



Phase II 2017 Long Term Control Plan

City of Bangor, Maine
73 Harlow Street
Bangor, ME 04401

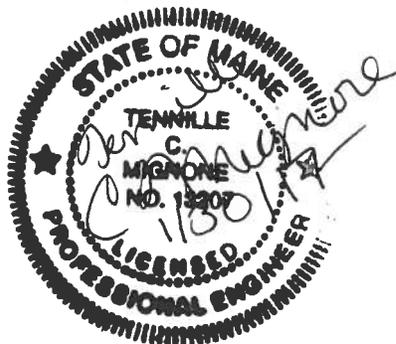
January 30, 2017

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PHASE II 2017 LONG TERM CONTROL PLAN CITY OF BANGOR, MAINE

Prepared for
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Glossary of Terms

Glossary of Terms

AACE	Association for the Advancement of Cost Estimating
BOD₅	Five-Day Biochemical Oxygen Demand
BMP	Best Management Practices
CCT	Chlorine Contact Tank
CD	Consent Decree
cfs	Cubic Feet Per Second
CIPP	Cured-in-place pipe
col/100mL	Colonies per 100 Milliliters
CSO	Combined Sewer Overflow
CMOM	Capacity, Management, Operations and Maintenance
CSS	Combined Sewer System
CWA	Clean Water Act
DEP	State of Maine Department of Environmental Protection
DWF	Dry Weather Flow
E. Col	Escherichia Coli.
EPA	United States Environmental Protection Agency
ENR	Engineering News Record
FM	Force Main
GM	Geometric Mean
gpd/sf	Gallons per Day per Square Foot
gpm	Gallons per Minute
HFMF	High Flow Management Facilities
HGL	Hydraulic Gradient Line
HRC	High-Rate Clarification
HRD	High Rate Disinfection
I/I	Infiltration and inflow
KOTC	Knee-of-the-curve
Lbs/day	Pounds per Day

lf	Linear Feet
LTCP	Long Term Control Plan
MEPDES	Maine Pollutant Discharge Elimination System
mg/L	milligrams per liter
MG	Million Gallons
MGD	Million Gallons Per Day
MGY	Million Gallons per Year
MHI	Median Household Income
MLSS	Mixed Liquor Suspended Solids
MMBB	Maine Municipal Bond Bank
N/A	Not Applicable or Not Available
NMC	Nine Minimum Controls
NPW	Net Present Worth
O&M	Operation and Maintenance
PCM	Post-Construction Compliance Monitoring
P&I	Principal and Interest
PS	Pump Station or Pumping Station
RDII	Rainfall-induced infiltration and inflow
RFI	Request for Information
RTB	Retention/Treatment Basin
RTC	Real-Time Control
SCADA	Supervisory Control and Data Acquisition
SOR	Surface Overflow Rate
SRF	State Revolving Loan Fund
SSES	Sewer System Evaluation Survey
SSO	Sanitary Sewer Overflow
SSS	Separate Sewer System
SWMM	EPA Storm Water Management Model
TBD	To Be Determined
TF/SC	Trickling Filter/Solids Contact

TM	Technical Memorandum or Memoranda
TRC	Total Residual Chlorine
TSS	Total Suspended Solids
UV	Ultraviolet Light
WDL	Waste Discharge License
WQS	Water Quality Standards
WWF	Wet Weather Flow
WWTP	Wastewater Treatment Plant

Executive Summary

Background and Purpose

Bangor’s wastewater collection system contains combined sewers, a pipe network that was designed to convey both sanitary and industrial wastes and stormwater during rainfall and snowmelt conditions. Combined Sewer Overflows (CSOs) are key features of combined sewers and are designed to regulate the amount of flow that is conveyed to the Wastewater Treatment Plant (WWTP) for treatment. The CSOs discharge to the Penobscot River and Kenduskeag Creek. Bangor’s CSO outfalls include:

- Barkersville (002)**
- Davis Brook (003)**
- Kenduskeag West (006)**
- Kenduskeag East (007)**
- Hammond St. (009)**
- Meadowbrook (011)**
- Cemetery (016)**
- Carr Brook (020)**
- Central St. (023)**

The key features of the wastewater collection and treatment system and CSO outfall locations are shown on Figure ES-1

Bangor’s initial plan to address CSO abatement was the 1993 CSO Facilities Plan. The plan established a long-term program of CSO abatement measures with a target level of volumetric control reduction of 80%. While this level of control has been achieved, the United States Environmental Protection Agency (EPA), through a 2015 Consent Decree, is now requiring the City to prepare this Phase II Long Term Control Plan (LTCP). A LTCP is a structured, technology-based approach of evaluating system characteristics and baseline conditions; alternative control measures; performance, costs and environmental benefits; financial impacts and affordability; and phased implementation.

As a result of the 1993 plan, three CSO storage facilities were constructed within the collection system. They provide 3.8 Million Gallons (MG) of storage capacity. Table ES-1 presents a summary of the three facilities listed in the order of their construction.

Table ES-1. Summary of Bangor’s Three CSO Storage Facility

Facility	Capacity (MG)	Type
Davis Brook	1.2	In-System Conduit
Kenduskeag East	1.2	Off-Line Tank
Barkersville	1.4	In-System Conduit
Total	3.8	

System Characterization

Monitoring of the combined system from 2012 to 2015 indicated that four major CSO outfalls - Barkersville (002), Davis Brook (003), Kenduskeag West (006) and Kenduskeag East (007) – comprise 95.7% of the City’s annual CSO discharge volume. As such, much of the focus of the Phase II LTCP is on these outfalls.

In order to plan for the additional CSO control, a baseline has been established from which to size abatement facilities. Baseline data are presented in Table ES-2 and are expressed in terms of annual activation frequency, volume in MG and flow rate in Million Gallons per Day (MGD).

Table ES-2. Baseline Characteristics for Typical Year (1974)

CSO Outfall	Activations	CSO Volume (MG)	Peak CSO Flow Rate (MGD)
Barkersville (002)	19 – 20	36.4 – 46.3	110.5
Davis Brook (003)	19	40.4 – 57.2	162.9
Kenduskeag West (006)	8 – 9	19.9 – 20.2	89.8
Kenduskeag East (007)	14	1.2 – 1.5	22.0
Hammond St. (009)	0	0.0	0.0
Meadowbrook (011)	12	0.9	5.8
Cemetery (016)	0	0.0	0.0
Carr Brook (020)	5	0.9	129.3
Central St. (023)	7	0.3	1.9
	84 – 86	100.0 – 127.2	

Ranges of baseline values are included to reflect the current peak capacity of the WWTP versus its rated capacity: 36 MGD and 43 MGD, respectively. The higher values in the table represent the lower WWTP capacity (36 MGD) while the lower values represent the higher WWTP capacity (43 MGD).

Alternatives for Additional CSO Control

Currently available control measures are grouped into the following categories: Source Controls, System Optimization, Conveyance Enhancements, Treatment and Storage. These are listed in Table ES-3 along with a notation if they have been implemented in Bangor’s long-term CSO abatement program.

Table ES-3. Available CSO Control Measures and Their Application in Bangor

Measure	Implemented in Bangor
Source Control	
• Best Management Practices/Nine Minimum Controls (BMP/NMC)	Yes
• I/I Reduction/Sewer Rehabilitation	Yes
• Sewer Separation	Yes
• Green Infrastructure	
System Optimization	
▪ Weir Adjustment	Yes
▪ Bending Weirs/Control Gates	
▪ Real Time Controls	
Conveyance Enhancements	
• Parallel Relief Interceptors	
• Pump Station Expansion	Yes
Treatment (Satellite and Centralized at WWTP)	
• Vortex Separation	
• Retention Treatment Basin (RTB)	
• High Rate Clarification (HRC)	
• WWTP Expansion (Wet Weather Capacity)	Yes
• Disinfection in conjunction with treatment technologies	
Storage	
• In-System/Conduit	Yes
• Off-Line Tank	Yes
• Tunnel	

Evaluation Process, Initial Costing and Determination of Level of Control:

A multi-step process was employed to evaluate the CSO control measures presented in Table ES-3. The first step was a fatal flaw analysis which allowed for certain measures to be screened out from further consideration due to one or more remaining factors that make them unsuited for CSO control in Bangor. The subsequent steps subjected the alternatives to more rigorous non-monetary and monetary or cost evaluations. All of the evaluations, including the initial fatal flaw analysis, considered the following: which controls were appropriate for a community the size of Bangor; the degree of treatment required for flow-through treatment processes (e.g., was a level of treatment beyond primary required, etc.), and operational compatibility with the three existing storage facilities. Through this process, it was determined that primary treatment and seasonal disinfection, the minimum treatment level required in the CSO policies, was adequate to reduce the bacteria loadings and that more sophisticated processes, such as HRC and tunnels were not warranted.

Based on these findings, storage was considered to be the primary control measure for the four larger outfalls – Barkersville (002), Davis Brook (003), Kenduskeag West (006) and Kenduskeag East (007) - along with RTB and vortex treatment plus disinfection. Sewer separation and sewer replacement/rehabilitation were only considered as supplemental controls for these large outfalls. Sewer separation was determined to be the most preferred control measure for the smaller outfalls.

Most of the other control measures were deemed not suitable for a number of factors, most importantly the small size of the Bangor collection system. Preliminary cost estimates were then developed for the CSO control measures remaining following the initial screening. The bases for the estimates were costs obtained from recent similar CSO abatement projects in Maine and, in the case of vortex, vendor-supplied estimates. The costs span the range of control levels (8, 6, 4 and 2 activations per year) and WWTP capacities (36 MGD to 43 MGD) and are presented in Table ES-4.

Table ES-4. Ranges of CSO Abatement Costs Expressed as Opinion of Probable Total Project Costs in Million Dollars¹

	Annual Activations			
	8	6	4	2
Barkersville - CSO 002				
Storage Conduit	\$12 - \$13	\$13 - \$20	\$19 - \$22	\$21 - \$25
Storage Tank	\$9	\$9 - \$18	\$15 - \$22	\$20 - \$26
RTB and Disinfection	\$15 - \$17	\$16 - \$17	\$17	\$16 - \$17
Vortex and Disinfection	\$15 - \$17	\$16	\$19	\$21
Davis Brook – CSO 003				
Storage Conduit	\$11 - \$15	\$14 - \$18	\$17 - \$22	\$27 - \$30
Storage Tank	\$9 - \$11	\$10 - \$16	\$15 - \$27	\$29 - \$35
RTB and Disinfection	\$6 - \$8	\$8 - \$9	\$9	\$10 - \$11
Vortex and Disinfection	\$8 - \$10	\$10	\$11 - \$12	\$11 - \$15
Kenduskeag West and East - CSOs 006 and 007				
Storage Tank	\$3	\$3 - \$4	\$9	\$19 - \$23
WWTP²	\$3	\$3	\$3	\$3

¹ Over range of 36 MGD to 43 peak wet weather WWTP capacity.

² Estimate of CSO treatment only to reliably attain 43 MGD; does not include related improvements to influent screens, grit handling, etc.

The more suitable sites for the CSO control facilities presented in Table ES-4 are summarized in Table ES-5.

Table ES-5. Siting of Remaining Control Alternatives at the Larger CSO Outfalls

CSO Outfall	Storage Conduit	Storage Tank	Treatment with Disinfection
Barkersville (002)	Bass Park	Bass Park	Emera Property
Davis Brook (003)	Waterfront	Waterfront	Waterfront
Kenduskeag West and East (006 and 007)	--	Park adjacent to KPS	--

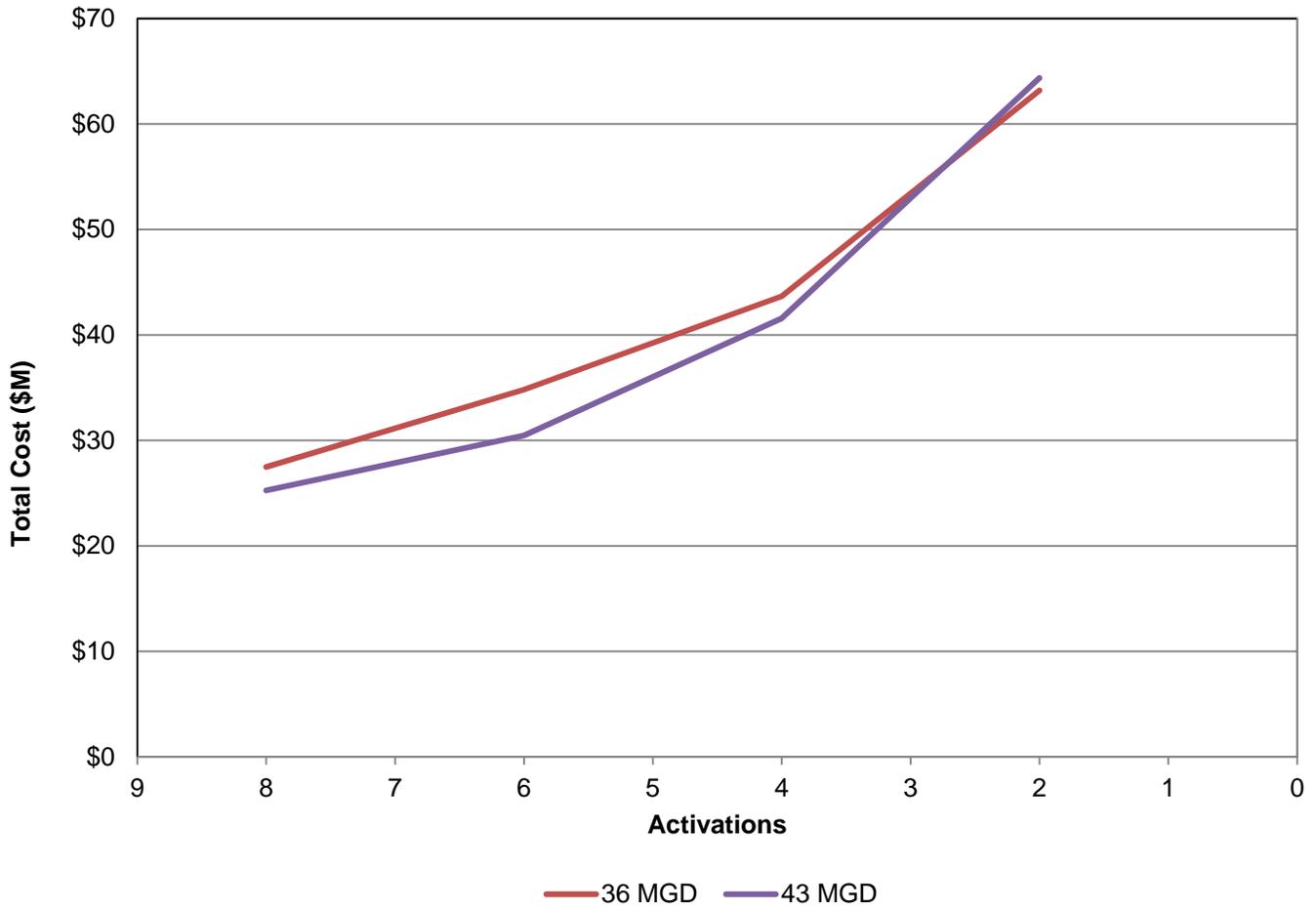


Figure ES-2. Opinion of Probable Total Project Abatement Costs at the Four Largest Outfalls vs Level of Control

In order to find the most cost-effective control level for Bangor, the average cost for each of the viable control measures at each location was plotted on a graph with the results shown in Figure ES-2. Two lines were plotted, one for the WWTP at 36 MGD (top) and the other with the WWTP at 43 MGD (bottom). Based on these results, it was clear that 4 activations per year, as indicated by the inflection point, or knee-of-the-curve (KOTC), under either WWTP capacity was the cost-effective level of control.

Non-monetary criteria were also used in the evaluation process. The non-monetary criteria selected as being most applicable to Bangor are shown in Table ES-6.

Table ES-6. Non-Monetary Criteria

Criterion	Consideration Factors
Regulatory Compliance	Compliance with DEP and EPA CSO policies.
Health and Safety (H&S) Requirements	Ability to comply with applicable H&S requirements.
Regulatory Uncertainties/Expandability	Ability for facility to be readily expanded to accommodate possible future stricter effluent limits (e.g., viruses, enterococcus, nitrogen, phosphorus, etc.) and/or higher levels of control (e.g., higher volumetric control and/or lower activation frequency).
Water Quality Impacts	Degree of pollutant loading reduction to the receiving waters.
Constructability	Unique challenges/obstacles associated with the proposed site.
Ease of Operation	Complexity of processes including pre-event preparation and post-event clean-up; also, similarity of the proposed facilities with current facilities so that operators already have requisite experience (i.e., no learning curve).
Public/Community Acceptance	Impacts to the immediate and surrounding area and any unique or sensitive resources
Ease of Implementation	Available solutions to overcome possible impediments to implementation.
Visual/Aesthetics	Concerns with visual aesthetics and the additional cost necessary to mitigate these concerns.
Process Reliability	Is the process dependable (e.g., number of moving parts, dependency on human interaction, process control requirements, etc.).

The non-monetary evaluations indicated that the storage alternatives (conduit or tank) rate higher than treatment and disinfection in virtually all of the evaluation categories. Treatment at this point in the evaluation process was confined to RTB and disinfection as vortex was deemed less viable due to the need for multiple units.

More detailed cost estimates were then developed for the remaining alternatives for the larger CSO outfalls using a variety of costing methodologies. The costs are presented as estimated total project costs which include an opinion of probable construction costs, engineering and owner's contingency, land acquisition and SRF loan administrative costs.

The resulting costs are summarized in Tables ES-7 and ES-8. Table ES-7 presents the resultant cost estimates for alternatives associated with a peak wet weather capacity at the WWTP of 36 MGD while Table ES-8 assumes that the WWTP is expanded to 43 MGD.

Table ES-7. Opinion of Probable Total Project Costs for Remaining Control Alternatives for the four Larger Outfalls at 4 Activations per Year and WWTP at 36 MGD (\$M)

CSO Outfall	Storage Conduit	Storage Tank	RTB Treatment with Disinfection
Barkersville (002)	\$21.5	\$20.4	\$16.7
Davis Brook (003)	\$22.0	\$22.0	\$12.1
Kenduskeag West and East (006 and 007)	--	\$9.0	--

Table ES-8. Opinion of Probable Total Project Costs for Remaining Control Alternatives for the four Larger Outfalls at 4 Activations per Year and WWTP at 43 MGD (\$M)

CSO Outfall	Storage Conduit	Storage Tank	RTB Treatment with Disinfection
Barkersville (002)	\$19.4	\$17.3	\$16.7
Davis Brook (003)	\$17.4	\$14.6	\$10.6
Kenduskeag West and East (006 and 007)	--	\$9.0	--
WWTP¹	\$3.0	\$3.0	\$3.0

¹ Estimate of costs to reliably attain peak capacity of 43 MGD; does not include costs related to improvements to influent screens, grit handling, etc., that would be eventually required at the WWTP regardless of peak wet weather capacity.

Preferred Alternative

Based upon the results of both the non-monetary and monetary evaluations, off-line storage tanks were deemed to be the most beneficial CSO control technology for Bangor in order to achieve the 4 overflows per year level of control. Storage was preferred over satellite treatment as it is a relatively simple process to operate and similar to the three existing storage facilities in Bangor. As with the existing tanks, following each storm event, the stored volume would be drained back to the collection system and on to the WWTP where it would receive full secondary treatment and seasonal disinfection. Satellite treatment would only provide an equivalent of primary treatment and seasonal disinfection. Satellite treatment also present both siting and operational challenges as each facility would require its own chemical storage and feed building along with the controls necessary to optimize the process and meet all of the imposed effluent limitations.

As shown in Table ES-9, three tanks are proposed to be built, one each at Barkersville (002), Davis Brook (003) and Kenduskeag West (006) to serve that outfall as well as the Kenduskeag East (007) outfall.

Table ES-9. Summary of Preferred Control Facilities for the Four Larger CSO Outfalls

CSO Outfall	Key Components/Location	Opinion of Probable Total Project Cost (\$M)
Barkersville (002)	3.6 MG Storage Tank at Bass Park	\$20.4
Davis Brook (003)	3.8 MG Storage Tank at Waterfront	\$22.0
Kenduskeag West and East (006 and 007)	1.1 MG Storage Tank in Park adjacent to Kenduskeag Pump Station	\$9.0
Total Larger CSO Outfall Sewer Separation Costs		\$51.4

These costs represent the WWTP at its current peak capacity of 36 MGD. Should the City elect to increase the capacity to 43 MGD, the costs for some of the tanks would decrease and an additional \$3M would be needed to be added for the necessary WWTP improvement.

Sewer separation was the preferred alternative for the smaller CSO outfalls and its Opinion of Probable Total Project Costs is presented in Table ES-10.

Table ES-10. Summary of Preferred Control Facilities for the Smaller CSO Outfalls

CSO Outfall	Linear Feet of New Sanitary Sewer Pipe	Linear Feet of New Stormwater Sewer Pipe	Opinion of Probable Total Project Cost (\$M)¹
Meadowbrook (011)	5,400	12,300	\$4.4
Cemetery (016)	1,250	4,325	\$1.9
Carr Brook (020)	5,400	13,800	\$4.2
Central (023)	550	2,600	\$1
Total Smaller CSO Outfall Sewer Separation Costs			\$11.5

The Opinion of Probable Total Project Costs for Phase II LTCP implementation, as shown in Tables ES-9 and ES-10, is \$62.9. This total does not consider ongoing repairs/replacement of the collection system or at the WWTP.

Financial Capabilities Assessment (FCA)

The costs associated with the Phase II LTCP along with other non-CSO wastewater system needs are evaluated in a Financial Capability and Affordability Assessment (FCA). The FCA allows the City to assess its ability to pay for the preferred CSO plan using metrics established by EPA. The FCA establishes that Bangor would experience a so-called medium burden as a result of these additional wastewater costs. More importantly, the FCA also concludes that sectors of Bangor households are already experiencing a so-called high financial burden and that additional wastewater costs would add to their existing financial stress. As such, care will need to be taken to evaluate all of the CWA requirements and to prioritize project implementation in a manner that results in achieving the greatest water quality benefit while still being affordable. The Phase II LTCP implementation schedule described below, takes this financial situation into consideration.

Sequencing and Implementation Schedule

The 2015 CD requires Bangor to complete the CSO abatement work called for in the Phase II LTCP by December 31, 2031, less than 15 years from the submittal date of the plan itself. There are also intermediate submittal dates included in the CD for the preparation of Statements of Work (SOWs) for plan implementation. However, because of the high cost of the preferred plan and the findings of the FCA, this schedule would cause an undue burden on all of the Bangor ratepayers and even more so for the already financially stressed segment of the population. As such, a time extension will likely need to be sought from EPA as the implementation progresses and the financial impact of the initial project or projects can be more fully assessed.

With respect to sequencing, the Davis Brook storage tank was determined to be the most beneficial initial major project due to the high level of CSO activity at Davis Brook outfall and its location along the waterfront.

The implementation schedule, presented in ES-11, focuses on the initial projects with a FCA reassessment phase following each major project.

Table ES-11. Implementation Schedule

Action	Date	Remarks
1. Submit Phase II LTCP	Jan. 2017	Jan 31, 2017 Per 2015 CD
2. Comment Period	Feb.-May 2017	Based on receipt of EPA and DEP comments by March 1, 2017
3. Phase 1 - Davis Brook Storage Tank	Aug. 2017-June 2021	Includes design, bidding/construction and start-up/commissioning
4. Preparation of SOW¹	June 2021	June 30, 2021 Per 2015 CD
5. Phase 2 - Barkersville CSO Storage Tank	TBD ²	Date will be based on results of revised FCA; could follow Kenduskeag West and East as Phase 3
6. Preparation of SOW	June 2026	June 30, 2026 Per 2015 CD
7. Phase 3 - Kenduskeag West and East CSO Storage Tank	TBD	Date will be based on results of revised FCA; could precede Barkersville as Phase 2
8. Phase 4 - WWTP Capacity Expansion (Optional)	TBD	Need for Phase 4 WWTP Expansion to be determined through PCM and other considerations
9. Abatement of Smaller Outfalls	Continuous small projects over implementation schedule	Detailed schedule to be developed based on related infrastructure improvements, SSES-related needs and other considerations
10. Post Construction Monitoring (PCM)	Following start-up of each major facility	Depending upon scheduling included in SOWs; will determine need for WWTP capacity expansion
11. Financial Capabilities and Affordability (FCA) Update	Following start-up of each major facility	And included in SOWs depending upon scheduling

¹ Statement of Work

² To be determined

With the exception of the CD milestones, the only firm dates included in the schedule are for the Phase 1 Davis Brook storage tank. The dates for the other major facilities will be based on the revised FCAs. It should be noted that for at least the first SOW should be moved at least one year to June 30, 2022, to allow adequate time for PCM period of the Davis Brook storage tank in order to assess its effectiveness, both at subsection and citywide.

1.0 Introduction

This section contains the background and purpose of this Phase II Long Term Control Plan (LTCP) prepared by the City of Bangor, Maine (“Bangor” or the “City”). It also contains a section by section overview of the content and format of this report.

While this Phase II LTCP provides definition of certain terms, please see also the Glossary of Terms, which is provided following the Table of Contents, for definitions of various acronyms.

1.1 Background

The City of Bangor is located on the Penobscot River in Penobscot County, Maine. See Figure 1-1. With a 2010 population of 33,039, Bangor is Maine’s third largest City following Portland and Lewiston. As with other older cities and towns throughout Maine and New England, Bangor’s wastewater collection system contains what are referred to as combined sewers, a pipe network designed to convey not only sanitary and industrial wastes but also stormwater discharged during rainfall and snowmelt conditions. Combined Sewer Overflows (CSOs), or hydraulic relief points, are key features of combined sewers. Bangor’s CSOs are designed to regulate the amount of flow that can be intercepted and conveyed to Bangor’s Wastewater Treatment Plant (WWTP) for treatment prior to discharge to the Penobscot River and Kenduskeag Stream. Bangor’s WWTP and CSO discharges are subject to laws and regulations promulgated by the United States Environmental Protection Agency (EPA) and the State of Maine Department of Environmental Protection (DEP) pursuant to the Clean Water Act (CWA) as well as EPA and DEP policies and guidance documents.

Bangor has been diligent in working to eliminate, reduce or otherwise abate and control its CSO discharges. As a result of these efforts dating back to the late 1980s, Bangor has eliminated 13 of its original 22 CSO outfalls and reduced its average annual discharge volume by approximately 80%.

Bangor initially addressed its CSO discharges under its 1993 CSO Facilities Plan. This plan established a long-term program of CSO abatement measures with a target level of volumetric control reduction of 80 percent, a level of control that has been attained. Under a 2015 Consent Decree with EPA and DEP (the 2015 CD), Bangor is required to prepare a Phase II Long Term Control Plan (LTCP). Like the 1993 CSO Facilities Plan, the Phase II LTCP is a structured, technology-based approach that evaluates CSO system characteristics and baseline conditions; alternative CSO control measures, performance, costs and environmental benefits, financial impacts and affordability; and includes phased implementation. The Phase II LTCP affords Bangor an opportunity to assess its progress to date and the additional steps that may be taken to further reduce the City’s CSO discharges.

1.2 Purpose

The purposes of this 2017 Phase II LTCP are summarized as follows:

- Assess progress made to date on the continuing abatement of Bangor’s CSOs.
- Ascertain current baseline conditions in comparison to those presented in the 1993 Facilities Plan.



Source: Maine GIS, 2016.

Figure 1-1. City of Bangor Location Map

- Evaluate higher levels of CSO abatement consistent with the requirements Par. 17 of the 2015 CD.
- Coordinate, and integrate to the extent practical, the findings of the CSO abatement evaluations with those of Sewer System Evaluation Survey (SSES) investigations, as required by Par. 9 of the 2015 CD.

1.3 Report Format

The Phase II LTCP is structured as follows:

- Executive Summary.
- Section 1: background information, the purposes of the LTCP, and report format.
- Section 2: overview of the regulatory framework for CSO planning and control.
- Section 3: description of Bangor's wastewater infrastructure, including the collection and treatment systems and CSOs.
- Section 4: summary of previous CSO planning efforts.
- Section 5: description of baseline CSS conditions
- Section 6: presentation of alternatives for further CSO reductions, including the initial screening steps up through the selection of the preferred plan, and development of the targeted level of control for the LTCP.
- Section 7: evaluation of remaining alternatives following initial screening.
- Section 8: description of the preferred plan, including SSES work and sewer separation opportunities.
- Section 9: description of project financing and an implementation schedule (developed in accordance with the Financial Capability and Affordability Assessment submitted under separate cover).

2.0 Regulatory Framework

This section of the Phase II LTCP describes the history of DEP and EPA actions and overall regulatory framework applicable to CSO control in the City of Bangor. Current DEP and EPA CSO control policies are briefly described below. Appendix D contains a listing of these and other applicable supporting documents.

2.1 1991 Consent Decree

The first major regulatory action pertaining solely to CSO abatement was a 1991 Consent Decree (CD) that Bangor and DEP entered into with EPA. The 1991 CD superseded a 1987 consent agreement between Bangor and DEP that primarily addressed the requirement for secondary treatment at Bangor's then primary WWTP but also included a requirement to conduct a Sewer System Evaluation Survey (SSES) of the collection system.

A key requirement of the 1991 CD was the preparation of a CSO Facilities Plan which ultimately established a timeframe for the plan's recommended CSO abatement projects. A draft of the plan was submitted to EPA and DEP in 1992. A final report and accompanying implementation schedule were subsequently submitted to EPA in 1993 and ultimately approved in 1994.

The CSO Facilities Plan, modified over time as additional information became available or as conditions so dictated, formed the basis for Bangor's extensive CSO abatement program that included, among other things, the construction of three storage facilities and numerous sewer separation and rehabilitation projects. The Final Report on CSO Abatement Program was submitted to EPA in April 2009, documenting all of the measures taken by Bangor to satisfy the requirements of the 1991 CD.

2.2 Section 308 Request for Information

Following Bangor's submittal of the Final Report on CSO Abatement Program to EPA in April 2009, EPA issued a series of Requests for Information (RFI) under Section 308 of the CWA, Docket No. 010-308 beginning in May 2010. In addition to requests for information on the operation of the collection system, the key CSO-related requirement of the RFI was the preparation of a Phase 2 LTCP by September 2012. A draft Phase 2 LTCP, consisting of a series of technical memoranda (TM), evaluated alternatives to meet higher levels of CSO control than the original 80% level of control contained in the CSO Facilities Plan. The draft Phase 2 LTCP is described in further detail in Section 4.

2.3 2015 Consent Decree

Following the Section 308 RFI process, EPA, DEP and Bangor entered into the 2015 CD. In addition to requiring preparation of this Phase II LTCP, the 2015 CD requires Bangor to (among other things) implement a Capacity, Management, Operations and Maintenance (CMOM) Corrective Action Plan and a Sewer System Asset Management Preventive Maintenance and Sewer Maintenance Improvement Plan (MIP), including a phased Sewer System Evaluation Survey (SSES).

2.4 MEPDES Permit

Bangor's current MEPDES Waste Discharge Permit, #ME0100781 (the MEPDES Permit), was issued by DEP on August 8, 2016. The MEPDES Permit not only regulates the operation and performance of the City's secondary WWTP, but also the nine permitted CSO discharges to the Penobscot River and Kenduskeag Stream. These nine CSO outfalls are listed below in Table 2-1 and their locations are shown in Figure 2-1.

Table 2-1 Bangor's Permitted CSO Outfalls

CSO Outfall	Location	Receiving Water/ Classification
002	Barkersville	Penobscot River/Class B
003	Davis Brook	Penobscot River/Class B
006	Kenduskeag West	Kenduskeag Stream/Class C
007	Kenduskeag East	Kenduskeag Stream/Class C
009	Hammond Street	Kenduskeag Stream/Class C
011	Meadowbrook	Kenduskeag Stream/Class C
016	Cemetery	Kenduskeag Stream/Class C
020	Carr Brook	Penobscot River/Class B
023	Central Street	Kenduskeag Stream/Class C

It should be noted that CSO storage conduits or tanks have been built at CSOs 002 (Barkersville), 003 (Davis Brook) and 007 (Kenduskeag East) which greatly reduce annual discharge activity and volume.

2.5 CSO Control Policies

Both DEP and EPA have promulgated CSO control policies and guidance documents that first began appearing in the late 1980s. The most significant and far reaching of these documents is the EPA CSO Control Policy which was published in the Federal Register in 1994. Section 402(q)(1) of the CWA codified the CSO Control Policy in 2001. Both DEP and EPA have established minimum treatment requirements for CSO discharges and have set goals for their ultimate elimination. The requirements for LTCP development are outlined in the EPA CSO Control Policy and have also been the subject of a series of EPA and DEP guidance documents.

The EPA CSO Control Policy established the minimum technology-based requirements for the control of CSO discharges, known as the Nine Minimum Controls (NMC); DEP also adopted this approach in its guidance documents. NMC are considered low-cost, source-control measures to address CSO reduction at the source through what are termed Best Management Practices (BMPs). These BMPs include such measures as street and catch basin cleaning, litter control and proper operation and maintenance (O&M) of the collection system. A key control for CSO communities is to maximize use of the wet weather capacities in their existing conveyance and treatment systems.

3.0 Wastewater Infrastructure

Bangor’s wastewater infrastructure includes a vast network of collector and interceptor sewers, pump stations, force mains, siphons and a secondary WWTP. The collection system includes two components: a combined sewer system (CSS) and a separate sewer system (SSS).

In addition to providing wastewater collection and treatment to Bangor, the City also provides treatment services to portions of the Town of Hampden to the South and to the Town of Hermon to the West. Hampden conveys flow to Bangor via three town-owned pump stations, and Hermon via two town-owned pump stations.

Bangor maintains a SCADA system which allows the operators at the WWTP to monitor various system components, including some of the pump stations from its service communities. The key features of the wastewater collection and treatment system are shown on Figure 2-1 and are described below.

3.1 Collection System and Pump Stations

The collection system includes approximately 157 miles of collector sewers plus 9 miles of interceptor sewers. Roughly 24% of the collector sewers are combined, down from 58% at the start of the CSO abatement program. This reduction in the CSS is the result of the significant sewer separation projects that Bangor has undertaken as part of its CSO abatement program.

There are five City-owned pump stations located throughout the collection system as listed in Table 3-1.

Table 3-1 Wastewater Pump Stations

Station Name	Pumping Capacity (gpm)	Remarks
Odlin Road	560	Station is planned to be upgraded/expanded.
Perry Road	2 @ 2,648	
Hildreth	942	
Kenduskeag East CSO Facility	960	
Kenduskeag	2 @ 10,000	Contains three pumps with room for a fourth.

There is also a raw sewage pump station at the WWTP that contains four pumps with room for a fifth.

There are four interceptor sewers as follows: Penobscot, Penobscot East, Kenduskeag, and Kenduskeag East. The conveyance capacity of the Penobscot Interceptor just upstream of the WWTP is estimated at 43 MGD under optimal conditions.

3.2 WWTP

Bangor’s original WWTP began operation in 1966 as a primary plant. It has been upgraded to provide secondary treatment in 1992. In response to recommendations contained in the 1993 CSO Facilities Plan, further improvements were completed in 1998 to accommodate higher rates of wet weather flow including

the addition of a CSO Bypass around the secondary treatment facilities, the operation of which is described below. The application for the CSO Bypass was approved by EPA in 1996.

3.2.1 Process Overview

The secondary WWTP employs the Trickling Filter/Solids Contact (TF/SC) process of using both an attached-growth trickling filter and suspended-growth activated-sludge processes in series. The WWTP includes raw sewage pumping, preliminary treatment (screening and grit removal), primary treatment, secondary treatment (TF/SC) and seasonal disinfection (chlorination/dechlorination). The secondary portion of the WWTP was designed for an average daily design flow of 18 million gallons per day (MGD) and a peak wet weather flow of 30 MGD.

A schematic of the WWTP is shown as Figure 3-1. The key permit conditions of the MEPDES Permit for the WWTP are summarized in Table 3-2.

Table 3-2 Key Parameters and Limits from MEPDES Permit

Parameter	Concentration			Loading			Notes
	Monthly Avg	Weekly Avg	Daily Max	Monthly Avg	Weekly Avg	Daily Max	
BOD5/TSS Secondary Effluent	30 mg/L	45 mg/L	50 mg/L	4,504 lbs/day	6,755 lbs/day	report	85% removal unless influent concentration <200 mg/L
BOD5 Blended Effluent	---	---	report	---	---	9,243 lbs/day	
TSS Blended Effluent	---	---	report	---	---	13,470 lbs/day	
E Coli Secondary Effluent	---	---	---	64 col/100 ml	---	427 col/100 ml	May 15-Sept 30
E Coli Blended Effluent	---	---	---	---	---	427 col/100 ml	May 15-Sept 30
TRC Secondary Effluent	---	---	---	1.0 mg/L	---	3.0 mg/L	
TRC Blended Effluent	---	---	---	---	---	1.0 mg/L	

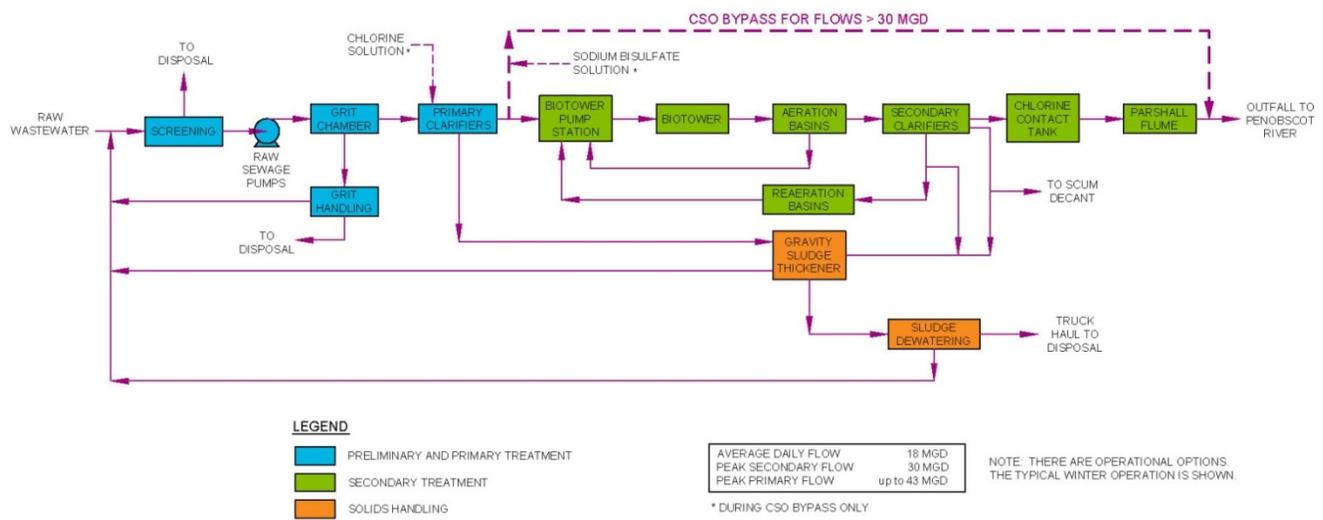


Figure 3-1. City of Bangor WWTP Schematic

The Permit requires that the combined (blended) secondary (Outfall 001A) and primary (CSO bypass, or Outfall 001B) effluents to meet the WWTP daily maximum secondary treatment numerical limits for BOD₅, TSS and E. Coli; the higher combined secondary and primary TRC limit of 1.0 mg/L is an exception. The blended effluent is designated as Outfall 001C.

It should be noted that while the WWTP is rated to treat 43 MGD to match the connected conveyance capacity of the Penobscot Interceptor (as recommended in the 1993 CSO Facilities Plan), that peak flow rate has never been recorded under actual operating conditions. The current raw sewage pumps can reliably deliver 36 MGD to the primary clarifiers and up to 39-40 MGD under certain conditions (e.g., wetwell level, condition of wear rings, etc.). Thus, this Phase II LTCP assumes a range of peak WWTP capacities of between 36 and 43 MGD to reflect both actual conditions and theoretical peak flow (should that higher capacity be deemed cost effective to achieve).

3.2.2 Disinfection Process

Both the secondary and primary CSO Bypass effluents are seasonally disinfected during the recreation season of May 15th through September 30th. The secondary effluent is disinfected in a Chlorine Contact Tank (CCT) whereas the CSO Bypass is disinfected within one of the three Primary Clarifiers that becomes a dedicated CSO settling and disinfection tank when influent flows exceed 30 MGD. Both effluents are disinfected using liquid sodium hypochlorite and dechlorinated using liquid sodium bisulfite. During bypass conditions, the two effluents are combined prior to discharge to the Penobscot.

3.2.3 High Flow Management Procedures

Flows in excess of 30 MGD, up to a peak of 43 MGD, receive preliminary and primary treatment and are then bypassed around the secondary treatment facilities as part of a permitted CSO Bypass as allowed for in the EPA CSO Control Policy and as regulated in the MEPDES Permit. As noted above, the CSO Bypass flows are blended with the secondary effluent and are required to meet the applicable numerical limitations.

3.3 Collection System

3.3.1 Subsections

The wastewater collection system has been divided into subsections. For the CSS, the subsections coincide with the tributary drainage area to each CSO outfall. In the case of the SSS, the subsections represent defined areas tributary to key connection points along the interceptor sewers.

3.3.2 Permitted CSOs

Table 3-3 contains the key features of the nine permitted CSO outfalls listed in Table 2-1 and shown on Figure 2-1. The data include the pipe network and acres of the total and combined portion of the subsection, from the model. The table also includes all separated sanitary sewers, listed after Central Street (CSO 023).

Table 3-3. Key Features of Combined Sanitary Sewer (CSS) and Separated Sanitary Sewer (SSS) Subsections

Subsection	CSO Outfall	Pipe Network (lf)	Total Area (acres)	Combined Area (acres)
<i>Barkersville</i>	002	82,300	785	577
<i>Davis Brook</i>	003	59,000	310	310
<i>Kenduskeag West</i>	006	34,000	153	102
<i>Kenduskeag East</i>	007	14,600	65	65
<i>Meadowbrook</i>	011	73,000	647	20
<i>Cemetery</i>	016	31,200	324	Not in model
<i>Carr Brook</i>	020	34,900	240	30
<i>Central Street</i>	023	1,700	6	6
Hildreth-Perry		54,000	1,142	
Dow		28,300	527	
Airport		56,700	977	
Capehart		37,000	391	
Burleigh		33,200	823	
Strickland		5,000	99	
Husson		6,500	220	
Arctic Brook		56,200	598	
Blanchard		11,900	110	
Fourteenth Street		12,100	83	
Mill Street		3,200	21	
Autumn		900	6	
Franklin		7,000	39	
Hancock		29,500	163	

Subsection	CSO Outfall	Pipe Network (lf)	Total Area (acres)	Combined Area (acres)
Woodlawn		20,600	347	
Penjajawoc		48,600	1,133	
Westland		6,300	133	
Glenwood		1,700	11	
Dutton		1,400	19	
May		1,900	11	

Note: Primarily combined subsections are shown in *italics*.

3.3.3 CSO Storage Facilities

Three CSO storage facilities were constructed as part of the City's ongoing CSO abatement program. In total, they provide 3.8 Million Gallons (MG) of storage capacity. The Davis Brook and Barkersville facilities are in-system or in-line conduits, and the Kenduskeag East facility is an off-line storage tank. The in-system facilities allow dry weather flow to pass continuously through, while the off-line design only accepts flow during wet weather conditions. The Davis Brook facility can be operated either way, although it has primarily been used as a flow through facility. All three facilities were constructed using pre-cast concrete sections. Both Davis Brook and Barkersville are configured as linear storage conduits, while Kenduskeag East is configured in the shape of a traditional storage tank.

Table 3-4 presents a summary of the three facilities listed in the order of their construction. The locations of these facilities are shown in Figure 2-1.

Table 3-4. Summary of Bangor's Three CSO Storage Facility

Facility	Capacity (MG)	Type
Davis Brook	1.2	In-System Conduit
Kenduskeag East	1.2	Off-Line Tank
Barkersville	1.4	In-System Conduit
Total	3.8	

The operation of each of the three facilities is controlled either through SCADA or by manual override by WWTP operations staff in order to optimize system-wide CSO capture and treatment.

4.0 Previous CSO Planning Documents

This LTCP is the second comprehensive evaluation of Bangor's CSO system. Other key earlier documents are described below beginning with the 1993 CSO Facilities Plan.

4.1 1993 CSO Facilities Plan

As noted earlier, the 1993 CSO Facilities Plan was the first comprehensive evaluation of Bangor's CSO system. In addition to recommending a long-term program of CSO abatement measures, the plan:

- Developed the initial hydrologic/hydraulic model of the collection system using the EPA Storm Water Management Model (SWMM).
- Established baseline conditions.
- Documented ambient water quality and CSO characteristics, and the impact of CSO discharges to the area receiving waters.
- Evaluated a wide range of control measures based on their ability to reduce CSO discharges and provide water quality benefits.
- Established 80% as the target level of CSO control.
- Recommended a series of abatement projects that included storage, treatment and sewer separation.
- Established a phased implementation schedule with key milestone dates.

While specific projects and milestones have been modified through processes consistent with both the 1991 CD and MEPDES Permits, the recommendations from the CSO Facilities Plan formed the basis of Bangor's CSO abatement program up to the present. The modifications that did occur over time were the result of Bangor's adopting an adaptive approach. This allowed Bangor to use lessons learned from earlier projects, and more detailed field conditions, to modify future control technology and design configurations.

4.2 Annual and CD-Related Reporting

Maine CSO communities are required to report annually on their CSO abatement and NMC activities. These annual reports are used by DEP to track abatement trends by community, river basin, and statewide.

Because Bangor was operating under the 1991 CD, it was also required to periodically report its progress with CSO abatement to EPA, including quarterly and semi-annual progress reports on the implementation of the recommended projects from the 1993 CSO Facilities Plan.

The 2015 CD contains similar requirements for progress reporting for the activities required by the CD, including the preparation of this LTCP.

4.3 2012 Phase 2 LTCP Progress Report

In response to the 2010 Section 308 RFI from EPA, Bangor prepared a draft Phase 2 LTCP in 2012 (2012 LTCP). This document, a series of nine Technical Memoranda (TM), was the precursor to this LTCP document.

The nine memoranda that comprised the draft Phase 2 LTCP, dated September 2012, included the following topics:

- Model update as TM P2LTCP.1
- Baseline characterization as TM P2LTCP.2
- Level of control evaluations as TM P2LTCP.3
- Decision framework and costing as TM P2LTCP.4
- Identification of feasible CSO controls as TM P2LTCP.5
- Feasible CSO control evaluation as TM P2LTCP.6
- Financial capabilities analysis as TM P2LTCP.7
- Affordability evaluation as TM P2LTCP.8
- Public participation summary as TM P2LTCP.9

A major focus of the 2012 draft LTCP was a preliminary evaluation of the additional control measures that Bangor would need to implement in order to increase the level of CSO control to EPA prescribed annual overflow frequencies of four, two, one and zero, all within the typical rainfall year. For example, a four overflow per year level of control denotes that, during a typical year, there would only be four storm and/or snowmelt events when one or more of the CSO outfalls would activate and a discharge to the receiving waters would occur.

5.0 System Characteristics

This section of the 2017 Phase II LTCP presents the historic and current characteristics of Bangor's Combined Sewer System (CSS), tracking progress from the original 1993 CSO Facilities Plan to the present. Data used in this process include rainfall and flow metering data that the City has collected over the past several years coupled with predictions from the updated hydrologic/hydraulic model of the collection system, the U.S. EPA Storm Water Management Model, or SWMM. Originally developed as part of the 1993 CSO Facilities Plan, the model has been periodically updated since that time to reflect physical changes to Bangor's collection and treatment system, and to incorporate additional CSO and rainfall data.

Since 2012, the City has been reporting CSO activity using data collected at flow meters at each CSO outfall. Table 5-1 contains a summary of the CSO activation and volume data reported to the DEP from 2012 to 2015. Based on the meter data, four of the CSOs make up the vast majority of the City's typical annual CSO volume. These four major CSOs are Barkersville (CSO 002), Davis Brook (CSO 003), Kenduskeag West (CSO 006) and Kenduskeag East (CSO 007) which resulted in 95.7% of the City's CSO volume from 2012 to 2015.

Table 5-1. CSO Monitoring Data (2012 to 2015)

Year	2012	2013	2014	2015	Average
Total Annual Rainfall (in)	42.3	39.3	43.9	35.5	40.3
Total Rainfall Associated with CSO	28.5	20.9	24.3	15.7	22.3
Volumes (MG)					
CSO Outfall					
Barkersville (002)	13.1	9.2	39.0	3.9	16.3
Davis Brook (003)	23.4	17.0	26.6	21.8	22.2
Kenduskeag West (006)	19.8	3.2	12.0	9.3	11.1
Kenduskeag East (007)	8.0	1.5	7.8	4.0	5.3
Hammond St. (009)	1.6	0.3	0.9	unknown	0.9
Meadowbrook (011)	3.3	0.7	1.4	0.7	1.5
Cemetery (016)	0.0	0.0	0.0	unknown	0.0
Carr Brook (020)	0.2	0.0	0.0	0.3	0.1
Central St. (023)	0.1	0.3	0.1	0.1	0.2
Systemwide CSO Volume (MG)	69.6	32.1	87.8	40.1	57.4

Activations					
CSO Outfall					
Barkersville (002)	17	11	22	10	15.0
Davis Brook (003)	28	23	32	18	25.3
Kenduskeag West (006)	10	6	7	3	6.5
Kenduskeag East (007)	8	4	5	3	5.0
Hammond St. (009)	12	3	3	1	4.8
Meadowbrook (011)	21	12	15	5	13.3
Cemetery (016)	0	0	0	1	0.3
Carr Brook (020)	3	4	7	3	4.3
Central St. (023)	7	8	7	5	6.8

These figures have been plotted and are presented in Figures 5-1 and 5-2 for annual activations and discharge volume, respectively. Both the individual CSO outfalls and system-wide values are shown.

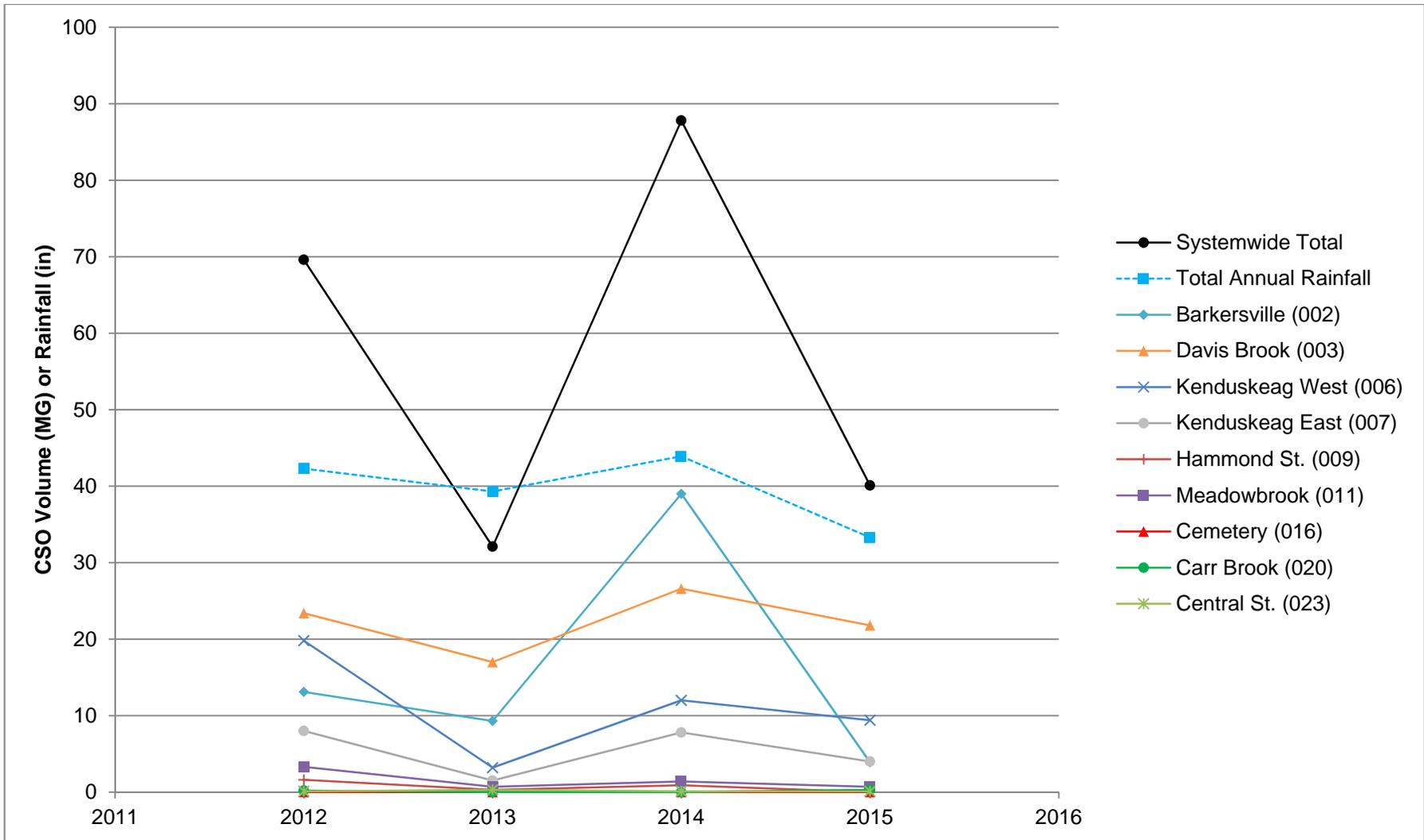


Figure 5-1. City of Bangor Annual CSO Volume (MG)

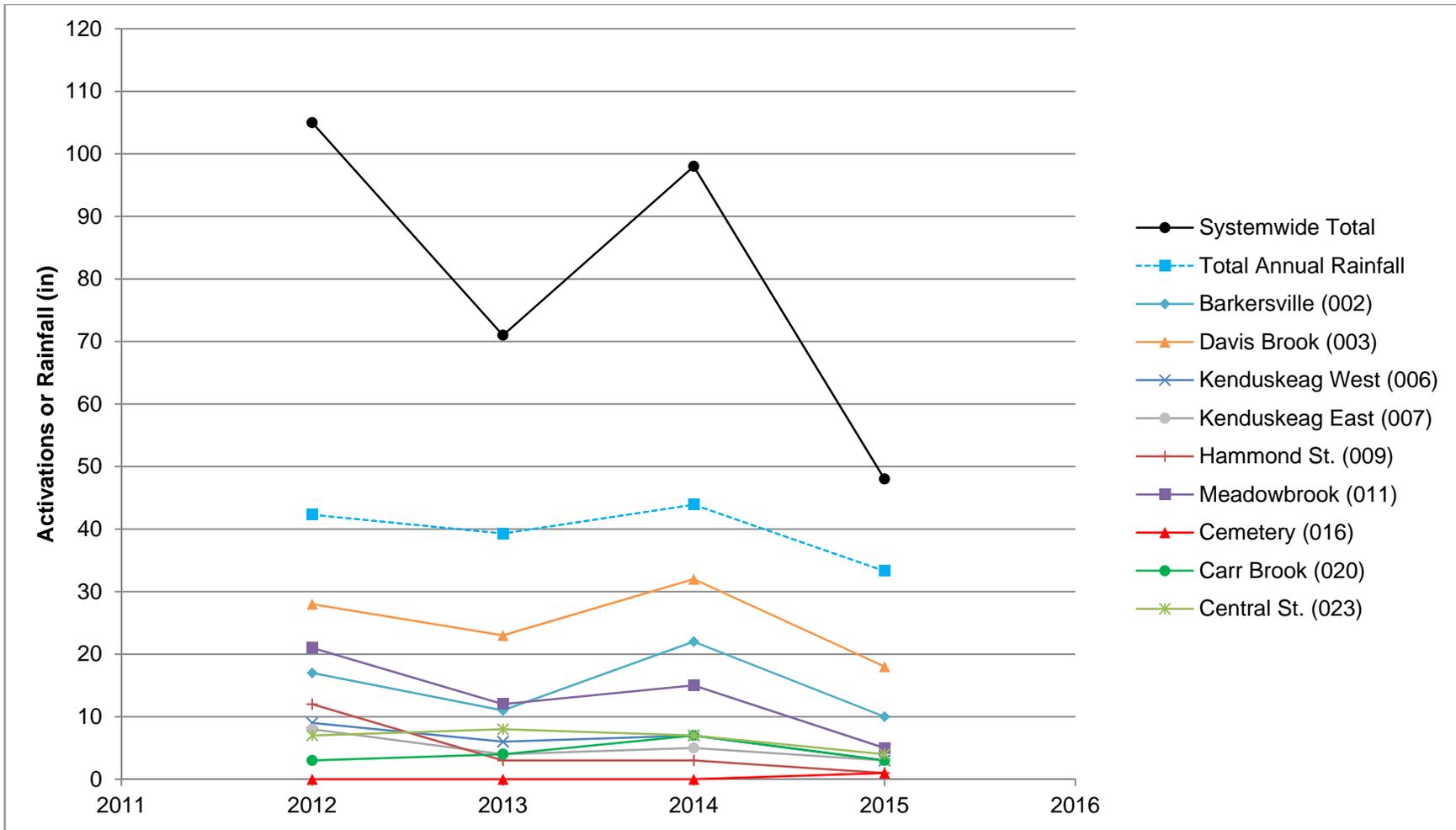


Figure 5-2. City of Bangor Annual CSO Activations

As part of the 2017 Phase II LTCP, the SWMM model was refined and recalibrated based on the additional flow meter data collected since the 2012 Phase 2 LTCP Progress Report. Details on the updated SWMM model calibration are presented in Appendix A. Table 5-2 contains a summary of the systemwide CSO volume distribution based on the meter data from Table 5-1 and two annual SWMM runs from the updated model: the 2014 annual run and the typical year (1974). The 1974 typical year rainfall was reviewed within the past 40 years of rainfall data and was determined to be a reasonable representation for the typical year. In addition, the model was run with more recent rainfall data to compare to current meter data.

Of the four largest outfalls, Davis Brook (CSO 002) and Barkersville (CSO 003) are the two largest contributors to the City’s annual CSO discharge, followed by Kenduskeag West (CSO 006) and Kenduskeag East (CSO 007) which rank third and fourth, respectively.

Of the remaining CSOs, Meadowbrook (CSO 011) has a relatively frequent amount of activations (an average of 13.25 from 2012 to 2015); however, it only contributes a small percentage of the system’s CSO volume (ranging from 0.5% to 2.6% from Table 5-2).

Table 5-2. Systemwide Distribution of CSO Volume

CSO Outfall	Percent of Annual CSO Volume		
	Flow Meter Data (2012 to 2015)	2014 SWMM Model Run	Typical Year SWMM Model Run (1974)
Barkersville (002)	28.4%	46.2%	36.3%
Davis Brook (003)	38.7%	42.8%	45.0%
Kenduskeag West (006)	19.3%	8.9%	15.8%
Kenduskeag East (007)	9.3%	1.4%	1.2%
Hammond St. (009)	1.6%	0.0%	0.0%
Meadowbrook (011)	2.6%	0.5%	0.7%
Cemetery (016)	0.0%	0.0%	0.0%
Carr Brook (020)	0.2%	0.1%	0.7%
Central St. (023)	0.3%	0.1%	0.2%

The updated SWMM model was used to evaluate the CSO characteristics over the typical year (i.e., the 1974 calendar year). The 2012 Phase 2 LTCP Progress Report established that the rainfall characteristic of 1974 were representative of the long-term precipitation patterns in the Bangor area and therefore was most suited to represent the typical rainfall year for the purposes of LTCP development. Prior to developing and evaluating CSO abatement alternatives, the model was first used to establish baseline values for systemwide CSO activations and volumes based on the typical year. Table 5-3 summarizes the baseline values for the collection system based on the updated SWMM model.

Table 5-3. System Baseline Characteristics for Typical Year (1974)

CSO Outfall	Activations	CSO Volume (MG)	Peak CSO Flow Rate (MGD)
Barkersville (002)	19 – 20	36.4 – 46.3	110.5
Davis Brook (003)	19	40.4 – 57.2	162.9
Kenduskeag West (006)	8 – 9	19.9 – 20.2	89.8
Kenduskeag East (007)	14	1.2 – 1.5	22.0
Hammond St. (009)	0	0.0	0.0
Meadowbrook (011)	12	0.9	5.8
Cemetery (016)	0	0.0	0.0
Carr Brook (020)	5	0.9	129.3
Central St. (023)	7	0.3	1.9
	84 – 86	100.0 – 127.2	

As shown, a range of values are included in the table to reflect the current peak WWTP capacity of the WWTP versus the theoretical capacity. As was described in Section 3, the rated capacity of the WWTP is 43 MGD based on the 1993 CSO Facilities Plan. However, the current raw sewage pumps can reliably deliver 36 MGD to the primary clarifiers, and up to 39-40 MGD under certain conditions (e.g., wetwell level, condition of wear rings, etc.). Thus, the baseline values have been calculated based upon this range of peak wet weather WWTP capacities: a low of 36 MGD to a high of 43 MGD. The higher values represent the lower WWTP capacity while the lower values represent the higher WWTP capacity.

6.0 Alternatives for Additional CSO Control

This section of the Phase II LTCP describes the process used to develop control measures that are available for consideration with respect to further advancing CSO reduction. This Phase II LTCP will build from the foundation of the existing, operational control measures. Also discussed is the multi-step process used to evaluate the measures, starting with a first-level or fatal flaw analysis to screen from consideration those measures that are not suited to Bangor. The remaining controls are then advanced for a more detailed evaluation and screening process. An important part of this process is the establishment of the targeted level of control for the LTCP with respect to reductions in annual systemwide CSO activations and discharge volume.

6.1 Available CSO Controls

CSO controls are typically grouped into categories that range from simpler, less costly source control measures to more complex and costly treatment and storage facilities. Table 6-1 contains the currently available measures grouped by the following categories: Source Controls, System Optimization, Conveyance Enhancements, Treatment and Storage.

Table 6-1. Available CSO Control Measures

Source Control
• Best Management Practices/Nine Minimum Controls (BMP/NMC)
• I/I Reduction/Sewer Rehabilitation
• Sewer Separation
• Green Infrastructure
System Optimization
▪ Weir Adjustment
▪ Bending Weirs/Control Gates
▪ Real Time Controls
Conveyance Enhancements
• Parallel Relief Interceptors
• Pump Station Expansion
Treatment (Satellite and Centralized at WWTP)
• Vortex Separation
• Retention Treatment Basin (RTB)
• High Rate Clarification (HRC)
• WWTP Expansion (Wet Weather Capacity)
• Disinfection in conjunction with treatment technologies
Storage
• In-System/Conduit
• Off-Line Tank
• Tunnel

For the most part, the more complex and costly measures also provide higher levels of volumetric and/or pollutant reduction control and are typically better suited for CSOs where a relatively high level of control is required in order to comply with the appropriate targeted reduction objectives.

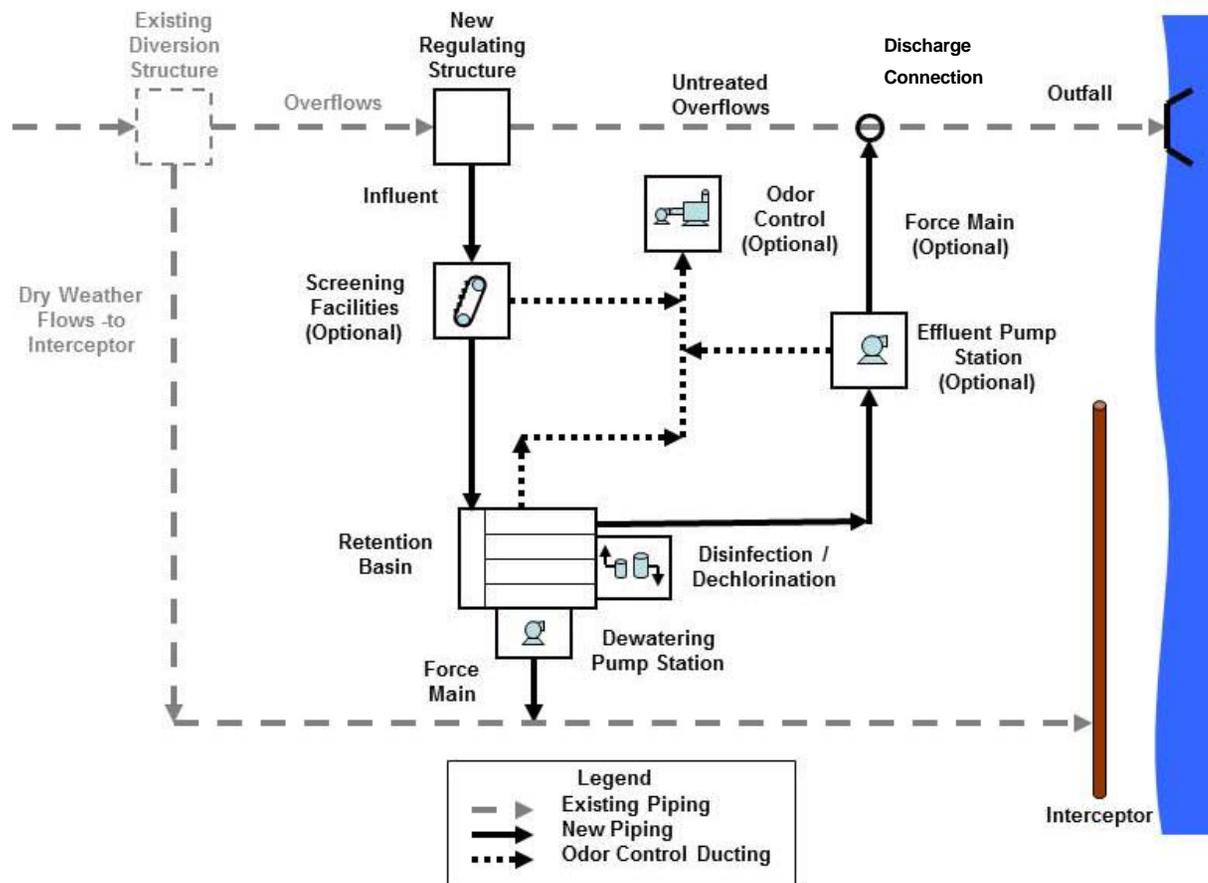


Figure 6-1. Retention Treatment Basin (RTB) Schematic

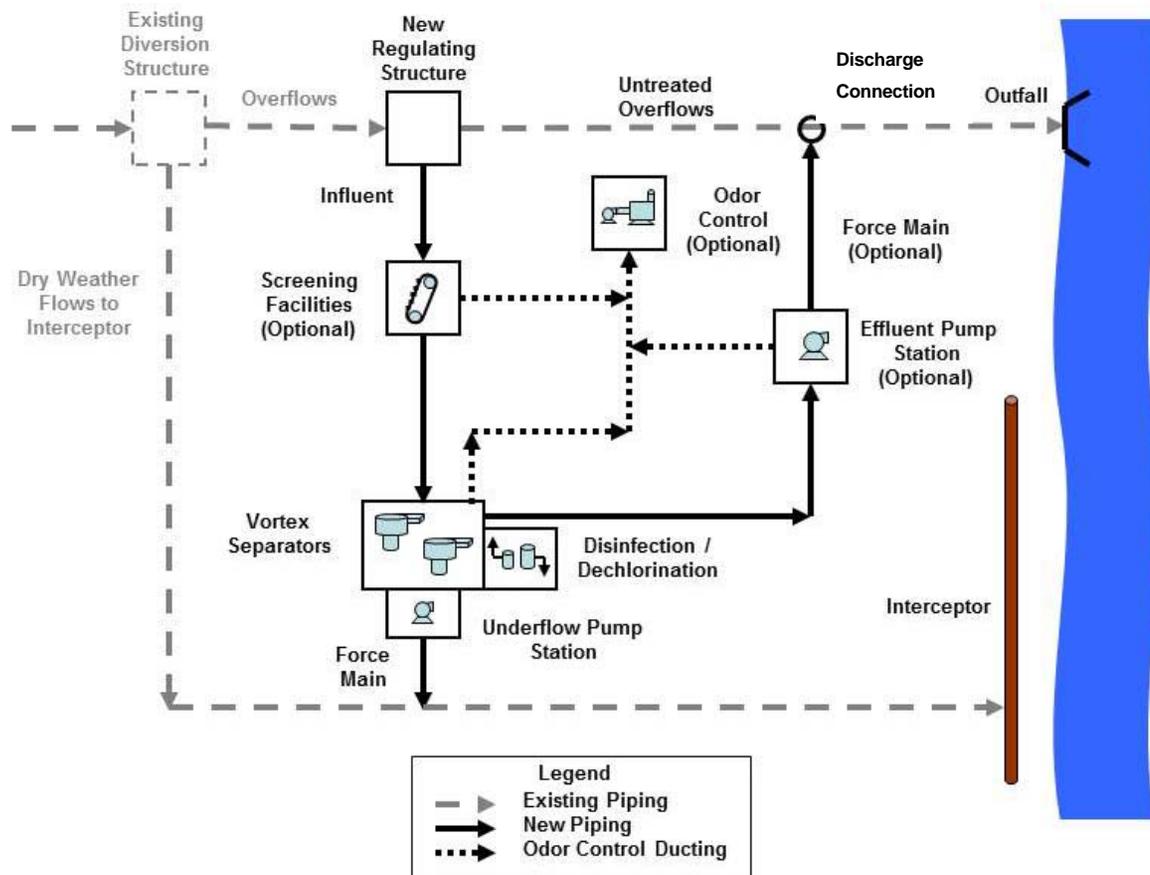


Figure 6-2. Vortex Separator with Disinfection Schematic

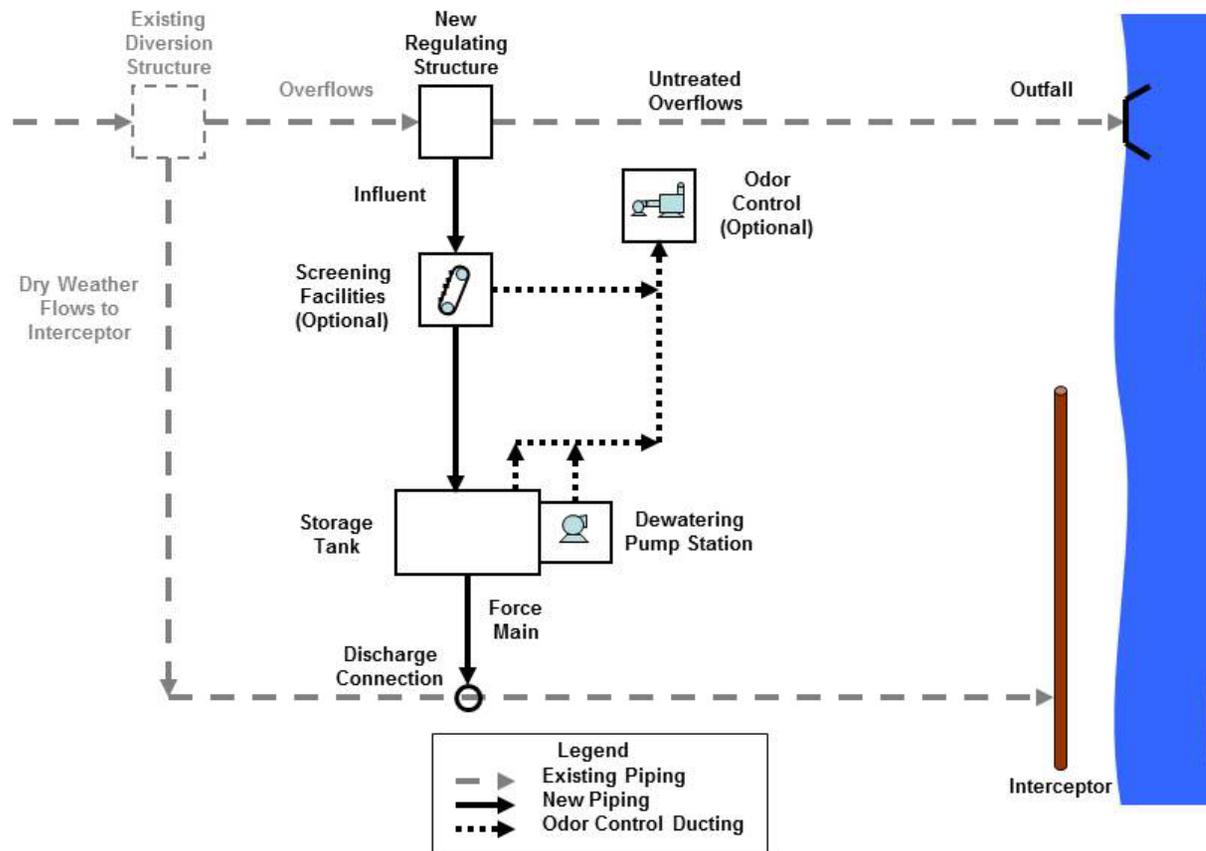


Figure 6-3. Offline Storage Tank Schematic

Schematic diagrams of the more commonly used Treatment (RTB and Vortex) and Storage (Off-line Tank) control alternatives are presented as Figures 6-1 through 6-3. It should be noted that the diagrams include possible influent or effluent pumping and odor control, elements that may or may not be required as determined in the course of the design. The following are controls that Bangor has implemented from the 1993 CSO Facilities Plan:

- All of the Source Control measures with the exception of Green Infrastructure (GI);
- Weir adjustments;
- WWTP expansion;
- In-system conduit storage and
- Off-line tank storage.

In general, and in particular for the largest CSO outfalls, storage is typically preferred over satellite treatment as it is a relatively simple process to operate. The stored volume is drained back to the WWTP following the storm where it receives full secondary treatment and seasonal disinfection. Satellite treatment on the other hand only provides an equivalent of primary treatment and seasonal disinfection. Satellite locations that include disinfection present both siting and operational challenges as each facility would require its own chemical storage and feed building along with the controls necessary to optimize the process and meet all of the imposed effluent limitations.

6.2 Evaluation and Screening Methodology

As noted previously, a multi-step process was employed to evaluate the available control measures. The first step is referred to as a fatal flaw analysis. This initial step allows for certain measures to be screened out from further consideration due to a single or multiple factors that make them unsuitable for CSO control in Bangor.

6.2.1 Fatal Flaw Analysis

Fatal flaws can include, but are not limited to: space limitations, complexity of operation, or any other consideration particular to Bangor and the current wastewater system operations. Another cause for this fatal flaw screening is that there are no further opportunities to implement the measure. Table 6-2 contains the results of this initial step.

Table 6-2. Results of Fatal Flaw Analysis

Source Control	Retained	Remarks
• Best Management Practices/Nine Minimum Controls (BMP/NMC)	No	Being implemented on a continuous basis and reported annually to DEP.
• I/I Reduction/Sewer Rehabilitation	Yes	Results from ongoing SSES investigations to be incorporated into LTCP, as appropriate.
• Sewer Separation	Yes	Primarily for the smaller subsections.
• Green Infrastructure	Yes	Limited public and private implementation; as a possible supplement to sewer separation.

Results of Fatal Flaw Analysis (Continued)		
System Optimization		
▪ Weir Adjustment	No	Already implemented; however additional beneficial adjustments may be found.
▪ Bending Weirs/Control Gates	No	May be included with other controls (e.g., storage tanks) to optimize operation.
▪ Real Time Controls	No	For future consideration when additional facilities are under design.
Conveyance Enhancements		
• Parallel Relief Interceptors	No	Primarily tied to wet weather WWTP expansion which is not viable due to limited space (see below).
• Pump Station Expansion	No	Primarily tied to wet weather WWTP expansion which is not viable due to limited space (see below).
Treatment (Satellite and Centralized at WWTP)		
• Vortex Separation	Yes	Satellite and WWTP site; provides primary equivalent treatment.
• Retention Treatment Basin (RTB)	Yes	Satellite only; provides primary equivalent treatment.
• High Rate Clarification (HRC)	No	Complex operation; need has not been established for treatment levels beyond primary equivalency.
• WWTP Expansion (Wet Weather Capacity)	No	Space limitations preclude major expansion; would also require significant increase in upstream interceptor and/or pump station capacity.
• Disinfection with Above Treatment Processes	Yes	Would be required seasonally at all treatment facilities.
Storage		
• In-System/Conduit	Yes	Similar to Barkersville and Davis Brook
• Off-Line Tank	Yes	Similar to Kenduskeag East only deeper
• Tunnel	No	Not suited for a city the size of Bangor.

As shown in the table, a majority of the available control measures were retained for further consideration. The definite exclusions included BMPs, the three System Optimization category measures, Conveyance Enhancements, high-rate satellite treatment and WWTP expansion, and tunnel storage. With regards to System Optimization, Bangor has been continually raising weirs at its CSO regulator structures and unless a new opportunity arises, additional weir adjustments will not be pursued as a stand-alone measure. Bending weirs, a more dynamic approach to static weirs, will not be considered as a stand-alone alternative but could be included in the design of a storage tank to optimize its operation.

HRC was eliminated as there was no established need for CSO treatment (satellite or at the WWTP) to be at a higher level than the minimum (primary) prescribed in both the DEP and EPA guidance documents. WWTP expansion was also eliminated as the current interceptor system capacity is limited to 43 MGD; any increase would require major re-construction of the lower end of the Penobscot Interceptor which was tunneled through bedrock in the 1960s.

Because of these restrictions, other Conveyance Enhancement category measures were likewise eliminated, specifically parallel relief interceptor sewers and/or pump station expansions. In order to be effective, the new conveyance facilities would have to transport high rates of flow to new wet weather treatment processes at the WWTP site (e.g., vortex separation or HRC), plus disinfection. The impact of new wet weather treatment processes on existing unit processes and equipment would need to be carefully explored, particularly influent pumping, screening and grit removal in addition to sludge thickening, storage and dewatering. Also to be considered would be the impact on the disinfection chemical storage and feed system which is currently designed to handle wet weather flows up to a maximum of 43 MGD.

Finally, tunnels were excluded due to Bangor's relatively small size when compared to the larger cities that have more area for this measure.

6.2.2 Second Level Screening

The second level of control measure screening builds upon the fatal flaw analysis described above. Based upon those results, the most suitable control measures for the individual outfalls are presented in Table 6.3. Also included in the table are the current controls for the Barkersville, Davis Brook and Kenduskeag East CSO outfalls.

Table 6-3. Control Measure Alternatives for Further Consideration

CSO Outfall	Current Control	Storage/ Additional Storage ¹	Sewer Separation ^{2,3}	Treatment ⁴ (RTB or Vortex)	Sewer Replacement/ Rehabilitation	Green Infrastructure (GI)
Barkersville (002)	1.4 MG Conduit	Yes	Yes	Yes	Supplement	Supplement
Davis Brook (003)	1.2 MG Conduit	Yes	Yes	Yes	Supplement	Supplement
Kenduskeag West (006)	--	Yes	Yes	Yes	Supplement	Supplement
Kenduskeag East (007)	1.2 MG Tank	Yes	Yes	No	Supplement	Supplement
Hammond Street (009)	--	No	Yes	No	Yes	Supplement
Meadowbrook (011)	--	No	Yes	No	Yes	Supplement
Cemetery (016)	--	No	Yes	No	Yes	Supplement
Carr Brook (020)	--	No	Yes	No	Yes	Supplement
Central Street (023)	--	No	Yes	No	Yes	Supplement

¹ Storage tank or linear storage conduit.

² Public inflow only (e.g., catch basins and drains); does not include private sources.

³ As (1) a stand-alone control (2) supplement to other control or (3) for CSO elimination/100% control.

⁴ Including seasonal disinfection.

As shown in the table, because of the relatively large volumes of overflow discharged from the four largest CSO outfalls - Barkersville, Davis Brook, Kenduskeag West and Kenduskeag East - storage was considered to be the primary control measure for those locations along with RTB and vortex treatment plus disinfection. Sewer separation, sewer replacement/rehabilitation and GI were only considered as supplemental controls for these large outfalls.

For the smaller outfalls, sewer separation and sewer replacement/rehabilitation were the primary control measures considered, along with GI where the application of such could be cost-effectively included on a case by case basis.

CSO elimination was not considered for Bangor's four largest outfalls due to both practical limitations and costs. However, in order to include this extreme level of control in the evaluation process, costs for sewer separation were developed for both the four largest CSO outfalls and the smaller ones as well in order to view and compare the full range of control levels.

6.3 Preliminary Sizes of Control Measures at Four Largest CSO Outfalls

The next step in the alternative development and evaluation process was sizing of the control facilities over the range of possible levels of control. This was performed for the control measures at the four largest outfalls remaining after the initial screening process as shown in Table 6-3. The level of control is defined as the number of activations that would result from implementation of the control measure over the typical rainfall year as described in Section 5. The range of possible controls considered for this Phase II LTCP included a high of 8 annual activations to a low of 2 annual activations with 6 and 4 activations included as mid-points.

During any particular wet weather event, one, two or all of the CSO outfalls may activate, but it only takes a single CSO outfall activation to be considered an event. Thus, the most frequently occurring CSO outfall determines the number of system-wide events.

It should be noted that in addition to annual activations, reductions in annual volume is another measure of control and is used in a parallel fashion with annual activations. It should also be noted that while a storage facility would totally capture a CSO discharge up to its storage capacity, corresponding to its design level of control, a satellite CSO treatment facility would treat the discharge up to its design level of control. While the resulting discharge from the treatment facility would have an effluent of less than secondary effluent quality, it would be in compliance with current applicable DEP and EPA CSO policies.

The sizing of the control measures is based either on one of two criteria: discharge volume or peak flow rate. Volume is used to size storage tanks or conduits, while peak flow rates are used to size treatment facilities whether RTB or vortex, plus disinfection. The updated SWMM, described in Section 5, was used to develop the volumes and flow rate values for the four major CSO outfalls for the range of possible control levels. Facility sizes required are shown in Tables 6-4 and 6-5 for storage and treatment alternatives, respectively.

Table 6-4. Storage Volumes at Individual Outfalls Over Range of Control Levels in Million Gallons (MG)

CSO Outfall	Annual Activations			
	8	6	4	2
Barkersville (002)	1.1 - 1.5	1.4 - 3.2	3.0 - 3.6	3.6 - 4.7
Davis Brook (003)	1.3 - 1.8	1.5 - 2.7	2.5 - 3.8	5.3 - 6.4
Kenduskeag West (006)	0.2	0.3	0.8 - 1.0	3.1 - 3.9
Kenduskeag East (007)	0.1	0.1	0.1	0.2
Subtotal – Four Largest	2.7 - 3.6	3.3 - 6.3	6.4 - 8.5	12.2 - 15.2
Systemwide	2.8-3.7	3.5 - 6.4	6.7 - 8.8	12.5 - 15.5

Table 6-5. Peak Flows at Individual Outfalls Over Range of Control Levels in Million Gallons per Day (MGD)

CSO Outfall	Annual Activations			
	8	6	4	2
Barkersville (002)	35.6 - 39.4	38.4 - 42.8	47.3 - 47.5	50.1 - 52.7
Davis Brook (003)	13.8 - 18.9	18.4 - 20.3	25.1 - 26.3	32.9 - 33.8
Kenduskeag West (006)	8.1	16.2 - 24.5	37.1 - 37.7	43.7 - 44.1
Kenduskeag East (007)	2.1 - 3.7	4.5 - 4.8	4.8 - 4.9	5.5 - 6.5

As shown in the two tables, a range of values is included for some entries which denote the degree of sensitivity to the variation in the peak wet weather capacity at the WWTP. The lower values represent the WWTP with a peak wet weather capacity of 43 MGD whereas the higher values would be the case for the WWTP at 36 MGD. Because of they are located hydraulically upstream of the Kenduskeag PS, some of the predicted values for Kenduskeag West and East were not impacted by WWTP capacity and, as such, a very small variation or single value is shown.

The sensitivity of the volumes with respect to level of control can be best illustrated by comparing the systemwide totals for 8 activations per year to 2 activations per year. The former is in the 2.8 to 3.7 MG range whereas the latter is in the 12.5 to 15.5 MG range, an approximate 4 fold increase. The peak flow rates have only an approximate 2 fold increase between 8 and 2 activations per year. However, while the peaks flows do not increase in the same order of magnitude as do the volumes, the actual volume associated with the discharges would increase in proportion.

Using the values from Tables 6-4 and 6-5, the control measures were physically sized for the four largest CSO outfalls over the range of control levels. The following criteria were generally used in the facility sizing:

1. Storage Conduits:

- Largest conduit cross-section was 12 ft. by 12 ft.; multiple (parallel) conduits were used when that size was exceeded.
- Conduits were not considered viable for Kenduskeag West or East (CSOs 006 and 007) due to availability of land and location of outfalls.

2. Storage Tanks:

- Storage tanks were assumed to be 18 ft. deep and to have a length-to-width ratio of 2:1.
- Storage tanks were the only control measure considered for Kenduskeag East (CSO 007).
- Because of their close proximity and discharge characteristics, a single storage tank was also considered for combining Kenduskeag West and East (CSOs 006 and 007).

3. RTB:

- RTBs were sized based on a Surface Overflow Rate (SOR) of 4,000 gallons per day per square foot (gpd/sf) at peak flow, were assumed to be 18 ft. deep, and to have a length-to-width ratio of 2:1.

4. Vortex:

- Units were sized based on a SOR of 15,000 gpd/sf, and would be 35 ft. deep or less; units with calculated diameters larger than 35 ft. would result in multiple units with an equivalent surface area plus the required flow distribution structure.
- Vortex was deemed to be unsuitable for Kenduskeag West or East (CSOs 006 and 007) due to the potential for downstream solids deposition in the Davis Brook Conduit from the foul sewer which is required to be in operation when the vortex unit is receiving flow.

5. Disinfection Building (for RTB or Vortex)

- Sized at 60 ft. by 60 ft. to house chemical storage and feed equipment and building support functions.

The results of the sizing exercise are presented in Tables 6-6, 6-7, 6-8, 6-9 and 6-10 for Barkersville (CSO 002); Davis Brook (CSO 003); Kenduskeag West (CSO 006); Kenduskeag East (CSO 007); and the combination of Kenduskeag West and East (CSOs 006 and 007), respectively.

Table 6-6. Approximate Facility Sizing Over Range of Control Levels in Feet – Barkersville (CSO 002)¹

Control Measure/Activations	8		6		4		2	
	Smallest	Largest	Smallest	Largest	Smallest	Largest	Smallest	Largest
Storage Conduit (1,850 ft long)	10 x 8	11 x 10	12 x 9	Twin 12 x 10	Twin 12 x 9	Twin 12 x 11	Twin 12 x 11	Not feasible ³
Storage Tank	128 x 64	149 x 75	142 x 71	218 x 109	211 x 106	231 x 116	231 x 116	264 x 132
RTB and Disinfection	172 x 57	163 x 54	179 x 60	170 x 57	188 x 63	188 x 63	199 x 66	194 x 65
Vortex and Disinfection ²	58 (dia)	55 (dia)	60 (dia)	57 (dia)	63 (dia)	63 (dia)	67 (dia)	65 (dia)

¹ Smallest size denotes WWTP at 43 MGD; largest denotes WWTP at 36 MGD.

² Diameter of single unit shown; if greater than 35 ft multiple units with equivalent surface area would be required.

³ Exceeds 12 ft by 12 ft max. cross section.

Table 6-7. Approximate Facility Sizing Over Range of Control Levels in Feet – Davis Brook (CSO 003)¹

Control Measure/Activations	8		6		4		2	
	Smallest	Largest	Smallest	Largest	Smallest	Largest	Smallest	Largest
Storage Conduit (2,250 ft. long)	10 x 8	12 x 9	12 x 9	Twin 9 x 9	Twin 12 x 9	Twin 11 x 10.5	Twin 12 x 11	Not feasible ³
Storage Tank	139 x 69	164 x 82	149 x 75	200 x 100	193 x 96	238 x 119	281 x 140	308 x 154
RTB and Disinfection	102 x 57	119 x 40	117 x 39	123 x 41	137 x 46	140 x 47	157 x 52	159 x 53
Vortex and Disinfection ²	34 (dia)	40 (dia)	40 (dia)	42 (dia)	46 (dia)	47 (dia)	53 (dia)	54 (dia)

¹ Smallest size denotes WWTP at 43 MGD; largest denotes WWTP at 36 MGD.

² Diameter of single unit shown; if greater than 35 ft multiple units with equivalent surface area would be required.

³ Exceeds 12 ft by 12 ft max. cross section.

Table 6-8. Approximate Facility Sizing Over Range of Control Levels in Feet – Kenduskeag West (CSO 006)¹

Control Measure/Activations	8		6		4		2	
	Smallest	Largest	Smallest	Largest	Smallest	Largest	Smallest	Largest
Storage Tank	--	55 x 27	67 x 33	67 x 33	109 x 55	122 x 61	241 x 120	215 x 107
RTB and Disinfection	--	78 x 26	110 x 37	136 x 45	167 x 56	168 x 56	181 x 60	182 x 61

¹ Smallest size denotes WWTP at 43 MGD; largest denotes WWTP at 36 MGD.

Table 6-9. Table 6-9. Approximate Facility Sizing Over Range of Control Levels in Feet – Kenduskeag East (CSO 007)¹

Control Measure/Activations	8		6		4		2	
	Smallest	Largest	Smallest	Largest	Smallest	Largest	Smallest	Largest
Storage Tank	--	52 x 17	37 x 18	60 x 20	37 x 18	61 x 20	47 x 24	64 x 21

¹Smallest size denotes WWTP at 43 MGD; largest denotes WWTP at 36 MGD.

Table 6-10. Approximate Facility Sizing Over Range of Control Levels in Feet – Combined Kenduskeag West and East (CSOs 006 and 007)

Control Measure/Activations	8		6		4		2	
	Smallest	Largest	Smallest	Largest	Smallest	Largest	Smallest	Largest
Storage Tank	--	75 x 37	75 x 38	76 x 38	115 x 57	130 x 65	222 x 111	245 x 123

¹Smallest size denotes WWTP at 43 MGD; largest denotes WWTP at 36 MGD.

A few observations of the sizing are noted as follows:

- In some cases, two parallel conduits were required for Barkersville (002) and Davis Brook (003). In other cases, conduits were not feasible due to the required cross section exceeded 12 ft. by 12 ft.
- As expected, the capacity of the WWTP had less of a factor in the sizing of the Kenduskeag West and East (CSOs 006 and 007) facilities than the Barkersville (002) or Davis Brook (003) facilities.
- The RTB at Kenduskeag West (CSO 006) was larger than the storage tank and as such, it was eliminated from further consideration.
- The single storage tank concept for Kenduskeag West and East (CSOs 006 and 007) appears to be economical and was henceforth used in lieu of two separate facilities.

These findings were incorporated in the preliminary cost estimating and determination of the targeted level of control as described below.

6.4 Preliminary Costing of Control Measures at Four Largest CSO Outfalls

Preliminary cost estimates were then developed for these sized control facilities. The preliminary costs at this stage in the evaluation did not take into account all of the site-specific cost elements, such as land purchases or contamination mitigation, but were used to develop a generalized trend to establish the knee-of-the-curve (KOTC) or the cost-effective level of control. The bases for the estimates were costs obtained from recent similar CSO abatement projects in Maine and, in the case of vortex, vendor-supplied estimates.

The results of this preliminary cost estimating are shown in Table 6-11. The costs span the range of control levels (8, 6, 4 and 2 activations per year) and WWTP capacities (36 MGD to 43 MGD). The highest costs denote the WWTP at 36 MGD whereas the lowest costs denote the WWTP at 43 MGD. Also included is an allowance to modify the WWTP so that it can reliably achieve a peak flow rate of 43 MGD. This allowance would not be required with the 36 MGD-based facilities.

Table 6-11. Estimated Ranges of CSO Abatement Costs Expressed as Opinion of Probable Total Project Costs in Million Dollars¹ (Based on ENR=10386, dated August 2016)

	Annual Activations			
	8	6	4	2
Barkersville - CSO 002				
Storage Conduit	\$12 - \$13	\$13 - \$20	\$19 - \$22	\$21 - \$25
Storage Tank	\$9	\$9 - \$18	\$15 - \$22	\$20 - \$26
RTB and Disinfection	\$15 - \$17	\$16 - \$17	\$17	\$16 - \$17
Vortex and Disinfection	\$15 - \$17	\$16	\$19	\$21
Davis Brook – CSO 003				
Storage Conduit	\$11 - \$15	\$14 - \$18	\$17 - \$22	\$27 - \$30
Storage Tank	\$9 - \$11	\$10 - \$16	\$15 - \$27	\$29 - \$35
RTB and Disinfection	\$6 - \$8	\$8 - \$9	\$9	\$10 - \$11
Vortex and Disinfection	\$8 - \$10	\$10	\$11 - \$12	\$11 - \$15
Kenduskeag West and East - CSOs 006 and 007				
Storage Tank	\$3	\$3 - \$4	\$9	\$19 - \$23
WWTP²	\$3	\$3	\$3	\$3

¹ Over range of 36 MGD to 43 peak wet weather WWTP capacity.

² Estimate of CSO treatment only to reliably attain 43 MGD; does not include related improvements to influent screens, grit handling, etc.

These costs were then used to establish the desired level of control for this Phase II LTCP.

6.5 Establishment of Level of Control

This section describes the determination of the level of control for this Phase II LTCP preceded by a summary of the process used in the 1993 CSO Facilities Plan to establish the original level of control.

6.5.1 1993 CSO Facilities Plan

The 1993 CSO Facilities Plan established an 80% volumetric control target. As was discussed in Section 5, Bangor met or exceeded this target through the diligent implementation of the key elements of the 1993 plan. The 80% level of control was developed by plotting volumetric reductions against the costs to attain the associated level of control. A KOTC was clearly evident at the 80% level of control and hence, that became the targeted level of control for City's initial CSO plan.

It should be noted that the 1993 CSO Facilities Plan was completed prior to the issuance of the EPA CSO Control Policy which was published in 1994. Under the EPA Policy, the concepts of both volumetric and CSO activations were introduced as control metrics. For example, in the so-called Presumptive Approach, a CSO community could be considered to be in compliance with the Policy if a number of factors were satisfied, the two most critical being that there was an 85% volumetric control or

no more than four overflows occurred in a typical year. While DEP never prescribed to the Presumptive Approach, the inclusion of these metrics in the EPA Policy established their importance in the development of LTCPs.

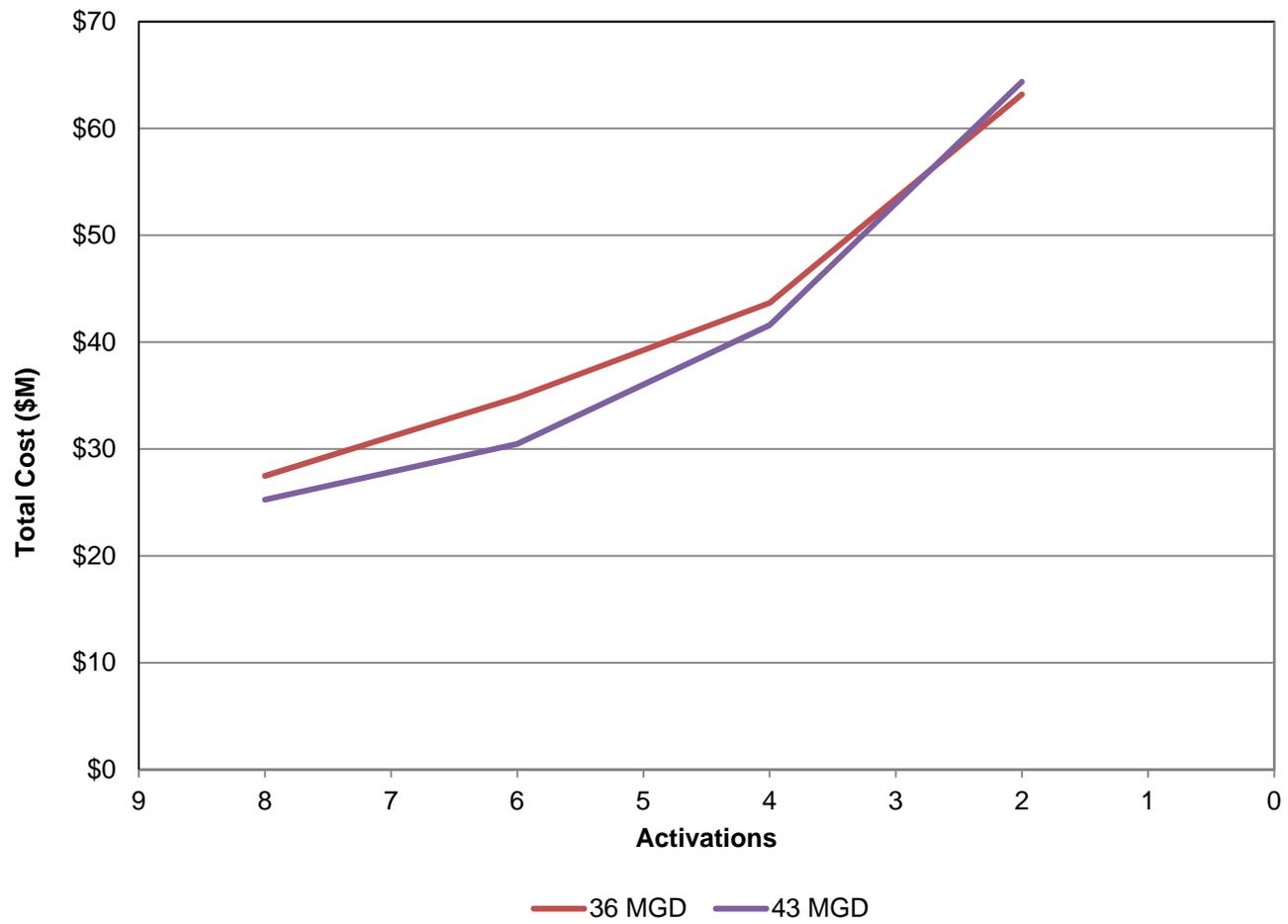
6.5.2 Current LTCP

Since the issuance of the 1994 EPA Policy, associated LTCP guidance documents indicate that in addition to volumetric reductions, a range of annual CSO activations should be considered in LTCP evaluations. For the purpose of this LTCP, typical-year activations of 8, 6, 4 and 2 were considered in concert with volumetric control.

The preliminary cost estimates described above for the CSO control alternatives were plotted over the range of control levels in order to determine if a cost-effective level of control was evident. The average cost for each of the viable control measures at each location was used to develop the plot. The results are shown in Figure 6-4. As shown, two lines were plotted, one for the WWTP at 36 MGD (top) and the other with the WWTP at 43 MGD (bottom). Based on these results, it is clear that 4 activations per year is the most cost-effective control level for Bangor as indicated by the inflection point, or KOTC, under either WWTP capacity. This denotes that the incremental costs that would be incurred by moving to the next higher level of control, 2 activations per year, would be both significantly more costly and less cost-effective.

It should be noted that in addition to assessing the cost-effective level of control using average costs for each control measure and at each location, cost-effectiveness was also assessed on a site-specific basis using costs for each individual control measure. This site-specific assessment serves as a check and supports the conclusion drawn from Figure 6-4 that 4 activations per year is the most cost-effective control level.

Based on this conclusion, the remainder of control alternatives development and evaluation will be based on 4 activations per year.



6.6 Outfall-Specific Control Measure Layouts

This section focuses on the individual outfalls and the manner in which the control measures would be sited, configured and operated.

6.6.1 Barkersville – CSO 002

Layouts for the control facilities sized at 4 activations per year were developed for the Barkersville outfall. Both types of storage configurations were deemed to be viable: linear storage conduits and off-line storage tanks. Both storage configurations could readily be sited at Bass Park, a City-owned property, where the existing 1.4 MG storage conduit is located. Treatment facilities, both RTB or vortex, would need to be located further downstream, closer to the Penobscot Interceptor so that the treated effluent would have access to the current CSO 002 outfall to the Penobscot River.

The layout of the new storage facilities at Bass Park are shown in Figure 6-5. With respect to the storage conduits, dual lines are necessary and these would be constructed parallel to the existing conduit. The storage tank would be located in a parking lot to the southeast of the head end of the existing conduit.

Operationally, the new conduits would be gravity fed and gravity drained, similar to the existing conduit. The influent flow would continue to enter the existing conduit and passively overflow into the new conduits as additional volume is needed. Excess flow would be allowed to discharge using the overflow structure in the existing conduit. Flow would enter the storage tank in a similar passive fashion as with the conduits.

With the parallel conduit configuration, the storage volume would be drained back into the system following the storm event in a similar manner to the existing conduit using control gates. For the storage tank, dewatering pumps would be used to drain the tank which would also be equipped with an automatic flushing mechanism to clean the tank floor of settled solids and debris following the dewatering. Details of the feed and drain features are shown in Figure 6-6.

RTB or vortex treatment would need to be located downstream of Bass Park in order that the treated effluent would have a path to the existing CSO 002 outfall sewer to the Penobscot River. The former Emera property was deemed to be the most suitable site for these facilities. It is also the location of the existing Barkersville regulator structure which would need to be modified or replaced to feed the treatment facilities.

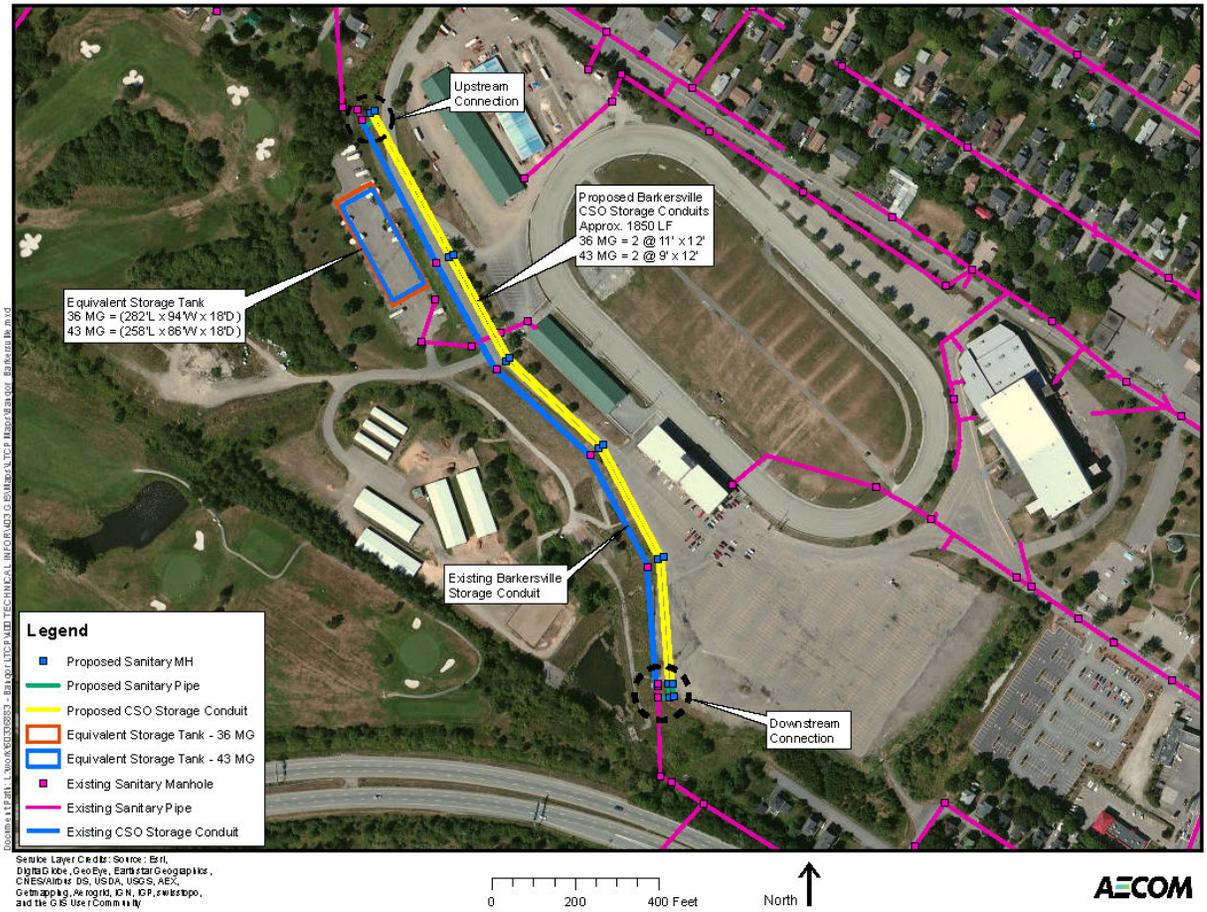


Figure 6-4. Barkersville Storage Tank and Storage Conduit Layouts

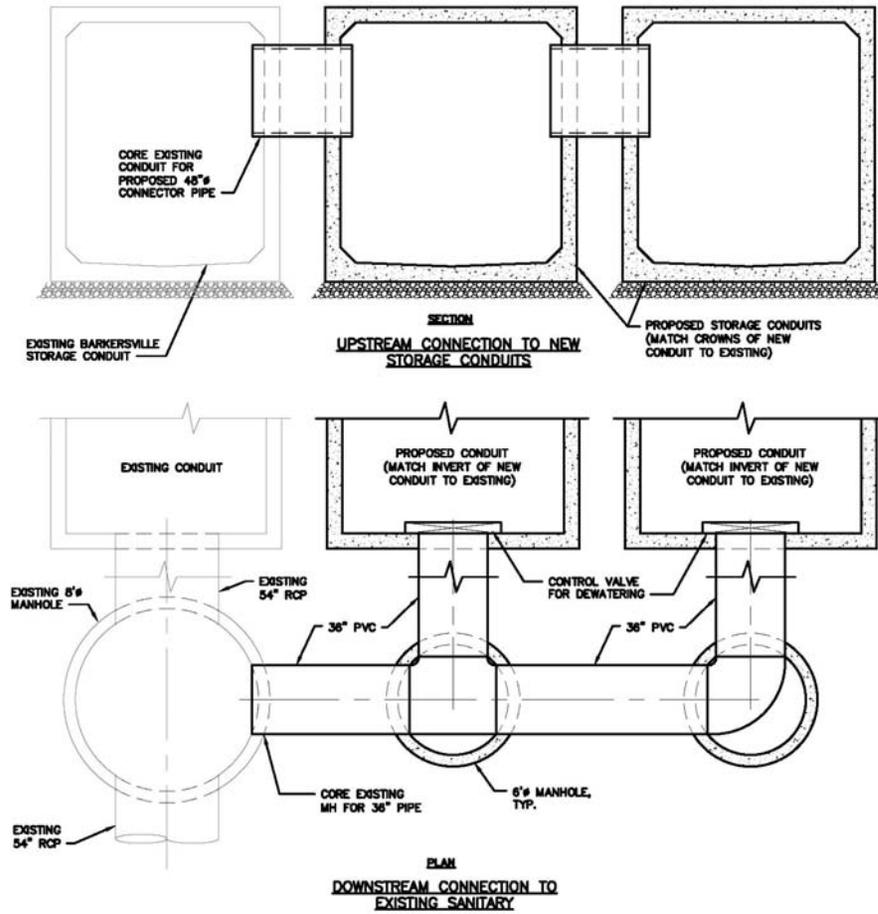


Figure 6-5. Barkersville Conceptual Parallel Conduit Layout

Layouts of the treatment facilities are shown in Figures 6-7 and 6-8 along with the new, replicated regulator structure. Also shown are the influent, effluent and chemical feed lines. As shown, influent into the treatment processes would originate from the new regulator structure constructed just downstream of the existing regulator structure. The treated effluent from either process would be connected to the existing CSO 002 outfall whereas the foul sewer or vortex underflow, or the dewatering force main from the RTB dewatering pumps, would be directed to the Penobscot Interceptor for eventual treatment at the WWTP. The RTB tank would also be equipped with dewatering pumps and an automated flushing mechanism to clean the floor of settled solids and debris. A 60 ft. by 60 ft. Disinfection Building would be included for both the vortex and RTB alternatives.

As shown in Figure 6-7, multiple vortex units, three at 36-ft. diameter, would be needed as a single unit would have a very large diameter for such facilities: 63 feet. Multiple units would require a splitter box to feed the units, three separate influent and effluent lines, and more complex chemical feed and process control systems for the two-chemical disinfection process. For these reasons, vortex is no longer considered viable for Barkersville, and RTB will remain as the single treatment alternative.

6.6.2 Davis Brook - CSO 003

Layouts were prepared for the control facilities sized at 4 activations per year. These are shown in Figure 6-9. As with Barkersville, the two types of storage configurations were both deemed to be viable for Davis Brook; linear storage conduits and off-line storage tanks. Both storage configurations would be located along the Penobscot River in the vicinity of the Waterfront Pavilion, a City-owned property. Also, as with Barkersville, the new conduits would be constructed parallel to the existing 1.2 MG conduit. Depending upon the WWTP capacity, a single or dual additional conduit would be required. Should a single conduit be installed, it could possibly be constructed in such a manner as to physically replace the existing Penobscot Interceptor. The interceptor is rarely used following activation of the Davis Brook conduit which serves as conveyance during dry weather and storage during wet weather—The placeholder site for the storage tank is further downstream to avoid, to the extent possible, disruption to the Waterfront Pavilion activities.

The additional flow into the new facilities would originate from the existing regulator structure on Main St. The existing regulator would need to be modified such that excess flow would be directed into the existing Davis Brook conduit instead of being discharged to the Penobscot River via the stone outfall sewer. These modifications are shown in Figure 6-10. A new sewer parallel to the existing Railroad St. sewer would be built for this purpose as shown in Figure 6-11. As with the Barkersville concepts described above, when the capacity of the existing Davis Brook conduit is exceeded, the excess flow would enter the new parallel conduit or conduits, or storage tank. This would also be the case for the influent to the RTB or vortex processes. For the storage concepts, flow in excess of both the existing and new storage facilities would continue to discharge via the high flow weir at the existing conduit that also discharges to the stone outfall sewer.

With the parallel conduit concepts, the storage volume would be drained back into the system following a storm event in a similar manner as with the existing conduit. This is shown in Figure 6-10. For the storage tanks, dewatering pumps would be used to drain the tank.

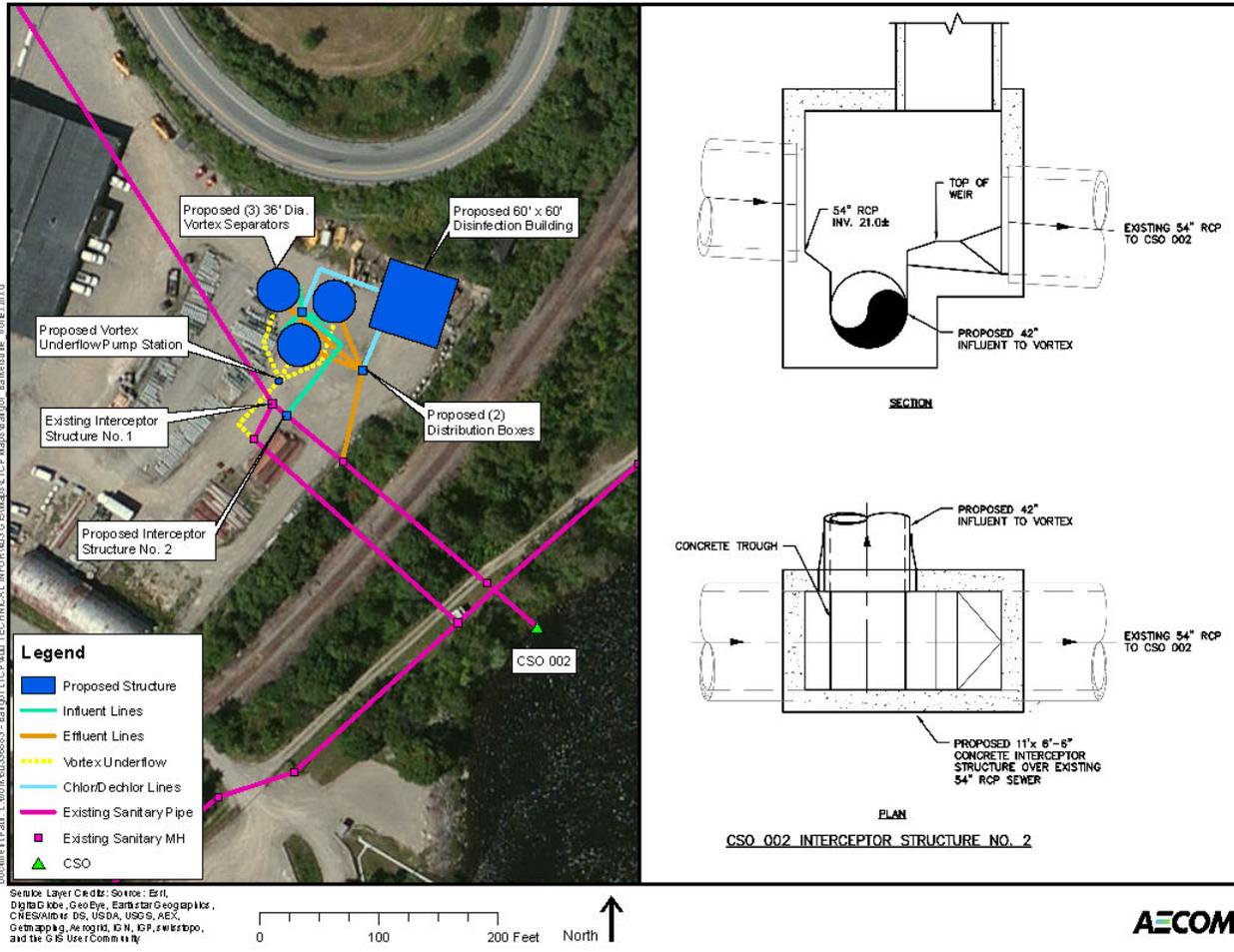
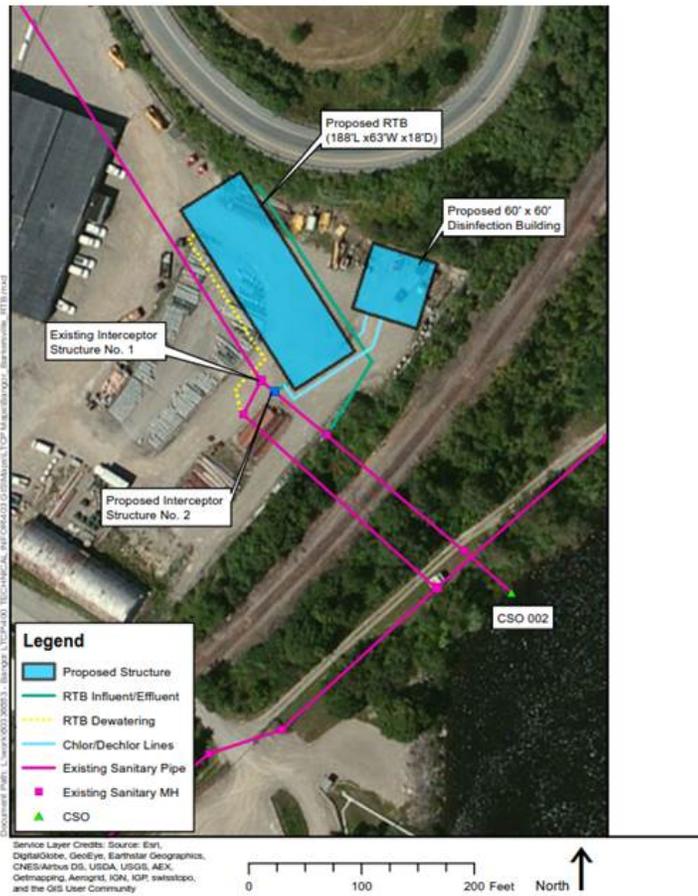
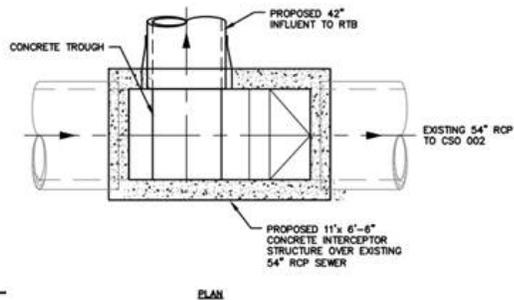
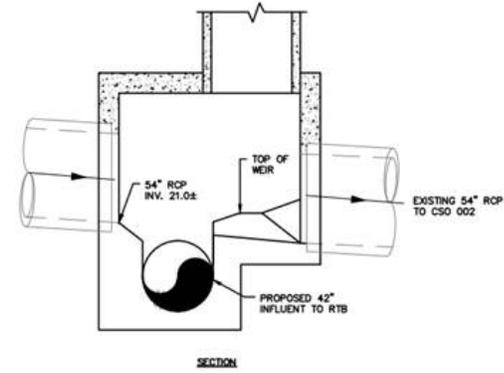


Figure 6-6. Barkersville Vortex Layouts



Conceptual Alternatives/Layouts- Barkersville: RTB



CSO 002 INTERCEPTOR STRUCTURE NO. 2



Figure 6-7. Barkersville RTB Layouts

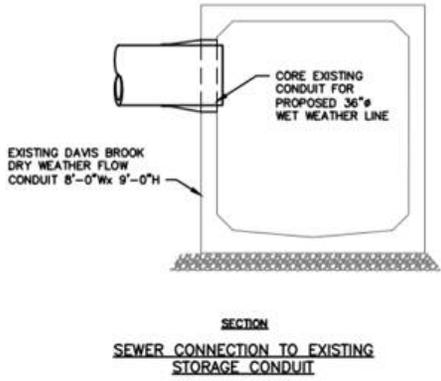
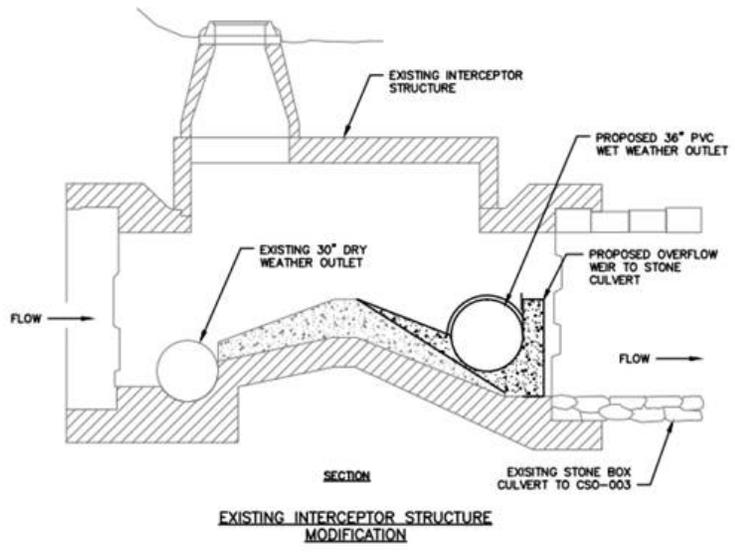


Figure 6-9. Davis Brook- Parallel Conduit Conceptual Layout

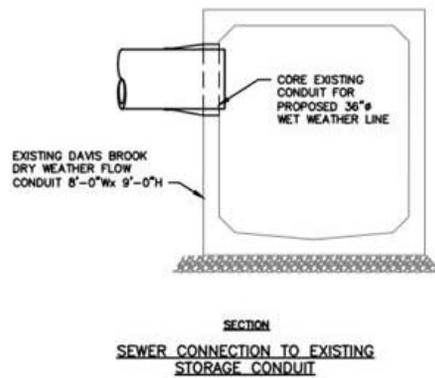
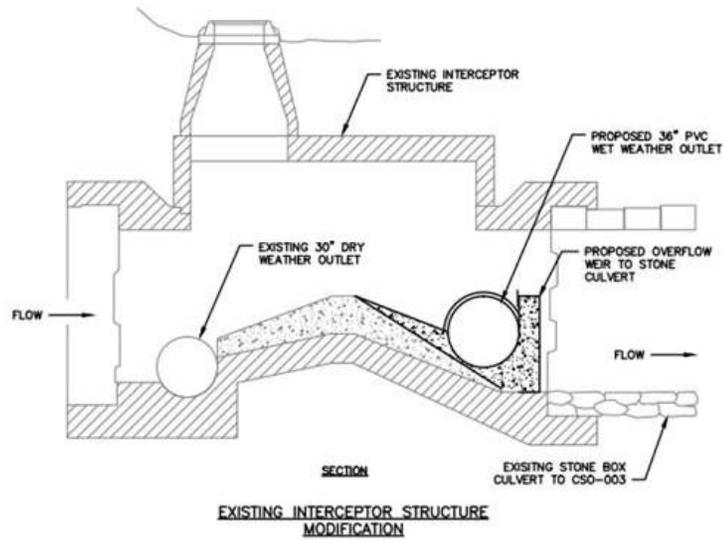
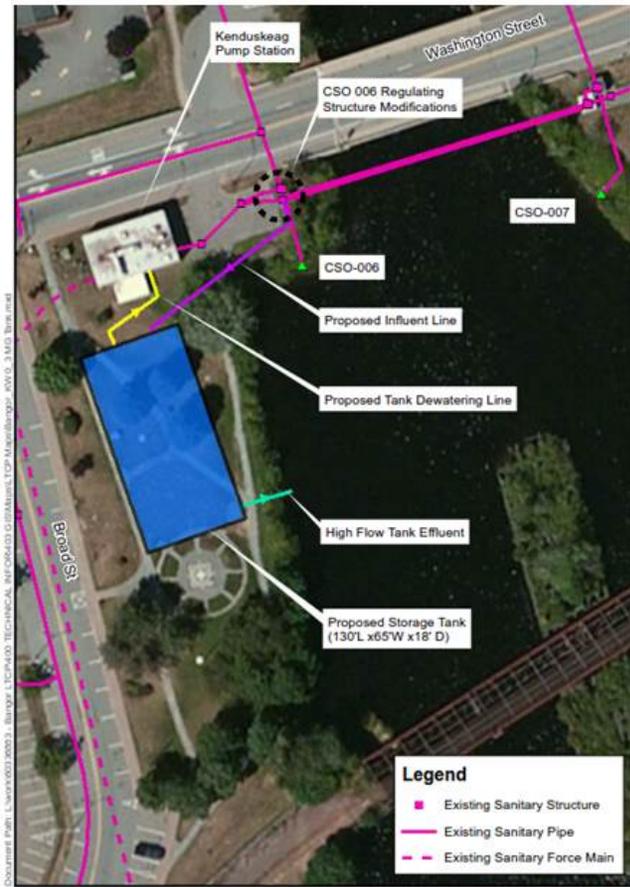


Figure 6-10. Davis Brook and Railroad Street Storage Conduit Conceptual Layouts



Conceptual Alternatives/Layouts- Kenduskeag West: 1.1 MG Storage Tank

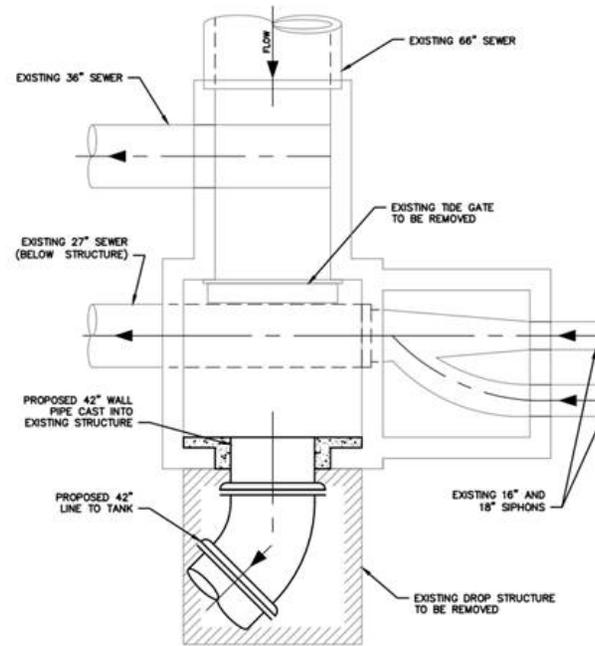


Figure 6-11. Kenduskeag East/West Storage Tank Conceptual Layout

The tank would also be equipped with an automatic flushing mechanism to clean the tank floor of settled solids and debris following dewatering.

As with Barkersville, the siting of the both the RTB and vortex processes present more of a challenge than siting of the storage options. Both require an outfall to the Penobscot for the treated effluent. A suitable site in the vicinity of the existing stone sewer outfall would suffice but this location would have a higher degree of impact to the Waterfront Pavilion and other shoreline based activities. Further complicating the situation is that the vortex process would also require that the underflow or foul sewer be continuously directed back to an interceptor for conveyance to the WWTP for treatment. Thus, a force main would be required to connect the flow back to the Penobscot Interceptor downstream of the existing conduit. Alternatively, the vortex process could be located towards the downstream end of the existing conduit but then a new outfall to the Penobscot River would be required for the treated effluent. For the purposes of having workable placeholder sites, both the RTB and vortex facilities have been located at the upstream end of the existing conduit in order to use the existing CSO 003 outfall.

As shown in Figure 6-9, two 33 ft. diameter vortex units would be required, as a single unit would have a 46 to 47 ft. diameter, somewhat larger than desirable. Multiple units would require a splitter box to feed the units, two separate influent and effluent lines, and a more complex chemical feed and process control system for the two-chemical disinfection process. As such, vortex is no longer considered viable for Davis Brook and RTB will remain as the single treatment alternative.

As with the Barkersville treatment concepts, a 60 ft. by 60 ft. Disinfection Building would be necessary for the RTB alternative. This above-ground building would need to be carefully sited as to minimize interference with Waterfront Pavilion or other recreational activities.

6.6.3 Kenduskeag West and East - CSOs 006 and 007

Unlike Barkersville and Davis Brook, there is no existing CSO control facility at the Kenduskeag West outfall. Kenduskeag East, which is the smallest and least active of the four largest CSO outfalls, does have an existing 1.2 MG off-line storage tank. However, it would be very difficult to enlarge or otherwise modify the existing tank to accommodate additional flow. After careful review of the outfall characteristics, and other constructability considerations, it was determined that the Kenduskeag East CSO flow should be combined with the Kenduskeag West flow and handled in a single control facility on the west side of Kenduskeag Stream.

In order to convey additional Kenduskeag East CSO flow to the proposed Kenduskeag West facility, the existing siphon structure would be modified to increase its capacity to the desired flow rate associated with specific levels of control. Once across the stream, excess wet weather flow would combine with the Kenduskeag West CSO flow at the modified outfall and enter the storage tank. Based on the predicted volumes of both outfalls, the combined tank would only need to be enlarged a modest amount to accommodate both outfalls.

Storage tanks, located in the park adjacent to the KPS, were deemed to be the most viable control measure for the two outfalls. Storage conduits were eliminated in favor of tanks due to siting limitations and the location of the park adjacent to the Kenduskeag PS (KPS). This would eliminate the need to construct conduits in public streets as no other viable sites are available in the vicinity of the CSO outfall. Also, RTBs were eliminated because they would need to be larger than storage tanks; vortex was eliminated because of the foul sewer discharge and potential for solids deposition, and possible odors, in the downstream Davis Brook conduit.

The layout of the storage tanks in the park is show in Figure 6-12. As shown, the existing Kenduskeag West regulator would be modified such that the outfall to Kenduskeag Stream would be directed into the storage tank. All of the flow would be directed to the tank and a high-flow

relief or emergency outfall would be installed in the tank to allow the excess flow a path to the stream. In essence, this would constitute a relocated CSO 006 outfall. The tank would be equipped with dewatering pumps and an automatic flushing mechanism to clean the tank floor of settled solids and debris following tank dewatering.

It may be possible to locate the storage tank dewatering pumps in the KPS as there is room for an additional pump. Potential hydraulic limitation with the concept would need to be evaluated at the time of the tank design, such as the fact the pumps would be located at a higher elevation than the tank floor.

6.7 Full Sewer Separation Alternative

Full sewer separation of all the CSO outfalls to achieve zero overflows in a typical year was evaluated. Costs for sewer separation were based on constructing new storm drains and replacing sanitary sewers as necessary. Based on review of the CCTV data, it was assumed that approximately 40% of the sanitary sewers would need to be replaced due to their structural condition, presence of excessive I/I, or to maintain minimum velocity. Costs for new storm drains would include new catch basins and new 12" catch basin laterals. The resulting cost estimates are shown in Table 6-12.

Table 6-12. Opinion of Probable Estimated Sewer Separation Costs

CSO Outfall	Linear Feet of New Sanitary Sewer Pipe	Linear Feet of New Stormwater Sewer Pipe	Opinion of Probable Total Project Cost (\$M)
Barkersville (002)	26,500	71,500	\$25
Davis Brook (003)	5,500	13,800	\$20.5
Kenduskeag West and East (006 and 007)	17,000	51,160	\$18.8
Meadowbrook (011)	5,400	12,300	\$4.4
Cemetery (016)	1,250	4,325	\$1.9
Carr Brook (020)	5,400	13,800	\$4.2
Central (023)	500	2,600	<u>\$1</u>
Total Sewer Separation Costs			\$75.8

Sewer separation and private inflow removal would theoretically denote 100% CSO control. In other EPA Region 1 CSO communities where private inflow removal was pursued, it accounted for 50% of the sewer separation costs. Therefore, the Opinion of Probable Total Project Costs for zero overflows per year would approach an estimated \$150M, or roughly twice the estimated \$76M cost in Table 6-12, which does not include private inflow removal.

Furthermore, EPA Region 1 communities that committed to large-scale sewer separation projects are re-evaluating the benefits of these projects. The following are some of the issues cited by several communities for moving away from large-scale sewer separation projects:

- Sewer separation costs increasing significantly (as much as doubling) between preliminary design and construction.
- Exceeding construction schedule by months or years.
- Neighborhood/business disruption.
- Difficulty in locating and removing private inflow sources, particularly in older, downtown areas.
- Potential stormwater regulations that may require Bangor to treat the resulting stormwater discharge in the future.
- Sewer separation causes clogging of the remaining combined sewer line; due to low flow conditions and lack of flushing by stormwater.

Based on the costs associated with full sewer separation, and the potential resistance to addressing private property inflow removal, plus concern relating to future stormwater regulations, achieving zero overflows in the typical year through sewer separation will not be further developed for this LTCP, even for the smaller CSO outfalls. Instead, sewer separation for the smaller outfalls to achieve a target level of control of 4 activations per year remains viable. This is particularly true as the use of small storage tanks or conduits at the small CSO outfall locations is typically cost-prohibitive and would create other CSO facilities to operate and maintain. Further, as opportunities arise, sewer separation for the smaller outfalls could also include green infrastructure where circumstances allow for such incorporation. Additionally, targeted sewer separation for both the larger and smaller CSO outfalls should be considered on a case-by-case basis as opportunities arise, such as local and state roadway projects or as part of private development projects

6.8 Next Steps in Alternatives Evaluation Process

Having established that 4 activations per year as the target level of control for this Phase II LTCP, and sizing and configuring the alternative control facilities for the largest CSO outfalls accordingly, the next critical step in the evaluation process is the monetary and non-monetary evaluation of the control alternatives. These are described in Section 7.

The monetary or economic evaluations, will include more detailed estimates of both construction cost and associated project costs. The latter costs include allowances for contingencies, engineering during design and construction, and land purchases, as appropriate. Together, these cost elements – construction and associated project costs – comprise the total project costs.

7.0 Evaluation of Remaining Alternatives

This section of the Phase II LTCP describes the non-monetary and economic or monetary evaluation of the remaining control alternatives resulting from the preliminary evaluation process described in Section 6. The remaining control alternatives for the major outfalls are shown in Table 7-1 along with their general location.

Table 7-1. Remaining Control Alternatives for Major Outfalls

CSO Outfall	Storage Conduit	Storage Tank	RTB Treatment with Disinfection
Barkersville (002)	Bass Park	Bass Park	Emera Property
Davis Brook (003)	Waterfront	Waterfront	Waterfront
Kenduskeag West and East (006 and 007)	--	Park adjacent to KPS	--

As noted earlier, the control alternatives for the smaller CSO outfalls - Hammond Street (009), Meadowbrook (011), Cemetery (016), Central (023) and Carr Brook (020) – will be centered around sewer replacement/rehabilitation and/or sewer separation with Green Infrastructure when specific opportunities arise. The control of these smaller CSO outfalls will be described in Section 8 along with the integration of SSES activities and a more detailed description of the resulting preferred alternatives for the larger outfalls that culminate from the evaluations described as follows.

7.1 Non-Monetary Evaluation

Non-monetary evaluation criteria typically include a wide range of factors that need to be considered when planning major CSO control facilities. For Bangor, the criteria selected as being most applicable are shown in Table 7-2.

Table 7-2. Non-Monetary Criteria

Criterion	Consideration Factors
Regulatory Compliance	Compliance with DEP and EPA CSO policies.
Health and Safety (H&S) Requirements	Ability to comply with applicable H&S requirements.
Regulatory Uncertainties/Expandability	Ability to readily expand facility to accommodate possible future stricter effluent limits (e.g., viruses, enterococcus, nitrogen, phosphorus, etc.) and/or higher levels of control (e.g., higher volumetric control and/or lower activation frequency).
Water Quality Impacts	Degree of pollutant loading reduction to the receiving waters.
Constructability	Unique challenges/obstacles associated with the proposed site.

Ease of Operation	Complexity of processes including pre-event preparation and post-event clean-up; also, similarity of the proposed facilities with current facilities so that operators already have requisite experience (i.e., no learning curve).
Public/Community Acceptance	Impacts to the immediate and surrounding area and any unique or sensitive resources
Ease of Implementation	Available solutions to overcome possible impediments to implementation.
Visual/Aesthetics	Concerns with visual aesthetics and the additional cost necessary to mitigate these concerns.
Process Reliability	Is the process dependable (e.g., number of moving parts, dependency on human interaction, process control requirements, etc.).

The remaining control alternatives for the larger CSO outfalls were then subjected to a non-monetary evaluation using these criteria. A few notes on this process are as follows:

1. It is a qualitative process and while costs could be applied to some criteria resulting in a so-called “triple bottom line” analysis that somewhat complex process was not deemed appropriate for a city the size of Bangor.
2. The alternatives were assessed in a comparative fashion using the following ratings:
 - Favorable or Highly Favorable
 - Neutral
 - Unfavorable or Highly Unfavorable

For example, when comparing storage to treatment plus disinfection, both would involve a new CSO control facility to operate and maintain. However the Bangor wastewater staff are familiar with satellite storage that does not include chemical handling. Therefore, a storage facility would be rated more favorably than a satellite treatment facility that includes disinfection.

3. Because of the results from the prior screening and alternatives elimination, the non-monetary evaluation process was confined to only two sets of evaluations:
 - Storage (conduits or tanks) versus RTB treatment at Barkersville (CSO 002)
 - Storage (conduits or tanks) versus RTB treatment at Davis Brook (CSO 003)

As was noted earlier, the only viable control facility for the two Kenduskeag CSO outfalls (CSOs 006 and 007) was a single storage tank.

With these considerations in mind, the control measures for the larger CSO outfalls were evaluated with the rating results presented in Table 7-3. As expected, the storage alternatives (conduit or tank) rated higher than RTB treatment and disinfection in virtually all of the evaluation categories. Overall, there were no “highly unfavorable” ratings for the storage alternatives while there were several for RTB treatment and disinfection.

Table 7-3. Non-Monetary Evaluation Rating of Remaining Alternatives

Criterion	Barkersville (002)		Davis Brook (003)	
	Storage ²	RTB Treatment and Disinfection	Storage ²	RTB Treatment and Disinfection
Regulatory Compliance	Yes	Yes	Yes	Yes.
Rating	<i>Neutral</i>	<i>Neutral</i>	<i>Neutral</i>	<i>Neutral</i>
Health and Safety (H&S) Requirements	Compatible with existing facilities; does not include satellite chemical storage.	Requires permitting and H&S training for stored chemicals.	Compatible with existing facilities; does not include satellite chemical storage.	Requires permitting and H&S training for stored chemicals
Rating	<i>Favorable</i>	<i>Highly Unfavorable</i>	<i>Favorable</i>	<i>Highly Unfavorable</i>
Regulatory Uncertainties/ Expandability	Stored volume would be treated at the WWTP where treatment enhancements could be made efficiently in a centralized manner.	Technically difficult and costly to adapt satellite treatment to more stringent requirements.	Stored volume would be treated at the WWTP where treatment enhancements could be made efficiently in a centralized manner.	Technically difficult and costly to adapt satellite treatment to more stringent requirements.
Rating	<i>Highly Favorable</i>	<i>Highly Unfavorable</i>	<i>Highly Favorable</i>	<i>Highly Unfavorable</i>
Water Quality Impacts	Lower pollutant loadings as storage volume would receive secondary treatment at the WWTP.	Higher pollutant loadings due to primary equivalency of treated effluent	Lower pollutant loadings as storage volume would receive secondary treatment at the WWTP.	Higher pollutant loadings due to primary equivalency of treated effluent
Rating	<i>Favorable</i>	<i>Neutral</i>	<i>Favorable</i>	<i>Neutral</i>
Constructability	Readily accommodated at City-owned Bass Park.	Would require purchasing of the Emera property; high probability of contaminated soils.	Would need to be sited in vicinity of existing storage conduit, parallel to, or along the existing Penobscot Interceptor, and the Waterfront Pavilion; high probability of contaminated soils.	Would need to be sited in vicinity of existing storage conduit, parallel to, or along the existing Penobscot Interceptor, and the Waterfront Pavilion; high probability of contaminated soils.

Rating	Highly Favorable	Unfavorable	Unfavorable	Highly Unfavorable
Ease of Operation	Similar to current operation with minimal pre-event preparation.	Requires (1) pre-, during and post-event activities associated with chemical storage and feed (2) additional routine O&M functions between events (3) additional staff and (4) additional general O&M for the Disinfection Building.	Similar to current operation with minimal pre-event preparation.	Requires pre-, during and post-event activities associated with chemical storage and feed; additional routine O&M functions between events (3) additional staff and (4) additional general O&M for the Disinfection Building.
Rating	Favorable	Highly Unfavorable	Favorable	Highly Unfavorable
Public/Community Acceptance	Would have short-term impact on Bass Park during construction.	Short- and long-term impact to the Emera site including loss of future development and tax revenue.	Short-term impact on the Waterfront Pavilion during construction and potential odor complaints.	Short- and long-term Impacts on future development at Waterfront Pavilion including permanent above-ground 60' by 60' Disinfection Building and potential odor complaints.
Rating	Neutral	Unfavorable	Unfavorable	Highly Unfavorable
Ease of Implementation	City-owned property.	Requires purchase of Emera property and concerns with long-term site/facility access.	City-owned property; requires coordination with Waterfront Pavilion build-out.	City-owned property; requires coordination with Waterfront Pavilion build-out. Also requires siting for permanent 60' by 60' above-ground Disinfection Building
Rating	Highly Favorable	Unfavorable	Unfavorable	Highly Unfavorable
Visual/Aesthetics	Minimal	Requires permanent 60' by 60' above-ground Disinfection Building.	Minimal	Requires permanent 60' by 60' above-ground Disinfection Building.
Rating	Neutral	Highly Unfavorable	Neutral	Highly Unfavorable
Process Reliability	Storage is very reliable.	Satellite disinfection is less reliable.	Storage is very reliable.	Satellite disinfection is less reliable.
Rating	Highly Favorable	Highly Unfavorable	Highly Favorable	Highly Unfavorable

Although this exercise is qualitative in nature, it should be noted that with respect to Barkersville, storage had no “unfavorable” or “highly unfavorable” ratings while RTB treatment and disinfection had two and five of each, respectively. For Davis Brook, storage had three “unfavorable” but no “highly unfavorable” ratings while RTB treatment and disinfection had a total of seven “highly unfavorable” ratings. In essence, construction of any facility along the waterfront was unavoidable (unfavorable) for Davis Brook but the Chemical Building drove the number of highly unfavorable ratings for RTB treatment and disinfection. Thus, from a non-monetary perspective, storage, whether conduit or tank was deemed to be more favorable than RTB treatment and disinfection for both Barkersville and Davis Brook.

Based on these results, three aspects of satellite RTB treatment and disinfection that resulted in the “unfavorable” and “highly unfavorable” ratings were:

- The need to site a remote 60 ft. by 60 ft. Chemical Building.
- Increased O&M requirements associated with a remote, intermittent use disinfection system including deliveries, storage and feed; instrumentation and controls, and general building support systems.
- Risks involved in not being able to meet future, more stringent effluent limits or levels of control at the remote CSO treatment facilities.

The costing of these remaining alternatives, including the storage tank for Kenduskeag West and East, is described as follows.

7.2 Monetary Evaluation

Opinions of probable cost for the remaining alternatives for the larger CSO outfalls, presented in Table 7-1, were prepared using a variety of methodologies including:

- Bottom-up approach: Review of quantities and components included for each control alternative. Material costs for various components were obtained from suppliers when applicable.
- Maine cost comparisons; review of completed CSO control facilities within the State of Maine based on a unit cost per gallon stored or treated.
- Cost curves; Comparison of cost curves developed by CH2M-Hill as reported in the draft 2012 Phase 2 LTCP for the City of Bangor.
- Cost curves: Cost curves prepared by AECOM for various clients for each control alternative. The cost curves were adjusted for this Phase II LTCP based on the current ENR for August 2016 (10386).

It should be noted that these methodologies were also employed to develop the preliminary cost estimates in Section 6 establishing the KOTC and the targeted level of control of 4 activations per typical rainfall year.

The resulting costs are summarized in Tables 7-4 and 7-5. The costs are presented as estimated total project costs which include the following components and contingencies:

Opinion of probable construction costs - The costs are planning-level estimates of materials, equipment and labor, so-called Level 5 estimates as described in Appendix B.

Estimated total project cost - Opinion of probable construction cost plus, engineering and Owner’s contingency, land acquisition and SRF loan administrative costs.

Estimate contingency (30%) - Includes construction related items (i.e., process piping, electrical conduits, etc.) not yet defined and modifications that would be further defined and quantified between the planning level and completion of bid documents.

Engineering and owner contingency (35%) - Engineering design and construction-related services plus an overall project contingency for items that are unforeseen.

The following are key site-specific assumptions that were made for Barkersville and Davis Brook:

- For Barkersville satellite treatment (vortex and RTB) at the Emera site, a land acquisition allowance of approximately \$2M was included in the total project costs.
- For the vortex option at Davis Brook, a force main would be required to connect the flow back to the Penobscot Interceptor downstream of the existing conduit. A cost of \$1.5M was included in the vortex option for the force main.
- All alternatives for Davis Brook include costs associated with a new conduit along or parallel to Railroad Street.

Table 7-4 presents the resultant Opinion of Probable Total Project Costs for alternatives associated with a peak wet weather capacity at the WWTP of 36 MGD. These costs are more conservative (i.e. higher) than those in Table 7-5 which assumes that the WWTP has peak wet weather capacity of 43 MGD.

Table 7-4. Opinion of Probable Total Project Costs for Remaining Control Alternatives for Larger Outfalls at 4 Activations per Year and WWTP at 36 MGD (\$M)

CSO Outfall	Storage Conduit	Storage Tank	RTB Treatment with Disinfection
Barkersville (002)	\$21.5	\$20.4	\$16.7
Davis Brook (003)	\$22.0	\$22.0	\$12.1
Kenduskeag West and East (006 and 007)	--	\$9.0	--

Table 7-5. Opinion of Probable Total Project Costs for Remaining Control Alternatives for Larger Outfalls at 4 Activations per Year and WWTP at 43 MGD (\$M)

CSO Outfall	Storage Conduit	Storage Tank	RTB Treatment with Disinfection
Barkersville (002)	\$19.4	\$17.3	\$16.7
Davis Brook (003)	\$17.4	\$14.6	\$10.6
Kenduskeag West and East (006 and 007)	--	\$9.0	--
WWTP¹	\$3.0	\$3.0	\$3.0

¹ Estimate of costs to reliably attain peak capacity of 43 MGD; does not include costs related to improvements to influent screens, grit handling, etc., that would be eventually required at the WWTP regardless of peak wet weather capacity.

As shown in Table 7-5, an allowance of \$3M was included to reliably bring the WWTP wet weather capacity to 43 MGD.

7.3 Selection of Preferred Control Alternatives

Based upon the results of both the non-monetary and monetary evaluation, the following decisions remain:

1. Barkersville (CSO 002):
 - Should storage be constructed at Bass Park or a RTB and disinfection facility at the former Emera site.
 - With storage, should the configuration be parallel conduits or a below ground storage tank.
 - Should the design be based on a peak wet weather WWTP capacity of 36 or 43 MGD

2. Davis Brook (CSO 003):
 - Should storage or a RTB and disinfection facility, be constructed along the waterfront.
 - With storage, should the configuration be parallel conduit or conduits or a below ground storage tank.
 - Should the design be based on a peak wet weather WWTP capacity of 36 or 43 MGD.

As previously noted, there are no remaining decisions for Kenduskeag West and East (CSOs 006 and 007) as storage, in form of a below ground tank was deemed the only viable alternative. Also, there was virtually no difference in the Kenduskeag tank size regardless of WWTP capacity at 36 or 43 MGD.

The following discussions focus on the Barkersville and Davis Brook decisions.

7.3.1 Barkersville (CSO 002)

While it is apparent that storage is preferred over RTB treatment and disinfection because of the previously mentioned favorability ratings, the decision as to whether to use conduits or tanks remains. When viewing the costs, conduit storage is more costly than tank storage at both WWTP flow rates: 36 and 43 MGD. Therefore a storage tank is the preferred configuration.

With respect to storage tank size, there is only a slight increase in size and resulting cost for the larger tank to reflect the lower WWTP peak wet weather capacity. Therefore, in order to be conservative, the larger tank should be a placeholder for the purposes of this Phase II LTCP. Should the WWTP be upgraded to reliably handle 43 MGD, the smaller tank could be considered at the time of design. Alternatively, the larger storage tank size could be retained to increase the level of annual CSO control.

In summary, the preferred control alternative for Barkersville is a 3.6 MG off-line storage tank located in Bass Park.

7.3.2 Davis Brook (CSO 003)

As with Barkersville, storage is preferred over RTB treatment and disinfection. The remaining decision is whether to use conduit or tank storage. When viewing the costs, conduit and tank storage is nearly equal with the WWTP at 36 MGD but tank storage is lower in cost with the WWTP at 43 MGD. Therefore tank storage is the preferred storage configuration.

With respect to size, the storage tank associated with the lower WWTP capacity of 36 MGD would be somewhat larger than with the WWTP capacity at 43 MGD: 3.8 MG versus 2.5 MG. Therefore, in order to be conservative, the larger tank should be a placeholder for the purposes of this Phase II LTCP. Should the WWTP be upgraded to reliably handle 43 MGD, the smaller tank could be considered at the time of design. Alternatively, the larger storage tank size could be retained to increase the level of annual CSO control.

In summary, the preferred control alternative for Davis Brook is a 3.8 MG off-line storage tank located along the waterfront.

7.4 Summary

The evaluation of the remaining control alternatives for the larger CSO outfalls from both non-monetary and monetary or economic perspectives resulted in the following:

- Storage tanks were the preferred control alternative for both Barkersville (CSO 002) and Davis Brook (CSO 003)
- The placeholder size of the tanks, 3.6 MG and 3.8 MG, respectively, should be based on the current reliable peak weather capacity of the WWTP of 36 MGD.
- Should the capacity be reliably increased to 43 MGD, these sizes could be reduced at the time of design, or remain at their placeholder size to achieve a higher level of annual CSO control.
- A storage tank for Kenduskeag West and East (CSOs 006 and 007) was determined to be the only viable control alternative. Tank sizing is only slightly impacted by peak WWTP wet weather capacity and a 1.1 MG tank was selected as the placeholder size

The details of these facilities, along with the program for control of the smaller CSO outfalls, are presented in Section 8.

8.0 Description of Preferred Plan

This section of the Phase II LTCP describes the full range of preferred control measures for both the large and small CSO outfalls, along with the integration of the SSES findings. The implementation of these control measures is described in Section 9 along with a phasing plan based on the results of the City’s Financial Capability and Affordability Assessment (FCA), also described therein.

It should be recognized that the City implemented the recommendations from the 1993 CSO Facilities Plan using an adaptive approach. It allowed Bangor to alter some of the recommendations to better suit changing conditions, increased knowledge on certain technologies and other factors such as lessons learned from its completed projects, as well as completed projects from other cities with similar CSO characteristics. That approach should again be used for this plan as the City must be able to adapt to technological changes and possible changes in regulatory requirements.

8.1 Larger CSO Outfalls

Table 8-1 summarizes the key components of the preferred controls for the larger CSO outfalls, by volume.

Table 8-1. Summary of Preferred Control Facilities for the Four Larger CSO Outfalls

CSO Outfall	Key Components/Location	Opinion of Probable Total Project Cost (\$M) ¹
Barkersville (002)	3.6 MG Storage Tank at Bass Park	\$20.4
Davis Brook (003)	3.8 MG Storage Tank at Waterfront	\$22.0
Kenduskeag West and East (006 and 007)	1.1 MG Storage Tank in Park adjacent to KPS	\$9.0

¹Refer to Section 7 for development of costs.

Each facility is described below.

8.1.1 Barkersville (CSO 002)

The location and general layout of the proposed storage tank for Barkersville was shown in Figure 6-5. As was described in Section 6, the 3.6 MG tank will be fed by gravity when the capacity of the existing conduit reaches a set elevation. Hence, the tank will only function for the events that exceed the capacity of the existing conduit. Following the event, and when treatment capacity is available at the WWTP, the tank will be dewatered by submersible pumps housed in a vault appended to the tank. The dewatering pumps will discharge downstream of the existing Barkersville storage conduit to avoid re-settling of the solids in the conduit. Excess flow to the entire system – conduit and tank – will continue to overflow at the weir internal to the existing conduit.

A summary of the tank features are as follows:

1. Dimensions:
 - Length – 282 ft.

- Width – 94 ft.
 - Depth – 18 ft.
2. Dewatering:
 - Two recessed-impeller pumps
 3. Post-event Cleaning;
 - Automatic tipping buckets
 4. Odor Control (optional):
 - Granular activated carbon

Recessed-impeller pumps were selected as the placeholder pump technology as they are able to reliably handle grit, one of the more problematic solids that will be deposited on the tank floor following dewatering. While none of Bangor's existing CSO storage tanks have influent screens, it is recommended that screens with openings sized to protect the dewatering pumps be considered during preliminary design. Also, while there are a number of flushing mechanisms available, tipping buckets were selected as the placeholder as they have proven to be more reliable than flushing gates, the system used at the Kenduskeag East tank, and they do not require confined space entry for routine maintenance.

8.1.2 Davis Brook (CSO 003)

The location and general layout of the proposed storage tank for Davis Brook was shown in Figure 6-9. As was described in Section 6, the 3.8 MG tank will be fed by gravity when the capacity of the existing conduit reaches a set elevation. Hence, the tank will only function for the events that exceed the capacity of the existing conduit. Following the event, and when treatment capacity is available at the WWTP, the tank will be dewatered by submersible pumps housed in a vault appended to the tank. The dewatering pumps will discharge downstream of the existing Davis Brook storage conduit to avoid re-settling of the solids in the conduit. Excess flow to the entire system – conduit and tank – will continue to automatically overflow at the weir in the existing conduit to the stone sewer below.

A summary of the tank features are as follows:

1. Dimensions:
 - Length – 238 ft.
 - Width – 119 ft.
 - Depth – 18 ft.
2. Dewatering:
 - Two recessed-impeller pumps
3. Post-event Cleaning;
 - Automatic tipping buckets
4. Odor Control (optional):
 - Granular activated carbon

Recessed-impeller pumps were selected as the placeholder as they are able to reliably handle grit, one of the more problematic solids that will be deposited on the tank floor following dewatering. While none of Bangor's existing CSO storage tanks have influent screens, it is recommended that screens with openings sized to protect the dewatering pumps be considered during preliminary design. Also, as with the proposed Barkersville tank, tipping buckets were selected as the placeholder flushing mechanism.

8.1.3 Kenduskeag West and East (CSOs 006 and 007)

The location and general layout of the proposed storage tank for Kenduskeag West and East was shown in Figure 6-12. As was described in Section 6, the 1.1 MG tank will be fed by gravity from the modified Kenduskeag West (CSO 006) regulator structure. It will also be fed from the modified siphon under Kenduskeag Stream that will allow additional flow from Kenduskeag East (007) to connect into the tank influent line. The additional flow from Kenduskeag East will be regulated with a control valve and will only be allowed into the new tank when the existing Kenduskeag East tank is at capacity. Following the event, and when treatment capacity is available at the WWTP, the tank will be dewatered by submersible pumps housed in a vault appended to the tank. It may be possible to house the dewatering pumps in the pump room of the adjacent Kenduskeag PS. While feasible, this would require that the pumps would be at a higher elevation than the tank floor and would require suction lift pumps. The flow from the dewatering process will be discharged into the PS wetwell. It should also be noted that the top portion of tank volume will be able to be drained back into the wetwell by gravity, thus saving some degree of pumping costs.

With regards to emergency relief, unlike the proposed Barkerville and Davis Brook tanks which will utilize the existing conduit overflow weirs for flows in excess of the design storage volumes, an emergency overflow pipe will be included in the proposed tank. Because it is envisioned to capture all of the Kenduskeag West discharge into the proposed tank, this emergency overflow pipe would essentially be a relocated CSO 006 outfall.

A summary of the tank features are as follows:

1. Dimensions:
 - Length – 130 ft.
 - Width – 65 ft.
 - Depth – 18 ft.
2. Dewatering:
 - Upper volume by gravity to Kenduskeag PS wetwell
 - Two recessed-impeller pumps for remainder
3. Post-event Cleaning;
 - Automatic tipping buckets
4. Odor Control (optional):
 - Granular activated carbon

Recessed-impeller pumps were selected as the placeholder as they are able to reliably handle grit, one of the more problematic solids that will be deposited on the tank floor following dewatering. While none of Bangor's existing CSO storage tanks have influent screens, it is recommended that screens with openings sized to protect the dewatering pumps be considered during preliminary design. Also, while there are a number of flushing mechanisms available, tipping buckets were selected as the placeholder as they have proven to be more reliable than flushing gates, the system used at the Kenduskeag East tank, and they do not require confined space entry for routine maintenance.

8.2 Smaller CSO Outfalls

A summary of the proposed sewer separation program for the smaller (by volume) CSO outfalls is presented in Table 8-2. As was described in Section 6, the separation program will target an overflow frequency of 4 per year to match that of the larger CSO outfalls.

Stand-alone sewer rehabilitation/replacement work is described in a separate section following this discussion of the smaller CSO outfall separation work. However, in some cases, sewer rehabilitation/replacement work has been included to reflect the findings of the SSES investigations that the City has completed to date. Based on review of the CCTV data, it was assumed that, in addition to construction of new storm drains, approximately 40% of the sanitary sewer in a given CSO tributary area would need to be replaced due to structural condition, excessive inflow and infiltration, or due to sewer separation, minimum velocity issues. In addition, the storm drain costs include installation of new 12" catch basin laterals.

Table 8-2. Opinion of Probable Project Cost Summary of Preferred Control Facilities for the Smaller CSO Outfalls

CSO Outfall	Linear Feet of New Sanitary Sewer Pipe	Linear Feet of New Stormwater Sewer Pipe	Total Project Cost (\$M)¹
Meadowbrook (011)	5,400	12,300	\$4.4
Cemetery (016)	1,250	4,325	\$1.9
Carr Brook (020)	5,400	13,800	\$4.2
Central (023)	550	2,600	<u>\$1</u>
Total Smaller CSO Outfall Sewer Separation Costs			\$11.5

¹Refer to Section 7 for development of costs.

The table does not break out the sewer separation costs for Hammond Street (CSO 009), another of the smaller outfalls, because reconstruction of the existing combined sewer on Hammond Street will begin in spring 2017 and Hammond Street meets the less than four overflows in a typical year.

The costs presented above are for full sewer separation of the public inflow or stormwater sources. Based on the costs associated with full sewer separation, and the potential political and/or homeowner resistance to addressing private property inflow removal, plus concerns related to future stormwater regulation, achieving zero overflows in the typical year through sewer separation was not selected as the targeted level of control for the smaller CSO outfalls. Instead, as was described in Section 6, a target level of control of 4 activations per year was deemed to be appropriate and achievable. Separation of public inflow sources as a means of CSO control is deemed appropriate as the use of small storage tanks or conduits at smaller CSOs is typically cost-prohibitive and would result in additional CSO facilities to operate and maintain. The extent of sewer separation for these smaller CSOs will be based on a build and measure approach so that the effectiveness of each individual separation project can be assessed before continuing with further work within the specific CSO tributary area.

Further, as opportunities arise, sewer separation for the smaller outfalls could also include green infrastructure where circumstances allow for such incorporation. Additionally, targeted sewer separation for both the larger and smaller CSO outfalls should be considered on a case by case basis as opportunities arise, such as local and state roadway projects or as part of private development projects.

8.3 Recommendations Resulting from SSES Scope of Work (SOW) Phase 2

In accordance with the 2015 CD, the Phase 2 SSES report summarizing the field work and results obtained, for the Airport and Dow subsections is being submitted along with this LTCP. In accordance with the 2015 CD, this Phase II LTCP must include the cost effectiveness analysis of the removal of sources of I/I identified through SSES, including, at a minimum a discussion of which public sources of I/I are more cost-effective to remediate than to transport and treat.

After review of the Phase 2 SSES data, including the CCTV and flow isolation work completed, recommendations on sewer rehabilitation were developed. Pricing for rehabilitation work was obtained from the Ted Berry Company of Livermore Falls, Maine, and full sewer replacement costs were developed as noted in Section 8.2, discussed above. The recommended rehabilitation work addresses both structural and inflow/infiltration issues.

Phase 2 SSES recommendations were based on a cost effectiveness analysis. The cost effectiveness analysis considers whether it is more cost effective to convey and treat the inflow and infiltration at the WWTP or if it is more cost effective to rehabilitate the existing pipe. For Bangor, the threshold where convey and treat is more cost-effective than rehabilitation is at a value of \$11/gallon. This was calculated based on five years of WWTP flows; WWTP operating expenses, and DEP recommended interest rates. This means that any rehabilitation option that costs less than \$11/gallon would be deemed cost effective.

Each rehabilitation cost represents the estimated construction cost for the noted rehabilitation method without an allowance for engineering and contingencies. With both the estimated rehabilitation cost and the estimated removable infiltration rate known, the unit cost of infiltration removed expressed in dollars per gallon is calculated for each source by dividing the rehabilitation cost by the removable infiltration. Infiltration rates shown are estimated removable infiltration rates. It was assumed that recommended rehabilitation work would remove 100% of the infiltration entering the system through manhole walls and bases and 50% of infiltration through main pipelines.

The types of rehabilitation evaluated include the following:

- Root treatment (chemical or cutting)
- Cleaning/CCTV
- Cut protruding services
- Lateral lining
- CIPP lining
- Short liners
- Full pipe replacement
- Grouting of joints
- Manhole rehabilitation

Based on the cost effective analysis and recommendations listed below, the associated costs were input into the FCA and are included in Section 9 for the implementation schedule.

Estimated inflow and infiltration removal costs are based on the type of repair recommended. However, it should be noted that inflow and infiltration removal is only an estimate and that many other factors affect the actual amount of flow removal after rehabilitation. Because, as indicated in the Phase 2 SSES report, the amount of inflow and infiltration emanating from private sources is significantly greater than from public sources, this will ultimately have an impact on the projected overall effectiveness of corrective programs that primarily focus on public sources, such as mainline rehabilitation.

8.3.1 Public Sources

The SSES summary table presented in the Phase 2 SSES report included both public and private inflow and infiltration sources. Table 8-3 is similar to the SSES summary Table 3, but focuses on the public infiltration sources, as noted above. Table 8-3 includes the following additional information for public sources:

- Rehabilitation recommendation based on the review of the pipe segment
- Cost Effectiveness Analysis threshold
- Final pipe segment recommendation
- Estimated infiltration removal

Table 8-3 presents a summary of the proposed rehabilitation methods for the removal of the infiltration sources found in the main pipelines and sewer manholes, including estimated removable infiltration rates, rehabilitation costs and unit costs. Table 8-3 also includes a priority ranking of infiltration sources from the lowest unit cost to the highest unit cost. All infiltration sources with a unit cost for removal equal to or less than \$11 per gallon are recommended to be rehabilitated. Also shown in the table are the public sources of infiltration deemed cost-effective to rehabilitate when applying that metric.

Table 8-3. Mainline Pipe Rehabilitation Recommendations based on Cost Effectiveness Analysis

Location				Pipe Information			Pipeline Defects						Rehabilitation				
Sewer Subsection	From MH	To MH	Street Name	Length (ft)	Type	Dia. (in)	Leak in Joint (1)	Roots	Separated or Offset Joint (1)	Cracked Pipe(1)	Broken or Fractured Pipe(1)	Estimated Infiltration (gpd)(2)	Recommended Rehabilitation	Preliminary Budget Costs for Rehabilitation	Unit cost (\$/gpd)	Cost Effective to Rehabilitate Main Line Pipe?	Estimated Infiltration removed (gpd)
Airport	AP058	AP057	Griffin	197	VCP	8	Almost All			35, 184, 187		2,000	CIPP	\$ 11,820.00	\$ 5.91	Y	1,000
Airport	AP202	AP203	Mitchell St Cross Country	165	VCP	8	155					10,000	Short liner	\$ 3,000.00	\$ 0.30	Y	5,000
Airport	AP233	AP232	Griffin Rd.	295	RCP	8		X		58; 60; 64; 129; 218; 229; 245; 271; 283	3; 117; 157; 253, 277; 282	200	Chemical Root Removal, Heavy Cleaning & CCTV	\$ 1,711.00	\$ 8.56	Y	100
Airport	AP408	AP407	Johnson St	66	VCP	8	34; 40; 43; 46; 66			3		4,200	CIPP	\$ 3,960.00	\$ 0.94	Y	2,100
Airport	AP415	AP414A	Texas Ave Cross Country	159	VCP	8	44				23; 35-46; 57; 105; 126; 136	3,000	CIPP	\$ 9,540.00	\$ 3.18	Y	1,500
Airport	AP416	AP415	Texas Ave Cross Country	151	VCP	8	118				118	700	Short liner	\$ 3,000.00	\$ 4.29	Y	350
Airport	AP440	AP408	Florida Ave	322	VCP	8	33; 67; 92; 125			2; 165	64; 243	2,600	CIPP	\$ 19,320.00	\$ 7.43	Y	1,300
Airport	AP442	AP443	Florida Ave	262	VCP	8	18; 198	X				3,000	Short liners & Chemical Root Control	\$ 6,615.70	\$ 2.21	Y	1,500
Airport	AP451	AP450	Maine Ave.	182(5)	VCP	8			5		5	400	Spot Repair Excavate & Replace	\$ 3,000.00	\$ 7.50	Y	200
Airport	AP481	AP482	Taft St	373	VCP	8	41; 99; 115; 122; 159; 176; 276; 361		328	68; 263; 329		3,000	CIPP	\$ 22,380.00	\$ 7.46	Y	1,500
Airport	AP500	AP400	Maine Ave	104	VCP	8	9; 10; 24; 95					5,600	CIPP	\$ 6,240.00	\$ 1.11	Y	2,800
Airport	AP603	AP602	Maine Ave Parking Lot	353	VCP	10	39; 41; 50; 56; 118; 135; 166; 188; 194; 201; 212; 218; 303; 309; 315			342; 345	146; 270; 282	2,500	CIPP	\$ 21,180.00	\$ 8.47	Y	1,250
Airport	AP607	AP608	Utah Ave.	567.5	PVC/VCP	10	Almost all					5,000	CIPP	\$ 34,050.00	\$ 6.81	Y	2,500

Location				Pipe Information			Pipeline Defects						Rehabilitation				
Sewer Subsection	From MH	To MH	Street Name	Length (ft)	Type	Dia. (in)	Leak in Joint (1)	Roots	Separated or Offset Joint (1)	Cracked Pipe(1)	Broken or Fractured Pipe(1)	Estimated Infiltration (gpd)(2)	Recommended Rehabilitation	Preliminary Budget Costs for Rehabilitation	Unit cost (\$/gpd)	Cost Effective to Rehabilitate Main Line Pipe	Estimated Infiltration removed (gpd)
Airport	AP609	AP610	Maine Ave	257	VCP/PVC	10	4; 35; 54; 90; 99; 103; 105; 107; 121; 134; 137; 143; 206; 223; 227; 250					3,000	CIPP	\$ 15,420.00	\$ 5.14	Y	1,500
Airport	AP651	AP650	Griffin Rd	337	VCP	8	59; 98; 103; 203; 315; 328			125		2,500	CIPP	\$ 20,220.00	\$ 8.09	Y	1,250
Airport	AP660	AP607	Griffin Rd	339	VCP/ PVC	10	8	X				1,400	Short liner & Chemical Root Control	\$ 3,796.65	\$ 2.71	Y	700
Airport	AP661	AP662	Griffin Rd	408	VCP/ PVC	10	30; 33; 39; 204; 206	X				9,200	CIPP & Chemical Root Control	\$ 25,276.65	\$ 2.75	Y	4,600
Airport	AP704	AP703	Utah Ave	292	VCP/ PVC	8			286		77	900	Spot Repair Excavate & Replace, & Short liner	\$ 6,000.00	\$ 6.67	Y	450
Airport	AP722	AP723	Wyoming St	167	VCP/ PVC	8	2; 76; 79				167	7,200	Short liners	\$ 6,000.00	\$ 0.83	Y	3,600
Airport	AP740A	AP700	Utah Ave Cross Country	130	VCP	8		X	129		5	700	Short liner & Chemical Root Control	\$ 3,305.50	\$ 4.72	Y	350
Airport	AP743	AP744	Polk St	242	AC/PVC	6						1,500	City to Re-CCTV	(3)	(3)	(3)	(3)
Airport	AP756	AP755	Griffin Rd Cross Country	76	VCP	8	68	X				700	Short liner & Chemical Root Control	\$ 3,178.60	\$ 4.54	Y	350
Airport	AP758	AP757	Griffin Rd	163	VCP	8	41; 42					300	Short liner	\$ 3,000.00	\$ 10.00	Y	150
Total Airport (Public)												68,100		\$ 232,014.10			34,050
Dow	DW214	DW213	Silver Rd	266	VCP/ PVC	8	243	X		14; 77	1	3,600	Short liner	\$ 12,000.00	\$ 3.33	Y	1,800
Dow	DW500	DW020	Aviator Dr	195	VCP	8	48; 60; 63; 165; 174				111	1,200	CIPP	\$ 11,700.00	\$ 9.75	Y	600
TOTAL Dow (Public)												4,800		\$ 23,700.00			2,400
Grand Total (Airport and Dow, Public)												72,900		\$255,714			36,450

Notes:

(1) The number in this column is distance in feet from the first manhole identified in the "Location" column, and represents the approximate location of the defect.

(2) Estimated infiltration is based upon a visual assessment of each infiltration source (pipeline defect).

(3) No infiltration source found; City to re-CCTV in future; thus no cost or cost per gallon could be established.

8.3.2 Rehabilitation of Private Inflow and Infiltration Sources

As noted above, and as contained in the accompanying Phase 2 SSES report, a significant portion of the inflow and infiltration was found to be emanating from private sources. However, with the amount of public mainline SSES rehabilitation work identified in the Airport and Dow subsections (see Table 8-3 above), and in other subsections, the City has decided to focus its private source inflow and infiltration control efforts on three of the largest sources as identified below:

- 1) During the Phase 2 SSES field work, the City of Bangor and Ted Berry noted that there were numerous laterals that were no longer in service. The City is committed to capping the laterals no longer in service in the Dow and Airport subsections, due to demolished buildings.
- 2) In addition, a significant source of private inflow (approximately ½ of the total) is attributable to a water line bleeding into Manhole DW601B. The City is worked with the Bangor Water District to remove this significant inflow source.
- 3) Through the flow isolation work, the City is also aware that a large inflow and infiltration contributor is the Air National Guard. In an effort to quantify the amount of inflow and infiltration from the Air National Guard, the City anticipates installation of a flow meter and review of flow monitoring data at this location for an extended period of time over the next 5 years.

8.3.3 Other SSES Results

As noted in the Phase 2 SSES report, several locations were noted to have deficiencies during flow isolation, but were not identified as a significant source of infiltration during the CCTV inspections nor would they have been cost effective to rehabilitate based on the cost effectiveness analysis. However, these pipe segments were noted to have structural deficiencies. It is recommended that these structural deficiencies be addressed by appropriate rehabilitation measures.

Table 8-4 is similar to the Phase 2 SSES report table 4, which presented these pipe segments but Table 8-4 includes the following additional information:

- Rehabilitation recommendation to address structural deficiencies based on review of pipe condition
- Cost associated with recommended rehabilitation

Several manhole locations were noted to have deficiencies but were not identified as a significant source of inflow or infiltration during the CCTV inspections nor would they have been cost effective to rehabilitate based on the cost effectiveness analysis. However, these manholes were noted to have structural deficiencies. It is recommended that these structural deficiencies be addressed by appropriate rehabilitation measures.

Table 8-5 presents the manhole rehabilitation recommendations and costs to address structural deficiencies.

Table 8-4. Pipe Segments Recommended for Rehabilitation Due to Structural Deficiency

Location				Pipe Information			Potential Infiltration Source	Recommended Rehabilitation	Preliminary Budget Costs for Rehabilitation
Sewer Subsection	From MH	To MH	Street Name	Length (ft)	Type	Dia. (in)			
Airport	AP024	AP023	Godfrey Blvd Cross Country	297	VCP	8	Joint leak at 4. Offset joint at 2. Broken & cracked pipe at 47, 65, 152, 200, 225, 237.	CIPP	\$ 17,820
Airport	AP025	AP024	Godfrey Blvd	303	VCP	8	Fractured/broken pipe from 3-7, 13, 35, 74, 98, 148	Excavate and replace	\$ 45,450
Airport	AP312	AP311	Bolling Dr	227	RCP	8	Total collapse near AP311	Excavate and replace	\$ 34,050
Airport	AP401	AP402	Cross-country	208	ACP	12	City plans to replace due to poor pipe condition	Excavate and replace	\$41,600
Airport	AP403	AP402	Cross-country	292	ACP	12	City plans to replace due to poor pipe condition	Excavate and replace	\$58,400
Airport	AP404	AP403	Cross-country	296	CI	8	City plans to replace due to poor pipe condition	Excavate and replace	\$44,400

Location				Pipe Information			Potential Infiltration Source	Recommended Rehabilitation	Preliminary Budget Costs for Rehabilitation
Sewer Subsection	From MH	To MH	Street Name	Length (ft)	Type	Dia. (in)			
Airport	AP405	AP404	Cross-country	300	CI	8	City plans to replace due to poor pipe condition	Excavate and replace	\$45,000
Airport	AP406	AP405	Johnson St Cross Country	203	VCP	8	Broken pipe at 47, 61, and 171	CIPP	\$12,180
Airport	AP409	AP408	Johnson St	277	VCP	8	Broken pipe at 26, 42, 52, 59, 125, and 264	Excavate and replace	\$41,550
Airport	AP413	AP412	Texas Ave Cross Country	185	VCP	8	Broken pipe at 11	CIPP and lateral liner	\$12,700
Airport	AP414A	AP414	Texas Ave Cross Country	310	VCP	8	Fractured pipe at 226	CIPP and lateral liner	\$20,200
Airport	AP430	AP405	Florida Ave Cross Country	55	VCP	8	Broken pipe at 52	Short liner and lateral liner	\$ 7,600
Airport	AP481	AP480	Taft St	279	VCP	8	Broken pipe at 210	CIPP	\$ 16,740
Airport	AP702	AP701	Utah Ave Cross Country	33	VCP	8	Joint offset at 23	Excavate and replace	\$ 4,950
Airport	AP754	AP753	Griffin Rd Cross Country	40	VCP	8	Joint offset at 20	Excavate and replace	\$ 6,000

Location				Pipe Information			Potential Infiltration Source	Recommended Rehabilitation	Preliminary Budget Costs for Rehabilitation
Sewer Subsection	From MH	To MH	Street Name	Length (ft)	Type	Dia. (in)			
Dow	DW400	DW017	Arthur Ave	362	VCP	8	Broken pipe at 66	CIPP	\$ 21,720
Dow	DW607	DW606	Texas Ave Cross Country	241	VCP	8	Fractured pipe at 205	Short liner and chemical root control	\$ 3,566
Dow	DW609	DW608	University Dr	344	VCP	8	Broken pipe at 8 and 291-294 (indications of potential pipe collapse at 291-294)	CIPP	\$ 20,640
Dow	DW611	DW610	Venture Way Cross Country	250	VCP	8	Fractured and broken pipe at 42, 74, and 143	CIPP and lateral liner	\$ 16,600
Dow	DW650	DW022	General Aviation Parking Lot	369	VCP	8	Fractured and broken pipe at 206, 221, and 237	CIPP and lateral liner	\$ 23,740
Total Estimated Rehabilitation Costs to Address Structural Deficiencies									\$ 494,906

Table 8-5. Airport and Dow Estimated Manhole Rehabilitation Methods and Costs to Address Structural Deficiencies

Manhole Rehabilitation	Number of Manholes	Estimated Unit Cost	Total Rehabilitation Cost
Manhole Cleaning	1	\$750	\$750
Repair Defective Chimney	11	\$1,000	\$11,000
Wrap Chimney	4	\$2,500	\$10,000
Reset Frame & Cover	2	\$1,000	\$2,000
Raise Frame & Cover	18	\$1,100	\$19,800
Replace Defective Frame & Cover	20	\$1,400	\$28,000
Root Control	8	\$1,250	\$10,000
Cementitious Coating	124	\$1,600	\$198,400
Cement Coating and Epoxy Sealing	12	\$3,000	\$36,000
Repair Bench	2	\$800	\$1,600
Rebuild Bench & Invert	10	\$1,400	\$14,000
Chemical Sealing Connection	1	\$1,000	\$1,000
Total Estimated Cost to Address Structural Deficiencies			\$332,550

As documented in the SSES report, several locations were identified as locations with less severe structurally deficiencies than those listed in Tables 8-4 and 8-5 above. While these locations are not recommended for rehabilitation at this time, it is recommended that they continue to be monitored for potential future rehabilitation.

Table 8-6 presents a list of pipe segments recommended to be monitored for potential future rehabilitation.

Table 8-6. Pipe Segments to be Monitored for Potential Future Rehabilitation

Location				Pipe Information			Pipeline Defects Mainline Pipe				
Sewer Subsection	From MH	To MH	Street Name	Length (ft)	Type	Dia. (in)	Leak in Joint	Roots	Separated or Offset Joint	Cracked Pipe	Broken or Fractured Pipe
Airport	AP231	AP230	Griffin Rd.	197	RCP/PVC	8		X			62; 65; 68
Airport	AP310	AP309	Off Griffin Rd	176	RCP/VCP	8		X		126	176
Airport	AP311	AP310	Bolling Dr	???	RCP	8				1; 13; 32; 104; 116	2; 14
Airport	AP351	AP350	Union Street	159	VCP	8		X		14; 32	
Airport	AP352	AP351	Union Street	319	VCP/PVC	8				148	
Airport	AP352	AP353	Union Street	260	VCP	8		X	42	43	1; 42
Airport	AP352	AP355	Union Street	342	VCP	8		X		15; 18; 75; 93; 96; 103; 109; 171; 197; 223; 337	75
Airport	AP356	AP355	Union Street	349	VCP	8		X		30	
Airport	AP371	AP370	Bolling Dr	183	VCP	8		X		11; 107	1; 30; 32; 138
Airport	AP371	AP372	Bolling Dr	165	VCP	8		X		1; 3	22
Airport	AP373	No MH	Bolling Dr	248	VCP	8		X			1
Airport	AP373	AP390	Bolling Dr	212	VCP	8		X	3; 18		3; 8; 17

Location				Pipe Information			Pipeline Defects Mainline Pipe				
Sewer Subsection	From MH	To MH	Street Name	Length (ft)	Type	Dia. (in)	Leak in Joint	Roots	Separated or Offset Joint	Cracked Pipe	Broken or Fractured Pipe
Airport	AP414	AP413	Texas Ave Cross Country	249	VCP	8					1
Airport	-	AP413	University Drive	-	VCP	6					
Airport	AP470	AP411	Maine Ave	228(5)	VCP	8			62		56-60
Airport	AP530	AP507	Maine Ave	242	VCP	8			17; 28; 145	35; 36; 119; 133; 137	118
Airport	AP701	AP700	Utah Ave Cross Country	165	VCP	8		X		30	
Airport	AP703	AP702	Utah Ave	77	VCP	8			71		
Airport	AP720	AP721	Hanger 464	237.6	VCP	8					
Airport	AP755	AP754	Griffin Rd Cross Country	119	VCP	8				112	
Airport	AP757	AP756	Griffin Rd Cross Country	252	VCP	8				15; 244	
Dow	DW018	DW017	Maine Ave	270	VCP	15		X		136; 160	86-103; 114-118; 130-135; 141-144; 163; 175- 185;

Location				Pipe Information			Pipeline Defects Mainline Pipe				
Sewer Subsection	From MH	To MH	Street Name	Length (ft)	Type	Dia. (in)	Leak in Joint	Roots	Separated or Offset Joint	Cracked Pipe	Broken or Fractured Pipe
											243(8); 252
Dow	DW022	DW021	General Aviation Parking Lot	353	VCP	15					54
Dow	DW102	DW101	Odlin Road	417	VC	8		X	145;215	5	
Dow	DW201	DW200	Mason Ave Cross Country	223	PCV	12					
Dow	DW203	DW202	Mason Ave Cross Country	333	PVC	12					
Dow	DW204	DW203	Mason Ave Cross Country	270	ACP	8					
Dow	DW251	DW250	Mildred Ave	262	PVC	8					
Dow	DW252	DW251	Mildred Ave	386	PVC	8	79				

Location				Pipe Information			Pipeline Defects Mainline Pipe				
Sewer Subsection	From MH	To MH	Street Name	Length (ft)	Type	Dia. (in)	Leak in Joint	Roots	Separated or Offset Joint	Cracked Pipe	Broken or Fractured Pipe
Dow	DW255	DW203	Mildred Ave	262	PVC	8			256		
Dow	DW017	DW450	Maine Ave	315	VCP	8					167
Dow	DW606	DW605	Texas Ave Cross Country	122	VCP	8				3	
Dow	DW610	DW609	University Dr	208	VCP	8		X		4	
Dow	DW611	DW610	Venture Way Cross Country	250	VCP	8		X		36; 80	42; 61; 74; 143; 249
Dow	DW612	DW611	Venture Way Cross Country	351	VCP	8		X		184; 292; 301	54; 292

9.0 LTCP IMPLEMENTATION

Section 8 describes the long term plan to bring Bangor's CSO outfalls to a higher level of control from that established in the 1993 CSO Facilities Plan. The current plan encompasses both the four larger outfalls, which discharge the vast majority of annual overflow volume, and the smaller outfalls with the aim of achieving a systemwide level of control of 4 overflows per typical year.

This section of the Phase II LTCP outlines the manner in which the preferred control facilities will be implemented with respect to sequencing, financing and implementation schedule. The key to developing the latter is the Financial Capability and Affordability Assessment (FCA) which takes into account not only the proposed LTCP-derived CSO abatement facilities, but all of Bangor's wastewater infrastructure needs including repair and replacement of the WWTP and collection system components to ensure reliable operation, public health protection and permit compliance.

9.1 Project Sequencing

Table 8-1 contains a summary of preferred control facilities for the four larger CSO outfalls: Barkersville (002); Davis Brook (003); Kenduskeag West and East (006 and 007). Based upon a number of factors, including but not limited to annual overflow activations and facility siting, the Davis Brook storage tank was deemed to be the most appropriate initial major project. The Barkersville or Kenduskeag West and East storage tanks would follow in an order to be determined following the completion of the Davis Brook facility. However, for the purposes of LTCP implementation, Barkersville was assumed to follow Davis Brook with Kenduskeag West and East following Barkersville. The upgrade of the peak wet weather capacity of the WWTP, if deemed necessary, could possibly be moved up to second or third, or could remain last in the sequence depending upon the collective systemwide effectiveness of the storage tanks as determined by post construction compliance monitoring (PCM).

With regards to PCM, a program will be designed into each major project and will be based upon facility operational data (e.g., volumetric capture, etc.), flow metering and SWMM model verification. Neither CSO effluent nor ambient monitoring will be included in the PCM programs because the control of CSO volume is a surrogate for pollutant removal in general and bacterial reductions in particular, the latter having been established as the pollutant of concern in the 1993 CSO Facilities Plan. Note that the City is in compliance with special condition N of the MEPDES permit.

Abatement of the smaller outfalls would occur concurrently with that of the larger outfalls, along with associated SSES-related work.

9.2 Financing

The projects described in Section 8 would primarily be financed through the State of Maine Revolving Loan Fund (SRF) which is administered jointly by DEP and the Maine Bond Bank. SRF allows communities to finance wastewater infrastructure projects at a reduced interest rate as subsidized by the SRF fund. The debt retirement cost, principal and interest (P&I) payments on the loans, would be paid by the users to the system.

While grants are rarer and more difficult to obtain, Bangor has been fortunate to receive special dedicated funding for some of its earlier CSO control facilities. With a renewed national emphasis on infrastructure renewal and replacement, it is possible that some level of grant funding could be made available in the not too distant future. As such, all sources of potential revenue should be investigated prior to the initiation of any of the projects contained in Section 8.

Considering only SRF financing, each million dollars in borrowing will result in a P&I payment of \$67,200 per year based on a 20-year bond at 3.0% interest. The resultant increase in P&I payments for the proposed the three large CSO storage tanks are shown in Table 9-1:

Table 9-1. Annual Debt Retirement Costs for the Four Larger CSO Outfalls

CSO Outfall	Opinion of Probable Total Project Cost (\$M)	Annual P&I Payment (\$T)¹
Barkersville (002)	\$20.4	\$1,307.9
Davis Brook (003)	\$22.0	\$1,478.4
Kenduskeag West and East (006 and 007)	\$9.0	\$537.6

¹Payments calculated based on a 20-year bond at 3.0% interest rate.

In addition to these annual P&I payments for the larger outfalls, there will be additional O&M costs to bear. In addition to, there will be finance costs for the smaller CSO outfalls should they be financed through the SRF as described in the FCA contained in Appendix C and as summarized below.

9.3 Financial Capability and Affordability Assessment (FCA)

The costs associated with the Phase II LTCP, along with other non-CSO wastewater system needs under the Clean Water Act (CWA), were evaluated in what is referred to as a the FCA. The FCA allows the City to assess its ability to pay for the preferred CSO plan using metrics established by EPA. The FCA, establishes that Bangor would experience a “medium” financial burden as a result of these additional wastewater costs, based on application of EPA’s FCA guidance. More importantly, the FCA also concluded that sectors of Bangor households are already experiencing a “high” financial burden and that additional wastewater costs would add to their existing financial stress. As such, care will need to be taken to evaluate all of the CWA requirements and to prioritize project implementation in a manner that results in achieving the greatest water quality benefit while still being affordable.

The most immediate major capital CWA project would be the initial phase of the LTCP, the Davis Brook CSO storage tank. While this initial LTCP project could be considered affordable at this time, the impact of future phases would need to be carefully evaluated while taking into consideration all of the other identified and yet to be identified WWTP and SSES-related needs of the City. The Phase II LTCP implementation schedule described below, took this financial situation into consideration in its development.

9.4 Implementation Schedule

The 2015 CD requires Bangor to complete the CSO abatement work called for in the Phase II LTCP by December 31, 2031, less than 15 years from the submittal date of the plan itself. There are also intermediate submittal dates included in the CD for the preparation of Statements of Work (SOWs) for plan implementation: June 30, 2021 and June 30, 2016. However, because of the high cost of the preferred plan as summarized in Section 8, and based on the findings of the FCA, this schedule will cause an undue burden on all of the Bangor ratepayers and even more so for the already financially stressed segment of the population. As such, a time extension will likely need to be sought from EPA as the implementation progresses and the financial impact of the initial project or

projects can be more fully assessed. Therefore, the implementation schedule, presented in Table 9-2, focuses on the initial projects with a FCA reassessment phase following each major project.

Table 9-2. Implementation Schedule

Action	Date	Remarks
1. Submit Phase II LTCP	Jan. 2017	Jan 31, 2017 per 2015 CD
2. Comment and Response Period	February-May 2017	Based on receipt of EPA and DEP comments by March 1, 2017
3. Phase 1 - Davis Brook Storage Tank		
• Design (18 months)	Aug. 2017–Jan. 2019	
• Bidding/Construction (25 months)	March 2019-March 2021	
• Start-up and Commissioning (3 months)	April 2021 to June 2021	
4. Preparation of SOW	June 2021	June 30, 2021 per 2015 CD
5. Phase 2 - Barkersville CSO Storage Tank	<i>Could follow Kenduskeag West and East as Phase 3</i>	
• Design (18 months)	TBD	Date will be based on results of revised FCA
• Bidding/Construction (25 months)	TBD	Date will be based on results of revised FCA
• Start-up and Commissioning (3 months)	TBD	Date will be based on results of revised FCA
6. Preparation of SOW	June 2026	June 30, 2026 per 2015 CD
7. Phase 3 - Kenduskeag West and East CSO Storage Tank	<i>Could precede Barkersville as Phase 2</i>	
• Design (18 months)	TBD	Date will be based on results of revised FCA
• Bidding/Construction (25 months)	TBD	Date will be based on results of revised FCA
• Start-up and Commissioning (3 months)	TBD	Date will be based on results of revised FCA
8. Phase 4 - WWTP Capacity Expansion (Optional)	<i>Need for Phase 4 WWTP Expansion to be determined through PCM and other considerations</i>	
• Design (18 months)	TBD	
• Bidding/Construction (25 months)	TBD	
• Start-up and Commissioning (3 months)	TBD	

Table 9-2. Implementation Schedule (Continued)		
Action	Date	Remarks
9. Abatement of Smaller Outfalls	Continuous small projects over implementation schedule	Detailed schedule to be developed based on related infrastructure improvements, SSES-related needs and other considerations
10. Post Construction Monitoring (PCM)	Following start-up of each major facility	Depending upon scheduling included in SOWs; will determine need for WWTP capacity expansion
11. Financial Capabilities and Affordability (FCA) Update	Following start-up of each major facility	And included in SOWs depending upon scheduling

As shown in the table, the only firm dates included in the schedule are for the Phase 1 Davis Brook storage tank and the CD deadlines. Specific dates were not included for the later phases primarily due to the uncertainty of affordability. It should be noted that the date for at least the first SOW would be better served if it were moved at least one year to June 30, 2022. This would allow adequate time for the PCM period for the Davis Brook storage tank in order to assess its effectiveness, both in the Davis Brook subsection and citywide.

APPENDICES

Appendix A: City of Bangor, Storm Water

Management Modeling(SWMM) Update

1.0 Introduction

The purpose of this Appendix is to summarize the Storm Water Management Model (SWMM) update performed in support of the 2017 Phase II Long Term Control Plan (LTCP) Update for the City of Bangor, Maine. This Appendix will address the following items related to the SWMM update:

- Hydrologic Model Updates;
- Hydraulic Model Updates;
- Model Calibration;
- Model Validation;
- System Characterization.

The City's SWMM model was developed by CH2M HILL during a previous LTCP Update in 2012. A document called Technical Memorandum P2LTCP.1, EPA September 30, 2012 Submittal, Combined Sewer System Model accompanied the LTCP and summarized the model's development, calibration and validation. This Appendix will focus on the modifications and updates performed since 2012. The advanced modeling software PCSWMM by Computational Hydraulics International (CHI) was used during the SWMM model update.

2.0 Hydrologic Model

The City's SWMM model consists of both combined and separated sewer subcatchments. The combined subcatchments are used to generate wet weather runoff using the non-linear reservoir model in SWMM. The separated areas utilize the RTK method to generate wet weather flows; however, the previous SWMM model also contained "dummy" catchments in the separated areas. These separated catchments appeared to only be in the model for visual purposes only, and are not used in any model computations.

The combined subcatchments were refined during this modeling update using the PCSWMM Watershed Delineation Tool (WDT), which defines subcatchments based on topographic data and the corresponding connections to the SWMM model network. The subcatchment parameters (areas, slopes, lengths and widths) were estimated using GIS tools. Similarly, the combined subcatchment impervious areas were calculated from an impervious data file available through the Maine Office of GIS. While the initial subcatchment properties were developed from GIS procedures, subcatchment properties were adjusted as needed during the calibration process. The subcatchment property modifications were generally slight adjustments to provide a closer match to the calibration data. The revised combined subcatchments are shown on Figure 2-1.

To simplify the model and eliminate potential confusion for future users, the separated subcatchments were removed from the model. These separated subcatchments did not serve a computational purpose within the model and are available as a GIS data layer for future reference. The flows in the separated areas are still based upon the RTK parameters established during the 2012 model development. Since these RTK parameters were calibrated during the previous model development, they were generally left unchanged during this model update.

In certain combined areas, the SWMM groundwater module was applied where the metering data appeared to show a significant groundwater component as indicated by a trailing source of inflow after the peak of the storm. The groundwater module applies a groundwater aquifer to its corresponding model subcatchment. The parameters of the flow interaction between the aquifer and the model network can be adjusted to achieve an adequate calibration.

The rainfall data used to run the models was provided by the City and verified against available National Oceanic and Atmospheric Administration (NOAA) rainfall data. The City collects rainfall data in fine increments (3, 5 and 15 minute intervals) and the NOAA data is only available in hourly increments. The NOAA data was generally used to compare total rainfall amounts to the City data, but the resolution of the

City data was preferred for the modeling. A summary of the calibration events used in the updated calibration is discussed in Section 5.

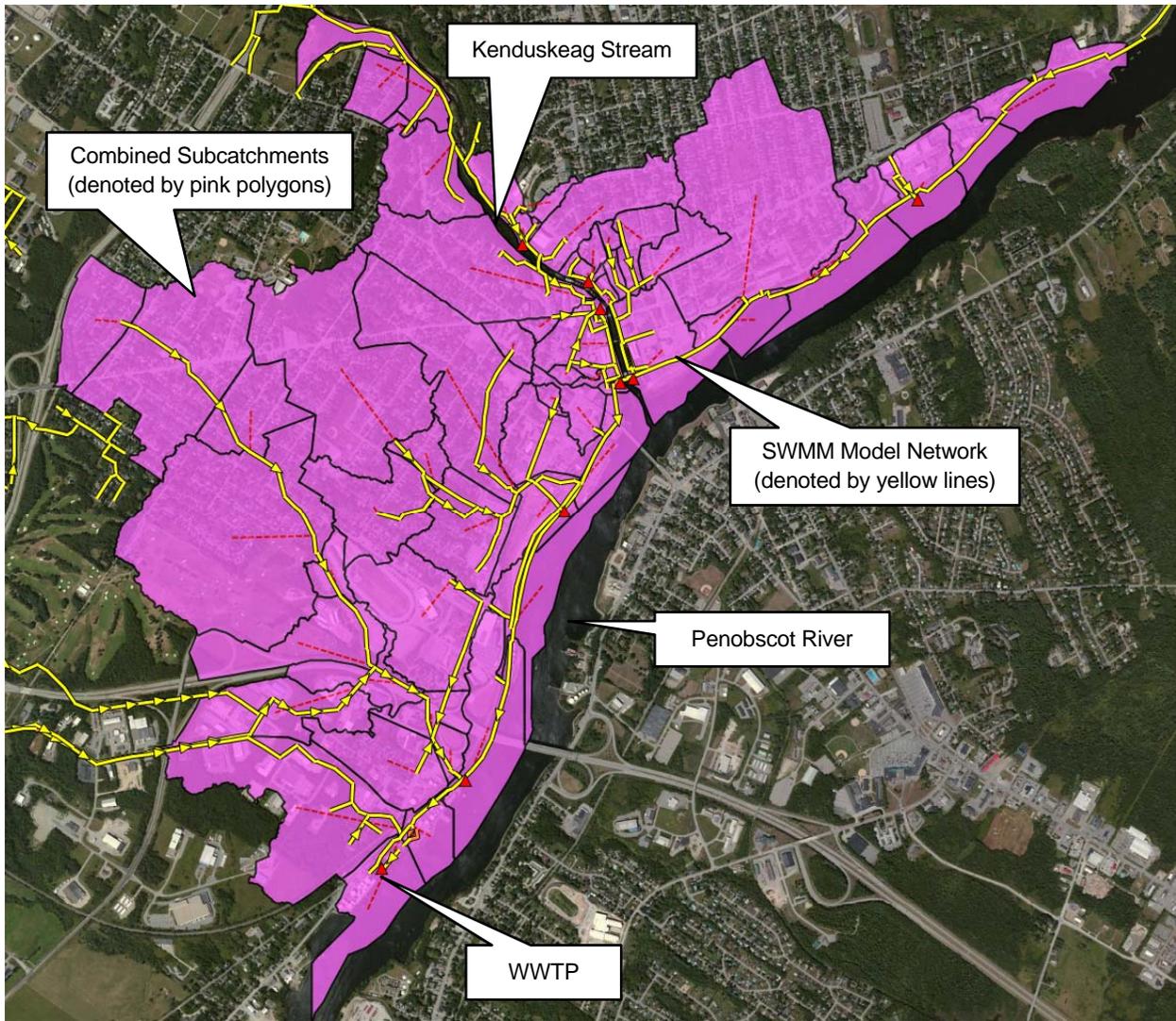


Figure 2-1. Combined Subcatchment Delineations

3.0 Hydraulic Model

The SWMM model's hydraulic network consists of conduits, nodes, storage, pump stations, controls (e.g., gates), weirs, orifices and outfalls. The following section summarizes the major changes made to the hydraulic model during the model update.

The extent of the hydraulic network was updated to extend further upstream into the collection system to capture larger diameter pipes (i.e., diameter of 18 inches and greater) and pipes that were hydraulically important, that were not previously included in the model. Figure 3-1 shows the previous model extent, which also includes separated subcatchment areas. As mentioned in the previous section, the separated areas were removed from the updated model. Figure 3-2 shows the updated model extent after the model updates. The majority of the modified extent is within the Barkersville and Kenduskeag subareas.

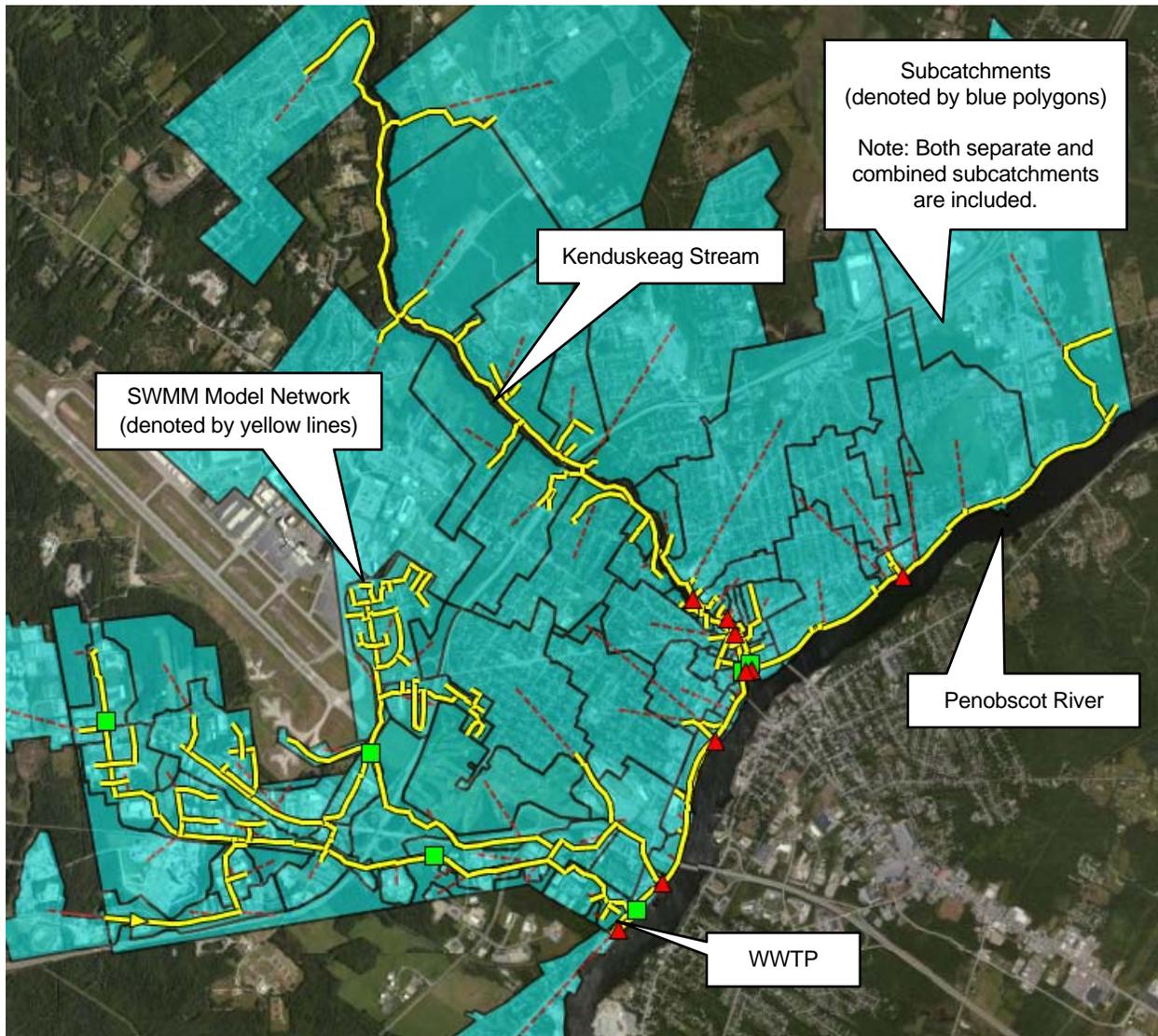


Figure 3-1. Previous SWMM Model Extent

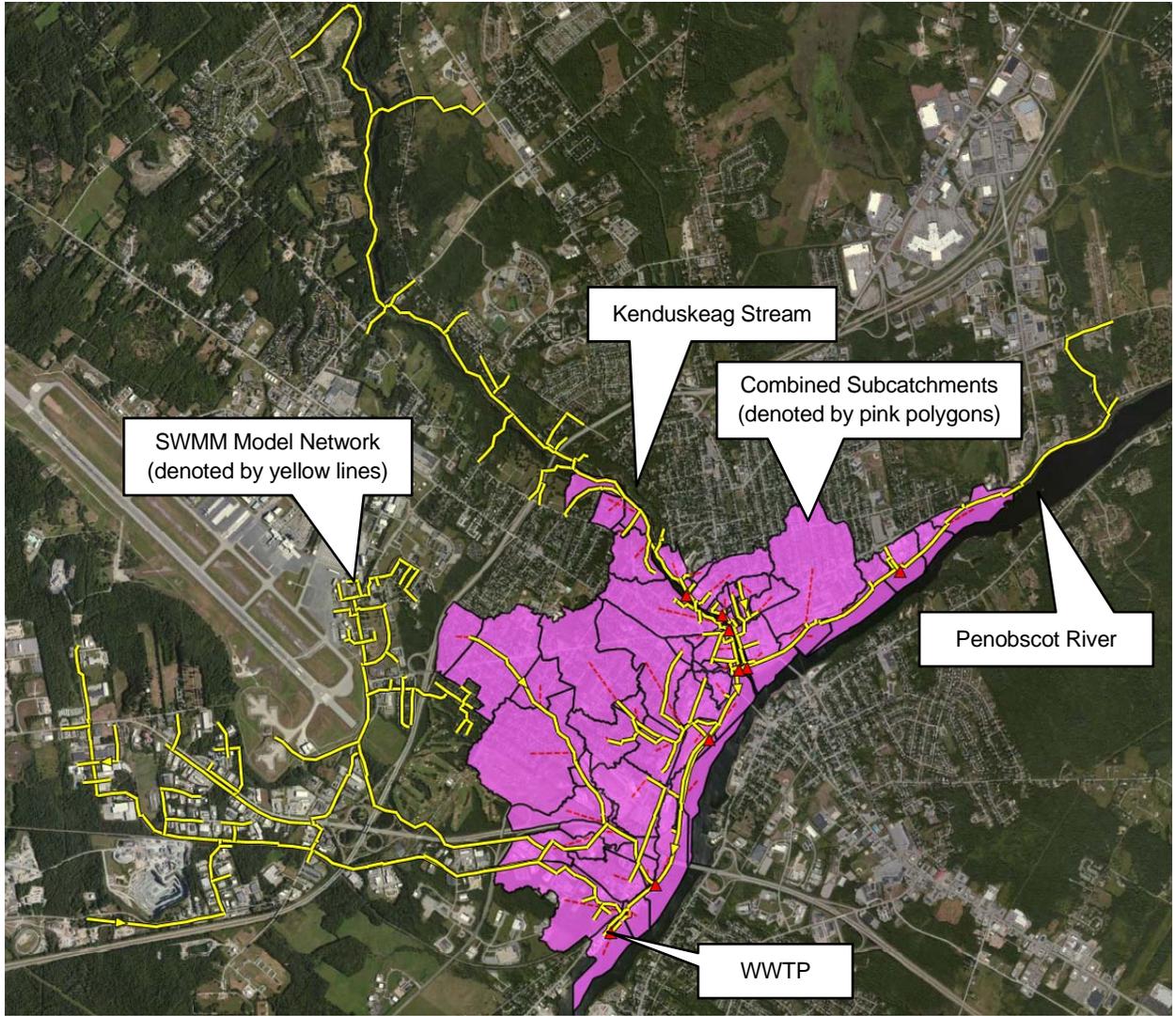


Figure 3-2. Updated SWMM Model Extent

Weir heights were adjusted to reflect changes made to the system since the 2012 model development:

- In 2012, the Barkersville weir was raised 19 inches, the Hammond Street weir was raised 17 inches, the Central Street weir was raised 11 inches and the Meadowbrook weir was raised by one course of brick to a total height of 13 inches.
- In 2013, overflow weirs at Hammond Street, Meadowbrook and Central Street were raised approximately three inches each by adding an additional course of brick to the overflow weir.
- The Barkersville weir was raised 9.5 inches on May 30, 2014.

The pump curves controlling the pump stations in the model were left untouched with the exception of the WWTP Influent Pump Station and the Kenduskeag Pump Station. In the model version that was provided to AECOM, the WWTP was modeled at a peak capacity of 29.5 MGD. The permitted capacity of the WWTP is 43 MGD. Based on correspondence with the City's WWTP staff, the current operation of the WWTP results in peak flow around 36 MGD due to wear and tear of the influent pumps. During the model calibration update, the WWTP Influent Pump Station curves were corrected to a peak capacity of 36 MGD in the model, corresponding to the WWTP capacity during the meter data deployment periods. For establishing the system baseline levels, the WWTP capacity was modeled at both 36 and 43 MGD.

For the Kenduskeag Pump Station, the pump control curves were modified to pump the peak capacity at a lower wet well elevation as typically observed by the WWTP staff. The previous version of the model required the wet well depth to reach levels that would cause flooding in the pump station before it reached peak pumping capacity. This may have resulted in an artificial increase in the hydraulic grade line that could have indirectly impacted the two Kenduskeag CSO locations (CSOs 006 and 007).

The collection system controls within the SWMM model were updated to reflect the City's latest Standard Operating Procedure for High Flow Management and Combined Sewer Overflow Control dated February 5, 2015. These real time controls mainly focus on gate and pump operations throughout the system for pre-storm, during storm, and post-storm situations.

The model time-steps were adjusted from 15 minutes for wet weather runoff to 5 minutes in the updated model. For long-term model runs, the routing time step was increased to 10 seconds from 1 second in the previous model, which maintained an appropriate level of model stability.

4.0 Model Calibration

A multi-phase metering program was conducted during the 2017 LTCP Update. The meters were deployed in the locations summarized in Table 4-1 and shown on Figure 4-1.

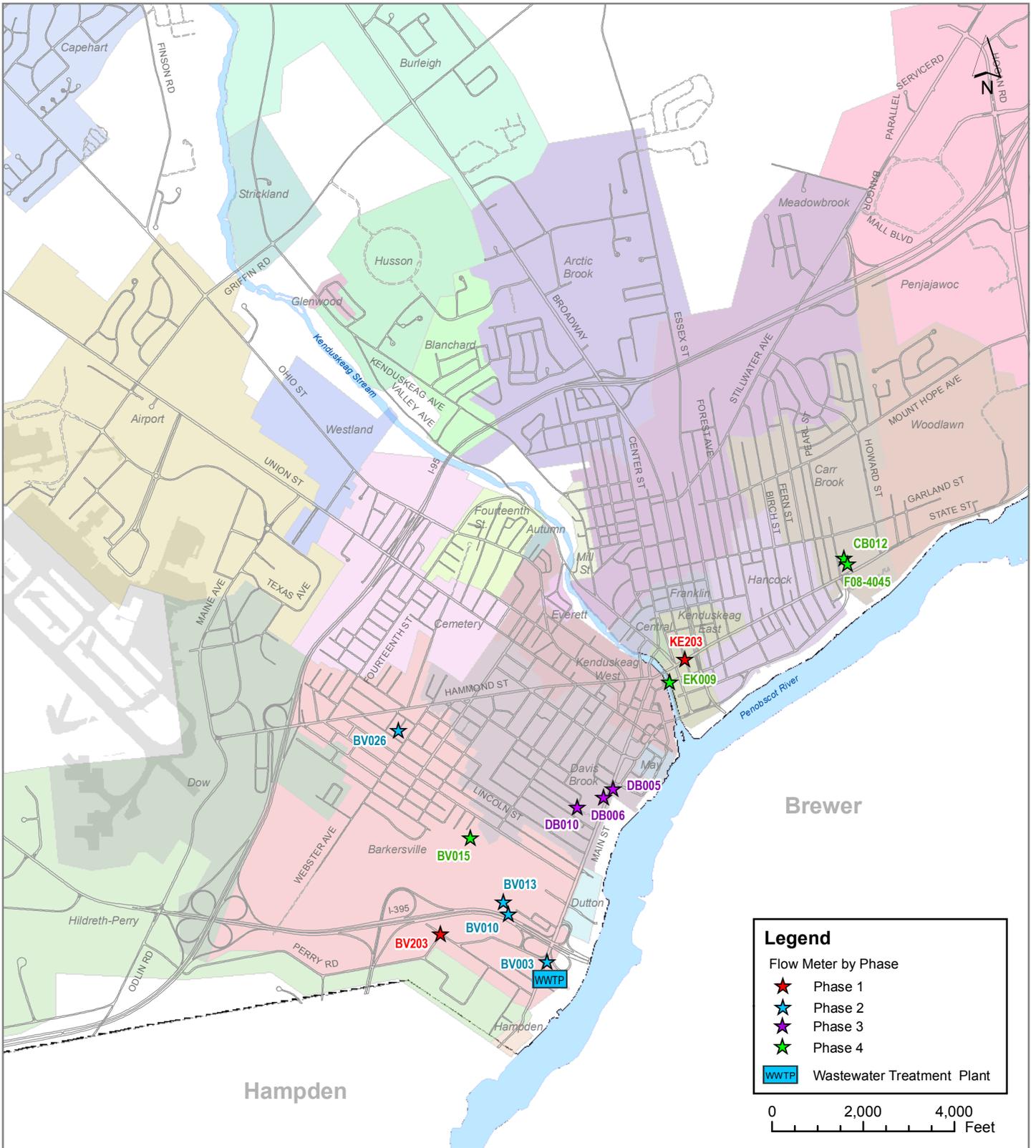
The goal of the calibration update was to establish a single set of parameters that worked over the entire year. The previous model calibration adjusted certain parameters to calibrate on a storm by storm basis. The previous approach is suitable for analyzing discrete storm events, but is not appropriate for long-term model simulations which are more appropriately based on a single set of input parameters.

As mentioned previously, the WWTP capacity was modeled during calibration at 36 MGD based on recent observations by WWTP staff during the calibration period. This peak flow, which is less than the 43 MGD permitted peak flow, is the result of wear and tear of the pumps.

In addition to the flow metering program, other data sources included SCADA data and permanent CSO meters (i.e., meters used for reporting at the overflow structures).

The following figures (4-2 to 4-15) contain a sample of the updated calibration results based on the various data sources used in the calibration process.

Figure 4-1. Flow Meter Locations



Legend

Flow Meter by Phase

- ★ Phase 1
- ★ Phase 2
- ★ Phase 3
- ★ Phase 4

WWTTP

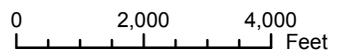


Table 4-1. Flow Metering Program

Meter Location	Manhole ID	Calibration Storm Events
Phase 1		
Inlet into SMH from Dow Cross Country Line	BV203	10/9/15 (0.5 in)
Inlet from north (French Street)	KE203	10/13/15 (0.3 in)
Inlet from east (State Street)	KE203	10/17/15 (0.2 in)
Phase 2 (Barkersville)		
Located in line coming in from BV050 (west)	BV003	11/20/15 (1 in) 12/1/15 (0.8 in)
Inlet from west; quantify flows entering BV from Dow and Hildreth Perry	BV010	
Inlet from north; quantify flows leaving the BV CSO Storage Tank	BV013	
Inlet from north; quantify flows from the northern portion of the subsection	BV026	
Phase 3 (Davis Brook)		
Outlet from SMH to south; manhole upstream of CSO regulator	DB005	12/22/15 to 12/23/15 (1 in) 1/10/16 (2 in)
Inlet from north; quantify flows from northeast portion of subsection	DB006	
Inlet from west; quantify flows from west portion of subsection	DB006	
Inlet from north; quantify flows from the north central portion of subsection	DB010	
Inlet from west; quantify flows from the northwest portion of subsection	DB010	
Phase 4		
Outlet from manhole to South	CB012	5/2/16 to 5/5/16 (1.1 in)
Inlet to manhole from 30" PVC to North	DMH F08-4045	
Inlet from north into SMH from East Kenduskeag Interceptor	EK009	
Outlet from manhole to south; quantify flows entering BV CSO Storage Tank	BV015	

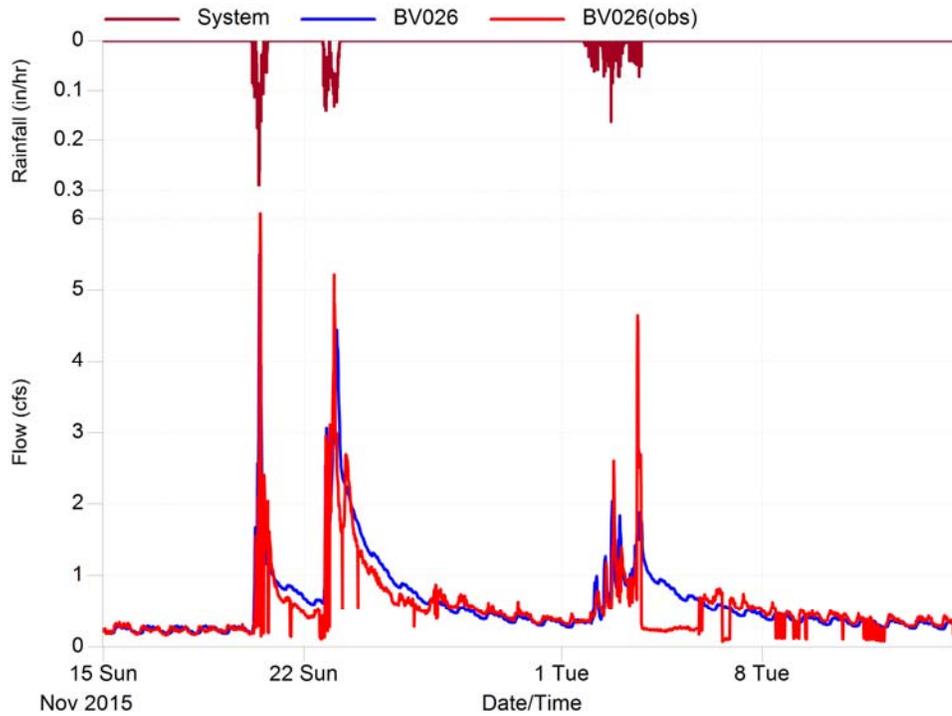


Figure 4-2. Phase 2, Barkersville: BV026 (Located Upstream of Storage Conduit)

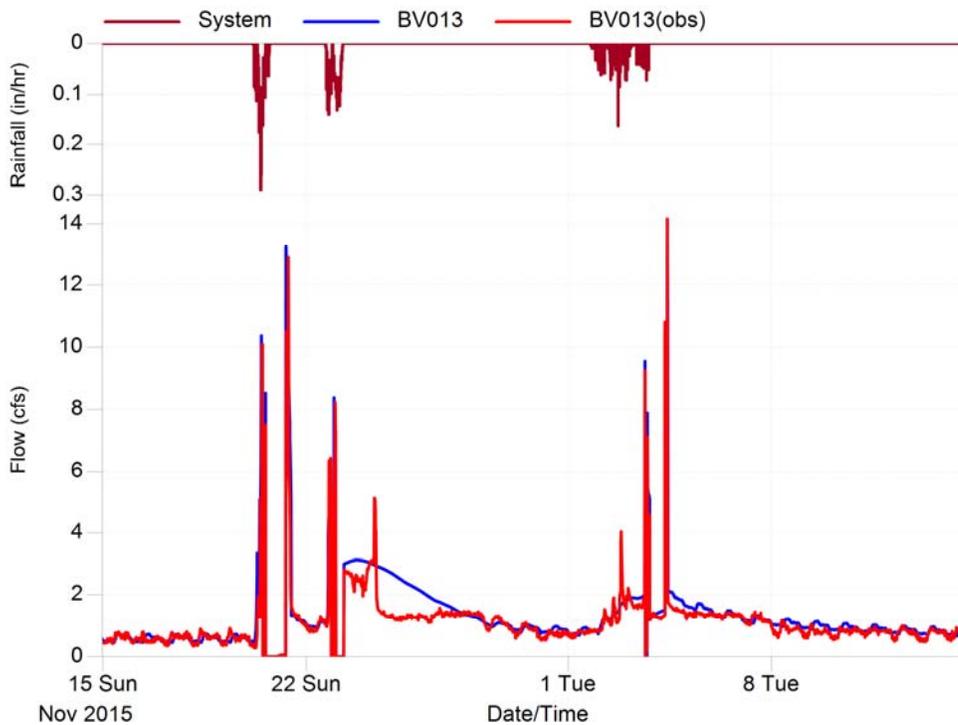


Figure 4-3. Phase 2, Barkersville: BV013 (Located Just Upstream of Storage Conduit)

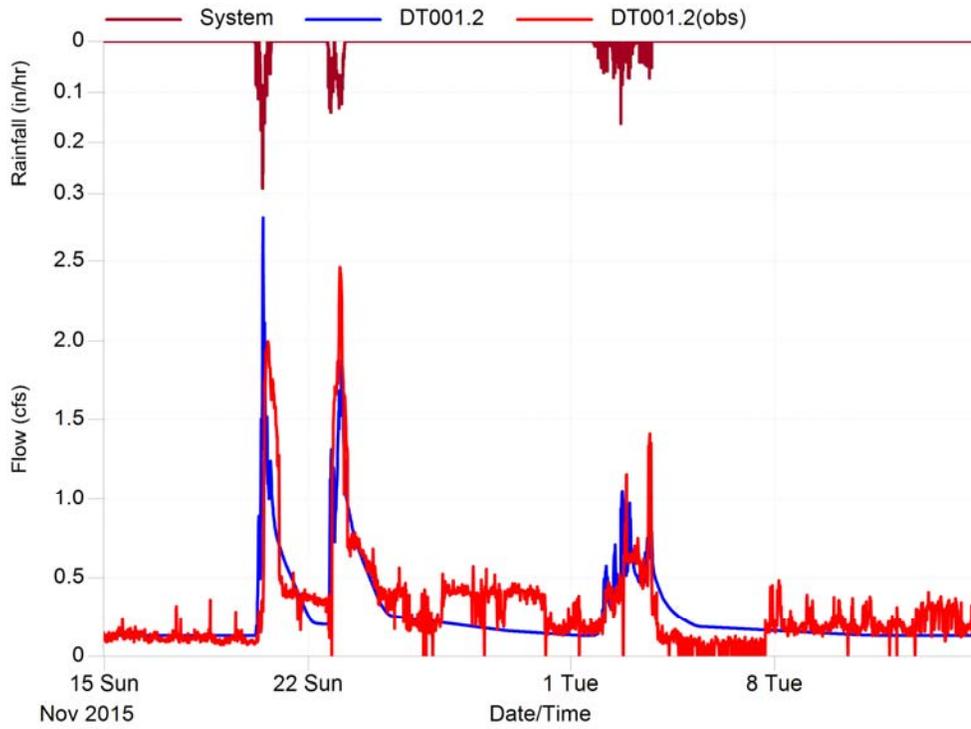


Figure 4-4. Phase 2, Barkersville: DT001 (Flow from West, Downstream of Storage Conduit)

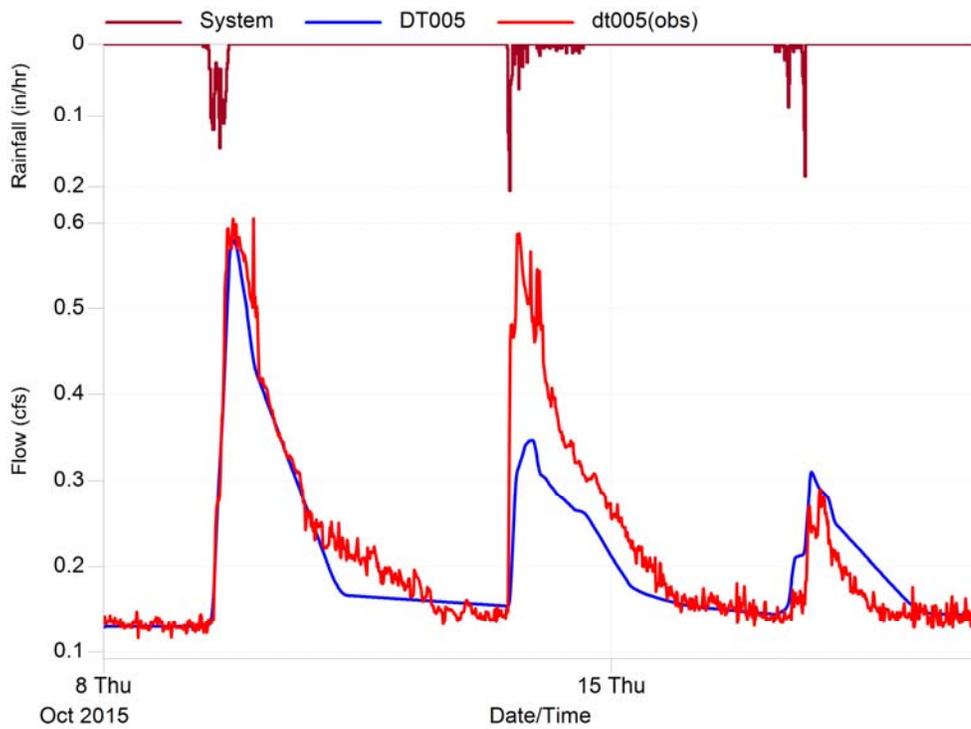


Figure 4-5. Phase 1, Barkersville: BV203/DT005 (Dow Cross Country Line)

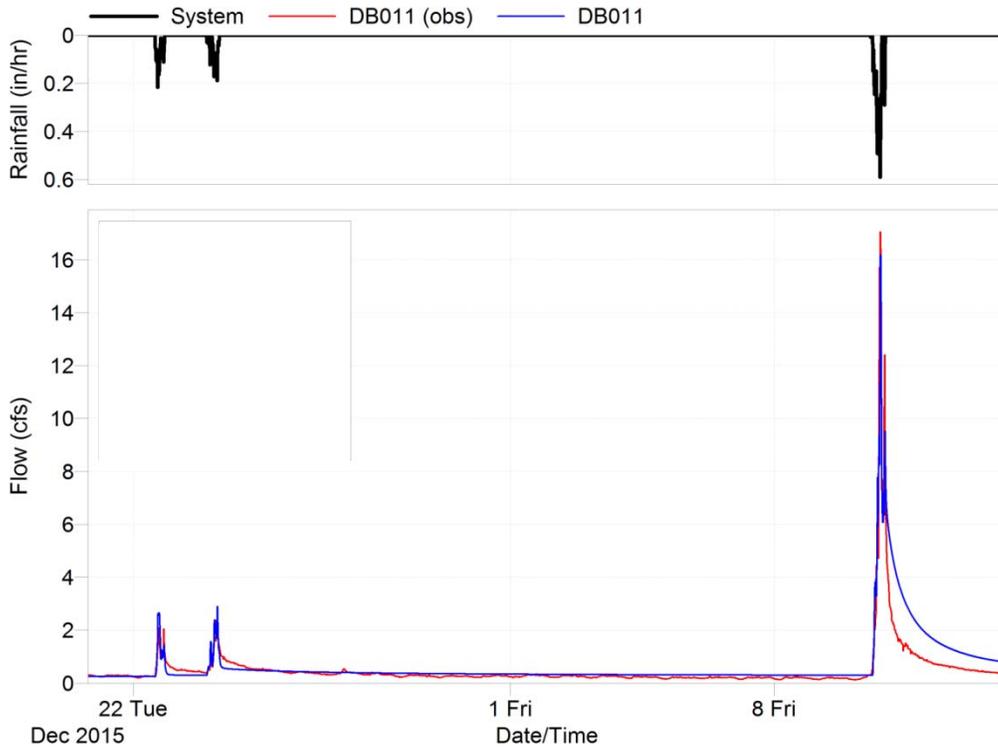


Figure 4-6. Phase 3, Davis Brook: DB011 (North Inlet to DB010)

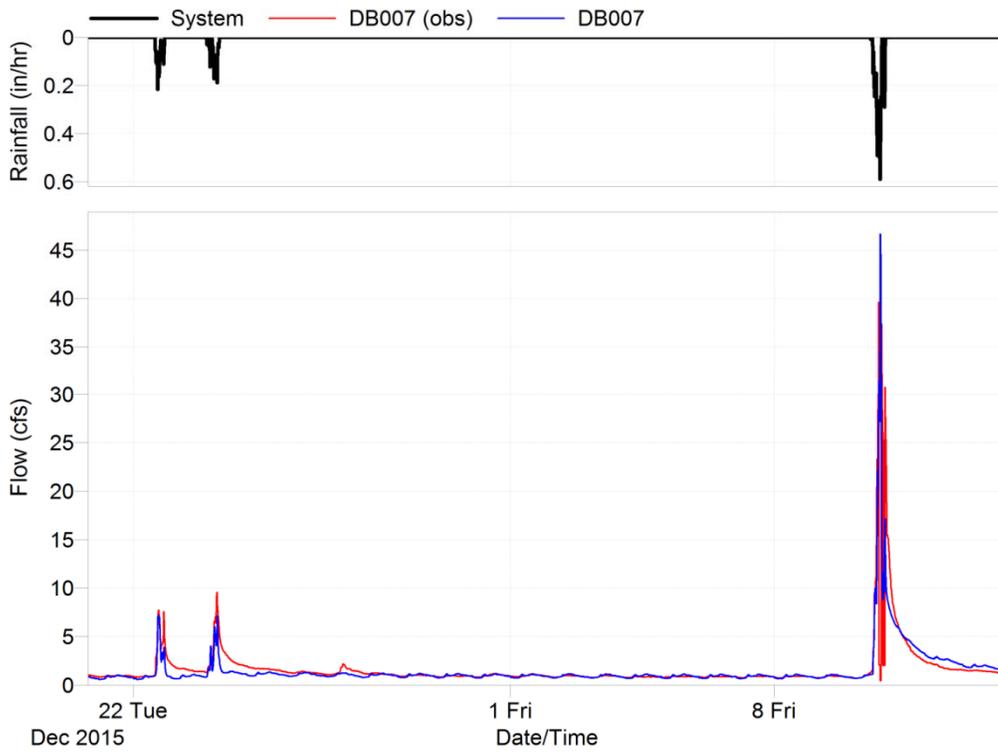


Figure 4-7. Phase 3, Davis Brook: DB011 (West Inlet to DB006)

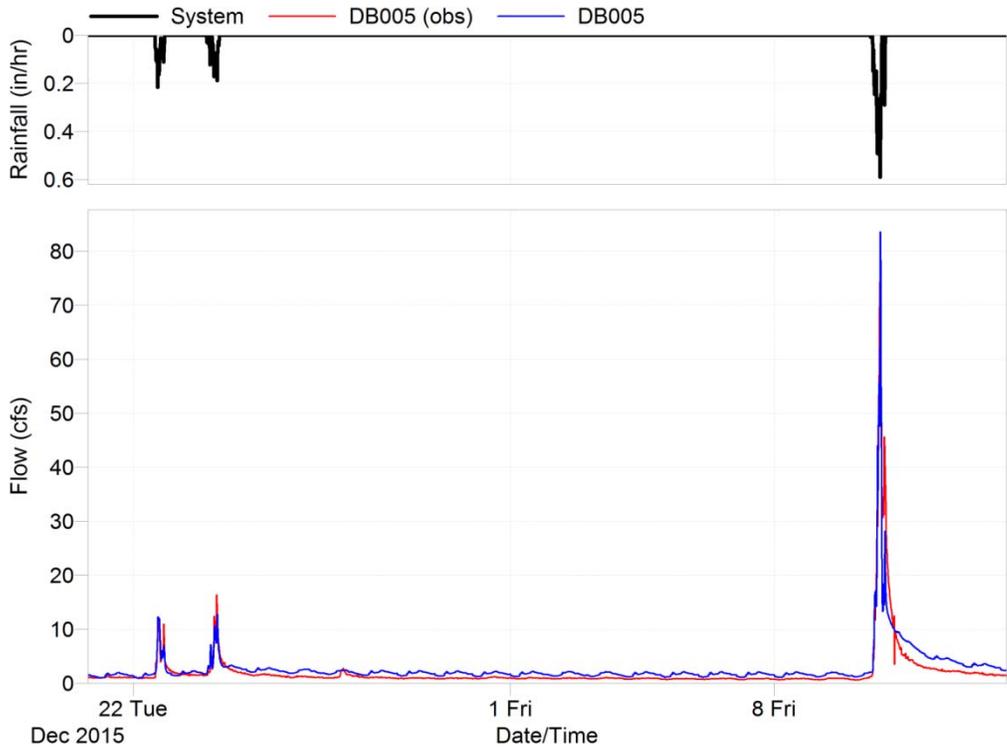


Figure 4-8. Phase 3, Davis Brook: DB005 (Outlet to Regulator)

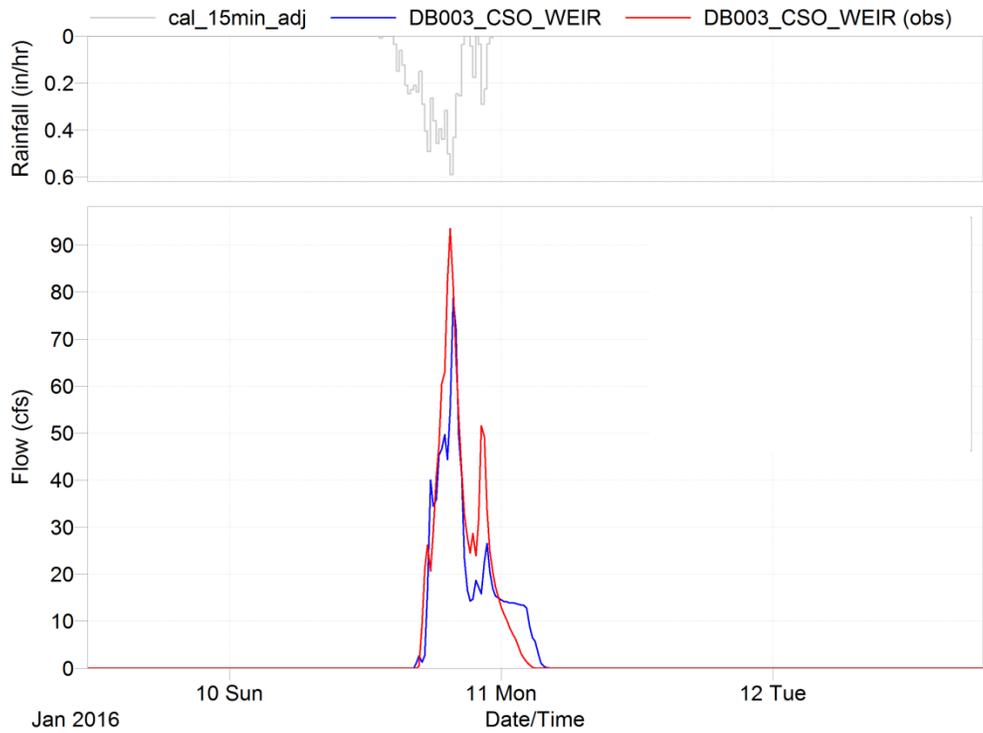


Figure 4-9. Davis Brook: CSO 003 Permanent Flow Meter

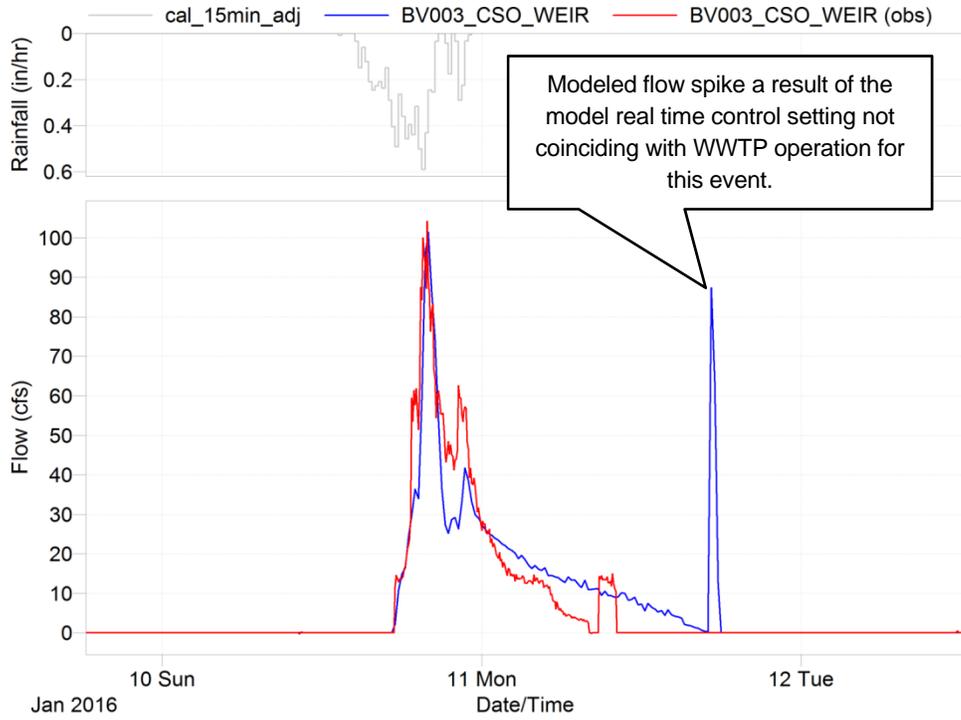


Figure 4-10. Barkersville: CSO 002 Permanent Flow Meter

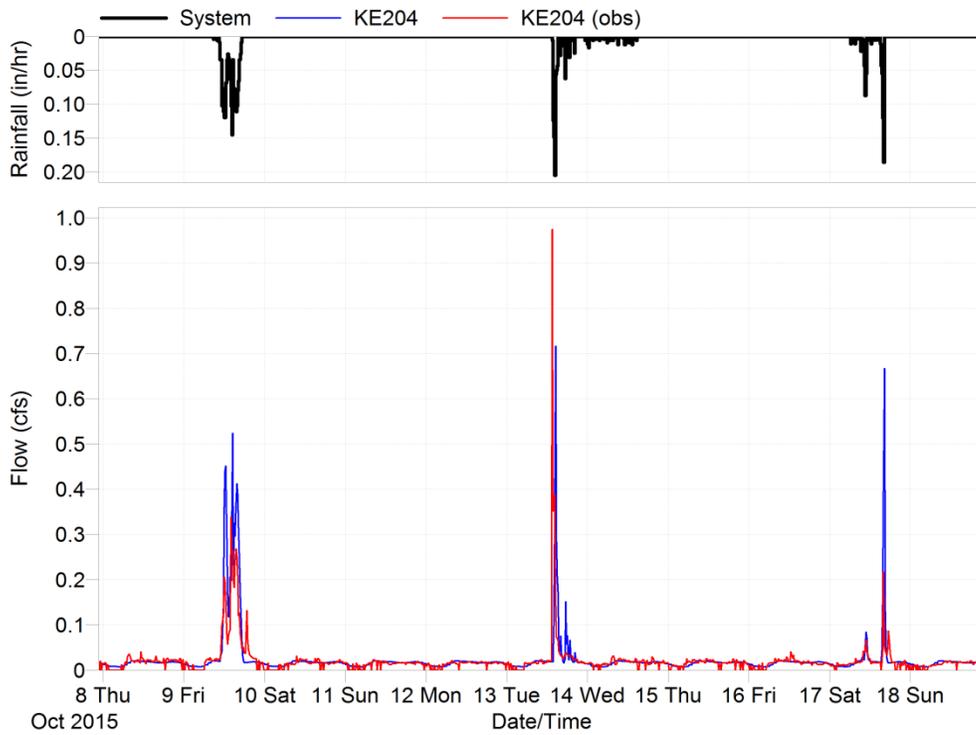


Figure 4-11. Phase 1, Kenduskeag East: KE204 (State Street)

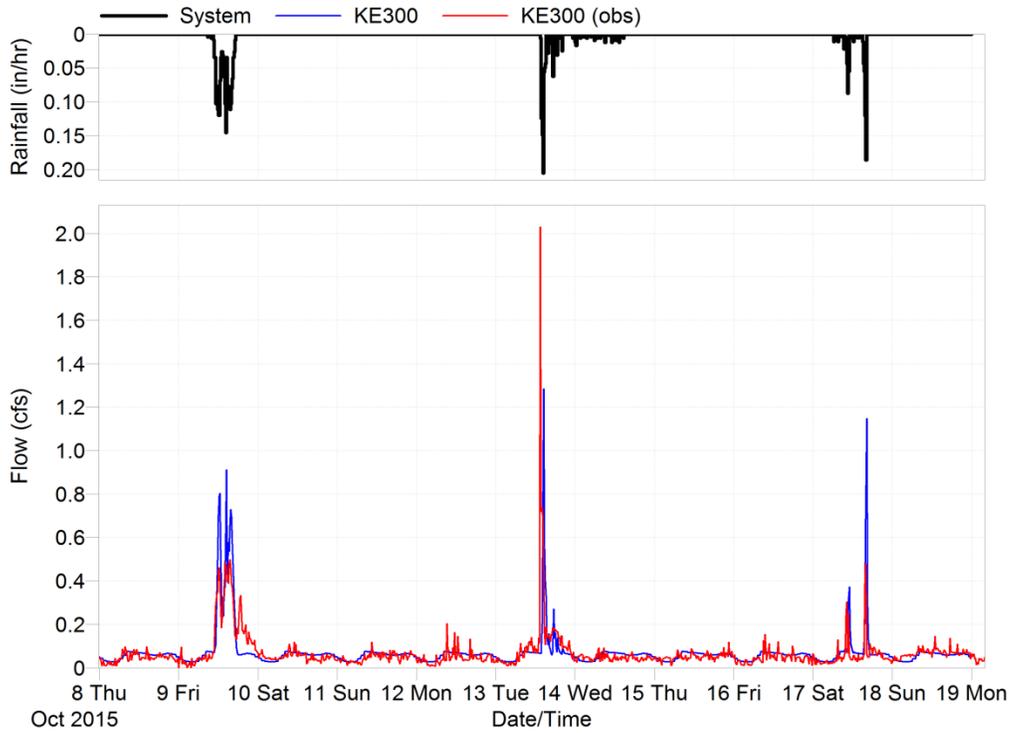


Figure 4-12. Phase 1, Kenduskeag East: KE300 (French Street)

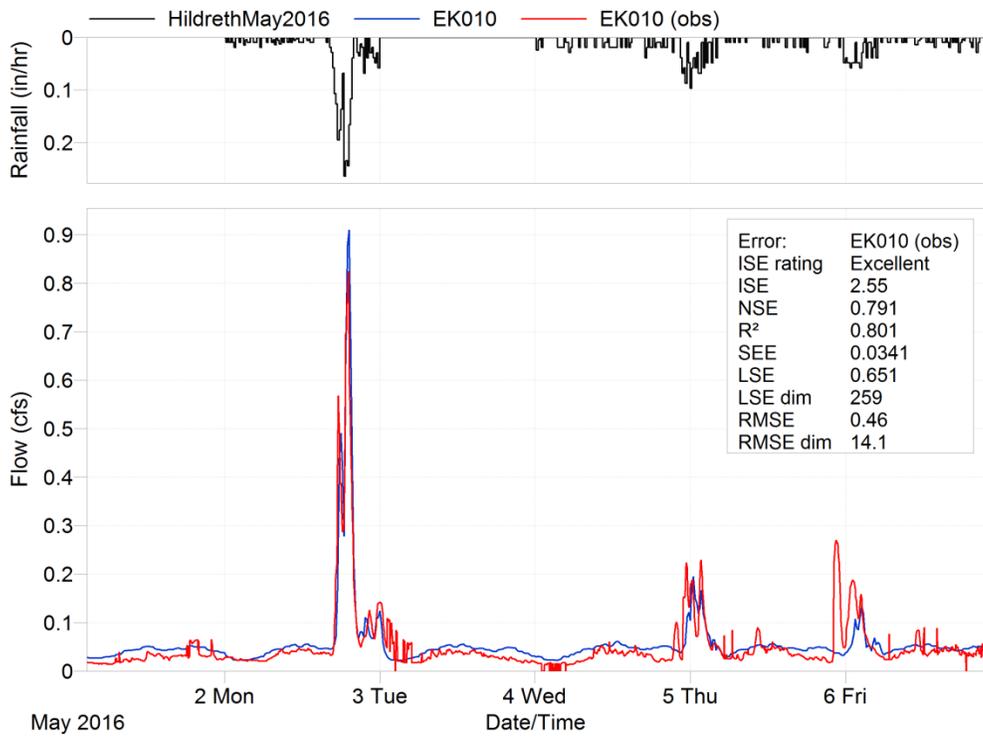


Figure 4-13. Phase 4, Kenduskeag East: EK010 (Inlet from North)

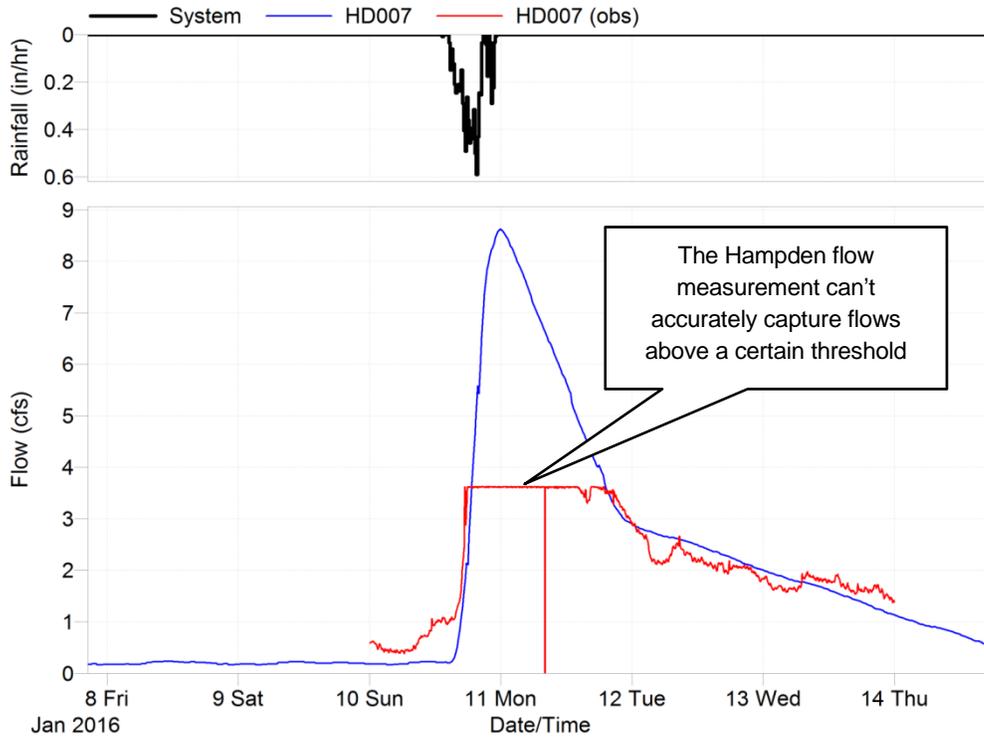


Figure 4-14. Hampden Flow to Bangor: HD007

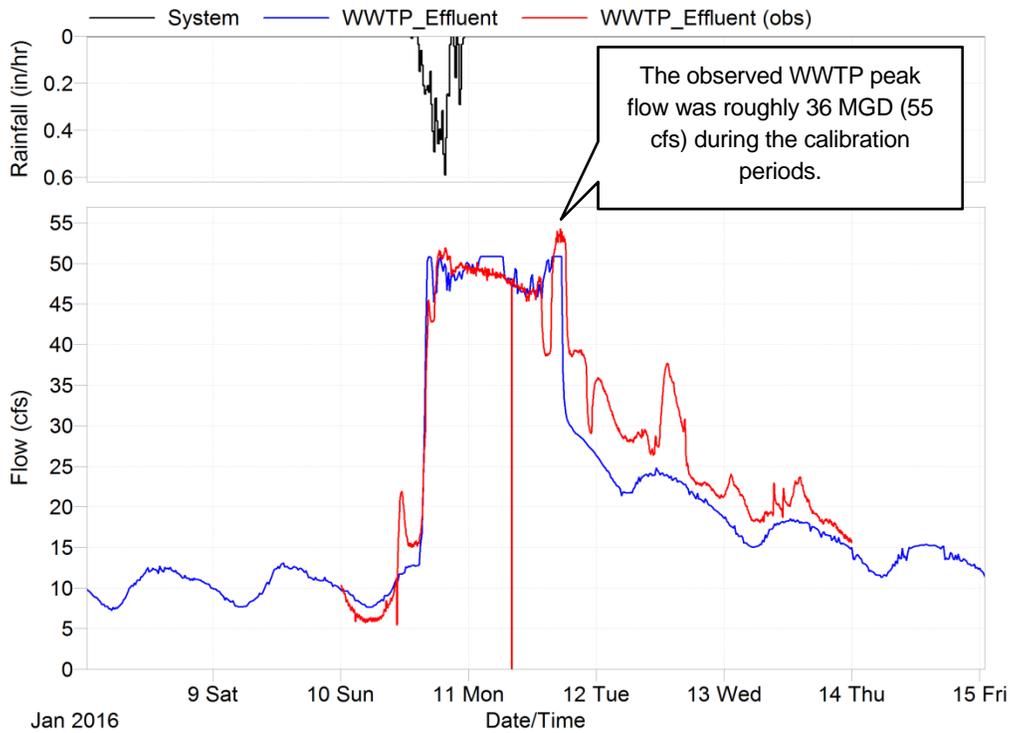


Figure 4-15. Bangor WWTP Effluent

5.0 Model Validation

The calibration update focused on selected metering locations for isolated storm events. In an attempt to test the updated model over a wide range of storm events and seasonal variations, the calibrated model was run for a long-term simulation and compared to available CSO data from the City's permanent CSO meters. The calendar year of 2014 was selected for the model validation since it was the most recent year with a full set of reliable rainfall data. Table 5-1 contains a summary of the long-term model results against the annual CSO data reported to the DEP. Figure 5-1 (CSO activations) and Figure 5-2 (CSO volumes) contain a visual representation of the data shown on Table 5-1.

For systemwide results, the updated model is over-predicting CSO volume by 10% (8.7 MG), but under-predicting the number of total activations by 14% (14 total activations across all active CSOs). The modest (10%) over-prediction on volume is considered appropriately conservative for long-term CSO control planning purposes and represents a reasonable factor of safety at this stage of project development. The volume distribution between the CSO locations is well represented in the model with Barkersville and Davis Brook contributing the most CSO volume over the year, which is consistent with the reported data. Similarly, the two Kenduskeag CSO locations follow as the third and fourth largest CSOs by volume.

Table 5-1. Model Validation Summary

CSO Location	Updated SWMM Model (WWTP at 36 MGD)		2014 DEP Report		Delta (Model – DEP Report)	
	Events	Volume (MG)	Events	Volume (MG)	Events	Volume (MG)
BV - 002	22	44.5	22	39.0	0	5.5
DB - 003	18	41.3	32	26.6	-14	14.7
KW - 006	8	8.6	7	12.0	1	-3.4
KE - 007	12	1.4	5	7.8	7	-6.4
HM - 009	1	0.0	3	0.9	-2	-0.9
MB - 011	11	0.5	15	1.4	-4	-0.9
CM - 016	0	0.0	0	0.0	0	0.0
CB - 020	3	0.1	7	0.0	-4	0.0
CS - 023	9	0.1	7	0.1	2	0.0
	84	96.4	98	87.7	-14	8.7
					-14%	+10%

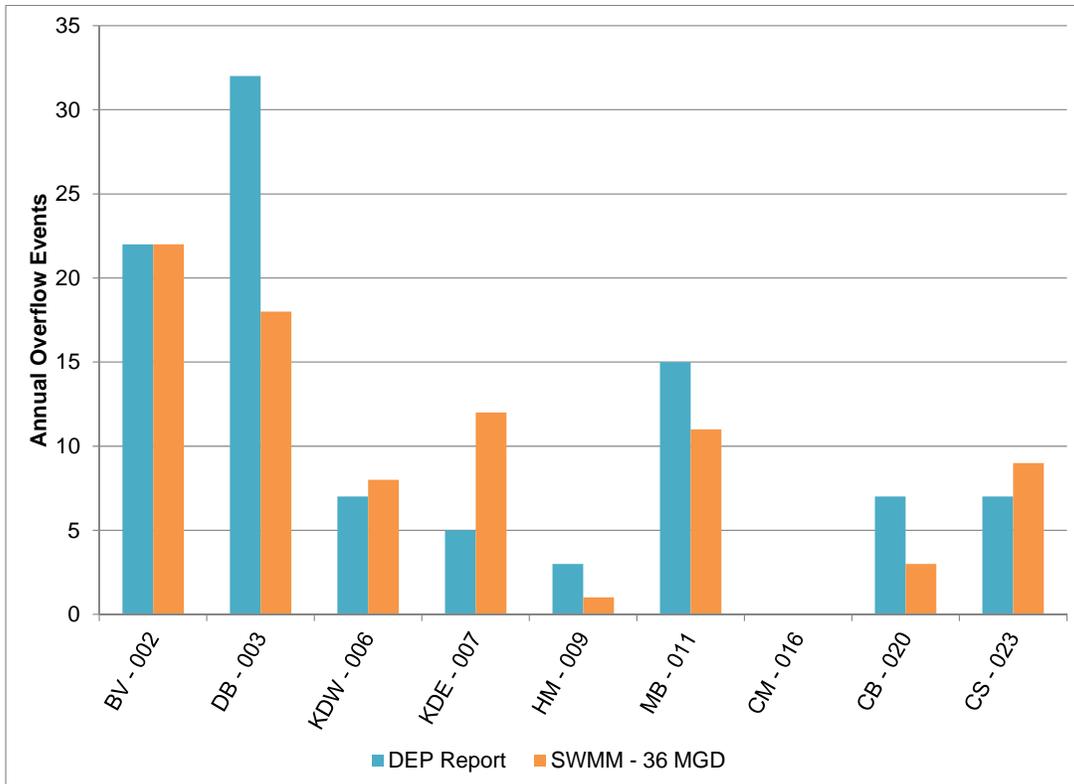


Figure 5-1. Model Validation: Overflow Event Comparison by CSO Location

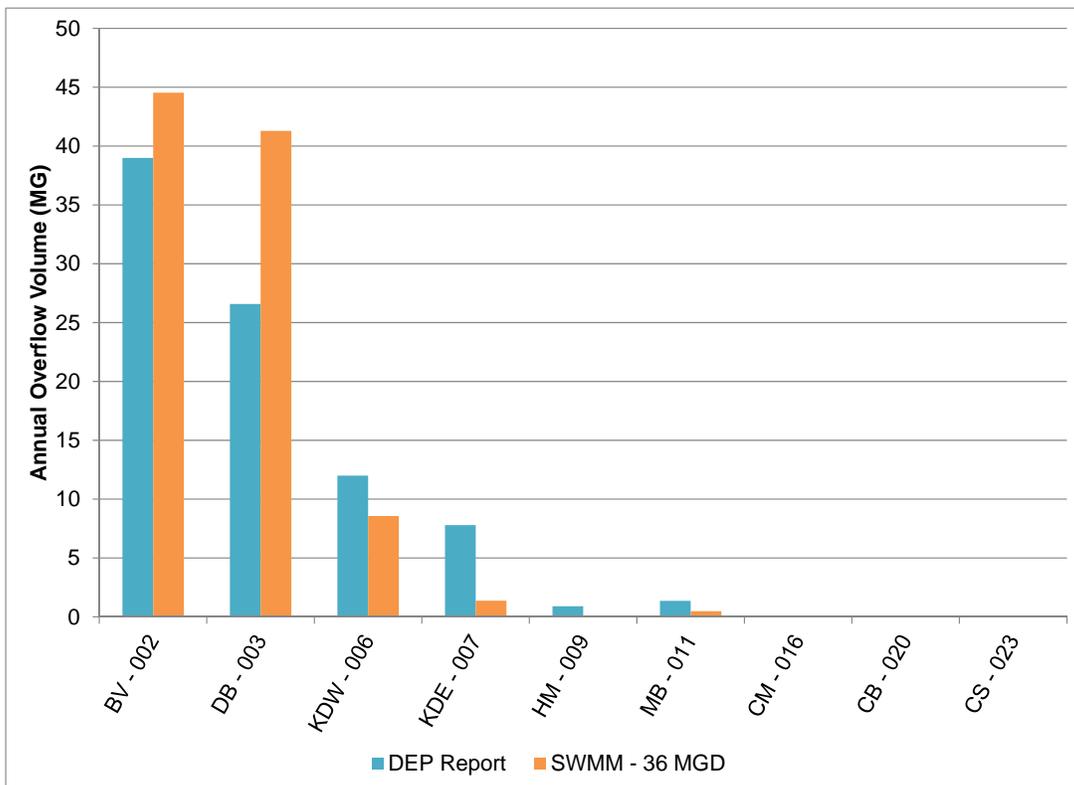


Figure 5-2. Model Validation: CSO Volume Comparison by CSO Location

Since 2012, the City has been reporting CSO activity using data collected at flow meters at each CSO location. Table 5-2 contains a summary of the CSO volume data reported to the DEP from 2012 to 2015 distributed as a percentage of the total systemwide CSO volume. Based on the meter data, four of the CSOs make up the majority of the City's typical annual CSO volume. These four major CSOs are Barkersville (CSO 002), Davis Brook (CSO 003), Kenduskeag West (CSO 006) and Kenduskeag East (CSO 007) which resulted in 95.7% of the City's CSO volume from 2012 to 2015. Table 5-2 also contains the results of the updated model runs for the 2014 model validation run and the typical year run (1974). Both of these model runs were based on a WWTP capacity of 36 MGD since that corresponds to the typical observed peak flow capacity at the WWTP during the monitoring period. The general trend of CSO distribution in the two model runs matches the data recorded over the four year span from 2012 to 2015.

Table 5-2. Systemwide Distribution of CSO Volume

CSO Location	Annual CSO Volume					
	Flow Meter Data (2012 to 2015)		2014 SWMM Model Run		Typical Year SWMM Model Run (1974)	
	CSO Volume (MG)	Percent of Total	CSO Volume (MG)	Percent of Total	CSO Volume (MG)	Percent of Total
Barkersville (CSO 002)	16.3	28.4%	44.5	46.2%	46.3	36.3%
Davis Brook (CSO 003)	22.2	38.7%	41.3	42.8%	57.2	45.0%
Kenduskeag West (CSO 006)	11.1	19.3%	8.6	8.9%	20.2	15.8%
Kenduskeag East (CSO 007)	5.3	9.3%	1.4	1.4%	1.5	1.2%
Hammond St. (CSO 009)	0.9	1.6%	0.0	0.0%	0.0	0.0%
Meadowbrook (CSO 011)	1.5	2.6%	0.5	0.5%	0.9	0.7%
Cemetery (CSO 016)	0.0	0.0%	0.0	0.0%	0.0	0.0%
Carr Brook (CSO 020)	0.1	0.2%	0.1	0.1%	0.9	0.7%
Central St. (CSO 023)	0.2	0.3%	0.1	0.1%	0.3	0.2%
Systemwide Total	57.6		96.4		127.2	

6.0 System Characterization

For the LTCP Update, the model was primarily used to evaluate the collection system over the typical year (i.e., the 1974 calendar year). The first step in the CSO abatement evaluation is to establish baseline values for systemwide CSO activations and volumes based on the typical year. Table 6-1 summarizes the baseline values for the collection system based on the updated model. These values are based on a WWTP capacity of 36 and 43 MGD, assuming the lost capacity due to the wear and tear of the influent pumps will be remediated at some point in the future. Larger numbers of activations and CSO volumes in Table 6-1 correspond to the 36 MGD WWTP capacity.

Table 6-1. System Baseline Characteristics for Typical Year (1974)

CSO Outfall	Activations	CSO Volume (MG)	Peak CSO Flow Rate (MGD)
Barkersville (002)	19 – 20	36.4 – 46.3	110.5
Davis Brook (003)	19	40.4 – 57.2	162.9
Kenduskeag West (006)	8 – 9	19.9 – 20.2	89.8
Kenduskeag East (007)	14	1.2 – 1.5	22.0
Hammond St. (009)	0	0.0	0.0
Meadowbrook (011)	12	0.9	5.8
Cemetery (016)	0	0.0	0.0
Carr Brook (020)	5	0.9	129.3
Central St. (023)	7	0.3	1.9
	84 – 86	100.0 – 127.2	

Due to the observed variability in the WWTP capacity during wet weather events, a sensitivity analysis was conducted for various WWTP peak capacities. Figure 6-1 contains a plot of the systemwide CSO activations and volumes for 33, 36, 43 and 50 MGD. The WWTP capacity does not significantly impact number of CSO activations. However, the systemwide CSO volume is directly impacted by the WWTP capacity – the more flow that can be treated by the WWTP leads to less CSO volume discharged throughout the system.

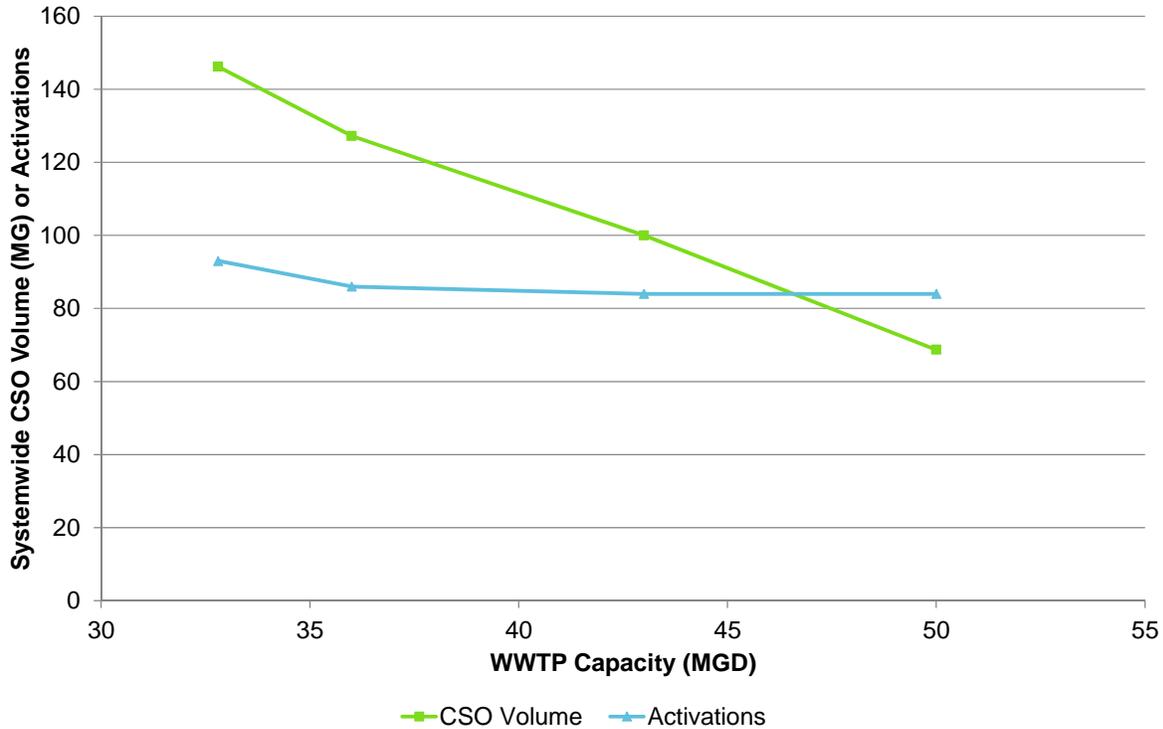


Figure 6-1. WWTP Capacity Sensitivity Analysis

7.0 Summary

The 2012 LTCP Update resulted in the development of a comprehensive SWMM representation of the City's collection system. As part of this 2017 LTCP Update, the model was updated and refined to provide an even more robust tool for assisting the City with their CSO abatement efforts. Based on the calibration results and long-term model validation, the model provides an adequate representation of the City's collection system and is a valuable tool in the City's CSO abatement planning. The system characterization presented in Table 6-1 was the basis for evaluating CSO abatement alternatives explored as part of the LTCP Update.

8.0 References

1. *Technical Memorandum P2LTCP.1, EPA September 30, 2012 Submittal, Combined Sewer System Model, CH2M HILL.*

Appendix B: Basis of LTCP Cost Estimates

BASIS OF LTCP COST ESTIMATES

1. Cost Estimating Accuracy:

Use Class 5 Cost Estimate Class from the American Association of Cost Engineering (AACE) Guidelines (ASTM E 2516-06) as shown below:

Standard AACE Cost Estimating Guidelines

Cost Estimate Class	Project Level Description	Estimate Accuracy Range	Recommended Estimate Contingency
5	Planning (0-2% Design)	-20 to -50% +30 to +100%	30 to 50%
4	Conceptual (1-15% Design)	-15 to -30% +20 to +5%	25 to 30%
3	Preliminary (10-40% Design)	-20 to -50% +10 to +30%	15 to 20%
2	Detailed (30-70% Design)	-50 to -15% +5 to +20%	10 to 15%
1	Final (50-100% Design)	-3 to -10% +3 to +15%	5 to 10%

2. **Estimated total project cost** - Opinion of probable construction cost plus, engineering and Owner's contingency, land acquisition and SRF loan administrative costs.

Opinion of probable construction costs - The costs are planning-level estimates of materials, equipment and labor, based on Level 5 estimates as described.

Estimate contingency (30%) - Includes construction related items (i.e., process piping, electrical conduits, etc.) not yet defined and modifications that would be further defined and quantified between the planning level and completion of bid documents.

Engineering and owner contingency (35%) - Engineering design and construction-related services plus an overall project contingency for items that are unforeseen.

3. Construction Cost Index:

Use August 2016 ENR (20 Cities) of 10386

4. Construction Cost Estimates:

- a. Storage conduits, storage tanks, and RTB ranged in \$/gallon based on size and location
- b. Sewer separation/rehabilitation was developed on a \$/per foot of pipe and varied for both pipe size and location. The stormwater pipes were upsized one pipe size from the existing combined sewer. Sanitary sewer pipes were estimated to be replaced in 1/3 of total sewer separation projects, based on review of CCTV. Sanitary sewer pipes were decreased one pipe size from the existing combined sewer. Sewer separation was more expensive in an urban area and more traffic congestion.

5. Present Worth:

- a. Life cycle at 20 Years
- b. Interest at 3%
- c. Present Worth Factor at 14.877
- d. Total Present Worth as the sum of Total Capital Cost plus the Present Worth of the first year annual Operation and Maintenance (O&M) Cost

Appendix C: Financial Capability and Affordability Assessment

Memorandum

To Andy Rudzinski, Superintendent, City of Bangor
Wastewater Treatment Plant and Debbie Cyr, City of
Bangor Finance Director Page 1

Subject Financial Capability and Affordability Assessment

From AECOM

Date January 31, 2017

1.0 INTRODUCTION AND BACKGROUND

This Memorandum presents the results of a Financial Capability and Affordability Assessment (FCA) that has been prepared to support the City of Bangor's Combined Sewer Overflow (CSO) Phase II Long Term Control Plan (LTCP). The FCA will be used to aid in preparation of the implementation schedule for capital projects proposed in the LTCP. This FCA addresses all estimated costs associated with the City's Clean Water Act (CWA) compliance programs and provides an analysis of affordability in light of the current financial and socioeconomic condition of the City and associated tributary service area.

The U.S. Environmental Protection Agency (EPA) has recognized the importance of taking a community's financial status into consideration when developing implementation schedules for compliance with CWA requirements, and to this end issued "Combined Sewer Overflows: Final Guidance for Financial Capability Assessment and Schedule Development" (EPA, 1997) (hereinafter, the "1997 Guidance"). The 1997 Guidance contains a two phase approach for assessing a permittee's financial capability to implement current and proposed wastewater treatment and CSO controls. Phase 1 calculates the financial impact of water pollution costs (wastewater and stormwater) on individual households to determine the Residential Indicator (RI), which examines the average cost of household water pollution costs relative to benchmarks of the service area median household income (MHI). The results of this preliminary screening analysis are assessed by placing the community in one of three categories:

- Low economic impact: average household CWA costs are less than 1% of MHI;
- Mid-range economic impact: average household CWA costs are between 1% and 2% of MHI; and
- High economic impact: average household CWA costs are greater than 2% of MHI.

Phase 2 evaluates the following six Financial Capability Indicators (FCIs) regarding a permittee's debt, socioeconomic, and financial conditions: bond rating, overall net debt as a percent of full market

property value (FMPV), unemployment rate, median household income, property tax revenues as a percent of FMPV, and property tax revenue collection rate. The FCIs are compared to national benchmarks and are used to generate a score that is the average of the six FCI scores. Lower FCI scores suggest weaker economic conditions, and thus the increased likelihood that additional water pollution control costs could cause a substantial economic impact.

The results of the first and second phases are entered into a Financial Capability Matrix, which provides an overall assessment of a permittee's financial capability. The result of this combined assessment can be used to establish an appropriate CSO control implementation schedule.

EPA has recognized that its RI and FCI metrics are not the sole basis for considering an appropriate CSO compliance schedule, and the 1997 Guidance encourages permittees to submit additional documentation and socioeconomic indicators that would create a more accurate and complete picture of their financial capability to implement the proposed CSO controls.

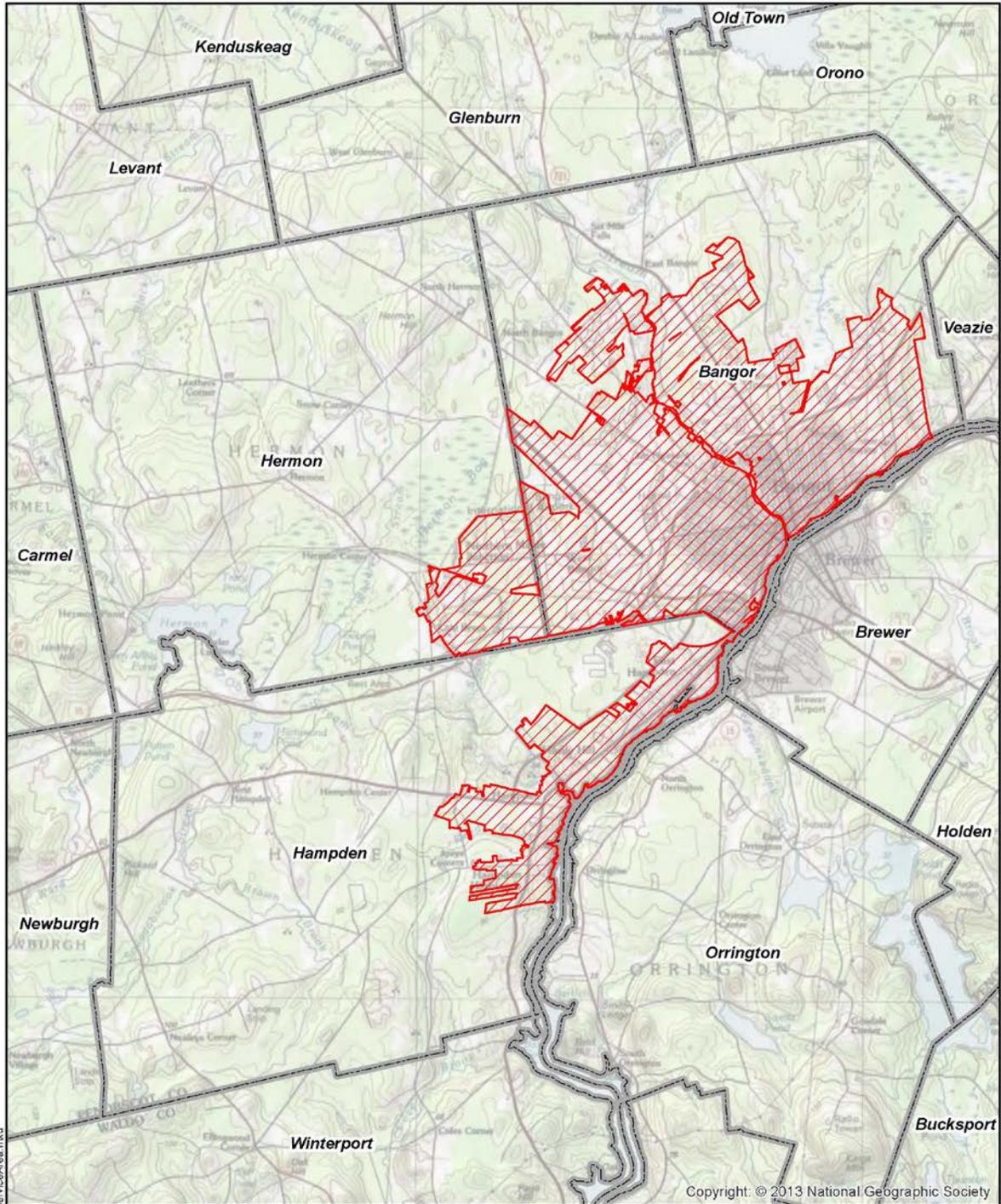
In 2012, EPA released its "Integrated Municipal Stormwater and Wastewater Planning Approach Framework" (EPA, 2012), which is supportive of a flexible approach to prioritizing projects with the greatest water quality benefits and states that "assessment of the community's financial capability should take into consideration current sewer rates, stormwater fees and other revenue, planned rate or fee increases, and the costs, schedules, anticipated financial impacts to the community of other planned stormwater or wastewater expenditures and other relevant factors impacting the utility's rate base" (EPA, 2012 at page 5).

In November of 2014, EPA released its "Financial Capability Assessment Framework" clarifying the flexibility within their CSO guidance (EPA, 2014). Although EPA did not modify the metrics established in the 1997 Guidance, the 2014 Framework reiterates that permittees are encouraged to supplement the core metrics with additional information that would "create a more accurate and complete picture of their financial capability" that may "affect the conclusion" of the analysis.

In light of the above-described EPA guidance and frameworks, this document presents the results of a FCA performed pursuant to the 1997 Guidance, including supplemental information and analysis of local considerations affecting financial capability and affordability.

2.0 WASTEWATER SERVICE AREA AND CONTRIBUTING MUNICIPALITIES

The Bangor Wastewater Treatment Plant (WWTP) serves portions of the following three municipalities: the City of Bangor ("Bangor" or the "City"), the Town of Hampden ("Hampden"), and the Town of Hermon ("Hermon"). Figure 2-1 identifies these three municipalities and illustrates the approximate existing wastewater service area boundary. Ratepayers in Bangor and Hermon are billed the same sewer rate and are charged based on their metered water consumption. Hampden is billed monthly based on the Hampden's percent contribution of total flow treated at the WWTP. Hampden's charges are based on operations and maintenance (O&M) and capital costs associated with the WWTP only, not the collection system. Hampden and Hermon have additional local wastewater collection costs that are passed on to their users.



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Legend

-  Sewer Service Area
-  Town Boundaries



0 5,000 10,000
Feet

FIGURE 2-1.

**APPROXIMATE CURRENT
BANGOR WWTP SERVICE AREA**

G:\Projects\MUNIBangor\Maps\ServiceArea.mxd

Information for each service area municipality is presented in the following sections. However, the focus of this assessment is on the City of Bangor since it includes the vast majority of service area households, approximately 92% as shown in Table 2-1, and shoulders the burden of most current and projected CWA program costs.

Table 2-1. Service Area Households by Municipality

Municipality	Households in Service Area	% of Total HH
Bangor	13,121	91.7%
Hampden	1,112	7.8%
Hermon	75	0.5%
<i>Total</i>	<i>14,308</i>	<i>100%</i>

3.0 PHASE 1 EVALUATION – DEVELOP RESIDENTIAL INDICATOR

The Phase 1 Evaluation determines the Residential Indicator (RI), which is used to measure the financial impact of the current and future or proposed CWA compliance costs on residential users. EPA Guidance Worksheets 1 and 2 were used for this evaluation. The sources of information for the worksheets are described below, and the completed worksheets for each service area community are provided in Attachment A.

3.1 Current and Projected Annual Clean Water Act Program Costs

Current annual CWA program costs for the service area municipalities are provided in Table 3-1. The costs reflect current wastewater management, combined sewer overflow (CSO) control, and stormwater management program costs as reported by the municipalities.

Projected annual CWA program costs reported by the service area municipalities are provided in Table 3-2. Projected costs for Bangor reflect projects identified in the City’s 2017-2021 WWTP Capital Improvement Program (CIP) as well as estimated LTCP project costs. The overall LTCP cost estimate of \$51.4 million used for this FCA is comprised of the following estimated project costs:

- New Davis Brook Storage Tank – \$22.0 million
- New Barkersville Storage Tank – \$20.4 million
- New Kenduskeag Storage Tank – \$9.0 million

These LTCP costs were based on the peak capacity of the WWTP remaining at 36 million gallons per day (MGD). Should the WWTP be expanded to 43 MGD, an additional \$3.0M would be required for that work, plus an additional \$3.0M for related WWTP improvements. Per the LTCP implementation schedule, the decision of whether or not to expand the WWTP will be made at a future date.

For estimating annual operation and maintenance (O&M) costs associated with the three new proposed CSO storage tanks, it was assumed there will be no additional staff required although a small amount of overtime might be accrued. As the number of tanks increase, the overtime would increase as well. Some of the additional O&M costs would be associated with the periodic

Table 3-1. Current Clean Water Act Annual Program Costs

Municipality	Program	Cost¹
Bangor	Wastewater Management and CSO Control	
	Annual O&M Expense (Excluding Depreciation)	\$6,416,830
	Annual Debt Service (Principal and Interest)	\$1,807,319
	Stormwater Management	
	Annual O&M Expense (Excluding Depreciation)	\$1,230,033
	Annual Debt Service (Principal and Interest)	\$74,133
	<i>Annual Bangor Subtotal</i>	<i>\$9,528,315</i>
Hampden	Wastewater Management and CSO Control	
	Annual O&M Expense (Excluding Depreciation)	\$171,321
	Annual Debt Service (Principal and Interest)	\$381,465
	Stormwater Management	
	Annual O&M Expense (Excluding Depreciation)	\$123,430
	Annual Debt Service (Principal and Interest)	\$0
	<i>Annual Hampden Subtotal</i>	<i>\$676,216</i>
Hermon	Wastewater Management and CSO Control	
	Annual O&M Expense (Excluding Depreciation)	\$34,716
	Annual Debt Service (Principal and Interest)	\$89,900
	Stormwater Management	
	Annual O&M Expense (Excluding Depreciation)	NA ²
	Annual Debt Service (Principal and Interest)	NA ²
	<i>Annual Hermon Subtotal</i>	<i>\$124,616</i>

¹ Information presented reflects FY 2017 costs for Bangor, Hampden, and Hermon.

² Nominal town-wide stormwater costs were provided by Hermon; however, no stormwater costs were used for this assessment since an accurate estimate of stormwater costs attributable to the sewer service areas in the town was not available.

maintenance of the new mechanical equipment, dewatering pumps, and tipping buckets, but general tank maintenance as well. It should be noted that the Kenduskeag East storage tank has both dewatering pumps and flushing gates, the latter being somewhat similar to tipping buckets but more difficult to maintain. Because of the additional annual capture of CSO discharge volume, there will be an incremental increase in both pumping and treatment costs. However, when compared to the annual flow that the City currently treats, this additional cost will be relative small. Therefore, an O&M allowance of \$15,000 was assumed for the first tank. This could increase to \$25,000 with the second tank, and up to \$35,000 with all three tanks on line. While there would be some cost increases due to the change in value of money over the period of assessment, no additional O&M costs were assumed for the proposed WWTP upgrades since costs are reported in 2016 dollars. Also, an estimated annual O&M cost of \$220,000 was assumed for ongoing sewer system evaluation survey (SSES) rehabilitation work which is not captured in the City’s current annual operating budget. Additional detail for these projects is provided in the LTCP document.

Projected costs for Hampden reflect proposed borrowing to pay the Town’s required share of ongoing improvements to the Bangor WWTP and a proposed sewer pump station and force main project. There are no O&M costs associated with this contribution to improvements to the Bangor WWTP. No projected wastewater or stormwater costs were reported by Hermon.

Table 3-2. Projected Clean Water Act Annual Program Costs

Municipality	Program	Cost
Bangor	Wastewater Management	\$12,258,000
	Stormwater Management ¹	\$0
	Estimated LTCP Costs	\$51,400,000
	<i>Total Cost Subtotal</i>	<i>\$63,658,000</i>
	Estimated Annual O&M Expenses	\$255,000
	Annual Debt Service (Principal and Interest)	\$4,356,852
	<i>Annual Cost Subtotal</i>	<i>\$4,611,852</i>
Hampden	Wastewater Management	\$1,077,000
	Stormwater Management	NA ²
	<i>Total Cost Subtotal</i>	<i>\$1,077,000</i>
	Estimated Annual O&M Expenses	\$0
	Annual Debt Service (Principal and Interest)	\$22,075
	<i>Annual Cost Subtotal</i>	<i>\$22,075</i>
Hermon	Wastewater Management	NA ²
	Stormwater Management	NA ²
	<i>Total Subtotal</i>	<i>\$0</i>
	Estimated Annual O&M Expenses	NA ²
	Annual Debt Service (Principal and Interest)	NA ²
	<i>Annual Cost Subtotal</i>	<i>\$0</i>

¹ Future stormwater costs are anticipated to be paid for with the City of Bangor's stormwater operating budget.

² No projected costs were provided by Hampden and Hermon.

To arrive at the annual debt service value for Bangor associated with the estimated LTCP project costs, it was assumed the LTCP projects identified above (i.e. the three new storage tanks) would be financed through the State of Maine Revolving Loan Fund (SRF), which is administered jointly by the Maine Department of Environmental Protection and the Maine Bond Bank. An average interest rate of 3.0% for SRF borrowing was assumed with a 20-year repayment period for the LTCP projects, resulting in a 0.0672 annualization factor (calculated using the annualization factor formula provided in the 1997 Guidance). To arrive at the annual debt service value for the proposed wastewater management project costs identified in the City's current WWTP CIP as well as the future wastewater management project costs identified by the Town of Hampden, an average interest rate of 4.0% for borrowing was assumed with a 20-year repayment period for all identified projects, resulting in a 0.0736 annualization factor.

Table 3-3 provides a summary of total current and projected annual CWA program costs for the service area municipalities.

Table 3-3. Total Current and Projected Annual Clean Water Act Program Costs

Municipality	Total Annual Cost
Bangor	\$14,140,167
Hampden	\$698,291
Hermon	\$124,616

3.2 Cost Per Household

To arrive at an estimated cost per household for the service area municipalities, a residential share of total CWA program costs was determined for each municipality. For Bangor, the percentage of wastewater treatment and CSO control costs paid by households was calculated based on water consumption records for all types of users (residential, industrial, commercial, etc.) provided by the City (City of Bangor, 2016a); 53.2% represents the portion of residential water consumption. The percentage of existing stormwater management costs paid by Bangor households was calculated based on the residential percentage (40.0%) of the City’s tax base to reflect the General Fund contribution to the City’s stormwater program cost as well as the residential percentage (24.8%) of stormwater utility fees collected by the City based on the residential share of impervious cover in the City (City of Bangor, 2017a; City of Bangor, 2017b). Applying these percentages to the total current and projected annual CWA program costs for the City results in a residential share of \$6,825,102 for wastewater and CSO costs, and a residential share of \$353,028 for stormwater costs.

The total number of households receiving wastewater service in Bangor is estimated to be 13,121. This reflects the upper end of the range of total sewer households calculated by using 2011-2015 American Community Survey 5-Year Estimates data and EPA Region I’s household estimation method that was provided to the City by EPA Region I during the City’s Consent Decree negotiations (U.S. Census Bureau, 2016; EPA, 2015). A copy of the spreadsheet used to develop this household estimate is included as Attachment B. Since wastewater ratepayers in Hermon are billed the same sewer rate as Bangor, the number of households served in Hermon, which is estimated to be 75 based on communication with the Hermon Town Manager, was added to the number of Bangor households (Town of Hermon, 2017) which results in a total of 13,196 households. Using this information, the wastewater and CSO program cost per household (CPH) for Bangor is \$517. In addition to this cost, the 13,121 households in Bangor have a stormwater program CPH of \$27, resulting in a total annual CWA program CPH of \$544 (see Table 3-4).

For Hampden, the residential share was assumed to be 70% of total CWA program costs based on communication with the Hampden Town Manager (Town of Hampden, 2017). Applying this percentage to the total current and projected annual CWA program costs for Hampden results in a residential share of \$528,825. The total number of households receiving wastewater service in Hampden is estimated to be 1,112 based on communication with the Hampden Town Manager (Town of Hampden, 2017). Using this information, the annual CWA program CPH for Hampden is \$476 (see Table 3-4).

Table 3-4. Cost Per Household

Municipality	Residential Share of Total Annual CWA Costs	Number of Households	Cost Per Household
Bangor			
Wastewater and CSO	\$6,825,102	13,196	\$517
Stormwater	\$353,028	13,121	\$27
<i>Total Bangor CPH</i>			\$544
Hampden	\$528,825	1,112	\$476
<i>Total Hampden CPH (within Bangor service area)</i>			\$476
Hermon			
Municipal Costs	\$100,939	2,127	\$47
Bangor Rate Cost		75	\$517
<i>Total Hermon CPH (within Bangor service area)</i>			\$565

For Hermon, the residential share was assumed to be 81% of total CWA program costs based on communication with the Hermon Town Manager (Town of Hermon, 2017). Applying this percentage to the total current and projected annual CWA program costs for Hermon results in a residential share of \$100,939. According to the Hermon Town Manager, costs to support the sewer system in Hermon are paid by all of the taxpayers in the Town (Town of Hermon, 2017). Therefore, all households in the Town (2,127 according to U.S. Census American Community Survey data) were assumed to contribute to paying for Hermon’s wastewater costs. Using this information, the annual CWA program CPH for Hermon is \$47. In addition to this cost, the 75 households that have sewer service in the Town pay an additional \$517 per household to cover costs associated with Bangor sewer rates, resulting in a total annual CWA program CPH of \$564 (see Table 3-4). Note this CPH value does not capture additional stormwater management costs that are paid by Hermon households, which would result in a slightly higher CPH value.

3.3 Residential Indicator

The Residential Indicator (RI) represents CPH as a percentage of adjusted median household income (MHI). Table 3-5 shows EPA’s RI criteria. When the RI is less than 1.0 percent, between 1.0 and 2.0 percent, or greater than 2.0 percent, the financial impact on residential users to implement the CWA program projects is assigned a rating of “Low”, “Mid-Range”, and “High”, respectively.

Table 3-5. Residential Indicator Criteria

Financial Impact	Residential Indicator (CPH as % of MHI)
Low	Less than 1.0% of MHI
Mid-Range	1.0 – 2.0% of MHI
High	Greater than 2.0% of MHI

U.S. Census American Community Survey (ACS) data were used to determine the MHI for the service area municipalities, and the MHI values were escalated to current year (2016) dollars using the average U.S. Bureau of Labor Statistics Consumer Price Index (CPI) inflation rate for the Boston Metro Area from the latest ACS year to the current year (U.S. Census Bureau, 2016; U.S. Bureau of Labor Statistics, 2016). Use of this EPA MHI escalation methodology results in the adjusted 2016 MHI values presented in Table 3-6.

Table 3-6. MHI for Service Area Municipalities

Municipality	MHI (2016 dollars)
Bangor	\$36,111
Hampden	\$83,272
Hermon	\$62,950

Using these adjusted 2016 MHI values and the CPH values reported in Section 3.2 results in the RI values presented in Table 3-7.

Table 3-7. Service Area Municipality Residential Indicators and Resulting Financial Impact Category

Municipality	Residential Indicator	Financial Impact Category
Bangor	1.51%	Medium
Hampden	0.57%	Low
Hermon	0.90%	Low

4.0 PHASE 2 EVALUATION – DEVELOP THE FINANCIAL CAPABILITY INDICATOR

The Phase 2 Evaluation uses six indicators from the following three categories to evaluate the financial capability of the service area communities, which will incur the debt for costs associated with implementation of the projected CWA program costs:

- Debt Indicators
- Socioeconomic Indicators
- Financial Management Indicators

Table 4-1 shows EPA’s Financial Capability criteria used to evaluate the six Financial Capability Indicators (FCIs). A value of “3”, “2”, or “1” is assigned to an indicator whose assessed value falls in the “Strong”, “Mid-Range”, or “Weak” column, respectively. EPA Guidance Worksheets 3 through 9 were used for this evaluation. The results for the six FCIs for the service area municipalities are described below, and the completed worksheets are provided in Attachment A.

4.1 Bond Rating

The most recent bond rating information and EPA benchmark score for Bangor and Hermon is presented in Table 4-2. No information is provided for Hampden since the Town does not issue bonds (Town of Hampden, 2017).

Table 4-1. Permittee Financial Capability Indicator Benchmarks

Indicator	Strong (3)	Mid-Range (2)	Weak (1)
Bond Rating	AAA-A (S&P) or Aaa-A (Moody's)	BBB (S&P) or Baa (Moody's)	BB-D (S&P) or Ba-C (Moody's)
Overall Net Debt as a Percent of Full Market Property Value	Below 2%	2% - 5%	Above 5%
Unemployment Rate	> 1% Below the National Average	± 1% of National Average	> 1% Above National Average
Median Household Income	> 25% Above Adjusted National MHI	± 25% of Adjusted National MHI	> 25% Below Adjusted National MHI
Property Tax Revenues as a Percent of Full Market Property Value	Below 2%	2% - 4%	Above 4%
Property Tax Collection Rate	Above 98%	94% - 98%	Below 94%

Table 4-2. Bond Rating Summary

Municipality	Bond Rating	Source	Benchmark Score
Bangor	Aa2	Moody's; May 5, 2016	Strong / 3
Hampden	NA		
Hermon	AA+	Standard & Poor's; June 30, 2015	Strong / 3

4.2 Overall Net Debt as a Percent of Full Market Property Value

Overall net debt and full market property value information for the service area municipalities, and the resulting overall net debt as a percent of full market property value, is presented in Table 4-3.

Table 4-3. Overall Net Debt as a Percent of Full Market Property Value (FMPV)

Municipality	Overall Net Debt	Market Value of Property (FY 2016)	Overall Net Debt as % of FMPV	Benchmark Score
Bangor	\$140,744,237	\$2,600,202,500	5.4%	Weak / 1
Hampden	\$27,111,392	\$602,533,000	4.5%	Mid-Range / 2
Hermon	\$2,670,230	\$472,927,465	0.6%	Strong / 3

4.3 Unemployment Rate

Unemployment rates for the service area municipalities as well as the average national unemployment rate are presented in Table 4-4. The information presented reflects the 2015 annual average unemployment rates based on data obtained from the Maine Center for Workforce Research and Information website (MCWRI, 2016).

Table 4-4. 2013 Annual Average Unemployment Rate

Municipality	Unemployment Rate (2015 Annual Value)	Compared to National Average	Benchmark Score
Bangor	4.0%	-1.3%	Strong / 3
Hampden	3.0%	-2.3%	Strong / 3
Hermon	3.4%	-1.9%	Strong / 3
National Average	5.3%	NA	NA

4.4 Median Household Income

MHI for the service area municipalities as well as the national MHI are presented in Table 4-5. MHI values were obtained from the U.S. Census ACS, and the MHI values were escalated to current year (2016) dollars using the average U.S. Bureau of Labor Statistics CPI inflation rate for the Boston-Brockton-Nashua Metro Area from the latest ACS year to the current year (U.S. Census Bureau, 2016; U.S. Bureau of Labor Statistics, 2016).

Table 4-5. Median Household Income

Municipality	MHI (2016 dollars)	Percent of National MHI	Benchmark Score
Bangor	\$36,111	66.2%	Weak / 1
Hampden	\$83,272	152.7%	Strong / 3
Hermon	\$62,950	115.4%	Mid-range / 2
National Average	\$54,549	NA	NA

4.5 Property Tax Revenues as a Percent of Full Market Property Value

Full market property value and property tax revenue information for the service area municipalities, and the resulting property tax revenue as a percent of full market property value, is presented in Table 4-6.

Table 4-6. Property Tax Revenue as a Percent of Full Market Property Value (FMPV)

Municipality	Property Tax Revenue (FY 2016)	Market Value of Property (FY 2016)	Property Tax Revenue as % of FMPV	Benchmark Score
Bangor	\$55,557,652	\$2,600,202,500	2.1%	Mid-Range / 2
Hampden	\$10,699,024	\$602,533,000	1.8%	Strong / 3
Hermon	\$5,387,495	\$472,927,465	1.1%	Strong / 3

4.6 Property Tax Collection Rate

Property tax revenue collected compared to property taxes levied for the service area municipalities, and the resulting property tax revenue collection rate, is presented in Table 4-7.

Table 4-7. Property Tax Collection Rate

Municipality	Property Tax Revenue Collected (FY 2016)	Property Taxes Levied (FY 2016)	Property Tax Collection Rate	Benchmark Score
Bangor	\$55,557,652	\$57,090,091	97.3%	Mid-Range / 2
Hampden	\$10,699,024	\$10,841,704	98.7%	Strong / 3
Hermon	\$5,387,495	\$5,675,130	94.9%	Mid-Range / 2

4.7 Summary of Financial Capability Indicators

Per the EPA Guidance, the benchmark scores for the six FCIs discussed above are summed and then divided by the number of entries to arrive at an average score for the Phase 2 Evaluation. The resulting un-weighted average scores for the service area municipalities are presented in Table 4-8.

Table 4-8. Overall Score of Financial Capability

Municipality	Average FCI Score	Benchmark
Bangor	2.00	Mid-Range
Hampden	2.80	Strong
Hermon	2.67	Strong

5.0 SUMMARY OF THE PHASE 1 AND PHASE 2 INDICATORS

The results of the Phase 1 (Residential Indicator) and the Phase 2 (Permittee Financial Capability Indicators) evaluations are combined in the Financial Capability Matrix (see Table 5-1) to evaluate the level of financial burden the current and future CWA program costs may impose on the service area municipalities. Depending on the RI and FCI results, a “Low Burden”, “Medium Burden”, or “High Burden” score is assigned to characterize the financial burden on a permittee. These scores are used by EPA to aid in negotiations to establish implementation schedules for CSO controls. The Financial Capability Matrix Score for each municipality was determined through the use of the EPA Guidance Worksheet 10 (see Attachment A), and the scores are summarized in Table 5-2. As shown in Table 5-2, the City of Bangor received a “Medium Burden” score, which indicates some financial burden concerns and warrants consideration of additional information and affordability considerations for the City; while the Towns of Hampden and Hermon each received a “Low Burden” score.

Table 5-1 Financial Capability Matrix

Permittee Financial Capability Indicators Score (Socioeconomic, Debt, and Financial Indicators)	Residential Indicator (Cost Per Household as a % of MHI)		
	Low Impact (Below 1.0%)	Mid-Range (Between 1.0 and 2.0%)	High Impact (Above 2.0%)
Weak (Below 1.5)	Medium Burden	High Burden	High Burden
Mid-Range (Between 1.5 and 2.5)	Low Burden	Medium Burden	High Burden
Strong (Above 2.5)	Low Burden	Low Burden	Medium Burden

Table 5-2. Financial Capability Matrix Score

Municipality	RI Score	FCIs Score	Financial Capability Matrix Category
Bangor	1.51%	2.00	Medium Burden
Hampden	0.57%	2.80	Low Burden
Hermon	0.90%	2.67	Low Burden

6.0 ALTERNATIVE CONSIDERATIONS OF HOUSEHOLD AFFORDABILITY

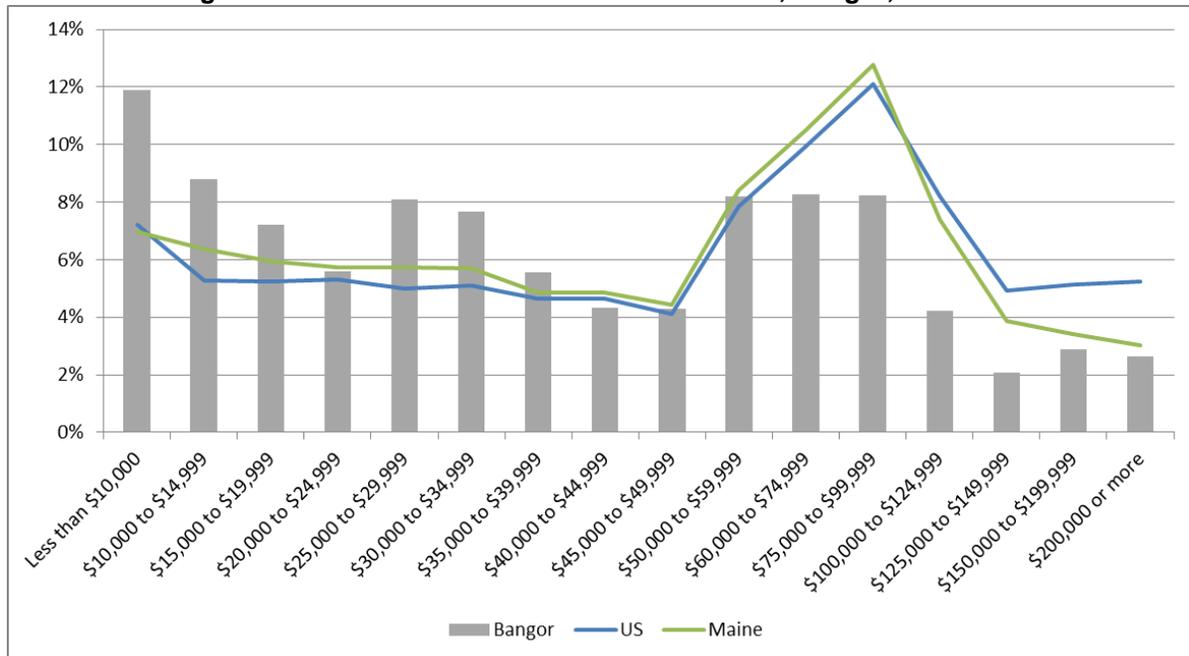
There are a number of important considerations to highlight when evaluating the affordability implications of the costs associated with anticipated CWA compliance on households within the Bangor service area. The City of Bangor would experience a “Medium Burden” based on its Phase 1 and Phase 2 indicator scores presented above, with the City of Bangor having RI of 1.51% and a FCI of 2.00. Since the City of Bangor has a “Medium Burden” financial capability matrix score and the City has a large number of low-income households that may experience adverse social and economic effects associated with future additional CWA charges, additional discussion of financial capability and affordability for the City of Bangor is warranted. The Towns of Hampden and Hermon are not discussed in this section given their “Low Burden” financial capability matrix scores and relatively small population and number of households served by the Bangor WWTP.

Bangor’s citywide MHI is lower than both the state and national MHI (28% and 34% lower, respectively), which is an indicator of the financial and economic stress the City is experiencing. More importantly, Bangor’s citywide MHI is not representative of the true financial condition of a large number of the City’s households. This section provides more detail on the significant number of households with substantially lower household income than the citywide MHI, and the corresponding burden on those households to shoulder the costs of additional CWA program compliance.

6.1 Household Income

As noted in Section 3.3, the MHI for Bangor is \$36,111 (2016 inflation-adjusted dollars). While the median represents an annual household income value at which half the households fall above and half fall below, the distribution of income across households in Bangor reveals the disparate impact of additional CWA compliance costs. Figure 6-1 shows the number of households in each of 16 income

Figure 6-1 Household Income Distribution in US, Bangor, and Maine



Source: U.S. Census Bureau, 2016. 2011-2015 American Community Survey 5-Year Estimates Data.

levels reported by the U.S. Census Bureau, compared to income distribution in the state and nationally across those same income levels. As shown in Figure 6-1, Bangor’s income is substantially clustered at the lower levels of income, while there is much greater spread across a greater number of income groups at the higher levels of income. Therefore, while the citywide MHI indicates the income level at which an equal number of households sit above or below, the reality is that a significant number of Bangor Households (over 33% percent) fall at annual income levels below \$25,000. In fact, the number of households with annual income levels below \$10,000 is the highest number of households reported in any income category. As shown in Table 6-1, the RI for CWA program compliance (based on per household cost of \$544 as reported in Section 3.2) for those households earning less than \$25,000 is 2.2% or higher, and the RI for those households earning less than \$10,000 is 5.4% or higher. This represents a significant burden on households across the lowest income categories; in other words the City’s most vulnerable population with respect to affordability issues and future increased CWA-related costs.

Another way to examine potential impacts to lower income population groups is to utilize household income quintile data. As shown in Table 6-2, the RI for CWA program compliance (again, based on per household cost of \$544 as reported in Section 3.2) for households in the lowest and second household income quintiles is 3.68% and 1.87%, respectively. These data indicate the 2.0% benchmark for “high” financial impact is significantly exceeded for the 20% of the City’s households that comprise the lowest quintile of household incomes, and this benchmark is almost exceeded for 40% of the City’s households.

Table 6-1. Residential Indicator by Income Level

Income Level	Percentage of Total Households	RI ¹
Less than \$10,000	11.9%	5.4%
\$10,000 to \$14,999	8.8%	3.6%
\$15,000 to \$19,999	7.2%	2.7%
\$20,000 to \$24,999	5.6%	2.2%
\$25,000 to \$29,999	8.1%	1.8%
\$30,000 to \$34,999	7.7%	1.6%
\$35,000 to \$39,999	5.6%	1.4%
\$40,000 to \$44,999	4.3%	1.2%
\$45,000 to \$49,999	4.3%	1.1%
\$50,000 to \$59,999	8.2%	0.9%
\$60,000 to \$74,999	8.3%	0.7%
\$75,000 to \$99,999	8.2%	0.5%
\$100,000 to \$124,999	4.2%	0.4%
\$125,000 to \$149,999	2.1%	0.4%
\$150,000 to \$199,999	2.9%	0.3%
\$200,000	2.6%	0.3%

¹ RI is based on cost per household of \$553 as reported in Section 3.2.

Table 6-2. Comparison of MHI RI to Household Income Quintiles

Income Level	2016 Dollars	RI ¹
Lowest Quintile Upper Limit	\$14,776	3.68%
Second Quintile Upper Limit	\$29,038	1.87%
Median Household Income	\$36,111	1.51%

¹ RI is based on cost per household of \$544 as reported in Section 3.2.

Source: U.S. Census Bureau, 2016. 2011-2015 American Community Survey 5-Year Estimates Data, escalated to 2016 dollars using CPI data.

Other very important factors when analyzing MHI across the households in the City’s service area are the difference in income between owners and renters, and the income status of the elderly. Both renter and elderly households are a subset of the households in the income categories noted above, but it is important to understand the particular financial condition of these sensitive population groups.

Property owners will often pass on additional utility or service costs to renters and, thus, renters are not typically in control of their housing costs, other than to potentially terminate a lease agreement and move to a lower cost unit within a community or to move outside a service area. The rental vacancy rate in the City of Bangor is under 5.0% according to recent U.S. Census data (U.S. Census, 2016), suggesting that limited rental options are available in the City and renters are more likely forced to absorb increased rents rather than being able to find a lower cost option, or may be forced to leave the City in search of lower cost rental options. These household movements can cause deterioration in stability within a community and in the economic marketplace. Many of the elderly live

on fixed incomes and, thus, cannot rely on additional sources of income to pay for increased CWA program costs. Thus, both renter and elderly households need special consideration when considering rate impacts for CWA program implementation. As shown in Table 6-3, renters comprise over 56% of households in the City of Bangor, and the income level with the highest percentage of renters (43.2%) is annual income below \$20,000. This compares to only 8.3% of all owner-occupied households having annual incomes below \$20,000.

Table 6-3. Income Distribution by Owner Type

Income distribution: Total households								
	Tenure	Total Households	Less than \$20,000	\$20,000 to \$34,999	\$35,000 to \$49,999	\$50,000 to \$74,999	\$75,000 to \$99,999	\$100,000 or more
Bangor, ME	Owner	6,182	513	1,011	914	1,325	937	1,482
	Renter	7,917	3,423	1,999	1,085	996	226	188
Income distribution: Percentage of total households								
	Tenure	Total Households	Less than \$20,000	\$20,000 to \$34,999	\$35,000 to \$49,999	\$50,000 to \$74,999	\$75,000 to \$99,999	\$100,000 or more
Bangor, ME	Owner	43.8%	8.3%	16.4%	14.8%	21.4%	15.2%	24.0%
	Renter	56.2%	43.2%	25.2%	13.7%	12.6%	2.9%	2.4%

Source: U.S. Census Bureau, 2016. 2011-2015 American Community Survey 5-Year Estimates Data.

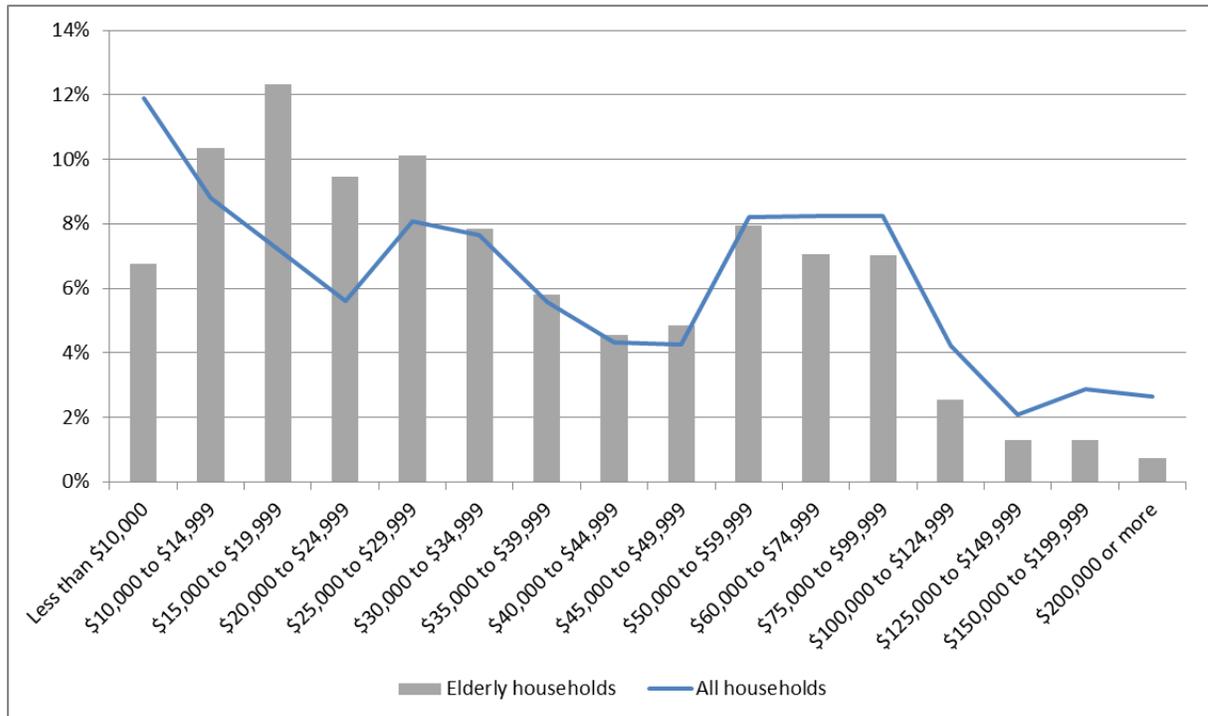
The RI for households with incomes less than \$20,000 is 2.7% or higher, and because there is such a large number of these households in the City of Bangor, an impact would be felt across the City.

As can be seen in Figure 6-2, a large share of elderly households (49%) has annual incomes below \$30,000. The greatest number of elderly households in the City has annual income between \$15,000 and \$19,999. The RI for the elderly population with annual income below \$20,000 is 2.7% or higher. As noted above, many of the elderly live on fixed incomes and do not have alternate means to pay for additional costs associated with CWA compliance. Also, the elderly population comprises 14.7% of the City’s sensitive renter population (U.S. Census, 2016).

6.2 Housing Burden as an indicator of Financial Capability and Affordability

The conventional public policy indicator of housing affordability in the United States is the percent of income spent on housing. Housing expenditures that exceed 30% of household income have historically been viewed as an indicator of a housing affordability problem (U.S. Census Bureau, Undated). The conventional 30% of household income that a household can devote to housing costs before the household is said to be “burdened” and evolved from the United States National Housing Act of 1937. In some cases, there is a further split of the housing-cost burden into moderate housing-cost burden (30.0% to 49.9% of income spent on housing costs) and severe housing-cost burden (50% or more of income spent on housing costs).

Figure 6-2. Income Distribution, Households with Householders 65 years and older, Bangor, Maine



Source: U.S. Census Bureau, 2016. 2011-2015 American Community Survey 5-Year Estimates Data.

Table 6-4 shows the housing burden of owner- and renter-occupied households in the City of Bangor by income level. As shown in the table, more than 62% of owner-occupied households with annual incomes of \$34,999 or less (which is just under the citywide 2016 adjusted MHI of \$36,111) has a housing burden of greater than 30%. This value increases to more than 67% for renter-occupied households with the same income level.

Table 6-4. Percent of Households with Greater than 30% Housing Burden

Income Level	Owner-occupied	Renter-occupied
Less than \$20,000	74.9%	86.4%
\$20,000 to \$34,999	62.4%	67.5%
\$35,000 to \$49,999	44.6%	19.6%
\$50,000 to \$74,999	28.6%	11.6%
\$75,000 or more	4.3%	3.4%

Source: U.S. Census Bureau, 2016. 2011-2015 American Community Survey 5-Year Estimates Data.

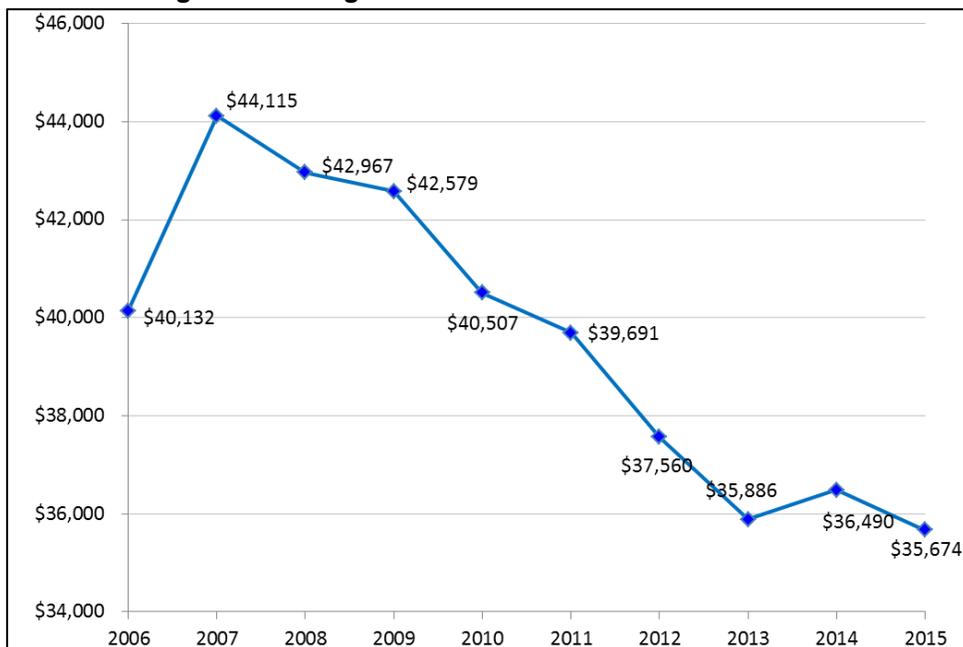
One of the elements of housing cost that goes into the calculation of housing burden is cost of electricity and heating fuel. Maine heating fuel prices peaked in 2014 and trended downward over the course of 2015, in part reflecting lower oil commodity prices. However, the Maine Energy office

reports that home heating fuel prices steadily increased in the second half of 2016. Between October and December 2016, the average statewide heating fuel prices increased between 9-15% depending on the type of fuel (Governor’s Energy Office, 2016). According to data provided by the U.S. Energy Information Agency in 2012, Maine is the most petroleum dependent state for home heating, spending more on residential petroleum per capita than any state in the United States (Governor’s Energy Office, 2014). Maine also has the largest percent of its population heating with heating oil than any other state. Also, New England ranks near the top in terms of high electricity prices compared to other regions of the Country according to data issued by the U.S. Energy Information Agency (EIA, 2016). The State of Maine offers financial assistance to help low-income homeowners and renters pay for heating costs through its Low-Income Home Energy Assistance Program to help offset these high costs for qualifying households. However, all residents do not receive relief through this program, and these increasing and higher than average home utility costs put additional burden on households that will also need to pay for the CWA compliance costs.

6.3 Downward Trend in MHI

There is concern that income levels among households in the City will continue to lag behind households elsewhere in the region and in the state. As shown in Figure 6-3, there has been a steep decline in MHI in the City of Bangor since 2007 when adjusting for inflation. Between 2007 and 2015 (the latest year for which data are available), the City’s MHI decreased by over 19%. With the increasing burden on households due to escalating utility and service costs, there is reason to believe that many households would face significant challenges and financial hardship assuming the additional burden of CWA program compliance unless these programs are implemented with care to control both the timing and amount of any rate increases.

Figure 6-3. Bangor Median Household Income Trend



Source: U.S. Census Bureau, 2006-2015 Median Household Data (adjusted for inflation).

7.0 SUPPLEMENTAL INFORMATION

The EPA Guidance for preparing Financial Capability and Affordability Assessments encourages communities to provide supplemental information to document a community's unique or challenging economic circumstances. This section summarizes some of the additional information related to the economic and financial condition of the City of Bangor.

7.1 Water Service Costs

In addition to the costs associated with CWA compliance programs, City of Bangor households are also responsible for payment of water service costs to the Bangor Water District. According to the District's Annual Report from December 31, 2015, there are a total of 11,021 water accounts. Residential accounts represent 77% of the total accounts. The total operating expenses for the District in 2015 were \$4,962,078. This represents an approximate cost of \$450 per residential service account. Some number of these accounts includes multi-family units. It is not possible to determine how each property owner allocates water service costs; i.e., whether the entire cost is added to rental fees or whether the property owner might bear a share of the cost. If one assumes that the water service cost per residential service might be shared among two customers (either a property owner and one renter household, or among two renter households), then the water service would represent a \$225 annual cost per residential household. When added to the cost per household for CWA compliance, the cost per household would rise from \$544 to \$769. When this cost is compared to the income of many households in the lower income ranges, particularly elderly and renter households, the RI for these lower income ranges would increase substantially.

7.2 Other Socioeconomic Indicators

A number of other economic and social indicators reflect the stresses that the City is facing and are described below:

- Approximately 26.2% of the City's population falls below the poverty level, compared to 13.9% for the State of Maine and 15.5% for the United States (U.S. Census Bureau, 2016).
- Of the households in the City below the poverty level, 91% are renter households (U.S. Census Bureau, 2016).
- Approximately 27% of households in the City receive some form of public assistance or food stamps (U.S. Census Bureau, 2016).
- Several significant retail establishments in Bangor have recently closed, and the City is concerned about a further decline in retail due to competition with discount stores and an increasing share of online sales (City of Bangor, 2017c). This recent and anticipated future decline in non-residential use will likely result in a greater share of the City's future CWA compliance costs being shouldered by residential users. The closing of businesses may also result in an increase in unemployment or underemployment in the City.
- The average property tax bill in Bangor has increased by 18.5% as a result of recent State policy and legislative decisions, where costs have been shifted to the municipality (Cities of Bangor and Brewer, 2015). This is expected to continue in the upcoming biennial budget cycle, resulting in additional housing costs (City of Bangor, 2017c).

8.0 CONCLUSION

The evaluation of financial capability and affordability indicators for the Bangor service area demonstrates that the City of Bangor would experience a “Medium Burden” as a result of additional CWA costs, while the Towns of Hampden and Hermon would experience a “Low Burden”. Table 5-2 summarizes the RI and FCI scores for each community. As stated in EPA’s Financial Capability Assessment Framework, financial capability is considered on a continuum, and additional information provided may affect the length of the proposed implementation schedule regardless of where the community is on the “high, medium, and low” continuum (EPA, 2014). While the RI for the City of Bangor is solidly within the medium burden category (1.51%) when considering citywide MHI, the RI for the upper limit of the City’s lowest household income quintile (3.68%) easily exceeds the 2.0% benchmark for “High” financial impact. This quintile includes many of the vulnerable renter and elderly households in the City. Furthermore, the RI of 1.87% for the upper limit of the City’s second household income quintile indicates that the 2.0% benchmark for “High” financial impact is almost exceeded for 40% of the City’s households. These results clearly indicate that close examination of future CWA compliance programs and costs, and their resulting impacts upon rate payers, is necessary.

For City of Bangor households already experiencing a high financial burden, additional CWA program costs will add to their existing financial stress; such households already face difficult decisions about how to allocate their limited funds between basic needs. Financial stress on lower income households inevitably ripples through the local economy, as the fixed cost of providing basic services and utilities is shifted to other groups that, in turn, have less discretionary income and will reduce spending in areas that help to maintain or stimulate the economy.

Therefore, care will need to be taken to evaluate all of the CWA requirements and to prioritize project implementation in a manner that results in achieving the greatest water quality benefit while still being affordable. The most immediate major capital CWA project would be the initial phase of the LTCP, the Davis Brook CSO Storage Tank. While this initial LTCP project could be considered affordable at this time, the impact of future phases would need to be carefully evaluated in the future while taking into consideration all of the other identified and yet to be identified WWTP and SSES-related needs of the City.

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10.0 ATTACHMENTS

Completed EPA financial capability assessment worksheets are included in Attachment A for the three service area municipalities, and copy of the spreadsheet used to develop the estimate of sewerage households in the City of Bangor using EPA Region I's household estimation method is included as Attachment B

Attachment A

EPA 1997 Guidance Financial Capability Assessment Worksheets

1997 Guidance Worksheets for Bangor, Maine

Financial Capability Assessment Worksheet 1, Cost Per Household (1997 USEPA Guidance)

Line Number	Item	Unit	Value
	Current Wastewater Management and CSO Costs (FY 2017)		
100	Annual O&M Expenses (Excluding Depreciation)	(\$)	\$6,416,830
101	Annual Debt Service (Principal and Interest)	(\$)	\$1,807,319
102	Subtotal	(\$)	\$8,224,149
	Projected Wastewater Management and CSO Costs (2016 Dollars)		
103	Estimated Annual O&M Expenses (Excluding Depreciation)	(\$)	\$255,000
104	Annual Debt Service (Principal and Interest)	(\$)	\$4,356,852
105	Subtotal	(\$)	\$4,611,852
106	Total Current and Projected Wastewater Management and CSO Costs	(\$)	\$12,836,001
	Residential Share of Total Wastewater Management and CSO Costs (2015 data)		
	Residential Flow	(HCF)	630,083
	Total Flow	(HCF)	1,185,000
	Residential Portion	(%)	53.17%
107	Cost Allocation	(\$)	\$6,825,102
108	Total Number of Households in Service Area (2015 Census Data and EPA Household Estimate Approach)	(EDUs)	13,196
109	Wastewater Management and CSO Cost Per Household	(\$)	\$517
	Additional Current Stormwater Cost Per Household (FY 2017)		
	Annual O&M Expenses (Excluding Depreciation)	(\$)	\$1,230,033
	Annual Debt Service (Principal and Interest)	(\$)	\$74,133
	Subtotal	(\$)	\$1,304,166
	Additional Projected Stormwater Costs (2016 Dollars)		
	Estimated Annual O&M Expenses (Excluding Depreciation)	(\$)	\$0
	Annual Debt Service (Principal and Interest)	(\$)	\$0
	Subtotal	(\$)	\$0
	Additional Total Current and Projected Stormwater Costs	(\$)	\$1,304,166
	Residential Share of Current Stormwater Costs (2016 data)		
	Stormwater Utility	(\$)	\$1,109,466
	Residential Percent of Stormwater Utility (Based on Impervious Surface)	(%)	24.8%
	Cost Allocation	(\$)	\$275,148
	General Fund (Used for Stormwater Utility)	(\$)	\$194,700
	Residential Percent of Tax Base	(%)	40%
	Cost Allocation	(\$)	\$77,880
	Residential Share of Projected Stormwater Costs		
	Stormwater Utility	(\$)	\$0
	Residential Percent of Stormwater Utility (Based on Impervious Surface)	(%)	24.8%
	Cost Allocation	(\$)	\$0
	Total Residential Share of Current and Projected SW Costs	(\$)	\$353,028
	Total Number of Households in Service Area	(EDUs)	13,121
	Stormwater Cost Per Household	(\$)	\$26.91
	Total Cost Per Household	(\$)	\$544

Financial Capability Assessment Worksheet 2, Residential Indicator (1997 USEPA Guidance)

Line Number	Item	Unit	Value
	Median Household Income (MHI)		
201	Census Year MHI (2015 ACS 5-year estimates)	(\$)	\$35,674
202	MHI Adjustment Factor		1.0123
203	Adjusted MHI (2016 inflation-adjusted dollars)	(\$)	\$36,111
204	Annual Cost Per Household (line 109)	(\$)	\$544
	Residential Indicator		
205	CPH as a percentage of adjusted MHI	(%)	1.51%

Financial Capability Assessment Worksheet 3, Bond Rating (1997 USEPA Guidance)

Line Number	Item	Unit	Value
	Most Recent General Obligation Bond Rating		
	Date		May 5, 2016
	Rating Agency		Moody's
301	Rating		Aa2
	Most Recent Revenue Bond		NA
	Date		
	Rating Agency		
	Bond Insurance		
302	Rating		
303	Summary Bond Rating		Aa2

Financial Capability Assessment Worksheet 4, Overall Net Debt as a Percent of Full Market Property Value (1997 USEPA Guidance)

Line Number	Item	Unit	Value
401	Direct Net Debt (G.O. Bonds Excluding Double-Barreled Bonds) (FY 2016)	(\$)	\$140,744,237
402	Debt of Overlapping Entities (Proportionate Share of Multi-jurisdictional Debt) (FY 2016)	(\$)	\$0
403	Overall Net Debt (FY 2016)	(\$)	\$140,744,237
404	Market Value of Property (FY 2016)	(\$)	\$2,600,202,500
405	Overall Net Debt as a Percent of Full Market Property Value	(%)	5.41%

Financial Capability Assessment Worksheet 5, Unemployment Rate (1997 USEPA Guidance)

Line Number	Item	Unit	Value
501	Unemployment Rate - Permittee	(%)	4.0%
	Source: Maine Center for Workforce Research and Information; 2015 annual average		
502	Unemployment Rate - County		N/A
	Benchmark		
503	Average National Unemployment Rate	(%)	5.3%
	Source: Maine Center for Workforce Research and Information; 2015 annual average		
	Comparison of Permittee with Benchmark	(%)	-1.3%

Financial Capability Assessment Worksheet 6, Median Household Income (1997 USEPA Guidance)

Line Number	Item	Unit	Value
601	MHI - Permittee (line 203)	(\$)	\$36,111
	Source: U.S. Census 2011-2015 American Community Survey 5-Year Estimates		
	Benchmark		
602	Census Year National MHI	(\$)	\$53,889
603	MHI Adjustment Factor (line 202)		1.0123
604	Adjusted National MHI	(\$)	\$54,549
	Source: U.S. Census 2011-2015 American Community Survey 5-Year Estimates		
	Comparison of Permittee with Benchmark	(%)	66.20%

Financial Capability Assessment Worksheet 7, Property Tax Revenues as a Percent of Full Market Property Value (1997 USEPA Guidance)

Line Number	Item	Unit	Value
701	Full Market Value of Real Property (line 404) (FY 2016)	(\$)	\$2,600,202,500
702	Property Tax Revenues (FY 2016)	(\$)	\$55,557,652
703	Property Tax Revenues as a Percent of Full Market Property Value	(%)	2.14%

**Financial Capability Assessment Worksheet 8, Property Tax Revenue Collection Rate
(1997 USEPA Guidance)**

Line Number	Item	Unit	Value
801	Property Tax Revenue Collected (line 702) (FY 2016)	(\$)	\$55,557,652
802	Property Taxes Levied (FY 2016)	(\$)	\$57,090,091
803	Property Tax Revenue Collection Rate	(%)	97.32%

**Financial Capability Assessment Worksheet 9, Summary of Permittee Financial Capability Indicators
(1997 USEPA Guidance)**

Line Number	Item	Value	Score
901	Bond Rating (line 303)	Aa2	3
902	Overall Net Debt as a Percent of Full Market Property Value (line 405)	5.41%	1
903	Unemployment Rate Compared with National Average (from Worksheet 5)	-1.30%	3
904	Median Household Income Compared with National Average (from Worksheet 6)	66.20%	1
905	Property Tax Revenues as a Percent of Full Market Property Value (line 703)	2.14%	2
906	Property Tax Revenue Collection Rate (line 803)	97.32%	2
907	Permittee Indicators Score		2.00

**Financial Capability Assessment Worksheet 10, Financial Capability Matrix Score
(1997 USEPA Guidance)**

Line Number	Item	Value
1001	Residential Indicator Score (line 205)	1.51%
1002	Permittee Financial Capability Indicators Score (line 907)	2.00
1003	Financial Capability Matrix Category	Medium Burden

1997 Guidance Worksheets for Hampden, Maine

Financial Capability Assessment Worksheet 1, Cost Per Household (1997 USEPA Guidance)

Line Number	Item	Unit	Value
	Current Wastewater Management, CSO, and Stormwater Costs		
100	Annual O&M Expenses (Excluding Depreciation) (FY 2016)	(\$)	\$294,751
101	Annual Debt Service (Principal and Interest) (FY 2017)	(\$)	\$381,465
102	Subtotal	(\$)	\$676,216
	Projected Wastewater Management, CSO, and Stormwater Costs (2016 Dollars)		
103	Estimated Annual O&M Expenses (Excluding Depreciation)	(\$)	\$0
104	Annual Debt Service (Principal and Interest)	(\$)	\$79,248
105	Subtotal	(\$)	\$79,248
106	Total Current and Projected Wastewater Management, CSO, and Stormwater Costs	(\$)	\$755,464
	Residential Share of Total Wastewater Management, CSO, and Stormwater Costs		
	Residential Flow	(HCF)	
	Total Flow	(HCF)	
	Residential Portion	(%)	70.00%
107	Cost Allocation	(\$)	\$528,825
108	Total Number of Households in Service Area	(EDUs)	1,112
109	Cost Per Household	(\$)	\$476

Financial Capability Assessment Worksheet 2, Residential Indicator (1997 USEPA Guidance)

Line Number	Item	Unit	Value
	Median Household Income (MHI)		
201	Census Year MHI (2015 ACS 5-year estimates)	(\$)	\$82,264
202	MHI Adjustment Factor		1.0123
203	Adjusted MHI (2016 inflation-adjusted dollars)	(\$)	\$83,272
204	Annual Cost Per Household (line 109)	(\$)	\$476
	Residential Indicator		
205	CPH as a percentage of adjusted MHI	(%)	0.57%

Financial Capability Assessment Worksheet 3, Bond Rating (1997 USEPA Guidance)

Line Number	Item	Unit	Value
	Most Recent General Obligation Bond Rating		NA
	Date		
	Rating Agency		
301	Rating		
	Most Recent Revenue Bond		NA
	Date		
	Rating Agency		
	Bond Insurance		
302	Rating		
303	Summary Bond Rating		NA

Financial Capability Assessment Worksheet 4, Overall Net Debt as a Percent of Full Market Property Value (1997 USEPA Guidance)

Line Number	Item	Unit	Value
401	Direct Net Debt (G.O. Bonds Excluding Double-Barreled Bonds) (FY 2017)	(\$)	\$4,924,040
402	Debt of Overlapping Entities (Proportionate Share of Multi-jurisdictional Debt) (FY 2017)	(\$)	\$22,187,352
403	Overall Net Debt (FY 2017)	(\$)	\$27,111,392
404	Market Value of Property (FY 2017)	(\$)	\$602,533,000
405	Overall Net Debt as a Percent of Full Market Property Value	(%)	4.50%

Financial Capability Assessment Worksheet 5, Unemployment Rate (1997 USEPA Guidance)

Line Number	Item	Unit	Value
501	Unemployment Rate - Permittee	(%)	3.0%
	Source: Maine Center for Workforce Research and Information; 2015 annual average		
502	Unemployment Rate - County		N/A
	Benchmark		
503	Average National Unemployment Rate	(%)	5.3%
	Source: Maine Center for Workforce Research and Information; 2015 annual average		
	Comparison of Permittee with Benchmark	(%)	-2.3%

Financial Capability Assessment Worksheet 6, Median Household Income (1997 USEPA Guidance)

Line Number	Item	Unit	Value
601	MHI - Permittee (line 203)	(\$)	\$83,272
	Source: U.S. Census 2011-2015 American Community Survey 5-Year Estimates		
	Benchmark		
602	Census Year National MHI	(\$)	\$53,889
603	MHI Adjustment Factor (line 202)		1.0123
604	Adjusted National MHI	(\$)	\$54,549
	Source: U.S. Census 2011-2015 American Community Survey 5-Year Estimates		
	Comparison of Permittee with Benchmark	(%)	152.65%

Financial Capability Assessment Worksheet 7, Property Tax Revenues as a Percent of Full Market Property Value (1997 USEPA Guidance)

Line Number	Item	Unit	Value
701	Full Market Value of Real Property (line 404) (FY 2017)	(\$)	\$602,533,000
702	Property Tax Revenues (FY 2017)	(\$)	\$10,699,024
703	Property Tax Revenues as a Percent of Full Market Property Value	(%)	1.78%

**Financial Capability Assessment Worksheet 8, Property Tax Revenue Collection Rate
(1997 USEPA Guidance)**

Line Number	Item	Unit	Value
801	Property Tax Revenue Collected (line 702) (FY 2016)	(\$)	\$10,699,024
802	Property Taxes Levied (FY 2016)	(\$)	\$10,841,704
803	Property Tax Revenue Collection Rate	(%)	98.68%

**Financial Capability Assessment Worksheet 9, Summary of Permittee Financial Capability Indicators
(1997 USEPA Guidance)**

Line Number	Item	Value	Score
901	Bond Rating (line 303)	NA	NA
902	Overall Net Debt as a Percent of Full Market Property Value (line 405)	4.50%	2
903	Unemployment Rate Compared with National Average	-2.30%	3
904	Median Household Income Compared with National Average	152.65%	3
905	Property Tax Revenues as a Percent of Full Market Property Value (line 703)	1.78%	3
906	Property Tax Revenue Collection Rate (line 803)	98.68%	3
907	Permittee Indicators Score		2.80

**Financial Capability Assessment Worksheet 10, Financial Capability Matrix Score
(1997 USEPA Guidance)**

Line Number	Item	Value
1001	Residential Indicator Score (line 205)	0.57%
1002	Permittee Financial Capability Indicators Score (line 907)	2.80
1003	Financial Capability Matrix Category	Low Burden

1997 Guidance Worksheets for Hermon, Maine

Financial Capability Assessment Worksheet 1, Cost Per Household (1997 USEPA Guidance)

Line Number	Item	Unit	Value
	Current Wastewater Management, CSO, and Stormwater Costs (FY 2017)		
100	Annual O&M Expenses (Excluding Depreciation)	(\$)	\$34,716
101	Annual Debt Service (Principal and Interest)	(\$)	\$89,900
102	Subtotal	(\$)	\$124,616
	Projected Wastewater Management, CSO, and Stormwater Costs 2016 Dollars)		
103	Estimated Annual O&M Expenses (Excluding Depreciation)	(\$)	\$0
104	Annual Debt Service (Principal and Interest)	(\$)	\$0
105	Subtotal	(\$)	\$0
106	Total Current and Projected Wastewater Management, CSO, and Stormwater Costs	(\$)	\$124,616
	Residential Share of Total Wastewater Management, CSO, and Stormwater Costs		
	Residential Flow	(HCF)	
	Total Flow	(HCF)	
	Residential Portion	(%)	81.00%
107	Cost Allocation	(\$)	\$100,939
108	Total Number of Households in Service Area (2015 Census Data)	(EDUs)	2,127
109	Cost Per Household	(\$)	\$47
	Additional Bangor Rate Cost Per Household	(\$)	\$517
	Total Cost Per Household	(\$)	\$564

Financial Capability Assessment Worksheet 2, Residential Indicator (1997 USEPA Guidance)

Line Number	Item	Unit	Value
	Median Household Income (MHI)		
201	Census Year MHI (2015 ACS 5-year estimates)	(\$)	\$62,188
202	MHI Adjustment Factor		1.0123
203	Adjusted MHI (2016 inflation-adjusted dollars)	(\$)	\$62,950
204	Annual Cost Per Household (line 109)	(\$)	\$564
	Residential Indicator		
205	CPH as a percentage of adjusted MHI	(%)	0.90%

Financial Capability Assessment Worksheet 3, Bond Rating (1997 USEPA Guidance)

Line Number	Item	Unit	Value
	Most Recent General Obligation Bond Rating		AA+
	Date		June 30, 2015
	Rating Agency		Standard & Poor's
301	Rating		
	Most Recent Revenue Bond		NA
	Date		
	Rating Agency		
	Bond Insurance		
302	Rating		
303	Summary Bond Rating		AA+

Financial Capability Assessment Worksheet 4, Overall Net Debt as a Percent of Full Market Property Value (1997 USEPA Guidance)

Line Number	Item	Unit	Value
401	Direct Net Debt (G.O. Bonds Excluding Double-Barreled Bonds) (FY 2015)	(\$)	\$2,670,230
402	Debt of Overlapping Entities (Proportionate Share of Multi-jurisdictional Debt) (FY 2015)	(\$)	\$0
403	Overall Net Debt (FY 2015)	(\$)	\$2,670,230
404	Market Value of Property (FY 2015)	(\$)	\$472,927,465
405	Overall Net Debt as a Percent of Full Market Property Value	(%)	0.56%

Financial Capability Assessment Worksheet 5, Unemployment Rate (1997 USEPA Guidance)

Line Number	Item	Unit	Value
501	Unemployment Rate - Permittee	(%)	3.4%
	Source: Maine Center for Workforce Research and Information; 2015 annual average		
502	Unemployment Rate - County		N/A
	Benchmark		
503	Average National Unemployment Rate	(%)	5.3%
	Source: Maine Center for Workforce Research and Information; 2015 annual average		
	Comparison of Permittee with Benchmark	(%)	-1.9%

Financial Capability Assessment Worksheet 6, Median Household Income (1997 USEPA Guidance)

Line Number	Item	Unit	Value
601	MHI - Permittee (line 203)	(\$)	\$62,950
	Source: U.S. Census 2011-2015 American Community Survey 5-Year Estimates		
	Benchmark		
602	Census Year National MHI	(\$)	\$53,889
603	MHI Adjustment Factor (line 202)		1.0123
604	Adjusted National MHI	(\$)	\$54,549
	Source: U.S. Census 2011-2015 American Community Survey 5-Year Estimates		
	Comparison of Permittee with Benchmark	(%)	115.40%

Financial Capability Assessment Worksheet 7, Property Tax Revenues as a Percent of Full Market Property Value (1997 USEPA Guidance)

Line Number	Item	Unit	Value
701	Full Market Value of Real Property (line 404) (FY 2015)	(\$)	\$472,927,465
702	Property Tax Revenues (FY 2015)	(\$)	\$5,387,495
703	Property Tax Revenues as a Percent of Full Market Property Value	(%)	1.14%

**Financial Capability Assessment Worksheet 8, Property Tax Revenue Collection Rate
(1997 USEPA Guidance)**

Line Number	Item	Unit	Value
801	Property Tax Revenue Collected (line 702) (FY 2015)	(\$)	\$5,387,495
802	Property Taxes Levied (FY 2016)	(\$)	\$5,675,130
803	Property Tax Revenue Collection Rate	(%)	94.93%

**Financial Capability Assessment Worksheet 9, Summary of Permittee Financial Capability Indicators
(1997 USEPA Guidance)**

Line Number	Item	Value	Score
901	Bond Rating (line 303)	AA+	3
902	Overall Net Debt as a Percent of Full Market Property Value (line 405)	0.56%	3
903	Unemployment Rate Compared with National Average	-1.90%	3
904	Median Household Income Compared with National Average	115.40%	2
905	Property Tax Revenues as a Percent of Full Market Property Value (line 703)	1.14%	3
906	Property Tax Revenue Collection Rate (line 803)	94.93%	2
907	Permittee Indicators Score		2.67

**Financial Capability Assessment Worksheet 10, Financial Capability Matrix Score
(1997 USEPA Guidance)**

Line Number	Item	Value
1001	Residential Indicator Score (line 205)	0.90%
1002	Permittee Financial Capability Indicators Score (line 907)	2.67
1003	Financial Capability Matrix Category	Low Burden

Attachment B

Sewered Household Estimate for the City of Bangor

EPA Region I Household Estimation Method

Source: 2011-2015 ACS 5-Year Estimates, DP04 Selected Housing Characteristics

LINE #		ACS Data Set - Bangor ME	Additional Housing Units
1	Total housing units	15,438	
2	Occupied units	14,099	
3	Vacant Housing Units Rate	8.7%	
4	Homeowner Vacancy Rate	1.9%	
5	Rental Vacancy Rate	4.2%	
6	1-unit, detached	6,387	n/a*
7	1-unit, attached	555	n/a*
8	2 units	1,550	775
9	3 or 4 units	2,824	1,883
10	5 to 9 units	1,654	1,323
11	10 to 19 units	589	530
12	20 or more units	1133	1,076
13	mobile homes	746	n/a**
14	Additional Housing Units***		5,103
15	Sewered additional housing units****		4,082
16	Sewered additional housing units(*)		4,961
17	difference (lines 16-15)		879
18	Residential Billing Accounts Reported by City		8,968
19	Bangor subsidized units (**)		808
20	Range of Total Sewered Housing Units (Households)		12,242
			13,121

* housing units considered as sewer building accounts

** assumed to be unsewered

*** assumed that the vacant housing units rate of 8.7% is applied to all multi-unit

**** City estimates that 80% of total housing units have connectivity to the sewer.

(*) Assumes all 3 or greater unit buildings are sewered; 80% is applied to only 2-unit buildings

(**) Assumes that there is no transfer of municipal funds to the sewer enterprise

Appendix D: Current DEP and EPA CSO

Control Policies

1. Consent Decree, United States of America, Plaintiff, v. City of Bangor and State of Maine, Defendants, No. 88-0048-B, CWA – Clean Water Act, Environmental Protection Agency, - Region 1, United States District Court, District of Maine, 1991 EPA Consent, Filed April 16, 1991.
2. Consent Decree, United States of America and State of Maine, Plaintiffs, v. City of Bangor, Maine, Defendant, Civil Action No.1:15-cv-00350-NT, Filed November 13, 2015.
3. Final Draft, Combined Sewer Overflow Facilities Plan for the City of Bangor, Volume 1: Facilities Plan, prepared by CH2MHill, December 1993.
4. Final Report on CSO Abatement Program, City of Bangor, Maine, April 2009
5. Phase 2 CSO Long Term Control Plan Progress Report (including Technical Memoranda P2LTCP.1 through P2LTCP.9), prepared by CH2MHill, September 30, 2012.
6. U.S. Environmental Protection Agency, Combined Sewer Overflow (CSO) Control Policy, 40 CFR Part 122, Federal Register, April 1994.
7. U.S. Environmental Protection Agency, Combined Sewer Overflows Guidance for Financial Capability Assessment and Schedule Development, February 1997.
8. U.S. Environmental Protection Agency, Request for Information Pursuant to Section 308 of the Clean Water Act, Docket No. 010-308, May 28, 2010.
9. State of Maine Department of Environmental Protection, Chapter 570, Combined Sewer Overflow Abatement, February 2000.
10. State of Maine Department of Environmental Protection, Program Guidance on Combined Sewer Overflow Facility Plans, DEPL W0846-1994, September 1994.
11. Maine Pollution Discharge Elimination System (MEPDES) Permit #ME0100781/Maine Waste Discharge License (WDL) Application #W001041-5M-K-M, Final Permit/WDL – City of Bangor, Maine, August 9, 2016.
12. Moore, B.L., Cyr, K. C., and Murphy, J. L., Ten Years of In-System Storage for Combined Sewer Overflow Control, Prepared for WEFTEC 2012, October 2010.

