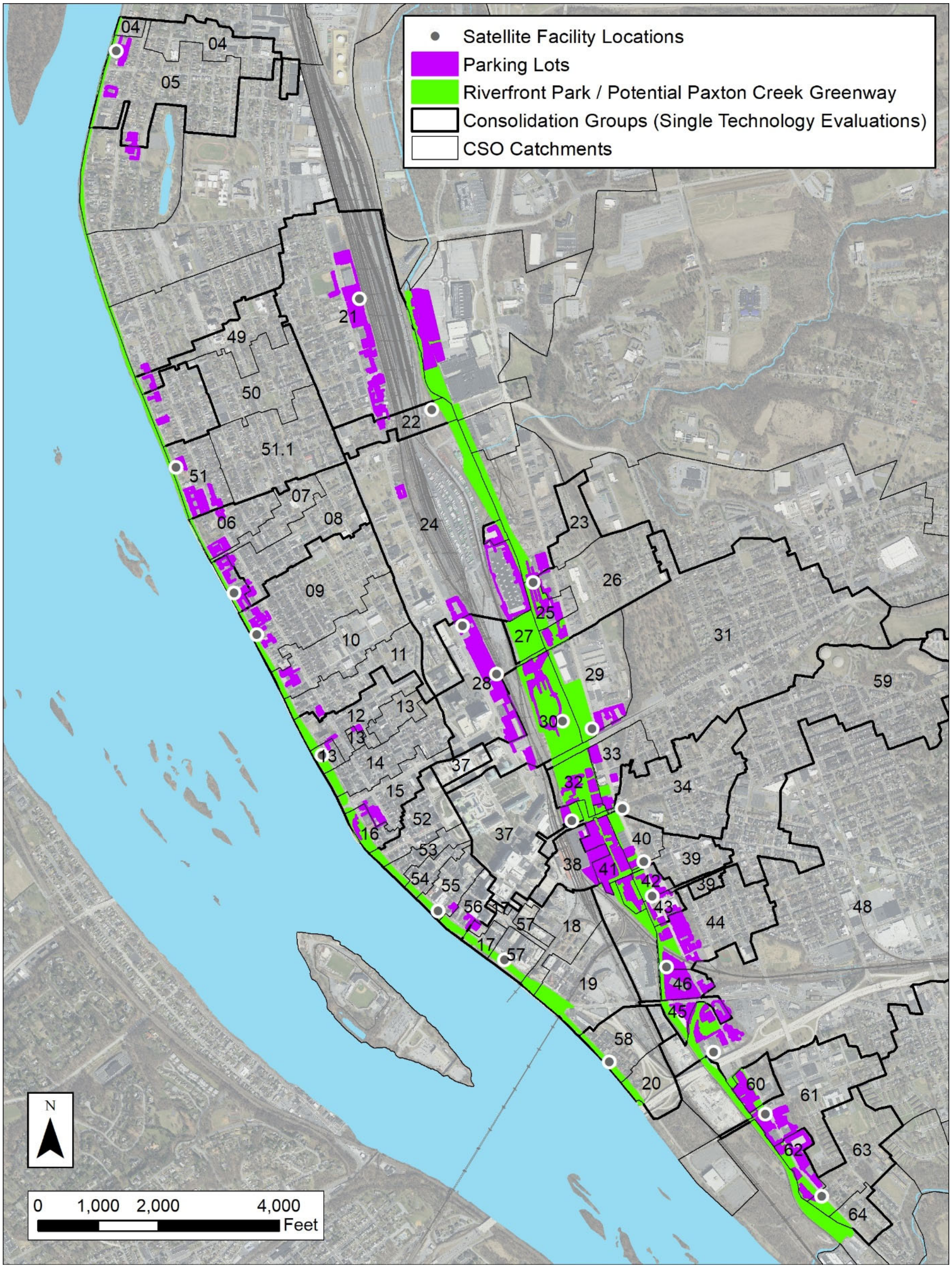

Figure 4.5-4: Potential Available Space for Satellite Facilities

4.6 Decentralized Satellite Treatment

Satellite treatment technologies reduce the pollutant loads to receiving waters by treating wet weather flows prior to discharging to the receiving waters (via existing CSO outfall pipes). Specific technologies can address different pollutant constituents. The pollutants of concern for the CRW service area are bacteria, suspended solids, biochemical oxygen demand and dissolved oxygen, nitrogen, and phosphorous. With this control technology, excess wet weather flows that exceed existing system capacities are conveyed to a network of satellite treatment facilities placed at strategic locations scattered throughout the combined sewer system. The excess flows receive treatment to reduce the pollutant loads before they are discharged into the receiving waters. CSOs are intermittent and characterized by highly variable flow rates relative to base sewage flow. Bacterial and organic loadings from the collection system also vary greatly, both within and between storm events. The screening/ treatment/ disinfection systems must be able to handle variable pollutant loadings and large fluctuations in flow that can change drastically.

For this single technology screening evaluation, four alternative treatment technology categories were evaluated, and each provides a different level of pollutant removal at a different cost. They are listed below in the order of the treatment technologies providing the lowest to the highest levels of control and described in greater detail in the following subsections.

Screening with Disinfection: Screening technologies, which vary in opening sizes and cleaning mechanisms, provide minimal CSO treatment prior to high-rate disinfection processes. Dechlorination would also be provided. In general, screening and disinfection systems are effective in removing floatable and visible solids and pathogenic bacteria but do not remove a significant amount of TSS, BOD, COD, or nutrients.

Retention-Treatment Basins (RTBs) with Disinfection: CSO discharges are treated via screening, skimming, settling and disinfection in RTBs prior to release into a water body. Dechlorination would also be provided. During smaller storms, there is no discharge and combined sewage is stored and subsequently sent to the AWTF. When an overflow of the RTB occurs during a larger rain event, the pollutants in the water discharged to a water body have already been largely reduced.

High-Rate Clarification with Disinfection: Also known as high-rate ballasted flocculation, high-rate clarification is a physical-chemical treatment process that uses micro-sand or sludge and a variety of additives to improve the settling properties of suspended solids through improved floc bridging. The treated flows are disinfected, dechlorinated, and released to the receiving water.

High-Rate Filtration with Disinfection: This treatment process uses a synthetic, porous filter media to trap and store solids and floatables. When the filter media are full, a backwash process is used after the storm event to clean and restore the filters and convey the removed pollutants to the interceptor and AWTF. The treated flows are disinfected, dechlorinated, and released to the receiving water.

As a simplifying assumption for the evaluation of these single technologies, the number of and locations for satellite treatment facilities were kept the same for each treatment technology. The facilities were sized to meet the LoCs and associated footprint areas were varied to meet the requirements of each technology. The locations of the treatment facilities and the associated catchment consolidation groups are shown in **Figure 4.6-1.**

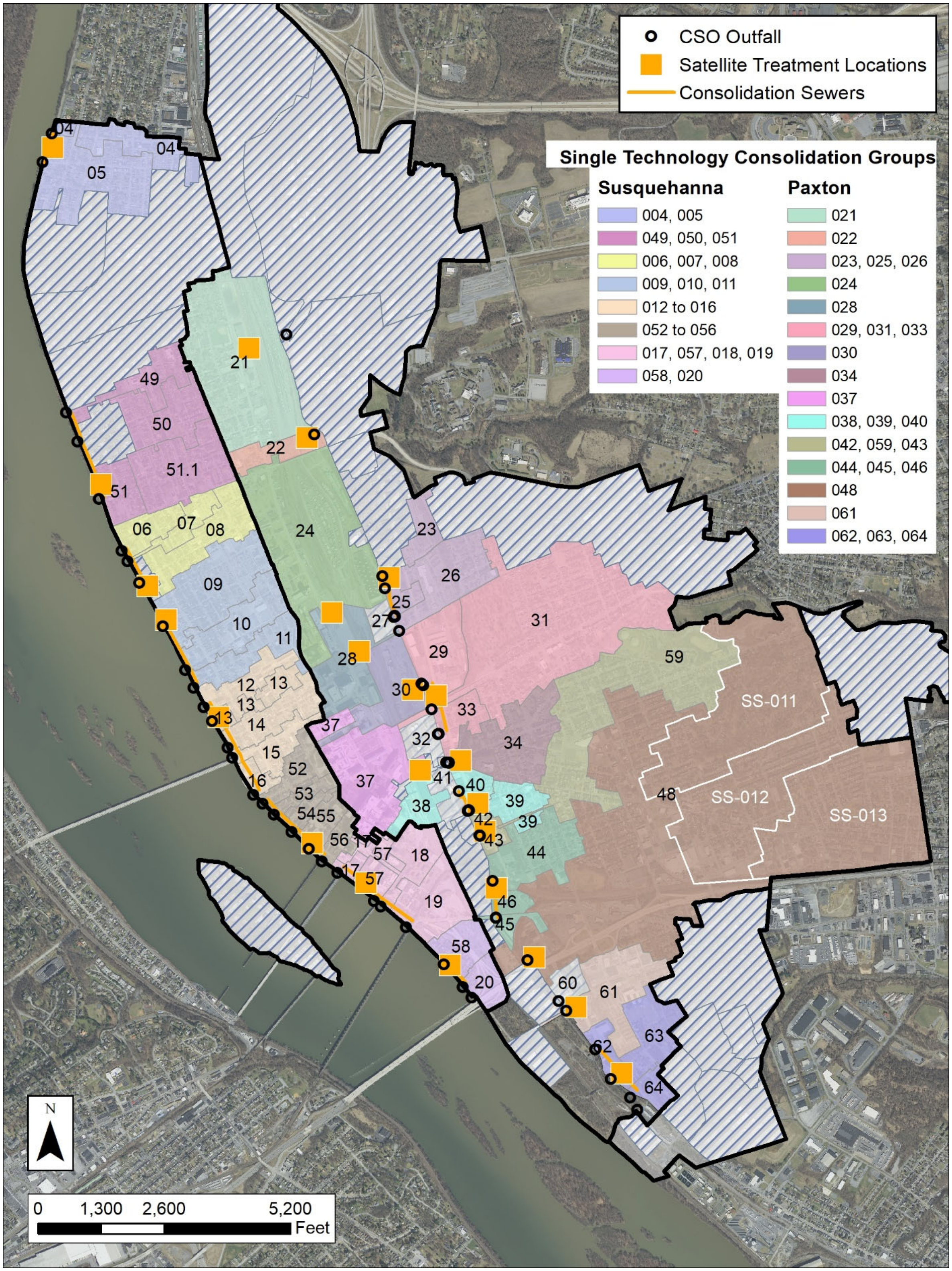

Figure 4.6-1: Potential Location of Control Facilities for Decentralized Satellite Treatment

Each of the evaluated satellite treatment technologies achieve different pollutant reductions. **Table 4.6-1** summarizes the estimated pollutant reductions for each technology. All treatment technologies assume a 4-log removal for bacteria. For other pollutants of concern, the pollutant removals are based on manufacturer-provided data or actual performance data from installations.

Table 4.6-1: Pollutant Removals Provided by Satellite Treatment Facilities

Treatment Technology	Pollutant Removal Percentages							
	BOD	E. Coli	Fecal Coliform	NH_3	NO_3	TKN	TP	TSS
Screening & Disinfection	30	99.99	99.99	5	5	5	5	35
Retention Treatment Basin	30	99.99	99.99	5	5	5	5	35
High-Rate Clarification	50	99.99	99.99	0	0	18	80	80
High-Rate Filtration	60	99.99	99.99	0	0	16	50	85

4.6.1 Satellite Treatment using Screening and Disinfection

Screening is typically used as preliminary treatment for the Retention-Treatment Basin, High-Rate Clarification, and High-Rate Filtration treatment technologies. In general, screening systems are effective in removing floatable and visible solids but do not remove a significant amount of TSS, BOD, COD, NH3, TKN, total phosphorous, or total nitrogen. Screened effluent flows are disinfected using high-rate chemical disinfection, most likely using sodium hypochlorite, to kill pathogen bacteria before being released to the receiving waters.

For this satellite treatment technology evaluation, the use of Climber Screens® by Suez was assumed to quantify the levels of treatment received, the associated facility footprint, and the facility cost. However, there are several similar types out there that perform similarly. These screen systems are more reliable and have much lower operation and maintenance requirements than others. However, there are several similar types of screening equipment that perform similarly. Climber-type systems employ a single rake mechanism mounted on a gear driven rack and pinion system. The gear drive turns cog wheels that move along a pin rack mounted on each side of the bar rack. During the cleaning cycle, the rake mechanism travels continuously up and down the bar rack to remove materials retained on the bars. Screenings are typically discharged from the bars at the top of the rack. This type of bar screen has no submerged bearings or sprockets and is less susceptible to blockages, damage and corrosion. Bar screens will remove essentially 100% of all rigid objects of which the minimum dimension is more than the spacing between the bars. For CSO applications where heavy debris loadings are likely, the minimum bar spacing should be approximately 1 inch.

Figure 4.6-2 shows images of typical climber screens. Screenings equipment which are not continuously cleaned, such as manually cleaned bar screens, were eliminated from this evaluation due to the potential for backup and surcharging of the collection system. Mechanical bar screens are already installed in many CSO facilities and operate successfully to remove floatables and visible solids over the fluctuations in flow rates seen in combined sewer systems. Mechanical bar screens can function intermittently at remote locations with a minimum level of instrumentation. A level detector is needed to determine when a CSO is occurring and to activate the screen. Differential head sensors located upstream and downstream of the screen will detect head loss and initiate a cleaning cycle. During periods where there are no overflows, a timer can be utilized to periodically exercise the screen, so it is ready for use.

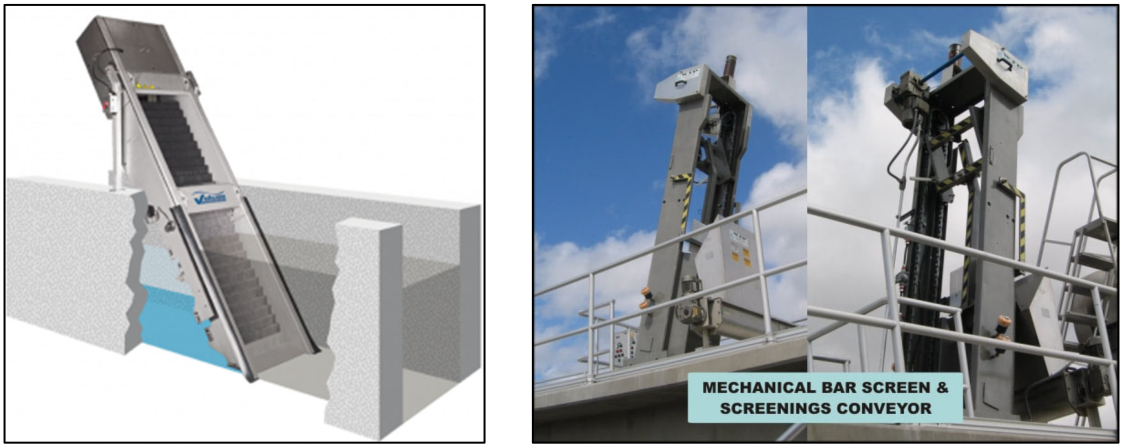

Figure 4.6-2: Images of Typical Climber Screens

4.6.1.1 Levels of Control Descriptions

Pre-Plan Conditions: Pre-Plan conditions reflect the performance of the CRW system, under typical year precipitation, when CRW assumed operation and maintenance (O&M) responsibilities for the wastewater and stormwater collection and conveyance systems in 2013.

First Control Point: The first control point under each single technology reflects the LoC achieved by the projects that are either already completed or are required to be completed in accordance with the implementation schedule within MPCD Appendix B. The specific projects are described in Sections 1.3 and 3.

Second Control Point: The second control point would provide a systemwide LoC whereby every outfall would have no more than 24 untreated overflows per year during typical year precipitation. The total systemwide screening and disinfection capacity for all the individual satellite treatment facilities is 34 MGD to achieve this LoC.

Third Control Point: The third control point would provide a systemwide LoC whereby every outfall would have no more than 20 untreated overflows per year during typical year precipitation. The total systemwide screening and disinfection capacity for all the individual satellite treatment facilities is 48 MGD to achieve this LoC.

Fourth Control Point: The fourth control point would provide a systemwide LoC whereby every outfall would have no more than 16 untreated overflows per year during typical year precipitation. The total systemwide screening and disinfection capacity for all the individual satellite treatment facilities is 91 MGD to achieve this LoC.

Fifth Control Point: The fifth control point would provide a systemwide LoC whereby every outfall would have no more than 12 untreated overflows per year during typical year precipitation. The total systemwide screening and disinfection capacity for all the individual satellite treatment facilities is 182 MGD to achieve this LoC.

Sixth Control Point: The sixth control point would provide a systemwide LoC whereby every outfall would have no more than 8 untreated overflows per year during typical year precipitation. The total systemwide screening and disinfection capacity for all the individual satellite treatment facilities is 335 MGD to achieve this LoC.

Seventh Control Point: The seventh control point would provide a systemwide LoC whereby every outfall would have no more than 4 untreated overflows per year during typical year precipitation. The total systemwide screening and disinfection capacity for all the individual satellite treatment facilities is 492 MGD to achieve this LoC.

Eighth Control Point: The eighth control point would provide a systemwide LoC whereby every outfall would have no untreated overflows during typical year precipitation. The total systemwide screening and disinfection capacity for all the individual satellite treatment facilities is 1,231 MGD to achieve this LoC.

4.6.1.2 Basis of Cost Estimates

The construction cost opinion for each screening facility was developed from construction cost data based on the peak flow to each facility, which was subsequently adjusted to the location and escalated to present day. In addition to the screening facility construction, the following elements were included for each facility: consolidation sewers, diversion chambers, influent and effluent sewers, disinfection, and dechlorination. In limited locations, a pumping station, sized to handle peak flow, was included because the hydraulics would not support gravity flow through the screening facility. To develop the present value lifecycle cost, annual operation and maintenance was estimated as 0.5% of the construction cost. At the end of the 20-year planning period, it was assumed that the screening facilities would require replacement or rehabilitation of 20% of the capital cost.

4.6.1.3 Site-Specific Feasibility and Applicability

Refer to Section 4.5.3 for discussion of consolidation groups. For this evaluation, the same groupings are used for all satellite treatment technologies.

Screening and disinfection require aboveground facilities (pump station, screening facilities, chlorination building) and underground facilities (chlorine contact tank). The chlorine contact tank is sized assuming a 15-minute contact time and side water depth of 10 ft. Other structures are sized based on interpolating footprints from historical projects. In general, screening and disinfection has minimal site constraints compared to the other treatment technologies.

4.6.1.4 Cost-Performance Summary

Table 4.6-2 provides the typical year CSO statistics and present value cost estimate associated with each LoC. For all treatment technologies, these statistics refer to untreated overflows. Typical year CSO volume is the systemwide total of individual CSO outfalls, and typical year CSO frequency represents the range of frequencies for individual CSO outfalls (Pre-Plan and Appendix B) or the target frequency corresponding to the LoC (control points two through eight).

Table 4.6-2: LoCs and Costs for Satellite Treatment using Screening and Disinfection

Control Point	Number of Facilities	Total Treatment Capacity (MG)	Estimated Cost ($ Million)	Typical Year CSO Volume (MG)	Typical Year CSO Frequency
Pre-Plan	NA	NA	NA	796	6 to 95
1 (App. B)	NA	NA	217	331	6 to 60
2	10	34	401	194	24
3	15	48	452	176	20
4	20	91	555	145	16
5	22	182	684	101	12
6	22	335	964	80	8
7	22	492	1,189	64	4
8	23	1,231	2,129	29	0

Figure 4.6-3 is the cost-performance plot of CSO frequency versus present value costs. For this technology screening evaluation, except for the Pre-Plan and Appendix B conditions, each of the LoC points along the curve would provide a consistent systemwide LoC whereby every outfall would have no more than the frequencies indicated in the CSO frequency column in the above table.

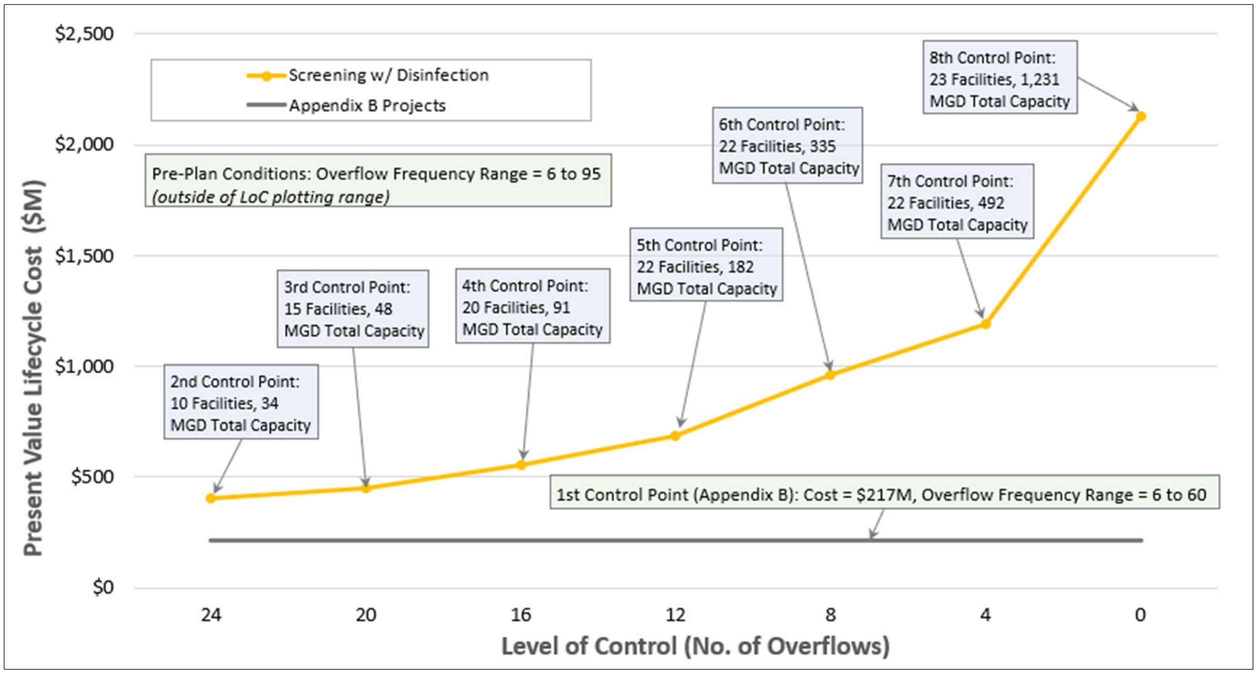

Figure 4.6-3: Typical Year CSO Frequency vs. Cost-Performance Curve for Decentralized Satellite Treatment using Screening with Disinfection

Figure 4.6-4 is the cost-performance plot of systemwide overflow volume versus present value costs.

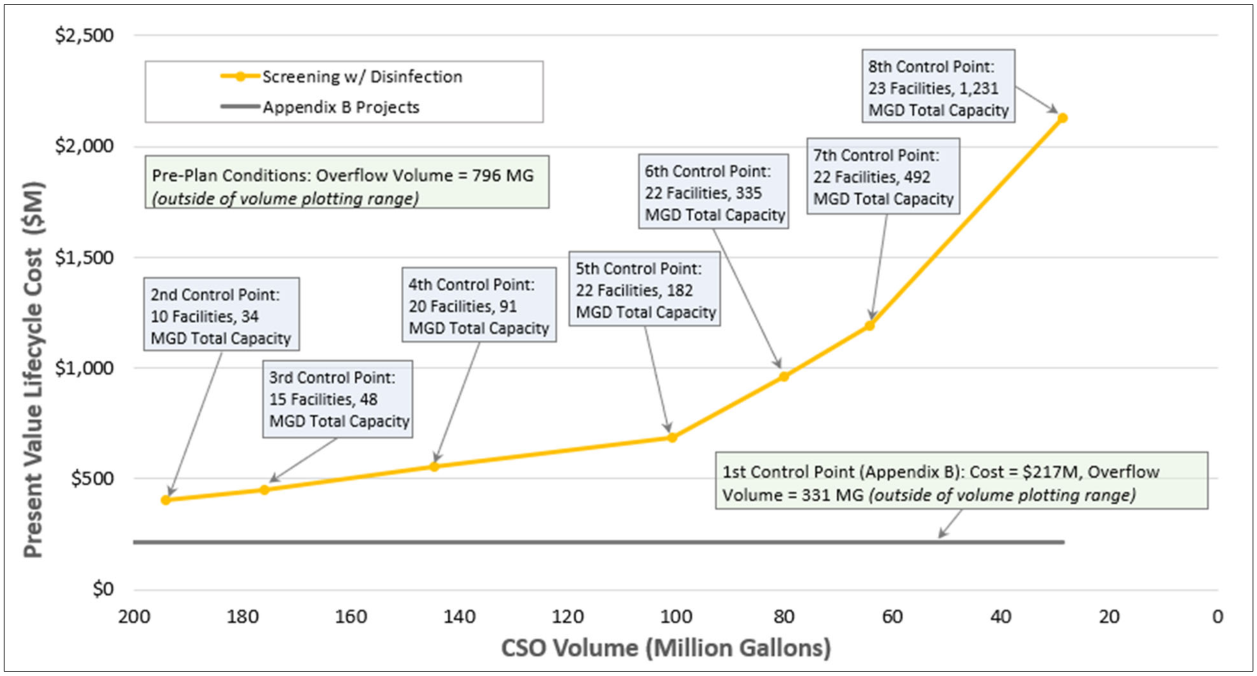

Figure 4.6-4: Typical Year CSO Volume vs. Cost-Performance Curve for Decentralized Satellite Treatment using Screening with Disinfection

4.6.2 Satellite Treatment using Retention-Treatment Basins

This satellite treatment technology uses Retention-Treatment Basins (RTBs) which collect and treat wet weather flow to avoid untreated overflows. CSO discharges are treated via screening, skimming, settling and disinfection in RTBs prior to release into a water body. During smaller storms, there is no discharge and combined sewage is stored and sent to the AWTF. When an overflow from the RTB occurs during a large rain event, the pollutants in the discharge to a water body have already been largely reduced, resulting in added protection of public health. For this satellite treatment technology evaluation, NPDES performance certification testing of RTBs in the early 2000's for the Rouge River National Wet Weather Demonstration Project was used to quantify the levels of treatment achieved, the associated facility footprint, and the facility cost.

During a large rain event, excess combined sewage gets sent to the RTB once the downstream capacities of the interceptor sewers and AWTF are exceeded. The combined sewage flows through screens that remove debris such as sanitary trash. A disinfectant is then applied to allow adequate time to kill disease causing organisms. In the basin, particulate matter settles out and the skimming baffle prevents the discharge of floatable material and oils. Once the capacity of the RTB is exceeded, the treated overflow is disinfected and sent to surface water resulting in a discharge that is protective of public health and the environment. When the rain event ends and as capacity becomes available in the sewer, the contents of the RTB are drained back to the interceptor sewer and sent to the wastewater treatment plant. RTB's are also equipped with flushing systems, which flush any remaining solids left in the RTB to the wastewater treatment plant, so the RTB is ready for the next rain event. The treated flows are disinfected using high-rate chemical disinfection, most likely using sodium hypochlorite, before being released to the receiving waters. **Figure 4.6-5** provides a typical RTB facility layout.

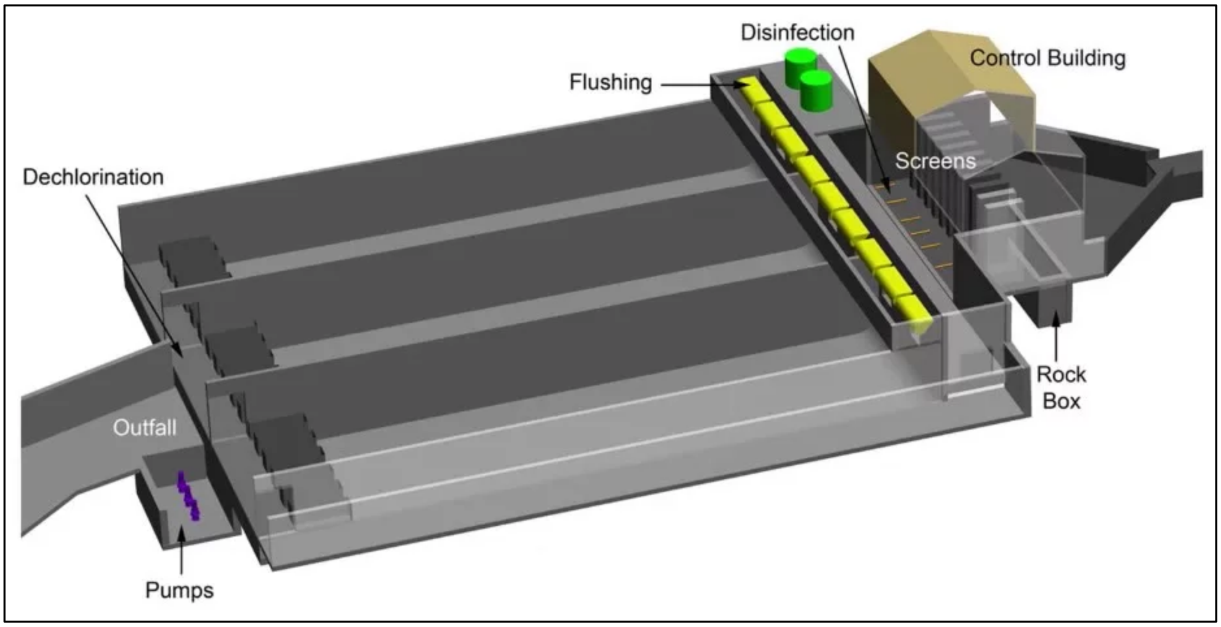

Figure 4.6-5: Typical Retention Treatment Basin Facility Layout

4.6.2.1 Levels of Control Descriptions

Pre-Plan Conditions: Pre-Plan conditions reflect the performance of the CRW system, under typical year precipitation, when CRW assumed operation and maintenance (O&M) responsibilities for the wastewater and stormwater collection and conveyance systems in 2013.

First Control Point: The first control point under each single technology reflects the LoC achieved by the projects that are either already completed or are required to be completed in accordance with the implementation schedule within MPCD Appendix B. The specific projects are described in Sections 1.3 and 3.

Second Control Point: The second control point would provide a systemwide LoC whereby every outfall would have no more than 24 untreated overflows per year during typical year precipitation. The total systemwide treatment capacity for all the individual satellite treatment facilities is 34 MGD to achieve this LoC.

Third Control Point: The third control point would provide a systemwide LoC whereby every outfall would have no more than 20 untreated overflows per year during typical year precipitation. The total systemwide treatment capacity for all the individual satellite treatment facilities is 48 MGD, which corresponds to a total RTB volume of 0.50 MG, to achieve this LoC.

Fourth Control Point: The fourth control point would provide a systemwide LoC whereby every outfall would have no more than 16 untreated overflows per year during typical year precipitation. The total systemwide treatment capacity for all the individual satellite treatment facilities is 91 MGD, which corresponds to a total RTB volume of 0.95 MG, to achieve this LoC.

Fifth Control Point: The fifth control point would provide a systemwide LoC whereby every outfall would have no more than 12 untreated overflows per year during typical year precipitation. The total systemwide treatment capacity for all the individual satellite treatment facilities is 182 MGD, which corresponds to a total RTB volume of 1.89 MG, to achieve this LoC.

Sixth Control Point: The sixth control point would provide a systemwide LoC whereby every outfall would have no more than 8 untreated overflows per year during typical year precipitation. The total systemwide treatment capacity for all the individual satellite treatment facilities is 335 MGD, which corresponds to a total RTB volume of 3.49 MG, to achieve this LoC.

Seventh Control Point: The seventh control point would provide a systemwide LoC whereby every outfall would have no more than 4 untreated overflows per year during typical year precipitation. The total systemwide treatment capacity for all the individual satellite treatment facilities is 492 MGD, which corresponds to a total RTB volume of 5.13 MG, to achieve this LoC.

Eighth Control Point: The eighth control point would provide a systemwide LoC whereby every outfall would have no untreated overflows during typical year precipitation. The total systemwide treatment capacity for all the individual satellite treatment facilities is 1,231 MGD, which corresponds to a total RTB volume of 12.82 MG, to achieve this LoC.

4.6.2.2 Basis of Cost Estimates

The construction cost opinion for each RTB facility was developed from construction cost data based on the total volume for 15-minute retention at each facility, which was subsequently adjusted to the location and escalated to present day. In addition to the RTB facility construction, the following elements were included for each facility: consolidation sewers, diversion chambers, influent and effluent sewers, and dechlorination. In limited locations, a pumping station, sized to handle peak flow, was included because the hydraulics would not support gravity flow through the RTB facility.

To develop the present value lifecycle cost, annual operation and maintenance was estimated as 0.70% of the construction cost. At the end of the 20-year planning period, it was assumed that the RTB facilities would require replacement or rehabilitation of 20% of the capital cost.

4.6.2.3 Site-Specific Feasibility and Applicability

Refer to Section 4.5.3 for discussion of consolidation groups. For this evaluation, the same groupings are used for all satellite treatment technologies.

RTBs requires aboveground facilities (pump station, screening facilities, chlorination building) and underground facilities (first flush capture basin and treatment channels/ chlorine contact tank). The first flush capture basin is sized assuming 15 to 20 minutes of detention time and a hydraulic loading rate of 8,000 gpd/ft^2 (assuming one of four treatment channels is always out of service). The chlorine contact tank is sized assuming a 15-minute contact time and side water depth of 10 ft. Other structures are sized based on interpolating footprints from historical projects. If necessary, to achieve smaller footprints, RTBs can also be constructed without the first flush capture basin. With this assumption, RTB footprints are comparable to screening and disinfection footprints.

4.6.2.4 Cost-Performance Summary

Table 4.6-3 provides the typical year CSO statistics and present value cost estimate associated with LoC. For all treatment technologies, these statistics refer to untreated overflows. Typical year CSO volume is the systemwide total of individual CSO outfalls, and typical year CSO frequency represents the range of frequencies for individual CSO outfalls (Pre-Plan and Appendix B) or the target frequency corresponding to the LoC (control points two through eight).

Table 4.6-3: LoCs and Costs for Satellite Treatment using Retention Treatment Basins

Control Point	Number of Facilities	Total Treatment Capacity/ Volume	Estimated Cost ($ Million)	Typical Year CSO Volume (MG)	Typical Year CSO Frequency
Pre-Plan	NA	NA	NA	796	6 to 95
1 (App. B)	NA	NA	217	331	6 to 60
2	10	34 MGD/ 0.36 MG	487	194	24
3	15	48 MGD/ 0.50 MG	530	176	20
4	20	91 MGD/ 0.95 MG	635	145	16
5	22	182 MGD/ 1.89 MG	730	101	12
6	22	335 MGD/ 3.49 MG	893	80	8
7	22	492 MGD/ 5.13 MG	1,033	64	4
8	23	1,231 MGD/ 12.82 MG	1,613	29	0

Figure 4.6-6 is the cost-performance plot of CSO frequency versus present value costs. For this technology screening evaluation, except for the Pre-Plan and Appendix B conditions, each of the LoC points along the curve would provide a consistent systemwide LoC whereby every outfall would have no more than the frequencies indicated in the CSO frequency column in the above table.

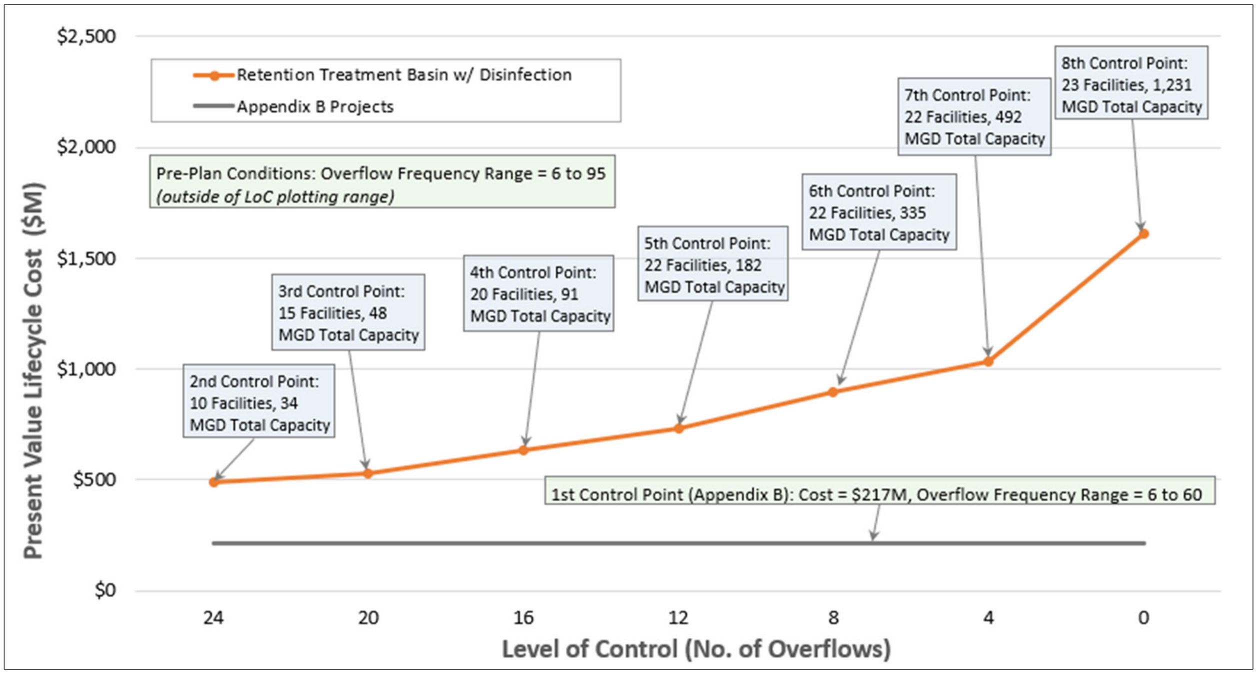

Figure 4.6-6: Typical Year CSO Frequency vs. Cost-Performance Curve for Decentralized Satellite Treatment using Retention Treatment Basins with Disinfection

Figure 4.6-7 is the cost-performance plot of systemwide overflow volume versus present value costs.

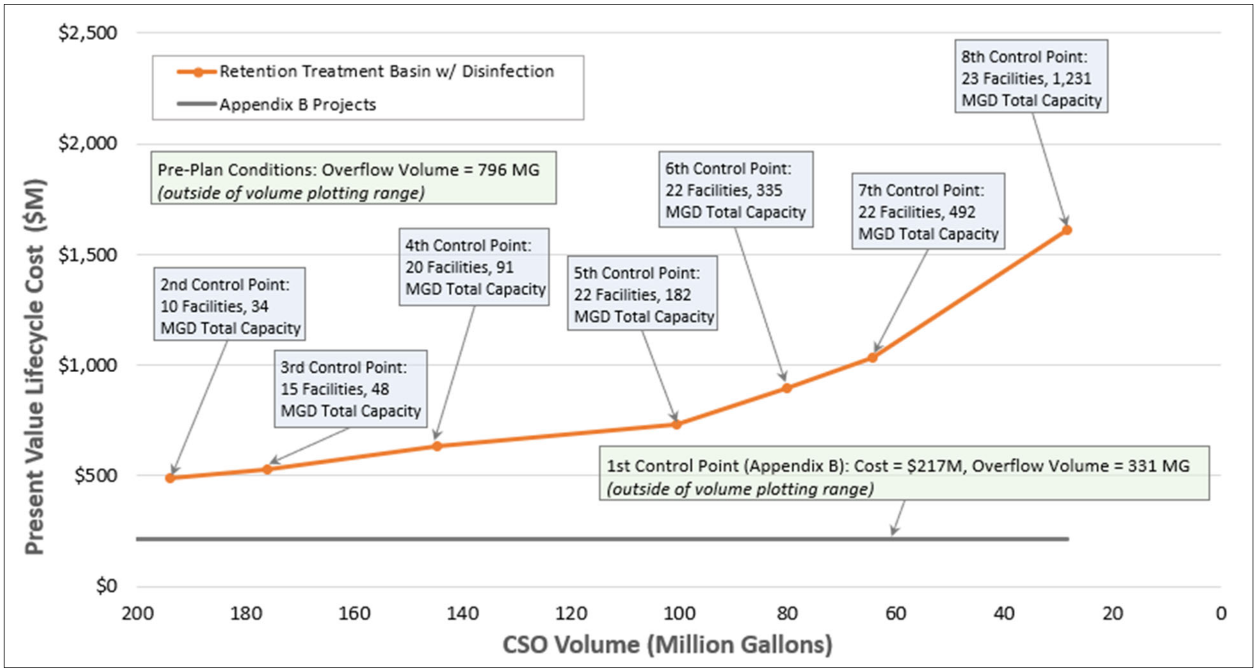

Figure 4.6-7: Annual CSO Volume vs. Cost-Performance Curve for Decentralized Satellite Treatment using Retention Treatment Basins with Disinfection and Dechlorination

4.6.3 Satellite Treatment using High-Rate Clarification

High-rate clarification, or ballasted flocculation, is a physical-chemical treatment process that uses micro-sand or sludge and a variety of additives to improve the settling properties of suspended solids through improved floc bridging. For this satellite treatment technology evaluation, the Actiflo® ballasted flocculation process was assumed to quantify the levels of treatment received, the associated facility footprint, and the facility cost. The Actiflo process can be fully automated, and the process train(s) can sit idle for extended periods of time and still be fully operational within 15 minutes of start-up. When installing the Actiflo unit in a remote CSO location, the flows will vary widely, and the sludge must be stored in ancillary tanks so it can be put back into the interceptor during periods of low flow. A process diagram for the Actiflo technology is provided in **Figure 4.6-8**.

Typically, high-rate clarification facilities are divided into “trains” of certain treatment capacities, such as 10 MGD, 25 MGD, or 50 MGD. When additional treatment capacity is needed the number of trains is increased. For example, a 40 MGD HRC layout could be comprised of four 10-MGD trains. The treated flows are disinfected using high-rate chemical disinfection, most likely using sodium hypochlorite, and released to the receiving waters. **T**he satellite treatment facilities' locations were provided in **Figure 4.6-1.**

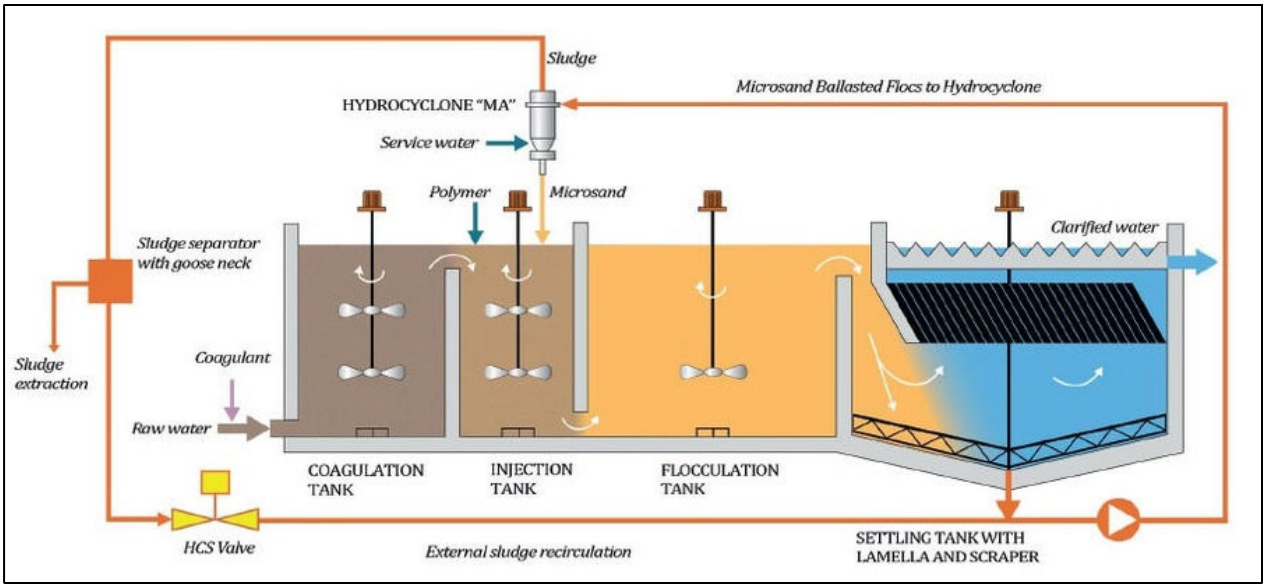

Figure 4.6-8: Process Diagram for the Actiflo®, Ballasted Flocculation Process

4.6.3.1 Levels of Control Descriptions

Pre-Plan Conditions: Pre-Plan conditions reflect the performance of the CRW system, under typical year precipitation, when CRW assumed operation and maintenance (O&M) responsibilities for the wastewater and stormwater collection and conveyance systems in 2013.

First Control Point: The first control point under each single technology reflects the LoC achieved by the projects that are either already completed or are required to be completed in accordance with the implementation schedule within MPCD Appendix B. The specific projects are described in Sections 1.3 and 3.

Second Control Point: The second control point would provide a systemwide LoC whereby every outfall would have no more than 24 untreated overflows per year during typical year precipitation. The total systemwide treatment capacity for all the individual satellite treatment facilities is 34 MGD to achieve this LoC.

Third Control Point: The third control point would provide a systemwide LoC whereby every outfall would have no more than 20 untreated overflows per year during typical year precipitation. The total systemwide treatment capacity for all the individual satellite treatment facilities is 48 MGD to achieve this LoC.

Fourth Control Point: The fourth control point would provide a systemwide LoC whereby every outfall would have no more than 16 untreated overflows per year during typical year precipitation. The total systemwide treatment capacity for all the individual satellite treatment facilities is 91 MGD to achieve this LoC.

Fifth Control Point: The fifth control point would provide a systemwide LoC whereby every outfall would have no more than 12 untreated overflows per year during typical year precipitation. The total systemwide treatment capacity for all the individual satellite treatment facilities is 182 MGD to achieve this LoC.

Sixth Control Point: The sixth control point would provide a systemwide LoC whereby every outfall would have no more than 8 untreated overflows per year during typical year precipitation. The total systemwide treatment capacity for all the individual satellite treatment facilities is 335 MGD to achieve this LoC.

Seventh Control Point: The seventh control point would provide a systemwide LoC whereby every outfall would have no more than 4 untreated overflows per year during typical year precipitation. The total systemwide treatment capacity for all the individual satellite treatment facilities is 492 MGD to achieve this LoC.

Eighth Control Point: The eighth control point would provide a systemwide LoC whereby every outfall would have no untreated overflows during typical year precipitation. The total systemwide treatment capacity for all the individual satellite treatment facilities is 1231 MGD to achieve this LoC.

4.6.3.2 Basis of Cost Estimates

The construction cost opinion for each high-rate clarification facility was developed from construction cost data based on the peak flow to each facility, which was subsequently adjusted to the location and escalated to present day. In addition to the high-rate clarification facility construction, the following elements were included for each facility: consolidation sewers, diversion chambers, influent and effluent sewers, disinfection, and dechlorination. In limited locations, a pumping station, sized to handle peak flow, was included because the hydraulics would not support gravity flow through the facility.

To develop the present value lifecycle cost, annual operation and maintenance was estimated as 1.0% of the construction cost. At the end of the 20-year planning period, it was assumed that the high-rate clarification facilities would require replacement or rehabilitation of 20% of the capital cost.

4.6.3.3 Site-Specific Feasibility and Applicability

Refer to Section 4.5.3 for discussion of consolidation groups. For this evaluation, the same groupings are used for all satellite treatment technologies.

High-rate clarification requires aboveground facilities (pump station, screening facilities, chlorination building, pump/chemical building, and HRC units) and underground facilities (chlorine contact tank and sludge storage). The chlorine contact tank is sized assuming a 15-minute contact time and side water depth of 10 ft. Other structures are sized based on interpolating footprints from historical projects. In general, high-rate clarification requires large footprints with several aboveground structures.

4.6.3.4 Cost-Performance Summary

Table 4.6-4 provides the typical year CSO statistics and present value cost estimate associated with each LoC. For all treatment technologies, these statistics refer to untreated overflows. Typical year CSO volume is the systemwide total of individual CSO outfalls, and typical year CSO frequency represents the range of frequencies for individual CSO outfalls (Pre-Plan and Appendix B) or the target frequency corresponding to the LoC (control points two through eight).

Table 4.6-4: LoCs and Costs for Satellite Treatment using High-Rate Clarification

Control Point	Number of Facilities	Total Treatment Capacity (MG)	Estimated Cost ($ Million)	Typical Year CSO Volume (MG)	Typical Year CSO Frequency
Pre-Plan	NA	NA	NA	796	6 to 95
1 (App. B)	NA	NA	217	331	6 to 60
2	10	34	579	194	24
3	15	48	673	176	20
4	20	91	851	145	16
5	22	182	1,093	101	12
6	22	335	1,517	80	8
7	22	492	1,878	64	4
8	23	1,231	3,365	29	0

Figure 4.6-9 is the cost-performance plot of CSO frequency versus present value costs. For this technology screening evaluation, except for the Pre-Plan and Appendix B conditions, each of the LoC points along the curve would provide a consistent systemwide LoC whereby every outfall would have no more than the frequencies indicated in the CSO frequency column in the above table.

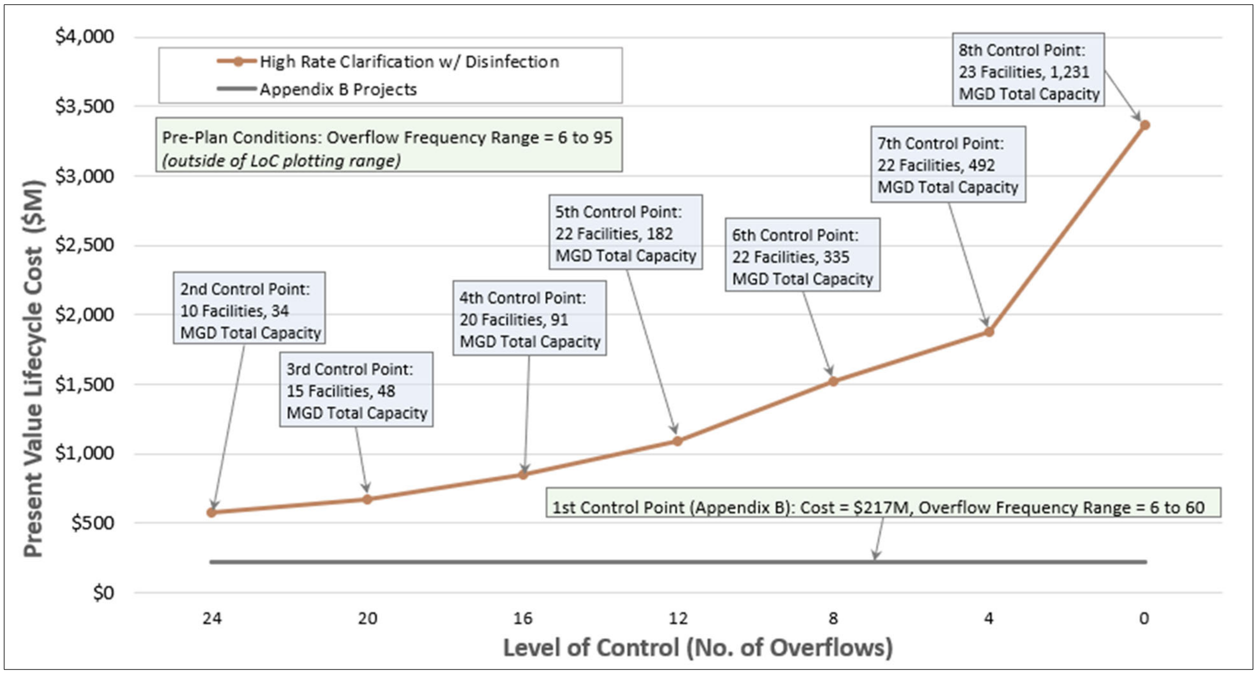

Figure 4.6-9: Typical Year CSO Frequency vs. Cost-Performance Curve for Decentralized Satellite Treatment using High-Rate Clarification with Disinfection

Figure 4.6-10 is the cost-performance plot of systemwide overflow volume versus present value costs.

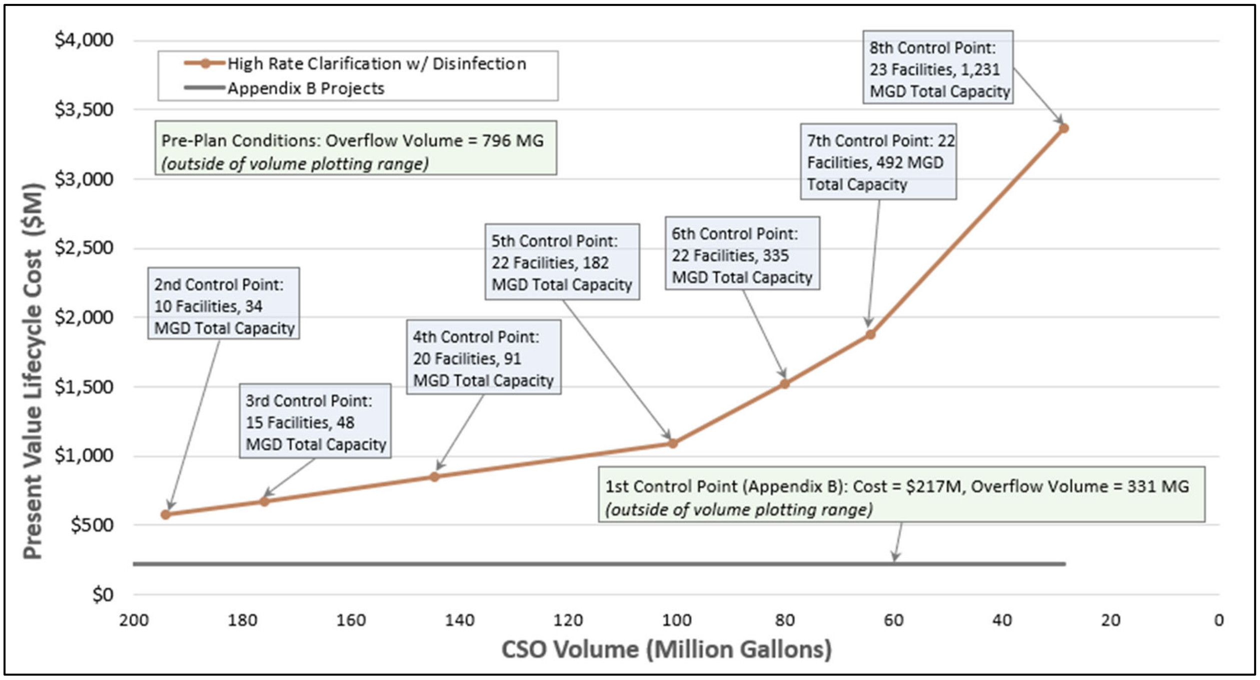

Figure 4.6-10: Typical Year CSO Volume vs. Cost-Performance Curve for Decentralized Satellite Treatment using High-Rate Clarification with Disinfection

4.6.4 Satellite Treatment using High-Rate Filtration

This treatment process uses a synthetic, porous filter media to trap and store solids and floatables. When the filter media are full, a backwash process is used to clean and restore the filters and convey the removed pollutants to the interceptor after the storm event. For this satellite treatment technology evaluation, the AquaStorm® process by Aqua-Aerobic Systems, Inc. was assumed to quantify the levels of treatment received, the associated facility footprint, and the facility cost. The AquaStorm filter system features a disk configuration and an outside-in flow path, which allows for three zones of solids removal. These zones are especially critical in wet weather applications due to the high solids typically associated with the first flush after wet weather events. A picture of a typical AquaStorm filter system is shown in **Figure 4.6-11**.

The top zone is the "floatable zone" where surface materials such as fats, oils, and grease are allowed to collect on the water surface. Solids are removed from this zone by allowing floating material to overflow a scum weir. The middle zone is the "filtration zone," where solids are removed through filtration. Here, solids deposit on the outside of the cloth media, forming a mat, as filtrate flows through the media. This buildup of solids on the media creates hydraulic resistance to flow through the media and causes the water level in the tank to rise. Once the predetermined liquid level or time setting is attained, the disks begin to rotate and the backwash pump starts, which draws filtered water from the inside of the disk through the media and removes solids from the filter media's surface. This process fluidizes fibers to provide an efficient release of stored solids deep within the fiber. The bottom or "solids zone" permits heavier solids to settle to the bottom of the tank for intermittent removal. The solids are evacuated from the hopper through collection laterals using the solids/backwash pump and discharged to the interceptor system after the storm has ceased and conveyance/treatment capacity becomes available. The treated flows are disinfected using high-rate chemical disinfection, most likely using sodium hypochlorite, and released to the receiving waters. The locations of the treatment facilities were shown in **Figure 4.6-1.**

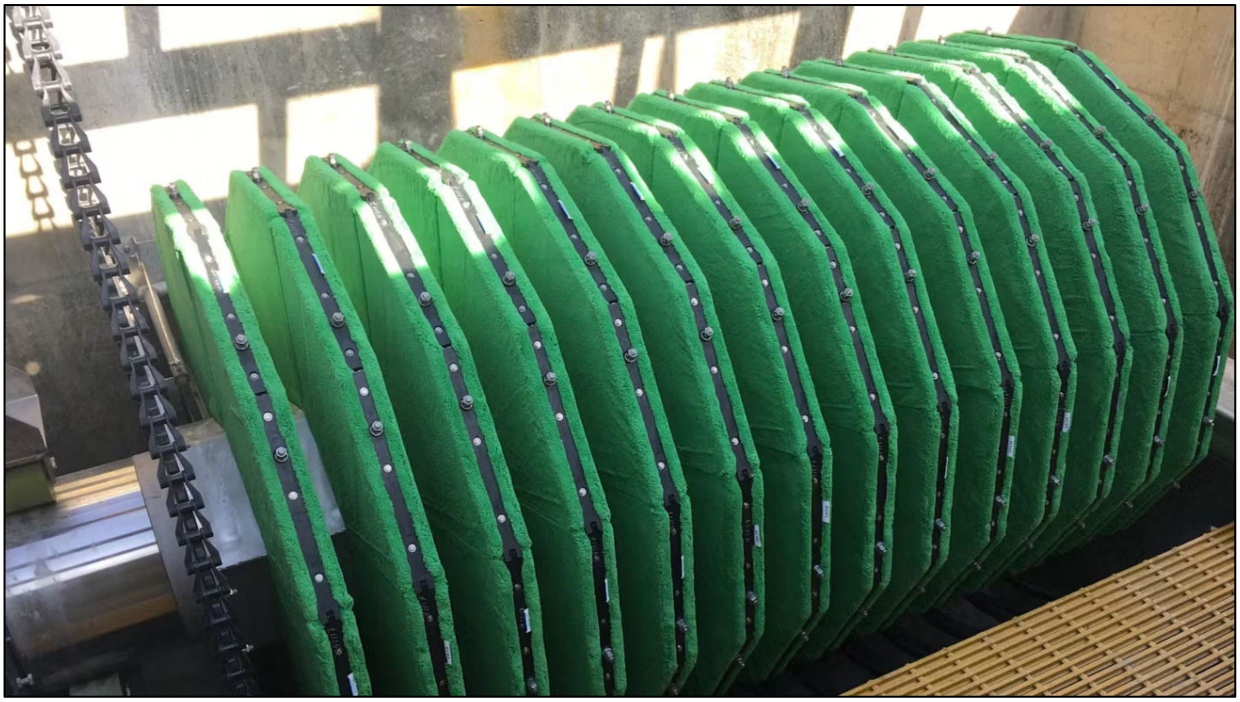

Figure 4.6-11: AquaStorm™ Cloth Media Filter by Aqua-Aerobic Systems

4.6.4.1 Levels of Control Descriptions

Pre-Plan Conditions: Pre-Plan conditions reflect the performance of the CRW system, under typical year precipitation, when CRW assumed operation and maintenance (O&M) responsibilities for the wastewater and stormwater collection and conveyance systems in 2013.

First Control Point: The first control point under each single technology reflects the LoC achieved by the projects that are either already completed or are required to be completed in accordance with the implementation schedule within MPCD Appendix B. The specific projects are described in Sections 1.3 and 3.

Second Control Point: The second control point would provide a systemwide LoC whereby every outfall would have no more than 24 untreated overflows per year during typical year precipitation. The total systemwide treatment capacity for all the individual satellite treatment facilities is 34 MGD to achieve this LoC.

Third Control Point: The third control point would provide a systemwide LoC whereby every outfall would have no more than 20 untreated overflows per year during typical year precipitation. The total systemwide treatment capacity for all the individual satellite treatment facilities is 48 MGD to achieve this LoC.

Fourth Control Point: The fourth control point would provide a systemwide LoC whereby every outfall would have no more than 16 untreated overflows per year during typical year precipitation. The total systemwide treatment capacity for all the individual satellite treatment facilities is 91 MGD to achieve this LoC.

Fifth Control Point: The fifth control point would provide a systemwide LoC whereby every outfall would have no more than 12 untreated overflows per year during typical year precipitation. The total systemwide treatment capacity for all the individual satellite treatment facilities is 182 MGD to achieve this LoC.

Sixth Control Point: The sixth control point would provide a systemwide LoC whereby every outfall would have no more than 8 untreated overflows per year during typical year precipitation. The total systemwide treatment capacity for all the individual satellite treatment facilities is 335 MGD to achieve this LoC.

Seventh Control Point: The seventh control point would provide a systemwide LoC whereby every outfall would have no more than 4 untreated overflows per year during typical year precipitation. The total systemwide treatment capacity for all the individual satellite treatment facilities is 492 MGD to achieve this LoC.

Eighth Control Point: The eighth control point would provide a systemwide LoC whereby every outfall would have no untreated overflows during typical year precipitation. The total systemwide treatment capacity for all the individual satellite treatment facilities is 1,231 MGD to achieve this LoC.

4.6.4.2 Basis of Cost Estimates

The construction cost opinion for each high-rate filtration facility was developed from construction cost data based on the peak flow to each facility, which was subsequently adjusted to the location and escalated to present day. In addition to the high-rate filtration facility construction, the following elements were included for each facility: consolidation sewers, diversion chambers, influent and effluent sewers, disinfection, and dechlorination. In limited locations, a pumping station, sized to handle peak flow, was included because the hydraulics would not support gravity flow through the facility.

To develop the present value lifecycle cost, annual operation and maintenance was estimated as 0.7% of the construction cost. At the end of the 20-year planning period, it was assumed that the high-rate filtration facilities would require replacement or rehabilitation of 20% of the capital cost.

4.6.4.3 Site-Specific Feasibility and Applicability

Refer to Section 4.5.3 for discussion of consolidation groups. For this evaluation, the same groupings are used for all satellite treatment technologies.

High-rate filtration requires aboveground facilities (pump station, screening facilities, chlorination building, pump/chemical building, and HRF units) and underground facilities (chlorine contact tank and sludge storage). The chlorine contact tank is sized assuming a 15-minute contact time and side water depth of 10 ft. Other structures are sized based on interpolating footprints from historical projects. In general, high-rate filtration requires large footprints with several aboveground structures.

Screening and disinfection require aboveground facilities (pump station, screening facilities, chlorination building) and underground facilities (chlorine contact tank). The chlorine contact tank is sized assuming a 15-minute contact time and side water depth of 10 ft. Other structures are sized based on interpolating footprints from historical projects. In general, screening and disinfection has minimal site constraints compared to the other treatment technologies.

4.6.4.4 Cost-Performance Summary

Table 4.6-5 provides the typical year CSO statistics and present value cost estimate associated with each LoC. For all treatment technologies, these statistics refer to untreated overflows. Typical year CSO volume is the systemwide total of individual CSO outfalls, and typical year CSO frequency represents the range of frequencies for individual CSO outfalls (Pre-Plan and Appendix B) or the target frequency corresponding to the LoC (control points two through eight).

Table 4.6-5: LoCs and Costs for Satellite Treatment using High-Rate Filtration

Control Point	Number of Facilities	Total Treatment Capacity (MG)	Estimated Cost ($ Million)	Typical Year CSO Volume (MG)	Typical Year CSO Frequency
Pre-Plan	NA	NA	NA	796	6 to 95
1 (App. B)	NA	NA	217	331	6 to 60
2	10	34	634	194	24
3	15	48	743	176	20
4	20	91	958	145	16
5	22	182	1,266	101	12
6	22	335	1,829	80	8
7	22	492	2,329	64	4
8	23	1,231	4,500	29	0

Figure 4.6-12 is the cost-performance plot of CSO frequency versus present value costs. For this technology screening evaluation, except for the Pre-Plan and Appendix B conditions, each of the LoC points along the curve would provide a consistent systemwide LoC whereby every outfall would have no more than the frequencies indicated in the CSO frequency column in the above table.

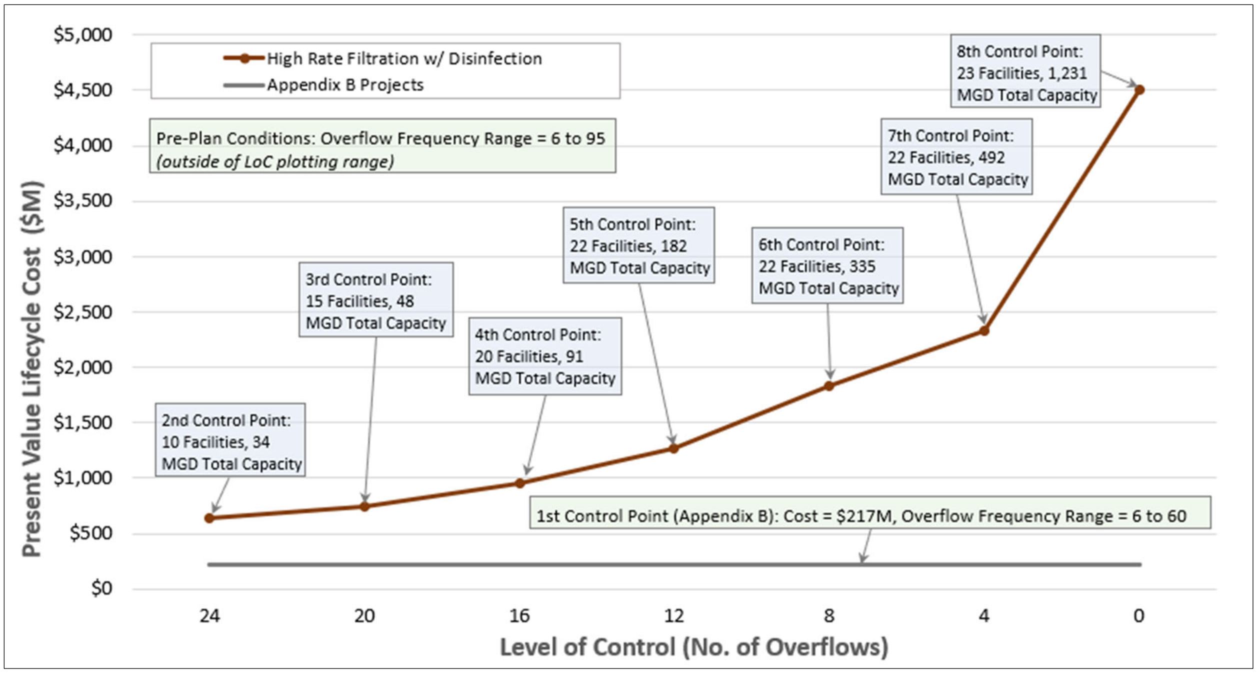

Figure 4.6-12: Typical Year CSO Frequency vs. Cost-Performance Curve for Decentralized Satellite Treatment using High-Rate Filtration with Disinfection

Figure 4.6-13 is the cost-performance plot of systemwide overflow volume versus present value costs.

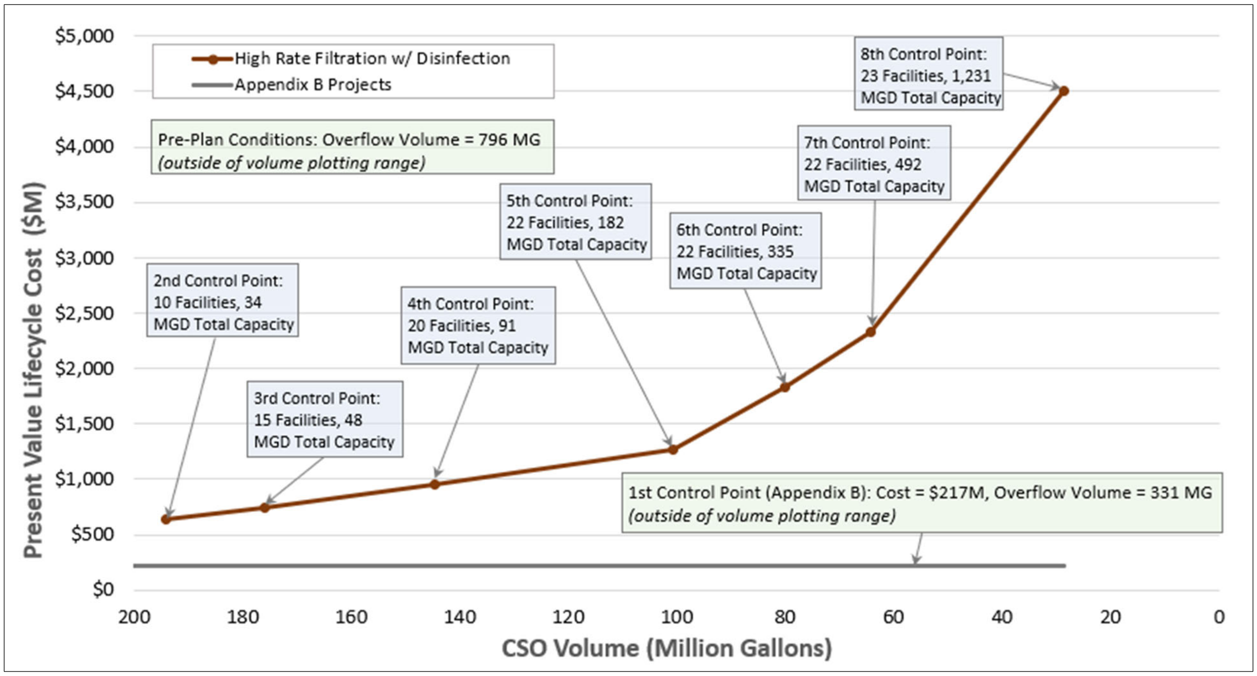

Figure 4.6-13: Typical Year CSO Volume vs. Cost-Performance Curve for Decentralized Satellite Treatment using High-Rate Filtration with Disinfection

4.7 Decentralized Control Strategy using Sewer Separation

With sewer separation, existing combined sewers are replaced with separate storm and sanitary sewer systems to prevent stormwater runoff from comingling with sanitary wastewater. Stormwater would be conveyed to the receiving waters and wastewater would be conveyed to the AWTF for treatment and discharge.

For the moderate and intermediate LoCs, with partial sewer separation within the catchment areas, it was assumed that new stormwater collection systems would be constructed, and the existing combined sewers would convey the wastewater flows. For the highest LoCs, with more complete sewer separation, it was assumed that new sanitary sewer systems would be constructed, and the existing combined sewer systems would be used to convey stormwater. It was assumed that sewer separation within each catchment area would begin in collection sewer areas closest to the receiving waters and then extend incrementally up into the collection system.

It is important to note that while sewer separation would reduce systemwide CSO discharge frequencies and volumes, there would be pollutant loads within the resulting separated stormwater discharges to receiving streams. These pollutant loads would require stormwater management measures to be put in place systemwide under CRW's MS4 Stormwater Permit.

4.7.1 Levels of Control Descriptions

Pre-Plan Conditions: Pre-Plan conditions reflect the performance of the CRW system, under typical year precipitation, when CRW assumed operation and maintenance (O&M) responsibilities for the wastewater and stormwater collection and conveyance systems in 2013.

First Control Point: The first control point under each single technology reflects the LoC achieved by the projects that are either already completed or are required to be completed in accordance with the implementation schedule within MPCD Appendix B. The specific projects are described in Sections 1.3 and 3.

Second Control Point: The second control point would provide a systemwide LoC whereby every outfall would have no more than 24 overflows per year during typical year precipitation. The total systemwide quantity of sewer separation area required to achieve this LoC is 243 acres.

Third Control Point: The third control point would provide a systemwide LoC whereby every outfall would have no more than 20 overflows per year during typical year precipitation. The total systemwide quantity of sewer separation area required to achieve this LoC is 328 acres.

Fourth Control Point: The fourth control point would provide a systemwide LoC whereby every outfall would have no more than 16 overflows per year during typical year precipitation. The total systemwide quantity of sewer separation area required to achieve this LoC is 469 acres.

Fifth Control Point: The fifth control point would provide a systemwide LoC whereby every outfall would have no more than 12 overflows per year during typical year precipitation. The total systemwide quantity of sewer separation area required to achieve this LoC is 652 acres.

Sixth Control Point: The sixth control point would provide a systemwide LoC whereby every outfall would have no more than 8 overflows per year during typical year precipitation. The total systemwide quantity of sewer separation area required to achieve this LoC is 807 acres.

Seventh Control Point: The seventh control point would provide a systemwide LoC whereby every outfall would have no more than 4 overflows per year during typical year precipitation. The total systemwide quantity of sewer separation area required to achieve this LoC is 949 acres.

Eighth Control Point: The eighth control point would provide a systemwide LoC whereby every outfall would have no overflows during typical year precipitation. The total systemwide quantity of sewer separation area required to achieve this LoC is 1,149 acres.

4.7.2 Basis of Cost Estimates

To develop the present value lifecycle cost, annual operation and maintenance costs were estimated as 0.1% of construction cost. At the end of the 20-year planning period, it was assumed that the facilities would not require replacement or rehabilitation beyond annual operation and maintenance. Since sewer separation will remove stormwater from the combined sewer system, a credit for wastewater treatment at the AWTF was also applied for the volume of stormwater removed in the typical year.

4.7.3 Site-Specific Feasibility and Applicability Findings

Like GSI, sewer separation can be applied throughout the collection system. However, sewer separation is most cost-effective when employed within a few blocks of the CSO regulator / interceptor. Otherwise, more expansive sewer separation generally requires construction of a significant number of new sewers, disconnection/reconnection of numerous residential and commercial properties, and other streetscaping components.

4.7.4 Cost-Performance Summary

Table 4.7-1 provides the typical year CSO statistics and present value cost estimate associated with each LoC. Again, it is important to note that while sewer separation would reduce systemwide CSO discharge frequencies and volumes, there would be pollutant loads within the resulting separated stormwater discharges that would need to be managed under CRW's MS4 Stormwater Permit.

Typical year CSO volume is the systemwide total of individual CSO outfalls, and typical year CSO frequency represents the range of frequencies for individual CSO outfalls (Pre-Plan and Appendix B) or the target frequency corresponding to the LoC (control points two through eight).

Table 4.7-1: LoCs and Costs for Sewer Separation

Control Point	Separated Impervious Acres	Estimated Cost ($ Million)	Typical Year CSO Volume (MG)	Typical Year CSO Frequency
Pre-Plan	NA	NA	796	6 to 95
1 (App. B)	NA	217	331	6 to 60
2	243	582	187	24
3	328	729	166	20
4	469	958	126	16
5	652	1,221	69	12
6	807	1,423	43	8
7	949	1,605	23	4
8	1,149	1,787	0	0

Figure 4.7-1 is the cost-performance plot of CSO frequency versus present value costs. For this technology screening evaluation, except for the Pre-Plan and Appendix B conditions, each of the LoC points along the curve would provide a consistent systemwide LoC whereby every outfall would have no more than the frequencies indicated in the CSO frequency column in the above table.

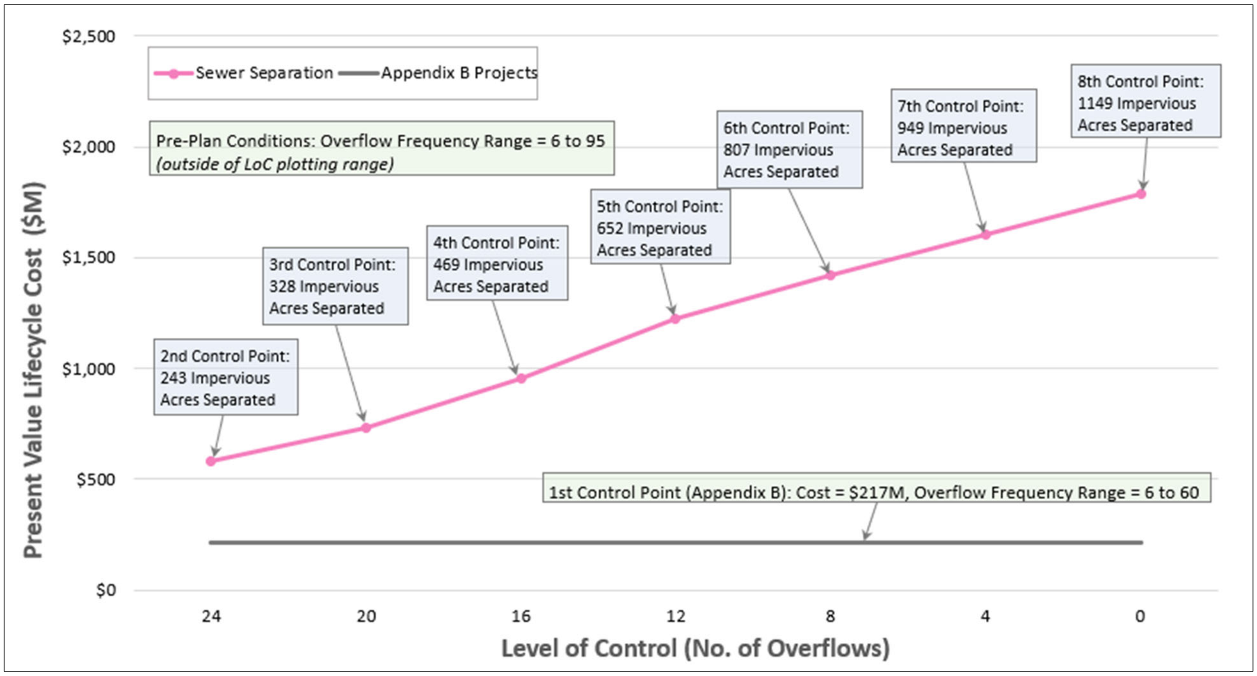

Figure 4.7-1: Typical Year CSO Frequency vs. Cost-Performance Curve for Sewer Separation

Figure 4.7-2 is the cost-performance plot of systemwide overflow volume versus present value costs.

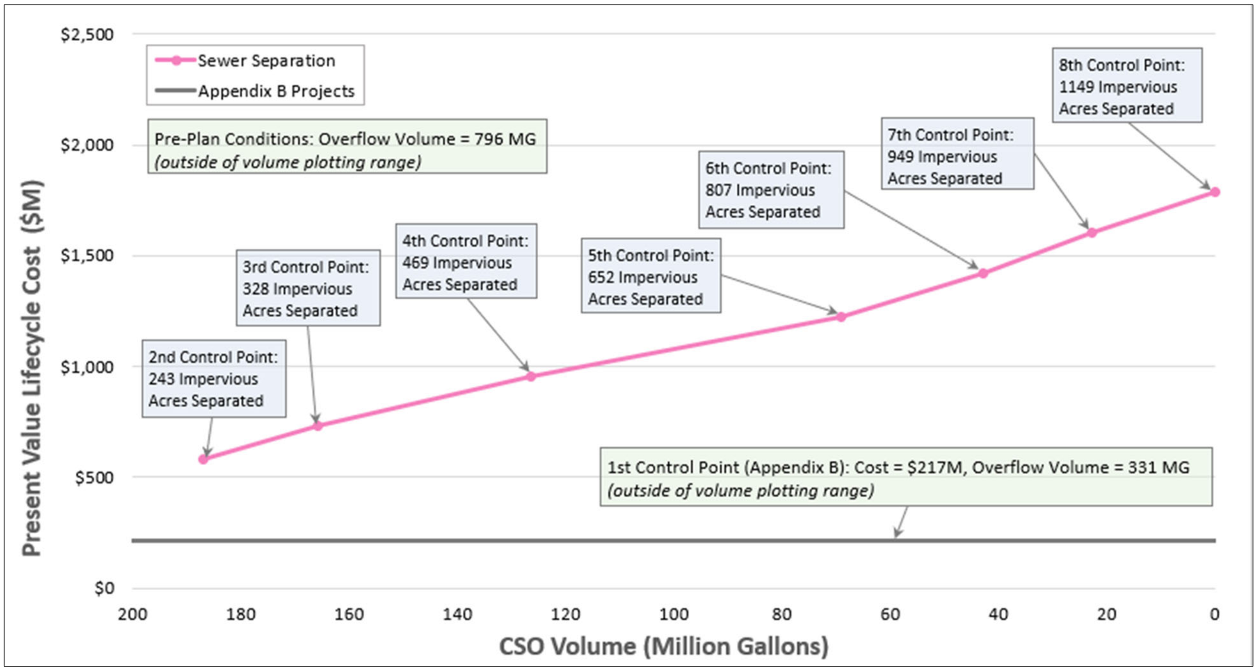

Figure 4.7-2: Typical Year CSO Volume vs. Cost-Performance Curve for Sewer Separation

4.8 Single Technology Control Evaluation Findings

Sections 4.1 through 4.7 document how each control technology was independently evaluated. This section summarizes how these independent evaluations were utilized to inform the development of the mixed technology alternatives (Section 6).

4.8.1 Single Technology Screening Criteria

The following single technology control evaluation criteria were utilized to further screen technologies and inform the development of the mixed technology alternatives.

- Cost effectiveness comparisons
- Ability to meet water quality criteria
- Facility footprint evaluation
- Applicable to satellite locations
- Use in combination with other technologies
- Collection system impacts

Cost Effectiveness Comparisons: The single technology evaluations facilitated a direct comparison of the relative cost effectiveness of each technology to provide a comparable range of LoCs. Cost-performance curves plot the cost of the required control facilities against each LoC. The “knee of the curve,” is identified as the point where the incremental change in cost per performance increases rapidly.

Two knee-of-the-curve plots were generated. For the first plot, the horizontal axis shows the maximum frequency during the typical year. For the second plot, the horizontal axis shows the systemwide overflow volume during the typical year. The vertical axis for both plots shows the total cost for each LoC, the sum of the present value of the estimated capital costs and annual operation and maintenance (O&M) costs.

Figure 4.8-1 shows the superimposed cost-performance curves, typical year CSO frequency versus the present value lifecycle cost, for all the evaluated control technologies. **Figure 4.8-2** shows the superimposed cost-performance curves, typical year CSO volume controlled versus the present value lifecycle cost, for all the evaluated control technologies. These plots provide a general comparison of the relative cost effectiveness of each technology to provide a comparable range of LoCs.

From both frequency and volume perspectives, high-rate filtration, high-rate clarification, and sewer separation had the highest costs. Comparable LoCs were provided at lower costs by the green stormwater infrastructure, satellite storage, screening and disinfection, retention treatment basin, and tunnel technologies. However, for the two types of storage technologies (storage tanks and tunnel), it was found to be more cost-effective to utilize decentralized storage tanks rather than a centralized tunnel system.

Ability to Meet Water Quality Criteria: Screening technologies, in general, are very effective in removing floatable and visible solids and pathogenic bacteria, but do not remove a significant amount of total suspended solids (TSS), biochemical oxygen demand (BOD), or nutrients. To meet the current bacteria water quality standards within both the Susquehanna River and Paxton Creek, screened effluent flows would be disinfected using high-rate chemical disinfection, most likely using sodium hypochlorite, to kill pathogen bacteria before being released to the receiving waters. Screening would not likely cause or contribute to new exceedances of water quality criteria for TSS, nitrogen, and phosphorus in the Susquehanna River and Paxton Creek. However, screening would likely be insufficient to resolve dissolved oxygen and BOD impairments Paxton Creek that are caused by CSO discharges. Sewer separation would reduce CSO discharge volumes but would create new separate stormwater pollutant loads to the receiving waters that would need to be mitigated.

Facility Footprint Evaluation: This criterion evaluates the required sizes of the control facility footprints associated with each technology and how the facilities would or would not fit within the available space. The enhanced conveyance technology would require significant additional space for the new expanded advanced wastewater treatment facility and the expanded Front Street Pump Station, which would make it difficult to implement. The high-rate clarification and high-rate filtration technology facilities require significantly larger footprints than the other technologies, and siting these facilities could be challenging for the higher LoCs. Details related to facility footprints are discussed in the “Site-Specific Feasibility and Applicability” sub-sections of each technology.

Summary of Evaluation Criteria: A tabular summary of the evaluation criteria used to evaluate and further screen the single control technologies is provided in **Table 4.8.1**. The table shows the conclusions from the evaluations used to inform the development of the mixed technology alternatives presented in Section 6.

Applicable to Satellite Locations: This evaluation criteria considered the applicability of the control technology for satellite locations. The high-rate clarification and high-rate filtration technologies would require operators to relocate from the AWTF to the control facility sites during storm events. These operation and maintenance demands would make these technologies impractical for satellite applications. All the other technologies are readily applicable for satellite locations.

Use with Other Technologies: Some control technologies work independently, while others work well in conjunction with other technologies. Screening is used in conjunction with high-rate clarification and filtration. GSI and small-scale sewer separation remove significant quantities of stormwater runoff before it enters the combined sewer system and thereby reduce the volume of satellite storage/treatment required to achieve the various LoCs. Components of the enhanced conveyance technology can be used with other technologies. For example, assuming a modest increase in interceptor capacity, the CSO regulator connector pipes can be expanded to increase flow to the interceptors, thereby reducing the required sizes of other technologies. Satellite storage and satellite treatment significantly reduce the peak wet weather flow, reducing the required conveyance capacities of the interceptor system and AWTF. Large-scale enhanced conveyance and tunnel storage systems generally require large upfront investments which can significantly limit use with other technologies.

Collection System Impacts: “End-of-pipe” technologies control wet weather flow at or near the points of connection with the interceptor system. These technologies do not reduce peak flows and surcharge conditions along trunk sewers. Therefore, they provide minimal control of basement back-ups, surface flooding, and other “Unauthorized Releases” as they are defined in the MPCD, which are prohibited.

Enhanced conveyance marginally reduces surcharge condition elevations along downstream reaches of the collection system by allowing more flow to be conveyed to the interceptor system. In contrast, GSI and sewer separation are highly effective in removing stormwater before it enters the collection system, and facilities can be placed throughout the collection systems.

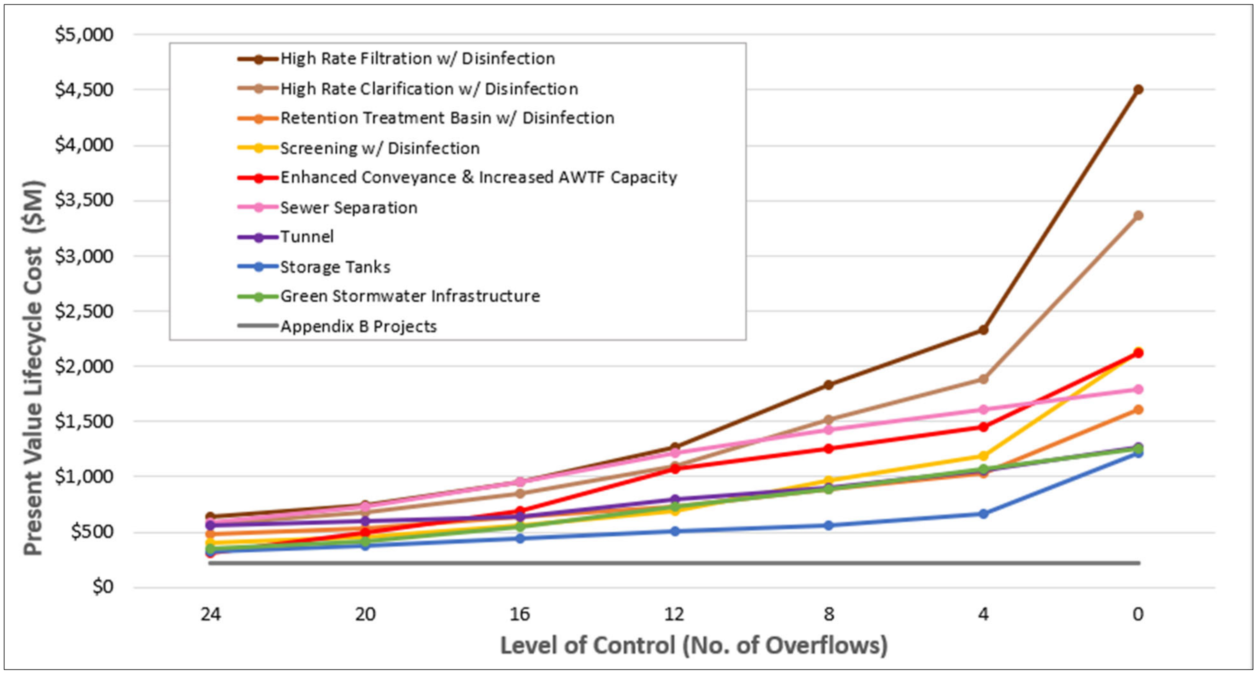

Figure 4.8-1: Typical Year CSO Frequency vs. Cost-Performance Curve for Evaluated Control Technologies

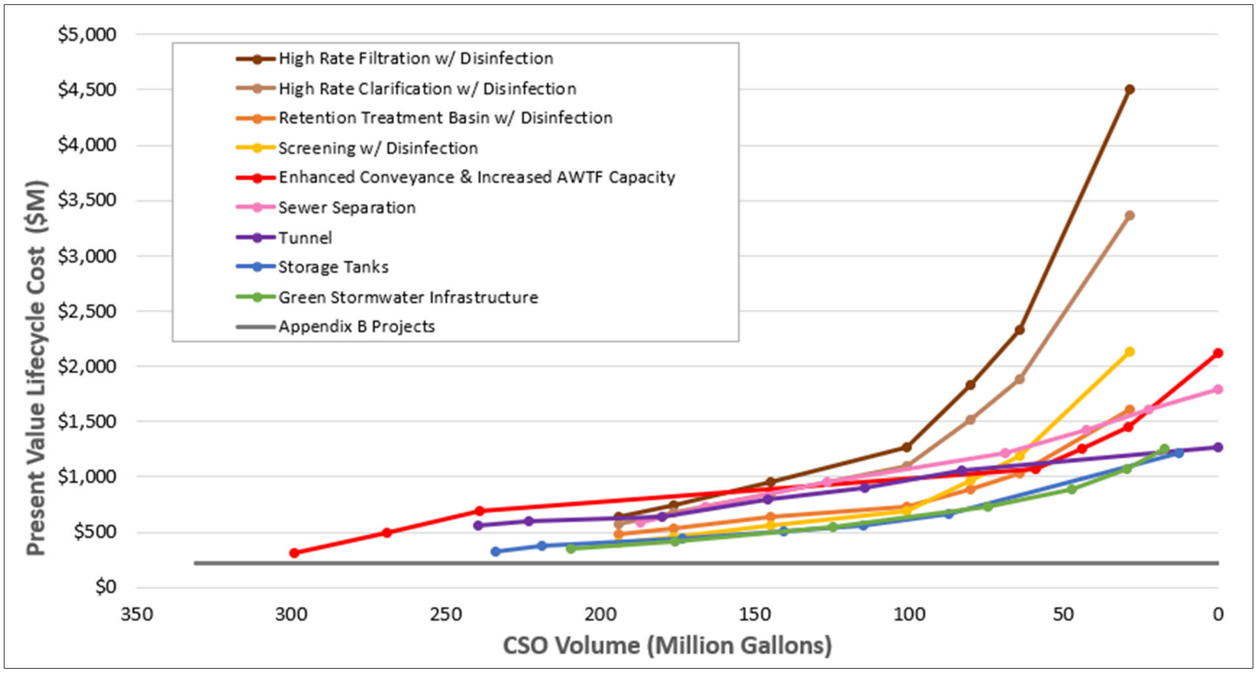

Figure 4.8-2: Typical Year CSO Volume vs. Cost-Performance Curve for Evaluated Control Technologies

Table 4.8-1: Single Technology Screening Criteria

Screening Criteria	Technology									Note
	Enhanced Conveyance **[EC]**	Tunnel Storage **[TS]**	Green Stormwater Infrastructure	Satellite Storage **[ST]**	Screening and Disinfection **[S&D]**	Retention Treatment Basin **[RTB]**	High-Rate Clarification **[HRC]**	High-Rate Filtration **[HRF]**	Sewer Separation **[SS]**	
Cost Effectiveness	↔	✓	✓	✓	✓	✓	X	X	X	HRC, HRC, and SS are most expensive
Ability to Meet WQ Criteria	✓	✓	✓	✓	X	✓	✓	✓	X	S&D would likely not meet water quality criteria; SS reduces CSO volumes, but creates new separate stormwater loads
Feasible Facility Footprint	X	✓	✓	↔	✓	↔	X	X	✓	EC requires additional space for new/expanded AWTF; HRC and HRF require large footprints; ST and RTB require large footprints for High LoCs
Applicable to Satellite Locations	✓	✓	✓	✓	✓	✓	X	X	✓	O&M demands for HRC and HRF make these impractical for satellite applications
Use with Other Technologies	X	X	✓	✓	✓	✓	✓	✓	✓	EC and TS require large upfront investments which limits use with other technologies
Collection System Benefits	✓	↔	✓	↔	↔	↔	↔	↔	✓	GSI and SS significantly improve collection system flooding; EC marginally improves flooding by pushing more flow to the interceptors

Legend:

Positive Impact	✓	Negative Impact	X	Neutral Impact	↔

4.8.2 Single Technology Screening Results

The results of the single technology screening, and how these technologies will be incorporated into the mixed technology alternatives (Section 6) are explained below and summarized conceptually in **Figure 4.8-3.**

Enhanced Conveyance and Treatment: Based on the cost-performance curves, this technology is not as cost-effective as some of the other technologies. Other control technologies can achieve the same LoCs for less cost. Additionally, for higher LoCs, expansion of the pump stations and AWTF would be difficult to implement due to siting constraints. For the mixed technology alternatives, increasing the conveyance and treatment capacities will be evaluated and applied where necessary to alleviate local "bottleneck" hydraulic restrictions.

Tunnel Storage: Based on the cost-performance curves, a regional tunnel storage system is cost-effective, but not as cost-effective as other storage technologies (e.g., decentralized storage tanks). However, the MPCD explicitly requires this technology to be evaluated, so the mixed technology alternatives will include one tunnel-based alternative. It is important to note that it can be cost-effective to utilize micro-tunneling technology to provide linear storage to consolidate separate satellite storage facilities.

Green Stormwater Infrastructure: Based on the cost-performance curves, GSI is a cost-effective control technology. While GSI is not the most cost-effective technology from a frequency reduction perspective, it is particularly cost-effective with respect to reducing overflow volume. GSI can work synergistically with other technologies (e.g., satellite storage) by reducing the end-of-pipe volumes, thereby reducing the required sizes and costs for other gray technologies. Therefore, for the mixed technology alternatives, GSI will be incorporated into all alternatives.

Satellite Storage: Based on the cost-performance curves, satellite storage is the most cost-effective technology at reducing overflow frequencies. For some consolidation groupings, at the higher LoCs, the required footprint is restrictive with respect to the available space. However, this can be alleviated somewhat by combining this technology with GSI to reduce the required facility volume and footprint. For the mixed technology alternatives, satellite storage will be included.

Screening and Disinfection: Based on the cost-performance curves, screening and disinfection is cost-effective. However, this technology does not achieve any biochemical oxygen demand (BOD) reduction, which eliminates this from consideration for CSOs discharging to Paxton Creek.

Retention Treatment Basin: Based on the cost-performance curves, retention treatment basins are cost-effective. For some consolidation groupings, at the higher LoCs, the required footprint is restrictive with respect to the available space. However, the required footprint can be reduced by eliminating the first flush basin (and still achieve adequate pollutant reductions). For the mixed technology alternatives, retention treatment basins will be included as the preferred treatment technology for Paxton Creek.

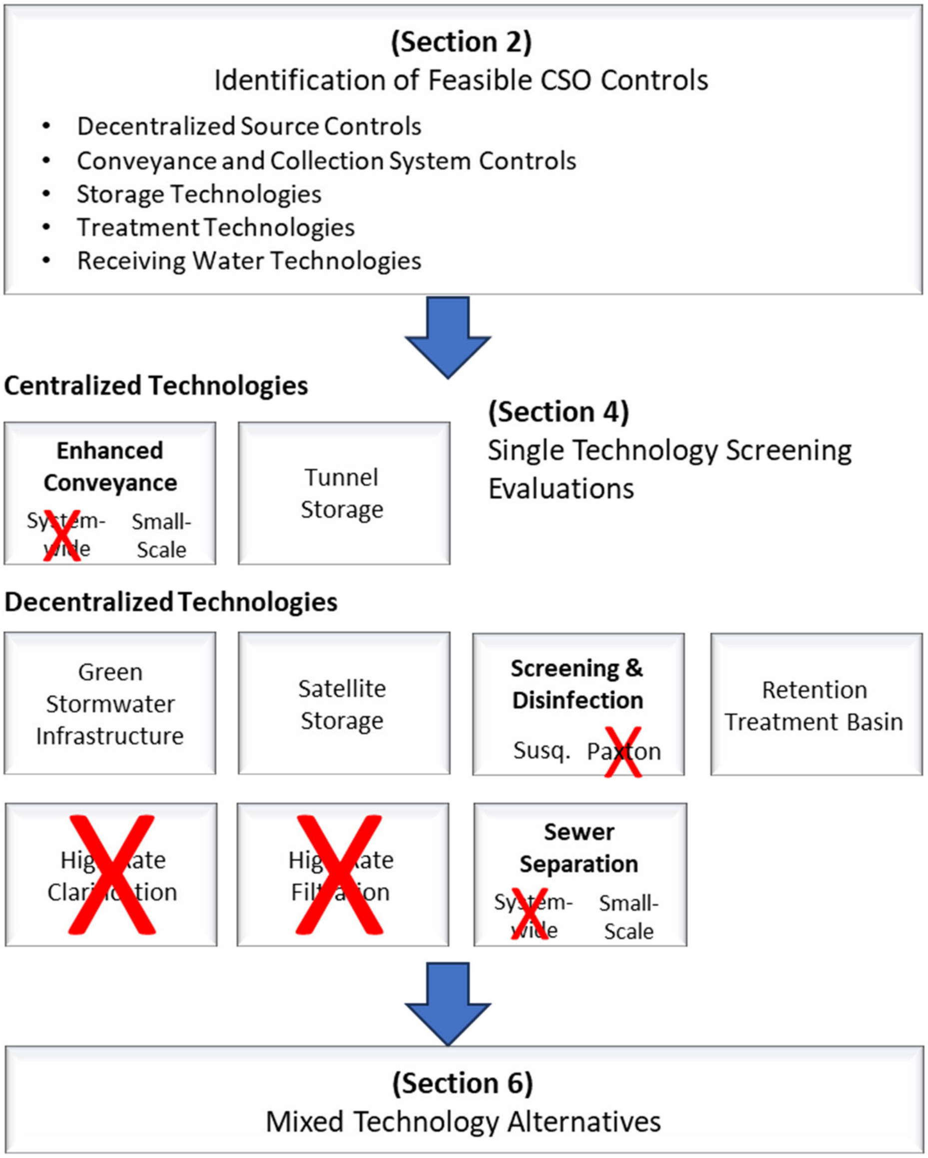

Figure 4.8-3: Conceptual Process for Single Technology Screening Evaluation

High-Rate Clarification: Based on the cost-performance curves, high-rate clarification is not cost-effective. Other satellite treatment technologies, such as retention treatment basins, can achieve the same LoCs for a lower cost. Additionally, this technology has a large footprint requirement (including above-ground facilities) and requires operators to be present during wet weather events, which makes this impractical for satellite applications. Therefore, high-rate clarification will not be considered for the mixed technology alternatives.

High-Rate Filtration: Based on the cost-performance curves, high-rate filtration is not cost-effective. Other satellite treatment technologies, such as retention treatment basins, can achieve the same LoCs for a lower cost. Additionally, this technology has a large footprint requirement (including above-ground facilities) and requires operators to be present during wet weather events, which makes this impractical for satellite applications. Therefore, high-rate filtration will not be considered for the mixed technology alternatives.

Sewer Separation: Based on the cost-performance curves, systemwide sewer separation is not cost-effective. Other control technologies can achieve the same LoCs for less cost. For the mixed technology alternatives, sewer separation will be applied within individual catchment areas where cost-effective opportunities exist.

5.0 Water Quality Monitoring and Modeling

5.1 Introduction

Capital Region Water (CRW) submitted a Water Quality Modeling Plan (WQMP) to the U.S. Environmental Protection Agency (EPA) and the Pennsylvania Department of Environmental Protection (PADEP) in February 2023 to meet the requirements of the Modified Partial Consent Decree or MPCD (CRW, 2023a). The WQMP describes the existing data inventory for the receiving waters and additional data collection required for the water quality model development and calibration. It also documents the recommended modeling platforms; model configuration, calibration, and validation approach; and model application approach to evaluate the impacts of the alternatives to manage the combined sewer overflows (CSO). The WQMP also lists the water quality modeling objectives for Paxton Creek and the Susquehanna River.

The water quality modeling objectives for Paxton Creek defined in Section 3.1 of WQMP are:

- *Develop a calibrated and validated water quality model representing the pollutants of concern (as defined in the MPCD and in **Section 3.2.1**).*
- *Apply the calibrated and validated model to Typical Year conditions (as defined in the draft MPCD) to assess the current baseline water quality.*
- *Apply the calibrated and validated model to Typical Year conditions to evaluate the projected water quality for selected CSO control alternatives evaluated for the [long-term control plan] LTCP.*

The water quality modeling objectives for the Susquehanna River defined in Section 4.1 of WQMP are:

- *Confirm the lateral extent of mixing of the CSO plume under a range of hydrologic conditions.*
- *Develop a calibrated and validated water quality model representing the pollutants of concern (as defined in the MPCD and in **Section 4.2.1**).*
- *Apply the calibrated and validated model to Typical Year conditions to assess the current baseline water quality.*
- *Apply the calibrated and validated model to Typical Year conditions to evaluate the projected water quality for selected CSO control alternatives evaluated for the LTCP.*

EPA and PADEP approved the WQMP on April 4, 2023. CRW subsequently submitted a WQMP Addendum to the WQMP in May 2023 (CRW, 2023b). The purpose of the proposed changes in the WQMP Addendum was to represent the impact of CSO and upstream discharges more accurately in the evaluation of CSO alternatives. EPA and PADEP approved the WQMP Addendum on August 16, 2023.

This section provides an overview of the water quality monitoring conducted by CRW to support the water quality model. It also summarizes the model development and calibration process for Paxton Creek and Susquehanna River. Finally, this section describes the application of water quality models to evaluate CSO alternatives in meeting the applicable instream water quality standards.

5.2 Water Quality Monitoring

CRW developed a Water Quality Monitoring Plan and a Quality Assurance Project Plan to document the plan and procedures for collecting data identified in the WQMP and WQMP Addendum (CRW, 2023c). A brief summary of the water quality monitoring plan and results is provided below.

5.2.1 Monitoring Plan

CRW planned to target rainfall events greater than 0.75 inches for sampling to increase the likelihood that CSOs would be occurring when the sampling was being conducted (CRW, 2023b). The location of water quality monitoring stations is shown in **Figure 5.2-1.** As per the WQMP Addendum, CRW planned to sample three wet weather events. The water quality monitoring consists of the following components:

1. Automated Water Quality Sampling: Teledyne ISCO 6712 automatic sampling instrumentation was used to collect individual samples during wet-weather events at three CSO outfalls (CSO-005,[11] CSO-051, and CSO-031[12]) and one stormwater outfall location (SS-01). The samplers collected samples at 5 min, 15 min, 30 min, 45 min and 60 mins after the initiation of the CSO discharge to capture temporal distribution of water quality during the event. The samples were analyzed for fecal coliform, Escherichia coli (*E. coli*), five-day biochemical oxygen demand (BOD5), total nitrogen (TN), total phosphorus (TP), and total suspended solids (TSS).

2. Instream Discrete Water Quality Sampling: Discrete water quality samples were taken at four locations on Paxton Creek (P1, P2, P3, and P4) and at station A1 on Asylum Run (**Figure 5.2-1**). Discrete water quality samples were collected in the Susquehanna River along eastern and western transects (**Figure 5.2-1**). The sampling was conducted during the wet weather events and preceding dry weather periods. The wet weather discrete sampling was planned to include the collection of samples at three times: one hour, three hours, and eight hours after the start of a CSO event. Field readings of dissolved oxygen (DO), pH, water temperature, and specific conductance were taken for each sample. The samples were analyzed for fecal coliform, *E. coli*, BOD5, TN, and TP.

3. Continuous Water Quality Measurements: Water quality sondes were deployed at three CSO outfalls (CSO-005, CSO-051, and CSO-031), one stormwater outfall location (SS1), and one Paxton Creek instream location (F1). The sondes measured DO, pH, temperature, and specific conductance.

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[11] CSO-005 and CSO-051 discharge to the Susquehanna River.

[12] CSO-031 and SS-01 discharges to Paxton Creek.

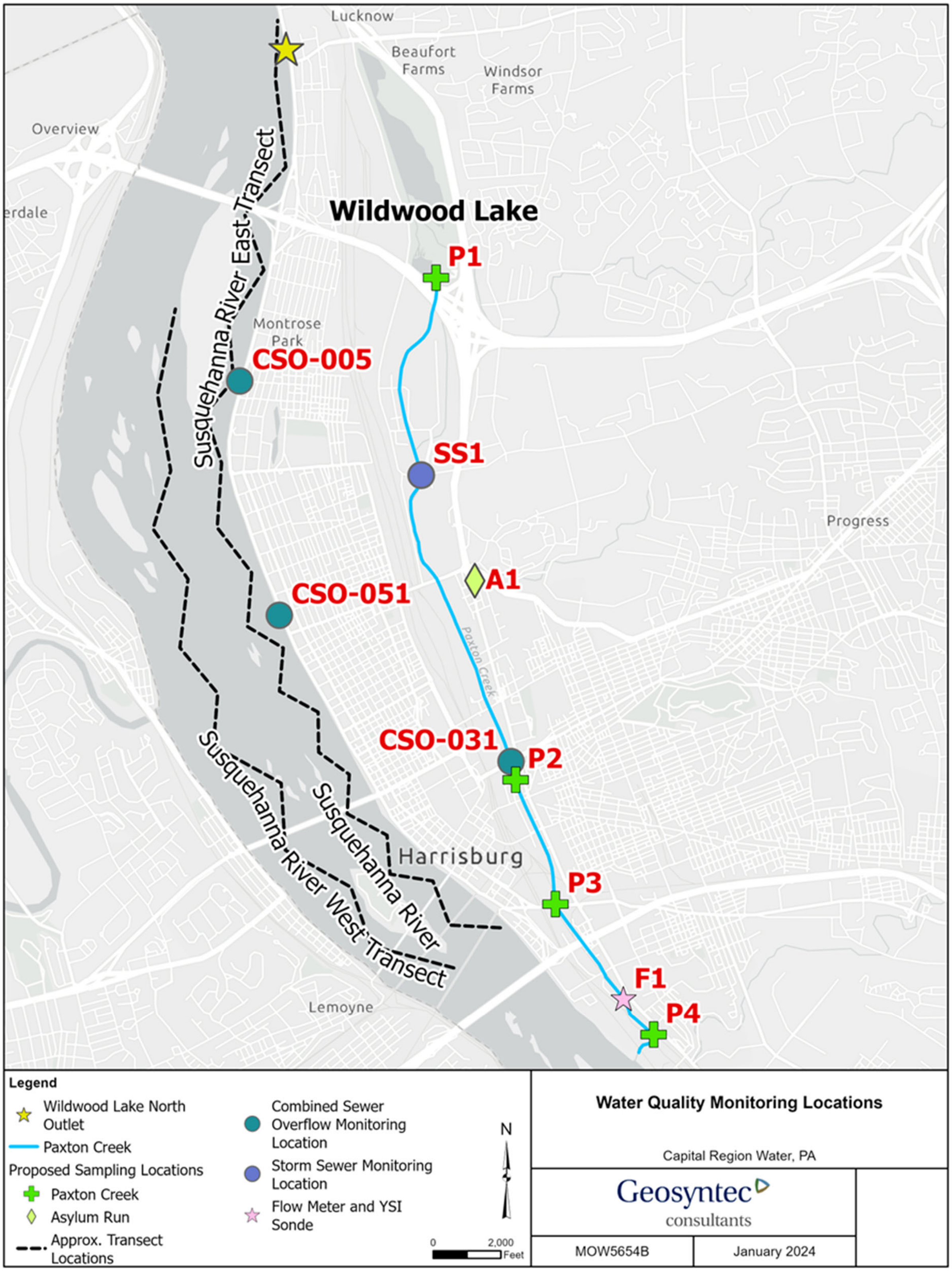

Figure 5.2-1: Monitoring Location Map

4. Depth and Flow Measurements: CRW installed depth sensors in November 2014 at four locations in Paxton Creek to develop hydraulic boundary conditions of the H&H model. These sensors collect depth data at 5-minute intervals. CRW had planned to collect discrete flow measurements at one depth sensor location (Station F1) to develop a flow rating curve. However, this could not be undertaken because of safety concerns during high flow conditions.

5.2.2 Monitoring Challenges

CRW initiated the water quality monitoring program in August 2023. Despite best efforts, CRW has not been able to collect the planned monitoring data for three rainfall events due to weather and safety conditions. Several events in 2023 were scattered, resulting in precipitation of less than 0.75 inches. The CRW region is in a mountain valley, which results in about 30 percent less precipitation compared to nearby high elevation areas. CRW could not undertake monitoring for several forecasted events because of safety concerns such as thunderstorms, lightning, cold weather approaches, and day light availability. **Table 5.2-1** provides a summary of potential events monitored by CRW; events where sampling occurred are indicated in bold.

Table 5.2-1 Summary of Rainfall Events Monitored by CRW

Storm Events	Sampling Performed	Comments
7-Aug-23	No	Thunderstorm
24-Aug-23	Yes	False Start
30-Aug-23	No	After dark
8-Sep-23	No	After dark
23-Sep-23	**Yes**	**Event #1 Limited data**
14-Oct-23	**Yes**	**Event #2**
21-Nov-23	**Yes**	**Event #3 Limited data**
10-Dec-23	Yes	False Start/Heavy Fog
9-Jan-24	No	After dark/Foggy
26-Jan-24	No	Ice on the Susquehanna River
28-Jan-24	No	After dark
13-Feb-24	No	After dark/Snow
28-Feb-24	No	After dark

CRW informed EPA and DOJ of this issue on a conference call on October 24, 2023. CRW plans to collect the data for the remaining events and complete the model calibration before the final submission of the LTCP on December 31, 2024.

5.2.3 Monitoring Results

CRW initiated the monitoring efforts in August 2023 after the approval of the WQMP Addendum. Despite best efforts, CRW has not been able to collect the planned monitoring data for three rainfall events due to weather and safety conditions. CRW informed EPA and DOJ of this issue on a conference call on October 24, 2023. CRW plans to collect the data for the remaining events and complete the model calibration before the final submission of the LTCP on December 31, 2024.

Water quality monitoring was conducted for two events on September 23 and October 14, 2023. A summary of the characteristics of the two rainfall events and Susquehanna River flows during the sampled events is provided below in **Table 5.2-2**.

Table 5.2-2: Summary of Sampled Rainfall Events Characteristics

Event Date	Event Start Time	Event Duration[a] (hours)	Total Precipitation[a] (inches)	Return Interval (years)	Susquehanna River Flow[b] (cfs)
September 23, 2023	07:40 AM	35	1.8	<1 year [c]	14,600 – 15,000
October 14, 2023	06:18 PM	21	1.2	<1 year [c]	15,200 – 15, 800

[a] Estimated based on average gage-adjusted rainfall data from CRW
[b] Estimated based on flow data from USGS Station 01570500
[c] Both storms were less than a 1 year return interval with duration ranging from 5-min to 24-hr

Figure 5.2-2 and **Figure 5.2-3** show the box and whisker plots[13] for measured *E. coli* and fecal coliform in the Susquehanna River (East and West transects), Paxton Creek, Asylum Run, and the CSO and stormwater outfall locations. The wet weather measurements in the Susquehanna River along the eastern transect, located close to the shoreline, are an order of magnitude higher than the western transect measurements. **Figure 5.2-4 and Figure 5.2-5** shows the spatial distribution of *E. coli* and fecal coliform, respectively, for the October 14 event. These indicate that the impact of CSO discharge (associated with high bacteria) is limited to the near-shore area of the Susquehanna River.

The measured bacterial levels in Paxton Creek are higher than in the Susquehanna River for both wet weather and dry weather events. The measured *E. coli* at the CSO outfall range from 10^3 to 10^6 most probable number per 100 milliliters (MPN/100 mL) while the stormwater outfall *E. coli* ranges from 10^2 to 10^6 MPN/100 mL.

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[13] Whiskers represent the minimum and maximum values, the edges of the box represent the 25th and 75th percentile values, and the central lines represents the median values. Text at the bottom of each box shows the numbers of samples available.

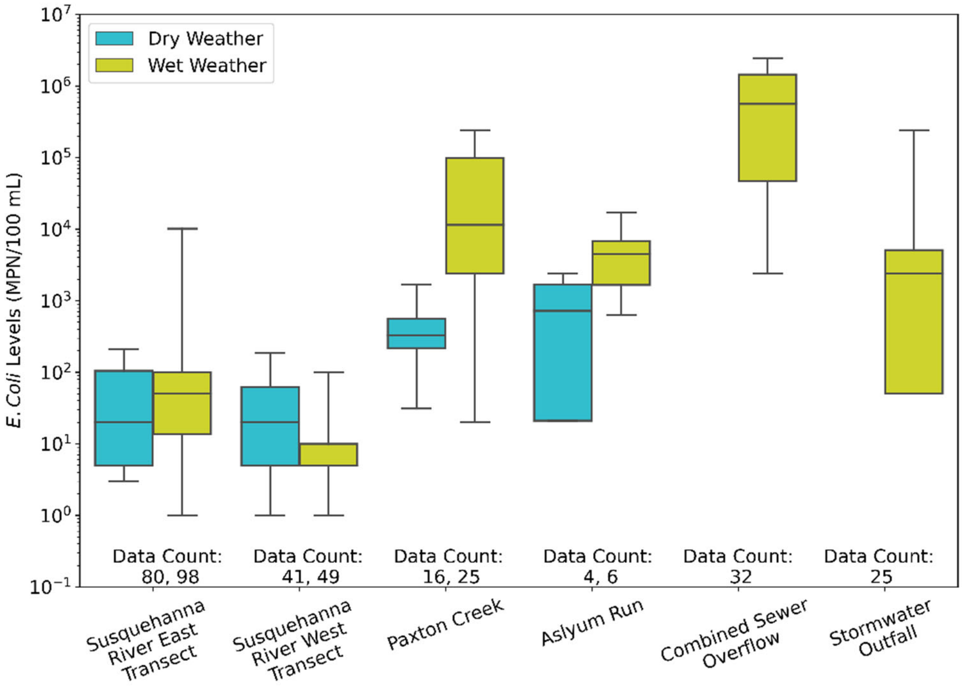


Figure 5.2-2: Measured *E. coli* Levels in 2023 (This includes eight measurements reported at upper detection limit of 2,419 MPN/100 mL for CS0-31)

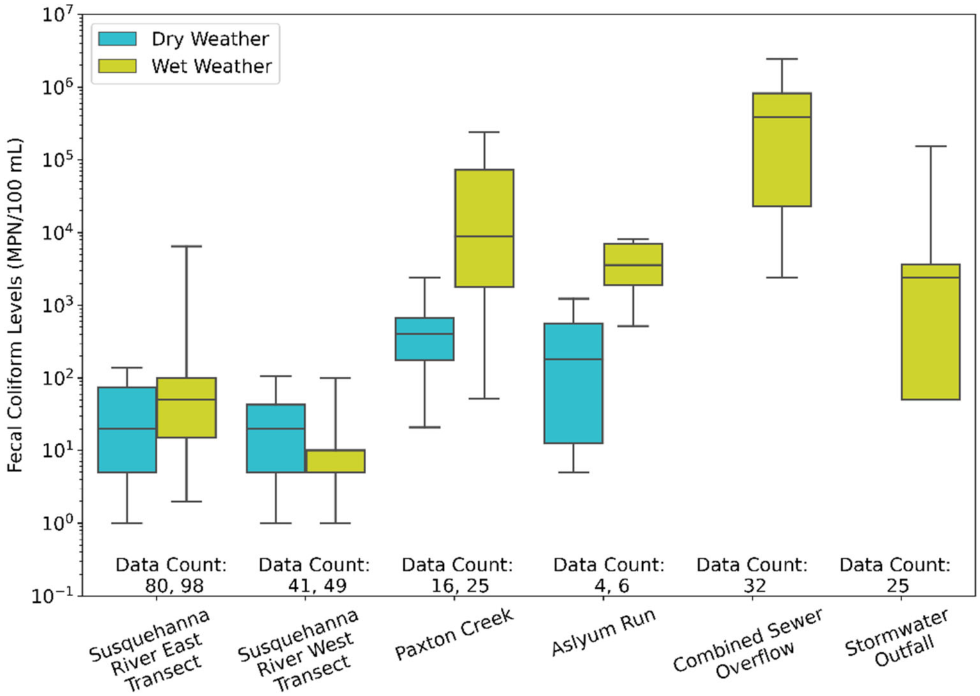
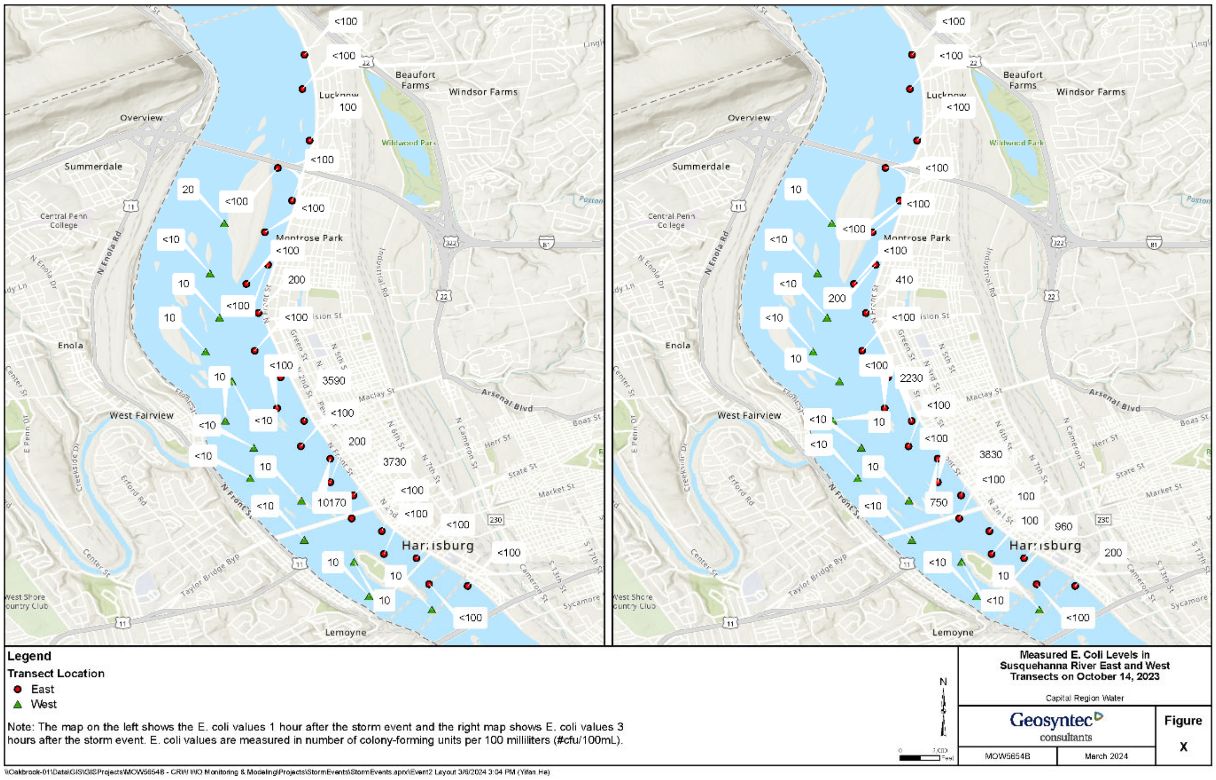


Figure 5.2-3: Measured Fecal Coliform Levels in 2023



Note: The map on the left shows the E. coli values 1 hour after the storm event and the right map shows E. coli values 3 hours after the storm event. E. coli values are measured in number of colony-forming units per 100 milliliters (#cfu/100mL).

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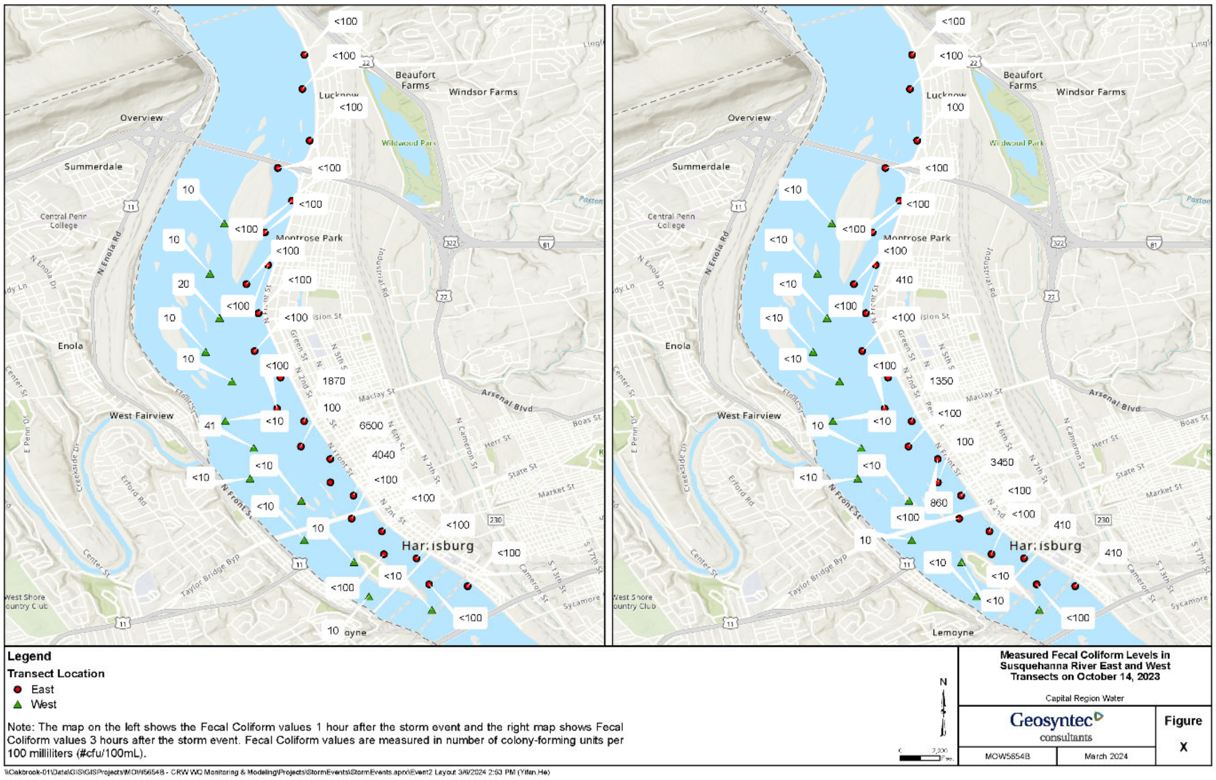
Figure 5.2-4: Measured *E. coli* levels in Susquehanna River East and West Transects on October 14, 2023



Note: The map on the left shows the Fecal Coliform values 1 hour after the storm event and the right map shows Fecal Coliform values 3 hours after the storm event. Fecal Coliform values are measured in number of colony-forming units per 100 milliliters (#cfu/100mL).

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Figure 5.2-5: Measured fecal coliform levels in Susquehanna River East and West Transects on October 14, 2023

Figure 5.2-6 shows the box and whisker plots for measured BOD5 concentrations in Paxton Creek (Stations P1, P2, P3, P4), Asylum Run, and the CSO and stormwater outfall locations. The measured wet weather concentrations in Paxton Creek at stations P2, P3, and P4, located downstream of CSOs, are significantly higher than the measured dry weather concentrations. This indicates that CSOs significantly impact the BOD5 in Paxton Creek. Upstream concentrations at station P1 are low, indicating that Wildwood Lake is not a significant source of BOD5.

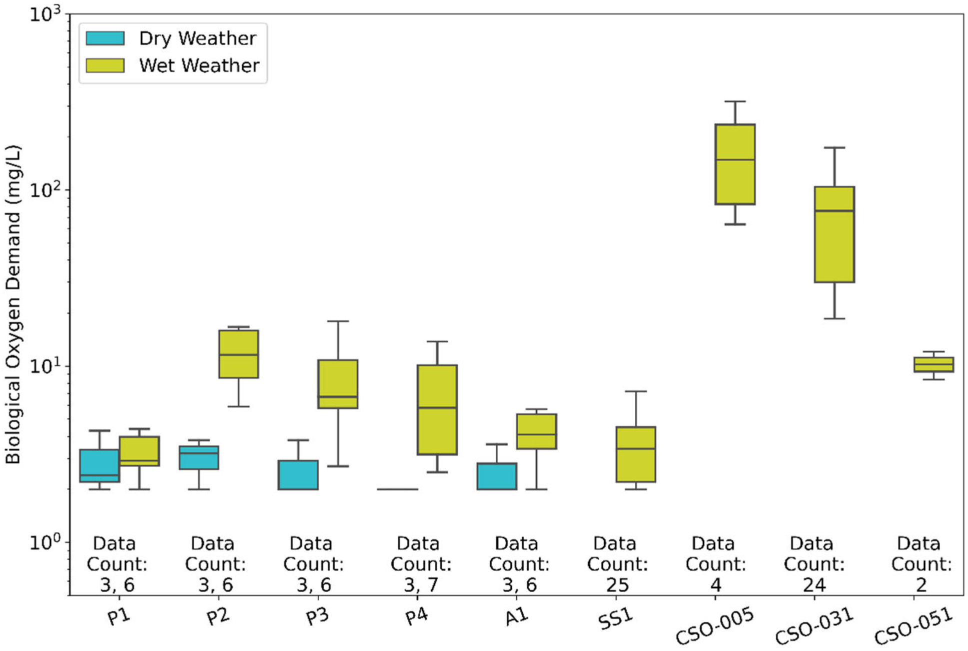

Figure 5.2-6: Measured Five-Day Biological Oxygen Demand (BOD5) Concentrations in 2023

Figure 5.2-7 shows the box and whisker plots for the continuous DO data measured at CSO and stormwater outfall locations. The measured DO concentrations in the stormwater discharge are, in general, higher than the measured concentrations in the CSO discharges, which can vary significantly depending on the location. The timeseries of measured DO concentration at station F1 in Paxton Creek is shown in **Figure 5.2-8**, which shows that the DO drops below the minimum DO criterion of 5 mg/L for extended periods from July to September 2023.

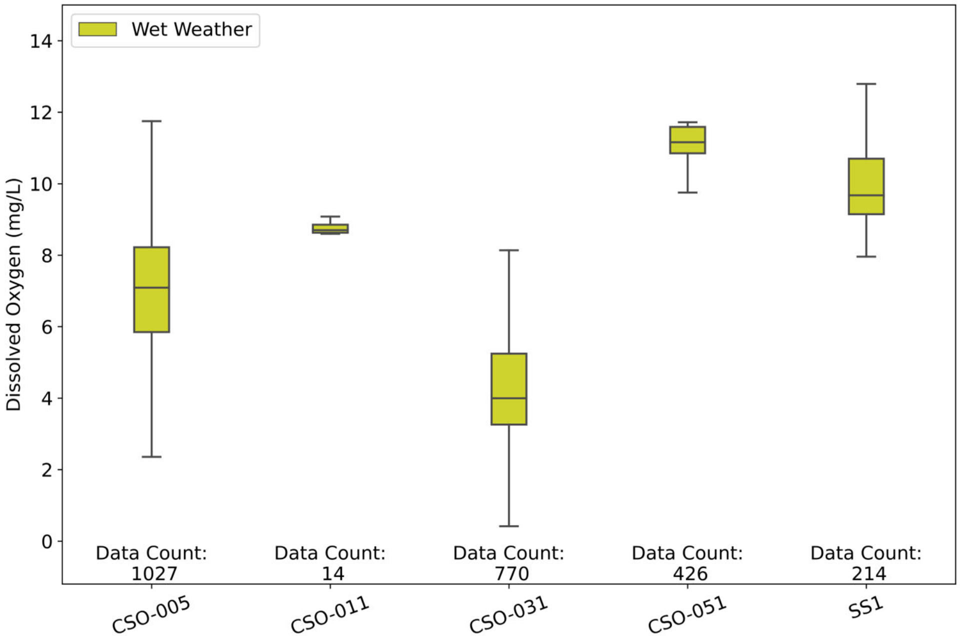

Figure 5.2-7: Measured Dissolved Oxygen Concentrations at Combined Sewer Overflow and Stormwater Outfall Locations in 2023

Figure 5.2-8: Measured Dissolved Oxygen Concentrations at Station F1 in Paxton Creek

5.3 Paxton Creek Model

CRW developed a linked modeling framework to meet the water quality modeling objectives for Paxton Creek. The model will be applied to assess the current baseline and projected water quality, specifically focusing on pollutants of concern and evaluating selected CSO control alternatives for the LTCP. As shown in **Figure 5.3-1**, the linked modeling framework consists of the following four models:

- Watershed models for CRW's separate sewer area and Wildwood Lake (described below),
- A hydrologic and hydraulic (H&H) model for CRW's combined sewer area (CRW, 2018a),
- An Instream model for Paxton Creek (described below).

The instream model was tentatively calibrated to water quality monitoring data collected in Paxton Creek. The model calibration will be updated once CRW has collected data per the WQMP and WQMP Addendum. A summary of the model development and calibration is provided below.

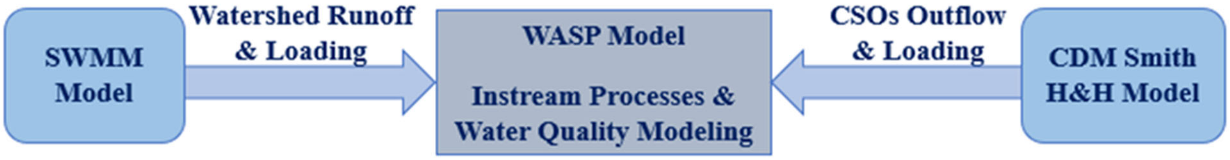

Figure 5.3-1: Paxton Creek Modeling Framework

5.3.1 Watershed Model

The watershed models were developed using the EPA Storm Water Management Model (SWMM version 5.1) platform (Rossman and Simon, 2022). Two separate SWMM models were developed to estimate the surface runoff and loading from the contributing area to Paxton Creek. The first SWMM model was used to simulate the Wildwood Lake outflows into Paxton Creek, while the second SWMM model (referred to as Separate Sewer Area SWMM) was used to simulate the stormwater runoff from CRW's separately sewered area into Paxton Creek. The stormwater bacteria and BOD5 load were calculated by the SWMM model using a land-use-based, event mean concentration approach described in Section 5.2 of the WQMP.

5.3.2 Instream Model

The WQMP states that the Paxton Creek instream model will be developed using the US EPA SWMM and Water Quality Analysis Simulation Program (WASP) to simulate hydraulics and water quality, respectively. Per the WQMP Addendum, CRW used only the WASP (version 8.4.0) model for Paxton Creek for simulating both hydraulics and water quality instead of the SWMM-WASP combination described in the WQMP.

The Paxton Creek instream model extends from the outlet of Wildwood Lake at the Morning Glory outlet to the confluence of Paxton Creek with the Susquehanna River (**Figure 5.2-1**). The Paxton Creek WASP model inputs and data sources include:

- Upstream flow: Wildwood Lake SWMM model
- Upstream concentration: Measured data at Station P1
- Stormwater flow and pollutant loading: Separate Sewer Area SWMM model and measured data at station SS-1
- CSO flow and pollutant loading: H&H model
- Stream characteristics: HEC-RAS model (USACE, 2021)

The instream model is currently set up to simulate the hydraulics, bacteria, DO and BOD levels in Paxton Creek based on the above inputs.

The hydraulic calibration was completed by comparing the simulated and measured water surface elevation at the four depth sensor locations since no flow data was available. **Figure 5.3-2** shows the comparison of measured and simulated water surface elevation at station P4 from September 15 to

October 20, 2023. The model predicted water surface elevations shows reasonable agreement during both high and low flow conditions.

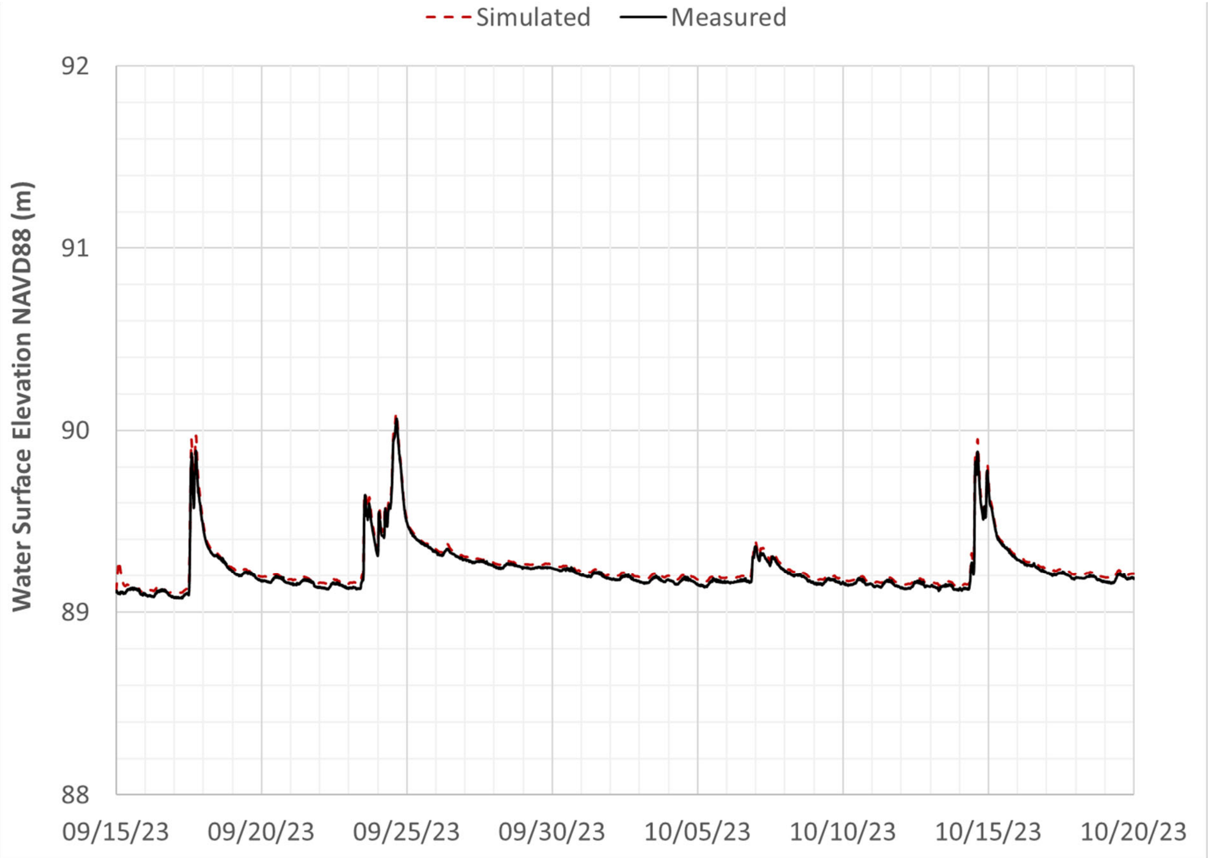

Figure 5.3-2: Comparison of Measured and Simulated Water Surface Elevation in Paxton Creek at Station F1 for the Period of September 15 to October 20, 2023

Preliminary calibration of the model was completed for bacteria using data from the monitoring events on September 23 and October 14, 2023. The calibration will be updated once additional data are collected. **Figure 5.3-3** and **Figure 5.3-4** show a scatter plot of the model simulated and measured *E. coli* and fecal coliform levels, respectively. The measurements for the September 23 event are capped at 2,420 MPN/100 mL). The 1:1 line (center dotted line) in each plot represents what would be an exact match between the simulated and measured concentrations. The other two dotted gray lines represent the lower and upper limits of the acceptable range for the bacteria level simulations where the simulated results are within one order of magnitude of the measured results. These results show that the model predicts measured bacteria levels within one order of magnitude, which meets the calibration target described in the WQMP. The instream model was validated using bacteria data from 2020 and 2021 collected by the Lower Susquehanna Riverkeeper (LSRK).

Preliminary calibration of model for DO was conducted by comparing the simulated DO with continuous DO data measured at Station F1. The results of the DO calibration are presented in **Figure 5.3-5**. The comparison indicates that the model reasonably captured the mean DO in Paxton Creek. The model is not able to capture the diurnal DO fluctuation since it does not include the impact of the plant and algal growth in Paxton Creek. The measured data shows a significant drop in the DO concentration on

October 7, 2023. However, the simulated DO concentrations showed the opposite trend, with increased DO during this period. Due to limited boundary condition data, the DO and BOD model calibration is considered preliminary. Refinement of the calibration will be pursued once additional measured data are collected in 2024.

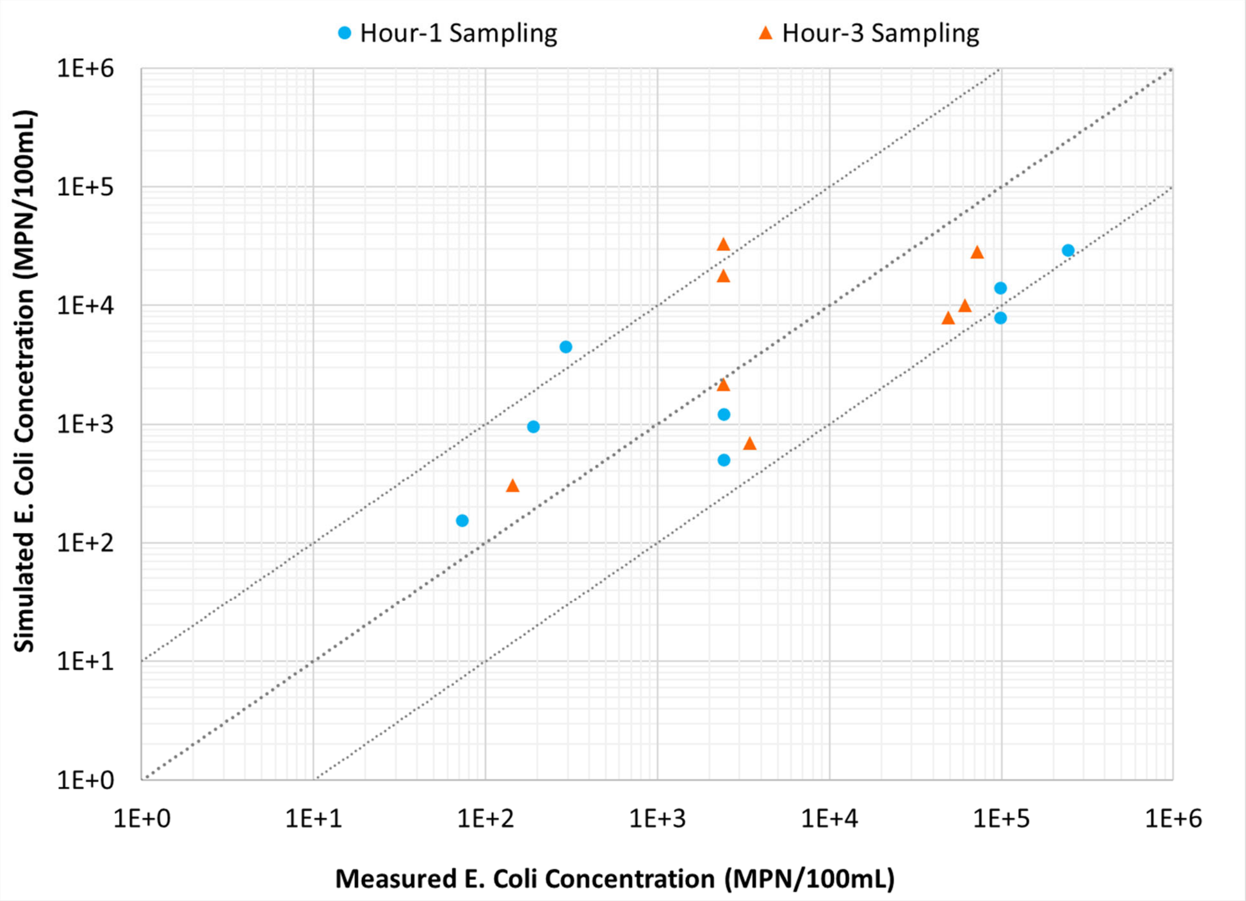

Figure 5.3-3: Comparison of Measured and Simulated E. coli Levels in Paxton Creek in 2023

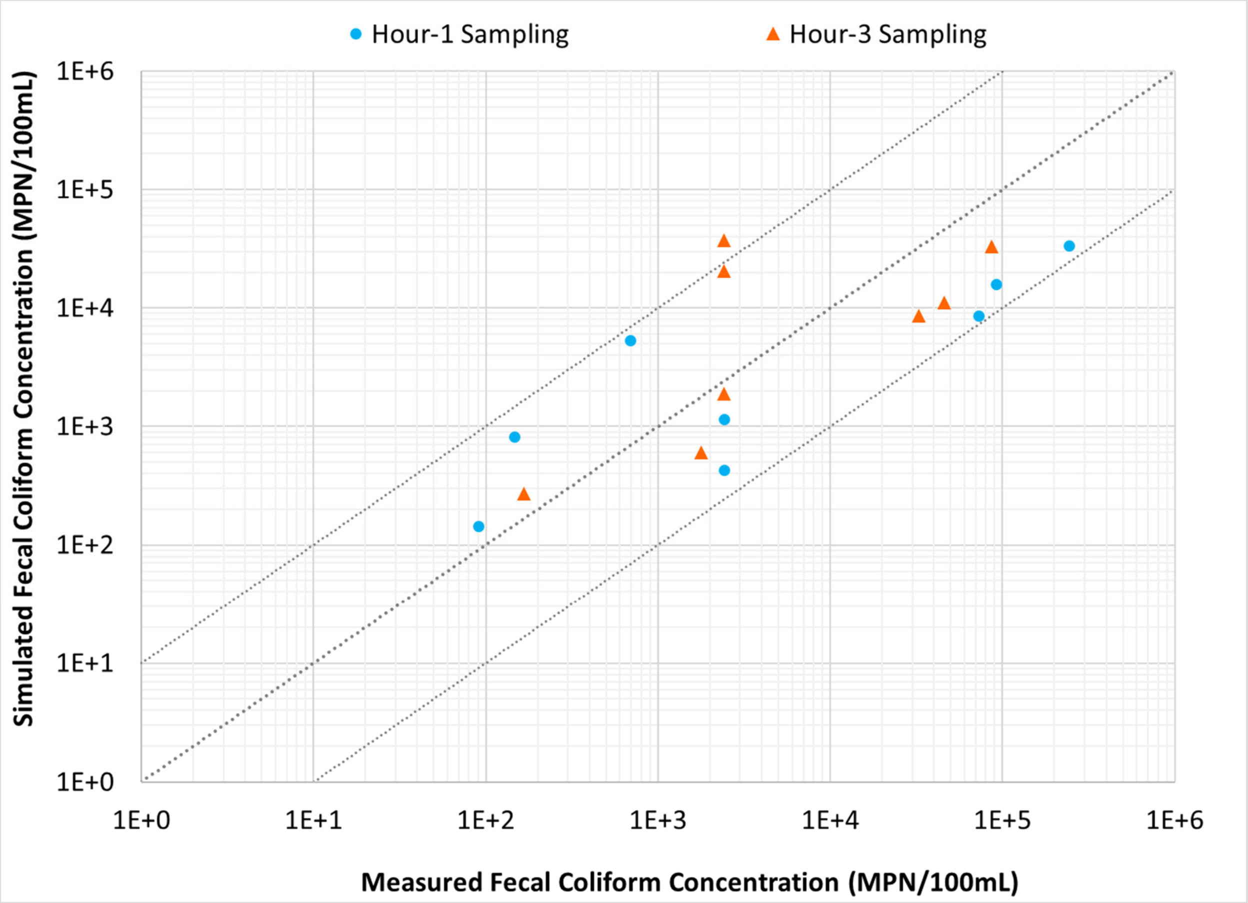

Figure 5.3-4: Comparison of Measured and Simulated Fecal Coliform Levels in Paxton Creek in 2023

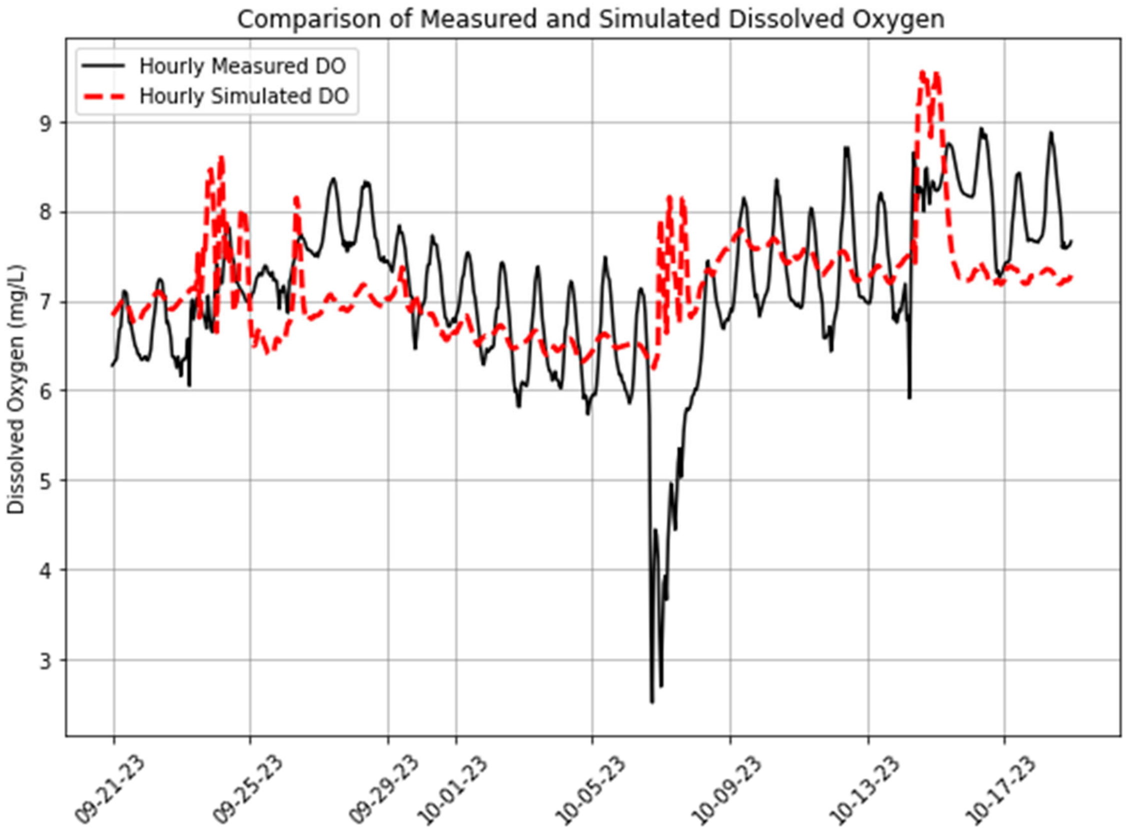

Figure 5.3-5: Comparison of Measured and Simulated DO Levels at Station F1 in Paxton Creek in 2023

5.4 Susquehanna River Model Development

CRW developed a two-dimensional (2D) model for the Susquehanna River to meet the objectives in Section 4.1 of the WQMP. The 2D model was developed using the Environmental Fluid Dynamics Code (EFDC) modeling platform. The EFDC model is capable of simulating near- and far-field lateral mixing in partially mixed systems like the Susquehanna River.

The 2D model domain starts from Rockville Bridge and ends at the Harrisburg City limits, immediately downstream of the confluence where Paxton Creek joins the Susquehanna River (**Figure 5.4-1**). Flow and pollutant loading from Paxton Creek are not considered in the Susquehanna River model.

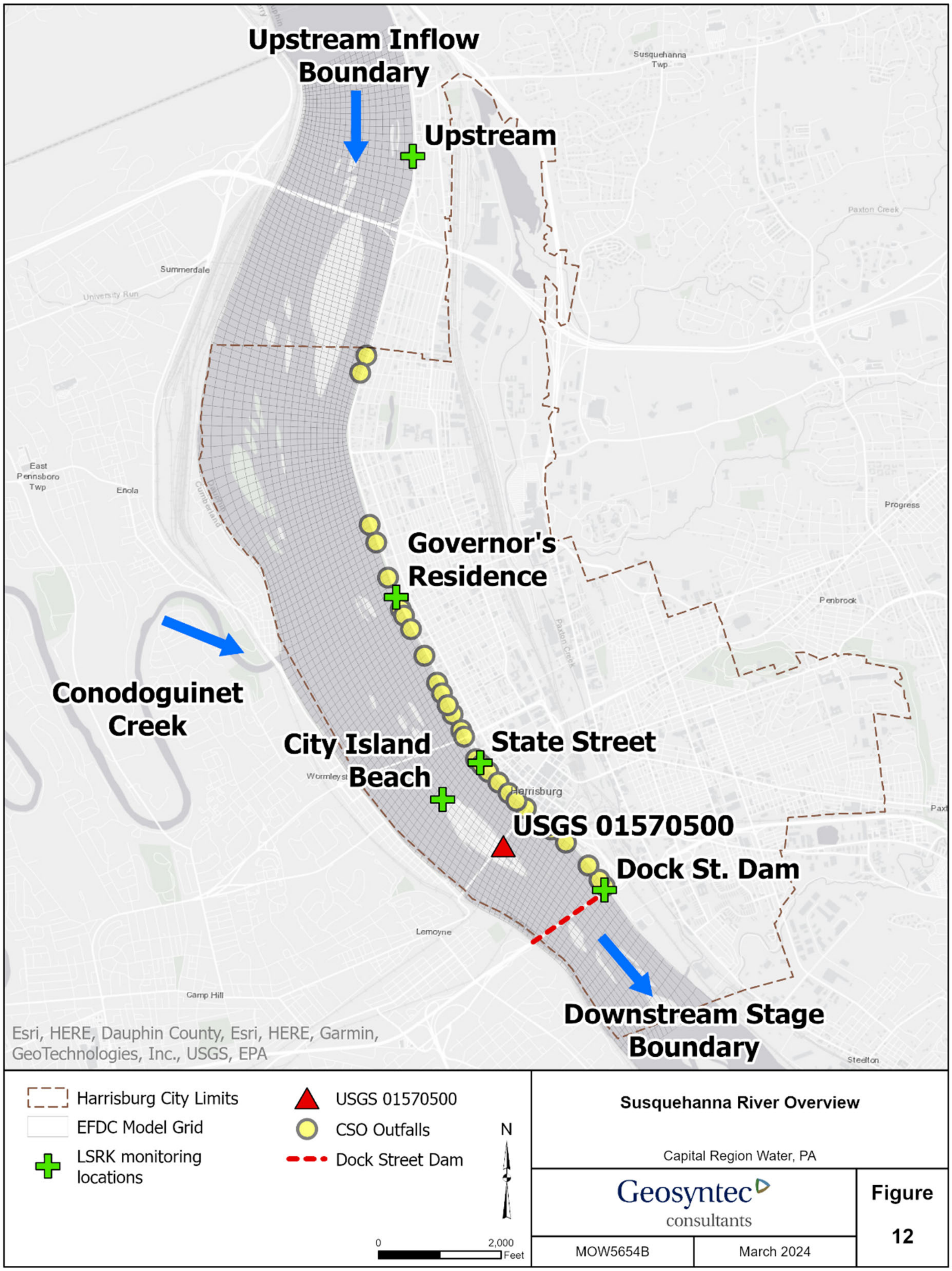

Figure 5.4-1: Susquehanna River Model Domain and Inputs

The 2D model inputs and data sources include the following:

- Upstream flow: Estimated based on measured flow data at USGS 01570500 Susquehanna River at Harrisburg, PA
- Upstream concentration: Measured concentration data from the CRW program for the calibration periods, and from LSRK for the validation periods.
- Conodoguinet Creek inflow: Measured data at USGS 01570000 Conodoguinet Creek Near Hogestown, PA
- CSO discharge flow and concentrations: CRW H&H model
- Rating curve at Dock St. Dam: Based on the HEC-RAS model for the Susquehanna River (Roland et al., 2014)
- Rating curve at the Downstream Boundary: Based on the HEC-RAS model for the Susquehanna River (Roland et al., 2014)

The EFDC model was calibrated to measured water surface elevation at USGS 01570500 Susquehanna River at Harrisburg. **Figure 5.4-2** shows the comparison of measured and simulated water surface elevation at USGS 01570500 from September 15 to October 20, 2023. The simulated WSE matches the measured data closely with an R^2 value of 0.99 and standard error of 0.01 m.

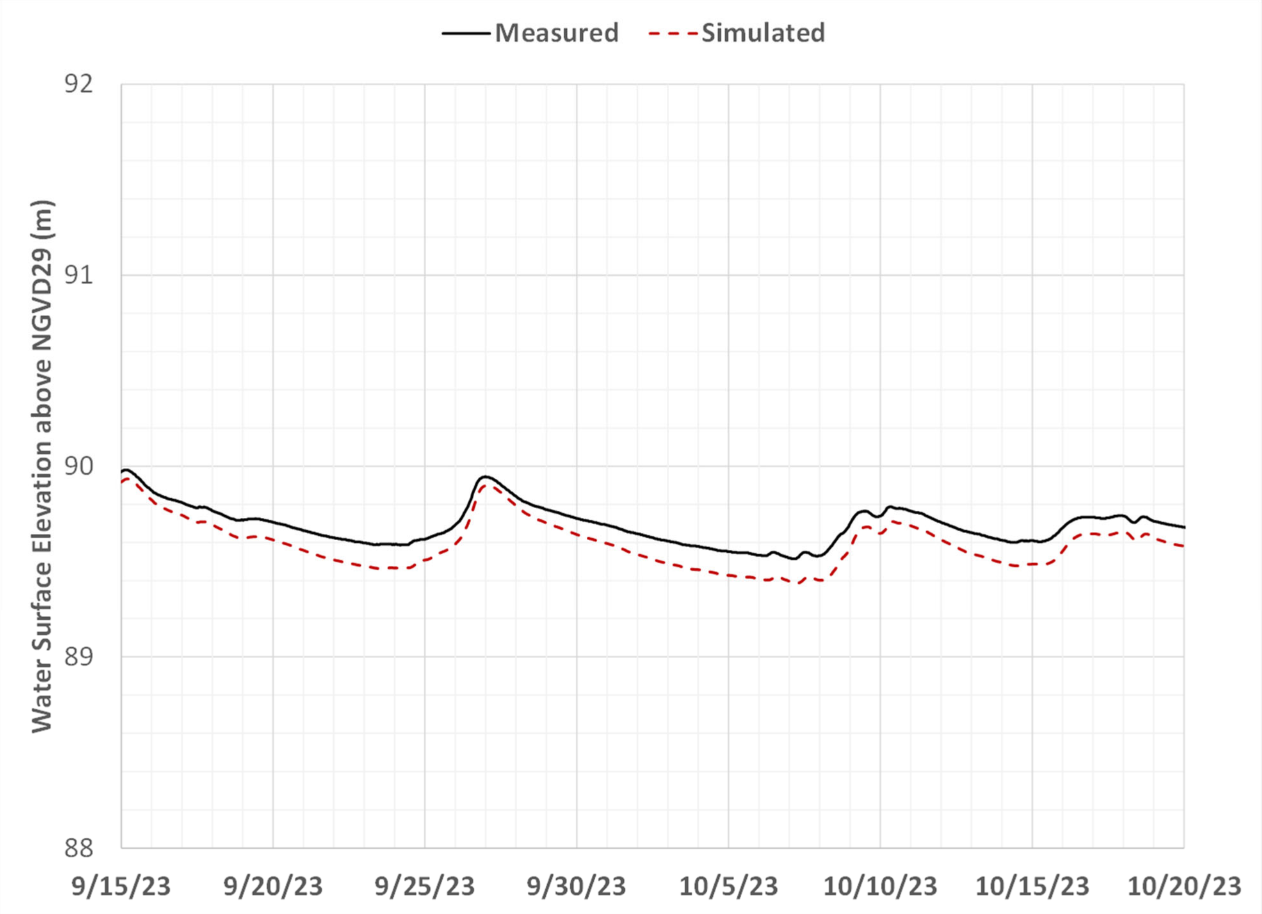

Figure 5.4-2: Comparison of Simulated and Measured Water Surface Elevation at USGS 01570500 Susquehanna River at Harrisburg from September 15 to October 20, 2023

For water quality calibration, all sample measurements were mapped to the nearest EFDC cells based on their sampling locations. Subsequently, simulated results at the corresponding sampling times were extracted and compared with the measured data. Water quality measurements collected at the most upstream transect station were used as upstream boundary condition. Hour-1 and Hour-3 water quality data collected along the east and west transects on Oct. 14, 2023, were used for model calibration.

Figure 5.4-3 and **Figure 5.4-4** present the comparison of simulated and measured concentrations for *E. coli* and fecal coliform, respectively. Measured data reported as "non-detects" are assumed to have concentrations equal to half of the detection limits. The two black vertical dashed lines represent one-half of the minimum detection limit for the eastern transect (100 MPN/100 mL) and western transect (10 MPN/100 mL), respectively. For the 2023 calibration period, 112 out of 122 comparisons for *E. coli* and 119 out of 122 comparisons for fecal coliform are within the acceptable range of one order of magnitude, which indicates very good agreement of model simulation with measured data.

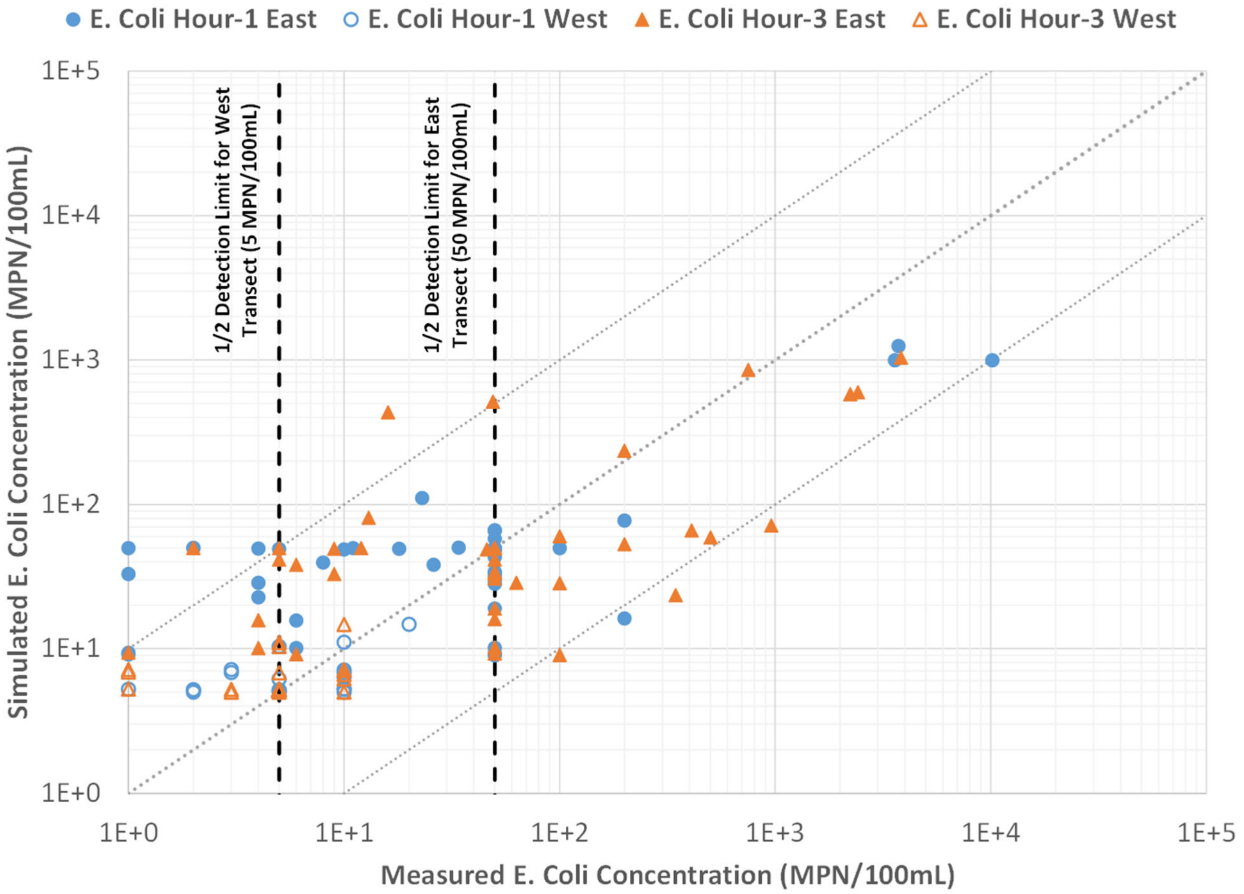

Figure 5.4-3: Comparison of Simulated and Measured E. coli Levels in 2023

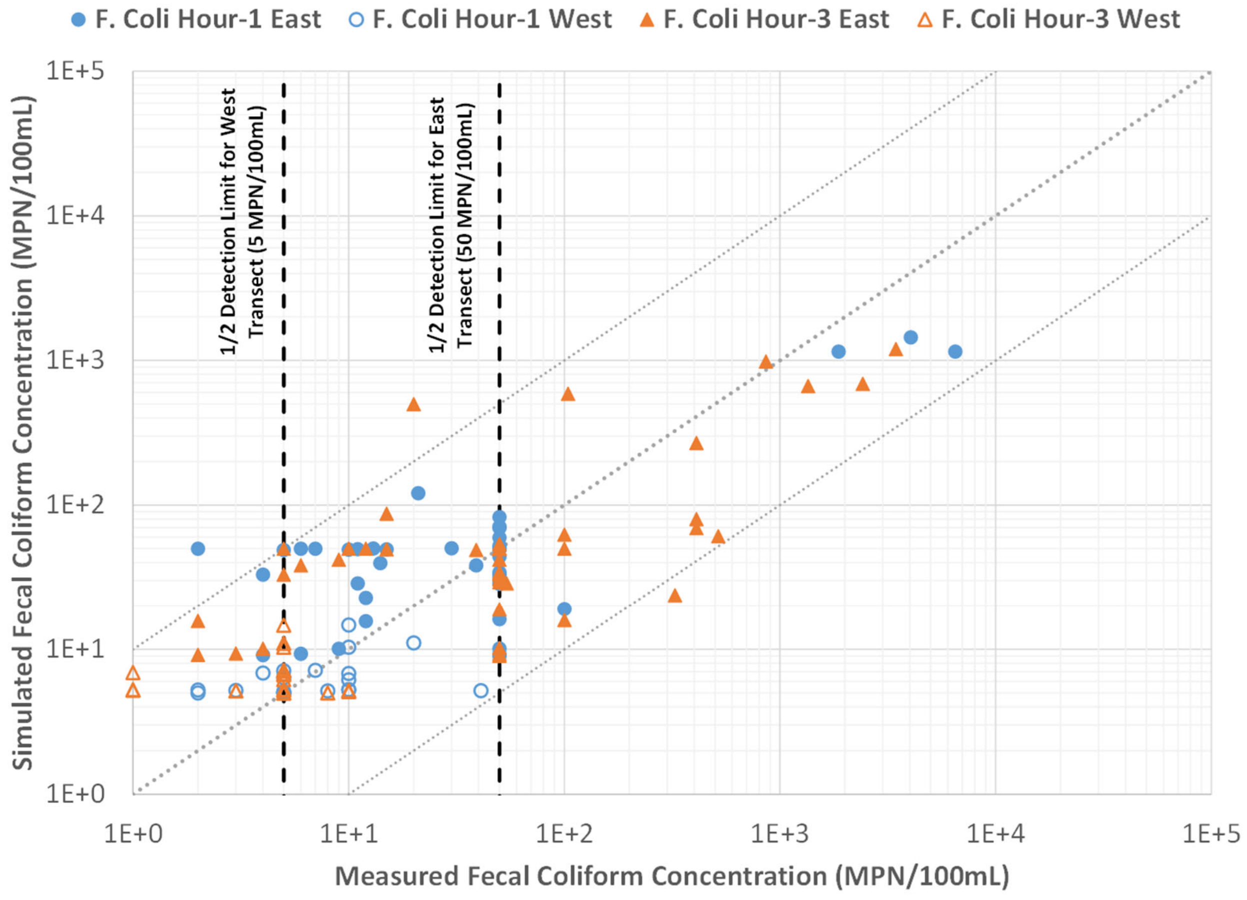

Figure 5.4-4: Comparison of Simulated and Measured Fecal Coliform Levels in 2023

5.5 Water Quality Metrics for Evaluating Alternatives

The instream model results for bacteria and dissolved oxygen were analyzed to assess compliance with applicable water quality standards for baseline conditions and proposed CSO alternatives. This analysis was conducted using the Typical Year precipitation dataset, as defined in the MPCD. CRW determined the Typical Year to be the rainfall data from October 2011 through September 2012, adjusted to match the event volumes and peak intensities over the long-term record (CRW, 2018b). The applicable water quality standards and metrics for evaluating the CSO alternatives are described below.

5.5.1 Bacteria

The current water quality standards for bacteria are described in Specific Water Quality Criteria in § 93.7 of the Pennsylvania Code:

> *(Escherichia coli colony forming units per 100 milliliters (CFU per 100 ml)) During the swimming season (May 1 through September 30), the maximum E. coli level shall be a geometric mean of 126 CFU per 100 ml. The geometric mean for the samples collected in the water body should not be greater than 126 CFU per 100 ml in any 30-day interval. There should not be greater than a 10% excursion frequency of 410 CFU per 100 ml for the samples collected in the same 30-day duration interval. (Fecal coliforms/100 ml) For the remainder of the year, the maximum fecal coliform level shall be a geometric mean of 2,000 CFU per 100 ml based on a minimum of five consecutive samples collected on different days during a 30-day period.*

The instream models for Susquehanna River and Paxton Creek were run for typical year conditions assuming the upstream boundary condition to be at 75 percent of the geometric mean water quality criterion following the requirements in the MPCD. The simulated timeseries of *E. coli* and fecal coliform corresponding to each model cell (or segment) for the Typical Year, reported at a frequency of 10 minutes, were used to assess compliance with geometric mean and statistical threshold value criteria described above. The timeseries was used to simulate a sampling program for each model cell (or segment) consisting of ten random samples over a period of 30 days. This process was repeated was repeated 50,000 times in a random sampling approach to get distribution of sampling iterations within the Monte Carlo analysis.[14] The geometric mean and number of samples less than the statistical threshold value criterion were calculated for each iteration. The cell (or segment) was determined to be meeting water quality criteria if it met the bacteria criterion (*E. coli* geometric mean below 126 cfu/100 mL; 9 out of 10 samples below 410 cfu/100 mL) in over 99 percent of sampling iterations based on 25 Pa. Code § 96.3 (c).

An example application of the random sampling approach for the Susquehanna River model results for the Typical Year is shown in **Figure 5.5-1**. This figure shows compliance with the statistical threshold value criterion of 410 cfu/100 mL. These results show that exceedances of water quality criteria during the Typical Year that are caused by CRW's CSO discharges are limited to a distance of 150 to 700 ft from Susquehanna River shoreline and do not impact City Island. Similar results are shown in **Figure 5.5-2** for Paxton Creek. The model results show that CSO discharges cause exceedances of current water quality standards downstream of river mile 2.5 in Paxton Creek during the Typical Year baseline conditions.

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[14] The random sampling approach was used to sample ALCOSAN's receiving water model for comparison to water quality standards (ALCOSAN, 2019 – p. 5-111).

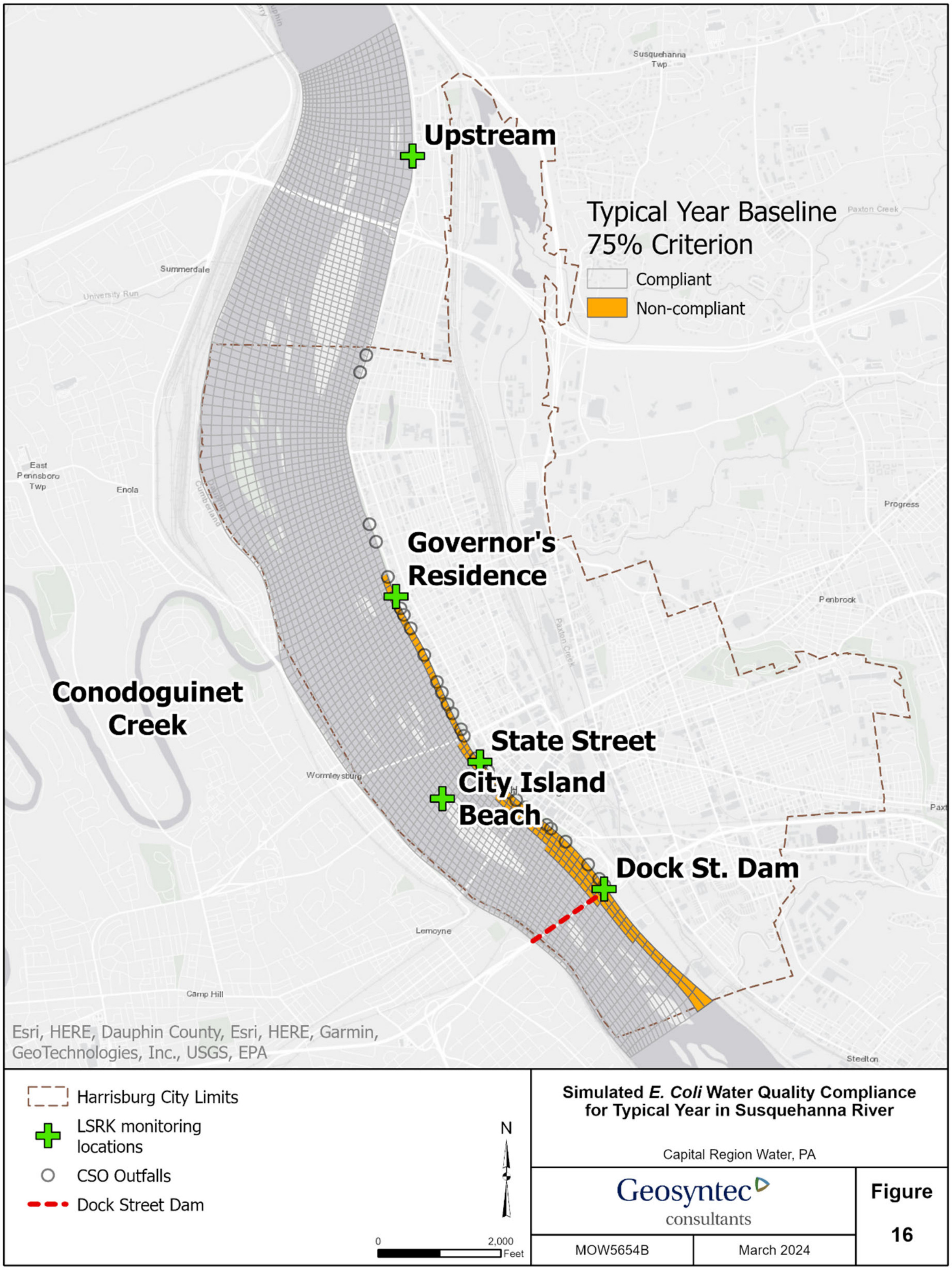

Figure 5.5-1: Simulated Compliance with *E. coli* Water Quality Standard for Typical Year Conditions in the Susquehanna River

REACH	RIVERMILES	CSOs	PERCENT ATTAINMENT
REACH_1	4.84		🟩
REACH_2	4.69		🟩
REACH_3	4.54		🟩
REACH_4	4.39		🟩
REACH_5	4.24		🟩
REACH_6	4.09		🟩
REACH_7	3.94		🟩
REACH_8	3.79		🟩
REACH_9	3.66		🟩
REACH_10	3.50	CSO- 21	🟩
REACH_11	3.34		🟩
REACH_12	3.19		🟩
REACH_13	3.08	CSO- 22	🟩
REACH_14	2.91		🟩
REACH_15	2.74		🟩
REACH_16	2.59		🟩
REACH_17	2.48	CSO- 23 & 24	🟩
REACH_18	2.30	CSO- 25, 26, 27, & 28	🟧
REACH_19	2.01	CSO- 29 & 30	🟧
REACH_20	1.91	CSO- 31	🟧
REACH_21	1.81	CSO- 32 & 33	🟧
REACH_22	1.72	CSO- 34 & 37	🟧
REACH_23	1.58	CSO- 38	🟧
REACH_24	1.49	CSO- 39, 40, & 41	🟧
REACH_25	1.39	CSO- 42, 43, & 59	🟧
REACH_26	1.20	CSO- 44	🟧
REACH_27	1.07	CSO- 45 & 46	🟧
REACH_28	0.95		🟧
REACH_29	0.85	CSO- 48	🟧
REACH_30	0.72		🟧
REACH_31	0.65	CSO- 60 & 61	🟧
REACH_32	0.52		🟧
REACH_33	0.42	CSO- 62, 63, & 64	🟧
REACH_34	0.14		🟧
REACH_35	0.08		🟧

Figure 5.5-2: Simulated Compliance with E. coli Water Quality Standard for Typical Year Conditions in the Paxton Creek

5.5.2 Dissolved Oxygen

Paxton Creek is designated for Water Fishes Use, and the numeric criterion for DO in such waterbodies is defined in the Specific Water Criteria in Ch 93.7 of the Pennsylvania Code as:

> *For flowing waterbodies, 7-day average 5.5 mg/L; minimum 5.0 mg/L*

The water quality compliance was assessed by comparing the simulated timeseries of instream DO in Paxton Creek for the typical year with the above criterion.

5.6 References

ALCOSAN. 2019. ALCOSAN's Clean Water Plan. September 2019. https://www.alcosan.org/clean-water-plan/plan-documents/clean-water-plan-docs

CRW. 2018a. Separate Sanitary Sewer Capacity Assessment Report, Version 2. Capital Region Water, February 2018

CRW. 2018b. City Beautiful H2O Program Plan. Capital Region Water. March 29, 2018.

CRW. 2023a. Water Quality Modeling Plan for Capital Region Water. Developed by CDM Smith for Capital Region Water. February 2023

CRW. 2023b. Water Quality Modeling Plan Addendum. Developed by Geosyntec Consultants for Capital Region Water. May 2023

CRW. 2023c. Water Quality Monitoring Plan and Quality Assurance Project Plan. Developed by Geosyntec Consultants for Capital Region Water. June 2023

CRW. 2024. Water Quality Monitoring and Modeling Report. Developed by Geosyntec Consultants for Capital Region Water. February 2024

Rossman and Simon, 2022. Stormwater Management Model User's Manual Version 5.2. Office of Research and Development, US Environmental Protection Agency

Roland, M. A., Underwood, S. M., Thomas, C. M., Miller, J. F., Pratt, B. A., Hogan, L. G., & Wnek, P. A. (2014). Flood-Inundation Maps for the Susquehanna River near Harrisburg, Pennsylvania, 2013. Reston, Virginia: U.S. Geological Survey.

USACE. 2021. Hydraulic Modeling Technical Summary Document for Paxton Creek. Prepared by the United States Army Corps of Engineers, Baltimore District, for the Federal Emergency Management Agency (FEMA). January 2021

6.0 Mixed Technology Alternatives to Achieve Water Quality Compliance

This report section describes the mixed technology alternatives evaluated for the Alternatives Analysis. The Modification to Partial Consent Decree[15] (MPCD) requires CRW to "assess the technical feasibility of the use of a wide range of demonstrated combined sewer overflow (CSO) control technologies in the Combined Sewer System that can be applied individually or in combination in each CSO-specific tributary area." The MPCD requires CRW to assess the feasibility of the following specific technologies:

- Source Controls (e.g., Green Stormwater Infrastructure)
- Collection System Controls
- Storage Technologies
- Rainfall Dependent Infiltration and Inflow (RDII) Reduction Technologies for tributary separate sanitary sewers
- Treatment Technologies

In Section 4 of this Alternatives Analysis Report, the best performing individual technologies with respect to CRW's system were identified. It is inefficient and not feasible to meet the requirements in the MPCD using just one of the individual technologies. Therefore, the individual technologies are combined to develop the mixed technology alternatives (MTAs) and evaluate performance.

This section is organized as follows:

- **Section 6.1** describes the methodology used to develop the MTAs.
- **Sections 6.2 through 6.9** describe each individual MTA.
- **Section 6.10** relates the preliminary water quality modeling described in Section 5 to the level of control (LoC) required for each MTA to meet current water quality standards.
- **Section 6.11** summarizes the MTAs and applies evaluation criteria.

Additionally, the following appendices supplement the information presented in this report section:

- **Appendix 2 – Project Cost Summary Tables:** details the cost information for individual projects included in each Mixed Technology Alternative control point.
- **Appendix 3 – Performance Graphics:** summarizes the performance of each Mixed Technology Alternative control point, including CSO statistics, facility sizing information for individual catchments, and costing information for individual catchments.

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[15] Modification to Partial Consent Decree, United States of America and Commonwealth of PA Dept. of Environmental Protection, Plaintiffs, v. Capital Region Water and the City of Harrisburg, PA, Defendants, effective August 25, 2023.

6.1 Development of Mixed Technology Alternatives

In Section 4 of this *Alternatives Analysis Report*, the best performing individual technologies with respect to CRW's system were identified. Green stormwater infrastructure (GSI), satellite storage, screening and disinfection, retention treatment basins, small-scale sewer separation, and small-scale conveyance enhancements are the most effective and cost-effective using the criteria identified in Section 4.8. These individual technologies were combined to develop the mixed technology alternatives (MTAs), which are the alternatives from which CRW will select a preferred alternative.

The following principles were applied in the development of the MTAs:

- Evaluate a wide range of wet weather control technologies.
- Exclude technologies found to be infeasible or impractical.
- Combine best performing technologies in a synergistic manner to achieve greater performance.
- Consider multiple degrees of catchment/outfall consolidation.
- It is assumed that some components of the Paxton Creek Greenway will move forward, which will provide opportunities for additional sewer separation and the placement of gray infrastructure. Please refer to Section 3.3 for a description of the greenway project.

Green Stormwater Infrastructure (GSI) is CRW's preferred approach for managing flows/pollutants within the collection system. All MTAs include a significant portion of GSI implementation. Section 6.1.1 provides a more detailed explanation for the utilization of GSI.

Table 6.1-1 summarizes the individual components that are included in each MTA, which are detailed in Sections 6.2 through 6.9. Sections 6.1.1 through 6.1.3 describe how the technologies are "layered" in each MTA.

Table 6.1-1. Components of Mixed Technology Alternatives

Single Technology	Mixed Technology Alternatives							
	1	2	3	4A	4B	5	6	7
Green Stormwater Infrastructure	✓	✓	✓	✓	✓	✓	✓	✓
Satellite Storage	✓	✓	✓	✓	✓	✓	✓	✓
Decentralized Sewer Separation	✓	✓	✓	✓	✓	✓	✓	✓
Enhanced Conveyance	✓						✓	
Tunnel Storage						✓		
Screening and Disinfection			✓	✓				
Retention Treatment Basin			✓	✓			✓	

It is worth noting again that the use of RDII reduction technologies was screened out in Section 2 because the satellite suburban communities served by CRW are already implementing RDII reduction programs. Within CRW's separate sanitary sewershed areas, CRW is planning to complete multiple capital projects to reduce RDII, including the CSO-48 stormwater diversion (explained in Section 3.5), Arsenal Boulevard Sewer Rehabilitation, and Spring Creek Interceptor rehabilitation. In Section 4, some technologies were found to be infeasible or not cost-effective, including high-rate clarification, high-rate filtration, systemwide sewer separation, and large-scale conveyance improvements. All the other control technologies are included in the MTAs.

The MTAs are built on top of the Appendix B projects and have many common components. **Table 6.1.1** shows some of the common as well as specific components in each of the alternatives. The high performing alternatives were identified and further refined. For example, MTA-4 was refined with two set of configurations (MTA-4A and MTA-4B).

6.1.1 Appendix B Project List ("First Control Point"):

All MTAs include the Appendix B projects.[16] These projects, required by the MPCD, were described in Section 3. As a result of these projects, the total annual overflow volume, under typical year precipitation conditions, is expected to decrease from 796 million gallons (MG) under Pre-Plan conditions to 331 MG. The corresponding annual overflow frequencies at each of the individual CSO outfall pipes are expected to decrease from up to 95 overflows per year under existing conditions to a range of 6 to 60 overflows. Typical year annual CSO discharge volumes and frequencies corresponding to Pre-Plan conditions and the completed Appendix B project list were shown in **Figures 3.4** and **3.5**, respectively. The CSO discharge statistics associated with the completion of the Appendix B Projects are shown graphically in **Figures 6.1-1 and 6.1-2**.

The height of the empty bars indicates the reduction in typical year CSO frequency at each individual CSO outfall. For example, the completed Appendix B projects reduced the annual CSO discharge frequency for CSO-14 along the Susquehanna River from 86 to 16 overflows per year and reduced the frequency for CSO-31 along Paxton Creek from 79 to 20 overflows per year.

The intensity of the colors indicates the relative volumes of the individual CSO discharges. For example, with the completed Appendix B projects for CSO-10 along the Susquehanna River, only one CSO event has a discharge volume greater than 1 MG, and four of the events have volumes from 0.5 to 1.0 MG, and so on. Comparing the Pre-Plan and post-Appendix B figures provides a visual representation of the CSO reductions provided.

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[16] Appendix B of the MPCD is a list of required priority remedial projects with a schedule of start and completion dates

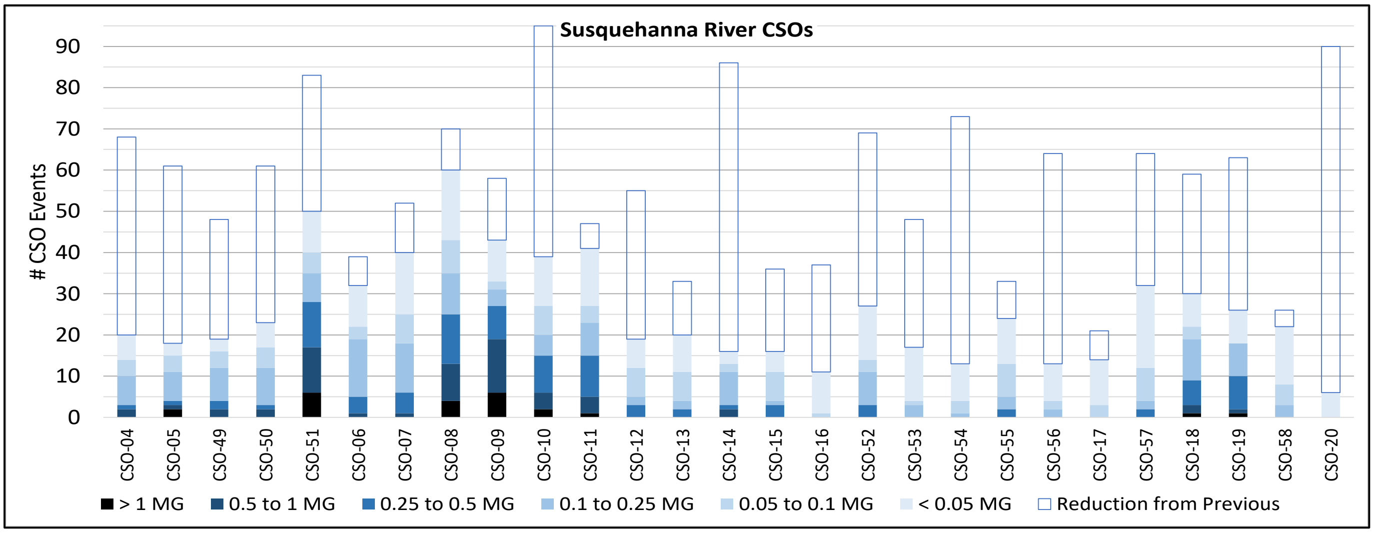

Figure 6.1-1: Frequency and Volume Reductions for Susquehanna River CSOs under Appendix B Conditions

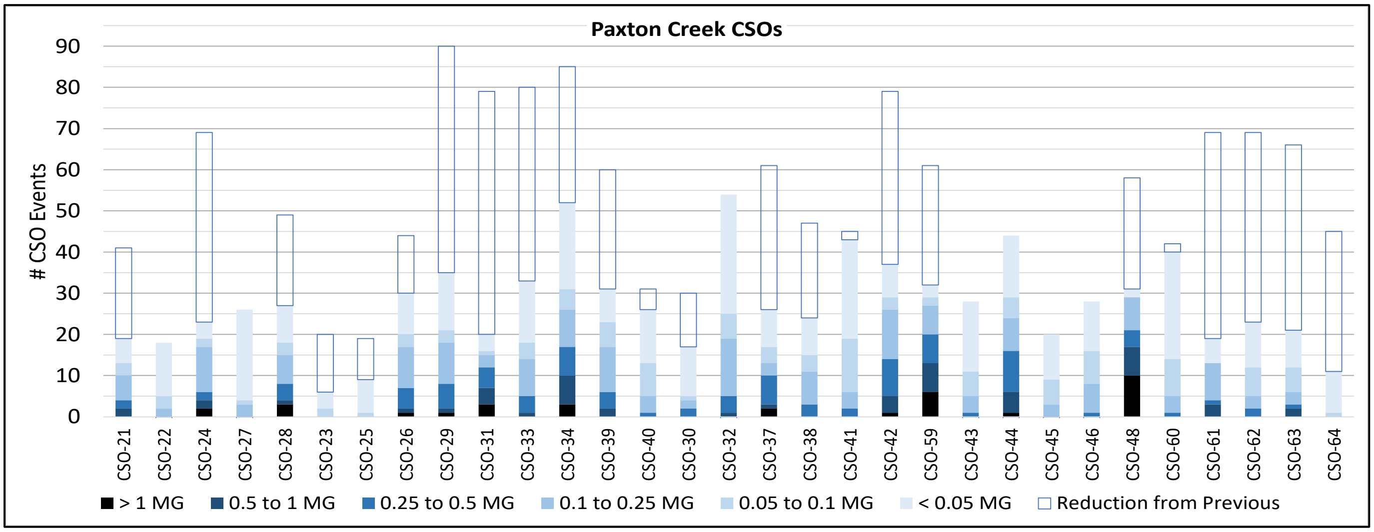

Figure 6.1-2: Frequency and Volume Reductions for Paxton Creek CSOs under Appendix B Conditions

6.1.2 Green Stormwater Infrastructure

In Section 4, the single technology analyses show GSI to be one of the best performing technologies. CRW will maximize the use of GSI where reasonably practicable due to the following advantages:

- GSI works in series with and complements gray infrastructure by reducing the facility sizes required for gray infrastructure offsetting much of the additional GSI cost.
- Except for sewer separation (which was found to not be cost-effective at a systemwide scale), GSI is the only technology that reduces collection system flooding (potential basement flooding and surface flooding). Controlling "Unauthorized Releases" of wastewater at a location other than a CSO outfall is a MPCD requirement.
- GSI is scalable and easier to implement than gray infrastructure within the urban landscape.

- GSI helps with pollutant mass reduction by keeping pollutants out of the combined sewer system.
- GSI achieves co-benefits, including significant community benefits as noted in Section 4, for Harrisburg's residents and businesses.

Each MTA includes a total of 294 impervious acres from which wet weather runoff will be managed by GSI, and implemented within seven design and construction phases, as described below:

- Completed Phase 1 and 2 GSI projects total approximately 10 acres (7.6 acres in the combined sewer system; 2.6 acres in the municipal separate storm sewer system). These costs are not included in future cost estimates.
- Appendix B project list includes 101 acres of GSI.
    - Approximately 31 acres are already completed (Phase 3 and 4). These are not included in future cost estimates.
    - Approximately 70 acres remain to be completed (phases 5 through 7). These are included in future cost estimates.
- Beyond the Appendix B project list, an additional 183 acres are strategically targeted and distributed systemwide. These are included in future cost estimates.

Distribution for Additional GSI Projects: As mentioned above, CRW will maximize GSI projects due to cost-effectiveness and other benefits offered by GSI. Three factors were used to identify the best potential locations for the GSI facilities. Where is the GSI most effective? Where is the GSI most needed? Where are the best available GSI opportunities? The H&H model was used to quantify the CSO control impacts of the GSI facilities and to determine the most effective and efficient locations for GSI facilities.

The following explains how the extent of this additional GSI (beyond Appendix B) was determined.

- As part of CRW's 2017 *Community Greening Plan,*[17] each parcel and street within the City of Harrisburg were assigned feasibility rankings from 0 to 7, where 7 is the easiest to implement.
- Additionally, CRW conducted an in-depth analysis to identify potential GSI projects within three priority planning areas: Uptown, Lower Front Street, and Lower Paxton Creek.[18]

The two datasets were used to identify "ease of implementation" of GSI within the combined sewer system. The impervious area that was assigned a feasibility ranking greater than or equal to 5, or any additional projects identified in the priority planning area analysis, are identified as potential GSI opportunities. Additionally, the assumed distribution was intended to efficiently utilize GSI projects. Therefore, any catchments with relatively low overflow frequencies were not considered for additional GSI.

Figure 6.1-3 shows the assumed GSI distribution. The same distribution is used for all MTA facility maps. The percent of managed impervious area is indicated in green shading (darker green indicates a higher percentage of managed impervious area). This shows the level of GSI varies for each catchment.

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[17] Community Greening Plan, Capital Region Water, January 2017.
[18] Community Greening Plan 2.0, Capital Region Water, October 2021.

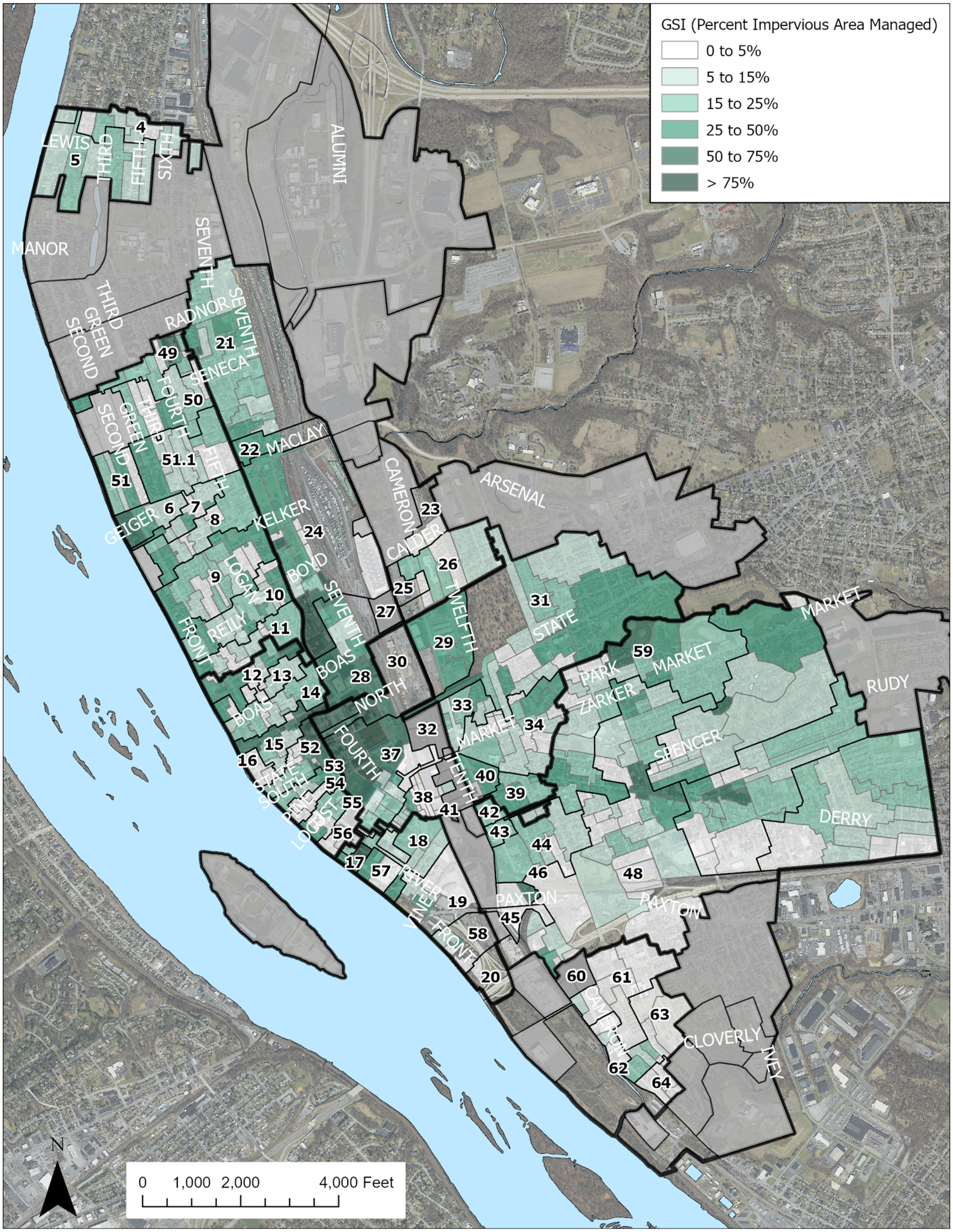

Figure 6.1-3: Distribution of GSI Control Facilities

For example, the Capitol Complex has a relatively higher percentage of managed impervious area because public properties received a higher feasibility ranking in the Community Greening Plan. The Hemlock Street planning area has a relatively lower percentage of managed impervious area because poor soil hydrology received a lower feasibility ranking. Catchment areas for CSO-12 through CSO-16 along the Susquehanna River have a lower percentage of managed impervious area because the Appendix B projects significantly reduce the annual CSO frequency and less GSI control is needed.

6.1.3 Sewer Separation Opportunities

Small-scale sewer separation is primarily utilized within the Paxton Creek corridor under the following criteria:

- The catchment (or portion of a catchment) is relatively small and can be cost-effectively separated (i.e., few connections and less dense sanitary/storm systems).
- The required volume to control is too small for a feasible/cost effective satellite storage tank or treatment facility.
- Rather than utilizing sewer separation, small volumes can be consolidated with a nearby facility (e.g., if a tunnel or consolidation sewer passes by a potential sewer separation candidate, it may be more feasible to connect to the tunnel or consolidation sewer). In these instances, sewer separation was not utilized.
- For catchments with small volumes that are isolated away from other consolidated facilities, sewer separation is considered.
- Additional consideration is given to areas that may be redeveloped as part of the Paxton Creek Greenway. All redevelopment within sewershed areas adjacent to Paxton Creek will be required to separate their sanitary and storm systems.

6.1.4 Gray Infrastructure Facilities

While the technologies in sections 6.1.2 and 6.1.3 effectively reduce the number of annual overflow events needed to reach each target LoC, they fall short of achieving the entire volume reduction goal. The remaining volumes to achieve each LoC are controlled by either tunnel storage, satellite storage, or satellite treatment. For large volumes/flows from an individual catchment, a dedicated storage/treatment facility may be feasible, but smaller volumes/flows from individual catchments are grouped together with a network of consolidation sewers. The MTAs explained in subsequent sections include various combinations of storage and treatment projects and different degrees of catchment/outfall consolidations. Regarding specific types of treatment technologies, high-rate clarification and high-rate filtration were screened out in Section 4. As explained in Section 4, screening and disinfection is the preferred treatment technology for Susquehanna River CSO outfalls and retention treatment basins are the preferred treatment technology for Paxton Creek CSO outfalls.

6.1.5 Levels of Control Descriptions Common to all Alternatives

The following levels of control are common to all the alternatives from Section 6.2 to 6.8.

Pre-Plan Conditions: Pre-Plan conditions reflect the performance of the CRW system, under typical year precipitation, when CRW assumed operation and maintenance (O&M) responsibilities for the wastewater and stormwater collection and conveyance systems in 2013.

First Control Point: The first control point reflects the LoC achieved by the projects that are either already completed or are required to be completed in accordance with the implementation schedule within MPCD Appendix B. The specific projects are described in Sections 1.3 and 3.

Second Control Point: The second control point would provide a systemwide LoC whereby every CSO outfall would have no more than 20 CSOs per year during typical year precipitation. This LoC is provided by the network of satellite treatment and/or storage facilities.

Third through Seventh Control Points: The number of satellite treatment and storage facilities and the associated treatment capacities and storage volumes are increased as required to provide a wide range of LoCs. Each of the alternatives evaluated within Section 6 provides the same LoCs. The third control point provides a systemwide LoC whereby every CSO outfall would have 16 or fewer CSO discharge events per year. The fourth control point provides a systemwide LoC of 10 or fewer CSO discharge events per year. Control points five through seven provide systemwide LoCs whereby every CSO outfall would have no more than five, two, or zero CSO discharge events per year, respectively. The locations, numbers, and sizes of the satellite storage facilities for each LoC are provided and depicted in the first figure and first table respectively in sections 6.2 to 6.8.

Appendix 2 provides a table and figures with the annual (typical year precipitation) CSO discharge frequency, volume, and duration of each individual CSO outfall for Pre-Plan conditions and each of the evaluated LoCs.

6.1.6 Cost Estimate Information

Appendix 1 – Basis of Costs provides a Project Cost Summary table of all the individual projects and facilities associated with each MTA and their associated cost. For each facility, the table columns provide the total construction cost; capital markups (engineering, administration, and legal costs); and land acquisition costs. Also included within the table is the present value of the series of O&M costs and the present value of the series of future renewal and replacement costs.

6.2 MTA-1: Enhanced Conveyance and Treatment

Mixed Technology Alternative 1 (MTA-1) includes hydraulic and process improvements at the advanced wastewater treatment facility (AWTF) to increase the peak wet weather capacity for primary treatment and disinfection. A system of decentralized satellite storage facilities is added, with an increasing number of facilities and storage volumes, to provide a wide range of LoCs. The storage facilities are located near the CSO regulator structures to capture volumes that would otherwise overflow into the receiving waters. Green stormwater infrastructure (GSI) facilities and sewer separation projects will further reduce the volume of stormwater runoff entering the combined sewer system. MTA-1 facilities are described below and their locations are shown in **Figure 6.2-1**. The number of satellite storage facilities for each LoC, and their corresponding storage volumes are provided in **Table 6.2-1**.

Details regarding the components included within MTA-1 are explained below:

Treatment Capacity: The peak wet weather capacity of the AWTF will be increased to 100 MGD, which includes the permitted bypassing of secondary treatment facilities. Improvements include adding an additional chorine contact tank and upsizing the piping from the headworks to the primary clarifiers and the outfall piping.

Conveyance Capacities: The peak wet weather capacity of the Front Street Pump Station will be expanded from 60 MGD to 80 MGD, so that the combined capacities of the Front Street and Spring Creek Pump Stations match the expanded capacity of the AWTF. This alternative utilizes the conveyance capacities along the Front Street and Paxton Creek Interceptors provided by the completion of the Appendix B projects.

Satellite Storage Facilities: For this alternative it is assumed that most of the satellite storage tanks are constructed underground along the interceptors and function as gravity-in/pumped-out facilities. A few gravity-in/ gravity-out storage tanks are included. To control the accumulation of solids and debris, the storage systems will be equipped with automated flushing mechanisms. New flow diversion structures will regulate the quantity of wet weather flow conveyed to the interceptor system and divert the excess wet weather flow to the storage tanks. A network of consolidation sewers will convey the wet weather flow from the flow diversion structures to the storage facilities. It is assumed that supervisory control and data acquisition (SCADA) systems and real time control (RTC) systems would optimize the dewatering of the storage vaults. See Section 4.5 for a more complete description of this control technology.

Green stormwater infrastructure: GSI facilities will be constructed at targeted locations throughout the combined sewer system to manage a total of 294 impervious acres. The GSI facilities will capture stormwater runoff near its source, prevent it from entering the combined sewer system, reduce the occurrence of "Unauthorized Releases" as they are defined in the MPCD, and reduce the required sizes of the satellite storage facilities.

Sewer Separation Projects: Sewer separation projects will be implemented within strategic catchments in addition to the Appendix B sewer separation projects. The locations of these separation projects are shown in **Figure 6.2.1**.

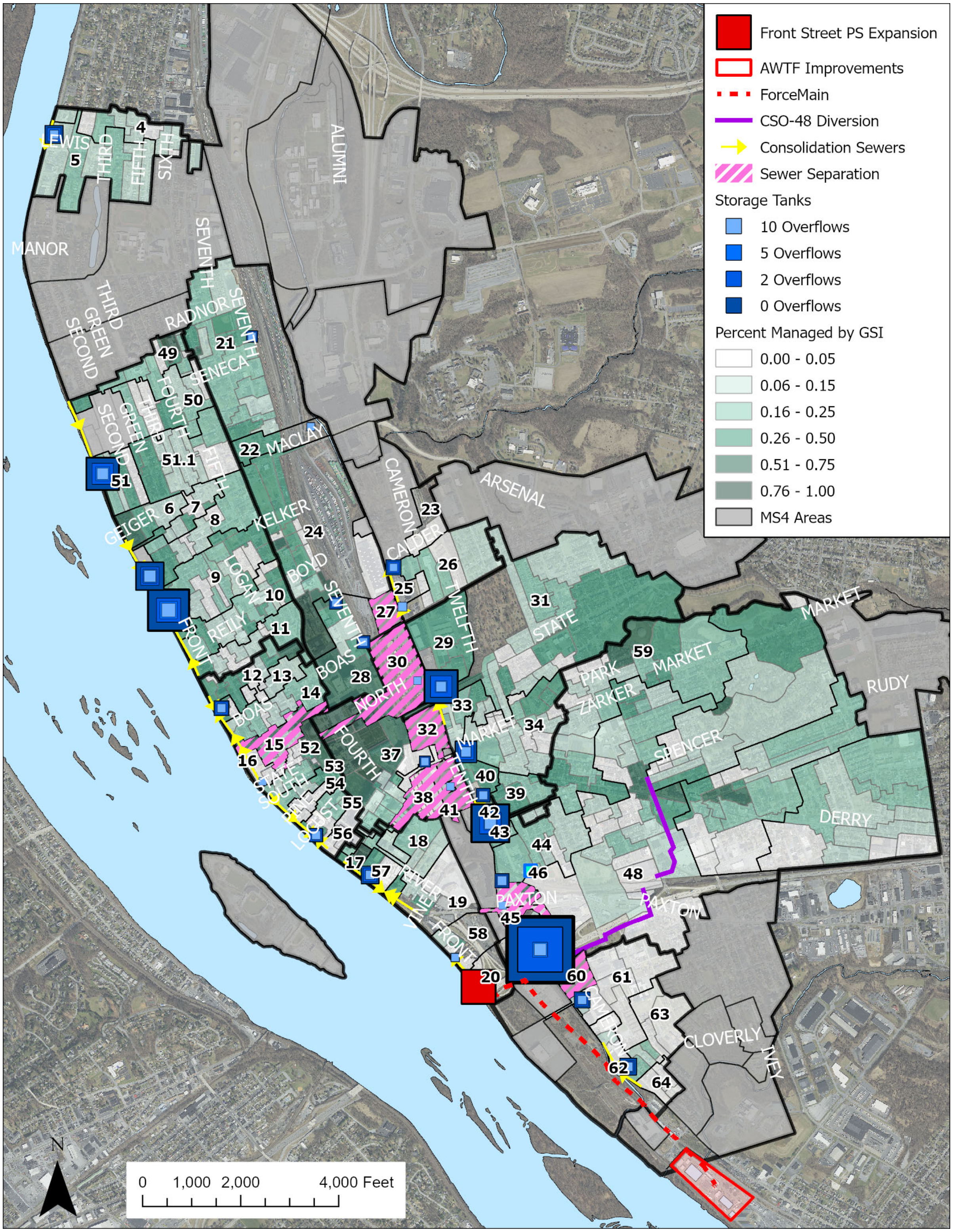

Figure 6.2-1: Locations of Control Facilities for MTA-1

Table 6.2-1: MTA-1 Facility Sizes and Locations

Planning Area	**CSO Outfall**	**Technology Size** (Location Indicated in Parentheses)					
		20 Overflows	**16 Overflows**	**10 Overflows**	**5 Overflows**	**2 Overflows**	**0 Overflows**
Riverside	CSO-04			0.11 MG (CSO-05)	0.19 MG (CSO-05)	0.84 MG (CSO-05)	1.48 MG (CSO-05)
	CSO-05						
Uptown	CSO-49			0.50 MG (CSO-51)	0.89 MG (CSO-51)	1.92 MG (CSO-51)	3.56 MG (CSO-51)
	CSO-50						
	CSO-51	0.27 MG	0.44 MG				
	CSO-06		0.42 MG (CSO-08)	0.56 MG (CSO-08)	0.90 MG (CSO-08)	1.49 MG (CSO-08)	2.89 MG (CSO-08)
	CSO-07	0.24 MG (CSO-08)					
	CSO-08						
	CSO-09	0.29 MG (CSO-09)	0.59 MG (CSO-09)	0.85 MG (CSO-09)	1.42 MG (CSO-09)	2.36 MG (CSO-09)	4.78 MG (CSO-09)
	CSO-10						
	CSO-11						
Middle Front Street	CSO-12			0.09 MG (CSO-13)	0.18 MG (CSO-13) (SS CSO-15; 17.4 ac)	0.71 MG (CSO-13) (SS CSO-15; 17.4 ac)	1.03 MG (CSO-13) (SS CSO-15; 17.4 ac)
	CSO-13						
	CSO-14						
	CSO-15						
	CSO-16						
	CSO-52			0.11 MG (CSO-55)	0.20 MG (CSO-55)	0.61 MG (CSO-55)	0.84 MG (CSO-55)
	CSO-53						
	CSO-54						
	CSO-55						
	CSO-56						
Lower Front Street	CSO-17				0.25 MG (CSO-57)	0.83 MG (CSO-57)	1.44 MG (CSO-57)
	CSO-57		0.05 MG (CSO-57)	0.16 MG (CSO-57)			
	CSO-18						
	CSO-19						
	CSO-58					0.08 MG (CSO-58)	0.17 MG (CSO-58)
	CSO-20						
Upper Paxton Creek - West	CSO-21			0.04 MG	0.07 MG	0.34 MG	0.55 MG
	CSO-22					0.04 MG	0.08 MG
	CSO-24			0.04 MG	0.06 MG	0.38 MG	0.74 MG
	CSO-27						
	CSO-28			0.05 MG	0.10 MG	0.43 MG	0.75 MG
Upper Paxton Creek - East	CSO-23					0.51 MG (CSO-23)	1.07 MG (CSO-23)
	CSO-25						
	CSO-26			0.14 MG	0.24 MG		
Middle Paxton Creek - East	CSO-29		0.04 MG (CSO-29)	0.33 MG (CSO-29)	0.58 MG (CSO-29)	1.96 MG (CSO-29)	3.65 MG (CSO-29)
	CSO-31						
	CSO-33						
	CSO-34	0.08 MG	0.14 MG	0.29 MG	0.47 MG	1.15 MG	1.98 MG
	CSO-39			0.09 MG (CSO-40)	0.17 MG (CSO-40)	0.46 MG (CSO-40)	0.87 MG (CSO-40)
	CSO-40						
Middle Paxton Creek - West	CSO-30					7.3 ac	7.3 ac
	CSO-32						
	CSO-37					0.25 MG	0.50 MG
	CSO-38			14.5 ac	14.5 ac	14.5 ac	14.5 ac
	CSO-41						
Lower Paxton Creek	CSO-42		0.33 MG (CSO-42)	0.55 MG (CSO-42)	0.79 MG (CSO-42)	1.96 MG (CSO-42)	4.31 MG (CSO-42)
	CSO-59	0.11 MG (CSO-42)					
	CSO-43						
	CSO-44	0.56 MG	0.56 MG	0.2 MG	0.28 MG	0.55 MG	0.93 MG
	CSO-45			7.9 ac	7.9 ac	7.9 ac	7.9 ac
	CSO-46			7.1 ac	7.1 ac	7.1 ac	7.1 ac
	CSO-48		0.11 MG	0.62 MG	1.03 MG	5.35 MG	8.40 MG
Hemlock Street	CSO-60						
	CSO-61			0.13 MG	0.22 MG	0.64 MG	1.19 MG
	CSO-62		0.04 MG (CSO-63)	0.16 MG (CSO-63)	0.25 MG (CSO-63)	0.55 MG (CSO-63)	1.31 MG (CSO-63)
	CSO-63						
	CSO-64						
AWTF/PS Capacity		100 MGD	100 MGD	100 MGD	100 MGD	100 MGD	100 MGD

Notes:

1. All alternatives include Appendix B projects and baseline level of GSI.

Color Coding:

Satellite Storage (End of Pipe)	Sewer Separation	Satellite Storage (Gravity In/Out)	Enhanced Conveyance

6.2.1 Basis of Cost Estimates

Optimized and Expanded AWTF: Multiple improvements are required to optimize the hydraulic operation of the existing AWTF and increase the peak capacity from its current operating capacity of 80 MGD to 100 MGD, which includes the permitted bypassing of secondary treatment facilities for wet weather flows above 45 MGD. These improvements include adding an additional chorine contact tank and upsizing the piping from the headworks to the primary clarifiers and the outfall piping. The total construction cost for these improvements is $11 million and the present value lifecycle cost is $18 million.

Expanded Pump Station: So that the combined capacities of the Front Street and Spring Creek Pump Stations match the expanded capacity of the AWTF**,** the peak hydraulic capacity of the Front Street Pump Station will be increased from 60 MGD to 80 MGD. The total construction cost for this expansion is $12 million and the present value lifecycle cost is $28 million.

Satellite Storage Facilities: The number, size, and total volume of the satellite storage facilities vary with the level of control. The Project Cost Summary tables provide the location, size, and present value lifecycle cost for each of the satellite storage facilities required to provide each LoC. The ancillary construction costs include consolidation sewers, diversion chambers, influent and effluent sewers, and a dewatering pumping station.

Sewer Separation Costs: In addition to the four sewer separation projects included in the Appendix B project list, MTA-1 includes sewer separation for up to four catchment areas for certain LoCs. The total construction cost for these sewer separation projects, when applicable, ranges from $23 million to $27 million, and the present value lifecycle cost ranges $35 million to $41 million.

6.2.2 Cost-Performance Summary

Table 6.2-2 provides the typical year CSO statistics and present value cost estimate associated with each MTA-1 control point. Typical year CSO volume is the systemwide total of individual CSO outfalls, and typical year CSO frequency represents the range of frequencies for individual CSO outfalls (Pre-Plan and Appendix B) or the target frequency corresponding to the LoC (for control points two through seven).

Table 6.2-2: MTA-1 LoCs, Control Facilities, and Associated Cost

Control Point	Receiving Water	Number of Storage Facilities	Total Storage Volume (MG)	Total Estimated Cost ($ Million)	Typical Year CSO Volume (MG)	Typical Year CSO Frequency
Pre-Plan	NA	NA	NA	NA	796	6 to 95
1 (App. B)	Susquehanna and Paxton	NA	NA	$217	331	6 to 60
2	Susquehanna	3	0.80	$145	79	20
	Paxton	3	0.75	$252	102	
3	Susquehanna	4	1.50	$162	66	16
	Paxton	7	1.22	$284	93	
4	Susquehanna	7	2.38	$207	45	10
	Paxton	12	2.64	$383	63	
5	Susquehanna	7	4.03	$259	28	5
	Paxton	12	5.43	$412	51	
6	Susquehanna	8	8.84	$347	12	2
	Paxton	14	14.6	$594	18	
7	Susquehanna	8	16.2	$463	2	0
	Paxton	14	26.3	$753	0	

Figure 6.2-2 is the systemwide cost-performance plot of CSO frequency versus present value costs for MTA-1. Except for the Pre-Plan and Appendix B conditions, each of the LoC points along the curve would provide a consistent systemwide LoC whereby every outfall would have no more than the frequencies indicated in the CSO frequency column in the above table. **Figure 6.2-3** provides the MTA-1 cost-performance plots of CSO frequency versus present value costs for each receiving water.

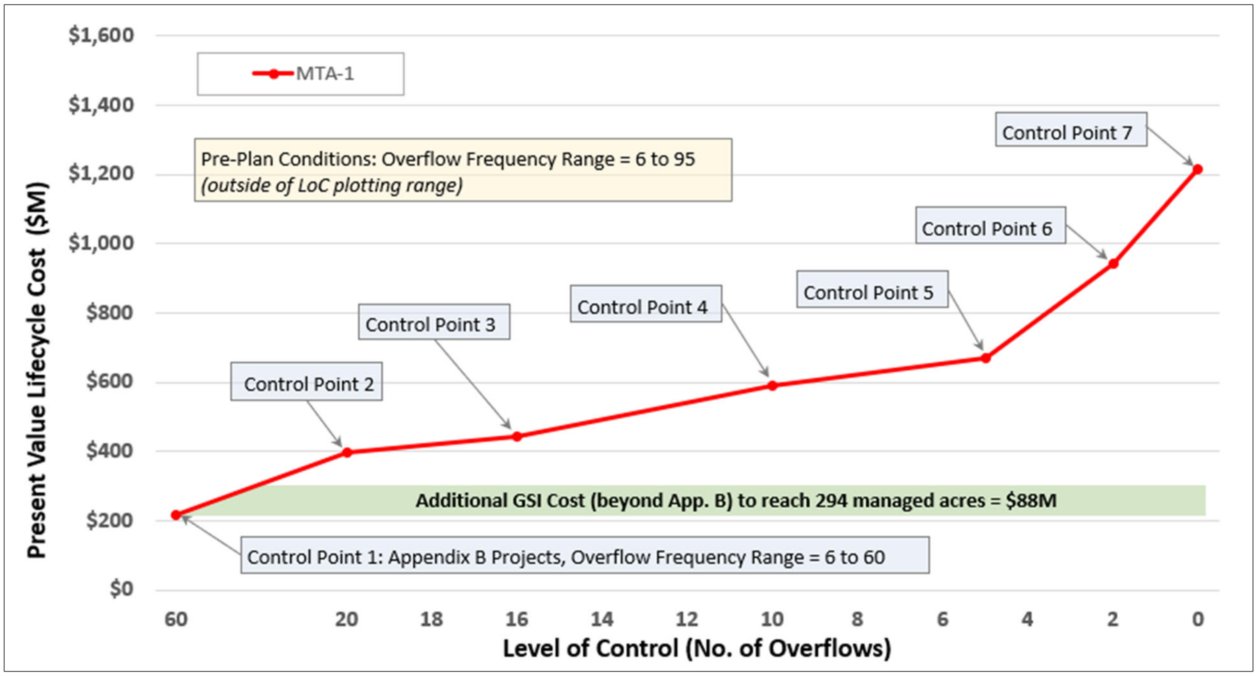

Figure 6.2-2: MTA-1 Systemwide Typical Year CSO Frequency vs. Cost-Performance Curve

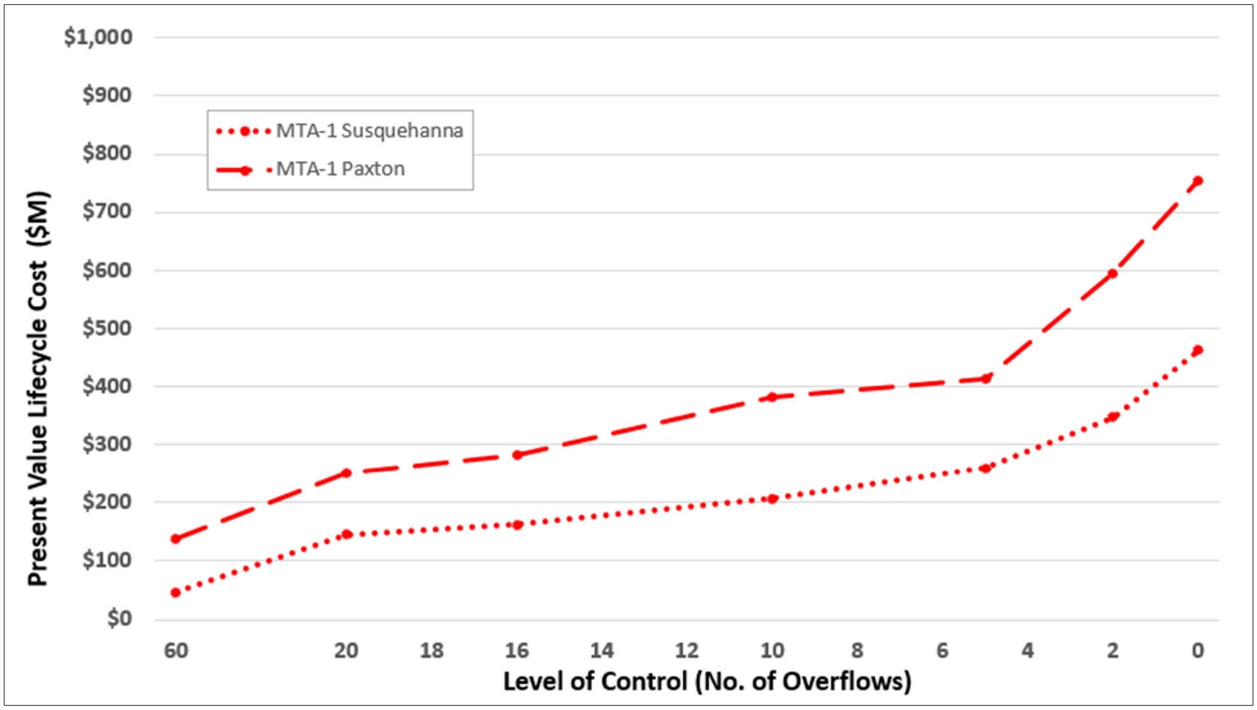

Figure 6.2-3: MTA-1 Typical Year CSO Frequency vs. Cost-Performance Curves by Receiving Water

Figure 6.2-4 is the systemwide cost-performance plot of overflow volume versus present value costs for MTA-1. **Figure 6.2-5** provides the MTA-1 cost-performance plots of overflow volume versus present value **costs for each receiving water.**

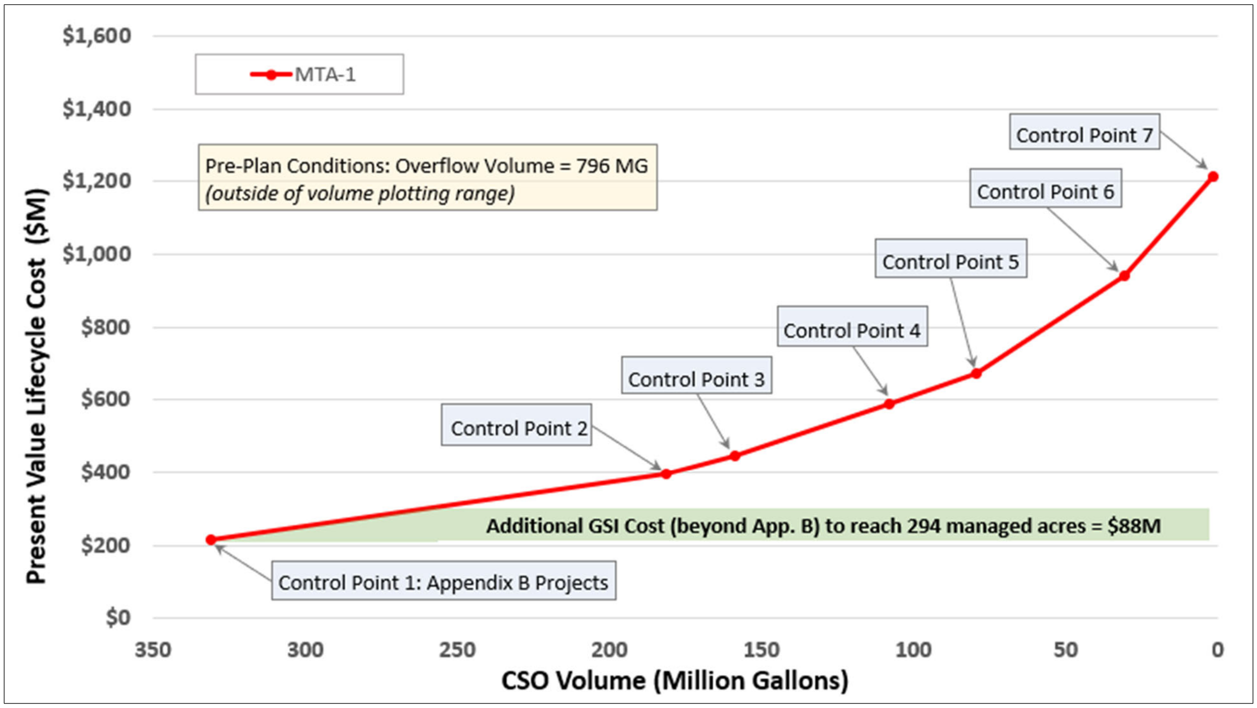

Figure 6.2-4: MTA-1 Systemwide Typical Year CSO Volume vs. Cost-Performance Curve

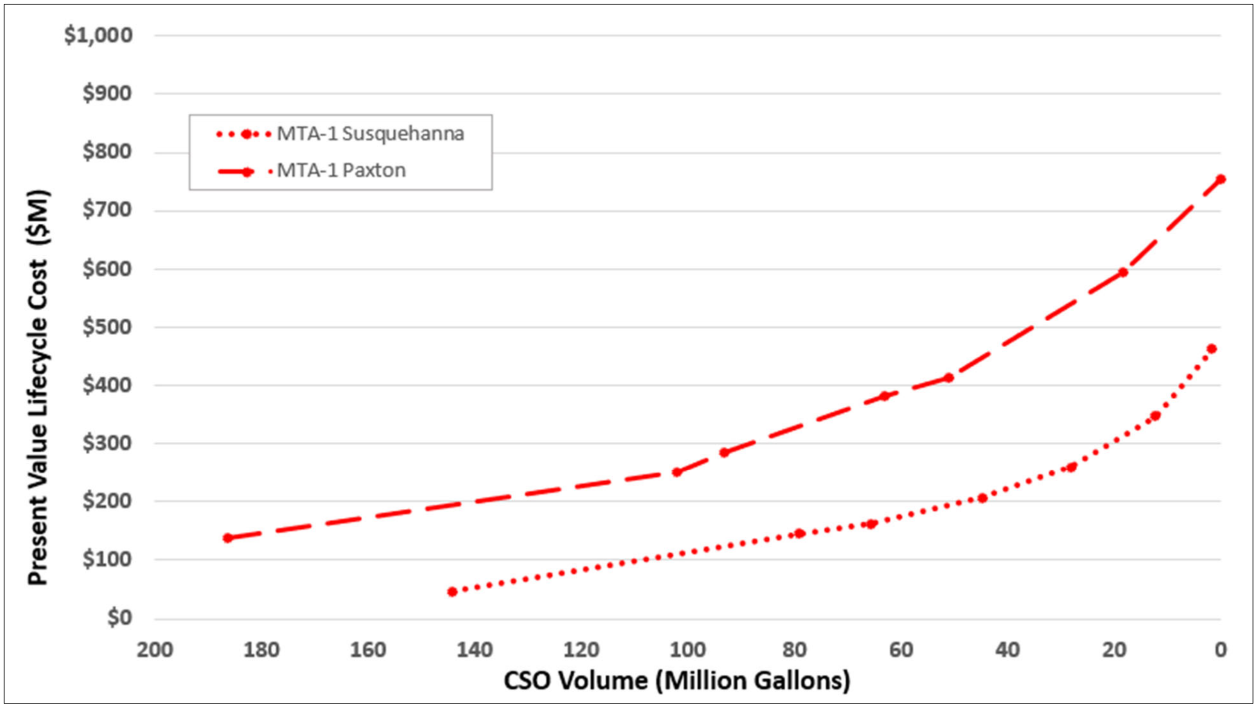

Figure 6.2-5: MTA-1 Typical Year CSO Volume vs. Cost-Performance Curves by Receiving Water

6.3 MTA-2: Satellite Storage with Limited Consolidation

Mixed Technology Alternative 2 (MTA-2) utilizes satellite storage as the primary means of controlling wet weather discharges. The alternative employs the interceptor and pump station conveyance capacities and the AWTF treatment capacity provided by the completion of the Appendix B projects. A system of decentralized satellite storage facilities is added, with an increasing number of facilities and storage volumes, to provide a wide range of LoCs. The storage facilities are located near CSO regulator structures to capture volumes that would otherwise overflow into the receiving waters. MTA-2 does not consolidate the control facilities to limit the number of storage tanks, but limits the additional costs and construction complexity associated with consolidation sewers. In contrast. MTAs 4A, 4B, 6, and 7 have a greater degree of facility consolidation and less storage facilities to construct, but incur the additional costs and complexity associated with consolidation sewers. Green stormwater infrastructure (GSI) facilities and sewer separation projects will further reduce the volume of stormwater runoff entering the combined sewer system. Alternative 2 facilities are described below and their locations are shown in **Figure 6.3-1**. The number of satellite storage facilities for each LoC, and their corresponding storage volumes are provided in **Table 6.3-1**.

Details regarding the components included within MTA-2 are explained below:

Treatment Capacity: The peak wet weather capacity of the AWTF will remain at 80 MGD, which includes the permitted bypassing of secondary treatment facilities.

Conveyance Capacities: The peak wet weather capacities of the Front Street and Spring Creek Pump Stations will remain at the levels provided at the completion of the Appendix B projects. The conveyance capacities along the Front Street and Paxton Creek Interceptors will also remain at the levels provided by the completion of the Appendix B projects.

Satellite Storage Facilities: For this alternative it is assumed that most of the satellite storage tanks are constructed underground along the interceptors and function as gravity-in/pumped-out facilities. A few gravity-in/ gravity-out storage tanks are included. To control the accumulation of solids and debris, the storage systems will be equipped with automated flushing mechanisms. New flow diversion structures will regulate the quantity of wet weather flow conveyed to the interceptor system and divert the excess wet weather flow to the storage tanks. A network of consolidation sewers will convey the wet weather flow from the flow diversion structures to the storage facilities. It is assumed that supervisory control and data acquisition (SCADA) systems and real time control (RTC) systems would optimize the dewatering of the storage vaults. See Section 4.5 for a more complete description of this control technology.

The number, size, and total volume of the satellite storage facilities vary with the level of control. The Project Cost Summary tables provide the location, size, and present value lifecycle cost for each of the satellite storage facilities required to provide each LoC. The ancillary construction costs include consolidation sewers, diversion chambers, influent and effluent sewers, and a dewatering pumping station.

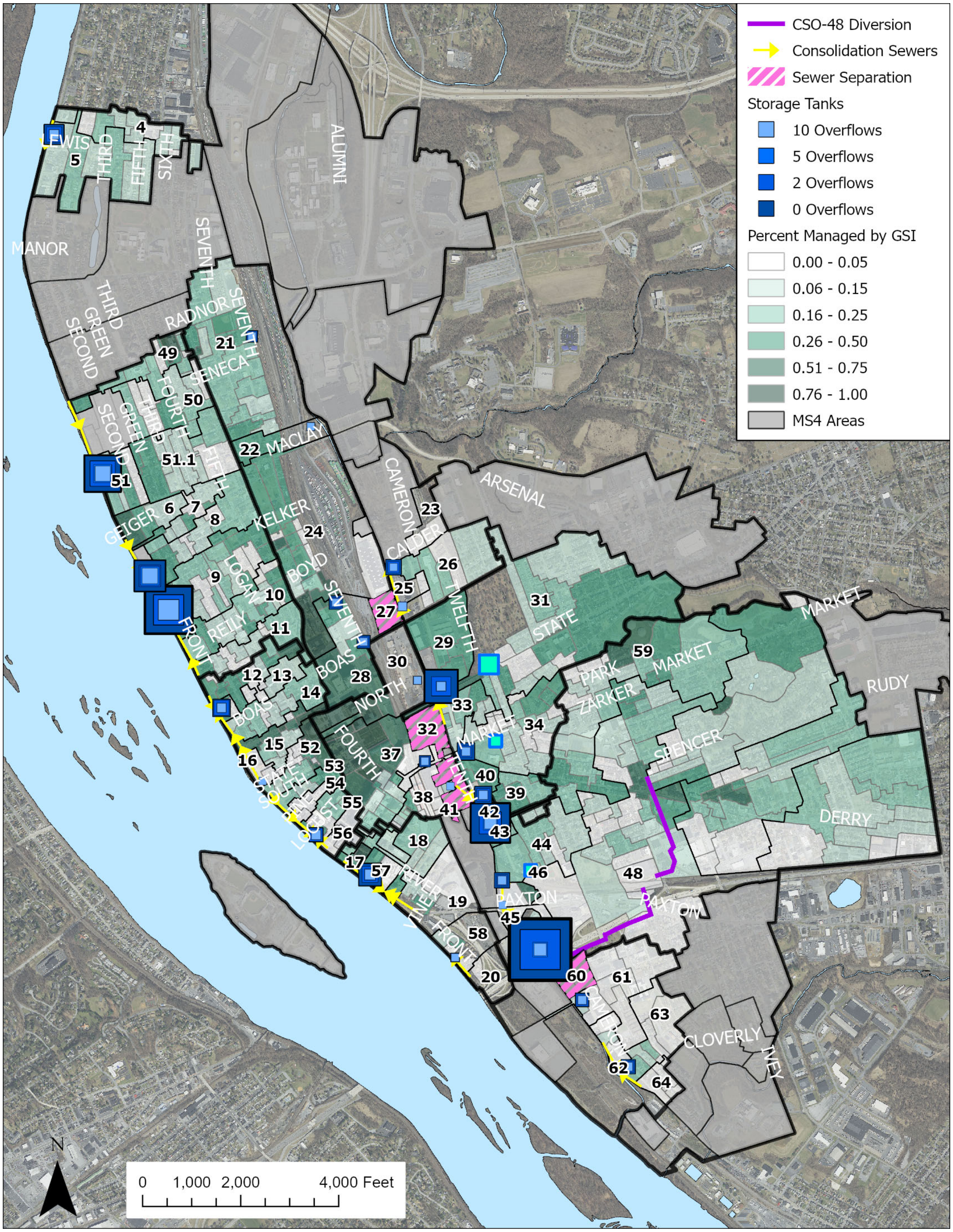

Figure 6.3-1: Locations of Control Facilities for MTA-2

Table 6.3-1: MTA-2 Facility Sizes and Locations

Planning Area	CSO Outfall	Technology Size (Location Indicated in Parentheses)					
		20 Overflows	16 Overflows	10 Overflows	5 Overflows	2 Overflows	0 Overflows
Riverside	CSO-04			0.24 MG (CSO-05)	0.34 MG (CSO-05)	1.08 MG (CSO-05)	1.77 MG (CSO-05)
	CSO-05						
Uptown	CSO-49			1.09 MG (CSO-51)	1.50 MG (CSO-51)	2.52 MG (CSO-51)	4.14 MG (CSO-51)
	CSO-50						
	CSO-51	1.07 MG	1.14 MG				
	CSO-06		1.14 MG (CSO-08)	1.14 MG (CSO-08)	1.56 MG (CSO-08)	1.96 MG (CSO-08)	3.38 MG (CSO-08)
	CSO-07	0.95 MG (CSO-08)					
	CSO-08						
	CSO-09	1.31 MG (CSO-09)	1.68 MG (CSO-09)	1.83 MG (CSO-09)	1.89 MG (CSO-09)	3.23 MG (CSO-09)	5.71 MG (CSO-09)
	CSO-10						
	CSO-11						
Middle Front Street	CSO-12			0.18 MG (CSO-13)	0.29 MG (CSO-13)	1.05 MG (CSO-13)	1.40 MG (CSO-13)
	CSO-13						
	CSO-14						
	CSO-15						
	CSO-16						
	CSO-52			0.24 MG (CSO-55)	0.31 MG (CSO-55)	0.77 MG (CSO-55)	0.97 MG (CSO-55)
	CSO-53						
	CSO-54						
	CSO-55						
	CSO-56						
Lower Front Street	CSO-17			0.36 MG (CSO-57)	0.55 MG (CSO-57)	1.17 MG (CSO-57)	2.15 MG (CSO-57)
	CSO-57		0.15 MG (CSO-57)				
	CSO-18						
	CSO-19						
	CSO-58				0.05 MG (CSO-58)	0.10 MG (CSO-58)	0.22 MG (CSO-58)
	CSO-20						
Upper Paxton Creek - West	CSO-21			0.04 MG	0.07 MG	0.34 MG	0.57 MG
	CSO-22					0.04 MG	0.09 MG
	CSO-24			0.03 MG	0.06 MG	0.39 MG	0.85 MG
	CSO-27						
	CSO-28			0.04 MG	0.08 MG	0.40 MG	0.79 MG
Upper Paxton Creek - East	CSO-23					0.53 MG (CSO-23)	1.14 MG (CSO-23)
	CSO-25						
	CSO-26		0.03 MG	0.12 MG	0.23 MG		
Middle Paxton Creek - East	CSO-29		0.04 MG (CSO-29)	0.19 MG (CSO-29) (1.62 MG, CSO-31)	0.33 MG (CSO-29) (1.62 MG, CSO-31)	1.66 MG (CSO-29) (1.62 MG, CSO-31)	3.68 MG (CSO-29) (1.62 MG, CSO-31)
	CSO-31						
	CSO-33						
	CSO-34	0.62 MG	0.62 MG	0.11 MG (0.62 MG, CSO-34)	0.21 MG (0.62 MG, CSO-34)	0.58 MG (0.62 MG, CSO-34)	1.41 MG (0.62 MG, CSO-34)
	CSO-39		0.04 MG (CSO-40)	0.17 MG (CSO-40)	0.32 MG (CSO-40)	0.76 MG (CSO-40)	1.36 MG (CSO-40)
	CSO-40						
Middle Paxton Creek - West	CSO-30						0.13 MG
	CSO-32						
	CSO-37				0.03 MG	0.25 MG	0.54 MG
	CSO-38			*	*	*	*
	CSO-41						
Lower Paxton Creek	CSO-42	0.14 MG (CSO-42)	0.34 MG (CSO-42)	0.62 MG (CSO-42)	0.94 MG (CSO-42)	2.05 MG (CSO-42)	4.56 MG (CSO-42)
	CSO-59						
	CSO-43						
	CSO-44	0.56 MG	0.56 MG	0.12 MG (CSO-44) (0.56 MG, CSO-44)	0.21 MG (CSO-44) (0.56 MG, CSO-44)	0.48 MG (CSO-44) (0.56 MG, CSO-44)	1.10 MG (CSO-44) (0.56 MG, CSO-44)
	CSO-45						
	CSO-46						
	CSO-48		0.27 MG	0.65 MG	0.99 MG	4.65 MG	7.74 MG
Hemlock Street	CSO-60						
	CSO-61			0.11 MG	0.19 MG	0.59 MG	0.88 MG
	CSO-62			0.12 MG (CSO-63)	0.19 MG (CSO-63)	0.55 MG (CSO-63)	0.97 MG (CSO-63)
	CSO-63						
	CSO-64						

Notes:

1. All alternatives include Appendix B projects and baseline level of GSI.

2. CSO-38 grouped with CSO-39 and CSO-40.

Color Coding:

Satellite Storage (End of Pipe)	Satellite Storage (Gravity In/Out)	Satellite Storage (End of Pipe + Gravity In/Out)

6.3.1 Basis of Cost Estimates

Satellite Storage Facilities: The number, size, and total volume of the satellite storage facilities vary with the level of control. The Project Cost Summary tables provide the location, size, and present value lifecycle cost for each of the satellite storage facilities required to provide each LoC. The ancillary construction costs include consolidation sewers, diversion chambers, influent and effluent sewers, and a dewatering pumping station.

6.3.2 Cost-Performance Summary

Table 6.3-2 provides the typical year CSO statistics and present value cost estimate associated with each MTA-2 control point. Typical year CSO volume is the systemwide total of individual CSO outfalls, and typical year CSO frequency represents the range of frequencies for individual CSO outfalls (Pre-Plan and Appendix B) or the target frequency corresponding to the LoC (for control points two through seven).

Table 6.3-2: MTA-2 LoCs, Control Facilities, and Associated Cost

Control Point	Receiving Water	Number of Storage Facilities	Total Storage Volume (MG)	Total Estimated Cost ($ Million)	Typical Year CSO Volume (MG)	Typical Year CSO Frequency
Pre-Plan	NA	NA	NA	NA	796	6 to 95
1 (App. B)	Susquehanna and Paxton	NA	NA	$217	331	6 to 60
2	Susquehanna	3	0.84	$174	84	20
	Paxton	3	1.32	$226	104	
3	Susquehanna	4	1.62	$203	68	16
	Paxton	7	1.90	$264	80	
4	Susquehanna	7	2.57	$252	44	10
	Paxton	13	3.94	$345	64	
5	Susquehanna	8	4.34	$280	30	5
	Paxton	14	5.47	$373	53	
6	Susquehanna	8	9.38	$376	13	2
	Paxton	14	13.2	$526	22	
7	Susquehanna	8	16.2	$464	2	0
	Paxton	14	26.3	$716	1	

Figure 6.3-2 is the systemwide cost-performance plot of CSO frequency versus present value costs for MTA-2. Except for the Pre-Plan and Appendix B conditions, each of the LoC points along the curve would provide a consistent systemwide LoC whereby every outfall would have no more than the frequencies indicated in the CSO frequency column in the above table. **Figure 6.3-3** provides the MTA-2 cost-performance plots of CSO frequency versus present value costs for each receiving water.

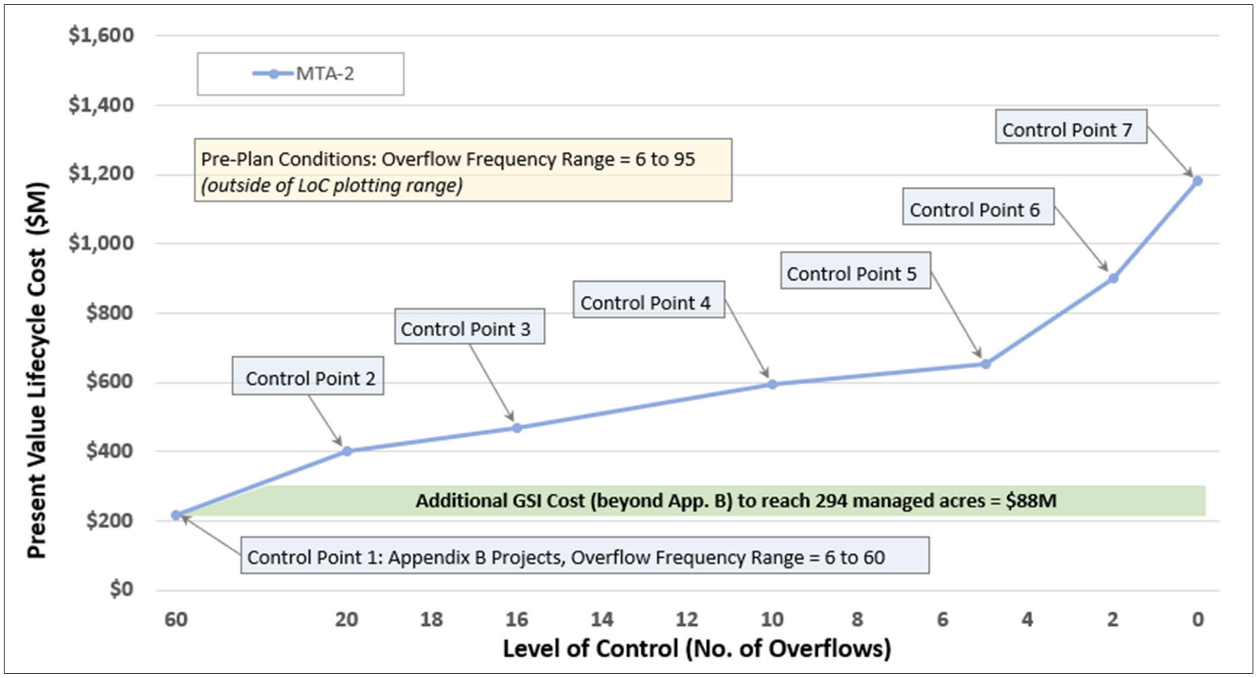

Figure 6.3-2: MTA-2 Systemwide Typical Year CSO Frequency vs. Cost-Performance Curve

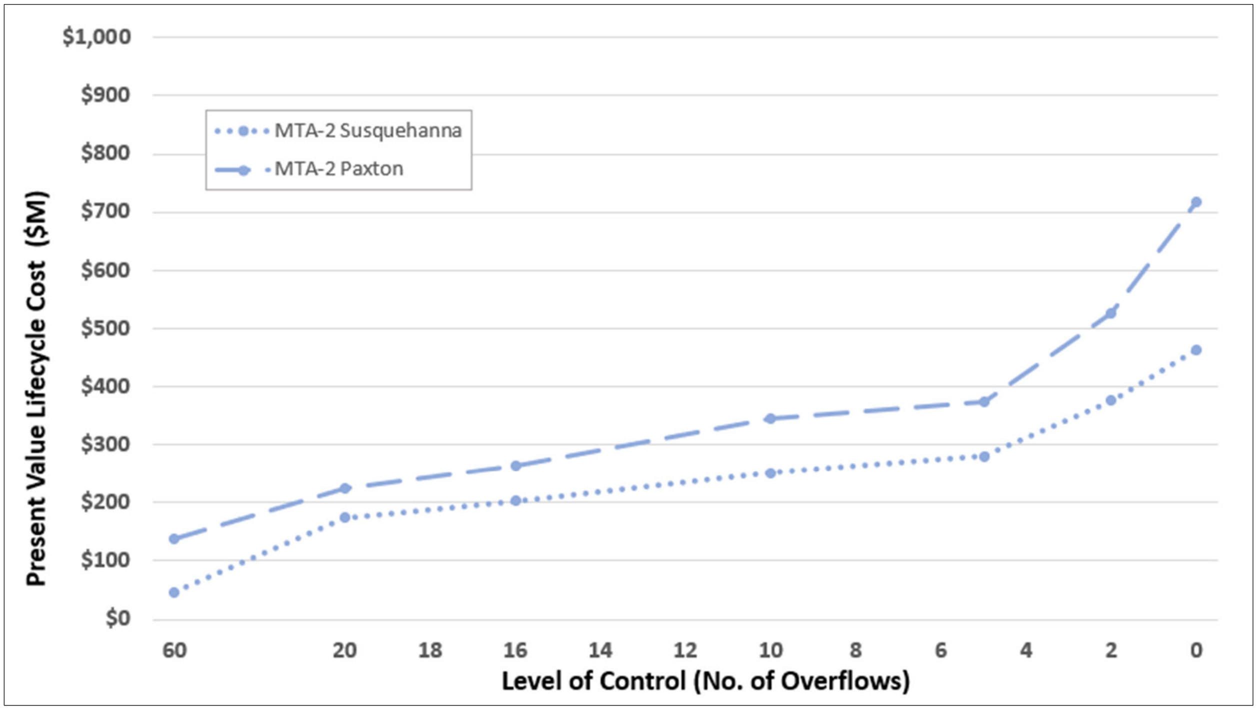

Figure 6.3-3: MTA-2 Typical Year CSO Volume vs. Cost-Performance Curves by Receiving Water

Figure 6.3-4 is the systemwide cost-performance plot of overflow volume versus present value costs for MTA-2. **Figure 6.3-5** provides the MTA-2 cost-performance plots of overflow volume versus present value **costs for each receiving water.**

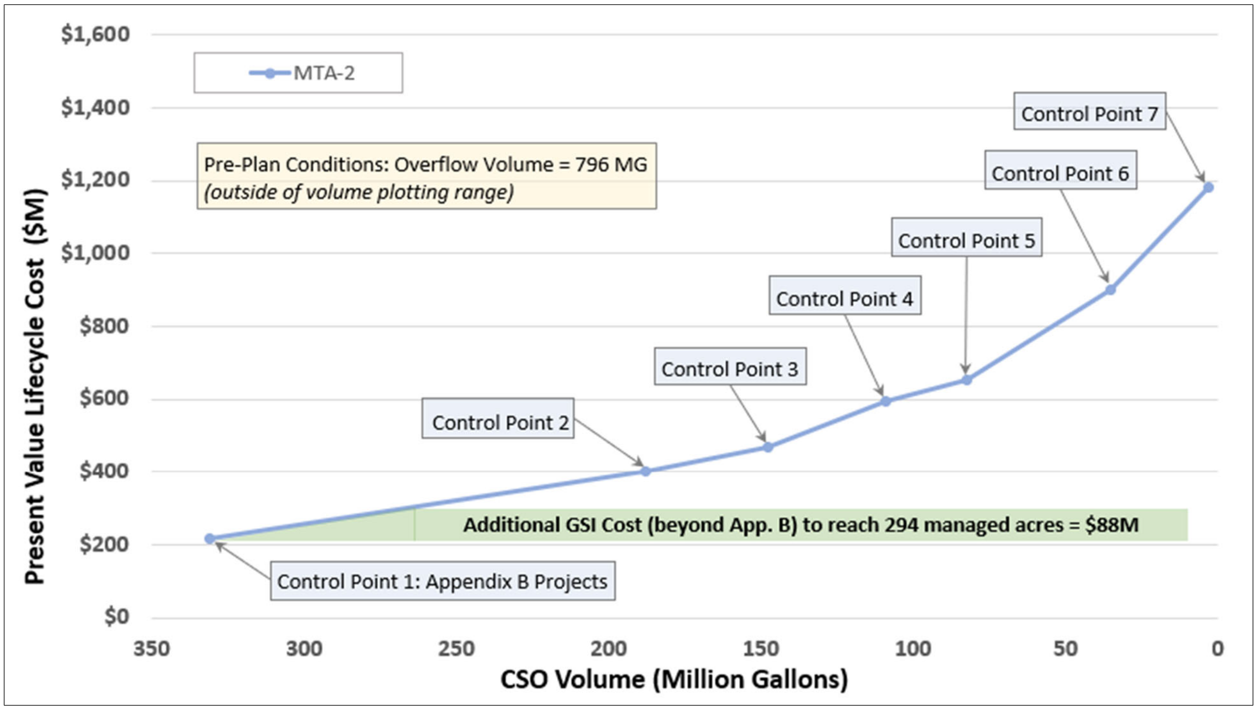

Figure 6.3-4: MTA-2 Systemwide Typical Year CSO Volume vs. Cost-Performance Curve

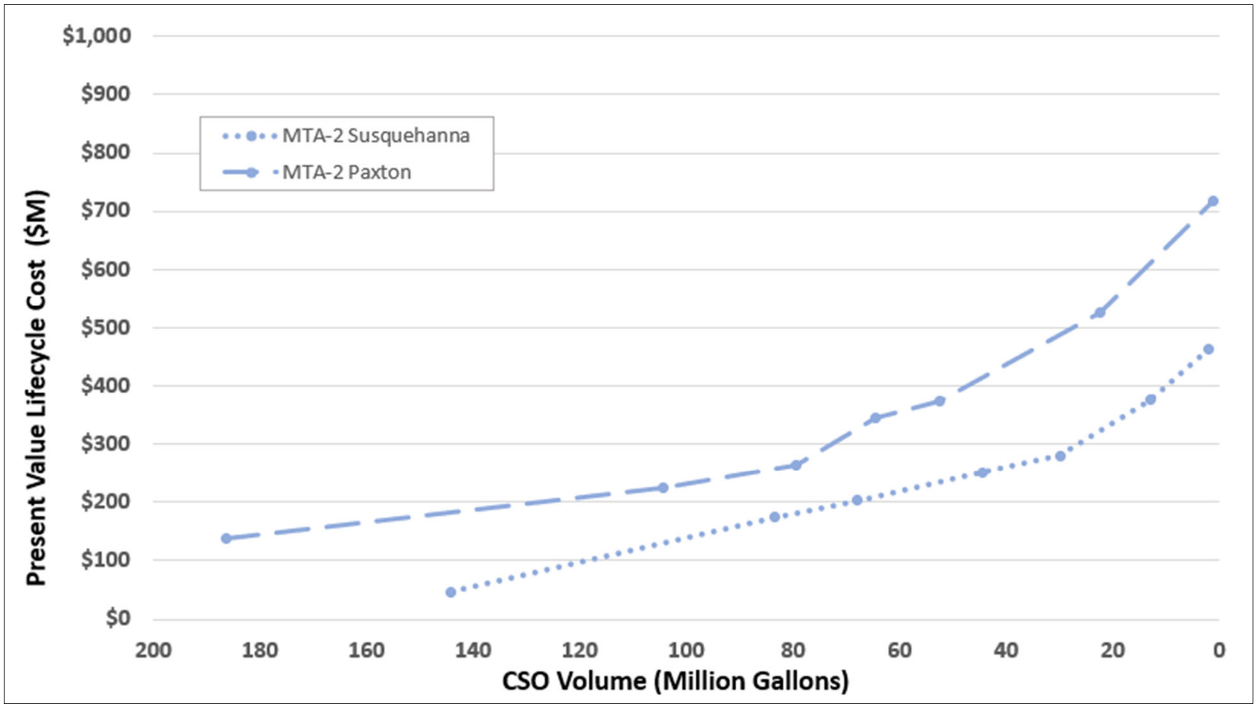

Figure 6.3-5: MTA-2 Typical Year CSO Volume vs. Cost-Performance Curves by Receiving Water

6.4 MTA-3: Satellite Treatment and Storage with Limited Consolidation

Mixed Technology Alternative 3 (MTA-3) utilizes a combination of satellite treatment and storage facilities to control wet weather discharges within the CRW service area. The alternative employs the interceptor and pump station conveyance capacities and the AWTF treatment capacity provided by the completion of the Appendix B projects. A system of decentralized satellite storage and treatment facilities are added, with an increasing number of facilities, storage volumes, and treatment capacities to provide a wide range of LoCs. The storage and treatment facilities are located near CSO regulator structures to capture volumes that would otherwise overflow into the receiving waters. Green stormwater infrastructure (GSI) facilities and sewer separation projects will further reduce the volume of stormwater runoff entering the combined sewer system. MTA-3 facilities are described below and their locations are shown in **Figure 6.4-1**. The number of satellite storage and treatment facilities for each LoC, and their corresponding storage volumes and treatment capacities are provided in **Table 6.4-1**. Footprints associated with each satellite storage and treatment facility are shown in the site-scale maps in **Appendix 6-3**.

Details regarding the components included within MTA-3 are explained below:

Treatment Capacity: The peak wet weather capacity of the AWTF will remain at 80 MGD, which includes the permitted bypassing of secondary treatment facilities.

Conveyance Capacities: The peak wet weather capacities of the Front Street and Spring Creek Pump Stations will remain at the levels provided at the completion of the Appendix B projects. The conveyance capacities along the Front Street and Paxton Creek Interceptors will also remain at the levels provided by the completion of the Appendix B projects.

Satellite Storage Facilities: For this alternative it is assumed that all of the satellite storage tanks are constructed underground along the interceptors and function as gravity-in/pumped-out facilities. To control the accumulation of solids and debris, the storage systems will be equipped with automated flushing mechanisms. New flow diversion structures will regulate the quantity of wet weather flow conveyed to the interceptor system and divert the excess wet weather flow to the storage tanks. A network of consolidation sewers will convey the wet weather flow from the flow diversion structures to the storage facilities. It is assumed that supervisory control and data acquisition (SCADA) systems and real time control (RTC) systems would optimize the dewatering of the storage vaults. See Section 4.5 for a more complete description of this control technology.

Satellite Treatment Facilities: The Susquehanna river has a large flow which leads to a high dilution of pollutant loads and a high assimilative capacity. Therefore, along the Susquehanna River it is assumed that screening and disinfection technologies will be used and would provide sufficient control to meet current water quality standards. For CSO applications where heavy debris loadings are likely, the minimum bar spacing was assumed to be approximately 1 inch. Screened effluent flows are disinfected using high-rate chemical disinfection, most likely using sodium hypochlorite, to kill pathogen bacteria before being released to the receiving waters. Mechanical bar screens were assumed because they can function intermittently at remote locations with a minimum level of instrumentation.

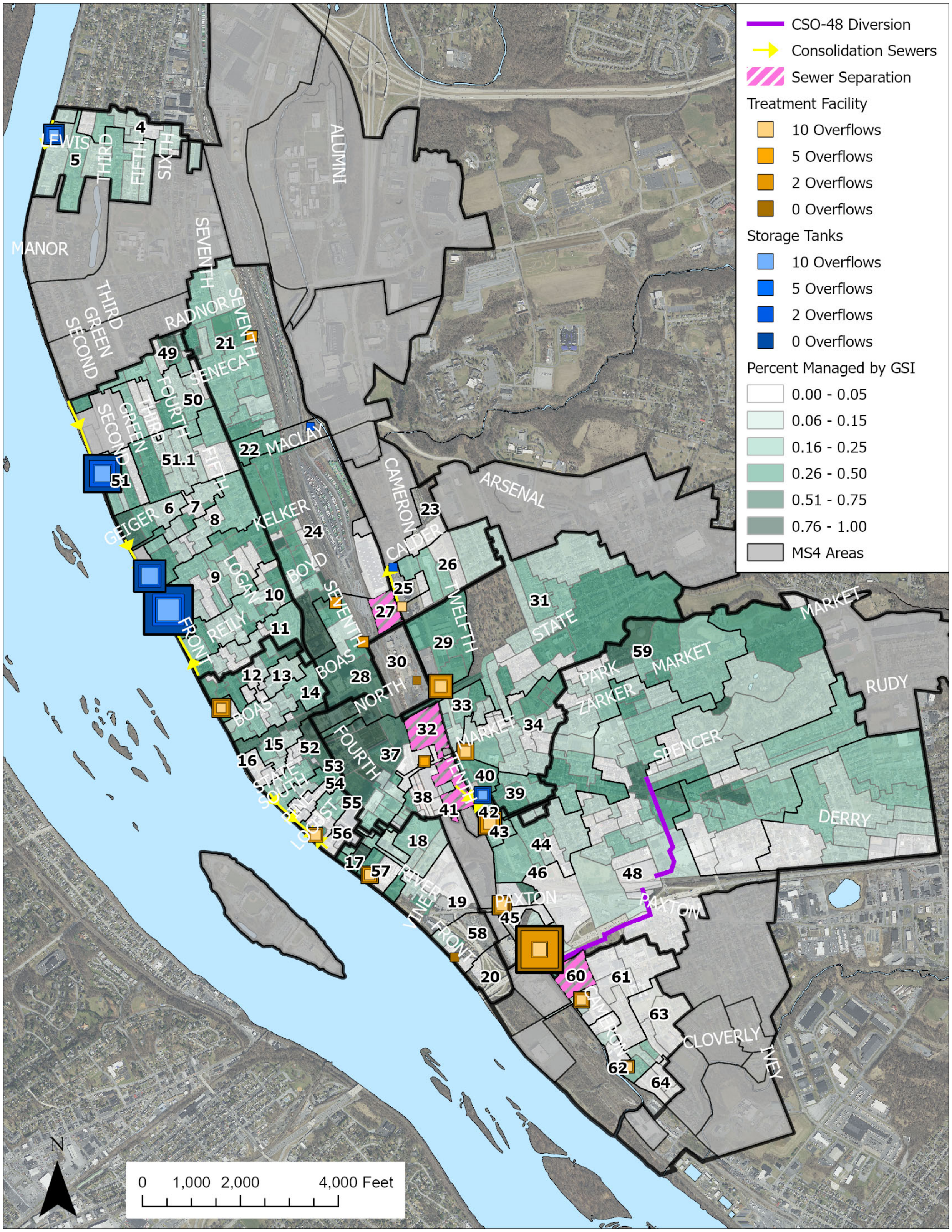

Figure 6.4-1: Locations of Control Facilities for MTA-3

Table 6.4-1: MTA-3 Facility Sizes and Locations

Planning Area	CSO Outfall	Technology Size (Location Indicated in Parentheses)					
		20 Overflows	16 Overflows	10 Overflows	5 Overflows	2 Overflows	0 Overflows
Riverside	CSO-04			0.28 MG (CSO-05)	0.35 MG (CSO-05)	1.15 MG (CSO-05)	1.83 MG (CSO-05)
	CSO-05						
Uptown	CSO-49			1.18 MG (CSO-51)	1.55 MG (CSO-51)	2.69 MG (CSO-51)	4.27 MG (CSO-51)
	CSO-50						
	CSO-51	1.07 MG	4.85 MGD				
	CSO-06		1.41 MG (CSO-08)	1.24 MG (CSO-08)	1.62 MG (CSO-08)	2.10 MG (CSO-08)	3.48 MG (CSO-08)
	CSO-07	0.95 MG (CSO-08)					
	CSO-08						
	CSO-09	1.31 MG (CSO-09)	2.07 MG (CSO-09)	1.99 MG (CSO-09)	2.56 MG (CSO-09)	3.45 MG (CSO-09)	5.89 MG (CSO-09)
	CSO-10						
	CSO-11						
Middle Front Street	CSO-12			5.88 MGD (CSO-13)	11.38 MGD (CSO-13)	34.42 MGD (CSO-13)	52.59 MGD (CSO-13)
	CSO-13						
	CSO-14						
	CSO-15						
	CSO-16						
	CSO-52			9.92 MGD (CSO-55)	17.46 MGD (CSO-55)	30.27 MGD (CSO-55)	1.00 MG (CSO-55)
	CSO-53						
	CSO-54						
	CSO-55						
	CSO-56						
Lower Front Street	CSO-17					31.87 MGD (CSO-57)	46.76 MGD (CSO-57)
	CSO-57		0.19 MG (CSO-57)	8.76 MGD (CSO-57)	12.99 MGD (CSO-57)		
	CSO-18						
	CSO-19						
	CSO-58				0.05 MG (CSO-58)	0.11 MG (CSO-58)	6.20 MGD (CSO-58)
	CSO-20						
Upper Paxton Creek - West	CSO-21			0.04 MG	0.07 MG	12.89 MGD	18.70 MGD
	CSO-22					0.04 MG	0.09 MG
	CSO-24			0.03 MG	0.06 MG	15.89 MGD	20.99 MGD
	CSO-27						
	CSO-28			0.04 MG	0.08 MG	12.83 MGD	18.41 MGD
Upper Paxton Creek - East	CSO-23					0.06 MG (CSO-23)	0.10 MG (CSO-23)
	CSO-25						
	CSO-26		0.03 MG	6.25 MGD	9.74 MGD	10.05 MGD	10.09 MGD
Middle Paxton Creek - East	CSO-29		0.03 MG	15.85 MGD (CSO-29)	24.37 MGD (CSO-29)	60.97 MGD (CSO-29)	76.84 MGD (CSO-29)
	CSO-31						
	CSO-33						
	CSO-34	3.58 MGD	5.07 MGD	12.75 MGD	21.97 MGD	34.04 MGD	44.86 MGD
	CSO-39		0.05 MG (CSO-40)	0.17 MG (CSO-40)	0.32 MG (CSO-40)	0.76 MG (CSO-40)	1.36 MG (CSO-40)
	CSO-40						
Middle Paxton Creek - West	CSO-30						2.91 MGD
	CSO-32						
	CSO-37				3.09 MGD	13.23 MGD	20.73 MGD
	CSO-38		*	*	*	*	*
	CSO-41						
Lower Paxton Creek	CSO-42	3.79 MGD (CSO-42)	6.10 MGD (CSO-43)	17.74 MGD (CSO-43)	25.00 MGD (CSO-43)	55.11 MGD (CSO-43)	74.27 MGD (CSO-43)
	CSO-59						
	CSO-43						
	CSO-44	2.03 MGD	4.86 MGD (CSO-45)	13.55 MGD (CSO-45)	24.72 MGD (CSO-45)	34.04 MGD (CSO-45)	55.27 MGD (CSO-45)
	CSO-45						
	CSO-46						
	CSO-48		7.03 MGD	27.68 MGD	38.68 MGD	138.06 MGD	181.29 MGD
Hemlock Street	CSO-60						
	CSO-61			8.03 MGD	16.22 MGD	27.08 MGD	40.40 MGD
	CSO-62			6.45 MGD (CSO-63)	11.88 MGD (CSO-63)	20.14 MGD (CSO-63)	25.71 MGD (CSO-63)
	CSO-63						
	CSO-64						

Notes:

1. All alternatives include Appendix B projects and baseline level of GSI.

2. CSO-38 grouped with CSO-39 and CSO-40.

Color Coding:

Satellite Storage (End of Pipe)	Satellite Treatment

A level sensor would be used to determine when a CSO is occurring and to activate the screen. Differential head sensors located upstream and downstream of the screen will detect head loss and initiate a cleaning cycle. During periods where there are no overflows, a timer will be utilized to periodically exercise the screen, so it does not freeze and is ready for use when needed. See Section 4.6.1 for a more complete description of this control technology.

Paxton Creek has a significantly lower flow when compared to the Susquehanna River, which leads to a lower dilution of pollutant mass and a lower assimilative capacity. The potential need for a higher level of control led to the conservative assumption that Retention-Treatment Basins (RTBs) will be used to collect and treat wet weather flow. CSO discharges will be treated via screening, skimming, settling and disinfection in RTBs prior to release into the creek. During smaller storms, there is no discharge and combined sewage is stored and sent to the AWTF. During a large rain event, excess combined sewage gets sent to the RTB where the combined sewage flows through screens that remove debris such as sanitary trash. A disinfectant is then applied to allow adequate time to kill disease causing organisms. In the basin, particulate matter settles out and the skimming baffle prevents the discharge of floatable material and oils. Once the storage capacity of the RTB is exceeded, the treated overflow is disinfected and sent to surface water resulting in a discharge that is protective of public health and the environment. When the rain event ends and as capacity becomes available, the contents of the RTB are drained back to the interceptor sewer and sent to the wastewater treatment plant. See Section 4.6.2 for a more complete description of this control technology.

6.4.1 Basis of Cost Estimates

Satellite Storage Facilities: The number, size, and total volume of the satellite storage facilities vary with the level of control. The Project Cost Summary tables provide the location, size, and present value lifecycle cost for each of the satellite storage facilities required to provide each LoC. The ancillary construction costs include consolidation sewers, diversion chambers, influent and effluent sewers, and a dewatering pumping station.

Screening and Disinfection Facilities: The number, size, and total treatment capacities of the screening and disinfection facilities along the Susquehanna River vary with the level of control. The Project Cost Summary tables provides the location, size, and present value lifecycle cost for each of the satellite treatment facilities required to provide each LoC. The Ancillary Construction Costs include consolidation sewers, diversion chambers, influent and effluent sewers, and a dewatering pumping station, if required.

Retention Treatment Basin and Disinfection Facilities: The number, size, and total treatment capacities of the RTB and disinfection facilities along the Paxton Creek vary with the level of control. The Project Cost Summary tables provides the location, size, and present value lifecycle cost for each of the satellite treatment facilities required to provide each LoC. The ancillary construction costs include consolidation sewers, diversion chambers, influent and effluent sewers, and a dewatering pumping station, if required.

6.4.2 Cost-Performance Summary

Table 6.4-2 provides the typical year CSO statistics and present value cost estimate associated with each MTA-3 control point. Typical year CSO volume is the systemwide total of individual CSO outfalls, and typical year CSO frequency represents the range of frequencies for individual CSO outfalls (Pre-Plan and Appendix B) or the target frequency corresponding to the LoC (for control points two through seven).

Table 6.4-2: MTA-3 LoCs, Control Facilities, and Associated Cost

Control Point	Receiving Water	Number of Storage Facilities	Total Storage Volume (MG)	Number of Treatment Facilities	Total Treatment Capacity (MGD)	Total Estimated Cost ($ Million)	Typical Year CSO Volume (MG)	Typical Year CSO Frequency
Pre-Plan	NA	NA	NA	NA	NA	NA	796	6 to 95
1 (App. B)	Susquehanna and Paxton	NA	NA	NA	NA	$217	331	6 to 60
2	Susquehanna	3	0.84	0	0.0	$176	81	20
	Paxton	0	0.00	3	9.40	$267	102	
3	Susquehanna	3	1.17	1	4.85	$186	65	16
	Paxton	3	0.10	4	23.1	$316	88	
4	Susquehanna	4	2.19	3	24.6	$246	41	10
	Paxton	4	0.27	8	108	$467	48	
5	Susquehanna	5	3.64	3	41.8	$280	26	5
	Paxton	4	0.52	9	176	$540	35	
6	Susquehanna	6	7.06	3	93.6	$352	10	2
	Paxton	3	0.85	13	434	$793	15	
7	Susquehanna	5	14.0	3	106	$442	1	0
	Paxton	3	1.54	13	590	$941	2	

Figure 6.4-2 is the systemwide cost-performance plot of CSO frequency versus present value costs for MTA-3. Except for the Pre-Plan and Appendix B conditions, each of the LoC points along the curve would provide a consistent systemwide LoC whereby every outfall would have no more than the frequencies indicated in the CSO frequency column in the above table. **Figure 6.4-3** provides the MTA-3 cost-performance plots of CSO frequency versus present value costs for each receiving water.

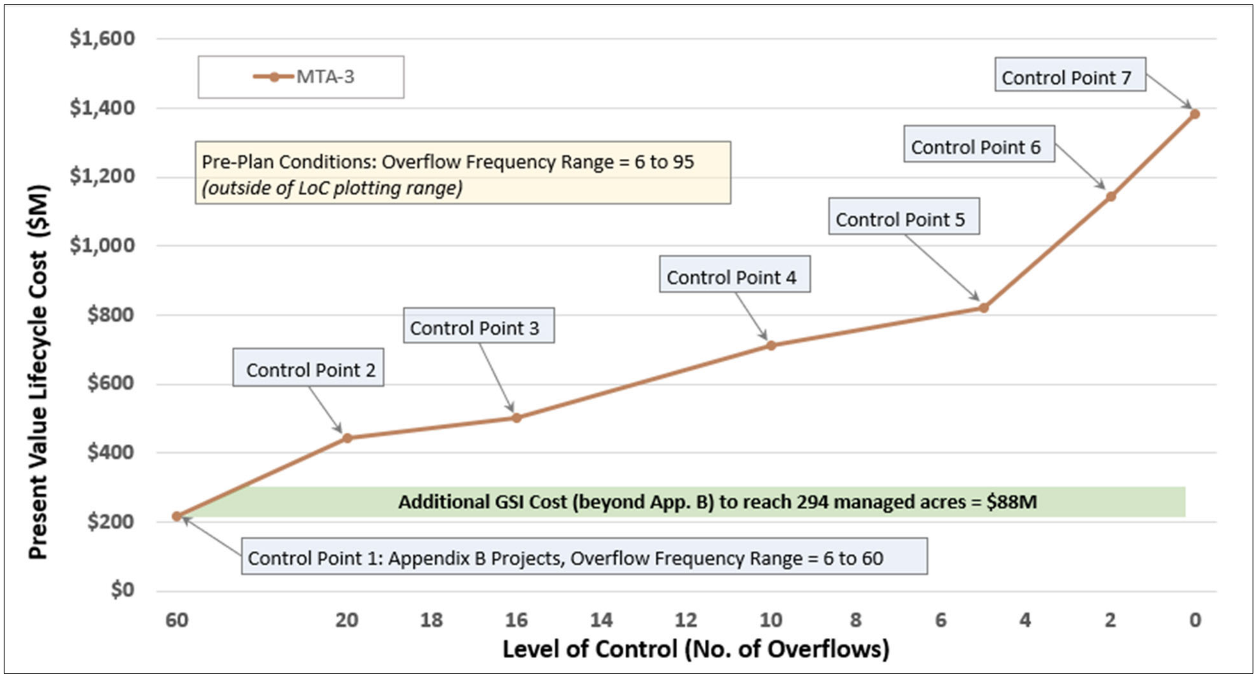

Figure 6.4-2: MTA-3 Systemwide Typical Year CSO Frequency vs. Cost-Performance Curve

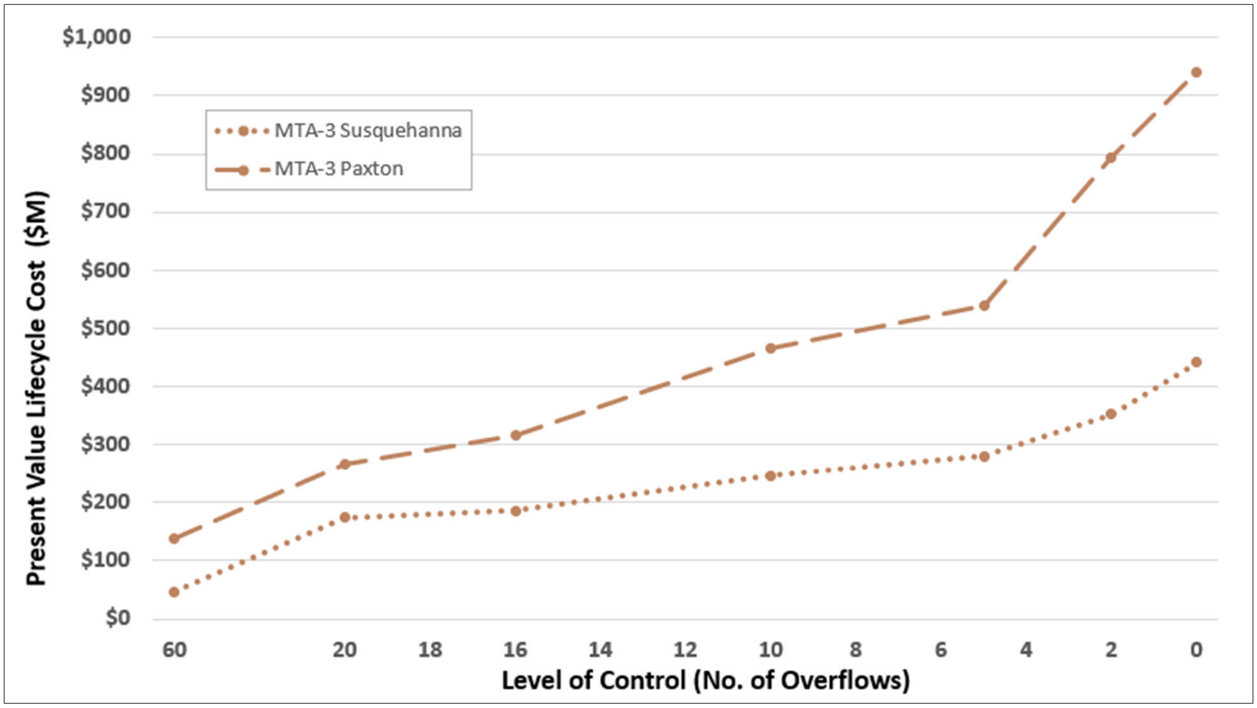

Figure 6.4-3: MTA-3 Typical Year CSO Volume vs. Cost-Performance Curves by Receiving Water

Figure 6.4-4 is the systemwide cost-performance plot of overflow volume versus present value costs for MTA-3. **Figure 6.4-5** provides the MTA-3 cost-performance plots of overflow volume versus present value costs for each receiving water.

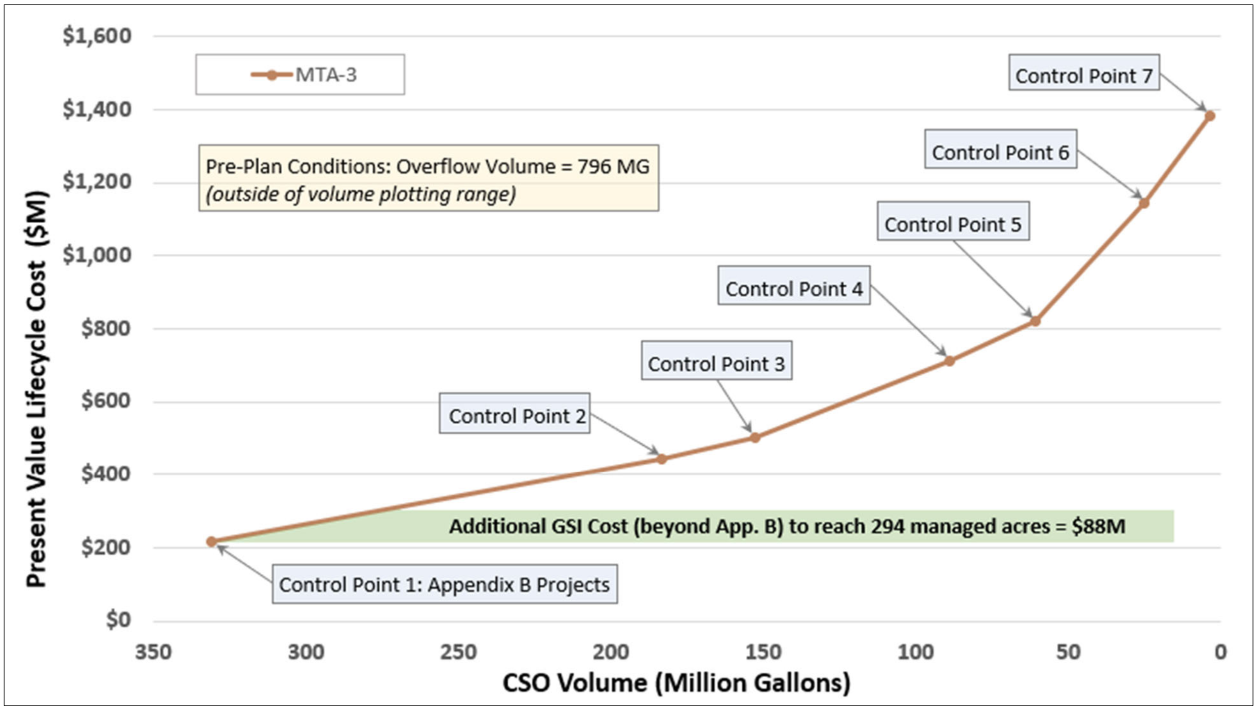

Figure 6.4-4: MTA-3 Systemwide Typical Year CSO Volume vs. Cost-Performance Curve

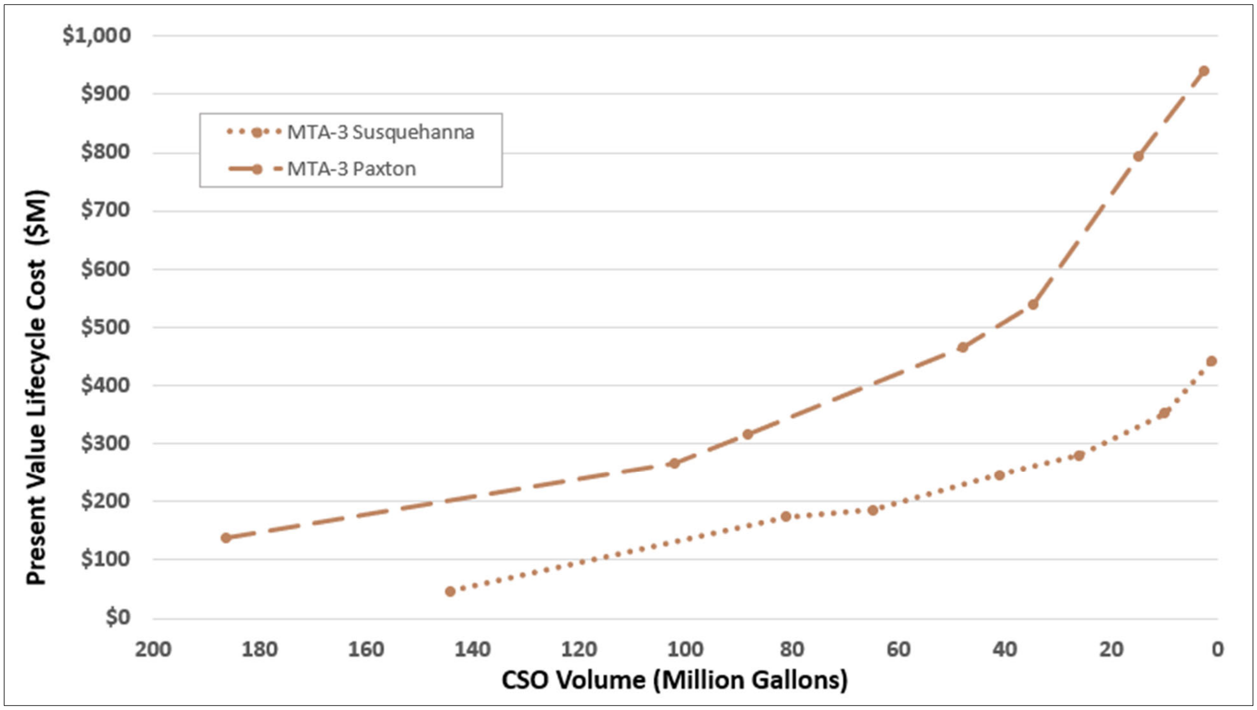

Figure 6.4-5: MTA-3 Typical Year CSO Volume vs. Cost-Performance Curves by Receiving Water

6.5 MTA-4A: Satellite Storage and Treatment with Maximized Consolidation

Mixed Technology Alternative 4A (MTA-4A) utilizes a combination of satellite treatment and storage as the primary means of controlling wet weather discharges and consolidates adjacent CSO regulator structures to limit the number of required facilities. This alternative employs the interceptor and pump station conveyance capacities and the AWTF treatment capacity provided by the completion of the Appendix B projects. A system of decentralized satellite storage and treatment facilities are added, with an increasing number of facilities, storage volumes, and treatment capacities to provide a wide range of LoCs. This alternative consolidates adjacent catchment areas into single control facilities using consolidation sewers. The storage and treatment facilities are located near CSO regulator structures to capture volumes that would otherwise overflow into the receiving waters. Green stormwater infrastructure (GSI) facilities and sewer separation projects will further reduce the volume of stormwater runoff entering the combined sewer system. MTA-4A facilities are described below and their locations are shown in **Figure 6.5-1**. The number of satellite storage and treatment facilities for each LoC, and their corresponding storage volumes and treatment capacities are provided in **Table 6.5-1**. Footprints associated with each satellite storage and treatment facility are shown in the site-scale maps in **Appendix 6-3**.

Details regarding the components included within MTA-4A are explained below:

Treatment Capacity: The peak wet weather capacity of the AWTF will remain at 80 MGD, which includes the permitted bypassing of secondary treatment facilities.

Conveyance Capacities: The peak wet weather capacities of the Front Street and Spring Creek Pump Stations will remain at the levels provided at the completion of the Appendix B projects. The conveyance capacities along the Front Street and Paxton Creek Interceptors will also remain at the levels provided by the completion of the Appendix B projects.

Satellite Storage Facilities: For this alternative it is assumed that all of the satellite storage tanks are constructed underground along the interceptors and function as gravity-in/pumped-out facilities. To control the accumulation of solids and debris, the storage systems will be equipped with automated flushing mechanisms. New flow diversion structures will regulate the quantity of wet weather flow conveyed to the interceptor system and divert the excess wet weather flow to the storage tanks. A network of consolidation sewers will convey the wet weather flow from the flow diversion structures to the storage facilities. It is assumed that supervisory control and data acquisition (SCADA) systems and real time control (RTC) systems would optimize the dewatering of the storage vaults. See Section 4.5 for a more complete description of this control technology.

Satellite Treatment Facilities: The Susquehanna river has a large flow which leads to a high dilution of pollutant loads and a high assimilative capacity. Therefore, along the Susquehanna River it is assumed that screening and disinfection technologies will be used and would provide sufficient control to meet water quality standards. For CSO applications where heavy debris loadings are likely, the minimum bar spacing was assumed to be approximately 1 inch. Screened effluent flows are disinfected using high-rate

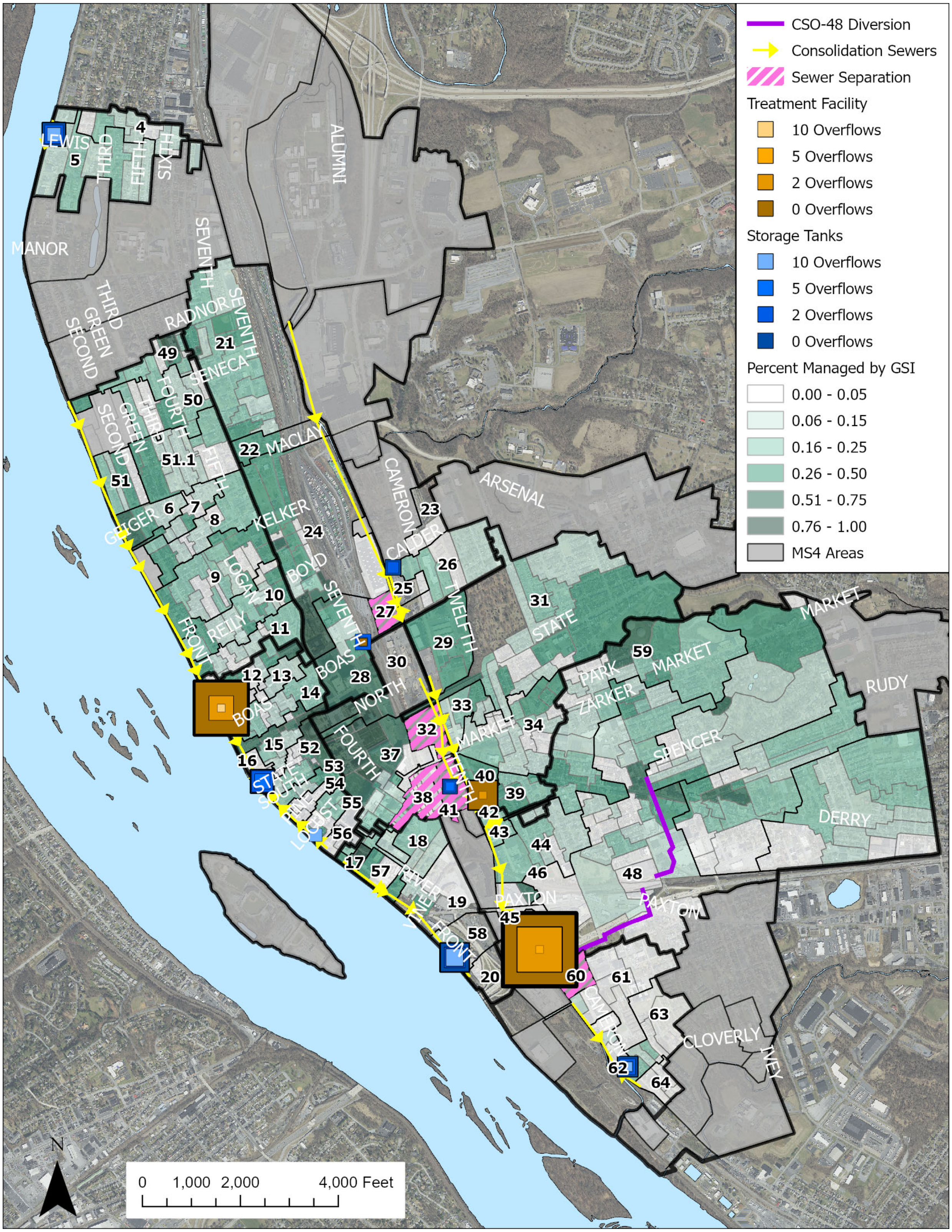

Figure 6.5-1: Locations of Control Facilities for MTA-4A

Table 6.5-1: MTA-4A Facility Sizes and Locations

Planning Area	CSO Outfall	Technology Size (Location Indicated in Parentheses)					
		20 Overflows	16 Overflows	10 Overflows	5 Overflows	2 Overflows	0 Overflows
Riverside	CSO-04			0.82 MG (CSO-05)	0.82 MG (CSO-05)	1.58 MG (CSO-05)	2.30 MG (CSO-05)
	CSO-05						
Uptown	CSO-49			62.54 MGD (CSO-13)	88.65 MGD (CSO-13)	164.17 MGD (CSO-13)	237.59 MGD (CSO-13)
	CSO-50						
	CSO-51	3.34 MG (CSO-11)	24.99 MGD (CSO-13)				
	CSO-06						
	CSO-07						
	CSO-08						
	CSO-09						
	CSO-10						
	CSO-11						
Middle Front Street	CSO-12						
	CSO-13						
	CSO-14				1.09 MG (CSO-16)	1.97 MG (CSO-16)	2.30 MG (CSO-16)
	CSO-15						
	CSO-16						
	CSO-52			0.75 MG (CSO-55)			
	CSO-53						
	CSO-54						
	CSO-55						
	CSO-56						
Lower Front Street	CSO-17			1.36 MG (CSO-58)	1.45 MG (CSO-58)	1.86 MG (CSO-58)	3.08 MG (CSO-58)
	CSO-57		2.57 MG (CSO-58)				
	CSO-18						
	CSO-19						
	CSO-58						
	CSO-20						
Upper Paxton Creek - West	CSO-21			0.10 MG (CSO-28)	0.21 MG (CSO-28)	1.17 MG (CSO-28)	61.99 MGD (CSO-28)
	CSO-22						
	CSO-24						
	CSO-27						
	CSO-28						
Upper Paxton Creek - East	CSO-23					0.53 MG (CSO-23)	1.14 MG (CSO-23)
	CSO-25						
	CSO-26		0.27 MG (CSO-40)	0.88 MG (CSO-40)	1.53 MG (CSO-40)		
Middle Paxton Creek - East	CSO-29	0.10 MG (CSO-29)				112.72 MGD (CSO-40)	144.74 MGD (CSO-40)
	CSO-31						
	CSO-33						
	CSO-34						
	CSO-39						
	CSO-40						
Middle Paxton Creek - West	CSO-30					0.54 MG (CSO-38)	1.04 MG (CSO-38)
	CSO-32						
	CSO-37				0.13 MG (CSO-38)		
	CSO-38	14.5 ac	14.5 ac	14.5 ac			
	CSO-41						
Lower Paxton Creek	CSO-42	0.20 MG (CSO-48)	0.77 MG (CSO-48)	1.56 MG (CSO-48)	88.41 MGD (CSO-48)	227.22 MGD (CSO-48)	310.84 MGD (CSO-48)
	CSO-59						
	CSO-43						
	CSO-44						
	CSO-45						
	CSO-46						
	CSO-48						
Hemlock Street	CSO-60						
	CSO-61			0.22 MG (CSO-63)	0.38 MG (CSO-63)	1.14 MG (CSO-63)	1.85 MG (CSO-63)
	CSO-62						
	CSO-63						
	CSO-64						

Notes:

1. All alternatives include Appendix B projects and baseline level of GSI.

Color Coding:

Satellite Storage (End of Pipe)	Sewer Separation	Satellite Treatment

chemical disinfection, most likely using sodium hypochlorite, to kill pathogen bacteria before being released to the receiving waters. Mechanical bar screens were assumed because they can function intermittently at remote locations with a minimum level of instrumentation. A level detector would be used to determine when a CSO is occurring and to activate the screen. Differential head sensors located upstream and downstream of the screen will detect head loss and initiate a cleaning cycle. During periods where there are no overflows, a timer will be utilized to periodically exercise the screen, so it is ready for use. See Section 4.6.1 for a more complete description of this control technology.

Paxton Creek has a significantly lower flow when compared to the Susquehanna River, which leads to a lower dilution of pollutant mass and a lower assimilative capacity. It is therefore assumed that Retention-Treatment Basins (RTBs) will be used to collect and treat wet weather flow. CSO discharges will be treated via screening, skimming, settling and disinfection in RTBs prior to release into the creek. During smaller storms, there is no discharge and combined sewage is stored and sent to the AWTF. During a large rain event, excess combined sewage gets sent to the RTB where the combined sewage flows through screens that remove debris such as sanitary trash. A disinfectant is then applied to allow adequate time to kill disease causing organisms. In the basin, particulate matter settles out and the skimming baffle prevents the discharge of floatable material and oils. Once the storage capacity of the RTB is exceeded, the treated overflow is disinfected and sent to surface water resulting in a discharge that is protective of public health and the environment. When the rain event ends and as capacity becomes available, the contents of the RTB are drained back to the interceptor sewer and sent to the wastewater treatment plant. See Section 4.6.2 for a more complete description of this control technology.

Sewer Separation Projects: Sewer separation projects will be implemented within one strategic catchment (S-038) in addition to the Appendix B sewer separation projects. The location of this separation project is shown in **Figure 6.5.1**.

6.5.1 Basis of Cost Estimates

Satellite Storage Facilities: The number, size, and total volume of the satellite storage facilities vary with the level of control. The Project Cost Summary tables provide the location, size, and present value lifecycle cost for each of the satellite storage facilities required to provide each LoC. The ancillary construction costs include consolidation sewers, diversion chambers, influent and effluent sewers, and a dewatering pumping station.

Screening and Disinfection Facilities: The number, size, and total treatment capacities of the screening and disinfection facilities along the Susquehanna River vary with the level of control. The Project Cost Summary tables provides the location, size, and present value lifecycle cost for each of the satellite treatment facilities required to provide each LoC. The ancillary construction costs include consolidation sewers, diversion chambers, influent and effluent sewers, and a dewatering pumping station, if required.

Retention Treatment Basin and Disinfection Facilities: The number, size, and total treatment capacities of the RTB and disinfection facilities along the Paxton Creek vary with the level of control. The Project Cost Summary tables provides the location, size, and present value lifecycle cost for each of the satellite treatment facilities required to provide each LoC. The ancillary construction costs include consolidation sewers, diversion chambers, influent and effluent sewers, and a dewatering pumping station, if required.

Sewer Separation Costs: In addition to the four sewer separation projects included in the Appendix B project list, MTA-4A includes sewer separation (for certain LoCs) within the S-038 catchment area within the Paxton Creek Restoration Master Plan corridor. The total construction cost for this sewer separation project is $7 million and the present value lifecycle cost is $10 million.

6.5.2 Cost-Performance Summary

Table 6.5-2 provides the typical year CSO statistics and present value cost estimate associated with each MTA-4A control point. Typical year CSO volume is the systemwide total of individual CSO outfalls, and typical year CSO frequency represents the range of frequencies for individual CSO outfalls (Pre-Plan and Appendix B) or the target frequency corresponding to the LoC (for control points two through seven).

Table 6.5-2: MTA-4A LoCs, Control Facilities, and Associated Cost

Control Point	Receiving Water	Number of Storage Facilities	Total Storage Volume (MG)	Number of Treatment Facilities	Total Treatment Capacity (MGD)	Total Estimated Cost ($ Million)	Typical Year CSO Volume (MG)	Typical Year CSO Frequency
Pre-Plan	NA	NA	NA	NA	NA	NA	796	6 to 95
1 (App. B)	Susquehanna and Paxton	NA	NA	NA	NA	$217	331	6 to 60
2	Susquehanna	1	0.84	0	0.0	$156	82	20
	Paxton	2	0.30	0	0.0	$252	101	
3	Susquehanna	1	0.07	1	25.0	$166	58	16
	Paxton	2	1.04	0	0.0	$268	84	
4	Susquehanna	3	0.43	1	62.5	$214	31	10
	Paxton	4	2.76	0	0.0	$328	59	
5	Susquehanna	3	0.86	1	88.7	$241	21	5
	Paxton	4	2.25	1	88.4	$374	40	
6	Susquehanna	3	2.91	1	164	$296	7	2
	Paxton	4	3.38	2	340	$599	13	
7	Susquehanna	3	5.18	1	238	$340	1	0
	Paxton	3	4.03	3	518	$764	2	

Figure 6.5-2 is the systemwide cost-performance plot of CSO frequency versus present value costs for MTA-4A. Except for the Pre-Plan and Appendix B conditions, each of the LoC points along the curve would provide a consistent systemwide LoC whereby every outfall would have no more than the frequencies indicated in the CSO frequency column in the above table. **Figure 6.5-3** provides the MTA-4A cost-performance plots of CSO frequency versus present value costs for each receiving water.

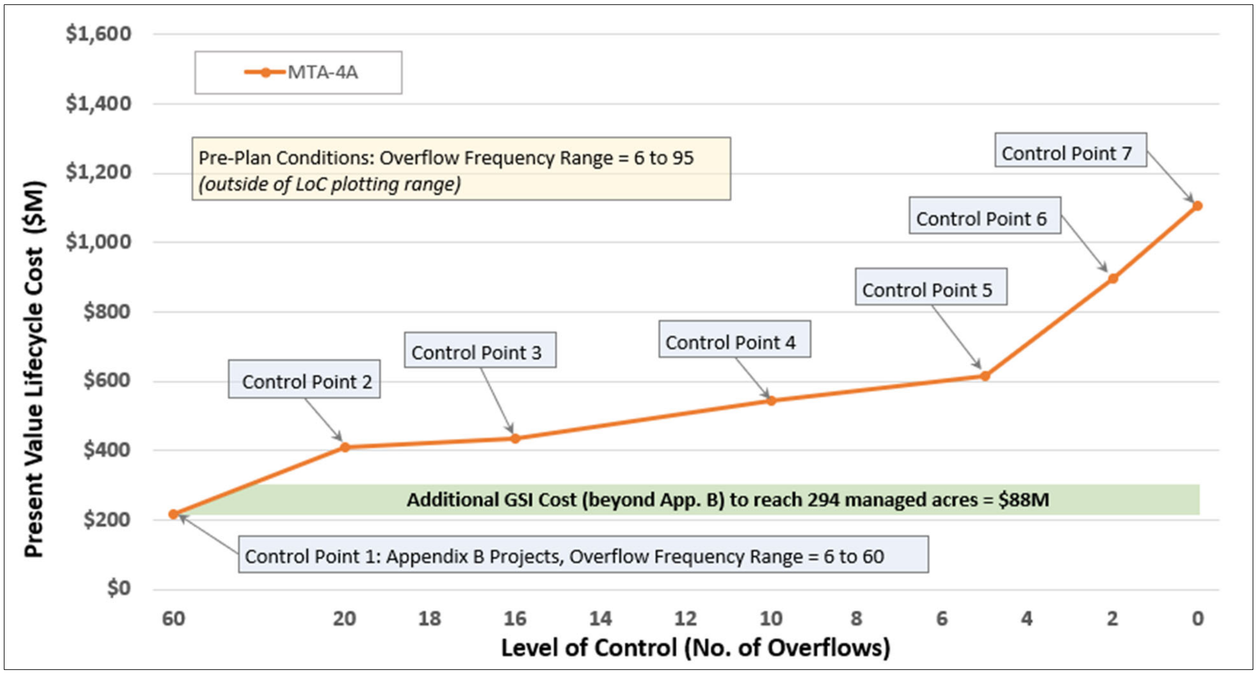

Figure 6.5-2: MTA-4A Systemwide Typical Year CSO Frequency vs. Cost-Performance Curve

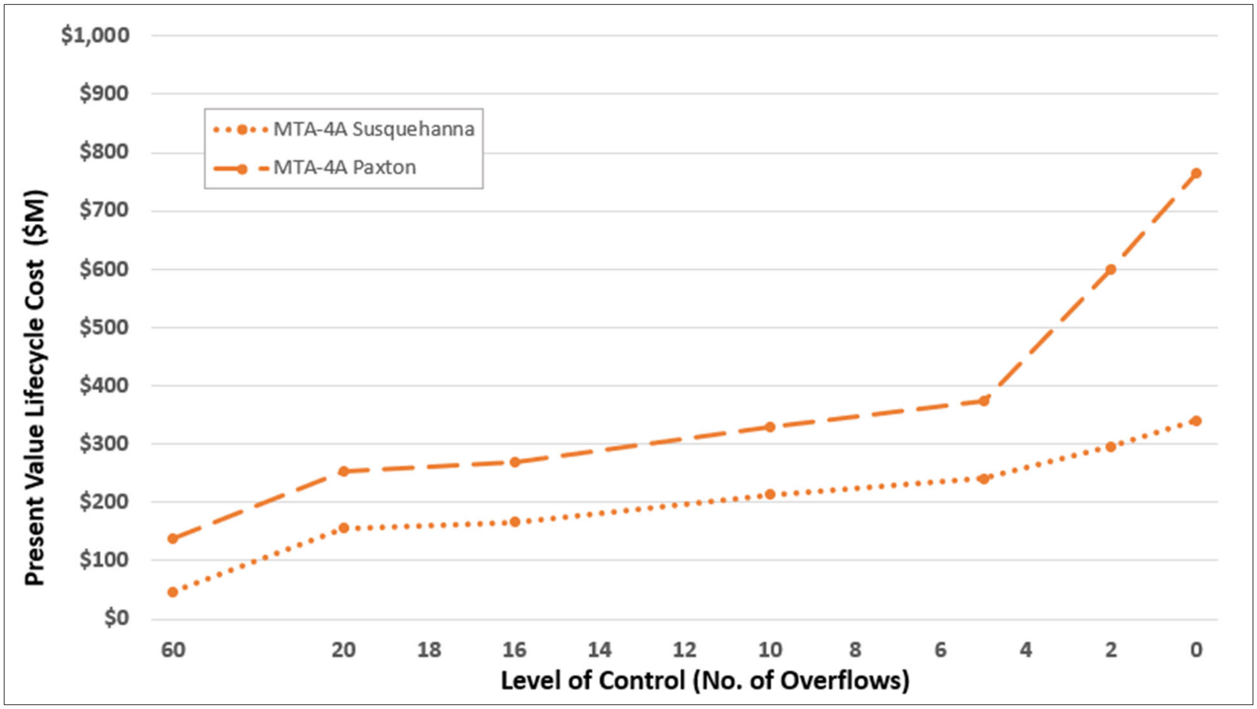

Figure 6.5-3: MTA-4A Typical Year CSO Volume vs. Cost-Performance Curves by Receiving Water

Figure 6.5-4 is the systemwide cost-performance plot of overflow volume versus present value costs for MTA-4A. **Figure 6.5-5** provides the MTA-4A cost-performance plots of overflow volume versus present value costs for each receiving water.

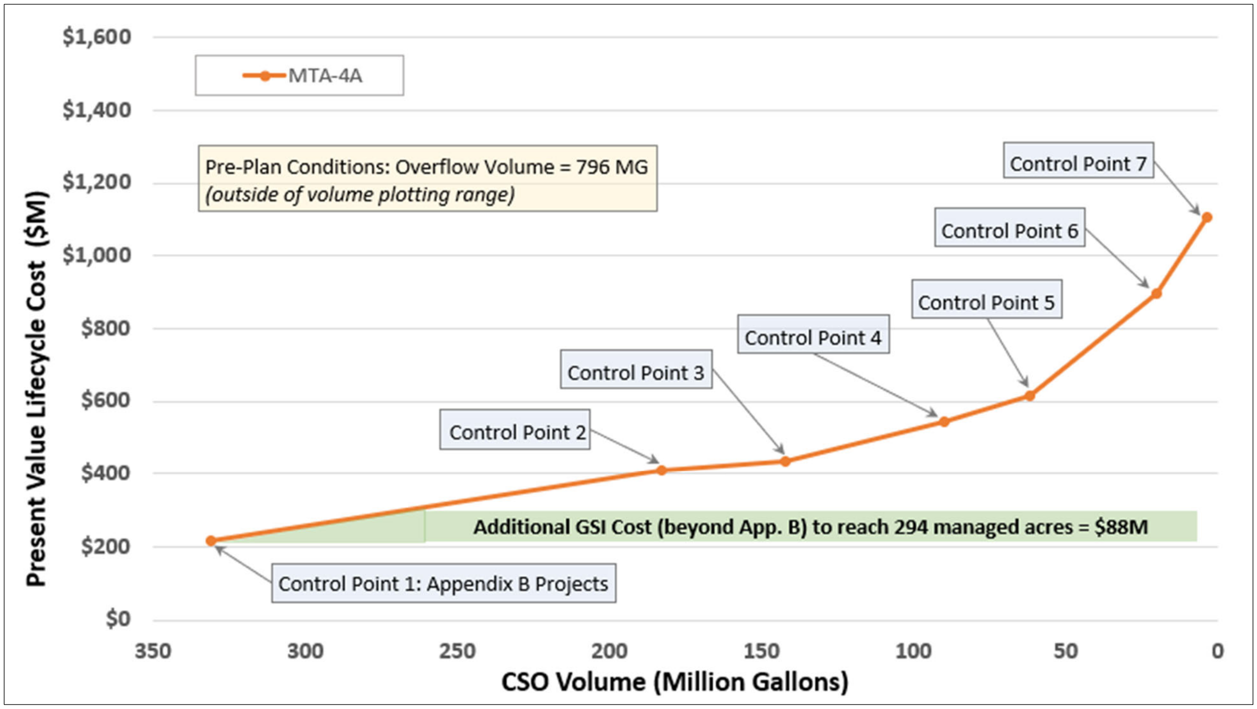

Figure 6.5-4: MTA-4A Systemwide Typical Year CSO Volume vs. Cost-Performance Curve

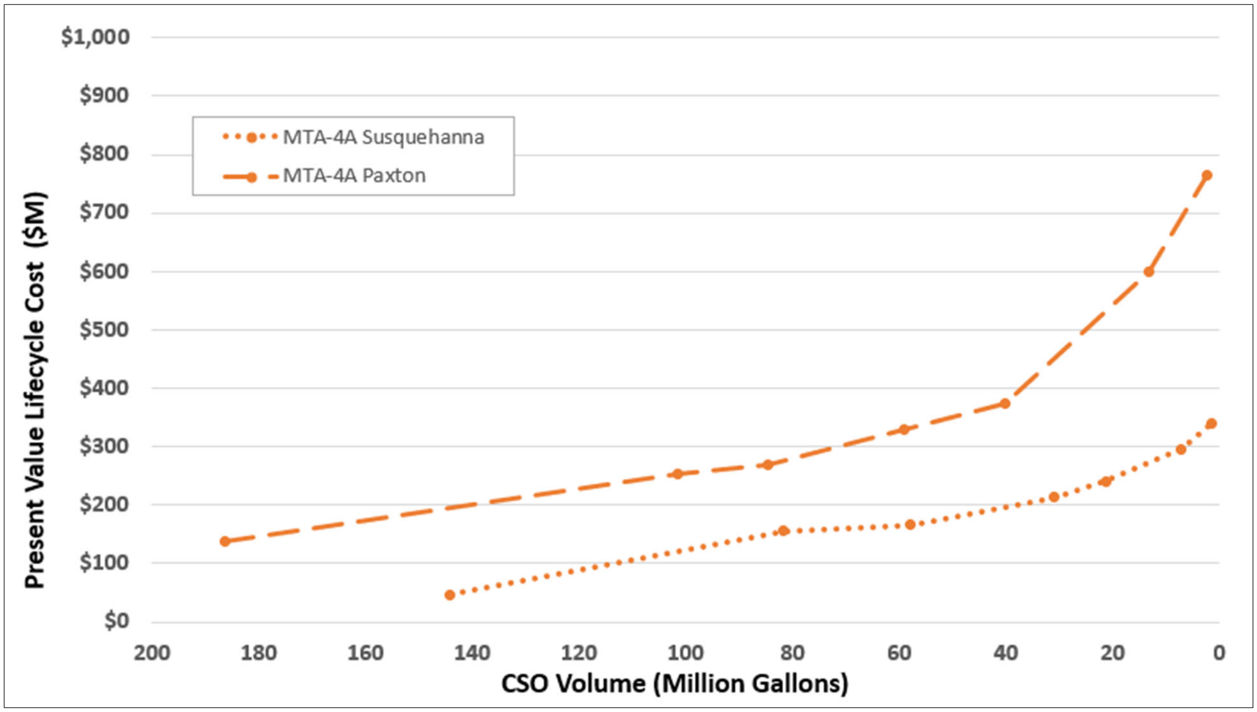

Figure 6.5-5: MTA-4A Typical Year CSO Volume vs. Cost-Performance Curves by Receiving Water

6.6 MTA-4B: Satellite Storage with Maximized Consolidation

Mixed Technology Alternative 4B (MTA-4B) utilizes consolidated satellite storage as the primary means of controlling wet weather discharges. The alternative employs the interceptor and pump station conveyance capacities and the AWTF treatment capacity provided by the completion of the Appendix B projects. A system of decentralized satellite storage facilities is added, with an increasing number of facilities and storage volumes to provide a wide range of LoCs. This alternative consolidates adjacent catchment areas into single control facilities using consolidation sewers. The storage facilities are located near CSO regulator structures to capture volumes that would otherwise overflow into the receiving waters. Green stormwater infrastructure (GSI) facilities and sewer separation projects will further reduce the volume of stormwater runoff entering the combined sewer system. Alternative 4B facilities are described below and their locations are shown in **Figure 6.6-1**. The number of satellite storage facilities for each LoC, and their corresponding storage volumes are provided in **Table 6.6-1**.

Details regarding the components included within MTA-4B are explained below:

Treatment Capacity: The peak wet weather capacity of the AWTF will remain at 80 MGD, which includes the permitted bypassing of secondary treatment facilities.

Conveyance Capacities: The peak wet weather capacities of the Front Street and Spring Creek Pump Stations will remain at the levels provided at the completion of the Appendix B projects. The conveyance capacities along the Front Street and Paxton Creek Interceptors will also remain at the levels provided by the completion of the Appendix B projects.

Satellite Storage Facilities: For this alternative it is assumed that all of the satellite storage tanks are constructed underground along the interceptors and function as gravity-in/pumped-out facilities. To control the accumulation of solids and debris, the storage systems will be equipped with automated flushing mechanisms. New flow diversion structures will regulate the quantity of wet weather flow conveyed to the interceptor system and divert the excess wet weather flow to the storage tanks. A network of consolidation sewers will convey the wet weather flow from the flow diversion structures to the storage facilities. It is assumed that supervisory control and data acquisition (SCADA) systems and real time control (RTC) systems would optimize the dewatering of the storage vaults. See Section 4.5 for a more complete description of this control technology.

Sewer Separation Projects: Sewer separation projects will be implemented within one strategic catchment (S-038) in addition to the Appendix B sewer separation projects. The location of this separation project is shown in **Figure 6.6.1.**

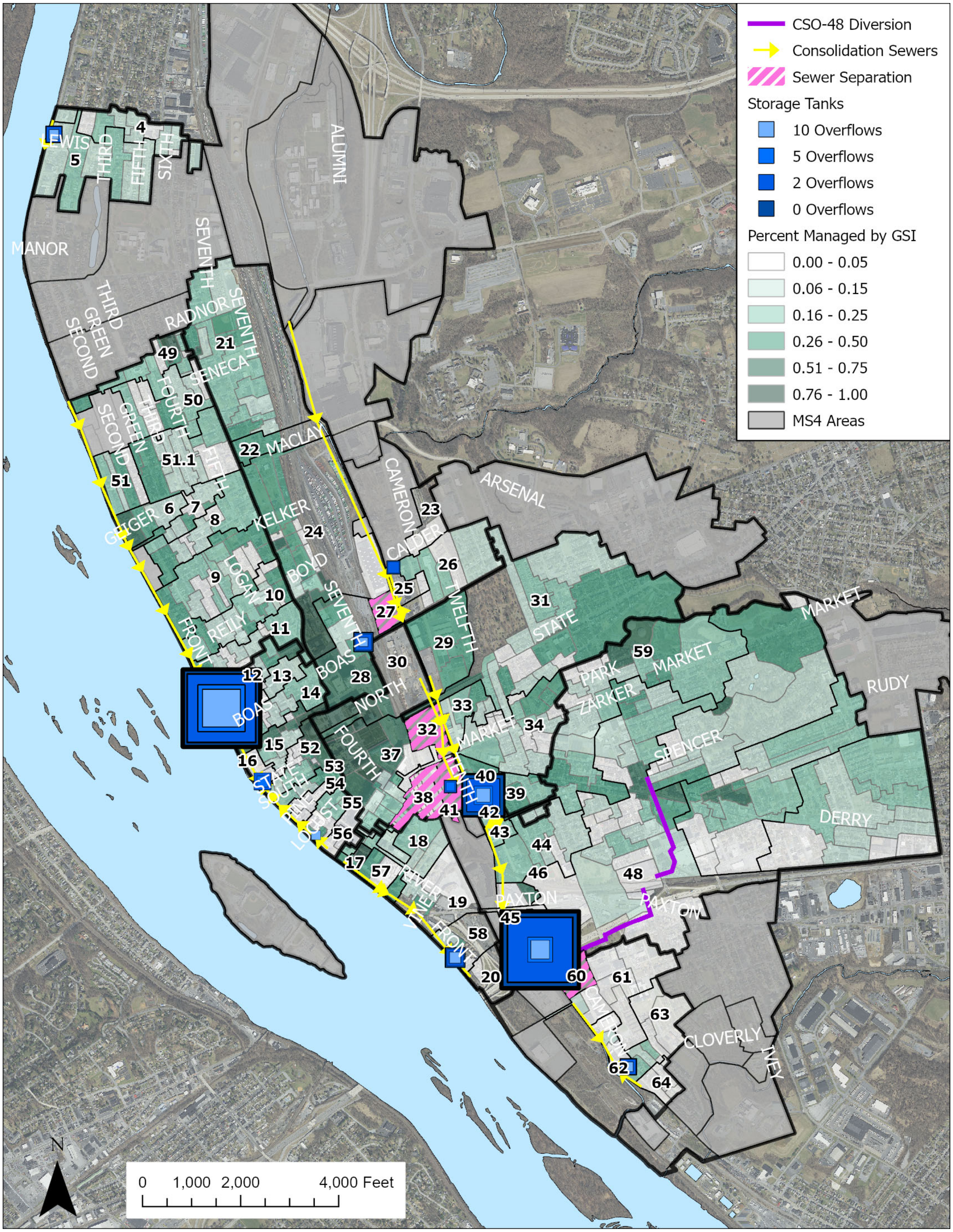

Figure 6.6-1: Locations of Control Facilities for MTA-4B

Table 6.6-1: MTA-4B Facility Sizes and Location

Planning Area	**CSO Outfall**	**Technology Size** (Location Indicated in Parentheses)					
		20 Overflows	**16 Overflows**	**10 Overflows**	**5 Overflows**	**2 Overflows**	**0 Overflows**
Riverside	CSO-04			0.22 MG (CSO-05)	0.34 MG (CSO-05)	1.07 MG (CSO-05)	1.77 MG (CSO-05)
	CSO-05						
Uptown	CSO-49			4.33 MG (Tank = 3.33 MG; Con. Sewers = 1 MG) (CSO-13)	5.64 MG (Tank = 4.64 MG; Con. Sewers = 1 MG) (CSO-13)	8.73 MG (Tank = 7.73 MG; Con. Sewers = 1 MG) (CSO-13)	14.02 MG (Tank = 13.02 MG; Con. Sewers = 1 MG) (CSO-13)
	CSO-50						
	CSO-51	3.44 MG (Tank = 2.79 MG; Cons. Sewers = 0.65 MG) (CSO-11)	4.03 MG (Tank = 3.23 MG; Cons. Sewers = 0.8 MG) (CSO-13)				
	CSO-06						
	CSO-07						
	CSO-08						
	CSO-09						
	CSO-10						
	CSO-11						
Middle Front Street	CSO-12						
	CSO-13						
	CSO-14				0.47 MG (CSO-16)	1.34 MG (CSO-16)	1.78 MG (CSO-16)
	CSO-15						
	CSO-16						
	CSO-52			0.23 MG (CSO-55)			
	CSO-53						
	CSO-54						
	CSO-55						
	CSO-56						
Lower Front Street	CSO-17			0.47 MG (CSO-58)	0.65 MG (CSO-58)	1.31 MG (CSO-58)	2.40 MG (CSO-58)
	CSO-57		0.24 MG (CSO-58)				
	CSO-18						
	CSO-19						
	CSO-58	0.06 MG					
	CSO-20						
Upper Paxton Creek - West	CSO-21			0.13 MG (CSO-28)	0.24 MG (CSO-28)	1.20 MG (CSO-28)	2.29 MG (CSO-28)
	CSO-22						
	CSO-24						
	CSO-27						
	CSO-28						
Upper Paxton Creek - East	CSO-23					0.52 MG (CSO-23)	1.13 MG (CSO-23)
	CSO-25						
	CSO-26		0.26 MG (CSO-40)	0.86 MG (CSO-40)	1.54 MG (CSO-40)		
Middle Paxton Creek - East	CSO-29	0.10 MG (CSO-29)				3.66 MG (CSO-40)	6.82 MG (CSO-40)
	CSO-31						
	CSO-33						
	CSO-34						
	CSO-39						
	CSO-40						
Middle Paxton Creek - West	CSO-30					0.53 MG (CSO-38)	1.01 MG (CSO-38)
	CSO-32						
	CSO-37				0.13 MG (CSO-38)		
	CSO-38	14.5 ac	14.5 ac	14.5 ac			
	CSO-41						
Lower Paxton Creek	CSO-42	0.20 MG (CSO-48)	0.80 MG (CSO-48)	1.56 MG (CSO-48)	2.47 MG (CSO-48)	8.27 MG (CSO-48)	14.75 MG (CSO-48)
	CSO-59						
	CSO-43						
	CSO-44						
	CSO-45						
	CSO-46						
	CSO-48						
Hemlock Street	CSO-60						
	CSO-61			0.25 MG (CSO-63)	0.37 MG (CSO-63)	1.05 MG (CSO-63)	1.77 MG (CSO-63)
	CSO-62						
	CSO-63						
	CSO-64						

Notes:

1. All alternatives include Appendix B projects and baseline level of GSI.

Color Coding:

Satellite Storage (End of Pipe)	Sewer Separation

6.6.1 Basis of Cost Estimates

Satellite Storage Facilities: The number, size, and total volume of the satellite storage facilities vary with the level of control. The Project Cost Summary tables provide the location, size, and present value lifecycle cost for each of the satellite storage facilities required to provide each LoC. The ancillary construction costs include consolidation sewers, diversion chambers, influent and effluent sewers, and a dewatering pumping station.

Sewer Separation Costs: In addition to the four sewer separation projects included in the Appendix B project list, MTA-4B includes sewer separation (for certain LoCs) within the S-038 catchment area within the Paxton Creek Restoration Master Plan corridor. The total construction cost for this sewer separation project is $7 million and the present value lifecycle cost is $10 million.

6.6.2 Cost-Performance Summary

Table 6.6-2 provides the typical year CSO statistics and present value cost estimate associated with each MTA-4B control point. Typical year CSO volume is the systemwide total of individual CSO outfalls, and typical year CSO frequency represents the range of frequencies for individual CSO outfalls (Pre-Plan and Appendix B) or the target frequency corresponding to the LoC (for control points two through seven).

Table 6.6-2: MTA-4B LoCs, Control Facilities, and Associated Cost

Control Point	Receiving Water	Number of Storage Facilities	Total Storage Volume (MG)	Total Estimated Cost ($ Million)	Typical Year CSO Volume (MG)	Typical Year CSO Frequency
Pre-Plan	NA	NA	NA	NA	796	6 to 95
1 (App. B)	Susquehanna and Paxton	NA	NA	$217	331	6 to 60
2	Susquehanna	1	0.99	$159	82	20
	Paxton	2	0.30	$252	102	
3	Susquehanna	2	1.79	$172	65	16
	Paxton	2	1.07	$270	83	
4	Susquehanna	4	2.77	$212	41	10
	Paxton Creek	4	2.83	$330	58	
5	Susquehanna	4	4.62	$237	26	5
	Paxton	5	4.77	$375	49	
6	Susquehanna	4	9.96	$331	7	2
	Paxton	5	9.34	$529	16	
7	Susquehanna	4	17.5	$410	0	0
	Paxton	5	16.6	$678	0	

Figure 6.6-2 is the systemwide cost-performance plot of CSO frequency versus present value costs for MTA-4B. Except for the Pre-Plan and Appendix B conditions, each of the LoC points along the curve would provide a consistent systemwide LoC whereby every outfall would have no more than the

frequencies indicated in the CSO frequency column in the above table. **Figure 6.6-3** provides the MTA-4B cost-performance plots of CSO frequency versus present value costs for each receiving water.

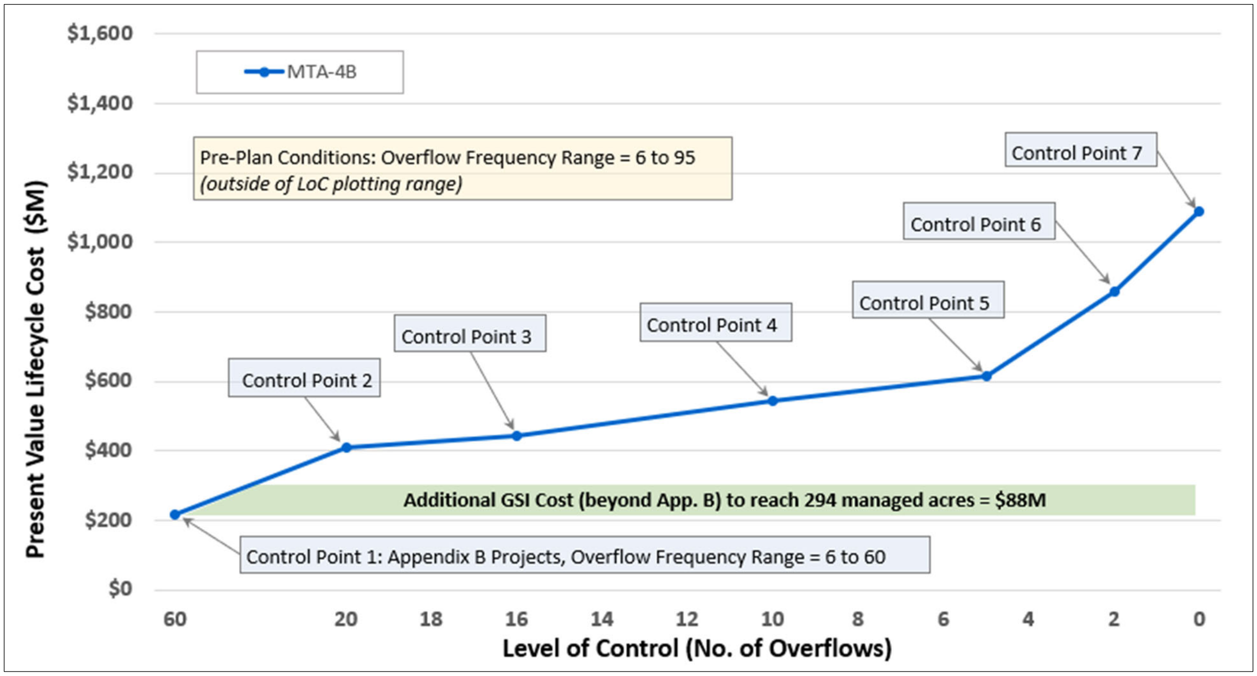

Figure 6.6-2: MTA-4B Systemwide Typical Year CSO Frequency vs. Cost-Performance Curve

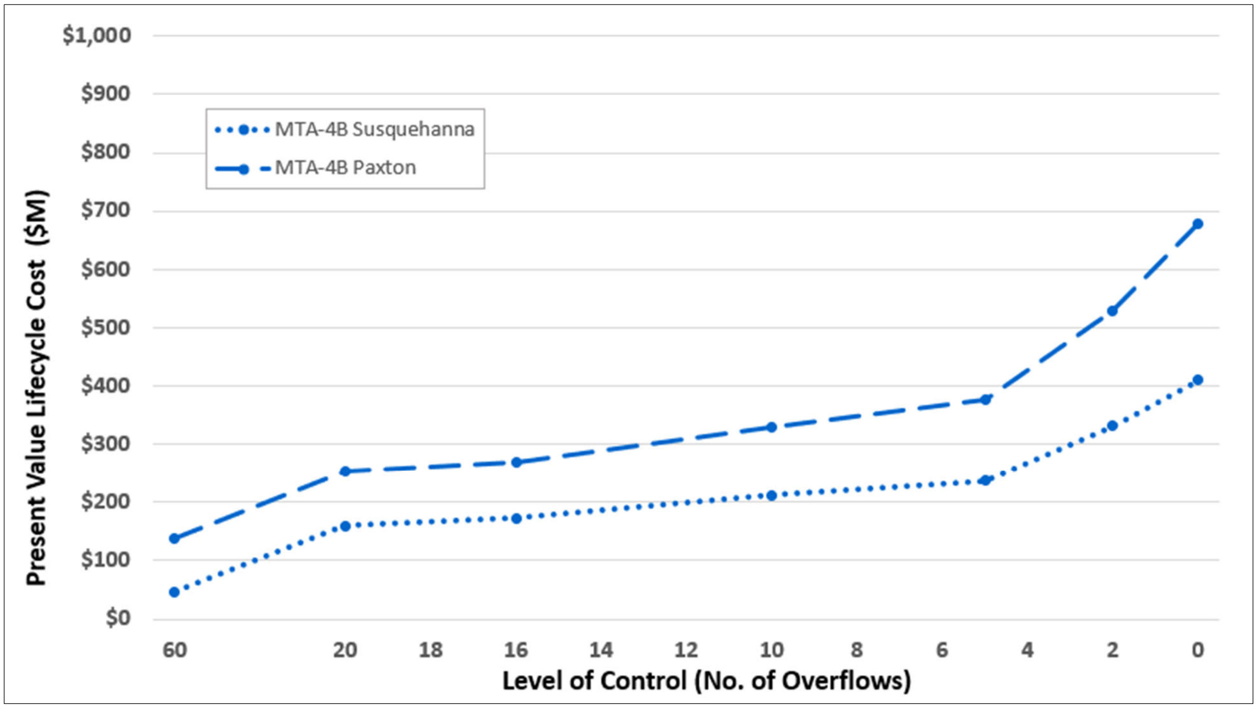

Figure 6.6-3: MTA-4B Typical Year CSO Volume vs. Cost-Performance Curves by Receiving Water

Figure 6.6-4 is the systemwide cost-performance plot of overflow volume versus present value costs for MTA-4B. **Figure 6.6-5** provides the MTA-4B cost-performance plots of overflow volume versus present value costs for each receiving water.

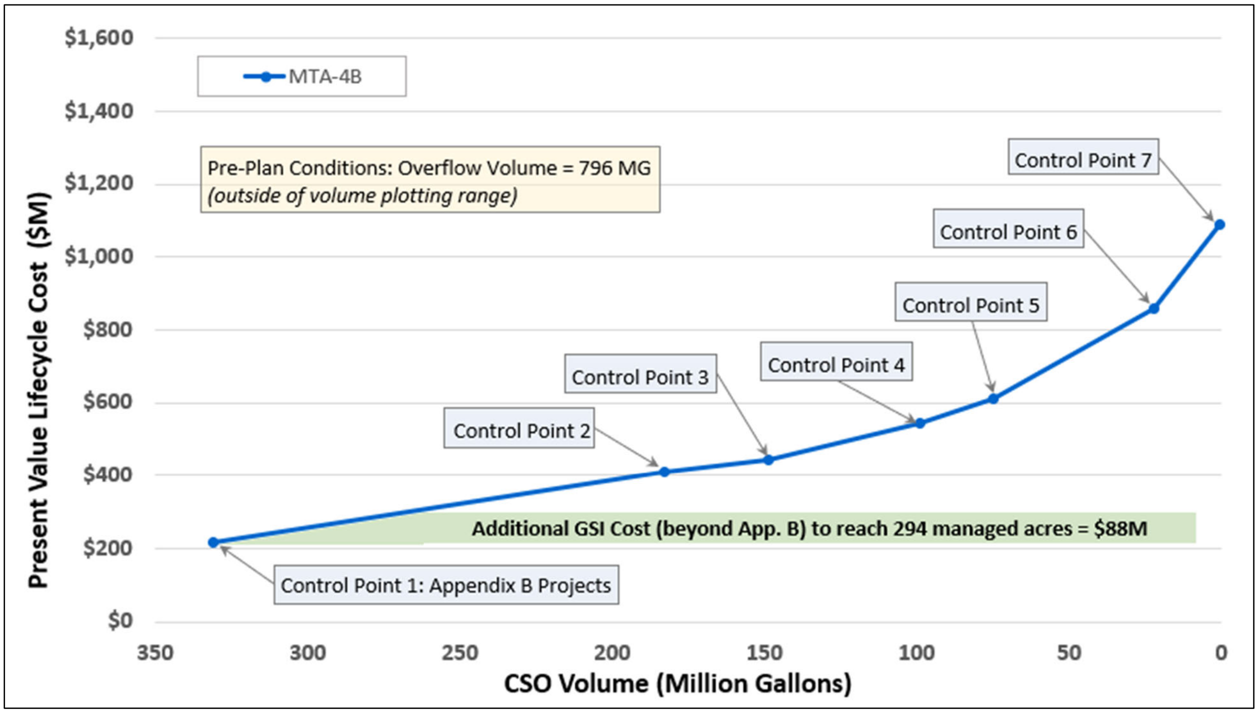

Figure 6.6-4: MTA-4B Systemwide Typical Year CSO Volume vs. Cost-Performance Curve

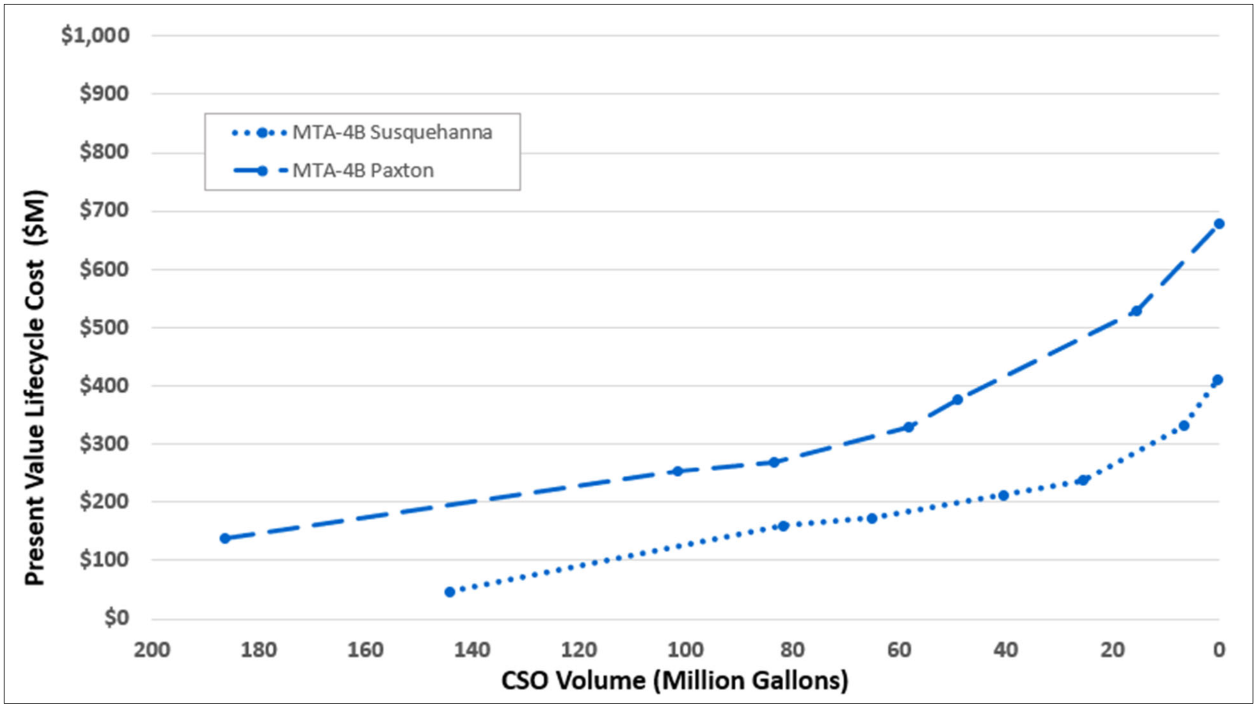

Figure 6.6-5: MTA-4B Typical Year CSO Volume vs. Cost-Performance Curves by Receiving Water

6.7 MTA-5: Tunnel Storage Based Control

Mixed Technology Alternative 5 (MTA-5) utilizes tunnel storage as the primary means of controlling wet weather discharges. The alternative employs the interceptor and pump station conveyance capacities and the AWTF treatment capacity provided by the completion of the Appendix B projects. A new tunnel storage system is evaluated with alignments parallel to the existing Front Street, Paxton Creek, and Hemlock Street interceptors and with invert elevations below the existing interceptor profiles. In this alternative, excess wet weather flows that exceed existing conveyance system capacities are conveyed to the tunnel system, stored temporarily, and dewatered to the AWTF after the storm passes and treatment capacity becomes available. For lower LoCs, required storage volumes are lower, tunnel diameters are smaller, and tunnel lengths are shorter. Therefore, a system of decentralized satellite storage facilities is added, at the upstream reaches of the combined sewer system, with an increasing number of facilities and storage volumes to provide a wide range of LoCs. This alternative consolidates adjacent catchment areas into single control facilities using consolidation sewers.

The storage facilities are fully automated and do not require on-site staffing. The storage facilities are located near CSO regulator structures to capture volumes that would otherwise overflow into the receiving waters. Green stormwater infrastructure (GSI) facilities and sewer separation projects will further reduce the volume of stormwater runoff entering the combined sewer system. MTA-5 facilities are described below and their locations are shown in **Figure 6.7-1**. The number of satellite storage facilities for each LoC, and their corresponding storage volumes are provided in **Table 6.7-1**.

Multiple variations of tunnel lengths and diameters could be evaluated to achieve the same tunnel volumes required to control CSO volumes. In Section 4, satellite storage was found to be more cost-effective than tunnel storage. Therefore, pairing satellite storage with tunnel storage is preferrable to tunnel storage alone. For this analysis, a balance between satellite storage and tunnel storage was sought such that the tunnel system would extend far enough to pick up key large volume CSO contributors, thus eliminating the need for multiple large volume satellite storage tanks. This resulted in the target LoC scenarios having different tunnel lengths, as shown in **Table 6.7-1**.

Details regarding the components included within MTA-5 are explained below:

Treatment Capacity: The peak wet weather capacity of the AWTF will remain at 80 MGD, which includes the permitted bypassing of secondary treatment facilities.

Conveyance Capacities: The peak wet weather capacities of the Front Street and Spring Creek Pump Stations will remain at the levels provided at the completion of the Appendix B projects. The conveyance capacities along the Front Street and Paxton Creek Interceptors will also remain at the levels provided by the completion of the Appendix B projects.

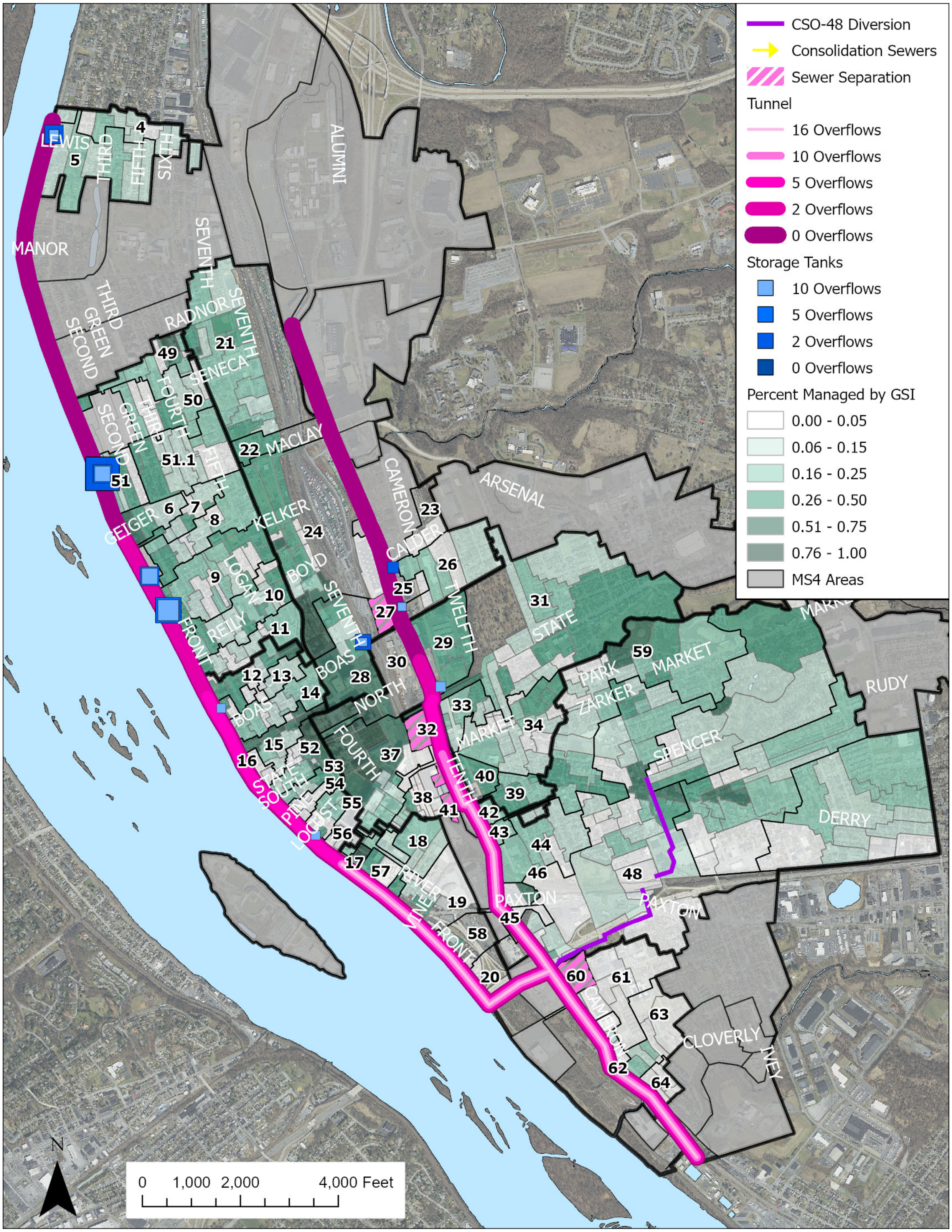

Figure 6.7-1: Locations of Control Facilities for MTA-5

Table 6.7-1: MTA-5 Facility Sizes and Locations

Planning Area	CSO Outfall	Technology Size (Location Indicated in Parentheses)					
		20 Overflows	**16 Overflows**	**10 Overflows**	**5 Overflows**	**2 Overflows**	**0 Overflows**
Riverside	CSO-04	Same as Alternative 1		0.25 MG (CSO-05)	0.36 MG (CSO-05)	1.60 MG (CSO-05)	**Susquehanna Branch:** 17.2 MG 23,400 ft 14' Diameter
	CSO-05						
Uptown	CSO-49			1.13 MG (CSO-51)	1.56 MG (CSO-51)	3.74 MG (CSO-51)	
	CSO-50						
	CSO-51		1.17 MG				
	CSO-06		1.17 MG (CSO-08)	1.19 MG (CSO-08)	1.63 MG (CSO-08)	**Susquehanna Branch:** 6.5 MG 14,400 ft 12' Diameter	
	CSO-07						
	CSO-08						
	CSO-09		1.72 MG (CSO-09)	1.91 MG (CSO-09)	2.56 MG (CSO-09)		
	CSO-10						
	CSO-11						
Middle Front Street	CSO-12			0.18 MG (CSO-13)	**Susquehanna Branch:** 0.75 MG; 10,800 ft 6' Diameter		
	CSO-13						
	CSO-14						
	CSO-15						
	CSO-16						
	CSO-52			0.23 MG (CSO-55)			
	CSO-53						
	CSO-54						
	CSO-55						
	CSO-56						
Lower Front Street	CSO-17		**Susquehanna Branch:** 0.07 MG 6,300 ft 3.5' Diameter	**Susquehanna Branch:** 0.20 MG 6,300 ft 5' Diameter			
	CSO-57						
	CSO-18						
	CSO-19						
	CSO-58						
	CSO-20						
Upper Paxton Creek - West	CSO-21			0.10 MG (CSO-28)	0.21 MG (CSO-28)	1.17 MG (CSO-28)	**Paxton Branch:** 27.0 MG 19,800 ft 14' Diameter **TOTAL:** 44.3 MG 43,300 ft 14' Diameter
	CSO-22						
	CSO-24						
	CSO-27						
	CSO-28						
Upper Paxton Creek - East	CSO-23					0.53 MG (CSO-23)	
	CSO-25						
	CSO-26		0.03 MG	0.12 MG	0.23 MG		
Middle Paxton Creek - East	CSO-29		0.24 MG (CSO-40)	0.35 MG (CSO-29)	0.20 MG	**Paxton Branch:** 13.0 MG 12,000 ft 14' Diameter **TOTAL:** 19.5 MG 26,400 ft 12' Diameter	
	CSO-31				**Paxton Branch:** 4.00 MG 11,400 ft 14' Diameter **TOTAL:** 4.75 MG 22,000 ft 6' Diameter		
	CSO-33						
	CSO-34			**Paxton Branch:** 2.26 MG 10,200 ft 14' Diameter **TOTAL:** 2.46 MG 16,600 ft 5' Diameter			
	CSO-39						
	CSO-40						
Middle Paxton Creek - West	CSO-30						
	CSO-32						
	CSO-37						
	CSO-38		**Paxton Branch:** 0.80 MG 9,600 ft 14' Diameter **TOTAL:** 0.87 MG 15,900 ft 3.5' Diameter				
	CSO-41						
Lower Paxton Creek	CSO-42						
	CSO-59						
	CSO-43						
	CSO-44						
	CSO-45						
	CSO-46						
	CSO-48						
Hemlock Street	CSO-60						
	CSO-61						
	CSO-62						
	CSO-63						
	CSO-64						

Notes:

1. All alternatives include Appendix B projects and baseline level of GSI.

Color Coding:

Satellite Storage (End of Pipe)	Tunnel

Tunnel Storage: For tunnel storage, each LoC is achieved by increasing the length, diameter, and corresponding storage volume of the tunnel system. It is assumed tunnels with diameters 6 feet and smaller are constructed using micro-tunneling, and tunnels with diameters greater than 6 feet are constructed using a tunnel boring machine (TBM). A dewatering pump station would empty the tunnel system after a storm event is over and capacity becomes available at the existing AWTF.

Drop shaft structures to convey the wet weather flow to the tunnel were assumed for costing purposes. The number of drop structures increases with the LoC and length of the tunnel system. Flow diversion structures and consolidation sewers were included to convey the diverted flow to the drop shaft structures.

Satellite Storage Facilities: For this alternative it is assumed that all the satellite storage tanks are constructed underground along the interceptors and function as gravity-in/pumped-out facilities. To control the accumulation of solids and debris, the storage systems will be equipped with automated flushing mechanisms. New flow diversion structures will regulate the quantity of wet weather flow conveyed to the interceptor system and divert the excess wet weather flow to the storage tanks.

A network of consolidation sewers will convey the wet weather flow from the flow diversion structures to the tunnel drop shaft structures and to the satellite storage facilities. It is assumed that supervisory control and data acquisition (SCADA) systems and real time control (RTC) systems would optimize the dewatering of the storage vaults. See Section 4.5 for a more complete description of this control technology.

6.7.1 Basis of Cost Estimates

Tunnel Storage System: The length, cross-sectional area, and total volume of the tunnel storage system varies with the level of control. The Project Cost Summary tables provide the location, size, and present value lifecycle cost for each tunnel storage system required to provide each LoC. The construction costs include the access shafts to the tunnel, the connector pipes between the existing regulator structures, and the tunnel system. The costs for pipes up to 6 ft in diameter were based on installation using micro-tunneling, and the costs for pipes lager than 6 ft were based on installation utilizing a tunnel boring machine.

Satellite Storage Facilities: The number, size, and total volume of the satellite storage facilities vary with the level of control. The Project Cost Summary tables provide the location, size, and present value lifecycle cost for each of the satellite storage facilities required to provide each LoC. The ancillary construction costs include consolidation sewers, diversion chambers, influent and effluent sewers, and a dewatering pumping station.

6.7.2 Cost-Performance Summary

Table 6.7-2 provides the typical year CSO statistics and present value cost estimate associated with each MTA-5 control point. Typical year CSO volume is the systemwide total of individual CSO outfalls, and typical year CSO frequency represents the range of frequencies for individual CSO outfalls (Pre-Plan and Appendix B) or the target frequency corresponding to the LoC (for control points two through seven).

Table 6.7-2: MTA-5 LoCs, Control Facilities, and Associated Cost

Control Point	Receiving Water	Total Tunnel Volume (MG)	Tunnel Dimensions (feet)	Number of Storage Facilities	Total Storage Volume (MG)	Total Estimated Cost ($ Million)	Typical Year CSO Volume (MG)	Typical Year CSO Frequency
Pre-Plan		NA	NA	NA	NA	NA	796	6 to 95
1 (App. B)	Susquehanna and Paxton	NA	NA	NA	NA	$217	331	6 to 60
2	Susquehanna	NA	NA	3	0.80	$145	84	20
	Paxton			3	0.75	$252	104	
3	Susquehanna	0.91	15,900 3.5 ft dia.	3	1.56	$254	63	16
	Paxton			2	0.27	$2800	83	
4	Susquehanna	2.46	16,600 5.0 ft dia.	6	2.38	$304	39	10
	Paxton			3	0.57	$325	46	
5	Susquehanna	4.75	22,200 6.0 ft dia.	4	3.60	$332	25	5
	Paxton			3	3.11	$366	31	
6	Susquehanna	19.5	26,400 12 ft dia.	2	2.85	$384	7	2
	Paxton			2	1.75	$578	5	
7	Susquehanna	44.3	43,300 14 ft dia.	NA	NA	$412	1	0
	Paxton			NA	NA	$716	1	

Figure 6.7-2 is the systemwide cost-performance plot of CSO frequency versus present value costs for MTA-5. Except for the Pre-Plan and Appendix B conditions, each of the LoC points along the curve would provide a consistent systemwide LoC whereby every outfall would have no more than the frequencies indicated in the CSO frequency column in the above table. **Figure 6.7-3** provides the MTA-5 cost-performance plots of CSO frequency versus present value costs for each receiving water.

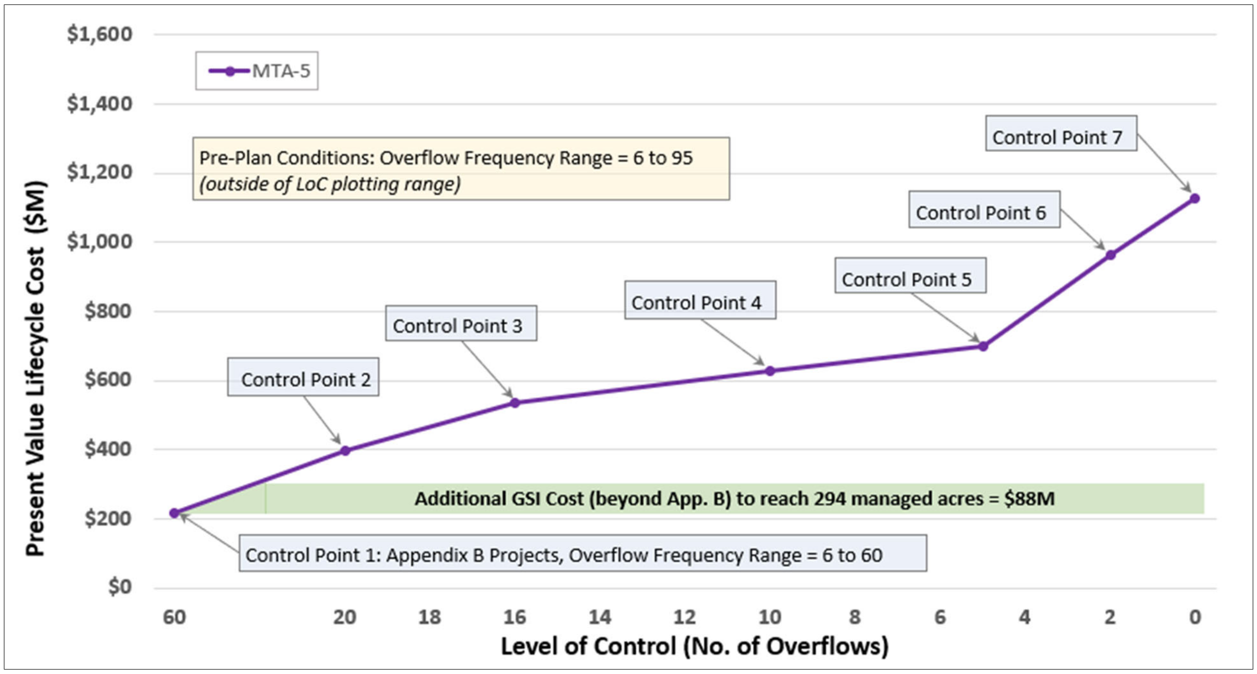

Figure 6.7-2: MTA-5 Systemwide Typical Year CSO Frequency vs. Cost-Performance Curve

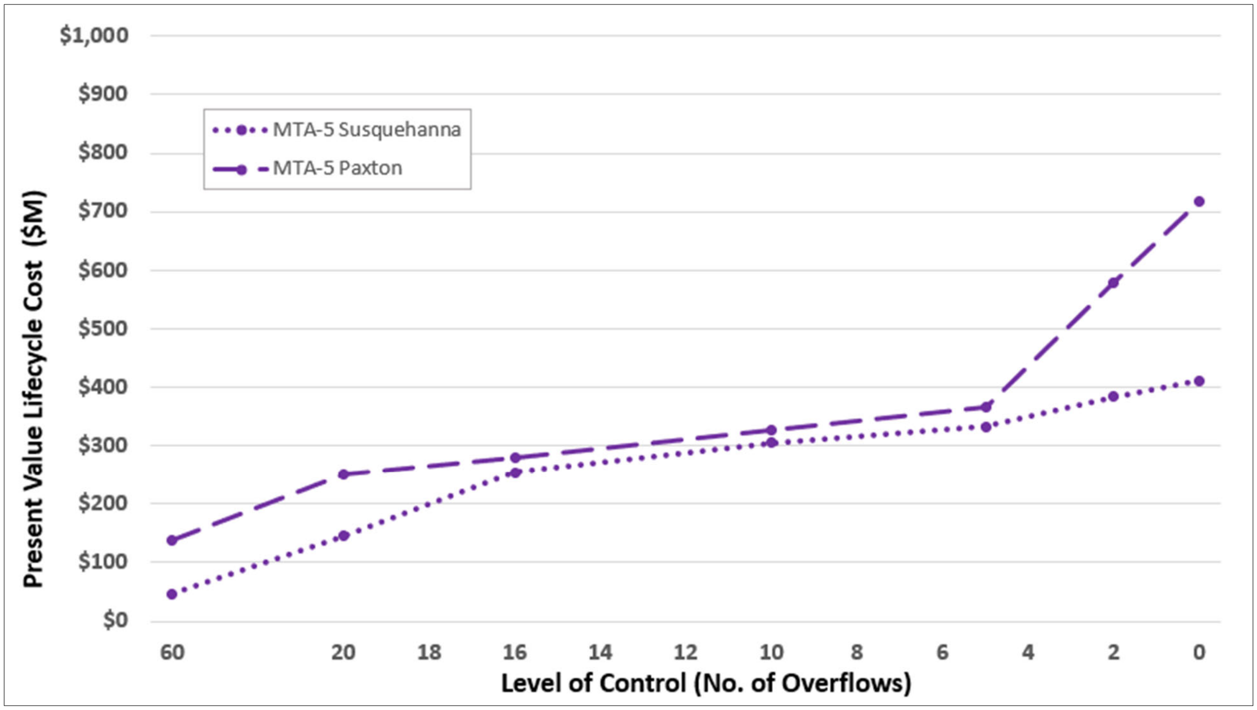

Figure 6.7-3: MTA-5 Typical Year CSO Volume vs. Cost-Performance Curves by Receiving Water

Figure 6.7-4 is the systemwide cost-performance plot of overflow volume versus present value costs for MTA-5. **Figure 6.7-5** provides the MTA-5 cost-performance plots of overflow volume versus present value costs for each receiving water.

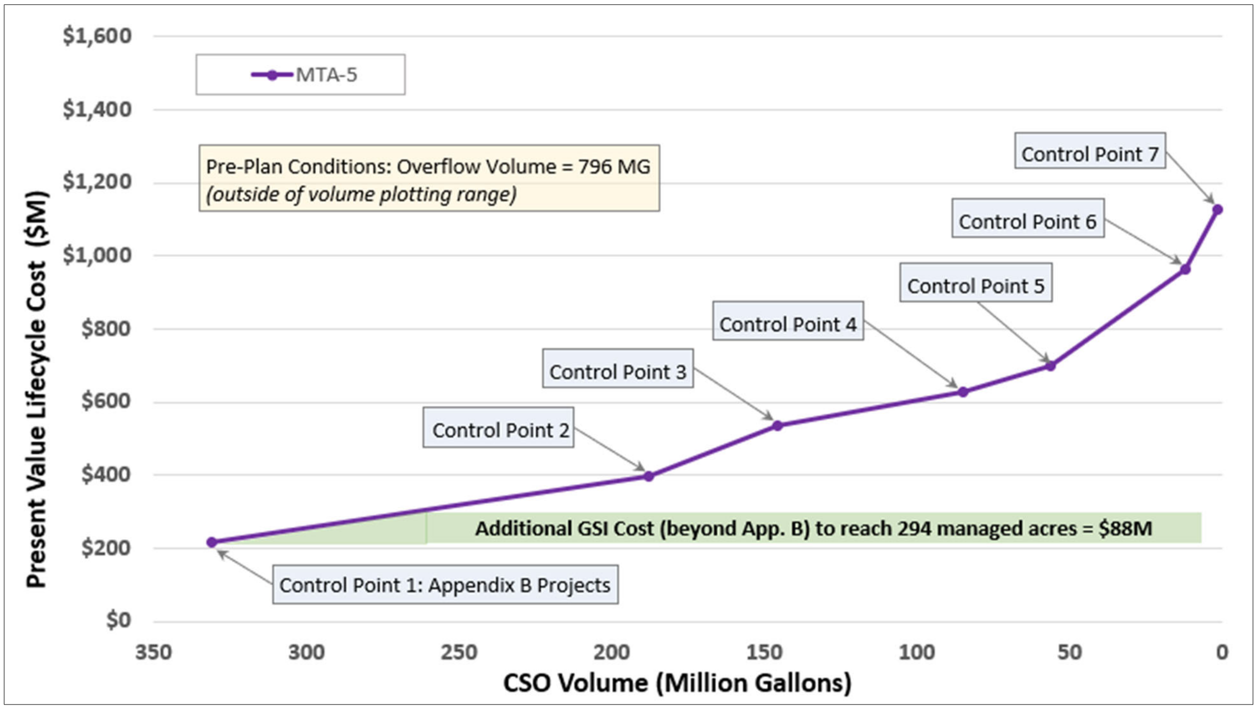

Figure 6.7-4: MTA-5 Systemwide Typical Year CSO Volume vs. Cost-Performance Curve

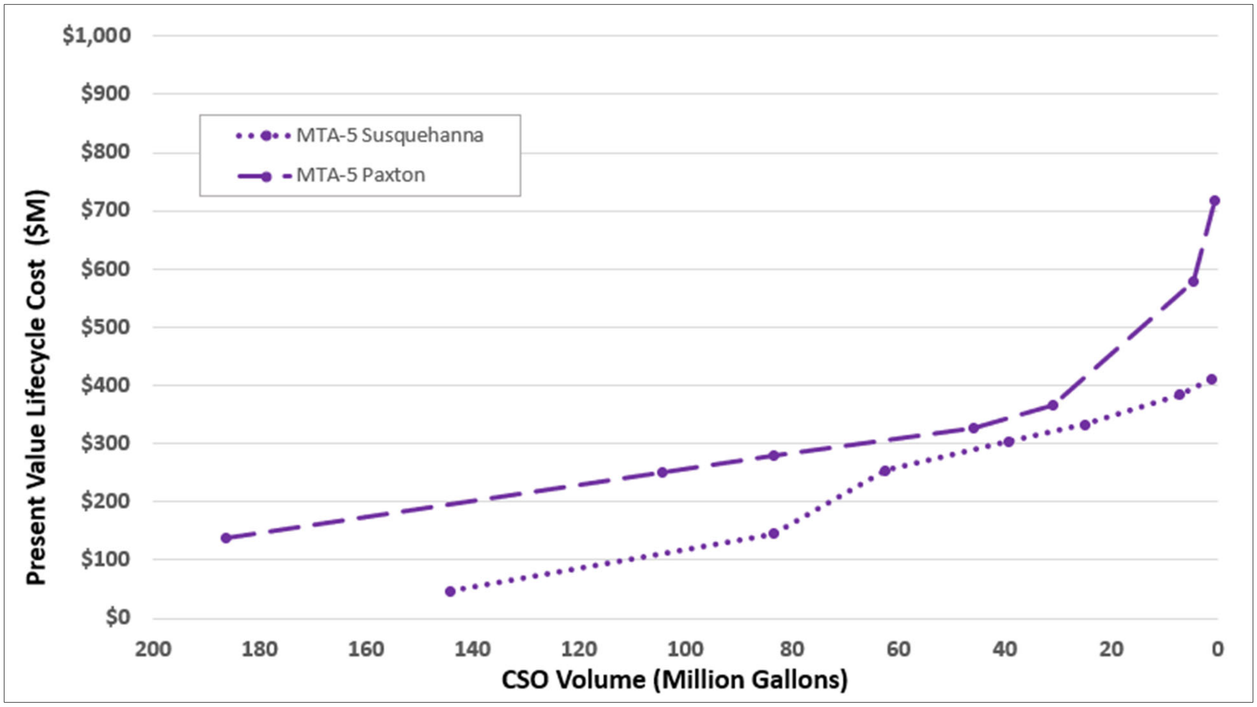

Figure 6.7-5: MTA-5 Typical Year CSO Volume vs. Cost-Performance Curves by Receiving Water

6.8 MTA-6: Maximize Conveyance and Treatment

Mixed Technology Alternative 6 (MTA-6) utilizes a new 70 mgd Retention Treatment Basin (RTB). This facility would be constructed adjacent to the existing AWTF. To provide conveyance to this new treatment facility, a new extension from the Paxton Creek Interceptor would be constructed. A flow diversion structure would be constructed at the bottom reach of the existing Paxton Creek Interceptor that would divert excess wet weather flow away from the Front Street Pump Station and direct it to the new treatment facility. A new pump station would be constructed to lift the flow from the new interceptor to the treatment facility.

The diameter for replaced the Paxton Creek Interceptor under Appendix B, would have to be enlarged to 72 inches. Additionally, the connector pipes from the CSO regulator structures contributing flow to Paxton Creek Interceptor and Front Street Interceptor, would be expanded to increase the flow into the interceptors. A system of decentralized satellite storage facilities is added, with an increasing number of facilities and storage volumes, to provide a wide range of LoCs. The storage facilities are located near CSO regulator structures to capture volumes that would otherwise overflow into the receiving waters. Green stormwater infrastructure (GSI) facilities and sewer separation projects will further reduce the volume of stormwater runoff entering the combined sewer system. MTA-6 facilities are described below, and their locations are shown in **Figure 6.8-1**. The number of satellite storage facilities for each LoC, and their corresponding storage volumes are provided in **Table 6.8-1**. Footprints associated with each satellite storage facility are shown in the site-scale maps in **Appendix 6-3**.

Details regarding the components included within MTA-6 are explained below:

Treatment Capacity: For this alternative, a 70 MGD Retention Treatment Basin (RTB) facility would be built near the existing AWTF. At this RTB, the wet weather combined sewage flows through screens that remove debris such as sanitary trash. A disinfectant is then applied to allow adequate time to kill disease causing organisms. In the basin, particulate matter settles out and the skimming baffle prevents the discharge of floatable material and oils. Once the storage capacity of the RTB is exceeded, the treated overflow is disinfected and sent to surface water resulting in a discharge that is protective of public health and the environment. RTBs are also equipped with flushing systems, which flush any remaining solids left in the RTB to the wastewater treatment plant, so the RTB is ready for the next rain event. The treated flows are disinfected using high-rate chemical disinfection, most likely using sodium hypochlorite, before being released to the receiving waters.

The peak wet weather capacity of the AWTF will remain at 80 MGD, which includes the permitted bypassing of secondary treatment facilities.

Conveyance Capacity: Under this alternative, the Appendix B project to replace the Paxton Creek interceptor would be modified. Instead of the replacement pipe providing equivalent conveyance capacity as the existing pipe system, the pipe diameter would be increased to 6 ft diameter to provide additional conveyance capacity. A new 3,700 ft extension to the Paxton Creek interceptor would connect the existing interceptor to the new wet weather treatment facility.

The peak wet weather capacities of the Front Street and Spring Creek Pump Stations will remain at the levels provided at the completion of the Appendix B projects.

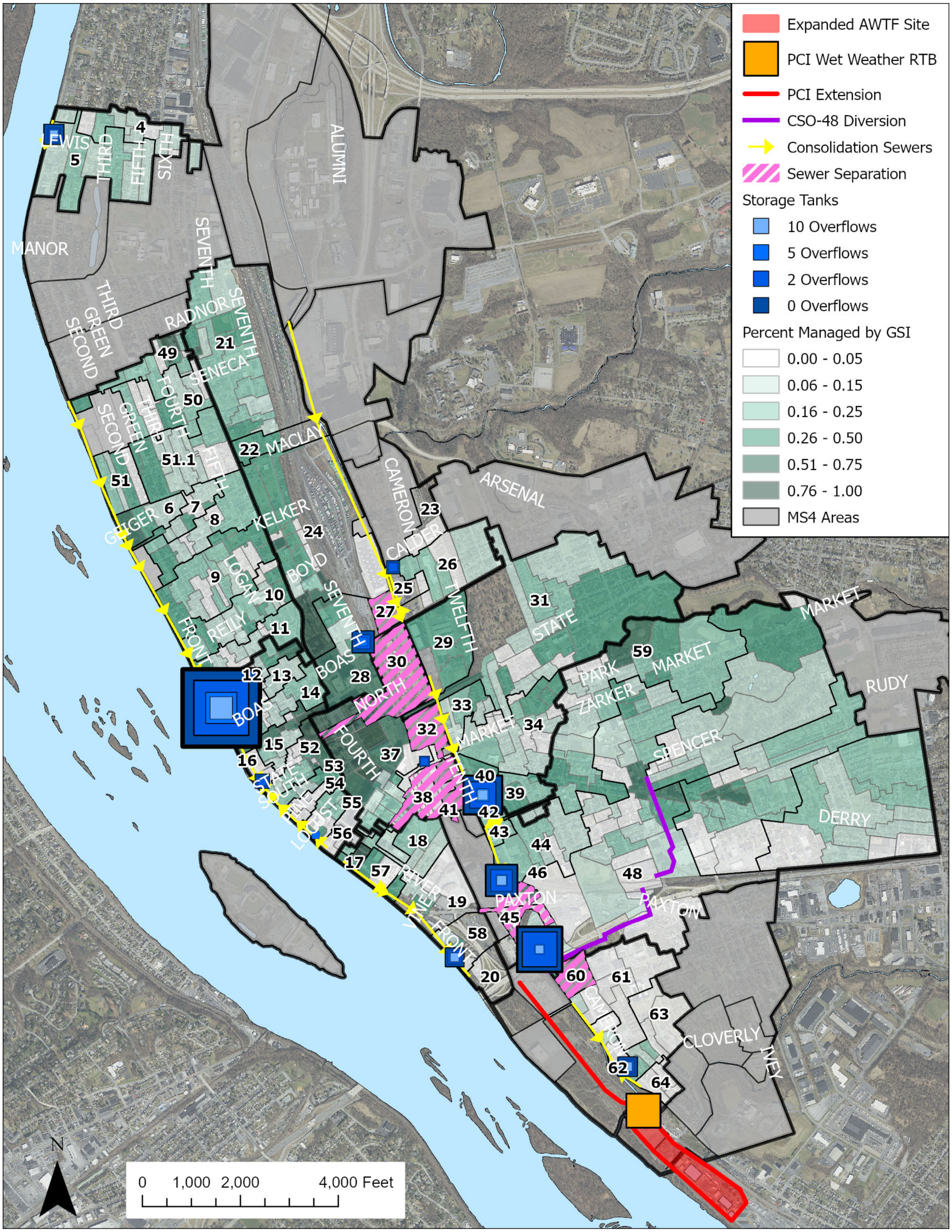

Figure 6.8-1: Locations of Control Facilities for MTA-6

Table 6.8-1: MTA-6 Facility Sizes and Locations

Planning Area	**CSO Outfall**	**Technology Size** (Location Indicated in Parentheses)					
		20 Overflows	**16 Overflows**	**10 Overflows**	**5 Overflows**	**2 Overflows**	**0 Overflows**
Riverside	CSO-04			0.12 MG (CSO-05)	0.27 MG (CSO-05)	0.86 MG (CSO-05)	1.82 MG (CSO-05)
	CSO-05						
Uptown	CSO-49				3.42 MG (Tank = 2.42 MG; Cons. Sewers = 1 MG) (CSO-13)	6.89 MG (Tank = 5.89 MG; Cons. Sewers = 1 MG) (CSO-13)	11.74 MG (Tank = 10.74 MG; Cons. Sewers = 1 MG) (CSO-13)
	CSO-50			2.14 MG (Tank = 1.14 MG; Cons. Sewers = 1 MG) (CSO-13)			
	CSO-51	0.85 MG (Tank = 0.2 MG; Cons. Sewers = 0.65 MG) (CSO-11)	1.51 MG (Tank = 0.86 MG; Cons. Sewers = 0.65 MG) (CSO-11)				
	CSO-06						
	CSO-07						
	CSO-08						
	CSO-09						
	CSO-10						
	CSO-11						
Middle Front Street	CSO-12						
	CSO-13						
	CSO-14					0.46 MG (CSO-16)	1.02 MG (CSO-16)
	CSO-15						
	CSO-16						
	CSO-52						
	CSO-53						
	CSO-54				0.03 MG (CSO-55)		
	CSO-55						
	CSO-56						
Lower Front Street	CSO-17					1.07 MG (CSO-58)	1.65 (CSO-58)
	CSO-57				0.32 MG (CSO-58)		
	CSO-18			0.20 MG (CSO-58)			
	CSO-19						
	CSO-58	0.02 MG	0.02 MG				
	CSO-20						
Upper Paxton Creek - West	CSO-21					1.16 MG (CSO-28)	2.11 MG (CSO-28)
	CSO-22						
	CSO-24				0.15 MG (CSO-28)		
	CSO-27						
	CSO-28						
Upper Paxton Creek - East	CSO-23					0.44 MG (CSO-23)	0.84 MG (CSO-23)
	CSO-25						
	CSO-26			0.37 MG (CSO-40)	0.82 MG (CSO-40)		
Middle Paxton Creek - East	CSO-29					2.87 MG (CSO-40)	4.47 MG (CSO-40)
	CSO-31						
	CSO-33						
	CSO-34						
	CSO-39						
	CSO-40						
Middle Paxton Creek - West	CSO-30					7.3 ac	7.3 ac
	CSO-32						
	CSO-37					0.21 MG	0.43 MG
	CSO-38					14.5 ac	14.5 ac
	CSO-41						
Lower Paxton Creek	CSO-42			0.29 MG (CSO-44)	0.52 MG (CSO-44)	2.22 MG (CSO-44)	3.47 MG (CSO-44)
	CSO-59						
	CSO-43						
	CSO-44						
	CSO-45					7.9 ac	7.9 ac
	CSO-46				7.1 ac	7.1 ac	7.1 ac
	CSO-48			0.09 MG	0.36 MG	4.07 MG	5.38 MG
Hemlock Street	CSO-60						
	CSO-61			0.22 MG (CSO-63)	0.36 MG (CSO-63)	1.03 MG (CSO-63)	1.76 MG (CSO-63)
	CSO-62						
	CSO-63						
	CSO-64						
Centralized Wet Weather Treatment		70 MGD	70 MGD	70 MGD	70 MGD	70 MGD	70 MGD

Notes:

1. All alternatives include Appendix B projects and baseline level of GSI.

Color Coding:

Satellite Storage (End of Pipe)	Sewer Separation	Retention Treatment Basin

Flow Diversion Structure: An engineered flow diversion structure will divert excess flow along the Paxton Creek Interceptor (up to 70 mgd) away from the Front Street Interceptor and towards the new RTB facility through the new extension of the Paxton Creek Interceptor. This flow diversion would allow the Front Street Pump Station to convey more of the Front Street Interceptor flow to the existing ATWF. It is assumed that the flow diversion structure would be incorporated into supervisory control and data acquisition (SCADA) systems and real time control (RTC) systems that would optimize the hydraulic operation of the interceptor system and the balance of wet weather flow treated between the existing AWTF and the new RTB.

Satellite Storage Facilities: For this alternative it is assumed that all of the satellite storage tanks are constructed underground along the interceptors and function as gravity-in/pumped-out facilities. To control the accumulation of solids and debris, the storage systems will be equipped with automated flushing mechanisms. New flow diversion structures will regulate the quantity of wet weather flow conveyed to the interceptor system and divert the excess wet weather flow to the storage tanks. A network of consolidation sewers will convey the wet weather flow from the flow diversion structures to the storage facilities. It is assumed that SCADA systems and RTC systems would optimize the dewatering of the storage vaults. See Section 4.5 for a more complete description of this control technology.

Sewer Separation Projects: Sewer separation projects will be implemented within strategic catchments in addition to the Appendix B sewer separation projects. The locations of these separation projects are shown in **Figure 6.8.1**.

6.8.1 Basis of Cost Estimates

RTB Wet Weather Treatment Facility: MTA-6 utilizes a 70 MGD Retention Treatment Basin. The construction cost includes the aboveground facilities (i.e., pump station, screening facilities, chlorination building) and the underground facilities (i.e., first flush capture basin and treatment channels/ chlorine contact tank). The construction cost also includes a new pump station to lift the wastewater flow from the interceptor to the entrance of the RTB. The construction cost assumes the first flush capture basin is sized assuming 15 to 20 minutes of detention time and a hydraulic loading rate of 8,000 gpd/ft^{2}and the chlorine contact tank is sized assuming a 15-minute contact time and side water depth of 10 ft. The total construction cost for these facilities is $54 million and the present value lifecycle cost is $93 million.

Paxton Creek Interceptor Extension: MTA-6 utilizes a 3,700 ft long, 6 ft diameter interceptor extension between the existing Paxton Creek Interceptor (PCI) and the new RTB treatment facility. The alternative also includes a new flow diversion structure to decouple the PCI wet weather flow from the Front Street Pump Station and convey the flow to the RTB treatment facility via the Paxton Creek interceptor extension. The total construction cost for these facilities is $8 million and the present value lifecycle cost is $12 million.

Satellite Storage Facilities: The number, size, and total volume of the satellite storage facilities vary with the level of control. The Project Cost Summary tables provide the location, size, and present value lifecycle cost for each of the satellite storage facilities required to provide each LoC. The ancillary construction costs include consolidation sewers, diversion chambers, influent and effluent sewers, and a dewatering pumping station.

Sewer Separation Costs: In addition to the four sewer separation projects included in the Appendix B project list, MTA-6 includes sewer separation for up to four catchment areas for certain LoCs. The total construction cost for these sewer separation projects, when applicable, ranges from $3 million to $16 million, and the present value lifecycle cost ranges $4 million to $24 million.

6.8.2 Cost-Performance Summary

Table 6.8-2 provides the typical year CSO statistics and present value cost estimate associated with each MTA-6 control point. Typical year CSO volume is the systemwide total of individual CSO outfalls, and typical year CSO frequency represents the range of frequencies for individual CSO outfalls (Pre-Plan and Appendix B) or the target frequency corresponding to the LoC (for control points two through seven).

Table 6.8-2: MTA-6 LoCs, Control Facilities, and Associated Cost

Control Point	Receiving Water	Number of Storage Facilities	Total Storage Volume (MG)	Total Estimated Cost ($ Million)	Typical Year CSO Volume (MG)	Typical Year CSO Frequency
Pre-Plan	NA	NA	NA	NA	796	6 to 95
1 (App. B)	Susquehanna and Paxton	NA	NA	$217	331	6 to 60
2	Susquehanna	3	0.56	$125	78	20
	Paxton	0	0.00	$320	65	
3	Susquehanna	3	1.17	$143	60	16
	Paxton	0	0.00	$320	65	
4	Susquehanna	5	1.99	$172	31	10
	Paxton	5	1.67	$374	48	
5	Susquehanna	6	3.50	$201	19	5
	Paxton	5	1.67	$410	40	
6	Susquehanna	4	7.78	$284	6	2
	Paxton	8	10.8	$630	7	
7	Susquehanna	5	14.8	$380	0	0
	Paxton	9	15.6	$703	0	

Figure 6.8-2 is the systemwide cost-performance plot of CSO frequency versus present value costs for MTA-6. Except for the Pre-Plan and Appendix B conditions, each of the LoC points along the curve would provide a consistent systemwide LoC whereby every outfall would have no more than the frequencies indicated in the CSO frequency column in the above table. **Figure 6.8-3** provides the MTA-6 cost-performance plots of CSO frequency versus present value costs for each receiving water.

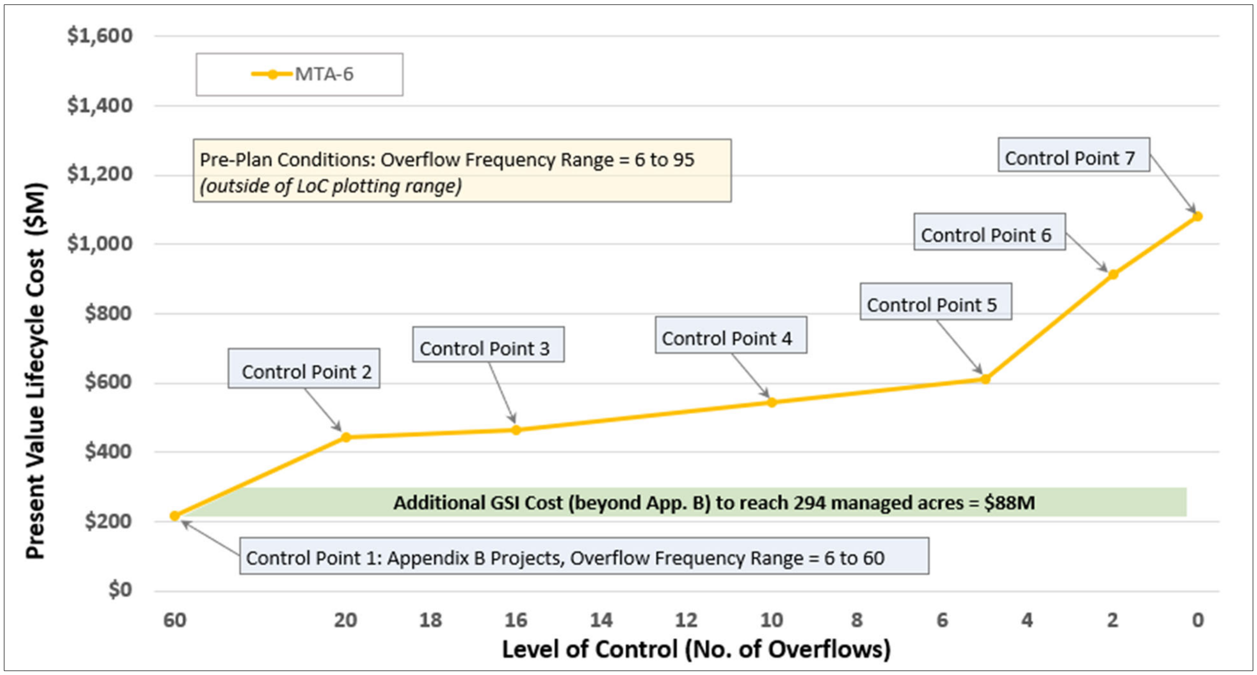

Figure 6.8-2: MTA-6 Systemwide Typical Year CSO Frequency vs. Cost-Performance Curve

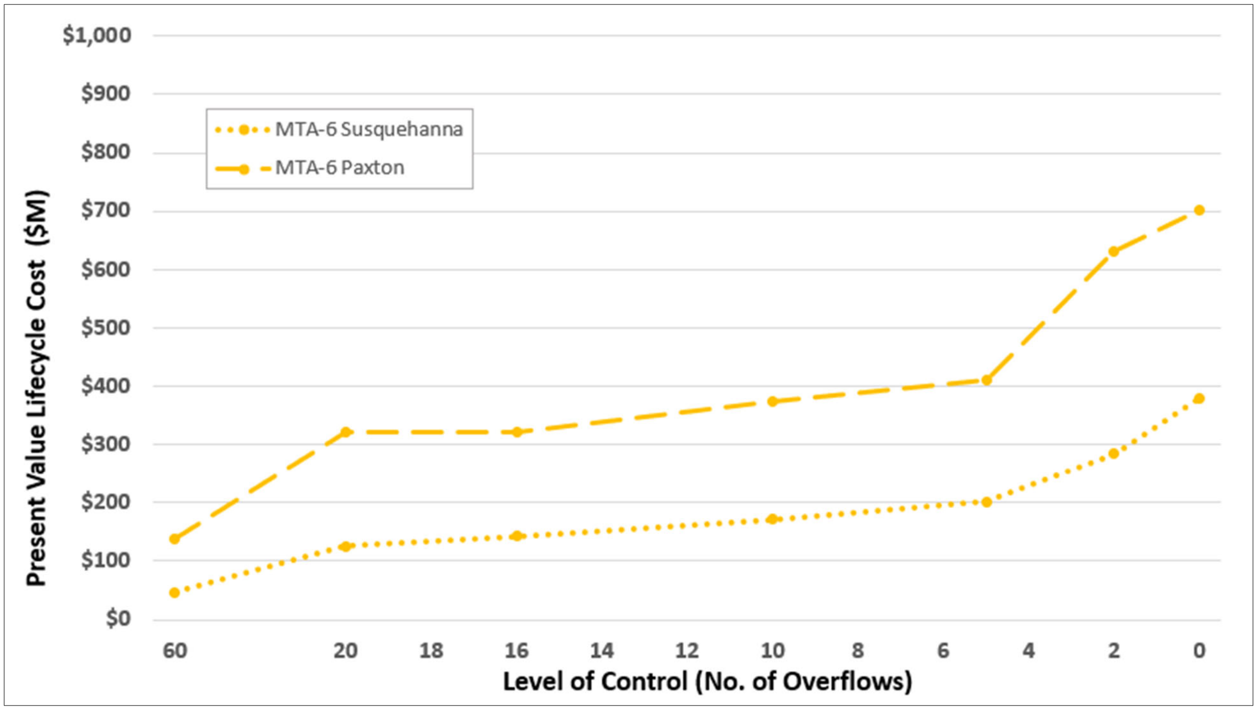

Figure 6.8-3: MTA-6 Typical Year CSO Volume vs. Cost-Performance Curves by Receiving Water

Figure 6.8-4 is the systemwide cost-performance plot of overflow volume versus present value costs for MTA-6. **Figure 6.8-5** provides the MTA-6 cost-performance plots of overflow volume versus present value costs for each receiving water.

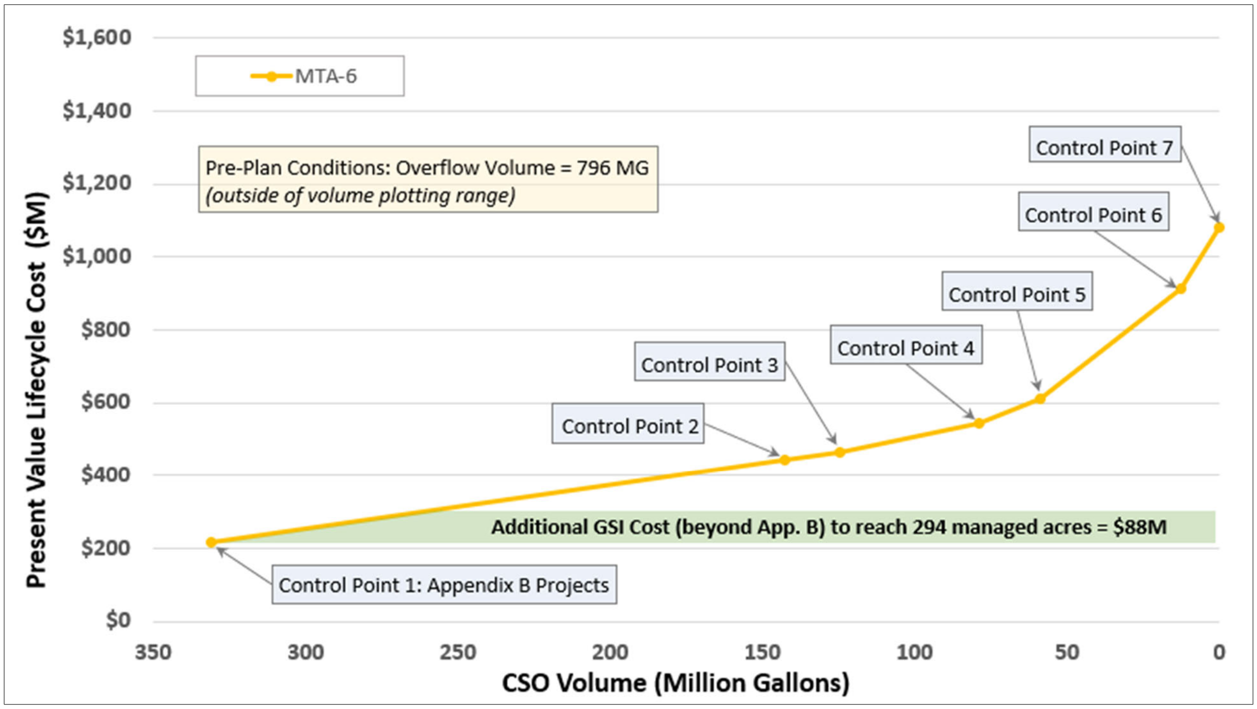

Figure 6.8-4: MTA-6 Systemwide Typical Year CSO Volume vs. Cost-Performance Curve

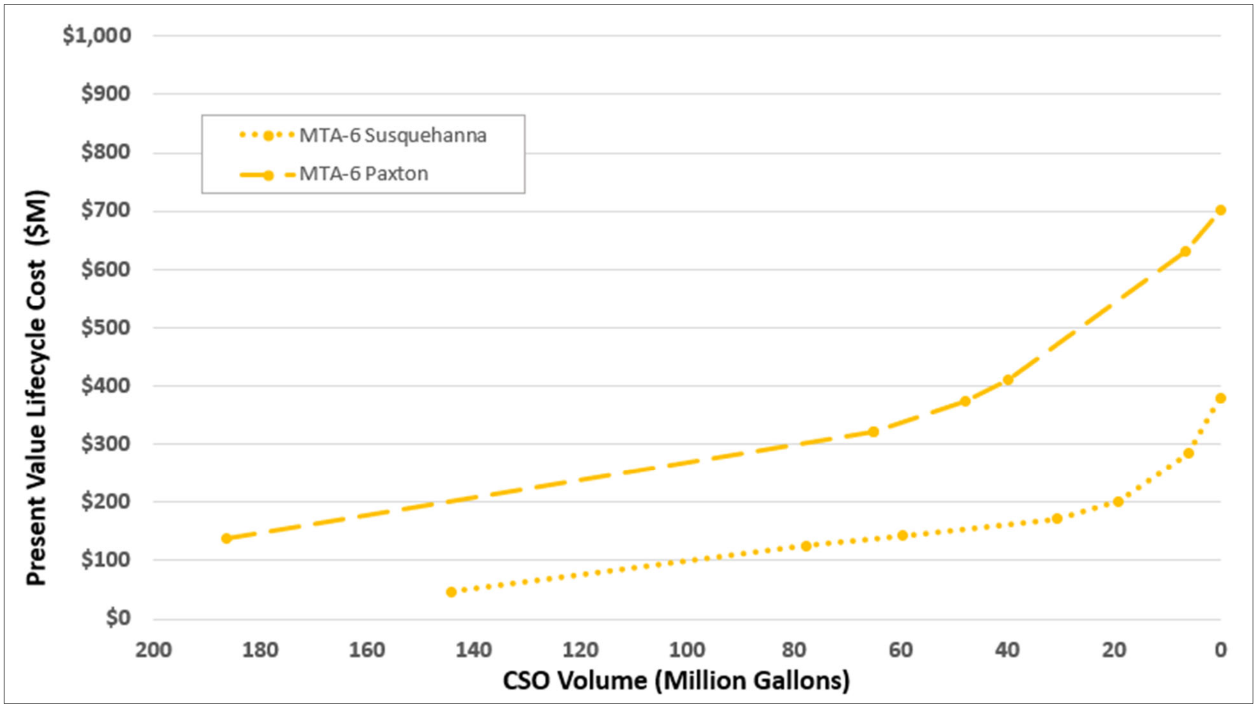

Figure 6.8-5: MTA-6 Typical Year CSO Volume vs. Cost-Performance Curves by Receiving Water

6.9 MTA-7: Paxton Creek Storage Conduit

Mixed Technology Alternative 7 (MTA-7) is a potential “add-on” that can be used in conjunction with the other alternatives listed above. In this concept, along the Paxton Creek, individual satellite storage facilities are replaced by a single linear conduit storage facility. This alternative is unique in that there is greater uncertainty and complexity regarding the construction of the linear conduit storage, particularly with designing and sequencing the alignment within the constraints of the Paxton Creek widening and stream restoration and redevelopment of this area. Therefore, CRW is not sufficiently confident that this alternative could be fully constructed and considered a standalone alternative. As part of CRW’s adaptive management strategy, portions of MTA-7 will be considered as the design/construction of the PCI replacement and Paxton Creek widening/redevelopment projects progress.

For reference, fully built MTA-7 facilities are described below and their locations are shown in **Figure 6.9-1**. The number of satellite storage facilities for each LoC, and their corresponding storage volumes are provided in **Table 6.9-1**. Footprints associated with each satellite storage facility are shown in the site-scale maps in **Appendix 6-3**.

Details regarding the components included within MTA-7 are explained below:

Linear Conduit Storage Facility: A large conduit would be installed adjacent to the Paxton Creek Interceptor. To provide the required range of LoCs, the length and the cross-sectional area of the box culvert conduit are increased to achieve the required storage volumes. The conduit will function as a gravity-in/pumped-out facility and a single pump station will be constructed at the downstream end of the conduit storage facility, which will empty the storage as downstream capacity becomes available.

6.9.1 Basis of Cost Estimates

Conduit Storage Facility: If MTA-7 were to be fully implemented for the entire conduit length, the total construction cost for the storage conduit and dewatering pump station would be $63.9 million and the present value lifecycle cost would be $101 million.

The Project Cost Summary tables also includes the costs associated with each of the satellite storage facilities.

6.9.2 Cost-Performance Summary

Table 6.9-2 provides the typical year CSO statistics and present value cost estimate associated with each MTA-7 control point. Typical year CSO volume is the systemwide total of individual CSO outfalls, and typical year CSO frequency represents the range of frequencies for individual CSO outfalls (Pre-Plan and Appendix B) or the target frequency corresponding to the LoC (for control points two through seven).

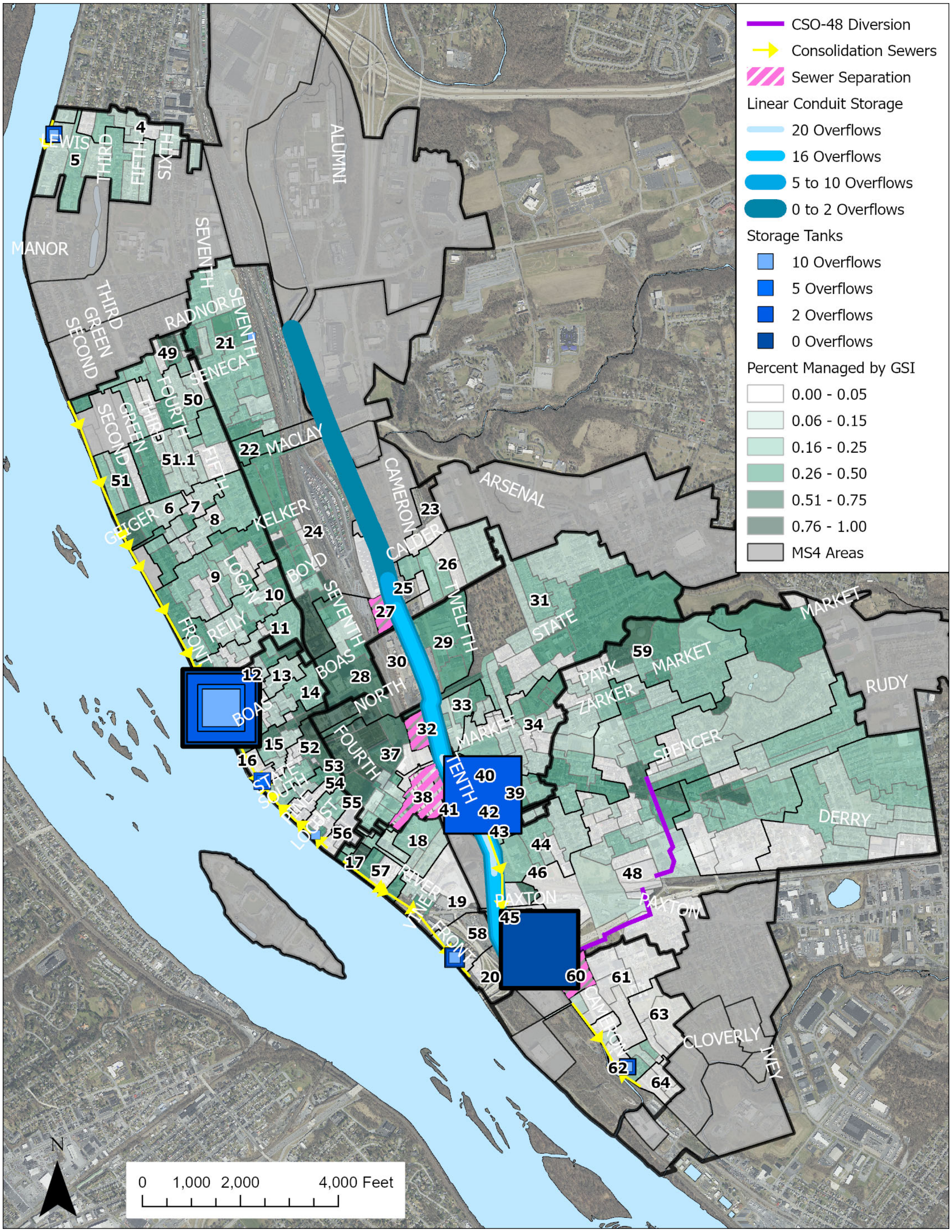

Figure 6.9-1: Locations of Control Facilities for MTA-7

Table 6.9-1: MTA-7 Facility Sizes and Locations

Planning Area	**CSO Outfall**	**Technology Size** (Location Indicated in Parentheses)					
		20 Overflows	**16 Overflows**	**10 Overflows**	**5 Overflows**	**2 Overflows**	**0 Overflows**
Riverside	CSO-04			0.22 MG (CSO-05)	0.34 MG (CSO-05)	1.07 MG (CSO-05)	1.77 MG (CSO-05)
	CSO-05						
Uptown	CSO-49			4.33 MG (Tank = 3.33 MG; Con. Sewers = 1 MG) (CSO-13)	5.64 MG (Tank = 4.64 MG; Con. Sewers = 1 MG) (CSO-13)	8.73 MG (Tank = 7.73 MG; Con. Sewers = 1 MG) (CSO-13)	14.02 MG (Tank = 13.02 MG; Con. Sewers = 1 MG) (CSO-13)
	CSO-50						
	CSO-51	3.44 MG (Tank = 2.79 MG; Cons. Sewers = 0.65 MG) (CSO-11)	4.03 MG (Tank = 3.23 MG; Cons. Sewers = 0.8 MG) (CSO-13)				
	CSO-06						
	CSO-07						
	CSO-08						
	CSO-09						
	CSO-10						
	CSO-11						
Middle Front Street	CSO-12						
	CSO-13						
	CSO-14				0.47 MG (CSO-16)	1.34 MG (CSO-16)	1.78 MG (CSO-16)
	CSO-15						
	CSO-16						
	CSO-52			0.23 MG (CSO-55)			
	CSO-53						
	CSO-54						
	CSO-55						
	CSO-56						
Lower Front Street	CSO-17			0.47 MG (CSO-58)	0.65 MG (CSO-58)	1.31 MG (CSO-58)	2.40 MG (CSO-58)
	CSO-57		0.24 MG (CSO-58)				
	CSO-18						
	CSO-19						
	CSO-58	0.06 MG					
	CSO-20						
Upper Paxton Creek - West	CSO-21			0.04 MG	0.07 MG	10.53 MG CSO-21 to 24: 5,470 ft **7' x 13' Box** Avg. Depth = 22.4' CSO-24 to 48 8,600 ft **10' x 13' Box** Avg. Depth = 23.8'	11.25 MG CSO-21 to 24: 5,470 ft **7' x 13' Box** Avg. Depth = 22.4' CSO-24 to 48 8,700 ft **10' x 13' Box** Avg. Depth = 23.8'
	CSO-22						
	CSO-24			2.60 MG 8,420 ft 7' x 7' Box Avg. Depth = 23.8'	4.31 MG 8,420 ft 9' x 9' Box Avg. Depth = 23.8'		
	CSO-27						
	CSO-28						
Upper Paxton Creek - East	CSO-23						
	CSO-25						
	CSO-26		CSO-26 to 48: 1.07 MG 7,360 ft 5' x 5' Box Avg. Depth = 23.7'				
Middle Paxton Creek - East	CSO-29					3.73 MG (CSO-40)	
	CSO-31						
	CSO-33						
	CSO-34	CSO-34 to 44: 0.29 MG 2,700 ft 4' x 4' Box Avg. Depth = 21.5'					
	CSO-39						
	CSO-40						
Middle Paxton Creek - West	CSO-30						
	CSO-32						
	CSO-37						
	CSO-38						
	CSO-41						
Lower Paxton Creek	CSO-42						14.76 MG (CSO-48)
	CSO-59						
	CSO-43						
	CSO-44						
	CSO-45						
	CSO-46						
	CSO-48						
Hemlock Street	CSO-60						
	CSO-61			0.25 MG (CSO-63)	0.37 MG (CSO-63)	1.05 MG (CSO-63)	1.77 MG (CSO-63)
	CSO-62						
	CSO-63						
	CSO-64						

Notes:

1. All alternatives include Appendix B projects and baseline level of GSI.

Color Coding:

Satellite Storage (End of Pipe)	Linear Storage

Table 6.9-2: MTA-7 LoCs, Control Facilities, and Associated Cost

Control Point	Receiving Water	Conduit Storage Volume (MG)	Number of Storage Facilities	Total Storage Volume (MG)	Total Estimated Cost ($ Million)	Typical Year CSO Volume (MG)	Typical Year CSO Frequency
Pre-Plan		NA	NA	NA	NA	796	6 to 95
1 (App. B)	Susquehanna and Paxton	NA	NA	NA	$217	331	6 to 60
2	Susquehanna	NA	1	0.84	$166	82	20
	Paxton	0.28	0	0.0	$232	103	
3	Susquehanna	NA	2	1.62	$181	56	16
	Paxton	1.05	0	0.00	$248	83	
4	Susquehanna	NA	4	2.55	$222	33	10
	Paxton	2.57	2	0.26	$285	50	
5	Susquehanna	NA	4	4.35	$247	26	5
	Paxton	4.19	2	0.45	$303	38	
6	Susquehanna	NA	4	9.38	$341	4	2
	Paxton	9.78	2	4.87	$424	7	
7	Susquehanna	NA	4	17.3	$418	0	0
	Paxton	11.4	2	15.6	$545	0	

Figure 6.9-2 is the systemwide cost-performance plot of CSO frequency versus present value costs for MTA-7. Except for the Pre-Plan and Appendix B conditions, each of the LoC points along the curve would provide a consistent systemwide LoC whereby every outfall would have no more than the frequencies indicated in the CSO frequency column in the above table. **Figure 6.9-3** provides the MTA-7 cost-performance plots of CSO frequency versus present value costs for each receiving water.

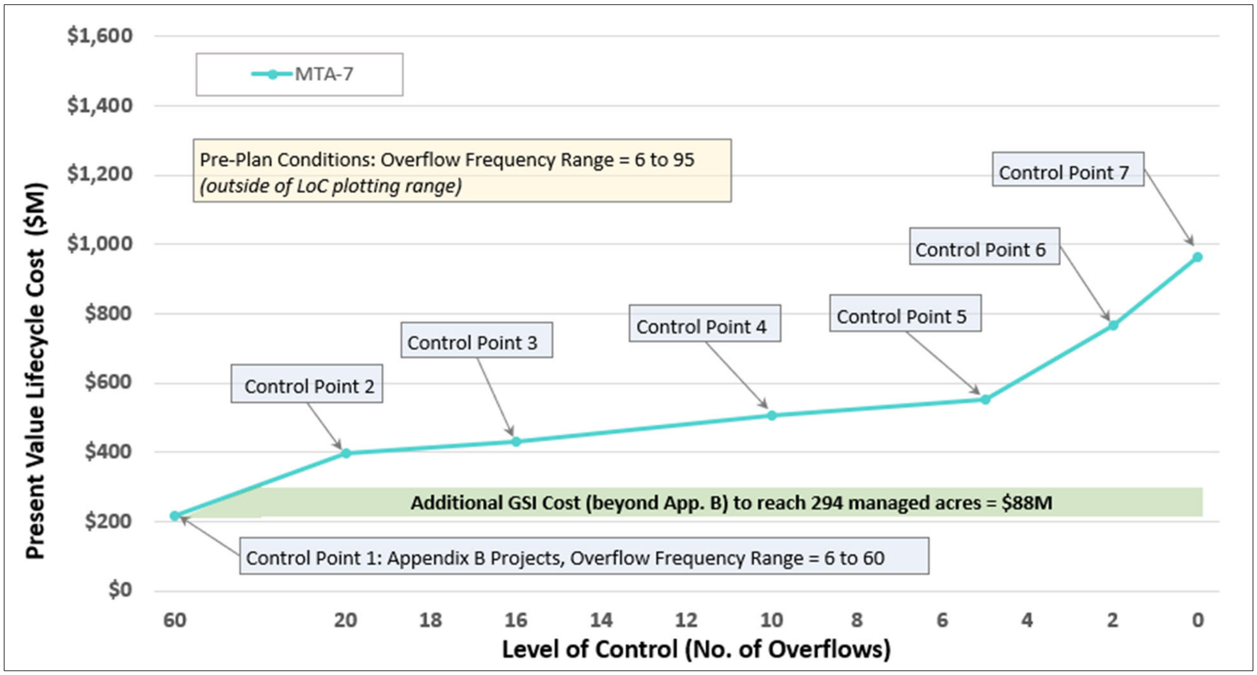

Figure 6.9-2: MTA-7 Systemwide Typical Year CSO Frequency vs. Cost-Performance Curve

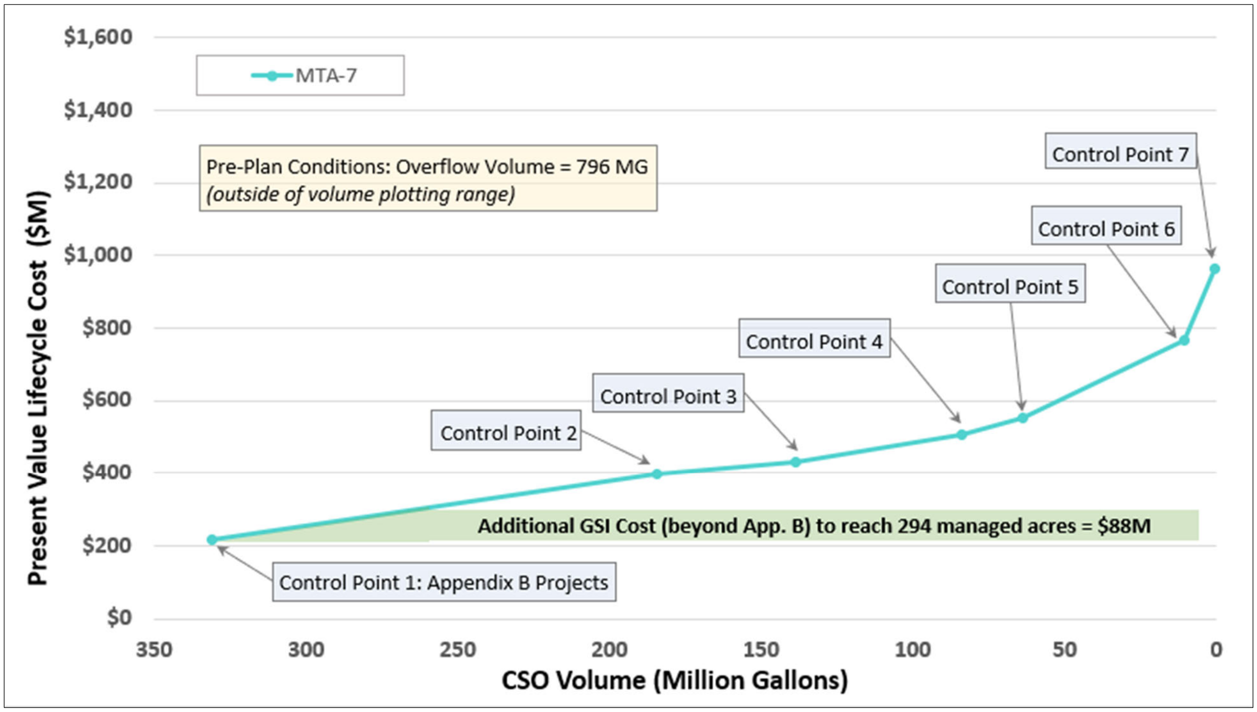

Figure 6.9-3: MTA-7 Typical Year CSO Volume vs. Cost-Performance Curves by Receiving Water

Figure 6.9-4 is the systemwide cost-performance plot of overflow volume versus present value costs for MTA-7. **Figure 6.9-5** provides the MTA-7 cost-performance plots of overflow volume versus present value costs for each receiving water.

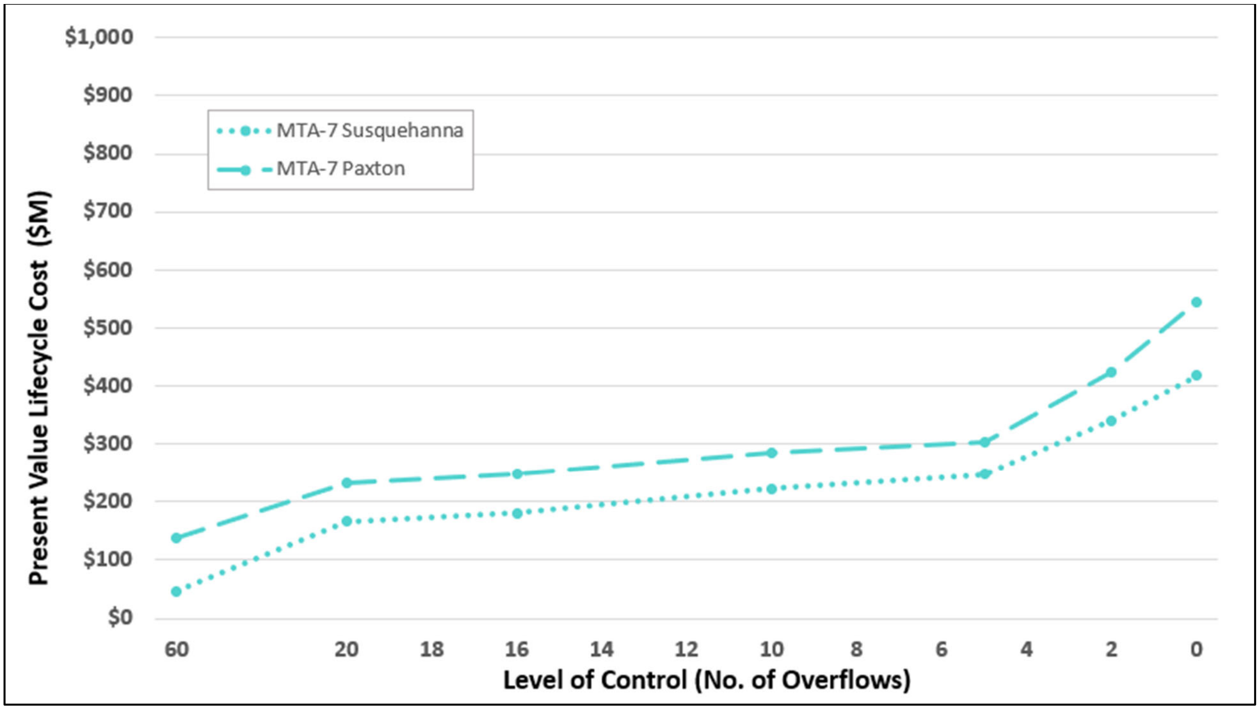

Figure 6.9-4: MTA-7 Systemwide Typical Year CSO Volume vs. Cost-Performance Curve

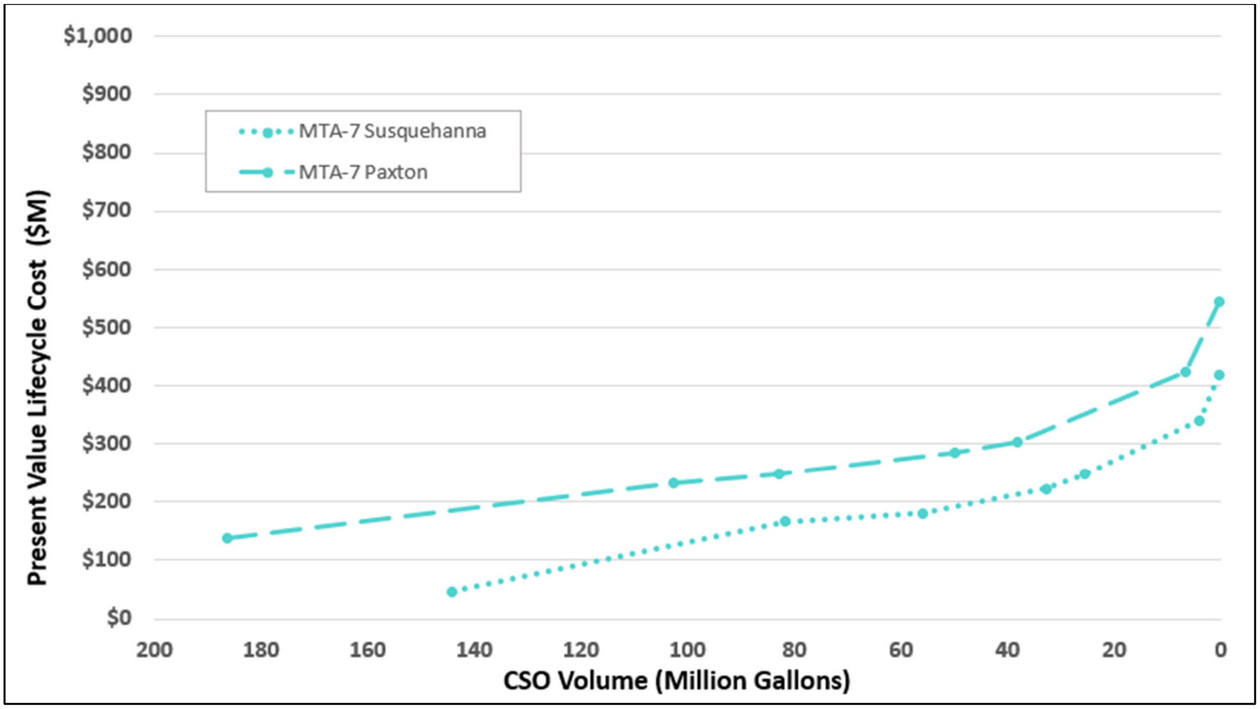

Figure 6.9-5: MTA-7 Typical Year CSO Volume vs. Cost-Performance Curves by Receiving Water

6.10 Required LoCs to Meet Current Water Quality Standards

As described in Sections 6.2 through 6.9, each of the MTAs can provide a wide range of LoCs. The H&H model was utilized to simulate CSO discharges and pollutant levels for each MTA LoC. This model output was used as a boundary condition to the water quality models described in Section 5. The water quality model scenarios were run for the typical year and a determination was made on whether or not each MTA LoC met the corresponding current water quality standards using the methodology described in Section 5.5.

Pollutant levels are simulated in CRW's H&H model by combining sanitary wastewater and stormwater within the modeled pipe network. Bacteria level assumptions are one of the principal water quality model calibration variables and are particularly important for assessing which MTA LoCs meet current water quality standards. The Water Quality Modeling Plan (WQMP) listed initial assumptions for bacteria based on literature values.[19] Following this, pollutant level assumptions in the H&H model were adjusted based on a comparison of modeled CSO outfall results and CSO outfall data collected for The Harrisburg Authority's (THA) 2005 LCTP.[20] This resulted in two scenarios – a high level of bacteria and a low level of bacteria – that were simulated with the preliminary water quality models.

CRW is currently collecting water quality data at the CSO outfalls and in both receiving waters to support water quality model calibration. As stated in Section 5, CRW collected some water quality data in 2023 and plans to collect additional data in 2024. The data collected thus far suggests that the bacteria levels in the CSOs may be up to an order of magnitude less than the original assumptions based on the THA data. This THA data corresponds to an old system configuration with less stormwater capture, which may explain the higher measurements in 2005. In particular, prior to CRW's stormwater inlet rehabilitation program, blocked and/or poor condition stormwater inlets may have prevented stormwater from entering the combined sewer system, thereby resulting in less diluted wastewater. However, given the limited available water quality data and the highly variable nature of bacterial levels, CRW is not yet able to finalize the assumed bacteria levels. Therefore, for this Alternatives Analysis, whether each MTA LoC meets current water quality standards is based on a range of bacteria levels as summarized in **Table 6.10-1** to bracket the uncertainty in this model parameter. Once the water quality monitoring program is completed in 2024, a definitive determination will be made regarding bacteria levels.

Table 6.10-1: Bacteria Level Assumptions

Parameter	Bacteria Levels (colony forming units/100 mL)			
	Lower Limit		Upper Limit	
	Stormwater	Wastewater	Stormwater	Wastewater
Fecal Coliform	3,821	$1\text{x}10^6$	3,821	$1\text{x}10^7$
E. coli	3,298	$8.6\text{x}10^5$	3,298	$8.6\text{x}10^6$

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[19] CRW. 2023a. Water Quality Modeling Plan for Capital Region Water. Developed by CDM Smith for Capital Region Water. February 2023

[20] THA. 2005. Combined Sewer Overflow Management and Control Program. Act 537 Plan Update Revision/Long Term Control Plan. Attachment H: Water Quality Monitoring Data Analysis Report. Prepared by Brinjac Engineering and Malcom Pirnie for The Harrisburg Authority.

Table 6.10-2 summarizes the required LoC to meet current water quality standards for each MTA. For Susquehanna River, each MTA requires a LoC of 10 to 16 overflows per year to meet water quality standards in the Typical Year. For Paxton Creek, each MTA requires a LoC of 2 to 10 overflows per year (during Typical Year) to meet water quality standards.

Table 6.10-2: Required Level of Control to Meet Water Quality Standards

Mixed Technology Alternative	Required Level of Control to Meet Current Water Quality Standards (Frequency)			
	Susquehanna River		Paxton Creek	
	Higher Bacteria Levels	Lower Bacteria Levels	Higher Bacteria Levels	Lower Bacteria Levels
MTA-1	10	16*	2	10*
MTA-2	10	16*	2	10*
MTA-3	10	16*	2	10*
MTA-4A	10	16*	2	10*
MTA-4B	10	16	2	10
MTA-5	10	16*	2	10*
MTA-6	10	16	2	10
MTA-7	10	16	2	5

*Note: For MTAs 1, 2, 3, 4A, and 5, the required level of control corresponding to the higher bacteria levels was not explicitly modeled and is assumed based on the results from MTAs 4B, 6, and 7.

Using the present value lifecycle costs presented in Sections 6.2 through 6.9, the costs to meet current water quality standards for each MTA are summarized in **Table 6.10-3**. This includes the cost to meet water quality standards in both the Susquehanna River and Paxton Creek; for reference, the cost to only meet Susquehanna River water quality standards is also included.

Table 6.10-3: Present Value Lifecycle Costs to Meet Current Water Quality Standards

Alternative	Cost to Meet Both Water Quality Standards ($Million)		Cost to Meet Only Susquehanna River Water Quality Standards ($Million)	
	Low Estimate	High Estimate	Low Estimate	High Estimate
MTA-1	570	826	354	398
MTA-2	604	834	376	424
MTA-3	681	1,068	360	421
MTA-4A	489	790	329	372
MTA-4B	495	720	334	371
MTA-5	572	858	416	461
MTA-6	522	797	413	442
MTA-7	479	749	342	381

6.11 Evaluation of Mixed Technology Alternatives

The Mixed Technology Alternatives (MTAs) provide a wide range of levels of control utilizing a wide range of control technologies. Initial screening criteria were applied to evaluate these alternatives and discern the best control measures to meet current water quality standards. This alternative analysis process began with a listing and initial screening of all possible wet weather control technologies that are documented in in Section 2. Any infeasible controls or controls that were not applicable or relevant to the CRW service area were screened out. A single technology screening analysis was subsequently implemented as described in Section 4. Additional screening evaluations were applied to evaluate these control technologies, and the findings utilized to inform the development of the MTAs documented in Section 6.

6.11.1 Evaluation Criteria

There are ten criteria that were used to compare and evaluate the MTAs. A summary of the screening evaluations is provided below in **Table 6.11-1**. The following narrative explains the evaluation reasoning and how the rankings within the table were determined.

Cost Effectiveness Comparisons: The cost of implementation is an important screening criterion because it determines how much water quality improvements can be achieved for a given level of funding. The superimposed systemwide CSO frequency cost-performance curves associated with all the alternatives are provided in **Figure 6.11-1**. The CSO frequency curves for Susquehanna River are provided in **Figure 6.11-2** and CSO frequency curves for Paxton Creek are provided in **Figure 6.11-3.** The superimposed systemwide CSO volume cost-performance curves associated with the alternatives are provided in **Figure 6.11-4**. The CSO volume curves for Susquehanna River are in **Figure 6.11-5** and CSO volume curves for Paxton Creek are provided in **Figure 6.11-6.** The curves show that alternatives MTA-1, MTA-2, MTA-3, and MTA-5 are least desirable by these criteria because they provide a comparable range of LoCs at a higher cost. Alternatives MTA-4A, MTA-4B, MTA-6, and MTA-7 are more desirable because they provide a comparable range of LoCs at a lower cost.

Table 6.11-1: Summary of Evaluation Criteria Results

Evaluation Criteria	MTA-1 (Enhanced Conveyance)	MTA-2 (Storage - Limited)	MTA-3 (Storage/Treatment - Limited)	MTA-4A (Storage/Treatment - Max)	MTA-4B (Storage - Max)	MTA-5 (Tunnel)	MTA-6 (Maximize Conveyance)	MTA-7 (Linear Storage)	Note
Cost-Effectiveness	X	X	X	✓	✓	X	↔	✓	MTA-6 cost is competitive overall, but requires large upfront investment
Ability to Meet WQ Standards	✓	✓	✓	✓	✓	✓	✓	✓	All MTAs can meet WQ standards
Flexibility/ Adaptability	↔	✓	✓	✓	✓	X	↔	↔	Tunnel is least adaptable; Paxton Creek corridor constraints an issue for MTA-7
Operation and Maintenance	✓	✓	X	X	✓	✓	↔	✓	Satellite treatment facilities require significant O&M demand; MTA-6 is more manageable
Hydraulic Improvements	✓	↔	↔	↔	↔	↔	✓	↔	MTA-6 significantly reduces flow to FSPS and reduces interceptor HGLs; MTA-1 also increases conveyance
Uncertainty	↔	↔	↔	↔	↔	X	↔	↔	There may be issues with siting satellite facilities; unforeseen geotechnical conditions for tunneling
Complexity	↔	↔	X	X	↔	X	X	X	MTA-5 (tunnel), MTA-6 (PCI extension to RTB), and MTA-7 (linear conduit storage) are the most complex projects
Near-Term Water Quality Benefits	✓	✓	✓	✓	✓	X	↔	↔	MTAs 5, 6, and 7 require large upfront investments before other projects can be completed
Number of Projects	↔	X	X	↔	↔	✓	✓	✓	Alternatives with more facilities may be more difficult to manage
Public Acceptability	↔	↔	X	X	✓	X	✓	✓	MTAs 4B, 6, and 7 require less projects, and the projects are underground

Legend:

Positive Impact	✓	Negative Impact	X	Neutral Impact	↔

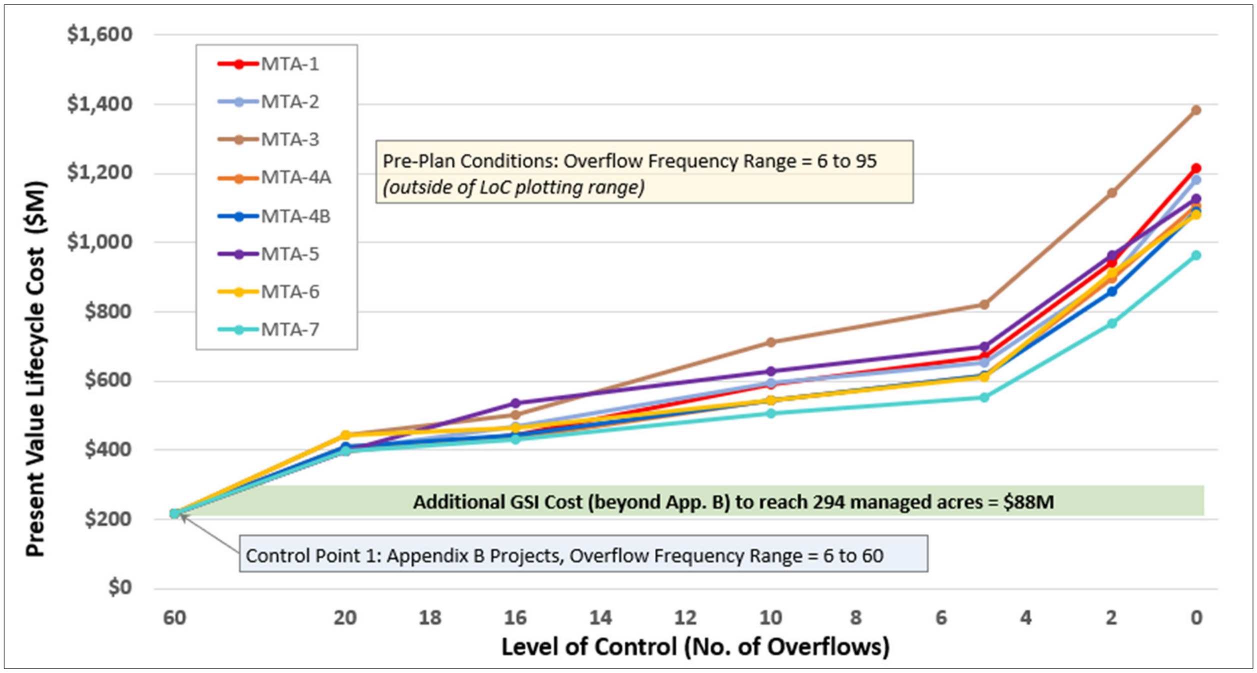

Figure 6.11-1: Systemwide Typical Year CSO Frequency vs. Cost-Performance Curves for All MTAs

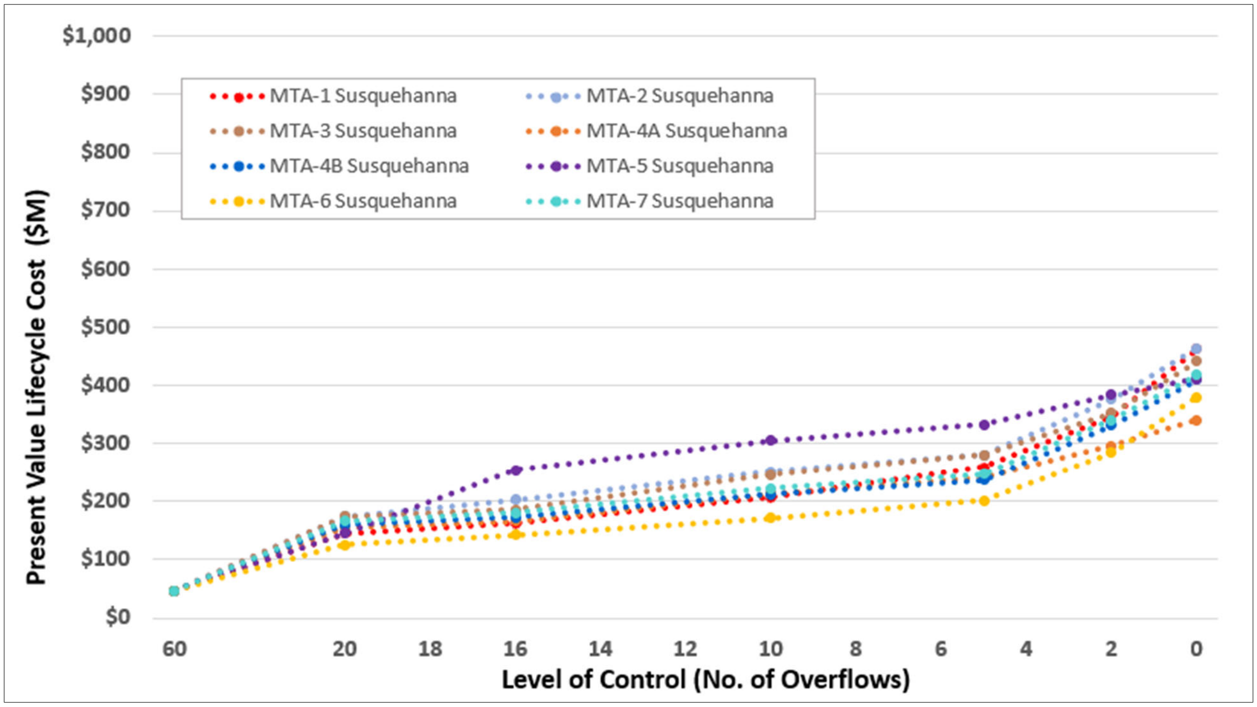

Figure 6.11-2: Susquehanna Typical Year CSO Frequency vs. Cost-Performance Curves for All MTAs

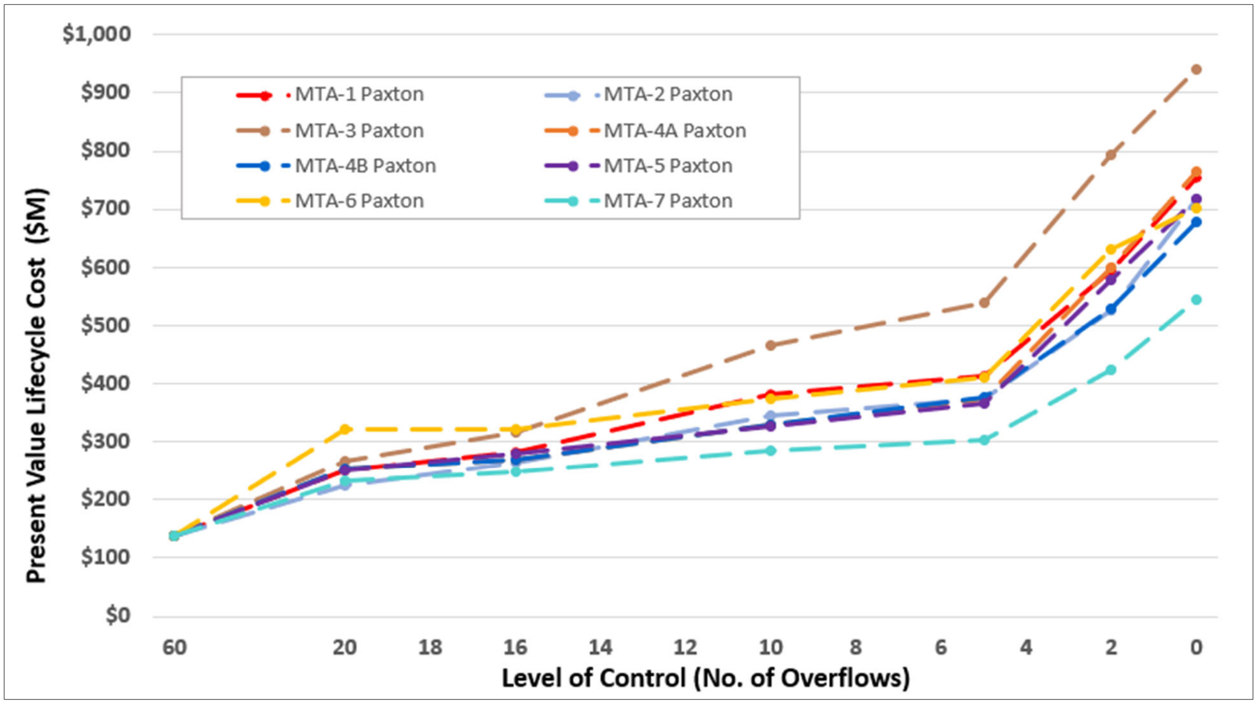

Figure 6.11-3: Paxton Typical Year CSO Frequency vs. Cost-Performance Curves for All MTAs

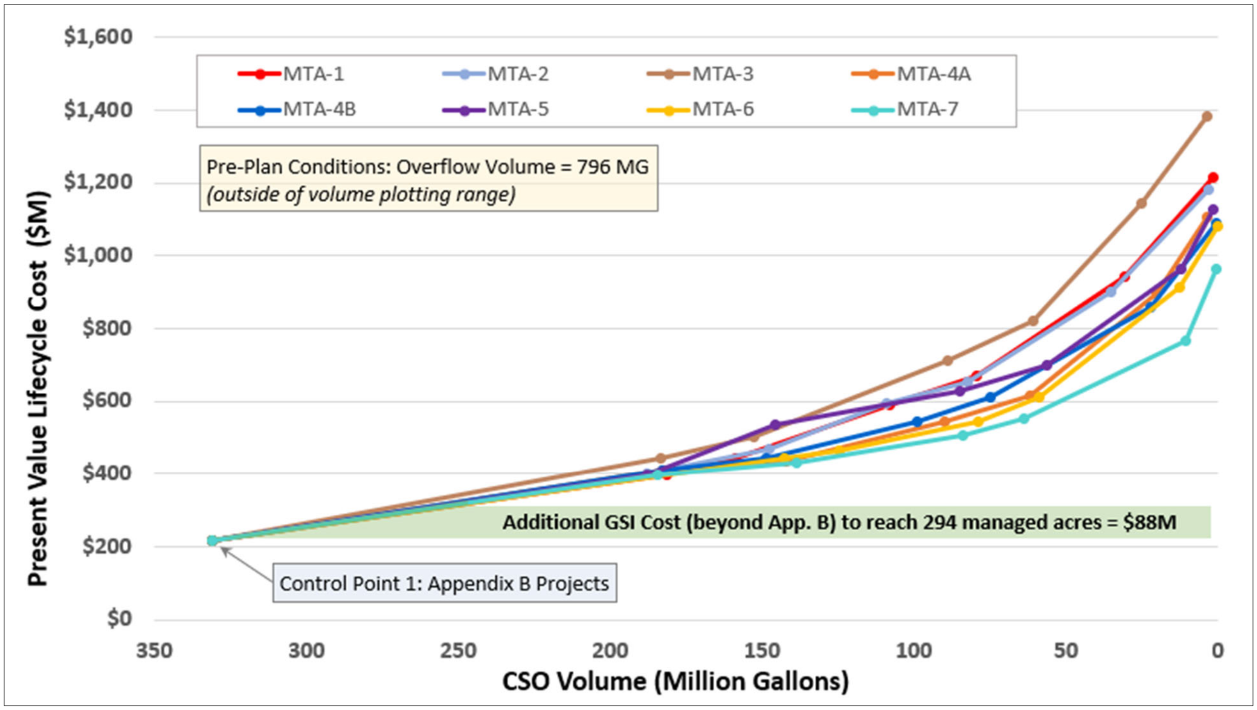

Figure 6.11-4: Systemwide Typical Year CSO Volume vs. Cost-Performance Curves for All MTAs

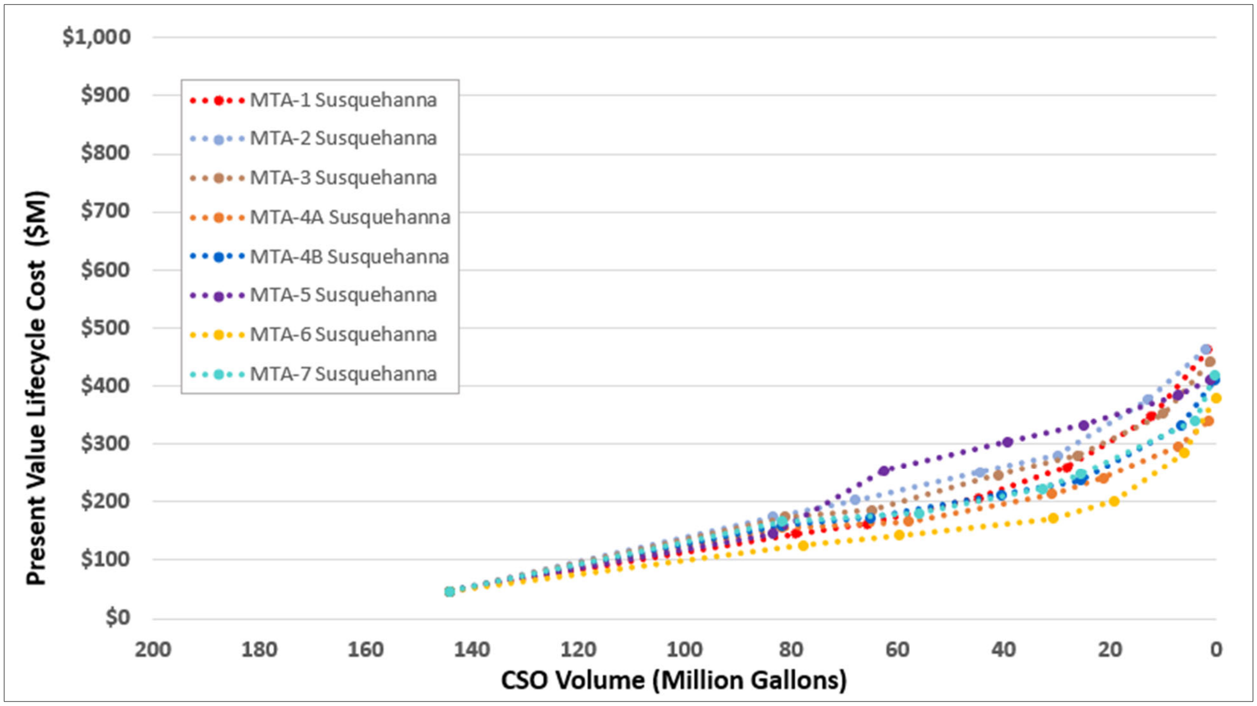

Figure 6.11-5: Susquehanna Typical Year CSO Volume vs. Cost-Performance Curves for All MTAs

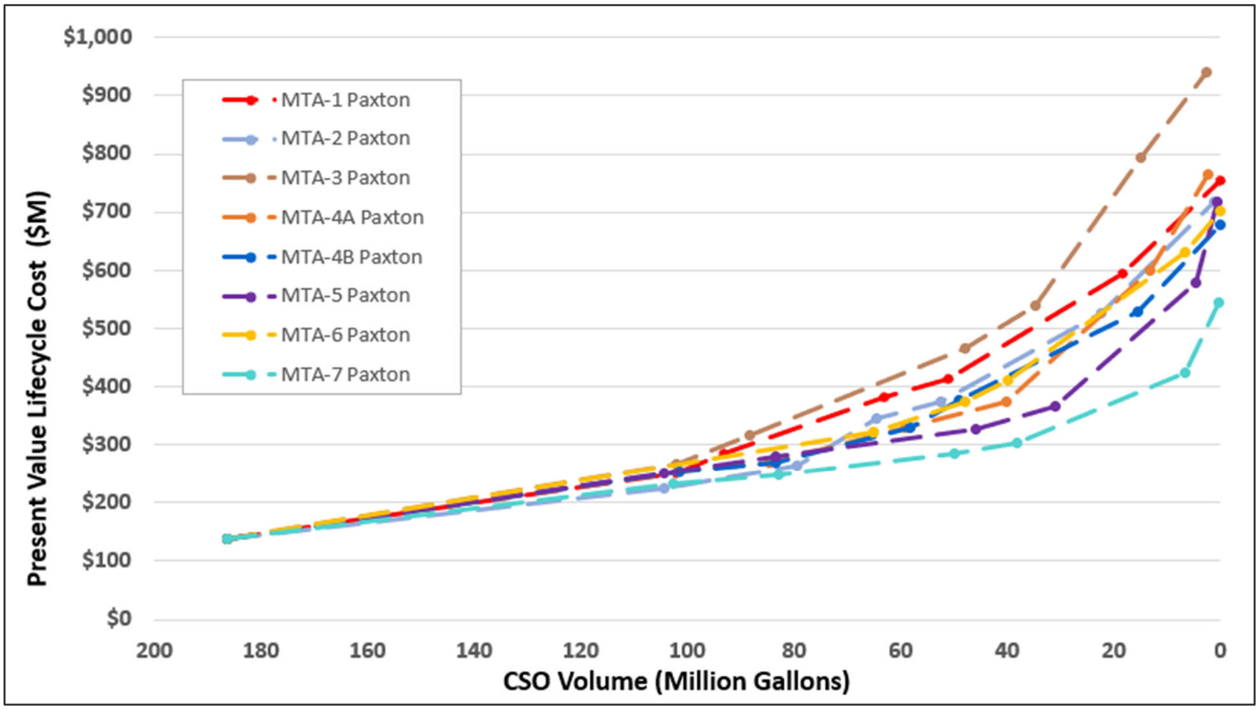

Figure 6.11-6: Paxton Typical Year CSO Volume vs. Cost-Performance Curves for All MTAs

Ability to Meet Water Quality Standards: All the MTAs can provide sufficient LoCs to meet current water quality standards along the Susquehanna River and Paxton creek. MTA-6 is designed to meet effluent requirements for disinfection at the new treatment facility. The satellite treatment facilities within MTA-3 and MTA-4A would provide suitable treatment and disinfection for all the pollutants of concern. The optimized AWTF within MTA-1 already meets or exceeds the discharge standards of its NPDES permit and the new wet weather treatment facility within MTA-6 would obtain an NPDES permit for its new outfall. The tunnel, satellite, and linear conduit storage facilities within MTA-2, MTA-4B, MTA-5, MTA-6, and MTA-7 would direct the stored wet weather wastewater to the treatment plant once capacity becomes available.

Flexibility and Adaptability: The greater the flexibility and adaptability of the control facilities, the easier it is to implement the associated alternative and adapt to changing or unforeseen conditions. MTA-4A and MTA-4B are the most desirable under this criterion because they have the greatest implementation flexibility since they have the fewest number of facilities and they can be constructed in any priority order, such as receiving water body or overflow volume, or under any implementation schedule, i.e., 20-year or 30-year. The design and construction packages would be independently self-contained and include the associated consolidation sewers and flow diversion structures. Similarly, MTA-1, MTA-2, and MTA-3 would be reasonably flexible and adaptable to implement but to a lesser degree because of the increased number of facilities to construct. MTA-6 would have a neutral flexibility because the new wet weather treatment facility and the new extension of the Paxton Creek Interceptor would need to be implemented first. MTA-5 would have a low implementation flexibility because most of the wet weather control is provided by the tunnel system.

Operation and Maintenance: All the new control facilities associated with each of the MTAs would require additional ongoing O&M effort and cost, but some alternatives would require more O&M effort than others. The tunnel storage, satellite storage, and linear conduit storage facilities within MTA-2, MTA-4B, MTA-5, and MTA-7 are fully automated and do not require operation staff to be on-site for them to function. In contrast, the satellite treatment facilities within MTA-3 and MTA-4A can commence automatically but require onsite staffing for the duration of the treatment processes, making them the least desirable by this criteria. The new wet weather treatment facility included in MTA-6 would require onsite staffing, but it is located adjacent to the existing AWTF, reducing the undesirable impact. The satellite storage facilities included in all MTAs would be equipped with flushing tanks to limit the buildup of solids and debris but would require periodic jet-rodding by O&M crews. The storage tunnel system within MTA-5 would be the most difficult to clean because of the depth and length.

Hydraulic Capacity: The primary reason CSO discharges occur is because of the limited hydraulic capacities of the interceptors, pump stations, and the treatment plant. Some alternatives compensate for this limited hydraulic capacity by providing systemwide or satellite storage and additional satellite treatment while others increase the conveyance capacity of the CRW system. MTA-6 is the most desirable alternative under this criterion because it provides the greatest hydraulic capacity by constructing a new wet weather treatment facility, an extension from the Paxton Creek Interceptor, and an expansion of the replacement size of the existing interceptor. This results in a significantly less hydraulic burden being placed on the Front Street Interceptor, and the Front Street Pump Station. MTA-1 would also be desirable because of the optimized capacity of the existing AWTF and the expanded capacity of the Front Street Pump Station. The other alternatives would be neutral in that they do not increase the hydraulic capacity of the CRW system.

Uncertainty: MTA-5 has the greatest degree of uncertainty because unforeseen conditions can result in tunneling difficulties, especially if below ground obstacles were not detected during the geotechnical investigations. The higher number of unconsolidated satellite storage and/or treatment facilities within MTA-1, MTA-2, and MTA-3, require more project sites and increase the potential level of uncertainty. MTA-4A and MTA-4B have fewer facilities to site because of the consolidation, but the reduced number of consolidated facilities is offset by the additional uncertainty from the extensive network of consolidation sewers.

Complexity: There are several factors that influence the complexity of the alternative to implement. Stored disinfection chemicals lose potency with age and determining the required dosing quantity for adequate disinfection can be a complex challenge for operators, making MTA-3 and MTA-4, which incorporate satellite treatment facilities, less desirable under this criterion. Larger facilities are more complex to site and construct than smaller ones. MTA-5 requires an extensive storage tunnel network and appurtenances to be constructed, including a tunnel along the Susquehanna River along the Capital Area Greenbelt. The potential disruption to this public park and the associated level of public coordination required, even using tunneling technology, would be complex making this alternative less desirable under this criterion. The tunnel network would also be complex because of the extensive geotechnical investigations and engineering analysis that would be required. The MTA-7 linear storage conduit would need to be constructed either at the same time as or outside the limits of the Paxton Creek widening/ redevelopment project greatly increasing the implementation complexity. All the satellite treatment and storage facilities have some level of complexity because they would be relatively deep, require extensive geotechnical engineering analysis as part of the design, and could be complex to construct.

Near-Term Water Quality Benefits: Projects that can be completed in a successive sequence can be completed more quickly and may result in faster near-term water quality improvements for the associated section of the receiving waters. MTA-6 would be less desirable under this criterion because water quality benefits would not be realized until the wet weather treatment plant, the Paxton Creek Interceptor (PCI) extension, and the PCI flow diversion structure are all completed, which given the size and complexity of the facilities would take long period of time. Similarly, MTA-5 would be undesirable because water quality benefits would not be realized until the large and complex network of storage tunnels was completed. The other alternatives would be equally desirable because water quality benefits would be realized as each satellite storage or treatment facility is constructed and operational.

Number of Facility Projects to Implement: Alternatives with a greater the number of facility projects to be designed and constructed, generally have a greater required level of effort and difficulty to implement them. The lack of consolidation results in MTA-2 and MTA-3 having the greatest number of control facilities to design, construct, and operate and would be least desirable by this criterion. MTA-5, MTA-6, and MTA-7 have the smallest number of control facilities to design and construct, which makes them desirable under this criteria.

Public Acceptability: It is critically important that the control facilities have a high degree of public acceptance since it is ratepayer funds that are paying for them. MTA-3 and MTA-4 would be least desirable under this criterion because of the satellite treatment facilities. They would be constructed above ground and would require the storage and use of disinfection chemicals. MTA-5 would also be less desirable because of the extensive long-term disruption to the Capital Area Greenbelt during construction of the Front Street branch of the tunnel. MTA-1 and MTA-2 would be less desirable because the low level of consolidation would require a greater number of control facilities to be constructed, resulting in a greater level of disruption. MTA-4B, MTA-6 and MTA-7 would be most desirable because the limited number of storage facilities would be constructed underground and only the control building would be visible. Public greenspace, athletic fields, and playgrounds are often provided above the storage tanks as additional public benefits.

6.11.2 Mixed Technology Alternative Evaluation Conclusions

Applying the selection criteria described above and summarized in **Table 6.11-1**, revealed that some of the Mixed Technology Alternatives were preferable to others. MTA-4B and MTA-6 provided the most preferable combination of technologies and control facilities to meet existing water quality criteria. MTA-7 is a potential “add-on” that can be used in conjunction with MTA-4B or MTA-6. Along the Paxton Creek, individual satellite storage facilities could be replaced by a single linear conduit storage facility. The justification for these choices is provided below.

MTA-4B: Satellite Storage with Maximized Consolidation

- From a cost perspective, it is desirable because it provides a wide range of levels of control at a lower cost than many of the alternatives.
- From a water quality perspective, it is desirable because it can provide a sufficient range of levels of control that is able to meet existing water quality standards along both the Susquehanna River and Paxton Creek.
- From a flexibility and adaptability perspective, it is desirable because the satellite storage facilities can be constructed in any priority order. Priority for facility implementation could be given to controlling discharges into one of the receiving waters, or priority could be given to controlling the CSO outfalls with the greatest frequency or volume. The storage facilities could be constructed under multiple different implementation schedules.
- From an operation and maintenance perspective, it is desirable because the satellite storage facilities are fully automated and do not require operation staff to be on-site for them to function. The satellite storage facilities would be equipped with flushing tanks to limit the buildup of solids and debris.
- From an uncertainty perspective, it is neutral because the high degree of facility consolidation and the reduced number of control facilities is offset by the additional uncertainty resulting from the extensive network of consolidation sewers as the associated potential for utility conflicts.
- From a complexity perspective, it is desirable because the degree of control facility consolidation reduces the number of facility projects to implement and limits the degree of potential disruption during construction. It is also desirable because satellite storage facilities are self-contained and release stored wastewater back into the interceptor system for

treatment at the AWTF. It requires no stored disinfection chemicals that would lose potency with age which could make the dosing quantity difficult to predict.

- MTA-4B is also desirable because it provides near-term water quality benefits. These benefits would be realized with each incremental step as each satellite storage facility is constructed and made operational.
- MTA-4B is desirable from a public acceptability perspective because the limited number of consolidated storage facilities would be constructed underground and only the control building would be visible. Public greenspace, athletic fields, and playgrounds are often provided above the storage tanks as additional public benefits.

MTA-6: Maximize Conveyance and Treatment

- From a cost perspective, it is desirable because it provides a wide range of levels of control at a lower cost than many of the alternatives.
- From a water quality perspective, it is desirable because it can provide a sufficient range of levels of control that is able to meet existing water quality standards along both the Susquehanna River and Paxton Creek.
- From a flexibility and adaptability perspective, it would have a neutral flexibility because the new wet weather treatment facility and the new extension of the Paxton Creek Interceptor would need to be implemented first and would take a longer time period to construct.
- From an operation and maintenance perspective, the new wet weather treatment facility would require onsite staffing, but it is located adjacent to the existing AWTF, reducing the undesirable impact.
- From a hydraulic perspective, it is highly desirable because it provides the greatest hydraulic capacity by constructing a new wet weather treatment facility, an extension from the Paxton Creek Interceptor, and an expansion of the replacement size of the existing interceptor.
- From an uncertainty perspective, it is desirable because the number of control facilities required along Paxton Creek is minimized by the increased conveyance and treatment capacities of the RTB and interceptor extension.
- From a complexity perspective, it is less desirable because the flow diversion structure would require real-time control and potentially complex hydraulic structures to divert optimum quantities of flow to the wet weather treatment facility. Additionally, achieving the proper disinfection to meet NPDES permit limits of a new outfall may be difficult.
- MTA-6 is desirable because the number of satellite storage projects along Paxton Creek is minimized due to the increased conveyance and treatment capacities.
- MTA-6 is desirable from a public acceptability perspective because the limited number of consolidated storage facilities would be constructed underground and only the control building would be visible. Public greenspace, athletic fields, and playgrounds are often provided above the storage tanks as additional public benefits.

7.0 Preferred Alternative and Recommended Plan

Section 6 provided evaluations of the mixed technology alternatives (MTAs) and identified MTA-4B and MTA-6 as the best performing alternatives for controlling combined sewer overflow (CSO) discharges. This report section summarizes further refinement of these two alternatives and the selection of the Preferred Alternative. The section also explains the process of integrating the preliminary water quality modeling and the affordability constraints of the submitted Financial Capability Assessment (FCA) into the Preferred Alternative to create the Recommended Plan. The report sections and the information they provide are summarized below.

- **Section 7.1** summarizes the Financial Capability Assessment (FCA) that was submitted to the regulatory agencies on Feb 23, 2024.
- **Section 7.2** compares the relative costs, benefits, and future opportunities associated with MTA-4B and MTA-6 and identifies the Preferred Alternative.
- **Section 7.3** summarizes additional evaluations to refine the Preferred Alternative with consideration of FCA affordability constraints.
- **Section 7.4** identifies the Recommended Plan.

7.1 Summary of FCA Results

A Financial Capability Assessment (FCA) was conducted for the CRW service area required by the CSO Policy and the Modification to the Partial Consent Decree (MPCD). The FCA was prepared in accordance with the “Clean Water Act Financial Capability Assessment Guidance” (2023 FCA Guidance) and was submitted to the regulatory agencies on Feb 23, 2024. The 2023 FCA Guidance provides a framework to assess the financial capability of the utility and service community to implement CSO control measures needed to meet Clean Water Act requirements and to develop a reasonable implementation schedule for the necessary improvements that will not excessively burden the community. The FCA capital investment scenario ($400 million) also assumed that CRW will not be able to share future wastewater regulatory-related capital projects with the suburban wholesale customers.[21] The CRW FCA utilized Alternative 2 of the 2023 Guidance which applies dynamic financial and rate models to evaluate the impacts of debt service and operation and maintenance costs on customer bills.

The FCA reached the following conclusions.

- Wastewater and stormwater rates are projected to double over the next 20-years, just to cover existing operational and capital commitments. The rate revenue to support system investments will result in high burdens on low-income households within CRW’s City retail service area.
- If CRW were to implement additional water pollution control capital investments, along with other system investment needs, totaling $400 million (in 2024 $s) over 20 years, this would

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[21] Financial Capably Assessment Report submitted on Feb 23, 2024, Section 5.2

place an excessively high economic burden on low-income households. Therefore, an extended implementation period, up to 40 years, would be required.

- If the required investment levels are higher than this amount, then a longer implementation schedule would be required.
- The FCA also explains CRW's efforts to reduce the impact on financially vulnerable and low-income customers.
- CRW has taken advantage of low-cost financing opportunities through PENNVEST and has received a PA H2O grant for the Paxton Creek Interceptor project.
- CRW primarily funds sewer and stormwater costs through user charges but supplements this revenue with other miscellaneous revenues.
- CRW has a rate design including usage-based rates and stormwater fees that help to reduce the burden on low-income residents.
- CRW has a customer assistance program that provides a credit of up to $300 per year ($150 for water and $150 for sewer) to residential customers who meet qualifying income guidelines.

Section 6.10 shows that all the evaluated MTAs require more than $400 million to meet current water quality standards along the Susquehanna River and Paxton Creek.

Therefore, this section of the Alternatives Analysis focuses on the levels of control (LoCs) that can be achieved within FCA affordability constraints.

7.2 Comparison of MTA-4B and MTA-6

Section 6 identified MTA-4B and MTA-6 as the two alternatives that meet the wet weather control needs of the CRW service area and best align with CRW's preferences based on the evaluation criteria identified in Section 6.11. These two alternatives were compared and evaluated.

The following factors were considered when evaluating MTA-4B:

- MTA-4B provides a wide range of levels of control, but at a lower cost than MTA-6.
- It provides implementation flexibility as individual satellite storage facilities can be constructed in any priority order.
- Satellite storage facilities are fully automated and do not require operation staff to be on-site for them to function.
- The green stormwater infrastructure (GSI) facilities decrease the risk of basement backups and localized flooding, lowers stormwater volumes in the CSS, reduce pollutant loads into receiving waters, and maximizes the amount of stormwater treated at advanced wastewater treatment facility.
- Incremental water quality benefits would be realized as each satellite storage facility is constructed and made operational.
- Storage facilities would be constructed underground and only the control building would be visible.

- The alternative does not require any control facilities that would require new NPDES permits.

Furthermore, it is also important to state that MTA-4B provides no flexibility for future expansion of the existing advanced wastewater treatment facility (AWTF). The existing AWTF is landlocked and has no available space for expansion. Should future regulatory requirements necessitate additional treatment levels and/or facilities, they would be prohibitively complicated and expensive to implement within site constraints. The existing AWTF site would have limited and costly options to provide increased treatment capacity to meet future rainfall extremes associated with climate change.

The following factors were considered when evaluating MTA-6:

- Conveyance and treatment capacities would be increased providing operational flexibility during wet weather conditions.
- To provide operational flexibility, Supervisory Control and Data Acquisition (SCADA) and real-time control (RTC) technologies would be implemented to manage the increased hydraulic control needs and complexity.
- A sharp increase in water quality benefits would be realized upon completion of the interceptor improvements and retention treatment basin (RTB).
- MTA-6 achieves a better net environmental benefit than MTA-4B because it achieves lower systemwide CSO discharge volumes for each level of control (LoC).
- The number of satellite storage facilities required along the Susquehanna River and Paxton Creek is minimized by the increased Paxton Creek Interceptor conveyance and RTB treatment capacities.
- Storage facilities would be constructed underground and only the control building would be visible.
- The green stormwater infrastructure (GSI) facilities decrease the risk of basement backups and localized flooding, lowers stormwater volumes in the CSS, reduce pollutant loads into receiving waters, and maximizes the amount of stormwater treated at advanced wastewater treatment facility.
- The wet weather treatment facility would require onsite staffing during wet weather events, but it is adjacent to the existing AWTF, which operations staff can access more quickly and easily.
- MTA-6 requires the construction of a new outfall for the RTB facility and would require securing the associated permits.
- Procurement of a property adjacent to the AWTF for the RTB would also provide other future expansion opportunities for an otherwise landlocked AWTF site.
- Further increases in conveyance/treatment capacity can be achieved with modular expansion of the RTB in the future.

For lower LoCs, MTA-4B is more cost effective at reducing CSO frequency relative to MTA-6. However, this advantage decreases with higher levels of control. This difference in cost effectiveness is primarily due to the high costs associated with the RTB featured in MTA-6, which receives excess wet weather flows diverted from the Paxton Creek Interceptor. In comparison to MTA-4B, the wet weather diversion to the RTB significantly reduces the number and sizes of satellite storage tanks throughout the rest of the system, due to increased capacity of the conveyance system, but this large upfront investment needs to be overcome to make this alternative as cost-effective as MTA-4B.

Considering the factors compared above, CRW has selected MTA-6 as the Preferred Alternative based on the following reasons:

- MTA-6 significantly increases the total conveyance and primary treatment capacity, which provides greater operational flexibility, resiliency for climate change, and changing regulatory conditions. Further increases in conveyance/treatment capacity can be achieved with modular expansion of the RTB in the future.
- MTA-6 reduces the number and size of satellite storage tanks throughout the system (relative to MTA-4B), which reduces the visual impacts of the facilities.
- MTA-6 attains a better net environmental impact than MTA-4B by achieving lower systemwide CSO volumes for each level of control.
- MTA-6 achieves a better net environmental benefit by capturing a larger CSO volume for each LoC, in comparison to MTA-4B. Expanding the connection pipes from CSO regulators to interceptors, increasing the pipe size of the replaced Paxton Creek Interceptor (PCI), and connecting the new PCI to the RTB, results in a systematic reduction in CSO volumes, even for CSO outfalls not directly targeted with satellite storage tanks.

Table 7.2-1 summarizes the CSO volumes corresponding to MTA-4B and MTA-6 for each LoC and each receiving water. This shows that MTA-6 provides a significantly lower CSO discharge volume compared to MTA-4B for each LoC, particularly for Paxton Creek. In this table, “Centralized Conveyance” refers to additional centralized conveyance improvements beyond the Appendix B project list. For MTA-6, centralized conveyance refers to the Paxton Creek Interceptor extension and 70 MGD RTB. For MTA-4B, there are no centralized conveyance components. The expanded centralized conveyance needed for MTA-6 results in a CSO volume reduction of 74 million gallons and this is not a component for MTA-4B. For a LoC of 20 overflows, MTA-6 results in a 40 million gallons reduction of CSO volume (22% less) when compared to MTA-4B.

Table 7.2-1: CSO Volume Comparison between MTA-4B and MTA-6

Level of Control	MTA-4B			MTA-6		
	Susquehanna River	**Paxton Creek**	**Total**	**Susquehanna River**	**Paxton Creek**	**Total**
Appendix B	144	186	331	144	186	331
Appendix B + GSI	109	117	227	109	117	227
Centralized Conveyance	-	-	-	88	65	153
20 Overflows	82	101	183	78	65	143
16 Overflows	65	83	148	60	65	125
10 Overflows	41	58	99	31	48	79
5 Overflows	26	49	75	19	40	59
2 Overflows	7	16	22	6	7	13
0 Overflows	0	0	0	0	0	0

Table 7.2-2 provides a comparison of the two alternatives from a Water Quality (WQ) perspective, particularly for Paxton Creek. The simulation results from the water quality model are represented in the table. For this comparison, a LoC of 16 overflows per year was selected. Each row within the table represents a reach of Paxton Creek from the upstream limit of the study area to the confluence with the Susquehanna River. The green cells represent reaches where a LoC of 16 overflows per year is sufficient to attain WQ standards, and the brown cells indicate stream reaches where this LoC is insufficient to meet WQ standards. The table shows that for this LoC, MTA-6 provides better water quality results by achieving greater CSO volume reductions (and therefore less bacteria loading to Paxton Creek). Water quality compliance was determined using the results from the H&H model incorporated into the water quality model.

Comparison Conclusions: The detailed comparison and analysis of MTA-4B and MTA-6 shows that MTA-6 is the better performing and hence the Preferred Alternative that will best meet the wet weather control needs of the CRW service area and best align with CRW's evaluation criteria and preferences.

Table 7.2-2: Water Quality Compliance in Paxton Creek for MTA-4B and MTA-6 (16 overflows)

Reach	River Miles	CSO Outfalls	Water Quality Compliance			
			Higher Bacteria Levels		Lower Bacteria Levels	
			MTA-4B	MTA-6	MTA-4B	MTA-6
REACH_1	4.8		🟩	🟩	🟩	🟩
REACH_2	4.7		🟩	🟩	🟩	🟩
REACH_3	4.5		🟩	🟩	🟩	🟩
REACH_4	4.4		🟩	🟩	🟩	🟩
REACH_5	4.2		🟩	🟩	🟩	🟩
REACH_6	4.1		🟩	🟩	🟩	🟩
REACH_7	3.9		🟩	🟩	🟩	🟩
REACH_8	3.8		🟩	🟩	🟩	🟩
REACH_9	3.7		🟩	🟩	🟩	🟩
REACH_10	3.5	CSO- 21	🟩	🟩	🟩	🟩
REACH_11	3.3		🟩	🟩	🟩	🟩
REACH_12	3.2		🟩	🟩	🟩	🟩
REACH_13	3.1	CSO- 22	🟩	🟩	🟩	🟩
REACH_14	2.9		🟩	🟩	🟩	🟩
REACH_15	2.7		🟩	🟩	🟩	🟩
REACH_16	2.6		🟩	🟩	🟩	🟩
REACH_17	2.5	CSO- 23 & 24	🟩	🟩	🟩	🟩
REACH_18	2.3	CSO- 25, 26, 27, & 28	🟧	🟩	🟩	🟩
REACH_19	2	CSO- 29 & 30	🟧	🟩	🟩	🟩
REACH_20	1.9	CSO- 31	🟧	🟩	🟩	🟩
REACH_21	1.8	CSO- 32 & 33	🟧	🟩	🟩	🟩
REACH_22	1.7	CSO- 34 & 37	🟧	🟧	🟩	🟩
REACH_23	1.6	CSO- 38	🟧	🟧	🟩	🟩
REACH_24	1.5	CSO- 39, 40, & 41	🟧	🟧	🟧	🟩
REACH_25	1.4	CSO- 42, 43, & 59	🟧	🟧	🟧	🟩
REACH_26	1.2	CSO- 44	🟧	🟧	🟧	🟩
REACH_27	1.1	CSO- 45 & 46	🟧	🟧	🟧	🟩
REACH_28	1		🟧	🟧	🟧	🟩
REACH_29	0.9	CSO- 48	🟧	🟧	🟧	🟩
REACH_30	0.7		🟧	🟧	🟧	🟩
REACH_31	0.7	CSO- 60 & 61	🟧	🟧	🟧	🟩
REACH_32	0.5		🟧	🟧	🟧	🟩
REACH_33	0.4	CSO- 62, 63, & 64	🟧	🟧	🟧	🟧
REACH_34	0.1		🟧	🟧	🟧	🟧
REACH_35	0.1		🟧	🟧	🟧	🟧

Color Coding:

🟩	Compliant (Percent Attainment > 99%)
🟧	Incompliant (Percent Attainment < 99%)

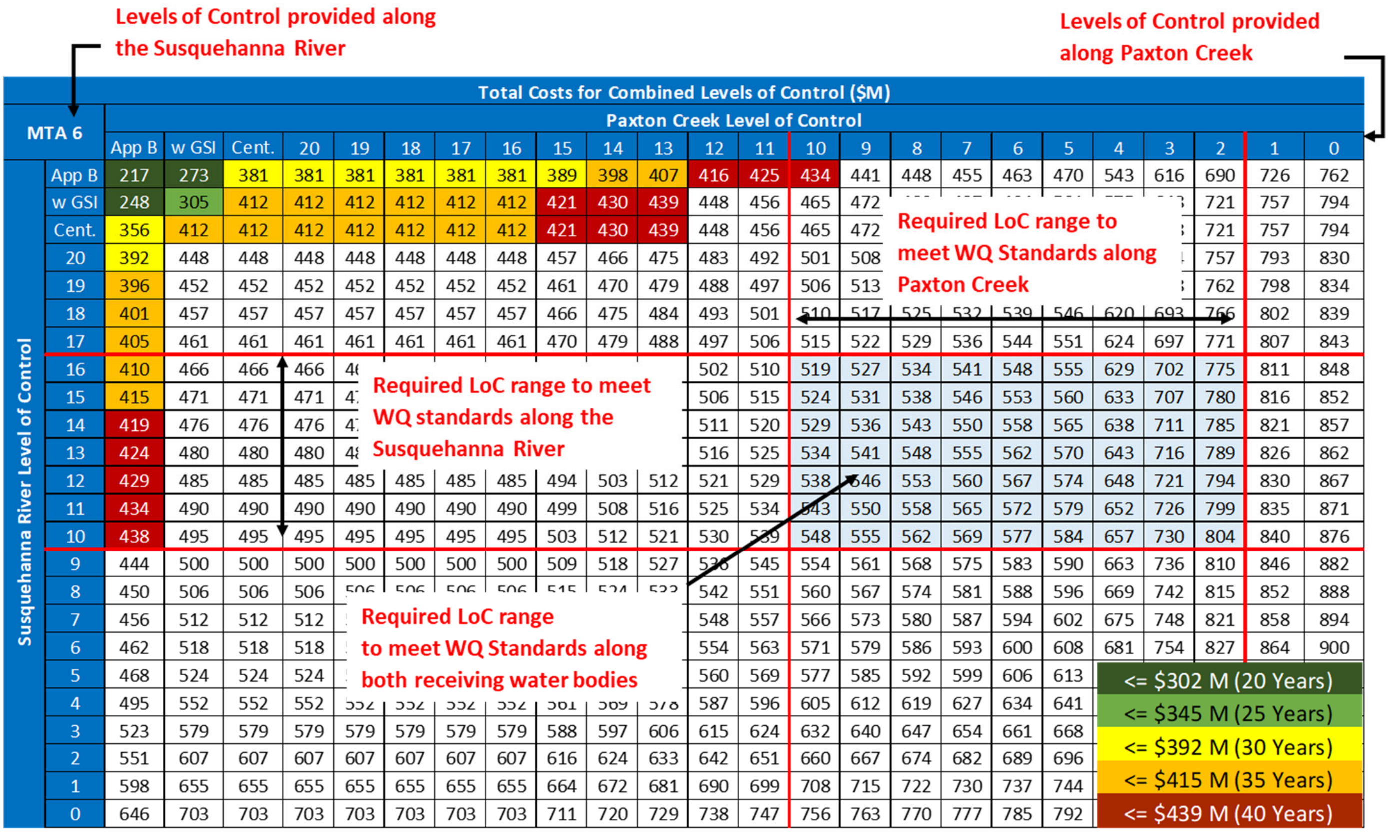
Note: the table results for both higher and lower bacteria levels are based upon a LoC of 16 annual overflows during typical year precipitation.

7.3 Refinements to Address Implementation Constraints

Refinement of the Preferred Alternative, MTA-6, is the final step in the alternatives evaluation process to develop the Recommended Plan. The economic model developed for the FCA was applied to the sequence of capital and lifecycle operation and maintenance costs associated with the Preferred Alternative MTA-6. The economic model showed that the implementation of MTA-6 within a 20-year period would place an excessively high economic burden on households within CRW's City retail service area. Therefore, implementation periods of 25, 30, 35, and 40 years were analyzed using the economic model. **Table 7.3-1** summarizes the costs associated with MTA-6 for various combinations of levels of control for Susquehanna River and Paxton Creek. These "cost matrices" are used throughout this section, and the following explains how to interpret them.

- The level of control (LoC) is defined as the combination of CSO control facilities required to reduce each CSO outfall at least to the target numbers of annual overflows during typical year precipitation (allowing for +/- 1 to 3 overflows for each target frequency).
- In each cost matrix, the rows define the LoCs for Susquehanna River, and the columns define the LoCs for Paxton Creek. For example, in **Table 7.3-1**, the cost to achieve a LoC of 20 overflows along the Susquehanna River and 20 overflows along Paxton Creek is $448 million.
- The modeled LoCs are Appendix B projects ("App B"), Appendix B projects with total GSI ("w GSI"), Appendix B projects with total GSI and the centralized Paxton Creek Interceptor conveyance projects ("Cent."), 20 overflows, 16 overflows, 10 overflows, 5 overflows, 2 overflows, and 0 overflows. All other LoCs are linearly interpolated.
- For reference, the upper and lower limits of the required LoCs to meet current water quality standards are shown as red lines. As Section 6.10 explained, the required LoCs range is from 10 to 16 overflows for Susquehanna River and 2 to 10 overflows for Paxton Creek. These LoCs are based on a preliminary water quality model and are subject to refinement and change as additional sampling data is collected.
- The rectangle bound by these limits, and the light blue shading between, represent the range of LoCs required to meet current water quality standards within both receiving waterways.
- The color shading indicates the LoCs, over a range of implementation periods, that fall within the FCA affordability criteria and do not result in control costs that would induce an excessively high economic burden on CRW ratepayers. The color shading is as follows: implementation within 20 years (dark green); within 21 to 25 years (green); 26 to 30 years (yellow); 31 to 35 years (orange); and 36 to 40 years (red).

Table 7.3-1: Applying the FCA Economic Model to MTA-6 for a Range of Implementation Periods



MTA 6		Total Costs for Combined Levels of Control ($M)																							
		Paxton Creek Level of Control																							
		App B	w GSI	Cent.	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Susquehanna River Level of Control	App B	217	273	381	381	381	381	381	381	389	398	407	416	425	434	441	448	455	463	470	543	616	690	726	762
	w GSI	248	305	412	412	412	412	412	412	421	430	439	448	456	465	472	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	721	757	794
	Cent.	356	412	412	412	412	412	412	412	421	430	439	448	456	465	472	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	721	757	794
	20	392	448	448	448	448	448	448	448	457	466	475	483	492	501	508	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	757	793	830
	19	396	452	452	452	452	452	452	452	461	470	479	488	497	506	513	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	762	798	834
	18	401	457	457	457	457	457	457	457	466	475	484	493	501	510	517	525	532	539	546	620	693	766	802	839
	17	405	461	461	461	461	461	461	461	470	479	488	497	506	515	522	529	536	544	551	624	697	771	807	843
	16	410	466	466	466	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	502	510	519	527	534	541	548	555	629	702	775	811	848
	15	415	471	471	471	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	506	515	524	531	538	546	553	560	633	707	780	816	852
	14	419	476	476	476	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	511	520	529	536	543	550	558	565	638	711	785	821	857
	13	424	480	480	480	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	516	525	534	541	548	555	562	570	643	716	789	826	862
	12	429	485	485	485	485	485	485	485	494	503	512	521	529	538	546	553	560	567	574	648	721	794	830	867
	11	434	490	490	490	490	490	490	490	499	508	516	525	534	543	550	558	565	572	579	652	726	799	835	871
	10	438	495	495	495	495	495	495	495	503	512	521	530	539	548	555	562	569	577	584	657	730	804	840	876
	9	444	500	500	500	500	500	500	500	509	518	527	536	545	554	561	568	575	583	590	663	736	810	846	882
	8	450	506	506	506	506	506	506	506	515	524	533	542	551	560	567	574	581	588	596	669	742	815	852	888
	7	456	512	512	512	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	548	557	566	573	580	587	594	602	675	748	821	858	894
	6	462	518	518	518	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	554	563	571	579	586	593	600	608	681	754	827	864	900
	5	468	524	524	524	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	560	569	577	585	592	599	606	613	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	4	495	552	552	552	552	552	552	552	561	569	578	587	596	605	612	619	627	634	641	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	3	523	579	579	579	579	579	579	579	588	597	606	615	624	632	640	647	654	661	668	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	2	551	607	607	607	607	607	607	607	616	624	633	642	651	660	667	674	682	689	696	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	1	598	655	655	655	655	655	655	655	664	672	681	690	699	708	715	722	730	737	744	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	0	646	703	703	703	703	703	703	703	711	720	729	738	747	756	763	770	777	785	792	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

- <= $302 M (20 Years)
- <= $345 M (25 Years)
- <= $392 M (30 Years)
- <= $415 M (35 Years)
- <= $439 M (40 Years)

Table 7.3-1 shows, based on the FCA results summarized in Section 7.1, CRW cannot meet current water quality standards within both the Susquehanna River and Paxton Creek, within implementation periods between 20 and 40 years, without resulting in significant cash flow constraints, requiring CRW to increase its sewer rates to unreasonable levels, and inducing an excessively high economic burden on CRW customers. Therefore, CRW evaluated additional refinements to MTA-6 that would achieve the greatest environmental benefit considering the FCA affordability constraints.

For the Recommended Plan, refinements will determine the LoC for each receiving water and the implementation schedule for the required control facilities that minimize the utility rate increases and impact on customer bills, but still pose a high burden for the community. Three elements were evaluated to refine MTA-6, the ***retention treatment basin*** and ***green stormwater infrastructure*** in balance with the sizing of ***satellite storage facilities***. An analysis was conducted using the hydrologic and hydraulic (H&H) model, to identify a more cost-effective peak treatment capacity for the retention treatment basin, and the most effective combination of GSI facilities and storage volumes. These refinements allow a LoC sufficient to meet current water quality standards along the Susquehanna River (assumed to be 10 overflows per typical year) and provide the greatest LoC and greatest reductions in CSO discharges to Paxton Creek within FCA affordability constraints.

7.3.1 Refining the Size of the Retention Treatment Basin

The original MTA-6, as defined in Section 6, includes a 70 MGD RTB which stores and treats excess wet weather flow diverted from the Paxton Creek Interceptor (PCI). The RTB design capacity corresponds to the PCI peak flow associated with the largest typical year storm and the size is appropriate for the higher LoCs evaluated in Section 6. However, the range of LoCs required to meet current water quality standards along the Susquehanna River, 10 to 16 overflows per typical year according to the preliminary WQ model, could adequately utilize a smaller RTB. The tradeoff in reducing the RTB size is that reducing the peak treatment capacity results in additional and/or slightly larger satellite storage tanks throughout the CRW system to compensate.

Three RTB sizes were analyzed utilizing the H&H model, 70 MGD, 50 MGD, and 30 MGD. **Table 7.3-2** shows the cost impacts of reducing the size and capacity of the RTB from 70 MGD to 50 and 30 MGD.

Table 7.3-2: Cost Reductions Resulting from RTC Size/Capacity Reductions

Peak RTB Treatment Capacity (million gallons per day)	RTB Storage Volume (million gallons)	Cost in $ Million (including increased conveyance costs)	Cost Difference ($ million)
70	0.73	$107.3	N/A
50	0.52	$83.9	$23.4
30	0.31	$58.2	$49.1

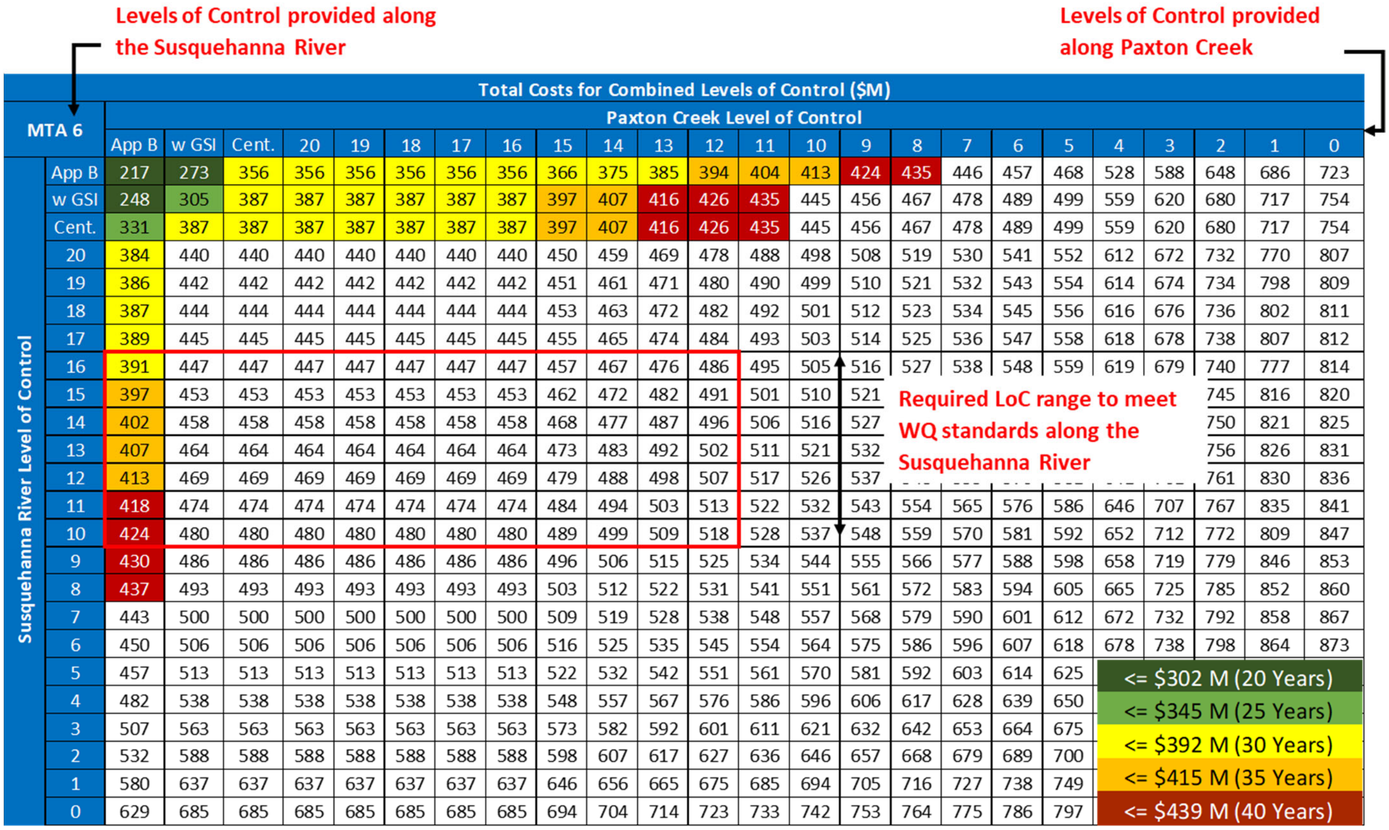
Simulations were performed with the H&H model with the 50 MGD and 30 MGD RTBs. **Table 7.3-3** shows how reducing the RTB size impacts the required number, size, and locations of satellite storage tanks throughout the CRW system. The analysis shows that reducing the RTB peak design flow from 70 MGD to 30 MGD results in only minor changes to required satellite storage volumes for the LoCs associated with meeting current water quality standards along the Susquehanna River. For a LoC of 16 overflows per year, 1.08 MG of additional compensating storage volume was required, and for a LoC of 10 overflows per year, 1.14 MG of additional compensating storage was required.

The total costs associated with these modified MTA-6 scenarios are then developed utilizing the costing methodology that was explained in Sections 4 and 6. These modified MTA-6 scenarios were input into the FCA economic model to determine the LoCs that can be achieved for a range of implementation periods without imposing an excessively high economic burden on CRW ratepayers. The total costs associated with the modified MTA-6 scenarios are shown in **Table 7.3-4** and **Table 7.3-5**. The targeted LoCs are indicated within the red box: LoCs of 10 to 16 overflows per year along the Susquehanna and LoCs of 12 to 20 overflows per year along Paxton Creek. This LoC range should meet current water quality standards along the Susquehanna according to the preliminary water quality model but would not achieve water quality compliance along Paxton Creek.

Table 7.3-3: Facility Sizes for MTA-6 with 70, 50, and 30 MGD RTB

Planning Area	**CSO Outfall**	**Technology Size (Location Indicated in Parentheses)**					
		Storage Tanks		**Storage Tanks**		**Storage Tanks**	
		16 Overflows	**10 Overflows**	**16 Overflows**	**10 Overflows**	**16 Overflows**	**10 Overflows**
Riverside	CSO-04		0.12 MG (CSO-05)		0.16 MG (CSO-05)		0.18 MG (CSO-05)
	CSO-05						
Uptown	CSO-49						
	CSO-50		2.14 MG (Tank = 1.14 MG; Cons. Sewers = 1 MG) (CSO-13)		2.62 MG (Tank = 1.62 MG; Cons. Sewers = 1 MG) (CSO-13)		3.04 MG (Tank = 2.04 MG; Cons. Sewers = 1 MG) (CSO-13)
	CSO-51	1.51 MG (Tank = 0.86 MG; Cons. Sewers = 0.65 MG) (CSO-11)		2.05 MG (Tank = 1.40 MG; Cons. Sewers = 0.65 MG) (CSO-11)		2.57 MG (Tank = 1.92 MG; Cons. Sewers = 0.65 MG) (CSO-11)	
	CSO-06						
	CSO-07						
	CSO-08						
	CSO-09						
	CSO-10						
	CSO-11						
Middle Front Street	CSO-12						
	CSO-13						
	CSO-14						
	CSO-15						
	CSO-16						
	CSO-52						
	CSO-53						
	CSO-54						
	CSO-55						
	CSO-56						
Lower Front Street	CSO-17						
	CSO-57						
	CSO-18		0.20 MG (CSO-58)		0.27 MG (CSO-58)		0.38 MG (CSO-58)
	CSO-19						
	CSO-58	0.02 MG		0.03 MG		0.04 MG	
	CSO-20						
Upper Paxton Creek - West	CSO-21						
	CSO-22						
	CSO-24						
	CSO-27						
	CSO-28						
Upper Paxton Creek - East	CSO-23						
	CSO-25						
	CSO-26		0.37 MG (CSO-40)		0.39 MG (CSO-40)		0.52 MG (CSO-40)
Middle Paxton Creek - East	CSO-29						
	CSO-31						
	CSO-33						
	CSO-34						
	CSO-39						
	CSO-40						
Middle Paxton Creek - West	CSO-30						
	CSO-32						
	CSO-37						
	CSO-38						
	CSO-41						
Lower Paxton Creek	CSO-42		0.39 MG (CSO-44)		0.41 MG (CSO-48)		0.84 MG (CSO-48)
	CSO-59						
	CSO-43						
	CSO-44						
	CSO-45						
	CSO-46						
	CSO-48						
Hemlock Street	CSO-60						
	CSO-61		0.22 MG (CSO-63)		0.23 MG (CSO-63)		0.23 MG (CSO-63)
	CSO-62						
	CSO-63						
	CSO-64						
	Total:	**1.53 MG**	**3.44 MG**	**2.08 MG**	**4.08 MG**	**2.61 MG**	**5.19 MG**
Centralized Wet Weather Treatment		70 MGD		50 MGD		30 MGD	
Green Stormwater Infrastructure		294 ac		294 ac		294 ac	

Table 7.3-4: Cost Matrix for MTA-6, Modified with a 50 MGD RTB



Levels of Control provided along the Susquehanna River

Levels of Control provided along Paxton Creek

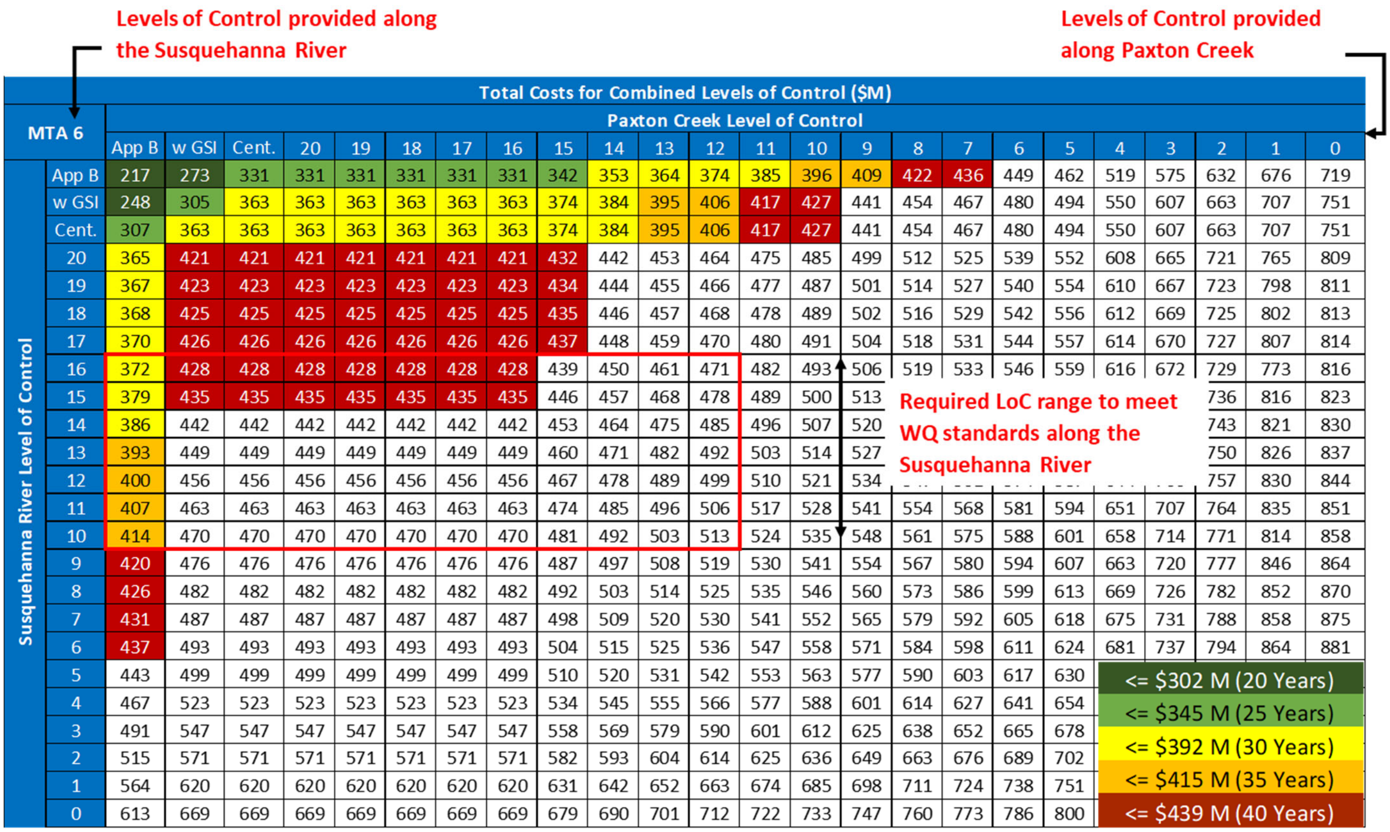
Required LoC range to meet WQ standards along the Susquehanna River

Total Costs for Combined Levels of Control ($M)

MTA 6	Paxton Creek Level of Control																					
Susquehanna River Level of Control	App B	w GSI	Cent.	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
App B	217	273	356	356	356	356	356	356	366	375	385	394	404	413	424	435	446	457	468	528	588	648	686	723
w GSI	248	305	387	387	387	387	387	387	397	407	416	426	435	445	456	467	478	489	499	559	620	680	717	754
Cent.	331	387	387	387	387	387	387	387	397	407	416	426	435	445	456	467	478	489	499	559	620	680	717	754
20	384	440	440	440	440	440	440	440	450	459	469	478	488	498	508	519	530	541	552	612	672	732	770	807
19	386	442	442	442	442	442	442	442	451	461	471	480	490	499	510	521	532	543	554	614	674	734	798	809
18	387	444	444	444	444	444	444	444	453	463	472	482	492	501	512	523	534	545	556	616	676	736	802	811
17	389	445	445	445	445	445	445	445	455	465	474	484	493	503	514	525	536	547	558	618	678	738	807	812
16	391	447	447	447	447	447	447	447	457	467	476	486	495	505	516	527	538	548	559	619	679	740	777	814
15	397	453	453	453	453	453	453	453	462	472	482	491	501	510	521	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	745	816	820
14	402	458	458	458	458	458	458	458	468	477	487	496	506	516	527	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	750	821	825
13	407	464	464	464	464	464	464	464	473	483	492	502	511	521	532	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	756	826	831
12	413	469	469	469	469	469	469	469	479	488	498	507	517	526	537	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	761	830	836
11	418	474	474	474	474	474	474	474	484	494	503	513	522	532	543	554	565	576	586	646	707	767	835	841
10	424	480	480	480	480	480	480	480	489	499	509	518	528	537	548	559	570	581	592	652	712	772	809	847
9	430	486	486	486	486	486	486	486	496	506	515	525	534	544	555	566	577	588	598	658	719	779	846	853
8	437	493	493	493	493	493	493	493	503	512	522	531	541	551	561	572	583	594	605	665	725	785	852	860
7	443	500	500	500	500	500	500	500	509	519	528	538	548	557	568	579	590	601	612	672	732	792	858	867
6	450	506	506	506	506	506	506	506	516	525	535	545	554	564	575	586	596	607	618	678	738	798	864	873
5	457	513	513	513	513	513	513	513	522	532	542	551	561	570	581	592	603	614	625	<= $302 M (20 Years)				
4	482	538	538	538	538	538	538	538	548	557	567	576	586	596	606	617	628	639	650	<= $345 M (25 Years)				
3	507	563	563	563	563	563	563	563	573	582	592	601	611	621	632	642	653	664	675	<= $392 M (30 Years)				
2	532	588	588	588	588	588	588	588	598	607	617	627	636	646	657	668	679	689	700	<= $415 M (35 Years)				
1	580	637	637	637	637	637	637	637	646	656	665	675	685	694	705	716	727	738	749	<= $439 M (40 Years)				
0	629	685	685	685	685	685	685	685	694	704	714	723	733	742	753	764	775	786	797					

The analysis results in **Table 7.3-4** show that current water quality standards along the Susquehanna River could not be attained within a 20 or 25-year implementation period within FCA affordability constraints with a 50 MGD RTB. If the implementation period is increased to 30, 35, or 40 years then the targeted LoCs of 10 to 16 overflows could lead to the attainment of current water quality standards along the Susquehanna, but with minimal improvement along Paxton Creek.

Table 7.3-5: Cost Matrix for MTA-6, Modified with a 30 MGD RTB


Levels of Control provided along the Susquehanna River

Levels of Control provided along Paxton Creek

Required LoC range to meet WQ standards along the Susquehanna River

MTA 6	Total Costs for Combined Levels of Control ($M)																							
	Paxton Creek Level of Control																							
Susquehanna River Level of Control	App B	w GSI	Cent.	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
App B	217	273	331	331	331	331	331	331	342	353	364	374	385	396	409	422	436	449	462	519	575	632	676	719
w GSI	248	305	363	363	363	363	363	363	374	384	395	406	417	427	441	454	467	480	494	550	607	663	707	751
Cent.	307	363	363	363	363	363	363	363	374	384	395	406	417	427	441	454	467	480	494	550	607	663	707	751
20	365	421	421	421	421	421	421	421	432	442	453	464	475	485	499	512	525	539	552	608	665	721	765	809
19	367	423	423	423	423	423	423	423	434	444	455	466	477	487	501	514	527	540	554	610	667	723	798	811
18	368	425	425	425	425	425	425	425	435	446	457	468	478	489	502	516	529	542	556	612	669	725	802	813
17	370	426	426	426	426	426	426	426	437	448	459	470	480	491	504	518	531	544	557	614	670	727	807	814
16	372	428	428	428	428	428	428	428	439	450	461	471	482	493	506	519	533	546	559	616	672	729	773	816
15	379	435	435	435	435	435	435	435	446	457	468	478	489	500	513	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	736	816	823
14	386	442	442	442	442	442	442	442	453	464	475	485	496	507	520	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	743	821	830
13	393	449	449	449	449	449	449	449	460	471	482	492	503	514	527	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	750	826	837
12	400	456	456	456	456	456	456	456	467	478	489	499	510	521	534	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	757	830	844
11	407	463	463	463	463	463	463	463	474	485	496	506	517	528	541	554	568	581	594	651	707	764	835	851
10	414	470	470	470	470	470	470	470	481	492	503	513	524	535	548	561	575	588	601	658	714	771	814	858
9	420	476	476	476	476	476	476	476	487	497	508	519	530	541	554	567	580	594	607	663	720	777	846	864
8	426	482	482	482	482	482	482	482	492	503	514	525	535	546	560	573	586	599	613	669	726	782	852	870
7	431	487	487	487	487	487	487	487	498	509	520	530	541	552	565	579	592	605	618	675	731	788	858	875
6	437	493	493	493	493	493	493	493	504	515	525	536	547	558	571	584	598	611	624	681	737	794	864	881
5	443	499	499	499	499	499	499	499	510	520	531	542	553	563	577	590	603	617	630					
4	467	523	523	523	523	523	523	523	534	545	555	566	577	588	601	614	627	641	654					
3	491	547	547	547	547	547	547	547	558	569	579	590	601	612	625	638	652	665	678					
2	515	571	571	571	571	571	571	571	582	593	604	614	625	636	649	663	676	689	702					
1	564	620	620	620	620	620	620	620	631	642	652	663	674	685	698	711	724	738	751					
0	613	669	669	669	669	669	669	669	679	690	701	712	722	733	747	760	773	786	800					

- <= $302 M (20 Years)
- <= $345 M (25 Years)
- <= $392 M (30 Years)
- <= $415 M (35 Years)
- <= $439 M (40 Years)

As depicted in **Table 7.3-5**, the analysis shows MTA-6 modified with a 30 MGD RTB could not attain current water quality standards, under FCA affordability constraints, within a 20 or 25-year implementation period. With a 30 or 35-year implementation period, the targeted LoCs of 10 to 16 overflows per year could be met and attain water quality standards along the Susquehanna, but with minimal improvement along Paxton Creek. However, with a 40-year implementation period, the alternative might be able to meet current water quality standards along the Susquehanna and provide targeted LoCs of 16 to 20 overflows per year along Paxton Creek.

7.3.2 Refining GSI Management

The original MTA-6, as defined in Section 6, includes a total of 294 acres of impervious area strategically managed by green stormwater infrastructure (GSI). The reason for including this level of GSI was summarized in Section 6.1.2, i.e., GSI works in combination with gray infrastructure; lowers the risk of basement flooding and surface flooding; and reduces peak flows, pollutant loads, and CSO discharges. However, it is recognized that some of these GSI benefits must be balanced with other technologies to achieve acceptable levels of CSO control, that do not induce an excessively high economic burden on customers. Therefore, CRW evaluated lower levels of GSI corresponding to 227 acres (roughly 75% of the originally evaluated GSI), 200 acres (roughly 65% of the originally evaluated GSI), and 159 acres (roughly 50% of the originally evaluated GSI). In these scenarios, the full amount of GSI could still be implemented, but the remainder would have to be completed well into the future, beyond the implementation schedule horizon of the City Beautiful H_2O Program Plan (CBH_2OPP). The cost differences associate with reducing the levels of GSI control to the analyzed levels are summarized in **Table 7.3-6**. These cost differences were reinvested into satellite storage.

Table 7.3-6: Cost Reductions Resulting from GSI Facility Reductions

Percent of Full GSI Control	Impervious Acres managed by GSI	Present Value Lifecycle Cost ($million)	Cost Difference ($million)
100	294	$119	N/A
75	227	$87	$32
65	200	$74	$45
50	159	$55	$64

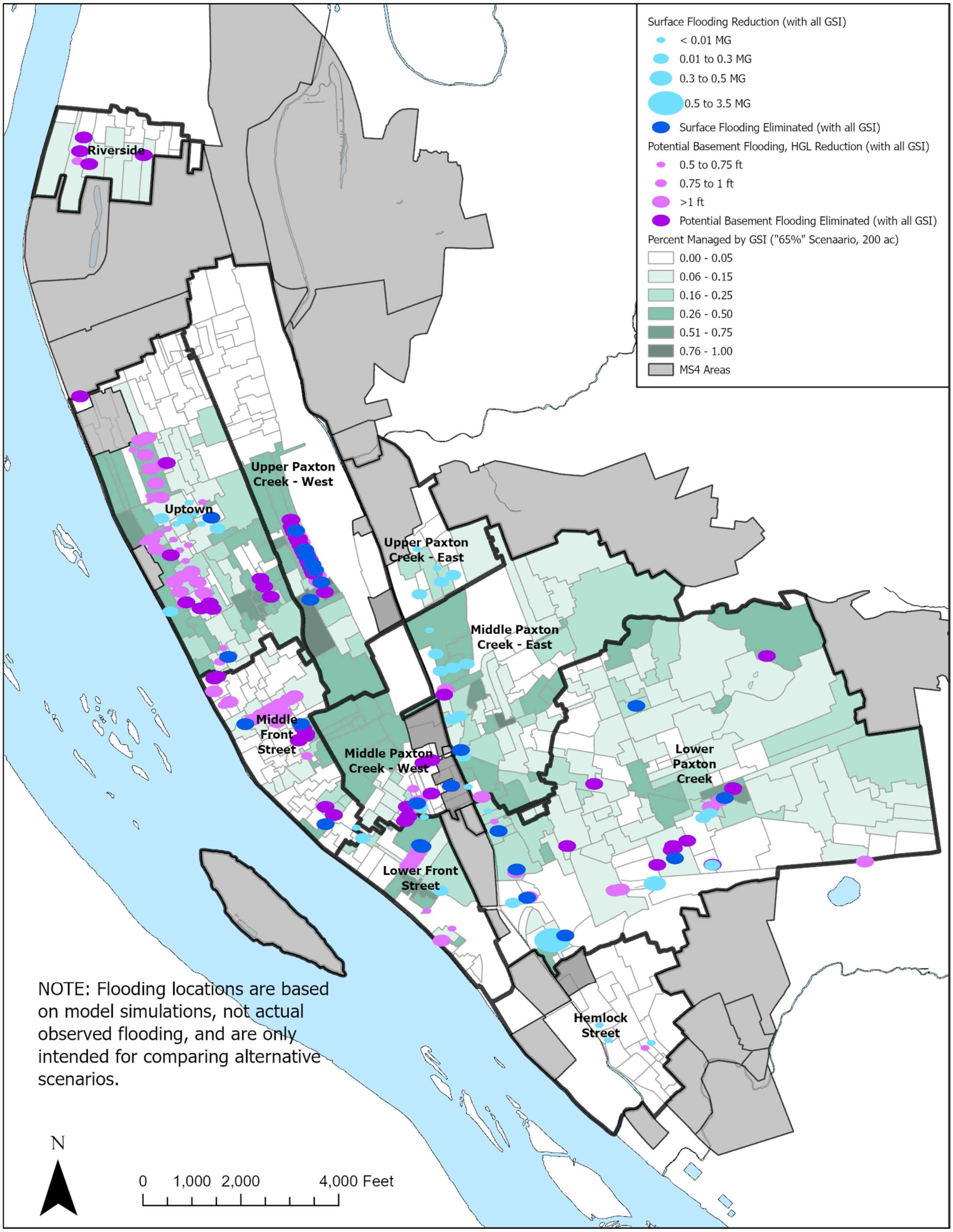
Note: For each scenario, the number of impervious managed acres includes 40 acres of existing projects, which are not included in the costs.

The primary tradeoff in reducing the level of GSI, relative to other modification options, is the corresponding reduction in collection system benefits. Reducing the level of GSI control would increase the volumes, pollutant loads, and peaks of stormwater runoff before it enters the combined sewer system and would increase the frequency and volume of CSO discharges. However, the reduction in GSI control was coupled with a corresponding increase in satellite storage volumes to provide the same range of LoCs.

The H&H model was used to quantify the impacts of reducing the level of impervious acres managed by GIS control from 294 acres to 159 acres. A 2-year design storm was used as the basis for quantifying collection system flooding statistics. The results of the model simulations are summarized in **Table 7.3-7**. The reduction in the number of manholes with potential basement flooding (defined as the hydraulic grade line less than six feet from the manhole rim) was reduced by 19% for both 200 and 227 acres of GSI control. The systemwide average reduction in the hydraulic grade lines within manholes was within 0.33 feet of the original 294 GSI-managed acres for the 227 and 200 acre scenarios. The systemwide reduction in surface flooding volume was within 4% with 75% and 65% of the original 294 GSI-managed acres. Reducing the level of GSI control by 50% was deemed unacceptable because this led to a significant decrease in the benefits GSI provides. Keeping the GSI level at 100% would place an excessively high economic burden on low-income households. The 65% and 75% levels of GSI produced comparable benefits. Therefore, it was decided to reduce the level of GSI control to 200 managed acres.

Table 7.3-7: 2-Year Design Statistics for Varying Levels of GSI

Performance Metric	Existing GSI	50% GSI 159 acres	65% GSI 200 acres	75% GSI 227 acres	100% GSI 294 acres
Number of MHs with HGL < 6' from Rim (Percent Reduction)	262 N/A	228 13%	211 19%	211 19%	202 24%
Reduction in HGL (Avg for all CSS MHs)	N/A	0.49 ft	0.68 ft	0.73 ft	0.88 ft
Surface Flooding Volume (MG) (Percent Reduction)	7.55 N/A	5.92 22%	5.21 31%	4.88 35%	4.81 36%



NOTE: Flooding locations are based on model simulations, not actual observed flooding, and are only intended for comparing alternative scenarios.

Figure 7.3-1: Distribution for 200 Acres of GSI Based on Collection System Benefits

The hydraulic benefits along the combined collection system resulting from 200 impervious acres managed by GSI were quantified by the H&H model and are depicted in **Figure 7.3-1**. The reduction in surface flooding, under typical year precipitation, is represented by the blue dots. The dark blue dots indicate surface flooding was eliminated by the GSI control. The light blue dots indicate a significant reduction in surface flooding. Dark purple dots indicate where the risk of potential basement flooding was eliminated by the GSI control, and light purple dots indicate a reduction in the HGL elevation and a corresponding decrease in the risk of potential basement flooding.

Another tradeoff resulting from reducing the impervious area from which runoff is controlled by GSI is that the number and volume of satellite storage facilities needs to increase to achieve each LoC (similar to reducing the RTB design flow). **Table 7.3-8** shows how reducing the level of GSI management impacts the size and locations of satellite storage tanks throughout the CRW system. With 294 acres managed with GSI, two satellite storage facilities along the Susquehanna, with a total storage volume of 2.61 MG, were required to obtain a LoC of 16 overflows per year. When the level of GSI management was reduced to 227 acres, the volume of the two storage facilities along the Susquehanna needed to be increased by 10% to 2.86 MG and two small storage facilities, with a total volume of 0.05 MG, needed to be added along Paxton Creek to maintain a LoC of 16 overflows per year. The table shows the locations of each satellite storage facility and shows the consolidated catchment areas tributary to each facility. The table shows that with 294 impervious acres under GSI management, the total systemwide storage volume to provide a LoC of 10 overflows per year was 5.19 MG within 6 facilities. When the level of GSI management was reduced to 227 acres, the total systemwide storage volume to provide a LoC of 10 overflows per year increased to 5.97 MG and an additional seventh facility along upper Paxton Creek was required. When the level of GSI management was further reduced to 200 acres, the total systemwide storage volume to provide a LoC of 10 overflows per year increased to 6.18 MG.

In addition to proven effectiveness in meeting stormwater management goals, GSI practices can yield many important co-benefits above and beyond water quality and/or volume control benefits. Co-benefits associated with GSI projects and programs can include the following.

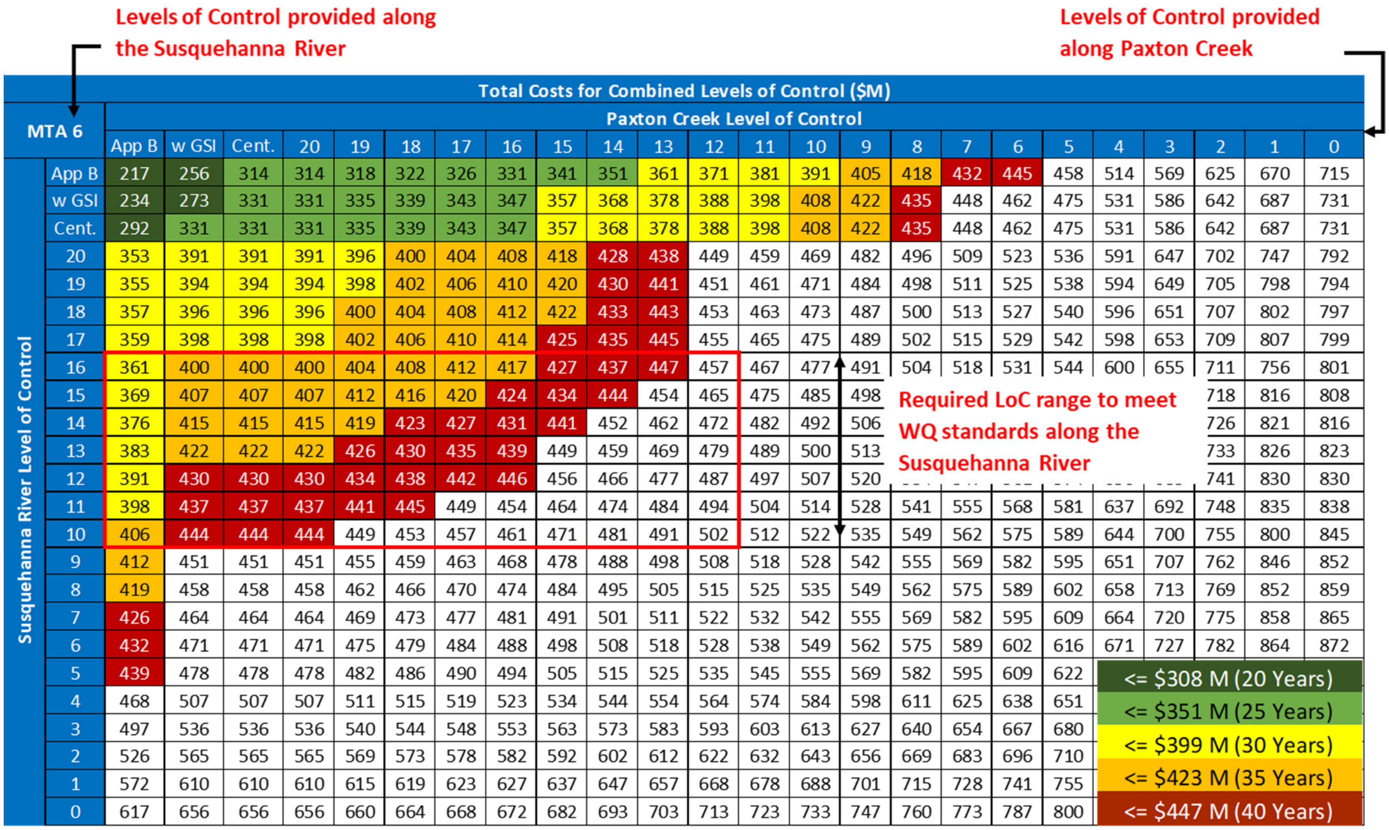
- Urban heat island stress reduction and associated energy savings
- Enhanced neighborhood aesthetics
- Increased or enhanced recreational opportunities
- Green job creation and economic development
- Improved air quality and associated public health benefits
- Habitat creation
- Carbon sequestration

Table 7.3-8: Satellite Storage Facility Sizes for MTA-6 with 294, 227, and 200 acres of GSI

Planning Area	CSO Outfall	Technology Size (Location Indicated in Parentheses)								
		GSI (ac)	Storage Tanks		GSI (ac)	Storage Tanks		GSI (ac)	Storage Tanks	
			16 Overflows	10 Overflows		16 Overflows	10 Overflows		16 Overflows	10 Overflows
Riverside	CSO-04	1.72		0.18 MG (CSO-05)	0		0.29 MG (CSO-05)	0		0.29 MG (CSO-05)
	CSO-05	4.99			2.5			2.5		
Uptown	CSO-49	5.54			0			0		
	CSO-50	3.93		3.04 MG (Tank = 2.04 MG; Cons. Sewers = 1 MG) (CSO-13)	0.24		3.39 MG (Tank = 2.39 MG; Cons. Sewers = 1 MG) (CSO-13)	0.24		3.41 MG (Tank = 2.41 MG; Cons. Sewers = 1 MG) (CSO-13)
	CSO-51	8.83	2.57 MG (Tank = 1.92 MG; Cons. Sewers = 0.65 MG) (CSO-11)		8.83	2.81 MG (Tank = 2.16 MG; Cons. Sewers = 0.65 MG) (CSO-11)		8.83	2.83 MG (Tank = 2.18 MG; Cons. Sewers = 0.65 MG) (CSO-11)	
	CSO-06	3.77			3.77			3.77		
	CSO-07	2.01			2.01			2.01		
	CSO-08	5.97			5.97			5.97		
	CSO-09	10.38			10.38			10.38		
	CSO-10	10.8			10.8			10.8		
	CSO-11	4.17			4.17			4.17		
Middle Front Street	CSO-12	4.28			0.12			0.12		
	CSO-13	0.93			0			0		
	CSO-14	4.36			2.29			2.29		
	CSO-15	6.93			0			0		
	CSO-16	0			0			0		
	CSO-52	6.1			3.05			3.05		
	CSO-53	1.97			0			0		
	CSO-54	0			0			0		
	CSO-55	1.79			1.79			1.79		
	CSO-56	0			0			0		
Lower Front Street	CSO-17	0.65			0			0		
	CSO-57	1.96			0			0		
	CSO-18	6.37		0.38 MG (CSO-58)	6.37		0.46 MG (CSO-58)	6.37		0.46 MG (CSO-58)
	CSO-19	3.55			3.55			3.55		
	CSO-58	0.22	0.04 MG		0.22	0.05 MG		0.22	0.05 MG	
	CSO-20	0			0			0		
Upper Paxton Creek - West	CSO-21	5.75			0			0		
	CSO-22	2.1			0			0		
	CSO-24	14.79			14.79		0.08 MG (CSO-28)	14.79		0.11 MG (CSO-28)
	CSO-27	0			0			0		
	CSO-28	16.69			16.69			8.34		
Upper Paxton Creek - East	CSO-23	0			0			0		
	CSO-25	0			0			0		
	CSO-26	2.56		0.52 MG (CSO-40)	2.56		0.60 MG (CSO-40)	2.56		0.63 MG (CSO-40)
Middle Paxton Creek - East	CSO-29	6.36			6.36			6.36		
	CSO-31	17.85			8.92			8.92		
	CSO-33	1.82			1.82			1.82		
	CSO-34	3.97			3.97	0.02 MG		3.97	0.02 MG	
	CSO-39	2.24			2.24			2.24		
	CSO-40	1.23			1.23			1.23		
Middle Paxton Creek - West	CSO-30	5.44			2.72			2.72		
	CSO-32	0			0			0		
	CSO-37	20.27			10.23			10.23		
	CSO-38	1.1			0.55			0.55		
	CSO-41	0			0			0		
Lower Paxton Creek	CSO-42	0.82		0.84 MG (CSO-48)	0.82	0.03 MG (CSO-44)	0.90 MG (CSO-48)	0.82	0.05 MG (CSO-44)	1.03 MG (CSO-48)
	CSO-59	14.12			14.12			7.06		
	CSO-43	0.75			0.75			0.75		
	CSO-44	5			5			5		
	CSO-45	0.07			0			0		
	CSO-46	1.23			0			0		
	CSO-48	64.83			64.83			52.85		
Hemlock Street	CSO-60	0			0			0		
	CSO-61	0.35		0.23 MG (CSO-63)	0		0.25 MG (CSO-63)	0	0.03 MG (CSO-61)	0.25 MG (CSO-63)
	CSO-62	0.13			0			0		
	CSO-63	0.62			0			0		
	CSO-64	0			0			0		
	Total:	294 ac	2.61 MG	5.19 MG	227 ac	2.91 MG	5.97 MG	200 ac	2.98 MG	6.18 MG
Centralized Wet Weather Treatment		30 MGD			30 MGD			30 MGD		

The total costs associated with these additional modified MTA-6 scenarios are then developed utilizing the costing methodology that was explained in Sections 4 and 6. These modified MTA-6 scenarios, with a 30 MGD RTB and the analyzed range of GSI control were input into the FCA economic model to determine the LoCs that can be achieved for a range of implementation periods without imposing an excessively high economic burden on CRW ratepayers. The total costs associated with these modified MTA-6 scenarios are shown in **Table 7.3-9** and **Table 7.3-10**. The targeted LoCs are indicated within the red box that reflects LoCs of 10 to 16 overflows per year along the Susquehanna and LoCs of 12 to 20 overflows per year along Paxton Creek. This LoC range should meet current water quality standards along the Susquehanna, according to the preliminary water quality model, but would not achieve water quality compliance along Paxton Creek.

Table 7.3-9: Cost Matrix for MTA-6, Modified with a 30 MGD RTB and 227 acres of GSI



Levels of Control provided along the Susquehanna River

Levels of Control provided along Paxton Creek

Total Costs for Combined Levels of Control ($M)

MTA 6	Paxton Creek Level of Control																							
Susquehanna River Level of Control	App B	w GSI	Cent.	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
App B	217	256	314	314	318	322	326	331	341	351	361	371	381	391	405	418	432	445	458	514	569	625	670	715
w GSI	234	273	331	331	335	339	343	347	357	368	378	388	398	408	422	435	448	462	475	531	586	642	687	731
Cent.	292	331	331	331	335	339	343	347	357	368	378	388	398	408	422	435	448	462	475	531	586	642	687	731
20	353	391	391	391	396	400	404	408	418	428	438	449	459	469	482	496	509	523	536	591	647	702	747	792
19	355	394	394	394	398	402	406	410	420	430	441	451	461	471	484	498	511	525	538	594	649	705	798	794
18	357	396	396	396	400	404	408	412	422	433	443	453	463	473	487	500	513	527	540	596	651	707	802	797
17	359	398	398	398	402	406	410	414	425	435	445	455	465	475	489	502	515	529	542	598	653	709	807	799
16	361	400	400	400	404	408	412	417	427	437	447	457	467	477	491	504	518	531	544	600	655	711	756	801
15	369	407	407	407	412	416	420	424	434	444	454	465	475	485	498							718	816	808
14	376	415	415	415	419	423	427	431	441	452	462	472	482	492	506							726	821	816
13	383	422	422	422	426	430	435	439	449	459	469	479	489	500	513							733	826	823
12	391	430	430	430	434	438	442	446	456	466	477	487	497	507	520							741	830	830
11	398	437	437	437	441	445	449	454	464	474	484	494	504	514	528	541	555	568	581	637	692	748	835	838
10	406	444	444	444	449	453	457	461	471	481	491	502	512	522	535	549	562	575	589	644	700	755	800	845
9	412	451	451	451	455	459	463	468	478	488	498	508	518	528	542	555	569	582	595	651	707	762	846	852
8	419	458	458	458	462	466	470	474	484	495	505	515	525	535	549	562	575	589	602	658	713	769	852	859
7	426	464	464	464	469	473	477	481	491	501	511	522	532	542	555	569	582	595	609	664	720	775	858	865
6	432	471	471	471	475	479	484	488	498	508	518	528	538	549	562	575	589	602	616	671	727	782	864	872
5	439	478	478	478	482	486	490	494	505	515	525	535	545	555	569	582	595	609	622					
4	468	507	507	507	511	515	519	523	534	544	554	564	574	584	598	611	625	638	651					
3	497	536	536	536	540	544	548	553	563	573	583	593	603	613	627	640	654	667	680					
2	526	565	565	565	569	573	578	582	592	602	612	622	632	643	656	669	683	696	710					
1	572	610	610	610	615	619	623	627	637	647	657	668	678	688	701	715	728	741	755					
0	617	656	656	656	660	664	668	672	682	693	703	713	723	733	747	760	773	787	800					

Required LoC range to meet WQ standards along the Susquehanna River

<= $308 M (20 Years)
<= $351 M (25 Years)
<= $399 M (30 Years)
<= $423 M (35 Years)
<= $447 M (40 Years)

Table 7.3-10: Cost Matrix for MTA-6, Modified with a 30 MGD RTB and 200 acres of GSI

Levels of Control provided along the Susquehanna River

Levels of Control provided along Paxton Creek

	MTA 6	Total Costs for Combined Levels of Control ($M)																							
		Paxton Creek Level of Control																							
		App B	w GSI	Cent.	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Susquehanna River Level of Control	App B	217	245	303	303	310	317	324	332	342	352	363	373	383	394	405	417	428	439	451	508	564	621	667	713
	w GSI	232	260	318	318	325	332	339	346	357	367	378	388	398	409	420	432	443	454	466	523	579	636	682	728
	Cent.	290	318	318	318	325	332	339	346	357	367	378	388	398	409	420	432	443	454	466	523	579	636	682	728
	20	352	380	380	380	387	394	401	409	419	429	440	450	461	471	482	494	505	517	528	585	641	698	744	790
	19	354	382	382	382	389	396	403	410	421	431	442	452	462	473	484	496	507	518	530	586	643	700	798	792
	18	356	383	383	383	391	398	405	412	423	433	443	454	464	475	486	497	509	520	532	588	645	702	802	794
	17	358	385	385	385	392	400	407	414	424	435	445	456	466	476	488	499	511	522	533	590	647	703	807	796
	16	360	387	387	387	394	402	409	416	426	437	447	458	468	478	490	501	513	524	535	592	649	705	752	798
	15	366	393	393	393	400	408	415	422	432	443	453	464	474	484	496							711	816	804
	14	372	399	399	399	407	414	421	428	439	449	459	470	480	491	502							717	821	810
	13	378	406	406	406	413	420	427	434	445	455	465	476	486	497	508							724	826	816
	12	384	412	412	412	419	426	433	440	451	461	472	482	492	503	514							730	830	822
	11	390	418	418	418	425	432	439	447	457	467	478	488	499	509	520	532	543	555	566	623	679	736	835	828
	10	396	424	424	424	431	438	445	453	463	473	484	494	505	515	526	538	549	561	572	629	685	742	788	835
	9	405	432	432	432	439	447	454	461	471	482	492	503	513	523	535	546	558	569	580	637	694	750	846	843
	8	413	441	441	441	448	455	462	469	480	490	501	511	521	532	543	555	566	577	589	645	702	759	852	851
	7	421	449	449	449	456	463	471	478	488	499	509	519	530	540	552	563	574	586	597	654	710	767	858	860
	6	430	457	457	457	465	472	479	486	497	507	517	528	538	549	560	571	583	594	606	662	719	776	864	868
	5	438	466	466	466	473	480	487	495	505	515	526	536	547	557	568	580	591	603	614					
	4	467	495	495	495	502	509	516	523	534	544	555	565	575	586	597	609	620	631	643					
	3	496	524	524	524	531	538	545	552	563	573	583	594	604	615	626	637	649	660	672					
	2	525	552	552	552	560	567	574	581	592	602	612	623	633	644	655	666	678	689	701					
	1	570	598	598	598	605	612	619	626	637	647	658	668	678	689	700	712	723	734	746					
	0	615	643	643	643	650	657	665	672	682	693	703	713	724	734	745	757	768	780	791					

Required LoC range to meet WQ standards along the Susquehanna River

<= $312 M (20 Years)
<= $358 M (25 Years)
<= $409 M (30 Years)
<= $439 M (35 Years)
<= $453 M (40 Years)

Cost performance curves were prepared to compare alternatives MTA-4B, MTA-6, and the refined MTA-6. **Figure 7.3-2** provides these superimposed cost curves.

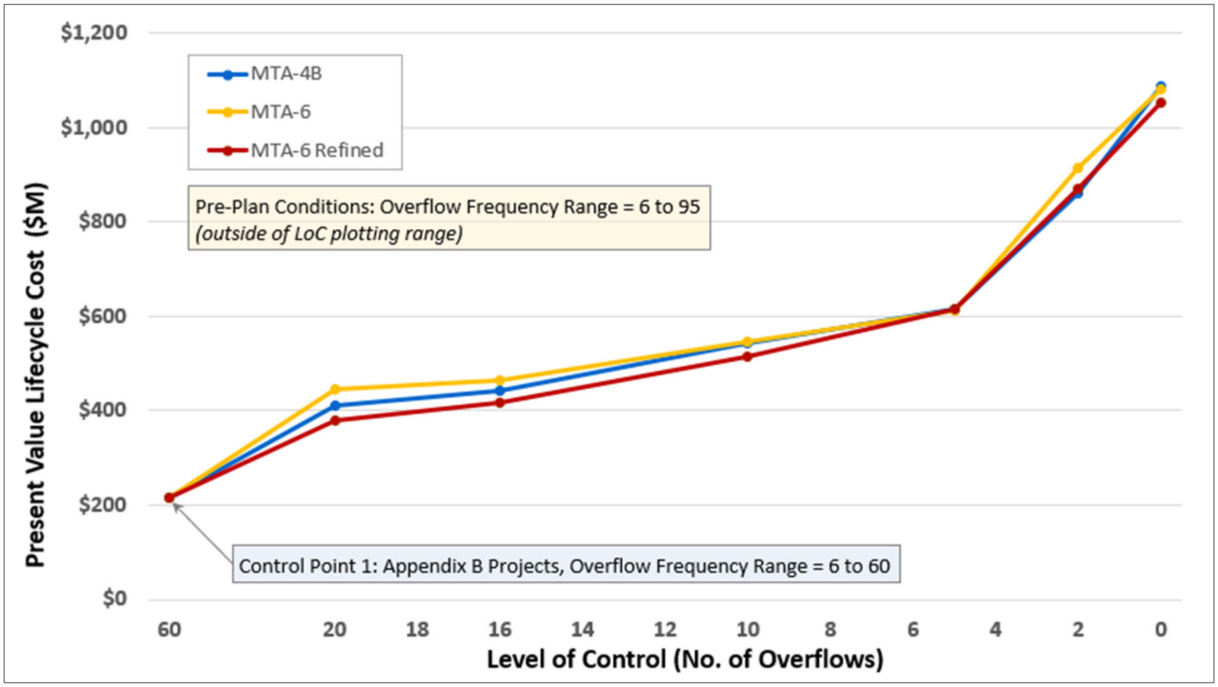


Figure 7.3-2: Cost-Performance Curves for MTA-4B, MTA-6, and Refined MTA-6

The cost-performance curves indicate that the original MTA-6 (as defined in Section 6) is less cost-effective than MTA-4B with respect to reducing frequency over the entire range of LoCs. However, once the facility size adjustments were made to conform MTA-6 with FCA affordability constraints, lowering costs to a level that will not result in high burdens on lower income households, the modified MTA-6 became most cost-effective.

Analysis results in **Table 7.3-9** show that achieving current water quality standards in the Susquehanna River within a 20 or 25-year timeframe will not be possible under current affordability constraints, even with a 30 MGD RTB and 227 impervious acres managed under GSI. However, extending the implementation period to 30 or 35 years allows for reaching the target LoCs of 10 to 16 overflows per year along the Susquehanna River, allowing it to meet current water quality standards, but the improvements to Paxton Creek would be minimal in this scenario.

The analysis results in **Table 7.3-10** show that current water quality standards along the Susquehanna River could not be attained within a 20 or 25-year implementation period within FCA affordability constraints with a 30 MGD RTB and 200 acres under GSI management. If the implementation period is increased to 30 years, then the targeted LoCs of 10 to 16 overflows could lead to the attainment of current water quality standards along the Susquehanna, but with but with minimal improvement along Paxton Creek. However, if the implementation period is increased to 40 years then not only could the current water quality standards be attained along the Susquehanna, but a LoC of 12 to 20 overflows per year could be achieved along Paxton Creek, which will provide a significant improvement.

7.4 Recommended Plan

Based on the comprehensive analyses documented within Sections 4, 5, and 6 of this Alternatives Analysis, and the comparison analyses documented within Section 7.2, CRW has chosen MTA-6 as the Preferred Alternative for controlling wet weather flow within the CRW service area. In consideration of FCA affordability constraints, to prevent an excessively high economic burden on low-income households, additional refinements and modifications were made.

Based on the refinements described in Section 7.3, CRW has selected MTA-6 modified with a 30 MGD retention treatment basin and 200 acres of impervious area managed by GSI as its Recommended Plan. The Recommend Plan would achieve levels of control of approximately 10 overflows per year along the Susquehanna River and 16 overflows per year along Paxton Creek under typical year precipitation. These target LoCs are approximate with an accepted tolerance range, allowing for +/- 1 to 3 overflows within the target frequency. The LoC along the Susquehanna would conservatively meet current water quality standards according to the preliminary water quality model. The LoC along Paxton Creek would significantly reduce the frequency and volume of CSO discharges, and significantly reduce the pollutant loads, but would not be sufficient to meet current water quality standards. However, a Use Attainability Analysis (UAA) would be implemented to achieve compliance with the Clean Water Act.

7.4.1 Components that Comprise the Recommended Plan

Major components of this plan include the following:

- The completion of the MPCD Appendix B Projects, including the CSO-048 stormwater diversion system, rehabilitation and expansion of the Spring Creek Pump Station, and modifications to the regulator structures to increase flow into the interceptors.
- A 30 MGD retention treatment basin (RTB) located adjacent to the existing Advanced Wastewater Treatment Facility (AWTF).
- Replacement of the Paxton Creek Interceptor (PCI) under Appendix B projects.
- Extension of the Paxton Creek Interceptor (3,700 LF) to the RTB.
- A flow diversion structure along the PCI, equipped with Supervisory Control and Data Acquisition (SCADA) and Real Time Control (RTC) capabilities, to divert excess wet weather flow from the PCI to to the RTB.
- Network of GSI facilities at strategic locations to manage the stormwater runoff and associated pollutant loads from 200 acres of impervious area (40 acres have already been completed).
- 17 acres of sewer separation along Paxton Creek (under Appendix B projects).
- Satellite storage tanks to provide the desired levels of control.
    - 3 facilities (1 large, 2 small) along Susquehanna River.
    - 3 small facilities along Paxton Creek.
- A network of consolidation sewers, with a total length of approximately 12,000 feet, to connect satellite storage facilities with their tributary catchment areas.
- A network of flow diversion structures, located near the CSO regulator structures, to control wet weather flow conveyed to the interceptor and storage facilities.

These facilities that comprise the Recommended Plan are depicted on a map in **Figure 7.4-1.** The expansion of the existing AWTF site is shown with red shading, and the location of the retention treatment basin (RTB) is shown with an orange square. The extension from the Paxton creek Interceptor is shown on the map as a red line. The blue squares represent the satellite storage facilities and are not drawn to scale, but their relative sizes represent their relative storage volumes. The facility located at CSO-013, along the Susquehanna River, has a storage area of 3.41 MG and is much larger than any of the other storage facilities along the Susquehanna or Paxton Creek. The consolidation sewers connecting satellite storage facilities with their tributary catchment areas are depicted with yellow arrows. The catchment areas managed by GSI facilities are depicted with green shading. The increasing darkness of the green shading reflects the increased percentage of the impervious area managed by GSI. The catchment areas designated for sewer separation are depicted with pink crosshatching.

Table 7.4-1 provides the impervious acres under GSI management within each of the catchment areas and shows the satellite storage facility sizes and locations. The table also indicates the catchment areas that are tributary to each storage facility.

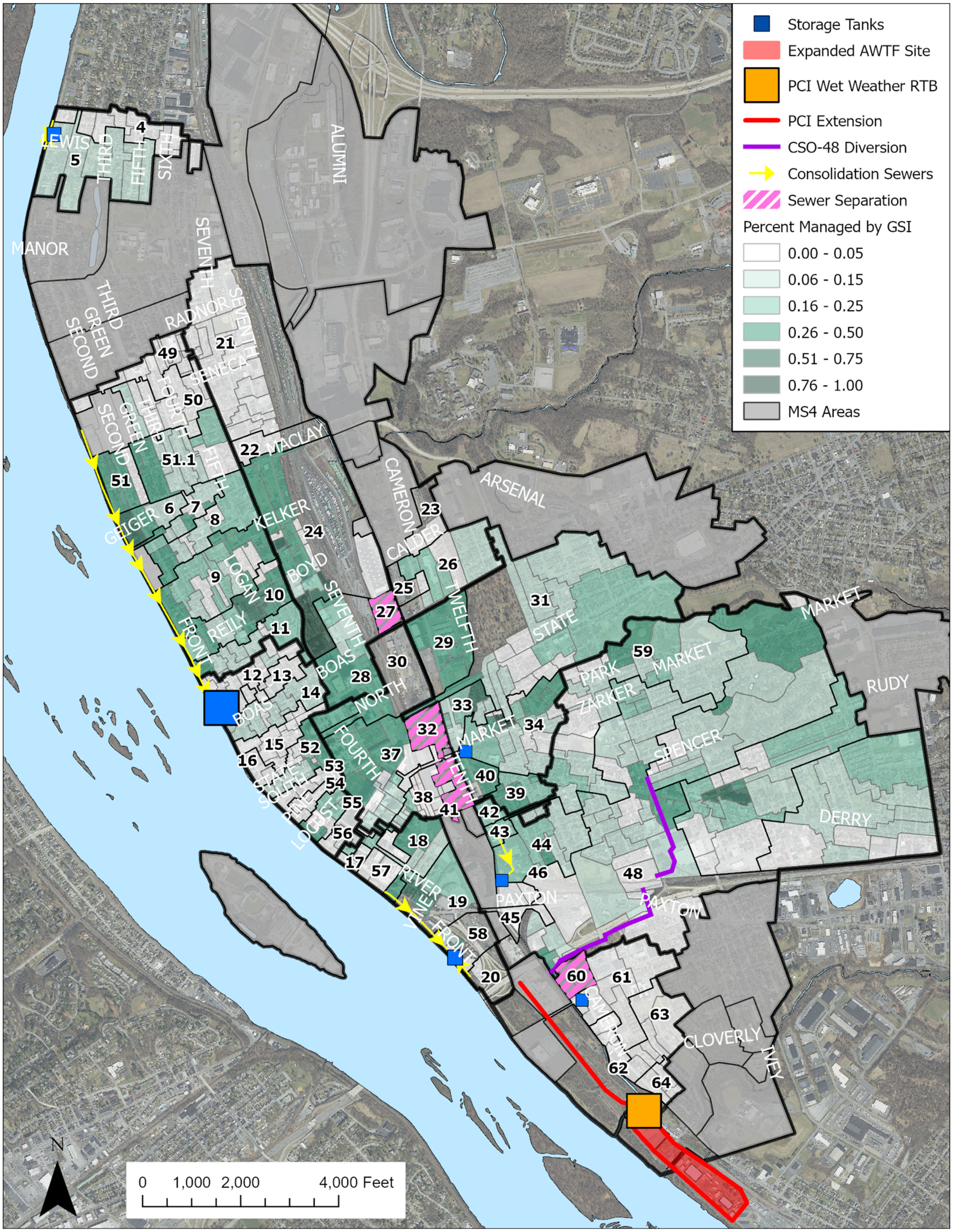


Figure 7.4-1: CSO Control Facilities for Recommended Plan

Table 7.4-1: Facility Sizes for Recommended Plan

Planning Area	**CSO Outfall**	**Technology Size (Location Indicated in Parentheses)**	
		GSI, Managed Impervious Acres	**Storage Tanks** **Susquehanna: 10 Overflows** **Paxton: 16 Overflows**
Riverside	CSO-04	0	0.29 MG (CSO-05)
	CSO-05	2.5	
Uptown	CSO-49	0	
	CSO-50	0.24	3.41 MG (Tank = 2.41 MG; Cons. Sewers = 1 MG) (CSO-13)
	CSO-51	8.83	
	CSO-06	3.77	
	CSO-07	2.01	
	CSO-08	5.97	
	CSO-09	10.38	
	CSO-10	10.8	
	CSO-11	4.17	
Middle Front Street	CSO-12	0.12	
	CSO-13	0	
	CSO-14	2.29	
	CSO-15	0	
	CSO-16	0	
	CSO-52	3.05	
	CSO-53	0	
	CSO-54	0	
	CSO-55	1.79	
	CSO-56	0	
Lower Front Street	CSO-17	0	
	CSO-57	0	
	CSO-18	6.37	0.46 MG (CSO-58)
	CSO-19	3.55	
	CSO-58	0.22	
	CSO-20	0	
Upper Paxton Creek - West	CSO-21	0	
	CSO-22	0	
	CSO-24	14.79	
	CSO-27	0	
	CSO-28	8.34	
Upper Paxton Creek - East	CSO-23	0	
	CSO-25	0	
	CSO-26	2.56	
Middle Paxton Creek - East	CSO-29	6.36	
	CSO-31	8.92	
	CSO-33	1.82	
	CSO-34	3.97	0.02 MG
	CSO-39	2.24	
	CSO-40	1.23	
Middle Paxton Creek - West	CSO-30	2.72	
	CSO-32	0	
	CSO-37	10.23	
	CSO-38	0.55	
	CSO-41	0	
Lower Paxton Creek	CSO-42	0.82	0.05 MG (CSO-44)
	CSO-59	7.06	
	CSO-43	0.75	
	CSO-44	5	
	CSO-45	0	
	CSO-46	0	
	CSO-48	52.85	
Hemlock Street	CSO-60	0	
	CSO-61	0	0.03 MG (CSO-61)
	CSO-62	0	
	CSO-63	0	
	CSO-64	0	
Total:		**200 ac**	**4.26 MG**
Centralized Wet Weather Treatment		30 MGD	

7.4.2 Cost for the Recommended Plan

The corresponding costs for this alternative are summarized in **Table 7.4-2**. This Recommended Plan would cost approximately $453 million (20-year present value lifecycle cost, 2024 dollars) and would require a 40-year implementation period to keep utility rates and customer bill impacts from imposing an excessively high economic burden on low-income households.

For comparison of each MTA, cost estimates were developed based on a 20-year present value lifecycle cost, which assumed that all projects were constructed at the start of the 20-year period, incurring O&M costs for the full 20 years, and incurring 20-year renewal and replacement costs at the end of the planning period. This is a standard way of presenting costs, which is useful for comparison to other evaluated alternatives (same costing methodology as analyses in Section 4 and 6). The total present value lifecycle cost to implement the Appendix B projects (2024 dollars) is $184 million. The total capital costs (2024 dollars) for the Recommended Plan control facilities listed and described above, excluding Appendix B projects is $233 million. Annual operation and maintenance (O&M) costs for all control facilities total $1.7 million. Adding in the present value of 20 years of O&M costs ($21 million), renewal and replacement (R&R) costs ($8 million), and land acquisition costs ($7 million) results in the 20-year present value lifecycle cost of approximately $453 million, as referenced above and as shown in the cost matrix for the Recommended Plan (**Figure 7.3-9**).

However, to develop a more realistic approach for estimating the actual costs of the Recommended Plan with projects constructed in phases over the 40-year implementation period, the FCA economic model was used to dynamically estimate the cost of the Recommended Plan. For example, projects completed at the beginning of the implementation period would incur 40 years of O&M and R&R costs, but projects completed near the end of the implementation period would only incur a few years of these annual costs. Based on the FCA economic model, the total present value of the 40-year costs for the ongoing O&M of the control facilities is approximately $13 million, and the total present value cost for the eventual renewal and replacement (R&R) of the control facilities is approximately $10 million. The total Recommended Plan cost is slightly different than the cost shown in **Table 7.4-3** because of the difference in the ways the various economic models and cost calculations account for the 40-year costs. However, these dynamic cost considerations have already been incorporated into the affordability constraints referenced in this section.

7.4.3 Implementation Period for the Recommended Plan

The Recommended Plan was input into the FCA economic model to determine what implementation period would be required to avoid imposing an excessively high economic burden on CRW ratepayers. The total costs for the Recommended Plan are shown in **Table 7.4-3** along with color-coded implementation schedules coinciding the FCA affordability constraints. CRW's selection is based on prioritizing water quality within the Susquehanna River and doing as much as possible within Paxton Creek. This is consistent with the conclusions of the *Sensitive Areas Report*[22] that states, "CRW intends to develop a CSO LTCP and implementation schedule that, among other criteria, gives higher priority to controlling CSOs to the Susquehanna River". A conservative level of control of 10 overflows per year

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[22] Sensitives Areas Report, Capital Region Water, September 22, 2023.

under typical year precipitation was used for Susquehanna River CSO outfalls to ensure that current water quality standards are met. This more conservative assumption to achieve water quality standards is expected to meet or go beyond meeting water quality standards once the additional water quality sampling and model calibration is complete.

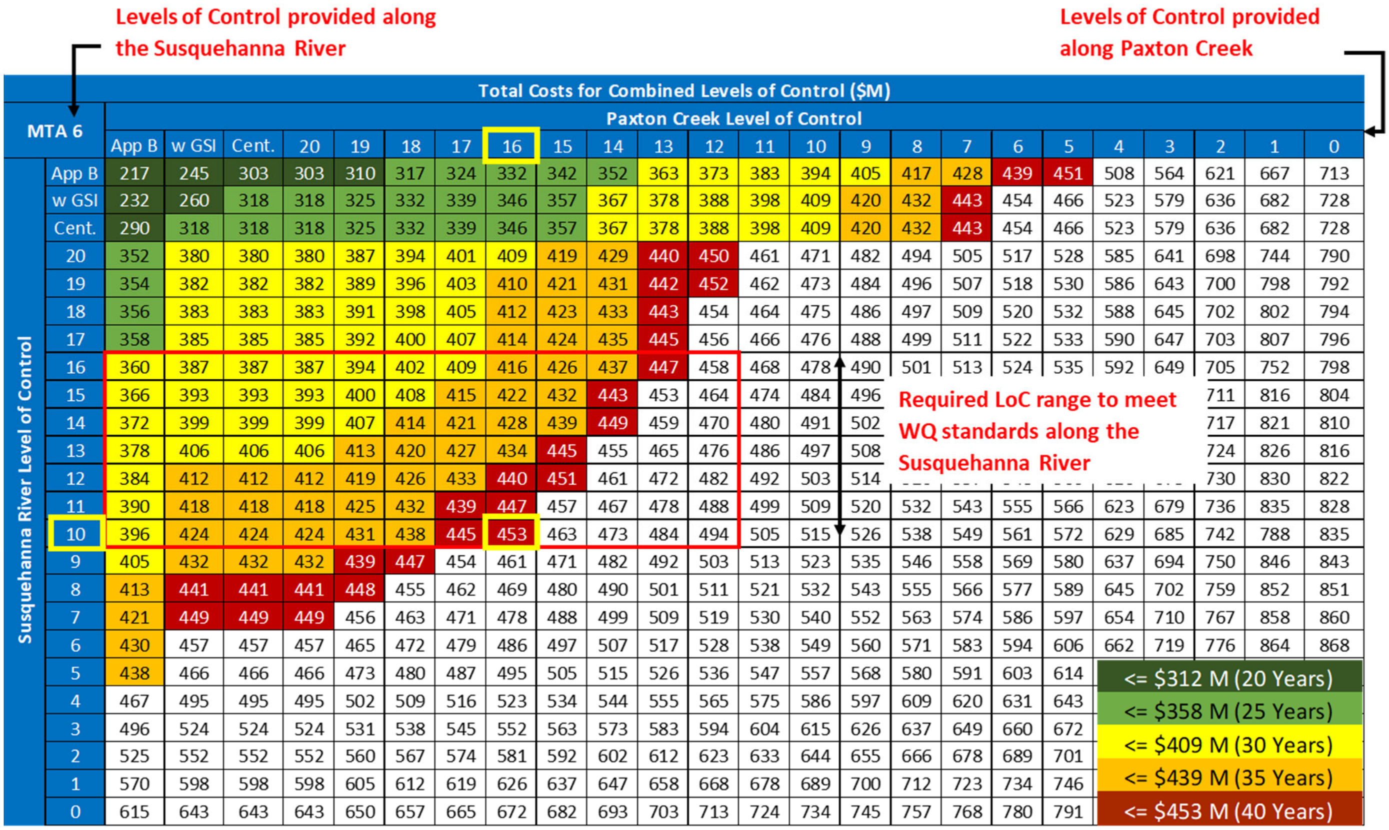
Table 7.4-2: Control Facility Costs (2024 dollars) Associated with the Recommended Plan

Location	Consol. Group	Project Type / Size		Total Construction Cost ($M)	Capital Markups ($M)	Annual O&M Cost ($M)	Replace-Rehab Cost, 20 Years ($M)	Present Value Lifecycle Cost, 20 Years ($M)
-	-	Appendix B Projects (less GSI):	-	-	-		-	184
-	-	Systemwide GSI (ac):	159.37	40	20	1.3	0.0	76
-	-	PCI Wet Weather RTB (MGD):	30.00	33	16	0.2	2.8	58
CSO-05	04 to 05	Storage Tank (MG):	0.29	7	4	0.02	0.4	12
CSO-13	50 to 13	Storage Tank (MG):	3.42	47	24	0.12	2.7	76
CSO-58	57 to 20	Storage Tank (MG):	0.46	11	6	0.03	0.7	19
CSO-34	34	Storage Tank (MG):	0.02	5	2	0.01	0.3	8
CSO-44	42 to 44	Storage Tank (MG):	0.04	7	3	0.02	0.4	11
CSO-61	61 to 62	Storage Tank (MG):	0.03	6	3	0.02	0.4	10
			Total	**156**	**77**	**1.7**	**8**	**453**

Notes:

1. Systemwide GSI represents 200 acres minus 40 acres of projects already completed.
2. Land costs total approximately $7 million.

Table 7.4-3: Cost Matrix for MTA-6, Modified with a 30 MGD RTB and 200 acres of GSI



Levels of Control provided along the Susquehanna River

Levels of Control provided along Paxton Creek

Required LoC range to meet WQ standards along the Susquehanna River

	MTA 6	Total Costs for Combined Levels of Control ($M)																							
		Paxton Creek Level of Control																							
		App B	w GSI	Cent.	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Susquehanna River Level of Control	App B	217	245	303	303	310	317	324	332	342	352	363	373	383	394	405	417	428	439	451	508	564	621	667	713
	w GSI	232	260	318	318	325	332	339	346	357	367	378	388	398	409	420	432	443	454	466	523	579	636	682	728
	Cent.	290	318	318	318	325	332	339	346	357	367	378	388	398	409	420	432	443	454	466	523	579	636	682	728
	20	352	380	380	380	387	394	401	409	419	429	440	450	461	471	482	494	505	517	528	585	641	698	744	790
	19	354	382	382	382	389	396	403	410	421	431	442	452	462	473	484	496	507	518	530	586	643	700	798	792
	18	356	383	383	383	391	398	405	412	423	433	443	454	464	475	486	497	509	520	532	588	645	702	802	794
	17	358	385	385	385	392	400	407	414	424	435	445	456	466	476	488	499	511	522	533	590	647	703	807	796
	16	360	387	387	387	394	402	409	416	426	437	447	458	468	478	490	501	513	524	535	592	649	705	752	798
	15	366	393	393	393	400	408	415	422	432	443	453	464	474	484	496							711	816	804
	14	372	399	399	399	407	414	421	428	439	449	459	470	480	491	502							717	821	810
	13	378	406	406	406	413	420	427	434	445	455	465	476	486	497	508							724	826	816
	12	384	412	412	412	419	426	433	440	451	461	472	482	492	503	514							730	830	822
	11	390	418	418	418	425	432	439	447	457	467	478	488	499	509	520	532	543	555	566	623	679	736	835	828
	10	396	424	424	424	431	438	445	453	463	473	484	494	505	515	526	538	549	561	572	629	685	742	788	835
	9	405	432	432	432	439	447	454	461	471	482	492	503	513	523	535	546	558	569	580	637	694	750	846	843
	8	413	441	441	441	448	455	462	469	480	490	501	511	521	532	543	555	566	577	589	645	702	759	852	851
	7	421	449	449	449	456	463	471	478	488	499	509	519	530	540	552	563	574	586	597	654	710	767	858	860
	6	430	457	457	457	465	472	479	486	497	507	517	528	538	549	560	571	583	594	606	662	719	776	864	868
	5	438	466	466	466	473	480	487	495	505	515	526	536	547	557	568	580	591	603	614					
	4	467	495	495	495	502	509	516	523	534	544	555	565	575	586	597	609	620	631	643					
	3	496	524	524	524	531	538	545	552	563	573	583	594	604	615	626	637	649	660	672					
	2	525	552	552	552	560	567	574	581	592	602	612	623	633	644	655	666	678	689	701					
	1	570	598	598	598	605	612	619	626	637	647	658	668	678	689	700	712	723	734	746					
	0	615	643	643	643	650	657	665	672	682	693	703	713	724	734	745	757	768	780	791					

<= $312 M (20 Years)
<= $358 M (25 Years)
<= $409 M (30 Years)
<= $439 M (35 Years)
<= $453 M (40 Years)

With the LoC for Susquehanna River selected, **Table 7.4-3** shows that Paxton Creek can be controlled to 16 overflows per year with a 40-year implementation period (i.e., the right-most red shaded cell in the row corresponding to 10 overflows for Susquehanna River). These LoCs along the Susquehanna River and Paxton Creek are only possible with a 40 year implementation schedule without rates rising to a level that will result in excessively high economic burdens on low-income households within CRW's City retail service area.

7.4.4 Performance of the Recommended Plan

The hydrologic and hydraulic (H&H) model and the water quality (WQ) models were utilized to quantify the performance of the Recommended Plan with respect to reducing CSO discharge frequency, volume, and duration; and achieving current water quality standards along the receiving waters. For the Recommended Plan, **Figures 7.4-2** and **7.4-3** show CSO volume reductions for each individual CSO outfall, relative to Pre-Plan conditions. The annual systemwide CSO discharge volume under Pre-Plan conditions, under typical year precipitation, was 794 MG. The annual systemwide CSO discharge volume was reduced to 112 MG with the implementation of the Recommended Plan. These reductions are sufficient to meet current water quality standards along the Susquehanna River, but are not sufficient along Paxton Creek.

The height of the "empty" bars show CSO volumes for Pre-Plan conditions, and the height of the "solid" bars show CSO volumes for the Recommended Plan. Pre-Plan conditions reflect when CRW first assumed ownership and operation and maintenance responsibility for the wastewater and stormwater collection, conveyance, and treatment systems in 2013. The difference between the bar heights represents the CSO volume reduction achieved by the Recommended Plan. For the CSO outfalls where consolidated storage facilities are located, (e.g., CSOs 13 and 58), the annual CSO volume increases and represents multiple consolidated CSO outfall volumes.

Figures 7.4-4 and **7.4-5** show CSO annual discharge frequency reductions for each individual CSO outfall, relative to Pre-Plan conditions. As with the volume bar charts, the height of the "empty" bars show annual CSO frequency for Pre-Plan conditions, the height of the "solid" bars show CSO frequencies under the Recommended Plan, and the difference between the bar heights represents the CSO frequency reduction achieved by the Recommended Plan. Under Pre-Plan conditions, there was a wide range of annual CSO frequencies, ranging from 5 to 95. Under the Recommended Plan, which has a target control range of 10 overflows per year along the Susquehanna River, the modeled overflow frequencies range from 0 to 13 overflows per year. This is within the accepted tolerance range, allowing for +/- 1 to 3 overflows within the target frequency. Under the Recommended Plan, which has a target control range of 16 overflows per year along Paxton Creek, the modeled overflow frequencies ranged from 0 to 19 overflows per year. This was within the accepted tolerance range, allowing for +/- 1 to 3 overflows within the target frequency.

The following performance is achieved with the Recommended Plan under typical year precipitation:

- Systemwide CSO volume is reduced from 794 MG to 131 MG, a reduction of 663 MG (84%)
  - Susquehanna River: CSO volume is reduced from 280 MG to 43 MG, a reduction of 237 MG (85%)
  - Paxton Creek: CSO volume is reduced from 513 MG to 89 MG, a reduction of 424 MG (83%)
- Susquehanna River outfalls are reduced to a typical year frequency of approximately 10 overflows, compared to a maximum of 95 overflows under Pre-Plan conditions. This is sufficient to meet current water quality standards.
- Paxton Creek outfalls are reduced to a typical year frequency of approximately 16 overflows, compared to a maximum of 90 overflows under Pre-Plan conditions.
- Water quality compliance is achieved for Susquehanna River, and for Paxton Creek, 21 to 32 reaches (out of a total of 35 reaches) meet the percent attainment criteria.

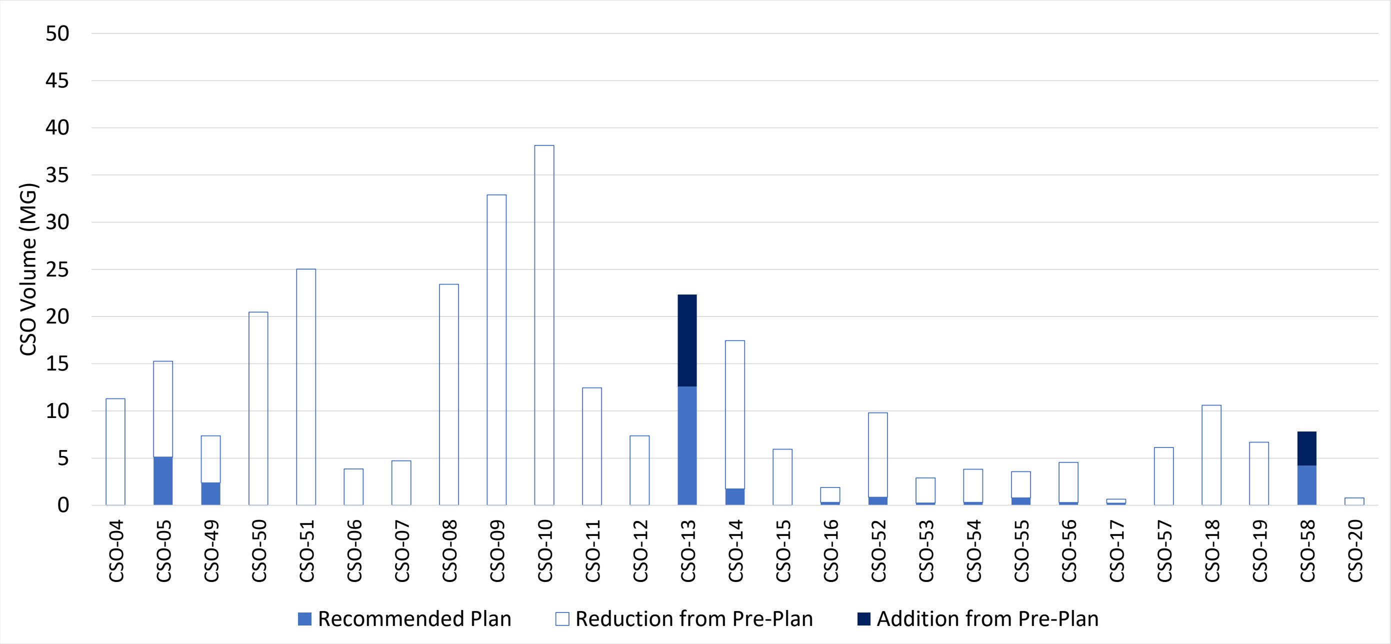


Figure 7.4-2: Recommended Plan - CSO Volume Reduction for Susquehanna River (Typical Year)

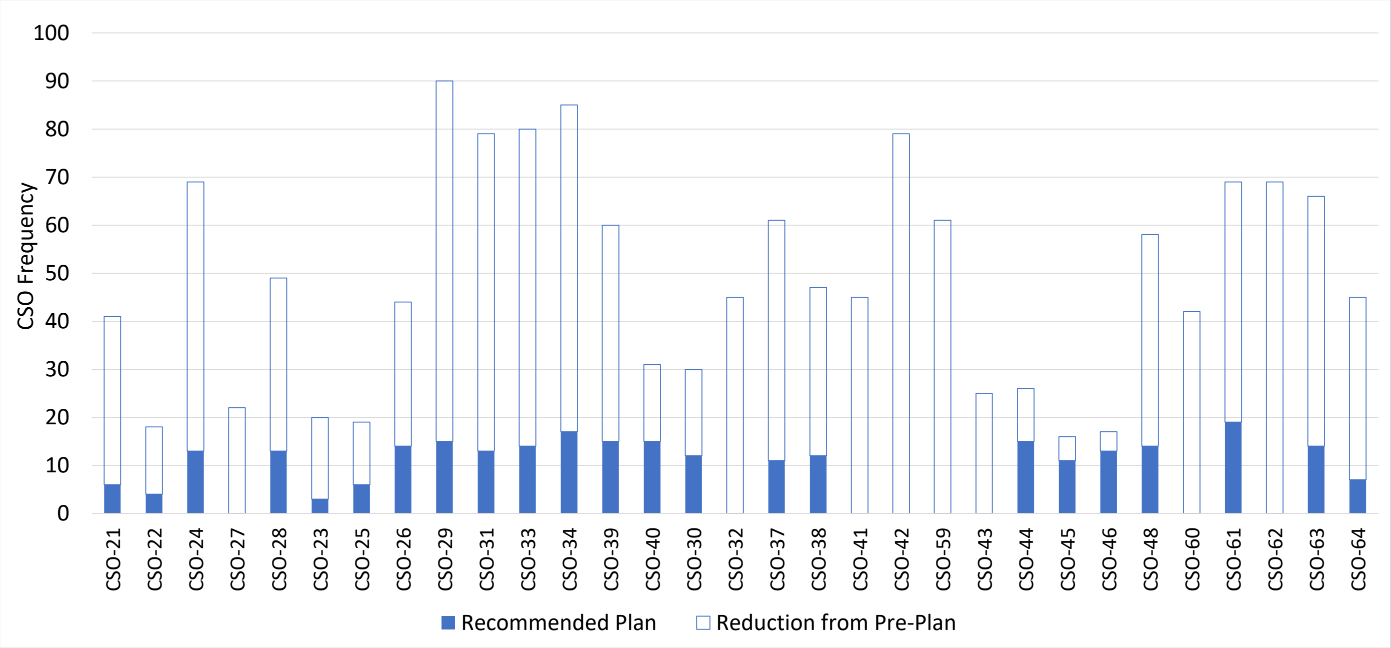


Figure 7.4-3: Recommended Plan - CSO Volume Reduction for Paxton Creek (Typical Year)

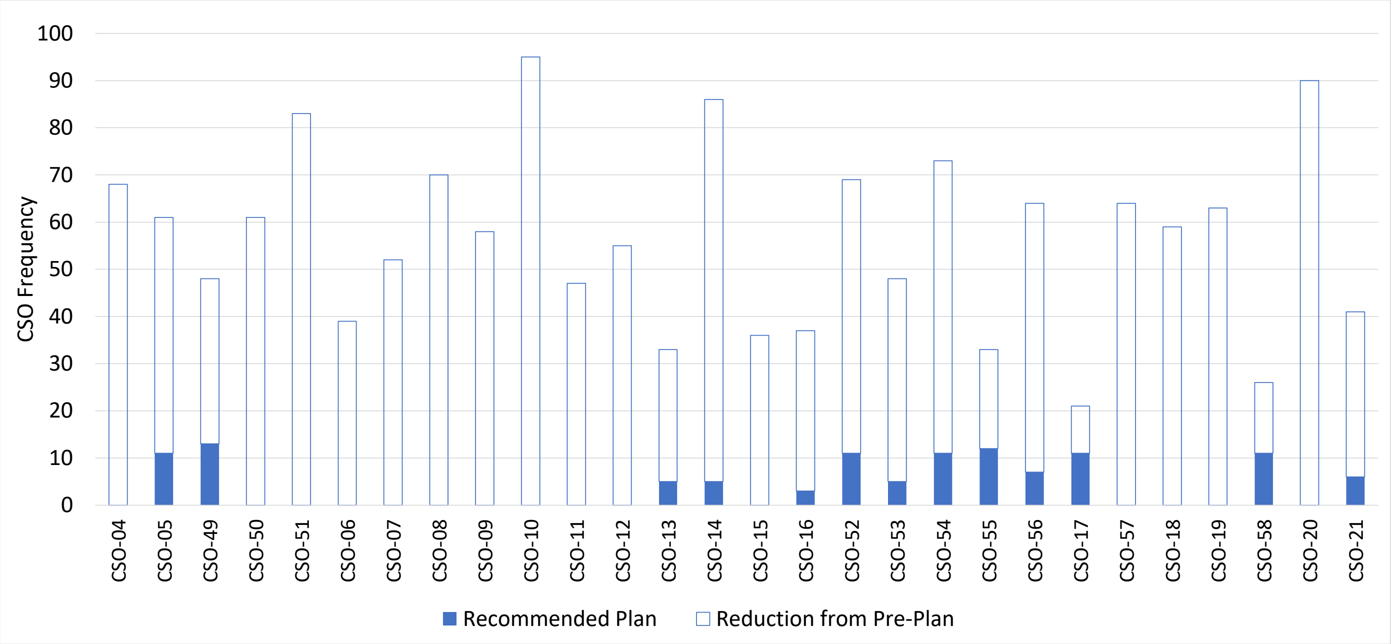


Figure 7.4-4: Recommended Plan - Frequency Reduction for Susquehanna River (Typical Year)

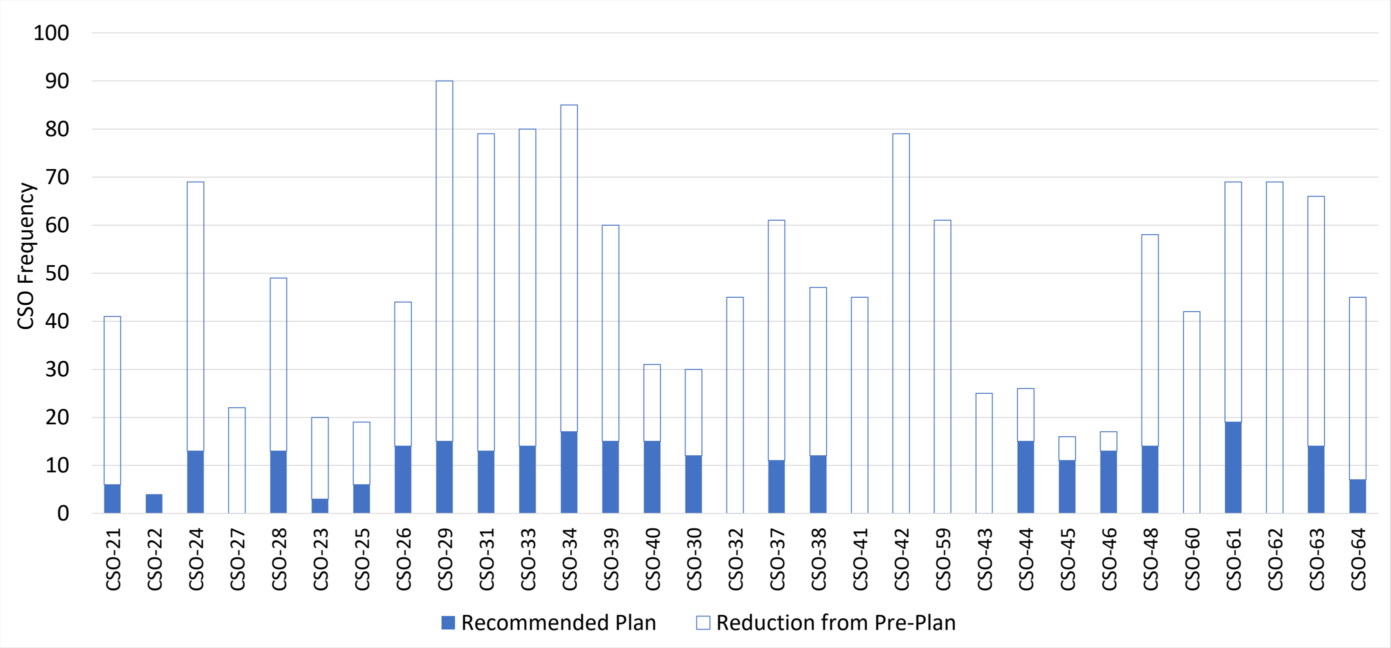


Figure 7.4-5: Recommended Plan - Frequency Reduction for Paxton Creek (Typical Year)

Figures 7.4-6 and **7.4-7** show the same annual CSO volumes as the stacked bar charts above, but present them geographically by individual catchments. Each combined sewer catchment is depicted, and color-coding was used to visually illustrate the differing annual CSO volume ranges from catchment to catchment. **Figure 7.4-6** shows the annual CSO volumes under Pre-Plan conditions, before CRW assumed ownership and operation of the sewer system.

The annual CSO volumes corresponding to the Recommend Plan are shown in **Figure 7.4-7.** The white areas indicate catchments where flow diversion structures and consolidation sewers conveyed all the wet weather flow for all the typical year storm events to a satellite storage facility. For the CSO outfalls where consolidated storage facilities are located, (e.g., CSOs 13 and 58), the annual CSO volume increases and represents multiple consolidated volumes.

Figures 7.4-8 and **7.4-9** show the same annual CSO frequencies as the stacked bar charts above, but present them geographically by individual catchments. Color-coding was used to visually illustrate the differing annual CSO frequency ranges from catchment to catchment. **Figure 7.4-8** shows the annual CSO frequencies, under Pre-Plan conditions, before CRW assumed ownership and operation of the sewer system. Most of the CSO outfalls overflowed from 25 to 95 times per year.

The annual CSO discharge frequencies corresponding to the Recommend Plan are shown in **Figure 7.4-9.** The white areas indicate catchments where flow diversion structures and consolidation sewers conveyed all the wet weather flow for all the typical year storm events to a satellite storage facility.

Additional graphical representations of the performance of the Recommended Plan are provided in **Appendix 3 – Performance Graphics.**

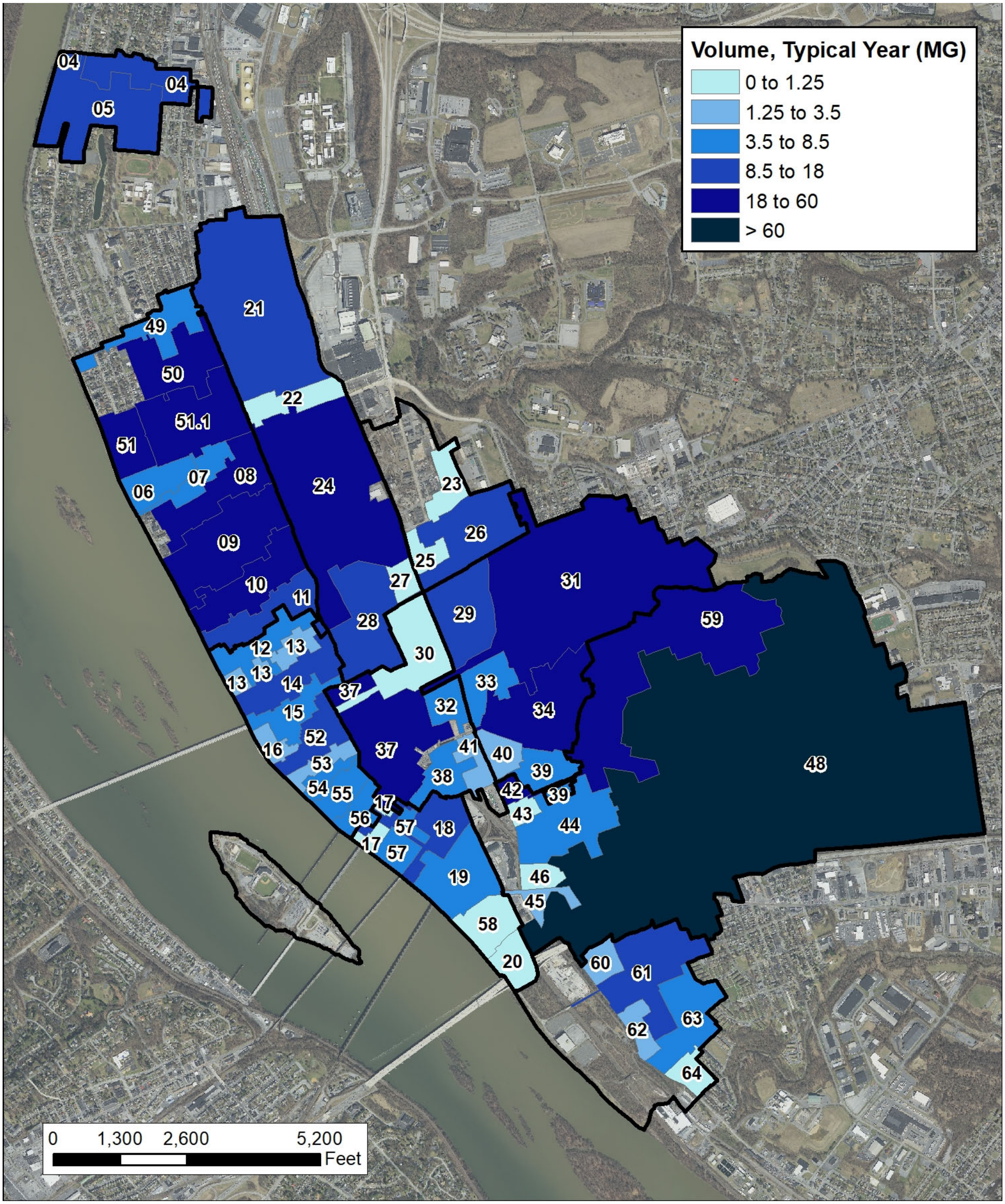


Figure 7.4-6: Pre-Plan Conditions – Annual CSO Volume, Typical Year Precipitation

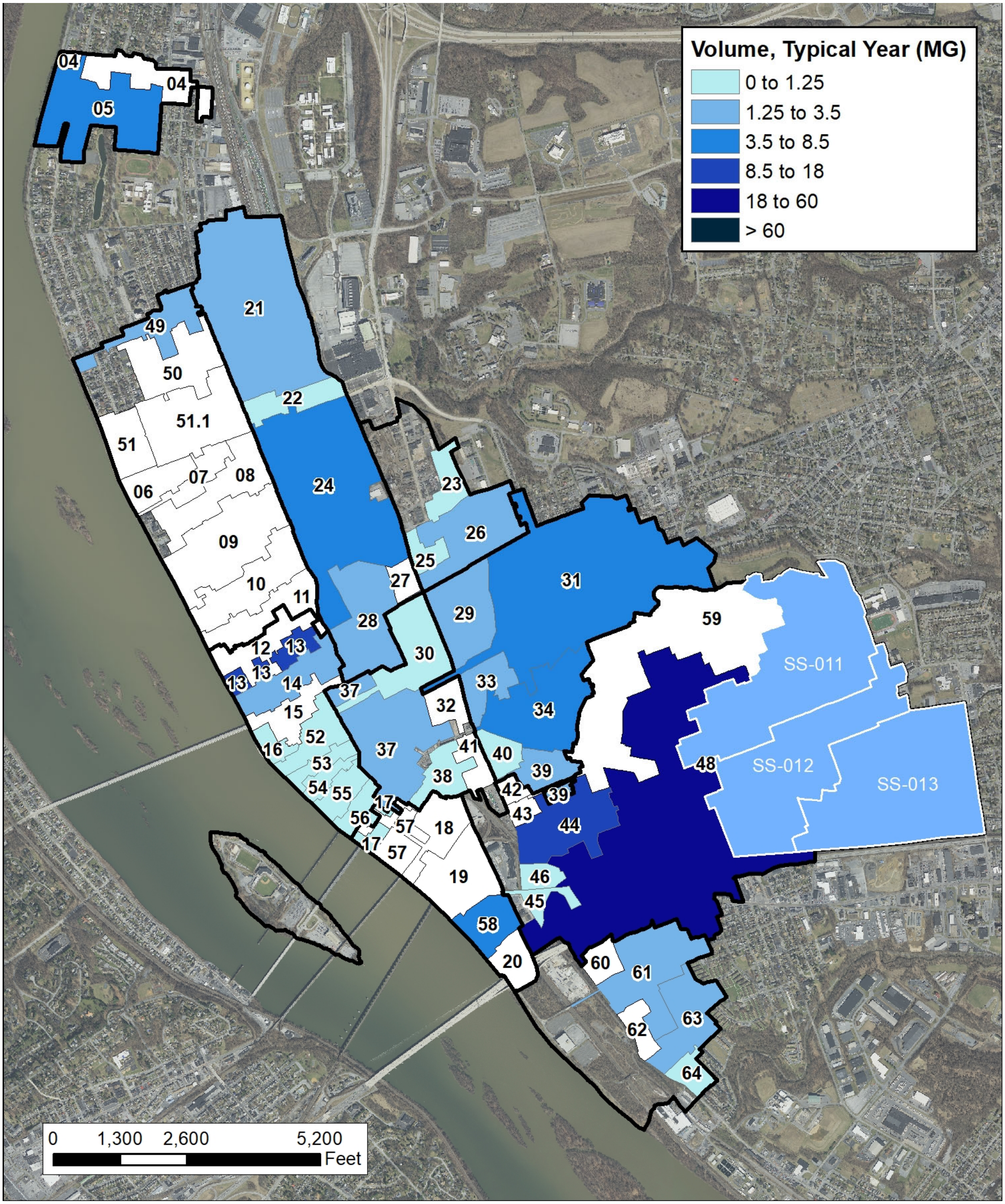


Figure 7.4-7: Recommended Plan – Annual CSO Volume, Typical Year Precipitation

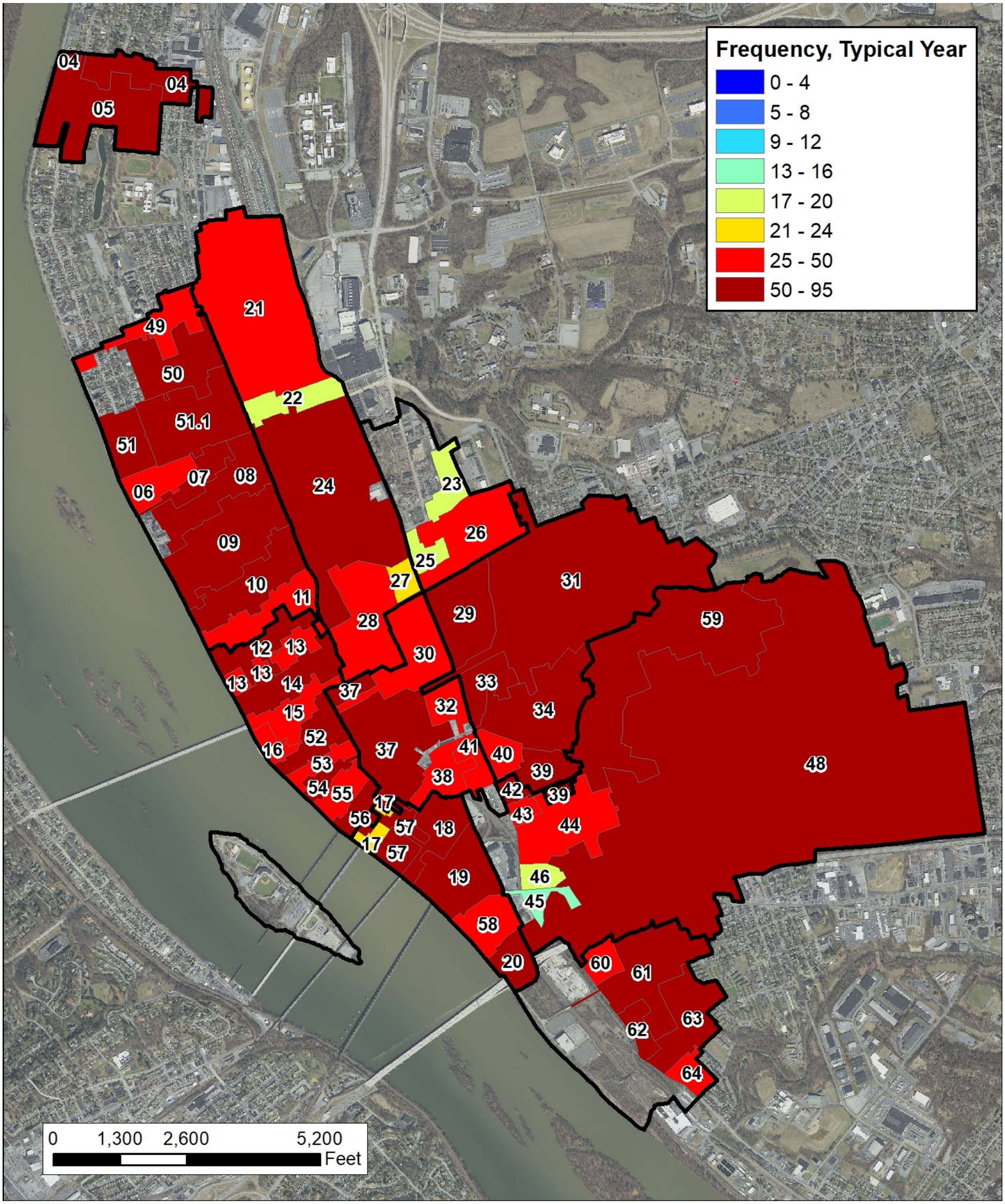


Figure 7.4-8: Pre-Plan Conditions – Annual CSO Frequency, Typical Year Precipitation

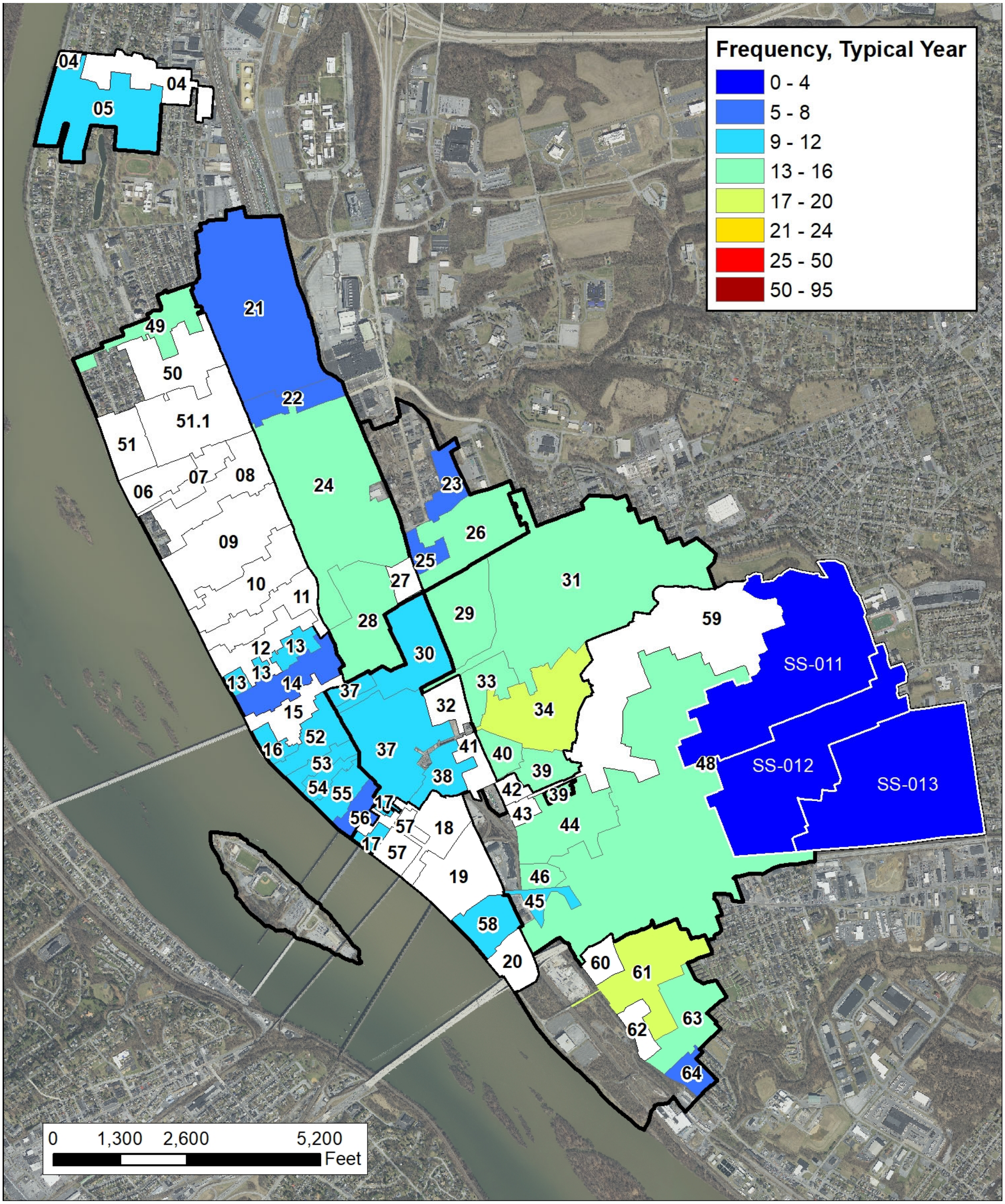


Figure 7.4-9: Recommended Plan – Annual CSO Frequency, Typical Year Precipitation

Figures 7.4-10 (Baseline Condition) and **7.4-11** (Recommended Plan) provide a graphical representation of the simulation results from the water quality models for the Susquehanna River. Water quality compliance was determined using the results from the H&H model incorporated into the water quality model. As shown in **Figure 7.4-11**, the Recommended Plan achieves water quality compliance within the Susquehanna River. “Baseline” represents the completion of the Appendix B projects.

The water quality models are preliminary models. CRW is currently collecting water quality data at the CSO outfalls and in both receiving waters to support water quality model calibration. As stated in Section 5, CRW collected some water quality data in 2023 and plans to collect additional data in 2024. The data collected thus far suggests that the bacteria levels in the CSOs may be up to an order of magnitude less than the original assumptions based on the THA data. This THA data corresponds to an old system configuration with less stormwater capture, which may explain the higher measurements in 2005. In particular, prior to CRW’s stormwater inlet rehabilitation program, blocked and/or poor condition stormwater inlets may have prevented stormwater from entering the combined sewer system, thereby resulting in less diluted wastewater. However, given the limited available water quality data and the highly variable nature of bacterial levels, CRW is not yet able to finalize the assumed bacteria levels. Once the water quality monitoring program is completed in 2024, a definitive determination will be made regarding bacteria levels.

Table 7.4-11 provides a graphical representation of the water quality model results for Paxton Creek. Each row within the table represents a reach of from the upstream limit of the study area to the confluence with the Susquehanna River. The green cells represent river reaches where the targeted LoC of 10 overflows per year is sufficient to attain WQ standards, and the brown cells indicate stream reaches where this LoC is insufficient to meet WQ standards. For higher bacteria levels, the Recommended Plan achieves compliance within 21 of 35 reaches (compared to 17 reaches of compliance for the Baseline condition). For lower bacteria levels, the Recommended Plan achieves compliance within 32 of 35 reaches (compared to 17 reaches of compliance for the Baseline condition).

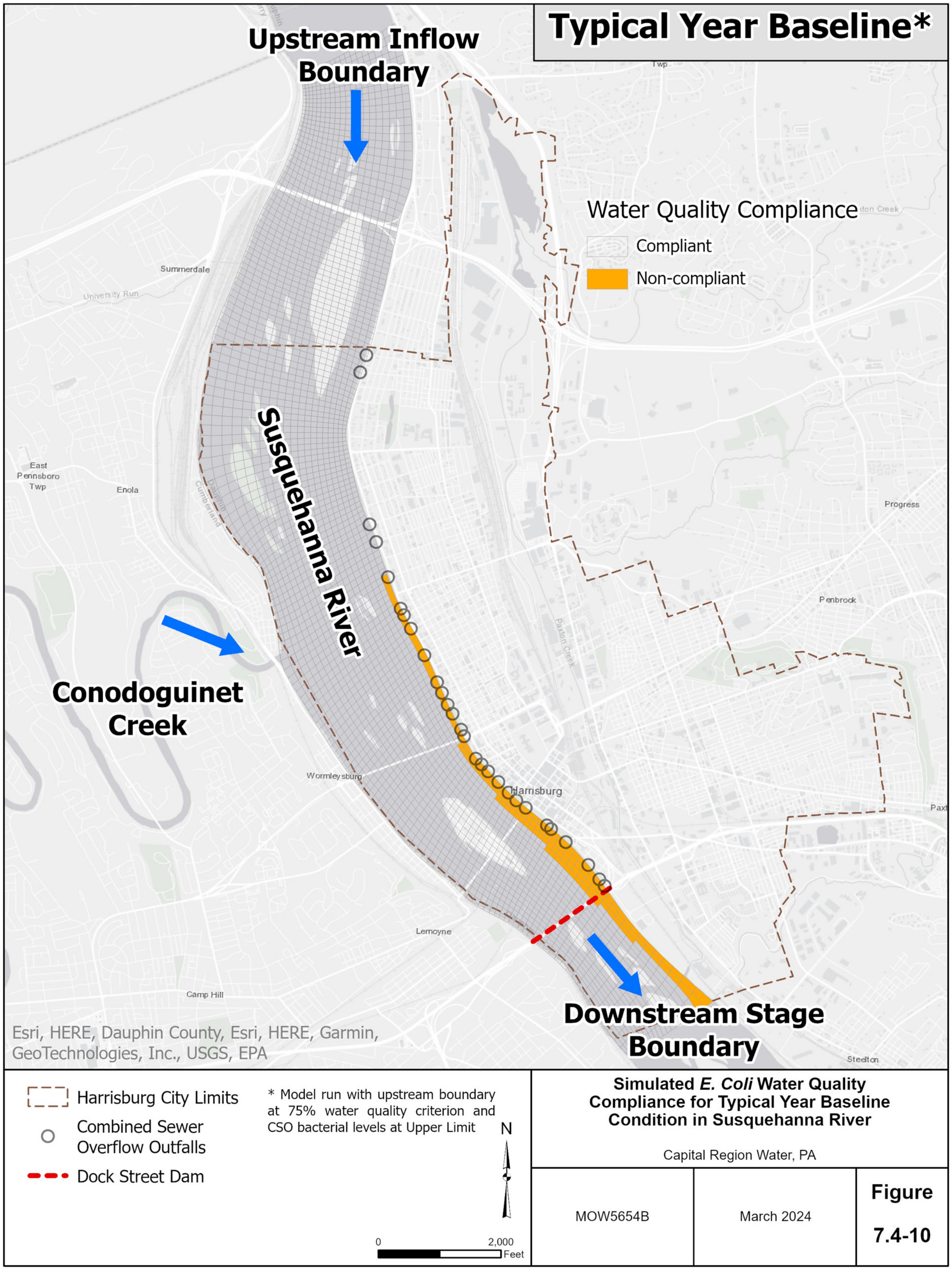


Figure 7.4-10: Simulated E. Coli Water Quality Compliance for Typical Year Baseline Condition in Susquehanna River

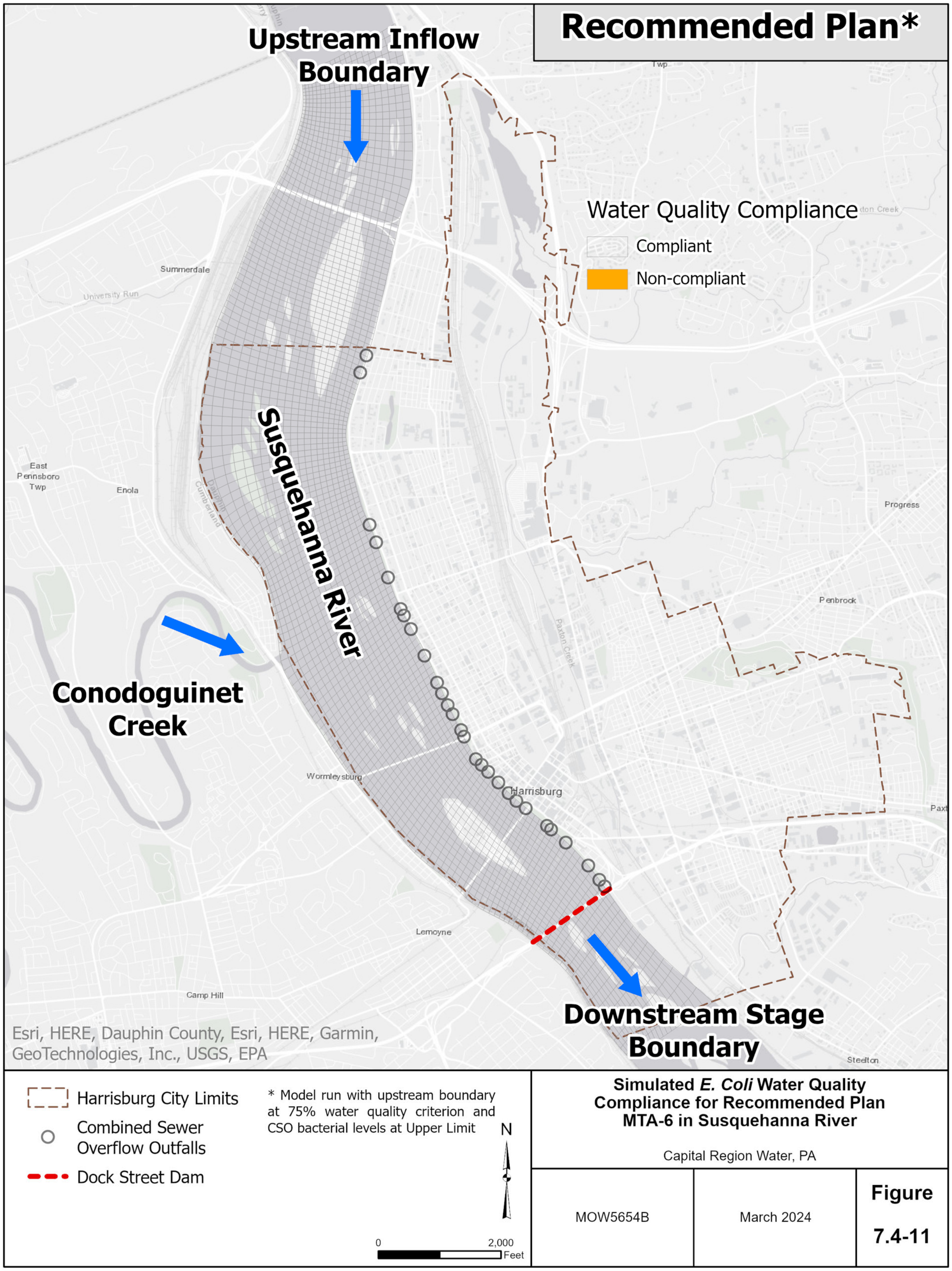


Figure 7.4-11: Simulated E. Coli Water Quality Compliance for Recommended Plan in Susquehanna River

Table 7.4-11: Water Quality Compliance in Paxton Creek for Recommended Plan

Reach	River Miles	CSO Outfalls	Water Quality Compliance			
			Higher Bacteria Levels		Lower Bacteria Levels	
			Baseline	MTA-6 (Recommended Plan)	Baseline	MTA-6 (Recommended Plan)
REACH_1	4.8		🟩	🟩	🟩	🟩
REACH_2	4.7		🟩	🟩	🟩	🟩
REACH_3	4.5		🟩	🟩	🟩	🟩
REACH_4	4.4		🟩	🟩	🟩	🟩
REACH_5	4.2		🟩	🟩	🟩	🟩
REACH_6	4.1		🟩	🟩	🟩	🟩
REACH_7	3.9		🟩	🟩	🟩	🟩
REACH_8	3.8		🟩	🟩	🟩	🟩
REACH_9	3.7		🟩	🟩	🟩	🟩
REACH_10	3.5	CSO- 21	🟩	🟩	🟩	🟩
REACH_11	3.3		🟩	🟩	🟩	🟩
REACH_12	3.2		🟩	🟩	🟩	🟩
REACH_13	3.1	CSO- 22	🟩	🟩	🟩	🟩
REACH_14	2.9		🟩	🟩	🟩	🟩
REACH_15	2.7		🟩	🟩	🟩	🟩
REACH_16	2.6		🟩	🟩	🟩	🟩
REACH_17	2.5	CSO- 23 & 24	🟩	🟩	🟩	🟩
REACH_18	2.3	CSO- 25, 26, 27, & 28	🟧	🟩	🟧	🟩
REACH_19	2	CSO- 29 & 30	🟧	🟩	🟧	🟩
REACH_20	1.9	CSO- 31	🟧	🟩	🟧	🟩
REACH_21	1.8	CSO- 32 & 33	🟧	🟩	🟧	🟩
REACH_22	1.7	CSO- 34 & 37	🟧	🟧	🟧	🟩
REACH_23	1.6	CSO- 38	🟧	🟧	🟧	🟩
REACH_24	1.5	CSO- 39, 40, & 41	🟧	🟧	🟧	🟩
REACH_25	1.4	CSO- 42, 43, & 59	🟧	🟧	🟧	🟩
REACH_26	1.2	CSO- 44	🟧	🟧	🟧	🟩
REACH_27	1.1	CSO- 45 & 46	🟧	🟧	🟧	🟩
REACH_28	1		🟧	🟧	🟧	🟩
REACH_29	0.9	CSO- 48	🟧	🟧	🟧	🟩
REACH_30	0.7		🟧	🟧	🟧	🟩
REACH_31	0.7	CSO- 60 & 61	🟧	🟧	🟧	🟩
REACH_32	0.5		🟧	🟧	🟧	🟩
REACH_33	0.4	CSO- 62, 63, & 64	🟧	🟧	🟧	🟧
REACH_34	0.1		🟧	🟧	🟧	🟧
REACH_35	0.1		🟧	🟧	🟧	🟧

Color Coding:

🟩 Compliant (Percent Attainment > 99%)

🟧 Incompliant (Percent Attainment < 99%)

Note: Baseline indicates conditions after the completion of the Appendix B projects.

7.4.5 Design Changes to Proposed Facilities

The control facilities presented in this alternatives analysis are based on a planning level of design and a preliminary water quality model. Between now and the submission of the Updated City Beautiful H_2O Program Plan on December 31, 2024, additional water quality sampling will be conducted and the data will be used to calibrate the water quality model. When the results of the refined and calibrated water quality model are applied to the hydrologic and hydraulic model representation of the Recommended Plan, refinements to the facility sizes and configurations will likely occur. Public participation input may also result in revisions to the Recommended Plan. It is also expected that feedback from Pennsylvania Department of Environmental Protection, Environmental Protection Agency, or Department of Justice may result in revisions to the Recommended Plan. Examples of these potential revisions include but are not limited to the following:

- The size of individual satellite storage facilities may change.
- A smaller satellite storage facility may no longer be required to achieve current water quality standards and would be eliminated.
- The sizes of the Paxton Creek Interceptor replacement pipes under MPCD Appendix B may change.
- The diameters of the consolidation sewers may change.

7.4.6 Adaptive Management

CRW plans to implement its Long-Term Control Plan, the *City Beautiful* H_2O *Program Plan (CBH2OPP)*, utilizing an adaptive management process. The final performance criteria proposed will allow adjustments to CSO control facilities (type, size, location) during design and implementation to reflect the final calibration of the water quality model. This means that some of the specific CSO control facility types, sizes, and locations are subject to change after the submission and approval of the *Updated City Beautiful* H_2O *Program Plan* as unforeseen opportunities and/or challenges occur, or as additional analyses warrant further refinements. The control facilities analyzed and presented in this *Alternatives Analysis Report* are based on planning level design. Each control facility will undergo a detailed preliminary and final design process as it is implemented under the specific schedule provided in the Updated CBH_2OPP. The specific details regarding the adaptive management process will be further explained in the updated CBH_2OPP which is scheduled to be submitted by December 31, 2024. Examples of these potential adaptive management revisions include but are not limited to the following:

- The relocation of a control facility due to unforeseen site conditions.
- The replacement of individual satellite storage facilities along Paxton Creek with comparable inline storage facilities.
- The replacement of a planned GSI facility with a substitute facility as new opportunities are identified, or new development or redevelopment occurs.