CSS Long Term Control Plan Update

LTCPU REPORT

City of Alexandria, VA
Alexandria Renew Enterprises

DRAFT for Public Comment
March 23, 2018

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The City previously developed a Long Term Control Plan Update (LTCPU) in 2016 as a series of technical memoranda that was submitted to the Virginia Department of Environmental Quality (VDEQ) for review and comment. Although these documents served as the basis for this final LTCPU, specific aspects of the final LTCPU Report have changed since the original technical memoranda were written in response to the 2017 CSO Law. As such, these reference documents should be used to gain a deeper understanding of the methodologies used in developing the final LTCPU Report.

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Abbreviations

$M	Dollars in Millions
AACE	Association of Advancement of Cost Engineering
AADF	Annual Average Daily Flow
AC	Acres
ADF	Average Daily Flow
AlexRenew	Alexandria Renew Enterprises
ARP	Area Reduction Plan
ASA	Alexandria Sanitation Authority
BMP	Best Management Practices
BOD	Biochemical Oxygen Demand
CCI	Construction Costs Indices
CI	Commonwealth Interceptor
CIP	Capital Improvement Plan
City	City of Alexandria, VA
COA	City of Alexandria
CSO	Combined Sewer Overflow
CSO 001	Pendleton Street Outfall
CSO 002	Royal Street Outfall
CSO 003	Duke Street Outfall
CSO 004	Hooffs Run Outfall
CSS	Combined Sewer System
Ct	Contact Time
CWA	Clean Water Act
DC	District of Columbia
DCA	Ronald Reagan Washington National Airport
DEC	Department of Environmental Conservation
DEM	Dynamic Estuary Model
DEP	Department of Environmental Protection
DEQ	Department of Environmental Quality
DO	Dissolved Oxygen
DOJ	Department of Justice
DOS	Disk Operating System
DVP	Dominion Virginia Power
DWSD	Detroit Water and Sewage Department
E & S	Erosion and Sediment
EAP	Environmental Act Plan
ELCIRC	Euler-Lagrangian Circulation
ENR	Engineering News-Record
EOS	Edge of Stream
EPA	Environmental Protection Agency
EPBM	Earth Pressure Balance Machine
EPC	Environmental Policy Commission
FCWA	Federal Clean Water Act
ft	Feet
gal	Gallon

GARP .... Greened Acre Retrofit Program
GI .... Green Infrastructure
GIS .... Geographic Information System
GPD .... gallon per day
GRD .... Grease Removal Devices
HDD .... Horizontal Directional Drilling
HGL .... Hydraulic Grade Line
HOV .... High Occupancy Vehicle
hr .... Hour
HRJC .... Hooffs Run Junction Chamber
HSPF .... Hydrologic Simulation Program FORTRAN
HY .... Hybrid
I/I .... Inflow and Infiltration
ICPRBP .... Interstate Commission on the Potomac River Basin
IDDE .... Illicit Discharge Detection and Elimination
in .... Inch
ITE .... Institute of transportation Engineers
kWH .... Kilowatt Hours
lbs .... Pounds
LEED .... Leadership in Energy and Environmental Design
LF .... Linear Foot
LID .... Low Impact Development
LTCP .... Long Term Control Plan
LTCPU .... Long Term Control Plan Update
M .... Millions
MG .... Million Gallons
mg/L .... Milligram/liter
MGD .... Million Gallons per Day
min .... Minute
mL .... Milliliters
MS4 .... Municipal Separate Storm Sewer System
MTBM .... Micro Tunnel Boring Machine
MWCOG .... Metropolitan Washington Council of Governments
N .... Nitrogen
P .... Phosphorous
TSS .... Total Suspended Solids
$NaHSO_3$ .... Sodium Bisulfite
NaOCl .... Sodium Hydrochlorite
NGVD .... National Geodetic Vertical Datum
NMC .... Nine Minimum Control
NMF .... Nutrient Management Facility
NOAA .... National Oceanic and Atmospheric Administration
NPDES .... National Pollution Discharge Elimination System
NPS .... National Park Services
NPW .... Net Present Worth
NRCS .... Nutrient Resources Conservation Service
NWS .... National Weather Service

O&M .... Operating and Maintenance
PAA .... Peracetic Acid
PER .... Preliminary Engineering Report
POTW .... Publicly Owned Treatment Works
PPP .... Public Participation Plan
PPT .... Pre-cast Post Tension Tanks
PYTS .... Potomac Yard Trunk Sewer
ROW .... Right-of-Way
RPA .... Resource Protection Area
RTC .... Real Time Control
SANDAG .... San Diego Association of Governments
SF .... Square Foot
SOM .... Sewer Overflow Model
SP .... Separation
Sq ft .... Square Feet
SSO .... Sanitary Sewer Overflow
ST .... Storage
SWMIP .... Stormwater Management Incentives Program
SWMM .... Storm Water Management Model
T&ES .... Department of Transportation and Environmental Services
TAZ .... Traffic Analysis Zone
TBM .... Tunnel Boring Machine
TMDL .... Total Maximum Daily Load
TR .... Treatment
TRC .... Total Residual Chlorine
TSS .... Total Suspended Solids
TU .... Tunnels
UAA .... Use Attainability Analysis
URL .... Uniform Resource Locator
USDOE .... United States Department of Energy
USEPA .... United States Environmental Protection Agency
UV .... Ultraviolet
VA .... Virginia
VDEQ .... Virginia Department of Environmental Quality
VDH .... Virginia Department of Health
VDOT .... Virginia Department of Transportation
VIMS .... Virginia Institute of Marine Science
VPDES .... Virginia Pollutant Discharge Elimination System
VMRC .... Virginia Marine Resources Commission
WIP .... Watershed Implementation Plan
WLA .... Waste Load Allocation
WMATA .... Washington Metropolitan Transit Authority
WPCP .... Water Pollution Control Plant
WQS .... Water Quality Standards
WRRF .... Water Resources Recovery Facility
WWPS .... Wet Weather Pump Station
WWTP .... Wastewater Treatment Plant

XPSWMM .... XP Solutions Storm Water Management Model

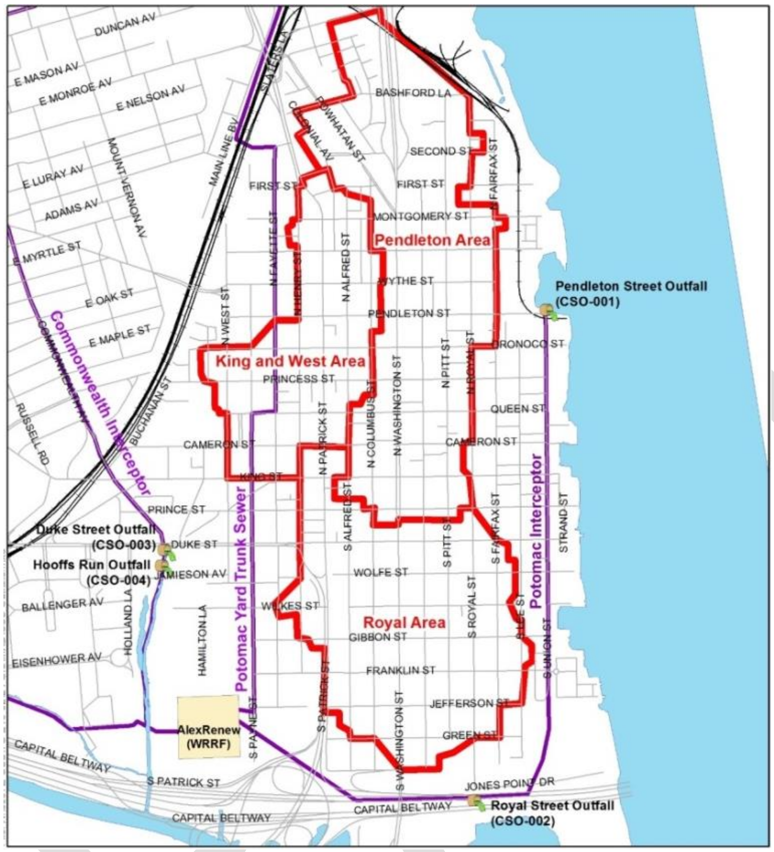
Executive Summary

ES.1 Background

There are two types of sewer systems in the City of Alexandria – a combined sewer system and a separate sewer system. In a combined sewer systems (CSS), there is only one pipe to convey both sewage and stormwater to a wastewater treatment plant. Many older cities in the United States are served by combined sewers, including portions of the City of Alexandria. During wet weather events, the sewage collection system and/or wastewater treatment plant may be unable to handle the combined flows, which are primarily comprised of stormwater. During these conditions, Alexandria's combined sewers discharge excess flows into the waterways through its four permitted combined sewer outfalls. This is known as a combined sewer overflow (CSO).

The City's sewer system covers approximately 15.4 square miles, of which less than 6% (540 acres) is served by the CSS as shown in Figure ES-1. During wet weather, after the capacity of the sewer system is reached, combined sewer flows in the CSS discharge (i.e. overflow) to the surrounding waterbodies through four outfalls that serve three subareas within the CSS (CSO 003 and CSO 004 serve the same subarea). The City operates its CSS under a permit issued by Virginia Department of Environmental Quality (VDEQ) and has had an approved Long Term Control Plan for the CSS since 1999.

Figure ES-1
CSS Overview



ES.1.1 Hunting Creek Bacteria Total Maximum Daily Load (TMDL)

On November 2, 2010, VDEQ issued Bacteria TMDLs for the Hunting Creek, Cameron Run, and Holmes Run Watersheds. The TMDL assigns bacteria loads to all the sources contributing bacteria load to Hunting Creek. These bacteria loads are known as Waste Load Allocations (WLA). The WLAs in the TMDL require higher reductions in bacteria from the City's combined sewer overflows than called for in the previously approved LTCP. In addition, the TMDL requires very high bacteria reductions from other sources, including stormwater, septic, and wildlife to meet water quality standards. Among the City's four CSO outfalls, the Hunting Creek TMDL applies to three of these outfalls (CSO 002, CSO 003, and CSO 004). It should be noted that CSO 001 is not included in the Hunting Creek TMDL because it discharges to Oronoco Bay, which is not part of the Hunting Creek watershed.

ES.1.2 2017 CSO Law

A previous version of the LTCPU was submitted to VDEQ on August 12, 2016. VDEQ provided comments and the LTCPU was revised and resubmitted on December 2, 2016 for VDEQ approval. While VDEQ was reviewing the LTCPU for approval, new CSO legislation was signed into law on April 26, 2017 by Virginia which imposes additional requirements on combined sewer outfalls not already under a consent decree. The 2017 CSO Law requires:

> *"Any owner of a CSO outfall…shall, by July 1, 2023, initiate construction activities necessary to bring the CSO outfall into compliance and shall, by July 1, 2025, bring the CSO outfall into compliance with Virginia law, the federal Clean Water Act, and the Presumption Approach described in the EPA CSO Control Policy, unless a higher level of control is necessary to comply with a TMDL."*

The 2017 CSO Law requires the City to substantially revise the 2016 LTCPU and to greatly accelerate the implementation of the plan to meet the July 1, 2025 deadline. In addition, the 2017 CSO Law requires mitigation of overflows at CSO 001 (Oronoco Bay) to meet the EPA CSO Control Policy Presumption Approach as described in Section 3.1.1.

ES.1.3 City and AlexRenew Partnership

The Alexandria Sanitation Authority, doing business as Alexandria Renew Enterprises (AlexRenew), is a political subdivision of the Commonwealth of Virginia that was created in 1952 under the Virginia Water and Wastes Authority Act. AlexRenew owns and operates a Water Resource Recovery Facility (WRRF) that provides sanitary and combined sewage treatment services to the City of Alexandria and sanitary sewer treatment services to Fairfax County. AlexRenew is working as a partner with the City of Alexandria to leverage the WRRF to achieve CSO remediation requirements and to meet the legislative deadline. As part of this partnership, AlexRenew and the City of Alexandria have jointly authored this document.

In addition to the CSO remediation requirements, AlexRenew's current VPDES permit includes requirements to put forth a plan to minimize the occurrences of separate sanitary wet weather overflows at the Hooffs Run Junction Chamber (HRJC), located at the AlexRenew site. The plan put forth in this document eliminates the HRJC and satisfies the AlexRenew permit requirement.

ES.1.4 Purpose of the Long Term Control Plan Update (LTCPU)

In August 2013, the City received a new CSS permit issued by VDEQ. One of the conditions of this permit required the City to update its existing 1999 Long Term Control Plan by August 23, 2016 in order to meet the Hunting Creek TMDL bacteria reductions. The update was published in December 2016 but never formally adopted by VDEQ. This LTCPU document serves as an updated plan to address the CSS permit condition, the Hunting Creek TMDL, and the 2017 CSO Law.

ES.2 Basis of Planning

The EPA CSO Control Policy lays out a framework for developing the LTCPU. The EPA CSO Control Policy, in addition to providing a technical approach, also calls for public involvement and outreach. The City conducted extensive public outreach, including the creation of a community stakeholder group. Ideas from of the stakeholder group were incorporated during the conceptualization and drafting of the final LTCPU Plan described herein.

One approach for CSO planning under the EPA CSO Control Policy is the *Presumption Approach*. This approach states that if the number of CSO events can be limited to 4 – 6 overflows per year during a typical year, it can be presumed to provide an adequate level of control to meet the water quality-based requirements of the CWA, provided the permitting authority determines that such presumption is reasonable. Per the EPA CSO Control Policy, the City used a typical rainfall year to evaluate the alternatives and select a proposed approach for the LTCPU. To determine the typical assessment year, a 40-year time period from 1974 through 2013 was selected and analyzed. Based on this analysis, the year 1984 was selected as the typical year for the LTCPU and best represents the long-term average rainfall conditions. More detailed information about the evaluation of the typical year can be found in the *Typical Year Selection Technical Memorandum* dated September 2014.

In addition to the typical year, the Hunting Creek TMDL established WLAs and bacteria reduction percentages based on the hydrologic conditions in years 2004 and 2005. The sizing of the proposed CSO infrastructure is driven by the storms used in the development of the Hunting Creek TMDL. In order to design systems to demonstrate compliance with the TMDL, various iterations of infrastructure sizing were analyzed to comply with the mandated performance requirements.

ES.3 2000-2016 Climate Period

During the development of this plan, VDEQ requested evaluation of the performance for a more recent climate period, which was viewed as being a wetter period and therefore more representative of current and future conditions than the analysis used to establish the 1984 typical year. The 2000 – 2016 climate period was also evaluated to determine how each of the CSO control options would perform. The 2000 – 2016 climate period is presented for informational purposes only and is not required for regulatory compliance.

ES.4 CSO Technologies Screening

A wide range of technologies were screened to identify suitable CSO control technologies for further evaluation. Based upon the screening of technologies, the following technologies were identified as primary technologies for detailed consideration as part of the alternatives evaluation:

- Disinfection
- Green Infrastructure (GI)
- Sewer Separation
- Storage Tanks
- Storage and Conveyance Tunnels
- Wet Weather Treatment
- Combinations of the above technologies

ES.5 Evaluation of Preliminary Alternatives

Evaluation criteria were developed and used to rate each of the CSO control options during the alternatives analysis portion of the LTCPU. The evaluation criteria were developed and tailored to meet the requirements of the Hunting Creek TMDL and 2017 CSO Law while providing a solution unique to the needs of the City of Alexandria. Following a series of workshops over several months between the City and AlexRenew, a shortlist of CSO control strategies was developed for further evaluation. The list of three options is provided here and will be referred to as Option A, Option B, and Option C. Each of the shortlisted strategies is described in detail in Section 6.

Table ES-1
Shortlist of CSO Control Strategies

Option	Option Name	Option Description
A	Separate Tunnels	Separate Tunnels for CSOs 003/004 and CSOs 001/002 with Wet Weather Treatment at AlexRenew for 003/004 Only
B	Unified Tunnels	Tunnels Connected by Pumping from 003/004 Tunnel to 001/002 Tunnel
C	Tunnel and Tanks	Conveyance Tunnel and Wet Weather Treatment for CSOs 003/004 and Storage Tanks for CSOs 001/002

ES.6 Recommended Plan

The City of Alexandria and AlexRenew are committed to the improvement of local and regional waterways for the benefit of community and environmental health and safety. The selection of the Recommended Plan (the Plan) for this LTCPU considers both the legislative requirements, as well as the physical and financial impacts on the community, and the longevity and adaptability of the proposed option. As discussed in Section 2, public input was solicited, received, and considered through an extensive public participation process. The Plan focuses on the construction of new infrastructure to meet the CSO requirements, which includes storage and conveyance tunnels strategically coupled with AlexRenew's WRRF, to maximize the volume of CSO flow receiving treatment.

As discussed in Section 6, each option was scored based on a set of evaluation criteria. Option B scored higher than the other options in all criteria. Based on feedback received during the Stakeholder Group process, the LTCPU proposes an enhanced Option B – Unified Tunnel (referred to as Option B+) as the plan to address CSO discharges from CSO's 001, 002, 003, and 004. The Plan is illustrated in Figure ES-2 and includes the following major components:

- Unified Tunnel
  - Storage tunnels
  - Conveyance tunnels
  - Diversion facilities (diversion chambers and drop shafts)
  - Dewatering pumping stations
- AlexRenew WRRF upgrades
  - Wet weather pumping station
  - Increase WRRF peak capacity from 108 to 116 MGD
- Wet weather treatment utilizing existing and improved facilities at the WRRF

Figure ES-2
Proposed Plan[1]

[1] The tunnel alignment shown is for illustrative purposes. Exact locations are still to be determined.

Hydrologic and hydraulic modeling predicts that the infrastructure proposed in the Plan eliminates overflows in the typical year of 1984 (although not a regulatory requirement) and complies with the Hunting Creek TMDL. The selected controls maximize the use of existing facilities, provide conveyance through a tunnel from CSO's 003 and 004 to AlexRenew's WRRF, provide additional storage for CSO's 001 and 002 in a storage and conveyance tunnel, and leverages AlexRenew's WRRF to provide treatment of wet weather flows.

Table ES-2
Summary of Model Performance, Typical Year (1984)

Item	Existing	Recommended Plan (Option B+)
Number of Overflows (4 to 6 per Presumption Approach)		
CSO-001	38	**0**
CSO-002	52	**0**
CSO-003	62	**0**
CSO-004	70	**0**
Systemwide Percent Capture (85% per Presumption Approach)	80.6%	**100%**

As discussed in Section 3, the Hunting Creek TMDL assigns waste load allocations to CSO's 002, 003, and 004 and a waste load allocation for future growth of point sources at the AlexRenew WRRF, which totals 8.52E+13 cfu/year. Table ES-3 illustrates that the Plan meets the Hunting Creek TMDL total aggregate waste load allocation of 8.52E+13 cfu/year.

Table ES-3
Summary of Model Performance, Hunting Creek TMDL

Year	Recommended Plan (Option B+) Bacteria Load (cfu/year)	Aggregate Waste Load Allocation (cfu/year)
2004	**3.43E+13**	8.52E+13
2005	**2.13E+13**	

In addition to the performance with respect to the regulatory requirements illustrated in Table ES-2 and Table ES-3, anticipated performance during the 2000-2016 climate period is demonstrated in Table ES-4 for informational purposes only.

Over the 2000-2016 climate period the model results show less than four overflow events per year on average from each outfall (Table ES-4). The systemwide percent capture of combined sewer flows is greater than 96%, well above the CSO Policy requirement of 85% capture.

Table ES-4
Summary of Model Performance, 2000-2016

Item	Existing	Recommended Plan (Option B+)
Number of Overflows		
CSO-001	34.1	**2.2**
CSO-002	78.4	**1.9**
CSO-003	60.4	**1.2**
CSO-004	71.4	**<1**
Systemwide Percent Capture	70.4	**96.4**

Table ES-5 summarizes the advantages and additional benefits of the Plan.

Table ES-5
Advantages and Benefits of the Recommended Plan

Advantages	Additional Benefits
■ Lowest cost to build and operate with respect to other shortlisted options ■ Simplest construction schedule with the highest potential to meet the mandated milestone based on current conceptual planning ■ Minimizes operational equipment and components in the community ■ Minimizes construction operations in the community by conceptually placing the most disruptive operations at the AlexRenew WRRF ■ Minimizes disruptive, long-term maintenance by centralizing major equipment at the AlexRenew WRRF and not within the community ■ Minimizes construction and operation costs by retrofitting existing facilities at the AlexRenew WRRF for dual use ■ Allows for future modification for enhanced wet weather treatment ■ Provides flexibility and adaptability for future regulatory and/or climate conditions ■ Preserves space at the AlexRenew WRRF for future regulatory needs	■ Exceeds required control measures established by the EPA CSO Policy ■ Captures a majority of the floatables (e.g. bottles, bags, trash, etc.) currently discharged via the combined sewer system to the receiving waters ■ Provides significant reductions in the discharge of solids to the waterbodies via capture and treatment at AlexRenew's WRRF ■ Provides reduction in the discharge of nutrients (e.g. nitrogen and phosphorous) to the waterbodies through capture and treatment at AlexRenew's WRRF ■ Relocates an outfall downstream of the African American Heritage Park ■ Provides control of sewer flooding and basement backups ■ Eliminates discharges to Hooffs Run from the Hooffs Run Junction Chamber ■ Does not require storage tanks in the City

ES.6.1 Ongoing City of Alexandria Strategies

The City of Alexandria is employing several strategies, outside of the LTCPU, both citywide and within the combined sewer system to assist in the reduction of combined sewer overflows, which include:

- Green infrastructure (GI): GI can be used to gradually reduce the stormwater entering the combined sewer system over time and provide other ancillary benefits for the community A GI strategy that provides the City with flexibility to install GI citywide will serve as the best approach to maximizing GI benefits and benefits to water quality in the Chesapeake Bay. The City is currently evaluating the use of GI on a broader scale to achieve its Chesapeake Bay TMDL goals as part of their Municipal Separate Storm Sewer System (MS4) permit and associated *Chesapeake Bay TMDL Action Plan*. It is anticipated that the Action Plan will be finalized in 2019 and GI will be an integral component of that Action Plan. In the meantime, the City will continue to encourage and promote GI citywide, including in the CSS area, through the development and redevelopment process as other opportunities arise, and will administer the implementation of GI through its MS4 program.
- Targeted sewer separation: Targeted sewer separation can be used to further reduce CSS overflows over time. The City currently has a program for separating combined sewers, whenever practicable, as a condition of redevelopment and intends continue to administer the Area Reduction Plan (ARP).

ES.7 Budget and Funding

A summary of the planning level capital costs for the LTCPU is included in Table ES-6. All costs presented are escalated to the mid-point of construction.

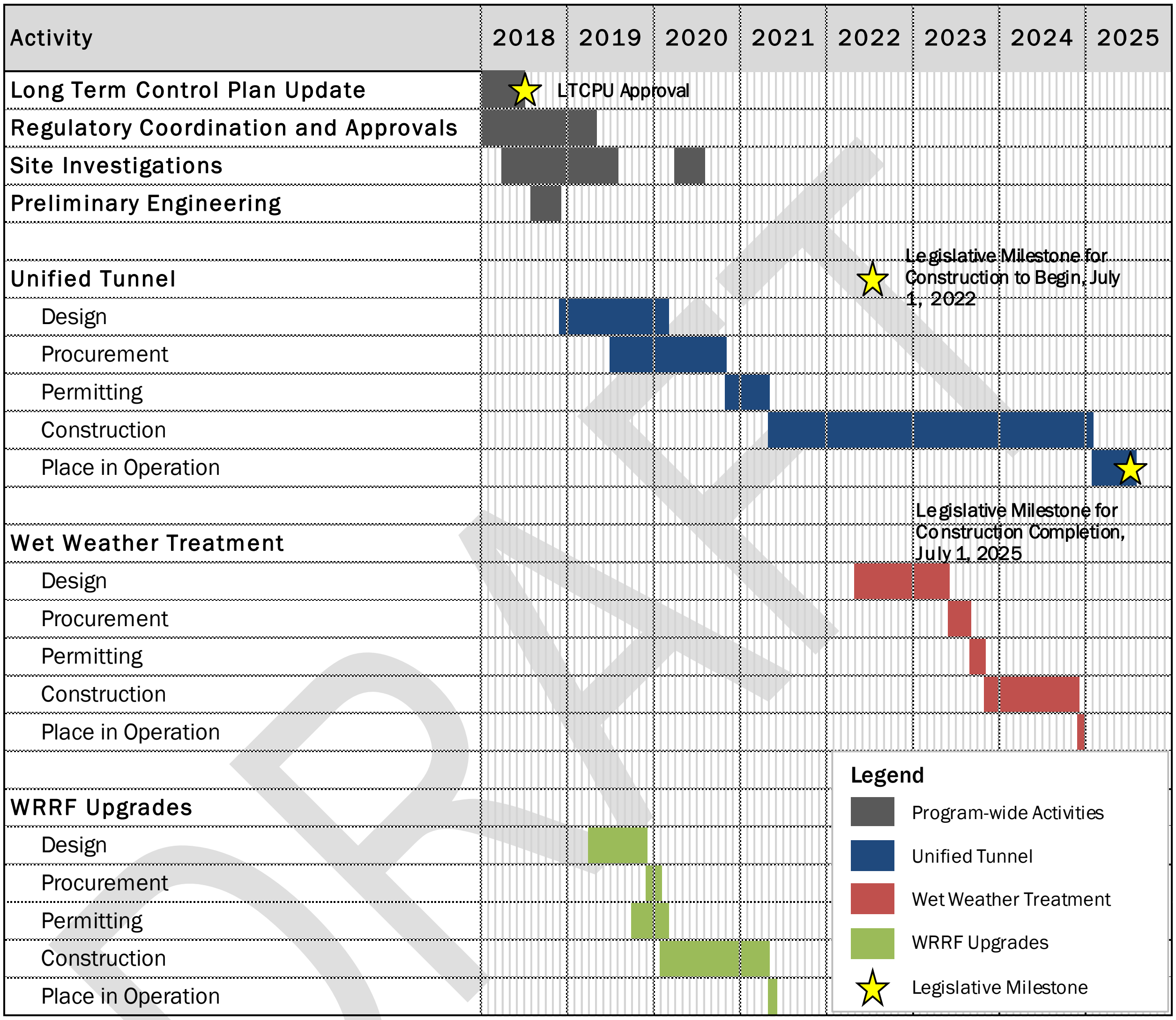
Table ES-6
Proposed Plan Preliminary Capital Costs

	Capital Costs ($)	Capital Costs +50% ($)
AlexRenew WRRF Upgrades	$2,700,000	$4,000,000
Wet Weather Treatment	$10,000,000	$15,000,000
CSO 003/004 Tunnel and Wet Weather Pumping Station	$130,000,000	$195,000,000
CSO 001/002 Tunnel	$213,000,000	$320,000,000
Total Costs	**$356,000,000**	**$534,000,000**

ES.8 Implementation

The LTCPU recommends that the proposed infrastructure projects be constructed in phases. A preliminary program implementation schedule for the proposed projects included in the LTCPU is provided in Figure ES-3.

Figure ES-3
Preliminary LTCPU Implementation Schedule



Section 1 Introduction

1.1 Background

There are two types of sewer systems in the City of Alexandria – a combined sewer system and a separate sewer system. Separate sewer systems consist of two sets of pipes. One pipe conveys stormwater runoff from storm drains to local waterways. The other pipe conveys sanitary sewage to a local wastewater treatment plant as shown in Figure 1-1.

Figure 1-1
Separate Sewer Systems

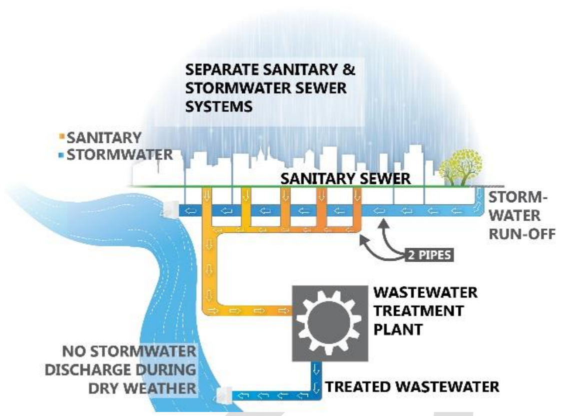
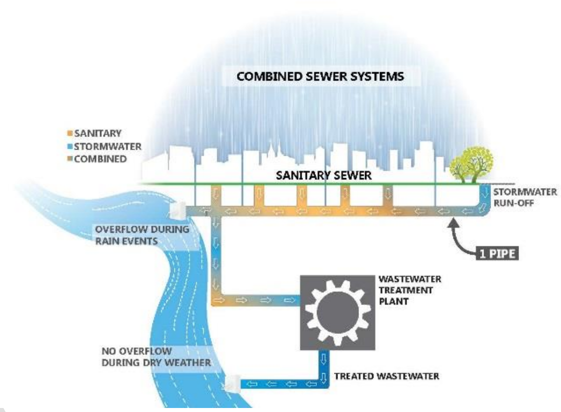


Figure 1-2
Combined Sewer Systems



Combined sewer systems (CSS) have only one pipe which conveys both sewage and stormwater to a wastewater treatment plant as shown in Figure 1-2. Many older cities in the United States are served by combined sewers. The CSS is designed to maximize flows to the Alexandria Renew Enterprises (AlexRenew) Water Resources Recovery Facility (WRRF); however during some larger wet weather events, the sewage collection system and/or wastewater treatment plant is unable to handle the combined flows. During these conditions, Alexandria's combined sewers discharge excess flows into the waterways through one of its four combined sewer outfalls.

1.2 City's Sewer System

An overview of the City of Alexandria's sewer system is shown in Figure 1-3. The City's sewer system covers approximate 15.4 square miles and consists of both a separate sewer system and a 540-acre (0.9 square miles) combined sewer system (CSS), which represents 6% of the City. During wet weather, flows in the CSS discharge to the surrounding waterbodies through four permitted outfalls that serve three subareas within the CSS (Outfall 003 and Outfall 004 serve the same subarea). Figure 1-4 shows the CSS areas and outfalls in more detail.

- Pendleton Street CSO (CSO 001);
- Royal Street CSO (CSO 002);
- Duke Street CSO (CSO 003); and

- Hooffs Run CSO (CSO 004).

More information about the City's existing combined sewer system can be found in the *Combined Sewer System Characterization Technical Memorandum* dated September 2014.

Figure 1-3
Sewer System Overview

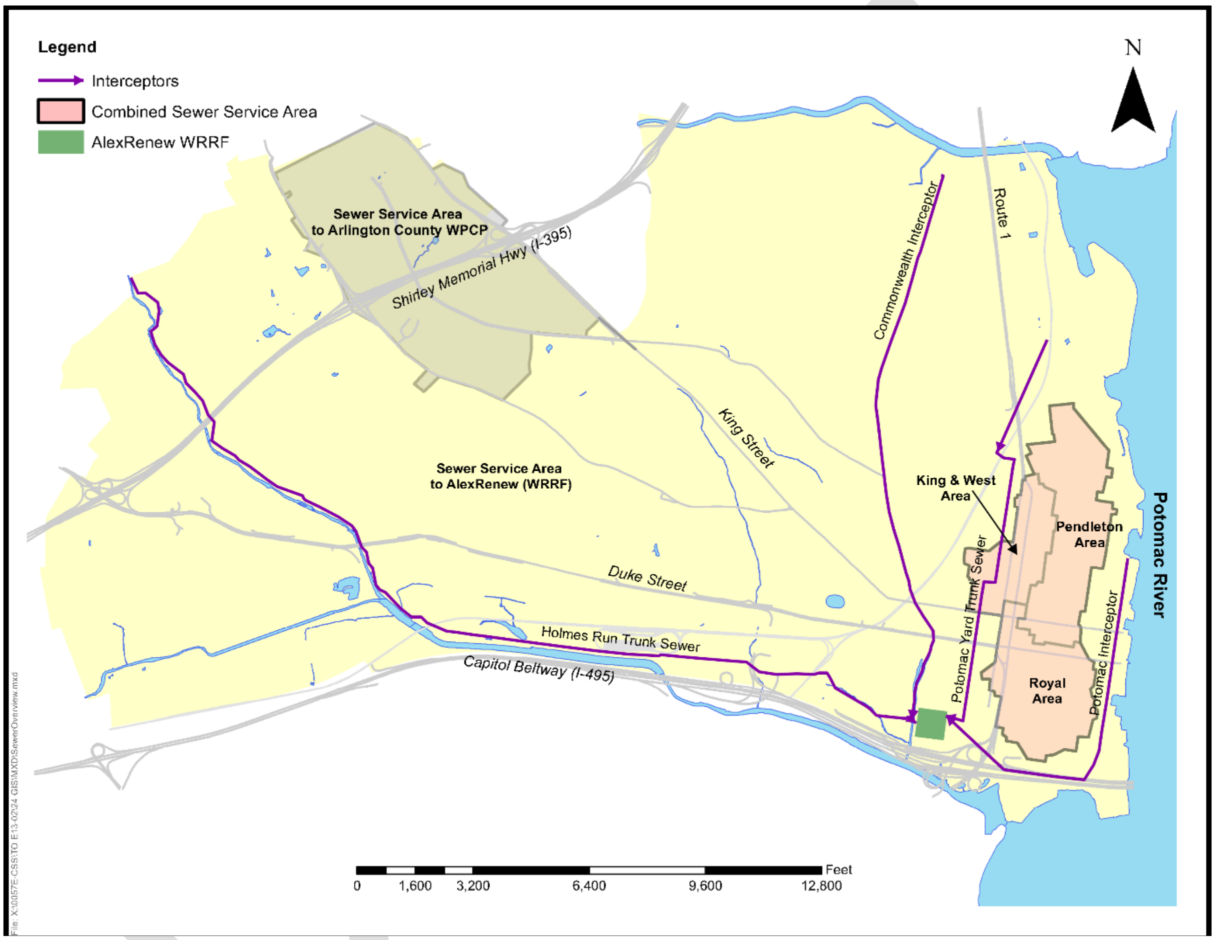
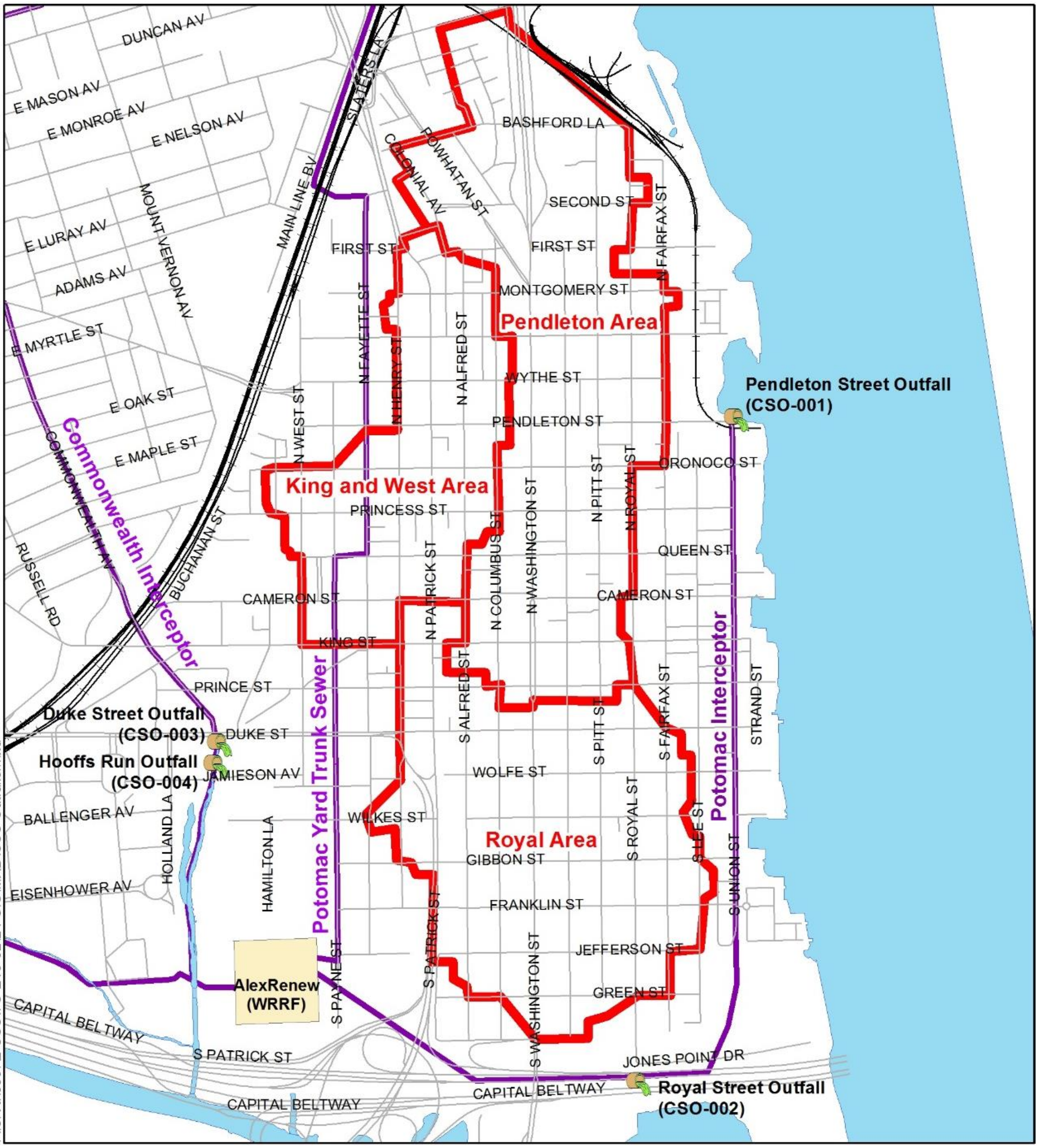


Figure 1-4
CSS Overview



1.3 History of Combined Sewer System Permit

In 1990, the City applied for a combined sewer system discharge permit and in 1995 the VDEQ issued the City its first CSS permit (VPDES Permit No. VA0087068). Prior to the end of the first five (5)-year permit term, the City reapplied for a new permit that was then issued in 2001. The City was issued a new permit in 2007 and received its current five (5)-year permit on August 23, 2013 expiring on August 22, 2018. City reapplied for renewal on February 20, 2018 in accordance with permit requirement.

1.4 1999 City's Approved LTCP

In 1999, the City developed a Long Term Control Plan (LTCP) consistent with the guidance provided in the United States Environmental Protection Agency's (USEPA) Combined Sewer Overflow Control Policy. Through extensive study and modeling, it was shown that, although the receiving waters are impaired, the City's CSOs do not prevent these waters from meeting designated uses. The 1999 LTCP consists of: 1) conduct proper operations and regular maintenance programs, 2) maximize use of the collection system for storage, 3) control of non-domestic discharges, 4) maximize flow to the treatment plant, 5) prohibit CSOs during dry weather, 6) control solid and floatable materials, 7) develop and implement a pollution prevention program, 8) notify the public, and 9) monitor the CSOs. These are typically known as the Nine Minimum Controls (NMCs) and are implemented in CSO systems throughout the country. This plan was submitted to the VDEQ and was approved in 1999. The City has been operating its CSS in compliance with its VPDES permit, consistent with the approved 1999 LTCP.

1.5 2010 Hunting Creek Total Maximum Daily Load (TMDL)

On November 2, 2010, VDEQ issued bacteria TMDLs for the Hunting Creek, Cameron Run, and Holmes Run Watersheds; these watersheds are shown on Figure 1-5. A TMDL can be thought of as a "pollution budget", in this case, that the pollutant is *E. coli* bacteria. The TMDL assigns bacteria loads known as Waste Load Allocations (WLA) or "budgets" to all the sources contributing to Hunting Creek under a particular critical condition scenario. Actual WLAs in colony forming units, or cfu/year, are shown on Table 1-1. It should be noted that CSO 001 is not included in the Hunting Creek TMDL. This is because CSO 001 discharges to Oronoco Bay, which is not part of the Hunting Creek watershed.

Figure 1-5
Relevant Local Watersheds

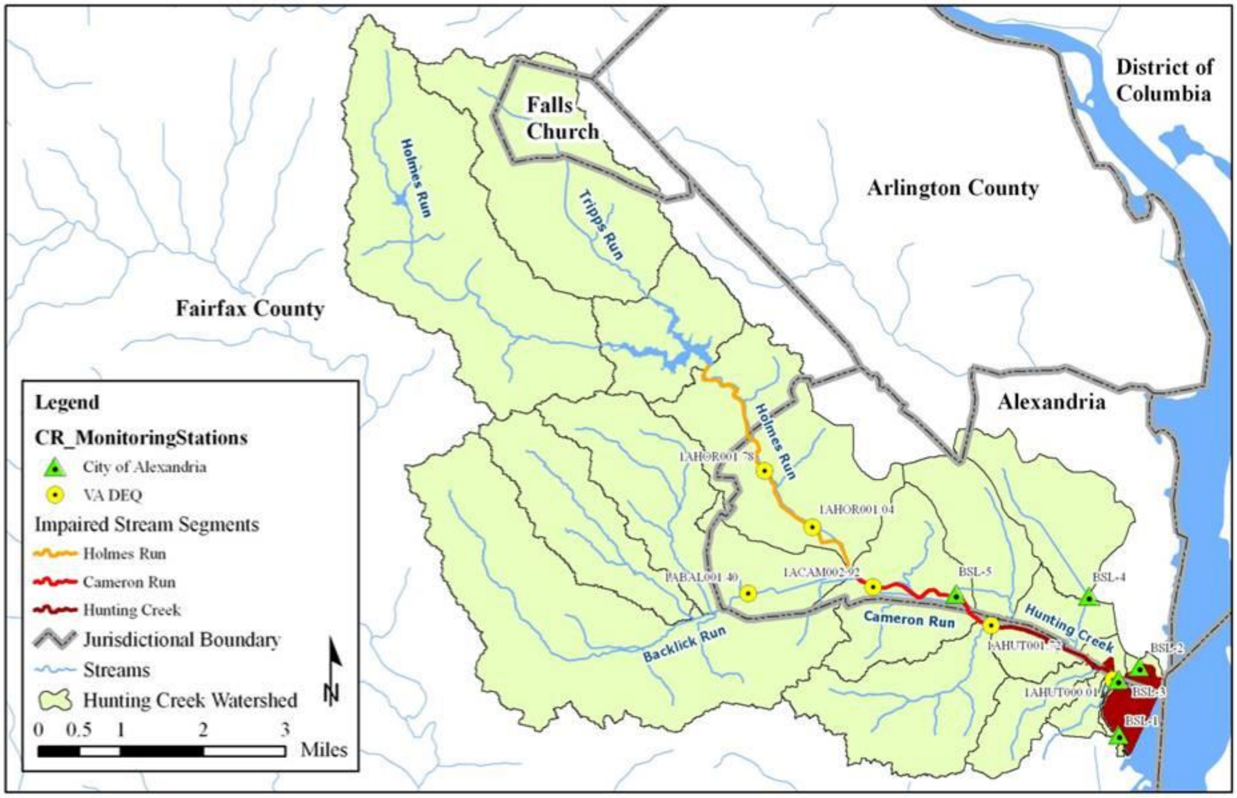


Table 1-1
Waste Load Allocation for COA Combined Sewer System (Hunting Creek TMDL)

Permit Number	CSO Outfall	Wasteload Allocation (cfu/year)	Percent Reduction (%)
VA0087068	CSO 002	6.26E+13	80%
	CSO 003	7.68E+11	99%
	CSO 004	8.52E+11	99%
	Total	6.42E+13	86%

In addition to the WLA reductions, the Hunting Creek TMDL also simulated AlexRenew's Water Resource Recovery Facility (WRRF) at its current design flow of 54 MGD and an allocation for future growth of point sources to an additional daily average flow of 12 MGD and a bacteria concentration of 126 cfu/100mL. Table 1-2 illustrates AlexRenew's WLA along with the future growth allocation.

Table 1-2
Hunting Creek TMDL WLA for AlexRenew's WRRF

Allocation	Design Flow (MGD)	WLA (cfu/year)
Base	54	9.40E+13
Future Growth of Point Sources	12	2.10E+13
Total	66	1.15E+14

It is important to note this future allocation is aggregated as a total with the CSO 002, 003, and 004 WLAs under the Hunting Creek TMDL in this Plan.

1.6 2017 CSO Law

A previous version of the LTCPU was submitted to VDEQ on August 12, 2016. VDEQ provided comments and the LTCPU was revised and resubmitted on December 2, 2016 for VDEQ approval. While VDEQ was reviewing the LTCPU for approval, new CSO legislation was signed into law on April 26, 2017 by Virginia which imposes additional requirements on combined sewer outfalls not already under a consent decree. The 2017 CSO Law requires:

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The 2017 CSO Law requires the City to substantially revise the 2016 LTCPU and to greatly accelerate the implementation of the plan to meet the July 1, 2025 deadline. In addition, the 2017 CSO Law accelerates the deadline to address overflows at CSO 001 (Oronoco Bay) to meet the EPA CSO Control Policy Presumption Approach as described in Section 3.1.1.

1.7 City and AlexRenew Partnership

The Alexandria Sanitation Authority, doing business as Alexandria Renew Enterprises (AlexRenew), is a political subdivision of the Commonwealth of Virginia that was created in 1952 under the Virginia Water and Wastes Authority Act. AlexRenew owns and operates a Water Resource Recovery Facility (WRRF) that provides sanitary and combined sewage treatment services to both the City of Alexandria and Fairfax County. AlexRenew is committed to being a leader in establishing cleaner, healthier waterways for the benefit of both the community and the environment. In addition, AlexRenew is working as a partner with the City of Alexandria to leverage the WRRF to assist in achieving CSO remediation goals and to meet the legislative deadline. As part of this partnership, AlexRenew and the City of Alexandria have jointly authored this document.

The Hooffs Run Junction Chamber (HRJC) is located at the AlexRenew site. AlexRenew's current VDPES permit, requires AlexRenew to:

> "*…commence an engineering evaluation of options/alternatives to study the need, feasibility, and possible means of minimizing the occurrences of wet weather overflows at the Hooffs Run Junction Chamber. …The final study and any proposed plan and implementation schedule should be compatible with the City of Alexandria's Long Term Control Plan Update…and shall be submitted to DEQ-NRO for review and approval on or before 31 December 2017 or one year from date of DEQ approval of the City's final LTCPU, whichever occurs later.*"

The plan put forth in this document eliminates the HRJC and satisfies the AlexRenew permit requirement.

1.8 Purpose of the Long Term Control Plan Update (LTCPU)

In August 2013, the City received a new combined sewer system permit issued by VDEQ. One of the conditions of this permit required the City to update its existing Long Term Control Plan to meet the new 2010 Hunting Creek TMDL bacteria reductions. While the City has reduced the impact of combined sewers through its approved 1999 LTCP, these measures are not adequate to meet the new requirements of the Hunting Creek TMDL or the 2017 CSO Law. This LTCPU presents a plan which the City and AlexRenew will implement to address the new bacteria waste load allocations for Combined Sewer Overflow (CSO) discharges to Hunting Creek and from CSO 002, CSO 003, CSO 004, and AlexRenew's WRRF, while also meeting the Presumption Approach performance requirement at CSO 001 (Oronoco Bay).

The previous 2016 LTCPU was developed (or in part through) as a series of technical memoranda submitted to VDEQ dating back to May 2014 and are used as the foundation of this LTCPU. This document summarizes the details of those technical memoranda. More detail about any of the information presented below can be found in those documents, which are included as references to this report.

Section 2 Public Participation

The City developed a public participation program to disseminate information and receive feedback. The overall goal of the public participation program was to inform and educate the public about the LTCPU. Additionally, the City actively sought to involve the affected public in the City's decision making process. The specific goals for the City's Public Participation Process were:

1. **Inform:** Increase stakeholder awareness of combined sewer systems and the LTCPU project and opportunities for public participation;
2. **Educate:** Develop basic knowledge or understanding of the LTCPU project and the potential effects of decision alternatives among stakeholders; and
3. **Be Responsive:** Awareness, consideration, and responsiveness on the part of the City about stakeholders' views on the project and project alternatives.

The objectives that describe how the City went about implementing these goals included:

1. **Establish and sustain an open and transparent public participation process.** Establish and sustain an open and transparent public participation process that informs, educates, and gathers feedback from external and internal LTCPU stakeholders.
2. **Create awareness and educate stakeholders.** Create awareness of water quality issues in Alexandria and increase the stakeholders' knowledge of the City's ongoing initiatives to protect the environment, enhance water quality, and improve quality of life in the community.
3. **Facilitate two-way communication.** Create opportunities for two-way communication with external and internal LTCPU stakeholders that enable them to provide input and ask questions about potential LTCPU project alternatives.
4. **Identify and address stakeholder concerns and questions.** Identify and respond to concerns and questions raised by external and internal LTCPU stakeholders about potential LTCPU project alternatives.
5. **Balance stakeholder expectations.** Balance stakeholder expectations for CSO project alternatives for the costs, potential impacts to residents, businesses and visitors, time horizon, and regulatory requirements

The City has implemented several different types of public participation:

- Local Outreach
- Public Meetings
- City Council
- AlexRenew Board
- Technical Review Panel
- CSS Stakeholder Group
- City Website

A listing of all meetings in which staff or the City team made presentations about the LTCPU to various groups can be found in Appendix A. More information about the City's public participation plan can be found in the *Public Participation Plan Technical Memorandum* originally dated October 2014 and revised in March 2018.

2.1 Local Outreach

Staff has engaged with many local civic groups throughout the development of the LTCPU, beginning in October of 2013. At these meetings staff walked the groups through the LTCPU process, including the background information, reasons the LTCPU is required, CSO technologies, shortlist of CSO strategies, and the selected final plan. City staff then went back to these same local civic groups at multiple check-in points during the development of the LTCPU to provide progress updates and solicit feedback. The City believes that engaging the public as much as possible helps to produce a plan with public support.

2.2 Public Meetings

In addition to the local outreach, the City's combined sewer system (CSS) permit requires public meetings at specified times during the LTCPU development. Three public meetings were held during the development of the 2016 LTCPU on February 5, 2015, June 18, 2015, and April 21, 2016. Following the 2017 CSO Law, the City conducted an additional public meeting on May 30, 2017 and will be holding a meeting on April 5, 2018. Similar to the local outreach, these meetings inform the public of the LTCPU process and development. This was an opportunity for the public to provide feedback and have influence in the development of the LTCPU and the final plan. Materials from these meetings, including handouts, video of the meetings, and responsiveness summaries are available on the City website (https://www.alexandriava.gov/Sewers).

2.3 30-Day Public Comment Period

On March 23, 2018, the City released this DRAFT of the LTCPU to the public for a 30-day comment period. The LTCPU can be found online by visiting the City's website at alexandrava.gov/sewers. Details for how to provide comments are provided on the above website. Public comments will be considered and responded to in a Responsive Summary, which will be shared following the 30-day comment period.

2.4 City Council

Throughout the previous 2016 LTCPU development dating back to 2013, staff provided several progress updates to City Council as part of their legislative meetings and public hearings. Staff will be introducing this LTCPU document at the Council's legislative meeting on April 10, 2018. A public hearing will be held on April 14, 2018, in which the public can voice their opinions on the plan before Council votes. Following the closing of the 30-day public comment period on April 23, 2018, City Council will vote on the authorization to submit this final LTCPU to VDEQ at its legislative meeting on April 24, 2018.

2.5 AlexRenew Board

Following the 2017 CSO Law, the City reconvened the CSS Stakeholder Group. One member of the AlexRenew board was assigned as Ex-Officio set on the Group. The AlexRenew Board has a combined sewer system update standing item on its monthly Board of Directors meeting agenda for its public meetings to receive updates from AlexRenew staff regarding the LTCPU development status.

2.6 CSS Stakeholder Group

City Council passed a resolution in June 2015 that established an ad hoc stakeholder group with the charge of providing input to City staff throughout the development of the LTCPU. City staff conducted a series of monthly meetings beginning in October 2015 and ending in April 2016 that walked the group through the development of the LTCPU. Following the 2017 CSO Law, City Council passed a second resolution in June 2017 that reconvened a reconstituted ad hoc stakeholder group with the charge of providing input to City staff throughout the significant revisions of the LTCPU, including the incorporation of CSO 001. Fourteen (14) stakeholders were selected by the City Manager from a pool of applicants that represented constituents from civic groups, residents, several departments within the City, and environmental groups. City staff, along with AlexRenew, conducted a series of meetings beginning in October 2017 and ending in March 2018 that walked the group through the development of options for the LTCPU. These Stakeholder Group meetings were open to the public. During these meetings questions and feedback from the public were received. Feedback received as part of the stakeholder process was considered as part of this LTCPU.

The CSS Stakeholder Group submitted a summary memorandum to City Council that generally stated their support for the LTCPU. Representatives from the VDEQ regularly attended these meetings. Handouts and meeting summaries are available on the City's website (https://www.alexandriava.gov/Sewers).

Section 3 Basis of Planning

Factors considered in planning included: regulatory approaches, sewershed changes, flow projections, typical year selection, and hydrologic and hydraulic modeling.

3.1 Regulatory Approaches

In order to properly select CSO controls it is important to define the performance measures against which each alternative will be evaluated. The following regulatory approaches are intended to be the basis for controls on CSO 001, CSO 002, CSO 003, and CSO 004. Based on information developed as part of the *Regulatory Requirements Technical Memorandum* dated February 2018, there are two general areas of criteria that have been considered in evaluating proposed infrastructure. These include:

- USEPA Presumption Approach
- Hunting Creek TMDL WLA (does not apply to CSO 001)

3.1.1 USEPA Presumption Approach

The Clean Water Act requires communities to meet one of the three individual options under the presumption approach:

- Presumption Option (i): "*No more than an average of four overflow events per year, provided that the permitting authority may allow up to two additional overflow events per year.*"
- Presumption Option (ii): "*The elimination or the capture for treatment of no less than 85% by volume of the combined sewage collected in the CSS during precipitation events on a system-wide annual average basis*"; and
- Presumption Option (iii): "*The elimination or removal of no less than the mass of the pollutants, identified as causing water quality impairment through the sewer system characterization, monitoring, and modeling effort, for the volumes that would be eliminated or captured for treatment under paragraph ii.*"

All the City's combined sewer control strategies proposed as part of this LTCPU provide levels of control that will meet all three options (rather than just one) under the presumption approach for all four of the City's outfalls during the typical year as described in Section 3.4.

3.1.2 Hunting Creek TMDL Waste Load Allocations

As described above, the Hunting Creek TMDL calls for the City's CSOs 002, 003, and 004 to not discharge more than a specific loading of bacteria based on the TMDL years of 2004 and 2005. This amount is referred to as a waste load allocation (WLA). All of the combined sewer control strategies can meet the required WLA.

3.2 CSS Sewershed Changes

The LTCPU considered and incorporated anticipated and future changes to the sewershed so that the CSO controls will continue to meet their long-term intended goals. In the City of Alexandria, most of the sewershed is built out; however, there are redevelopment projects anticipated. As part of the requirements for redevelopment the City has implemented the Area Reduction Plan (ARP). The ARP generally requires developers to separate storm and/or sanitary sewers during new and redevelopment projects within the CSS sewershed, whenever practicable. When separation is infeasible, the project developer pays into a fund to support City-led separation projects.

Anticipated changes planned for the CSS area have been taken into account in the LTCPU. These anticipated changes include projects that are in the planning stages of development or under design, projects under construction, and projects nearing completion. For the most part, these changes can be classified into redevelopment projects or sewer system projects. Both types of projects have the opportunity to change both the amount of flow being delivered to the sewer system as well as the current configuration of the sewer system. The majority of separation projects only remove the sanitary flows from the CSS. More information about the future redevelopment and separation projects can be found in the *Combined Sewer System (CSS) Sewershed Changes Technical Memorandum* dated January 2015.

3.3 Flow Projections

Average daily flow projections from 2020 to 2040 were calculated for all the City of Alexandria sewersheds served by the Alexandria Renew Enterprises (AlexRenew) Water Resources Recovery Facility (WRRF) as shown on Table 3-1. Average daily flow projections establish the baseline flows in the system and serve as a basis for any wastewater storage and/or capacity planning that will occur in the future. The 2040 flow values were used in the hydraulic model for evaluating alternatives under the City's LTCPU.

Table 3-1
Total Average Daily Flow Projections

	2020 Total Average Flow (MGD)	2025 Total Average Flow (MGD)	2030 Total Average Flow (MGD)	2035 Total Average Flow (MGD)	2040 Total Average Flow (MGD)
City of Alexandria	17.1	18.1	19.0	19.9	20.8

Peak flow projections from 2020 to 2040 were also calculated for the combined sewersheds. Peak flows are based on a variety of factors such as specific rain events and the sewer system configuration. For the basis of the report, a simple calculation was used; the values were estimated by setting peak flows equal to the full pipe capacities of the pipes upstream and downstream of the different CSO regulator structures. In addition to the total average flow, the flow projections for each of the individual sewersheds in the City was calculated based on current flows and future population projections. More information on these flows can be found in the *Flow Projections Technical Memorandum* dated September 2014.

3.4 Typical Year Selection

In accordance with the EPA CSO Control Policy, the City used a typical year to represent long-term average design conditions for evaluating the alternatives and selecting a proposed approach for the

LTCPU. Each of the alternative analyses conducted for the LTCPU were evaluated based on the typical year.

To determine the typical year, a 40-year time period from 1974 through 2013 was selected and analyzed. Hourly rainfall data recorded at Ronald Reagan Washington National Airport (DCA) was used in the analysis. Next, several evaluation criteria were developed and each criterion was assigned a weighting. These criteria were developed based on rainfall characteristics and the weightings were selected based on how each characteristic contributes to CSOs. The typical assessment year evaluation criteria and weightings were developed to consider the historical rainfall that the City has received as well as to account for the City-specific goals for the LTCPU; these criteria and weightings are shown in Table 3-2.

Table 3-2
Criteria Weightings

Evaluation Criteria	Weight
Annual Rainfall	30%
Back-to-Back Events	5%
Number of Events Greater than 0.10 inches	12%
Number of Events Greater than 0.25 inches	13%
Average Rainfall Duration	15%
Average Rainfall Intensity	10%
Maximum Peak Intensity	5%
Maximum Storm Size	10%

Yearly averages as well as the time period average were then calculated. The yearly averages were compared to the time-period average and ranked. Based on the weighted rankings, the year 1984 was ranked first and selected as the typical year for the LTCPU and best represents the long-term average rainfall conditions. Significantly, the year 1984 rainfall is better suited for the LTCPU than the Hunting Creek TMDL years (2004-2005) because the TMDL years contain extreme wet weather events, including an event with a return frequency equal to or greater than a 60-year storm event. This type of extreme wet weather event is outside the range of wet weather events when planning and developing CSO controls. More detailed information about the evaluation of the typical year can be found in the *Typical Year Selection Technical Memorandum* dated September 2014.

3.5 2000-2016 Climate Period

During the development of this the plan, VDEQ requested evaluation of the performance for a more recent climate period, which was viewed as being a wetter period than the analysis used to establish the 1984 typical year. Specifically, DEQ requested an evaluation of the 17-year period from 2000-2016. This 17-year period includes approximately 30 named storm events (hurricanes, tropical storms, and other extreme, named events). The 2000 – 2016 climate period is presented in Section 6 for informational purposes only and is not required for regulatory compliance.

3.6 Hydrologic and Hydraulic Modeling

The City of Alexandria's hydrologic and hydraulic CSS model has been developed, updated, and maintained for over 15 years. The model was developed using GIS information, CCTV inspections, and survey information. Most recently, this comprehensive model has been coordinated with AlexRenew to incorporate both the City's CSS model and AlexRenew's interceptor model to provide a unified model for the entire collection system. This allows for a more comprehensive understanding of the current conditions of the system as well as to evaluate future needs.

The model has been calibrated against multiple years of flow meter data at each of the City's CSOs as well as many points throughout the combined sewershed and also in the separate part of the sanitary sewer system. The calibration and subsequent recalibrations have been conducted at multiple points throughout the development and updates to the model. The LTCPU uses the recalibration that occurred in 2013 when the CSS model was combined with the interceptor model and updated to use the XPSWMM software.

The hydrologic and hydraulic model has been used to evaluate the system's response to wet weather conditions when implementing proposed CSO controls. The CSO controls have been evaluated against the typical hydrologic year of 1984 as well as the 2004 – 2005 Hunting Creek TMDL climate period; this baseline model did not include any CSO controls and has been used to evaluate proposed CSO control alternatives that were developed as part of the LTCPU. The hydrologic portion of the model uses precipitation data from DCA in hourly intervals. These data were used to represent uniform rainfall across the entire sewershed, which yields a conservative estimate of flows within the system.

All CSO controls were evaluated and modeled under future flow conditions in Year 2040 as discussed above. Areas currently being separated (or separated in the near-term) from the CSS as described above had their flows removed from the CSS portion of the model and accounted for in the interceptor portion.

The hydrologic and hydraulic CSS model was used to simulate the effect each proposed CSO control technology would have, once implemented within the system, with respect to number and total volume of combined sewer overflows. The model results were analyzed to estimate the effect of control technologies on CSO flow rates and volumes. The results of the model runs are presented in the Infrastructure Sizing Analysis, Section 6.4 of this document.

Section 4 Preliminary Alternatives

4.1 CSO Technologies Screening

A wide range of technologies were screened to identify suitable CSO control technologies for further evaluation. The technologies considered were evaluated for their ability to meet the following primary goals of: 1) bacteria reduction and; 2) CSO volume reduction. Although not explicitly required by the 2017 CSO Law, the following secondary goals were also considered for the various technologies: 1) improving the oxygen conditions in the waters to promote wildlife; 2) reducing floatables and litter entering the water; and, 3) ancillary environmental / public benefits such as increasing the urban tree canopy and/or adding more green infrastructure.

Based upon the screening of technologies, the following technologies were identified as primary technologies for detailed consideration, both separately and in various combinations, as part of the alternatives evaluation:

- Disinfection (at outfall locations)
- Green Infrastructure
- Sewer Separation
- Storage Tanks
- Storage Tunnels
- Conveyance Tunnels
- Wet Weather Treatment (at AlexRenew's WRRF)
- Combinations of the above technologies

More information on the technologies screening can be found in the *CSO Control Technology Screening Technical Memorandum* dated January 2015.

4.2 Preliminary Alternatives

4.2.1 Disinfection (at outfall locations)

Disinfection of combined sewer overflows is a common practice in the United States, with facilities installed in Detroit and Boston, among others. In most cases it is not a standalone control strategy, but used in conjunction with other CSO control strategies. Various physical and chemical disinfection technologies were considered. Disinfection using sodium hypochlorite (NaOCl) as the disinfectant served as the basis for the evaluation. Disinfection would be accomplished by mixing a disinfectant with the CSO flow and retaining it for a short period of time for allowing the disinfectant to kill the bacteria (similar to bleach). Another chemical would then be added to neutralize the disinfectant before discharge to the receiving waters.

When compared to the other alternatives, disinfection has some advantages in terms of requiring a small footprint and is generally low in cost. Disinfection was evaluated by locating an individual disinfection facility at each individual outfall or locating a central disinfection facility at the AlexRenew WRRF where flow from all outfalls captured flow would be disinfected. For the reasons provided below, standalone disinfection located at the individual outfalls was eliminated from further consideration as part of the LTCPU due to:

- Insufficient space to site the facilities for CSO 003/004;
- No volume reduction of the CSOs;
- No opportunity for nutrient and sediment credits;
- Only disinfects the bacteria load with no reduction in other pollutants;
- Requires delivery and storage of large quantities of strong oxidation and reduction chemicals in the urban setting of the City;
- Infrequent operation of mechanical equipment may lead to reliability challenges; and
- Deterioration of the stored sodium hypochlorite overtime due to infrequent operation.

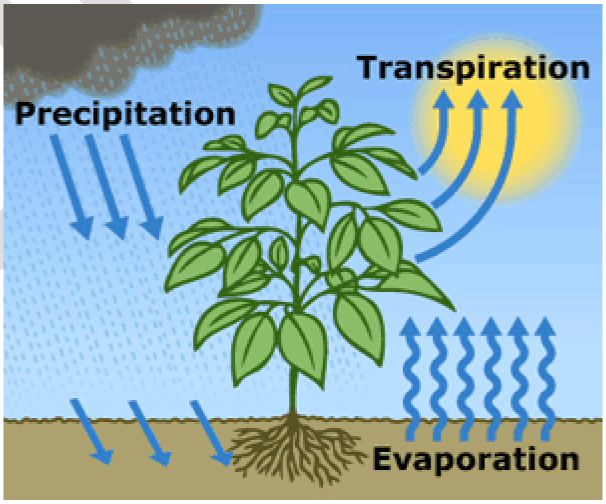
Disinfection at the AlexRenew WRRF in conjunction with tunnels and storage was carried forward as part of some of the options evaluated in the LTCPU. This is addressed as discussed further in Section 4.2.7.

More detailed information about disinfection as a primary strategy can be found in the *Alternatives Evaluation: CSO Disinfection Technical Memorandum* dated October 2015.

4.2.2 Green Infrastructure

Green infrastructure (GI) is a source control mechanism that reduces stormwater runoff volumes, peak flows, and/or pollutant loads by mimicking natural conditions. GI utilizes the processes of infiltration (storing rainfall so that it soaks in to the ground), evapotranspiration (trees and plants absorb the rainfall and it evaporates through the leaves, see Figure 4-1), and capture for re-use to reduce the amount of stormwater runoff volume. GI can be used as a complementary CSO control strategy in conjunction with traditional infrastructure solutions.

Figure 4-1
Evapotranspiration



(Source: water.usgs.gov)

GI's benefits extend beyond reducing the flow of water into the CSS during wet weather events. Through mimicking a more naturalized system, GI can deliver a broad range of ecosystem services or benefits to people, some of which include: improved community livability (aesthetics), human health, air quality, water quality, groundwater recharge, wildlife habitats and connectivity, reduced heat island effects, reduced energy use, green jobs, and recreational opportunities (USEPA, 2014).

GI opportunity is dependent on land use, impervious area, local topography, underlying soils, and proximity to natural offloading points such as streams and pervious subsoils. If a nearby stream or stormwater only conveyance system is unavailable, and if the underlying soils are unable to infiltrate the captured runoff, then an underdrain would be needed in order to prevent the GI from filling up and flooding. The underdrain would be connected back in to the sewer system, so while it would reduce the peak stormwater flows it would not necessarily significantly reduce the stormwater volume. In addition, GI provides very little hydraulic offloading during the larger and/or higher intensity storm events. Based on an evaluation of implementing GI in the City's CSS, it would not be possible to achieve the goals of the LTCPU through implementation of GI alone; therefore, it was not selected as a primary strategy. While GI was eliminated as a primary strategy of the LTCPU, it is being utilized as an adaptive management strategy to help achieve the goals of the Chesapeake Bay TMDL. This program will be implemented City wide and administered through the City's Stormwater program. More detailed information about green infrastructure as a primary strategy can be found in the *Alternatives Evaluation: Green Infrastructure Technical Memorandum* dated October 2015.

4.2.3 Sewer Separation

Sewer separation is the conversion of a combined sewer system into separate stormwater and sanitary sewage collection systems by constructing new sanitary sewers, stormwater sewers, or both. This alternative prevents sanitary wastewater from being discharged to receiving waters and, therefore, prevents discharges of bacteria and floatables associated with sanitary sewage.

In 2005, the City developed the CSS Area Reduction Plan (ARP), which was amended in 2013. The ARP provides a road map for separation of storm and/or sanitary sewers as redevelopment occurs within the CSS sewershed, whenever practicable. Over the last 10-15 years the City has separated or planned for separation of more than 46 acres from the combined sewer system. The ARP is tied to redevelopment projects within the combined sewer area. In order to meet the regulatory timeline as outlined in this LTCPU, certain separation projects would need to proceed independently of redevelopment.

To meet the timeline required for this LTCPU, a "sewer separation-only" solution would require that separation of approximately 75 acres of Old Town be separated annually, on average. This would require continuous separation construction projects until 2025. The aggressive schedule dictated by the 2017 CSO Law makes a sewer separation only solution infeasible. In addition to being the most disruptive alternative evaluated, it is also more expensive than other control strategies considered. For these reasons, sewer separation was eliminated from consideration as a primary strategy in the LTCPU. However, separation will still occur as part of the development/redevelopment process. More information about sewer separation as a primary strategy can be found in the *Alternatives Evaluation: Sewer Separation Technical Memorandum* dated October 2015.

4.2.4 Storage Tanks

Storage tanks are a commonly accepted technology to control combined sewage overflows. During a rain event, the combined sewer overflow is diverted to storage tanks. After the rain event, the stored combined sewer volume is sent to a wastewater treatment facility for treatment. The storage tanks can either be constructed above ground or underground. The storage tank(s) are located in the vicinity of the existing outfalls. Storage tanks have been used in other CSO communities including Richmond, VA, Seattle, WA, and Syracuse, NY, among several others.

Underground storage tanks were considered as options to address overflows from CSO 001 and CSO 002 and evaluated in Section 5. Storage tanks are not recommended for CSO 003/004 due to space limitations in the vicinity of Duke Street. More information about storage tanks as a primary strategy can be found in the *Alternatives Evaluation: Storage Tanks Technical Memorandum* dated October 2015.

4.2.5 Storage Tunnels

The objective of storage tunnels is to reduce overflows by capturing combined sewer flows during wet weather events for controlled release to the wastewater plant before the plant reaches capacity or for when capacity becomes available. If the wastewater plant is at capacity during the event, captured flows are stored and later pumped to the plant for treatment, similar to storage tanks. Storage tunnels are typically constructed deep below-grade, can provide significant storage volume, and also provide for the conveyance of captured flows. Diversion chambers and drop shafts sited near the existing CSO outfalls direct captured flows from the existing collection system to the deep storage tunnel. A dewatering pumping system is typically required at the downstream end of the tunnel to convey captured volumes to the treatment facility. Once the tunnels are full and there is no ability to pump the stored flow for treatment, either the tunnel requires an overflow relief structure or overflow needs to be diverted away from inlets to the tunnel inlets.

Tunnels are advantageous since they cause minimal surface disruption and require minimal right of way for construction. Storage tunnels are a commonly accepted technology for storage and conveyance of combined sewer overflow. The District of Columbia Water and Sewer Authority is currently constructing a series of large-diameter, deep, underground tunnels to mitigate their combined sewer overflows. Many other communities have installed tunnels to address their combined sewer systems, including, for example, Atlanta, Boston, Chicago, Cleveland, Milwaukee, and Richmond.

4.2.6 Conveyance Tunnels

Conveyance tunnels are similar to storage tunnels, but sized to transport the peak flow rate during a storm event (or series of events). Sizing is therefore dictated by the peak rate of diversion from the existing collection system and capacities of downstream facilities, such that the size is typically smaller than storage tunnels as discussed above. Unless they have a free discharge outlet, conveyance tunnels require continuous pumping to keep up with rate of inflow. Conveyance tunnels are typically constructed between a CSO outfall and a pumping station or treatment facility.

4.2.7 Wet Weather Treatment

Wet weather treatment combines screening, primary sedimentation, and disinfection to produce effluent with very little residual bacteria. Primary sedimentation is used to settle suspended particles (or solids).

There are several primary sedimentation technologies that provide varying degrees of solids removal that could be employed prior to disinfection. The main objective of disinfecting wastewater and wet weather flows is to control the quantity and concentration of pathogens. Liquid sodium hypochlorite has been most widely used due to its cost-effectiveness at treating wet weather flows. Other disinfection methods that are being used in wet weather treatment facilities include peracetic acid, ozone, ultraviolet light, and electron beam irradiation.

Wet weather treatment facilities can be constructed at the WRRF and coupled with storage and conveyance tunnels to transport flows from the collection system to the plant. The following are a summary of common wet weather treatment technologies that have been evaluated as part of the LTCPU.

- **Screening:** Screening systems are typically the first unit process in a wet weather treatment facility that provide high rate solids/liquid separation for combined sewer floatables and debris. Screening facilities are typically housed within a building for effective management and eventual transport to a landfill.
- **High-Rate Disinfection (HRD):** HRD utilizes rapid mixing of disinfection chemical(s) at relatively higher dosages (compared with conventional disinfection) in order to achieve necessary bacteria reductions in shorter contact times. HRD would be deployed either following or part of each of the solids-removal treatment alternatives described below.
- **UV Disinfection:** UV disinfection uses light with wavelengths between 40 and 400 nanometers for disinfection. UV light can penetrate cells of pathogenic organisms, structurally altering DNA and preventing cell function
- **Chemically Enhanced Primary Treatment (CEPT):** CEPT is a solids-removal technology comprised of adding two chemicals (coagulant and flocculant) to wastewater to enhance solids settling. This treatment approach significantly reduces the solids in the wastewater prior to disinfection.
- **Ballasted Flocculation:** Ballasted Flocculation is a solids-removal technology that uses a coagulant, a flocculant, and a flocculant enhancer such as either a microsand or recycled sludge to further enhance the settling of solids.
- **Compressed Media Filters:** Compressed media filters are a relatively new solids-removal technology that include compressible filter media beds consisting of a layer of permeable, synthetic balls which can be compressed to an adjustable fraction of their original uncompressed size. This adjustment in media size combined with the porosity of the media aids in the removal of suspended solids and produces a high-quality effluent.
- **Retention Treatment Basin (RTB):** RTBs are based on a very basic solids-removal technology that consist of influent conveyance followed by a set of parallel detention/settling tanks which overflow to an effluent collection channel. RTBs can serve two purposes, to act as storage and equalization basins during smaller wet weather events and to also provide treatment through solids removal and disinfection during larger wet weather events.
- **Vortex Separators:** Vortex separation is a solids-removal technology, typically used to passively treat CSOs. Vortex separators are typically cylindrical in shape, have a center cone for collecting grit and solids, a baffle plate which directs the flow to the overflow weir and an over-flow collection trough.

More information regarding wet weather treatment as a strategy can be found in the *Alternatives Evaluation: Wet Weather Treatment Technical Memorandum* dated February 2018.

4.2.8 Combinations of Technologies

In addition to the individual technologies discussed above, this LTCPU also evaluated combinations of technologies. More specifically, the LTCPU evaluated implementing different technologies at different outfalls. A preliminary list of eight CSO Control Strategies was developed, these were:

- S-1. 2016 LTCPU Submitted December 2, 2016: Tunnel for CSOs 003/004, tank for CSO 002, and phased sewer separation and green infrastructure for CSO 001
- S-2. Separate Tunnels for CSOs 003/004 and CSOs 001/002 with Wet Weather Treatment at AlexRenew
- S-3. Separate Tunnels for CSOs 003/004 and CSOs 001/002 with Wet Weather Treatment at AlexRenew for 003/004 Only
- S-4. Connected Tunnel System to Outfall 001
- S-5. Connected Tunnel System to Outfall 002
- S-6. Tunnels Connected by Pumping from 003/004 Tunnel to 001/002 Tunnel
- S-7. Connected Tunnel System to CSO 001 and Wet Weather Treatment
- S-8. Wet Weather Treatment for CSO 003/004 and Storage Tanks for CSO 001/002

4.3 Initial Alternatives Selection

The eight (8) CSO control were screened through a series of technical workshops held between the City and AlexRenew. The result of these workshops was a shortlist of options that were then evaluated in detail against the evaluation criteria.

4.3.1 2016 LTCPU: Submitted December 2, 2016 (S-1)

This option was eliminated from further consideration because it could not meet the schedule laid out in the 2017 CSO Law.

4.3.2 Separate Tunnels for CSOs 003/004 and CSOs 001/002 with Wet Weather Treatment at AlexRenew (S-2)

This option was eliminated from further consideration because it was determined that it was not feasible to provide the required treatment facility on the limited space available at AlexRenew.

4.3.3 Separate Tunnels for CSOs 003/004 and CSOs 001/002 with Wet Weather Treatment at AlexRenew for 003/004 Only (S-3)

This option was retained for further consideration and is described in more detail in Section 6. This option will be herein referred to as Option A for the remainder of the document.

4.3.4 Connected Tunnel System to Outfall 001 (S-4)

During a preliminary analysis of this option it was determined that it would be infeasible to prevent flows from CSOs 001/002 from taking up capacity in the CSO 003/004 tunnel. This loss of capacity would preclude this option from meeting the 99% bacteria reduction required in the Hunting Creek TMDL for CSOs 003 and 004. This option was eliminated from further consideration.

4.3.5 Connected Tunnel System to Outfall 002 (S-5)

During a preliminary analysis of this option it was determined that it would be infeasible to prevent flows from CSOs 001/002 from taking up capacity in the CSO 003/004 tunnel. This loss of capacity would preclude this option from meeting the 99% bacteria reduction required in the Hunting Creek TMDL for CSOs 003 and 004. This option was eliminated from further consideration.

4.3.6 Tunnels Connected by Pumping from 003/004 Tunnel to 001/002 Tunnel (S-6)

This option was retained for further consideration and is described in more detail in Section 6. This option will be herein referred to as Option B for the remainder of the document.

4.3.7 Connected Tunnel System to CSO 001 and Wet Weather Treatment (S-7)

This option was eliminated from further consideration because it was determined that it was not feasible to provide the required treatment facility on the limited space available at AlexRenew.

4.3.8 Wet Weather Treatment for CSOs 003/004 and Storage Tanks for CSOs 001/002 (S-8)

This option was retained for further consideration and is described in more detail in Section 6. This option will be herein referred to as Option C for the remainder of the document.

4.4 Shortlist of CSO Strategies

Following a series of technical workshops, a shortlist of CSO control strategies was developed for further evaluation. The list of three CSO control strategies is provided in Table 4-1 and will be referred as Option A, Option B, and Option C throughout the remainder of this document. Each of the shortlisted strategies is described in detail in Section 6.

Table 4-1
Shortlist of CSO Control Strategies

Option	Option Name	Option Description
A	Separate Tunnels	Separate Tunnels for CSOs 003/004 and CSOs 001/002 with Wet Weather Treatment at AlexRenew for 003/004 Only
B	Unified Tunnels	Tunnels Connected by Pumping from 003/004 Tunnel to 001/002 Tunnel
C	Tunnel and Tanks	Conveyance Tunnel and Wet Weather Treatment for CSOs 003/004 and Storage Tanks for CSOs 001/002

Section 5 Evaluation of Options

5.1 Evaluation Criteria

Evaluation criteria were developed to assess and rank the shortlisted CSO control options as part of an alternatives analysis. The evaluation criteria were developed and tailored, with input from the CSS Stakeholder Group, to meet the regulatory and legislative requirements while providing a solution unique to the needs of the City of Alexandria and AlexRenew. The following criteria were used in evaluating each strategy.

5.1.1 Life Cycle Costs

The life cycle costs are the costs that will be incurred to plan, design, construct, operate, and maintain each option. Capital cost estimates are developed for each option and escalated to the midpoint of construction. Additionally, operation and maintenance costs were developed for each option and are estimated over a 20-year period. These two cost estimates (capital costs and operation and maintenance costs) are added together to produce the life cycle costs, expressed as Net Present Value in 2018 dollars.

5.1.2 O&M Complexity and Reliability

O&M Complexity refers to how complex it would be to run any particular option. For instance, having facilities in different areas or multiple facilities to run and maintain during wet weather would result in more complexity. Reliability refers to the ability of each option to continue to meet the regulatory and legislative requirements consistently.

5.1.3 Adaptability

The adaptability of an option refers to the ability of each option to meet future needs that may arise. Some potential future needs may be increasing capacity, addressing environmental regulations, or adapting to climate change. In addition to addressing future needs, adaptability also refers to the ability of each option to integrate with other planned City projects and/or to create opportunities for green infrastructure. An option that is determined to be more adaptable is considered to be better.

5.1.4 Schedule

The schedule for completing each option is important because in the 2017 CSO Law, there is a deadline for implementation of July 1, 2025. A schedule was developed for each option and the ability to meet the 2025 deadline was assessed. The schedule could be influenced by a variety of factors including, but not limited to, the ability to obtain the necessary permits, planning, design, and the method of construction.

5.1.5 Community Acceptance

Community acceptance was broken down into three main components:

- Disruption during construction
- Disruption during regular operation and maintenance
- Opportunities to incorporate community benefits.

Options that minimized disruption and were able to incorporate community benefits were considered to have a higher community acceptance rating.

The evaluation criteria along with their descriptions are summarized in Table 5-1.

Table 5-1
Evaluation Criteria

Evaluation Criteria	Description

Life Cycle Costs	• Optimize the solution to minimize the impact to rate payers.
	  • Capital costs: planning, design, and construction
	  • Annual Operation and Maintenance Costs

O&M Complexity and Reliability	• Maximizes reliability of meeting VPDES permit.
	  • Combined Sewer System Permit
	  • AlexRenew Wastewater Treatment Facility Permits
	• Minimizes location and number of facilities to operate and maintain.

Adaptability	• Ability to meet future capacity, environmental, or regulatory needs and navigate climate change impacts. • Provides for opportunities for adaptive management and resiliency. • Integrate other planned City project needs if feasible. • Opportunities for complementary Green Infrastructure.
Schedule	• Risk of compliance with the mandated schedule. • Ability to secure necessary construction permits in a timely manner from local, state, and federal agencies.
Community Acceptance	• Minimize disruption to the community during construction. • Minimize disruption to the community caused by regular Operation and Maintenance activities. • Maximize opportunities to incorporate community benefits.

Section 6 Evaluation and Selection of Proposed Option

6.1 Shortlist of Options

Three shortlisted options were evaluated as part of the LTPCU and include a combination of traditional storage and conveyance systems coupled with wet weather treatment. The three options are discussed in further detail within this section and include:

- Option A – Separate Tunnels
- Option B – Unified Tunnels
- Option C – Tunnel and Tanks

6.1.1 Option A – Separate Tunnels

Option A includes a conveyance tunnel to transport captured flows from CSO's 003 and 004 to the WRRF, while captured flows from CSO's 001 and 002 are stored within a separate tunnel that connects to the east side of the WRRF. The tunnel systems are hydraulically separate due to the need to control the hydraulic grade line to mitigate basement backups and sewer flooding along the Commonwealth Interceptor and Holmes Run Trunk Sewer within the CSO 003/004 system.

6.1.1.1 CSOs 003/004 Conveyance Tunnel System Operation

Depending on the size and intensity of the storm event, the CSO 003/004 conveyance tunnel system can operate under three scenarios as illustrated in Figure 6-3 and described as follows:

- **Typical Operation.** Captured flows are stored and conveyed to the WRRF for full treatment up to the peak plant capacity of 116 MGD (116 MGD represents an upgrade in peak flow capacity to the existing 108 MGD WRRF).
- **Design Condition Operation.** When the WRRF capacity is exceeded, flows are pumped continuously to keep up with the rate of inflow to a new wet weather treatment facility and discharged via a new outfall.
- **Excess Flow Operation.** When the WRRF and the new wet weather treatment facility are at capacity, captured CSOs are pumped to a relocated CSO 004 outfall. Combined sewer flows exceeding tunnel inlet capacity at CSO 003 will discharge as CSOs out the existing CSO 003 outfall.

6.1.1.2 CSOs 001/002 Storage Tunnel System Operation

Captured flows from CSO's 001 and 002 are proposed to be stored in a tunnel designed to capture the volume of a storm event to meet the requirements of the 2017 CSO Law outlined in Section 1.6.

- **Typical Operation:** Captured flows are stored and conveyed to the WRRF for full treatment up to the peak plant capacity of 116 MGD.
- **Design Condition Operation:** When the WRRF capacity is exceeded, flows are stored in the tunnel. After the storm event the stored volume is pumped back to the WRRF when there is capacity.

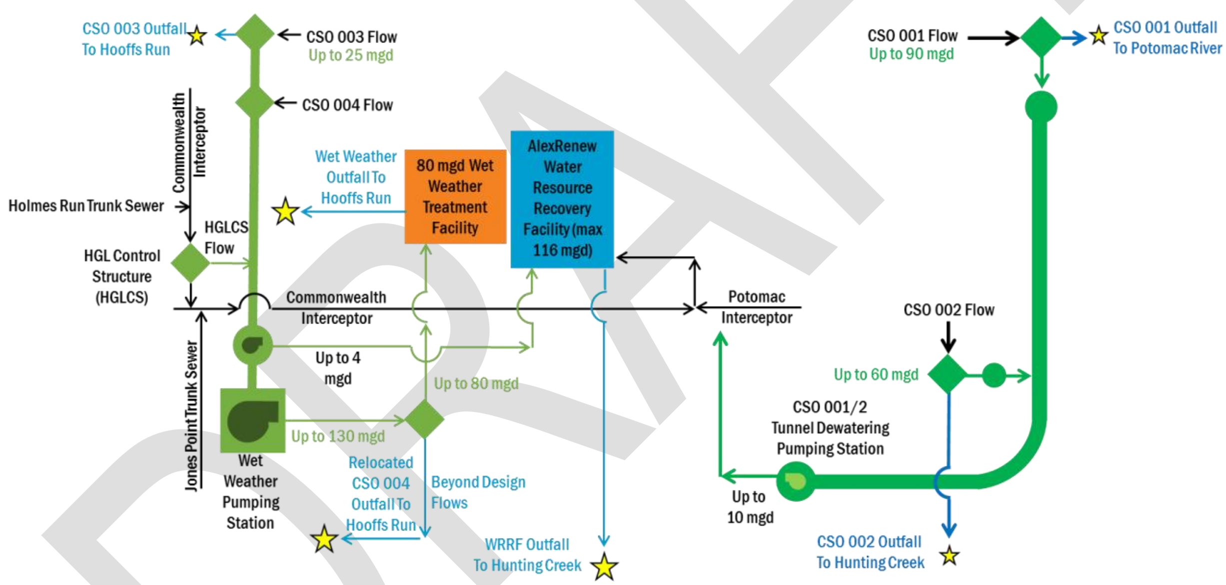
- **Excess Flow Operation:** In the event that combined sewer flows exceed the tunnel capacity, these flows will discharge by gravity via the CSO 001 outfall. Under excess flow conditions, overflows can also occur at the CSO 002 outfall if the capacity of the regulator is exceeded.

6.1.1.3 Wet Weather Treatment of CSO003/004 at WRRF

Option A includes increasing the maximum treatment capacity at AlexRenew's WRRF from 108 MGD to 116 MGD while adding a new 80 MGD wet weather treatment facility on-site for the treatment of flows from the 003/004 conveyance tunnel. Flows would be directed to the new wet weather treatment facility once the WRRF reaches its peak treatment capacity of 116 MGD.

Figure 6-1 illustrates a schematic of Option A.

Figure 6-1
Option A – Separate Tunnels



6.1.2 Option B – Unified Tunnels

Option B includes a unified, but hydraulically separate tunnel system. Unlike Option A and Option C, Option B does not include wet weather treatment. Similar to Option A, the CSO 003/004 system is proposed to be a conveyance tunnel system to the AlexRenew WRRF, while the CSO 001/002 system is proposed as a conveyance and storage tunnel.

6.1.2.1 CSO 003/004 Conveyance Tunnel System Operation

Depending on the size of the storm event, the CSO 003/004 conveyance system can operate under three scenarios as illustrated in Figure 6-3 and described as follows:

- **Typical Operation.** Captured flows are stored and conveyed to the WRRF for full treatment up to the peak plant capacity of 116 MGD (116 MGD represents an upgrade in peak flow capacity to the existing 108 MGD WRRF).
- **Design Condition Operation.** When WRRF capacity is exceeded, flows are pumped continuously to keep up with the rate of inflow to the CSO 001/002 tunnel.
- **Excess Flow Operation.** When WRRF and both tunnel systems are at capacity, captured CSOs are pumped to the relocated CSO 004 outfall. Flows exceeding tunnel inlet capacity at CSO 003 will discharge as CSOs at the existing CSO 003 permitted location.

6.1.2.2 CSO 001/002 Storage Tunnel System Operation

- **Typical Operation:** Captured flows from CSOs 001 and 002 will be stored in a tunnel designed to capture the volume of a storm event to meet the requirements of the 2017 CSO Law outlined in Section 1.6. When the WRRF has available capacity, the tunnel will be dewatered and pumped to the WRRF for full treatment.
- **Design Condition Operation:** In the event that storms beyond the design capacity exceed the tunnel volume, flows will discharge by gravity via the CSO 001 outfall.
- **Excess Flow Operation:** Under excess flow conditions, overflows can also occur at the CSO 002 outfall if capacity of the regulator is exceeded.

Figure 6-2 illustrates a schematic of Option B.

Figure 6-2
Option B – Unified Tunnels

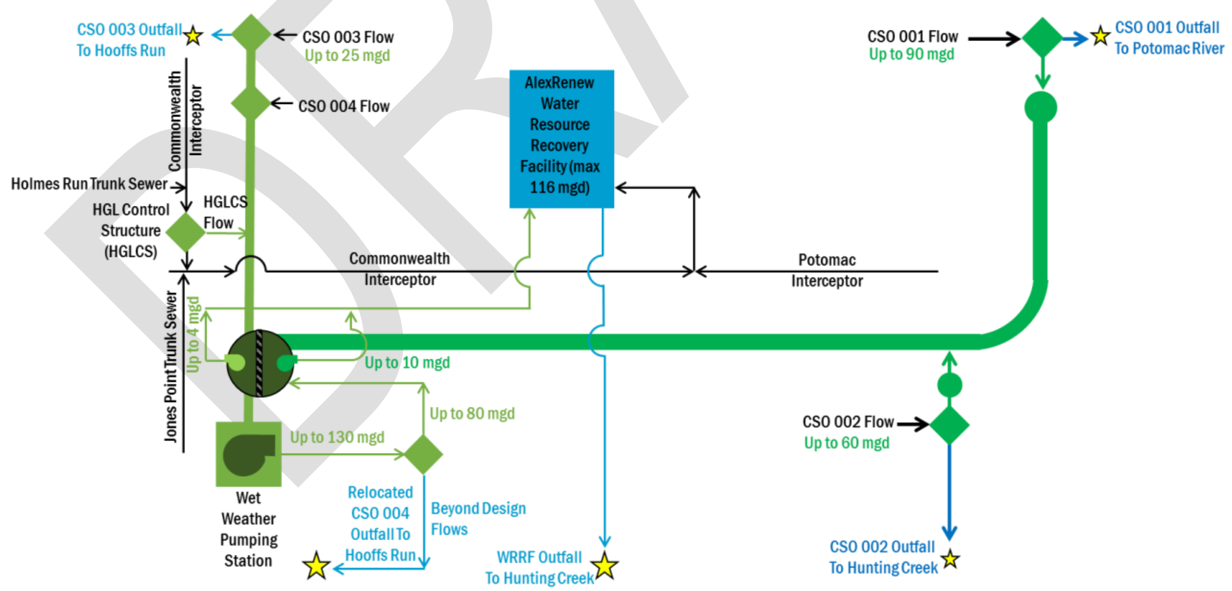
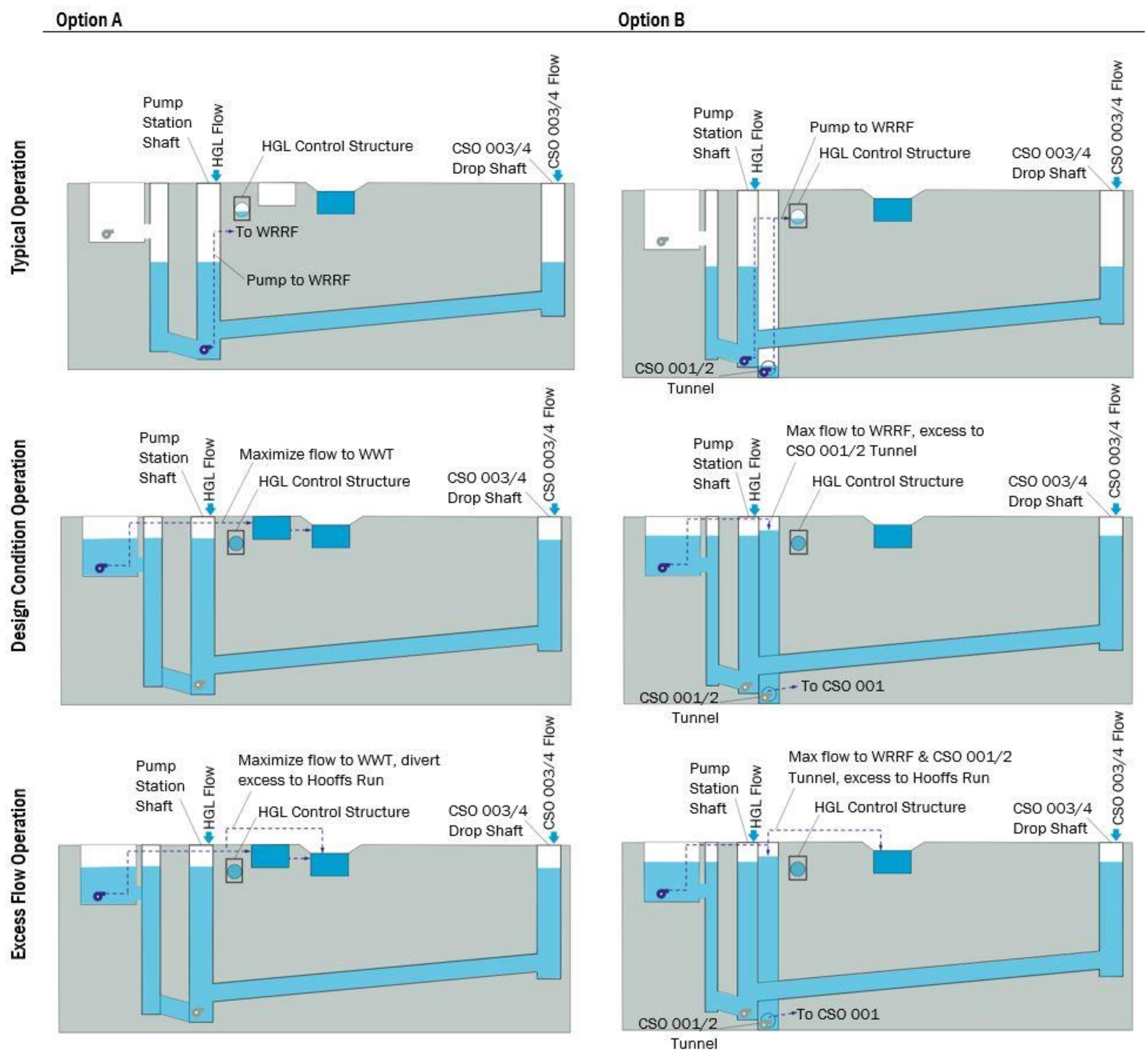


Figure 6-3
Operating Scenarios for Options A and B



6.1.3 Option C – Tunnel and Tanks

Option C is similar to Option A, but replaces the CSO 001/002 storage tunnel with storage tanks located near the existing outfalls for CSO 001 and CSO 002. CSO 001 flows are proposed to be stored in a tank near Oronoco Bay/Park, while CSO 002 flows will be stored in a tank near the intersection of South Royal Street and Jones Point Drive. When the Potomac Interceptor and WRRF have available capacity, the tanks will be dewatered and pumped through existing infrastructure for full treatment. In the event that a storm exceeds the capacity of the tanks, flows will overflow from their respective existing outfall locations. Figure 6-4 illustrates a schematic of proposed Option C.

6.1.3.1 CSOs 003/004 Conveyance Tunnel System Operation

Depending on the size and intensity of the storm event, the CSO 003/004 conveyance tunnel system can operate under three scenarios as illustrated in Figure 6-3 and described as follows:

- **Typical Operation.** Captured flows are stored and conveyed to the WRRF for full treatment up to the peak plant capacity of 116 MGD (116 MGD represents an upgrade in peak flow capacity to the existing 108 MGD WRRF).
- **Design Condition Operation.** When the WRRF capacity is exceeded, flows are pumped continuously to keep up with the rate of inflow to a new wet weather treatment facility and discharged via a new outfall.
- **Excess Flow Operation.** When the WRRF and the new wet weather treatment facility are at capacity, captured CSOs are pumped to a relocated CSO 004 outfall. Combined sewer flows exceeding tunnel inlet capacity at CSO 003 will discharge as CSOs out the existing CSO 003 outfall.

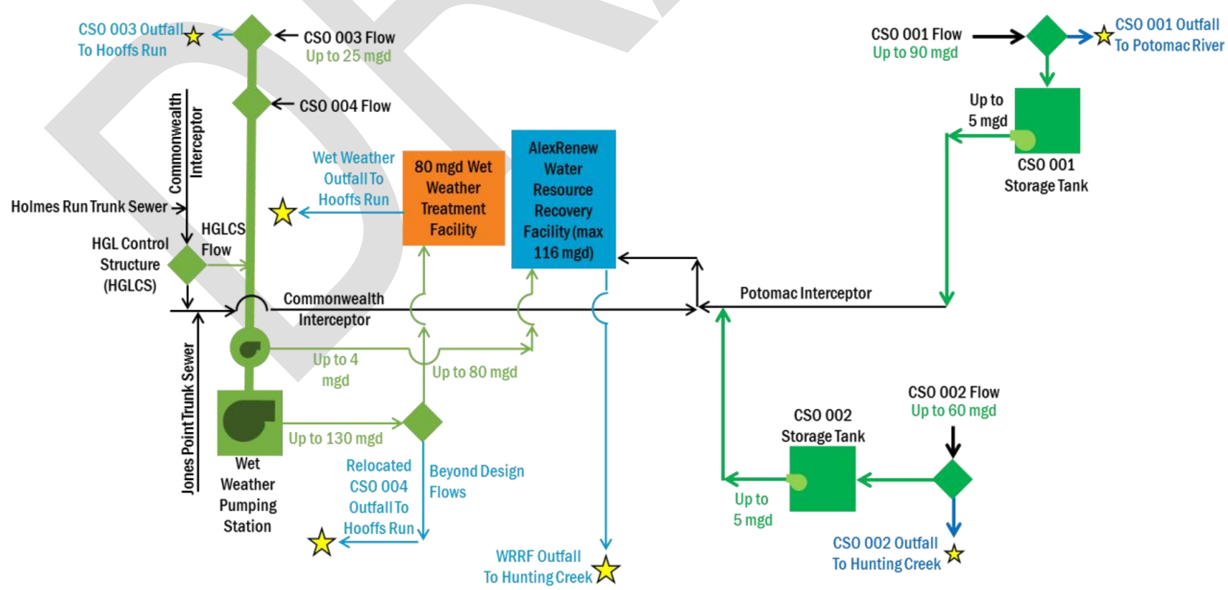
6.1.3.2 CSOs 001/002 Storage Tanks

The storage tanks for CSOs 001 and 002 can operate under different conditions as follows:

- **Typical Operation:** As CSO flow enters the tanks it is continuously pumped into the Potomac Interceptor when it has capacity where it is conveyed to the WRRF for treatment.
- **Design Condition Operation:** When the Potomac Interceptor is at capacity and CSO flows are still entering the tanks, the tanks will begin to fill and store the flow preventing overflow.
- **Excess Flow Operation:** When the Potomac Interceptor is at capacity and the storage tanks become full, only then will there be overflows from CSO 001 and CSO 002.

Figure 6-4

Option C – Tunnel and Tanks



6.2 Evaluation of Options

Evaluation criteria were developed for evaluating and comparing options as discussed in Section 5. The intent of the criteria was to ensure that the recommended option provided a balanced, engineered solution for handling all wet weather impacts, considered stewardship toward the use of public funds, considered a wide-range of potential impacts, and assessed the long-term viability of each option as outlined in Table 5-1. The options outlined in this section were evaluated against these criteria to select the proposed option to be carried forward in the implementation of the LTCPU.

6.2.1 Life Cycle Costs

Conceptual opinions of probable construction cost (OPCC) were prepared for each option and include escalation to the midpoint of construction. Additionally, operations and maintenance costs were developed for each option over a 20-year period to analyze and compare life cycle cost estimates. The OPCCs are consider Class 4 estimates as defined by Association for the Advancement of Cost Engineering (AACE). The accuracy range for Class 4 estimates is -30% to +50%. Table 6-1 summarizes the capital and life cycle costs for each option and provides a +50% value of the total estimate to represent the conceptual level of planning for each option.

Table 6-1
Opinion of Probable Capital and Life Cycle Costs

Component	Option A	Option B	Option C
Capital cost estimate (escalated to the midpoint of construction)	$424M	$346M	$371M
Operations and maintenance cost estimate	$14M	$8M	$18M
Total 20-year life cycle cost estimate	**$438M**	**$354M**	**$389M**
+50% total life cycle cost estimate	*$657M*	*$531M*	*$583M*

As illustrated in Table 6-1, Option B has the lowest capital and life cycle costs.

6.2.2 Schedule

Conceptual schedules for each option were developed and are illustrated in Figure 6-5, Figure 6-6, and Figure 6-7. In general, all options have the potential to meet the legislative mandated deadlines for construction initiation and completion based on current planning, but some schedules carry more risk due to, among other factors, concurrent work, construction and regulatory permitting requirements, and easements and property acquisition needs.

Figure 6-5
Option A – Conceptual Schedule

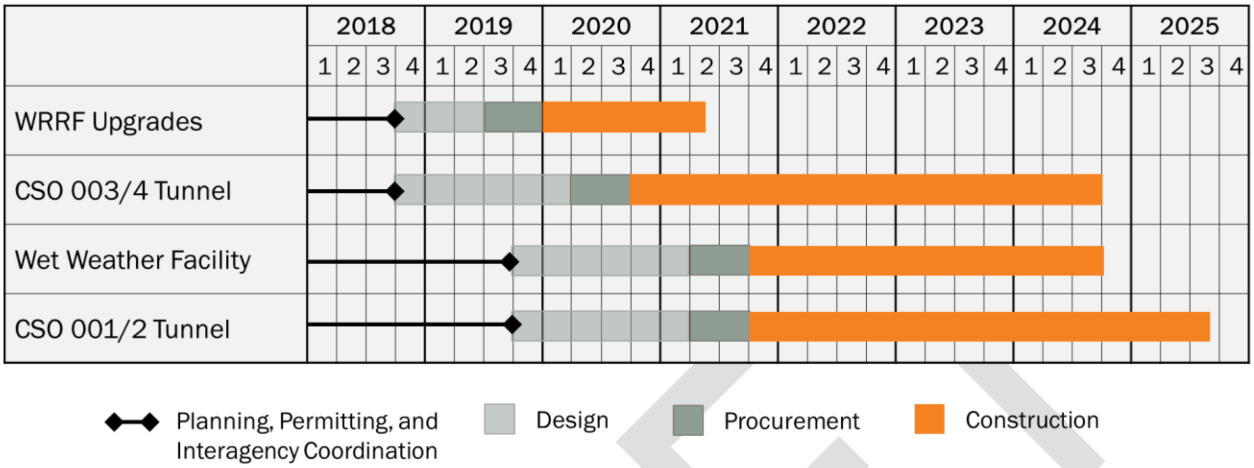


Figure 6-6
Option B – Conceptual Schedule

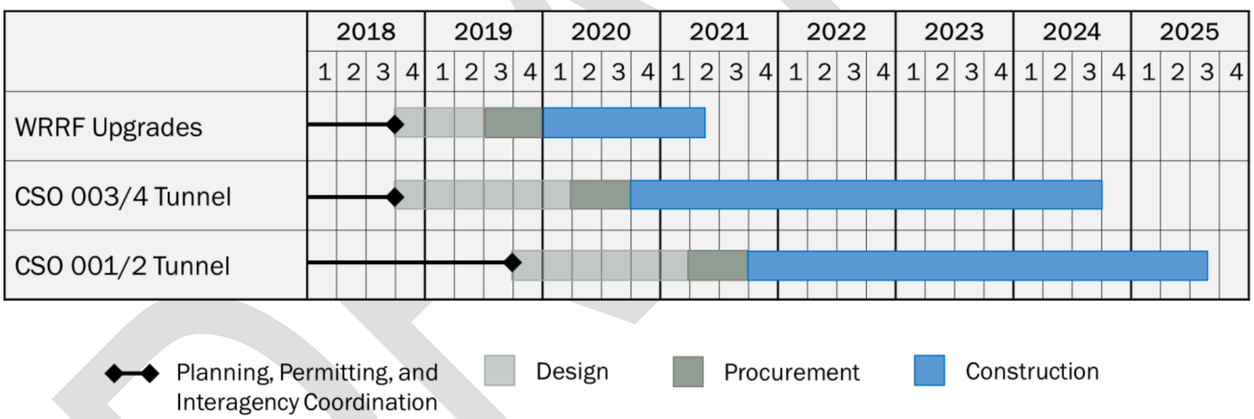
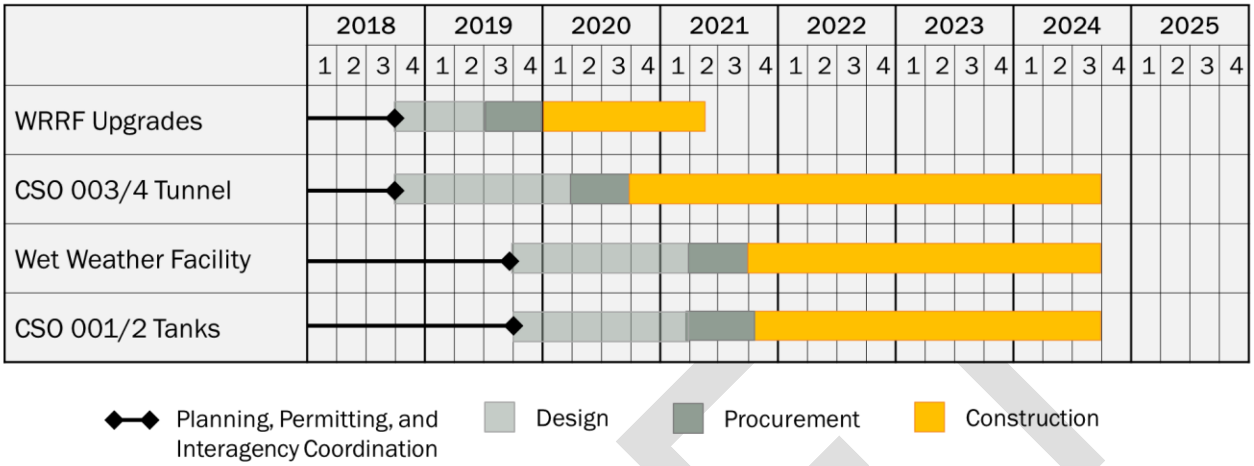


Figure 6-7
Option C – Conceptual Schedule



Constructability and schedule were considered as two key risk categories for all options. Both of these risk categories were considered for impacts at AlexRenew's WRRF. In order to mitigate impacts to the community and provide efficiencies for construction with respect to the options, the preferred concept for conducting tunnel construction operations would involve starting construction from AlexRenew's WRRF. It is estimated that approximately 3 acres of staging area are required to support tunnel construction, while 0.75 acres of staging area are required for shaft and pumping station construction. Approximately 1 acre would be required for a wet weather treatment facility. As illustrated in Figure 6-8, there is limited space available at AlexRenew's WRRF. There are approximately 0.7 acres of open space adjacent to existing Building J, 0.5 acres adjacent to Building G, and about 3 acres at the front end of the WRRF along Payne Street. The Payne Street area also includes City right-of-way and City property outside of AlexRenew's urban footprint. It should be noted that Figure 6-8 does not show underground facilities within the AlexRenew WRRF or right-of-way, which also must be considered when siting and constructing proposed infrastructure.

Due to these space limitations, and other constraints, construction of facilities at the WRRF adds logistical complexity that could affect every day operations of the WRRF. Construction of a new wet weather treatment facility would require the relocation of existing plant components and the demolition of existing buildings. This space needs to be balanced with staging needed for tunnel construction, shaft/pumping station construction, traffic, and space needed to ensure maximum operability of the WRRF. For any of the options, construction activities at the WRRF will need to be carefully managed to ensure project success and to maintain WRRF permit compliance.

When evaluating options for constructability, staging, and schedule risks at the WRRF, Option B carries the least risk. The space currently available at the WRRF can be utilized to construct the shafts, tunnels, and pumping station(s) needed to meet the 2017 CSO Law and would not require additional demolition and relocation of existing WRRF facilities.

Figure 6-8
Potential Construction Staging Areas at AlexRenew WRRF

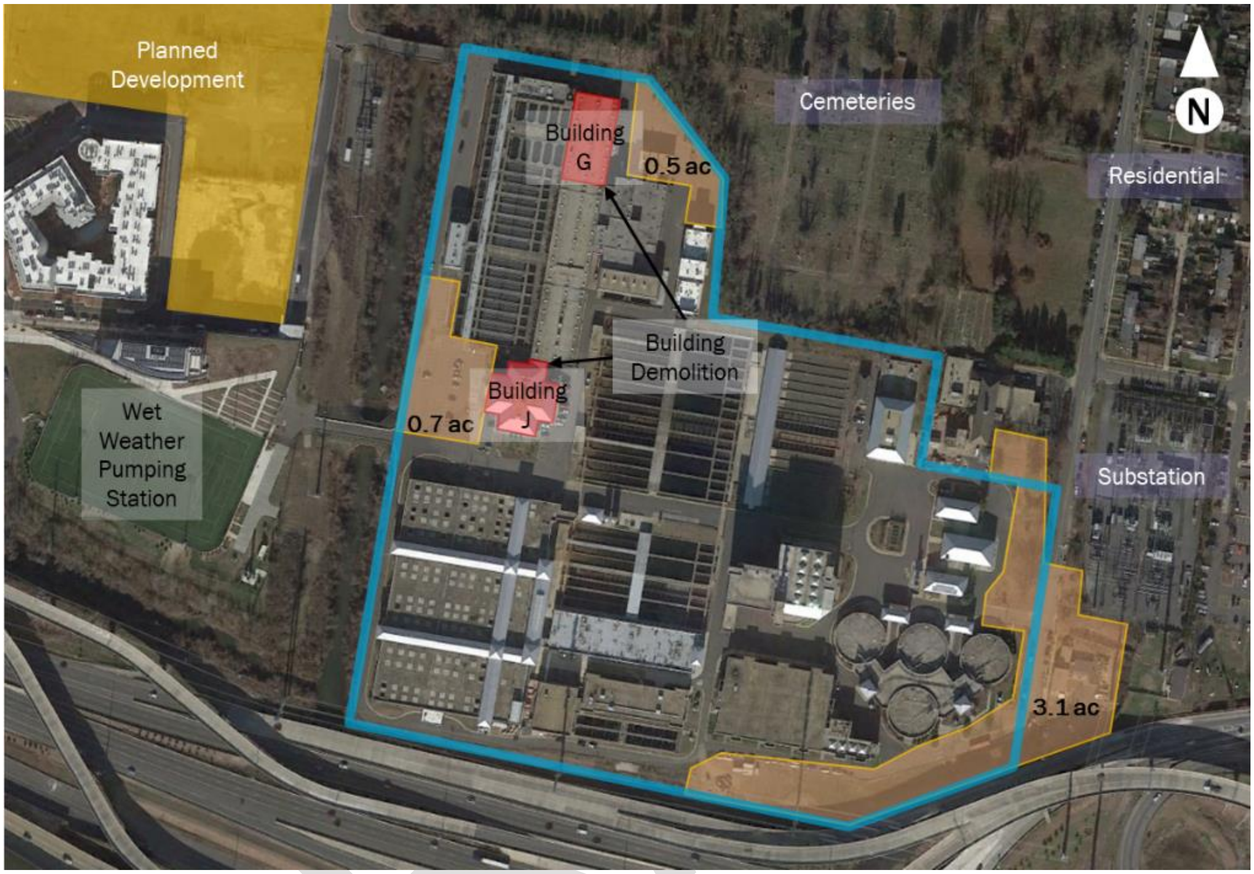


Table 6-2 summarizes additional key schedule risks for completion of the Program by the 2017 CSO Law mandated milestone. Schedules for all options carry some risk due to the tight schedule for completing this CSO Program, with Options A and B carrying slightly more risk than Option C, due to the linear nature of tunnel construction. Option B has the lowest risk of schedule delay due to the minimization of concurrent work and also has lower risk of construction and regulatory permitting because most facilities are below grade. Because the temporary and permanent surface footprints are much smaller for tunnels than tanks, and because Options A and B utilize tunnels to address all CSOs, the temporary and permanent surface footprints are much smaller than tanks. These two options will require less land acquisition for construction and permanent operation. In general, Option B carries the lowest risk overall when considering its ability to meet the 2017 CSO Law milestone, concurrent work, permitting, and land acquisition.

Table 6-2
Summary of Key Known Schedule Risks

Item	Option A	Option B	Option C
Ability to meet legislative milestone	**High risk**, no schedule flexibility for delays	**High risk**, no schedule flexibility for delays	**Moderate risk**, limited flexibility for delays
Concurrent construction projects	**High risk** • Complex coordination at WRRF • Single delay can affect critical path	**Lowest risk**, less complex coordination	**Moderate risk** • Majority of projects require coordination at WRRF • Single delay can affect critical path
Construction and regulatory permitting	**Moderate risk** since most facilities are below-grade	**Moderate risk** since most facilities are below-grade	**Highest risk** due to temporary and permanent footprint and above-grade structures
Easements and property acquisition	**Low risk** due to small size of temporary and permanent surface footprints	**Low risk** due to small size of temporary and permanent surface footprints	**High risk** due to large size of temporary and permanent surface footprints

6.2.3 Community Impact

The impacts on the community were assessed in terms of near-term disruption from both construction work and long-term impacts on the community due to operations and maintenance. Impacts considered during construction were construction footprint, duration, work hours, truck traffic, pile driving, soil disturbances, impacts to groundwater, noise and vibrations, dust and emissions, temporary traffic lane closures or restrictions, and disruptions to utilities. Impacts considered following construction included maintenance operations and frequency, along with the addition of above-grade structures in scenic areas of the community. As part of the evaluation of the options, it was determined that Option C creates the highest short- and long-term impacts to the community, while Options A and B present more favorable conditions.

Table 6-3
Summary of Community Impacts

Impacts	Option A	Option B	Option C
Short-term	**Lower impact** over larger area	**Lower impact** over larger area	**Highest impact** in a concentrated area
Long-term	**Low impact** • Most mechanical equipment located at WRRF	**Low impact** • Most mechanical equipment located at WRRF	**High impact** within community: • Permanent above-ground facilities • Mechanical facilities in community • Requires frequent visits to tank locations

6.2.4 Operations and Maintenance (O&M) Complexity

O&M complexity of each option was evaluated based on the location of mechanical facilities, residuals handling locations and the need to maintain new treatment facilities as summarized in Table 6-4. The utilization of the proposed wet weather facility and frequency of its use was also a driver in analyzing each option. The average use of the wet weather facility from the 2000-2016 recent climate period was simulated to be approximately 20 hours per year. There were some years within the study period that did not require the use of the facility at all. Operations and maintenance for an infrequently used facility is challenging as some chemicals can expire after a few months, and some equipment may require regular maintenance and attention to ensure that it is ready when needed during a significant wet weather event.

Table 6-4
Summary of O&M Complexity

Item	Option A	Option B	Option C
Location of mechanical facilities	**Low complexity** since mechanical equipment is centralized at WRRF	**Least complexity** since mechanical equipment is centralized at a single location (at WRRF)	**Highest complexity** due to multiple locations of mechanical equipment
Residuals (solids and floatables) handling	**Low complexity** due to self-cleaning and centrally located residuals facilities	**Least complexity** due to self-cleaning and single location for handling residuals	**Highest complexity** due to routine access, multiple residuals handling locations, and flushing system
New treatment facilities	**Complex** since limited operation requires equipment exercising	**Least complex**, no separate wet weather treatment facility	**Complex since** limited operation requires equipment exercising

As outlined in Table 6-4, Option B has the lowest complexity with respect to the location of mechanical facilities, and residuals- handling locations at the WRRF, and also the least complexity as it does not rely on a new wet weather treatment facility that would be minimally used.

6.2.5 Adaptability

Each option was evaluated based on its adaptability to meet future requirements. Options A and B provide the most flexibility since they connect to the WRRF and can be expanded by the addition of pumping and new or additional wet weather treatment facilities. Option B is considered to be more adaptable, since it connects both the CSO 003/004 and CSO 001/002 systems. Option C was considered the least adaptable due to its dependence on capacity-limited interceptor system to transport flows from the storage tanks to the AlexRenew WRRF and the potential need to expand tank capacity or addition of a remote treatment system to respond to potential future requirements.

6.3 Scoring of Options and Selected Option

The Evaluation Criteria, previously discussed in Section 5, were presented to the CSS Stakeholder Group during regularly scheduled meetings and online in the form of a survey. Stakeholder feedback included the weighting of each criterion on a scale of 1-5; the results of their input were averaged for each criterion. These weights were then scaled to a percentage of the total. Stakeholder weighting scores and percentages are shown in Table 6-5.

Table 6-5
Evaluation Criteria Weighting

Evaluation Criteria	CSS Stakeholder Group Weighting	CSS Stakeholder Group Percentage
Life Cycle Costs	4.07	25%
Schedule	3.43	18%
Community Impact	3.21	12%
O&M Complexity and Reliability	4.07	25%
Adaptability	3.93	20%

A separate Evaluation Committee was established to review each option with respect to the evaluation criteria and conduct scoring based on the weighting established by the Stakeholder Group. The Evaluation Committee was comprised of City of Alexandria and AlexRenew staff who have been heavily involved in the planning and update of the LTCPU. The Evaluation Committee was also supported by a technical team to provide detailed information related to each option. Prior to the evaluation, details associated with the analysis of each option with respect to the evaluation criteria were discussed with the CSS Stakeholder Group during a public meeting on February 1, 2018. On February 6, 2018, the Evaluation Committee met to review each option with respect to the evaluation criteria and discuss feedback received from the Stakeholder Group and community.

Each option was scored for each criterion and the scores were weighted using the Stakeholder Group weighting. Table 6-6 shows the results of the scoring exercise. The higher the score, the more consideration it was given as the potential recommended option. A sensitivity analysis was also completed by scoring the options using different weightings for each criterion, which did not affect the results and Option B was selected. Option B scored higher than Options A and C in all criteria. The feedback received from the CSS Stakeholder Group members at the February meetings was consistent with the analysis to recommend Option B as the preferred option. The following bullets further reinforce the reasoning for recommending Option B:

- **Life Cycle Costs.** Option B had the lowest overall life cycle cost.
- **O&M Complexity and Reliability.** Option B has all of the major equipment centralized at the AlexRenew WRRF as opposed to out in the community. Additionally, it does not require the operation of a new, separate wet weather treatment facility.
- **Adaptability.** Option B provides the most adaptability due to connectivity with the WRRF and a unified tunnel system. Option B is the most flexible solution and preserves space at the WRRF for addressing potential future regulatory and climate change needs. Options A and C would require construction of a new wet weather treatment facility or additional storage would need to be constructed for such potential future considerations. Any additional required for Option C would require expansion of the existing tanks, which would prove to be difficult within the community.
- **Schedule Risk.** All options, including Option B, have aggressive schedules for meeting the legislative mandate of July 1, 2025.
- **Community Impact.** Option B conceptually places a majority of the mining operations at the AlexRenew WRRF and not out in the community. Additionally, most of the disruptive, labor-intensive long-term maintenance would also take place at the AlexRenew WRRF and not within the community; whereas when compared to Option C would require periodic O&M staff attention at the remote storage tanks to ensure operational readiness for wet weather events.

Table 6-6
Options Scoring Summary

Evaluation Criteria	Score		
	Option A	Option B	Option C
Life Cycle Costs	0.38	1.00	0.63
Schedule	0.42	0.57	0.45
Community Impact	0.40	0.40	0.08
O&M Complexity and Reliability	0.67	1.21	0.38
Adaptability	0.57	0.93	0.17
Weighted Totals	**2.4**	**4.1**	**1.7**

Based on the analysis and scoring discussed herein, Option B is presented as the preferred technical option to address all CSO outfalls and the 2017 CSO Law.

6.4 Infrastructure Sizing Analysis

The performance of each of the options described in Section 6.1 was evaluated against the Hunting Creek TMDL for CSOs 002, 003, and 004 and the Presumption Approach for CSO 001. The Hunting Creek TMDL and Presumption Approach requirements are described in Section 3.1. In accordance with the 2017 CSO Law, the CSO Program must meet the requirements established by EPA's Presumption Approach or Hunting Creek TMDL, whichever is more stringent. The Presumption Approach evaluates CSO compliance on an average annual basis, meaning the number of overflow events or percent capture on a systemwide basis during an average year. The average or "typical" year established by the City is represented by 1984 (see Section 3.4).

In addition to the typical year, the Hunting Creek TMDL established WLAs and bacteria reduction percentages based on the hydrologic conditions in years 2004 and 2005. The sizing of the proposed CSO infrastructure is driven by the storms used in the development of the Hunting Creek TMDL. In order to design systems to demonstrate compliance with the TMDL, various iterations of infrastructure sizing were analyzed to comply with the mandated performance requirements. Based on extensive modeling efforts, Table 6-7 summarizes the infrastructure sizing required to comply with the Hunting Creek TMDL hydrologic period of 2004 and 2005 and to meet the Presumption Approach for CSO 001. Performance of this infrastructure sizing is discussed in Section 6.4.1 for the typical year (1984) and for the 2000-2016 climate period.

Table 6-7
Infrastructure Sizing Summary

Component	Unit(s)	Option A	Option B	Option C
CSOs 003/004	Conveyance Tunnel Diameter (ft)	6	6	6
Wet Weather Treatment	Capacity (MGD)	80	N/A	80
CSOs 001/002	Storage Tunnel Diameter (ft)	12	10	N/A
	Volume (MG)	8.0 (tunnel)	5.6 (tunnel)	8.5 (tanks)

In summary, Options A and C both require a 6-foot diameter tunnel and 80 MGD of wet weather treatment for the CSO 003/004 system, while the CSO001/002 system requires a storage volume of either a 12-foot tunnel for Option A or two storage tanks with a total volume of 8.5 MG for Option C. Option B would utilize a 6-foot diameter tunnel for the CSO 003/004 system and a 10-foot diameter tunnel for the CSO 001/002 system.

6.4.1 Performance of Options

It is noted that at this stage, the proposed LTCPU options are still conceptual. As such, all data and costs presented within this LTCPU, inclusive of the appendices, are preliminary in nature and subject to change based on further refinement and development as the planning and design progress.

6.4.1.1 Performance with Respect to Number of Overflow Events

The performance with respect to the number of overflow events represents compliance with the EPA's CSO Control Policy Presumption Approach for the typical year (1984). Figure 6-9 shows the number of overflow events for all options from each outfall in the 1984 Typical Year. The yellow box on this figure (and the subsequent figures) illustrates the allowable range of overflows with respect to the Presumption Approach. Figure 6-9 demonstrates that all options meet the presumption approach requirements of 4-6 overflows per year. In addition the performance for the 2000 – 2016 climate period is presented on Figure 6-10 for informational purposes only.

Figure 6-9
Number of Overflows for the Typical Year, 1984

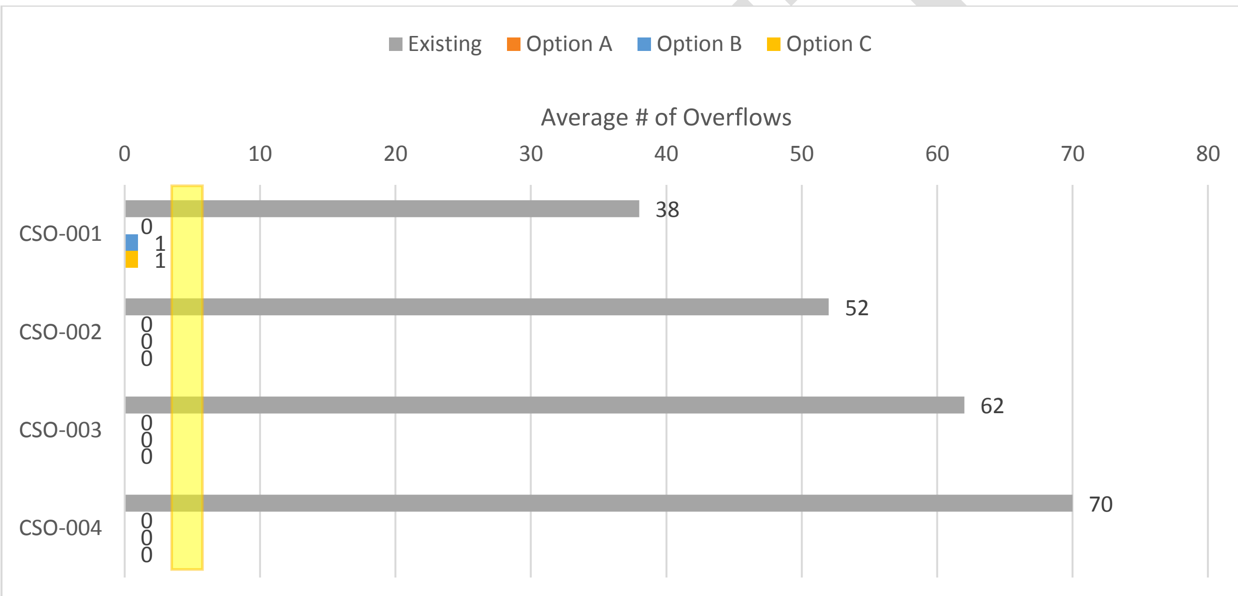
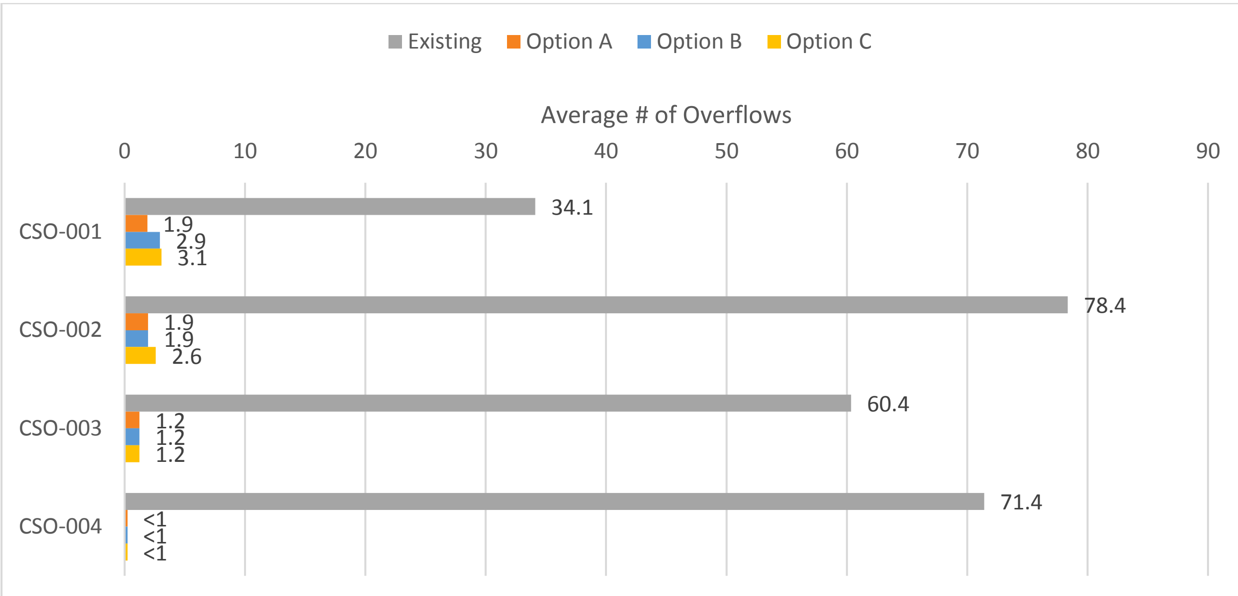


Figure 6-10
Average Number of Overflows for the 2000 – 2016 Climate Period



6.4.1.2 Performance with Respect to the Hunting Creek TMDL

As discussed in Section 1.5, the Hunting Creek TMDL assigns waste load allocations to CSO's 002, 003, and 004 and a waste load allocation to future growth of point sources at tributary to the AlexRenew WRRF as outlined in Section 1.5 (total aggregate = 8.52E+13 cfu/year). Table 6-8 presents the components of the aggregated load.

Table 6-8
Hunting Creek TMDL WLAs for CSO's 002, 003, 004, and Future WRRF Growth

Allocation	WLA (cfu/year)
002	6.26E+13
003	7.68E+11
004	8.52E+11
Future 12 MGD WRRF Growth	2.10E+13
Total	8.52E+13

Figure 6-11 shows the total aggregate waste load discharged for each option modeled for the 2004-2005 hydrologic period. In addition the performance for the 2000 – 2016 climate period is presented for informational purposes only.

Figure 6-11
Total Aggregate Waste Load for the 2004-2005 Climate Period

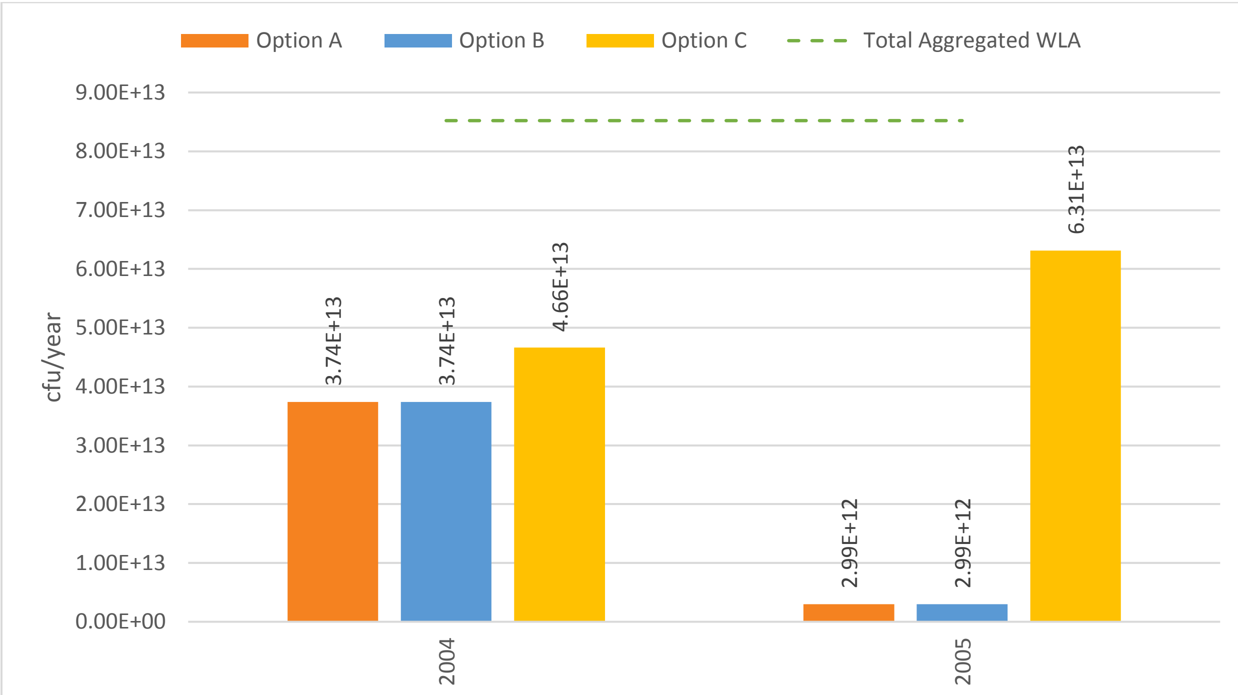
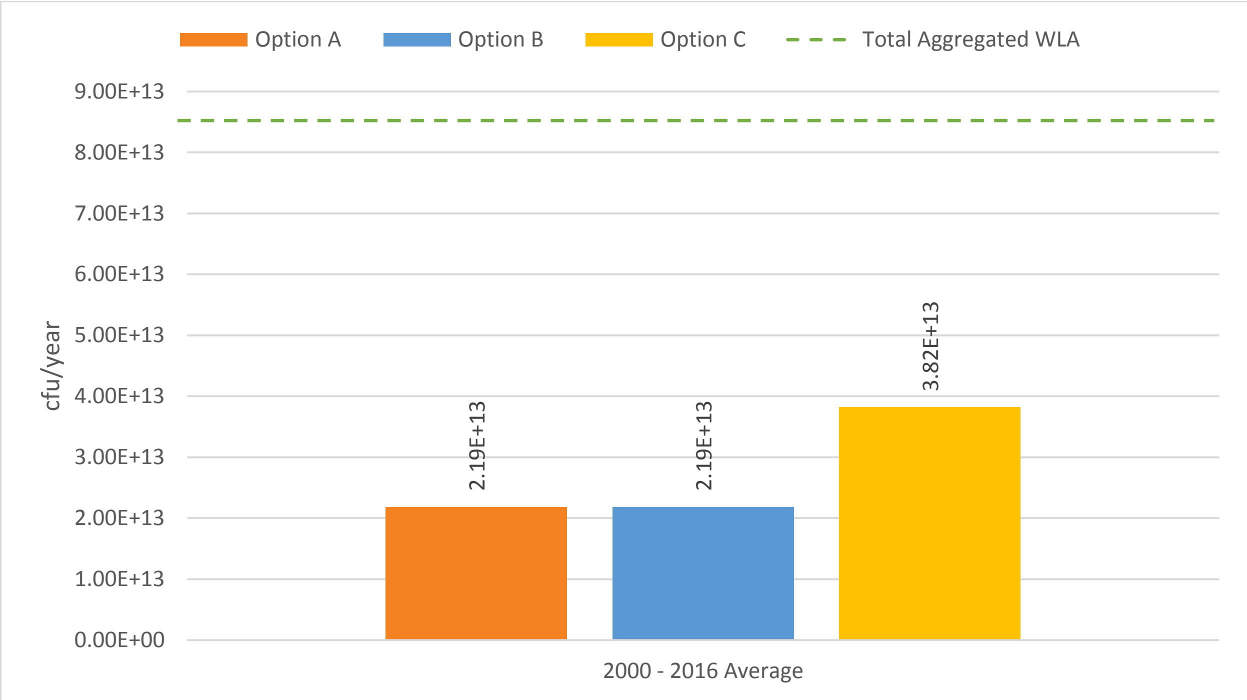


Figure 6-12
Average Total Aggregated Waste Load for the 2000 – 2016 Climate Period



More detail on the performance of each option can be found in the *Response to VDEQ's January 17, 2018 Email Technical Memorandum* dated March 7, 2018.

Section 7 Recommended Plan

The City of Alexandria and AlexRenew are committed to the improvement of local and regional waterways for the benefit of community and environmental health and safety. The selection of the recommended plan (Plan) not only considers meeting the 2017 CSO Law, but also the physical and financial impacts on the community, and the longevity and adaptability of the proposed infrastructure.

7.1 Unified Tunnel (Option B+)

Public input was solicited, received, and considered through public stakeholder meetings. Public feedback was also considered in the scoring and selection of the recommended plan. In keeping with this commitment to the public, the Plan includes an enhancement to Option B, herein referred to as Option B+, which includes unified storage and conveyance tunnels strategically coupled with wet weather treatment at AlexRenew's WRRF to maximize the volume of CSO flow receiving treatment. Based on feedback received from the public as part of the CSS Stakeholder Group process, regarding overflow volume discharged at CSO 001 and the percent capture provided by Option B, the Plan was further enhanced to address these concerns. This enhancement is referred to as Option B+ and the Plan is drafted around this option, which is illustrated schematically in Figure 7-1 and includes the following major components:

- Unified Tunnel
  - CSO 003/004 conveyance tunnel
  - CSO 001/002 storage and conveyance tunnel
  - Diversion facilities
  - Hydraulic grade line control structure
  - Dewatering pumping stations
  - Wet weather pumping station
- Wet weather treatment via retrofitting existing facilities at AlexRenew's WRRF
- Upgrades to AlexRenew's WRRF

As described in Section 3, different regulatory drivers apply for each of the outfalls. EPA's Presumption Approach applies to CSO 001, while the Hunting Creek TMDL applies to CSO's 002 through 004. Coupling Option B with additional wet weather treatment through dual use facilities at the WRRF will greatly reduce the frequency and volume of CSO overflows to the receiving waterbodies. Table 7-1 illustrates compliance with respect to the Presumption Approach for the predicted reduction of overflow events and percent capture.

Figure 7-1
Schematic of Option B+ (Recommended Plan)

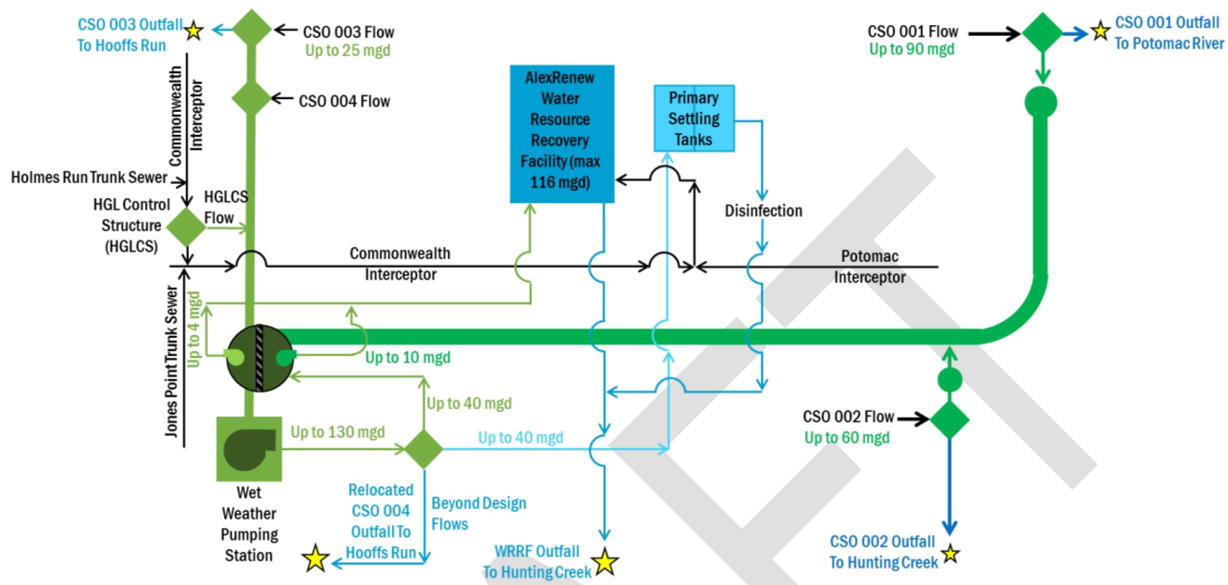


Table 7-1
Summary of Modeled Performance, Typical Year (1984)

Item	Existing	Option B	Recommended Plan (Option B+)
Number of Overflows (4 to 6 per Presumption Approach)			
CSO-001	38	1	**0**
CSO-002	52	0	**0**
CSO-003	62	0	**0**
CSO-004	70	0	**0**
Systemwide Percent Capture (85% per Presumption Approach)	80.6	99.8%	**100%**

As discussed in Section 3, the Hunting Creek TMDL assigns waste load allocations to CSO's 002, 003, and 004 and a waste load allocation for future growth of point sources at the AlexRenew WRRF, which totals 8.52E+13 cfu/year. Table 7-2 illustrates that the Plan meets the Hunting Creek TMDL total aggregate waste load allocation of 8.52E+13 cfu/year.

Table 7-2
Summary of Modeled Performance, Hunting Creek TMDL

Year	Option B Bacteria Load (cfu/year)	Recommended Plan (Option B+) Bacteria Load (cfu/year)	Aggregate Waste Load Allocation (cfu/year)
2004	3.74E+13	**3.43E+13**	8.52E+13
2005	2.99E+12	**2.13E+13**	

In addition to the performance with respect to the regulatory requirements illustrated in Table 7-1 and Table 7-2, performance during the 2000-2016 climate is demonstrated in Table 7-3 for informational purposes only.

Table 7-3
Summary of Recommended Plan Performance, 2000-2016 Climate Period

Item	Existing	Option B	Recommended Plan (Option B+)
Number of Overflows			
CSO-001	34.1	2.9	**2.2**
CSO-002	78.4	1.9	**1.9**
CSO-003	60.4	1.2	**1.2**
CSO-004	71.4	<1	**<1**
Systemwide Percent Capture	70.4	92.0	**96.4**

The Plan selected for Alexandria's CSO system is predicted to limit overflows to less than 4 events per year in the typical year of 1984 and comply with the Hunting Creek TMDL. Additionally, over the 2000 to 2016 climate period, overflows are estimated to be less than 4 events per year on average. The Plan maximizes the use of existing facilities, provides conveyance through a tunnel from CSO's 003 and 004 to AlexRenew's WRRF, and provides additional storage for CSO's 001 and 002 in a storage and conveyance tunnel. In addition, the Plan leverages AlexRenew's WRRF to provide treatment of wet weather flows through the use of dual use facilities to further reduce CSO discharges and provide increased percent capture. Table 7-4 summarizes the advantages and additional benefits of the Plan, while Sections 7.1.1 through 7.1.3 discuss the major planning and performance assumptions of the proposed controls.

Table 7-4
Advantages and Additional Benefits of the Recommended Plan

Advantages	Additional Benefits
▪ Lowest cost to build and operate with respect to other shortlisted options ▪ Simplest construction schedule with the highest potential to meet the mandated milestone based on current conceptual planning ▪ Minimizes operational equipment and components in the community ▪ Minimizes construction operations in the community by conceptually placing the most disruptive operations at the AlexRenew WRRF ▪ Minimizes disruptive, long-term maintenance by centralizing major equipment at the AlexRenew WRRF and not within the community ▪ Minimizes construction and operation costs by retrofitting existing facilities at the AlexRenew WRRF for dual use ▪ Allows for future modification for enhanced wet weather treatment ▪ Provides flexibility and adaptability for future regulatory and/or climate conditions ▪ Preserves space at the AlexRenew WRRF for future regulatory needs	▪ Exceeds required control measures established by the EPA CSO Policy ▪ Captures a majority of the floatables (e.g. bottles, bags, trash, etc.) currently discharged via the combined sewer system to the receiving waters ▪ Provides significant reductions in the discharge of solids to the waterbodies via capture and treatment at AlexRenew's WRRF ▪ Provides reduction in the discharge of nutrients (e.g. nitrogen and phosphorous) to the waterbodies through capture and treatment at AlexRenew's WRRF ▪ Relocates an outfall downstream of the African American Heritage Park ▪ Provides control of sewer flooding and basement backups ▪ Eliminates discharges to Hooffs Run from the Hooffs Run Junction Chamber ▪ Does not require storage tanks in the City

Figure 7-2
Recommended Plan[2]

[2] The tunnel alignment shown is for illustrative purposes. Exact locations are still to be determined.

7.1.1 CSO 003/004 Components

A conveyance tunnel is recommended for reduction of combined sewer discharges from CSO's 003 and 004. This tunnel is proposed to be constructed from AlexRenew's WRRF to the vicinity of the existing CSO 003 and 004 outfalls. As part of the Plan, CSO 004 is proposed to be relocated from its current location near the intersection of Duke Street and Dangerfield Lane to the AlexRenew WRRF.

Tunnel infrastructure will be constructed near the existing CSO outfalls and the Hooffs Run Junction Chamber to control CSO discharges and mitigate surcharging in the Commonwealth and Holmes Run Trunk sewers during storm events. This infrastructure is referred to as a "diversion facility," which typically consists of a wet weather flow regulator (or diversion chamber) and drop shaft. Diversion chambers are typically constructed downstream of the existing dry weather flow regulators to direct wet weather flows from the existing combined sewer system to a drop shaft. Drop shafts vertically transport flows captured by the diversion chambers to the tunnel system.

The CSO 003/4 tunnel will be served by a dewatering pumping station to empty the tunnel during and after storm events. Flows from the dewatering pumping station will be directed to AlexRenew's WRRF to receive full treatment when the plant has capacity. The CSO 003/4 tunnel will also be served by a wet weather pumping station, which will serve the following purposes:

- Mitigate sewer surcharging and basement backups along the Commonwealth Interceptor and Holmes Run Trunk Sewer
- Direct flows from the CSO 003/004 tunnel through wet weather treatment at AlexRenew's WRRF
- Direct flows from the CSO 003/004 tunnel to the CSO 001/002 tunnel when the WRRF and wet weather treatment are at capacity. Once the CSO 001/002 tunnel reaches capacity, combined sewer flows will discharge by gravity via the CSO 001 outfall. Flows may also discharge under certain conditions at the CSO 002 outfall.
- Direct flows from the 003/004 tunnel to relocated CSO 004 along Hooffs Run

Part I, Paragraph E.13 of AlexRenew's VPDES permit requires the permittee to:

> *"Commence an engineering evaluation of options/alternatives to study the need, feasibility and possible means of minimizing the occurrences of wet weather overflows at the Hooffs Run Junction Chamber…The final study and any proposed plan and implementation schedule should be compatible with the City of Alexandria's Long Term Control Plan Update…and shall be submitted to DEQ-NRO for review and approval on or before 31 December 2017 or one year from date of DEQ approval of the City's final LTCPU, whichever occurs later."*

The intent of this LTCPU, developed in partnership with AlexRenew, satisfies this requirement. This will be accomplished by constructing a diversion chamber on the Commonwealth Interceptor, which will be hydraulically connected to the wet weather pumping station. During storm events, wet weather pumps will be engaged to continuously draw flow from the Commonwealth Interceptor and lower Holmes Run Trunk Sewer and control the hydraulic grade line to prevent sewer surcharging, which can lead to basement backups, sewer flooding at upstream locations, and wet weather discharges to Hooffs Run.

A variety of potential alignments and diversion facility locations are being considered for the CSO 003/4 tunnel. Detailed alignments and diversion facility layouts will be further analyzed, refined, and optimized during the planning and design phases.

7.1.2 CSO 001/002 Components

A storage/conveyance tunnel is recommended for reduction of combined sewer discharges from CSO's 001 and 002. This tunnel is proposed to connect AlexRenew's WRRF to CSO's 001 and 002 and store and convey captured flows from these outfalls to the WRRF for treatment. During excess flow conditions, the CSO 001/2 tunnel will also convey excess flow from the CSO 003/4 system and discharge flows to the Potomac River via the CSO 001 outfall.

Diversion facilities will be constructed in the general vicinity of the existing CSO outfalls and the CSO 001/002 tunnel will be served by a dewatering pumping station to empty the tunnel during and after storm events. Flows from the dewatering pumping station will be directed to AlexRenew's WRRF to receive full treatment when the plant has capacity.

A variety of potential alignments and diversion facility locations are being considered for the CSO 001/2 tunnel. Detailed alignments and diversion facility layouts will be further analyzed, refined, and optimized during the planning and design phases.

7.1.2.1 CSO 001 Outfall Extension

AlexRenew in conjunction with the City, will investigate opportunities to extend the CSO 001 outfall from its current termination point in Oronoco Bay to the shoreline of the Potomac River per feedback from the City Stakeholder Group. The extension of the outfall would relocate remaining CSO 001 overflows to the main flow path of the Potomac River. The extension of the outfall requires coordination and permits from multiple agencies and will continue to be investigated as a potential opportunity to relocate remaining overflows from Oronoco Bay.

7.1.3 AlexRenew WRRF Components

The recommended plan reflects that AlexRenew's WRRF will operate at its current permitted dry weather design capacity of 54 MGD on an annual average basis. As part of the Plan, AlexRenew will increase the peak capacity through primary treatment of its WRRF from 108 to 116 MGD.

In addition to the WRRF upgrades to 116 MGD, the Plan includes additional wet weather treatment beyond that required to comply with the 2017 CSO Law. The wet weather treatment facility includes a combination of primary sedimentation and high rate disinfection as an enhancement to Option B. The wet weather component, developed as a response to stakeholder input, will add approximately $10 million to the capital cost of Option B.

The wet weather treatment facility will repurpose portions of AlexRenew's primary treatment process, which will be retrofitted to provide primary sedimentation and disinfection during wet weather events. The objective is to provide AlexRenew with the ability to retain primary settling for typical dry weather operations and convert tankage to wet weather mode to provide further CSO reductions as part of the

Plan. Following settling and disinfection, wet weather flows will be dechlorinated prior to discharge to the waterbodies.

Disinfected wet weather flows will be conveyed to Hunting Creek via an existing unused flow channel that connects to WRRF Outfall 001 downstream of AlexRenew's final effluent sampling location. It is intended to permit the wet weather treatment facility discharge separately from the WRRF's final treated effluent outfall and include provisions for separate sampling prior to conveyance to Hunting Creek.

The proposed treated wet weather outfall may be considered a CSO-related bypass consistent with language provided in the CSO Policy. The CSO Policy addresses the specific case where existing primary treatment capacity at a wastewater treatment plant exceeds secondary treatment capacity and it is not possible to utilize the full primary treatment capacity without overloading the secondary facilities. Under these conditions, the CSO Policy allows for the diversion of flows around secondary facilities, provided that *"all wet weather flows passing the headworks of the POTW treatment plant will receive at least primary clarification and solids and floatables removal and disposal, and disinfection."*

The regulatory basis for a CSO-related bypass is discussed in 40 CFR 122.41(m)(4), which prohibits bypasses, except where the following criteria are met:

- *The bypass was unavoidable to prevent loss of life, personal injury, or severe property damage.* The definition of which includes damage to the treatment facilities, causing them to become inoperable, such as, the washout of the secondary treatment system.
- *There was no feasible alternative to the bypass, such as the use of auxiliary treatment facilities, retention of untreated wastes, or maintenance during normal periods of equipment downtime.*

In order to satisfy the first criterion above, the CSO Policy states that "the long-term control plan, at a minimum, should provide justification for the cut-off point at which the flow will be diverted from the secondary treatment portion of the treatment plant." In order to meet the Presumption Approach and Hunting Creek TMDL requirements, the Plan includes increasing the primary treatment capacity of AlexRenew's WRRF to 116 MGD. Flows greater than 116 MGD entering the WRRF would cause "severe property damage" as a result of washing out the secondary treatment system. The WRRF will treat wet weather flows entering the raw sewage pumping station up to a capacity of 116 MGD prior to diverting captured flows through the wet weather treatment facility.

The CSO Policy further states that the no feasible alternatives requirement can be met if *"records demonstrating that the secondary treatment system is properly operated and maintained, that the system has been designed to meet secondary limits for flows greater than the peak dry weather flow, that the system has been designed to meet secondary limits for flows greater than the peak dry weather flow plus an appropriate quantity of wet weather flow, and that it is either technically or financially infeasible to provide secondary treatment for greater amounts of wet weather flow."* The AlexRenew WRRF also meets these requirements, as the compliance records show that the secondary treatment system is properly operated and maintained; and it is technically infeasible to provide secondary treatment for the additional wet weather flow due to AlexRenew's constrained urban site.

In addition, it has been demonstrated herein that the CSO-related bypass will not cause any exceedances of water quality standards as it complies with the discharge requirements established for the CSO system within the Hunting Creek TMDL. The selection of the Plan further demonstrates that increasing the excess wet weather flow treatment is an effective component that will significantly increase percent capture and greatly minimize the CSO discharges.

7.1.4 Ongoing City of Alexandria Strategies

The City of Alexandria is employing several strategies, outside of the LTCPU, both citywide and within the combined sewer system to assist in the reduction of combined sewer overflows, which include:

- Green infrastructure (GI): GI can be used to gradually reduce the stormwater entering the combined sewer system over time and provide other ancillary benefits for the community A GI strategy that provides the City with flexibility to install GI citywide will serve as the best approach to maximizing GI benefits and benefits to water quality in the Chesapeake Bay. The City is currently evaluating the use of GI on a broader scale to achieve its Chesapeake Bay TMDL goals as part of their Municipal Separate Storm Sewer System (MS4) permit and associated *Chesapeake Bay TMDL Action Plan*. It is anticipated that the Action Plan will be finalized in 2019 and GI will be an integral component of that Action Plan. In the meantime, the City will continue to encourage and promote GI citywide, including in the CSS area, through the development and redevelopment process as other opportunities arise, and will administer the implementation of GI through its MS4 program.
- Targeted sewer separation: Targeted sewer separation can be used to further reduce CSS overflows over time. The City currently has a program for separating combined sewers, whenever practicable, as a condition of redevelopment and intends continue to administer the Area Reduction Plan (ARP).

7.2 Adaptive Management in Response to Future Regulatory Drivers

The Plan may be adapted to respond to future regulatory changes if necessary. The Plan is the most adaptable of all options due to a unified system and connectivity with the WRRF. The following outline some strategies for adaptive management of the Plan in response to future regulatory drivers:

- Construct additional dewatering pumping station capacity
- Construct additional wet weather treatment facilities
- Real-time controls (RTC): RTC are methods of providing greater control by making adjustments to the system dynamically as flows in the system are changing. Real-time controls can be used to compliment and optimize the Plan
- New technologies: As technology advances continue, there might be new and/or different ways to provide additional CSO controls. The Plan has maximum flexibility to consider such technologies as they arise
- Combinations of the above

Section 8 Operational Plan

This section describes the operation of the Plan, which includes the following major elements:

- Unified Tunnels
  - Storage tunnels
  - Conveyance tunnels
  - Diversion facilities (diversion chambers and drop shafts)
  - Dewatering pumping stations
  - Wet weather pumping station
- AlexRenew WRRF upgrades
  - Increase the WRRF peak capacity from 108 to 116 MGD
- Wet weather treatment at the WRRF through retrofitted dual use facilities.

8.1 Operational Overview

8.1.1 Typical Operation

During typical operation, wet weather flows will be maximized through the existing collection system to AlexRenew's WRRF. As levels in the combined sewer system rise, they will exceed the capacity of the existing regulators. When this occurs, flows will be conveyed downstream to the existing CSO outfalls where they will be intercepted by new diversion chambers and directed to the new tunnel via drop shafts. The drop shafts deliver flow to the deep tunnels, where they act as a storage/conveyance system to deliver captured flows to the WRRF. As the tunnel system fills, water levels will rise sufficiently to activate the CSO 003/004 and CSO 001/002 tunnel dewatering pumping stations at the WRRF. The pumping stations will lift flow from the tunnel to the WRRF, where it will be sent through full treatment. Flows will be dewatered to the WRRF as long as it has capacity, up to 116 MGD. As this process continues, the tunnels will act as equalization.

8.1.2 Design Condition Operation

If the wet weather event is large enough and flow has been maximized to the WRRF, tunnel water levels will continue to rise. As the water levels in the CSO 003/004 tunnel continue to rise, they will trigger the new wet weather pumping station at the WRRF. The wet weather pumping station will first direct flows through wet weather treatment until its capacity is reached, at which time, flows from CSO 003/004 will be pumped to the CSO 001/002 tunnel. As the CSO 001/002 tunnel continues to fill beyond its capacity, it will preferentially overflow at CSO 001.

8.1.3 Excess Flow Operation

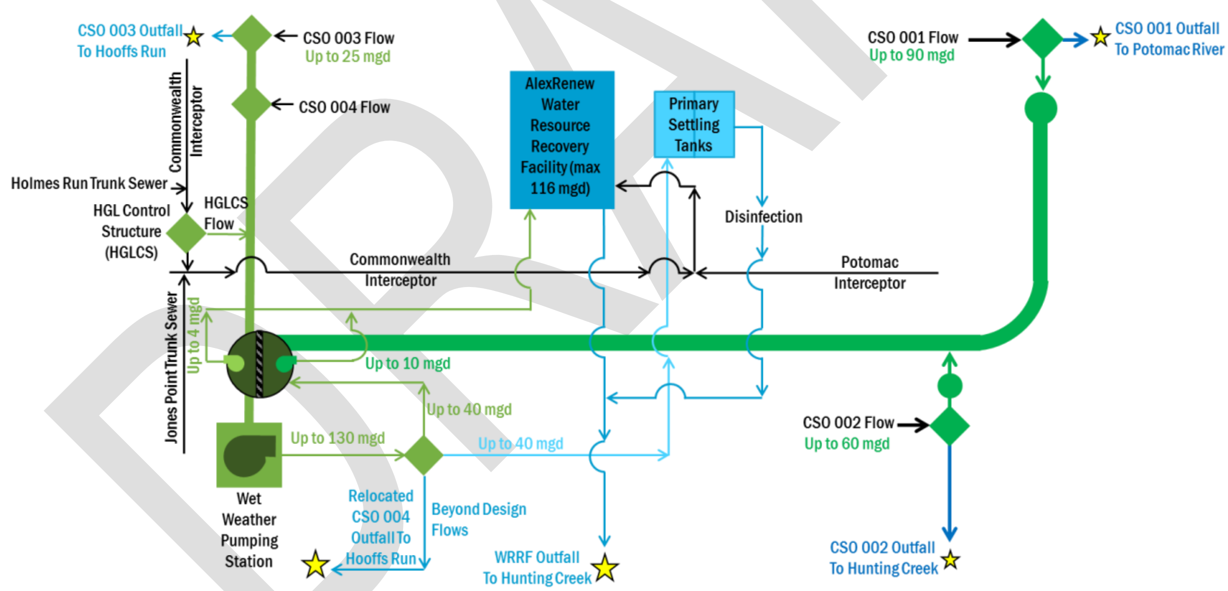
If the CSO 003/004 tunnel continues to fill after flow is directed to the WRRF, wet weather treatment, and the CSO 001/002 tunnel, additional wet weather pumps will be engaged and the tunnel will be relieved via the relocated CSO 004 outfall as a relief to prevent the system from surcharging. Under these excess flow conditions, overflows may also occur due to the capacity of the new diversion chambers being exceeded. Therefore, overflows may occur at CSO's 002, 003, and 004 for very large wet weather events.

8.2 CSO 003/004 Conveyance Tunnel System Operation

Depending on the size of the storm event, the CSO 003/004 conveyance system can operate under three scenarios as illustrated in Figure 6-3 and described as follows:

- **Typical Operation.** Captured flows are stored and conveyed to the WRRF for full treatment up to the peak plant capacity of 116 MGD (116 MGD represents an upgrade in peak flow capacity to the existing 108 MGD WRRF).
- **Design Condition Operation.** When the WRRF capacity is exceeded, flows are pumped continuously to keep up with the rate of inflow to wet weather treatment facilities (dual-use primary settling tanks).
- **Excess Flow Operation.** When WRRF and both tunnel systems are at capacity, captured CSOs are pumped to the relocated CSO 004 outfall. Flows exceeding tunnel inlet capacity at CSO 003 will discharge as CSOs at the existing CSO 003 permitted location.

Figure 8-1
Option B+ - Enhanced Unified Tunnels



8.3 CSO 001/002 Storage Tunnel System Operation

- **Typical Operation:** Captured flows from CSOs 001 and 002 will be stored in a tunnel designed to capture the volume of a storm event to meet the requirements of the 2017 CSO Law outlined in Section 1.6. When the WRRF has available capacity, the tunnel will be dewatered and pumped to the WRRF for full treatment.

- **Design Condition Operation:** In the event that storms beyond the design capacity exceed the tunnel volume, flows will discharge by gravity via the CSO 001 outfall.
- **Excess Flow Operation:** Under excess flow conditions, overflows can also occur at the CSO 002 outfall if capacity of the regulator is exceeded.

Section 9 Program Implementation Plan

The proposed program implementation plan for the LTCPU projects is discussed in this section. This includes the program implementation schedule, program costs and anticipated spending projections, and a brief discussion on funding strategy for the LTCPU projects.

9.1 Proposed Facilities

The LTCPU implementation includes the following proposed facilities which are described in detail in previous sections (Section 6 and Section 7).

- Unified Tunnels
  - Storage tunnels
  - Conveyance tunnels
  - Diversion facilities (diversion chambers and drop shafts)
  - Dewatering pumping stations
  - Wet weather pumping station
- AlexRenew WRRF upgrades
  - Increase the WRRF peak capacity from 108 to 116 MGD
- Wet weather treatment at the WRRF through retrofitted dual use facilities

9.2 Program Implementation Schedule

9.2.1 Program Assumptions

The following general assumptions are made with regard to the LTCPU program implementation.

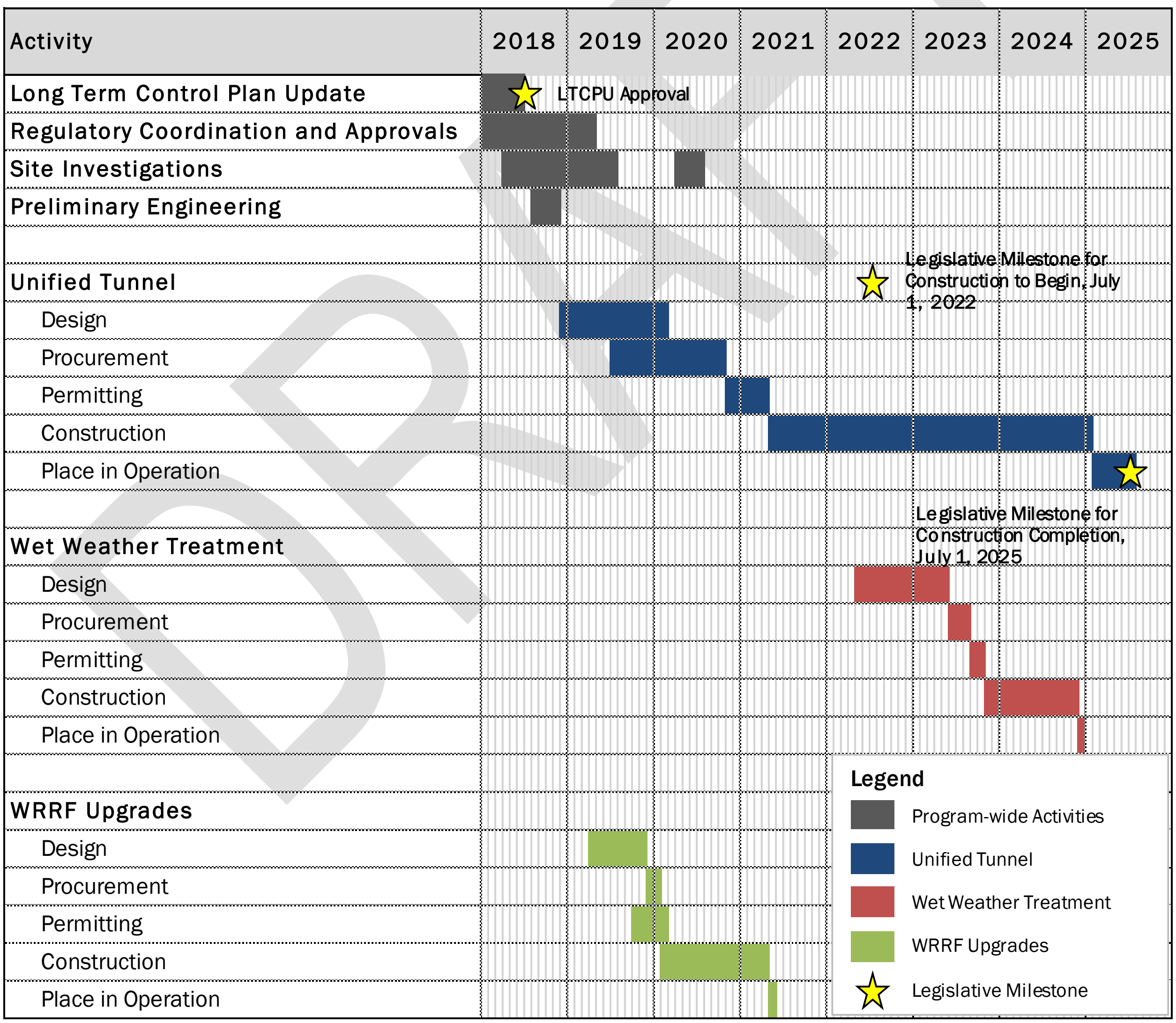
- **Recommended Plan:** The timeline mandated in the 2017 CSO Law requires a very aggressive planning, design and construction schedule to meet the July 1, 2025 milestone. It is anticipated that the infrastructure projects will be constructed in staggered, but largely parallel projects. The critical path of the program is through the unified tunnel. The first project entering the construction phase is likely to be the WRRF upgrades (108 MGD to 116 MGD) in an effort to limit overlapping construction activities at the constrained AlexRenew site. The unified tunnel is anticipated to proceed next, followed by the dual-use wet weather treatment facilities.
- **Flexibility:** The schedule presented herein is conceptual in nature and is anticipated to change as the design progresses. The City and AlexRenew will investigate a variety of project delivery mechanisms. Alternative delivery, sequencing, or packaging may be advantageous and will be considered further.
- **State and Federal Legislation:** The LTCPU provides a plan for the City to comply with the Hunting Creek TMDL and the 2017 CSO Law with large-scale combined sewer infrastructure being constructed by July 1, 2025. As such, this plan complies with all current State and Federal regulations and mandates.

It is likely that there may be changes in the schedule or order of the projects to accommodate changes in conditions given the very aggressive completion deadline. If changes in the schedule or order of the projects are necessary, the City will notify VDEQ of such changes.

9.2.2 Implementation Schedule

An implementation schedule for the proposed projects included in the LTCPU is provided in Figure 9-1. Per the 2017 CSO Law, we anticipate that VDEQ will provide direction by July 1, 2018. The schedule assumes approval of the LTCPU, including AlexRenew's HRJC plan, by VDEQ no later than September 1, 2018. If approval is delayed, then the LTCPU implementation schedule will have to be adjusted accordingly.

Figure 9-1
Preliminary LTCPU Implementation Schedule



9.3 Program Costs and Spending Projections

A summary of the estimated capital costs for the Long Term Control Plan Update is included in Table 9-1. All costs are escalated to mid-point of construction.

Table 9-1
Preliminary Estimated Capital Costs

	Capital Costs ($)	Capital Costs +50% ($)
AlexRenew WRRF Upgrades	$2,700,000	$4,000,000
Wet Weather Treatment	$10,000,000	$15,000,000
CSO 003/004 Tunnel	$130,000,000	$195,000,000
CSO 001/002 Tunnel	$213,000,000	$320,000,000
Total Costs	**$356,000,000**	**$534,000,000**

9.4 Program Funding Strategy

The LTCPU projects will be funded through the issuance of bonds which are paid back through the sanitary sewer rates. Currently, the average household in Alexandria pays $45-50 per month on their sewer bill. Studies are underway to determine the impact of these projects on the sewer rates, but preliminary estimates indicate that the expected impact will be an increase of $20-30 per month after project implementation. The City will pursue grant funding assistance and any other available subsidies toward mitigating these significant rate increases which are necessary to comply with the 2017 CSO Law.

Section 10 Post Construction Monitoring Plan

10.1 Post Construction Monitoring

The LTCPU implementation will include post construction monitoring for the proposed infrastructure. The monitoring data will be used to assess the effectiveness of projects in meeting program performance measures. The goal of the post construction monitoring for the proposed infrastructure will be to demonstrate that the CSOs meet the Hunting Creek TMDL (outfalls 002, 003, and 004) and the Presumption Approach from EPA's National CSO Control Policy (outfall 001). Attainment of the goals will be assessed through flow monitoring and modeling.

It must be noted that the bacteria TMDL water quality goals in the receiving waters will not be achieved unless controls for the other sources (including stormwater, septic, and wildlife) contributing to the bacteria load are implemented in addition to the CSO controls.

10.2 Flow Monitoring Plan

Post-construction flow monitoring will be conducted at CSO 001, CSO 002, CSO 003, and relocated CSO 004 outfalls to monitor CSO overflows. Flow monitoring will be conducted over a 2-year period and used to calibrate the combined sewer system model. This model will be used to compare actual performance against the typical year (1984) for compliance with the presumption approach and 2004-2005 for the Hunting Creek TMDL.

Appendix A

List of Meetings

#	Date	Presentation Title	Audience
1	8/5/2013	Proposed Combined Sewer System Permit	Public Meeting (through EPC)
2	10/30/2013	Combined Sewer System Permit and Long-Term Control Plan Update	Federation of Civic Associations
3	11/13/2013	Combined Sewer System Permit and Long-Term Control Plan Update	Old Town Civic Association
4	11/14/2013	Combined Sewer System Permit and Long-Term Control Plan Update	West Old Town Citizens Association
5	1/28/2014	Joint Work Session with Alexandria Renew Enterprises – Sanitary Sewer and CSO Issues	City Council Work Session
6	5/19/2014	Combined Sewer System and Long Term Control Plan Update (LTCP-U)	Environmental Policy Commission
7	9/18/2014	Combined Sewer System Permit and Long-Term Control Plan Update	Porto Vecchio
8	10/21/2014	Combined Sewer System Permit and Long-Term Control Plan Update	AlexRenew Board
9	10/27/2014	Combined Sewer System Permit and Long-Term Control Plan Update	Agenda Alexandria
10	1/27/2015	Combined Sewer System Long-Term Control Plan Update	City Council Legislative Session
11	1/28/2015	Combined Sewer System Permit and Long-Term Control Plan Update	Federation of Civic Associations
12	2/2/2015	Combined Sewer System Permit and Long-Term Control Plan Update	Environmental Policy Commission
13	2/5/2015	Combined Sewer System Permit and Long-Term Control Plan Update	LTCPU Phase I Public Meeting
14	2/11/2015	Combined Sewer System Permit and Long-Term Control Plan Update	Old Town Civic Association
15	3/18/2015	Combined Sewer System Permit and Long-Term Control Plan Update	NorthEast Citizens' Association
16	5/18/2015	Combined Sewer System Long Term Control Plan Update	Environmental Policy Commission
17	5/19/2015	Combined Sewer System Long Term Control Plan Update	Waterfront Commission
18	5/26/2015	Combined Sewer System Long Term Control Plan Update	City Council Work Session
19	6/11/2015	Combined Sewer System Long Term Control Plan Update	West Old Town Citizens Association
20	6/18/2015	Combined Sewer System Long Term Control Plan Update	LTCPU Phase II Public Meeting
21	10/7/2015	CSS Stakeholder Group Meeting #1	CSS Stakeholder Group
22	11/2/2015	CSS Stakeholder Group Meeting #2	CSS Stakeholder Group
23	1/7/2016	CSS Stakeholder Group Meeting #3	CSS Stakeholder Group
24	2/4/2016	CSS Stakeholder Group Meeting #4	CSS Stakeholder Group

#	Date	Presentation Title	Audience
25	3/3/2016	CSS Stakeholder Group Meeting #5	CSS Stakeholder Group
26	3/8/2016	Combined Sewer System Long Term Control Plan Update	City Council Work Session
27	4/6/2016	Combined Sewer System Permit and Long Term Control Plan Update	Virginia Society of Professional Engineers
28	4/7/2016	CSS Stakeholder Group Meeting #6	CSS Stakeholder Group
29	4/13/2016	Combined Sewer System Permit and Long Term Control Plan Update	Old Town Civic Association
30	4/21/2016	Combined Sewer System Long Term Control Plan Update	LTCPU Phase III Public Meeting
31	5/10/2016	Combined Sewer System and the Long Term Control Plan Update	City Council Work Session
32	5/14/2016	Combined Sewer System and the Long Term Control Plan Update	City Council Public Hearing
33	5/30/2017	Long Term Control Plan Update and Impact of Recent Combined Sewer Legislation	Public Meeting
34	10/12/2017	CSS Stakeholder Group Meeting #1	CSS Stakeholder Group
35	11/20/2017	CSS Stakeholder Group Meeting #2	CSS Stakeholder Group
36	1/20/2018	CSS Stakeholder Group Meeting #3	CSS Stakeholder Group
37	2/1/2018	CSS Stakeholder Group Meeting #4	CSS Stakeholder Group
38	2/22/2018	CSS Stakeholder Group Meeting #5	CSS Stakeholder Group
39	3/19/2018	CSS Stakeholder Group Meeting #6	CSS Stakeholder Group
40	4/5/2018	Combined Sewer System Long Term Control Plan Update	Public Meeting
41	4/10/2018	Combined Sewer System Long Term Control Plan Update	City Council Legislative Meeting
42	4/24/2018	Combined Sewer System Long Term Control Plan Update	City Council Public Hearing

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