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Volume 2

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Long Term Control Plan

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Prepared for:
City of Seattle
Seattle Public Utilities
Seattle Municipal Tower, Suite 4900
700 Fifth Avenue
Seattle, Washington 98124-4018

CP Project Manager
3/12/2015

LTCP Project Engineer
3/12/2015

This report has been prepared under the direction of a registered professional engineer.

Prepared by:
CH2M HILL
Brown and Caldwell
Environmental Science Associates (ESA)
Seattle Public Utilities
UrbanTech Systems
Wayworks

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Appendix content submitted electronically under separate cover

List of Abbreviations and Glossary

Term	Definition
2010 Plan	2010 CSO Reduction Plan Amendment
3C	LTCP Conceptual Cost Calculator
3R	Repair, Rehabilitation and Replacement
AACE	Association for the Advancement of Cost Engineering
ACU-SWM	Automated Calibration and Uncertainty Analysis for Storm Water Management Model
CCTV	closed-circuit television
CDPD	cellular digital packet data
CFR	Code of Federal Regulations
cfs	cubic foot/feet per second
CIP	capital improvement program
City	City of Seattle
CMMS	Maximo 7 Computerized Maintenance Management System
CMOM	Capacity, Management, Operations, and Maintenance
Consent Decree	Final and Fully Executed Consent Decree
COTool	cleaning optimization tool
CSO	combined sewer overflow
CSS	combined sewer system
CV	control volumes
CWA	Clean Water Act
CY	cubic yards

Term	Definition
DNRP	King County Department of Natural Resources and Parks—Wastewater Treatment Division
DWF	dry-weather flows
DWO	dry weather overflow
Ecology	Washington State Department of Ecology
EIS	Environmental Impact Statement
EPA	U.S. Environmental Protection Agency
FOG	fats, oils, and grease
FSE	food service establishment
FTE	full-time equivalent employee
GHG	greenhouse gas
GI	green infrastructure
GIS	geographic information system
GOF	goodness-of-fit
HCC	hydraulic control chamber
HLKK	Hanford, Lander, Kingdome, King Street
I/I	infiltration and inflow
Joint Plan	Joint Operations and System Optimization Plan
JOIST	Joint Operations Information Sharing Team
LTCP	Long Term Control Plan
LTS	long-term simulations
MAUT	multi-attribute utility theory

MG	million gallons
MGD	million gallons per day
MMSD	Milwaukee Metropolitan Sewerage District
MODA	multiple objective decision analysis
NASSCO	National Association of Sewer Service Companies
NDS	natural drainage systems
NIRR	no impact release rate
NMC	Nine Minimum Controls
NPDES	National Pollutant Discharge Elimination System
NPV	net present value
O&M	operations and maintenance
PACP	pipeline assessment and certification program
PCMP	post-construction monitoring plan
POTW	publicly owned treatment works
QA/QC	quality assurance/quality control
RCM	reliability centered maintenance
RCW	Revised Code of Washington
ROW	right-of-way
SCADA	Supervisory Control and Data Acquisition
SDOT	Seattle Department of Transportation
SEPA	State Environmental Policy Act
SF	square feet
SMC	Seattle Municipal Code
Soft Costs	all non-construction costs
SOP	standard operating procedures
SPU	Seattle Public Utilities
SSO	sanitary sewer overflow
State	State of Washington
SWMM5	EPA Storm Water Management Model, Version 5
TBD	to be determined
TBM	tunnel boring machine
The Plan	The Plan to Protect Seattle's Waterways
WAC	Washington Administrative Code
WQS	water quality standards
WRIA	Watershed Resource Inventory Area
WSDOT	Washington State Department of Transportation
WTD	King County Wastewater Treatment Division's
WWTP	wastewater treatment plant

Term	Definition
20-year moving average	The average number of untreated discharge events per CSO outfall over a 20-year period for purposes of compliance with Washington Administrative Code (WAC) 173-245-020(22)
Alternative	There are 3 alternatives for the Plan to Protect Seattle's Waterways. • The LTCP Alternative is focused solely on reducing CSOs under an approved Long-term Control Plan (LTCP). • The Integrated Plan (IP) Alternative includes reduction of both CSOs and stormwater pollution • The EIS will also evaluate a No Action Alternative to provide a baseline for comparison of potential effects of the Plan alternatives, as required by the State Environmental Policy Act (SEPA)
Average annual volume	An annual CSO overflow volume based on a twenty year moving average
Code of Federal Regulations (CFR)	A compilation of federal laws
Combined sewer overflow (CSO)	During rainfall events, the volume of the stormwater entering a combined sewer system often is greater than the capacity of the collector pipes and sewage treatment plant and, as a result, the untreated sewage and stormwater mixture flows directly into receiving waters through designated overflow points
Combined sewer system (CSS)	The wastewater collection and conveyance system owned or operated by the City, including all pipes, force mains, gravity sewer segments, pump stations, lift stations, interceptors, diversion structures, manholes, and appurtenances thereto, designated to collect and convey municipal sewage, including residential, commercial, and industrial wastewaters, and stormwater, through a single-pipe system to King County's wastewater treatment plants, King County's CSO treatment plants, or to permitted CSO outfalls
Consent Decree	A written agreement entered in United States District Court for Western District of Washington on July 3, 2013, between the City of Seattle, Washington State Department of Ecology, the EPA, and the United States Department of Justice that describes the actions that The City must take to address violations of the Clean Water Act caused by Combined Sewer Overflows.
Controlled	The control of a CSO outfall in accordance with WAC 173-245-020(22)
Control Measure	Construction, control measures, actions, and other activities set forth in the City's Long Term Control Plan or any supplemental Compliance Plan.
Control Status	The Consent Decree's definition of "greatest reasonable reduction" of CSOs; an average of no more than one overflow occurrence per outfall per year determined on a 20 year moving average
Control Volume	The amount of combined sewage that would need to be stored in order for a basin to achieve control status
Controlled Basin	A basin that experiences an average of one or fewer CSO occurrences annually on a 20 year moving average

Term	Definition
Cost-benefit analysis	Systematic process for calculating and comparing benefits and costs of a project, decision, or government policy
Combined Sewer System	An infrastructure strategy that builds a single pipe to carry both stormwater and sewage in lieu of two separate pipes.
Combined Sewer Overflow	Discharge of a combination of sewage and stormwater at designated and permitted overflow points from a combined sewer system when the local system's hydraulic capacity is reached to prevent sewage backup into homes and onto surface streets or private property.
CSO Area	A logical grouping of one or more outfalls based on hydraulic relationships, receiving waters, neighborhoods, or other readily recognizable features
CSO control measure	The construction, control measures, actions, and other activities set forth in the City's Long-Term Control Plan or any Supplemental Compliance Plan provided for in Section V.B. of the Consent Decree
CSO outfall	The outfall structure from which a CSO is discharged
CWA	Clean Water Act; passed by congress in 1972, meant to restore and maintain the integrity of the nation's waters
Design criteria	The minimum attributes of a given CSO control measure, such as storage volumes, treatment capacities, or pumping and/or conveyance capacities as specified in the Long-Term Control Plan or any Supplemental Compliance Plan provided for under Section V.B. of the Consent Decree
Designated receiving water	Waters determined by SPU as having sufficient capacity to receive discharges of drainage water such that a site discharging to the designated receiving water is not required to implement flow control. Includes the Duwamish River, Puget Sound, Lake Washington, Lake Union, Elliott Bay, Portage Bay, Union Bay, and the Lake Washington Ship Canal
Dewatering	The pumping of groundwater from an excavated area to facilitate construction
Early Action Projects	A series of projects mandated by Section V.A. of the City's Consent Decree that requires the City to implement all CSO control measures necessary to reduce discharges from CSO outfalls in North and South Henderson CSO areas.
Ecology	The State of Washington Department of Ecology
Environmental Impact Statement (EIS)	A document that discloses the probable significant adverse environmental impacts of a development project or a planning proposal, discusses reasonable mitigation of identified impacts, and evaluates alternatives to the project and/or proposal. EISs are required under certain circumstances by the Washington State Environmental Policy Act (SEPA)
Environmental justice	The fair treatment of people of all races and incomes with respect to actions affecting the environment. Fair treatment implies that there is equity of the distribution of benefits and risks associated with a proposed project and that one group does not suffer disproportionate adverse effects

Term	Definition
EPA	The U.S. Environmental Protection Agency and any of its successor departments or agencies
EPA CSO Control Policy	Explains how to control CSOs while meeting CWA requirements; includes implementation of the Nine Minimum Controls and the development of a Long-Term Control Plan including the following elements: 1. Characterization, Monitoring, and Modeling of the CSS 2. Public Participation 3. Consideration of Sensitive Areas 4. Evaluation of Alternatives 5. Cost/Performance Considerations 6. Operational Plan 7. Maximizing flow to the existing Publically Owned Treatment Works (POTW) 8. Implementation Schedules 9. Post-Construction Monitoring Plan
EPA LTCP Guidance Document	*Combined Sewer Overflows Guidance for Long-Term Control Plan*
Green infrastructure (GI)	Systems and practices that use or mimic natural processes to infiltrate, evapotranspire, and/or harvest stormwater on or near the site where it is generated. Green infrastructure may include, but is not limited to, green roofs, downspout disconnection, trees and tree boxes, rain gardens, vegetated swales, pocket wetlands, infiltration planters, vegetated median strips, permeable pavements, reforestation, and protection and enhancement of riparian buffers and floodplains.
Groundwater	Water that infiltrates into earth and is stored in the soil and rock within the zone of saturation below the earth's surface. Groundwater is created by rain, which soaks into the ground and flows down until it is collected at a point where the ground is not permeable. Groundwater then usually flows laterally toward a river, lake, or ocean. It is often used for supplying wells and springs.
Hard cost	The actual cost of constructing a project (i.e., paid to the contractor) plus sales tax
HLKK	An acronym for a proposed stormwater treatment plant to be built in the vicinity of King County's Hanford, Lander, Kingdome, and King Street Regulators.
Hydrobrake	A static stormwater treatment device that can be installed in a pipe network to control release of excess flows at a measured rate.
Impaired waters	Waters whose beneficial uses are impaired by pollutants
Infiltration and	A general category of extraneous water that enters a sewer system and uses its sewage-carrying hydraulic capacity, thereby contributing to overflows. Sources are either from the

Term	Definition
inflow (I/I)	groundwater leaking through deteriorated joints and cracks (infiltration) or openings/illicit connections at manholes (inflow).
Launching portal	A primary portal used to insert a tunnel boring machine for excavation of tunnels. Liner section installation and ventilation operations would also occur at these portals.
Long Term Control Plan (LTCP)	The Long Term Control Plan under development by the City in accordance with Section V.B. of the Consent Decree, as well as any additional remedial measures for eliminating or reducing the City's CSOs included in any Supplemental Compliance Plan developed and implemented in accordance with Section V.B. of the Consent Decree.
LTCP Option	An overall system approach that will ultimately resolve all SPU uncontrolled outfalls; the four LTCP Options are: Neighborhood Storage, Shared Storage, Shared West Ship Canal Tunnel, Shared Ship Canal Tunnel
MODA	Multiple Objective Decision Analysis; an evaluation tool that incorporates consideration of non-monetary (social and environmental) factors as well as cost to compare competing solutions in a comprehensive manner
Monte Carlo simulation	A computational algorithm that uses repeated random sampling to obtain numerical results; e.g., by running simulations many times to calculate probabilities of outcomes.
Neighborhood Solution	A CSO control measure that is implemented by Seattle Public Utilities independent from other agencies or jurisdictions.
NPDES Permit	The City's National Pollutant Discharge Elimination System permit, No. WA-003168-2, issued by the State of Washington Department of Ecology on October 27, 2010 and modified on September 13, 2012.
Open cut	See "trenching"
Partially separated stormwater system	Street drainage system that routes stormwater runoff from paved areas to separate storm sewers and conveys the remaining drainage, generally all flows from private properties, in a combined sewer.
Performance criteria	The Performance Criteria specified in the Long-Term Control Plan or any Supplemental Compliance Plan provided for under Section V.B. of the CD.
Pile	A large pole driven into the earth to support a building or other superstructure
The Plan	The Plan to Protect Seattle's Waterways, includes four Volumes: Executive Summary, Long Term Control Plan, Integrated Plan, and Environmental Impact Statement
Post-Construction Monitoring Plan (PCMP)	The plan that the City developed in accordance with Section V.B. of the Consent Decree, as well as any additional post-construction monitoring or modeling activities included in any Supplemental Compliance Plan developed and implemented in accordance with Section V.B. of the Consent Decree. The PCMP has two parts: Post-Construction Performance Monitoring (overflow frequency), and Sediment Sampling (water quality).
Post-Construction Performance	Satisfies requirements set in Consent Decree Appendix C: LTCP Requirements, Section D, Post-Construction Monitoring Program.

Term	Definition
Monitoring	
Pump station	A structure that houses pumps and other equipment for lifting stormwater or wastewater in pipes to higher elevations so that it can continue to flow by gravity
Rain garden	Small, vegetated depressions with designed soil mixes that retain runoff for subsequent infiltration or delayed release to the combined sewer system
RainWise	A voluntary program sponsored and partially funded by the City to encourage homeowners to construct private stormwater retention facilities on their property to reduce flows and pollutant loads to the combined sewer system
Receiving water	Any body of water that receives CSO and stormwater discharges
Recovery or retrieval portal	A primary portal used to remove a tunnel boring machine following construction of a tunnel.
Retrofit program	A program designed to reduce CSOs by optimizing the use of existing systems through advanced technologies such as real-time controls, as well as minor structural modifications such as weir height adjustments.
Sanitary sewer system	The portion of the wastewater collection system designed to convey only sewage, and not stormwater, from residences, commercial buildings, industrial plants, and institutions for treatment at a wastewater treatment plant.
Sensitive Area Study	A study that uses a 7 point criteria scale to score basins and determine which basins have the largest negative impact on receiving water bodies and human health.
Sewer overflow	Any overflow, spill, diversion, or release of wastewater from or caused by the sanitary sewer system or the combined sewer system upstream of a City's CSO outfall. This term shall include: (i) discharges to surface waters of the State or United States from the sanitary sewer system and (ii) any release of wastewater from the sanitary sewer system to public or private property that does not reach waters of the United States or the State.
Shared	A reduction strategy that is implemented jointly by the City of Seattle and King County.
soft cost	The costs of engineering design, contract administration, legal services, and other non-hard costs associated with a project.
State Environmental Policy Act (SEPA)	A Washington State law (Chapter 43.21C RCW) that requires state agencies and local governments to consider environmental impacts when making decisions regarding certain activities, such as development proposals over a certain size, and comprehensive plans. As part of this process, environmental impacts are documented and opportunities for public comment are provided
Storm drain	A system of gutters, pipes, or ditches used to carry stormwater from surrounding lands to streams, lakes, or other receiving water. Also refers to the end of the pipe from which the stormwater is discharged
Storm sewer	A pipe (separate from sanitary sewers) that carries only stormwater runoff from buildings and land surfaces
Stormwater	Stormwater is rain and melting snow that runs off surfaces that cannot readily absorb water, including streets, rooftops, and parking lots. As stormwater runs across these hard

Term	Definition
Runoff	surfaces, it picks up pollutants such as oil, grease, and metals, carrying them through the City's storm drain system to our lakes, streams, rivers, and Puget Sound. It also flows into the combined sewer system and causes overflows of raw sewage and polluted stormwater into Seattle waterways
Surface water	Any water, including fresh water and salt water, on the surface of the earth
System characterization	Uses flow monitoring, hydraulic modeling, and existing data on the Combined Sewer System to develop a detailed understanding of conditions
SWMM	EPA's Storm Water Management Model (SWMM) is a rainfall-runoff simulation model used to simulate runoff quantity and quality from urban areas. SWMM tracks the quantity and quality of runoff, and the flow rate, flow depth, and quality of water in each pipe and channel.
Total project cost	The sum of all costs for a project including hard costs, soft costs, property costs, contingencies and management reserves.
Trenching	A method for installing pipe near surface, also called "open cut". The trenching method consists of three stages: digging a trench and stockpiling excavated materials; installing pipe in the trench; and backfilling the trench and restoring the surface
Truck trip	A trip made by a truck hauling materials to or from a construction project
Tunnelling	Method used for excavating a tunnel within the earth. A tunnel boring machine (TBM) is inserted through a launching portal and retrieved from a recovery portal.
Uncontrolled outfall	A CSO outfall that experiences an average of more than one untreated CSO discharge event annually on a twenty year moving average
Wastewater collection system	The collection and conveyance system owned or operated by the City, including all pipes, force mains, gravity sewer segments, pump stations, lift stations, interceptors, diversion structures, manholes, and appurtenances thereto, designed to collect and convey municipal sewage, including residential, commercial, and industrial wastewaters, and stormwater, to King County's wastewater treatment plants or to a permitted CSO outfall. The wastewater collection system includes the combined sewer system, sanitary sewer system, and the partially separated system.

Summary

The Plan to Protect Seattle's Waterways

The City of Seattle (City) owns and operates a Wastewater Collection System that collects residential and industrial wastewaters, and conveys the collected wastewater to regional conveyance systems and wastewater treatment plants owned and operated by King County. About two-thirds of the City is served by a combined sewer system (CSS) that carries a combination of untreated sewage and stormwater. During heavy rains, the CSS can be overwhelmed and overflows at designed relief points in order to avoid sewage flooding in streets and backups into homes and businesses. These overflows are called "Combined Sewer Overflows" or CSOs, and they contribute pollutants to surrounding water bodies and impact their quality and uses. Untreated stormwater runoff from streets, parking lots, and buildings also contributes a wide range of pollutants to receiving waters in Seattle.

The City is preparing a comprehensive strategy, The Plan to Protect Seattle's Waterways (the Plan), to reduce CSOs and stormwater pollutants in order to protect public health, the environment, and to comply with federal and state regulations. The Plan is being developed under a Consent Decree agreement with the U.S. Environmental Protection Agency (EPA), the Washington State Department of Ecology (Ecology), and the U.S. Department of Justice. The Consent Decree was entered in United States District Court for Western District of Washington on July 3, 2013. The Plan will define projects to control a significant source of contamination and when implemented, the Plan will bring the City into compliance with the State and Federal requirements for CSO discharges. Specifically, the Plan will:

- Identify areas of Seattle where projects are needed to reduce combined sewer overflows.
- Evaluate alternatives for reducing combined sewer overflows in these areas.
- Identify additional areas where projects to control and treat polluted stormwater runoff will improve water quality.
- Recommend a schedule for designing and constructing projects.
- Estimate program costs and associated impacts on Seattle Public Utilities customer bills.
- Consider public and stakeholder input.

The Plan includes an Executive Summary (Volume 1), the Long Term Control Plan (Volume 2), the Integrated Plan (Volume 3), and the Environmental Impact Statement (Volume 4).

This volume, the LTCP, includes the following chapters:

1. Introduction and Background
2. System Characterization
3. Development and Evaluation of Alternatives for CSO Control
4. Selection and Implementation of CSO Control Measures
5. Selection and Implementation of Recommended LTCP CSO Control Option

Chapter 1 Introduction and Background

Previous CSO Planning

Seattle has completed five major CSO planning efforts since the 1980's to identify CSO reduction projects. Some projects associated with these plans involved maintenance or modification of existing sewer facilities while others involved construction of diversion structures to direct flows away from CSO outfalls or storage facilities to store excess wastewater until flows decrease enough for the stored wastewater to be returned to the conveyance system. The major CSO reduction planning efforts were as follows:

- 1980 Facility Plan (201 Facilities Planning)
- 1988 CSO Reduction Plan
- 2001 CSO Reduction Plan Amendment
- CSO Reduction Plan Amendment 2005 Update
- 2010 CSO Reduction Plan Amendment

Over the last 25 years, the City of Seattle has successfully reduced CSO discharge volumes into surrounding receiving waters by nearly 70 percent. However, there is still work to be done to control the remaining CSOs and the final reduction in CSO volume is the most challenging.

Regulatory Requirements

The City's CSO Control Program is subject to a number of federal and state regulatory requirements that must be considered in the development of the LTCP, including the following:

- Clean Water Act
- CSO Control Policy and Guidance Documents
- Consent Decree, United States of America and the State of Washington vs. City of Seattle, WA.,
- Washington Administrative Code
- National Pollutant Discharge Elimination System Waste Discharge Permit, No. WA0031682 as modified

In addition, the City must also meet the requirements of two enforcement orders:

- Modified Request for Information and Compliance Order by Consent
- Agreed Order No. 8040 between City of Seattle and Ecology

The Consent Decree has established a schedule for LTCP implementation that includes the following major milestone dates as shown in Table S-1.

Table S-1. LTCP Implementation Milestone Dates

Submit Draft LTCP	May 30, 2014
Submit Final LTCP and PCMP for approval	May 30, 2015
Construction Completion of all CSO control measures in the approved LTCP	December 31, 2025

The City has utilized published EPA guidance documents for the development of its LTCP. The Final LTCP recommends cost-effective CSO controls that will attain water quality standards using the presumption approach in accordance with state, federal, and the City's Consent Decree requirements. One year following construction completion of each CSO control measure, the City will document that the associated CSO outfall has been "controlled" to no more than one untreated discharge (overflow) per year based on a 20-year moving average."

This date may be extended if there is insufficient precipitation during the year following construction completion to demonstrate that a CSO Outfall has been controlled.

The City of Seattle and King County both manage CSO outfalls in the Seattle area: The City currently manages 86 outfalls; King County manages 38. In 2014, a total of 406 CSO events from City-managed outfalls resulted in 116 million gallons of overflow.

CSO Control Status

CSO control is being provided in three phases as summarized below:

- 2010 Plan Projects: Eight outfalls will be controlled through capital projects completed during the years 2010-2020, including CSO reduction projects for Windermere, Genesee, West Seattle, Henderson and the Central Waterfront CSO areas. South Henderson CSO outfall 049 is uncontrolled based on the 2013 Annual CSO Report and the City will complete construction by December 31, 2025, and achieve controlled status by December 31, 2026. The City is also implementing system improvement projects (retrofits) through a parallel program to reduce CSOs. Additional CSO reduction efforts were initiated through the Green Infrastructure program in Ballard, Magnolia, Montlake, North Union Bay, Fremont/Wallingford, and Delridge CSO areas.
- Early Action CSO Programs and Measures: The Consent Decree requires early action for the two North Henderson (044 and 045) and three South Henderson (046, 047 and 171) uncontrolled CSO outfalls. Construction will be completed for the new facilities for basins 044/045 by 2018 and for basins 046/047 and 171 by 2015. Construction of CSO facilities for outfalls in Genesee (044 and 045) will be completed in 2015. Controlled status will be achieved for each of these outfalls one year after completion of construction.
- LTCP: The remaining 22 uncontrolled CSO outfalls will be controlled through the implementation of the approved LTCP which recommends CSO control measures and an implementation schedule to meet the Consent Decree Construction Completion milestone date of December 31, 2025, and the achievement of control status for each outfall as defined in the Consent Decree.

Chapter 2 System Characterization

Nine Minimum Controls

On April 11, 1994, EPA issued a CSO Control Policy. Included in the policy were nine minimum technology-based controls (Nine Minimum Controls or NMC) for addressing CSOs that did not require extensive engineering studies or construction and could be instituted prior to implementation of long term measures. The control policy states that CSO control options should include implementation of the NMC and development of an LTCP in order to meet CWA regulations. Accordingly, the City has commenced a detailed NMC implementation plan.

The CSO outfalls addressed in the LTCP are those outfalls that remain uncontrolled after implementation of the NMC strategies, Early Action projects, and the 2010 Plan projects. Individual CSO locations display characteristics that can vary greatly. Existing data from the 2010 Plan was evaluated as a starting point of the LTCP, but further research was necessary to determine current baselines and control volumes. Therefore, the City conducted extensive system characterization.

CSO Flow Monitoring Program

Flow monitoring was conducted to characterize flows and operational conditions, and identify overflow frequencies and volumes in order to calibrate system modelling of the CSS. The City installed flow meters at 264 sites and collected 3 years of data in 12 CSO areas for uncontrolled CSO outfalls associated with the LTCP. The data provided a solid foundation for hydrologic and hydraulic model calibration and supported the City's efforts to continuously reduce CSOs in compliance with its NPDES permit and the Consent Decree in the most cost-effective manner.

The flow monitoring data was included in the December 2010 LTCP Flow Monitoring Report.

Sensitive Areas

EPA guidelines for Sensitive Areas assist in determining which CSOs have the largest negative impact on receiving water bodies and human health. The LTCP will give the highest priority to controlling overflows in sensitive areas. The SPU's Sensitive Area Study was completed in accordance with the EPA CSO control policy that states:

> *EPA expects a permittee's long-term CSO control plan to give the highest priority to controlling overflows to sensitive areas. Sensitive areas, as determined by the NPDES authority in coordination with State and Federal agencies, as appropriate, include designating Outstanding National Resource Water, National Marine Sanctuaries, waters with threatened and endangered species and their habitat, waters with primary contact recreation, public drinking water intakes or their designated protection areas, and shellfish beds.*

Uncontrolled CSO Basins were ranked using methods defined in published EPA Combined Sewer Overflows Guidance for Screening and Ranking. All uncontrolled CSO outfalls were evaluated and scored using the seven criteria outlined in the guidance document. The seventh criterion (reserved for site-specific concerns not addressed through the other criteria) was defined as annual average CSO frequency and overflow volume based on 20-year long-term simulations using the approved LTCP Hydraulic Model. Priority ranking was then determined by deriving final scores for each outfall's combined total.

The initial (draft LTCP) Sensitive Areas analysis was revised based on CSO control performance reported in the 2013 Annual Report and updated hydraulic model results using a 20 year moving average. The results of this analysis are shown in Figure S-1 and are reported in Section 5.3.6. The updated report replaced the earlier version as Appendix F.

Hydraulic Modeling

Hydraulic models were developed for the uncontrolled CSO basins and outfalls using Build 5.0.022 of EPA SWMM5. SWMM is a dynamic rainfall-runoff simulation model used for single-event or long-term (continuous) simulation of runoff quantity and quality from primarily urban areas. The runoff component of SWMM operates on a collection of sub-catchment areas that receive precipitation and generate runoff. The routing portion of SWMM transports this runoff through a system of pipes, channels, storage, pumps, and regulators. SWMM tracks the quantity of runoff generated within each sub-catchment, and the flow rate and flow depth in each pipe and channel during a simulation period comprising multiple time steps.

Figure S-2 shows the LTCP basin boundaries included in the hydraulic modeling process.

The LTCP Hydraulic Model Report was prepared in accordance with Consent Decree Appendix C, Item B.2, which established requirements for the development and documentation of hydraulic models. The report summarizes the project background, development, and calibration of computer models of the CSS in the 12 uncontrolled CSO areas. These hydraulic models were developed to assess the performance of the existing system, predict wet weather flows, estimate the frequency and volume of CSO events, and support the analysis of system modifications and new CSO control facilities. The reports were submitted to EPA and Ecology for approval in December 2012 and were approved in April 2013.

The EPA's CSO Guidance for Long-Term Control Plan (EPA 832-B-95-002) document indicates that the primary objective of CSS modeling is "to understand the hydraulic response of the CSS to a variety of precipitation and drainage area inputs". Using the flow monitoring statistics, hydraulic models were calibrated so that the City could calculate control volumes for each uncontrolled outfall. A control volume is the amount of combined sewage that would need to be stored in order to meet the overflow performance standard of not more than one discharge event per outfall per year based on a 20-year moving average. The City has determined the uncontrolled CSO outfall annual overflow frequencies, annual overflow volumes and the control volumes required to meet the performance standard. Table S-2 presents the LTCP hydraulic model simulation results based on the 20-year moving average.

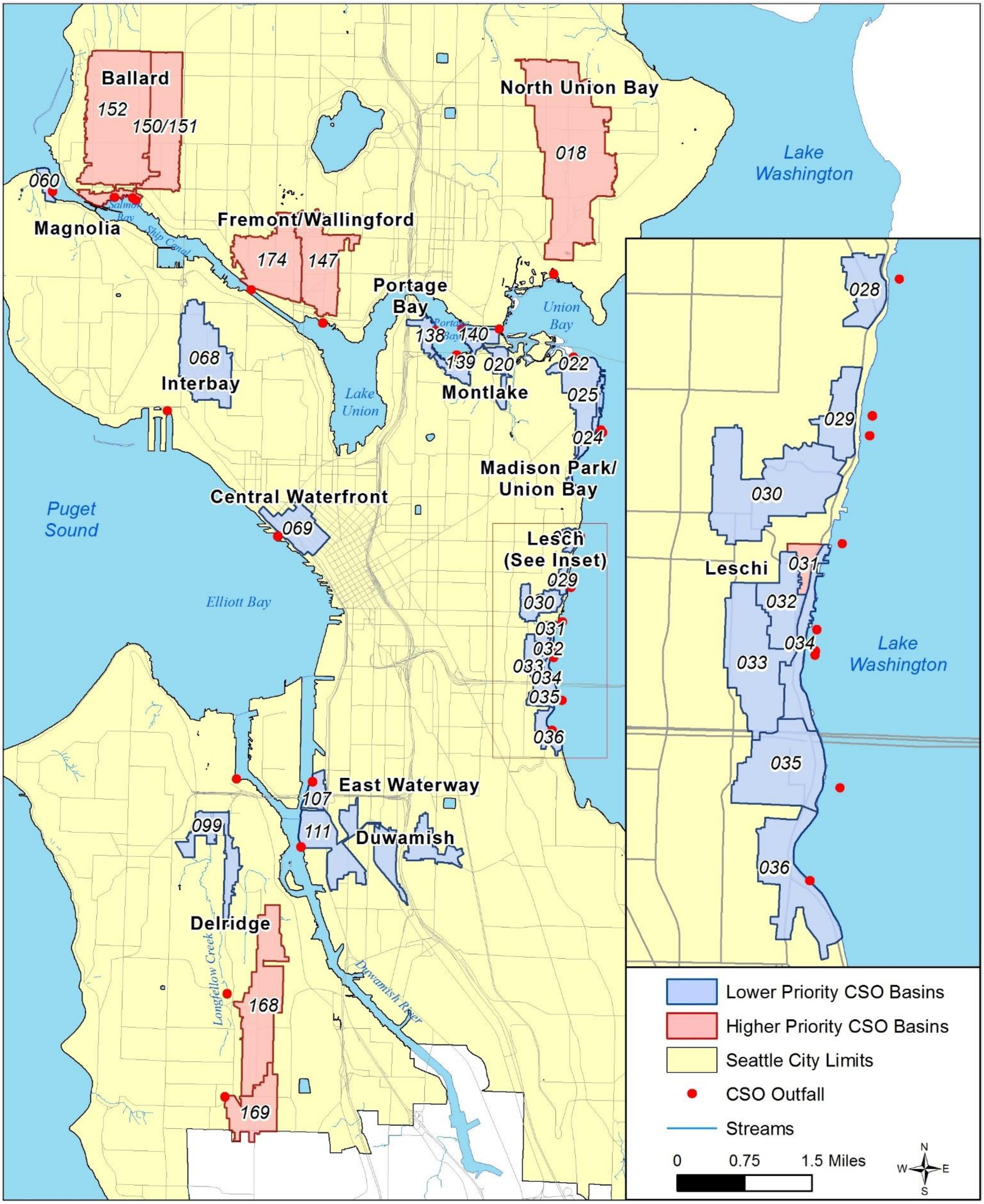

Figure S-1. LTCP Basins Ranked by Highest Priority by Sensitive Area Study

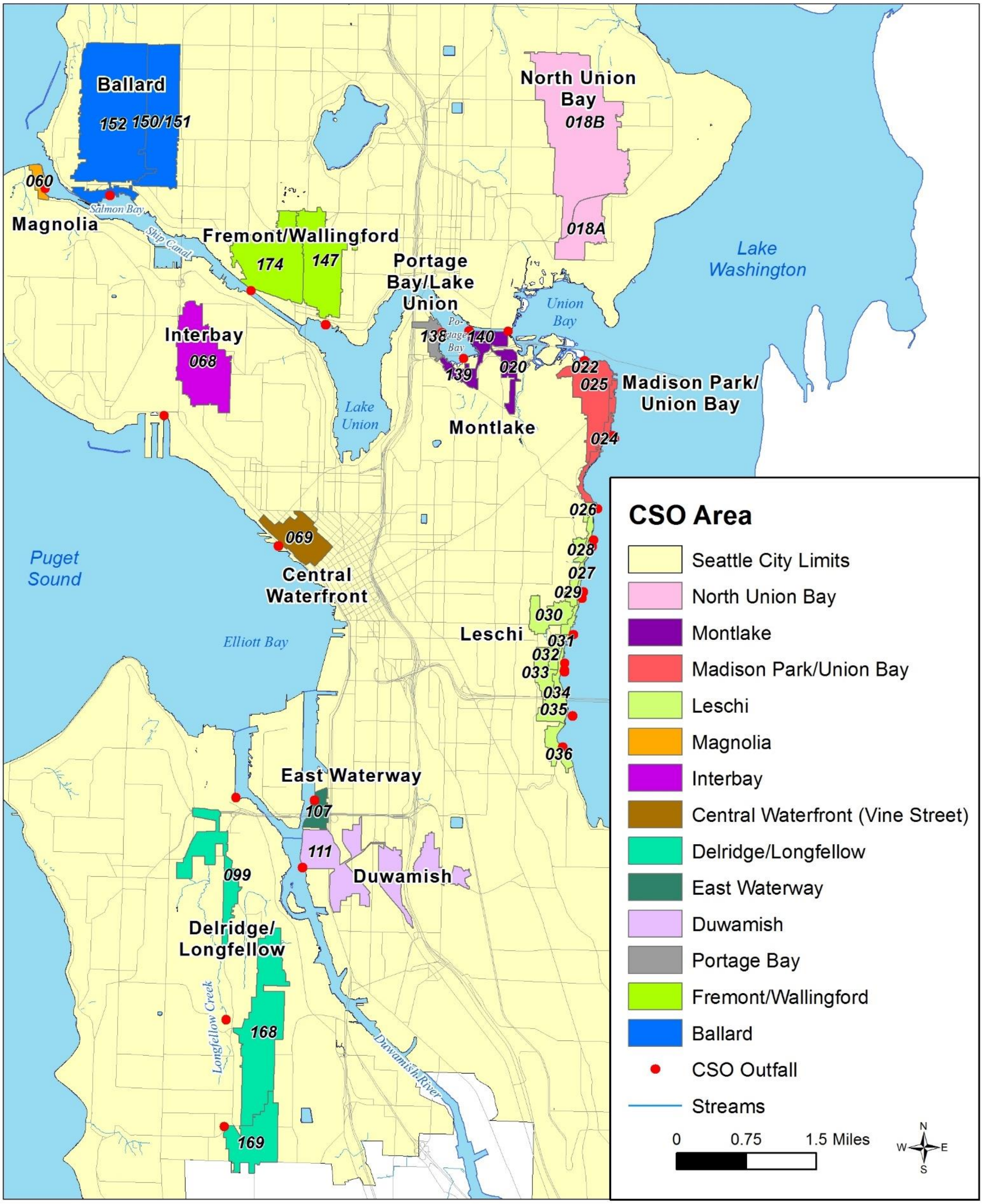

Figure S-2. LTCP Model Basin Boundaries

Table S-2. LTCP Hydraulic Results

CSO area	CSO overflow structure number	Average annual overflow frequency [a]	Average annual overflow volume (MG)[a,c]	Control volume with climate change (MG)[c]	Control volume without climate change (MG)[b,c]
North Union Bay	018A	4.1	0.7	0.26	0.19
North Union Bay	018B	2.4	4.3	1.37	0.98
Montlake	020	1.1	0.64	0.16	0.12
Leschi	026	0.1	<0.01	0	0
Leschi	027	0	0	0	0
Leschi	028	1.2	0.03	< 0.01	< 0.01
Leschi	029	1.6	0.01	0.02	0.01
Leschi	030	0.6	0.06	< 0.01	< 0.01
Leschi	031	16	0.93	0.31	0.25
Leschi	032A	1.7	0.05	0.01	< 0.01
Leschi	032B	6.6	0.22	0.07	0.05
Leschi	033	0.1	<0.01	0	0
Leschi	034	0.9	0.3	0.03	< 0.01
Leschi	035	1.1	0.01	< 0.01	< 0.01
Leschi	036	2.1	0.12	0.03	0.017
Magnolia	060	3.1	0.26	0.11	0.09
Interbay	068A	0.5	0.18	0.02	< 0.01
Interbay	068B	0.6	0.09	0.01	< 0.01
CWF Vine St.	069	1.4	0.54	0.13	0.05
Delridge	099	1.5	0.81	0.17	0.11
East Waterway	107	4.6	0.9	0.5	0.45
Duwamish	111B	1.1	0.2	< 0.01	< 0.01
Duwamish	111C	1.1	0.2	< 0.01	< 0.01
Duwamish	111H	0.7	0.21	0.01	< 0.01
Portage Bay	138	1.7	0.31	0.11	0.07
Montlake	139	1.2	0.04	0.01	< 0.01
Montlake	140	4.4	0.28	0.05	0.02
Fremont	147A	37.5	8.6	2.08	1.90
Fremont	147B	4.4	0.3	0.07	0.06
Ballard	150/151	16	2.9	0.62	0.45
Ballard	152	47.8	23.5	5.38	4.38

Table S-2. LTCP Hydraulic Results

CSO area	CSO overflow structure number	Average annual overflow frequency [a]	Average annual overflow volume (MG)[a,c]	Control volume with climate change (MG)[c]	Control volume without climate change (MG)[b,c]
Delridge/Longfellow	168	2.3	4.42	2.00	1.45
Delridge/Longfellow	169	1.8	2.81	1.19	0.74
Fremont-Wallingford	174	8.6	3.8	1.06	0.99

[a] *From 32 or 34 yr simulation with Rainfall scaling =1.0*
[b] *Estimated control volume after removal of climate change uncertainty but keeping other uncertainties*
[c] *Estimated control volumes less than 5,000 gallons are shown as < 0.01. Control volumes of 0.005 to 0.01 are rounded up to 0.01.*

During 2014, outfall 026 was formally abandoned. Figure S-3 displays 87 CSO outfalls (including the abandoned outfall 026) and specifies their control status based on the 2013 Annual CSO Report.

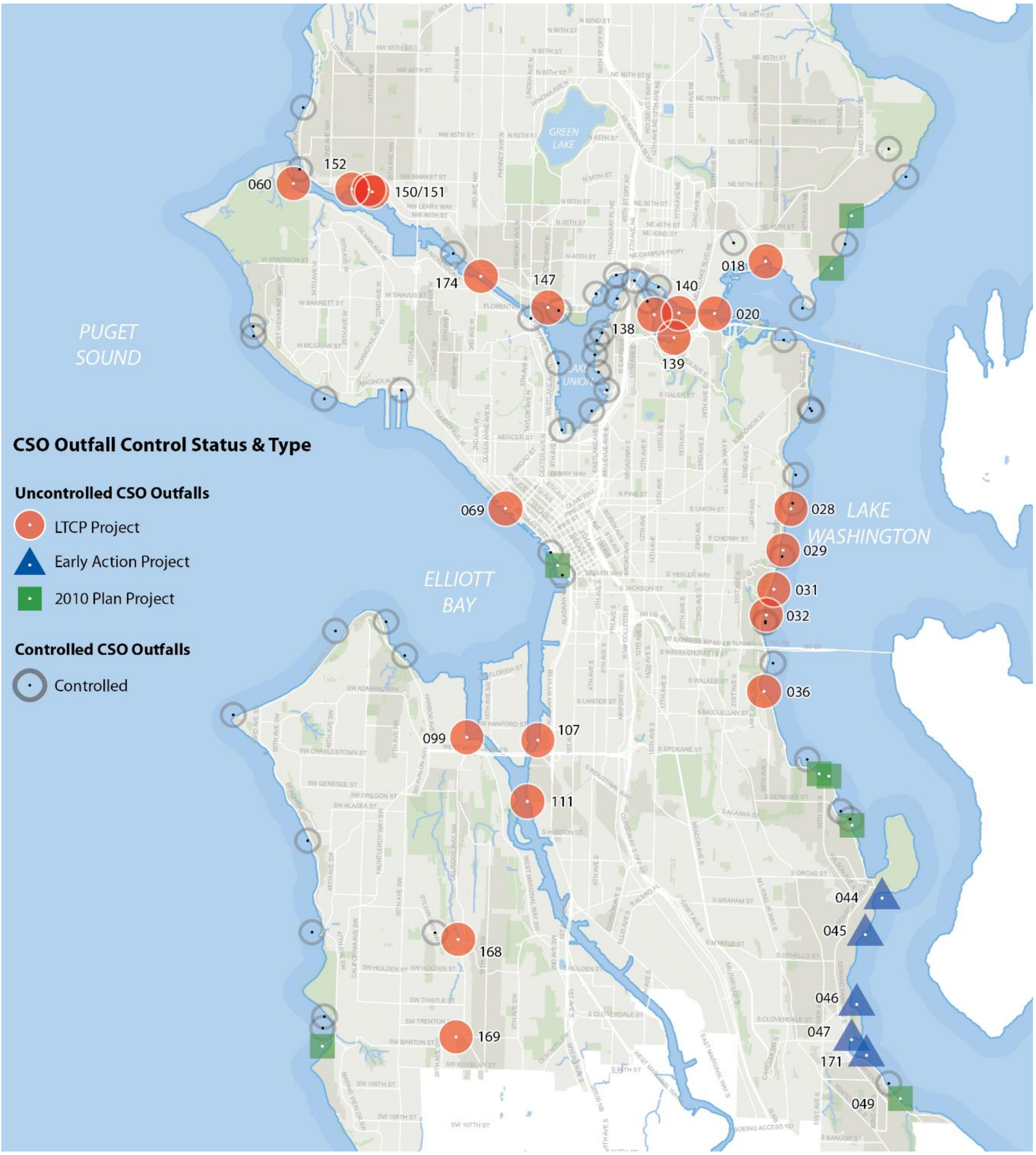

Figure S-3. Seattle's CSO Outfall Locations, Control Status and Project Implementation Phases

Chapter 3 Development and Evaluation of Alternatives for CSO Control

Approach

The Consent Decree (Appendix C, Section C, Paragraph 2) states, "The LTCP shall build upon the alternative analysis work that was performed as part of the development of the City's 2010 CSO Reduction Plan Amendment". The 2010 Plan specified a series of CSO reduction projects for the most critical overflow areas and included projects that will be designed and constructed in accordance with a schedule included in the City's NPDES Permit as well as projects that will be completed in accordance with the Consent Decree Early Action projects. Projects were included for the Windermere, Genesee, Henderson, Ballard, North Union Bay, Interbay, Montlake, Fremont-Wallingford, Central Waterfront, West Seattle and Delridge CSO areas. The 2010 CSO Plan also included preliminary recommendations for CSO Control measures for the remaining uncontrolled CSO basins.

City and King County CSO Project Coordination

The City recognizes the importance of strong coordination with King County in controlling CSOs in the City. All of the proposed LTCP options have elements that may have an impact on King County's downstream wastewater system. Three of the proposed LTCP options include shared City/King County projects along the Ship Canal. Several of the proposed LTCP options include sewer system improvements that will convey additional wastewater volume to the downstream King County system. Regardless of which LTCP option is selected, coordination between the City and King County is critical to successfully designing, constructing, and operating the proposed CSO control projects in the City.

The City and King County are continuing to work together closely to analyze and refine a recommended LTCP option to enhance cost-effectiveness, produce better environmental outcomes, and minimize disruptions to communities. King County has determined the benefits of a shared project to the regional system and the implications of such a project to its own Long Term Control Plan and Consent Decree. Development of a shared City/King County project will be dependent on the City's and King County's analytical results as well as a number of joint factors that will be mutually agreed to in the City/King County coordination strategy. These factors include such things as which agency will be responsible for the design/construction/operations of the shared facility, each agency's project cost-share, operational and implementation roles and responsibilities, the process for dispute resolution, and the ability to fulfil regulatory and contractual obligations. A shared project agreement between the two agencies will be necessary prior to designing and constructing the project. In addition, the City and King County will analyze the impacts of any recommended project on the downstream King County system and agree on an approach to addressing those impacts prior to constructing the project.

LTCP CSO Control Measures

Since the 2010 CSO Reduction Plan was prepared, the control status of some uncontrolled CSO outfalls has changed, as documented in the 2013 Annual CSO Report. In addition, more accurate control volumes have been determined for numerous CSO outfalls as the result of the extensive system characterization effort that was conducted. Because of these changes, some CSO control measures that were eliminated in the 2010 Plan are now being reconsidered, and some recommendations from the 2010 Plan are no longer under consideration.

Sewer system improvements (or retrofits) were proposed as a recommended control measure in the 2010 CSO Plan only for the Delridge CSO area. However, by using the calibrated hydraulic models and supporting flow monitoring data to both test and confirm potential solutions for the City's CSO areas, additional low-cost sewer system improvements have been identified that significantly reduced or eliminated the need for competing storage measures. It is anticipated that as retrofit opportunities are identified and successfully implemented in succeeding program years, they will be incorporated into the detailed planning and design of storage facilities to reduce the size and scope of those facilities.

From this starting point, ongoing alternative evaluation relied on refinements in system characterization, additional demonstration projects under the Green Infrastructure program, retrofit analysis and feasibility, regulatory input, public comment, and other factors to screen for and focus on in the LTCP list of control measures. Table S-3 lists LTCP CSO control measures that have been evaluated in the LTCP.

Table S-3. CSO Control Measures Evaluated in the LTCP

2010 CSO Reduction Plan		LTCP	
2010 recommended control measures	**CSO outfall**	**Feasibility for LTCP after evaluation**	**CSO outfalls**
Roadside rain gardens	150/151, 152, 060, 020,140, 030	The Consent Decree requires that the City identify measures to control all uncontrolled outfalls. The City must document the performance of Green Infrastructure in targeted CSO basins before EPA and Ecology will allow the City to reduce the size of any “grey” control measures. If the effectiveness is proven and approved, the City may implement smaller “grey” control measures and take credit for flow reductions associated with Green Infrastructure.	150/151, 152, 099, 168, 169, 018, 020, 139, 140, 147,138
(RainWise) residential rain gardens	152, 060, 018, 068, 020, 040, 147, 174		099, 168, 169, 111, 028, 029, 031, 032, 036, 018, 020, 139, 140, 147, 174, 138
Cisterns	152, 140, 030		(see RainWise)
Permeable pavements	152, 140		Future re-evaluation
I/I control	152, 020, 34	Due to a lack of cost-effectiveness, will not be considered for CSO Outfalls 152, 020, and 034	N/A
Regulating devices and backwater gates or hydraulically operated sluice gates	169 & 169	CSO retrofit control measures will provide partial control of CSO Outfalls 168 and 169	018, 111, 168, 169
Flow diversion	None	Although not considered in 2010 Plan, may be feasible for CSO Outfall 107 because of close proximity to King County treatment plant	060, 018, 028, 029, 031, 032, 036, 020, 139, 140, 107, 111, 099
In-line storage	150/151, 060	Not technically applicable	N/A
Off-line storage	152, 069, 147, 174, 111, 107, 031, 030, 032, 034, 035, 036, 025, 024, 138, 168, 169,	Will continue to be considered because of cost-effectiveness	060, 150/151, 152, 147, 174, 020, 139, 140, 138, 028, 029, 031, 032, 036, 069, 107, 111, 099, 168, 169
Deep tunnel storage	None	Because of potential shared King County/City project opportunities, the LTCP will evaluate the cost-effectiveness of deep tunnel storage	150/151. 152, 147, 174, 018, 020, 139, 140, 138, 028, 029, 031, 032, 036,
Treatment	None	The 2012 King County CSO Plan evaluated CSO treatment opportunities and determined that the King County Hanford-Lander-King St-Kingdome CSO plant is the most cost effective shared treatment opportunity.	107

The City and King County started to identify potential collaborative CSO control measures in 2009. The two agencies evaluated 40 potential shared projects and identified four feasible shared projects to evaluate in each agency's respective CSO plan: shared Fremont/Wallingford/3rd Ave. W Regulator storage, shared North Union Bay/University Regulator storage, shared Montlake/Montlake Regulator storage, and a tunnel along the Ship Canal. Following the submittal and approval of King County's recommended CSO Control Plan, a second shared tunnel alternatives was developed (Shared West Ship Canal Tunnel) to control Ballard/Fremont/Wallingford/3rd Ave. W.

LTCP Options

The final City-only (independent) and shared alternatives were combined into four system-wide options including:

- Neighborhood Storage Option: Includes independent City storage facilities (storage tanks or CSO storage tunnel)
- Shared Storage Option: Includes 3 shared storage facilities with King County plus independent City storage facilities and flow diversions.
- Shared West Ship Canal Tunnel Option: Includes a shared West Ship Canal Tunnel with King County plus independent City storage facilities and City flow diversions
- Shared Ship Canal Tunnel Option: Includes a shared Ship Canal Tunnel with King County plus independent City storage and City flow diversions.

Table S-4 provides a basin by basin description of the four LTCP CSO control options.

Table S-4. LTCP CSO Control Options

NPDES basins	LTCP Options			
	Neighborhood Storage	**Shared Storage**	**Shared West Ship Canal Tunnel**	**Shared Ship Canal Tunnel**
Ballard	Off-line storage tank or deep tunnel with Fremont/Wallingford Basin	Off-line storage tank	Shared deep tunnel with Fremont/Wallingford and King County 3rd Ave West Regulator	See Table note
Magnolia	Off-line storage pipe	Off-line storage pipe	Flow diversion to North Interceptor	Flow diversion to North Interceptor
North Union Bay	Collection system improvement	Shared off-line storage tank	Collection system improvement	See Table note
Central Waterfront	Off-line storage pipe	Off-line storage pipe	Off-line storage pipe	Off-line storage pipe
Fremont/ Wallingford	Off-line storage tank or deep tunnel with Ballard Basin	Shared off-line storage tank	Shared deep tunnel with Ballard and King County 3rd Ave West Regulator	See Table note

Table S-4. LTCP CSO Control Options

NPDES basins	LTCP Options			
	Neighborhood Storage	**Shared Storage**	**Shared West Ship Canal Tunnel**	**Shared Ship Canal Tunnel**
Duwamish	2 off-line storage pipes	2 off-line storage pipes	2 off-line storage pipes	Flow diversion to Duwamish Interceptor
Delridge	3 off-line storage pipes	3 off-line storage pipes	3 off-line storage pipes	Flow diversion to Harbor trunk plus 2 off-line storage pipes
Montlake	3 off-line storage pipes	Shared off-line storage tank	3 off-line storage pipes	See Table note
Leschi	3 off-line storage pipes plus 1 off-line storage tank	Shared off-line storage tank	3 off-line storage pipes plus 1 off-line storage tank	See Table note
East Waterway	Off-line storage tank	Flow diversion to King County Hanford-Lander-Kingdome-King Street treatment plant	Flow diversion to HLKK treatment plant	Flow diversion to King County Hanford-Lander-Kingdome-King Street treatment plant
Portage Bay	Off-line storage pipe	Off-line storage pipe	Off-line storage pipe	See Table note

Shared deep tunnel with Ballard, Fremont/Wallingford, North Union Bay, Montlake, Portage Bay, Madison Park, Leschi, and King County University, Montlake and 3rd Ave West Regulators

Chapter 3 provides additional detail on the four final LTCP options as presented in the draft LTCP in May 2014. These options were the basis for public participation, other agency reviews and additional refinement as discussed in Chapter 5 of this Final LTCP.

Project Costs

The City developed cost models for planning-level construction costs, allied soft costs, annual operation and maintenance cost, total project costs and net present value (NPV). The cost models were validated through a comparison with the actual construction bid prices for the Windermere and Genesee CSO projects. Tunnel costs and schedules were validated by third party expert consultant and contractor.

Facilities constructed under the LTCP will include real-time controls and will require extensive commissioning. These commissioning costs have been capitalized along with engineering and construction costs. Non-capital costs include recurring annual operation and maintenance expenses, fees paid to King County for treatment of additional flows, ongoing flow monitoring for system control, and post-construction monitoring to demonstrate Consent Decree compliance.

Total project costs based on 2013 construction costs were developed and presented in the Draft LTCP in May 2013 and are further described in Chapter 3. Additional detail is also provided for operational and maintenance costs.

The project costs were modified during the refinement process and are described in Chapter 5.

Chapter 4 Selection and Implementation of CSO Control Measures

Rating and Ranking

The Draft LTCP performed a "rating and ranking" of the LTCP options in accordance with the EPAs "Combined Sewer Overflows Guidance for Long-Term Control Plan, 1995". Non-monetary factors were evaluated based on the conceptual development work on the LTCP options. This technique is called Multiple Objective Decision Analysis (MODA) and incorporates a mechanism for consideration of non-monetary, social, and environmental factors as well as cost to create a structured comparison of competing solutions in support of a decision

Environmental Impacts

There are two tables in Chapter 4 (4-10,Summary of Construction Impacts and 4-11, Summary of Operational Impacts) that list each LTCP Option and their impacts based on13 different resources. These resources are:

1. Earth
2. Air Quality
3. Surface Water
4. Biological Resources
5. Energy and Climate Change
6. Environmental Health and Public Safety
7. Noise and Vibration
8. Land Use and Visual Quality
9. Recreation
10. Historic, Cultural, and Archaeological Resources
11. Transportation
12. Utilities
13. Socioeconomics and Environmental Justice

Construction and operational impacts for each option are primarily related to Noise and Vibration, Land Use and Visual Quality, Recreation, and Transportation, which are summarized below in Table S-5. Because this is a plan-level evaluation, project details and construction methods have not yet been defined. Actual construction activities would vary and would be determined during subsequent, project-specific review. Please refer to Chapter 4 for full versions of Environmental Impacts tables.

Table S-5. Summary of Major Impacts Considered in the EIS

Construction impacts	Operational impacts
Neighborhood Storage Option	
The Neighborhood Storage Option would likely result in the most geographically dispersed impacts throughout the Plan area. Construction impacts would last from between 1.5 years for a storage pipe to as long as 5 years for a large storage tank. Noise and Vibration: Construction of projects would result in short-term, moderate to substantial, increases in noise. The longest duration impacts would occur in Ballard and Fremont/Wallingford associated with storage tank construction. Land Use and Visual Quality: Temporary easements would be needed from some private landowners, depending on the project. Property acquisition could be required for storage tanks and tunnel portals. Impacts would potentially be greatest under this option. Recreation: Impacts could occur if tanks or tunnels are located in or adjacent to parks. SPU would attempt to avoid siting tanks or tunnels in park locations. Transportation: Potential construction-related transportation impacts would be highly visible and are of concern to local residents, business owners, and commuters. Transportation impacts would include increases in traffic volumes due to construction-generated truck trips and commute trips of construction workers, and roadway lane and sidewalk closures where construction activities take place. More dispersed impacts would occur under this option. Under this option, localized impacts would occur in certain areas (e.g. Leschi) where the ability to accommodate lane closures for storage pipe construction is highly constrained due to limited arterials.	Operational impacts are not expected to be significant. Noise and Vibration: The net operational effects would be minor in the Plan area. Noise would be generated by pump stations and odor control facilities. All facilities would be designed and maintained to reduce noise to permissible levels. Because this option would likely have the most project sites needing pump stations and other facilities, potential noise impacts are greatest for this option. Land Use and Visual Quality: Private property or permanent easements could be acquired. Visual impacts would be minimal. Recreation: This option has the highest potential to cause park and recreation impacts because it would likely include the most tank facilities. If located in a park, it could constrain certain future uses of that area for park purposes. However, there is a potential to provide recreational facilities on top of storage tanks following construction. Transportation: Overall, the operational effects from vehicle trips generated by facility maintenance are expected to be minor Utilities: There is a potential for downstream impacts to King County's wastewater facilities. The City will work closely with King County to avoid potential impacts, but if downstream impacts cannot be avoided, the City will work with the County to develop appropriate and adequate mitigation.
Shared Storage Option	
The Shared Storage Option reduces the total number of tanks constructed, but concentrates impacts at shared tank locations in the Ship Canal and Lake Washington neighborhoods. Construction duration ranges from 1 year for sewer system improvements to 4.5 years for a large shared storage tank. Noise and Vibration: Impacts would be similar to the Neighborhood Storage Option but would be of potentially higher intensity and concentrated at fewer locations. Land Use and Visual Quality: Impacts would be similar to the Neighborhood Storage Option, but fewer project sites would be required. However, the larger, shared tanks would require a larger construction footprint. Recreation: Impacts would be similar to the Neighborhood Storage Option but concentrated at	The Shared Storage Option concentrates impacts at shared tank locations in the Ship Canal and Lake Washington neighborhoods; however, operational impacts of the shared tanks are expected to be minor for most resources. Noise and Vibration: Impacts would be similar to the Neighborhood Storage Option but there would be less noise-generating pump stations and mechanical facilities. Land Use and Visual Quality: Impacts would be similar to the Neighborhood Storage Option. Recreation: Impacts would be similar to the Neighborhood Storage Option, but fewer project sites would be required. If located in a park, the larger, shared tanks could have a larger impact. Transportation: Impacts would be the same as under the Neighborhood Storage Option.

Table S-5. Summary of Major Impacts Considered in the EIS

Construction impacts	Operational impacts
fewer locations. Transportation: Impacts would be similar to the Neighborhood Storage Option but concentrated at fewer locations.	Utilities: There is a potential for downstream impacts to King County's wastewater facilities. The City will work closely with King County to avoid potential impacts, but if downstream impacts cannot be avoided, the City will work with the County to develop appropriate and adequate mitigation.
Shared West Ship Canal Tunnel Option	
The Shared West Ship Canal Tunnel Option reduces the total number of tanks constructed, but concentrates impacts at tunnel construction locations in the Ship Canal neighborhoods. Construction duration would range from 1 year for some flow diversion projects to as long as 6 years for the shared tunnel. Noise and Vibration: Impacts would be similar to the Neighborhood Storage Option but would be of potentially higher intensity and concentrated at fewer locations. Vibration impacts along the tunnel routes are likely to be a concern to property owners. Land Use and Visual Quality: Land use impacts would potentially be the least under the tunnel options, though impacts would be concentrated at fewer locations (tunnel construction locations). Recreation: Impacts would be similar to the Neighborhood Storage Option but concentrated at fewer locations. Transportation: Impacts would be similar to the Neighborhood Storage Option but concentrated at fewer locations. This option would result in substantially more truck trips over a multi-year period in Ballard compared to the Neighborhood Storage and Shared Storage Options. There is a potential to remove tunnel materials by barge, with the potential to eliminate over 16,000 potential truck round trips	Operational impacts of the tunnel are generally expected to be minor, but will require agreements with King County to ensure that operational impacts to their facilities do not occur, or appropriate mitigation if impacts are unavoidable. Noise and Vibration: Impacts would be similar to the Neighborhood Storage Option but there would be less noise-generating pump stations and mechanical facilities. Recreation: This option would have less potential for long-term impacts than both the Neighborhood Storage and Shared Storage Options since the tunnel would replace the need to site several storage tanks in the Ship Canal Neighborhoods, with less potential for recreation impacts. Land Use and Visual Quality: Impacts would be similar to the Neighborhood Storage Option, though less property or easements would need to be retained following construction. Area needed for construction staging could be sold following tunnel construction. Transportation: Impacts would be the same as under the Neighborhood Storage Option.
Shared Ship Canal Tunnel Option	
The Shared Ship Canal Tunnel Option reduces the total number of tanks constructed, but concentrates impacts at tunnel construction locations in the Ship Canal and Lake Washington neighborhoods. Noise and Vibration: Impacts would be similar to the Neighborhood Storage Option but would be of potentially higher intensity and concentrated at fewer locations. Vibration impacts along the tunnel routes are likely to be a concern to property owners. Land Use and Visual Quality: Land use impacts would potentially be the least under the tunnel options, though impacts would be concentrated at fewer locations. Recreation: Impacts would be similar to the Neighborhood Storage Option but concentrated at	Impacts would generally be minor for most resources. Operation of the tunnel would be conducted in accordance with agreements with King County, to avoid operational impacts to King County facilities. If impacts to downstream facilities cannot be avoided, the City will work with the County to develop appropriate mitigation. Noise and Vibration: Impacts would be similar to the Neighborhood Storage Option but there would be fewer noise-generating pump stations and mechanical facilities. Land Use and Visual Quality: Impacts would be similar to the Neighborhood Storage Option, though less property or easements would need to be retained following construction. Roughly one-half acre of land would be permanently required for the tunnel, and the land acquired for

Table S-5. Summary of Major Impacts Considered in the EIS

Construction impacts	Operational impacts
fewer locations. Transportation: Impacts would be similar to the Neighborhood Storage Option but concentrated at fewer locations. This option would result in substantially more truck trips over a longer period on the south side of the Ship Canal at the potential tunnel launch location. The potential to excavate materials by barge would be similar to the Shared West Ship Canal Tunnel Option, with the potential to eliminate over 32,000 potential truck round trips.	construction could be sold. Recreation: This option would have less potential for long-term impacts than all options since the tunnel would replace the need to site several storage tanks, with reduced potential for recreation impacts. There would be a potential for impacts on the south side of the Ship Canal and in North Union Bay if the tunnel portals are sited in a park or recreation area. Transportation: Impacts would be the same as under the Neighborhood Storage Option.

Implementation of LTCP Options

The implementation schedules include the sequence and duration of steps to complete for each LTCP CSO Control Measure including design, construction, commissioning and demonstration of control. The implementation schedules will affect rates, employment, public and local businesses, agency resource allocation, and other agencies projects.

If it is not possible for the City to design and construct all measures simultaneously, the LTCP includes a phased schedule based on the relative importance of each measure, with the highest priority given to those projects which have the highest pollutant reduction.

The LTCP used two methods to determine the priority of projects. The first method followed the EPA guidelines for Sensitive Areas, which gives the highest priority to the highest ranked sensitive areas. The second method compares the relative cost-effectiveness of each CSO project on a total project cost per gallon of CSO discharge volume reduced. The highest priority is given to the CSO projects with the lowest cost per CSO discharge gallon reduced.

For each CSO Control Measure, the Consent Decree requires the implementation schedule to specify the critical milestone dates for the following project activities: Engineering Report, Plans and Specifications, Construction Start, Construction Completion and Achievement of Controlled Status. Because the CSO projects range in construction complexity and project costs, the CSO projects have project durations ranging from 3 years to 14 years based on SPU project implementation experience. The project durations assumptions are listed in Table S-6.

Table S-6. Option Development (Months)

CSO control measure	Overall project duration	Engineering report	Plans and specifications	Construction start	Construction completion	Achievement of control status
Large CSO tanks (1 MG or larger)	148	36	36	6	54	16
CSO tanks	109	24	24	6	39	16
Pipe storage	73	12	12	6	27	16
Flow diversion	109	24	24	6	39	16
Collection system improvements (retrofits)	73	12	12	6	27	16
West Ship Canal Tunnel	148	36	36	6	54	16
Ship Canal Tunnel	184	36	36	6	90	16

Detailed schedules for each of the four options are presented in Chapter 4. These schedules were established in support of balanced City resource allocation and to level rate impacts.

The implementation schedules were re-analyzed for the preferred option and are presented in Chapter 5. The schedules meet the Consent Decree construction completion milestone dates for the City (2025); however, the Shared West Ship Canal Tunnel schedule does not meet King County's Consent Decree milestone construction completion date for 3rd Ave W (2023). A minor schedule milestone modification to the King County Consent Decree will be required.

Projected Rates

Using planning-level cost estimates, the City evaluated the overall impact to the monthly wastewater and drainage rates to implement the LTCP and the Integrated Plan alternatives. A preliminary rate schedule was developed in the Draft LTCP published in May 2014 and is presented in Chapter 4.

Subsequent to publication of the Draft LTCP, the refinements discussed in Chapter 5 were incorporated into a revised rate analysis and are shown in Chapter 5.

Operational Planning

While the City and King County own and operate discrete wastewater collection and conveyance systems, parts of King County's system are interconnected with the City's where the operation of one impacts the operation of the other. All of the wastewater collected in the City's Wastewater Collection System is discharged to a King County owned interceptor for transport to one of King County's wastewater treatment plants. In addition, the City owns CSO outfalls which are located upstream and in close proximity to King County owned CSO outfalls. The City is currently working with King County to prepare a Joint Operations and System Optimization Plan ("Joint Plan") for the City's Wastewater Collection System and those interdependent portions of King County's regional wastewater conveyance and treatment system that are hydraulically connected to the City's system. The result of this effort is the development of a Joint Plan that is consistent with both entities' operational objectives, ensuring the optimal level of coordination and information sharing is maintained, and optimizing system and shared operations between both entities. The Joint Plan will describe a procedure for operating their existing systems, include a process for incorporating the Joint Plan into the design of new capital projects for the combined systems, ensure the optimal level of coordination and information sharing is maintained, and optimize system and shared operations. The Final Joint Operations and System Optimization Plan ("Joint Plan") will be submitted for approval to EPA and Ecology in March 2016. The operations plan presented in the Draft LTCP will include preliminary results from the Joint Plan and will be subject to revisions based on the approved Joint Plan. Based on the recommended LTCP option, SPU will prepare a final operation plan incorporating the final implementation schedule and updated Joint Operations and System Optimization Plan information.

Operations and maintenance staffing requirements have been prepared for specific positions, number of FTEs, and staff responsibilities for each LTCP option. Table S-7 summarizes the additional operations and maintenance LTCP staffing requirements for current (2015), near term (2020), Construction Completion (2025) and Achievement of Controlled Status (2030).

Table S-7. Operations and Maintenance Staffing Needs for Proposed LTCP Options

LTCP option	LTCP staffing requirements (FTEs)			
	2015 (current)	2020 (near term)	2025 (construction completion)	2030 (controlled status)
Neighborhood Storage				
Operations	0.0	0.5	4.2	4.2
Maintenance	0.0	0.7	7.4	7.4
Total O&M staff	0.0	1.2	11.6	11.6
Neighborhood West Ship Canal Tunnel				
Operations	0.0	0.5	4.1	4.2
Maintenance	0.0	0.7	7.1	7.1
Total O&M staff	0.0	1.2	11.2	11.2
Shared Storage				
Operations	0.0	0.4	2.9	2.9
Maintenance	0.0	0.4	6.1	6.1
Total O&M staff	0.5	0.8	9.0	9.0

Table S-7. Operations and Maintenance Staffing Needs for Proposed LTCP Options

LTCP option	LTCP staffing requirements (FTEs)			
	2015 (current)	2020 (near term)	2025 (construction completion)	2030 (controlled status)
Shared West Ship Canal Tunnel				
Operations	0.0	0.5	4.1	4.1
Maintenance	0.0	0.7	6.9	6.9
Total O&M staff	0.0	1.2	11.0	11.0
Shared Ship Canal Tunnel				
Operations	0.0	0.2	2.0	2.0
Maintenance	0.0	0.2	4.5	4.5
Total O&M staff	0.0	0.4	6.5	6.5

The general overall operating strategy is to provide sufficient real time flow monitoring for each CSO facility to determine the influent flows, CSO facility performance, CSO overflow and CSO storage release flows back into the City or King County interceptor system. Figure S-4 illustrates how the typical LTCP CSO facility will need to operate using the proposed Fremont-Wallingford Neighborhood Storage Tank as an example.

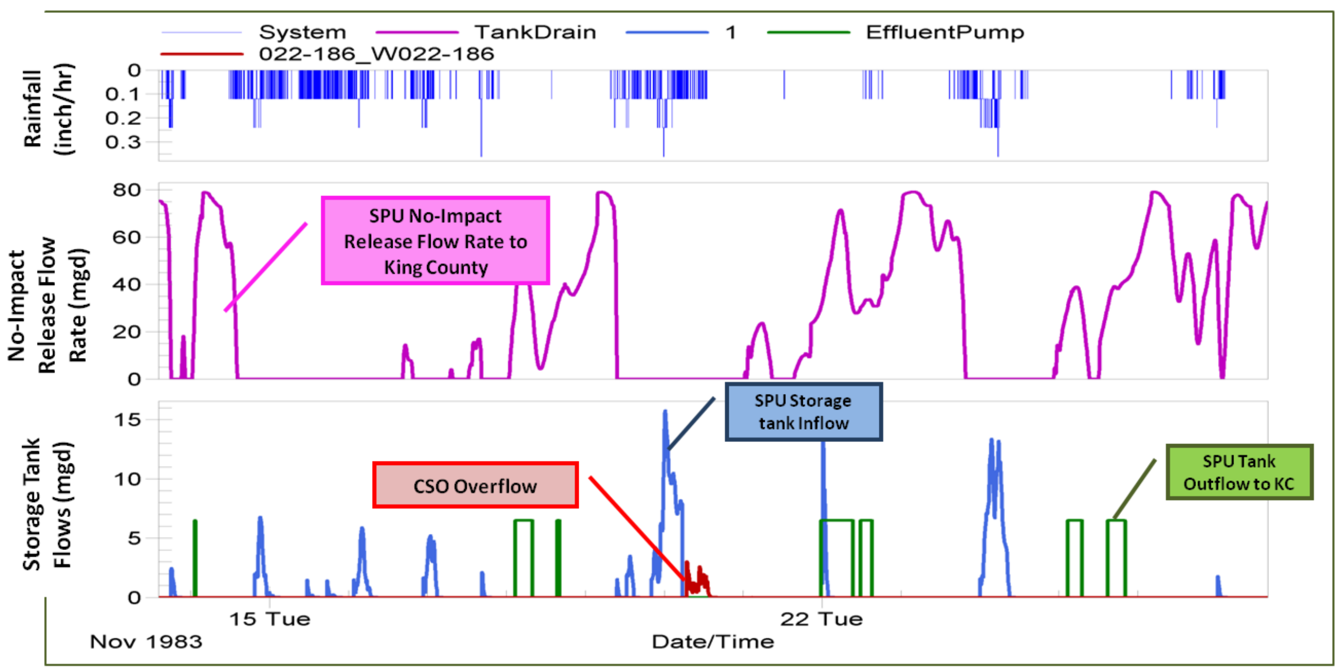

Figure S-4. Example of Fremont/Wallingford Storage Operating Strategy

As the rainfall increases (top row in Figure S-4), CSO flows will increase in both the King County and City sewer systems. To prevent CSOs, rain-induced combined sewer flows (bottom row) will be diverted into the proposed LTCP storage projects to prevent overflows. As rainfall subsides and interceptor capacity is available, stored flows can be released back into the sewer system.

However, since all City flows go into the King County interceptor system, the King County interceptor and treatment plant capacity is a major factor in determining how the City CSO facilities operate and when the City CSO facilities can release City stored flows into the King County system. Available King County interceptor capacity is shown over time as "no impact release rates" (middle row). LTCP facilities will need to release stored flows multiple times during prolonged CSO event such as the example storm event shown.

Sufficient flow monitoring and real-time control systems must be provided to determine when and how much flow needs to be diverted into storage and when the stored flows can be released to the King County interceptor system.

Chapter 5 Selection and Implementation of Recommended LTCP CSO Control Option

Overview

Subsequent to issuance of the draft LTCP publication in May 2014, and receipt of comments, additional refinements were made to the four final LTCP options. The City received updated storage release rates from King County that were used to analyze and adjust the sizing of the proposed control measures. Cost estimates were updated based on the new sizing, then community and environmental impacts were re-assessed. The four options were compared and two of the options (Neighborhood Storage and Shared West Ship Canal Tunnel options) were selected for final analysis. Since costs of the options were similar, the final analysis focused more on environmental and community impacts and the ability of the City and County to collaborate on a shared project.

Public and Regulatory Agency Participation Program

SPU has included a comprehensive public and regulatory agency participation program in preparing the draft and final LTCP. A summary of the overall participation program is presented in Table S-8.

Table S-8. Public Participation Plan

Consent Decree requirements (Appendix C, Section A.1-A.5)	Proposed public participation
How the City will make LTCP information available for public review.	Community Guide update briefings Video for website Briefings offered Spring/Fall (Spring 2013 - Spring 2015) or if specifically requested by a stakeholder group. Website updates to be completed spring/fall (Spring 2013 – Spring 2015)
How the City will solicit public comments on the development of the LTCP	Briefings given to stakeholder group (Sounding Board) in 2010-2011 Scoping meetings Scoping Summary Reports Online Questionnaires in Spring 2013, Fall 2013, and Spring 2014 Public meeting on the Draft LTCP/Integrated Plan and Public Hearing on Draft EIS June 2014 Public Ordinance Process to adopt the preferred alternative (Spring 2015)

Table S-8. Public Participation Plan

Consent Decree requirements (Appendix C, Section A.1-A.5)	Proposed public participation
Summary of public hearings during LTCP development to provide public with information and to solicit public comments.	Draft EIS public hearing summary report LTCP/Integrated Plan Public and Regulatory Agency Participation Summary Report
Program for consideration of comments provided by the public as the City develops the LTCP.	Public Meeting
How the City will ensure that Plaintiffs are kept informed of the LTCP development. Regular report submittal to Plaintiffs summarizing public comments.	Quarterly meetings with EPA/Ecology (addresses both LTCP and Integrated Plan) Status updates in annual CSO Reports. Submission of Draft Final Plan for review and comment (February 2015)

Public and Regulatory Comments

Following publication of the Draft LTCP in May 2014, the City received comments from the public, agencies and EPA/Ecology, which have been incorporated into the Final LTCP. Comments were also received on the draft EIS and were incorporated into the Final EIS which was published in December 2014.

Evaluation of King County Boundary Conditions or "No Impact Release Rates"

All of the City's CSO basins discharge into the King County system through various facilities. In order to analyze potential impacts to their system, King County provided time series of flow rates at key locations in their interceptor system. These time series of flow rates, called no-impact release rates (NIRR), provide times and maximum flow rates for release of stored flow from the City CSO control facilities that would result in minimal or no impact on the operation of King County's facilities. Please refer to Figure S-4.

The City analyzed the CSO Control Measure using the approved Version 5 (SWMM) v22 models using the King County NIRRs to confirm that the CSO control measures would comply with regulatory performance requirements and minimize impacts to the King County system. Where necessary, minor modifications were made to the City's LTCP CSO control measures to account for the NIRR restrictions.

Joint Evaluation of King County and City Shared Options

The City recognizes the importance of coordination with King County in controlling CSOs in Seattle. All City LTCP options have elements that may impact King County's downstream wastewater system. Three of the evaluated LTCP options include shared City/King County projects along the Ship Canal. Several of the evaluated LTCP options include sewer system improvements that would convey additional wastewater volume to the downstream King County system. All interagency coordination will be conducted in accordance with commitments included in the SPU and King County coordination strategy, developed by both agencies. The coordination strategy considers specific factors that will be considered in evaluating and making a recommendation on which CSO projects will be undertaken jointly or independently by either the City or King County. Section 5.4.2 discusses the evaluation factors and the process.

Assessment of Control Benefits from System Improvement Program

The City has been conducting an ongoing program to identify, design, and construct system improvement projects in CSS areas. These projects are typically smaller in scope and consist of minor, low-cost modifications to existing infrastructure.

The implementation of these improvement projects will likely result in a reduction in the control volume required to bring the LTCP basins into control. The impact of these improvements on the control volumes of CSO control measures recommended in this LTCP will be analyzed after the construction of the improvement projects. If the sewer system improvement is successful and controlled status is attained, it will be documented in the annual CSO Report and no future storage facility will be needed. If the sewer system improvement reduces the control volume but does not achieve controlled status, reductions in the size of the future storage facility will be address in the engineering report that is submitted for approval for the individual LTCP project.

As improved system characterization and hydraulic model application has occurred during the LTCP planning process following issuance of the Draft LTCP in May 2014, the potential for significant CSO control resulting from system improvements has become apparent. For this reason, the LTCP refinement activity has made substantial changes in the prioritization and scheduling of the individual CSO control measures to allow time for construction and evaluation of system improvements proposed under the Retrofit Program.

Final LTCP Options for Evaluation

Two LTCP options were retained for final evaluation: Neighborhood Storage and Shared West Ship Canal Tunnel. Table S-9 summarizes the LTCP CSO areas and the specific CSO control measures for each option.

Table S-9. Final LTCP Option Descriptions and CSO Control Measures

CSO area	LTCP options	
	Neighborhood Storage	Shared West Ship Canal Tunnel
Ballard	Off-line storage tank	Shared deep tunnel with Fremont/ Wallingford and WTD 3rd Ave. W and 11th Ave. NW
Magnolia	Off-line storage pipe	Off-line storage pipe
North Union Bay	Collection system improvement	Collection system improvement
Central Waterfront	Off-line storage pipe	Off-line storage pipe
Fremont/ Wallingford	Off-line storage tank	Shared deep tunnel with Ballard and WTD 3rd Ave. W and 11th Ave. NW
Duwamish	2 off-line storage pipes	2 off-line storage pipes
Delridge	3 off-line storage pipes	3 off-line storage pipes

Table S-9. Final LTCP Option Descriptions and CSO Control Measures

CSO area	LTCP options	
	Neighborhood Storage	Shared West Ship Canal Tunnel
Montlake	3 off-line storage pipes	3 off-line storage pipes
Leschi	3 off-line storage pipes plus 1 off-line storage tank	3 off-line storage pipes plus 1 off-line storage tank
East Waterway	Off-line storage tank	Off-line storage tank
Portage Bay	Off-line storage pipe	Off-line storage pipe

Identification of Recommended LTCP Option

Based on the evaluations of the two final options, results of the EIS prepared for the LTCP, and cooperative agreements with King County, the City selected the Shared West Ship Canal Tunnel Option as the recommended LTCP option. The City would be the lead agency for construction and operation of the facility under the terms of a joint project agreement to be executed with King County.

The Shared West Ship Canal Tunnel option is recommended because it is a more flexible means of controlling CSOs in the area of the West Ship Canal that also should result in the least long-term impacts to the neighborhoods where the tunnel would be located. Cost difference is not a determining factor in the recommendation because the options considered are within the same cost range. The determining factors in support of the recommendation are as follows:

- The Shared West Ship Canal Tunnel option allows the City and King County to work together to build a single facility to serve multiple common needs. Opportunities to achieve economies of scale and operational flexibility are greater with the Shared Tunnel than with separate neighborhood storage tanks.
- The Shared West Ship Canal Tunnel option is consistent with terms contained in each jurisdiction's Consent Decrees requiring coordination of the planning, implementation, and operation of CSO control within the combined system serving the Seattle area.
- The Shared West Ship Canal Tunnel option will likely have greater impacts to neighborhoods during construction than the Neighborhood Storage option. However, once constructed, the Shared West Ship Canal Tunnel will largely be underground. The impact to neighborhoods resulting from hosting permanent facilities is less than the Neighborhood Storage option.

Flow diversion for the East Waterway CSO control measure under the recommended LTCP option was revised to a neighborhood storage CSO control measure because the King County Hanford/Lander/King Street/Kingdome (HLKK) CSO plant will not be completed until December 31, 2030 and without an operating HLKK CSO Plant, the City will not meet its Consent Decree construction completion date of December 31, 2025. Constructing a neighborhood storage CSO control measure will allow the City to meet its Consent Decree construction completion date of December 31, 2025.

Flow diversion for the Magnolia CSO control measure was revised to a neighborhood storage pipe because of hydraulic capacity limitations of the existing King County North Interceptor at the Magnolia CSO discharge location. Constructing a neighborhood storage CSO control measure will allow the City to discharge its CSO flows to the WTD interceptor without impacting the WTD interceptor hydraulic capacity.

There were no other changes to the option descriptions provided in Section 3.6.2

A summary of the comparison between the two final options is presented in Table S-10.

Table S-10. Comparison of Final LTCP Options

Evaluation factors		**LTCP option**	
Factor	**Items to be considered**	**Neighborhood Storage Option**	**Shared West Ship Canal Tunnel Option**
Financing	Financial benefits are to be realized and shared by both agencies through economies of scale and other efficiencies from replacing a larger number of independently designed and constructed storage projects with a smaller number of jointly developed storage projects.	The construction and long-term operating costs of the two alternatives for the City ratepayers are very similar. The total project cost and NPV of the two alternatives, given the accuracy of project development phase cost estimates, does not indicate a significant cost difference between the two options.	
Scheduling	The effect of implementing joint projects on either the City's or King County's ability to meet their respective Consent Decree milestone dates and King County's approved LTCP project implementation sequence will be considered. Both utilities must agree that a shared project can be managed within their respective schedules before recommending shared project implementation.	More complicated permitting/regulatory compliance requirements from dispersed large tank construction and operation.	The City's and King County's Consent Decrees contain identical language requesting the agencies to work together for a regional solution. The tunnel option requires a partnership for a joint project with WTD that independent tanks do not require. Completion of Construction for King County's 3rd Ave W facility will require an amendment in the milestone for construction completion from December 31, 2023 to December 31, 2025. The agencies are working together to confirm the schedule for construction completion.

Table S-10. Comparison of Final LTCP Options			
Evaluation factors		**LTCP option**	
Factor	**Items to be considered**	**Neighborhood Storage Option**	**Shared West Ship Canal Tunnel Option**
Community impacts	The evaluation of whether to develop shared CSO control projects in lieu of independent City and King County projects needs to consider the number of affected communities and the scale of larger joint CSO control facilities on host communities. Shared CSO control projects present the opportunity for the City and King County to reduce the total number of CSO control facilities to be constructed, which can reduce the number of communities impacted by their construction, operation, and maintenance. Conversely, larger joint CSO control facilities could result in larger-scale impacts to host communities.	There are significantly more short-term construction impacts from major tank construction and more long-term community impacts from land use restrictions and loss of property for dedicated major tank sites.	Community impacts from construction noise, traffic disruption, property consumed and removed from potential other uses and street disruptions are lower with this option. A large portion of the tunnel construction sites could be sold for private use following the completion of construction.
Regulatory considerations	All CSO control projects must meet the control standard of no more than one CSO event per year. The evaluation of shared or independent CSO control projects should consider which type(s) of project are most likely to meet compliance standards.	Both agencies have evaluated CSO control options of storage or treatment. The King County LTCP approved plan contains both treatment and storage projects based on cost effectiveness (cost and regulatory compliance). These projects are required to meet a phased implementation schedule included in King County's consent decree.	The Shared West Ship Canal Tunnel provides greater flexibility to adequate control for all seven outfalls due to the ability to optimize storage for each basin depending on the variability of rainfall and flows in each basin. The Shared West Ship Canal Tunnel CSO control measure is estimated to have a 20-year moving average CSO overflow frequency of 0.5 events per year and an annual CSO volume reduction of 80%.
Local agency designation and responsibilities	Efficient implementation of a joint CSO control project may require the designation of a lead agency or the creation of a joint project management structure will be considered. Key evaluation decisions include which agency will act as lead, and what responsibilities are inherent in a lead agency, or whether a joint project management structure is appropriate and what responsibilities are inherent in a joint project management structure. The final recommendation on a joint project will be documented in a joint project agreement.	Both agencies have recent experience in the construction of large storage tanks. King County has extensive experience in the operation of facilities off-site from their treatment works and has dedicated operators and maintenance staff. The City has constructed and operated numerous pipe storage facilities and two large cylindrical storage tanks. The City is currently constructing new state of the art rectangular tank storage facilities. The Windermere and Genesee CSO storage	The City will be the lead agency for a Shared West Ship Canal Tunnel. King County and the City will enter a project-specific agreement to construct and operate the Shared West Ship Canal Tunnel.

Table S-10. Comparison of Final LTCP Options			
Evaluation factors		**LTCP option**	
Factor	**Items to be considered**	**Neighborhood Storage Option**	**Shared West Ship Canal Tunnel Option**
		facilities will be complete in 2015. The City is also performing final design of the Henderson CSO storage facilities which will be completed by 2018.	

Overview of Project Costs

The project costs and net present values of the various components of the LTCP options were presented in Chapters 3 and 4. Following the short-listing of the two final options, the costs of each were updated to reflect the results of ongoing refinement and evaluation. Major areas of cost revision were:

- Previous estimates (expressed in 2013 dollars) were escalated to August 2014 dollars.
- Final control measure modeling resulted in minor changes to control measure sizes and volumes.
- Project schedules were adjusted as appropriate to allow retrofit projects to be completed prior to final design of the LTCP control measures. This will allow SPU to optimize the size of final control measures, and it resulted in changes to NPVs.
- More detailed analysis of pre and post-construction monitoring affected that portion of the cost.
- Substitution of storage projects for the proposed flow diversions in the Magnolia and East Waterway neighborhoods affected the overall option NPVs.

Because Ballard and Fremont/Wallingford are the largest basins and are included in a shared project with King County, further refinement of the costs was deemed to be appropriate. The City and King County engaged an independent cost estimator to prepare an independent project cost estimate for the major elements of each of the options. This was done for two primary purposes: one was to update King County project costs that were dated and prepared under different methods and the other was to assure that the estimates used to compare the agencies' projects were done on an equivalent basis.

Detailed costs are presented in section 5.7. Overall costs comparisons for the two final options are shown in table S-11.

Table S-11 Final Option Total Project Cost and Net Present Values

Option	Total project cost, $M	City total project cost share, $M	Total project NPV, $M	City NPV cost share, $M
Neighborhood storage tanks	$394	$394	$401	$401
Shared West Ship Canal Tunnel	$503	$387	$491	$386[a]

Notes:
NPV = Net Present Value
[a] As a shared project, King County would also contribute funding for the Shared West Ship Canal Tunnel. The cost shown in this table is limited to the City's share of the NPV. See Section 5.7.4 for details on the cost share methodology.

Performance Evaluation of Recommended LTCP Option

Based on the CSO Control Measures and No Impact Release Rates previously described, the 20-year moving average annual overflow frequency and volume were estimated for each CSO outfall using the LTCP hydraulic models incorporating the recommended CSO Control Measures. The results are shown in Table S-12. All recommended LTCP CSO Control Measures will reduce the annual CSO overflow frequencies to less than one event per outfall per year based on a 20-year moving average.

Table S-12. Projected Annual Performance After Implementation of CSO Control Measures

CSO area	CSO outfall number	Recommended CSO control measure	20-year moving average annual overflow frequency[a]	Average annual overflow volume (MG)[b]	Peak no-impact release rate (MGD)[c]	Comments
Shared West Ship Canal (Joint City and King County)						
Fremont /Wallingford	147	15.24 MG deep tunnel storage located north of the Ship Canal	0.5	1.5	n/a	Overflows diverted to tunnel until tunnel is full
Fremont/ Wallingford	174		0.5	1.0	n/a	Overflows diverted to tunnel until tunnel is full
Ballard	150/ 151		0.5	1.0	n/a	Overflows diverted to tunnel until tunnel is full
Ballard	152		0.5	3.6	n/a	Overflows diverted to tunnel until tunnel is full
WTD 3rd Ave West	008		0.5	3.1	n/a	Overflows diverted to tunnel until tunnel is full
WTD 11th Ave NW	004		0.4	3.9	n/a	Overflows diverted to tunnel until tunnel is full
Tunnel Performance and Effluent Pump Station Flow Rate			Not Applicable	Not Applicable	32	Tunnel Effluent PS discharge rate based on Ballard Wet Weather Siphon NIRR
Off-line storage						
Montlake	020	0.16 MG off-line storage pipe	0.6	0.40	0.32	Flows released from storage are passed through existing City Pump Station13 so that peak outflow from the basin is not increased
Leschi	028	0.01 MG off-line storage pipe	0.5	0.02	0.02	
Leschi	029	0.02 MG off-line storage pipe	0.5	0.03	0.04	
Leschi	031	0.33 MG off-line storage tank/pipe	0.5	0.17	0.66	Outflow from common storage tank
Leschi	032		0.4	0.01		

Table S-12. Projected Annual Performance After Implementation of CSO Control Measures

CSO area	CSO outfall number	Recommended CSO control measure	20-year moving average annual overflow frequency[a]	Average annual overflow volume (MG)[b]	Peak no-impact release rate (MGD)[c]	Comments
Leschi	036	0.03 MG off-line storage pipe	0.5	0.06	0.06	
Magnolia	060	0.11 MG off-line storage pipe	0.5	0.15	0.22	
Central Waterfront	069	0.13 MG off-line storage pipe	0.7	0.50	0.26	
Delridge/ Longfellow	099	0.17 MG off-line storage pipe	0.8	0.55	0.34	
East Waterway	107	0.5 MG off-line storage tank	0.7	0.01	1.0	
Duwamish	111	0.01 MG off-line storage pipe	0.7	0.09	0.02	
Portage Bay/Lake Union	138	0.11 MG off-line storage pipe	0.6	0.15	n/a	Flows released from storage are passed through the existing City PS #20 so that please outflow from the basin is not increased
Montlake	139	0.01 MG off-line storage pipe	0.5	0.02	n/a	Flows released from storage are passed through the existing City PS #25 so that please outflow from the basin is not increased
Montlake	140	0.05 MG off-line storage pipe	0.4	0.08	n/a	Flows released from storage are passed through the existing City PS #25 so that please outflow from the basin is not increased
Delridge/ Longfellow	168	0.25 MG off-line storage pipe	1.0	2.50	n/a	Peak outflow rate not increased
Delridge/ Longfellow	169	0.25 MG off-line storage pipe	0.5	0.80	n/a	Peak outflow rate not increased
Flow Diversion						
North Union Bay	018	Modifications to CSO control structure 018B	0.8	1.8	n/a	Increase peak flow from 5.5 MGD to 9 MGD to WTD

Notes:
[a] 20-year moving average overflow frequency with Rainfall scaling factor of 1.0
[b] Estimated volumes less than 5,000 gallons are shown as < 0.01 MG. Volumes of 5,000 to 10,000 gallons are rounded up to 0.01 MG
[c] Maximum discharge rates from storage facilities based on WTD provided "no-impact release rates"

LTCP Option Implementation Schedules

Figure S-5 presents the overall schedule for the recommended CSO control measure projects. The schedules show the project duration and the Consent Decree milestone dates for construction completion and the achievement of controlled status.

The implementation of CSO projects has been prioritized based on the results of the sensitive area study. The high priority CSO basins from the City sensitive area study include the following CSO basins:

- Ballard 150, 151, and 152
- Fremont/Wallingford 147 and 174
- Delridge 168 and 169
- North Union Bay 018

The uncontrolled CSO basins in the Ballard and Fremont/Wallingford CSO areas will be controlled with the completion of the Shared West Ship Canal Tunnel. This CSO control measure is one of the first projects to begin, due to the long duration of the project.

A sewer system improvement project is currently being implemented in Basins 168 and 169 in Delridge, with an NPDES permit milestone deadline to complete construction by November 1, 2015. If post-project performance monitoring indicates that these retrofit projects do not bring the basins into control, an additional CSO control measure would be implemented beginning in 2021.The CSO control measure for Basin 018 in North Union Bay is currently being implemented, with a scheduled construction completion date of September 30, 2017.

The implementation schedule for the lower priority CSO basins was determined based on budget availability and coordination with the retrofit program. See figure S-5.

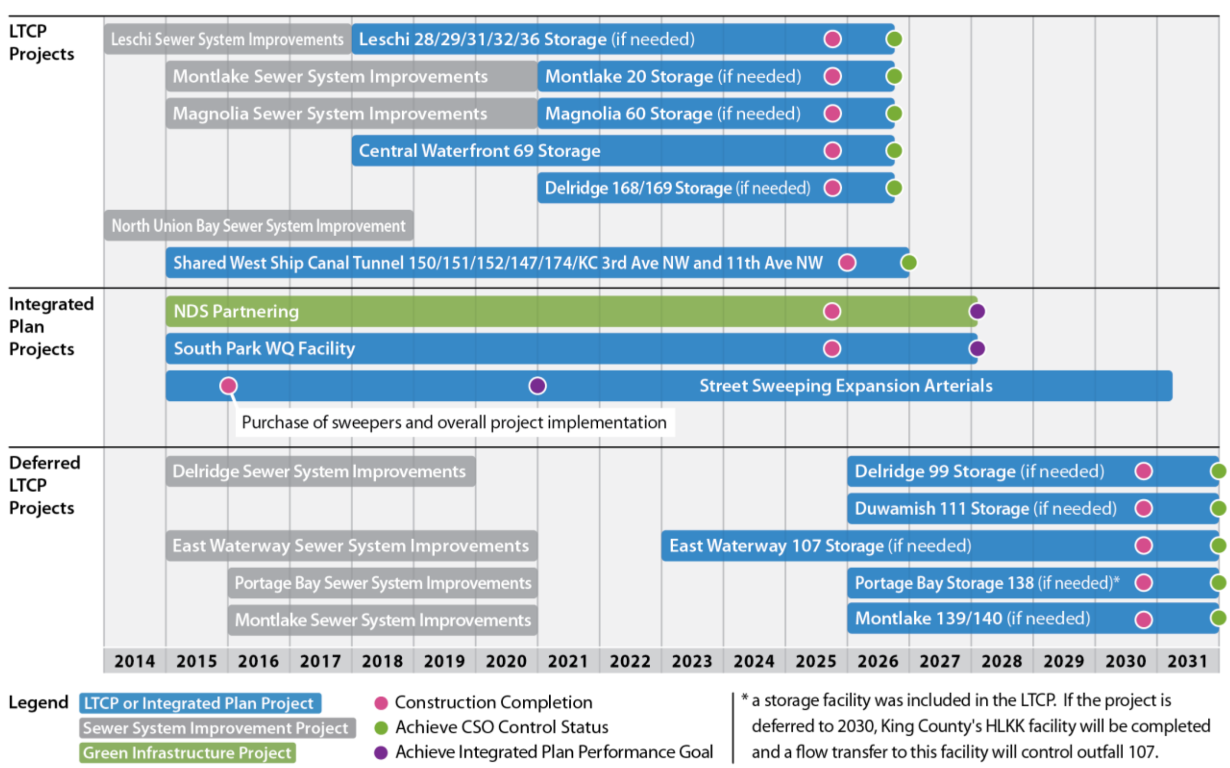

Figure S-5. Overall Schedule for the Recommended CSO Control Measure Projects

Factors Potentially Affecting Schedule

The LTCP Implementation schedule reflects the project order and sequence that the LTCP CSO control measures will be implemented between 2015 and the achievement of control status. The implementation schedule will affect sewer rates, City resource workload, City resources, and local and regional projects. There are major internal and external factors that impact the timing and implementation decisions of the LTCP options and/or individual LTCP projects were identified for the LTCP.

City drainage and wastewater rates will need to be increased to implement the LTCP options. In addition, the City rate payers will also be paying for the implementation of the 2010 Plan CSO projects and the Consent Decree Early Action Projects during the same time period (2015-2025). The implementation schedule for the LTCP projects have considered rate impacts in order to reduce or “flatten” the rate increases.

The City and King County both have CSO Consent Decrees and NPDES Permits with varying compliance dates and priorities that makes coordination of shared projects challenging. The City and King County will enter into an agreement for working together on plans, projects, and activities that have the potential to affect both agencies. The City and King County have developed a coordination strategy that addresses projects having the potential to impact both agencies, and it includes factors for determining joint or independent projects, project coordination levels, and tiered project management and oversight levels. It is expected that this strategy will be updated and modified periodically over time.

The City and King County are each implementing Capital Improvement Programs (CIPs) within the City of Seattle, including independent and joint combined sewer overflow (CSO) control, capacity improvements, sanitary sewer overflow (SSO) control, drainage improvement and asset management projects. King County has an approved Long Term Control Plan. The City has prepared a Final LTCP. King County and the City are developing and will implement a Joint System Optimization and Operations Plan. Both agencies will also implement post-construction monitoring plans in the same water bodies. Both agencies agree to assess the cost-efficient level of coordination on all of these projects, and where coordination seems useful, both agencies will work together to develop joint project agreements or detail sheets for each project with the appropriate coordination activities for each project phase.

CSO Basin 107 (East Waterway) will be impacted by the future King County Hanford-Lander-King St – Kingdome CSO Treatment Plant project (HLKK Project). The proposed HLKK Project includes an up to 151-MGD CSO treatment facility and modifications to the Elliott Bay Interceptor to divert wet weather flows to the CSO treatment facility. The flow diversion may result in decreased CSO control requirements for CSO Basins 107 depending on the final configuration. The City’s Consent Decree currently requires that CSO Basin 107 obtain construction completion by 2025. Close coordination of the CSO Basin 107 project with King County’s HLKK project will need to occur to identify the most cost-effective solution and implementation schedule.

The proposed CSO Basin 069 (Central Waterfront) control measure for the recommended LTCP option must be coordinated with the Elliott Bay Seawall (North) Project. The CSO Basin 069 project location will be significantly impacted by the Elliott Bay Seawall (North) project construction which is currently scheduled for 2018-2020. The specific construction schedule cannot be finalized until the City obtains funding for the Elliott Bay Seawall (North) project construction. Constructing the CSO Basin 069 project before the Elliott Bay Seawall (North) project would result in additional disruption to the community and significant additional construction costs for the Seawall project to protect the CSO Basin 069 project in place.

Financial Plan for Recommended LTCP Option

Based on the planning level cost estimates prepared and the implementation schedules for each LTCP option, the City analyzed how the recommended LTCP option may affect monthly City wastewater and drainage rates. Table S-13 shows the total monthly estimated rates (baseline and including the costs of the recommended LTCP option) between 2015 and 2030.

Table S-13. Monthly Wastewater and Drainage Rates for LTCP Implementation (with Inflation)

LTCP option	2015	2020	2025	2030
Total baseline rate only	$80.31	$110.64	$127.80	$140.46
Recommended Shared West Ship Canal Tunnel Option	$81.36	$115.44	$133.15	$145.57

Figure S-6 Monthly Wastewater and Drainage Rates for Baseline and LTCP Implementation, shows the total monthly rate (Total Baseline Rate and additional LTCP Rates).

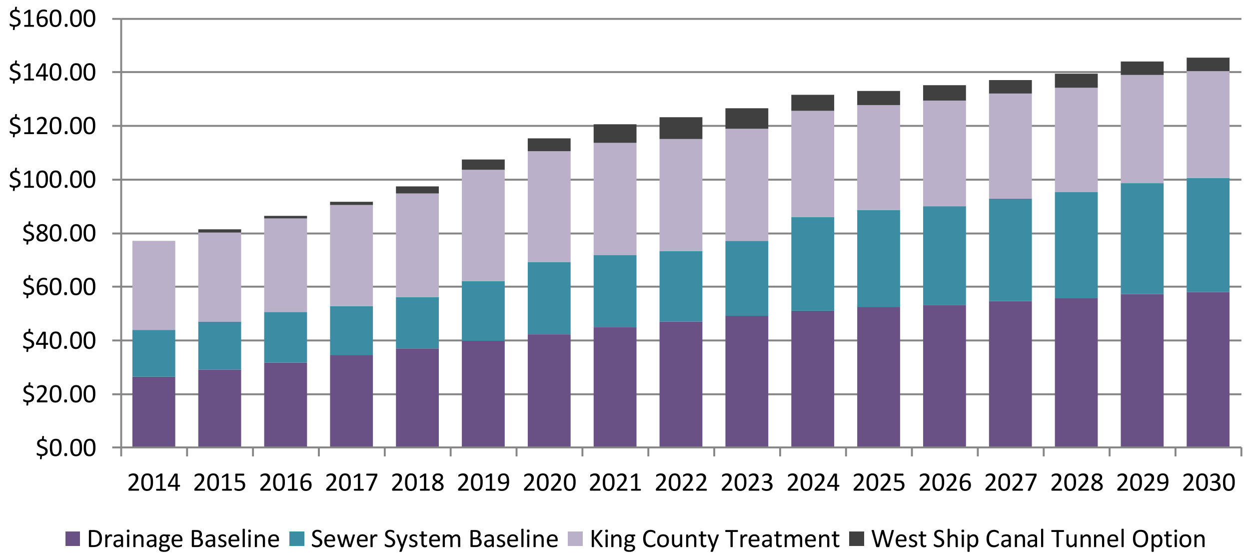

Figure S-6. Monthly Wastewater and Drainage Rates for Baseline and LTCP Implementation

City/King County Monitoring and Modeling Memorandum of Agreement

The City and King County have developed flow monitoring and modelling requirements for the purpose of quantifying whether and how large of an impact the completed CSO control measures have on downstream King County facilities. In general, these requirements include several years of pre-construction flow monitoring to establish baseline conditions, followed by a minimum of five years of post-construction flow monitoring. This data is then used to determine what payments the City will be required to make to King County for increased capital and/or operational expenses at downstream locations.

These requirements will be finalized with the approval by each agency of term and detail sheets for each shared project.

Measure of Success

The measure of success for the City's CSO program will be the successful construction and operation of the recommended LTCP projects by the required critical milestone dates and performing Post-Construction Monitoring to demonstrate achievement of CSO control status in accordance with the Consent Decree.

Achieving CSO control status has been defined in the Consent Decree and requires flow monitoring of the constructed CSO control measure to obtain actual operating information, revising the approved hydraulic model to incorporate the "as-constructed" CSO control measure project, calibrating the "as-constructed" model with actual performance and flow data, performing a moving 20-year average annual overflow frequency analysis using one year of actual performance data and 19-years of computer simulations (assuming the constructed CSO control measure was operating in those years), and submitting a Post-Construction Monitoring Plan Report to EPA/Ecology.

The Post-Construction Monitoring Plan will summarize the data collected and analyze whether the completed CSO control measures have met/continue to meet the design criteria and performance criteria specified in the LTCP, and whether the City's operation of its CSS complies with the CSO Control Policy and Clean Water Act implementing regulations, all applicable state law and regulations, and the City's NPDES Permit. EPA/Ecology approval of the Post-Construction Monitoring Plan Report will confirm that the City's CSO control measures satisfied the Consent Decree requirements for Post-Construction Monitoring.

LTCP Timeline

The Draft LTCP performed a "rating and ranking" of the LTCP options in accordance with the EPA requirements in the *"Combined Sewer Overflows Guidance for Long-Term Control Plan, 1995".* On May 29, 2014, the Draft LTCP was submitted for EPA and Ecology review and comment. In addition, the City issued the Draft EIS. Following the appropriate public process, a Final EIS was issued in December 2014.

Additional evaluation of LTCP options was performed and a preferred LTCP option was recommended in early 2014. In early 2015, the City Council reviewed and adopted the Final LTCP through a City Ordinance process. By May 30, 2015, the Final LTCP will be submitted to EPA and Ecology for approval. By the end of 2015, the final plan is anticipated to be approved by EPA and Ecology and LTCP implementation will commence in late 2015 or early 2016. Construction completion of all approved LTCP projects shall be achieved by December 31, 2025.

The LTCP timeline showing major milestones and activities is shown on Figure S-7.

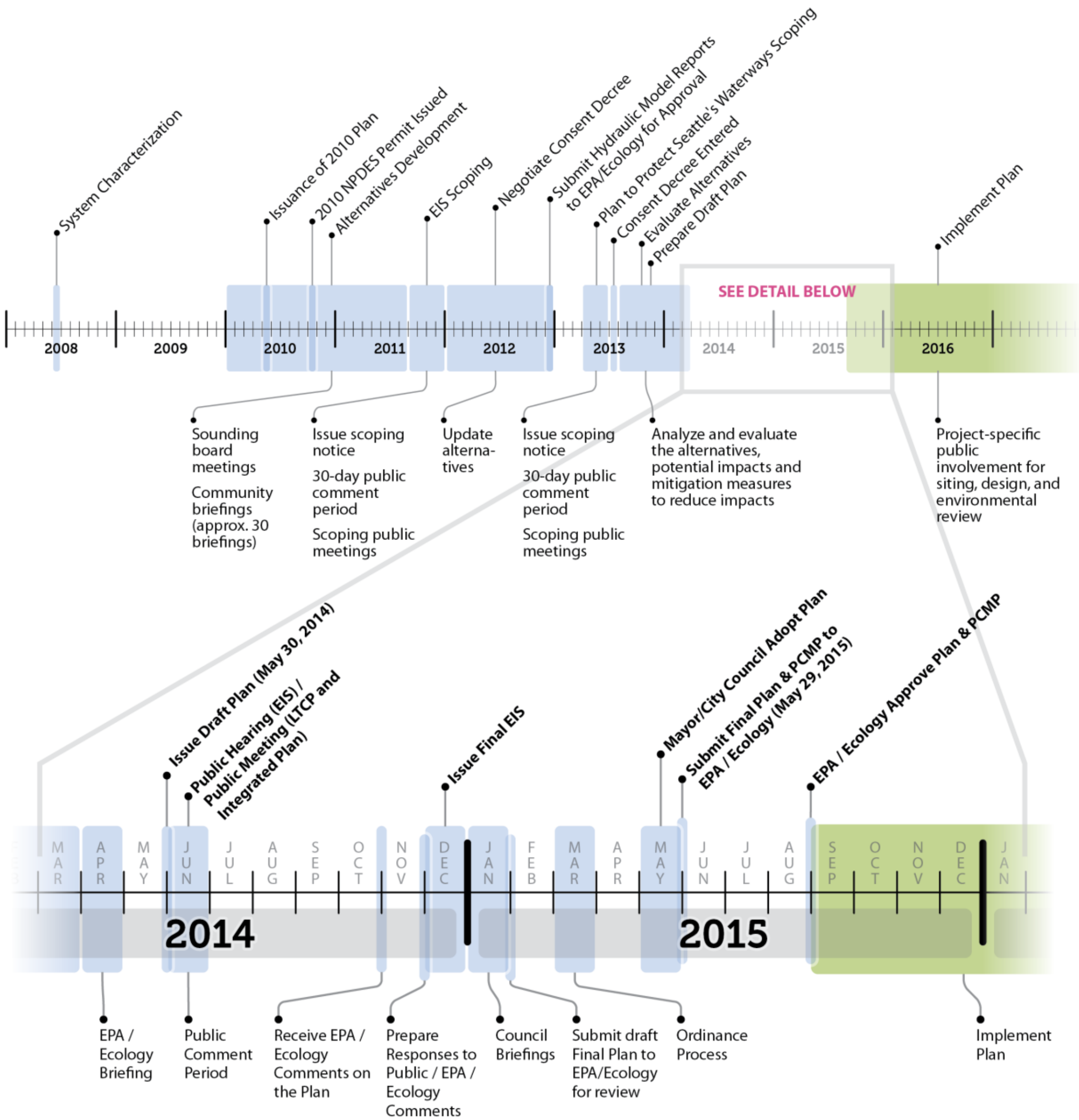

Figure S-7. Current LTCP Schedule

CHAPTER 1

Introduction and Background

1.1 Long Term Control Plan Document Organization

The following sections describe the organization of the Long Term Control Plan (LTCP) document and how it fits in with the overarching Plan to Protect Seattle's Waterways.

1.1.1 The Plan to Protect Seattle's Waterways Organization (4 Volumes)

The Plan to Protect Seattle's Waterways contains four volumes that describe the plan to protect and improve the water quality in and around the City of Seattle (City). The four volumes are summarized below:

- Volume 1: Executive Summary – The Executive Summary contains a summary of the LTCP, Integrated Plan, and the Programmatic EIS.
- Volume 2: LTCP – The LTCP contains a recommended plan to reduce combined sewer overflows (CSOs) in the City to meet state and federal requirements.
- Volume 3: Integrated Plan – The Integrated Plan proposes CSO as well as stormwater projects prioritized and sequenced to achieve water-quality benefits beyond what would be achieved with CSO investments alone. While all CSOs must still achieve the state standard, compliance may be achieved under a revised schedule that extends beyond 2025.
- Volume 4: Programmatic Environmental Impact Statement (EIS) – The Programmatic EIS covers environmental impacts from the projects recommended in the LTCP and the Integrated Plan.

1.1.2 LTCP (Volume 2) Document Organization

The organization of the LTCP is described below.

- Chapter 1 Introduction – This chapter includes a history of the City's control policy for CSOs and a summary of the policy's key elements. Also provided are general descriptions of the current CSO control efforts, regulatory requirements, and an overview of the long-term planning approach.
- Chapter 2 System Characterization – This chapter provides extensive analysis of CSO areas. The chapter includes descriptions of how the Nine Minimum Controls have been implemented by the City, descriptions of receiving water bodies, results of the sensitive area study, and summaries of the flow monitoring and modeling efforts by the City. The chapter also includes the baseline conditions for CSO basins in the City.
- Chapter 3 Development and Evaluation of Alternatives for CSO Control – This chapter discusses the approach and factors used to identify, develop, evaluate, and select CSO control measures that make up the recommendations in the LTCP. Four LTCP options are presented for final consideration and evaluation.
- Chapter 4 Evaluation of LTCP CSO Control Options – This chapter includes an explanation of the values-based risk management process used to rate and rank the LTCP options. Issues discussed include community values, benefit/cost analysis, environmental impact, technical concerns, and implementation schedules compatible with the Consent Decree requirements. Also discussed is the public participation process during the LTCP process.
- Chapter 5 Selection and Implementation of Recommended LTCP CSO Control Option – This chapter

summarizes the public and regulatory participation process and comments that were received on the draft LTCP. It also describes the process used to refine the options that were developed in Chapters 3 and 4 and the final evaluation and factors that were used to select the recommended option. Updated information is also presented on community and environmental impacts, operational impacts, design criteria for the recommended CSO control measures, capital and operational costs, control measure performance, implementation schedules and a financial analysis.

1.2 Introduction and Background

1.2.1 Introduction

The LTCP is an update to the City's plan for reducing overflows from its combined sewer system (CSS) into surrounding water bodies. Over the past 20 years, the City's CSO Program has significantly reduced the number of CSO events and overflow volumes. Many of these projects were identified in the City's 1988 CSO Reduction Plan (Reference 1) and its subsequent amendments in 2001 (Reference 2), 2005 (Reference 3), and 2010 (Reference 4). The LTCP addresses the remainder of the City's CSS and aims to limit untreated overflows at each CSO outfall to an average of no more than one per year on a 20-year rolling average, a performance standard established in the City's National Pollutant Discharge Elimination System (NPDES) CSO permit (Reference 5). The City of Seattle and King County both manage CSO outfalls in the Seattle area: The City currently manages 86 outfalls; King County manages 38. In 2014 a total of 406 CSO events from City-managed outfalls resulted in 116 million gallons of overflow.

1.2.2 Background

CSOs are untreated discharges of wastewater and stormwater into water bodies that occur during storm events when combined sewers are full. Combined sewers, which carry both wastewater and stormwater, exist in many parts of older cities across the nation, including the City of Seattle. Stormwater can cause extreme variations in wastewater flows, resulting in challenges to the treatment process and the need for large wastewater facilities. To protect treatment plants and avoid sewer backups into homes, businesses, and streets during heavy storm events, combined sewers in the City have been designed to overflow into the surrounding water bodies.

The City's combined sewer system dates from the 1890s. The City is responsible for the sewage collection system serving sewershed areas of up to 1000 acres in size. The King County Department of Natural Resources, Wastewater Treatment Division, is responsible for sewer trunks serving areas greater than 1000 acres and for wastewater and CSO treatment plants.

Beginning in the 1950s, additions to the sewer system were designed as separated systems, with separate networks of pipes for sewage and stormwater.

Since the 1960s, the City has undertaken a number of efforts to partially separate previously combined systems; in partially separated systems, stormwater from streets and parking lots runs into separate storm drains, but stormwater from other sources, mostly building roofs, still enters a combined system.

The earlier separation projects were supplemented with storage tanks where necessary to further reduce CSOs. During the 1980s, increasing the storage capacity became Seattle's preferred solution to controlling CSOs. Seattle has constructed 38 facilities for overflow control.

The City does not own a wastewater or CSO satellite treatment plant. All the sewage collected in the City's wastewater collection system is conveyed to King County for regional conveyance and treatment, or is discharged via one of the CSO outfalls. King County operates three secondary wastewater treatment plants (WWTP) (West Point WWTP, the South WWTP, and the Brightwater WWTP) and four CSO storage and treatment facilities (Alki, Carkeek, Mercer/Elliott West, and Henderson/Norfolk). Ultimately, the treated wastewater from all of these facilities discharges to Puget Sound, Elliott Bay, or the Duwamish River.

1.3 Regulatory Requirements

In 1972, the federal Clean Water Act (CWA) (Reference 6) was passed by Congress. The primary objective of the CWA is to restore and maintain the integrity of the nation's waters. This objective translates into two national goals: to eliminate the discharge of pollutants into the nation's waters and to achieve and maintain fishable and swimmable waters. One way that the first goal is being achieved is through the National Pollutant Discharge Elimination System (NPDES) permit program. The second goal is being addressed by developing pollution control programs to meet water quality standards for water bodies.

The CWA requires all wastewater treatment facilities and industries that discharge effluent into surface waters to have an NPDES permit. In Washington State, NPDES permits are issued by the Washington State Department of Ecology (Ecology) and define appropriate technology controls and limits on the quality and quantity of effluent discharged from point sources such as treatment plants, CSOs, and industrial facilities. The City holds an NPDES permit for its 86 CSO outfalls.

The City developed this LTCP in compliance with requirements of the EPA CSO Control Policy (Reference 7); the July 3, 2013, Consent Decree (Reference 8); and the City's NPDES permit for the combined sewer system, as discussed in the following paragraphs.

1.3.1 Consent Decree Requirements

On July 3, 2013, the Final and Fully Executed Consent Decree (the Consent Decree) with the City of Seattle was approved by the United States District Court for the Western District of Washington. The Consent Decree established an enforcement mechanism that will ensure that certain dates are met for implementation of the LTCP. The Consent Decree establishes the requirements paraphrased below:

1. Early action CSO control program and measures: The City shall implement all CSO control measures necessary to reduce discharges from CSO Outfalls 044 and 045 (North Henderson) and CSO Outfalls 046 and 047/171 (South Henderson) by the following dates:
    a. Construction completion for CSO Outfalls 046 and 047/171 by December 31, 2015
    b. Achievement of controlled status for CSO Outfalls 046 and 047/171 by December 31, 2016
    c. Construction completion for CSO Outfalls 044 and 045 by December 31, 2018
    d. Achievement of controlled status for CSO Outfalls 044 and 045 by December 31, 2019
2. Development and implementation of long-term control plan and post-construction monitoring plan:
    a. The LTCP shall specify
        i. all CSO control measures that the City must implement to ensure compliance with the provisions of the CWA and its implementing regulations that apply to CSOs, any applicable state law and regulations that apply to CSOs, those portions of the City's NPDES permit that apply to CSOs, and EPA's CSO Control Policy;
        ii. all design criteria and performance criteria developed for each CSO control measure; and
        iii. a schedule of critical milestones for each CSO control measure.

   b. The City shall develop and perform a post-construction monitoring program.
3. Capacity, Management, Operations, and Maintenance (CMOM) Performance Program Plan: On December 31, 2012, the City submitted to EPA and Ecology for their approval a comprehensive CMOM Performance Program Plan (Reference 9). The City shall annually review its CMOM Performance Program Plan and update the program as necessary to ensure the City is achieving the performance thresholds contained in the approved CMOM Performance Program Plan. The City shall report in its annual report the metrics regarding sanitary sewer overflow (SSO) performance.
4. Fats, Oils, and Grease (FOG) Control Plan: On December 31, 2012, the City submitted to EPA and Ecology for their approval a FOG Control Program Plan (Reference 10) designed to ensure that grease accumulations are not restricting the capacity of the wastewater collection system contributing to overflows. The City shall annually review its FOG Program Plan and update the program as necessary. The City shall submit as part of its annual report summaries of FOG inspections and enforcement actions taken by the City during the preceding year.
5. Revised Floatable Solids Observation Program Plan: On December 31, 2012, the City submitted to EPA and Ecology for their approval a revised Floatable Solids Observation Program Plan (Reference 11). The City shall annually review and update the plan as appropriate.
6. Joint Operations and System Optimization Plan (Joint Plan) between City and County: No later than March 1, 2016, the City shall submit to EPA and Ecology a Joint Plan that the City will develop with King County. This Joint Plan shall be applicable to the City's and the County's respective CSO systems, and that
   a. is consistent with each entity's operational objectives
   b. optimizes the capacity of both systems while balancing risk to both entities. The City and King County shall review the joint plan every three years and update the plan as necessary to ensure the operational level of coordination and information sharing is maintained between the two entities.

1.3.2 Ecology Agreed Order No. 8040

The Ecology Agreed Order Number 8040 (Reference 12), which was approved by the Seattle City Council in October 2010, is an agreement that commits the City to implementing the LTCP by December 31, 2025. According to the Agreed Order:

> *In order to meet the requirements of WAC 173-245-020(22), SPU shall complete construction of CSO reduction projects identified in the 2010 CSO Reduction Plan Amendment or future amendments submitted by the City and approved by Ecology to reduce CSOs from the remaining 37 uncontrolled CSO basins down to an average of one overflow per site per year by December 31, 2025. Future CSO Reduction Plan Amendments may not result in a compliance date later than December 31, 2025.*

1.3.3 EPA LTCP Requirements

In April 1994, EPA published a CSO Control Policy to explain how communities and states could control CSOs while meeting CWA requirements and to provide a process to be followed in addressing CSOs. The first step in the process is the development and implementation of a Nine Minimum Controls (NMC) Plan (Reference 13) which includes controls or measures that can reduce CSOs without significant engineering studies or major construction. This step has been completed by the City, and the processes in the NMC Plan continue to be followed.

The next step is the development of an LTCP. The CSO Control Policy requires that cities such as Seattle that have CSOs take the needed action to bring the discharges into compliance with the CWA. The policy states:

> *Permittees with CSOs are responsible for developing and implementing long term CSO control plans that will ultimately result in compliance with the requirements of the CWA. The long-term plans should consider the site-specific nature of CSOs and evaluate the cost effectiveness of a range of control options/strategies.*

The CSO Control Policy lists specific elements that must be evaluated and developed in LTCPs, as listed below:

1. Characterization, monitoring, and modeling of the combined sewer system
2. Public participation
3. Consideration of sensitive areas
4. Evaluation of alternatives
5. Cost/performance considerations
6. Operational plan
7. Maximizing flow to the existing Publicly Owned Treatment Works (POTW)
8. Implementation schedule
9. Post-construction compliance monitoring

The CSO Control Policy recommends that the development and implementation of the LTCP be covered under an enforceable mechanism such as a consent decree that provides for enforcement of the schedule.

1.3.4 Ecology Requirements

In 1984, Ecology introduced legislation requiring agencies with CSOs to develop plans for "the greatest reasonable reduction [of CSOs] at the earliest possible date." In January 1987, Ecology published a new regulation (Chapter 173-245 WAC) (Reference 14) that defined the greatest reasonable reduction in CSOs as "control of each CSO such that an average of one untreated discharge may occur per year." The City's NPDES permit and consent decree establish a standard of no more than one untreated discharge per year based on a 20-year moving average. The number of untreated discharges that occurred over each of the previous 20 years (or that would have occurred had the CSO control measures been in place) is reported for each CSO site and then averaged. This moving average will be used each year to assess compliance with the performance standard for CSOs identified as controlled.

1.3.5 NPDES Permit (2010-2015)

The City's wastewater collection system is regulated by Ecology via NPDES Waste Discharge Permit WA0031682. This permit was re-issued on October 27, 2010, went into effect on December 1, 2010, was modified on September 13, 2012, and will expire on November 30, 2015.

This permit contains a number of terms and conditions, as paraphrased below:

1. Monitoring requirements: The City must use automatic equipment at all permitted outfalls to monitor discharge location, discharge duration, discharge volume, and weather-related information (precipitation and storm duration).
2. Reporting and recording requirements: The City must submit a monthly CSO discharge monitoring report to summarize CSO monitoring results.
3. Operation and maintenance: The City must at all times properly operate and maintain all facilities and

systems of conveyance and control (and related appurtenances) that are installed.

4. Nine minimum controls: The City must implement the Nine Minimum Controls for CSOs and document them in the annual CSO report.
5. CSO reports and engineering documents:
   a. The City must submit an annual report to Ecology for review and approval by March 30th of each year. The annual report must include a summary of the number and volume of CSOs from each outfall for the prior year, indicate which CSO outfalls are categorized as controlled, and include documentation of compliance with the Nine Minimum Controls.
   b. The City must submit an amendment of its CSO Reduction Plan (Reference 4) to Ecology for review and approval with the application for permit renewal.
   c. The City must submit to Ecology an engineering report, plans, and specifications for each CSO reduction construction project.
6. Compliance schedule: In order to achieve the greatest reasonable reduction of combined sewer overflows at the earliest possible date, the City must complete the activities shown in Table 1-1, as described in the 2010 CSO Reduction Plan Amendment (2010 Plan).

Table 1-1. 2010-2015 NPDES Permit Compliance Schedule

Project or activity	Required completion date
Windermere CSO Basin	
Complete and submit draft plans and specifications	March 30, 2012
Complete and submit for review and approval final plans and specifications	August 31, 2012
Begin construction	December 31, 2012
Complete construction	August 30, 2015
Genesee CSO Basin 043 project	
Complete and submit a draft engineering report	December 31, 2010
Complete and submit for approval a final engineering report	May 31, 2011
Complete and submit draft plans and specifications	January 31, 2013
Complete and submit for review and approval final plans and specifications	June 30, 2013
Begin construction	August 31, 2013
Complete construction	October 31, 2015

Table 1-1. 2010-2015 NPDES Permit Compliance Schedule

Project or activity	Required completion date
Genesee CSO Basins 040 and 041 project	
Complete and submit a draft engineering report	December 31, 2010
Complete and submit for approval a final engineering report	May 31, 2012
Complete and submit draft plans and specifications	January 31, 2014
Complete and submit for review and approval final plans and specifications	June 30, 2014
Begin construction	August 31, 2014
Complete construction	October 31, 2015
South Henderson CSO Basin projects (046 and 047/171)	
Complete and submit a draft engineering report	August 30, 2011
Complete and submit for approval a final engineering report	March 31, 2012
Complete and submit draft plans and specifications	October 31, 2014
Complete and submit for review and approval final plans and specifications	March 30, 2015
Begin construction	May 31, 2015
North Henderson CSO Basin projects (044 and 045)	
Complete and submit a draft engineering report	August 30, 2012
Complete and submit for approval a final engineering report	January 31, 2013
Complete and submit draft plans and specifications	October 31, 2014
Complete and submit for review and approval final plans and specifications	March 30, 2015
Begin construction	May 31, 2015

Table 1-1. 2010-2015 NPDES Permit Compliance Schedule	
Project or activity	**Required completion date**
CSO retrofit projects	
Complete construction of hydraulic improvements to overflow structures for CSO Basins 018, 095, 111, 147, and 152	December 31, 2011
Complete construction of Windermere retrofit for CSO 013	December 31, 2012
Complete construction of weir height adjustments for category 3 weirs[a]	November 30, 2011
Complete construction of weir height adjustments for category 4 weirs[b]	October 31, 2011
Complete construction of Longfellow/Delridge Basin (168 and 169) modifications	November 1, 2015
Complete construction of Henderson retrofits for CSO Basins 047 and 049	November 30, 2015
Green Infrastructure (GI) projects	
Start construction of GI roadside rain garden projects in Ballard Basins150/151 and 152	October 31, 2015
Start construction of GI roadside rain garden projects in Delridge Basin 168 or 169	October 31, 2015
Pump station backup power capital improvement projects	
Complete installation of emergency generator plugs[c]	June 30, 2011
Complete installation of new permanent generators at pump stations 7, 25, 39, 43, 49, 59, 62, 63, and 77	June 30, 2012
Complete installation of new permanent generators at pump stations 39	December 31, 2013
CSO outfall repairs[d]	
Complete repairs on CSO Outfall 085	December 31, 2011
Complete repairs on CSO Outfalls 064, 095, and 150	December 31, 2014

Table 1-1. 2010-2015 NPDES Permit Compliance Schedule	
Project or activity	**Required completion date**
Complete repairs on CSO Outfalls 028, 031, 045, 129	November 1, 2015
Public notification of CSO events	
Have web-based public notification system of CSO events operational	March 31, 2011

Notes
a Weirs are specified in Table 2-1 of SPU's NMC Compliance Report, May 2010.
b Weirs are specified in Table 2-1 of SPU's NMC Compliance Report, May 2010.
c As listed in Table 2, Page 5, NMC #5 of SPU's NMC Compliance Report, May 2010
d For each of the CSO outfall repairs listed in this table, SPU shall repair the deficiencies noted in the August 2006 Outfall Evaluation Report (Reference 15). If additional deficiencies are discovered during the repair of these outfalls, SPU shall submit a plan that describes the approach and schedule for these additional repairs.

7. Requirements for controlled CSO outfalls:
   a. Compliance with the performance standard will be determined annually and based on a 20-year moving averaging period, including past years and the current year, and will be based on historical discharge data, modeling, or other reasonable methods as approved by Ecology.
   b. For controlled CSO Outfalls 062 and 013, the City must begin to implement a post-construction compliance monitoring program adequate to verify compliance with water quality standards and protection of designated uses as well as ascertain the effectiveness of CSO controls.
8. Outfall rehabilitation plan: The City must submit to Ecology for review and approval an outfall rehabilitation plan by October 31, 2015, that describes outfalls to be repaired or replaced during the next permit cycle.
9. Sediment monitoring: The City must submit to Ecology for review and approval a Sediment Sampling and Analysis Plan for sediment monitoring at controlled CSO Outfalls 062 and 013. The City must also submit a Sediment Sampling and Analysis Plan for uncontrolled CSO Outfalls 107, 147, and 152. Following Ecology approval of the plans, The City must collect sediment data and submit a Sediment Data Report containing the results of all sediment sampling and analysis.
10. Application for permit renewal: The City must apply for renewal of this permit prior to May 31, 2015.

Ecology modified the permit on September 13, 2012, to incorporate changes requested by the City on June 14, 2012, including:

- Elimination of three outfalls that were sealed and no longer in use
- Revision of the GI implementation requirements.
- Modification of the schedule for installation of an emergency generator at Pump Station 39
- Modification of the outfalls to be rehabilitated

1.3.6 EPA Modified Request for Information and Compliance Order By Consent

In March 2008, the EPA performed a compliance inspection of Seattle's wastewater collection system. EPA found that the City was not in total compliance with the Nine Minimum Controls. Subsequent to the inspection, the EPA and the City entered into a Request for Information and Compliance Order by Consent (Compliance Order) in August 2009 (Reference 16). This Compliance Order was subsequently amended to incorporate minor modifications in December 2009. The amended Compliance Order requirements included the development and implementation of the following plans:

- CSO Weir Height Adjustments Project Plan
- Gravity Pipe Cleaning Preventative Maintenance Data Analysis Plan
- CSO Control Structure Inspection and Cleaning Plan
- Pipe Cleaning QA/QC Plan
- Observation of solids and floatables at CSO outfall locations
- Emergency generator plugs and backup generators

The City submitted these documents to EPA in a timely manner.

1.4 History of CSO Control

Planning for CSO control is a dynamic process that must respond to changing regulations and conditions. To date, the City has completed five CSO control plans, beginning in 1980. This section presents a history of CSO control planning by the City.

1.4.1 Previous CSO Reduction Planning Efforts

The City has completed several planning efforts since the 1980s to identify CSO reduction projects. Some of the projects involved maintenance or modification of existing sewer facilities. Others involved construction of diversion structures to direct flows away from CSO outfalls or storage facilities to store excess wastewater until flows decrease enough for the stored wastewater to be returned to the conveyance system. The major CSO reduction planning efforts are described in the following sections:

1.4.1.1 1980 Facility Plan (201 Facilities Planning)

The 1980 Facility Plan (201 Facilities Planning) addressed CSO reduction in high priority areas based on human contact potential and environmental protection: Longfellow Creek, Lake Washington, and Puget Sound beaches. Storage facilities were recommended for 50 outfalls, with an estimated cost of $13.2 million (1978 dollars).

1.4.1.2 1988 CSO Reduction Plan

The 1988 CSO Reduction Plan addressed CSO reduction in Portage Bay, Lake Union, the Ship Canal, Elliott Bay, and the Duwamish River. The plan recommended storage facilities for 30 uncontrolled outfalls, with an estimated cost of $60 million (1988 dollars).

1.4.1.3 2001 CSO Reduction Plan Amendment

The 2001 CSO Reduction Plan Amendment proposed the implementation of various best management practices as a way to reduce the volume of CSOs prior to the implementation of additional storage projects. This plan re-evaluated previously studied areas of Seattle and expanded the evaluation to include other areas. Estimated cost of the recommended improvements was $58 million (2001 dollars).

1.4.1.4 CSO Reduction Plan Amendment 2005 Update

The 2005 update was prepared to evaluate the effectiveness of best management practice projects from the 2001 amendment that had been completed, and to revise cost estimates and schedules for remaining projects from the 2001 amendment.

1.4.1.5 2010 CSO Reduction Plan Amendment

The 2010 CSO Reduction Plan Amendment was a regulatory requirement by WAC 173-245-090(2). Per the regulation, the plan must include three elements:

1. an assessment of the effectiveness of the CSO Reduction Plan to date
2. a re-evaluation of the CSO sites' projects priority ranking
3. a listing of projects to be accomplished in the next five years

The 2010 CSO Reduction Plan Amendment is an update to Seattle's previous planning efforts for reducing overflows from the combined sewer system into surrounding surface waters. The 2010 CSO Reduction Plan Amendment identified CSO outfalls that currently meet the state regulatory requirement of WAC 173-245-020(22), as well as future projects that will limit untreated overflows at each CSO outfall to no more than one per year on average. The plan indicates that by 2015, the City will have accomplished the following projects:

- Construct CSO retrofits to optimize CSO control infrastructure in multiple uncontrolled CSO basins
- Complete the construction of the Windermere CSO reduction project
- Substantially complete the construction of the Genesee CSO reduction project
- Initiate construction on the Henderson CSO reduction project
- Construct Green Infrastructure projects in the Ballard CSO basin to measure the effectiveness of green solutions
- Complete installation of new permanent generators at certain pump stations
- Fully implement a web-based public notification system of CSOs
- Complete the 2015 CSO Reduction Plan Amendment (the LTCP)

The 2010 CSO Reduction Plan Amendment summarized compliance with EPA's Nine Minimum Controls for CSO systems, provided a revised CSO baseline frequency and volume estimates, and described CSO control alternatives.

1.4.2 Historical CSO Reduction Efforts

The City has been constructing CSO control facilities since 1968, first by re-routing roadway drainage to partially separate combined sewer areas. This was followed by construction in the 1980s of 35 storage facilities with over 8.1 million gallons (MG) of capacity to provide additional storage during storm events. More recently, emphasis has been placed on constructing retrofit projects to enhance system operating efficiency.

From 1968 through 1976, costs related to CSO reduction were incurred for partial separation projects that were completed under the Forward Thrust program. Both partial separation and storage facilities were constructed during the 1980s. From 1997 through 2005, CSO reduction costs were incurred for the Denny Way/Lake Union project (in conjunction with King County) and retrofits of existing facilities. In total, the City has expended over $524 million (2009 dollars) on CSO control and reduction efforts, including about $385 million (73 percent) for partial separation projects, $134 million (26 percent) for storage projects, and $5 million (1 percent) for retrofits.

1.4.2.1 History of CSO Discharges

Over the last 25 years, the City of Seattle has successfully reduced CSO discharge volumes by nearly 70 percent. The volume of CSO discharges by the City has declined from an estimated 400 MG per year in the 1980s to an average of approximately 155 MG per year from 2007 to 2012 (Reference 18). Similarly, overflow frequency has declined from an estimated 2,800 events per year in the 1980s to an average of approximately 287 events per year from 2007 to 2012 (Reference 18). For 2013, a volume of 38 million gallons were discharged in 219 CSO events (SPU 2013).

The City has been collecting reliable flow monitoring data since 2008. The data includes overflow event time, frequency, duration, and volume. These data, along with rainfall information, are reported to Ecology both monthly and annually.

The CSO reduction will be implemented through three separate phases of the CSO implementation program. These phases are summarized below:

- 2010 Plan Projects: Seven outfalls will be controlled through capital projects completed during the years 2010-2018, including CSO reduction projects for Windermere, Genesee, Central Waterfront, and West Seattle CSO areas. Additional CSO reduction efforts were initiated through the Green Infrastructure program in Ballard, Magnolia, Montlake, North Union Bay, Fremont/Wallingford, and Delridge CSO areas.
- Early Action CSO Programs and Measures: The Consent Decree requires early action for the two North Henderson (045 and 046) and three South Henderson (046, 047 and 171) uncontrolled CSO outfalls. CSO Outfalls 044 and 045 will achieve controlled status by December 31, 2019, and CSO Outfalls 046, 047, and 171 will achieve controlled status by December 31, 2016. South Henderson CSO Outfall 049 is also uncontrolled based on the 2013 Annual CSO Report and the City will complete construction by December 31, 2018 and achieve controlled status by December 31, 2019.
- LTCP: The remaining 22 uncontrolled CSO outfalls will be controlled through the implementation of the approved LTCP, which recommends CSO control measures and an implementation schedule to meet the Consent Decree Construction Completion milestone date of December 31, 2025, and the achievement of control status for each outfall as defined in the Consent Decree.

1.4.2.2 Constructed CSO Reduction Facilities

The City's existing CSO storage facilities range from 16-inch diameter pipe to 100-foot-diameter, 35-foot-deep concrete storage tanks. Storage volumes range from a few hundred gallons to 1.6 MG. The CSO storage tanks and pipes were, for the most part, designed to store excess runoff from a 1-year, 24-hour design storm (i.e., a storm that statistically should be exceeded only once per year). The two largest tanks, located along Longfellow Creek in the Delridge neighborhood, were designed for a 10-year, 24-hour storm. Experience and extensive flow monitoring data have shown that most of the constructed facilities have substantially reduced the number and volume of overflows. However, in many cases additional system improvements are required to achieve the design objective (average of no more than one CSO event per year).

Table 1-2 lists the facilities constructed from 1985 through 2004 by basin and by construction contract (Reference 4).

Table 1-2. Constructed CSO Reduction Facilities

CSO basin number	Major facility elements	Year
Windermere		
013	Flow control structure with weir; off-line storage Downstream flow control chamber with HydroBrake; in-line storage	1988

Table 1-2. Constructed CSO Reduction Facilities

CSO basin number	Major facility elements	Year
014	Downstream manholes with two overflow weirs and HydroBrake; in-line storage	
015	Downstream manholes with overflow weir and HydroBrake; in-line storage Two control structures to divert flow into detention; off-line storage; downstream outflow-overflow chamber with HydroBrake and weir.	
North Union Bay		
018	Upstream flow control manhole with overflow weir, in-line storage, downstream manhole with HydroBrake Upstream inflow control chamber (with overflow weir to storm overflow control chamber), storm overflow control chamber (with overflow weir to pump station discharge), off-line storage, and downstream manhole with HydroBrake	1989
Montlake		
020	Two overflow weirs associated with lift station. The first weir diverts flow to off-line storage. Flows overflowing second weir directed to outfall	1988
140	HydroBrake with off-line storage. Stored flows are pumped back to gravity system.	1994
Union Bay		
023, 024, 025	Two separate outfalls. Flow control structure with overflow weir and in-line storage. Overflow weir at inlet to wet well.	1987
Leschi		
029	HydroBrake with in-line storage	1986
030	HydroBrake with in-line storage	
032	HydroBrake with in-line storage	
033, 034	Two HydroBrakes with off-line storage	1987
035	HydroBrake with off-line storage	
036	HydroBrake with in-line storage	
North Genesee		
038	HydroBrake with in-line and off-line storage	1987

Table 1-2. Constructed CSO Reduction Facilities

CSO basin number	Major facility elements	Year
Genesee		
040	HydroBrake with in-line storage	1986
042	HydroBrake with off-line storage	
043	HydroBrake with in-line storage	
Henderson		
044	HydroBrake with off-line storage	1985
045	HydroBrake directs flow to Pump Station 10	
047, 171	Two orifice/weir manholes regulate flow to lift station. Excess flows diverted to in-line storage. HydroBrake regulates flow from storage. Control facility has two separate outfalls. HydroBrake with in-line storage Weir control structure with in-line storage Weir diverts excess flow to storm drain (both basins)	1985
049	HydroBrake with off-line storage	1985
Magnolia		
062, 063	HydroBrake with in-line storage	1987
	Two in-line flow control structures with downstream HydroBrake. Two overflow outfalls from this CSO control facility	
Interbay		
068	Flow control structure with HydroBrake and weir; off-line storage; overflow manhole with weir Flow control structure with HydroBrake and overflow weir; in-line storage	1990
Central Waterfront		
070	Diversion structure with orifice and flap valve. Overflow structure with flexible check valve	1993
West Waterway		
099	Flow control structure with HydroBrake; overflow structure with 2 weirs; off-line storage; low flow diversion from storm drain to lift station	1993

Table 1-2. Constructed CSO Reduction Facilities

CSO basin number	Major facility elements	Year
Duwamish		
111	Five overflow structures with weirs; low flow diversion from storm drain to County's Duwamish Pump Station HydroBrake with in-line storage	1994
Lake Union/Portage Bay		
130, 132, 135, 175	Five new connections to reroute flow to King County's Denny Way/ Lake Union CSO Control Facility and City's share of facility cost: • Roy Street and Eighth Avenue North • Republican Street and Eighth Avenue North • Roy Street and Dexter Avenue North • Valley Street and Westlake Avenue North • Valley Street, east of Fairview Avenue North	1997 - 2004
138	HydroBrake with off-line storage	1994
Delridge		
168	HydroBrake with off-line storage tank	1984
169	HydroBrake with off-line storage tank	1984
170	Overflow weir in manhole; HydroBrake; off-line storage	1983

1.4.2.3 Committed 2010 CSO Reduction Projects

The City's focus through 2015 is to reduce CSOs at the most critical and sensitive sites through a cost-effective blend of traditional and sustainable infrastructure. The path forward involves a four-pronged approach:

1. optimize existing CSO infrastructure through low-cost retrofits
2. construct large CSO infrastructure projects to reduce overflows to Lake Washington
3. construct natural "green" solutions to reduce CSOs throughout the City
4. develop and implement a Long Term Control Plan to control all remaining CSOs and achieve water quality goals.

Table 1-3 presents the projects scheduled to be completed.

Table 1-3. 2010 Plan CSO Reduction/Control Projects

Applicable CSO basins	CSO control measures	Implementation status as of May 2014
Windermere		
013 015	Off-line storage retrofit	CSO Basin 013 construction began in October 2012 and is planned for November 2014 completion. CSO Basin 015 construction completion August 2012. Post-construction monitoring started Sept 2012 and will continue until 2014.
Genesee		
040 041 043	Off-line storage Off-line storage Off-line storage	CSO Basin 040 and 041 storage have been combined into a single off-line storage project. CSO Basin 043 has a separate off-line storage project. Both projects began construction in April 2013 and planned for October 2014 completion.
040, 041 and 043	Green infrastructure	Residential RainWise program is offered in these basins.
Ballard		
150/151 and 152	Green infrastructure	CSO Basin 152 pilot project constructed in 2011-12 and post-construction monitoring was performed in 2012-13. Additional GI right-of-way projects will start construction 2015. RainWise is offered in this basin.
Magnolia		
060	Green infrastructure	Residential RainWise program is offered in CSO Basin 060. No other green infrastructure projects are planned.
North Union Bay		
018	Green infrastructure	Residential RainWise program is offered in this basin. Additional GI projects in evaluation.
Interbay		
068	Green infrastructure	This basin is now controlled based on the 2012 Annual CSO Report.
Henderson		
049	Off-line storage	A storage project is in the preliminary engineering phase.
Montlake		
140	Green infrastructure	Residential RainWise program is offered in this basin.
Fremont/Wallingford		
147 & 174	Green infrastructure	Residential RainWise program is offered in this basin.

Table 1-3. 2010 Plan CSO Reduction/Control Projects

Applicable CSO basins	CSO control measures	Implementation status as of May 2014
Central Waterfront		
069 070 & 071	Off-line storage Off-line storage	Since the northern portion of the Elliott Bay Seawall project (which includes CSO Outfall 069) will not be constructed until after 2020, it was determined that the LTCP should include a CSO Outfall 069 project. During the SDOT's Elliott Bay Seawall and Central Waterfront Project design phases, it was determined that CSO Basins 070 and 071 should be coordinated and constructed with the first phase of the Elliott Bay Seawall project. The anticipated completion date is 2018-2020.
West Seattle		
095	Retrofit	CSO Basin 095 construction completed June 2013. Post-construction monitoring started July 2013 and will continue for 1 year.
Delridge		
168 169	Retrofit Retrofit	Bid in 2014. Construction completion December 2014. Post-construction monitoring will start January 2015 and continue for two years. RainWise program is offered in these basins. Green Infrastructure projects will start construction 2015.

1.4.2.4 Consent Decree Early Action CSO Control Programs and Measures

The Consent Decree requires the City to implement early action CSO control measures in the Henderson CSO area. Those requirements include:

- Construction completion for CSO Outfalls 046 and 047/171 by December 31, 2015
- Achievement of controlled status for CSO Outfalls 046 and 047/171 by December 31, 2016
- Construction completion for CSO Outfalls 044 and 045 by December 31, 2018
- Achievement of controlled status for CSO Outfalls 044 and 045 by December 31, 2019

Additionally, the Consent Decree requires that if a CSO outfall is not controlled within one year following construction completion of the CSO project, the City must submit to the EPA and Ecology a Supplemental Compliance Plan that outlines how the City will bring the outfall into compliance.

Their project status is shown on Table 1-4.

Table 1-4. Early Action Projects

CSO basins	CSO control measures	Implementation status as of May 2014
North Henderson		
044 045	Off-line storage	CSO Basin 044 and 045 storage will be a 2.65 MG off-line storage project. The project is in final design.

Table 1-4. Early Action Projects

CSO basins	CSO control measures	Implementation status as of May 2014
South Henderson		
046	Off-line storage	This project involves an upgrade of Wastewater Pump Station 9 which is located at South Grattan Street. The upgrade consist of increasing the pumping capacity from 3.2 MGD to 3.9 MGD and replacing the force main.
047/171	Off-line storage	A storage project is being constructed to serve Basins 047 and 171.

1.4.3 City CSO Discharge Control Status

The following sections present the control status of the City's CSO outfalls and the methodology used to determine the control status. As prescribed by Ecology, a CSO outfall is considered controlled if it discharges no more than once per year on a 20-year moving average.

Several approaches of varying complexity were available for estimating CSO control status. The approach used for each basin was chosen based on the stage of completion and method of analysis being performed by the various consultants employed by the City to assess basins in various areas of the City. Some methods were based on direct use of overflow data reported to Ecology, and others were based on computer modeling. Table 1-5 describes the various estimating approaches.

Table 1-5. Summary of CSO Control Status Estimating Approaches

Annual overflow data approach	
Underlying principle	Control status may be estimated from direct monitoring of overflows.
Description	Review the City's permanent CSO monitoring data to establish long-term range of overflow frequency.
Required information	Accurate, reliable flow monitoring data indicating frequency and volume of overflows for the subject basin
Use and accuracy	This approach is considered appropriate for planning purposes. In the 2010 CSO Reduction Plan Amendment, this approach was used to determine the control volume for the majority of the CSO basins. This approach was also used to determine which CSO areas should undergo detailed hydraulic and hydrologic modeling.

Table 1-5. Summary of CSO Control Status Estimating Approaches	
Annual overflow data approach	
Annual overflow data approach	Computer models can use detailed system information and historical flow records to estimate overflow frequency and volume over long periods and a wide range of conditions. Long-term simulation allows evaluation of overflow performance for a wider range of conditions than available from the permanent metering program. It therefore provides a higher level of confidence that the selected control volume is not a statistical anomaly.
Underlying principle	Develop a hydrologic/hydraulic model of one basin or several connected basins using available system information. Conduct flow monitoring to provide data for calibration of the model. Use the calibrated model to simulate a range of historical flow events for validation and further refinement based on comparison of model results to recorded data. Use the final refined model to simulate flows for approximately 30 years of rainfall data recorded by the City's rain gauge network. Identify the 31st largest overflow volume and use it as the basin's CSO control volume.
Description	City GIS records provide hydraulic loading data (census data, roof or pavement area, etc.) and sewer network physical characteristics. Sewer system as-built information enables error correction and confirmation of attributes at key hydraulic structures. Rainfall data have been recorded at 17 locations across the City with most gauges having a data record back to 1978. Models are calibrated using data from short-term flow metering and rainfall information from a suitable rain gauge. Further refinement is made by validation against historical overflow records. As part of the refinement process, a field survey program was performed to verify physical parameters at a number of key structures.
Required information	Long-term model simulations are considered the highest level of accuracy for determining control volumes for CSO basins. Long-term simulations were used to determine the control volumes for the uncontrolled CSO outfalls.

1.4.3.1 CSO Discharges Control Status

Table 1-6 presents the control status for all City of Seattle CSO basins as indicated in Appendix A of the Consent Decree.

Table 1-6. Consent Decree CSO Discharges Control Status

CSO area	CSO outfall	Consent Decree control status
Ballard	057	Controlled
	059	Controlled
	150/151	Uncontrolled
	152	Uncontrolled
Central Waterfront	069	Uncontrolled
	070	Controlled

Table 1-6. Consent Decree CSO Discharges Control Status		
CSO area	**CSO outfall**	**Consent Decree control status**
	071	Uncontrolled
	072	Controlled
Delridge	099	Uncontrolled
	168	Uncontrolled
	169	Uncontrolled
	170	Controlled
Duwamish	107	Uncontrolled
	111	Uncontrolled
Fremont/Wallingford	147	Uncontrolled
	148	Controlled
	174	Uncontrolled
Genesee	038	Controlled
	040	Uncontrolled
	041	Uncontrolled
	042	Controlled
	043	Uncontrolled
	165	Controlled
Henderson	044	Uncontrolled
	045	Uncontrolled
	046	Uncontrolled
	047	Uncontrolled
	048	Controlled
	049	Uncontrolled
	171	Uncontrolled

Table 1-6. Consent Decree CSO Discharges Control Status

CSO area	CSO outfall	Consent Decree control status
Interbay	068	Uncontrolled
Lake Union/North	141	Controlled
	144	Controlled
	145	Controlled
	146	Controlled
Lake Union/West	120	Controlled
	121	Controlled
	124	Controlled
	127	Controlled
Leschi	026	Controlled
	027	Controlled
	028	Uncontrolled
	029	Uncontrolled
	030	Controlled
	031	Uncontrolled
	032	Uncontrolled
	033	Controlled
	034	Uncontrolled
	035	Controlled
	036	Uncontrolled
Madison Park/Union Bay	022	Controlled
	024	Controlled
	025	Uncontrolled
Magnolia	060	Uncontrolled

Table 1-6. Consent Decree CSO Discharges Control Status

CSO area	CSO outfall	Consent Decree control status
	061	Controlled
	062	Controlled
	064	Controlled
Montlake	020	Uncontrolled
	139	Uncontrolled
	140	Uncontrolled
North Union Bay	018	Uncontrolled
	019	Controlled
Portage Bay	129	Controlled
	130	Controlled
	131	Controlled
	132	Controlled
	134	Controlled
	135	Controlled
	136	Controlled
	138	Uncontrolled
	175	Controlled
West Seattle	078	Controlled
	080	Controlled
	083	Controlled
	085	Controlled
	088	Controlled
	090	Controlled
	091	Controlled

Table 1-6. Consent Decree CSO Discharges Control Status		
CSO area	**CSO outfall**	**Consent Decree control status**
	094	Controlled
	095	Uncontrolled
Windermere	012	Controlled
	013	Uncontrolled
	014	Controlled
	015	Uncontrolled
	016	Controlled
	161	Controlled

1.5 Long-Term Planning Approach Summary

The following sections summarize the planning approach used to develop the City's LTCP, including a description of relevant EPA LTCP requirements, control criteria, the relationship between the City's and King County's CSO programs, and the public participation process.

1.5.1 Compliance with EPA CSO Control Policy

The EPA CSO Control Policy lists nine elements that should be addressed in the overall planning approach. Table 1-7 presents the locations in this LTCP where the EPA CSO Control Policy elements are addressed.

Table 1-7. Comparison of EPA CSO Control Policy Elements and LTCP Chapters	
EPA CSO Control Policy element	**LTCP section**
Characterization, monitoring, and modeling activities as the basis for selection and design of effective CSO controls	Chapter 2, Section 2.3, 2.4, and 2.6
A public participation process that actively involves the affected public in the decision-making to select long-term CSO controls	Chapter 4, Section 4.2 Chapter 5, Section 5.2
Consideration of sensitive areas as the highest priority for controlling overflows	Chapter 2, Section 2.5
Evaluation of alternatives that will enable the permittee, in consultation with the NPDES permitting authority, water quality standards (WQS) authority, and the public, to select CSO controls that will meet CWA requirements	Chapter 3
Cost/performance considerations to demonstrate the relationships among a comprehensive set of reasonable control alternatives	Chapter 4, Section 4.1

Table 1-7. Comparison of EPA CSO Control Policy Elements and LTCP Chapters	
EPA CSO Control Policy element	**LTCP section**
Operational plan revisions to include agreed-upon long-term CSO controls	Chapter 4, Section 4.5 Chapter 5, Section 5.11
Maximization of treatment at the existing POTW treatment plant for wet-weather flows	Chapter 2, Section 2.2.
An implementation schedule for CSO controls	Chapter 4, Section 4.4 Chapter 5, Section 5.9
A post-construction compliance monitoring program adequate to verify compliance with water-quality-based CWA requirements and ascertain the effectiveness of CSO controls	Chapter 5, Section 5.12
Selection of a recommended control option	Chapter 5

1.5.2 Conformance with Consent Decree Requirements and EPA Guidance for Long-Term Control Plan

1.5.2.1 Consent Decree Requirements

In addition to the EPA's CSO Control Policy, the Consent Decree stipulates specific criteria and requirements for the LTCP. Table 1-8 is a matrix that summarizes where the Consent Decree LTCP requirements are addressed in Volume 2 LTCP. Appendix A includes a detailed matrix of the Consent Decree requirements, and where the LTCP report addresses the requirements.

Table 1-8. Consent Decree Compliance Matrix			
Consent Decree item	**Consent Decree reference and description**	**LTCP section**	**Comments**
Appendix C, LTCP Requirements			
A.1 through. A.5	A. Public and Regulatory Agency Participation Program.	Chapter 4, Section 4.2 and Chapter 5 Section 5.2	Describes the public and regulatory agency participation program performed for the LTCP Refer to 2013 CSO Annual Report (Reference 18)
B.1 and B.2.	B. Hydraulic Model Development and Hydraulic Model Report	Chapter 2, section 2.6 Appendix B	Describes the hydraulic modeling for the LTCP. East Waterway CSO Basin 107 Hydraulic Model Report is included in Appendix B.
C.1. through C.14	C. Long Term Control Plan	Chapter 3	Chapter 3 describes how the LTCP used the 2010 CSO Reduction Plan as the basis for the CSO control measure alternative analysis, CSO control measure screening, project cost methodology, and the development of the LTCP options.

Table 1-8. Consent Decree Compliance Matrix

Consent Decree item	Consent Decree reference and description	LTCP section	Comments
		Chapter 4	Chapter 4 describes the evaluation of project costs, implementation schedule, rate analysis, and the rating and ranking of the LTCP options. This chapter is based on financial direction provided in *Combined Sewer Overflows: Guidance for Financial Capability Assessment and Schedule Development* (Reference 19). The City has completed this assessment and it can be found in Appendix C. The chapter also describes the final decision-making process for the selection of the recommended LTCP CSO control measures for the LTCP. The *Option Rating and Ranking Report (MODA)* is included as Appendix D.
		CSO Alternative Analysis Report (December 31, 2014)	A draft Final LTCP was submitted for EPA review in February 2015 for preliminary approval. That submittal is documented (in Chapter 5, Section 5.4) the selection process for a recommended LTCP option. EPA/Ecology agreed that this would satisfy the requirement for the CSO Alternative Analysis Report submittal.
		LTCP Implementation Schedule Report (December 31, 2014)	An implementation schedule was included in the draft LTCP for the four options presented. A draft Final LTCP was submitted for EPA review in February 2015 for preliminary approval. That submittal documented (in Chapter 5, Section 5.9) the selection process for a recommended LTCP option. That draft also included a detailed implementation schedule for the recommended LTCP CSO control measures. EPA/Ecology agreed that this would satisfy the requirement for the Implementation Schedule Report submittal.
		Financial Analysis Report	A financial analysis was included in the draft LTCP for the four options that were presented. A draft Final LTCP was submitted for EPA review in February 2015 for preliminary approval. That submittal documented (in Chapter 5, Section 5.10) the selection process for a recommended LTCP option. That submittal included an evaluation of the City's financial capability to fund the selected alternative or combination. EPA and Ecology agreed that this would satisfy the requirement for the Financial Analysis Report submittal.

Table 1-8. Consent Decree Compliance Matrix			
Consent Decree item	**Consent Decree reference and description**	**LTCP section**	**Comments**
D.1 through. D.3	D. Post-Construction Monitoring Program	Chapter 5, Section 5.12 Final PCMP (May 31, 2015)	Describes the post-construction monitoring program for the CSO control measures. Detailed *Post-Construction Monitoring Plan* (PCMP) required under the Consent Decree will be submitted as a separate document by May 31, 2015.

1.5.2.2 EPA Guidance for Long-Term Control Plan

The EPA guidance document *Combined Sewer Overflows, Guidance for Long Term Control Plan* (1995) (Reference 20) provides guidance and recommendations on how to prepare a comprehensive long-term control plan for CSOs. Table 1-9 is a matrix that summarizes where the *EPA Guidance for Long Term Control Plan* requirements are addressed in Volume 2, the LTCP.

Table 1-9. EPA Guidance Document Compliance Matrix			
Guidance Document item	**Guidance document reference and description**	**LTCP section**	**Comments**
Chapter 1 - Introduction			
1.1	Background	All LTCP Chapters	Background information only, no specific LTCP requirements
1.2	History of the CSO Control Policy	All LTCP Chapters	Background information only, no specific LTCP requirements
1.3	Key elements of the CSO Control Policy	All LTCP Chapters	CSO Control Policy principles used in the preparation of the LTCP
1.4	Guidance to support implementation of the CSO Control Policy	All LTCP Chapters	EPA reference documents used in the preparation of the LTCP
1.5	Goal of this guidance document	All LTCP Chapters	EPA guidance document goals used in the preparation of the LTCP
1.6	Long-term planning approach summary	All LTCP Chapters	Overall EPA planning approach incorporated in the preparation of the LTCP
Chapter 2 – System Characterization			
2.1	Public participation and agency interaction	Chapter 4, section 4.2; Chapter 5, Section 5.2	Describes the public and regulatory agency participation program performed for the LTCP

Table 1-9. EPA Guidance Document Compliance Matrix

Guidance Document item	Guidance document reference and description	LTCP section	Comments
2.2	Objective of system characterization	Chapter 2, section 2.1	Describes the system characterization objectives
2.3	Implementation of the Nine Minimum Controls	Chapter 2, section 2.2	Describes the City's implementation program for the Nine Minimum Controls
2.4	Compilation and analysis of existing data	Chapter 2, sections 2.3, 2.4, and 2.7	Describes the existing CSO system information, flow monitoring data, sewer modeling and CSO control status evaluation work.
2.5	Combined sewer system and receiving water monitoring	Chapter 2, section 2.4	IV.9 (ee) of the Consent Decree defined a presumptive approach which was used for this LTCP No receiving water monitoring was performed under the presumptive approach.
2.6	Combined sewer system and receiving water modeling	Chapter 2, section 2.6	IV.9 (ee) of the Consent Decree defined a presumptive approach which was used for this LTCP. No receiving water monitoring was performed under the presumptive approach.
Chapter 3 – Development and Evaluation of Alternatives for CSO Control			
3.1	Public participation and agency interaction	Chapter 4, section 4.2 Chapter 5, Section 5.2	Describes the public and regulatory agency participation program performed for the LTCP
3.2	Long-term control plan approach	Chapter 3, section 3.1	Describes long-term control plan approach including compliance with performance criteria IV.9 (ee) of the Consent Decree defined a presumptive approach which was used for this LTCP.
3.3	Development of alternatives for CSO control	Chapter 3	Chapter 3 describes how the LTCP evaluated various CSO control measures, screened CSO control measures, and developed the LTCP system wide options including joint projects with King County.

Table 1-9. EPA Guidance Document Compliance Matrix

Guidance Document item	Guidance document reference and description	LTCP section	Comments
3.4	Evaluation of alternatives for CSO control	Chapter 4, section 4.1 Chapter 5, Section 5.3 and 5.4	CSO alternative analysis and rating and ranking of LTCP options
3.5	Financial capability	Chapter 5, Section 5.10	Financial analysis performed for LTCP options.
Chapter 4 – Selection and Implementation of CSO Control Measures			
4.1	Public participation and agency interaction	Chapter 4, section 4.2 Chapter 5, Section 5.2	Describes the public and regulatory agency participation program performed for the LTCP
4.2	Final Selection and development of recommended plan	Chapter 4, section 4.1	CSO alternative analysis and rating and ranking of LTCP options
4.3	Financing plan	Chapter 5, Section 5.10	Financial analysis performed for Draft LTCP options.
4.4	Implementation schedule	Chapter 4, section 4.4 Chapter 5, Section 5.9	LTCP Implementation Schedules prepared for LTCP options.
4.5	Operational plan	Chapter 4, section 4.5 Chapter 5, Section 5.11	Operations and maintenance approach prepared for LTCP options
4.6	Post-construction compliance monitoring	Chapter 5, Section 5.12	PCMP overview described in LTCP. Final PCMP described in a separate report.
4.7	Re-evaluation and update	Chapter 5, Section 5.8	Data evaluation and CSO performance reporting requirements described

1.5.3 Demonstration versus Presumption Approach

The EPA CSO Control Policy identifies two general approaches to CSO control: the demonstration approach and the presumption approach. The demonstration and presumption approaches provide municipalities with targets for CSO controls that achieve compliance with the CWA, particularly protection of designated uses.

Under the demonstration approach, the municipality would be required to successfully demonstrate compliance with each of the following criteria:

1. The planned control program is adequate to meet WQS and protect designated uses, unless WQS or uses cannot be met as a result of natural background conditions or pollution sources other than CSOs.

2. The CSO discharges remaining after implementation of the planned control program will not preclude the attainment of WQS or the receiving waters' designated uses or contribute to their impairment. Where WQS and designated uses are not met in part because of natural background conditions or pollution sources other than CSOs, a total maximum daily load, including a waste load allocation, a load allocation, or other means should be used to apportion pollutant loads.
3. The planned control program will provide the maximum pollution reduction benefits reasonably attainable.
4. The planned control program is designed to allow cost-effective expansion or cost-effective retrofitting if additional controls are subsequently determined to be necessary to meet WQS or designated uses.

Under the presumption approach, controls adopted in the LTCP should be required to meet one of the following criteria:

1. 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. For the purpose of this criterion, an overflow event is one or more overflows from a CSS as the result of a precipitation event that does not receive the minimum treatment specified.
2. The elimination or the capture for treatment of no less than 85 percent by volume of the combined sewage collected in the CSS during precipitation events on a system-wide annual average basis.
3. 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 item 2 above.

Appendix C, C.1 of the Consent Decree indicates that "meeting the performance criteria [of one CSO per outfall per year on a 20-year rolling average] is equivalent to meeting the presumption approach in the LTCP guidance."

1.5.4 CSO Control Performance Criteria (Moving 20-year Average)

As indicated in the Consent Decree and Ecology regulations, the CSS will be considered controlled if there is no more than one overflow per year per outfall, on a 20-year moving average.

The Consent Decree further explains how to calculate the 20-year moving average:

> *For previously controlled CSO Outfalls and where monitoring records exist for the past 20 consecutive years, the twenty year moving average shall mean the average number of untreated discharges per CSO Outfall over the 20 year record. On an annual basis, the twenty year moving average will be calculated and includes the current monitored year and each of the previous 19 years of monitored CSO data. For CSO reduction projects and controlled CSO Outfalls where a complete twenty year record of monitored data does not exist, missing annual CSO frequency data will be generated based on the predicted CSO frequency for a given year as established in the approved engineering report or facility plan. For each CSO reduction project, the engineering report or facility plan shall predict the CSO frequency for each CSO Outfall based on long-term simulation modeling using a 20-year period of historical rainfall data, the hydraulic model, the CSO control project design and assuming the CSO control project existed throughout the 20-year period. For CSO reduction projects, the level of control is the number of discharge events per CSO outfall per year that are estimated to occur based on the designed CSO control project over a 20-year period. The level of control will be estimated for each year for a period of 20 years in the engineering report or facility plan. For*

the time period between the approval of the engineering report and the CSO reduction project's Construction Completion date, the City shall use the same model for the approved design along with the corresponding measures for eliminating or reduction the City's CSOs included in any Supplemental Compliance Plan developed and implemented in accordance with Section V.B.

1.5.5 Relationship between City and King County CSO Control Efforts

Both King County and Seattle Public Utilities own CSO outfalls within the City of Seattle limits. Based on agreements made at the start of the regional system in 1958, both King County and the City are responsible for CSOs and are working to control them under long-term CSO control plans.

Because the City drainage basins are smaller, overflows from the city system are usually smaller in volume and shorter in duration but may occur more frequently than overflows from the county system. King County is also amending its long-term CSO control plan. The two agencies communicate frequently and participate in each other's CSO control planning efforts. The City will consider shared CSO control projects with King County if the projects are deemed to be cost-effective for ratepayers, provide a better environmental outcome, or have the potential to minimize construction disruption to nearby communities.

1.5.6 Public and Regulatory Agency Participation Program

The Consent Decree specifies that the LTCP shall include a public and regulatory agency participation program. The purpose of this program is to ensure that there is ample public participation throughout all stages of development of the City's LTCP. Table 1-10 describes how public and regulatory agency participation requirements of the Consent Decree have been implemented in the LTCP.

Table 1-10 Public and Regulatory Agency Participation Program

Consent Decree requirement	Public and regulatory agency participation approach
The means by which the City will make information pertaining to the development of the LTCP available for public review.	The City's Community Guide updates will provide updates on the LTCP/Integrated Plan and Programmatic EIS: • Animations • Visualizations • Video for website • Briefings • Website updates • Updates to the project listserv
The means by which the City will solicit comments from the public on the development of the LTCP.	• Scoping meetings (October 2011) • Online Questionnaires • Re-scoping meetings (May 2013) • Briefings • Public Meeting/Hearing on the Draft LTCP/Integrated Plan/EIS Spring 2014 • Comments and questions can be submitted anytime to the City via e-mail at CSO_LTCP@seattle.gov.

Table 1-10 Public and Regulatory Agency Participation Program	
Consent Decree requirement	**Public and regulatory agency participation approach**
Summary of public hearings at meaningful times during the LTCP development process to provide the public with information and to solicit comments from the public regarding components of the LTCP.	• Draft EIS public hearing summary report • *LTCP/Integrated Plan Public and Regulatory Agency Participation Summary Report*
Program for consideration of comments provided by the public as the City develops the LTCP.	Summary reports to be prepared for all public meetings. The summary reports will include a comment response section: • Scoping summary report (2011) • Re-scoping summary report (spring 2013) • Final EIS comment response • *LTCP/Integrated Plan Public and Regulatory Agency Participation Final Summary Report*
Measures that the City will employ to ensure that Plaintiffs are kept informed of the City's progress in developing its LTCP development process and regular submittal of reports to Plaintiffs summarizing the public comments received throughout implementation of the Program.	• Quarterly meetings with EPA and Ecology (addresses both LTCP and Integrated Plan) • Webinars for plaintiffs at meaningful times – emphasis of webinar will be to report on public involvement activities and comments received at major milestones. • June/July 2013: Re-scoping recap • May 2014 Draft LTCP/Integrated Plan/DEIS rollout • Oct/Nov 2014: LTCP/Integrated Plan/DEIS public hearing recap

1.5.7 2010 CSO Reduction Plan Amendment as LTCP Starting Basis

This LTCP uses the 2010 CSO Reduction Plan Amendment as the starting point for developing CSO reduction projects. As indicated in the Consent Decree:

> *The LTCP shall build upon the alternative analysis work that was performed as part of the development of the City's 2010 CSO Reduction Plan Amendment (2010 Plan). Alternatives that were screened out as part of the 2010 Plan will not be evaluated further in the LTCP.*

In Chapter 3, the LTCP will discuss the recommended projects in the 2010 CSO Reduction Plan Amendment and what changes have been made to the recommendations.

1.5.8 Controlling Uncontrolled CSO Basins

In 2013, there were 219 overflow events and 38 million gallons discharged from Seattle Public Utilities' permitted outfalls. Table 5-8 of the City's 2013 CSO Annual Report shows which CSO basins are controlled and which are uncontrolled based on up to 20 years of flow monitoring supplemented with hydraulic modeling as appropriate. The 35 uncontrolled CSO basins will be controlled through the City's CSO reduction program. Table 1-11 lists the uncontrolled CSO basins and where each basin's recommended control measure is identified.

Table 1-11. Controlling Uncontrolled Basins

CSO area	CSO basin	CSO reduction project source
Ballard	150/151	LTCP project
	152	LTCP project
Central Waterfront	069	LTCP project
	071	2010 CSO Reduction Plan project
Delridge	099	LTCP project
	168	CSO Retrofit Program and LTCP project
	169	CSO Retrofit Program and LTCP project
Duwamish	107	LTCP project
	111	LTCP project
Fremont/Wallingford	147	LTCP project
	174	LTCP project
Genesee	040	2010 CSO Reduction Plan project
	041	2010 CSO Reduction Plan project
	043	2010 CSO Reduction Plan project
Henderson	044	Early Action
	045	Early Action
	046	Early Action
	047	Early Action
	049	2010 CSO Reduction Plan project
	171	Early Action
Leschi	028	LTCP project
	029	LTCP project
	031	LTCP project
	032	LTCP project
	036	LTCP project
Magnolia	060	LTCP project

Table 1-11. Controlling Uncontrolled Basins

CSO area	CSO basin	CSO reduction project source
Montlake	020	LTCP project
	139	LTCP project
	140	LTCP project
North Union Bay	018	LTCP project
Portage Bay	138	LTCP project
West Seattle	095	2010 CSO Reduction Plan project
Windermere	013	2010 CSO Reduction Plan project
	015	2010 CSO Reduction Plan project

1.5.9 CSO Discharges Covered by LTCP

The CSO basins included in the LTCP are those that are uncontrolled and do not already have CSO reduction projects being implemented in them, or basins that are controlled but hydraulically linked to uncontrolled LTCP basins (which could cause them to become uncontrolled).

Table 1-12 presents the CSO basins that were evaluated in the LTCP.

Table 1-12. CSO Basins Included in the LTCP

CSO area	CSO basin
Ballard	150/151, 152
Central Waterfront (Vine Street)	069
Delridge	099, 168, 169
Duwamish	111
East Waterway	107
Fremont/Wallingford	147, 174
Leschi	028, 029, 031, 032, 036
Magnolia	060
Montlake	020, 139, 140
North Union Bay	018
Portage Bay	138

1.5.10 Factors Considered in LTCP Approach

As described in the Consent Decree, the LTCP approach must consider several factors:

- Evaluation of the technical feasibility and applicability of each alternative or combination of alternatives at each CSO outfall or grouping of CSO outfalls
- A determination of the estimated project costs, including capital costs, annual operation and maintenance costs, and life cycle costs, for each separate component of each alternative or combination of alternatives
- An analysis of alternatives for reducing the City's CSOs, including:
  - An evaluation of the annual performance capabilities and effectiveness of various alternatives
  - An analysis of design and development capabilities for the alternatives, including basin-specific information on flow management, topographical or hydrological constraints, and construction capacities
  - An evaluation of project costs, including capital costs, annual operations and maintenance costs, and total present worth
- The screening of selected CSO control alternatives, involving additional evaluation of the geotechnical environment and property information, as well as the preparation of the appropriate environmental review, for the identified project area
- The basis for the City's selection of the preferred alternatives
- An evaluation of the City's financial capability to fund the selected alternative or combination of alternatives
- An expeditious schedule for the design, construction, and implementation of all CSO control measures
- An assessment of the costs, benefits, and effectiveness of the alternatives evaluated for reducing CSOs
- The basis for determining that the CSO control measures set forth in the LTCP will ensure that the City's CSOs comply with the CSO Control Policy
- The basis for determining that the schedule for implementing the LTCP attains construction completion of all CSO control measures no later than December 31, 2025

1.5.11 Measures of Success

The NMC and the LTCP requirements under the CSO Policy require that the effectiveness of the controls be measured to determine if the goals of the Policy and the requirement of the CWA have been met. The evaluation of the effectiveness of the LTCP against the NMC and CSO LTCP requirements will be measured based upon the EPA published guidelines. In addition to these required measures of success, the LTCP will also focus on five specific values:

- Identify areas of Seattle where projects are needed to reduce sewage overflows
- Evaluate alternatives for reducing sewage overflows in these areas
- Recommend a schedule for designing and constructing projects
- Estimate program costs and associated impacts on Seattle Public Utilities customer bills
- Consider public and stakeholder input

CHAPTER 2

System Characterization

2.1 Objective of System Characterization

The primary objective of system characterization is to develop a detailed understanding of the current conditions of the combined sewer system and receiving waters. System characterization consists of three activities:

- Compiling and analyzing existing data on the CSS
- Monitoring flow throughout the CSS
- Modeling the CSS

This assessment, a crucial component of the planning process, establishes existing baseline conditions and provides the basis for determining receiving water goals and priorities and identifying specific CSO controls in the LTCP.

2.1.1 Purpose

The purpose of combined sewer system characterization and evaluation, monitoring, and modeling is to better understand the response of the system to various wet-weather events, the characteristics of the overflows, and the baseline CSO conditions. The CSS characterization information is imperative for developing a CSO control plan adequate to meet the Clean Water Act and Consent Decree.

2.1.2 Characterization Elements

The major elements of a sewer system characterization are listed below with the description from the United States EPA guidance document *Combined Sewer Overflows Guidance for Long-Term Control Plan* (EPA LTCP Guidance Document). Subsequent sections describe major elements in more detail:

- Characterization and evaluation – "The permittee should evaluate the nature and extent of its sewer system through evaluation of available sewer system records, field inspections, and other activities."
- Monitoring - "The permittee should develop a comprehensive, representative monitoring program that measures the frequency, duration, flow rate, volume, and pollutant concentration of CSO discharges and assesses the impact of the CSOs on the receiving waters." This can include the following: number of CSOs, locations of CSOs, frequency of CSOs, and volume of CSOs.
- Modeling – "The primary objective of CSS modeling is to understand the hydraulic response of the CSS to a variety of precipitation and drainage area inputs." Once the model is calibrated and verified, it can be used for numerous applications that support CSO planning efforts.

2.1.2.1 Characterization and Evaluation

One of the first technical activities within system characterization is the characterization and evaluation of existing data. The following subsections describe the four components of characterization and evaluation; watershed mapping, collection system understanding, CSO and non-CSO source characterization, and receiving water investigation.

See Section 2.3 for details on characterization and evaluation activities completed by the City.

2.1.2.1.1 Watershed Mapping

The EPA LTCP Guidance Document defines a watershed as "a water body and the entire land area that drains into that water body." Watershed mapping consists of delineating watersheds and subwatersheds, and overlaying relevant data including topography, political boundaries, land use categories, soils, infrastructure, natural resources, recreational areas, special fish and habitat areas, and existing pollution control structures.

2.1.2.1.2 Collection System Understanding

The EPA LTCP Guidance Document indicates that a municipality should "evaluate the nature and extent of its combined sewer system through evaluation of available sewer system records, field inspections and other activities necessary to understand the number, location and frequency of overflows and their location relative to sensitive areas and to pollution sources in the collection system, such as indirect significant industrial users."

See Sections 2.3.1, 2.3.3, and 2.3.4 for details on collection system understanding activities completed by the City.

2.1.2.1.3 CSO and Non-CSO Source Characterization

The EPA LTCP Guidance Document recommends that municipalities should "identify areas that contain probable sources of significant loadings, such as industrial areas with significant indirect industrial users."

2.1.2.1.4 Receiving Water Investigation

The EPA LTCP Guidance Document recommends that municipalities should characterize the receptors of CSOs and watershed pollutant sources and their effects as completely as possible. See Section 2.3.7 for details on the results of the receiving water investigations.

2.1.2.2 Monitoring

The EPA LTCP Guidance Document indicates that in many cases, "existing data will not be sufficient to establish existing baseline dry-weather or wet weather conditions. Thus, the next step in the long-term planning process generally will be to develop and conduct a monitoring program to adequately characterize existing conditions, as well as provide the necessary calibration and verification data for system modeling."

The City has conducted an extensive rainfall and flow monitoring program throughout the CSS. This program has consisted of flow monitoring at CSO locations since 2000, two seasons (2008-2009 and 2009-2010) of detailed flow monitoring in the LTCP CSS basins, additional flow monitoring at specific locations since 2010, and continuous rainfall monitoring at 17 rain gages across the CSS since 1978. See Section 2.4 for details on monitoring activities completed by the City's CSO Program.

2.1.2.3 Combined Sewer System Modeling

The EPA LTCP Guidance Document indicates that the primary objective of CSS modeling is "to understand the hydraulic response of the CSS to a variety of precipitation and drainage area inputs." The calibrated and verified model can be used for numerous applications that support CSO planning efforts, including predicting overflow occurrence and volume, predicting performance of portions of the CSS that have not been extensively monitored, developing CSO statistics, optimizing the CSS performance as part of the Nine Minimum Controls implementation, and evaluating and optimizing control alternatives. The City has calibrated and verified 13 hydrologic and hydraulic models of CSS basins in Seattle.

2.2 Implementation of Nine Minimum Controls

The EPA CSO Control Policy, published in 1994, provides guidance to stakeholders for coordinating the planning, selection, and implementation of CSO controls that meet the requirements of the CWA. Among other things, the policy establishes two main objectives for permittees: implementation of nine minimum controls (Reference 21) and development and implementation of an LTCP.

As the name implies, the LTCP is intended to be a far-reaching plan that presents a comprehensive approach to the identification, evaluation, and implementation of long-term, capital-intensive controls to reduce the impact of CSOs. The development and implementation of the LTCP can take several decades to complete.

Conversely, it was intended that the NMCs "reduce CSOs and their effects on receiving water quality, do not require significant engineering studies or major construction, and can be implemented in a relatively short period of time." The EPA envisioned that "implementing the nine minimum controls is among the first steps a municipality should take to reduce combined sewer overflow impacts." Similar to the intent of the LTCP, efforts undertaken for the NMCs are not considered as temporary measures. They should be integrated into a community's long-term efforts to control CSOs.

The following subsections describe the City's implementation of the NMC's.

2.2.1 Nine Minimum Controls Performance

The controls ensure that maximum use is being made of existing infrastructure, management emphasis, and regulatory programs prior to major investment in new capital projects. They are intended to enhance combined sewer system performance through focused maintenance and relatively low-cost improvements. The nine minimum controls have been integrated into the City's regular operation and maintenance procedures. They include enhanced or more frequent maintenance and retrofit of flow-control devices such as HydroBrakes and weirs. They are typically low-cost, easy to implement, and less disruptive than other CSO reduction approaches.

The following subsections describe the NMC work that was performed in 2013 on each of these nine control measures.

2.2.1.1 Control 1: Provide System Operations and Maintenance

Reduce the magnitude, frequency, and duration of CSOs through proper operation and maintenance (O&M) of the combined sewer system.

Each year the City performs extensive system O&M activities to reduce the frequency and volume of preventable overflows. Routine maintenance activities include sewer inspections, cleaning, and non-emergency point repairs; catch basin inspection, cleaning, and repairs; control structure and storage structure cleaning; valve and flap gate inspection, cleaning, lubricating, and servicing; and pump station electrical, mechanical, and facilities inspection and servicing. The City uses the National Association of Sewer Service Companies (NASSCO) pipeline assessment and certification program (PACP) defect coding system to identify and prioritize pipes to be scheduled for maintenance or rehabilitation.

Once a sewer has been identified as having a maintenance-related problem, the sewer is placed on a routine cleaning schedule to prevent future maintenance-related backups. The initial cleaning frequency is based on the cause of the initial backup, and the cleaning frequency is increased or decreased over time as appropriate. Corrective activities include:

- Jetting for light to medium debris
- Dragging for heavy debris in pipes greater than 18-inch diameter
- Hydrocutting for roots and grease
- Rodding for pipes with an active blockage
- Chemical root treatment, in sanitary and combined sewers only, when roots are present with no grease

The City's routine maintenance frequencies range from as short as once a month to as long as once every six years. The challenge for sewer utilities is to clean sewers as frequently as necessary to maintain system capacity but no more than necessary, as cleaning sewers shortens the sewer's functional life span. In 2011 the City launched the use of a cleaning optimization tool (COTools) (Reference 22) to analyze sewer pipe cleaning data and recommend appropriate cleaning frequencies. The City staff review these software-generated recommendations and implement those that provide the right balance between sewer capacity and sewer lifespan. In 2013, the City continued to use COTools to analyze and adjust pipe maintenance frequencies.

Pump station electrical and mechanical components are replaced as necessary during routine pump station maintenance. In 2008, the City began implementing Reliability Centered Maintenance (RCM) (Reference 23) at its wastewater pump stations. The objective of RCM is to ensure the right maintenance is performed at the right intervals, which optimizes life-cycle costs while increasing system reliability. In addition, RCM ensures the right data is collected and evaluated, adding discipline to the decision-making process around operations, spare parts inventory, maintenance strategies, and data collection.

Over a three-year period, maintenance strategies were developed for each of the 68 wastewater pump stations, taking into consideration site-specific conditions and the consequences of failure. The RCM strategies were used to create work order that contain maintenance tasks and intervals that were implemented in 2011. Data collected from these work orders are analyzed and used to adjust future maintenance tasks and intervals. In 2013, the City continued to use and adjust the RCM-based strategies.

The City's 2013 O&M accomplishments are summarized in Table 2-1. Compared to 2012 O&M accomplishments, productivity increased in most areas. Most significantly, the City cleaned over 25 percent of the collection system in 2013. In addition, the City cleaned approximately 63 percent more pipe and inspected approximately 10 percent more sewers in 2013 than in 2012. The O&M activities summarized in Table 2-1, and the capacity, management, operation, and maintenance (CMOM) program initiatives described in Section 2.2.2 helped the City limit the number and volume of overflows in the collection system.

Control 1 also requires that the City take affirmative steps to prevent tidal inflow into the combined sewer system. The City reviews flow monitoring results on a regular basis to determine whether there are any outfalls experiencing tidal inflow and, if so, to help determine solutions. In 2011, the City replaced leaking flap gates at Overflow Structures 111A and 111C to prevent inflow from the tidally influenced reach of the Duwamish River. In early 2012, the City sealed Overflow Structures 111E and 111F, further preventing tidal inflow from the Duwamish River. And in 2009, the City sealed the leaking flap gates at Outfalls 069, 070, 071, and 072 along the Central Waterfront, effectively changing the overflow elevation at these outfalls to the previously designated "emergency overflow weirs", which are higher than the high-water level of Elliott Bay.

Table 2-1. 2013 Operation and Maintenance Accomplishments

Activity	Quantity
Miles of mainline pipe cleaned	418
Miles of mainline pipe inspected via CCTV	124
Miles of mainline pipe rehabilitated	10.6
Number of pump station inspections	1,802
Number of maintenance holes inspected	518
Number of force mains inspected and repaired, replaced, or rehabilitated	2
Number of CSO structure inspections	304
Number of CSO structure cleanings	129
Number of CSO HydroBrake inspections	225
Number of CSO HydroBrake cleanings	51
Linear feet of pipe receiving chemical treatment to inhibit root growth	63,152
Number of catch basins inspected	905
Number of catch basins cleaned	2,025
Number of catch basins repaired	21
Number of catch basin traps replaced	136

2.2.1.2 Control 2: Maximize Storage of Flows

Maximize the use of the collection system for wastewater storage, in order to reduce the magnitude, frequency, and duration of CSOs.

The City maximizes storage in its collection system through a multi-faceted approach that includes:

- Regular collection-system maintenance so that existing capacity is available during storm events
- Retrofits to storage facilities whose existing capacity is not fully utilized
- Increasing the height of overflow weirs when doing so increases collection system storage capacity without creating backups
- Eliminating excessive inflow and infiltration

In 2013, the City continued to perform regular O&M activities as described in Control 1. Those activities helped to minimize sewer blockages and optimize system capacity.

In addition, the City continued to design and construct system retrofits to better utilize existing sewer system capacity. Work on system retrofits is described in the City's CSO Annual Report.

2.2.1.3 Control 3: Control Nondomestic Sources

Implement selected CSO controls to minimize CSO impacts resulting from nondomestic discharges.

Two important programs are implemented to help control nondomestic discharges into the Seattle sewer system: the Fats, Oils, and Grease Control Program and the Industrial Pretreatment Program.

The City administers the City's FOG Control Program, enforcing Seattle Municipal Code requirements to pretreat FOG-laden wastewater before it is discharged to the sewer system. FOG has a deleterious effect on the sewer system as it combines with calcium and grease in wastewater to form hard calcium deposits that adhere to the inside of sewers, decreasing their capacity. FOG Control Plan development activities are summarized in the City's CSO Annual Report.

FOG control inspection and enforcement activities conducted in 2013 are summarized in Section 3.3 of the City's 2013 CSO Annual Report.

The Industrial Pretreatment Program is administered by King County. King County issues industrial waste pretreatment permits that include appropriate discharge limits. King County also provides regular site inspections and periodic permit reviews. The City and King County work together if permittees are found to have a negative impact on the sewer system.

2.2.1.4 Control 4: Deliver Flows to the Treatment Plant

Operate the collection system to maximize flows to the treatment plant, within the treatment plant's capacity.

The City maximizes flow to the King County treatment plant by implementing the measures described in Controls 1 and 2 and also through a program of routine system performance monitoring and analysis.

In 2010, the City integrated its former water and wastewater control centers into a single Control Center (CC). The Control Center is staffed 24 hours a day and receives real-time Supervisory Control and Data Acquisition (SCADA) information.

Initially, the Control Center received SCADA information only from the City's 68 wastewater pump stations. The City continues to regularly analyze performance of the 68 pump stations to ensure that they are operating at their design capacity during storm events. Control Center staff respond to any alarms at the wastewater pump stations or the CSO facilities that would indicate a drop in performance or other problem. In addition, the City monitors pump station, overflow structure, and outfall flow data as it is collected and uses the data to detect maintenance issues that may be affecting system performance.

In 2011, monitoring and controls for the City's first sewer system facility with active controls and SCADA connectivity were also brought into the Control Center. In 2012, a second major control project was completed and brought into the Control Center for full operation. The project, located in the Windermere Area (Basin 13), includes two storage tanks and a motor-operated gate valve. The valve is programmed to fill or evacuate storage based on water levels in the downstream sewer (the Lake Line). Upon completion, the CSO storage projects in the Windermere, Genesee, and South Henderson CSO areas will be monitored from the Control Center.

In 2013, the City made continued progress constructing and implementing the infrastructure, hardware, and software that comprise the Drainage and Wastewater I-SCADA Program. This capital program will allow the City to transition from consultant-provided flow monitoring services to a City operated monitoring network. By the end of 2013, seven CSO sites and all 17 rain gauges had been transitioned. The goal is to have all monitoring locations transmit real-time data to the Control Center by the end of 2015.

The program also included the upgrade of SCADA equipment in all of the City's wastewater pump stations. This work was completed in early 2013. Implementation of a major upgrade of the Wonderware SCADA software and the hardware used in the Control Center was also completed in 2013.

2.2.1.5 Control 5: Prevent Dry-Weather Overflows

Prevent dry weather overflows; they are not authorized. Report any dry weather overflows within 24 hours and take prompt corrective action.

The City experienced three dry weather overflows (DWOs) from its permitted CSO outfalls in 2013, none of which were caused by the City or any other City entity:

- The first DWO occurred on February 1, 2013, at Outfall 071 on the Central Waterfront, and was caused by a subcontractor on the SR-99 bored tunnel construction contract. The subcontractor inadvertently removed a maintenance hole cover that allowed debris into a 21-inch diameter sewer, blocking flow and causing an estimated 58,760 gallon DWO. The City issued Notices of Violation to the lead agency (Washington State Department of Transportation) (WSDOT) and the prime contractor (Seattle Tunnel Partners).
- It should be noted that proactive efforts by the City helped avoid two additional DWOs on February 15 and July 2, 2013, when subcontractors drilled into two large diameter the City sewers. To reduce the risk of recurring construction-caused problems, the City issued Notices of Violation to WSDOT, Seattle Tunnel Partners, and Malcolm Drilling.
- The other two DWOs occurred at Outfall 129 on the east side of Lake Union. Both were caused by unusually high 45-60 mile per hour winds, which led to failure of private side sewers serving houseboats in Lake Union, which in turn caused high flows, debris, and upset conditions in the collection system. The first of these two DWOs occurred between November 2 and November 4, and the volume was approximately 53,670 gallons. The second DWO occurred on November 6, and the volume was approximately 11,240 gallons. Once the houseboat management association repaired the private side sewers, collection system flows returned to normal.

The details of these DWOs were provided in letters to Ecology and EPA.

The City also experienced five exacerbated CSOs in 2013 (wet-weather overflows at CSO outfalls that, while already discharging as a result of precipitation, were exacerbated by mechanical failures, blockages, equipment outages, or power outages):

- On January 9, 2013, a 590-gallon CSO at Outfall 012 was exacerbated by equipment and sensor malfunctions at City wastewater pump station 51. The equipment and sensors were subsequently repaired.
- On January 9, 2013, a 2,693-gallon CSO at Outfall 022 was exacerbated by an inflow of rocks and sediment from a broken side sewer lateral that restricted the pumping performance at City wastewater pump station 50. Emergency operation and maintenance procedures were put in place until the lateral could be repaired.
- On April 7 and 13, 2013, two CSOs at Outfall 022 (907 gallons and 7,802 gallons, respectively) were exacerbated by an inflow of rocks and sediment that restricted the pumping performance at City wastewater pump station 50, also causing SSO discharges from the overflow chamber into the street. The vault at this air-assisted lift station was cleaned to restore functionality and planning was initiated for a pump station rehabilitation project.

- On September 6, 2013, a 902-gallon CSO at Outfall 19 was exacerbated by a pump replacement project at Wastewater Pump Station 35. The pumps had reached the end of their life and were being replaced, starting in August and beginning with the largest pump (which provides storm event pumping capacity). Work to replace the largest pump had not been completed when early rains occurred on September 6. Replacement of the large pump was completed before the next storm event.

To help prevent DWOs and exacerbated CSOs, each combined sewer system overflow location has been configured with an alarm that is triggered if there are potential overflow conditions. The alarms alert analysts or field crews to assess the situation and take corrective action if possible.

In addition, whenever the City experiences a DWO or exacerbated CSO, the City investigates to identify the cause and takes action to address the overflow and reduce or eliminate the probability of recurrence. Investigation includes manual inspection of the site where the overflow occurred, CCTV inspection of adjacent pipe, and review of SCADA data. Whenever possible, the outfall structure and adjacent pipes are cleaned immediately following the event, and the City reviews and analyzes the cleaning results. The City holds monthly "after action" review meetings to learn from experience and apply any lessons learned toward preventing additional SSOs, DWOs, and exacerbated CSOs. The City also looks at the rolling history of DWOs and exacerbated CSOs to determine if there are any patterns and if a systematic solution is required. For example, in past years pump station electrical outages contributed to DWOs, so the City implemented projects to ensure that each pump station has either an on-site backup generator or an emergency plug that allows a portable generator to be easily placed in service.

A summary of the DWOs and exacerbated CSOs from 2007-2013 is included in Table 2-2.

Table 2-2. Dry Weather Overflows (DWOs) and Combined Sewer Overflows (CSOs) Exacerbated by System Maintenance Issues 2007 – 2013

Year	Dry-weather overflows		CSOs exacerbated by system maintenance issues[a]	
	Number of overflows	Volume (gallons)	Number of overflows	Volume (gallons)
2007	7	499,264	--	--
2008	1	148,282	8	470,444
2009	1	3,509	3	156,153
2010	0	0	13	12,320,400
2011	0	0	10	2,317,068
2012	0	0	11	5,846,647
2013	3[b]	123,670	5	12,894

Notes

a CSOs exacerbated by system maintenance issues were not reported prior to 2008. The 'exacerbated CSOs' listed in this table are listed as CSO discharges in Table 5-4 of Reference 18 and are included in the discharges summarized in Tables 5-5, 5-6, 5-7, and 5-8 of Reference 18.

b None of these DWOs were caused by the City.

2.2.1.6 Control 6: Control Solids and Floatable Materials

Implement measures to control solid and floatable materials in CSOs.

The City implements several measures to control floatables:

Catch basins are designed to prevent floatables from entering the system. Specifically, the City's catch basins are designed to overflow only when the water level in the catch basin is well above the overflow pipe opening. Because floatables remain on the water surface, they are trapped in the catch basins.

Catch basins are inspected and cleaned regularly to remove debris and potential floatables. In 2013, City crews:

- Inspected 905 combined sewer system catch basins
- Cleaned 2,025 combined sewer system catch basins
- Replaced 136 traps in combined sewer system catch basins
- Repaired 21 combined sewer system catch basins

In addition, the City of Seattle runs several solid waste and city clean-up programs to prevent and reduce the amount of street litter, including:

- Street sweeping, including increased efforts for Fall leaf pickup
- Spring cleaning
- Storm drain stencilling
- Recycling event
- Public litter and recycling cans
- Waste free holidays
- Product bans
- Illegal dumping investigation and response

2.2.1.7 Control 7: Prevent Pollution

Implement a pollution prevention program focused on reducing the impact of CSOs on receiving waters.

The City conducts multiple pollution prevention programs to keep contaminants from entering the sewer system and subsequently being discharged in sewage overflows. Pollution prevention programs performed by the City in 2013 include:

- Public education programs
- Solid waste collection and recycling
- Product ban or substitution
- Control of product use such as cleaning and yard care recommendations
- Illegal dumping prevention
- Bulk refuse disposal
- Hazardous waste collection
- Commercial and industrial pollution prevention
- Spill response
- Business inspections
- Water quality complaint response

The City of Seattle Department of Transportation (SDOT) performs street sweeping, including sweeping downtown streets every night and cleaning alleys three nights per week. In 2013, SDOT street sweeping crews swept 8,650 curb miles in the combined sewer system area.

The City also supports public education programs on pollution prevention, such as:

- Spring Clean
- Clean and Green
- Adopt-a-Street
- Adopt-a-Drain
- Storm drain stencilling
- Surface Water Pollution Report Line
- Pet waste disposal
- Natural yard care
- Car tips (to decrease automobile leaks)
- Reduce, reuse, and recycle tips

The City also has reduced the potential for pollution by reducing the volume of sewage entering the sewer system. For years, the City has been a leader in potable water conservation through the Saving Water Partnership, actually reducing the regional water system annual demand while the population has increased. As a result of these efforts, the total Seattle regional water system demand has dropped from a base (winter) flow of approximately 150 MGD in the late 1980s to a current base flow of 100 MGD, thus reducing the capacity demands on the regional sewer system by approximately 50 MGD.

The City and King County are both utilizing green infrastructure to reduce the volume of stormwater entering the combined sewer system. The City encourages installation of rain gardens and cisterns on private properties and is installing roadside rain gardens in street rights-of-way. Please see Section 4.2 of the City's 2013 CSO Annual Report for more information on these GI programs.

Finally, if sewage contamination of surface waters occurs due to side sewer breaks or illicit connections or discharges, the City uses regulatory tools such as notices of violation and associated penalties to help remedy the problem in a timely manner.

2.2.1.8 Control 8: Notify the Public

Implement a public notification process to inform the citizens of when and where CSOs occur.

Figure 2-1. Example of Outfall Signage

The City, together with King County and Seattle King County Public Health, maintains a sewage overflow notification and posting program. Signs at each outfall identify the outfall and warn of possible sewage overflows. The signs include the phone number for the CSO Hotline, staffed and managed by Seattle King County Public Health. Seattle King County Public Health also provides a website with detailed information about CSOs, potential public health hazards, and precautions the public may take to protect themselves. If sewage overflows occur due to side sewer breaks or illicit connections or discharges, the City posts additional warning signs at impacted waterways until the problem is resolved.

In addition, King County has hosted an overflow website since December 2007, providing notification of recent and current King County CSO overflows. In

2009, the City began working with King County to incorporate City of Seattle real-time overflow information on the King County site. This work was accomplished in 2011. Now the community is able to access consolidated information to assist in making choices about use of local waters. In 2013, the public notification web pages were viewed 11,736 times, with a peak one-day use of 2,167 views on September 30, 2013. An example of the real-time overflow notification website is shown on Figure 2-2.

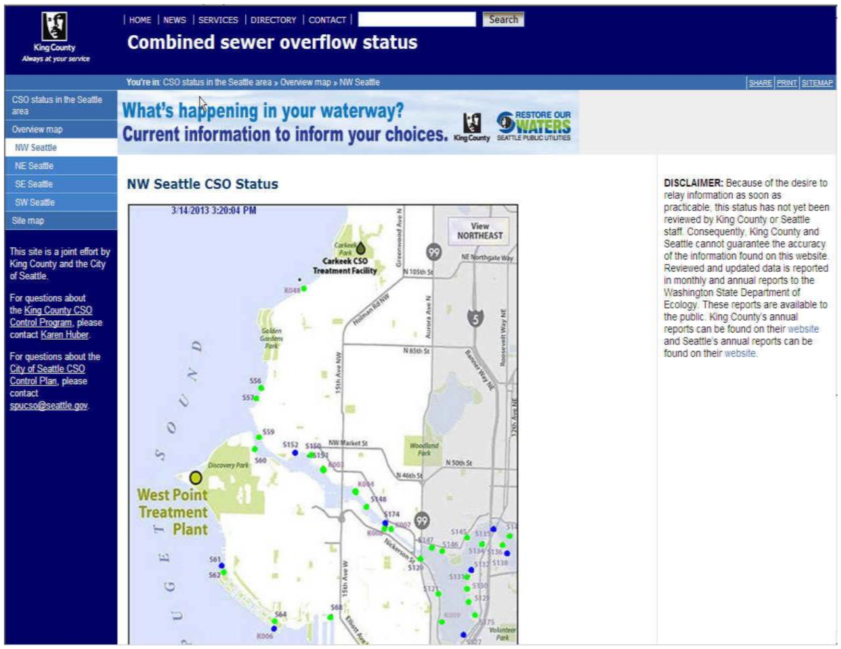

Figure 2-2. King County/SPU Real-Time Overflow Notification Website

2.2.1.9 Control 9: Monitor CSOs

Monitor CSO outfalls to characterize CSOs and the effectiveness of CSO controls.

The City monitors each of its CSO outfalls to detect sewage overflows. The City also tracks the performance of its flow monitors to ensure consistent, high-quality measurements. The flow, precipitation, and flow monitor performance monitoring programs and results are described and summarized in Section 2.4 of this report.

In addition, the City concluded its Seattle Combined Sewer Overflow Supplemental Characterization Study 2010 (Reference 24) that analyzed the constituents in combined sewer overflows.

2.2.2 CMOM Performance Program Plan

The CMOM Performance Program Plan committed the City to completing performance, productivity, and efficiency initiatives in each of the following program areas:

- Planning and scheduling
- Sewer cleaning
- FOG control program
- Repair, rehabilitation, and replacement
- Condition assessment
- SSO response

Work in each of these program areas is described in the City's CSO Annual Report.

2.2.3 Joint Operations and System Optimization Plan

The City's and King County's consent decrees each contain language directing both agencies to work together to develop a single Joint Operations and System Optimization Plan (Joint Plan). In 2013, the Joint Plan team began development of the plan by focusing on understanding the interconnectedness between each agency's systems, each agency's operable facilities, and the greatest areas for optimization opportunities. Highlights of the year include the following:

- Completed a memorandum of understanding committing both agencies to development of the Joint Plan by March 1, 2016
- More than 60 staff – management, technical staff (planners, engineers, modelers), and operators – from each agency participated in 10 educational activities over the course of the year. The educational activities involved facility tours and technical presentations of key operable facilities in each agency's system.
- Shared operational objectives were developed and jointly approved for use, which satisfies the Consent Decree requirement for shared operational objectives for King County Wastewater Treatment Division's (WTD) and Seattle Public Utilities' (SPU) combined systems.
- Divided the combined wastewater system managed by SPU and WTD into 13 planning basins for joint operations analysis. Basins were delineated based on hydrologic and hydraulic parameters, operational strategies, locations of significant operable facilities, and input from technical staff.
- Developed and approved two early actions for implementation – formation of a Joint System Event Debrief Committee and formation of a Joint Operations Information Sharing Team (JOIST)
- Submitted a 2013 Annual Progress Report for the Joint Plan on December 17, 2013, as required by both agencies' consent decrees (Reference 25)

In 2014, the Joint Plan team began development and evaluation of operational alternatives in planning basins where there is the greatest opportunity for operations and system optimization. In addition, more early actions, similar to the Joint System Event Debrief Committee and JOIST, will likely be developed and implemented.

2.3 Description of System

This following sections present a detailed description of the physical characteristics of the CSS and receiving water bodies.

2.3.1 Geographical Area and Climate

The City of Seattle is located in western Washington State between the saltwater Puget Sound (an arm of the Pacific Ocean), to the west, and the freshwater Lake Washington, to the east. To the west, beyond the Puget Sound, are the Kitsap Peninsula and Olympic Mountains on the Olympic Peninsula; to the east, beyond Lake Washington and the eastside suburbs, is the Cascade Range.

The City of Seattle is divided by the Lake Washington Ship Canal, which consists of two man-made canals, Lake Union, and the Hiram M. Chittenden Locks at Salmon Bay, as shown below in Figure 2-3. The population of the City is approximately 620,000, and the area is approximately 84 square miles. The topography of the City is primarily hilly. Land uses within the City are primarily urban (residential, commercial, and industrial).

Seattle typically has moderate, dry summers and mild, wet winters. Regional climate data are reported at Seattle-Tacoma International Airport. Average annual precipitation is 37.1 inches.

The Seattle area experiences three categories of storm types (MGS Engineering Consultants, Inc. (MGS), 2003), as described below:

- Short-duration storms are primarily warm-season events that produce high precipitation intensities over isolated areas; they are often the controlling storm types for sizing conveyance structures in urbanized areas.
- Intermediate-duration storms occur throughout the year but are most common in the fall and early winter. These storms often contain moderate to high precipitation intensities for a period of several hours and precipitation commonly occurs over 6 to 18 hours.
- Long-duration storms are associated with continental-scale weather systems originating over the Pacific Ocean and precipitation occurs over very large areas. Long-duration storms are primarily late fall and winter events, characterized by low to moderate precipitation intensities and durations of 24 hours or more. The long-duration storm is usually the controlling storm type for the design and analysis of stormwater detention facilities where both runoff volume and peak discharge are primary considerations (MGS, 2003).

2.3.2 Existing Wastewater Collection System

The City's wastewater collection system includes gravity sewage pipelines, pump stations, force mains, CSO outfalls, and CSO control facilities. Currently, the collection system includes:

- Approximately 448 miles of sanitary sewer pipes
- Approximately 968 miles of combined sewers
- 68 sewage pump stations
- 5.5 miles of force mains
- 87CSO outfalls
- 38 CSO control detention tanks and pipes
- 28 HydroBrakes
- 3 controlled sluice gates

The pipe diameters range from 4 to 144 inches, of which approximately 62 percent are 8-inch collector pipes. The average age of the City's collection system piping is 75 years. Approximately one-third of the system is combined, one-third partially separated, and one-third fully separated. Figure 2-4 presents the wastewater collection system in the City of Seattle.

The City does not own a wastewater or CSO satellite treatment plant. All the sewage collected in the City's wastewater collection system is conveyed to King County for regional conveyance and treatment or is discharged via one of the CSO outfalls. King County operates three secondary wastewater treatment plants (West Point WWTP, the South WWTP, and the Brightwater WWTP) and four CSO storage and treatment facilities (Alki, Carkeek, Elliott West and Henderson/MLK). Ultimately, the treated wastewater from all of these facilities discharges to either Puget Sound, Elliott Bay, or the Duwamish River.

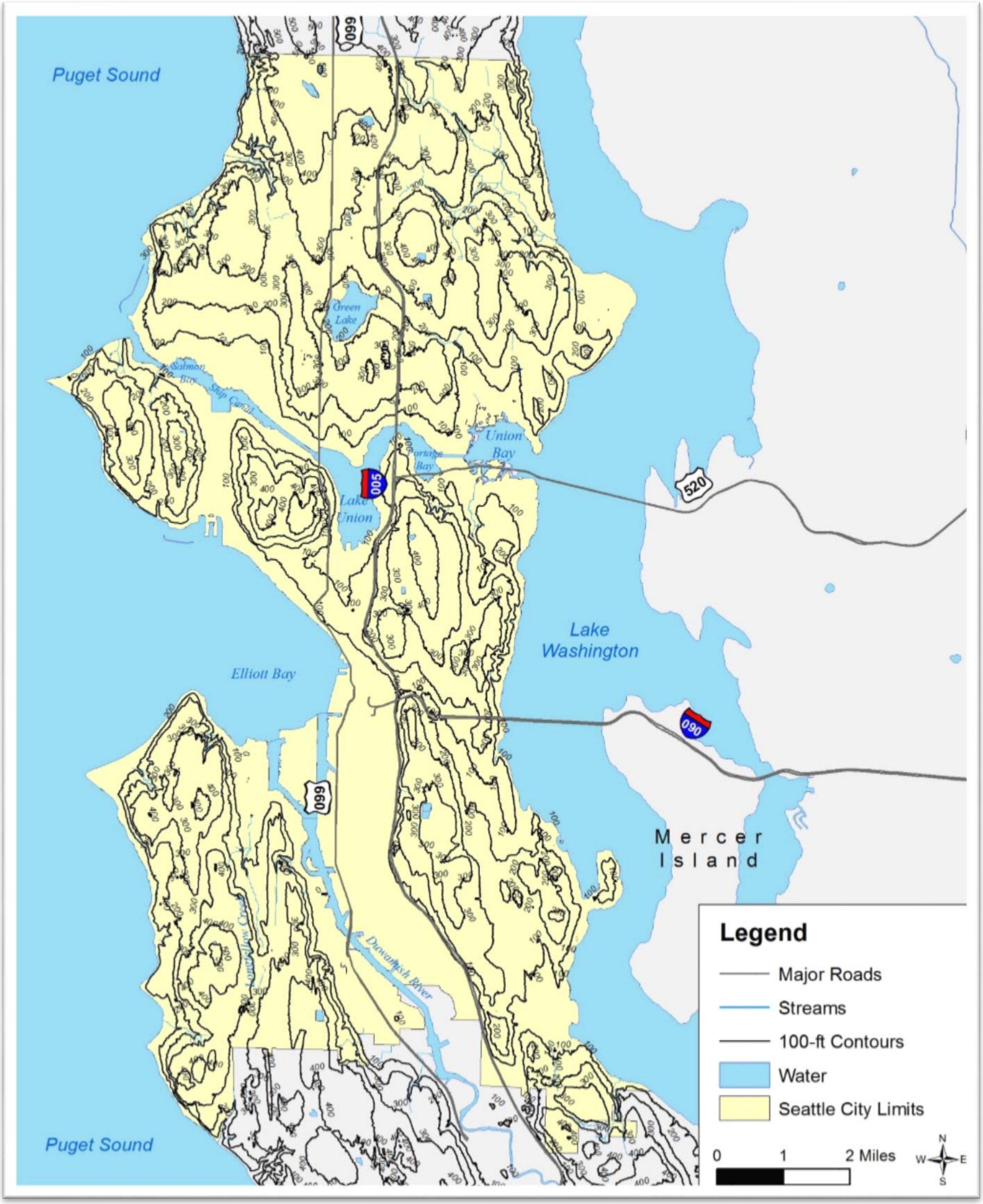

Figure 2-3. Geography and Topography of Seattle

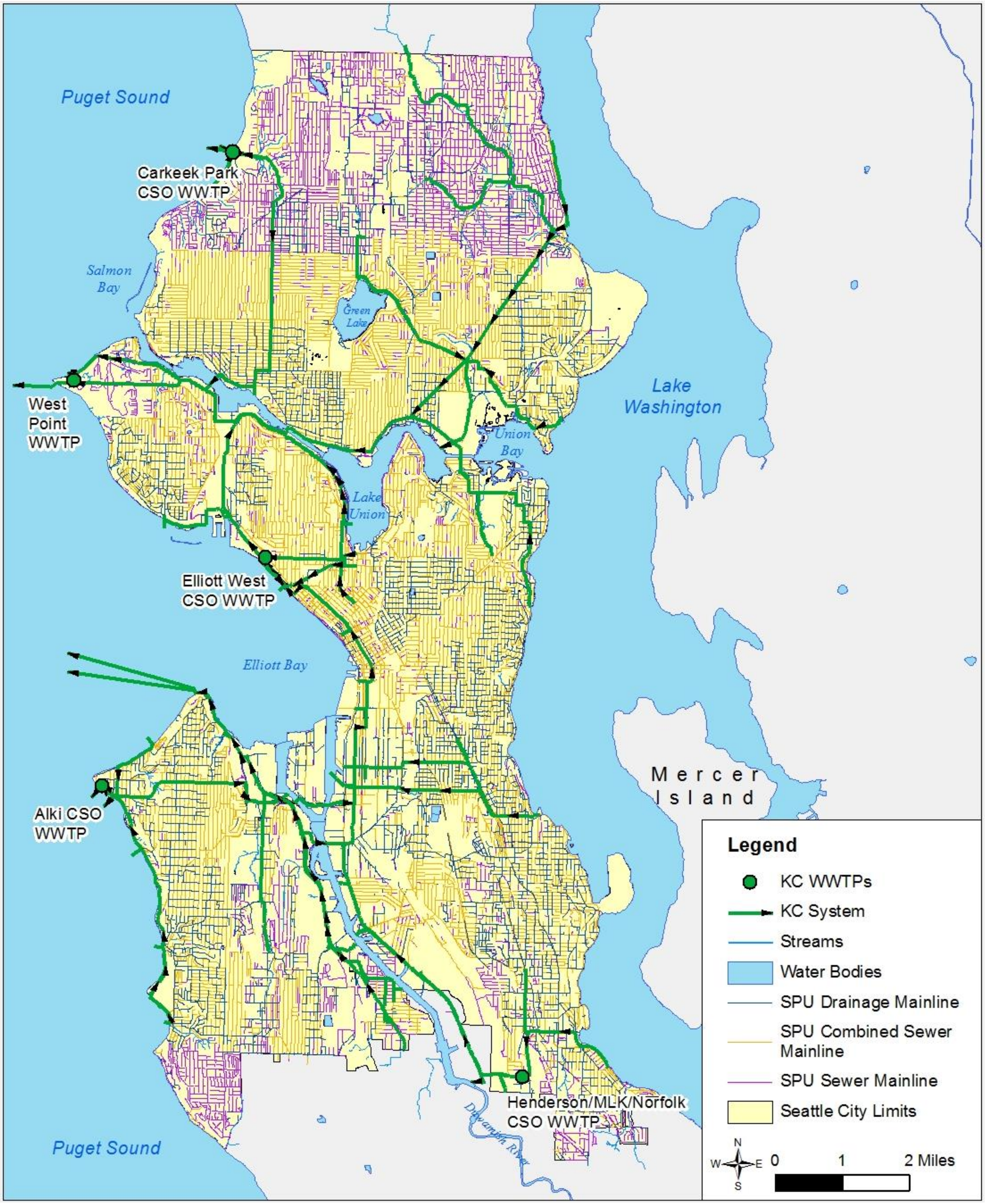

Figure 2-4. Wastewater Collection Systems in Seattle

2.3.3 CSO Outfalls

Table 2-3 presents a list of the City's CSO outfalls and their respective locations.

Table 2-3. CSO Basin Number and Location

CSO outfall number	Location
012	NE 60th St. at NE Windermere Rd.
013	Windermere Park NE 50th St.
014	55th Ave. NE at NE 43rd St.
015	51st Ave. NE at NE Laurelhurst Ln.
016	Webster Pt NE at W Laurelhurst Dr.
018	38th Ave. NE at NE 41st St.
019	NE 45th St. at Montlake Blvd. NE
020	Shelby St. at E Park Dr.
022	39th Ave. E at E Lakeside Blvd.
024	43rd Ave. E at E Lee St.
025	43rd Ave. E at E Lee St.
026	Denny Blaine Pl. E [a]
027	Lake Washington Blvd.
028	Lake Washington Blvd. E at E Pike St.
029	Lake Washington Blvd. E at E James St.
030	Lake Washington Blvd. E at E Alder St.
031	Lake Washington Blvd. S at S Main St.
032	Lake Washington Blvd. S at S Dearborn St.
033	Lake Washington Blvd. S at S Charles St.
034	Lake Washington Blvd. S at S Charles St.
035	Lake Washington Blvd. S at S Massachusetts St.
036	Lake Washington Blvd. S at S College St.
038	Lake Washington Blvd. S at 45th Ave. S
040	Lake Washington Blvd. S at 49th Ave. S
041	Lake Washington Blvd. S at 50th Ave. S
042	Lake Washington Blvd. S. at S Snoqualmie St.

Table 2-3. CSO Basin Number and Location

CSO outfall number	Location
043	Lake Washington Blvd. S at S Alaska St.
044	Lake Washington Blvd. S south of Juneau St.
045	57th Ave. S at S Brighton St.
046	S Island Dr. at S Grattan St.
047	Seward Park Ave. S at S Henderson St.
048	Rainier Ave. S at S Perry St.
049	Rainier Ave. S at S Cooper St.
057	Seaview Ave. NW at NW 68th St.
059	Seaview Ave. NW at NW 57th St.
060	W Cramer St. at 39th Ave. NW
061	W Ray St. at Logan Ave. W
062	W Ray St. at Logan Ave. W
064	32nd Ave. W at Logan Ave. W
068	W Garfield St. at 17th Ave. W
069	Alaskan Way at Vine St.
070	Alaskan Way at University St.
071	Alaskan Way at Madison St.
072	Alaskan Way S at S Washington St.
078	Harbor Ave. SW at Fairmont Ave. SW
080	Harbor Ave. SW at SW Maryland Pl.
083	Alki Ave. SW at SW Arkansas St.
085	Alki Ave. SW at Point Pl. SW
088	SW Beach Dr. north of SW Bruce St.
090	SW Beach Dr. at Murray Ave. SW
091	Fauntleroy Way SW north of SW Trenton St. in Lincoln Park
094	Fauntleroy Ave. SW north of SW Director St.
095	Fauntleroy Ave. SW at SW Brace Pt Dr.
099	SW Hinds St. at Duwamish River West Waterway
107	SW Hinds St. at Alaskan Way S
111	S Oregon St. at East Duwamish

Table 2-3. CSO Basin Number and Location

CSO outfall number	Location
120	Westlake Ave. N at Aurora Ave. N
121	Westlake Ave. N at Crockett St.
124	Westlake Ave. N south of Aloha St.
127	Fairview Ave. E at Yale Ave. E
129	Fairview Ave. E at E Newton St.
130	Fairview Ave. E. at E. Lynn St.
131	Fairview Ave. E at Louisa St.
132	Fairview Ave. E at E Roanoke St.
134	Fairview Ave. E at E Allison St.
135	Eastlake Ave. E at Portage Bay Pl. E
136	Portage Bay Pl. E at E Allison St.
138	E. Shelby St., Portage Bay
139	16th Ave. E at Louisa St.
140	E Shelby St. at W Park Dr.
141	Brooklyn Ave. NE at Boat St.
144	Latona Ave. NE at NE Northlake Way
145	N 36th St. at NE Northlake Way
146	Carr Pl. N at N Northlake Way
147	Stone Way at Northlake Way
148	8th Ave. NW at NW 41st St.
150/151	24th Ave. NW and NW Market St.
152	28th Ave. NW and NW Market St.
161	NE 65th St. and 65th Ave. NE
165	Lake Washington Blvd. at S Alaska St.
168	Delridge Ave. SW at SW Myrtle St.
169	Between 24th and 25th Ave. SW north of SW Thistle St.
170	27th Ave. SW at SW Webster St.
171	Rainier Ave. S at Ithaca Pl. S
174	NW 36th St. at 2nd Ave. NW
175	E Garfield St. at Fairview Ave. E

a Outfall was abandoned I on 9/9/14.

Figure 2-5 is a map of the basins listed in the previous table.

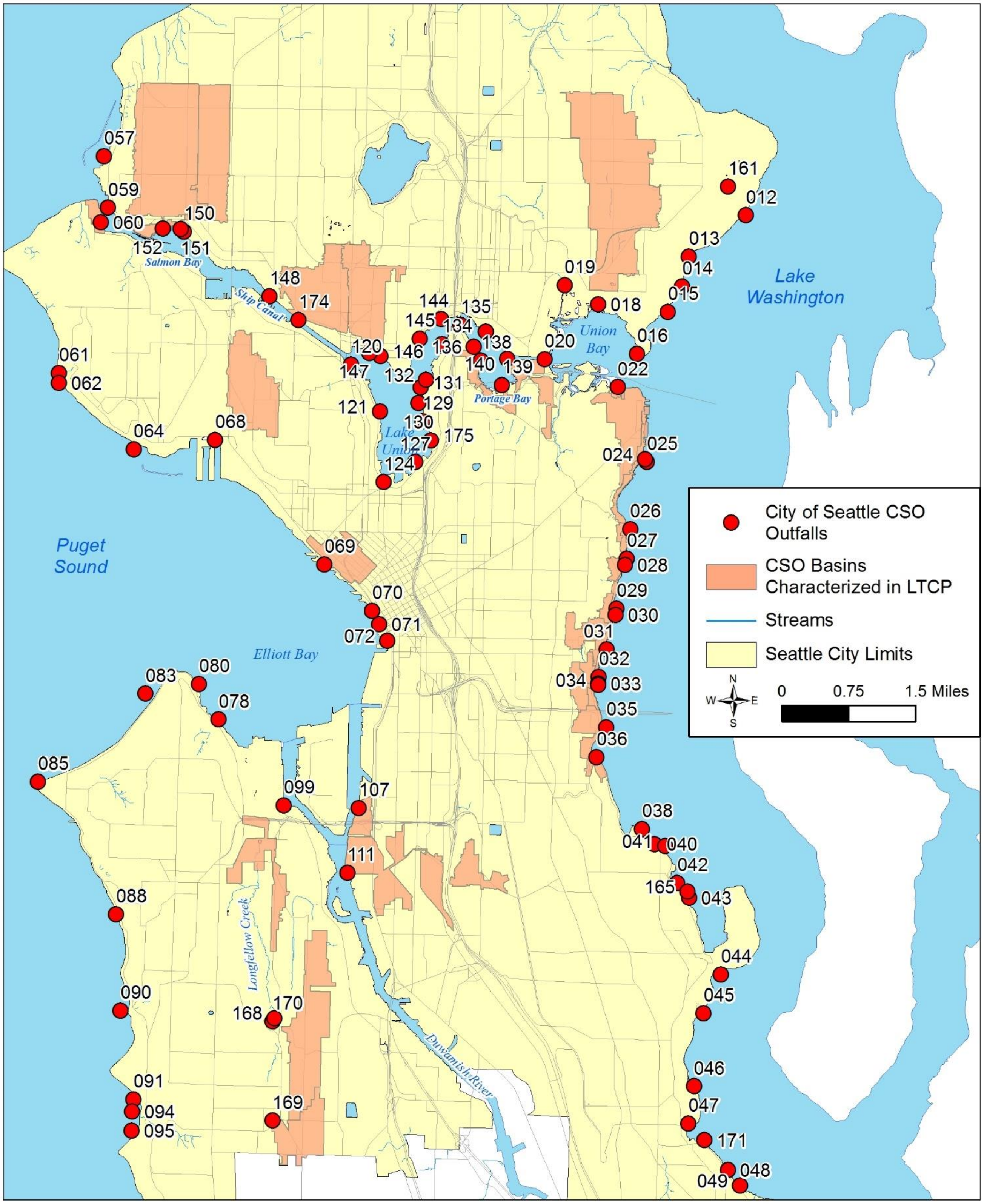

Figure 2-5. Locations of the City's CSO Outfalls

2.3.4 CSO Basin Delineation

The City's combined sewer system is divided into 19 CSO areas: Ballard, Central Waterfront, Delridge/Longfellow, Duwamish, East Waterway, Fremont/Wallingford, Genesee, Henderson, Interbay, Lake Union North, Lake Union West, Leschi, Madison Park/Union Bay, Magnolia, Montlake, North Union Bay, Portage Bay, West Seattle, and Windermere. These CSO areas are further subdivided into CSO basins that are delineated based on the tributary area to each individual CSO outfall. The 13 CSO areas included in the LTCP system characterization are presented in Figure 2-6.

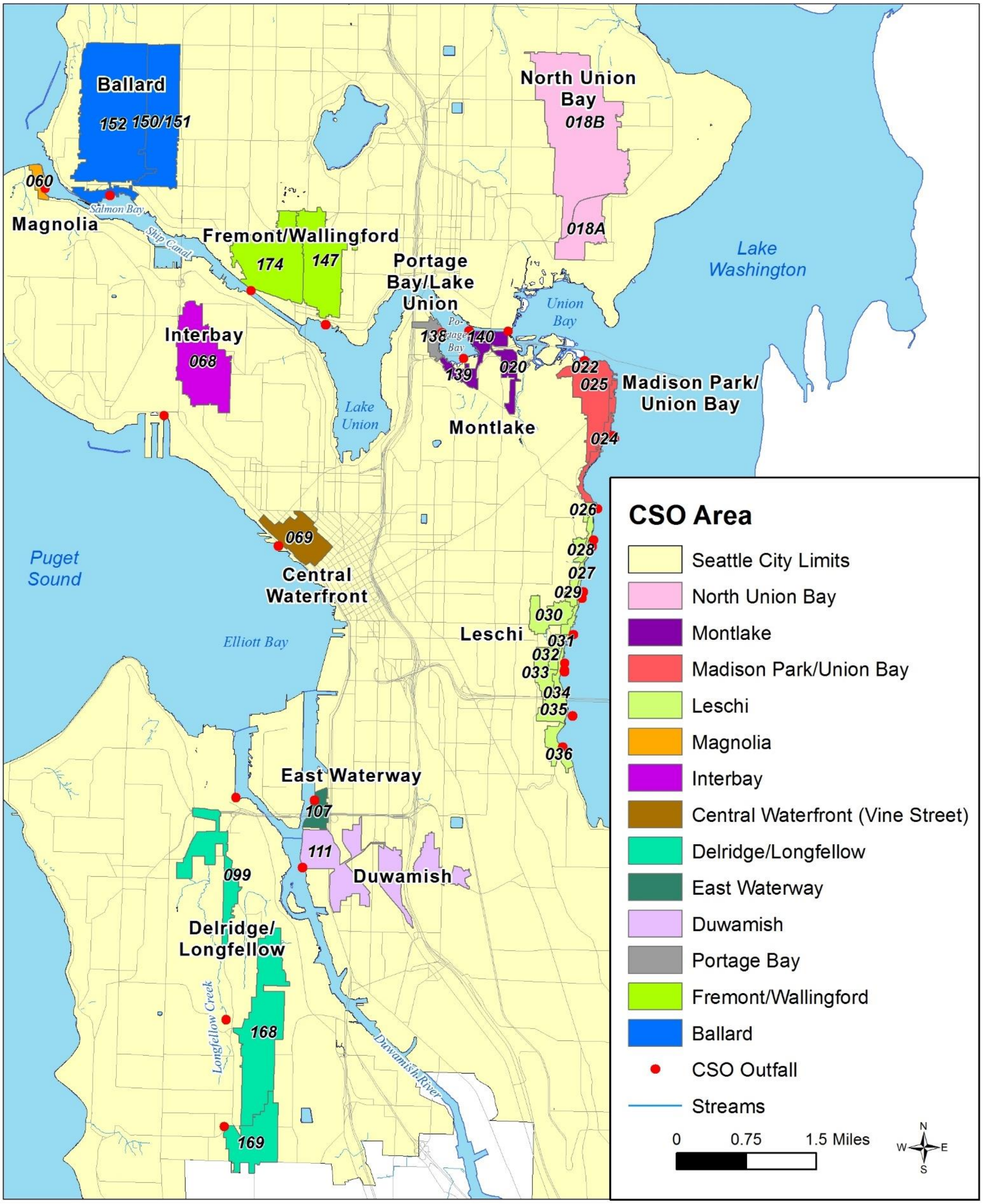

Figure 2-6. CSO Areas Included in the LTCP System Characterization

2.3.5 CSO Areas of LTCP Outfalls

Table 2-4 presents all of the LTCP CSO basins within each CSO area.

Table 2-4. Comparison of LTCP CSO Areas and LTCP CSO Basin Outfalls

CSO area	CSO basins and outfalls
Ballard	2 basins: 150/151, 152
Central Waterfront	1 basin: 069
Delridge/Longfellow	3 basins: 099, 168, 169
Duwamish	1 basin: 111
East Waterway	1 basin: 107
Fremont/Wallingford	2 basins: 147, 174
Interbay	1 basin: 068
Leschi	11 basins: 026, 027, 028, 029, 030, 031, 032, 033, 034, 035, 036
Madison Park/Union Bay	3 basins: 022, 024, 025
Magnolia	1 basin: 060
Montlake	3 basins: 020, 139, 140
North Union Bay	1 basin: 018
Portage Bay/Lake Union	1 basins: 138

The following subsections describe the existing wastewater collection system in each of the 13 LTCP CSO areas.

2.3.6 LTCP CSO Areas

2.3.6.1 Ballard CSO Area

The Ballard CSO area covers 1,170 acres (1.8 square miles) in northwest Seattle; it is bounded approximately by 30th Avenue NW to the west, 15th Avenue NW to the east, NW 85th Street to the north, and the Lake Washington Ship Canal and Salmon Bay to the south (see Figure 2-7). The Ballard CSO area comprises CSO Basins 150/151 and 152 that drain from north to south toward the Lake Washington Ship Canal and Salmon Bay. The CSO Basin 150/151 has a single overflow point, but the outfall divides into two branches, each with its own designation. The wastewater generated in these basins flows by gravity to King County's Ballard siphon for conveyance to the West Point Wastewater Treatment Plant (WWTP).

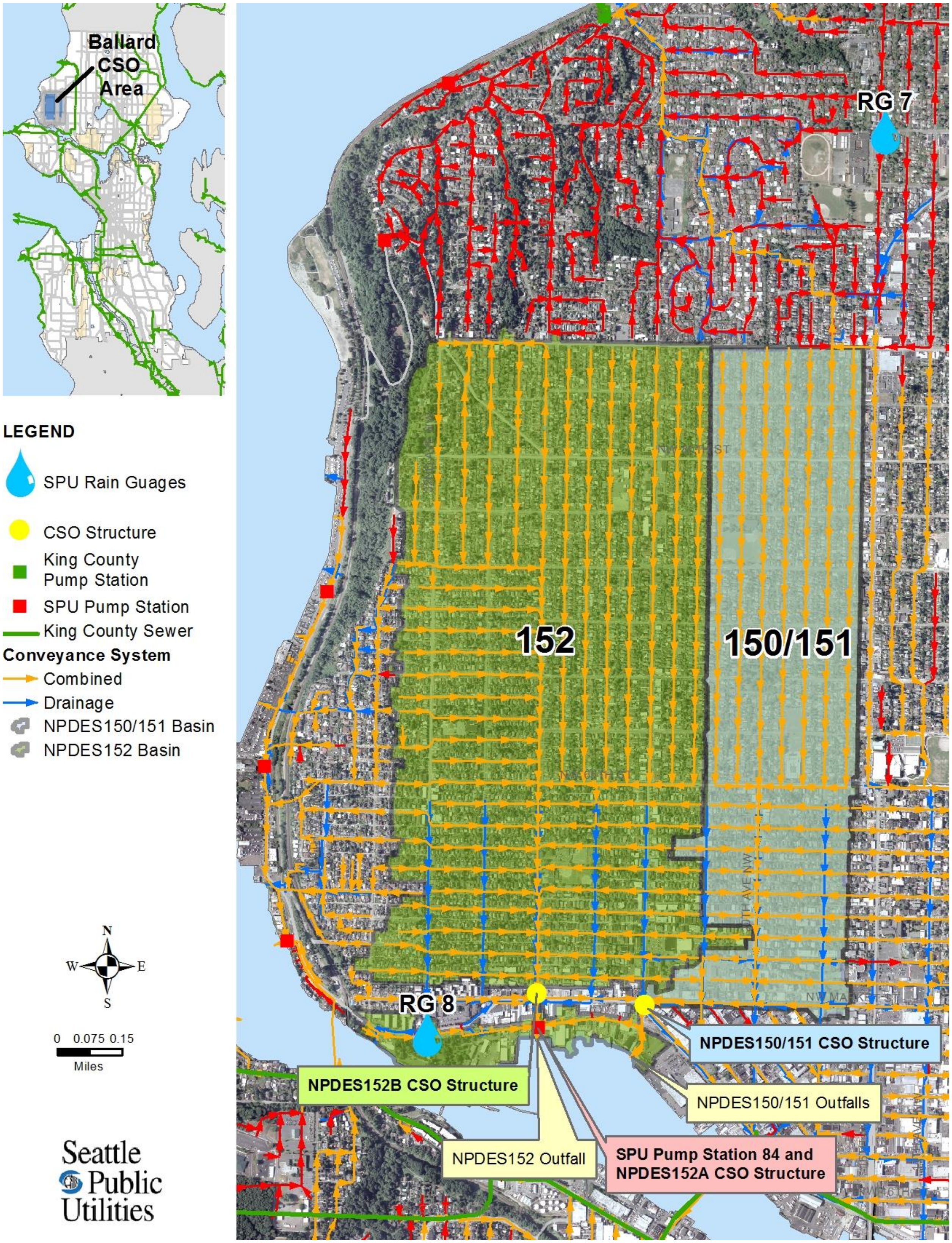

Figure 2-7. Overview of the Ballard CSO Area

The CSS in the Ballard CSO area conveys both sanitary and stormwater flow. The area to the north of NW 65th Street (about two-thirds of the total area) is fully combined. The area south of NW 65th Street is partially separated. Storm sewers collect and convey street runoff and a portion of private property runoff. Stormwater from partially separated areas of the Ballard CSO area is discharged into the ship canal and Salmon Bay. CSO Basins 150/151 and 152 contain permitted CSO structures that discharge overflows to Salmon Bay during large precipitation events when the capacity of the CSS is exceeded. Salmon Bay is located on the freshwater side of the Hiram M. Chittenden Locks.

Table 2-5 presents a summary of the key components of the wastewater collection system in the Ballard CSO area.

Table 2-5. Summary of Sewer Pipe in the Ballard CSO Area

Component	Description
Length of pipe (LF)	186,000
Diameter range	6” to 48”
Number of connecting structures	750+
City pump stations	1 (PS84)
HydroBrakes	None
Storage facilities	None

2.3.6.2 Central Waterfront (Vine Street)

The Vine Street CSO area is located in the northern part of downtown Seattle near the waterfront. The area encompasses 150 acres (0.23 square mile) and is bounded approximately by Denny Way to the north, Bay Street to the northwest, 5th and 4th Avenues to the north and east, and Alaskan Way to the south and west (see Figure 2-8.). The Vine Street CSO area is included in the larger Central Waterfront CSO area, which includes four CSO outfalls and their respective CSO Basins: 069 (Vine), 070, 071, and 072. The LTCP focuses on CSO Basin 069. Note that the control of CSO Basins 070, 071, and 072 is being planned for as part of broader planning for the City of Seattle's central waterfront. Flow from CSO Basin 069 drains to the King County Elliott Bay Interceptor for conveyance, treatment, and discharge at the West Point WWTP.

The CSS in CSO Basin 069 conveys both sanitary and stormwater flow. Areas north and east of the BNSF Railroad tracks (adjacent to Alaskan Way) are fully combined. Storm sewers collect runoff from roadway areas along Alaskan Way and discharge into Elliott Bay, but these pipes are not included in the model. CSO Basin 069 contains a permitted CSO structure that discharges overflows to Elliott Bay in large precipitation events when the capacity of the CSS is exceeded.

Figure 2-8. Overview of the Central Waterfront CSO Area

Table 2-6 presents a summary of the key components of the wastewater collection system in the 069 basin.

Table 2-6. Summary of Sewer Pipe in the Central Waterfront CSO Area

Component	Description
Length of pipe (LF)	23,000
Diameter range	4” to 48”
Number of connecting structures	660+
City pump stations	None
HydroBrakes	None
Storage facilities	None

2.3.6.3 Delridge/Longfellow

The Delridge/Longfellow CSO area, located in West Seattle along Longfellow Creek, comprises CSO Basins 099, 168, 169, and 170, as shown in Figure 2-9. The total area is approximately 705 acres. The four basins are geographically separated and hydraulically independent. They individually discharge into the King County system through King County’s Delridge trunk line along 26th Avenue SW, which runs from south to north through the basin. CSO Basin 170 is controlled and is not included in the LTCP.

The CSS in the Delridge/Longfellow Area conveys both sanitary and stormwater flow. CSO Basins 169 and 170 are nearly fully combined. CSO Basins 168 and 169 are partially separated. Storm sewers collect and convey street runoff and a portion of private property runoff in the combined areas. Stormwater from the partially separated areas is conveyed to Longfellow Creek for CSO Basins 168, 169, and 170. CSO Basin 99 stormwater from the partially separated areas discharges to the Duwamish River at the north end of the basin. All four CSO basins contain permitted CSO structures that discharge overflows to either Longfellow Creek or the Duwamish River during large precipitation events when the capacity of the CSS is exceeded.

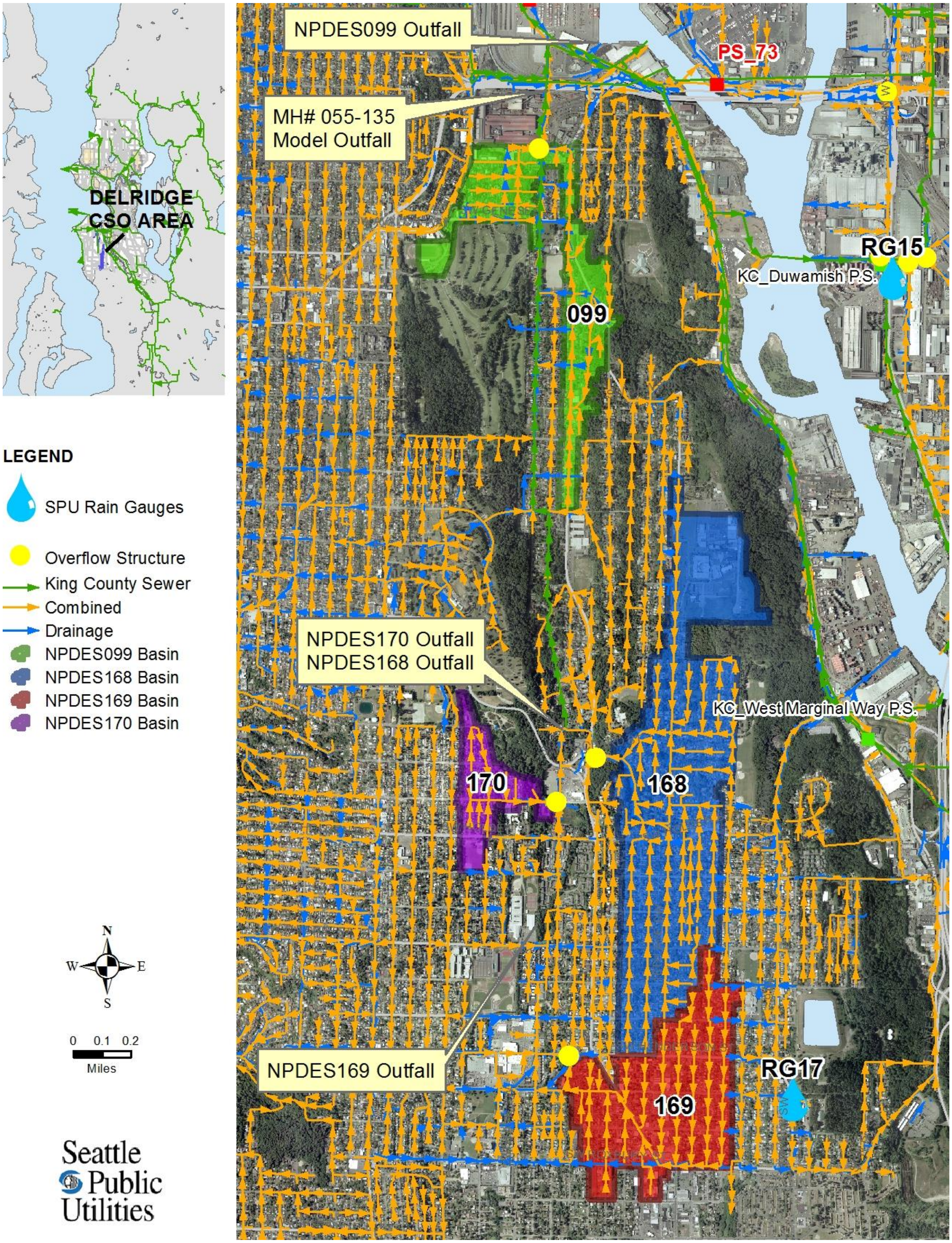

Figure 2-9. Overview of the Delridge/Longfellow CSO Area

Table 2-7 presents a summary of the key components of the wastewater collection system in the Delridge/Longfellow CSO area.

Table 2-7. Summary of Sewer Pipe in the Delridge/Longfellow CSO Area	
Component	**Description**
Length of pipe (LF)	114,000
Diameter range	8” to 96”
Number of connecting structures	710+
City pump stations	None
HydroBrakes	4 Basins (099, 168, 169, 170)
Storage facilities	CSO Basin 099 – 0.16 MG storage pipe CSO Basin 168 – 1.6 MG storage tank CSO Basin 169 – 1.6 MG storage tank CSO Basin 170 – 0.2 MG storage pipe

2.3.6.4 Duwamish

The Duwamish CSO area covers 487 acres (0.68 square mile) in southeast Seattle; it is bounded by S Hanford Street to the north, the Duwamish River to the west, S Hudson Street to the south, and Beacon Hill to the east (see Figure 2-10). The Duwamish CSO area comprises CSO Basin 111. Basin 111 drains from east to west toward the Duwamish River where there is a single overflow point. The wastewater generated in this basin flows by gravity to King County’s Duwamish pump station (at the corner of Diagonal Avenue S and E Marginal Way S) for conveyance to the West Point WWTP.

The CSS in the Duwamish CSO area conveys both sanitary and stormwater flow. The area is partially separated. Storm sewers collect and convey street runoff and a portion of private property runoff. Stormwater from partially separated areas of the Duwamish CSO area is discharged into the Duwamish River. The single permitted outfall for CSO Basin 111 contains eight individual CSO structures (A–H), two of which (111E and 111F) have been plugged and no longer overflow. The remaining active CSO structures discharge overflows to the Diagonal Avenue storm drain and thence to the Duwamish River during large precipitation events when the capacity of the CSS is exceeded.

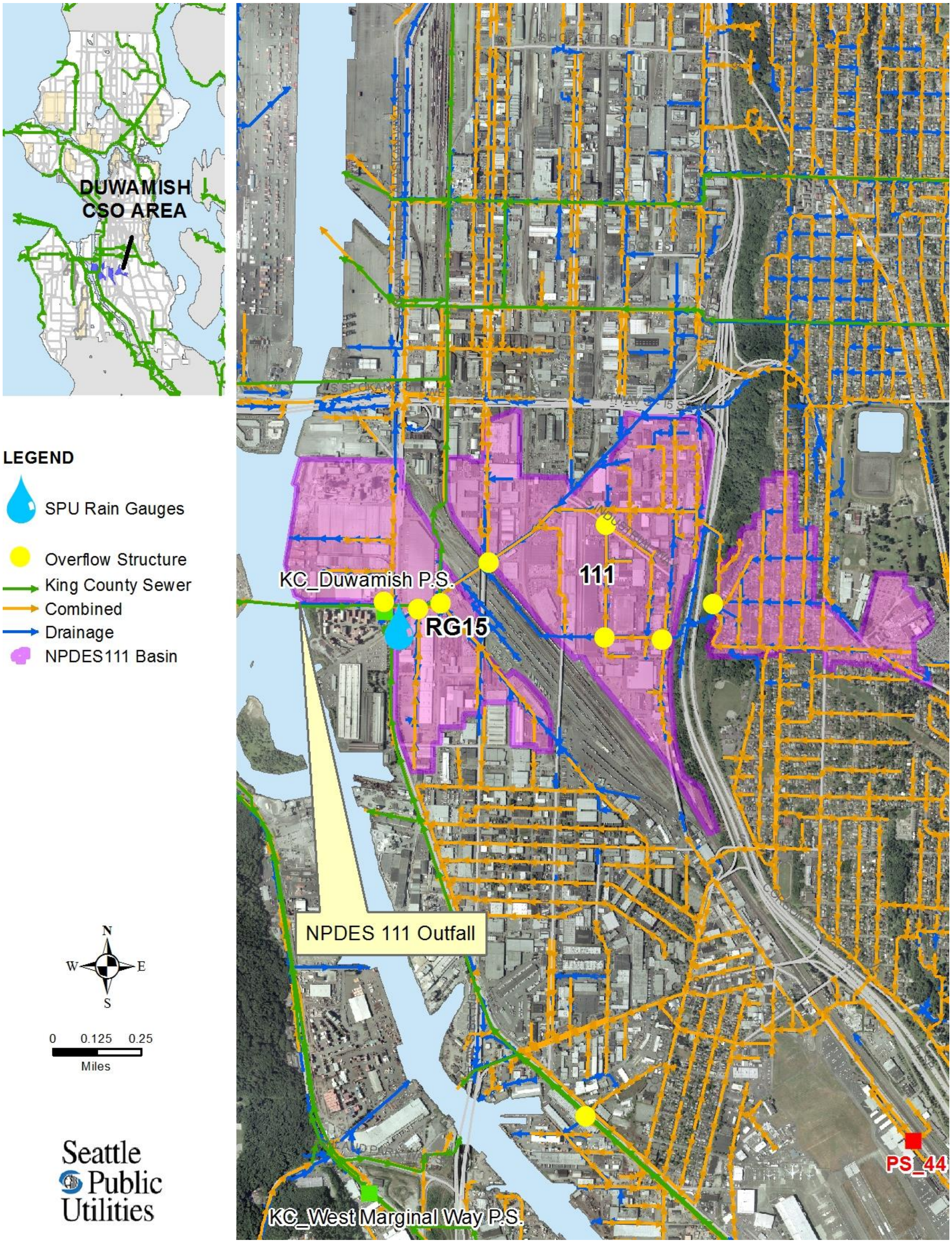

Figure 2-10. Overview of the Duwamish CSO Area

Table 2-8 presents a summary of the key components of the wastewater collection system in the Duwamish CSO area.

Table 2-8. Summary of Sewer Pipe in the Duwamish CSO Area

Component	Description
Length of pipe (LF)	49,000
Diameter range	8” to 54”
Number of connecting structures	320+
City pump stations	None
HydroBrakes	1 Basin 111(H)
Storage facilities	CSO Basin 111(H) – 0.12 MG storage facility

2.3.6.5 Fremont/Wallingford

The Fremont/Wallingford CSO area covers 657 acres (1.0 square mile) in north Seattle; it is bounded approximately by Woodlawn Avenue N to the east, Lake Union and the Lake Washington Ship Canal to the south and west, and the Woodland Park Zoo to the north (see Figure 2-11). The Fremont/Wallingford CSO area comprises CSO Basins 147, 148, and 174, which drain from north to south toward Lake Union and the Lake Washington Ship Canal. CSO Basin 147 has two overflow points (147(A) and 147(B)), that discharge to a single outfall. Both CSO Basins 148 and 174 have an individual overflow point and outfall. CSO Basin 148 discharges via a pump station to CSO Basin 17. The wastewater generated in these basins flows by gravity to King County’s North Interceptor for conveyance to the West Point WWTP. CSO Basin 148 is considered controlled and is not included in the LTCP.

The CSS in the Fremont/Wallingford CSO area conveys both sanitary and stormwater flow. The majority of the Fremont/Wallingford CSO area is partially separated. The area to the west of Stone Way N is mostly partially separated. Storm sewers collect and convey street runoff and a portion of private property runoff. Stormwater runoff from portions of CSO Basin148 and a few localized areas of CSO Basin 174, (that are west of Stone Way N), and areas to the east of Stone Way N drain to the combined system. Stormwater from partially separated areas of the Fremont/Wallingford CSO area is discharged into the ship canal. CSO Basins147 and 174 contain permitted CSO structures that discharge overflows to Lake Union and the Lake Washington Ship Canal during large precipitation events when the capacity of the CSS is exceeded or when the King County North Interceptor levels are high.

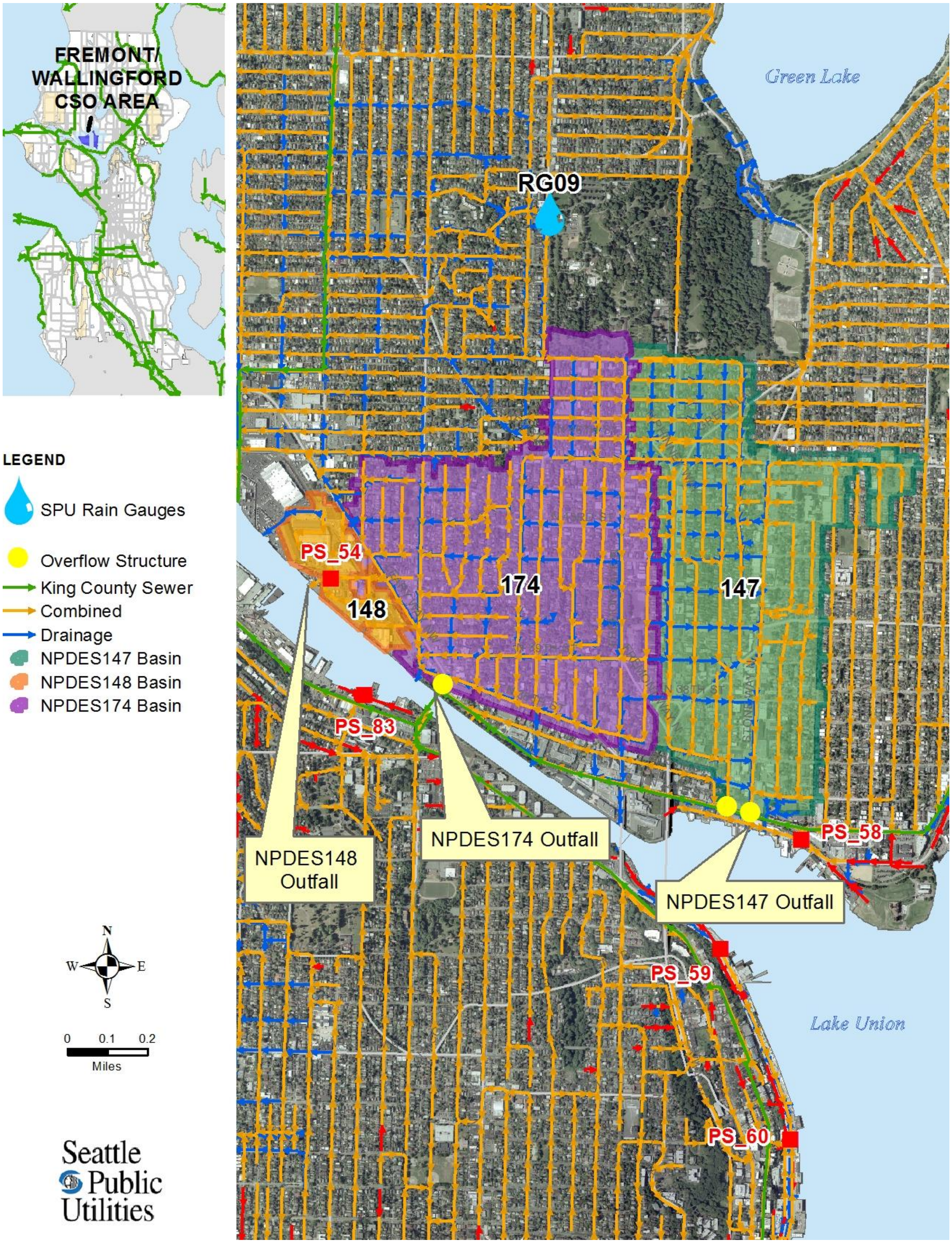

Figure 2-11. Overview of the Fremont/Wallingford CSO Area

Table 2-9 presents a summary of the key components of the wastewater collection system in the Fremont/Wallingford CSO area.

Table 2-9. Summary of Sewer Pipe in the Fremont/Wallingford CSO Area

Component	Description
Length of pipe (LF)	125,000
Diameter range	8” to 54”
Number of connecting structures	640+
City pump stations	1 (PS54)
HydroBrakes	None
Storage facilities	None

2.3.6.6 Interbay

The Interbay CSO area covers 290 acres (0.45 square mile) in northwest Seattle; it lies on the west side of Queen Anne to the east of the Interbay railroad yards (see Figure 2-12). The wastewater generated in these basins flows by gravity to King County's North Interceptor for conveyance to the West WWTP. Each basin has a single overflow structure: CSO Basins 68(A) and 68(B). During large precipitation events, when the capacity of the CSS is exceeded, the flows discharge through these overflow structures into a storm drain and the combined flows overflow through CSO Outfall 068.

The CSS in the Interbay CSO area conveys both sanitary and stormwater flow. Just over three-fourths of the Interbay CSO area is partially separated. Storm sewers collect and convey street runoff and private property runoff. Stormwater from partially separated areas of the Interbay CSO area is discharged into Elliott Bay.

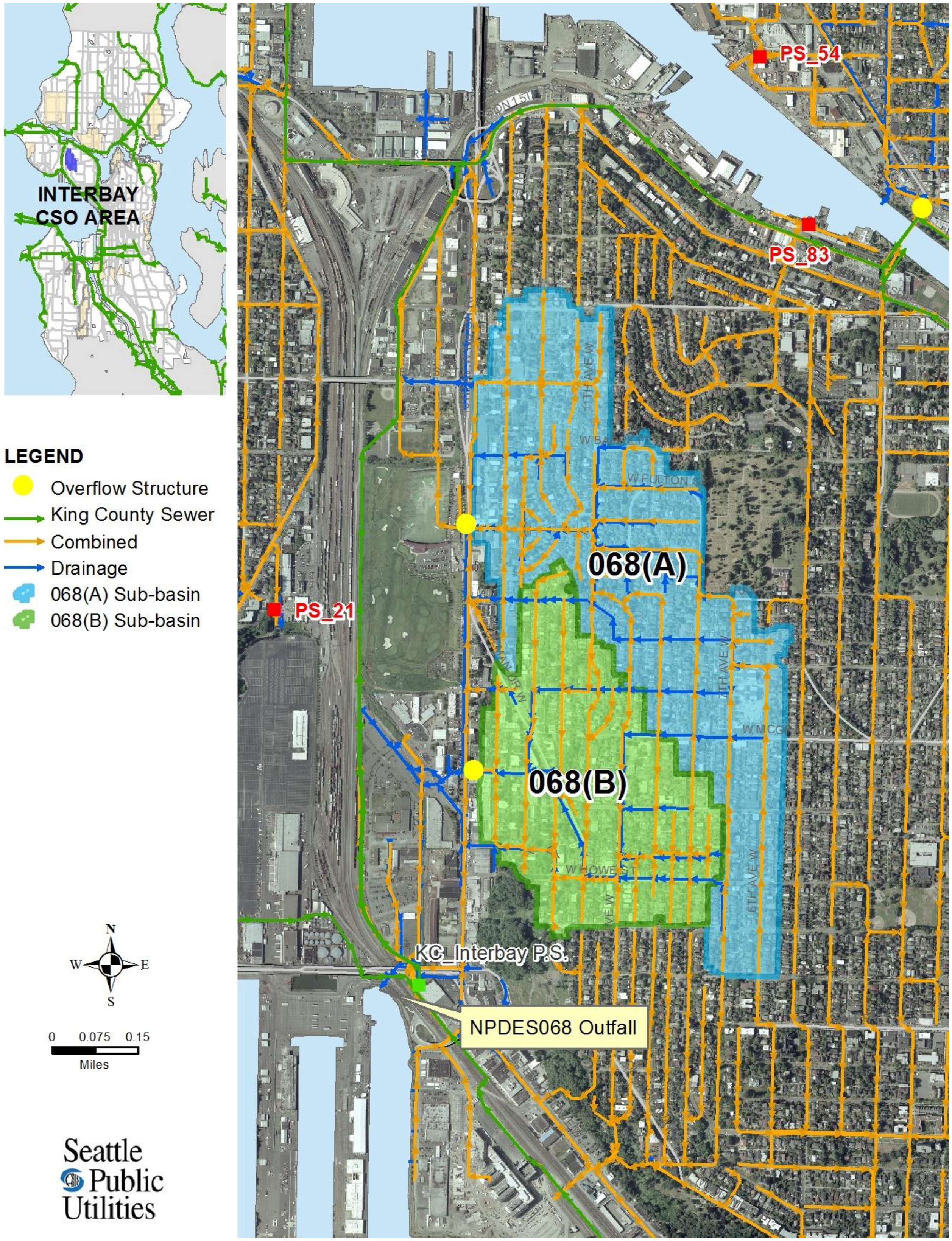

Figure 2-12. Overview of the Interbay CSO Area

Table 2-10 presents a summary of the key components of the wastewater collection system in the Interbay CSO area.

Table 2-10. Summary of Sewer Pipe in the Interbay CSO Area

Component	Description
Length of pipe (LF)	65,000
Diameter range	8" to 72"
Number of connecting structures	500+
City pump stations	None
HydroBrakes	2 Basins 068(A) and (B)
Storage facilities	CSO Basin 068(A) - 0.30 MG storage pipe CSO Basin 068(B) – 0.12 MG storage pipe

2.3.6.7 Leschi

The Leschi CSO area covers 405 acres (0.63 square mile) in east Seattle; it is located on the western shore of Lake Washington along Lake Washington Boulevard from approximately S McClellan Street to E John Street (see Figure 2-13). The Leschi CSO area, comprised of CSO Basins 026 through 036, drains from south to north toward the King County East Pine Street pump station, with the exception of CSO Basin 026, which drains from north to south.

CSO Basin 032 has two overflow points; each has its own CSO designation (032(A) and 032(B)), but they share a common outfall. CSO Basins 33 and 34 have separate overflow points. The wastewater generated in all the Leschi basins flows by gravity to King County's East Pine Street PS for conveyance to the West Point WWTP.

The CSS in the Leschi CSO area conveys both sanitary and stormwater flow. The Leschi CSO area is partially separated. Storm sewers collect and convey street runoff and a portion of private property runoff. Stormwater from partially separated areas of the Leschi CSO area is discharged into Lake Washington. The basins within the Leschi CSO area contain permitted CSO structures that discharge overflows to Lake Washington during large precipitation events when the capacity of the CSS is exceeded.

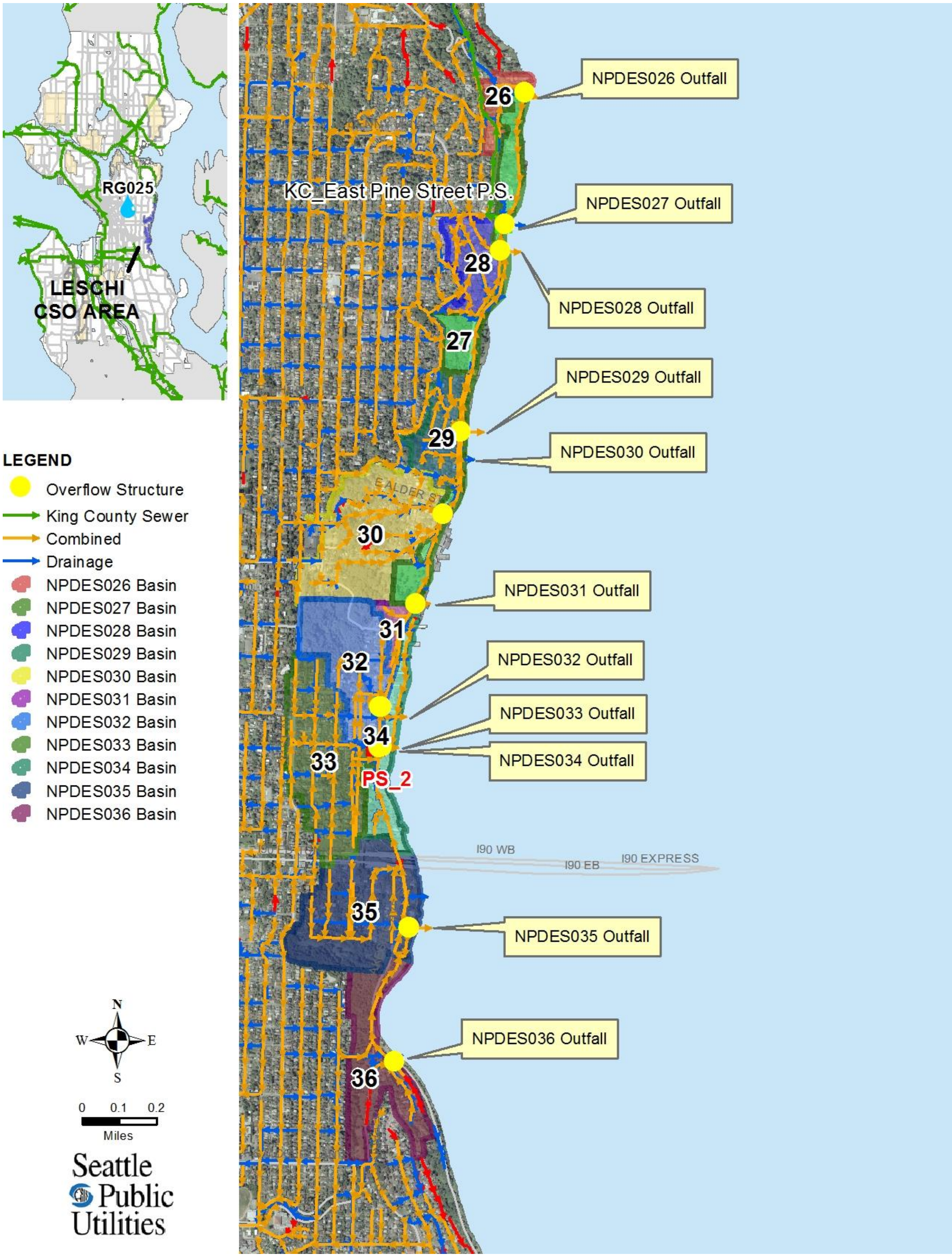

Figure 2-13. Overview of the Leschi CSO Area

Table 2-11 presents a summary of the key components of the wastewater collection system in the Leschi CSO area.

Table 2-11. Summary of Sewer Pipe in the Leschi CSO Area

Component	Description
Length of pipe (LF)	72,000
Diameter range	8” to 48”
Number of connecting structures	450+
City pump stations	1 (PS2)
HydroBrakes or sluice gates	6 Basins (029, 032, 033, 030, 035, 036)
Storage facilities	CSO Basin030 – 0.02 MG in-line storage pipe CSO Basin034 – 0.04 MG offline storage pipe CSO Basin035 – 0.01 MG offline storage pipe

2.3.6.8 Madison Park/Union Bay

The Madison Park/Union Bay CSO area covers 240 acres (0.4 square mile) in east Seattle; it is bounded approximately by Lake Washington to the east, Union Bay to the north, and the Leschi CSO area to the south (see Figure 2-14). The Madison Park/Union Bay CSO area comprises CSO Basins 022, 024, and 025, which drain generally toward Union Bay and Lake Washington. The wastewater generated in these basins flows to the City’s PS 7, and is then pumped to King County’s South Lake Washington trunk line for conveyance to the West Point WWTP.

The CSS in the Madison Park/Union Bay CSO area conveys both sanitary and stormwater flow. Apart from a small area in the south of CSO Basin 024, the entire area is partially separated. Storm sewers collect and convey street runoff and a portion of private property runoff. Stormwater from partially separated areas of the Madison Park/Union Bay CSO area is discharged into Union Bay and Lake Washington. CSO Basins 022, 024, and 025 contain permitted CSO structures that discharge overflows to Union Bay and Lake Washington during large precipitation events when the capacity of the CSS is exceeded.

This CSO area is now controlled and is no longer a part of the LTCP.

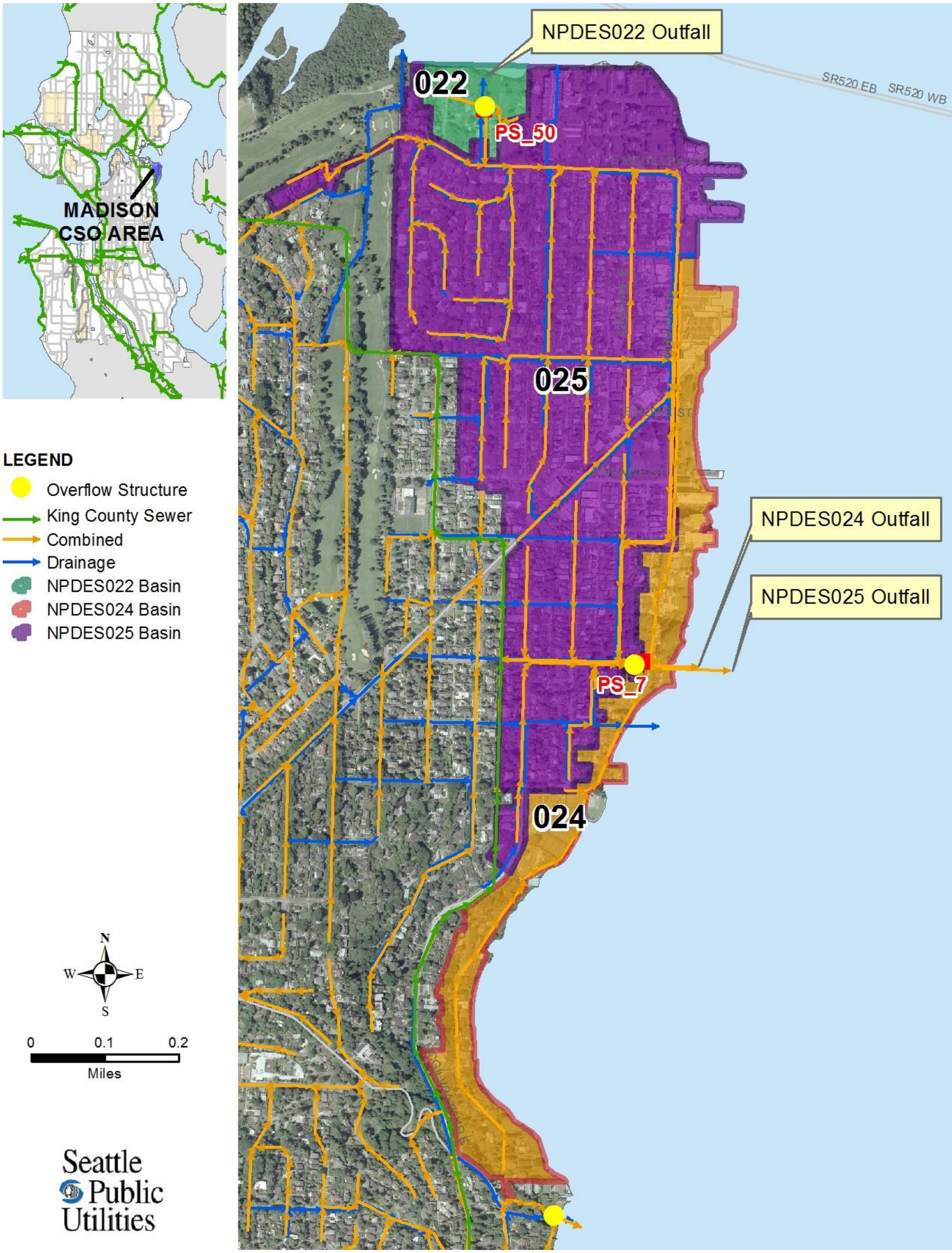

Figure 2-14. Overview of the Madison Park/Union Bay CSO Area

Table 2-12 presents a summary of the key components of the wastewater collection system in the Madison Park/Union Bay CSO area.

Table 2-12. Summary of Sewer Pipe in the Madison Park/Union Bay CSO Area

Component	Description
Length of pipe (LF)	41,500
Diameter range	6” to 54”
Number of connecting structures	190+
City pump stations	2 (PS7, PS50)
HydroBrakes	None
Storage facilities	025 – 0.08 MG in-line storage pipe

2.3.6.9 Montlake CSO Area

The Montlake CSO area covers 140 acres (0.2 square mile) in east Seattle; it is bounded approximately by the Lake Washington Ship Canal to the north, Portage Bay to the north and west, Delmar Drive E and Boyer Avenue E to the south, and Lake Washington Boulevard E and Union Bay to the east (see Figure 2-15). The Montlake CSO area comprises CSO Basins 020, 139 and 140. The flows from CSO Basins 139 and 140 drain to the City’s PS 25, from which they are pumped into the Montlake gravity system that then flows into the King County South Lake Washington trunk line. Flows from CSO Basin 020 drain to the City’s pump station 13, from which they are pumped to King County’s South Lake Washington trunk line for conveyance, treatment, and discharge at the West Point WWTP.

The CSS in the Montlake CSO area conveys both sanitary and stormwater flow. CSO Basin 140 and CSO Basin 020 north of Highway 520 (about 30 percent of the total area) are fully combined. CSO Basin 139 and CSO Basin 020 south of Highway 520 are partially separated. Storm sewers collect and convey street runoff and a portion of private property runoff. Stormwater from partially separated areas of the Montlake CSO area is discharged into the Ship Canal and Union Bay. The Montlake CSO area includes three permitted CSO outfalls that discharge overflows to the Ship Canal during precipitation events when the capacity of the CSS is exceeded.

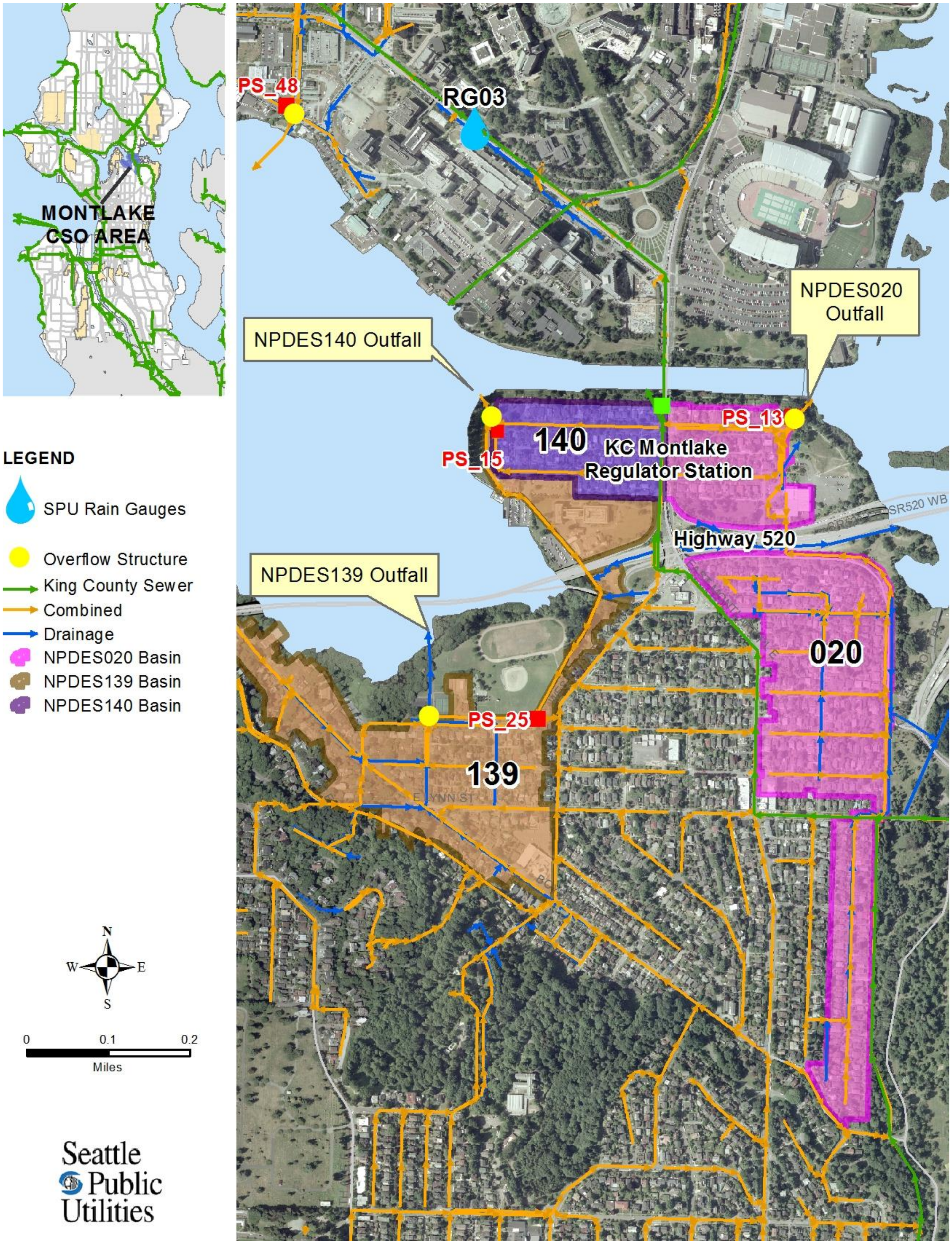

Figure 2-15. Overview of the Montlake CSO Area

Table 2-13 presents a summary of the key components of the wastewater collection system in the Montlake CSO area.

Table 2-13. Summary of Sewer Pipe in the Montlake CSO Area

Component	Description
Length of pipe (LF)	26,600
Diameter range	4” to 120”
Number of connecting structures	150+
City pump stations	3 (PS13, PS15, PS25)
HydroBrakes	1 Basin (140)
Storage facilities	CSO Basin 020 – 0.12 MG offline storage pipe CSO Basin 140 – 0.02 MG offline storage pipe

2.3.6.10 North Union Bay

The North Union Bay CSO area covers approximately 900 acres (1.4 square miles) in northeast Seattle; it is bounded approximately by NE 85th Street to the north and NE 41st Street to the south. The western boundary generally runs between 30th and 35th Avenues NE and the eastern boundary runs between 45th and 50th Avenues NE (see Figure 2-16). The North Union Bay CSO area includes CSO Basin 018, which drains from north to south toward Union Bay and Lake Washington. CSO Basin 018 has two overflow points, designated 18(A) and 018(B). CSO Basin 018(B) overflows are conveyed downstream in the storm drainage system. Overflows from 18(A) enter the same storm drainage system and together the overflows are conveyed to a single outfall into Union Bay. The wastewater generated in these basins flows by gravity to King County’s Laurelhurst trunk for conveyance to the West Point WWTP. The CSS in the North Union Bay CSO area conveys both sanitary and stormwater flow. Most of the basin contains storm sewers and is considered partially separated. The fully combined subcatchments are distributed in pockets throughout the area, with the largest concentration in the northern and northeastern parts of the area (i.e., north of NE 75th Street).

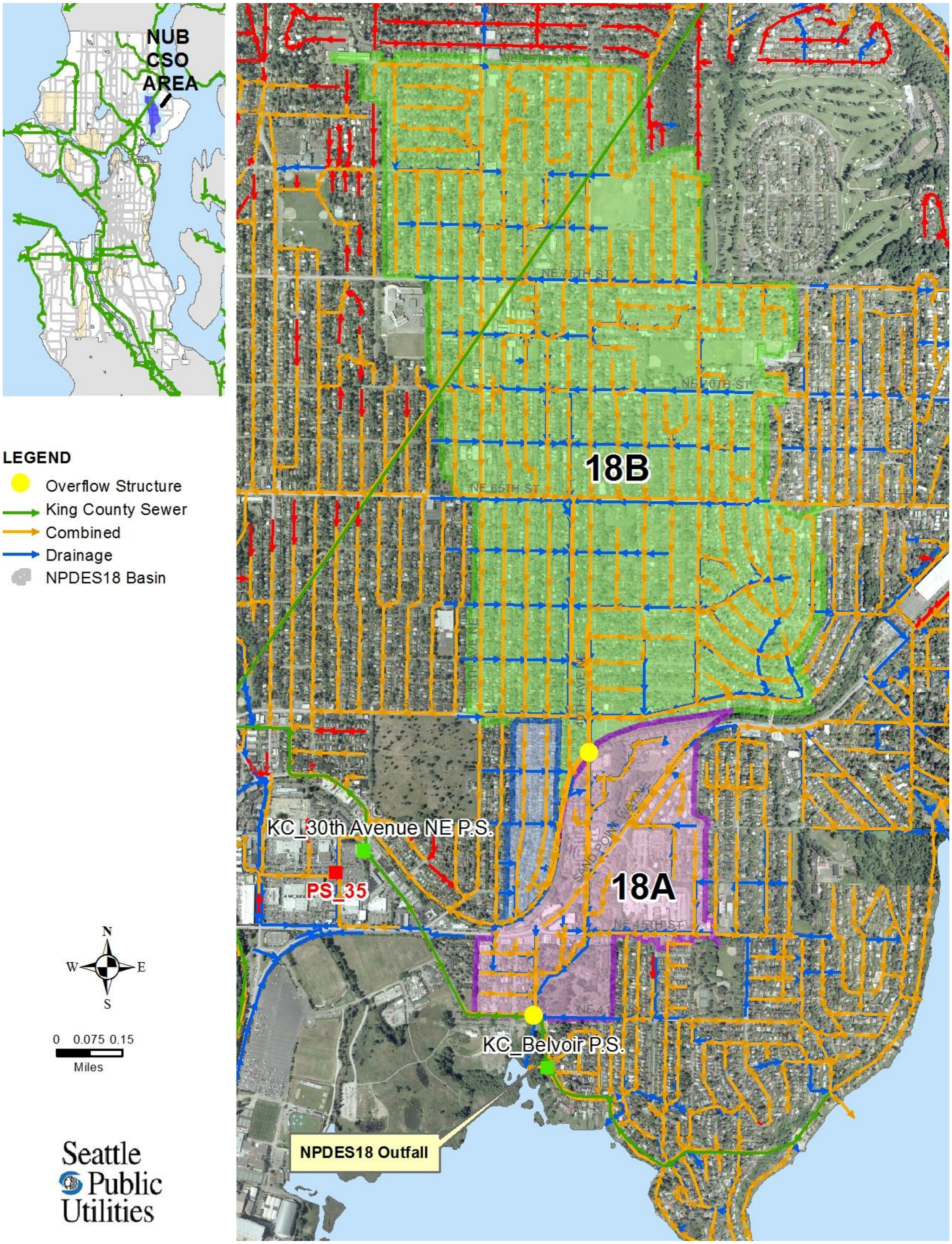

Figure 2-16. Overview of the North Union Bay CSO Area

Table 2-14 presents a summary of the key components of the wastewater collection system in the North Union Bay CSO area.

Table 2-14. Summary of Sewer Pipe in the North Union Bay CSO Area

Component	Description
Length of pipe (LF)	164,000
Diameter range	8” to 72”
Number of connecting structures	850+
City pump stations	None
HydroBrake or sluice gate	Sluice Gate 018(A) HydroBrake 018(B)
Storage facilities	CSO Basin 018(A) – 0.15 MG in-line storage pipe CSO Basin 018(B) – 1.8 MG in-line and offline storage pipes

2.3.6.11 Portage Bay/Lake Union CSO Area

The Portage Bay/Lake Union CSO area covers 387 acres (0.6 square mile) in central Seattle. The Portage Bay/Lake Union CSO area is bounded by Portage Bay to the North, 11th Avenue E to the East, E Newton Street to the south, and Lake Union to the west (see Figure 2-17). The Portage Bay/Lake Union CSO area examined comprises CSO Basins 127, 129, 130, 131, 132, 134, 135, 136, 138, and 175. Of the CSO basins, only 138 is uncontrolled and included in the LTCP.

Five of the nine basins are partially separated and hydraulically dependent: 138, 135, 132, 130, and 175, listed from upstream to downstream. The Portage Bay/Lake Union CSO area generally drains from north to south along Eastlake Avenue E. Flow from CSO Basin 138 is pumped by PS20 into CSO Basin 135, and flows by gravity through CSO Basins 132, 130, and 175 to join the King County system farther south. Flows from house connections in CSO Basins 127, 129, 131, and 134 are pumped uphill by pump stations 62, 63, 64, and 65 to join the main sewer line. Flows from CSO Basin 136 are pumped to CSO Basin 138 by pump station 66. Stormwater from the partially separated areas of the Portage Bay/Lake Union CSO area is discharged directly into Lake Union and Portage Bay. All of the CSO basins contain permitted CSO structures that discharge overflows to Lake Union or Portage Bay during large precipitation events when the capacity of the CSS is exceeded.

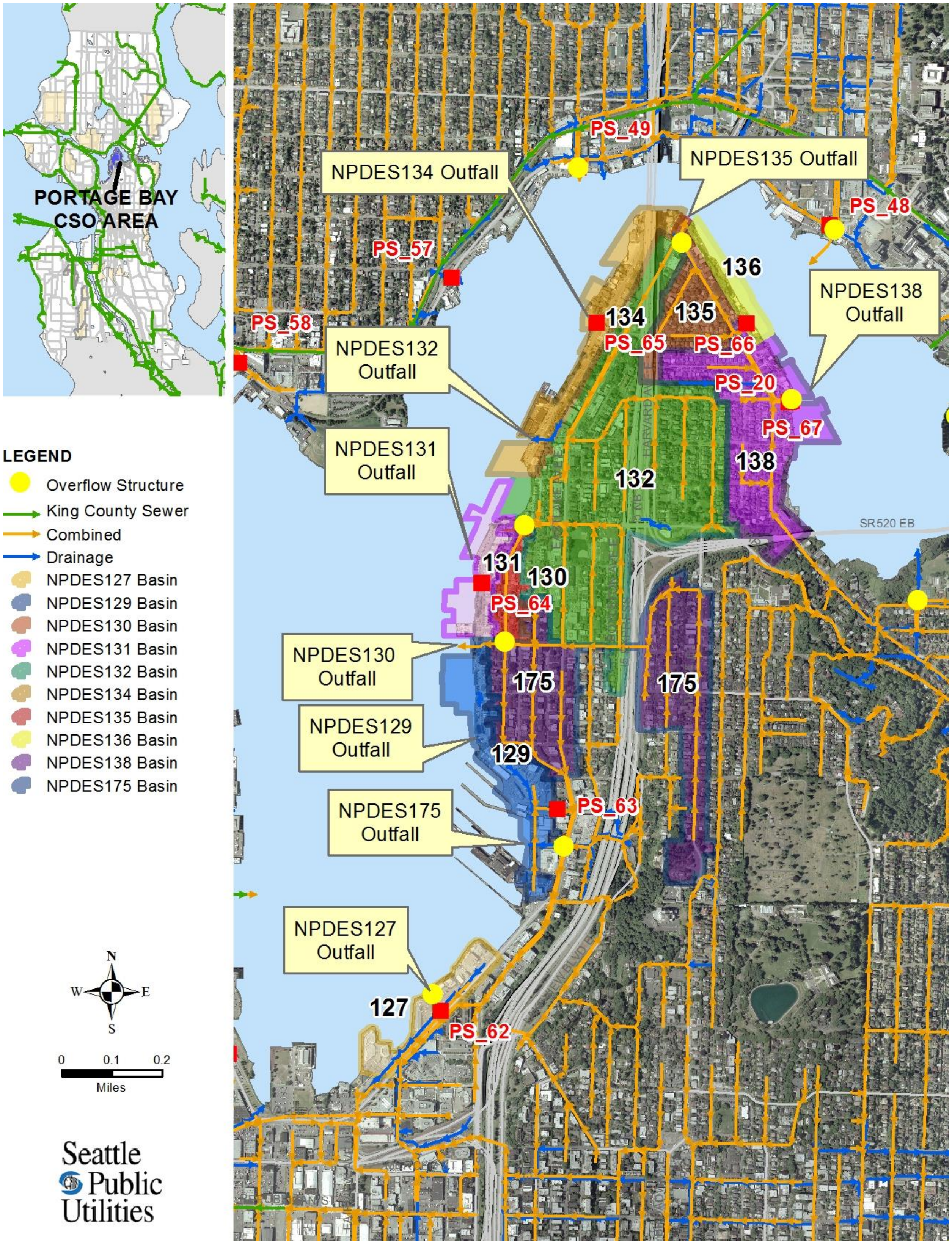

Figure 2-17. Overview of the Portage Bay/Lake Union CSO Area

Table 2-15 presents a summary of the key components of the wastewater collection system in the Portage Bay/Lake Union CSO area.

Table 2-15. Summary of Sewer Pipe in the Portage Bay/Lake Union CSO Area

Component	Description
Length of pipe (LF)	65,000[a]
Diameter range	8" to 54"[a]
Number of connecting structures	*390*[a]
City pump stations	6 (PS20, PS62, PS63, PS64, PS65, PS66, PS67)
HydroBrakes	1 Basin (138)
Storage facilities	CSO Basin 138 – 0.13 MG storage pipes

[a] Components from CSO Basin 127 not included in totals, basin was not included in the Portage Bay/Lake Union hydraulic model.

2.3.6.12 Magnolia

The Magnolia CSO area (CSO Basin 060) is located south of the ship canal, west of Salmon Bay, east of Discovery Park and north of West Commodore Way (see Figure 2-18). Topographically, the basin generally slopes from west to east. The 28-acre basin is served by a combined sewer system and consists of residential land use.

Flow within CSO Basin 60 is regulated by pump station22 and by an overflow weir located within MH 010-159. Under normal conditions, sewage is routed toward pump station. 22 and is pumped via an 8-inch force main to a 144-inch diameter King County North Interceptor, which conveys sewage toward the West Point WWTP. As flows increase, the wet well associated with pump station 22 fills and sewage backs up into the control structure (MH 010-159). At an elevation of 11.66 feet (NAVD88), sewage flows over the weir and enters a 20-inch diameter outfall pipe that discharges into Salmon Bay.

Table 2-16 presents a summary of the key components of the wastewater collection system in the Magnolia CSO area.

Table 2-16. Summary of Sewer Pipe in the Magnolia CSO Area

Component	Description
Length of pipe (LF)	5,000
Diameter range	6" to 20"
Number of connecting structures	30+
City pump stations	1 (PS22)
HydroBrakes	None
Storage facilities	None

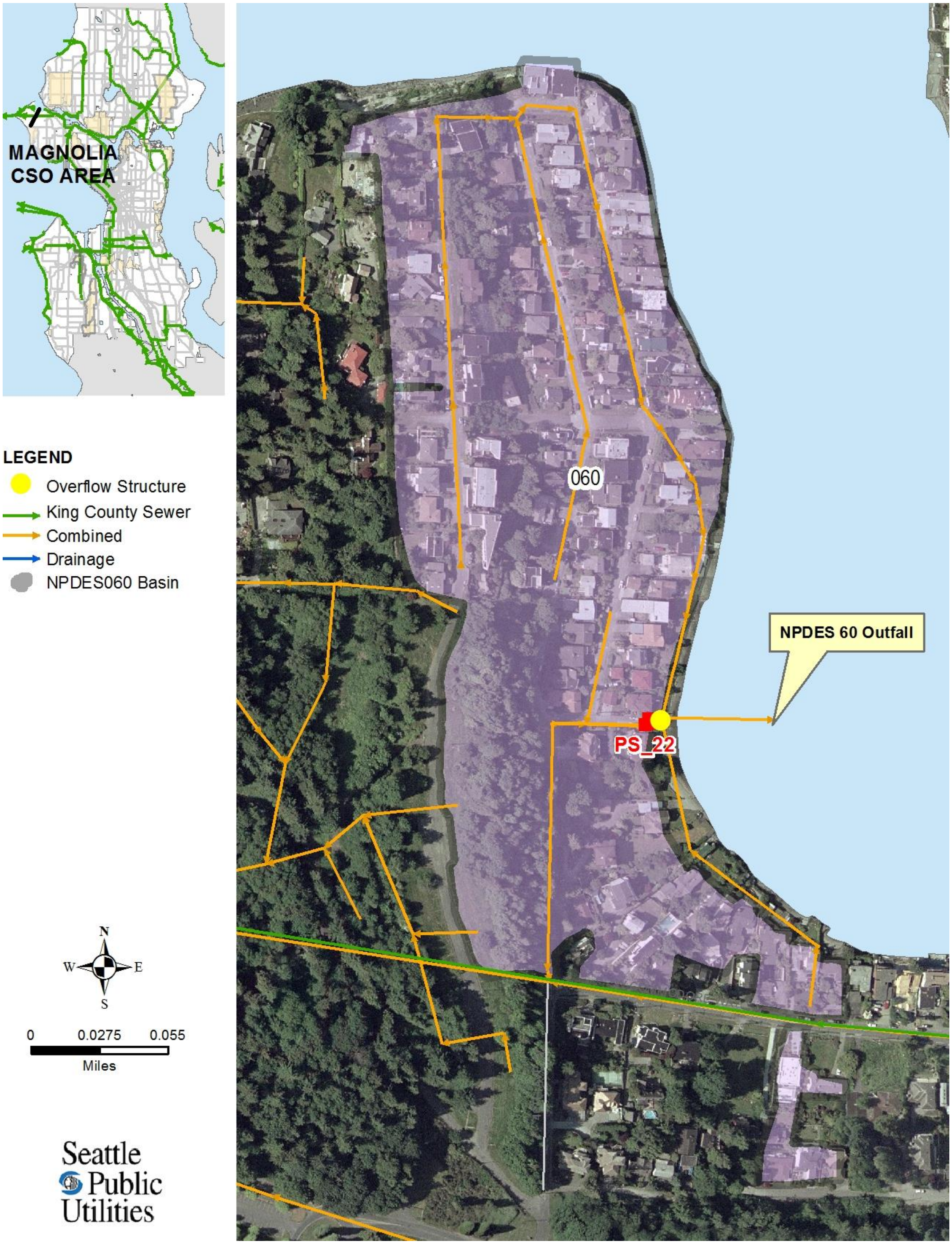

Figure 2-18. Overview of the Magnolia CSO Area

2.3.6.13 East Waterway CSO Area

The Duwamish River East Waterway CSO area comprises CSO Basin 107 and covers 58.7 acres (0.09 square mile) in southeast Seattle; it is bounded by S Hanford Street to the north, the East Waterway of the Duwamish River to the west, industrial properties to the south, and East Marginal Way S to the east (see Figure 2-19). Topographically, CSO Basin 107 is generally flat, and land use consists entirely of industrial property.

Flow in CSO Basin 107 drains toward a single overflow point near the intersection of East Marginal Way S and S Spokane Street (MH 056-097). The wastewater generated in this basin flows by gravity to the King County Elliot Bay Interceptor in Colorado Avenue S for conveyance to the West Point WWTP. Overflows at this location occur only when the water level in the King County interceptor is above the level of the overflow point.

Table 2-17 presents a summary of the key components of the wastewater collection system in the East Waterway CSO area.

Table 2-17. Summary of Sewer Pipe in the East Waterway CSO Area

Component	Description
Length of pipe (LF)	9,000
Diameter range	6” to 36”
Number of connecting structures	80+
City pump stations	None
HydroBrakes	None
Storage facilities	None

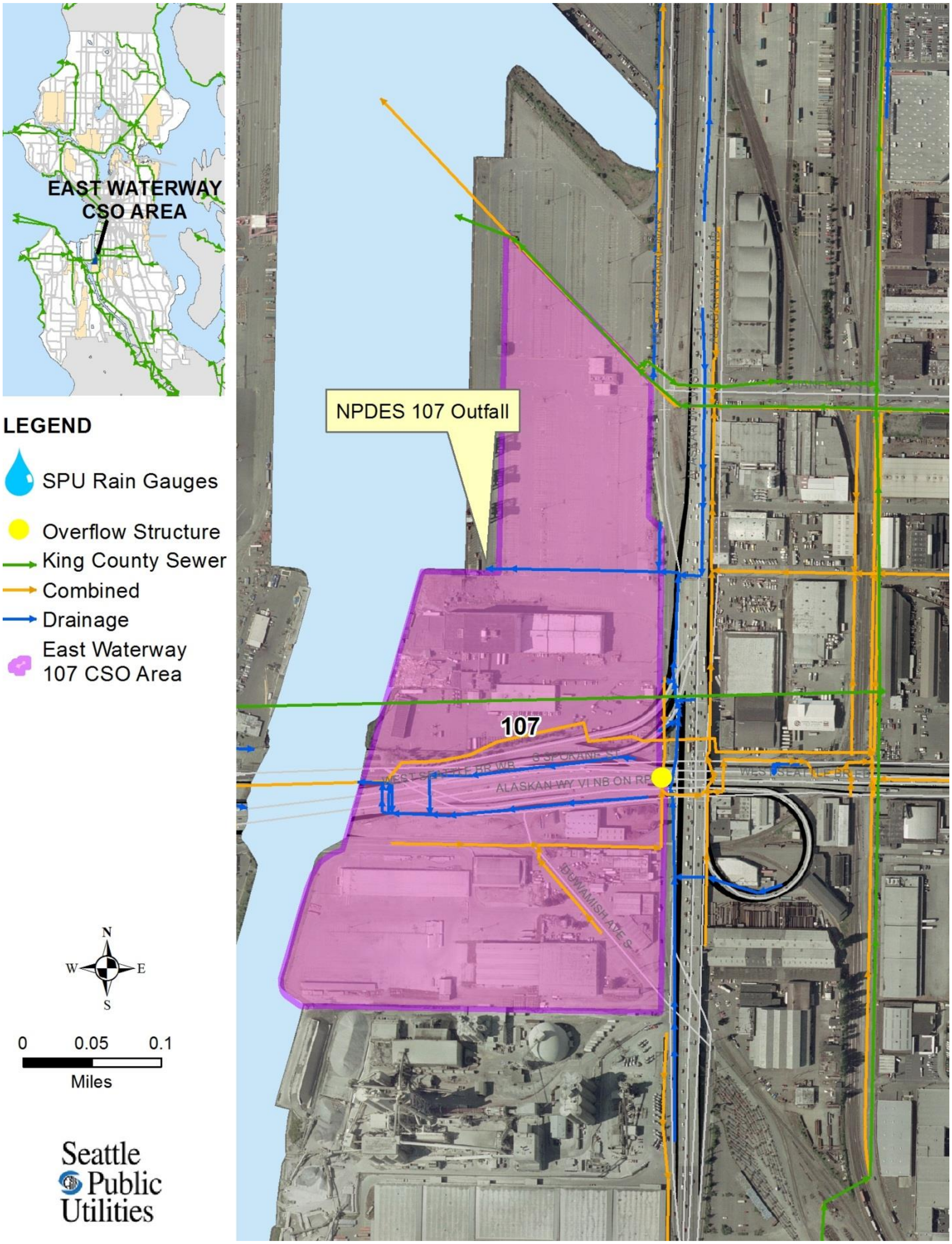

Figure 2-19. Overview of East Waterway CSO Area

2.3.7 Receiving Waters

The majority of Seattle is located within the Lake Washington/Cedar/ Sammamish Watershed (Watershed Resource Inventory Area (WRIA) 8). The Duwamish Waterway and Elliott Bay, located in south-western Seattle, are part of the Green/Duwamish and Central Puget Sound Watershed (WRIA 9). Seattle is characterized by a variety of surface water features including marine areas, rivers, lakes, and creeks. Each type is briefly summarized below:

Marine: Seattle's west side is situated adjacent to Puget Sound, a major marine embayment.

Rivers: Portions of south Seattle drain to the lower reaches of the Duwamish River (called the Duwamish Waterway). The river receives flow from the South Park basin, Norfolk basin, Longfellow Creek, and other smaller urban creeks and drains to Elliott Bay in south Puget Sound.

Lakes: Freshwater lakes and ponds, within or adjacent to the City, include the Portage Bay/Lake Union/Ship Canal system, linking Lake Washington and Puget Sound through the Hiram Chittenden Locks. Other freshwater lakes include Green, Haller, and Bitter lakes in the north portion of the City (also located in the Lake Union/Ship Canal drainage basin). Seattle also contains a many small ponds and wetlands.

Creeks: Runoff from Seattle's landscape drains to creek systems of varying size. Major creeks in the western regions of the City drain directly to Puget Sound and include Piper's and Fauntleroy creeks. Longfellow Creek is a main creek in the southwest portion of the City that drains to the Duwamish Waterway. Thornton Creek, Taylor Creek, and other smaller creeks drain the eastern portions of the City to Lake Washington.

Table 2-18 specifies the waterbody into which each CSO area included in the LTCP discharges. The following section describes the major waterbodies in the City in greater detail: Puget Sound, Elliott Bay, the Ship Canal, Lake Washington, the Duwamish River, and Longfellow Creek.

Table 2-18. Receiving Waterbody by CSO Area

CSO area	Receiving waterbody
Ballard	Salmon Bay
Central Waterfront (Vine Street)	Elliott Bay
Delridge	Duwamish River (Basin 099) Longfellow Creek (Basin 168 and Basin 169)
Duwamish	Duwamish River
East Waterway	Duwamish River
Fremont/Wallingford	Lake Union
Interbay	Elliott Bay
Leschi	Lake Washington
Madison Park/Union Bay	Lake Washington (Basin 024 and Basin 025) Union Bay (Basin 022)
Magnolia	Salmon Bay

Table 2-18. Receiving Waterbody by CSO Area

CSO area	Receiving waterbody
Montlake	Ship Canal
North Union Bay	Union Bay
Portage Bay	Lake Union (Basin 175) Portage Bay (all others)

Figure 2-20 presents a map showing the locations of the receiving waterbodies.

2.3.7.1 Lake Washington

Lake Washington is the second largest natural lake in Washington, with a surface area of 21,500 acres and a watershed of 472 square miles. The Lake Washington drainage system has been highly altered and now drains through the Lake Washington Ship Canal system rather than the Duwamish River. Most of the lake shoreline is highly developed and lake levels are regulated by the U.S. Corps of Engineers through operation of the Lake Washington Ship Canal system.

Union Bay is also considered part of Lake Washington and is located near the eastern end of the Ship Canal.

2.3.7.2 Puget Sound

Puget Sound is a fjord-like estuary that consists of four major interconnected basins that stretch from Hood Canal to north of Admiralty Inlet. The four basins include the Main (Admiralty Inlet and the Central basin), Whidbey, Southern, and Hood Canal basins. All of Seattle's marine CSOs discharge to the Central basin. Puget Sound borders the Ship Canal neighborhoods and Elliott Bay within the plan area. CSOs in the Ballard, Fremont and Wallingford area discharge to the Ship Canal and eventually drain to Puget Sound via the Hiram M. Chittenden Locks. Freshwater flows influence water circulation in this portion of Puget Sound with seasonal variation in the amount of freshwater input and an accompanying effect on water temperature, salinity, and density. The two main freshwater inputs to Puget Sound in the plan area are the Green/Duwamish River, which enters Elliott Bay, and the Cedar River (Lake Washington drainage basin), which flows into the Sound through the Lake Washington Ship Canal.

2.3.7.3 Ship Canal

The Lake Washington Ship Canal system is an 8.6-mile-long man-made navigable waterway connecting Shilshole Bay in Puget Sound to Union Bay in Lake Washington in Seattle. This system includes several interconnected waterways—Hiram M. Chittenden Locks (Ballard Locks), Salmon Bay, Salmon Bay Waterway. Fremont Cut, Lake Union, Portage Bay and Montlake Cut. Lake Union is a freshwater lake and receives most of its inflow from Lake Washington via the Montlake Cut and Portage Bay.

Figure 2-20. Receiving Water Bodies in the City of Seattle

2.3.7.4 Elliott Bay

Elliott Bay is a partially enclosed embayment that is bordered on the north, east, and south sides by urbanized areas and by Puget Sound on the west. The eastern shoreline borders the downtown neighborhoods and has been heavily modified from historical development. As a result, the shoreline along Elliott Bay is much steeper than a natural shoreline. The southern portion of the Bay is heavily altered through man-made port facilities including Harbor Island, completed in 1909. Elliott Bay is influenced by Green River freshwater flows through the heart of Seattle's industrial area and port facilities where the Green River becomes the Duwamish River.

2.3.7.5 Duwamish River

The Duwamish River originates at the confluence of the Green and Black Rivers near Tukwila and flows northwest for approximately 12 miles, splitting at the southern end of Harbor Island to form the East and West Waterways before discharging into Elliott Bay. The Duwamish River flows through the Delridge/Duwamish neighborhoods. The downstream portion of the Duwamish River serves as a major shipping route for bulk and containerized cargo, and the shoreline along the majority of the lower Duwamish has been developed for industrial and commercial operations. A portion of the lower Duwamish is maintained as a federal navigation channel by U.S. Army Corps of Engineers.

2.3.7.6 Longfellow Creek

Seattle's second largest watershed, the Longfellow Creek basin, is located in West Seattle in the Delridge area. The creek is 4.6 miles long and drains to the Duwamish River near Harbor Island through a 3,250-foot culvert. Approximately one third of the main channel length is piped. The watercourse is relatively flat compared to other major watercourses in Seattle, dropping 250 feet in elevation from its headwaters near the southern city limits to its mouth at the Duwamish River near Harbor Island. The watershed is highly developed.

2.4 Compilation and Analysis of Existing Data: Flow Monitoring

As described in the EPA guidance manual: Combined Sewer Overflows: Guidance for Monitoring and Modeling (Reference 26), the EPA CSO Control Policy identifies several possible objectives of a CSS monitoring program, including:

- To gain a thorough understanding of the sewer system
- To adequately characterize the system's response to wet-weather events, such as the volume, frequency and duration of CSOs
- To support a mathematical model to characterize the CSS
- To support development of the LTCP
- To evaluate the expected effectiveness of a range of CSO control options

The City has been gathering flow monitoring data at numerous locations within the CSS since 1998. The following sections describe the various flow monitoring programs undertaken by the City.

2.4.1 CSO Flow Monitoring Program (Prior to 2007)

The City's CSO flow monitoring program began in 1998, when flow monitors were installed at all of the City's pump station CSO overflow locations. These early flow monitors were able to measure only frequency and duration, but not volume. By the end of 2000, flow monitors had been installed at all of the City's CSO overflow locations (pump station and non-pump station overflows), to measure frequency, duration, and volume of CSOs.

During this period, the City was using Supervisory Control and Data Acquisition (SCADA), telemetry, and Cellular Digital Packet Data (CDPD) systems in its CSO monitoring program. There were two sets of monitoring systems used to monitor overflows at pump stations. Permanent and temporary flow meters using the CDPD communications system were used for CSO overflow point sites, Overflow data (volume and duration), flow depth, and velocity at CSO sites were collected, analyzed, and archived for future use every five minutes. Monitoring data at the SCADA-based pump stations was collected every 15 seconds. The rainfall data was collected and archived every minute.

2.4.2 CSO Flow Monitoring Program (Post 2007)

In an effort to increase data quality, reduce monitoring down-time, and provide advance warning to prevent dry-weather overflows, the City revamped its permanent CSO and rainfall monitoring system in 2007. The City replaced its network of 17 rain gauges and 84 wastewater flow monitors with new, state-of-the-art instrumentation. In addition, the City established SOPs for monitor installation, maintenance, calibration, and data validation (quality assurance/quality control) to improve the quality of the flow monitoring data. Finally, the City implemented a real-time dry-weather overflow warning system to notify the City prior to the occurrence of a dry-weather overflow. The system has proven successful in reducing dry-weather overflows.

2.4.3 LTCP Flow Monitoring 2008-2012

A key element of the effort to reduce CSOs is the City's LTCP Flow Monitoring project. This project, a comprehensive effort to characterize flows and operational conditions in the City's combined sewer system, was divided into three phases comprising two years of data collection. Phase 1 (October 1, 2008 through May 31, 2009) was the wet season of the first year of monitoring. Phase 2 (June 1, 2009 through September 30, 2009) and Phase 3 (October 1, 2009 through May 31, 2010) were the dry and wet seasons, respectively, of the second year of monitoring.

The *December 2010 LTCP Flow Monitoring Report* (Reference 27) consisted of the following five volumes:

- Volume 1 summarizes the project objectives, the strategic methods used to identify and evaluate potential monitoring locations, the execution of the Flow Monitoring project, and the monitoring results. This information is presented in greater detail in Volumes 2–5.
- Volume 2 and Volume 3 are the Quality Assurance Project Plans, also known as the Flow Monitoring Plans, for the first year (Phase 1) and the second year (Phases 2 and 3) of the project, respectively. These volumes describe the project's goals and objectives, success criteria, and site selection methodology.
- Volume 4 summarizes the data collected during Phase 1 (October 1, 2008 through May 31, 2009). This volume also describes the suitability of the flow monitoring data for meeting the City's goals and objectives, suitability of rainfall data, and at-a-glance summaries of each monitoring site.
- Volume 5 summarizes the data collected during Phases 2 and 3 (June 1, 2009 through May 31, 2010) in a manner similar to Volume 4. This volume also summarizes the flow monitoring data collected during Phases 2 and 3 to support the City's system-wide model development effort.

The project targeted 12 CSO areas: Ballard, Delridge/Longfellow, Duwamish, Fremont/Wallingford, Interbay, Leschi, Madison Park/Union Bay, Magnolia, Montlake, North Union Bay, Portage Bay/Lake Union and West Seattle, which are subdivided into 38 smaller CSO basins. Each CSO basin represents one outfall, so the LTCP

Flow Monitoring project targeted about 43 percent of the City's total outfalls. In addition, rainfall data were collected from rain gauges installed citywide. During Phases 2 and 3, monitoring was also conducted at 53 system-wide monitoring locations across the City. Figure 2-21 and Figure 2-22 present the flow monitoring locations throughout the City during the 2008-2010 Flow Monitoring Program. The data obtained was used in calibration of a system-wide hydraulic model and to provide the foundation for the CSO control strategies to be implemented through the LTCP.

A Phase 4 monitoring effort was conducted following publication of the 2010 report. The goal of the LTCP Phase 4 Flow Monitoring project was to collect continuous rainfall; flow depth, level, and velocity; and operational data for refined model calibration in the Leschi and North Union Bay CSO basins during the wet season, (October 1, 2011 through March 31, 2012) to supplement data collected earlier in the program. The data were used to characterize the hydrologic and hydraulic performance of the CSS and support development of the LTCP. Detailed results of the Phase 4 program are documented in Appendix E.

In summary, the data collected from the 12 CSO basins and the system-wide flow monitoring locations, combined with the rainfall data also collected, provide a solid foundation for hydrologic and hydraulic model calibration and subsequent development of CSO reduction strategies. A brief summary of the flow and rainfall monitoring is presented in the following sections.

2.4.3.1 Flow Data

Data were collected over two wet seasons in order to gather sufficient rainfall, flow (depth, flow, velocity), and operational data (pump on-off data, run times, overflow structure behaviour, etc.) to allow accurate representation of conditions in the City's sewers. These data were used to characterize the hydrologic and hydraulic performance of the combined sewer system and support development of the LTCP.

Overall, the data collected in the 12 CSO areas and system-wide monitoring locations are reliable and representative and provide a solid foundation for hydrologic and hydraulic model calibration. For the 13 areas and the system-wide monitoring locations for which monitoring was conducted during the LTCP Flow Monitoring project, 96 percent of the data were classified as "Excellent," "Good," or "Some Limitations," meaning that they are valuable in varying degrees to calibrate and verify hydraulic models. Figure 2-23 shows the final overall flow monitoring data quality classifications for the 12 uncontrolled CSO basins and the system-wide meters that were monitored during the LTCP Flow Monitoring project.

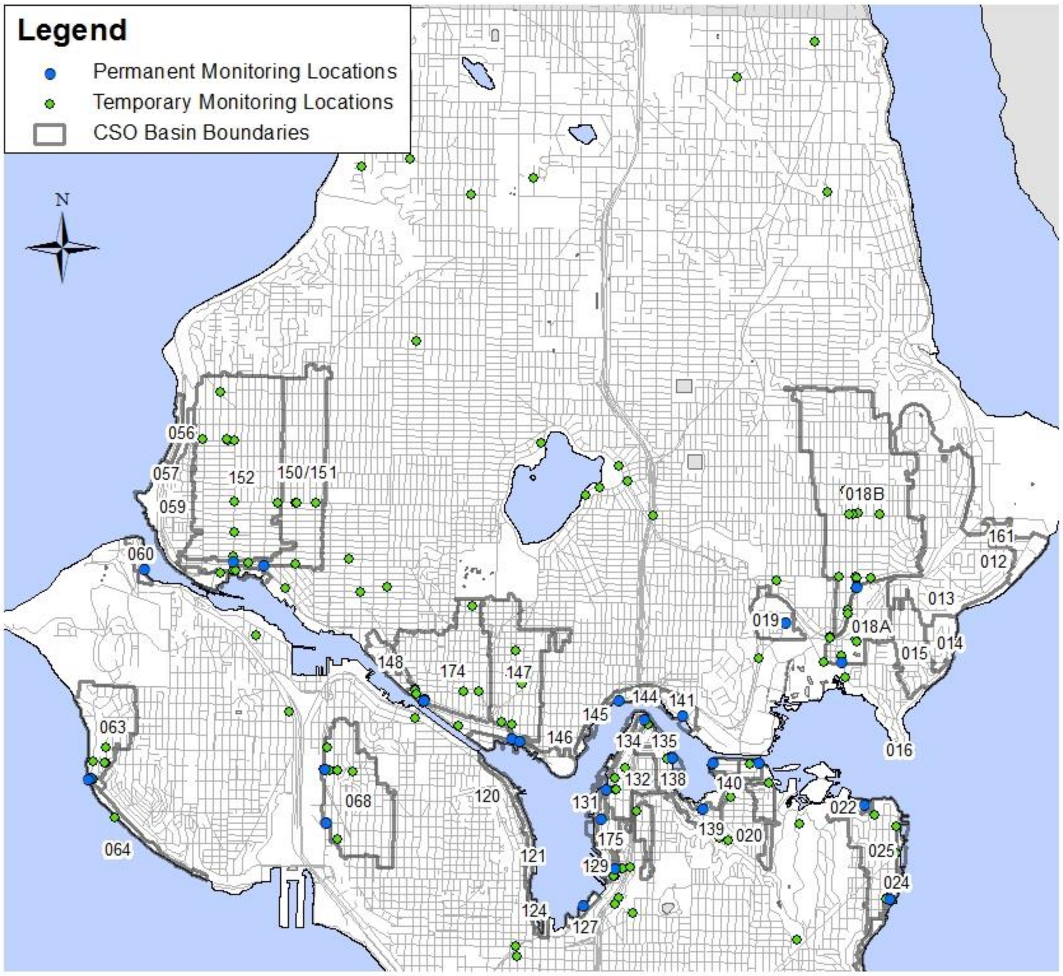

Figure 2-21. 2008-2010 Flow Monitoring Locations in Northern Seattle

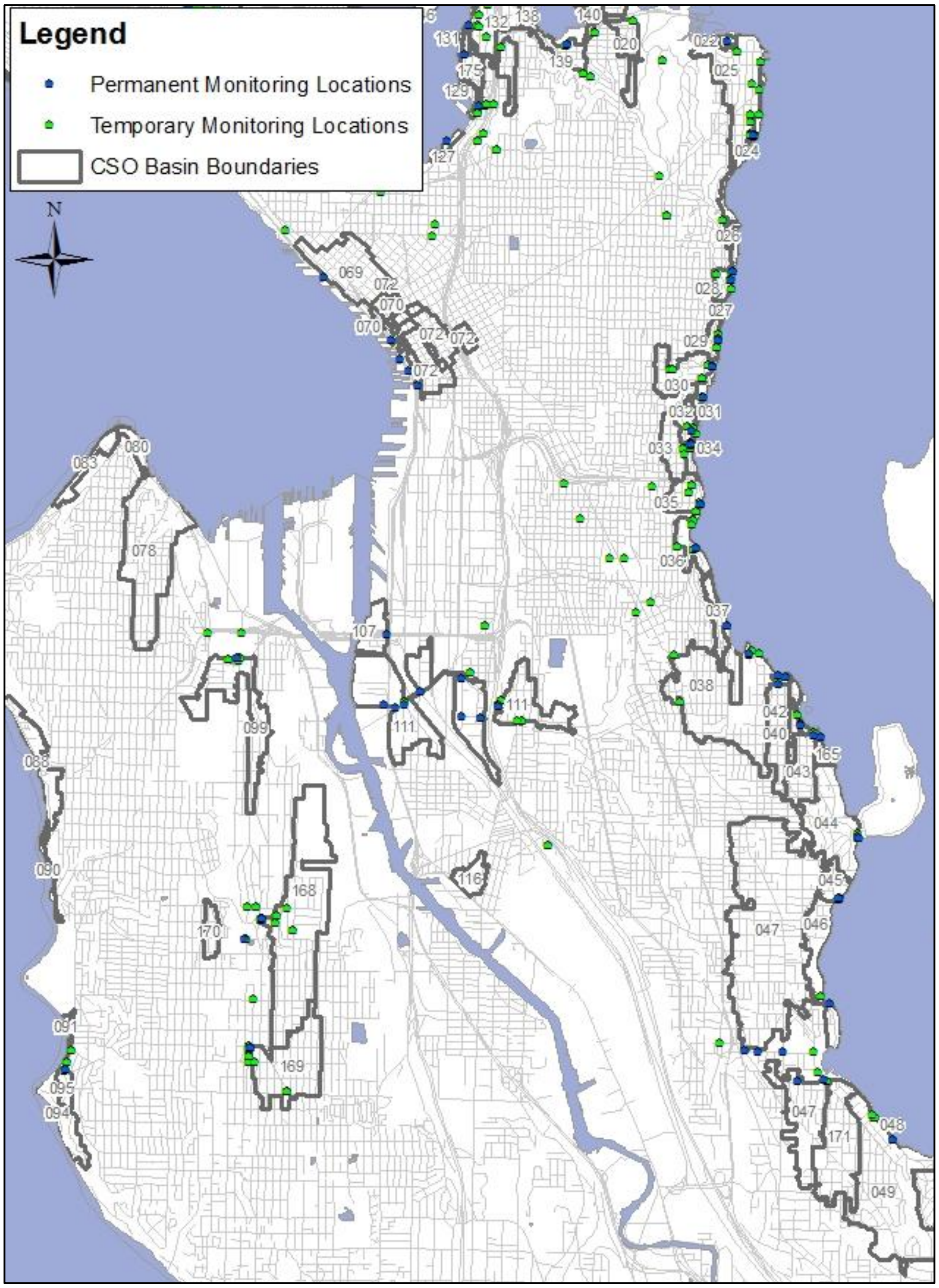

Figure 2-22. 2008-2010 Flow Monitoring Locations in Central and Southern Seattle

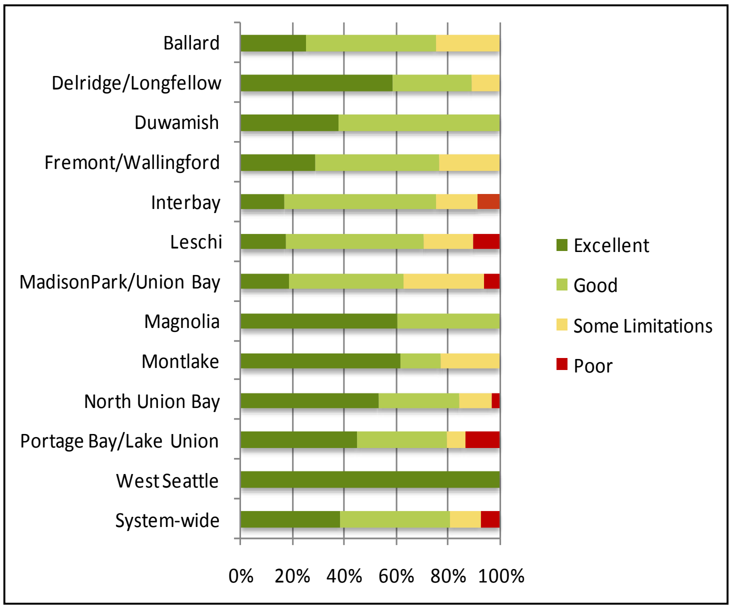

Figure 2-23. Overall Flow Monitoring Data Quality Classifications

2.4.3.2 Rainfall

In addition to flow monitoring, the LTCP Flow Monitoring project included rainfall monitoring. The objectives for the rainfall monitoring component of the project were as follows:

- Capture data before, during, and after a wide range of storm events with a range of antecedent moisture conditions. In terms of recurrence intervals this objective was achieved by meeting both of the following criteria:
  - A minimum of three storm events of recurrence interval between 6 months and 1 year at any duration
  - A minimum of two storm events of recurrence interval between 1 year and 10 years at any duration spaced throughout the wet season.
- Recommend storm events for model calibration and future flow monitoring in the event that the desired storms do not occur during the project monitoring period.

Rainfall data were collected for the LTCP through the City's rain gauge network. Data from 9 of the 17 gauges were applicable to the CSO basins included in the LTCP. Each of these nine gauges was assigned with a CSO basin for review of flow monitoring results. Figure 2-24 presents the Theissen polygons of the City's 17 rain gages.

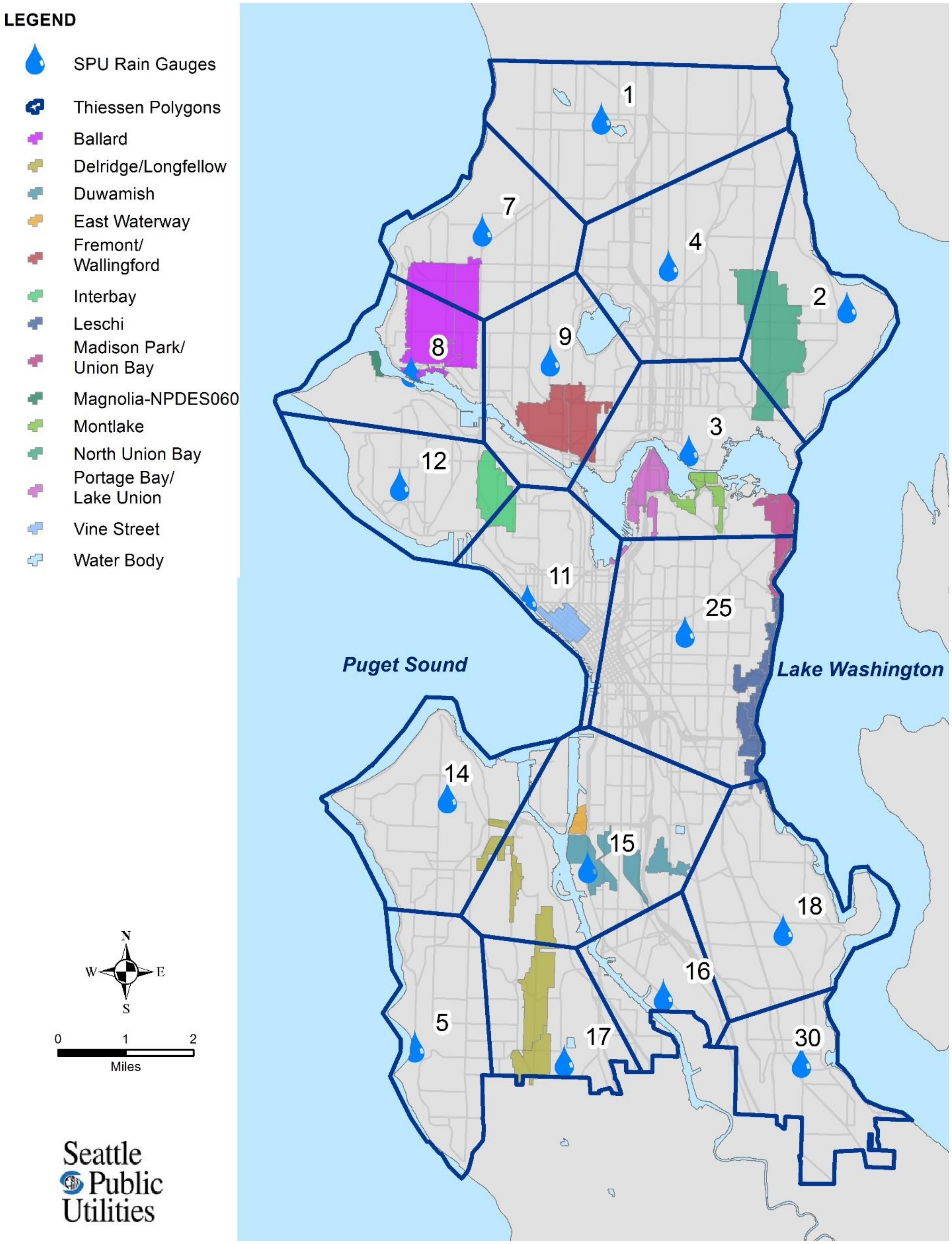

Figure 2-24. Thiessen Polygons for Each of the City's Rain Gauges

2.4.4 Continuing Flow Monitoring Efforts

The City continues to monitor each of its 87 CSO outfalls to detect sewage overflows. The City also tracks the performance of its flow monitors to ensure consistent, high quality measurements. In 2011, the cumulative average "up-time" of each flow monitor was over 99 percent. The City also continues to collect precipitation data from its network of 17 rain gages.

During 2011, the City continued monitoring at a total of 115 sites. During 2012 this number was reduced to 103 sites. Dedicated monitoring program staff frequently review the monitoring results from these locations and evaluate data quality and monitor performance. If emerging problems that might lead to or mask overflows are identified during these reviews (such as data showing slow storage tank drainage or missing data), the issues are rapidly addressed by requesting field service from the monitoring consultant or from the City's Drainage and Wastewater crews. The consultant and City staff also perform on-site troubleshooting. For example, at a couple of monitoring sites, surface water was leaking around and through the maintenance hole lids and compromising the ultrasonic depth monitoring equipment. The solution was to install special sealed lids. These sites have since provided much improved overflow monitoring data.

Each month, the consultant's lead data analyst and senior engineer and the City monitoring staff meet to review and analyze any apparent overflows that occurred the previous month, taking into consideration rainfall, knowledge of site hydraulics, and the best available monitoring data. During these meetings a final determination is made regarding whether or not an overflow occurred and any necessary follow-up actions are documented.

In 2011, all non-pump station monitoring sites were converted to a two-minute recording interval from a five-minute recording interval as they approach overflow conditions. This allows for greater overflow quantity precision, particularly on the rising and falling limb of the overflow event. The City also had 15 temporary backup meters installed at pump station monitoring sites by a second flow monitoring consultant. This has reduced the risk of monitoring outages at these sites and provided a supplemental method of reporting overflows if the primary monitoring system suffers a loss of power or communication.

2.5 Sensitive Area Study

The following subsections present the preliminary sensitive area study based on information available for the 2013 Draft LTCP. This study was subsequently updated with new information in 2014. See Section 5.3.6 for the final results of the sensitive area study. The purpose of the sensitive area study is to prioritize CSO basins based on their environmental impacts to receiving water bodies and impacts to human health. The results of the study will be used to identify basins where CSO reduction projects are expected to provide the highest environmental and human health benefits.

This study was undertaken to satisfy the requirement of the EPA's CSO Control Policy, which states the following principle:

> *EPA expects a permittee's long-term CSO control plan to give the highest priority to controlling overflows to sensitive areas. Sensitive areas, as determined by the NPDES authority in coordination with State and Federal agencies, as appropriate, include designated Outstanding National Resource Water, National Marine Sanctuaries, waters with threatened and endangered species and their habitat, waters with primary contact recreation, public drinking water intakes or their designated protection areas, and shellfish beds.*

2.5.1 Methodology

The Combined Sewer Overflows Guidance for Screening and Ranking Study (Reference 28) follows the guidelines established in the EPA policy documents providing guidance for screening and ranking. The purpose of the EPA screening and ranking document is to:

> *Give communities with multiple CSOs to multiple receiving water bodies a tool for ranking CSOs. Ranking CSOs will give the communities a basis for allocating resources to eliminate or control, in accordance with the CSO Control Policy, CSOs with the most significant impacts and to maximize the environmental benefits achieved for the resources expended.*

CSO basins included in the study were ranked through a seven-criterion process using site-specific information. Each CSO basin received a score for each of the seven criteria. These scores were totalled, and the resulting total scores were used to rank the CSO basins.

Criteria one through six are established by the EPA screening and ranking document, while criterion seven is reserved for site-specific concerns that are not addressed in the other six criteria. For this study, points were scored for criterion seven based on the average annual CSO volume and frequency at the CSO outfall. From 0 to 100 points were scored for the average annual CSO frequency, and 0 to 100 points were scored for the average annual CSO volume. These scores were combined to come up with the total score for criterion seven. The average annual CSO frequencies and volumes are based on 32- or 34-year long-term simulations (LTS) using the LTCP hydraulic model that was developed for the City's wastewater system using EPA SWMM5 Build 5.0.022.

Criteria one through seven are summarized in Table 2-20, Sensitive Area Study Ranking Criteria. Refer to Appendix F for the Long Term Control Plan Sensitive Area Study. Results of the scoring are shown in Figure 2-25 and Figure 2-26.

2.5.2 Ranking Criteria

The ranking criteria used in the sensitive area study are based on the guidance provided in Reference 28, and are presented in Table 2-19.

Table 2-19. Sensitive Area Study Ranking Criteria

Criterion 1
If any CSOs pose a direct risk to public health or contribute to the non-attainment of designated uses on an ongoing basis, or if the potential impacts from CSOs are significant to areas designated under federal or state law as sensitive or protected resources, points are assigned as follows: • Discharges to water experiencing beach closings or where there is a significant risk to public health from direct contact with pollutants in CSOs: Score 250 points • Discharges to Outstanding National Resource Waters, National Marine Sanctuaries, or waters with threatened and endangered species and their habitat; public drinking water intakes or their designated protection areas; or shellfish beds: Score 200 points

Table 2-19. Sensitive Area Study Ranking Criteria

Criterion 2

If dry-weather overflows (DWOs) occur within the CSO basin, score the following points depending on the frequency of the DWOs:

- Chronic DWOs (i.e., they occur on a regular basis and are not caused by an occasional blockage of a regulator by debris): Score 150 points
- Infrequent DWOs caused by infrequent maintenance: Score 75 points

Criterion 3

Depending on the type of water body receiving the CSO, as well as the body's turbulence and mixing characteristics (energy), score points according to the table below:

Water Body Type	Low Energy	Medium Energy	High Energy
Estuarine and Wetland	100	N/A	N/A
Near-Shore Oceanic	60	40	20
Off-Shore Oceanic	30	15	10
Lakes and Ponds	100	N/A	N/A
River	40	20	10
Streams	60	40	20
N/A = Not Applicable			

Criterion 4

If the measured or estimated proportion of the flow rate(s) of all CSO outfalls to the receiving water flow rate (including CSO flow) in streams or rivers is:

- More than 50 percent: Score 50 points
- 25 to 50 percent: Score 30 points
- Less than 25 percent: Score 10 points

Note that since the proportion of CSO flow rate(s) to receiving water flow rate cannot be calculated for lakes and estuaries, they should automatically receive 30 points.

Table 2-19. Sensitive Area Study Ranking Criteria

Criterion 5

If a drinking water intake is within 10 miles (downstream in flowing water systems) of any CSO outfall, score the following points:

- Within 5 miles: Score 100 points
- Between 5 and 10 miles: Score 50 points

Criterion 6

If the composition of wastewater flows prior to any CSO outfall (based on dry-weather flows) includes:

- More than 50 percent industrial and commercial discharges or significant individual sources of potentially toxic materials: Score 50 points
- 30 to 50 percent industrial and commercial discharges or significant individual sources of potentially toxic materials: Score 25 points
- Less than 30 percent industrial and commercial discharges or significant individual sources of potentially toxic materials: Score 0 points

Criterion 7

Criterion 7 is reserved for site-specific concerns that are not addressed in the other six criteria. For this study, points were scored for Criterion 7 based on the average annual CSO volume and frequency at the CSO outfall. Points were scored as shown in the table below.

Average Annual CSO Frequency	Frequency Score	Average Annual CSO Volume (MG)	Overflow Volume Score
>= 20	100	>= 10	100
10 - 19.99	80	5 - 9.99	80
5 - 9.99	60	2 - 4.99	60
2 - 4.99	40	1 - 1.99	40
1.51 - 1.99	20	0.1 - 0.99	20
1 - 1.5	10	< 0.1	10
0 – 0.99	0	0	0

MG = millions of gallons

2.5.3 Ranking of Sensitive Areas

The CSO basins were scored based on the seven criteria and their results were ranked, as shown in Figure 2-25. The basins were divided into two categories:

- LTCP Priority Basins – High Priority: These basins are included in the LTCP and are not eligible for deferral as part of the Integrated Plan Alternative. Eight CSO basins from Ballard, Fremont, Delridge, North Union Bay, and Leschi CSO areas are included in this category.
- Potential Integrated Plan Basins – Lower Priority: These basins are included in the LTCP and are eligible for deferral as part of the Integrated Plan Alternative. Twenty CSO basins from the East Waterway, Duwamish, Leschi, Montlake, Portage Bay, Montlake, Madison Park, Central Waterfront, Magnolia, and Interbay CSO areas are included in this category.

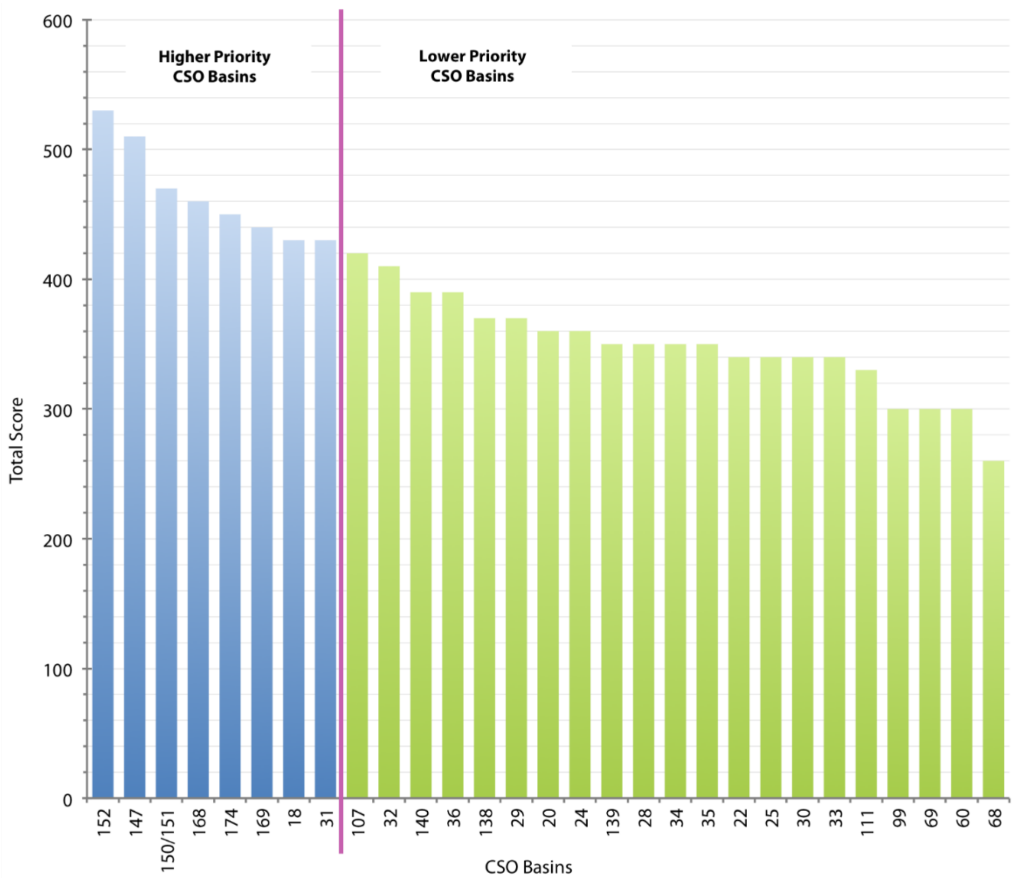

Figure 2-25. Ranking of LTCP CSO Basins Based on Sensitive Area Study

Figure 2-26 shows the locations of the higher and lower priority basins resulting from the Sensitive Area scoring.

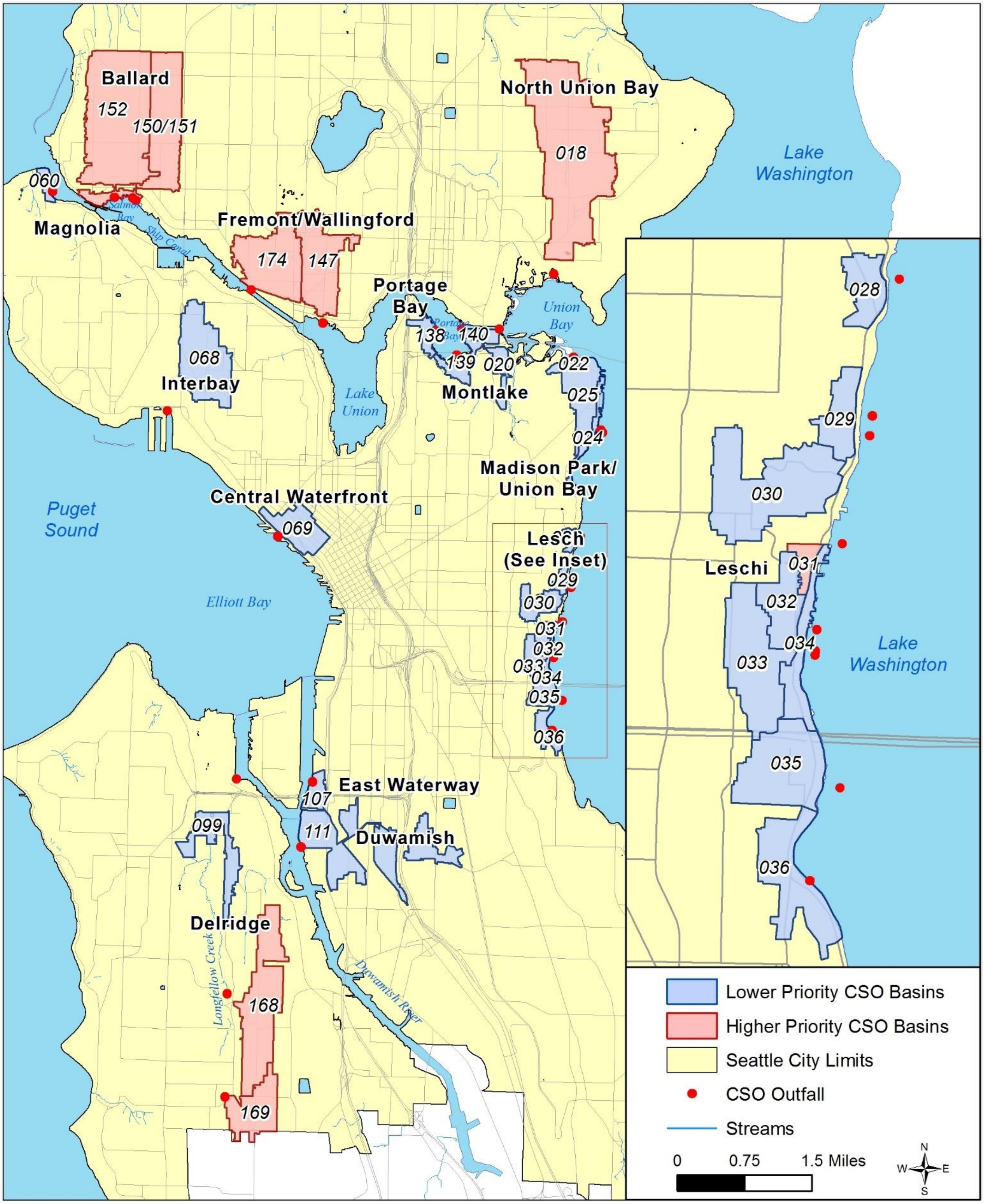

Figure 2-26. Prioritization of LTCP CSO Basins Based on Sensitive Area Study

2.6 Hydraulic Modeling and Baseline Characterization

The EPA's Combined Sewer Overflows Guidance for Long-Term Control Plan document indicates that the primary objective of CSS modeling is "to understand the hydraulic response of the CSS to a variety of precipitation and drainage area inputs." Hydraulic models of 13 CSO areas were developed to assess the performance of the existing wastewater collection system, predict wet-weather flows, estimate the frequency and volume of CSO events, and support the analysis of system modifications and new CSO control facilities that will meet the City's LTCP.

2.6.1 Combined Sewer System Modeling Objectives

The goals of hydraulic modeling were to estimate a baseline CSO frequency and volume and to develop a tool to support the evaluation of CSO control measures. The hydraulic model is also a valuable tool for understanding the sewer system hydraulics, the response of the sewer system to various precipitation events, and the characteristics of CSOs. To achieve these goals, modeling accomplished the following objectives:

- Characterize the hydrology of the LTCP basins
- Characterize the performance of the existing diversion structures, outfall structures, and conveyance pipes
- Represent the performance of City pump stations
- Simulate and evaluate hydraulic grade lines and flow rates throughout the LTCP basins under varying conditions based on historical precipitation and known boundary conditions
- Compute long-term CSO frequencies, volumes, and flow rates

2.6.2 Model Selection

The City chose the EPA's Stormwater Management Model Version 5 (EPA SWMM5) as its standard modeling platform and this software was used in development of the LTCP. The selection process and a description of the software are given below. This software satisfies the requirements of the Consent Decree.

In 2008, the City undertook a process to select a hydraulic modeling platform for use in various modeling projects, including the LTCP. This process included convening a panel of the City, local consultant, and King County staff involved with sewer modeling. The panel developed a list of needed features and attributes of a hydraulic model necessary to complete the most common type of modeling. From this, a list of available modeling software was developed that would satisfy the requirements. The various software products were obtained and tested on a common basin problem. The software products were then ranked by the panel based on performance, satisfaction of requirements, ease of use, special features, and cost. Based on this process, the City selected the EPA SWMM5 as the platform for use in the LTCP.

The project teams also utilized PCSWMM, a modeling interface to EPA SWMM5 with a robust geographic information system (GIS) module developed by Computational Hydraulics Institute to build hydraulic models for each basin. All modeling work was performed using Build 5.0.022 of EPA SWMM5.

2.6.3 Model Description

In general, each hydraulic model contains three essential components:

- the network of sewer infrastructure (pipes, pumps, and structures)
- tributary basins served by the sewer network (the source of flows to the network)
- boundary condition (i.e., flow and water levels that represent the system beyond the model boundaries)

Hydraulic models of the 13 modelled CSO basins contain all of the public pipes and maintenance holes in the system. These models also contain special hydraulic structures including pump stations, weirs, gates, orifices, storage tanks, and HydroBrakes.

Each model was subdivided into discrete subcatchment areas, based on different types of runoff-generating surfaces and land uses. Models generally have separate subcatchment categories for building rooftops, private parcels, and public rights-of-way. The boundary conditions were selected based on local hydraulic conditions and data availability. For some of the CSO areas, temporary flow monitors were installed to compute flow rates and water levels where wastewater exits the model.

SWMM is a dynamic rainfall-runoff simulation model used for single-event or long-term (continuous) simulation of runoff quantity and quality from primarily urban areas. The runoff component of SWMM operates on a collection of subcatchment areas that receive precipitation and generate runoff. The routing portion of SWMM transports this runoff through a system of pipes, channels, storage, pumps, and regulators. SWMM tracks the quantity of runoff generated within each subcatchment, and the flow rate and flow depth in each pipe and channel during a simulation period comprising multiple time steps. The LTCP models used the following methodology for flow generation and flow routing. (More complete descriptions are available in the SWMM5 User's Manual.)

- Flow routing: Dynamic wave routing, which solves the complete one-dimensional Saint Venant equations, is used. This method allows accurate simulation of the hydraulics of any general network including storage, backwater, and pressurized flow, without resort to simplifications.
- Pervious surface infiltration: Infiltration of rainfall on pervious surfaces uses the Green-Ampt method. Infiltration is the source for groundwater inflow.
- Surface runoff: Surface runoff from impervious and pervious surfaces is generated using the standard SWMM5 nonlinear reservoir method.
- Groundwater infiltration to sewer system: Groundwater inflow to the sewer system is generated using the SWMM5 groundwater module. This module balances infiltration from the surface, evapotranspiration, percolation between layers and to deep groundwater, and inflow to the sewers.
- Dry-weather flows: Dry-weather flows from residences and businesses were estimated from flow monitoring and water use records. Diurnal variation in dry-weather flows was developed from flow monitoring records.

2.6.4 Model Calibration and Verification Summary

Calibration is the process of adjusting modeling input parameters so that the model output matches as closely as possible the monitored conditions within the system. Verification involves testing a calibrated model's predictions against field observations that are independent of the data used for calibration.

2.6.4.1 Procedures for Calibration

The LTCP hydraulic models were calibrated using an innovative automated process named Automated Calibration and Uncertainty Analysis for Storm Water Management Model (ACU-SWMM). ACU-SWMM is a software package created by MGS Engineering Consultants, Inc. for use with SWMM5. It was designed primarily for use with CSSs where uncertainties from multiple sources can make model calibration difficult and severely impact the reliability of sewer flow predictions.

ACU-SWMM randomly varies the set of input values between upper and lower boundaries established for each parameter and performs many model simulations (typically 500) using various combinations of the parameter values. For each set of model parameters, a simulation is performed and numerical goodness-of-fit (GOF) measures are computed for sewer flow volume and peak flow rate based on comparison of simulated and recorded sewer flows. Model error is estimated by computation of the standard deviation of sewer flow volume GOF measures for the sewer flow hydrographs recorded at the various metering sites for multiple storm events encompassing both dry- and wet-weather events of varying magnitude.

Modeling parameter sets that produced the best combination of GOF measures were deemed candidate parameter sets. The best-fit model parameter set was selected based on visual comparison of simulated and recorded sewer-flow hydrographs for the candidate parameter sets together with the GOF statistics. In many cases, multiple ACU-SWMM runs were performed to narrow the range of parameters. The best-fit model parameter set was then locked into the SWMM model, and ACU-SWMM was repeated for the next downstream calibration basin. Figure 2-27 shows an example ACU-SWMM calibration plot for the Delridge CSO area.

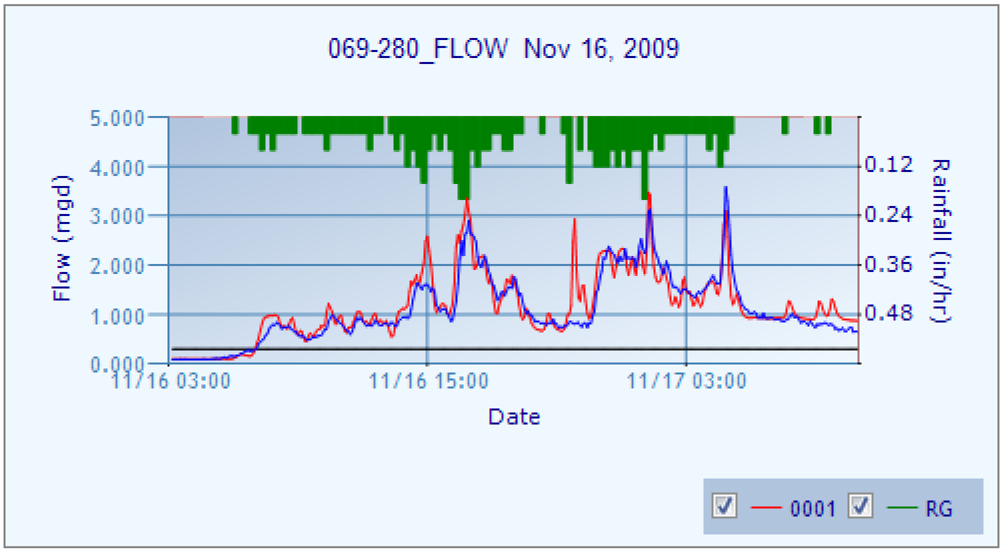

Figure 2-27. ACU-SWMM Calibration Plot for Monitoring Site in CSO Basin 168

After automated calibration was complete, the LTCP hydraulic model outputs were compared to water-level data collected at the permanent CSO monitoring sites. As needed, the hydraulic characteristics of these facilities were refined to achieve a better agreement between simulated and recorded water levels.

2.6.4.2 Model Verification

The automated calibration runs were conducted over a wide range of storm events representing a wide range of system responses. GOF was computed over the full range of these events, typically 6 to 10 events. The performance of the subcatchments was thus verified by arriving at parameter sets that optimized the model response over a wide range of storm conditions.

In addition, LTCP hydraulic model calibrations were verified by comparing the models' predictions of CSO events, depths at overflow structures, and overflow volumes to observed data. This method of verification is powerful, because it tests model capabilities to reproduce the very metrics required to control CSO events (i.e., event frequency and volume).

In this process, the models were shown to provide accurate estimates of CSO frequency, structure depth, and overflow volumes and to represent the observed data.

2.6.5 Model Application for Alternative Analysis

The models were built using the best available infrastructure data and then calibrated to flow monitoring data at more than 120 locations around the City across a diverse range of storm characteristics. The calibration included automated calibration procedures that resulted in robust calibration results that were evaluated by visual inspection and computing and goodness of fit statistics.

The models were verified by comparing simulated and recorded level data collected at the CSO structures and by comparing the simulated and reported frequency and volume of CSO events across a multi-year period. The models reproduced the character of CSO events. This indicates that the models are a suitable tool for the evaluation of LTCP CSO reduction alternatives.

2.6.6 LTCP Hydraulic Model Reports

The 2012 LTCP Hydraulic Model Report (Reference 29) was prepared to meet requirements of the Consent Decree, Appendix C, Item B.2, which establishes requirements for the development and documentation of hydraulic models. The report summarizes the project background, development, and calibration of computer models of the CSS in the 12 uncontrolled CSO areas listed above. These hydraulic models were developed to assess the performance of the existing system, predict wet-weather flows, estimate the frequency and volume of CSO events, and support the analysis of system modifications and new CSO control facilities that will make up the City's LTCP. The reports were submitted to EPA and Ecology for approval in December 2012 and were approved in April 2013.

The 2012 LTCP Hydraulic Model Report consists of the following 13 volumes:

- Volume 1 is this Executive Summary, which provides an overview of the modeling approach and documentation.
- Volumes 2–13 are the basin-specific Hydraulic Model Reports for 12 uncontrolled CSO areas. These volumes are organized to serve two purposes: to be an ongoing technical reference for the City staff and to clearly illustrate that the content of the volumes complies with the requirements of the Consent Decree.

The East Waterway CSO Basin 107, which is located near the Duwamish River, is also an uncontrolled CSO outfall. This small basin is hydraulically connected to King County's Elliott Bay Interceptor downstream of the Duwamish pump station. Overflows at this location are strongly correlated with wastewater levels in King County's Elliott Bay Interceptor. Based on the City King County Interceptor Hydraulic Model completed in 2012 (Reference 30), and flow data provided by King County, the City constructed a hydraulic model for CSO Outfall 107 in 2013; the report is included in Appendix B.

Table 2-20 lists the CSO areas modelled as part of the LTCP.

Table 2-20. Hydraulic Model Reports

	CSO area	CSO outfall numbers
2012 LTCP hydraulic model report volume (December 2012)		
2	Ballard	150/151, 152
3	Delridge/Longfellow	099, 168, 169, 170
4	Duwamish	111

Table 2-20. Hydraulic Model Reports

	CSO area	CSO outfall numbers
2012 LTCP hydraulic model report volume (December 2012)		
5	Fremont/Wallingford	147, 148, 174
6	Interbay	068
7	Leschi	026, 027, 028, 029, 030, 031, 032, 033, 034, 035, 036
8	Madison Park/Union Bay	022, 024, 025
9	Montlake	020, 139, 140
10	North Union Bay	018
11	Portage Bay/Lake Union	130, 132, 135, 138, 175
12	Magnolia	060
13	Central Waterfront	069
LTCP Appendix B – LTCP hydraulic model report		
	East Waterway	107

2.7 CSO Outfall Control Status

2.7.1 Consent Decree

Appendix A of the Consent Decree, List of Existing CSO outfalls, lists the control status of the City's CSO outfalls. Table 2-21 summarizes the Consent Decree appendix control status for the LTCP CSO outfalls (those outfalls to be controlled by an LTCP control measure rather than through other committed projects). This list was based on the 2010 CSO Reduction Plan Amendment and was prepared prior to completion of the LTCP CSO hydraulic models.

Table 2-21. Consent Decree – CSO Outfall Control Status

LTCP CSO outfall number	CSO name	Status
018	38th Ave. NE at NE 41st St.	Uncontrolled
020	Shelby St. at E Park Dr.	Uncontrolled
022	39th Ave NE at NE 41st St.	Controlled
024	43rd Ave. E at E Lee St.	Controlled
025	43rd Ave. E at E Lee St.	Uncontrolled
026	Denny Blaine Pl. E	Controlled
027	Lake Washington Blvd.	Controlled

Table 2-21. Consent Decree – CSO Outfall Control Status

LTCP CSO outfall number	CSO name	Status
028	Lake Washington Blvd. E at E Pike St.	Uncontrolled
029	Lake Washington Blvd. E at E James St.	Uncontrolled
030	Lake Washington Blvd. E at E Alder St.	Controlled
031	Lake Washington Blvd. S at S Main St.	Uncontrolled
032	Lake Washington Blvd. S at S Dearborn St.	Uncontrolled
033	Lake Washington Blvd. S at S Charles St.	Controlled
034	Lake Washington Blvd. S at S Charles St.	Uncontrolled
035	Lake Washington Blvd. S at S Massachusetts St.	Uncontrolled
036	Lake Washington Blvd. S at S College St.	Uncontrolled
060	W Cramer St. at 39th Ave. NW	Uncontrolled
068	W Garfield St. at 17th Ave. W	Uncontrolled
069	Alaskan Way at Vine St.	Uncontrolled
099	SW Hinds St. at Duwamish River West Waterway	Uncontrolled
107	SW Hinds St. at Alaskan Way S	Uncontrolled
111	S Oregon St. at East Duwamish	Uncontrolled
138	E Shelby St., Portage Bay	Uncontrolled
139	16th Ave. E at Louisa St.	Uncontrolled
140	E Shelby St. at W Park Dr.	Uncontrolled
147	Stone Way N at Northlake Way	Uncontrolled
150/151	24th Ave. NW and NW Market St.	Uncontrolled
152	28th Ave. NW and NW Market St.	Uncontrolled
168	Delridge Ave. SW at SW Myrtle St.	Uncontrolled
169	Between 24th and 25th Ave. SW north of SW Thistle St.	Uncontrolled
174	NW 36th Street at 2nd Ave. NW	Uncontrolled

2.7.2 NPDES Permit Annual CSO Report

The City's NPDES Permit (No. WA-003168-2) issued on October 27, 2010, requires that the City issue an Annual Combined Sewer Overflow Report as described under Section S6. Paragraph A. Specifically the Annual Combined Sewer Overflow Report must:

1. Include a summary of the number and volume of untreated discharge events per outfall for that year.
2. Determine and list which of the permitted CSO outfalls can be categorized as meeting the Performance Standard for Controlled CSOs as defined in Condition S8A, based on historical long-term discharge data (up to 20 years – past and present data), modeling, and/or other reasonable methods as approved by Ecology

The 2012 Annual CSO Report submitted on March 31, 2013, was the first to report CSO control status based on the historical long-term discharge data (20 years) using a combination of flow monitoring data and hydraulic modeling as required under the 2010 NPDES Permit. Completion of the LTCP hydraulic models in late 2010 enabled the City to perform long-term modeling using historical rainfall data to supplement the actual flow data to create a 20-year moving average.

The 2013 Annual CSO Report submitted in March 2014 lists four LTCP CSO outfalls included in Appendix A of the Consent Decree as uncontrolled that are now reported to be controlled. These are CSO Outfalls 025, 034, 035 and 068.

2.7.3 Final LTCP CSO Outfall Control Status

Table 2-22 lists the final status for the LTCP CSO outfalls that were evaluated for CSO control measures to bring the system into compliance with the moving 20-year performance criteria and the long-term overflow frequency based on flow data and long-term modeling.

The final number of uncontrolled LTCP CSO outfalls now total 22 after removing CSO Outfalls 025, 034, 035 and 068 as uncontrolled CSO outfalls based on the 2013 Annual CSO Report results. (Outfalls 150/151 and 152 are reported as separate outfalls.)

Table 2-22. LTCP Outfall Control Status

CSO area	CSO outfall	Consent Decree control status note [c]	2013 Annual CSO Report control status note [d]	2013 Annual CSO Report moving 20-year average overflow frequency note [d]	LTCP control status
North Union Bay	018	Uncontrolled	Uncontrolled	4.1	Uncontrolled
Montlake	020	Uncontrolled	Uncontrolled	1.4	Uncontrolled
Madison Park/Union Bay	022	Controlled	Controlled	1.0	Controlled
Madison Park/Union Bay	024	Controlled	Controlled	1.0	Controlled
Madison Park/Union Bay	025	Uncontrolled	Controlled	0.8	Controlled
Leschi	026	Controlled	Controlled	0.2	Controlled
Leschi	027	Controlled	Controlled	0	Controlled

Table 2-22. LTCP Outfall Control Status

CSO area	CSO outfall	Consent Decree control status note [c]	2013 Annual CSO Report control status note [d]	2013 Annual CSO Report moving 20-year average overflow frequency note [d]	LTCP control status
Leschi	028	Uncontrolled	Uncontrolled	2.7	Uncontrolled See Note [a]
Leschi	029	Uncontrolled	Uncontrolled	2.7	Uncontrolled See Note [a]
Leschi	030	Controlled	Controlled	0.9	Controlled See Note [a]
Leschi	031	Uncontrolled	Uncontrolled	13.1	Uncontrolled See Note [a]
Leschi	032	Uncontrolled	Uncontrolled	5.4	Uncontrolled See Note [a]
Leschi	033	Controlled	Controlled	0.3	Controlled See Note [b]
Leschi	034	Uncontrolled	Controlled	1.0	Controlled See Note [b]
Leschi	035	Uncontrolled	Controlled	0.9	Controlled See Note [b]
Leschi	036	Uncontrolled	Uncontrolled	2.1	Uncontrolled See Note [b]
Magnolia	060	Uncontrolled	Uncontrolled	2.7	Uncontrolled
Interbay	068	Uncontrolled	Controlled	0.7	Controlled
Central Waterfront	069	Uncontrolled	Uncontrolled	1.6	Uncontrolled
Delridge	099	Uncontrolled	Uncontrolled	1.6	Uncontrolled
East Waterway	107	Uncontrolled	Uncontrolled	4.9	Uncontrolled
Duwamish	111	Uncontrolled	Uncontrolled	1.8	Uncontrolled
Portage Bay/Lake Union	138	Uncontrolled	Uncontrolled	1.5	Uncontrolled

Table 2-22. LTCP Outfall Control Status

CSO area	CSO outfall	Consent Decree control status note [c]	2013 Annual CSO Report control status note [d]	2013 Annual CSO Report moving 20-year average overflow frequency note [d]	LTCP control status
Montlake	139	Uncontrolled	Uncontrolled	1.2	Uncontrolled
Montlake	140	Uncontrolled	Uncontrolled	3.9	Uncontrolled
Fremont/ Wallingford	147	Uncontrolled	Uncontrolled	38.1	Uncontrolled
Ballard	150/151	Uncontrolled	Uncontrolled	17.1	Uncontrolled
Ballard	152	Uncontrolled	Uncontrolled	45.8	Uncontrolled
Delridge	168	Uncontrolled	Uncontrolled	2.6	Uncontrolled
Delridge	169	Uncontrolled	Uncontrolled	2.5	Uncontrolled
Fremont/ Wallingford	174	Uncontrolled	Uncontrolled	8.7	Uncontrolled

Notes
a LTCP hydraulic modeling indicated that CSO Basins 28, 29, 30, 31, and 32 are all hydraulically "linked" and must be evaluated as a system in the LTCP.
b LTCP hydraulic modeling indicated that 33, 34, 35, and 36 are all hydraulically "linked" and must be evaluated as a system in the LTCP.
c July 3, 2013 Consent Decree, APPENDIX A: List of Existing CSO Outfalls
d 2013 CSO Annual Report Combined Sewer Overflow (CSO) Reduction Program, March 30, 2014, Table 5-8. Outfalls Meeting Performance Standard for Controlled CSOs based on Flow Monitoring Results and Modeling.

Figure 2-28 shows the CSO outfall locations, control status, and the specific CSO program phase for each uncontrolled CSO outfall. The LTCP will address the uncontrolled CSO outfalls shown as LTCP Project on the figure. The other uncontrolled CSO outfalls will be corrected through the 2010 Plan Projects or the Early Action Projects.

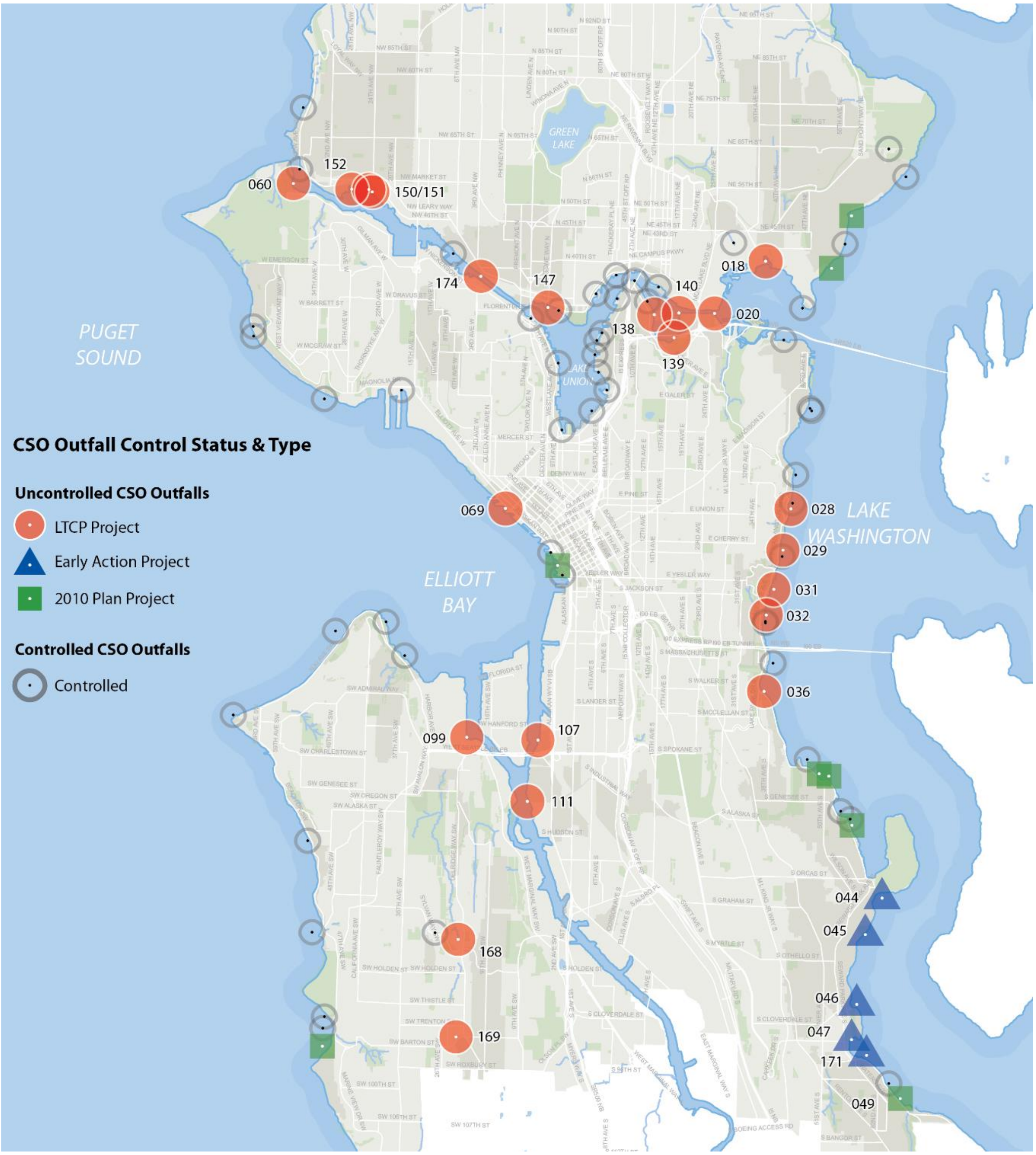

Figure 2-28. Controlled and Uncontrolled CSO Outfalls and CSO Implementation Program Phase

2.8 CSO Control Volumes

For the 22 uncontrolled LTCP CSO outfalls listed in Table 2-23, control volumes (CV) for each outfall were computed using hydraulic models re-calibrated or refined in EPA-SWMM5 Build 5.0.022. A CV is the amount of CSO storage required to limit annual CSO overflows to 1.0 or less events per year on a long-term simulation basis. A detailed description of the computation of CVs, average annual overflow frequency and average annual overflow volumes is included in Appendix G, Long Term Model Simulation Results

For each uncontrolled CSO outfall, hydraulic model long-term simulations were conducted using a 32- or 34-year precipitation time series (1978 through 2009 or 2011). A CSO CV with a once-per-year overflow frequency was determined by choosing the 32nd or 34th largest overflow volume from the time series of computer-simulated overflows. An uncertainty analysis was also performed where 11 separate LTSs were conducted in which the historical precipitation time series was scaled in a manner to reflect the magnitude of uncertainties from several sources. This approach yielded 11 plausible futures with regard to the manner in which uncertainties can affect the magnitude of sewer flows and overflow volumes. These 11 plausible futures allowed determination of the CSO best estimate CV and uncertainty bounds.

The four sources of uncertainty evaluated included:

1. Representativeness of historical precipitation time series: Use of the historical precipitation time series record to model the characteristics of future precipitation produces uncertainties in model-predicted flows for future conditions. Assuming a stationary climate, the longer the historical record is, the more likely it becomes that that record will be representative of future storm characteristics. Assessment of the precipitation record using the results from state-wide and Seattle-specific precipitation-frequency studies results in a standard error of estimation (standard deviation) for precipitation-frequency of 5 percent. Thus, using conventional sampling statistical theory, the range and distribution of future precipitation can be modeled as the historical long-term time series scaled by a precipitation scaling factor with a mean of 1.00 and a standard deviation of 0.05 drawn from a normal distribution.
2. Possible effects of climate change: Scientific consensus is that the climate is not stationary and that climate change is underway. The historical precipitation time series already contains any effects of climate change in the recent past (1978–2011). The primary interest for the future 30-year planning period is what additional changes may occur. A simplified probabilistic model was formulated that considers that precipitation in the future 30-year planning period may range from no change to an increase of 15 percent, with a most-likely value being a 5 percent increase. An empirical likelihood function was developed for use in conducting the uncertainty analysis. The range of effects of climate change are mimicked by scaling the historical precipitation time series by a precipitation scaling factor obtained from Monte Carlo selection from the climate change likelihood function. Including this factor provides an upper bound to CV values. Excluding it provides a lower bound.
3. Model uncertainties: Uncertainties exist in model-predicted flow values because of inaccuracies and uncertainties in the model inputs and imperfections in the structure and governing algorithms used to make predictions. The magnitude of uncertainties in model-predicted sewer flows, described in Section 5 of the LTCP Hydraulic Model Reports, was estimated using global GOF measures computed during the model calibration process. Ideally, uncertainties in prediction of sewer flows for the LTSs would be modeled by adjusting the predicted sewer flows at locations within the SWMM5 model. However, this approach is impractical in the SWMM5 model. Alternatively, precipitation scaling factors were used to re-scale the historical precipitation time series as a surrogate, forcing function to mimic changes in sewer flows. This was a practical approach recognizing the linearity of the response of stormwater runoff from impervious areas to small changes in precipitation.

4. Residual uncertainties: Residual uncertainties account for uncertainties that arise from sources other than the three categories described above. This includes the effect of the number of flow meters, quality of flow data, and representativeness of precipitation used in model calibration. It also includes uncertainties associated with hydraulic components such as HydroBrakes, pump stations, flap gates, overflow weirs, and storage tanks that add to the uncertainty of system performance in the long-term future. The effects of residual uncertainties were mimicked using precipitation scaling factors in the same manner as described above for model uncertainties.

Computer modeling estimated the volume and duration of each overflow event simulated during the 32-year period for each LTS and computed the average annual overflow frequency and overflow volume for each uncontrolled CSO outfall. The collection of overflows was ranked from largest to smallest and the once-per-year CV for each LTS is computed. The CSO best-estimate CV is computed as the mean of the 11 CVs for the 11 LTSs.

The long-term average annual overflow frequency, average annual overflow volume, and CVs for each uncontrolled CSO outfall are shown in Table 2-23. Control volumes were estimated with and without effects of future climate change. Frequency of overflow was computed assuming a minimum 24-hour period between overflows to define the beginning and ending of events. For the LTCP, the CVs including climate change was used for the basis of CSO control measure sizing and evaluation.

Table 2-23. LTCP Hydraulic Modeling Results

CSO area	CSO outfall structure number	Average annual overflow frequency[a]	Average annual overflow volume (MG)[a,c]	Control volume with climate change (MG)[c]	Control volume without climate change (MG)[b,c]
North Union Bay	018A	4.1	0.7	0.26	0.19
North Union Bay	018B	2.4	4.3	1.37	0.98
Montlake	020	1.1	0.64	0.16	0.12
Leschi	026	0.1	<0.01	0	0
Leschi	027	0	0	0	0
Leschi	028	1.2	0.03	< 0.01	< 0.01
Leschi	029	1.6	0.01	0.02	0.01
Leschi	030	0.6	0.06	< 0.01	< 0.01
Leschi	031	16	0.93	0.31	0.25
Leschi	032A	1.7	0.05	0.01	< 0.01
Leschi	032B	6.6	0.22	0.07	0.05
Leschi	033	0.1	<0.01	0	0
Leschi	034	0.9	0.3	0.03	< 0.01
Leschi	035	1.1	0.01	< 0.01	< 0.01
Leschi	036	2.1	0.12	0.03	0.017

Table 2-23. LTCP Hydraulic Modeling Results

CSO area	CSO outfall structure number	Average annual overflow frequency[a]	Average annual overflow volume (MG)[a,c]	Control volume with climate change (MG)[c]	Control volume without climate change (MG)[b,c]
Magnolia	060	3.1	0.26	0.11	0.09
Interbay	068A	0.5	0.18	0.02	< 0.01
Interbay	068B	0.6	0.09	0.01	< 0.01
Central Waterfront	069	1.4	0.54	0.07	0.05
Delridge/Longfellow	099	1.5	0.81	0.17	0.11
East Waterway	107	5.7	1.5	0.50	0.45
Duwamish	111B	1.1	0.2	< 0.01	< 0.01
Duwamish	111C	1.1	0.2	< 0.01	< 0.01
Duwamish	111H	0.7	0.21	0.01	< 0.01
Portage Bay/Lake Union	138	1.7	0.31	0.11	0.07
Montlake	139	1.2	0.04	0.01	< 0.01
Montlake	140	4.4	0.28	0.05	0.02
Fremont/Wallingford	147A	37.5	8.6	2.08	1.90
Fremont/Wallingford	147B	4.4	0.3	0.07	0.06
Ballard	150/151	16	2.9	0.62	0.45
Ballard	152	47.8	23.5	5.38	4.38
Delridge/Longfellow	168	2.3	4.42	2.00	1.45
Delridge/Longfellow	169	1.8	2.81	1.19	0.74
Fremont/Wallingford	174	8.6	3.8	1.06	0.99

Notes:
[a] *From 32 or 34 yr simulation with Rainfall scaling =1.0*
[b] *Estimated control volume after removal of climate change uncertainty but keeping other uncertainties*
[c] *Estimated control volumes less than 5,000 gallons are shown as < 0.01. Control volumes of 0.005 to 0.01 are rounded up to 0.01.*

CHAPTER 3

Development and Evaluation Of Alternatives for CSO Control

3.1 Long-Term Control Plan Approach

The Long Term Control Plan uses a combination of three CSO control strategies to control CSO overflows:

- **"**Fix it First" to make sure that maximum capacity in the existing system is achieved and utilized
- "Keep Stormwater Out" to implement a variety of measures that use soil to absorb stormwater or slow the rate of flow of stormwater into the system
- "Store What's Left" to temporarily hold combined sewage during a storm and gradually release it to a wastewater treatment facility when there is capacity available in the combined sewer system

The City's strategy aligns with EPA's guidance documents that recommend collection system controls (Fix it First), source controls (Keep Stormwater Out), and storage technologies (Store What's Left).

This chapter presents an overview of the LTCP planning approach, including the integration of previous City CSO planning efforts and current CSO capital improvements into the overall LTCP, CSO control measure development and evaluation, shared CSO control measures between the City and King County, and the LTCP options.

Figure 3-1 summarizes the LTCP planning approach used for the Draft LTCP. A brief summary of the approach is presented below:

- The 2010 CSO Reduction Plan Amendment was the basis for the LTCP. Appendix C, Paragraph C.2 of the Consent Decree stated: "*The LTCP shall build upon the alternative analysis work that was performed as part of the development of the City's 2010 CSO Reduction Plan Amendment (2010 Plan)*."
- The 2010 CSO Reduction Plan Amendment recommended CSO control measures for all CSO outfalls considered uncontrolled at that time. The 2010 CSO Reduction Plan Amendment identified two phases of CSO project implementation: 2010-2015 committed projects and future LTCP projects.
- A comprehensive system characterization was performed for the LTCP. LTCP flow monitoring was performed from 2008 through 2012 and SWMM Version 5 combined sewer modelling was performed for the LTCP CSO basins.
- The City's Consent Decree defined a performance criterion based on a "*Twenty Year Moving Average" to determine if a CSO outfall is "controlled". The Consent Decree stated in Section IV, Paragraph 9(ee): "For previously Controlled CSO Outfalls and where monitoring records exist for the past 20 consecutive years, the twenty year moving average shall mean the average number of untreated discharges per CSO Outfall over the 20 year record. On an annual basis, the twenty year moving average will be calculated and includes the current monitored year and each of the previous 19 years of monitored CSO data. For CSO reduction projects and Controlled CSO Outfalls where a complete twenty year record of monitored data does not exist, missing annual CSO frequency data will be generated based on the predicted CSO frequency for a given year as established in the approved engineering report or facility plan*."
- The Consent Decree also identified Early Action CSO Control Programs and Measures in Section V,

Paragraph A for CSO Outfalls 044 and 045 (North Henderson) and CSO Outfalls 46, and 47/171.

- In the 2013 Annual CSO Report, the City determined the control status for all 87 CSO outfalls in accordance with the Twenty Year Moving Average criterion as described in Section 1.5.4.
- The 2013 Annual CSO Report determined that there are 35 uncontrolled City-managed CSO outfalls. CSO control is being provided in three phases as summarized below:
  - **2010 Plan Projects:** Eight outfalls will be controlled through capital projects completed during the years 2010-2018, including CSO reduction projects for Windermere, Genesee, West Seattle, and South Henderson CSO areas. CSO control for the Central Waterfront will be coordinated with the schedule for major changes in that neighborhood. Additional CSO reduction efforts were initiated through the Green Infrastructure (GI) program in Ballard, Magnolia, Montlake, North Union Bay, Fremont/Wallingford, and Delridge CSO areas. In addition, a storage project to control South Henderson CSO Outfall 049 will be completed during the years 2023-2025.
  - **Early Action CSO Programs and Measures**: The Consent Decree requires early action for the two North Henderson (044 and 045) and three South Henderson (046, 047 and 171) uncontrolled CSO outfalls. CSO Outfalls 044 and 045 will achieve controlled status by December 31, 2019, and CSO Outfalls 046, 047, and 171 will achieve controlled status by December 31, 2016.
  - **LTCP:** The remaining 22 uncontrolled CSO outfalls will be controlled through the implementation of the recommended CSO control measures on an implementation schedule to meet the Consent Decree construction completion milestone date of December 31, 2025, and the achievement of control status for each outfall as defined in the Consent Decree.
- The LTCP evaluated potential CSO control measures for the remaining uncontrolled CSO outfalls using the four major EPA categories of CSO control measures: Source Controls, Collection System Controls, Storage Technologies, and Treatment Technologies. Conceptual engineering and evaluation of these CSO control measures and the non-monetary factors screening indicated that storage technologies (tanks or tunnels) were the likely cost effective solution for most of the basins. Several CSO area-specific opportunities for flow diversion and Green Infrastructure were also feasible. The City will continue to implement source control measures (GI) and collection system control measures (retrofits) under the 2010 Plan Projects. The CSO reduction benefits of these control measures will ultimately be reflected in reduced sizes and scopes of constructed LTCP storage facilities.
- The LTCP provides a comprehensive solution for the remaining LTCP uncontrolled CSO outfalls to reduce overflows to one per outfall per year. The individual control measures for each uncontrolled outfall were combined into four aggregate or system-wide options that achieve this objective. For the LTCP, system-wide options were developed under two basic concepts: the City meets their consent decree-mandated control responsibilities through implementation of independent or neighborhood CSO control measures or the City participates in one or more shared projects with King County to take advantage of potential cost and impact reduction opportunities.
- A detailed evaluation was performed to evaluate and compare non-monetary factors against cost to rate and rank the system-wide options for the Draft LTCP. The system-wide options included two City independent (neighborhood) options and three shared City/King County options.

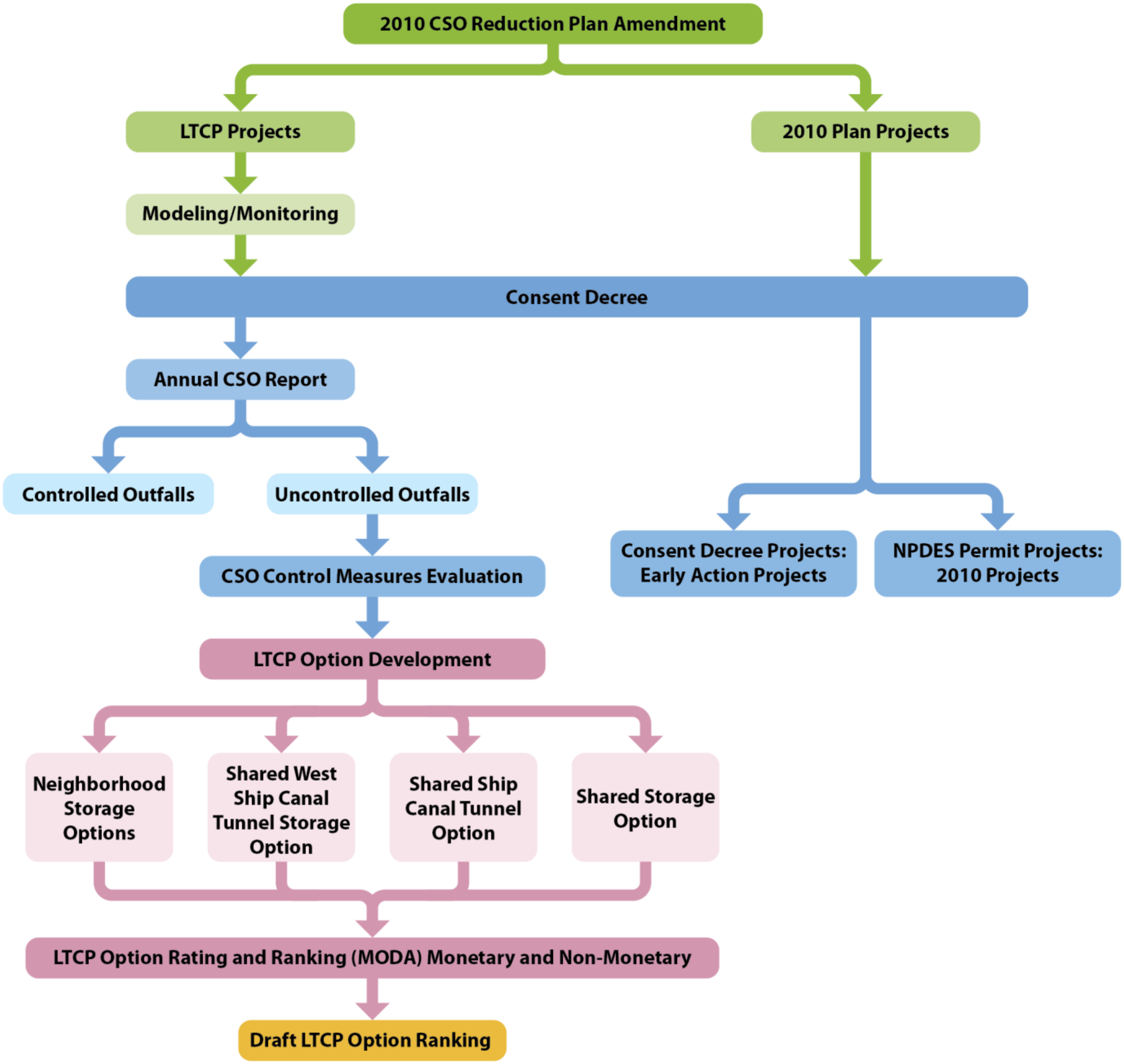

Figure 3-1. LTCP Option Decision Flow Chart

3.1.1 City and King County CSO Project Coordination

The City recognizes the importance of strong coordination with King County in controlling CSOs in the City. All of the proposed LTCP options have elements that may have an impact on King County's downstream wastewater system. Three of the proposed LTCP options include shared City/King County projects along the Ship Canal. Several of the proposed LTCP options include sewer system improvements that will convey additional wastewater volume to the downstream King County system. Regardless of which LTCP option is selected, coordination between the City and King County is critical to successfully designing, constructing, and eventually operating the proposed CSO control projects in the City.

The City and King County are continuing to work together closely to analyze and recommend shared LTCP options that are more cost-effective, produce better environmental outcomes, and minimize disruption to communities than independent LTCP options. King County must also reach its own conclusions about the benefits of a shared project to the regional system and the implications of such a project to its own Long Term Control Plan (Reference 31) and Consent Decree (Reference 32). Selection of a shared City/King County project will depend on the City's and County's analytical results as well as a number of joint factors mutually agreed upon in a City/County coordination plan. These factors include such things as which agency will be responsible for the design, construction, and operation of the shared facility; each agency's project cost-share; operational and implementation roles and responsibilities; the process for dispute resolution; and the ability to fulfil regulatory and contractual obligations. If the City and King County choose to implement a shared City/King County project, then a shared project agreement between the two agencies will be necessary prior to designing and constructing the project. In addition, the City and King County will analyze the impacts of any recommended project on the downstream King County system and agree on an approach to addressing those impacts prior to constructing the project.

3.1.2 Performance Criteria

As described in Ecology regulations and the Consent Decree, CSOs must be limited to an average of one untreated discharge per year per outfall based on a 20-year moving average in order to be considered controlled. Additional details on control criteria are described in Sections 1.5.3 and 1.5.4.

3.1.3 CSO Control Measure Development

The 2010 CSO Reduction Plan amendment specified a series of projects for the most critical CSO overflow areas that were underway in various stages of design or construction. These were described in Table ES-1 of the 2010 Plan as 2010-2015 committed CSO control projects. The table lists the recommended control measure, estimated costs and the projected year of completion.

For those uncontrolled outfalls for which committed projects had not been identified, the 2010 Plan used a series of cost curves and estimated CVs to craft a cost-effective combination of potential control strategy solutions for each CSO control area.

In accordance with the direction of the Consent Decree, the LTCP alternative analysis process begins with the control measures recommended in the 2010 CSO Reduction Plan Amendment.

As a part of the LTCP planning process, the City reviewed and validated the recommendations of the 2010 Plan and simultaneously reconsidered basic CSO controls to develop a comprehensive list of component control measures. This list of existing and new alternatives was then subjected to evaluation incorporating refinements in system characterization, additional demonstration projects under the GI program, retrofit analysis and feasibility, interagency communication, regulatory input, public comment, and other factors to screen and focus on the optimal control measure for each basin and ultimately for the LTCP options.

3.1.4 Shared City and King County CSO Control Measures

Because of the interconnectedness of the City and King County wastewater collection systems, individual CSO control measures adopted by either agency can potentially exacerbate an overflow for the other. CSO control measures for long-term control of the City's CSOs affect, or are affected by, strategies and decisions related to the County's system.

King County began its CSO update planning in 2009. Because the two agencies were preparing similar documents during the same period and the two combined sewer systems were geographically and hydraulically linked, King County approached the City to identify potential collaborative opportunities.

The two agencies evaluated 40 potential shared projects and identified four feasible shared storage projects to evaluate in each agency's respective CSO plan: shared Fremont/Wallingford/3rd Avenue W Regulator storage, shared North Union Bay/University Regulator storage, shared Montlake/Montlake Regulator storage, and a deep tunnel along the Ship Canal.

These shared projects are more fully detailed in Section 3.5.2.

3.1.5 CSO Control Measure Evaluation Process

The feasibility of specific CSO control strategies within a specific basin varies depending on basin characteristics. The 2010 CSO Reduction Plan Amendment performed the initial development and screening of CSO control concepts for each of the uncontrolled CSO areas. As additional analysis and system characterization proceeded, new strategies were considered and analyzed. In some cases, executive decisions resulted in elimination of alternatives. Other measures were eliminated on the basis of site-specific issues (soil contamination), significant cost, or other factors. An intermediate screening process described in subsequent parts of this document was also used.

The goal of the screening and evaluation process was to reduce the list of potential control measures for each CSO area to the best solution so that system-wide combinations of control measures could be assessed in a more detailed triple bottom line evaluation process. A triple bottom line evaluation is used to consider the cost, environmental, and social impacts of various alternatives.

The technique used for this final analysis process is called multiple objective decision analysis (MODA). This technique incorporates a mechanism for considering non-monetary social and environmental issues as well as cost to create a structured comparison of competing solutions.

For additional detail, see Section 4.1.1 Evaluation of LTCP Alternative Options.

3.2 2010 CSO Reduction Plan Amendment Projects

3.2.1 Preliminary Recommended CSO Control Projects

Figure 2-28 is a map of the City's uncontrolled basins. The recommended control measures include 2010 Plan committed projects, Early Action projects, and LTCP Projects.

3.2.2 2010 Plan Committed Projects

Table 3-1 lists the 2010 committed projects and their current status including the continued existence of the project as a viable control measure.

Table 3-1. 2010 Plan CSO Reduction/Control Projects	
Applicable CSO basins	**Implementation status as of March 2015**
Windermere	
013: Off-line storage 015: Retrofit	CSO Basin 013 construction began in October 2012 and construction completion is planned for 2015. CSO Basin 015 achieved construction completion in August 2012. Post project performance monitoring started Sept 2012 and continued until 2014.
Genesee	
040: Off-line storage 041: Off-line storage 043: Off-line storage 040, 041 and 043: GI	CSO Basins 040 and 041 storage has been combined into a single off-line storage project. CSO Basin 043 will be a separate off-line storage project. Both projects began construction in April 2013 and construction completion is planned for 2015 completion. Residential RainWise program is offered in these basins.
South Henderson	
049: Off-line storage	CSO Basin 049 is a storage project that will be constructed between by December 31, 2025.
Ballard	
150/151 and 152: GI	CSO Basin 152 pilot project constructed in 2011-12 and post-construction monitoring was performed in 2012-13. Additional GI right-of-way projects will start construction 2015. RainWise is offered in this basin.
Magnolia	
060: GI	Residential RainWise program is offered in CSO Basin 060. No other 2010 Plan projects are planned.
North Union Bay	
018: GI	Residential RainWise program is offered in this basin.
Interbay	
068: GI	This basin is now controlled based on the 2013 Annual CSO Report.
Montlake	
140: GI	Residential RainWise program is offered in this basin.
Fremont/Wallingford	
147 & 174: GI	Residential RainWise program is offered in this basin.

Table 3-1. 2010 Plan CSO Reduction/Control Projects	
Applicable CSO basins	**Implementation status as of March 2015**
Central Waterfront	
069: Off-line storage	Since the northern portion of the Elliott Bay Seawall project (which includes CSO Basin 069) will not be constructed until after 2020, it was determined that CSO Basin 069 should be an LTCP project.
070 & 071:Off-line storage	During the SDOT's EBS and CWF Project design phases, it was determined that CSO Basins 070 and 071 should be coordinated and constructed with the first phase of the EBS construction as a 2010 Plan project. The anticipated completion date is 2018-2020.
West Seattle	
095: Retrofit	Basin 095 construction completed June 2013. Post project performance monitoring started July 2013 and continued for two years.
Delridge	
168: Retrofit 169: Retrofit	Bid in 2014. Construction completion is planned in 2015. Post project performance monitoring will start following construction and continue for 2 years. RainWise program is offered in these basins. GI roadside right-of-way project will start construction in 2015.

3.2.3 Early Action Projects

The 2010 Plan identified CSO projects for the Windermere, Genesee, Henderson, Ballard, North Union Bay, Interbay, Montlake, Fremont-Wallingford, Central Waterfront, West Seattle and Delridge CSO areas. The July 2013 Consent Decree defined the Henderson CSO projects as "Early Action" including North Henderson and South Henderson projects with specific consent decree milestone completion dates. Consequently, the North and South Henderson projects are no longer part of the 2010-2015 phase and are considered Early Action Projects. Their project status is shown on Table 3-2.

Table 3-2. Early Action Projects	
Applicable CSO basins	**Implementation status as of May 2014**
North Henderson	
044: Off-line storage 045: Off-line storage	CSO Basins 044 and 045 have been combined into a single off-line storage project. The project submitted 90% plans and specifications to EPA and Ecology in 2014. Planned completion date is December 31, 2018.
South Henderson	
046: Off-line storage 047/171: Off-line storage	CSO Basin 046 is a flow diversion project and submitted 90% plans and specifications to EPA and Ecology in December 2013. CSO Basin 047/171 is a storage project and started construction in late 2013.

3.2.4 2010 Plan Recommendations for LTCP CSO Reduction/Control Projects

For those uncontrolled outfalls for which committed projects had not been identified, the 2010 Plan used a series of cost curves and estimated CVs to craft a cost-effective combination of potential control strategy solutions for each CSO control area. The 2010 Plan recommendations for projects to be considered during preparation of the LTCP is shown in Table 3-3 along with pertinent comments regarding their continuing applicability. Additional clarification of the comments is included in subsequent portions of this document.

Table 3-3. 2010 Plan Preliminary LTCP CSO Reduction/Control Projects

2010 CSO Reduction Plan		LTCP CSO control measure evaluation	
CSO basin	**Proposed LTCP CSO control measure**	**Potential LTCP CSO control measure**	**Comments**
Ballard			
150/151	In-line storage	Yes	The 2013 Annual CSO Report determined that this CSO outfall is uncontrolled based on a moving 20-year average frequency. An LTCP project will be required.
152	Infiltration and inflow removal (I/I)	No	I/I analysis evaluation (See Appendix H) following issuance of the 2010 Plan Amendment indicated that I/I reduction is not a cost-effective solution compared to storage and thus will no longer be considered as a CSO control measure for this NPDES basin.
	Off-line storage	Yes	
Magnolia			
060	In-line storage	Yes	
North Union Bay			
018	In-line storage	No	Retrofit program design work indicated that a sewer system improvement CSO control measure (i.e., retrofit) will control CSO Basin 18 and is more cost-effective than in-line storage.
Interbay			
068	In-line storage	No	The 2013 Annual CSO Report determined that this CSO outfall is in control based on a moving 20-year average frequency. No LTCP project will be required.
Central Waterfront			
069	Off-line storage (2010 CSO Plan Amendment considered this CSO basin as a 2010-2015 committed project)	Yes	Since the northern portion of the Elliott Bay Seawall project (which includes CSO Basin 069) will not be constructed until after 2020, it was determined that CSO Basin 69 should be an LTCP project.

Table 3-3. 2010 Plan Preliminary LTCP CSO Reduction/Control Projects

2010 CSO Reduction Plan		LTCP CSO control measure evaluation	
CSO basin	**Proposed LTCP CSO control measure**	**Potential LTCP CSO control measure**	**Comments**
Fremont/Wallingford			
147	Off-line storage	Yes	The 2013 Annual CSO Report determined that this CSO outfall is uncontrolled based on a moving 20-year average frequency. An LTCP storage project will be required.
174	Off-line storage	Yes	The 2013 Annual CSO Report determined that this CSO outfall is uncontrolled based on a moving 20-year average frequency. An LTCP storage project will be required.
Duwamish			
111	Off-line storage	Yes	The 2013 Annual CSO Report determined that this CSO basin is uncontrolled based on a moving 20-year average frequency. An LTCP project will be required.
Delridge			
099	2010 CSO Plan Amendment considered this CSO basin as controlled.	Yes	The 2013 Annual CSO Report determined that this CSO basin is uncontrolled based on a moving 20-year average frequency. An LTCP project will be required.
168	Retrofit	Yes	Sewer system improvements are being constructed in 2015 that may control this outfall. A LTCP project will be constructed if the sewer system improvement cannot achieve full control of CSO Basin 168.
169	Retrofit	Yes	Sewer system improvements are being constructed in 2015 that may control this outfall. A LTCP project will be constructed if the sewer system improvement cannot achieve full control of CSO Basin 169.
Montlake			
020	Roof drain disconnects	No	The Consent Decree requires that the City identify measures to control all uncontrolled outfalls. The City must document the performance of GI in targeted CSO basins before EPA and Ecology will allow the City to reduce the size of any “grey” control measures. If the effectiveness is proven and approved, the City may implement smaller “grey” control measures and take credit for flow reductions associated with GI.

Table 3-3. 2010 Plan Preliminary LTCP CSO Reduction/Control Projects

2010 CSO Reduction Plan		LTCP CSO control measure evaluation	
CSO basin	**Proposed LTCP CSO control measure**	**Potential LTCP CSO control measure**	**Comments**
	Roadside fain gardens	No	The Consent Decree requires that the City identify measures to control all uncontrolled outfalls. The City must document the performance of GI in targeted CSO basins before EPA and Ecology will allow the City to reduce the size of any “grey” control measures. If the effectiveness is proven and approved, the City may implement smaller “grey” control measures and take credit for flow reductions associated with GI.
	I/I	No	I/I analysis evaluation following issuance of the 2010 Plan Amendment indicated that I/I reduction is not a cost-effective solution compared to storage and thus will no longer be considered as a CSO control measure for this NDPES basin.
	Off-line storage (not considered cost-effective in 2010 Plan Amendment)	Yes	The 2013 Annual CSO Report determined that this CSO basin is uncontrolled based on a moving 20-year average frequency. An LTCP project will be required.
139	2010 CSO Plan Amendment considered this CSO basin as controlled.	Yes	The 2013 Annual CSO Report determined that this CSO basin is uncontrolled based on a moving 20-year average frequency. An LTCP project will be required.
140	2010 CSO Plan Amendment considered this CSO basin as controlled.	Yes	The 2013 Annual CSO Report determined that this CSO basin is uncontrolled based on a moving 20-year average frequency. An LTCP project will be required.
Leschi			
028	Cisterns	No	RainWise program will be offered in this CSO basin. The Consent Decree requires that the City identify measures to control all uncontrolled outfalls. The City must document the performance of GI in targeted CSO basins before EPA and Ecology will allow the City to reduce the size of any “grey” control measures. If the effectiveness is proven and approved, the City may implement smaller “Grey” control measures and take credit for flow reductions associated with GI.
	In-line storage	Yes	
029	In-line storage	Yes	
030	Roof drain disconnects	No	The 2013 Annual CSO Report determined that this CSO basin is in control based on a moving 20-year average frequency. No LTCP project will be required.

Table 3-3. 2010 Plan Preliminary LTCP CSO Reduction/Control Projects

2010 CSO Reduction Plan		LTCP CSO control measure evaluation	
CSO basin	**Proposed LTCP CSO control measure**	**Potential LTCP CSO control measure**	**Comments**
	Roadside rain gardens	No	The 2013 Annual CSO Report determined that this CSO basin is in control based on a moving 20-year average frequency. No LTCP project will be required.
	I/I	No	The 2013 Annual CSO Report determined that this CSO basin is in control based on a moving 20-year average frequency. No LTCP project will be required.
031	Off-line storage	Yes	The 2013 Annual CSO Report determined that this CSO basin is uncontrolled based on a moving 20-year average frequency. An LTCP project will be required.
032	Off-line storage	Yes	The 2013 Annual CSO Report determined that this CSO basin is uncontrolled based on a moving 20-year average frequency. An LTCP project will be required.
034	Roof drain disconnects	No	The 2013 Annual CSO Report determined that this CSO basin is in control based on a moving 20-year average frequency. No LTCP project will be required.
	I/I reduction	No	The 2013 Annual CSO Report determined that this CSO basin is in control based on a moving 20-year average frequency. No LTCP project will be required.
035	Roof drain disconnects	No	The 2013 Annual CSO Report determined that this CSO basin is in control based on a moving 20-year average frequency. No LTCP project will be required.
036	In-line storage	Yes	The 2013 Annual CSO Report determined that this CSO basin is uncontrolled based on a moving 20-year average frequency. An LTCP project will be required.
Madison Park			
024	2010 CSO Plan Amendment considered this CSO basin as controlled.	No	The 2013 Annual CSO Report determined that this CSO basin is in control based on a moving 20-year average frequency. No LTCP project will be required.
025	Off-line storage	No	The 2013 Annual CSO Report determined that this CSO basin is in control based on a moving 20-year average frequency. No LTCP project will be required.
East Waterway			
107	Off-line storage	Yes	The 2013 Annual CSO Report determined that this CSO basin is uncontrolled based on a moving 20-year average frequency. An LTCP project will be required.
Portage Bay			

Table 3-3. 2010 Plan Preliminary LTCP CSO Reduction/Control Projects

2010 CSO Reduction Plan		LTCP CSO control measure evaluation	
CSO basin	**Proposed LTCP CSO control measure**	**Potential LTCP CSO control measure**	**Comments**
138	In-line storage	Yes	The 2013 Annual CSO Report determined that this CSO basin is uncontrolled based on a moving 20-year average frequency. An LTCP project will be required.

3.3 Available CSO Control Measures

EPA guidance documents list four major categories of CSO control measures that are can be used to bring combined systems into compliance. These categories were used to evaluate specific control measures for each LTCP CSO area.

3.3.1 Collection System Controls

Collection system controls focus on maximizing storage and conveyance within the existing CSS to reduce overflows. Examples include retrofits, sewer separation, weir adjustment, I/I, and flow diversion.

3.3.2 Source Controls

Source controls are aimed at reducing the total flow reaching the combined system. Examples include downspout separation and GI. These control techniques are the equivalent of "Keep Stormwater Out". GI is a source control strategy that retards or retains stormwater flows for infiltration or subsequent treatment and thereby reduces CSOs.

GI feasibility analysis considers two factors that result in its estimated effectiveness. The first factor is the technical suitability of the combined sewer area (soils, topography, land use, density of development, etc.). The second factor is the anticipated level of public participation in the necessary GI projects. These two factors combine to produce a wide variety of potential GI effectiveness levels.

Potential GI applicability and feasibility for long-term CSO control is reported on in a report, Green Infrastructure Analysis for CSO Control, in Appendix I.

In all cases, some implementation of GI will provide a reduction in overflow volume.

There are two aspects to the City's GI program:

- RainWise is a City program pays property owners to mitigate the impacts of impervious roof surfaces by installing properly sized and constructed rain gardens or cisterns. The amount of the payment is based on the amount of roof area controlled.
- Roadside rain gardens are bioretention facilities constructed in public right-of-way.

The City is implementing a GI capital program in selected basins. Evaluations of the quantity of CSO reduction will be documented in an engineering report, and will be taken into account during the design phase of LTCP projects located in basins where GI is implemented. GI is a lead strategy in attaining control of CSOs. While it may not be technically suitable in some areas and may not have the capacity to be the sole CSO control technique, it is consistent with the concept of sustainability and is supported by a broad public constituency.

GI control measures are not being considered for the LTCP as a specific control measure because the Consent Decree requires a “grey” CSO control measure to be proposed for each uncontrolled outfall.

3.3.3 Storage Technologies

Storage solutions temporarily store enough CSO volume to prevent overflow from an overtaxed conveyance system. Examples of storage solutions include below-grade tanks, in-line or off-line enlarged pipes in the right-of-way, and deep tunnels. The City is currently constructing storage tanks for the Windermere and Genesee CSO projects and they will be operational in late 2015.

3.3.4 Treatment Technologies

Treatment technologies target specific removal or mitigation of pollutants at each outfall. Such technologies typically require construction of treatment and solids disposal facilities and their supporting structural, mechanical, electrical, and instrumentation systems.

3.3.5 Control Measure Application

Using a combination of the 2010 CSO Reduction Plan and EPA guidance documents, 75 independent and 40 shared control measures were identified and evaluated.

The evaluation made use of an intensive flow monitoring and modeling effort conducted by the City as a part of system characterization requirements.

During the evaluation period, the City’s ongoing retrofit efforts identified a number of potential system modifications and the City embarked on a program of modeling and analysis to define cost-effective CSO reduction opportunities.

Discussions with regulatory officials during the period also provided criteria for acceptable alternative control measures.

3.4 Screening of CSO Control Measures

3.4.1 2010 CSO Reduction Plan Recommended Projects

The 2010 CSO Reduction Plan represented the first screening of possible alternatives. The Consent Decree directs that the list of potential solutions described in the plan be the starting point for further alternative analysis. The feasibility of those measures is presented in Table 3-4.

An important result of the Consent Decree direction is the acknowledgement that the 2010 Plan evaluation of two potential control measures – sewer separation and point of discharge treatment – is sufficient to eliminate them from further consideration in the LTCP.

Table 3-4. CSO Control Measures to be Evaluated in the LTCP			
2010 CSO Reduction Plan		**LTCP**	
2010 Proposed control measures	**CSO outfall**	**Feasibility for LTCP after evaluation**	**LTCP CSO outfalls**
Roadside rain gardens	150/151, 152, 060,020,140, 030	The Consent Decree requires that the City identify measures to control all uncontrolled outfalls. The City must document the performance of GI in targeted CSO basins before EPA and Ecology will allow the City to reduce the size of any "grey" control measures. If the effectiveness is proven and approved, the City may implement smaller "grey" control measures and take credit for flow reductions associated with GI.	150/151, 152, 099, 168, 169, 018, 020, 139, 140, 147,138
(RainWise) Residential rain gardens	060, 018, 068, 020, 140, 147, 174		099, 168, 169, 111, 028, 029, 031, 032, 036, 018, 020, 139, 140, 147, 174, 138
Cisterns	152, 140, 030		(see RainWise)
Permeable pavements	152, 140		
Bioretention swale	140		
I/I	152, 020, 034	Due to a lack of cost-effectiveness, will not be considered for any CSO basin	
Regulating devices and backwater gates or hydraulically operated sluice gates	168 & 169	Retrofit CSO control measures will provide partial control of these NDPES basins.	018, 111, 168, 169
Flow diversion	None	Although not considered in 2010 Plan, may be feasible for CSO Basin107 because of close proximity to King County treatment plant	060, 018, 028, 029, 031, 032, 036, 020, 139, 140, 107, 111, 099
In-line storage	049, 150/151, 060, 018, 028, 029, 036, 138,	Control volumes, hydraulic operations, and site-specific nature of this control measure make this CSO control measure inapplicable in any basin,	

Table 3-4. CSO Control Measures to be Evaluated in the LTCP

2010 CSO Reduction Plan		LTCP	
2010 Proposed control measures	**CSO outfall**	**Feasibility for LTCP after evaluation**	**LTCP CSO outfalls**
Off-line storage	152, 069, 147, 174, 111, 107, 031, 030, 032, 034, 035, 036, 025, 024, 138, 168, 169,	Will continue to be considered because of cost-effectiveness.	049, 060, 150/151, 152, 147, 174, 020, 139, 140, 138, 028, 029, 031, 032, 036, 069, 107, 111, 099, 168, 169
Storage in the right of way	None	Because of potential shared King County/City project opportunities, the LTCP will evaluate the cost-effectiveness of storage in the right of way.	150/151, 152, 147, 174, 018, 020, 139, 140, 138, 028, 029, 031, 032, 036
Treatment	None	2012 King County CSO Plan evaluated CSO treatment opportunities and determined that the King County Hanford, Lander, Kingdome, King St. (HLKK) CSO plant is the most cost effective shared treatment opportunity.	069, 107

3.4.2 Impact of Revised Performance Criteria (20 Year Moving Average)

Analysis of the controlled/uncontrolled status of each outfall has historically been based on a 5-year moving average of overflows until 2010. The Consent Decree revises the analysis period to a 20-year moving average using a combination of actual measured flows and modeled performance to establish that an outfall meets the control criteria. As shown in Table 2-21, LTCP Outfall Control Status, analysis of flow monitoring data and updated modeling under this new performance standard resulted in the shift of two CSO areas (Interbay and Madison Park) from uncontrolled to controlled status.

3.4.3 Impact of Hydraulic Model Results

The City has concurrently (with the LTCP) pursued an extensive program of flow monitoring and hydrologic and hydraulic model development in order to characterize the CSS response to anticipated rainfall conditions. The results of this modeling effort have been applied as they became available and incorporated into the ongoing control measure evaluation process. The net effect of updated model predictions has been refinement of CVs (both increases and decreases) and the adjustment of alternative details and costs.

3.4.4 Impact of Retrofit Program

The concurrent Retrofit Program has examined a prioritized list of the uncontrolled CSO areas in search of cost-effective, low-impact collection system modifications. As the results of the retrofit analysis of CSO areas have become known, they have been incorporated into the alternative evaluation process. In some cases, potential retrofits have significantly reduced or eliminated the need for competing storage measures. It is anticipated that as retrofit opportunities are identified and successfully implemented in succeeding program years, they will be incorporated into the detailed planning and design of storage facilities to reduce the size and scope of those facilities.

Implementation of any retrofit project will require City coordination with King County. Specifically, the City and King County will need to analyze the impacts of the proposed project on the downstream system and agree on an approach to address those impacts.

3.4.5 Impact of Green Infrastructure

The City has a robust GI program. The 2010 Plan Amendment evaluated and recommended a number of GI techniques in several CSO areas. Further GI evaluation has refined the GI strategies within Seattle's CSO basins. Due to the nature of the City's CSO basins, which are primarily composed of drainage areas that have already undergone stormwater separation, significant GI opportunities do not exist in all CSO basins. Where appropriate, the City's concurrent GI programs applied in rights-of-way and private parcels, as well as companion stormwater code requirements to implement GI to the maximum extent feasible, will continue to be pursued. It is anticipated that the results of the GI engineering reports and analysis in several CSO basins will be incorporated into the detailed planning and design of storage facilities to reduce the size and scope of those facilities.

A GI feasibility evaluation is included as Appendix I to this document. The potential effectiveness of GI control measures (RainWise and roadside rain gardens) consider both the technical suitability of the area being evaluated as well as the range of public participation levels anticipated. Table 3-5 presents a summary of the feasibility evaluation.

3.4.6 Impact of Shared Project Negotiations

The 2010 Plan Amendment did not address the possibility of pursuing shared projects with King County. Collaboration between the City and King County staff have identified and evaluated several tank and tunnel projects. Prior to implementing any shared projects with King County and the City, a joint project agreement will need to be executed between the two agencies.

Table 3-5. Green Infrastructure Potential Effectiveness

CSO area	Basin	V22 CV	Practical participation		Maximum participation	
			CV reduction through GI	Percent of total	CV reduction through GI	Percent of total
Duwamish	111H	0.01	0.016	100.0%	n/a	
Leschi	028	0.01	0.002	20.0%	0.015	100.0%
Leschi	029	0.02	0.001	5.0%	0.008	40.0%
Leschi	031	0.31	0.0004	0.1%	0.003	1.0%
Leschi	032	0.08	0.001	1.3%	0.01	12.5%
Leschi	036	0.03	0.001	3.3%	0.011	36.7%

Table 3-5. Green Infrastructure Potential Effectiveness

CSO area	Basin	V22 CV	Practical participation		Maximum participation	
			CV reduction through GI	Percent of total	CV reduction through GI	Percent of total
North Union Bay	018	1.63	0.45	27.6%	0.79	48.5%
Montlake	020	0.16	0.021	13.1%	0.066	41.3%
Montlake	139	0.01	0.006	60.0%	0.025	100.0%
Montlake	140	0.05	0.019	38.0%	0.026	52.0%
Ballard	150/151	0.62	0.172	27.7%	0.273	44.0%
Ballard	152	5.38	1.07	19.9%	1.718	31.9%
Fremont/Wallingford	147	2.15	0.02	0.9%	0.484	22.5%
Fremont/Wallingford	174	1.06	0.054	5.1%	0.122	11.5%
Portage Bay	138	0.11	0.007	6.4%	0.011	10.0%
Delridge	099	0.17	0.017	10.0%	0.043	25.3%
Delridge	168	2.00	0.162	8.1%	0.266	13.3%
Delridge	169	1.19	0.152	12.8%	0.192	16.1%

3.4.7 Impact of the City's Infiltration and Inflow Removal Evaluation Report

The 2010 Plan Amendment proposed I/I projects in several CSO areas as a component solution. The City staff performed a detailed analysis of the feasibility of I/I in those CSO areas. In general, the report indicated that I/I is not a cost-effective method of achieving CSO reduction compliance and this control strategy has been eliminated from further consideration.

3.4.8 CSO Control Measures to be Considered for LTCP

Ongoing refinement, evaluation, and interim screening of the range of feasible control measures and the application of external factors and requirements described above resulted in a trend toward the use of storage technologies (tanks or tunnels) as the likely solution for most of the basins. Several CSO area-specific opportunities for flow diversion were also feasible and remain under consideration. Source control measures (GI) and collection system control measures (retrofits) will continue to be implemented because of their potential to reduce overflows at a lower cost per gallon than storage facilities. The positive effects of these control measures will ultimately be reflected in reduced sizes and scopes of constructed storage facilities.

3.5 Control Measure Definition and Application

The following subsections present the various control measures developed for this LTCP. Implementation of any neighborhood and shared project will require City coordination with King County. Specifically, the City and King

County will need to analyze the impacts of the proposed project on the downstream system and agree on an approach to address those impacts. Prior to implementing any shared project with King County and the City, a joint project agreement will need to be executed between the two agencies.

3.5.1 Control Measures for Specific CSO Areas

3.5.1.1 Ballard CSO Area

The Ballard CSO area is the largest of the City's CSO contributing area and includes 1,170 acres (1.8 square miles) in northwest Seattle; The Ballard CSO area includes CSO Basins 150/151 and 152. CSO Basin 150/151 has a single overflow point, but the outfall divides into two branches, each with its own CSO outfall designation. The wastewater generated in these basins flows by gravity to King County's Ballard siphon for conveyance to the West Point WWTP. Figure 3-2 shows the Ballard CSO area boundaries, CSO outfall locations, and general area for potential CSO control measure implementation.

3.5.1.1.1 CSO Control Volumes

Section 2.8 described the LTCP hydraulic modelling performed to determine the CVs for each uncontrolled CSO outfall. Table 3-6 lists the Ballard CSO outfalls' long-term average annual overflow frequency, average annual overflow volume, and CV. Control volumes were estimated for possible effects with and without future climate change. For the LTCP, the Ballard CSO outfall CV including climate change were used as the basis for CSO control measure sizing and evaluation.

Figure 3-2. Ballard CSO Area Boundaries, CSO Outfall Locations, and General Area for Potential CSO Control Measure Implementation

Table 3-6. Ballard CSO Outfall Control Volumes

CSO Outfall	Average annual overflow frequency[a]	Average annual overflow volume (MG)[b,c]	Control volume with climate change (MG)[d]	Control volume without climate Change (MG)[c, d]
150/151	17.1	2.67	0.62	0.45
152	45.8	21.38	5.38	4.38

[a] *2013 Annual CSO Report, Table 5-8. Outfalls Meeting Performance Standard for Controlled CSOs based on Flow Monitoring Results and Modeling*
[b] *From 20-year (1993-2012) long-term simulations with Rainfall scaling =1.0*
[c] *Estimated overflow volume after removal of climate change uncertainty but keeping other uncertainties*
[d] *Estimated control volumes less than 5,000 gallons are shown as < 0.01. Control volumes of 0.005 to 0.01 are rounded up to 0.01.*

3.5.1.1.2 CSO Control Measure Evaluation

Section 3.4 described the screening performed to identify the CSO control measures for LTCP evaluation. Table 3-7 lists the screened CSO control measures for further evaluation and summarizes results of the LTCP CSO control measures evaluation for this CSO area.

Table 3-7. Ballard CSO Control Measures

CSO control measure	LTCP evaluation results
GI	Ballard is a primary opportunity for GI applications. As shown in Appendix I, GI approaches have an estimated CV reduction of as much as 1.99 MG. The City is implementing selected GI control measures in the Ballard CSO area and will evaluate the performance of GI in Ballard. If the effectiveness of GI is proven and approved, the City may implement smaller "grey" control measures and take credit for flow reductions associated with GI. For the LTCP, no Ballard CSO reduction credit will be associated with GI because the Consent Decree requires 100 percent "grey" CSO control measures be proposed in the LTCP to resolve all uncontrolled outfalls.
Off-line storage	Because the two Ballard CSO outfalls are so geographically close to each another, conceptual planning concluded that a single CSO control measure for both CSO outfalls was the most cost effective solution. Because of the large Ballard CSO area storage volumes (6 MG), the LTCP evaluated two off-line storage CSO control measure alternatives: a single off-line tank and parallel large-diameter storage pipes. Evaluation of the large diameter pipe control measure removed it from further consideration due to construction impacts, cost effectiveness, and long-term impacts on crossing utilities in a congested corridor.

Table 3-7. Ballard CSO Control Measures

CSO control measure	LTCP evaluation results
Deep tunnel storage	Because of the geographical proximity of the Ballard and Fremont-Wallingford CSO basins and the large combined storage volume of 9.2 MG, the LTCP evaluated the cost-effectiveness of deep tunnel storage between Ballard and Fremont-Wallingford CSO areas. The evaluation is presented in Section 3.5.1.12, Neighborhood West Ship Canal Tunnel. Because of potential shared King County/City project opportunities and the large Ballard CSO area storage volumes (6 MG), the LTCP evaluated the cost-effectiveness of deep tunnel storage as described in Section 3.5.2, Shared Project Control Measures.

3.5.1.1.3 Final Ballard CSO Control Measures

There are two final LTCP CSO control measures for the Ballard CSO area: Off-line storage and deep-tunnel storage. Figure 3-2 shows general area for potential CSO control measure implementation.

Since the basins connect to the same combined sewer and are adjacent to each other, the off-line storage CSO control measure combines the storage needs for both CSO Basins 150/151 and 152 in one off-line storage facility. The Ballard CSO control measure consists of the transferring of combined sewage overflow (CSO) volume to multiple collection system control structures, a new multi-cell underground storage tank, and the necessary infrastructure to divert and convey combined sewer flows to and from storage. In order to reduce the number of CSO occurrences in the Ballard basin to an average of one per year, an estimated storage volume of 6.00 MG is required. Control measure modelling confirmed the feasibility of the and estimated that this CSO control measure for CSO Outfalls 150/151 and 152 will reduce the annual overflow frequencies from 17.1 and 45.8 respectively to one or less events per year.

There are three potential deep-tunnel storage CSO control measures for the Ballard CSO area and they are more fully described in Section 3.5.2.2, Shared Tunnel Projects. One deep-tunnel option will provide CSO storage for both the Ballard and Fremont/Wallingford CSO areas. In addition, there are two shared tunnel projects with King County where the Ballard CSO area will be included in the storage capacity.

Implementation of any neighborhood and shared project will require City coordination with King County. Specifically, the City and King County will need to analyze the impacts of the proposed project on the downstream system and agree on an approach to address those impacts. Prior to implementing any shared project with King County and the City, a joint project agreement will need to be executed between the two agencies.

3.5.1.2 Magnolia CSO Area

The Magnolia Basin (CSO Outfall 060) is located south of the Ship Canal, west of Salmon Bay, east of Discovery Park and north of West Commodore Way. Topographically, the basin generally slopes from west to east. The 28-acre basin is served by a combined sewer system and consists of residential land use. The wastewater generated in this basin flows to the 144-inch diameter King County North Interceptor, which conveys sewage toward the West Point WTTP. Figure 3-3 shows the Magnolia CSO area boundary, CSO outfall location, and general area for potential CSO control measure implementation.

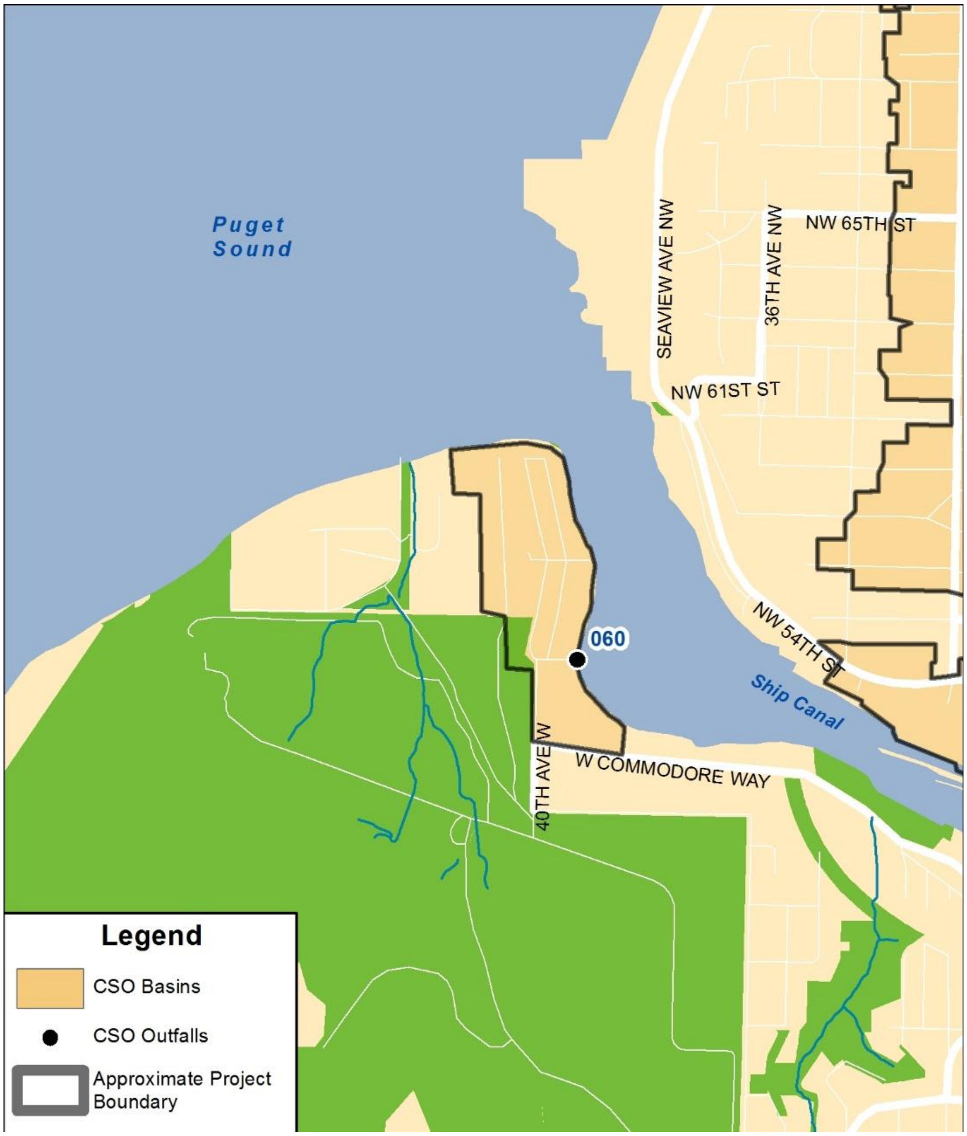

Figure 3-3. Magnolia CSO Boundaries, CSO Outfall Locations, and General Area for Potential CSO Control Measure Implementation

3.5.1.2.1 CSO Control Volumes

Section 2.8 described the LTCP hydraulic modelling performed to determine the CVs for each uncontrolled CSO outfall. Table 3-8 lists the Magnolia CSO outfall's long-term average annual overflow frequency, average annual overflow volume, and CV. Control volumes were estimated for possible effects with and without future climate change. For the LTCP, the Magnolia CSO outfall CV including climate change was used as the basis for CSO control measure sizing and evaluation.

3.5.1.2.2 CSO Control Measure Evaluation

Section 3.4 described the CSO screening performed to identify the CSO control measures for LTCP evaluation. Table 3-9 lists the screened CSO control measures for further evaluation and summarizes results of the LTCP CSO control measures evaluation for this CSO area.

Table 3-8. Magnolia CSO Outfall Control Volume

CSO Outfall	Average annual overflow frequency[a]	Average annual overflow volume (MG)[b,c]	Control volume with climate change (MG)[d]	control volume without climate change (MG)[c, d]
60	2.7	0.30	0.11	0.09

[a] 2013 Annual CSO Report, Table 5-8. Outfalls Meeting Performance Standard for Controlled CSOs based on Flow Monitoring Results and Modeling
[b] From 20-year (1993-2012) long-term simulations with Rainfall scaling =1.0
[c] Estimated overflow volume after removal of climate change uncertainty but keeping other uncertainties
[d] Estimated control volumes less than 5,000 gallons are shown as < 0.01. Control volumes of 0.005 to 0.01 are rounded up to 0.01.

Table 3-9. Magnolia CSO Control Measures

CSO control measure	LTCP evaluation results
Flow diversion	The City's Retrofit Program evaluated potential retrofit solutions to control CSO outfall 060 and identified a flow diversion option. CSO Outfall 060 control is achieved through transferring the peak storm flows out of the Magnolia CSO basin to the Fort Lawton Tunnel (operated by King County) via increased pumping and force main capacity.
Off-line storage	Three off-line storage options were evaluated: a tank in the street right-of way, a pipe in the street right-of way, and a tank on private property. The three off-line storage CSO control measures were equivalent in costs and impacts. The off-line storage pipeline in the street right-of way was selected as the Magnolia off-line CSO control measure for LTCP evaluation.

3.5.1.2.3 Final Magnolia CSO Control Measures

There are two final LTCP Magnolia CSO control measures: off-line storage and flow diversion. Figure 3-3 shows the general area for potential Magnolia CSO control measure implementation.

The Magnolia CSO basin off-line storage control measure consists of transferring combined sewage overflow to a new off-line storage pipe. This CSO control measure includes a storage pipe and the necessary infrastructure to divert and convey combined sewer flows to and from the pipe. The estimated storage volume required is 0.11 million gallons. Control measure modelling confirmed the feasibility of this CSO control measure and estimated that it will reduce the annual overflow frequencies from 2.7 to 1 or less events per year.

The Magnolia CSO basin flow diversion control measure includes transferring the peak storm flows out of the Magnolia CSO basin to the Fort Lawton Tunnel (operated by King County) by increasing the pump capacity at Pump Station No. 22 from 0.86 MGD to 3.3 MGD and constructing a new 12-inch diameter pipe. It is described in additional detail in Section 3.5.2.3, Flow Diversion Projects. Control measure modelling confirmed the feasibility of this concept for this CSO control measure and estimated that it will reduce the annual overflow frequency to one or less events per year.

3.5.1.3 North Union Bay CSO Area

The North Union Bay CSO area covers approximately 900 acres (1.4 square miles) in northeast Seattle. The North Union Bay CSO area includes CSO Basin 018, which drains from north to south toward Union Bay and Lake Washington. The basin has two overflow points, designated overflows 018(A) and 018(B). Overflows from both points are conveyed by the storm drainage system to a single outfall (CSO Outfall 018) into Union Bay. The wastewater generated in these basins flows by gravity to King County's Laurelhurst trunk for conveyance to the West Point WWTP. Figure 3-4 shows the North Union Bay CSO area boundary, CSO outfall location, and general area for potential CSO control measure implementation.

Figure 3-4. North Union Bay CSO Boundaries, CSO Outfall Locations, and General Area for Potential CSO Control Measure Implementation

3.5.1.3.1 CSO Control Volumes

Section 2.8 described the LTCP hydraulic modelling performed to determine the CVs for each uncontrolled CSO outfall. Table 3-10 lists the North Union Bay CSO outfall long-term average annual overflow frequency, average annual overflow volume, and CVs. Control volumes were estimated for possible effects with and without future climate change. For the LTCP, the North Union Bay CSO outfall CV including climate change was used as the basis for CSO control measure sizing and evaluation.

Table 3-10. North Union Bay CSO Outfall Control Volume

CSO Outfall	Average annual overflow frequency[a]	Average annual overflow volume (MG)[b,c]	Control volume with climate change (MG)[d]	Control volume without climate change (MG)[c, d]
18	4.1	5.1	1.63	1.17

[a] *2013 Annual CSO Report, Table 5-8. Outfalls Meeting Performance Standard for Controlled CSOs based on Flow Monitoring Results and Modeling*
[b] *From 20-year (1993-2012) long-term simulations with Rainfall scaling =1.0*
[c] *Estimated overflow volume after removal of climate change uncertainty but keeping other uncertainties*
[d] *Estimated control volumes less than 5,000 gallons are shown as < 0.01. Control volumes of 0.005 to 0.01 are rounded up to 0.01.*

3.5.1.3.2 CSO Control Measure Evaluation

Section 3.4 described the CSO control measure screening performed to identify the CSO control measures for LTCP evaluation. Table 3-11 lists the screened CSO control measures for further evaluation and summarizes results of the LTCP CSO control measure evaluation for this CSO area.

Table 3-11. North Union Bay CSO Control Measures

CSO control measure	LTCP evaluation results
Flow diversion	The City's Retrofit Program identified a retrofit flow diversion project to the King County Laurelhurst Interceptor.
Off-line storage	Two types of off-line storage were evaluated: independent City storage and shared City/King County storage. For Independent City storage, two storage control measure options for the northern portion of the basin and five alternatives for the southern portion of the basin were evaluated. The northern control measures involved storage in street right-of-way and storage on private property. The southern control measures involved storage on private property. Because of the potential shared King County/City project opportunity, the LTCP evaluated the cost-effectiveness of shared storage with the King County University Regulator project which is described in Section 3.5.2, Shared Project Control Measures.
Deep tunnel storage	Because of potential shared King County/City project opportunities, the LTCP evaluated the cost-effectiveness of deep tunnel storage. North Union Bay is a tributary area to a deep tunnel storage option more fully described in Section 3.5.2, Shared Project Control Measures.

3.5.1.3.3 Final North Union Bay CSO Control Measures

The final LTCP North Union Bay CSO control measure is a flow diversion. Figure 3-4 shows the general area for potential North Union Bay CSO control measure implementation.

The North Union Bay CSO basin flow diversion control measure will involve modifying the existing City CSO storage facility's outflow structure to achieve the current HydroBrake manufacturer's design performance. It is described in additional detail in Section 3.5.2.3, Flow Diversion Projects. This CSO control measure will restore the original design capacity for storage and flows. Control measure modelling confirmed the feasibility of this CSO control measure and estimated that it will reduce the annual overflow frequencies from 4.1 to 1 or less events per year. This CSO control measure was selected based on cost-effectiveness compared to the off-line storage control measure

There are two potential shared CSO control measures for the North Union Bay CSO area; they are described in Section 3.5.2, Shared Project Control Measures. The first is a shared storage CSO control measure and will include storage for the King County University Regulator and the City's North Union Bay CSO basin. The second, a ship canal tunnel shared with King County, will meet storage requirements for several King County CSO outfalls and City CSO areas.

3.5.1.4 Central Waterfront CSO Area

The Central Waterfront CSO area is located in the northern part of downtown Seattle, near the waterfront. The area encompasses 150 acres (0.23 square mile) and is bounded approximately by Denny Way to the north, Bay Street to the northwest, 5th and 4th Avenues to the north and east, and Alaskan Way to the south and west (see Figure 2-7.). The Vine Street CSO area is included in the larger Central Waterfront CSO area, which includes four CSO outfalls and their respective basins: 069 (Vine), 070, 071, and 072. The LTCP focused on the uncontrolled CSO outfall 069 and the 2010 CSO Reduction Plan projects will include control of CSO Outfall 071. Flow from CSO Basin 069 drains to the King County Elliott Bay Interceptor for conveyance, treatment, and discharge at the West Point WWTP. Figure 3-5 shows the Central Waterfront CSO area boundary, CSO outfall location, and general area for potential CSO control measure implementation.

Figure 3-5. Central Waterfront CSO Boundaries, CSO Outfall Locations, and General Area for Potential CSO Control Measure Implementation

3.5.1.4.1 CSO Control Volumes

Section 2.8 described the LTCP hydraulic modelling performed to determine the CVs for each uncontrolled CSO outfall. Table 3-12 lists the Central Waterfront CSO outfall long-term average annual overflow frequency, average annual overflow volume, and CVs. Control volumes were estimated for possible effects with and without future climate change. For the LTCP, the Central Waterfront CSO outfall CV including climate change was used as the basis for CSO control measure sizing and evaluation.

Table 3-12. Central Waterfront CSO Outfall Control Volume

CSO Outfall	Average annual overflow frequency[a]	Average annual overflow volume (MG)[b,c]	Control volume with climate change (MG)[d]	Control volume without climate change (MG)[c, d]
069	1.6	0.82	0.07	0.05

[a] *2013 Annual CSO Report, Table 5-8. Outfalls Meeting Performance Standard for Controlled CSOs based on Flow Monitoring Results and Modeling*
[b] *From 20-year (1993-2012) long-term simulations with Rainfall scaling =1.0*
[c] *Estimated overflow volume after removal of climate change uncertainty but keeping other uncertainties*
[d] *Estimated control volumes less than 5,000 gallons are shown as < 0.01. Control volumes of 0.005 to 0.01 are rounded up to 0.01.*

3.5.1.4.2 CSO Control Measure Evaluation

Section 3.4 described the CSO control measure screening performed to identify the CSO control measures for LTCP evaluation. Table 3-13 lists the screened CSO control measures for further evaluation and summarizes results of the LTCP CSO control measures evaluation for this CSO area.

Table 3-13. Central Waterfront CSO Control Measures

CSO control measure	LTCP evaluation results
Off-line storage	Two types of off-line storage were evaluated: storage tanks and pipe storage. Because of high groundwater and poor soils conditions, storage tank construction is not cost effective and will interfere with the final configuration of the City's Elliott Bay Seawall Replacement and Central Waterfront Projects. Off-line pipe storage was evaluated and was determined to be the most cost effective CSO control measure. It also minimizes impacts to the City's Elliott Bay Seawall Replacement and Central Waterfront Projects.

3.5.1.4.3 Final Central Waterfront CSO Control Measures

The Central Waterfront (Vine Street) CSO control measure consists of off-line CSO storage upstream of the King County Elliot Bay Interceptor, which directs flow to the King County West Point WWTP. The storage volume will be provided by an off-line storage pipe in the vicinity of CSO Outfall 069. Figure 3-5 shows general area for potential Central Waterfront CSO control measure implementation.

As shown in Table 3-12, Central Waterfront CSO Outfall Control Volume, the LTCP hydraulic modelling estimated a CV with climate change of 0.07 MG. Control measure modelling for the final off-line CSO storage indicated that a storage volume of 0.13 MG is required based on King County Elliot Bay Interceptor hydraulic limitations. With 0.13 MG of storage volume, the modelling confirmed the feasibility of this concept and estimated that it will reduce the annual overflow frequencies from 1.6 to 1 or less events per year.

Implementation of any neighborhood project will require City coordination with King County. Specifically, the City and King County will need to analyze the impacts of the proposed project on the downstream system and agree on an approach to address those impacts.

No shared King County/City storage opportunities were identified for this CSO area.

3.5.1.5 Fremont/Wallingford CSO Area

The Fremont/Wallingford CSO area covers 657 acres (1.0 square mile) in north Seattle and includes CSO outfalls 147, 148, and 174, which drain from north to south toward Lake Union and the Lake Washington Ship Canal. CSO Outfalls 147 and 174 are uncontrolled and are addressed in the LTCP. CSO Outfall 148 is controlled and is not evaluated in the LTCP. CSO Basin 147 has two overflow points (147(A) and 147(B)), that discharge to a single outfall (CSO Outfall 147). Both the CSO Basins148 and 174 each have single overflow points and outfalls. Wastewater generated in these basins flows by gravity to King County's North Interceptor for conveyance to the West Point WWTP. Figure 3-6 shows the Fremont-Wallingford CSO area boundary, CSO outfall location, and general area for potential CSO control measure implementation.

Figure 3-6. Fremont/Wallingford CSO Boundaries, CSO Outfall Locations, and General Area for Potential CSO Control Measure Implementation

3.5.1.5.1 CSO Control Volumes

Section 2.8 described the LTCP hydraulic modelling performed to determine the CVs for each uncontrolled CSO outfall. Table 3-14 lists the Fremont-Wallingford CSO outfall long-term average annual overflow frequency, average annual overflow volume, and CVs. Control volumes were estimated for possible effects with and without future climate change. For the LTCP, the Fremont-Wallingford CSO outfall CVs including climate change were used as the basis for CSO control measure sizing and evaluation.

Table 3-14. Fremont-Wallingford CSO Outfall Control Volume

CSO Outfall	Average annual overflow frequency[a]	Average annual overflow volume (MG)[b,c]	Control volume with climate change (MG)[d]	Control volume without climate change (MG)[c, d]
147	38.1	8.14	2.15	1.96
174	8.7	3.33	1.06	0.99

[a] *2013 Annual CSO Report, Table 5-8. Outfalls Meeting Performance Standard for Controlled CSOs based on Flow Monitoring Results and Modeling*
[b] *From 20-year (1993-2012) long-term simulations with Rainfall scaling =1.0*
[c] *Estimated overflow volume after removal of climate change uncertainty but keeping other uncertainties*
[d] *Estimated control volumes less than 5,000 gallons are shown as < 0.01. Control volumes of 0.005 to 0.01 are rounded up to 0.01.*

3.5.1.5.2 CSO Control Measure Evaluation

Section 3.4 described the CSO Control Measure screening performed to identify the CSO control measures for LTCP evaluation. Table 3-15 lists the screened CSO control measures for further evaluation and summarizes results of the LTCP CSO control measures evaluation for this CSO area.

Table 3-15. Fremont-Wallingford CSO Control Measures

CSO control measure	LTCP evaluation results
Off-line storage	Seven independent storage control measures in which the two CSO outfalls were served by a common storage facility were evaluated, as well as seven additional storage control measures (four for CSO Outfall 147 and three for CSO outfall 174) that served each individual outfall were evaluated. Because the two Fremont-Wallingford CSO outfalls are so close to each another, conceptual planning concluded that a single control measure for both CSO outfalls was the most cost effective solution. Because of the large Fremont-Wallingford CSO area storage volumes (3.2 MG), the LTCP evaluated two off-line storage alternatives: a single off-line tank and a storage tunnel serving only the Fremont/Wallingford CSO area. City management concluded that a single off-line storage tank on City-owned property was the most cost-effective control solution for this CSO area. Evaluation of the large diameter pipe control measure removed it from further consideration due to construction impacts, cost effectiveness, and long-term impacts on crossing utilities in a congested corridor Because of the potential for shared King County/City storage and the large Fremont-Wallingford CSO area storage volumes (3.2 MG), the LTCP evaluated

Table 3-15. Fremont-Wallingford CSO Control Measures

CSO control measure	LTCP evaluation results
	the cost-effectiveness of off-line storage with King County's 3rd Avenue West CSO area. This concept is described in Section 3.5.2, Shared Project Control Measures.
Deep tunnel storage	Because of the geographic proximity of the Ballard and Fremont-Wallingford CSO basins and the large combined storage volume of 9.2 MG, the LTCP evaluated the cost-effectiveness of deep tunnel storage between Ballard and Fremont-Wallingford CSO areas. The evaluation is presented in Section 3.5.1.12, Neighborhood West Ship Canal Tunnel. Because of the potential for shared King County/City storage and the large Fremont-Wallingford CSO area storage volumes (3.2 MG), the LTCP evaluated the cost-effectiveness of deep tunnel storage as described in Section 3.5.2, Shared Project Control Measures.

3.5.1.5.3 Final Fremont-Wallingford Control Measures

There are two final LTCP CSO control measures for the Fremont/Wallingford CSO area: Off-line storage and deep tunnel storage. Figure 3-6 shows the general area for potential Fremont/Wallingford CSO control measure implementation.

Since the basins connect to the King County North Interceptor and are adjacent to each other, the off-line storage CSO control measure combines the storage needs for both CSO Basins 147 and 174 in one off-line storage facility. The CSO control measure consists of transferring CSO volume to multiple collection system control structures, a new multi-cell underground storage tank, and the necessary infrastructure to divert and convey combined sewer flows to and from storage. In order to reduce the number of CSO occurrences in the Fremont/Wallingford CSO basin to an average of one per year, an estimated storage volume of 3.2 million gallons is required. Control measure modelling confirmed the feasibility of this concept and estimated that annual overflow frequencies for CSO Outfalls 147 and 174 will be reduced from 38.1 and 8.7, respectively, to 1 or less events per year.

The deep tunnel storage CSO control measure will provide CSO storage for both the Ballard and Fremont/Wallingford CSO areas. This evaluation is presented in Section 3.5.1.12, Neighborhood West Ship Canal Tunnel.

There are two potential shared CSO control measures involving the Fremont-Wallingford CSO area and they are described in Section 3.5.2, Shared Project Control Measures. The first is a shared storage CSO control measure that will include storage for the King County 3rd Avenue West Regulator and the City Fremont-Wallingford CSO outfalls. The second involves shared tunnel projects with King County where the Fremont-Wallingford CSO area will be included in the storage capacity.

3.5.1.6 Duwamish CSO Area

The Duwamish CSO area covers 487 acres (0.68 square mile) in southeast Seattle; it is bounded by S Hanford Street to the north, the Duwamish River to the west, S Hudson Street to the south, and Beacon Hill to the east.

The Duwamish CSO area comprises CSO Basin 111. CSO Basin 111 drains from east to west toward the Duwamish River where there is a single overflow point at CSO Outfall 111. The wastewater generated in this basin flows by gravity to King County's Duwamish pump station (at the corner of Diagonal Avenue S and East Marginal Way S) for conveyance to the West Point WWTP. The CSS in the Duwamish CSO area conveys both sanitary and stormwater flow. The area is partially separated. CSO Basin 111 contains eight permitted CSO structures (A–H) that discharge overflows to the Diagonal Avenue storm drain and then to the Duwamish River through CSO Outfall 111 during large precipitation events when the capacity of the CSS is exceeded. Figure 3-7 shows the Duwamish CSO area boundary, CSO outfall location, and general area for potential CSO control measure implementation.

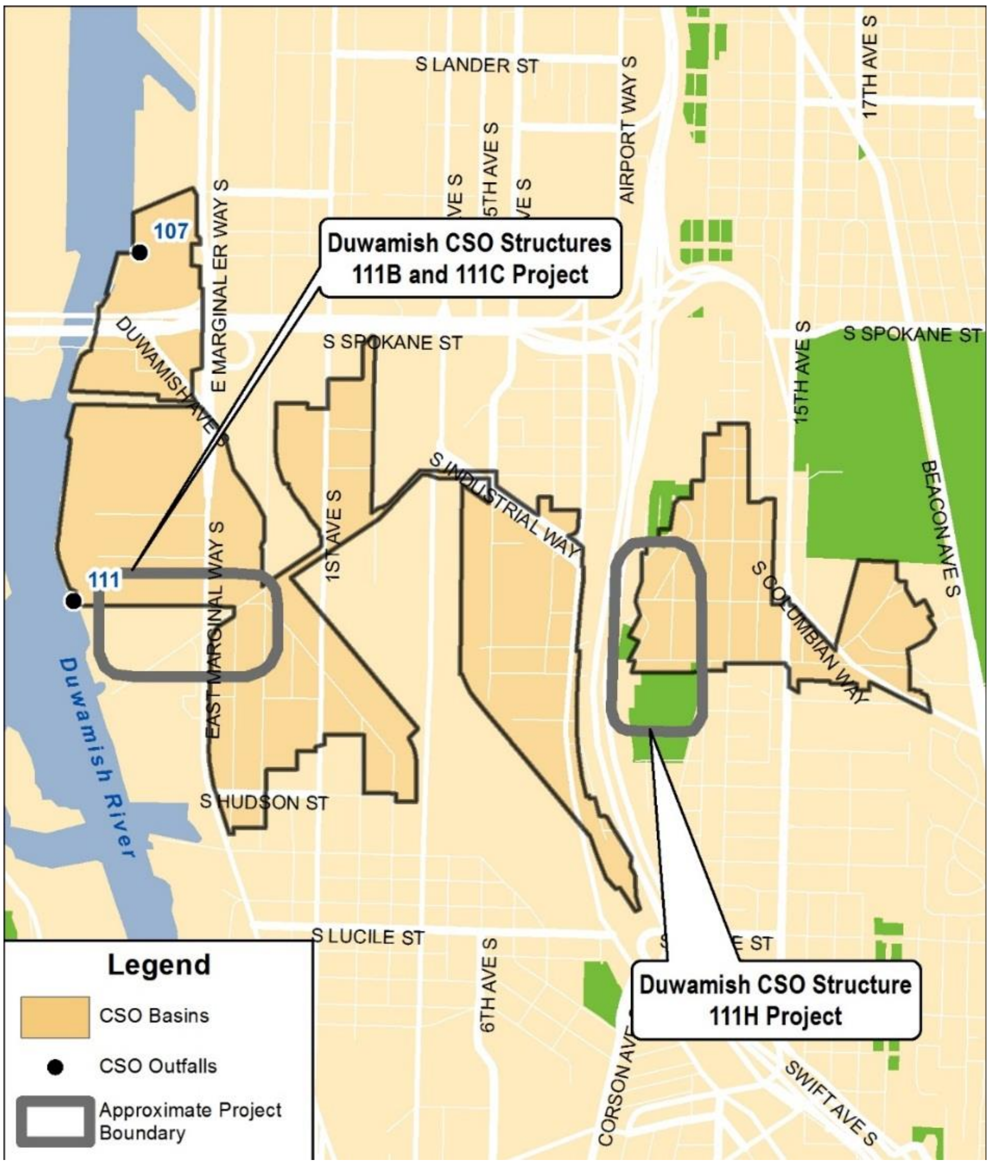

Figure 3-7. Duwamish CSO Boundaries, CSO Outfall Locations, and General Area for Potential CSO Measure Implementation

3.5.1.6.1 CSO Control Volumes

Section 2.8 described the LTCP hydraulic modelling performed to determine the CVs for each uncontrolled CSO outfall. Table 3-16 lists the Duwamish CSO outfall long-term average annual overflow frequency, average annual overflow volume, and CV. Control volumes were estimated for possible effects with and without future climate change. For the LTCP, the Duwamish CSO outfall CV including climate change was used as the basis for CSO control measure sizing and evaluation.

Table 3-16. Duwamish CSO Outfall Control Volume

CSO Outfall	Average annual overflow frequency[a]	Average annual overflow volume (MG)[b,c]	Control volume with climate change (MG)[d]	Control volume without climate change (MG)[c, d]
111	1.8	0.49	<0.01	<0.01

[a] *2013 Annual CSO Report, Table 5-8. Outfalls Meeting Performance Standard for Controlled CSOs based on Flow Monitoring Results and Modeling*
[b] *From 20-year (1993-2012) long-term simulations with Rainfall scaling =1.0*
[c] *Estimated overflow volume after removal of climate change uncertainty but keeping other uncertainties*
[d] *Estimated control volumes less than 5,000 gallons are shown as < 0.01. Control volumes of 0.005 to 0.01 are rounded up to 0.01.*

3.5.1.6.2 CSO Control Measure Evaluation

Section 3.4 described the CSO control measure screening performed to identify the CSO control measures for LTCP evaluation. Table 3-17 lists the screened CSO control measures for further evaluation and summarizes results of the LTCP CSO control measures evaluation for this CSO area.

Table 3-17. Duwamish CSO Control Measures

CSO control measure	LTCP evaluation results
Flow diversion	The City's Retrofit Program identified a retrofit flow diversion project for the King County Duwamish Interceptor. The City Retrofit Program evaluated potential retrofit solutions to control CSO Outfall 111 and identified a flow diversion retrofit CSO control option.
Off-line storage	CSO Outfalls 111B and 111C are close together and may be considered a single CSO control measure. CSO Outfall 111H is significantly geographically separated from 111B and 111C. Conceptual planning developed four independent storage control measures for CSO Outfalls 111B and 111C. These included a tank in the right-of-way, tanks on one of two government-owned properties, and a tank on private property. Two storage control measures were developed for CSO Outfall 111H including one on City-owned property and one on a park site. There were two storage control measures developed for a combined CSO Outfall 111B, 111C, and 111H storage site. Evaluation of the CSO control measures concluded that three off-line storage tanks in the right-of-way were the optimal control solution for this CSO area.

3.5.1.6.3 Final Duwamish CSO Control Measures

There are two final LTCP CSO control measures for the Duwamish CSO area: off-line storage and flow diversion. Figure 3-7 shows the general area for potential Duwamish CSO control measure implementation.

The off-line storage concept includes two separate CSO storage facilities:

- The Duwamish 111B and 111C CSO control measure consists of off-line CSO storage upstream of the King County Duwamish pump station. The Duwamish pump station directs flow to the King County Elliott Bay Interceptor. The 0.02 MG storage volume will be provided by modifying two existing control structures and re-routing storm drainage piping to isolate the structures.
- The Duwamish 111H CSO control measure will include an off-line storage pipe adjacent to the existing CSO Control Facility 35 storage tank. During CSO events, excess combined sewer flows will be diverted to a new 0.01 MG off-line storage pipe and flow through both the new storage pipe and the existing CSO Control Facility 35 tank to the downstream sewer conveyance system.
- Control measure modelling confirmed the feasibility of the concept and estimated that these CSO control measures will reduce the Duwamish CSO outfall annual overflow frequencies from 1.8 to 1 or less events per year.

The Duwamish CSO basin flow diversion control measures will divert flows to the King County Duwamish Interceptor and is described in additional detail in Section 3.5.2.3, Flow Diversion Projects.

No shared King County/City storage opportunities were identified for this CSO area.

3.5.1.7 East Waterway CSO Area

The East Waterway CSO area (CSO Basin 107) covers 58.7 acres (0.09 square mile) in southeast Seattle; it is bounded by S Hanford Street to the north, the East Waterway of the Duwamish River to the west, industrial properties to the south, and East Marginal Way S to the east. Topographically, CSO Basin 107 is generally flat, and land use consists entirely of industrial property. The wastewater generated in this basin flows by gravity to the King County Elliot Bay Interceptor in Colorado Avenue S for conveyance to the West Point WWTP. Flow in CSO Basin 107 drains toward a single overflow point (CSO Outfall 107) near the intersection of East Marginal Way S and S Spokane Street. Overflows at this location occur only when the water level in the King County interceptor is above the level of the overflow point. Figure 3-8 shows the East Waterway CSO area boundary, CSO outfall location, and general area for potential CSO control measure implementation.

Figure 3-8. East Waterway CSO Boundaries, CSO Outfall Locations, and General Area for Potential CSO Control Measure Implementation

3.5.1.7.1 CSO Control Volumes

Section 2.8 described the LTCP hydraulic modelling performed to determine the CVs for each uncontrolled CSO outfall. Table 3-18 lists the East Waterway CSO outfall long-term average annual overflow frequency, average annual overflow volume, and CVs. Control volumes were estimated for possible effects with and without future climate change. For the LTCP, the East Waterway CSO outfall CV including climate change was used as the basis for CSO control measure sizing and evaluation.

Table 3-18. East Waterway CSO Outfall Control Volume

CSO Outfall	Average annual overflow frequency[a]	Average annual overflow volume (MG)[b,c]	Control volume with climate change (MG)[d]	Control volume without climate change (MG)[c, d]
107	4.9	0.9	0.5	0.45

[a] 2013 Annual CSO Report, Table 5-8. Outfalls Meeting Performance Standard for Controlled CSOs based on Flow Monitoring Results and Modeling
[b] From 20-year (1993-2012) long-term simulations with Rainfall scaling =1.0
[c] Estimated overflow volume after removal of climate change uncertainty but keeping other uncertainties
[d] Estimated control volumes less than 5,000 gallons are shown as < 0.01. Control volumes of 0.005 to 0.01 are rounded up to 0.01.

3.5.1.7.2 CSO Control Measure Evaluation

Section 3.4 described the CSO control measure screening performed to identify the CSO control measures for LTCP evaluation. Table 3-19 lists the screened CSO control measures for further evaluation and summarizes results of the LTCP CSO control measures evaluation for this CSO area.

Table 3-19. East Waterway Basin CSO Control Measures

CSO control measure	LTCP evaluation results
Flow diversion	King County will be constructing a new CSO treatment plant, near the CSO outfall 107 location. The LTCP evaluated a flow diversion from CSO Outfall 107 to the new King County CSO treatment plant. This concept is described in Section 3.5.2.3, Flow Diversion Projects.
Off-line storage	A storage control measure was developed for CSO Outfall 107 consisting of an underground storage tank. Evaluation of the CSO control measure concluded that off-line storage tank was the optimal control solution for this CSO area.

3.5.1.7.3 Final East Waterway CSO Control Measures

There are two final LTCP CSO control measures for the East Waterway CSO area: off-line storage and flow diversion. Figure 3-8 shows the general area for potential East Waterway CSO control measure implementation.

The off-line storage CSO control measure concept consists of transferring CSO volume to collection system control structures, a new multi-cell underground storage tank, and the necessary infrastructure to divert and convey combined sewer flows to and from storage. In order to reduce the number of CSO occurrences in the East Waterway CSO basin to an average of one per year, an estimated storage volume of 0.5 million gallons is required. Control measure modelling confirmed the feasibility of this concept and estimated that the CSO Outfall 107 annual overflow frequency will be reduced from 4.6 to 1 or less events per year. The East Waterway CSO basin flow diversion control measure will divert flows to the King County Duwamish Interceptor and will consist of a new pumping station and force main to the proposed King County HLKK CSO plant. The flow diversion is described in additional detail in Section 3.5.2.3, Flow Diversion Projects.

No shared King County/City storage opportunities were identified for this CSO area.

3.5.1.8 Delridge/Longfellow CSO Area

The Delridge/Longfellow CSO area, located in West Seattle along Longfellow Creek, comprises Basins 099, 168, and 169. The total area is approximately 660 acres. The three basins are geographically separated and hydraulically independent. They individually discharge into the King County system through King County's Delridge trunk line along 26th Avenue SW, which runs from south to north through the basin.

All three CSO basins contain permitted CSO structures that discharge overflows to either Longfellow Creek or the Duwamish River during large precipitation events when the capacity of the CSS is exceeded. Figure 3-9 shows the Delridge/Longfellow CSO area boundary, CSO outfall location, and general area for potential CSO control measure implementation.

Figure 3-9. Delridge/Longfellow CSO Boundaries, CSO Outfall Locations, and General Area for Potential CSO Control Measure Implementation

3.5.1.8.1 CSO Control Volumes

Section 2.8 described the LTCP hydraulic modelling performed to determine the CVs for each uncontrolled CSO outfall. Table 3-20 lists the Delridge/Longfellow CSO outfall long-term average annual overflow frequency, average annual overflow volume, and CVs. Control volumes were estimated for possible effects with and without future climate change. For the LTCP, the Delridge/Longfellow CSO outfall CVs including climate change were used as the basis for CSO control measure sizing and evaluation.

Table 3-20. Delridge/Longfellow CSO Outfall Control Volume

CSO Outfall	Average annual overflow frequency[a]	Average annual overflow volume (MG)[b,c]	Control volume with climate change (MG)[d]	Control volume without climate change (MG)[c, d]
099	1.6	0.82	0.17	0.11
168	2.7	4.57	2.00	1.45
169	2.7	2.78	1.19	0.74

[a] 2013 Annual CSO Report, Table 5-8. Outfalls Meeting Performance Standard for Controlled CSOs based on Flow Monitoring Results and Modeling
[b] From 20-year (1993-2012) long-term simulations with Rainfall scaling =1.0
[c] Estimated overflow volume after removal of climate change uncertainty but keeping other uncertainties
[d] Estimated control volumes less than 5,000 gallons are shown as < 0.01. Control volumes of 0.005 to 0.01 are rounded up to 0.01.

3.5.1.8.2 CSO Control Measure Evaluation

Section 3.4 described the CSO control measure screening performed to identify the CSO control measures for LTCP evaluation. Table 3-21 lists the screened CSO control measures for further evaluation and summarizes results of the LTCP CSO control measures evaluation for this CSO area.

Table 3-21. Delridge/Longfellow Basin CSO Control Measures

CSO control measure	LTCP evaluation results
Flow diversion	The LTCP evaluated a flow diversion from CSO Outfall 099 to the King County Harbor Ave. trunk. This concept is described in Section 3.5.2.3, Flow Diversion Projects
Off-line storage	The City is currently implementing a retrofit project for CSO Outfalls 168 and 169 that will replace the existing HydroBrakes with improved controls and new controllable gates. This project will reduce the CSO overflows significantly. To reduce CSO overflows to less than one per year after the retrofit is completed, storage control measures were developed that include storage pipelines and underground storage tanks to control the remaining volume. Evaluation of the CSO control measures concluded that off-line storage tanks were the optimal control solution for this CSO area.

3.5.1.8.3 Final Delridge/Longfellow CSO Control Measures

There are two final LTCP CSO control measures for the Delridge/Longfellow CSO area: off-line storage and flow diversion. Figure 3-9 shows the general area for potential Delridge/Longfellow CSO control measure implementation.

The off-line storage concept includes three separate CSO storage facilities:

- As shown in Table 3-19, the LTCP hydraulic modelling estimated a CV with climate change of 2.0 MG and 1.19 MG for CSO Outfalls 168 and 169, respectively. The City is currently replacing existing HydroBrakes with improved upstream diversion structures, actively controlled valves, and an upstream and downstream flow monitoring system. This project will optimize the performance of existing City CSO control facilities 2 and 3 and will reduce CSOs at CSO Outfalls 168 and 169. Project construction must be completed by November 1, 2015 to meet the NPDES Permit compliance date. Control measure modelling of the retrofit project indicated that the project will reduce the CV for CSO Basin 168 to 0.25 MG from 2.0 MG and for CSO Basin 169 to 0.25 MG from 1.19 MG. These revised CVs were used to develop the final CSO control measures for CSO Basins 168 and 169.
- The control measure for CSO Basin 169 consists of a 0.25 MG off-line CSO storage pipe adjacent to the existing City control facility 2 storage tank that will store excess CSO after the existing control facility 2 tank is full. The stored CSO flows will be discharged to the existing King County interceptor when capacity is available.
- The control measure for CSO Basin 169 consists of a 0.25 MG off-line CSO storage pipe adjacent to the existing City control facility 3 storage tank that will store excess CSO after the existing control facility 3 tank is full. The stored CSO flows will be discharged to the existing King County interceptor when capacity is available.
- CSO Basin 099 is geographically remote from the other two basins. The control measure for CSO Basin 099 consists of a 0.17 MG off-line CSO storage pipe. The stored CSO flows will be discharged to the existing King County interceptor when capacity is available.
- Control measure modeling confirmed the feasibility of the above CSO control measures and estimated they will reduce the CSO Outfall 099, 168 and 169 annual overflow frequencies to one or less events per year per outfall.

The Delridge/Longfellow CSO basin flow diversion control measure will divert flows from CSO Outfall 099 to the King County Harbor Avenue Interceptor and will consist of a new pumping station and force main. The flow diversion is described in additional detail in Section 3.5.2.3, Flow Diversion Projects.

No shared King County/City storage opportunities were identified for this CSO area.

3.5.1.9 Montlake CSO Area

The Montlake CSO area covers 140 acres (0.2 square mile) in east Seattle; it is bounded approximately by the Lake Washington Ship Canal to the north, Portage Bay to the north and west, Delmar Drive E and Boyer Avenue E to the south, and Lake Washington Boulevard E and Union Bay to the east. The Montlake CSO area comprises CSO Basins 020, 139, and 140. The flows from CSO Basins 139 and 140 drain to City Pump Station 25, from which they are pumped into the Montlake gravity system that flows into the King County South Lake Washington trunk line. Flows from CSO Basin 020 drain to City Pump Station 13, from which they are pumped to King County's South Lake Washington trunk line. The trunk line conveys the flows to the West Point WWTP for treatment and discharge.

The CSS in the Montlake CSO area conveys both sanitary and stormwater flow. The Montlake CSO area includes three permitted CSO outfalls that discharge overflows to the Ship Canal during precipitation events when the capacity of the CSS is exceeded. Figure 3-10 shows the Montlake CSO area boundary, CSO outfall location, and general area for potential CSO control measure implementation.

Figure 3-10. Montlake CSO Boundaries, CSO Outfall Locations, and General Area for Potential CSO Control Measure Implementation

3.5.1.9.1 CSO Control Volumes

Section 2.8 described the LTCP hydraulic modelling performed to determine the CVs for each uncontrolled CSO outfall. Table 3-22 lists the Montlake CSO outfall long-term average annual overflow frequency, average annual overflow volume, and CVs. Control volumes were estimated for possible effects with and without future climate change. For the LTCP, the Montlake CSO outfall CVs including climate change were used as the basis for CSO control measure sizing and evaluation.

Table 3-22. Montlake CSO Outfall Control Volume

CSO Outfall	Average annual overflow frequency[a]	Average annual overflow volume (MG)[b,c]	Control volume with climate change (MG)[d]	Control volume without climate change (MG)[c, d]
020	1.4	0.61	0.16	0.12
139	1.2	0.03	0.01	<0.01
140	3.9	0.25	0.05	0.02

[a] *2013 Annual CSO Report, Table 5-8. Outfalls Meeting Performance Standard for Controlled CSOs based on Flow Monitoring Results and Modeling*
[b] *From 20-year (1993-2012) long-term simulations with Rainfall scaling =1.0*
[c] *Estimated overflow volume after removal of climate change uncertainty but keeping other uncertainties*
[d] *Estimated control volumes less than 5,000 gallons are shown as < 0.01. Control volumes of 0.005 to 0.01 are rounded up to 0.01.*

3.5.1.9.2 CSO Control Measure Evaluation

Section 3.4 described the CSO control measure screening performed to identify the CSO control measures for LTCP evaluation. Table 3-23 lists the screened CSO control measures for further evaluation and summarizes results of the LTCP CSO control measures evaluation for this CSO area.

Table 3-23. Montlake CSO Control Measures

CSO control measure	LTCP evaluation results
Flow diversion	The City Retrofit Program evaluated potential retrofit solutions to control Montlake CSO basins and identified a flow diversion retrofit flow diversion option for the King County interceptor.
Off-line storage	Two types of off-line storage were evaluated: independent City storage and shared City/King County storage. For Independent City storage, separate off-line storage control measures were evaluated for CSO Basins 020, 139, and 140. The LTCP evaluated the cost-effectiveness of shared storage with the King County Montlake Regulator project which is described in Section 3.5.2, Shared Project Control Measures.
Deep tunnel storage	The LTCP evaluated the cost-effectiveness of shared deep tunnel storage. Montlake CSO area is a tributary area to a deep tunnel storage option more fully described in Section 3.5.2, Shared Project Control Measures.

3.5.1.9.3 Final Montlake CSO Control Measures

There are two final LTCP CSO control measures for the Montlake CSO area: off-line storage and flow diversion. Figure 3-10 shows the general area for potential Montlake CSO control measure implementation.

Because of the relatively small storage requirements, separate off-line storage CSO control measures have been developed.

- The CSO Basin 020 CSO control measure consists of a 0.16 MG off-line CSO storage pipe. The stored CSO flows will be discharged to the existing King County interceptor.
- The CSO Basin 139 CSO control measure consists of a 0.01 MG off-line CSO storage pipe. The stored CSO flows will be discharged to the existing King County interceptor.
- The CSO Basin 140 CSO control measure consists of a 0.05 MG off-line CSO storage pipe. The stored CSO flows will be discharged to the existing King County interceptor.
- Control measure modelling confirmed the feasibility of the above CSO control measures and estimated that the CSO control measures will reduce the CSO Outfall 020, 139 and 140 annual overflow frequencies to one or less events per year per outfall.

The Montlake CSO basin flow diversion control measure will divert flows to the King County interceptor and will consist of a new pumping station and force main. The flow diversion is described in additional detail in Section 3.5.2.3, Flow Diversion Projects.

There are two potential shared CSO control measures involving the Montlake CSO area and they are described in Section 3.5.2, Shared Project Control Measures. The first potential shared CSO control measure is a shared storage tank that will include storage for the King County Montlake Regulator and the City Montlake and Leschi CSO basins. The second potential shared CSO control measure involves a shared tunnel project with King County where the Montlake CSO area will be included in the storage capacity.

3.5.1.10 Leschi CSO Area

The Leschi CSO area covers 405 acres (0.63 square mile) in east Seattle; it is located on the western shore of Lake Washington along Lake Washington Boulevard from approximately S McClellan Street to E John Street. The Leschi CSO area comprises CSO Basins 026 through 036, which drain from south to north toward the King County East Pine Street pump station, with the exception of CSO Basin 026, which drains from north to south.

CSO Basin 032 has two overflow points; each has its own CSO designation (032(A) and 032(B)), but they share a common outfall. The wastewater generated in all the Leschi basins flows by gravity to King County's East Pine Street pump station for conveyance to the West Point WWTP. The Leschi CSO area is partially separated. The basins within the Leschi CSO area contain permitted CSO structures that discharge overflows to Lake Washington during large precipitation events when the capacity of the CSS is exceeded. Figure 3-11 shows the Leschi CSO area boundary, CSO outfall location, and general area for potential CSO control measure implementation.

Figure 3-11. Leschi CSO Boundaries, CSO Outfall Locations, and General Area for Potential CSO Control Measure Implementation

3.5.1.10.1 CSO Control Volumes

Section 2.8 described the LTCP hydraulic modelling performed to determine the CVs for each uncontrolled CSO outfall. Table 3-24 lists the Leschi CSO outfall long-term average annual overflow frequency, average annual overflow volume, and CVs. Control volumes were estimated for possible effects of climate change and without future climate change. For the LTCP, the Leschi CSO outfall CV including climate change was used as the basis for CSO control measure sizing and evaluation.

Table 3-24. Leschi CSO Outfall Control Volume

CSO Outfall	Average annual overflow frequency[a]	Average annual overflow volume (MG)[b,c]	Control volume with climate change (MG)[d]	Control volume without climate change (MG)[c, d]
028	2.7	0.87	<0.01	<0.01
029	2.7	0.13	0.02	0.01
031	13.1	0.93	0.31	0.25
032	5.4	0.27	0.08	0.05
036	2.1	0.11	0.03	0.017

[a] *2013 Annual CSO Report, Table 5-8. Outfalls Meeting Performance Standard for Controlled CSOs based on Flow Monitoring Results and Modeling*
[b] *From 20-year (1993-2012) long-term simulations with Rainfall scaling =1.0*
[c] *Estimated overflow volume after removal of climate change uncertainty but keeping other uncertainties*
[d] *Estimated control volumes less than 5,000 gallons are shown as < 0.01. Control volumes of 0.005 to 0.01 are rounded up to 0.01.*

3.5.1.10.2 CSO Control Measure Evaluation

Section 3.4 described the CSO control measure screening performed to identify the CSO control measures for LTCP evaluation. Table 3-25 lists the screened CSO control measures for further evaluation and summarizes results of the LTCP CSO control measures evaluation for this CSO area.

Table 3-25. Leschi CSO Control Measures

CSO control measure	LTCP evaluation results
Flow diversion	The City Retrofit Program evaluated potential solutions to control Leschi CSO basins and identified a flow diversion retrofit option for the King County interceptor.
Off-line storage	Two types of off-line storage were evaluated: independent City storage and shared City/King County storage. For Independent City storage, the Leschi CSO area can be hydraulically divided into a north and south areas. The North Leschi area includes CSO Basins 028, 029, 031 and 032. The South Leschi area includes CSO Basin 036. Because of potential shared King County/City storage opportunity, the LTCP evaluated the cost-effectiveness of shared storage with the King County Montlake Regulator project which is described in 3.5.2, Shared Project Control Measures.
Deep tunnel storage	The LTCP evaluated the cost-effectiveness of deep tunnel storage shared with King County. The Leschi CSO area is a tributary area to a deep tunnel storage option more fully described in Section 3.5.2, Shared Project Control Measures.

3.5.1.10.3 Final Leschi CSO Control Measures

There are two final LTCP CSO control measures for the Leschi CSO area: off-line storage and flow diversion. Figure 3-11 shows the general area for potential Leschi CSO control measure implementation.

Because of the Leschi conveyance system configuration, the Leschi CSO area can be hydraulically divided into north and south areas. The North Leschi area includes CSO Basins 028, 029, 031 and 032. The South Leschi area includes CSO Basin 036.

The North Leschi area has three separate CSO control measures:

- The CSO Basin 028 control measure consists of a 0.01 MG off-line CSO storage pipe. The stored CSO flows will be discharged to the existing King County interceptor.
- The CSO Basin 029 control measure consists of a 0.02 MG off-line CSO storage pipe. The stored CSO flows will be discharged to the existing King County interceptor.
- The CSO Basin 031 and 032 control measure consists of a combined 0.39 MG off-line CSO storage pipe. The stored CSO flows will be discharged to the existing King County interceptor.

The South Leschi area will have a single CSO control measure for CSO Basin 036, a 0.03 MG off-line CSO storage pipe. The stored CSO flows will be discharged to the existing King County interceptor.

Control measure modelling confirmed the feasibility of these CSO control measures and estimated that the CSO control measures will reduce the Basins 028, 029, 031, 032, and 036 annual overflow frequencies to one or less events per year per outfall.

The Leschi CSO area flow diversion control measure will divert flows to the King County interceptor and will consist of a new pumping station and force main. The flow diversion is described in additional detail in Section 3.5.2.3, Flow Diversion Projects.

There are two potential shared CSO control measures involving the Leschi CSO area and they are described in Section 3.5.2, Shared Project Control Measures. The first is a shared storage tank that will include storage for the King County Montlake Regulator and the City Leschi and Montlake CSO areas. The second involves a shared tunnel project with King County where the Leschi CSO area will be included in the storage capacity.

3.5.1.11 Portage Bay/Lake Union CSO Area

The Portage Bay/Lake Union CSO area covers 387 acres (0.6 square mile) in central Seattle. The Portage Bay/Lake Union CSO area is bounded by Portage Bay to the north, 11th Avenue E to the east, E Newton Street to the south, and Lake Union to the west (see Figure 2-16.). The Portage Bay/Lake Union CSO area comprises CSO Basins 127, 129, 130, 131, 132, 134, 135, 136, 138, and 175. Of the CSO basins, only CSO Outfall 138 is uncontrolled and included in the LTCP.

The Portage Bay/Lake Union CSO area generally drains from north to south along Eastlake Avenue E. Flow from CSO Basin 138 is pumped by Pump Station 20 into CSO Basin135 and flows by gravity through CSO Basins132, 130, and 175 to join the King County system farther south. Flows from house connections in CSO Basins129, 131, and 134 are pumped uphill by Pump Stations 63, 64, and 65 to join the main sewer line. Flows from CSO Basin 136 are pumped to CSO Basin 138 by Pump Station 66. All of the CSO basins contain permitted CSO structures that discharge overflows to Lake Union or Portage Bay during large precipitation events when the capacity of the CSS is exceeded. Figure 3-12 shows the Portage Bay/Lake Union CSO area boundary, CSO outfall location, and general area for potential CSO control measure implementation.

Figure 3-12. Portage Bay/Lake Union CSO Boundaries, CSO Outfall Locations, and General Area for Potential CSO Control Measure Implementation

3.5.1.11.1 CSO Control Volumes

Section 2.8 described the LTCP hydraulic modelling performed to determine the CVs for each uncontrolled CSO outfall. Table 3-26 lists the Portage Bay/Lake Union CSO outfall long-term average annual overflow frequency, average annual overflow volume, and CVs. Control volumes were estimated for possible effects with and without future climate change. For the LTCP, the Portage Bay/Lake Union CSO outfall CV including climate change was used as the basis for CSO control measure sizing and evaluation.

Table 3-26. Portage Bay/Lake Union CSO Outfall Control Volume

CSO Outfall	Average annual overflow frequency[a]	Average annual overflow volume (MG)[b,c]	Control volume with climate change (MG)[d]	Control volume without climate change (MG)[c, d]
138	1.5	0.28	0.11	0.07

[a] 2013 Annual CSO Report, Table 5-8. Outfalls Meeting Performance Standard for Controlled CSOs based on Flow Monitoring Results and Modeling
[b] From 20-year (1993-2012) long-term simulations with Rainfall scaling =1.0
[c] Estimated overflow volume after removal of climate change uncertainty but keeping other uncertainties
[d] Estimated control volumes less than 5,000 gallons are shown as < 0.01. Control volumes of 0.005 to 0.01 are rounded up to 0.01.

3.5.1.11.2 CSO Control Measure Evaluation

Section 3.4 described the CSO control measure screening performed to identify the CSO control measures for LTCP evaluation. Table 3-27 lists the screened CSO control measures for further evaluation and summarizes results of the LTCP CSO control measures evaluation for this CSO area.

Table 3-27. Portage Bay/Lake Union CSO Control Measures

CSO control measure	LTCP evaluation results
Off-line storage	Conceptual planning developed two independent storage control measures. These included a storage pipe and an underground storage tank.
Deep tunnel storage	The LTCP evaluated the cost-effectiveness of deep tunnel storage shared with King County. The Portage Bay/Lake Union CSO area is a tributary area to a deep tunnel storage option more fully described in Section 3.5.2, Shared Project Control Measures.

3.5.1.11.3 Final Portage Bay/Lake Union CSO Control Measures

There is one final LTCP CSO control measure, off-line storage, for the Portage Bay/Lake Union CSO area: Figure 3-12 shows the general area for potential Portage Bay/Lake Union CSO control measure implementation.

The SPU Portage Bay CSO control measure consists of transferring the combined sewage overflow from the SPU NPDES138 basin to a storage pipe in the right-of-way. A total maximum storage volume of 0.11 million gallons is required to control the outfall overflows at NPDES138 basin. The proposed storage pipe would be located upstream of the existing storage facility 36.

Control measure modelling confirmed the feasibility of this control measure and estimated that it will reduce the Basin 138 annual overflow frequency from 1.5 to 1 or less events per year.

There is a potential shared CSO control measures for the Portage Bay/Lake Union CSO area: a shared tunnel project with King County where the Portage Bay/Lake Union CSO area will be included in the storage capacity. The deep tunnel storage option more fully described in Section 3.5.2, Shared Project Control Measures.

3.5.1.12 Neighborhood West Ship Canal Tunnel

During evaluation of shared tunnel opportunities with King County, the conceptual planning effort identified that the Ballard and Fremont/Wallingford areas were suitable for deep tunnel construction based on existing geological information and previous tunnel construction work. This information was developed for a joint King County and City tunnel constructability workshop in December 2011.

The Neighborhood West Ship Canal Tunnel would store CSO flows from CSO Basins 150/151, 152, 147 and 174. The tunnel would be aligned between Fremont/Wallingford and Ballard as shown on Figure 3-13.

Figure 3-13. Neighborhood West Ship Canal Tunnel CSO Boundaries, CSO Outfall Locations, and General Area for Potential CSO Control Measure Implementation

3.5.1.12.1 CSO Control Volumes

Section 2.8 described the LTCP hydraulic modelling performed to determine the CVs for each uncontrolled CSO outfall. As described above, the Neighborhood West Ship Canal Tunnel would combine the storage requirements for the Ballard and Fremont/Wallingford CSO area into a single deep storage tunnel. Table 3-28 lists the Neighborhood West Ship Canal Tunnel CSO outfall long-term average annual overflow frequency, average annual overflow volume, and CVs. Control volumes were estimated for possible effects with and without future climate change. For the LTCP, a Neighborhood West Ship Canal Tunnel CSO outfall total CV of 9.2 MG, including climate change, was used as the basis for CSO control measure sizing and evaluation.

Table 3-28. Neighborhood West Ship Canal Control Volume

CSO Outfall	Average annual overflow frequency[a]	Average annual overflow volume (MG)[b,c]	Control volume with climate change (MG)[d]	Control volume without climate change (MG)[c, d]
150/151	17.1	2.67	0.62	0.45
152	45.8	21.38	5.38	4.38
147	38.1	8.14	2.15	1.96
174	8.7	3.33	1.06	0.99
Total			9.21	

[a] *2013 Annual CSO Report, Table 5-8. Outfalls Meeting Performance Standard for Controlled CSOs based on Flow Monitoring Results and Modeling*
[b] *From 20-year (1993-2012) long-term simulations with Rainfall scaling =1.0*
[c] *Estimated overflow volume after removal of climate change uncertainty but keeping other uncertainties*
[d] *Estimated control volumes less than 5,000 gallons are shown as < 0.01. Control volumes of 0.005 to 0.01 are rounded up to 0.01.*

3.5.1.12.2 CSO Control Measure Evaluation

The storage tunnel alignment is generally in the right-of-way from a site in the vicinity of the southern end of CSO Basin 147 toward CSO Basin 150/151 and 152 outfalls. There would be an effluent pump station at the west end of the tunnel and it would discharge to the King County Ballard Siphon. Hydraulic modeling of the tunnel indicates that 9.21 MG of combined Ballard and Fremont-Wallingford storage would be required to reduce overflow frequency to one or less annual overflows at the contributing outfalls.

The City employed an expert tunnel engineer and a tunnel contractor to validate the costs and schedule for the independent and shared West Ship Canal Tunnel control measures. Both costs and schedules were validated by the expert designer and contractor and several recommendations were provided that can be found in the two independent reports entitled LTCP Cost and Schedule Review Final Report, Jacobs Associates, February 21, 2014; and Cost Review Report LTCP Tunnel Construction Cost Estimate Validation & Schedule Review, Frank Coluccio Construction Co., January 10, 2014.

3.5.1.12.3 Final Neighborhood West Ship Canal Tunnel CSO Control Measure

Based on the expert review recommendations, a minimum tunnel diameter was recommended to accommodate spoils removal and intervention. Consequently, the tunnel volume for this control measure increased from 9.2 MG to 13 MG.

Control measure modeling estimated that the Neighborhood West Ship Canal Tunnel with a storage volume of 13 MG will reduce the CSO Basin 150/151, 152. 147, and 174 annual overflow frequencies to 0.5 events per year per outfall.

3.5.2 Shared Project Control Measures

King County began its CSO update planning in 2009. Because the City and the County were preparing similar documents during the same period and the two combined sewer systems were geographically and hydraulically linked, King County approached the City to identify potential collaborative opportunities.

The two agencies evaluated 40 potential shared projects and identified 4 feasible shared storage projects to evaluate in each agency's respective CSO plan: shared Fremont/Wallingford/3rd Avenue W Regulator storage, shared North Union Bay/University Regulator storage, shared Montlake/Montlake Regulator storage, and a deep tunnel along the Ship Canal.

During evaluation of the deep tunnel along the Ship Canal, an additional opportunity became apparent consisting of a deep tunnel serving the Ballard/Fremont/Wallingford/3rd Avenue W Regulator. This option was termed the Shared West Ship Canal Tunnel and is similar in concept to the Neighborhood West Ship Canal Tunnel described in an earlier section of this plan.

In addition to shared storage, the two agencies also looked at flow diversion opportunities for Montlake, Leschi, Magnolia, East Waterway, and Duwamish.

3.5.2.1 Shared Surface Tank Storage

Three of the City's largest CSO areas lie along the Ship Canal and are adjacent to King County regulators. The proximity of each agency's CSO control projects creates the opportunity for cost and environmental impact reductions through sharing facilities. These areas are depicted in Figure 3-14.

Figure 3-14. Shared Storage Projects Overview

3.5.2.1.1 City North Union Bay/King County University Regulator

Two shared alternatives were developed for CSO Basin 018 and King County's University Regulator. One was a tank on private property and the other a tunnel in the right-of-way. The private property alternative became the basis for the shared project and was subsequently recommended as a preferred alternative in the King County CSO Plan.

3.5.2.1.1.1 CSO Control Volumes

Section 2.8 described the LTCP hydraulic modelling performed to determine the CVs for each uncontrolled CSO outfall. Table 3-29 lists the NUB CSO outfall's long-term average annual overflow frequency, average annual overflow volume, and CVs. For the City outfalls, CVs were estimated with and without future climate change. For the LTCP, the CSO outfall CVs including climate change were used as the basis for CSO control measure sizing and evaluation except for King County.

Table 3-29. North Union Bay/University Regulator CSO Outfall Control Volumes

CSO Outfall	Average annual overflow frequency	Average annual overflow volume (MG)	Control volume with climate change (MG)	Control volume without climate change (MG)
CSO Outfall 018	4.1[a]	5.1[b,c]	1.63[d]	1.17[c, d]
King County University Regulator	1.6[e]	19.4[e]	NA[f]	2.94[g]

[a] 2013 Annual CSO Report, Table 5-8. Outfalls Meeting Performance Standard for Controlled CSOs based on Flow Monitoring Results and Modeling
[b] From 20-year (1993-2012) long-term simulations with Rainfall scaling =1.0
[c] Estimated overflow volume after removal of climate change uncertainty but keeping other uncertainties
[d] Estimated control volumes less than 5,000 gallons are shown as < 0.01. Control volumes of 0.005 to 0.01 are rounded up to 0.01.
[e] Long-term average (LTA) value from King County 2010 modeling (King County, 2011 CSO Control Program Review, Summary of Technical Memorandums, Table 3-3. Annual Average Frequency and Volume of Untreated CSOs: Monitored CSOs Compared to Modeled CSOs, November 2011). Reference 33
[f] Climate change was not explicitly considered in King County modeling.
[g] Estimated overflow volume from King County 2010 modeling (King County, 2011 CSO Control Program Review, Summary of Technical Memorandums, Table 4-5. Key Results from October 2010 Modeling Run, November 2011).

3.5.2.1.1.2 CSO Control Measure Evaluation

Section 3.4 described the CSO control measure screening performed to identify the CSO control measures for LTCP evaluation. Table 3-30 lists the screened control measures for further evaluation and summarizes the results of the LTCP CSO control measures for the affected CSO outfalls.

Table 3-30. NUB/University Regulator CSO Control Measures

CSO control measure	LTCP evaluation results
Off-line storage	Two types of off-line storage were evaluated: storage tanks and a short tunnel. The storage tank was determined to be the most cost-effective shared option.

3.5.2.1.1.3 Final Shared NUB/University Regulator Control Measure

The North Union Bay/University Regulator shared CSO control measure consists of transferring CSO overflow volume to multiple collection system control structures, a new multi-cell underground storage tank, and the necessary infrastructure to divert and convey combined sewer flows to and from storage. In order to reduce the number of CSO occurrences in the North Union Bay /University Regulator area to an average of one per year, an estimated storage volume of 4.57 million gallons is required.

3.5.2.1.2 City Montlake/City Madison Park/City Leschi Regulator

Diversion of all Montlake/Madison Park/Leschi flows to a proposed shared tank was evaluated as a potential shared project with King County. This tank was subsequently recommended as a preferred alternative in the King County CSO Plan.

3.5.2.1.2.1 CSO Control Volumes

Section 2.8 described the LTCP hydraulic modelling performed to determine the CVs for each uncontrolled CSO Outfall. Table 3-31 lists the Montlake/Leschi CSO outfall's long-term average annual overflow frequency, average annual overflow volume, and CVs. City CVs were estimated with and without future climate change. For the LTCP, the Montlake/Leschi CSO outfall CVs including climate change were used as the basis of CSO control measure sizing and evaluation except for King County.

Table 3-31. Montlake/Leschi/Montlake Regulator CSO Outfall Control Volumes

CSO Outfall	Average annual overflow frequency	Average annual overflow volume (MG)	Control volume with climate change (MG)	Control volume without climate change (MG)
020	1.3[a]	0.61[b,c]	0.16[d]	0.12[c, d]
139	1.2[a]	0.03[b,c]	0.01[d]	<0.01[c, d]
140	3.7[a]	0.25[b,c]	0.05[d]	0.02[c, d]
028	2.6[a]	0.87[b,c]	<0.01[d]	<0.01[c, d]
029	2.4[a]	0.13[b,c]	0.02[d]	0.01[c, d]
031	13.8[a]	0.93[b,c]	0.31[d]	0.25[c, d]
032	5.5[a]	0.27[b,c]	0.08[d]	0.05[c, d]
036	2.0[a]	0.11[b,c]	0.03[d]	0.017[c, d]
King County Montlake Regulator	10.8[e]	28.8[e]	NA[f]	6.60[g]

[a] 2013 Annual CSO Report, Table 5-8. Outfalls Meeting Performance Standard for Controlled CSOs based on Flow Monitoring Results and Modeling
[b] From 20-year (1993-2012) long-term simulations with Rainfall scaling =1.0
[c] Estimated overflow volume after removal of climate change uncertainty but keeping other uncertainties
[d] Estimated control volumes less than 5,000 gallons are shown as < 0.01. Control volumes of 0.005 to 0.01 are rounded up to 0.01.
[e] Long-term average (LTA) value from King County 2010 modeling (King County, 2011 CSO Control Program Review, Summary of Technical Memorandums, Table 3-3. Annual Average Frequency and Volume of Untreated CSOs: Monitored CSOs Compared to Modeled CSOs, November 2011).
[f] Climate change was not explicitly considered in King County modeling.
[g] Estimated overflow volume from King County 2010 modeling (King County, 2011 CSO Control Program Review, Summary of Technical Memorandums, Table 4-5. Key Results from October 2010 Modeling Run, November 2011).

3.5.2.1.2.2 CSO Control Measure Evaluation

Section 3.4 described the CSO control measure screening performed to identify the CSO control measures for LTCP evaluation. Table 3-32 lists the screened control measures for further evaluation and summarized the results of the LTCP CSO control measures for the affected CSO outfalls.

Table 3-32. Montlake/Leschi/Montlake Regulator CSO Control Measures

CSO control measure	LTCP evaluation results
Off-line storage	A storage tank was the only alternative evaluated. The storage tank was determined to be the most cost-effective shared option.

3.5.2.1.2.3 Final Shared Montlake/Leschi/Montlake Regulator CSO Control Measure

The Montlake/Leschi/Montlake Regulator shared CSO control measure consists of transferring CSO overflow volume to multiple collection system control structures, a new multi-cell underground storage tank, and the necessary infrastructure to divert and convey combined sewer flows to and from storage. In order to reduce the number of CSO occurrences in the Montlake/Leschi/Montlake Regulator areas to an average of one per year, an estimated storage volume of 7.26 million gallons is required.

3.5.2.1.3 City Fremont/Wallingford/King County 3rd Avenue W Regulator

Four collaborative alternatives were developed by the City and one by King County. The City alternatives included storage within the right-of-way, a tank on a park site, and tanks on one of two private properties. King County developed a storage site on the south side of the Ship Canal. The storage within the right-of-way was recommended as a preferred alternative in the King County CSO Plan.

3.5.2.1.3.1 CSO Control Volumes

Section 2.8 described the LTCP hydraulic modelling performed to determine the CVs for each uncontrolled CSO outfall. Table 3-33 lists the Fremont/Wallingford/3rd Avenue W Regulator CSO outfall's long-term average annual overflow frequency, average annual overflow volume, and CVs. For the City outfalls, CVs were estimated with and without future climate change. For the LTCP, the Fremont/Wallingford CSO outfall CVs including climate change were used for the basis of CSO control measure sizing and evaluation except for King County.

Table 3-33. Fremont/Wallingford/3rd Ave W Regulator CSO Outfall Control Volumes

CSO Outfall	Average annual overflow frequency	Average annual overflow volume (MG)	Control volume with climate change (MG)	Control volume without climate change (MG)
147	38.1[a]	8.14[b,c]	2.15[d]	1.96[c, d]
174	8.4[a]	3.33[b,c]	1.06[d]	0.99[c, d]
King County 3rd Ave W Regulator	16.6[e]	17.1[e]	NA[f]	4.18[g]

[a] 2013 Annual CSO Report, Table 5-8. Outfalls Meeting Performance Standard for Controlled CSOs based on Flow Monitoring Results and Modeling
[b] From 20-year (1993-2012) long-term simulations with Rainfall scaling =1.0
[c] Estimated overflow volume after removal of climate change uncertainty but keeping other uncertainties
[d] Estimated control volumes less than 5,000 gallons are shown as < 0.01. Control volumes of 0.005 to 0.01 are rounded up to 0.01.
[e] Long-term average (LTA) value from King County 2010 modeling (King County, 2011 CSO Control Program Review, Summary of Technical Memorandums, Table 3-3. Annual Average Frequency and Volume of Untreated CSOs: Monitored CSOs Compared to Modeled CSOs, November 2011).
[f] Climate change was not explicitly considered in King County modeling.
[g] Estimated overflow volume from King County 2010 modeling (King County, 2011 CSO Control Program Review, Summary of Technical Memorandums, Table 4-5. Key Results from October 2010 Modeling Run, November 2011).

3.5.2.1.3.2 CSO Control Measure Evaluation

Section 3.4 described the CSO control measure screening performed to identify the CSO control measures for LTCP evaluation. Table 3-34 lists the screened control measures for further evaluation and summarized the results of the LTCP CSO control measures for the affected CSO outfalls.

Table 3-34. Fremont/Wallingford/3rd Ave W Regulator CSO Control Measures

CSO control measure	LTCP evaluation results
Off-line storage	Two types of off-line storage were evaluated: storage tanks and a deep tunnel. The deep tunnel was determined to be the most cost-effective shared option.

3.5.2.1.3.3 Final Shared Fremont/Wallingford/3rd Ave W Regulator CSO Control Measure

The Fremont/Wallingford/3rd Ave W Regulator shared CSO control measure consists of transferring CSO overflow volume to multiple collection system control structures, storage within the right-of-way, and the necessary infrastructure to divert and convey combined sewer flows to and from storage. In order to reduce the number of CSO occurrences in the Fremont/Wallingford/3rd Ave W Regulator area to an average of one per year, an estimated storage volume of 7.39 million gallons is required.

3.5.2.2 Shared Tunnel Projects

3.5.2.2.1 Shared West Ship Canal Tunnel

During evaluation of shared tunnel opportunities with King County, the conceptual planning effort identified that the Ballard and Fremont/Wallingford areas were suitable for deep tunnel construction based on existing geological information and previous tunnel construction work. This information was developed for a joint King County and City tunnel constructability workshop in December 2011.

The Shared West Ship Canal Tunnel would store CSO flows from City CSO Outfalls 150/151, 152, 147 and 174 and from King County's 3rd Avenue West Regulator.

Figure 3-15. Shared West Ship Canal Tunnel

3.5.2.2.1.1 CSO Control Volumes

Section 2.8 described the LTCP hydraulic modelling performed to determine the CVs for each uncontrolled CSO outfall. Table 3-35 lists the Fremont/Wallingford/Ballard/3rd Avenue W Regulator CSO outfall's long-term average annual overflow frequency, average annual overflow volume, and CVs. City CVs were estimated with and without future climate change. For the LTCP, the CVs including climate change were used as the basis of CSO control measure sizing and evaluation except for King County.

Table 3-35. Shared West Ship Canal Tunnel CSO Outfall Control Volumes

CSO Outfall	Average annual overflow frequency	Average annual overflow volume (MG)	Control volume with climate change (MG)	Control volume without climate change (MG)
147	38.1[a]	8.14 [b,c]	2.15 [d]	1.96 [c, d]
174	8.4[a]	3.33 [b,c]	1.06 [d]	0.99 [c, d]
150/151	17.1 [a]	2.67 [b,c]	0.62 [d]	0.45 [c, d]
152	45.8 [a]	21.38 [b,c]	5.38 [d]	4.38 [c, d]
King County 3rd Avenue W Regulator	16.6 [e]	17.1 [e]	NA[f]	4.18 [g]

[a] *2013 Annual CSO Report, Table 5-8. Outfalls Meeting Performance Standard for Controlled CSOs based on Flow Monitoring Results and Modeling*
[b] *From 20-year (1993-2012) long-term simulations with Rainfall scaling =1.0*
[c] *Estimated overflow volume after removal of climate change uncertainty but keeping other uncertainties*
[d] *Estimated control volumes less than 5,000 gallons are shown as < 0.01. Control volumes of 0.005 to 0.01 are rounded up to 0.01.*
[e] *Long-term average (LTA) value from King County 2010 modeling (King County, 2011 CSO Control Program Review, Summary of Technical Memorandums, Table 3-3. Annual Average Frequency and Volume of Untreated CSOs: Monitored CSOs Compared to Modeled CSOs, November 2011).*
[f] *Climate change was not explicitly considered in King County modeling.*
[g] *Estimated overflow volume from King County 2010 modeling (King County, 2011 CSO Control Program Review, Summary of Technical Memorandums, Table 4-5. Key Results from October 2010 Modeling Run, November 2011).*

3.5.2.2.1.2 Control Measure Evaluation

The storage tunnel alignment is generally in the right-of-way from a site in the vicinity of the southern end of CSO Basin147 (Fremont/Wallingford) toward the CSO Basin 150/151 and 152 outfalls (Ballard). There would be an effluent pump station at the west end of the tunnel that would discharge to the King County Ballard Siphon. A dual discharge system was evaluated that would direct flows to either the Ballard or Fremont siphons as operating hydraulic conditions required. Based on communications between the City and King County modelers, this control measure was modified to direct flows only to the Ballard siphon. Hydraulic modeling of the tunnel indicated that 13.39 MG of combined Ballard and Fremont-Wallingford and 3rd Avenue West Regulator storage would be required to reduce overflow frequency to one or less annual overflows.

The City employed an expert tunnel engineer and a tunnel contractor to validate the costs and schedule for the Shared West Ship Canal Tunnel control measure (as well as for the Ship Canal Tunnel and Neighborhood West Ship Canal Tunnel). Both costs and schedules were validated by the expert designer and contractor and several recommendations were provided that can be found in the two independent reports entitled LTCP Cost and Schedule Review Final Report, Jacobs Associates, February 21, 2014; and Cost Review Report LTCP Tunnel Construction Cost Estimate Validation & Schedule Review, Frank Coluccio Construction Co., January 10, 2014.

Investigation of this shared tunnel with King County is ongoing.

3.5.2.2.2 Final Shared West Ship Canal Tunnel Control Measure

Control measure modelling estimated that the Shared West Ship Canal Tunnel with a storage volume of 13.39 MG will reduce the CSO Outfall 150/151, 152. 147, and 174 and King County 3rd Avenue W Regulator annual overflow frequencies to less than 1.0 event per year per outfall. Appropriate odor control, surge control, redundancy, and maintenance facilities were included in the costs for the final control measure.

3.5.2.2.3 Ship Canal Tunnel

A separate collaborative storage control measure was developed consisting of a deep tunnel generally located beneath the Ship Canal and spanning from the University District to Fremont/Wallingford. This is called the Ship Canal tunnel.

Diversion of all Ballard, Fremont/Wallingford, North Union Bay, Montlake, Portage Bay, and Leschi flows to the Ship Canal Tunnel would be a part of the tunnel construction project. King County CSO flows from University Regulator, Montlake Regulator, and 3rd Avenue West Regulator would also be included. In its original form, the Ship Canal Tunnel did not include flows from Ballard, but conveyance lines were added to transport flows from the two Ballard basins to the tunnel. Figure 3-16 presents the Ship Canal Tunnel boundaries.

Tunnel workshops were conducted in 2011 with King County and several tunnel experts to review the opportunities and risks associated with this concept. Conclusions from the tunnel workshops are included in the report entitled: Joint City/King County CSO Tunnel Option Expert Panel Review, January 2012. In general, the assembled subject matter experts concluded that a tunnel would be feasible.

Figure 3-16. Shared Ship Canal Tunnel

3.5.2.2.3.1 Control Volumes

Section 2.8 described the LTCP hydraulic modelling performed to determine the CVs for each uncontrolled CSO outfall. Table 3-36 lists the Ship Canal Tunnel contributing CSO outfall's long-term average annual overflow frequency, average annual overflow volume, and CVs. Control volumes were estimated with and without future climate change. For the LTCP, the contributing CSO outfall CVs including climate change were used for the basis of CSO control measure sizing and evaluation except for King County.

Table 3-36. Shared Ship Canal Tunnel CSO Outfall Control Volumes

CSO Outfall	Average annual overflow frequency	Average annual overflow volume (MG)	Control volume with climate change (MG)	Control volume without climate change (MG)
150/151	17.1[a]	2.67 [b,c]	0.62 [d]	0.45 [c, d]
152	45.8[a]	21.38 [b,c]	5.38 [d]	4.38 [c, d]
147	38.1[a]	8.14 [b,c]	2.15 [d]	1.96 [c, d]
174	8.4[a]	3.33 [b,c]	1.06 [d]	0.99 [c, d]
138	1.4[a]	0.28 [b,c]	0.11 [d]	0.07 [c, d]
018	4.1[a]	5.1 [b,c]	1.63 [d]	1.17 [c, d]
020	1.3[a]	0.61 [b,c]	0.16 [d]	0.12 [c, d]
139	1.2[a]	0.03 [b,c]	0.01 [d]	<0.01 [c, d]
140	3.7[a]	0.25 [b,c]	0.05 [d]	0.02 [c, d]
028	2.6[a]	0.87 [b,c]	<0.01 [d]	<0.01 [c, d]
029	2.4[a]	0.13 [b,c]	0.02 [d]	0.01 [c, d]
031	13.8[a]	0.93 [b,c]	0.31 [d]	0.25 [c, d]
032	5.5[a]	0.27 [b,c]	0.08 [d]	0.05 [c, d]
036	2.0[a]	0.11 [b,c]	0.03 [d]	0.017 [c, d]
King County 3rd Avenue W Regulator	16.6 [e]	17.1 [e]	NA[f]	4.18 [g]
King County University Regulator	1.6 [e]	19.4 [e]	NA[f]	2.94 [g]
King County Montlake Regulator	10.8 [e]	28.8 [e]	NA[f]	6.60 [g]

[a] *2013 Annual CSO Report, Table 5-8. Outfalls Meeting Performance Standard for Controlled CSOs based on Flow Monitoring Results and Modeling*
[b] *From 20-year (1993-2012) long-term simulations with Rainfall scaling =1.0*
[c] *Estimated overflow volume after removal of climate change uncertainty but keeping other uncertainties*
[d] *Estimated control volumes less than 5,000 gallons are shown as < 0.01. Control volumes of 0.005 to 0.01 are rounded up to 0.01.*

[e] *Long-term average (LTA) value from King County 2010 modeling (King County, 2011 CSO Control Program Review, Summary of Technical Memorandums, Table 3-3. Annual Average Frequency and Volume of Untreated CSOs: Monitored CSOs Compared to Modeled CSOs, November 2011).*

[f] *Climate change was not explicitly considered in King County modeling.*

[g] *Estimated overflow volume from King County 2010 modeling (King County, 2011 CSO Control Program Review, Summary of Technical Memorandums, Table 4-5. Key Results from October 2010 Modeling Run, November 2011).*

3.5.2.2.3.2 Control Measure Evaluation

The storage tunnel alignment is generally in the right-of-way from a site in the vicinity of CSO Basin 018 (University District) toward the CSO Outfall 174 (Fremont/Wallingford). An effluent pump station at the west end of the tunnel would discharge to the King County Ballard Siphon. Hydraulic modelling of the tunnel indicated that 27.39 MG of combined storage would be required to reduce overflow frequency to one or less annual overflows at each of the contributing outfalls.

The City employed an expert tunnel engineer and a tunnel contractor to validate the costs and schedule for the Ship Canal Tunnel control measure (as well as for the Shared West Ship Canal Tunnel and Neighborhood West Ship Canal Tunnel). Both costs and schedules were validated by the expert designer and contractor and several recommendations were provided that can be found in the two independent reports entitled LTCP Cost and Schedule Review Final Report, Jacobs Associates, February 21, 2014; and Cost Review Report LTCP Tunnel Construction Cost Estimate Validation & Schedule Review, Frank Coluccio Construction Co., January 10, 2014.

3.5.2.2.3.3 Final Ship Canal Tunnel Control Measure

Control measure modelling estimated that the Ship Canal Tunnel with a storage volume of 27.39 MG will reduce the CSO Outfall 150/151, 152. 147, and 174, 138, 018, 020, 139, 140, 028, 029, 031, 032, 036, , and King County 3rd Avenue W Regulator, University Regulator and Montlake Regulator annual overflow frequencies to less than 1.0 event per year per outfall.. Appropriate odor control, surge control, redundancy, and maintenance facilities were included in the costs for the final control measure.

Figure 3-17. Flow Diversion Projects Overview

3.5.2.3 Flow Diversion Projects

Flow diversions are projects that transfer flows (generally through constructed pipes and pump stations) from overflow points to other places in the system where capacity is available. These projects are shown in Figure 3-17.

Implementation of flow diversion projects will require coordination with King County. Specifically, the City and King County will need to analyze the impacts of the proposed project on the downstream system and agree on an approach to address those impacts.

3.5.2.3.1 Duwamish Flow Diversion

Two collaborative alternatives were developed for Duwamish. Both involved conveyance of flows to King County's Duwamish pump station as a flow diversion.

3.5.2.3.2 Magnolia Flow Diversion

Two collaborative alternatives were developed based on transfer of flows to the Fort Lawton tunnel. One replaced a pump station and the second added a new pump station to the existing one. Further analysis under the Retrofit Program returned this control measure to the list of potential opportunities.

3.5.2.3.3 Leschi Flow Diversion

Two collaborative diversion control measure alternatives were developed for Leschi. These involved conveyance of flows north into the King County system. The diversion concept is being refined under the Retrofit Program. Two collaborative alternatives were developed based on flow diversion control measures of flows north into the King County System. These flow diversion concepts are being refined under the Retrofit Program.

3.5.2.3.4 East Waterway Flow Diversion

The proximity of the outfall to the proposed King County HLKK wet-weather treatment plant suggested that a flow diversion to the plant might be a more cost-effective solution. This control alternative has been evaluated and would be considered under the strategy of shared City/King County projects.

3.5.2.3.5 Delridge Flow Diversion

During the Sewer System Improvement Program's analysis of the Delridge CSO area, a concept was developed that transferred flows from CSO Basin 099 to the Harbor Island trunk.

Table 3-37 summarizes CVs and CSO control measure options that are applicable to each basin.

Table 3-37. Summary of LTCP Control Volumes and Options

CSO basin	LTCP control volume (MG)	LTCP CSO control measure options	Comments
Ballard			
150/151	0.622	Off-line storage Deep tunnel storage (shared City/King County) Deep tunnel (City only)	
152	5.375	Off-line storage Deep tunnel storage (shared City/King County) Deep tunnel (City only)	
Magnolia			
060	0.110	Off-line storage Collection system improvements (retrofit) Flow diversion to King County North Interceptor	
North Union Bay			
018	1.627	Off-line storage Collection system improvements (retrofit) Shared City/King County storage	

Table 3-37. Summary of LTCP Control Volumes and Options			
CSO basin	**LTCP control volume (MG)**	**LTCP CSO control measure options**	**Comments**
Central Waterfront			
069	0.070	Off-line storage	
Fremont-Wallingford			
147	2.150	Off -line storage Shared City/King County storage Deep tunnel storage (shared City/King County) Deep tunnel (City only)	
174	1.060	Off -line storage Shared City/King County storage Deep tunnel storage (shared City/King County) Deep tunnel storage (City only)	
Duwamish			
111	0.012	Off-line storage (2) Collection system improvements (retrofit) Flow diversion to King County interceptor	
East Waterway			
107	0.500	Off-line storage Flow diversion to King County HLKK CSO plant	The approved King Co CSO Plan identified two opportunities for flow diversion projects related to the HLKK CSO plant. Because of the close proximity of the City CSO Basin 107 to the proposed King County HLKK CSO plant, it is potentially cost-effective to divert CSO Basin 107 flows to the new King County CSO plant.
Delridge/Longfellow			
099 168 169	0.171 0.250 0.250	Collection system improvements (retrofit) Off-line storage (3)	The proposed 2010-15 retrofits will significantly reduce the overflow frequencies for CSO Basin 168 and 169. Additional CSO Basin 168 and 169 CSO control measures will be evaluated to meet the CSO performance standard, and will be included as an LTCP project for this basin.

Table 3-37. Summary of LTCP Control Volumes and Options

CSO basin	LTCP control volume (MG)	LTCP CSO control measure options	Comments
Montlake			
020	0.163	Collection system improvements (retrofit) Off-line storage Shared City/King County storage Deep tunnel (shared City/King County)	
139	0.007	Collection system improvements (retrofit) Off-line storage Shared City/King County storage Deep tunnel (shared City/King County)	
140	0.058	Collection system improvements (retrofit) Off-line storage Shared City/King County storage Deep tunnel (shared City/King County)	
Leschi			
028	0.003	Collection system improvements (retrofit) Off-line storage Shared City/King County storage Deep tunnel storage shared City/King County)	LTCP hydraulic modelling indicated that CSO Outfalls 028, 029, 030, 031, 032, and 033 are hydraulically linked and must be evaluated as a system in the LTCP.
029	0.015	Collection system improvements (retrofit) Off-line storage Shared City/King County storage Deep tunnel storage shared City/King County)	
031	0.313	Collection system improvements (retrofit) Off-line storage Shared City/King County storage Deep tunnel storage shared City/King County)	
032	0.075	Collection system improvements (retrofit) Off-line storage Shared City/King County storage Deep tunnel storage shared City/King County)	
036	0.027	Collection system improvements (retrofit) Off-line storage Shared City/King County storage Deep tunnel storage shared City/King County)	LTCP hydraulic modelling indicated that CSO Outfalls 033, 034, 035, and 036 are hydraulically linked and must be evaluated as a system in the LTCP.

Table 3-37. Summary of LTCP Control Volumes and Options			
CSO basin	**LTCP control volume (MG)**	**LTCP CSO control measure options**	**Comments**
Portage Bay			
138	0.106	Off-line storage Deep tunnel storage (shared City/King County)	

3.6 LTCP Alternative Option Definition

The long-term control plan must provide a comprehensive solution to overflows from the CSS. This means that the control measures for uncontrolled CSO area must as a whole meet the requirements of the Consent Decree in reducing overflows to one per outfall per year. The individual control measures detailed above have been combined into four groups of options that achieve this objective. The groups include an independent storage option (either neighborhood tanks or a neighborhood tunnel) and three shared City/King County options. These are graphically displayed in Table 3-38 and Figures 3-18 through 3-21.

For the LTCP, system-wide options were developed under one of two basic concepts: the City meets their consent decree-mandated control responsibilities through implementation of independent control measures, or the City participates in one or more shared projects with King County to take advantage of potential cost and impact reduction opportunities.

Individual control measures for each CSO area were developed by the City to support an independent (neighborhood) system-wide solution.

One option under the shared project strategy is to combine facilities when both agencies must construct storage facilities close to one another. This resulted in the Shared Storage option. CSO areas that are not part of the shared project will require implementation of the independent (neighborhood) control measure.

Another option under the shared project strategy is to consolidate CSO storage for six City uncontrolled CSO basins and three King County uncontrolled CSO basins in a deep tunnel. This resulted in the Ship Canal Tunnel Option. CSO areas that are not part of the shared project will require implementation of the independent (neighborhood) control measures.

During development of the Ship Canal Tunnel Option, the feasibility of another potentially cost-effective shared tunnel solution, the West Ship Canal Tunnel (combining volumes from Ballard, Fremont/Wallingford, and 3rd Avenue W Regulator) was identified and evaluated. This option became the Neighborhood and Shared West Ship Canal Tunnel options.

The Table 3-38 presents the LTCP basin areas and explains how they fit into the four CSO control options.

Table 3-38. Option Development

CSO areas	LTCP options			
	Neighborhood Storage	**Shared storage**	**Shared West Ship Canal Tunnel**	**Shared Ship Canal Tunnel**
Ballard	Off-line storage tank or deep tunnel with Fremont/Wallingford	Off-line storage tank	Shared deep tunnel with Fremont/ Wallingford	Shared deep tunnel
Magnolia	Off-line storage pipe	Off-line storage pipe	Flow diversion to North Interceptor	Flow diversion to North Interceptor
North Union Bay	Collection system improvement	Shared off-line storage tank	Collection system improvement	Shared deep tunnel
Central Waterfront	Off-line storage pipe	Off-line storage pipe	Off-line storage pipe	Off-line storage pipe
Fremont/ Wallingford	Off-line storage tank or shared deep tunnel with Ballard	Shared off-line storage tank	Shared deep tunnel with Ballard	Shared deep tunnel
Duwamish	2 off-line storage pipes	2 off-line storage pipes	2 off-line storage pipes	Flow diversion to Duwamish Interceptor
Delridge	3 off-line storage pipes	3 off-line storage pipes	3 off-line storage pipes	Flow diversion to Harbor trunk plus 2 off-line storage pipes
Montlake	3 off-line storage pipes	Shared off-line storage tank	3 off-line storage pipes	Shared deep tunnel
Leschi	3 off-line storage pipes plus 1 off-line storage tank	Shared off-line storage tank	3 off-line storage pipes plus 1 off-line storage tank	Shared deep tunnel
East Waterway	Off-line storage tank	Flow diversion to HLKK treatment plant	Flow diversion to HLKK treatment plant	Flow diversion to HLKK treatment plant
Portage Bay	Off-line storage pipe	Off-line storage pipe	Off-line storage pipe	Shared deep tunnel

The following figures show the component basin projects included in each of the four LTCP options. Additionally, attached to each area map is an explanation of the option itself and how the option plans to address the uncontrolled basins not immediately affected by the shared project.

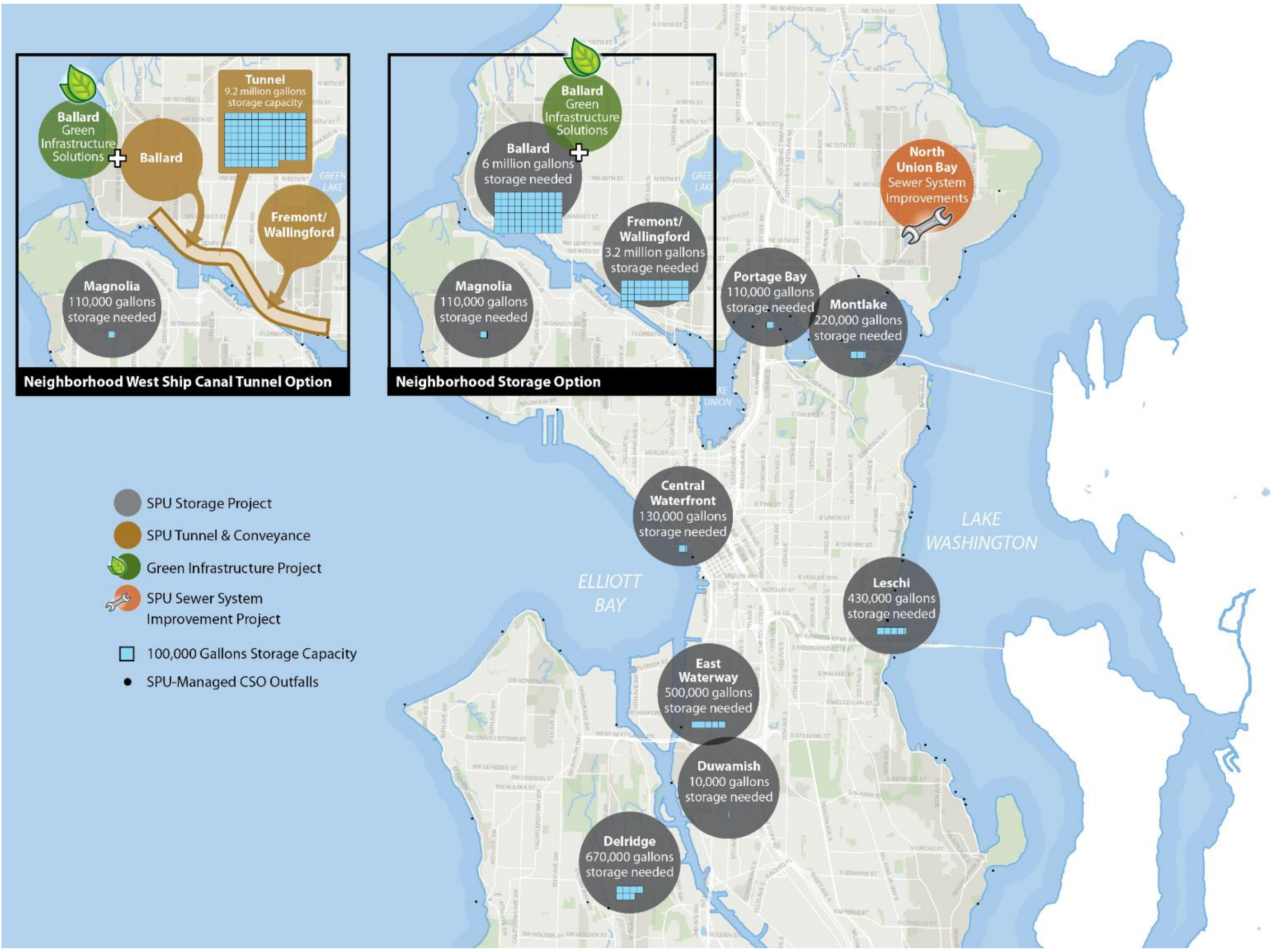

Figure 3-18. Neighborhood Storage Options

3.6.1 Neighborhood Storage Options

Under the Neighborhood Storage Option, the City would build underground storage facilities in Ballard, Fremont/Wallingford, Magnolia, Portage Bay, Montlake, Leschi, Central Waterfront, Duwamish, Delridge, and East Waterway CSO areas and sewer system improvements in the North Union Bay CSO area. This option involves building the largest number of storage facilities throughout the city.

There are two variations in the Neighborhood Storage Option: One would provide storage in tanks and pipes only, and the other would include a tunnel (Neighborhood West Ship Canal Tunnel) in combination with tanks and pipes. The storage tank/pipe option involves the greatest number of affected locations. The Neighborhood West Ship Canal Tunnel Option was developed because the two CSO areas with the largest storage volumes (Ballard and Fremont/Wallingford) are relatively close to one another. The Neighborhood West Ship Canal Tunnel Option likely reduces the number of facilities and neighborhood impacts.

Implementation of the North Union Bay sewer system improvements will require City coordination with King County because additional flows will be transferred to the King County system. Specifically, the City and King County will need to analyze the impacts of the proposed project on the downstream system and agree on an approach to address those impacts.

Figure 3-19. Shared West Ship Canal Tunnel Option

3.6.2 Shared West Ship Canal Tunnel Option

The Shared West Ship Canal Tunnel Option combines three of the largest CSO areas into a single deep tunnel. The West Ship Canal Tunnel is proposed as a shared option because the three CSO areas (two from the City and one from King County) with the largest CVs are relatively close to one another. The tunnel would extend from Fremont/Wallingford to Ballard and would provide the storage needed to address sewage overflows in Ballard, Fremont/Wallingford, and King County's 3rd Avenue West CSO basins. The tunnel would eliminate the need for a separate King County CSO project at an outfall near 3rd Avenue West.

Prior to implementing any shared projects between the City and King County, a shared project agreement would need to be signed between the two agencies.

Within this option, the remaining CSO areas would be controlled by their respective neighborhood control measures except for Magnolia and East Waterway, where flow diversions to King County's system are proposed. Any City flow diversion projects would require coordination with King County. Specifically, the City and King County would need to analyze the impacts of the proposed flow diversion projects on the downstream system and agree on an approach to address those impacts.

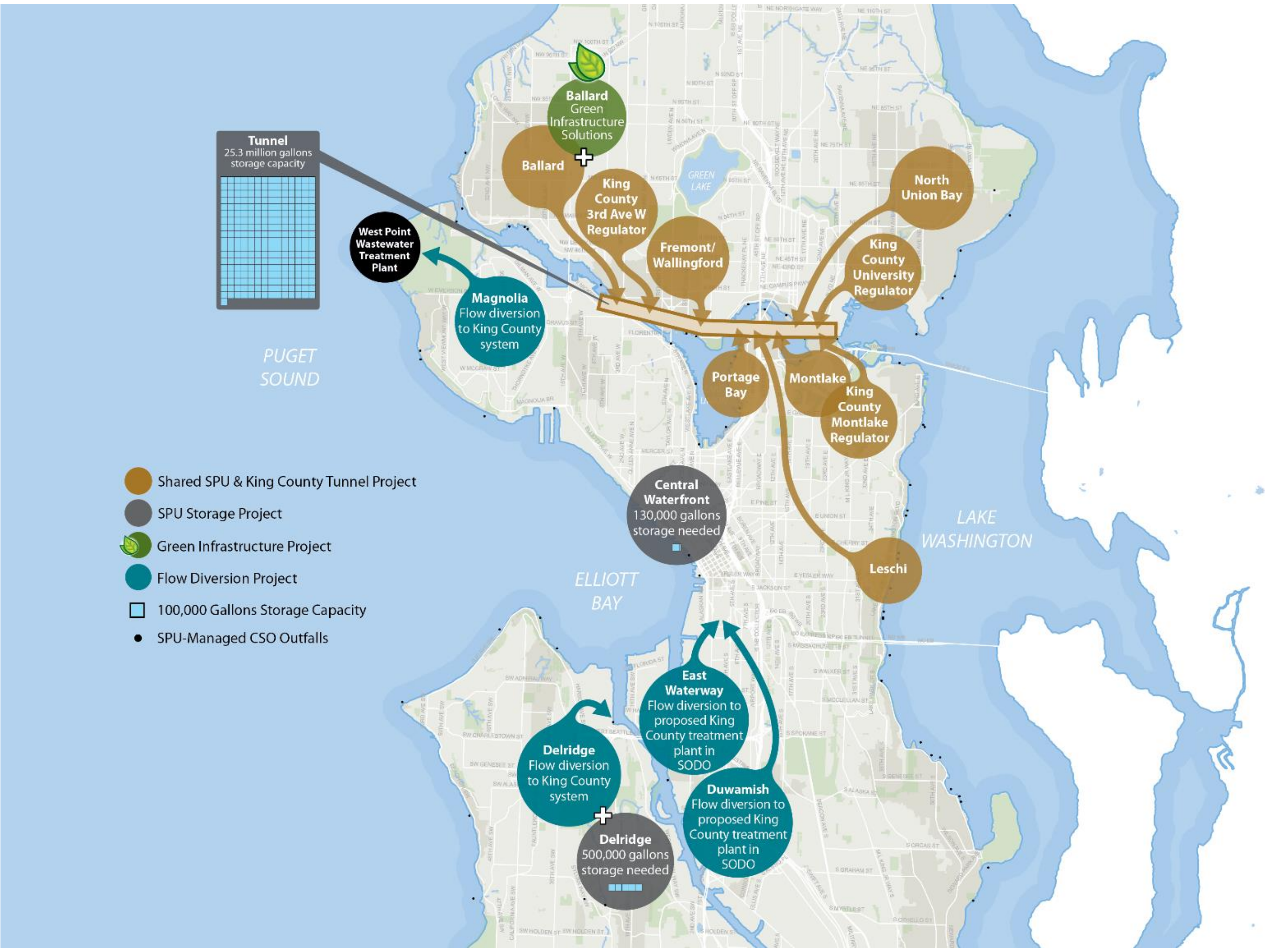

Figure 3-20. Shared Ship Canal Tunnel Option

3.6.3 Shared Ship Canal Tunnel Option

The Shared Ship Canal Tunnel Option combines the CVs from six of City CSO areas along the Ship Canal and Lake Washington, and three of the largest King County CSO areas along the Ship Canal in a deep tunnel extending from the University District to Fremont/Wallingford. The tunnel would provide the storage needed to address sewage overflows in the City's CSO areas of Ballard, Fremont/Wallingford, Portage Bay, Montlake, North Union Bay, and Leschi. The tunnel would also eliminate the need for three separate King County CSO projects at outfalls near Pacific Street (University Regulator), Montlake Avenue (Montlake Regulator), and 3rd Avenue West.

The remaining City CSO areas (Magnolia, Duwamish, East Waterway, and the northernmost Delridge CSO basin) would be diverted to King County under the assumption that flow diversions could be incorporated into mutual interagency agreements. The Central Waterfront and the southern Delridge CSO neighborhoods would continue to be served by their respective neighborhood control measures.

Prior to implementing any shared projects between the City and King County, a shared project agreement would need to be signed between the two agencies.

Specifically, the City and King County would need to analyze the impacts of the proposed project on the downstream system and agree on an approach to address those impacts.

Figure 3-21. Shared Storage Option

3.6.4 Shared Storage Option

Under the Shared Storage Option, the City and King County would jointly build larger but fewer storage tanks in three CSO areas:

- Fremont/Wallingford and King County 3rd Avenue W CSO
- North Union Bay and King County University Regulator CSO
- Montlake/Leschi and King County Montlake Regulator.

These three shared storage projects were recommended in the approved 2012 King County CSO plan. In the Duwamish CSO area, the City would divert flows to a treatment facility proposed by King County. All other LTCP CSO areas would have the same storage facilities as proposed under the Neighborhood Storage Option.

Prior to implementing any shared projects between the City and King County, a shared project agreement would need to be signed between the two agencies.

Specifically, the City and King County would need to analyze the impacts of the proposed project on the downstream system and agree on an approach to address those impacts.

3.6.5. Incorporating Green Infrastructure Control Measures

Green Infrastructure control measures were developed and evaluated in parallel with final grey control measures for uncontrolled CSO basins with potential for GI application. The GI program is currently being implemented in uncontrolled CSO basins where it is practicable. GI effectiveness will be evaluated during the implementation phase for individual LTCP projects and any potential reductions in the storage volume requirements for the grey control measure will be addressed in an engineering report which will be submitted to EPA and Ecology for approval, in accordance with the Consent Decree.

The proposed grey control measures presented in this LTCP meet 100 percent of the control requirements; possible contributions from GI are not included in meeting the requirement.

3.7 Project Cost Methodology

3.7.1 Capital Cost

Table 3-39 presents the capital cost of the proposed control measures that make up the LTCP options. The total project cost shown includes construction costs for major parts of each control measure (conveyance, storage, pump stations, special construction, etc.) as well as estimated soft costs such as project contingencies, management reserves, property costs, commissioning, and stabilization period costs.

A project contingency and management reserve fund allowance were included in the total project costs. These allowances typically include potential construction risks, permit conditions, and site-specific mitigation. During the design, the total project costs will be revised to include site specific conditions.

These costs were developed for the May 2014 Draft LTCP, submitted to Ecology and the EPA. See Section 5.7 for updated costs of the recommended LTCP option.

Table 3-39. Cost Summary of System Options (April 2013 Total Project Cost $Millions)

CSO area and CSO basins		Neighborhood Storage Tanks	Neighborhood West Ship Canal Tunnel	Shared West Ship Canal Tunnel	Shared Ship Canal Tunnel	Shared storage
Neighborhood Projects						
Leschi	028-036	$ 25.6	$ 25.6	$ 25.6	0	0
Montlake	020/139/ 140	$ 12.4	$ 12.4	$ 12.4	0	0
Portage Bay	138	$ 8.0	$ 8.0	$ 8.0	0	$ 8.0
Duwamish	111	$ 3.7	$ 3.7	$ 3.7	$ 9.7	$ 3.7
East Waterway	107	$ 29.1	$ 29.1	$ 13.5	$ 13.5	$ 13.5
Magnolia	060	$ 5.7	$ 5.7	$ 5.0	$ 5.0	$ 5.7

Table 3-39. Cost Summary of System Options (April 2013 Total Project Cost $Millions)						
CSO area and CSO basins		**Neighborhood Storage Tanks**	**Neighborhood West Ship Canal Tunnel**	**Shared West Ship Canal Tunnel**	**Shared Ship Canal Tunnel**	**Shared storage**
Central Waterfront	069	$ 9.6	$ 9.6	$ 9.6	$ 9.6	$ 9.6
Ballard	150/151/152	$ 127.7			0	$ 127.7
Fremont/ Wallingford	147/174	$ 81.9			0	0
Delridge	099	$ 7.0	$ 7.0	$ 7.0	$ 12.8	$ 7.0
	168	$ 8.1	$ 8.1	$ 8.1	$ 8.1	$ 8.1
	169	$ 7.2	$ 7.2	$ 7.2	$ 7.2	$ 7.2
North Union Bay	018	$ 1.3	$ 1.3	$ 1.3	0	0
Neighborhood West Ship Canal Tunnel			$ 254.4			
Shared Projects						
Shared West Ship Canal Tunnel				$ 257.8		
Shared Ship Canal Tunnel					$ 617.0	
Shared University Tank						$ 117.1
Shared Fremont/Wallingford/3rd Ave Storage Facility						$ 191.2
Shared Montlake Tank						$ 166.8
Total Project Cost						
Total Project Cost of LTCP Option (City + King County Cost)		NA, see City cost below	NA, see City cost below	$ 359.2	$ 682.9	$ 665.6
Total Project Cost of LTCP Option (City Cost) [b]		$ 327.3	$ 372.2	$ 281.9	$ 331.2	$ 327.7

Notes:

[a] Total Project Cost includes construction, engineering, property, SPU soft costs, sales tax, contingency, MRF, commissioning and stabilization (acceptance testing)

[b] Based on preliminary cost shares developed for the Draft LTCP. See Section 5.7.4 for updated costs and details on the cost share used for the Final LTCP.

The initial conceptual development and evaluation of feasible control measures was completed using a cost model called Tabula (Reference 34), developed by King County. Use of this cost model provides a quick means to evaluate the cost effectiveness of the City's alternatives. Projects that could be shared with King County could also be evaluated on a common basis. Tabula produces a Class 5 construction cost estimate (minus 50 percent to plus100 percent accuracy).

To permit a more detailed and flexible evaluation of control measures, the City developed a new cost model called the LTCP Conceptual Cost Calculator (3C) (Appendix J). The tool was created in Microsoft Excel. The workbook consists of a number of Excel sheets serving one of three functions: model input, cost estimate, or schedule estimate. The tool combines features of both American Public Works Association (APWA) and Construction Specifications Institute (CSI) formats to allow estimates for linear and vertical construction elements and is set up in such a way that quantity or activity inputs can be fed into a Microsoft Project scheduler to generate a construction schedule. In addition, the model generates a summary of major material quantities and equipment hours for use in support of environmental analysis.

The cost estimating tool uses definitions and soft-cost values as presented in the City's Cost Estimating Guidelines to generate a total project cost. The level of detail in the 3C estimate is considered to approach a Class 4 estimate per the Association for the Advancement of Cost Engineering (AACE), with an accuracy of minus 20 percent to plus 30 percent.

The 3C tool has been updated using the April 2013 Engineering News Record (ENR) construction index and incorporates recent bid price updates based on construction bids received for the City's Windermere and Genesee CSO projects.

Validation of the 3C tool was completed in April 2013 using bid information from the Windermere and Genesee CSO projects that are currently in construction. The tool calculated a construction cost that was within four percent of the actual construction bid amounts.

A multi-agency tunnel evaluation workshop conducted in 2011 recommended that all deep tunnel control measures be evaluated using a "bottom up" (rather than a parametric) construction cost estimate. The "bottom up" estimate corresponded closely with the 3C tool estimate and provided additional detail in key areas.

For ease of comparison, the costs for all of the control measures presented in this LTCP have been estimated using the 3C tool only. This includes the various King County alternatives against which the shared options are compared.

3.7.2 Operating Cost

Non-capital costs include recurring annual operation and maintenance expenses, fees paid to King County for treatment of additional flows, ongoing flow monitoring for system control, and post-construction monitoring to demonstrate consent decree compliance.

An operation and maintenance cost model (Appendix K) was developed for comparing control measures. This cost model incorporated existing City operating experience with storage facilities and conveyance systems augmented by recent monitoring and construction commissioning data.

Facilities constructed under the LTCP will require commissioning costs beyond those typically encountered to complete construction. These include stabilization costs to ensure that the constructed facilities will perform as designed.

Table 3-40 presents information on the maintenance costs for the proposed control measures that are included in the LTCP options. The table includes anticipated annual costs for maintenance broken down by major activities for each control measure. The operating cost shown includes the expected cost of energy (both the "readiness to serve" and energy charge).

Table 3-40. Operating Cost Summary for System Options (April 2013 $Millions) [a,b]

CSO area and CSO basins		Neighborhood Storage Tanks	Neighborhood West Ship Canal Tunnel	Shared West Ship Canal Tunnel	Shared Ship Canal Tunnel	Shared storage
Neighborhood projects						
Leschi	028-036	$ 1.4	$ 1.4	$ 1.4	0	0
Montlake	020/139/ 140	$ 0.8	$ 0.8	$ 0.8	0	0
Portage Bay	138	$ 0.4	$ 0.4	$ 0.4	0	$ 0.4
Duwamish	111	$ 0.3	$ 0.3	$ 0.3	$ 0.6	$ 0.3
East Waterway	107	$ 0.2	$ 0.2	$ 0.2	$ 0.2	$ 0.2
Magnolia	060	$ 0.4	$ 0.4	$ 0.3	$ 0.3	$ 0.4
Central Waterfront	069	$ 0.5	$ 0.5	$ 0.5	$ 0.5	$ 0.5
Ballard	150/151/152	$ 0.7			0	$ 0.7
Fremont/ Wallingford	147/174	$ 0.7			0	0
Delridge	099	$ 0.4	$ 0.4	$ 0.4	$ 0.7	$ 0.4
	168	$ 0.5	$ 0.5	$ 0.5	$ 0.5	$ 0.5
	169	$ 0.5	$ 0.5	$ 0.5	$ 0.5	$ 0.5
North Union Bay	018	$ 0.3	$ 0.3	$ 0.3	0	0
Neighborhood West Ship Canal Tunnel			$ 1.8			
Shared projects						
Shared West Ship Canal Tunnel				$ 1.4		
Shared Ship Canal Tunnel					$ 2.4	
Shared University Tank						$ 0.1
Shared F/W/3rd Storage Facility						$ 0.6
Shared Montlake Tank						$ 0.6
Total project cost						
Total Operating Cost of LTCP Option (City + King County Cost)		NA, see City cost below	NA, see City cost below	$ 7.0	$ 5.7	$ 5.2
Total Operating Cost of LTCP Option (City Cost) [b]		$ 7.1	$ 7.5	$ 6.6	$ 4.3	$4.3

Notes:

[a] System operating costs include maintenance labor and equipment, power and chemicals, odor control consumables, Post-construction monitoring, permanent flow monitoring, and treatment fees to King County

[b] Based on preliminary cost shares developed for the Draft LTCP. See Section 5.7.4 for details on the cost share used for the Final LTCP.

CHAPTER 4

Evaluation of LTCP CSO Control Options

4.1 Overview of LTCP CSO Control Option Evaluation Process

The LTCP contains a rating and ranking of the LTCP options in accordance with the EPA requirements from the *"Combined Sewer Overflows Guidance for Long-Term Control Plan, 1995".* In May 2014, the Draft LTCP was submitted to the EPA and Ecology for review and comment with this rating and ranking evaluation included. In addition, the City issued a public notice and held a public meeting and official public comment period for the Draft LTCP. After the comment period and receipt of EPA and Ecology comments, additional evaluation was performed, as described in Chapter 5, resulting in the selection of the recommended LTCP Option.

4.1.1 Rating and Ranking of LTCP Alternative Options

Based on the final LTCP options development work described in Chapter 3, an evaluation of the non-monetary factors was performed. The technique used for the LTCP option evaluation is called Multiple Objective Decision Analysis. This technique incorporates a mechanism for consideration of non-monetary, social, and environmental factors as well as cost to create a structured comparison of competing. The steps in the Multiple Objective Decision Analysis process are summarized as follows and described in detail below.

- Establish the decision goal
- Identify and specify fundamental objectives
- Develop performance measures to assess project performance against objectives
- Assign scores to the performance measures
- Assign weights to the objectives
- Score LTCP options and calculate total value scores
- Calculate total net present value costs for comparison with total value scores and conduct a sensitivity analysis

4.1.1.1 Decision Goal

The decision goal for the Draft LTCP is to perform an evaluation rating and perform a ranking (highest to lowest) of the LTCP options.

4.1.1.2 Objective Hierarchy

A series of objectives typically must be met to achieve the decision goal. Those objectives can be classified as fundamental, or main, objectives and sub-objectives. The main objectives are the singular factors that are most important to achieving the decision goal. Attributes that define the main objective that are referred to as sub-objectives. The objectives and sub-objectives are arranged in a hierarchy referred to as an objectives hierarchy or value hierarchy. The value hierarchy developed for this analysis is shown in Table 4-1.

Table 4-1. LTCP MODA Value Hierarchy	
Main objectives	**Sub-objectives**
1. Technical complexity and performance risk	Does implementation require complex overall system controls? How many individual CSO facilities are needed to implement control strategy? How does the King County no-impact release rate affect City CSO operations?
2. Flexibility	Can the LTCP option meet changing control criteria and flow conditions?
3. Constructability	Are construction risks associated with the LTCP option significant? What are the expected permitting, regulatory, and land use compliance complexities and how difficult is it expected to be to obtain permits and approvals?
4. Consent Decree compliance schedule	Does the LTCP option meet the City Consent Decree Construction Completion Milestone Date of Dec 31, 2025? Does the LTCP shared option meet the King County Consent Decree Dates for the University, Montlake and 3rd Avenue West CSO projects?
5. King County concurrence on shared projects	Has King County indicated their concurrence or objections to LTCP shared options to the City?
6. Construction impacts (short term)	What level of disruption will occur? Are the cumulative construction impacts significant?
7. Community impacts (long term)	Can the facility be designed to be compatible with the community? How will O&M activities impact the community?
8. Environmental and social justice	What are the LTCP option's overflow and operation impacts and benefits? Does the alternative result in unequal impacts and benefits to historically underserved communities and low-income populations during construction or operation of the facility?
9. Environmental	Will the construction impact wetlands, streams, shorelines, habitats, or endangered species?
10. Ease of Operation and Maintenance and Safety	What level of staffing is required for operation and shutdown (how often is the facility used, how long is the facility in use, how many operators are required, what level of operator experience is required, what are travel times)? What are peak staff required? Does the facility have access requirements in the right-of-way or require confined space entry? Are traffic control procedures required? Does access require a street use permit or lane closure?

4.1.1.3 Develop Performance Measures and Scoring

Once the objectives are fully developed and the decision makers agree that they fully represent the important issues in the problem, performance measures are required to determine how well the LTCP options perform against objectives. Performance measures may be quantitative or qualitative, depending upon the objective and the availability of data for each measure. All non-monetary objectives were scored using a 1 to 3 scale, where the worst potential outcome was given a score of 1 and the best possible outcome was given a score of 3. The performance measures are shown in Table 4-2.

Table 4-2. LTCP MODA Performance Measures

Criteria	Performance measures (high, medium, low)		
	High = 3.0 (best)	**Medium = 2.0**	**Low = 1.0 (worse)**
1. Technical complexity and performance risk	System operation is less complex because a large number of independent CSO outfall storages have been combined into fewer CSO control facilities... Reduces the requirements for coordinating operations of numerous independent CSO storage facilities for a large number of CSO outfalls. King County interceptor capacity does not impact City CSO facility release rates or increase City storage requirements. King County will not request additional capital costs to accommodate City CSO flows.	System operation is moderately complex because some CSO outfall storages have been combined into a single CSO control facility. (e.g., shared tanks or tunnels). Reduces the requirements for coordinating operations of several independent CSO storage facilities for a specific geographic area. King County interceptor capacity may impact City CSO facility release rates or increase City storage requirements. King County may request additional capital costs to accommodate City CSO flows.	System operation is very complex because each CSO outfall storage must control overflows independently (e.g., tanks at each outfall). Requires coordinating operations of numerous independent CSO storage facilities to achieve performance standard. King County interceptor capacity will significantly limit City CSO facility release rates or increase City storage requirements. King County will request major capital costs to accommodate City CSO flows.
2. Flexibility	Will require minimal modifications of controls and existing infrastructure. Significant space available for future expansion.	Will require moderate modifications to controls and infrastructure. Limited space for future expansion. e.g. Shared City/KC storage will rate medium	Will require significant modifications to controls and infrastructure. No Space for future expansion e.g. Neighborhood storage will rate lowest
3. Constructa-bility	Site is not constrained; site is stable with low slope; groundwater elevations not affected during construction or operation. Adequate area for access; staging and operation of special equipment can be accommodated. There are several potential sites available for purchase including publicly and privately owned property. Property may be used for multiple benefit (meet regulatory needs and provide an amenity to the community). Multiple transport routes and modes are available.	Site may be constrained; site has low to moderate slope; site requires some dewatering and robust foundations including piles or tiebacks. Access and staging are not required for adequate construction sequencing. Contractor may have to provide offsite staging and operations. There are limited acceptable. Use of property may require mitigation to make construction feasible and the facility publically acceptable. Adequate transport routes are available.	Site is constrained; site has steep slopes with groundwater and soils conditions that increase instability if disturbed, requiring careful construction sequencing. Several move-in, move-out stages will be required to accommodate specialty contractors as well as conventional construction. Contractor must provide offsite staging and operations. Locating a site is difficult. (e.g., potential sites have cultural /or historical status, have binding covenants that preclude utility structures, or are not subject to condemnation by the City.) Condemnation may be required. Significant mitigation may be required to make the facility publically acceptable. Constrained transport routes are available.

Table 4-2. LTCP MODA Performance Measures

Criteria	Performance measures (high, medium, low)		
	High = 3.0 (best)	**Medium = 2.0**	**Low = 1.0 (worse)**
4. Consent Decree compliance schedule	All City facilities meet Consent Decree Construction Completion milestone of December 31, 2025. Shared King County/City facilities meet milestone dates stated in the King County Consent Decree.	Shared King County/City facilities do not meet the City Consent Decree Construction Completion milestone of December 2025 but is deferred based on approved King County Consent Decree without penalty from EPA or Ecology.	No Shared King County/City facilities meet the City Consent Decree Construction Completion milestone of December 31, 2025, and EPA or Ecology would impose penalties. Shared King County/City facilities do not meet milestone dates stated in the King County Consent Decree, and EPA/Ecology impose penalties.
5. King County concurrence on shared projects	King County participation is not needed or the King County Consent Decree requires King County to build shared storage with the City.	King County and the City are continuing discussion. (West Ship Canal)	King County CSO Plan does not recommend ship canal tunnel (Shared Tunnel)
6. Construction impacts (short term)	Disruption during construction is lowest in terms of number of sites, area affected, and construction duration and intensity. Mitigation options are available, potential public benefits and cumulative impacts are lowest (including King County facilities).	Disruption during construction is moderate in terms of area affected, number of sites, and construction duration and intensity. Mitigation options available which offset impacts. Cumulative impacts are moderate.	Disruption during construction is highest in terms of area affected, number of sites affected, and construction duration and intensity. Mitigation options are limited. Cumulative impacts are highest.
7. Community impacts (long term)	Facility is compatible with the surrounding community and minimal staff will be present infrequently. Traffic, odor, noise and visual impacts from the facility would require limited mitigation to be acceptable to the community.	Facility and grounds can be designed to screen facility and minimal staff visits are necessary. Traffic, odor noise and visual impacts from the facility would require mitigation to be acceptable to the community.	The facility will negatively impact the community and there would be staff on-site regularly. Traffic, odor, noise and visual impacts from the facility would require significant mitigation to be acceptable to the community.
8. Environ-mental and social Justice	The option provides social, environmental, health, and economic benefits to historically underserved communities and low-income populations at levels equal to or greater than those experienced by white middle- and high-income populations.	The option produces no net change in social, environmental, health, and economic impacts or benefits to historically underserved communities and low-income populations.	The option causes adverse and inequitable social, environmental, health, and economic impacts to historically underserved communities and low-income populations.

Table 4-2. LTCP MODA Performance Measures

Criteria	Performance measures (high, medium, low)		
	High = 3.0 (best)	Medium = 2.0	Low = 1.0 (worse)
9. Environ-mental	It is unlikely that the LTCP option would adversely impact wetlands, streams, shorelines, habitats, or endangered species. Mitigation options are available. City-wide cumulative impacts are lowest for most environmental resources.	It is likely that the LTCP option would impact wetland or stream buffers or streams, but endangered species, habitats and shoreline areas are unlikely to be impacted. Mitigation options are available. City-wide cumulative impacts are moderate for all environmental resources.	It is likely that the LTCP option would adversely impact a number of high value wetlands, streams, shorelines, habitats, or endangered species. Mitigation options are limited. City-wide cumulative impacts are high for a number of environmental resources.
10. Ease of O&M and safety	The facility requires no operating staff or can be remotely operated. Peak staff times require < 1 operator. The facility can be shut down with minimal staff time. Cleanup work is automated or can be scheduled to be integrated with other staff duties. The facility requires only annual preventive maintenance. The processes have minimal mechanical and instrumentation components (e.g., storage tank). The facility is reliable when used only intermittently. The facility does not have right-of-way access requirements or no permit is required for confined space entry. No traffic control procedures are required during operations and maintenance.	The facility can generally be remotely operated. An operator may need to be present periodically for sampling, chemical make-up, chemical delivery acceptance or other discrete tasks. Peak staff times require 1-2 operators. The facility can be shut down with minimal staff time. Cleanup work is generally automated; however, 1-2 personnel may be required. The facility requires monthly maintenance such as bumping pumps. The processes have an increased level of mechanical and instrumentation components (e.g., pump station). The facility has right-of-way access requirements or a permit is required for confined-space entry during non-routine operation and maintenance procedures. Traffic control procedures are required during non-routine operations and maintenance procedures. Work is in a moderately populated (residential or commercial) environment.	The facility requires operator attention during a storm. Peak staff times require 2 or more operators. The facility requires significant effort for shut down (e.g., vac/boom truck) and several days for cleanup. Cleanup work is generally manual with 2 or more personnel required for more than one day. Most procedures of shutdown need to be conducted immediately. The facility require monthly maintenance such as bumping pumps. The processes have an increased level of mechanical and instrumentation components (e.g., treatment facility). Equipment is prone to failure with intermittent use. The facility has right-of-way access requirements or a permit is required for confined space entry during routine operation and maintenance procedures. Traffic control procedures are required during routine operations and maintenance procedures. Work is in a densely populated (residential or commercial) environment.

4.1.1.4 Assign Scores to the Performance Measures

Rating or scoring the LTCP options is the process by which the performance scales are applied to the LTCP options. Each LTCP option is scored to determine the extent to which that option meets each objective (high, medium, or low). The scores and the rationale for each constructed scale are shown in Appendix D, LTCP Option Rating and Ranking Report. After scoring, each performance measure is normalized to a scale of zero to one by a linear transformation of each score according to its distance from the scale endpoints. The results of the analysis is shown in Table 4-3.

Table 4-3. MODA Results

Evaluation criteria	Scores				
	Neighborhood Storage Tanks	**Neighborhood West Ship Canal Tunnel**	**Shared Storage**	**Shared Ship Canal Tunnel**	**Shared West Ship Canal Tunnel**
1. Technical complexity and performance risk	**1.0**	**2.0**	**2.5**	**1.0**	**1.0**
2. Flexibility	**1.0**	**2.5**	**2.0**	**1.0**	**1.0**
3. Constructability	**1.0**	**1.5**	**1.5**	**2.0**	**2.0**
4. Consent Decree compliance schedule	**3.0**	**3.0**	**1.0**	**1.0**	**1.0**
5. King County concurrence on shared projects	**3.0**	**3.0**	**2.0**	**1.0**	**1.0**
6. Construction impacts (short term)	**1.0**	**1.5**	**1.0**	**2.5**	**2.0**
7. Community impacts (long term)	**1.5**	**2.0**	**2.0**	**2.5**	**2.5**
8. Environmental/ social justice	**2.0**	**1.5**	**2.0**	**1.5**	**2.0**
9. Environmental	**1.5**	**1.5**	**2.0**	**2.5**	**2.0**
10. Ease of O&M and safety	**1.0**	**2.0**	**2.5**	**1.0**	**1.0**

4.1.1.5 Assign Weights to the Objectives

Assigning weights to objectives is a subjective exercise based on the values of the stakeholders. Weighting was done after the performance measures were developed, so project team members could include in their consideration the extent to which the full set of LTCP options vary in performance. The weight assigned to an objective is a measure of that objective's relative contribution to the decision. Table 4-4 presents the weights developed for the objectives hierarchy.

Table 4-4. MODA Objective Weighting

Evaluation criteria	Relative importance weight	% of total
1. Technical complexity and performance risk	100	12%
2. Flexibility	70	8%
3. Constructability	100	12%
4. Consent Decree compliance schedule	100	12%
5. King County concurrence on shared LTCP options	100	12%
6. Construction impacts (short term)	60	7%
7. Community impacts (long term)	80	9%
8. Environmental and social justice	80	9%
9. Environmental	80	9%
10. Ease of O&M and safety	80	9%

Weights were assigned in a two-step process. First, weights were assigned to establish the relative importance of the sub-objectives within each of the main objectives. The most important sub-objective was assigned an importance weight of 100, and the other sub-objectives were assigned weights proportional to the highest rated objective. After all sub-objectives were scored, the group assigned weights to the main objectives. Again, the most important objective was assigned a weight of 100 and the other objectives were assigned weights proportional to that objective.

4.1.1.6 Score LTCP options and Calculate Total Value Score

The total value score for each LTCP option was calculated using a weighted averaging process in which the total value score is the sum of the percentage-weighted, normalized scores (times 100) of each sub-objective. The results of the analysis are shown in Table 4-5.

Table 4-5. LTCP Option Rating

Evaluation criteria	Neighborhood-all tanks	Neighborhood-West Ship Canal Tunnel	Shared storage	Shared Ship Canal Tunnel	Shared West Ship Canal Tunnel
Total score	**32.9**	**54.4**	**42.9**	**27.6**	**25.9**
1. Technical complexity and performance risk	0.0	5.9	8.8	0.0	0.0
2. Flexibility	0.0	6.2	4.1	0.0	0.0
3. Constructability	0.0	2.9	2.9	5.9	5.9
4. Consent Decree compliance schedule	11.8	11.8	0.0	0.0	0.0
5. King County concurrence on shared projects	11.8	11.8	5.9	0.0	0.0
6. Construction impacts (short term)	0.0	1.8	0.0	5.3	3.5
7. Community impacts (long term)	2.4	4.7	4.7	7.1	7.1
8. Environmental and social justice	4.7	2.4	4.7	2.4	4.7
9. Environmental	2.4	2.4	4.7	7.1	4.7
10. Ease of O&M and safety	0.0	4.7	7.1	0.0	0.0

4.1.1.7 Compare Life Cycle Costs with Value Scores

All comparison of control measure costs used in the LTCP option rating and ranking process were made using a net present value (NPV) calculation based on a discount rate of three percent and a 100-year life cycle and include salvage value. In addition to initial capital costs and ongoing operating costs, the NPV calculation incorporated future replacements for metering equipment (5-year cycle), electrical and instrumentation components (10-year cycle), mechanical and odor control equipment (25-year cycle), and major structure upgrade (50-year cycle). Replacement values were extracted from construction cost estimates.

Preliminary cost shares for the various shared options were developed for the Draft LTCP, and were based on a cost allocation methodology developed by the City and King County. To calculate the cost shares, the existing King County recommended CSO project costs were estimated using the LTCP 3C cost model for comparison with the LTCP option costs. The NPV costs were calculated as 100-year life-cycle costs and are summarized in Table 4-6. See Section 5.7.4 for details on the cost share used in the Final LTCP.

Table 4-6. Cost Summary of System Options (April 2013 NPV (100-Year) $Millions) [a]

CSO area and CSO basins		Neighborhood Storage Tanks	Neighborhood West Ship Canal Tunnel	Shared West Ship Canal Tunnel	Shared Ship Canal Tunnel	Shared Storage
Neighborhood projects						
Leschi	028-036	$ 26.9	$ 26.9	$ 26.9	0	0
Montlake	020,139, 140	$ 13.1	$ 13.1	$ 13.1	0	0
Portage Bay	138	$ 8.7	$ 8.7	$ 8.7	0	$ 8.7
Duwamish	111	$ 3.9	$ 3.9	$ 3.9	$ 8.4	$ 3.9
East Waterway	107	$ 27.4	$ 27.4	$ 14.5	$ 14.5	$ 14.5
Magnolia	060	$ 5.6	$ 5.6	$ 5.5	$ 5.5	$ 5.6
Central Waterfront	069	$ 9.0	$ 9.0	$ 9.0	$ 9.0	$ 9.0
Ballard	150/151 & 152	$ 119.5			0	$ 119.5
Fremont/ Wallingford	147, 174	$ 85.7			0	0
Delridge	099	$ 7.8	$ 7.8	$ 7.8	$ 12.2	$ 7.8
	168	$ 8.2	$ 8.2	$ 8.2	$ 8.2	$ 8.2
	169	$ 7.4	$ 7.4	$ 7.4	$ 7.4	$ 7.4
North Union Bay	018	$ 1.5	$ 1.5	$ 1.5	0	0
Neighborhood West Ship Canal Tunnel			$ 223.6			
Shared projects						
Shared West Ship Canal Tunnel				$ 231.1		
Shared Ship Canal Tunnel					$ 542.0	
Shared University storage facility						$ 95.5
Shared 3rd Ave. W storage facility						$ 170.0
Shared Montlake storage facility						$ 139.2
Flow monitoring		$ 48.6	$ 44.8	$ 44.8	$ 56.1	$ 56.1
Total Net Present Value		$ 373.3	$ 387.9	$ 382.4	$ 663.3	$ 645.4

Table 4-6. Cost Summary of System Options (April 2013 NPV (100-Year) $Millions) [a]

CSO area and CSO basins	Neighborhood Storage Tanks	Neighborhood West Ship Canal Tunnel	Shared West Ship Canal Tunnel	Shared Ship Canal Tunnel	Shared Storage
City Share total net present value	$ 373.3	$ 387.9	$ 312.8	$ 351.7	$ 361.3

[a] *NPVs presented in Table 4-6 have been superceded. Updated NPVs are presented in Chapter 5, Sections 5.4 and 5.7.*

The NPV costs are based in April 2013 dollars and includes the present-value cost of construction and operations, maintenance, and long-term replacement. The costs include factors such as land costs, contaminated soil mitigation, the potential for loans and grants, private and public park mitigation, and potential negotiated costs (or savings) with King County. It should be noted that the costs shown are planning level, conceptual costs (Class 4) that are expected to be accurate within minus 20 percent to plus 30 percent. Actual costs will vary depending on many factors. Note:

Table 4-7 shows the total value score for each LTCP option (as shown in Table 4-5, LTCP Option Rating) compared to its NPV (as shown in Table 4-6, Net Present Value, Class 4). The typical range of accuracy for a Class 4 estimate is also shown on Table 4-7.

Table 4-7. LTCP Value Score Comparison with Net Present Value [a]

LTCP option	Value score	City NPV cost share, $M	Lower NPV cost range $M (-20%)	Upper NPV cost range $M (+30%)
Neighborhood West Ship Canal Tunnel	54.4	$388	$310	$504
Shared Storage	42.9	$361	$289	$469
Neighborhood Storage Tanks	32.9	$373	$298	$485
Shared Ship Canal Tunnel	27.6	$352	$282	$458
Shared West Ship Canal Tunnel	25.9	$313	$250	$407

[a] *Note: NPV's presented in Table 4-6 have been superceded. Updated NPV's are presented in Chapter 5, Sections 5.4 and 5.7.*

4.1.1.8 LTCP Option Rankings

The Draft LTCP performed a rating and ranking of the LTCP options in accordance with the EPA requirements from the Combined Sewer Overflows Guidance for Long-Term Control Plan, 1995. Section 4.1.1, Final LTCP Alternative Selection Decision Process, describes the LTCP final option selection process in detail. The Draft LTCP ranking results are presented below.

Because the NPVs for the LTCP options are within the accuracy range for a Class 4 estimate (minus 20 percent to plus 30 percent), the LTCP option NPV costs are essentially the same and all the LTCP options can be considered equivalent in costs.

The LTCP options were then ranked based on the total value scores shown on Table 4-5, LTCP Option Rating. The highest ranked LTCP option from the Draft LTCP was the Neighborhood West Ship Canal Tunnel Option. See Section 5.4, Development of Short List and Selection of Recommended Option, for details on how these options were further evaluated following the publishing of the Draft LTCP.

4.2 Public and Regulatory Agency Participation Program

4.2.1 Overview

The City has performed a comprehensive public and regulatory agency participation program for the LTCP in accordance with the Consent Decree. This section describes the City's program performed through the publishing of the Draft LTCP in May 2014. Section 5.2 describes the additional public and regulatory agency participation conducted since the publishing of the Draft LTCP.

4.2.2 Consent Decree Requirements

Specific requirements for a public and regulatory agency participation program for the LTCP are listed in Appendix C, paragraph A, Public and Regulatory Agency Participation Program, of the Consent Decree. The Consent Decree contains the following requirements:

> *A. Public and Regulatory Agency Participation Program.*
>
> *The City shall implement a Public and Regulatory Agency Participation Program (the "Participation Program") designed to ensure that there is ample public participation and ample participation by the Plaintiffs, throughout all stages of development of the City's Long Term Control Plan. The Participation Program shall include, at a minimum, the following elements:*
>
> *1. The means by which the City will make information pertaining to the development of the LTCP available to the public for review.*
>
> *2. The means by which the City will solicit comments from the public on the development of the LTCP.*
>
> *3. Summary of public hearings at meaningful times during the LTCP development process to provide the public with information and to solicit comments from the public regarding the components of the LTCP.*
>
> *4. Program for consideration of comments provided by the public as the City develops its LTCP.*
>
> *5. Measures that the City will employ to ensure that Plaintiffs are kept informed of the City's progress in developing its LTCP, including scheduling periodic meetings with Plaintiffs at meaningful times during the LTCP development process and regular submittal of reports to Plaintiffs summarizing the public comments received throughout implementation of the Program.*

4.2.3 Public Participation Process and Approach

A summary of the participation program activities is presented in Table 4-8.

Table 4-8. Public and Regulatory Agency Participation Program

Consent Decree requirement (Appendix C, Section A)	City participation program activity										
	Community Guide updates briefings	Briefings	Website updates	Website animations, visualizations, and video	Updates to project listserv	Scoping meetings	On-Line questionnaires public hearing	Public hearing	Public meeting summary reports	Quarterly meetings with EPA and Ecology	Plaintiff webinars
A.1. The means by which the City will make information pertaining to the development of the LTCP available for public review.	●	●	●	●	●						
A.2. The means by which the City will solicit comments from the public on the development of the LTCP		●				●	●	●			
A.3. Summary of public hearings at meaningful times during the LTCP development process to provide the public with information and to solicit comments from the public regarding components of the LTCP									●		
A.4. Program for consideration of comments provided by the public as the City develops the LTCP.								●			
A.5. Measures that the City will employ to ensure that Plaintiffs are kept informed of the City's process in developing its LTCP development process and regular submittal of reports to Plaintiffs summarizing the public comments received throughout implementation of the Program										●	●

4.2.4 Public Participation and Review of Draft LTCP

Through May 2014, the City performed a comprehensive public and regulatory agency participation program to provide information pertaining to the development of the LTCP available for public review. Table 4-9 summarizes the work performed.

Table 4-9. LTCP Participation Program

Consent Decree requirements (Appendix C, Section A.1-A.5)	Proposed public participation
How the City will make LTCP information available for public review	Prepared the Community Guide to the Plan to Protect Seattle's Waterways Issue 2 (Spring 2013) to provide an overview of the plan purpose and alternatives, environmental review process, and ways to provide comments during scoping. Placed an article about the plan in the summer 2013 edition of Seattle Public Utilities' Curb Waste newsletter, which is mailed to approximately 330,000 Seattle residents Developed a six-minute video about the plan and environmental review process, which is available online at www.seattle.gov/CSO. Approximately 120 people viewed the video since May 2013 Conducted briefings with 13 community organizations and environmental groups reaching approximately 136 stakeholders. Additional briefings will be offered Spring/Fall (Spring 2014 - Spring 2015) or if specifically requested by a stakeholder group Convened four meetings (July, September, October and November 2013) of the Stakeholder Advisory Group to inform decisions about elements of the plan that affect Ballard, Fremont and Wallingford Website updates to be completed Spring/Fall (Spring 2014 – Spring 2015) Maintained a real-time reporting website which alerts the public when sewage overflows occur. Reports are available at www.seattle.gov/CSO by clicking "Real Time Reports of Raw Sewage Overflows."
How the City will solicit public comments on the development of the LTCP	Completed EIS scoping by offering a 30-day public comment period from May 20 – June 20, 2013 and hosting a public scoping meeting on June 3, 2013 Seattle Public Utilities accepted comments by mail, email, in person at the scoping meeting, or via an online survey. Seattle Public Utilities received four comment letters and emails and 26 completed online surveys during the comment period. Online questionnaires in Spring 2014 LTCP/Integrated Plan public meeting June 24, 2014 Public hearing on the Draft LTCP/Integrated Plan/DEIS June 24, 2014
Summary of public hearings during LTCP development to provide public with information and to solicit public comments.	Draft EIS public hearing summary report LTCP/IP Public and Regulatory Agency Participation Summary Report
Program for consideration of comments provided by the public as the City develops the LTCP.	LTCP/Integrated Plan public meeting June 24, 2014

Table 4-9. LTCP Participation Program

Consent Decree requirements (Appendix C, Section A.1-A.5)	Proposed public participation
How the City will ensure that Plaintiffs are kept informed of the LTCP development. Regular report submittal to Plaintiffs summarizing public comments.	Quarterly meetings with EPA and Ecology (addresses both LTCP and Integrated Plan) • March 2013– Reviewed LTCP alternatives; LTCP outline; LTCP schedule; Integrated Plan Project status update. • June 2013 - Reviewed EPA Guidance Document/Consent Decree Crosswalk; LTCP Finance Plan Requirements; Updated LTCP outline; Integrated Plan briefing on expert panel meeting; Integrated Plan stormwater project selection process • August 2013 – LTCP status update; Reviewed Consent Decree deliverables; review/approval of CMOM Performance Program Plan, Floatables Observation Plan and Fog Control Program Plan; CMOM status update; Early Action Program status update. • December 2013 – Reviewed Consent Decree compliance matrix; Early Action items status update; Joint Operations and System Optimization Plan status update; Integrated Plan schedule and status update; LTCP schedule and status update; CMOM activities status update • April 2014 – Briefed EPA and Ecology on Draft LTCP and Draft Integrated Plan documents Webinars for plaintiffs at meaningful times. Webinar will report on public involvement activities and comments received at major milestones.

4.2.5 Final LTCP Public Process

In early 2015, the City Council will review and adopt the Final LTCP through a City ordinance process. The ordinance process will require open public council hearings and meetings to discuss and approve the ordinance. By May 30, 2015, the Final LTCP will be submitted to EPA and Ecology for final approval. By the end of 2015, the final plan is anticipated to be approved by EPA and Ecology and LTCP implementation will commence in late 2015 or early 2016.

4.3 Environmental Impact of LTCP Options

4.3.1 Overview

This section describes the type of social and environmental impacts that could occur within the plan area from any of the LTCP options, as presented in the Draft EIS. For the results presented in the Final EIS, see Section 5.5.

4.3.2 Construction Impacts

CSO reduction projects included under the LTCP options – and common to both the LTCP Alternative and the Integrated Plan Alternative –would involve construction of a combination of sewer system improvements, flow diversions, and underground storage. Because this is a plan-level evaluation, project details and construction methods have not yet been defined. However, the information in Table 4-10 provides a reasonable estimate of the nature, extent, and duration of anticipated construction activities for the types of projects being considered. Actual construction activities will vary and will be determined during subsequent project-specific review. It should be noted that for EIS purposes, CSO areas are described in terms of “neighborhoods,” to promote better familiarity with a broad audience. These neighborhoods are generally consistent with CSO basin areas.

Table 4-10. Summary of Construction Impacts
Resource
Earth
Construction activities and equipment can cause temporary impacts to earth and groundwater during construction of major projects that require substantial excavation, trenching, or tunneling and removal of large quantities of soil. Any areas that are disturbed during construction would be subject to increased erosion and control measures would be required. Ground settlement from dewatering could cause settlement of nearby structures, roadways, and utilities. Vibration associated with tunneling operations could result in soil settlement along tunneling alignments. The primary differences in potential effects of the LTCP options are related to the amount of surface disturbance and excavation potentially required. The Neighborhood Storage Option (would likely result in the most geographically dispersed impacts, with the Ballard, Fremont/Wallingford, and East Waterway neighborhoods experiencing the most disturbance. Construction in the Leschi and Delridge neighbourhoods could occur near steep slopes and known or potential landslide-prone areas. Impacts associated with nine additional King County facilities would add to the earth-related impacts. The Neighborhood West Ship Canal Tunnel Option would reduce the total number of facilities constructed, but would concentrate impacts at portal locations in Fremont and Ballard. The Shared Storage Option reduces the total number of tanks, but concentrates impacts in the Fremont/Wallingford, North Union Bay, and Montlake neighborhoods. Dewatering could encounter contaminated groundwater. The Shared West Ship Canal Tunnel Option has the potential to encounter liquefiable soils in Fremont and Ballard, which could result in soil settling. Vibration along the tunnel route would be a concern. The number of tanks would be lower than with the neighborhood option, resulting in reduced earthwork. The Shared Ship Canal Tunnel Option would result in the highest amount of earthwork of all options, but would result in the fewest number of tanks being constructed. Impacts would be concentrated at the portal locations. Vibration and settlement along the tunnel route would be of concern to property owners along the route.
Air quality
Construction would not have a significant effect on air quality in the Seattle area, but may result in moderate localized impacts during the construction periods, largely related to vehicle emissions and dust. The primary differences in potential air quality and odor effects of the LTCP options are related to the length of construction period and estimated number of truck trips. The Neighborhood Storage Option has the most project locations, and therefore has the potential for short-term construction-related air and odor impacts in numerous neighborhoods. Storage tank construction in Ballard could last up to five years. The Shared Storage Option would affect fewer sites but would result in longer construction durations in the Fremont/Wallingford, North Union Bay, and Montlake neighborhoods. The Shared (and Neighborhood) West Ship Canal Options would result in fewer sites being potentially affected, but longer construction durations in the Ballard and Fremont/Wallingford neighborhoods. Overall, fewer facilities would be constructed because the City and King County would share some of their storage facilities. **The** Shared Ship Canal Tunnel Option results in the lowest number of facilities but a longer duration of construction at the portal locations, likely in the Ballard/Fremont and Lake Washington neighborhoods.
Surface water
Construction effects on surface water could include increased pollutants and sediments from site runoff and would require control measures. Construction of pipes, tanks, and portals could occur near sensitive receiving water bodies, including Lake Washington, the Ship Canal, and the Duwamish River. Discharges of dewatering water could introduce contaminants and sediments into local water bodies if not properly managed.

Table 4-10. Summary of Construction Impacts

Resource
The primary differences in potential effects of the LTCP options are related to the amount of surface disturbance and the amount of excavation potentially required. In general, the potential for construction-related impacts to surface waters in the plan area is low for all options because construction will comply with all applicable regulations and permit conditions. The greatest number of facilities would be constructed under the Neighborhood Storage Option with construction locations in up to 11 neighborhoods around the City. The Shared Storage Option reduces the total number of facilities constructed but increases the size of the facilities because they would be shared with King County. Potential for dewatering would occur with all options, but potential dewatering quantities are likely to be greatest for the tunnelling options, where construction durations would last between 3.5 and 7 years. In particular, the Shared (and Neighborhood) West Ship Canal and Shared Ship Canal Tunnel Options are likely to require substantial dewatering. Impacts to surface water would be avoided by compliance with applicable permit conditions.
Biological resources
No direct impacts to aquatic habitats, plants, and invertebrates would occur and no indirect impacts to fish, including federally listed salmonids, are anticipated because no in-water construction would occur. The potential for direct losses of terrestrial habitat associated with facility construction would be minimal under all plan alternatives because all construction will comply with applicable permit requirements. Indirect impacts to wildlife would be associated with increased level of noise and human activity during construction. The primary differences in potential effects of the LTCP options are related to amount of construction activity (surface disturbance) and proximity to mapped priority habitats or species. CSO control projects would be constructed in urbanized areas. The highest amount of surface disturbance would occur with the Shared Storage Option, which suggests a higher potential for habitat impacts. However, the total number of facilities is second to lowest, which would reduce the potential to cause indirect impacts to wildlife. The Shared Storage Option has the potential to impact priority species because construction would occur for up to five years in proximity to priority habitats along the Lake Washington Shoreline and Union Bay Natural Areas. The Neighborhood Storage Option affects the most neighborhoods, The Shared (and Neighborhood) West Ship Canal Tunnel Options result in lower overall disturbance but increase the duration of disturbance. The Shared Ship Canal Tunnel Option reduces the overall area disturbed, but results in construction activity lasting up to seven years in proximity to priority habitats.
Energy and climate change
None of the LTCP options would have a significant impact on energy resources in the Seattle area. The primary difference in energy consumption and greenhouse gas (GHG) emissions between the options relates to the type of storage facility (e.g., tank or tunnel) and whether it is part of the Neighborhood Storage Option or one of the shared options. While the shared options would have higher energy consumption and GHG emissions per facility, there would be fewer new storage facilities built by the City and King County. Therefore, overall emissions would likely be lower.
Environmental health and public safety
Ground excavations and dewatering have the potential to encounter contaminated materials and may require special handling methods depending on the site and type of materials encountered. Discharges of dewatering water could introduce contaminants and sediments into local waterways if not properly managed. In general, environmental health risks associated with construction under all of the LTCP options are low and the potential for the public to encounter contaminated soils or groundwater is also low. Larger projects, such as storage tanks and tunnels, have a greater potential for construction-related environmental health

Table 4-10. Summary of Construction Impacts
Resource
and public safety impacts than smaller projects constructed in the right-of-way, such as storage pipes and flow diversions.
Noise and vibration
Construction of projects under the plan alternatives would result in short-term moderate to substantial increases in noise. The primary differences in potential noise and vibration effects of the LTCP options are related to the amount of earthwork and the length of construction period. The Neighborhood Storage Option would have the most geographically dispersed noise and impacts throughout the plan area with the longest duration of impacts (up to five years) in Ballard. Fremont/Wallingford, and East Waterway neighborhoods. The Shared Storage Option would concentrate higher intensity noise at fewer locations in the Fremont/Wallingford, North Union Bay and Montlake neighborhoods for up to five years. For the Shared (and Neighborhood) West Ship Canal Tunnel Options, the impacts would be concentrated at the portals, in the Ballard and Fremont/Wallingford neighbourhoods for up to three and a half years. The Shared Ship Canal Tunnel Option would concentrate noise at the portal locations in the Ship Canal And Lake Washington neighborhoods for up to seven years, particularly at the launch portal site near the Fremont Cut.
Land use and visual quality
CSO control projects included under the LTCP range from those that would be located in the public right-of-way or streets and cause little or no land use or visual impact up to major infrastructure projects that could require acquisition of property or easements. The acquisitions and easements could be temporary, to accommodate access to a site or a location for project staging, or they could be permanent, for locating storage tanks or tunnels. Maintaining access to businesses and residences will be a key requirement. Impacts to visual quality during construction would be minor under all LTCP options. If public land is not available for facilities, acquisition of private property would likely be required. The primary differences in potential effects of the LTCP options are related to the types of projects and their potential location and the length of construction. The Neighborhood Storage Option has the largest number of CSO storage facilities and would have the greatest potential for temporary land use impacts. Access disruption could affect residences and businesses, as well as the University of Washington, for several years. The Shared Storage Option would reduce the total number of tanks but the construction would be concentrated at fewer, larger sites in the Ship Canal and Lake Washington neighborhoods of Fremont/Wallingford, North Union Bay, and Montlake. The Shared (and Neighborhood) West Ship Canal Tunnel Options would concentrate impacts in the Ballard and Fremont/Wallingford neighborhoods for up to three and a half years, although much of the area used for construction could be sold to private ownership following construction. The Shared Ship Canal Tunnel Option reduces the potential neighborhoods affected but concentrates potential impacts in the Ship Canal and Lake Washington neighborhoods, where construction could occur for up to seven years.
Historic, cultural, and archaeological resources
Construction under any of the LTCP options could have a potential adverse effect on historic, cultural, or archaeological resources in the plan area. The primary difference in impacts relates to the amount of excavation in geological layers and their potential to encounter cultural resources. All LTCP options include similar, minimal potential for impacts on aboveground historic resources. In general, storage tanks and pipes would have a greater amount of excavation in geological layers with potential to encounter cultural resources than the tunnel options, which would occur farther below the surface. There is minimal potential to affect aboveground resources although the potential to affect historic properties with vibration impacts will be a concern for the tunnelling options.
Transportation

Table 4-10. Summary of Construction Impacts
Resource
Construction of projects under the LTCP options would result in moderate to substantial\, adverse transportation impacts for temporary periods ranging from one to six years. Potential construction-related transportation impacts would be highly visible and are of concern to local residents, business owners, and commuters. Transportation impacts would include increases in traffic volumes due to construction-generated truck trips and commute trips of construction workers as well as roadway lane and sidewalk closures where construction activities take place. The primary differences in potential transportation impacts of the LTCP options are related to the length of construction period, estimated number of truck trips, and the road network in the affected neighborhood. The Neighborhood Storage Option would have the most dispersed transportation impacts because it would require roadway lane and sidewalk closures throughout the city to accommodate construction from 18 City and 9 King County facilities. Some neighborhoods could be affected for up to five years. Localized impacts in the Leschi, Montlake and Magnolia neighborhoods could occur because limited route alternatives could require temporary lane closures. The Shared Storage Option would reduce or eliminate impacts in the Leschi neighborhood but would increase impacts in the Fremont/Wallingford, North Union Bay, and Montlake neighborhoods. The Shared (and Neighborhood) West Ship Canal Tunnel Options would concentrate transportation impacts at the portal locations in Ballard and Fremont/Wallingford. This option would result in substantially more truck trips over a longer period in Ballard compared to the Neighborhood Storage and Shared Storage Options. With expected construction duration of three and a half years, truck trips generated by the tunnelling are expected to average 60 per day. The increase in truck traffic is relatively low compared to background levels, and is not expected to adversely affect roadway conditions. Total construction trips are expected to be over 100,000 truck round trips for the Shared Ship Canal Tunnel Option, generated primarily on the south side of the Ship Canal at the launch portal. With estimated construction duration of up to seven years, truck trips generated by the tunnelling are expected to average 70 per day, which is not expected to adversely affect roadway conditions. This option would result in substantially more truck trips over a longer period south of the Ship Canal, where the launch portal would likely be located, compared to the other options.
Public utilities
Construction of storage tanks, pipes, tunnels, pump stations, and appurtenant facilities would occur in areas highly constrained by existing underground and overhead utilities and would require extensive coordination with existing utilities to avoid conflicts. The primary difference in impacts between the options relates to the number of new storage facilities construction and the amount of new conveyance (pipelines) required to transport flows to the new storage facilities. Several of the options include flow diversions to King County facilities, which would necessitate coordination and prior agreements with King County to ensure that there are minimal impacts to King County facilities during construction. Coordination with all potentially affected agencies and utilities would be required. The Neighborhood Storage Option has the greatest potential for construction-related impacts to utilities due to the number of new storage tanks to be constructed and the amount of conveyance required to transport flows to storage facilities. Between the City and King County, a total of 27 facilities would be constructed, all located in areas with existing underground utilities. The Shared Storage Option would include three shared storage facilities with King County as well as a proposed flow diversion to a King County facility, which would require close coordination to ensure that there are minimal impacts to King County facilities during construction. The Shared West Ship Canal Tunnel Option involves the City and King County sharing a deep tunnel and two flow diversions to King County facilities, requiring a high level of coordination with King County to avoid potential construction-related impacts. Deep tunnels tend to be constructed below many underground utilities, reducing the potential for utility conflicts. However, temporary electrical substations to power the tunnel boring machine and construction of tunnel portals and other associated facilities would require utility coordination and reconfiguration. Construction impacts would be similar for the Neighborhood West Ship Canal Tunnel Option, but the tunnel would not be shared with King County. The Shared Ship Canal Tunnel Option involves the City and King County sharing a deep tunnel and includes four flow diversions to King County facilities. This option requires the highest level of coordination between the

Table 4-10. Summary of Construction Impacts
Resource
City and King County to avoid potential construction-related impacts.
Socioeconomics and environmental justice
Construction of projects under the LTCP options could cause construction disturbance and modified access to community resources and businesses, resulting in temporary reduction in neighborhood cohesion. Temporary disruptions may be a particular hardship for some residents – particularly transit-dependent persons – due to disruptions to access and public transportation in project areas. There could be short-term impacts on existing economic conditions in the construction areas due to construction disturbance and temporary changes in the use of the land during construction. In some cases, these changes would be permanent, while in other cases, economic activity would largely be restored following construction. Although construction effects may be substantial, none of the LTCP options would cause disproportionately high and adverse effects on minority and low-income populations.

4.3.3 Operational Impacts

Table 4-11 describes the potential effects of the plan after construction has been completed and the plan projects are in operation. Both the LTCP Alternative and the Integrated Plan Alternative would implement one of the four LTCP options, although some of these CSO reduction projects would be deferred under the Integrated Plan Alternative. Because CSO reduction facilities under the LTCP options would largely be underground, few operational effects to the environment would result from plan implementation. As noted above, for purposes of the EIS, CSO areas are referred to as "neighborhoods."

Table 4-11. Summary of Operational Impacts
Resource
Earth
Overall, the operational effects from the LTCP Alternative are expected to be minor. With the implementation of site-appropriate design, potential adverse impacts would be avoided and minimized. All storage tanks, pipes and tunnels would be designed in accordance with seismic design standards, which are intended to minimize the long-term risks to the system.
Air quality
The net operational effects of the LTCP Alternative on air quality and odors would be minor in the plan area. All facilities would be designed and maintained to minimize emissions of odorous compounds and would include odor control components as necessary. **The** Neighborhood Storage Option would have the highest number of potential odor-producing tanks and pipes located throughout the plan area, including in or near residential areas in the Ship Canal, Lake Washington, and Longfellow Creek/Duwamish Neighborhoods, which is expected to be of concern to area residents. All facilities would be designed and maintained to minimize emissions of odorous compounds. Therefore, operational effects of the CSO control facilities on air quality and odors would be minor in the plan area. The Shared Storage Option would reduce the total number of facilities implemented by the City and King County. The Shared (and Neighborhood) West Ship Canal Tunnel Option would reduce the number of potential odor-producing storage facilities in the Ballard and Fremont/Wallingford neighborhoods. The large tunnel would have the greatest potential for odors at the downstream tunnel portal (likely located along the Ship Canal in the

Table 4-11. Summary of Operational Impacts
Resource
vicinity of Ballard), which would be controlled by an odor control facility. The Shared Ship Canal Tunnel Option would largely eliminate the potential for odor in the Lake Washington neighborhoods of Montlake, Portage Bay, and Leschi. The large tunnel would have the greatest potential for odors at the downstream tunnel portal (likely located along the south side of the Ship Canal), which would be controlled by an odor control facility. Additional flow diversions in Duwamish and Delridge would further reduce the number of potentially odor-producing storage facilities in those neighborhoods.
Surface water
The LTCP Alternative would result in substantial reduction of pollutant loading from existing uncontrolled CSO outfalls when compared with the No Action Alternative. All options of the LTCP Alternative would comply with Clean Water Act requirements and the Consent Decree. The Ship Canal/Lake Union, Lake Washington, Duwamish River, Longfellow Creek, Elliott Bay, and Puget Sound would receive reduced discharges from CSOs. Pollutant loadings from control of 22 currently uncontrolled CSOs would be substantively reduced and would come into compliance with Clean Water Act requirements.
Biological resources
All options for the LTCP Alternative would have negligible to minor operational effects in the plan area. There would be long-term beneficial effects on fish and aquatic life from reducing CSOs. Implementation of the LTCP would reduce the volume of untreated sewage and stormwater runoff, thereby reducing the potential for related adverse effects on aquatic life. The total volume of the City's current CSO discharge would be decreased by nearly 60 percent with full implementation of the LTCP and would comply with the Consent Decree as well as other federal and state requirements.
Energy and climate change
All options for the LTCP Alternative would have minor operational effects on energy use in the city. The GHG emissions produced by operating and maintaining CSO facilities are not expected to cause appreciable climate change impacts. The City has incorporated climate change modelling in its development of the LTCP options and would incorporate additional modelling in the design of individual CSO facilities to minimize risks from anticipated changes in precipitation and sea level rise. The Shared Storage Option would have somewhat higher electrical requirements than the Neighborhood Storage Option because of the greater energy requirements of the larger shared storage tanks. The Shared (and Neighborhood) West Ship Canal Tunnel Option would potentially have a higher electrical requirement than both the Neighborhood and Shared Storage Options because of the electricity needed to pump the deeply stored water. The Shared Ship Canal Tunnel Option would likely have the highest electrical energy requirements of all the LTCP options because of the greater energy requirements for pumping associated with the large deep tunnel. Overall impacts from both the City and King County projects would likely be reduced under all of the shared options because the shared facilities would reduce the number of City and King County independently constructed CSO control facilities
Environmental health and public safety
Overall, the LTCP Alternative is expected to reduce environmental health risks associated with CSOs and stormwater by reducing untreated discharges. Reductions of CSO and stormwater discharges are to water bodies where water-contact recreation occurs, including Lake Union, the Ship Canal, Lake Washington, and the Duwamish Waterway.
Noise and vibration
The net operational effects of the LTCP Alternative would be minor in the plan area. Noise would be generated under all options by pump stations and odor control facilities. All facilities would be designed and maintained to reduce noise to permissible levels. The Neighborhood Storage Option and the Shared Storage Option would include pump stations and other facilities located in residential areas, particularly in the Lake Washington, Longfellow Creek / Duwamish, and Ship Canal neighborhoods. The

Table 4-11. Summary of Operational Impacts

Resource
Shared (and Neighborhood) West Ship Canal Tunnel and Shared Ship Canal Tunnel Options have fewer pump stations and noise-generating facilities so they would have a lower potential for noise impacts.
Land use and visual quality
Potential land use impacts associated with CSO control projects include conversion of land in residential, commercial, or industrial areas to public utility uses. These impacts differ between the options because of different property requirements of tanks as compared to tunnels. The completed facilities would largely be constructed below ground; aboveground facilities would have minimal visual impacts with the use of site-appropriate design and screening. The Neighborhood Storage Option would have the most storage tanks located throughout the plan area with the potential to cause permanent land use changes. Current land uses would be permanently changed to become storage facilities, however, the tanks and associated equipment would largely be underground. The presence of underground storage tanks would restrict certain future uses on top of the facility. While there is the potential to redevelop the surface area into certain beneficial uses, the previous land use at the site could be permanently altered. Ballard would have the largest storage tank (occupying an estimated 60,000 square feet (SF)). The completed facilities would be designed to visually blend with the surroundings, but it is likely that they will have a different appearance from pre-construction conditions. Storage pipes would be constructed in street rights-of-way and would have less potential for land use changes. The Shared Storage Option would result in fewer sites for storage tanks in the Ship Canal neighborhoods and no tank would be sited in the East Waterway area. Potential land use impacts from siting larger shared tanks could occur in the Lake Washington neighborhoods. These tanks would occupy an estimated 35,000 SF (North Union Bay) and 40,000 SF (Montlake). The Shared (and Neighborhood) West Ship Canal Tunnel Option would have lower potential for long-term land use impacts because the tunnel would replace the need to site several storage tanks and less property would need to be retained following construction. The City would be able to sell or lease approximately 75 percent of the tunnel launch portal lands following construction, where it could be developed for zoned uses (e.g., industrial or commercial). Approximately one-half acre of the launch portal would be retained by the City to house the pump station, odor control, and permanent shaft for access and maintenance. All of the area used for the smaller, retrieval end of the tunnel in Fremont/Wallingford would be retained by the City. Some additional areas would be retained for permanent shafts. The Shared Ship Canal Tunnel Option would result in impacts similar to the Shared West Ship Canal Tunnel. All of the area used for the smaller, retrieval end of the tunnel in North Union Bay would be retained by the City. Compared to the Shared West Ship Canal Tunnel Option, the Ship Canal Tunnel would result in less potential for land use impacts in Ballard and more potential for land use impacts on the south side of the Ship Canal and in North Union Bay.
Recreation
Overall, the operational effects from the LTCP Alternative on recreational activities are expected to be minor. Reductions in pollutant loading would benefit long-term water quality and help maintain beneficial uses at area beaches. Water-contact recreation in area water bodies would be enhanced by improved water quality in Lake Washington, Portage Bay, and Lake Union, in particular. Locating storage facilities in a park would constrain certain future uses of that area for park purposes. However, there is a potential to provide recreational facilities on top of storage tanks following construction. The Neighborhood Storage and Shared Storage Options would have the highest potential to cause park and recreation impacts because these options have the most tank facilities. Locating storage facilities in a park or its associated uses (such as parking) would constrain certain future uses of that area for park purposes. However, there is a potential to provide recreational facilities on top of storage tanks following construction. The Shared (and Neighborhood) West Ship Canal Option would have less potential for long-term impacts to recreation than both the Neighborhood Storage and Shared Storage Options since the tunnel would replace the need to site several storage

Table 4-11. Summary of Operational Impacts
Resource
tanks in the Ship Canal neighborhoods (Ballard and Fremont/ Wallingford). The Shared Ship Canal Tunnel Option would result in lower potential for recreation impacts in Ballard and more potential for impacts on the south side of the Ship Canal and in North Union Bay if the tunnel portals are sited in a park or recreation area, including university athletic fields, or the Burke Gilman Trail.
Historic, cultural, and archaeological resources
Operation of projects implemented under the LTCP Alternative is anticipated to have no effect on historic, cultural, and archaeological resources within the plan area.
Transportation
Overall, the operational effects from vehicle trips generated by facility maintenance under the LTCP Alternative are expected to be minor.
Utilities
Implementation of the LTCP would require close coordination with numerous utilities, particularly wastewater, stormwater, and water utilities within the service area. King County's West Point WWTP would receive additional sewage flows as a result of plan implementation. These additional flows could affect peak loading to West Point. Annual average flows would increase, resulting in greater operational and maintenance costs. Seattle and King County would address the incremental cost of these modified flows in a sewage disposal agreement. The potential implications to King County's combined sewer system vary depending upon the option implemented. The Neighborhood Storage Option would generally have minimal operational impacts to utilities once construction is complete. However, this option would require the greatest length of sewer pipe construction, with accompanying maintenance requirements. Sewer system improvements in North Union Bay could have operational implications to King County, which would be resolved according to agreements negotiated with King County. Selection of this option would necessitate the need for King County to construct the largest number of independent storage facilities to meet regulatory requirements. The Shared Storage Option would result in potential operational considerations for both King County and the City associated with flow diversion and shared storage projects. Potential operational implications would be coordinated with King County to ensure than detrimental impacts do not occur. The Shared West Ship Canal Tunnel Option would result in a large joint tunnel and flow diversions to King County in the East Waterway and Magnolia neighborhoods. These joint projects would be implemented in accordance with operational agreements between the City and King County. This option may reduce the operational complexity of controlling neighborhood storage tanks or shared storage tanks as it provides one large storage facility for all flows to be managed through a single pump station discharging to the West Point WWTP. However, King County has acknowledged operational risks associated with fewer storage facilities. The Shared Ship Canal Tunnel Option involves the City and King County sharing a deep tunnel, and includes four flow diversions to King County facilities. This option requires the highest level of coordination with King County, to reduce the potential for impacts. Extensive coordination between the City and King County would be conducted to develop operational agreements that are workable and efficient for both entities.
Socioeconomics and environmental justice
The operational effects of the LTCP Alternative would be minor to moderately beneficial, and there would be no adverse operational effects that would be predominantly borne by minority or low-income populations and underserved communities.

4.3.4 Summary

The construction impacts of the LTCP Alternative Options would be minor to moderate, assuming mitigation measures are implemented. Transportation impacts could be substantial in some neighborhoods. Long -term effects would be beneficial, particularly to water quality, biological resources, and environmental health, and there would be no adverse operational effects that would be predominantly borne by minority or low-income populations and underserved communities.

4.4 Implementation Plan Evaluation

4.4.1 Overview

The implementation schedule is the sequence and duration of design, construction and commencement of operations for the CSO control projects for each LTCP option. The implementation schedule will affect wastewater and drainage rates, employment, public and local businesses, agency resource allocation, and other agencies' projects.

The Consent Decree requires the LTCP to develop an expeditious schedule for the implementation of all CSO control measures. Appendix C Section C.8 of the Consent Decree stipulates that "if it is not possible for the City to design and construct all measures simultaneously, the LTCP shall include a phased schedule based on the relative importance of each measure with the highest priority given to those projects that most reduce the discharge of pollutants."

4.4.2 Prioritization and Scheduling Criteria

For each CSO control measure, the Consent Decree requires that the implementation schedule specify the critical milestone dates for the following project activities: engineering report, plans and specifications, construction start, construction completion, and achievement of controlled status. Because the CSO projects range in construction complexity and project costs, the CSO projects have project durations ranging from 3 years to 14 years based on the City's project implementation experience. The project duration assumptions are listed in Table 4-12.

The LTCP used two methods to determine the priority of projects that most reduce the discharge of pollutants. The first method followed the EPA guidelines for sensitive areas, which determines which basins have the largest impact on receiving water bodies and human health. The results of sensitive areas analysis was shown on Figure 2-26. The LTCP will give the highest priority to controlling overflows to the highest ranked sensitive areas. The second method is then used to rate the results as ranked by the first method to compare the relative cost-effectiveness of each CSO project on a total project cost per gallon of CSO discharge volume reduced. The LTCP will give the highest priority to controlling overflows to the CSO projects with the lowest cost per CSO discharge gallon reduced.

Table 4-12. Option Development (Months)

CSO control measure	Overall project duration	Engineering report	Plans and specifications	Construction start	Construction completion	Achievement of control status
Large CSO tanks (1 MG or larger)	148	36	36	6	54	16
CSO tanks	109	24	24	6	39	16
Pipe storage	73	12	12	6	27	16
Flow diversion	109	24	24	6	39	16
Collection system improvements (retrofits)	73	12	12	6	27	16
West Ship Canal Tunnel	148	36	36	6	54	16
Ship Canal Tunnel	184	36	36	6	90	16

4.4.3 LTCP Option Implementation Schedules

Figure 4-1 presents the overall schedule for the CSO control measure projects for each LTCP Option. The schedules show the project duration and two critical Consent Decree milestone dates: construction completion and achievement of controlled status. See Section 5.9.3 for the implementation schedule of the recommended LTCP option.

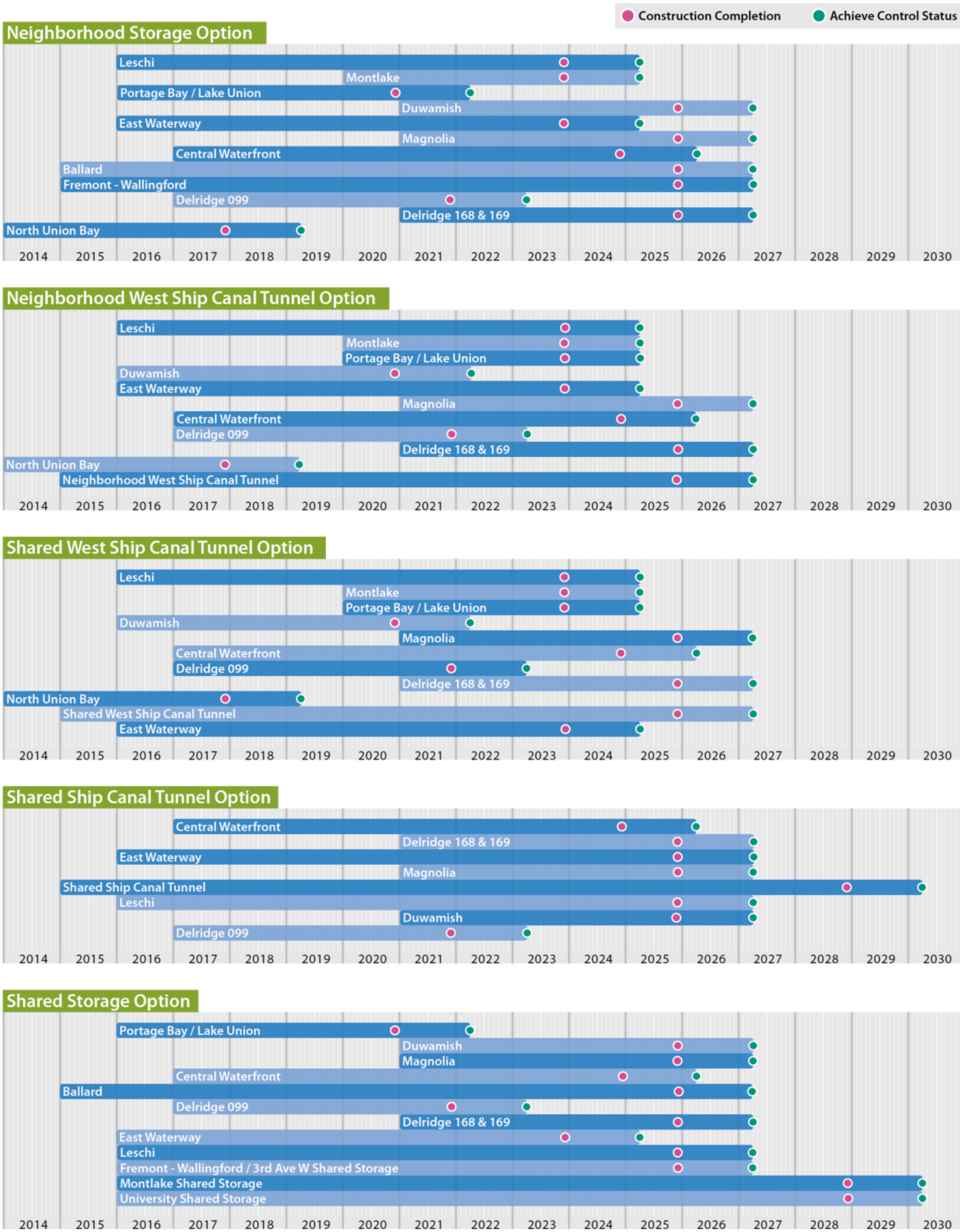

Figure 4-1. LTCP Option Implementation Schedules

Table 4-13 shows the Consent Decree milestone dates for the Neighborhood Storage Option.

Table 4-13. Neighborhood Storage (Tanks) Consent Decree Required Compliance Dates

	Draft engineering report	Final engineering report	Draft plans and specs	Final plans and specs	Construction start	Construction completion	Achieve controlled status
Neighborhood CSO control measures							
Leschi	6/30/2017	12/31/2017	6/30/2019	12/31/2019	7/1/2020	9/30/2023	3/31/2025
Madison Park	9/30/2020	12/31/2020	9/30/2021	12/31/2021	7/1/2022	9/30/2023	3/31/2026
Montlake	9/30/2020	12/31/2020	9/30/2021	12/31/2021	7/1/2022	9/30/2023	3/31/2026
Portage Bay/Lake Union	9/30/2016	12/31/2016	9/30/2017	12/31/2017	7/1/2018	9/30/2020	3/31/2022
Duwamish	9/30/2021	12/31/2021	9/30/2022	12/31/2022	7/1/2023	9/30/2025	3/31/2026
East Waterway	6/30/2017	12/31/2017	6/30/2019	12/31/2019	7/1/2020	9/30/2023	3/31/2025
Magnolia	9/30/2021	12/31/2021	9/30/2022	12/31/2022	7/1/2023	9/30/2025	3/31/2027
Central Waterfront	6/30/2018	12/31/2018	6/30/2020	12/31/2020	7/1/2021	9/30/2024	3/31/2026
Ballard	3/31/2017	12/31/2017	3/31/2020	12/31/2020	7/1/2021	9/30/2025	3/31/2027
Fremont/ Wallingford	3/31/2017	12/31/2017	3/31/2020	12/31/2020	7/1/2021	9/30/2025	3/31/2027
Delridge 99	9/30/2017	12/31/2017	9/30/2018	12/31/2018	7/1/2019	9/30/2021	3/31/2023
Delridge 168	9/30/2021	12/31/2021	9/30/2022	12/31/2022	7/1/2023	9/30/2025	3/31/2027
Delridge 169	9/30/2021	12/31/2021	9/30/2022	12/31/2022	7/1/2023	9/30/2025	3/31/2027
North Union Bay	n/a	n/a	6/30/2014	12/31/2014	7/1/2015	9/30/2017	3/31/2019

Table 4-14 shows the Consent Decree milestone dates for the Neighborhood West Ship Canal Tunnel Option.

Table 4-14. Neighborhood West Ship Canal Tunnel Consent Decree Required Compliance Dates

	Draft engineering report	Final engineering report	Draft plans and Specs	Final plans and Specs	Construction start	Construction completion	Achieve controlled status
Neighborhood CSO control measures							
Leschi	6/30/2017	12/31/2017	6/30/2019	12/31/2019	7/1/2020	9/30/2023	3/31/2025
Madison Park	9/30/2020	12/31/2020	9/30/2021	12/31/2021	7/1/2022	9/30/2023	3/31/2026
Montlake	9/30/2020	12/31/2020	9/30/2021	12/31/2021	7/1/2022	9/30/2023	3/31/2026
Portage Bay/Lake Union	9/30/2016	12/31/2016	9/30/2017	12/31/2017	7/1/2018	9/30/2020	3/31/2022
Duwamish	9/30/2021	12/31/2021	9/30/2022	12/31/2022	7/1/2023	9/30/2025	3/31/2026
East Waterway	6/30/2017	12/31/2017	6/30/2019	12/31/2019	7/1/2020	9/30/2023	3/31/2025
Magnolia	9/30/2021	12/31/2021	9/30/2022	12/31/2022	7/1/2023	9/30/2025	3/31/2027
Central Waterfront	6/30/2018	12/31/2018	6/30/2020	12/31/2020	7/1/2021	9/30/2024	3/31/2026
Delridge 99	9/30/2017	12/31/2017	9/30/2018	12/31/2018	7/1/2019	9/30/2021	3/31/2023
Delridge 168	9/30/2021	12/31/2021	9/30/2022	12/31/2022	7/1/2023	9/30/2025	3/31/2027
Delridge 169	9/30/2021	12/31/2021	9/30/2022	12/31/2022	7/1/2023	9/30/2025	3/31/2027
North Union Bay	n/a	n/a	6/30/2014	12/31/2014	7/1/2015	9/30/2017	3/31/2019
West Ship Canal Tunnel	3/31/2017	12/31/2017	3/31/2020	12/31/2020	7/1/2021	9/30/2025	3/31/2027

Table 4-15 shows the Consent Decree milestone dates for the Shared West Ship Canal Tunnel Option.

Table 4-15. Shared West Ship Canal Tunnel Consent Decree Required Compliance Dates

	Draft engineering report	Final engineering report	Draft plans and specs	Final plans and specs	Construction start	Construction completion	Achieve controlled status
Neighborhood CSO control measures							
Leschi	6/30/2017	12/31/2017	6/30/2019	12/31/2019	7/1/2020	9/30/2023	3/31/2025
Madison Park	9/30/2020	12/31/2020	9/30/2021	12/31/2021	7/1/2022	9/30/2023	3/31/2026
Montlake	9/30/2020	12/31/2020	9/30/2021	12/31/2021	7/1/2022	9/30/2023	3/31/2026
Portage Bay/Lake Union	9/30/2016	12/31/2016	9/30/2017	12/31/2017	7/1/2018	9/30/2020	3/31/2022
Duwamish	9/30/2021	12/31/2021	9/30/2022	12/31/2022	7/1/2023	9/30/2025	3/31/2026
Central Waterfront	6/30/2018	12/31/2018	6/30/2020	12/31/2020	7/1/2021	9/30/2024	3/31/2026
Delridge 99	9/30/2017	12/31/2017	9/30/2018	12/31/2018	7/1/2019	9/30/2021	3/31/2023
Delridge 168	9/30/2021	12/31/2021	9/30/2022	12/31/2022	7/1/2023	9/30/2025	3/31/2027
Delridge 169	9/30/2021	12/31/2021	9/30/2022	12/31/2022	7/1/2023	9/30/2025	3/31/2027
North Union Bay	n/a	n/a	6/30/2014	12/31/2014	7/1/2015	9/30/2017	3/31/2019
Shared CSO control measures							
Shared West Ship Canal Tunnel	3/31/2017	12/31/2017	3/31/2020	12/31/2020	7/1/2021	12/31/2025	6/30/2027
East Waterway flow diversion	6/30/2017	12/31/2017	6/30/2019	12/31/2019	7/1/2020	9/30/2023	3/31/2025
Magnolia flow diversion	9/30/2021	12/31/2021	9/30/2022	12/31/2022	7/1/2023	9/30/2025	3/31/2027

Table 4-16 shows the Consent Decree milestone dates for the Shared Ship Canal Tunnel Option.

Table 4-16. Shared Ship Canal Tunnel Consent Decree Required Compliance Dates

	Draft engineering report	Final engineering report	Draft plans and specs	Final plans and specs	Construction start	Construction completion	Achieve controlled status
Neighborhood CSO control measures							
Central Waterfront	6/30/2018	12/31/2018	6/30/2020	12/31/2020	7/1/2021	9/30/2024	3/31/2026
Delridge 168	9/30/2021	12/31/2021	9/30/2022	12/31/2022	7/1/2023	9/30/2025	3/31/2027
Delridge 169	9/30/2021	12/31/2021	9/30/2022	12/31/2022	7/1/2023	9/30/2025	3/31/2027
Shared CSO control measures							
East Waterway flow diversion	6/30/2017	12/31/2017	6/30/2019	12/31/2019	7/1/2020	9/30/2023	3/31/2025
Magnolia flow diversion	9/30/2021	12/31/2021	9/30/2022	12/31/2022	7/1/2023	9/30/2025	3/31/2027
Shared Ship Canal Tunnel	3/31/2017	12/31/2017	3/31/2020	12/31/2020	7/1/2021	12/31/2028	3/31/2030
Leschi flow diversion	3/31/2017	12/31/2017	3/31/2020	12/31/2020	7/1/2021	9/30/2025	3/31/2027
Duwamish flow diversion	9/30/2021	12/31/2021	9/30/2022	12/31/2022	7/1/2023	9/30/2025	3/31/2027
Delridge flow diversion	9/30/2017	12/31/2017	9/30/2018	12/31/2018	7/1/2019	9/30/2021	3/31/2023

Table 4-17 shows the Consent Decree milestone dates for the Shared Storage Option.

Table 4-17. Shared Storage Consent Decree Required Compliance Dates

	Draft engineering report	Final engineering report	Draft plans and specs	Final plans and specs	Construction start	Construction completion	Achieve controlled status
Neighborhood CSO control measures							
Portage Bay/Lake Union	9/30/2016	12/31/2016	9/30/2017	12/31/2017	7/1/2018	9/30/2020	3/31/2022
Duwamish	9/30/2021	12/31/2021	9/30/2022	12/31/2022	7/1/2023	9/30/2025	3/31/2026
Magnolia	9/30/2021	12/31/2021	9/30/2022	12/31/2022	7/1/2023	9/30/2025	3/31/2027
Central Waterfront	6/30/2018	12/31/2018	6/30/2020	12/31/2020	7/1/2021	9/30/2024	3/31/2026
Ballard	3/31/2017	12/31/2017	3/31/2020	12/31/2020	7/1/2021	9/30/2025	3/31/2027
Delridge 99	9/30/2017	12/31/2017	9/30/2018	12/31/2018	7/1/2019	9/30/2021	3/31/2023
Delridge 168	9/30/2021	12/31/2021	9/30/2022	12/31/2022	7/1/2023	9/30/2025	3/31/2027
Delridge 169	9/30/2021	12/31/2021	9/30/2022	12/31/2022	7/1/2023	9/30/2025	3/31/2027
Shared projects							
East Waterway flow diversion	6/30/2017	12/31/2017	6/30/2019	12/31/2019	7/1/2020	9/30/2023	3/31/2025
Leschi flow diversion	3/31/2017	12/31/2017	3/31/2020	12/31/2020	7/1/2021	9/30/2025	3/31/2027
Shared Fremont/ Wallingford and 3rd Ave. W storage	3/31/2017	12/31/2017	3/31/2020	12/31/2020	7/1/2021	12/31/2025	3/31/2027
Shared Montlake Ssorage	3/31/2023	12/31/2023	3/31/2025	12/31/2025	1/1/2026	12/31/2028	3/31/2030
Shared University storage	3/31/2023	12/31/2023	3/31/2025	12/31/2025	1/1/2026	12/31/2028	3/31/2030

The Shared West Ship Canal Tunnel option is estimated to take 11 years to design and construct and will meet the City Consent Decree construction completion milestone date (2025); however, it will not meet the County's construction completion milestone date for 3rd Avenue West (2023), unless the schedule can be compressed. Similarly, the Shared Ship Canal Tunnel Option will take 14 years to design and construct and will not meet the City's 2025 construction completion date nor the King County 3rd Avenue W completion date (2023). Two of the shared storage tank projects (North Union Bay and Montlake) proposed in King County's CSO Plan also will not meet the City's 2025 completion date.

4.4.4 LTCP Implementation Plan

As described in Section 4.1.1, Rating and Ranking of LTCP Alternative Options, the Draft LTCP has performed a rating and ranking of the LTCP options in accordance with the EPA requirements in the *Combined Sewer Overflows Guidance for Long-Term Control Plan, 1995.* The Draft LTCP was submitted in May2014 for EPA and Ecology review and comment. The City issued a public notice and held a public meeting and official public comment period for the Draft LTCP. After the comment period and receipt of EPA and Ecology comments, additional evaluation was performed to refine and re-evaluate the options in order to select a preferred LTCP option See Chapter 5.

4.4.5 Factors Potentially Affecting Schedule

The LTCP Implementation schedule is the sequence in which the LTCP options will be implemented. The implementation schedule will affect sewer rates, City resource workload, City resources, and local and regional projects. The following paragraphs describe major internal and external factors that may impact the timing and implementation decisions of the LTCP options and individual LTCP projects.

4.4.5.1 City Utility Rates

City drainage and wastewater rates will need to be increased to implement the LTCP options. In addition, the City rate payers will be paying for the implementation of the 2010 Plan CSO projects and the Consent Decree Early Action Projects during the same period (2015-2030). LTCP projects may need to be distributed throughout this period to reduce or “flatten” the rate increase. Rate impacts are discussed in detail in Section 4.5, Financial Plan.

4.4.5.2 King County Coordination on Shared Projects

There are three LTCP options that include shared projects with King County. The City and King County each have consent decrees and NPDES permits with varying compliance dates and priorities that make coordination of shared projects challenging. The City and King County are continuing to work together closely to analyze and recommend LTCP options that are more cost-effective, produce better environmental outcomes, and minimize disruption to communities. King County must also reach its own independent conclusions about the benefits of a shared project to the regional system and the implications of such a project to its own Long Term Control Plan and Consent Decree. Independent City-only neighborhood options have been developed that can also reduce impacts to communities if shared projects are not selected.

4.4.5.2.1 City Consent Decree Compliance Deadlines

The City Consent Decree requires “...Construction completion of all CSO control measures in the approved LTCP…” by December 31, 2025. For the neighborhood option, the City will be able to meet this consent decree deadline.

However, for the three shared LTCP options, the City and King County must agree on a mutual construction completion date for all shared projects and the City will need to obtain approval from EPA, Ecology, and the court if this date is different from their respective consent decrees. For example, for the Shared Storage Option, King County's Consent Decree has two of the shared projects (University Regulator and Montlake Regulator) with a required construction completion date of 2030. The City Consent Decree requires that all LTCP projects including shared projects have a construction completion date no later than December 31, 2025. If the City and County agree to implement these two shared projects, the City will need approval to implement these projects after the 2025 construction completion date. See Chapter 5, Section 5.4.2.2 and 5.9.5.2 for updated information regarding proposed Shared Projects and Consent Decree Milestone requirements.

4.4.5.3 Opportunities and Conflicts with other Projects

CSO Basin 107 (East Waterway) and CSO Basin 69 (Central Waterfront) may be impacted by the future King County Hanford-Lander-King St – Kingdome CSO Treatment Plant project. The proposed Hanford, Lander, Kingdome, King St. Project includes CSO treatment facility for up to 151-MGD (assuming the use of a ballasted sedimentation treatment process) near the Hanford St Regulator Station and modifications to the Elliott Bay Interceptor to divert flows to the CSO treatment facility. The flow diversion may result in decreased CSO control requirements for CSO Basins 107 and 069, depending on the final configuration of the HLKK flow diversion from the EBI to the new CSO plant. The City Consent Decree currently requires that CSO Basins 107 and 069 obtain construction completion by 2025. Close coordination of CSO Basins107 and 069 projects with the County's HLKK project will needed to identify the most cost-effective solution and implementation schedule.

4.4.5.4 Central Waterfront and Elliott Bay Seawall Projects

The proposed CSO Basin 069 (Central Waterfront) control measure for all LTCP options must be coordinated with the Elliott Bay Seawall (North) project. The CSO Basin 069 project location will be significantly impacted by the Elliott Bay Seawall (North) project construction which is currently scheduled for no earlier than 2018 to 2020. The specific construction schedule cannot be finalized until the City obtains funding for the Elliott Bay Seawall (North) project construction. Constructing the CSO Basin 069 project ahead of the Elliott Bay Seawall (North) project will result in significant additional construction costs for the seawall project to protect the CSO Basin 69 project in place.

4.5 Financial Plan

4.5.1 Overview

A financial analysis was performed for each of the options presented in the draft LTCP. See Chapter 5 Section 5.10 for the financial plan for the recommended LTCP option.

4.6 Operational Plan Evaluation

4.6.1 Overview

This section presents the City's operation and maintenance plan for the proposed LTCP options. The section includes proposed staffing requirements, and LTCP CSO operating strategies. Section 5.11 presents the operational plan for the recommended LTCP option, and provides a summary of the City and King County Joint Operations and System Optimization Plan.

4.6.2 Regulatory Requirements

4.6.2.1 EPA LTCP Requirements

The 1997 EPA LTCP Planning Guidance requirements for an operation plan are outlined in Section 4.6, Operational Plan Evaluation, and are summarized below:

> *As part of the implementation of the NMC, municipalities should be required to develop and document programs for operating and maintaining the components of their CSSs. Once an LTCP has been approved, however, the municipality's O&M program should be modified to incorporate the facilities and operating strategies associated with the LTCP controls. Typically, each facility constructed as part of the LTCP will have its own O&M manual detailing the equipment and features of the facility, including operating instructions, troubleshooting guides, and safety considerations. If the LTCP features multiple facilities, however, a master operating strategy should be developed to optimize the operation of the various LTCP components. Optimization might involve coordination of pump back timing, dynamic regulator operation, or other real-time operating strategies. Interim operating strategies might be required for phased projects and for construction-period operations and flow transitions.*
>
> *Maintenance programs should consider the unique operating conditions of CSO facilities, particularly with regard to schedules for inspecting and exercising idle equipment. Aspects of the Post-Construction Monitoring Program might also be incorporated into the operational plan, as regular schedules for sampling and maintaining sampling equipment are developed.*
>
> *If not addressed in the individual facility O&M manuals, the operational plan should identify staffing needs for CSO control facilities, both in terms of numbers of staff and specific positions necessary, with appropriate descriptions of responsibilities and minimum qualifications.*

4.6.2.2 Ecology NPDES Permit Requirements

The City CSO NPDES permit describes project-specific requirements for operation and maintenance in NPDES Permit No. WA-003168-2, Section S4. Operations and Maintenance. The majority of these requirements will be completed during the LTCP implementation phase following the Final LTCP approval. Key NPDES operation and maintenance requirements included in the LTCP operation plan are:

- S4.A. O& M Program; 1. Institute an adequate Operation and Maintenance Program for the entire combined sewage system.
- S4.C. Electrical Power; The Permittee must ensure that adequate safeguards prevent the discharge of untreated wastes or wastes not conveyed in accordance with the requirements of this permit during electrical power failure at sewage lift stations. Adequate safeguards include, but are not limited to, alternate power sources, standby generator(s), or retention of inadequately treated wastes, bypass pumping (for example, pumping of combined sewer flows with a means other than the pump station's pumps), or other equally protective means.

4.6.3 Staffing

4.6.3.1 SPU Operation and Maintenance Staff Organization

SPU is organized into eight branches. The Operations and Maintenance functions of the Drainage and Wastewater Line of Business Branch are responsible for operating and maintaining the City's CSO facilities. The

Operations and Maintenance functions include more than 480 employees. Field crews respond to emergencies, locate and utilize appropriate resources, and carry out critical operations and maintenance programs and capital improvements to keep our infrastructure and assets working efficiently. Figure 4-2 presents the current overall SPU organization.

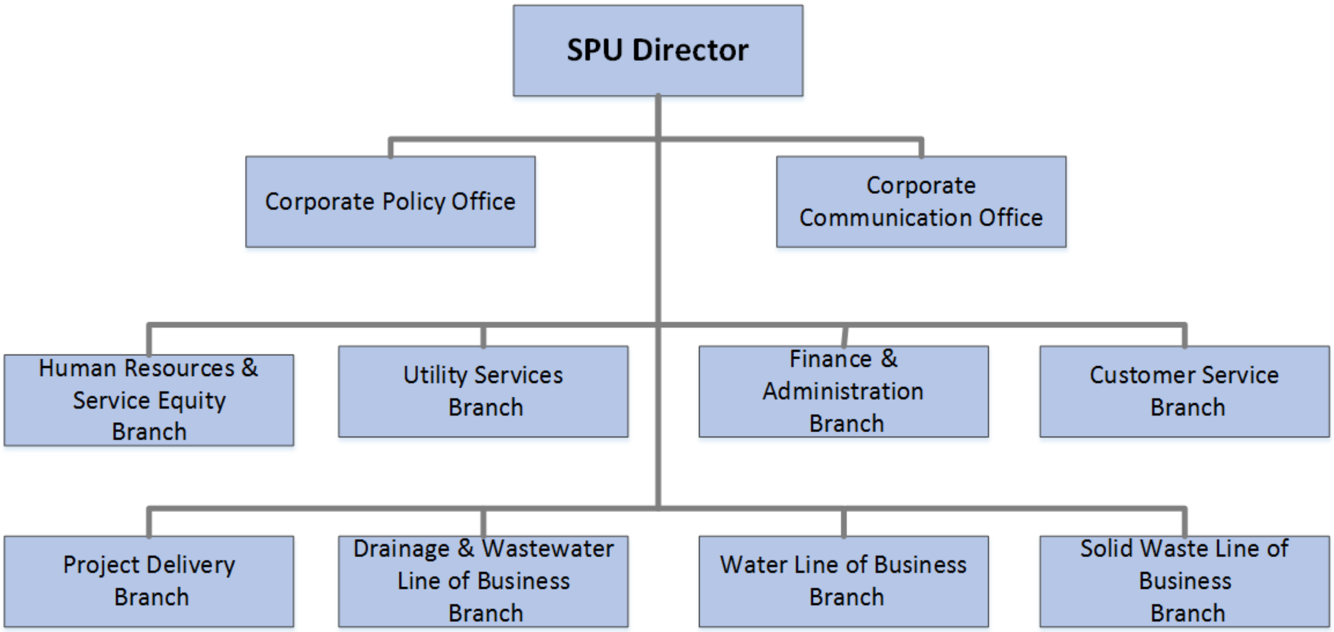

Figure 4-2. SPU Organization Chart

4.6.3.1.1 Drainage and Wastewater System Maintenance

The Drainage and Wastewater System Maintenance function includes managers, crew chiefs, and staff to maintain the drainage and wastewater assets within the City's service area. This group focuses on physical maintenance activities only and does not include any operations staff. There are separate crews for each of the following activities:

- Underground Storage Facilities
- Surface Water Management
- Line and Grade (Pipeline Maintenance)
- First Response (Responds to Customer Complaints and Emergencies)
- Closed Circuit TV (CCTV)
- Rehabilitation
- Ground Maintenance (Landscaping)

Figure 4-3 is an organization chart showing the division organization and its primary responsibility.

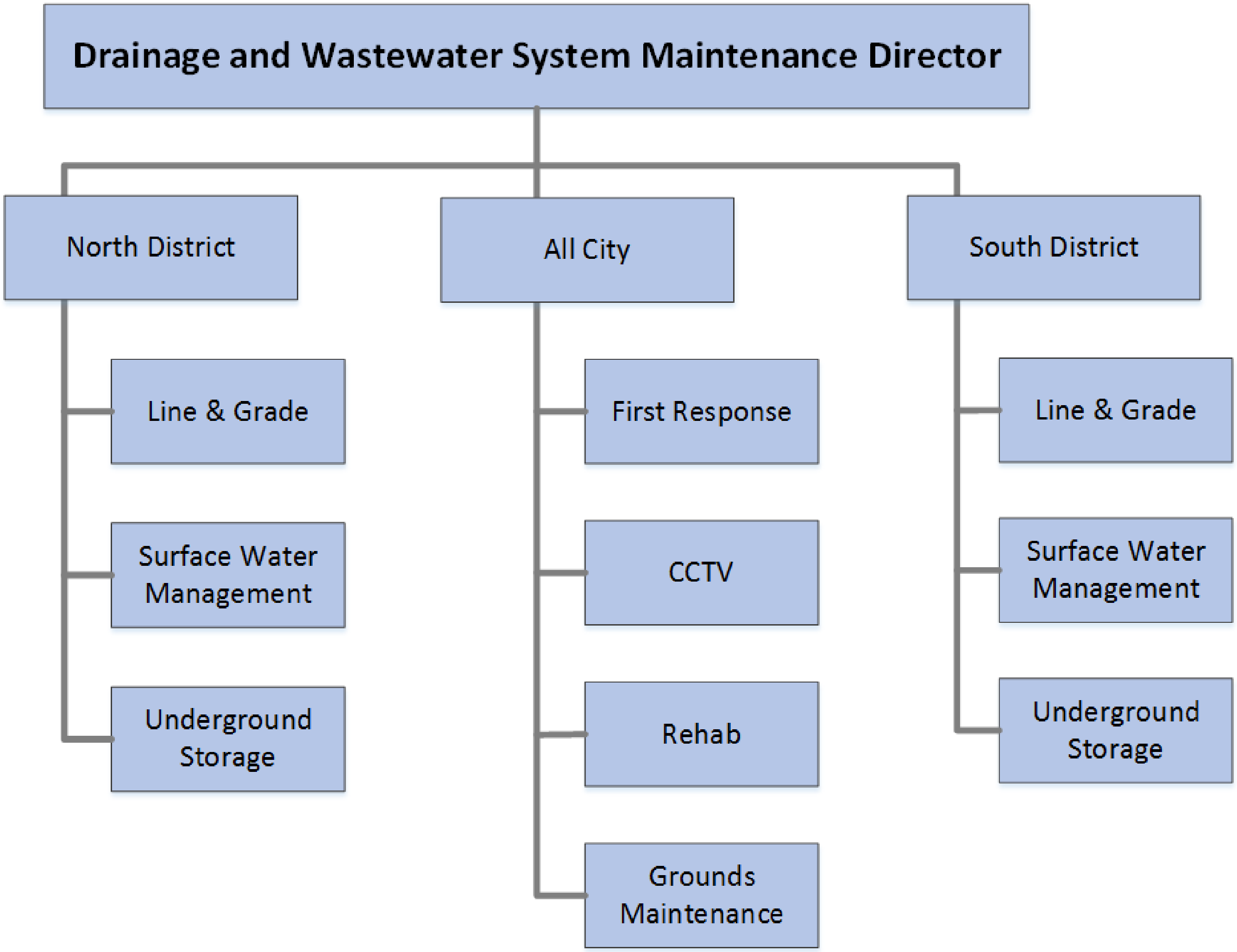

Figure 4-3. Drainage and Wastewater System Maintenance Organization Chart

4.6.3.1.2 Operations and Maintenance Function

There are four main sub-groups within the Operations and Maintenance function: Maintenance; Supervisory Control and Data Acquisition (SCADA); System Operations, Planning and Analysis (SOPA); and System Operations. The group contains a diverse set of skills including physical maintenance of electrical infrastructure, performance analysis, instrumentation and control engineering, and 24/7 control center operation. This organization allows the City to provide quality drainage and wastewater services to our customers under dry-weather and wet-weather conditions as well as unusual conditions such as flooding, SSOs or CSOs.

Figure 4-4 is an organization chart showing each sub-group and its primary responsibility.

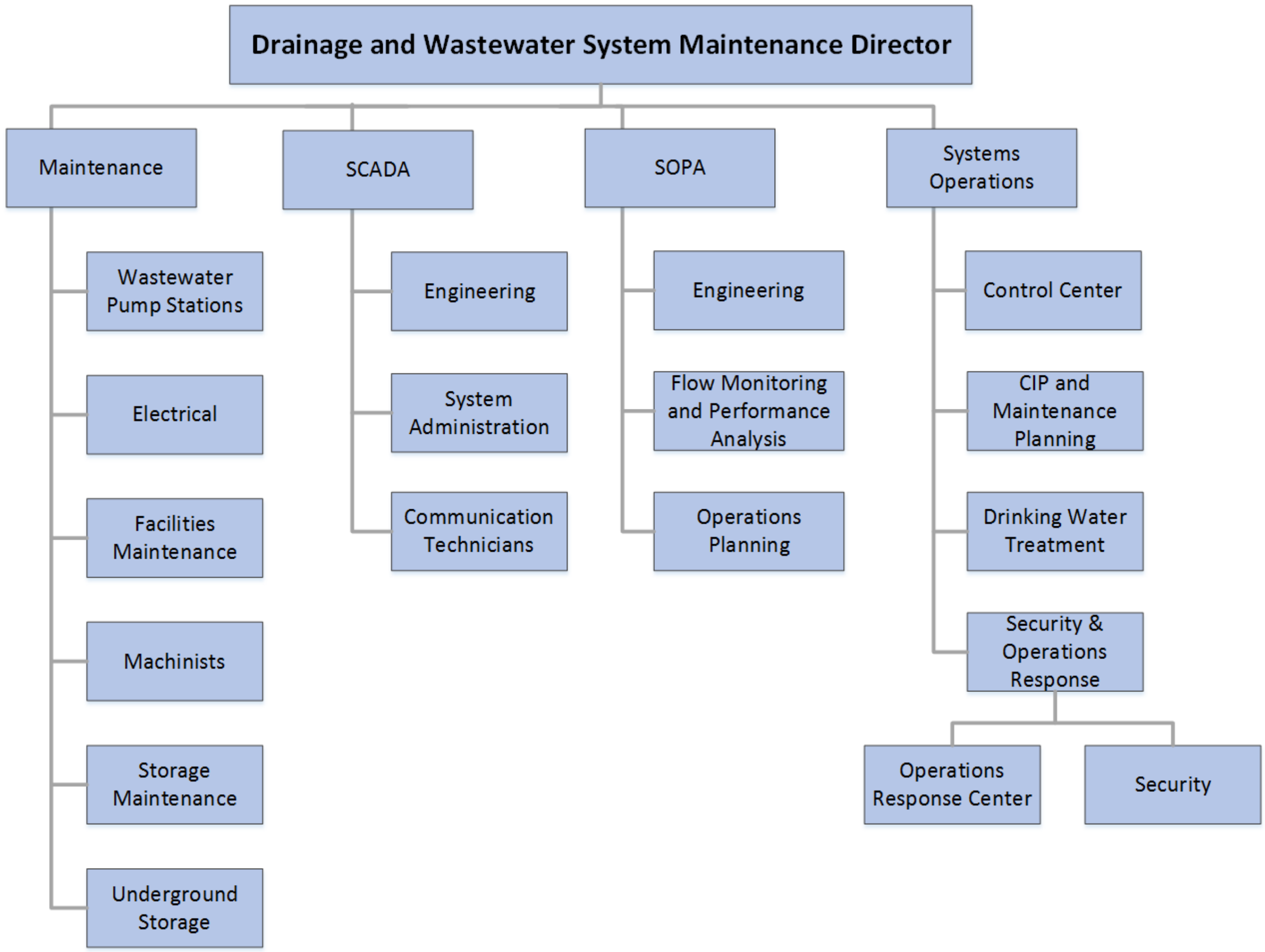

Figure 4-4. Operations and Maintenance Organization Chart

4.6.3.2 SPU Staffing Requirements

SPU has projected the additional operation and maintenance staffing requirements needed to commission, operate, and maintain the LTCP projects. Specific number of full-time-equivalent (FTE) employees and staff responsibilities for each LTCP options are summarized in Table 4-18 for current (2015), near-term (2020), construction completion (2025), and achievement of controlled status (2030).

Operation staff refers to Control Center operators (under the System Operations sub-group) and SOPA sub-group staff, who will conduct performance monitoring, modeling, post-construction monitoring reporting, facility configuration and control strategies management, and operations data stewardship. Maintenance staff refers to Maintenance sub-group staff, who will maintain pump stations, control structures, CSO storage and conveyance facilities.

Based on the LTCP Option Implementation schedules, the first additional LTCP operation and maintenance staff will be required for CSO facility commissioning and acceptance testing between 2018 and2020. Depending on the final recommended LTCP option, the total number of additional operation and maintenance staff will be approximately 7 to 12 FTE employees after construction completion in 2025.

Table 4-18. Operations and Maintenance Staffing Needs for Proposed LTCP Options

LTCP option	LTCP staffing requirements (FTEs)			
	2015 (current)	2020 (near term)	2025 (construction completion)	2030 (controlled status)
Neighborhood Storage				
Operations	0.0	0.5	4.2	4.2
Maintenance	0.0	0.7	7.4	7.4
Total O&M staff	0.0	1.2	11.6	11.6
Neighborhood West Ship Canal Tunnel				
Operations	0.0	0.5	4.1	4.2
Maintenance	0.0	0.7	7.1	7.1
Total O&M staff	0.0	1.2	11.2	11.2
Shared Storage				
Operations	0.0	0.4	2.9	2.9
Maintenance	0.0	0.4	6.1	6.1
Total O&M staff	0.5	0.8	9.0	9.0
Shared West Ship Canal Tunnel				
Operations	0.0	0.5	4.1	4.1
Maintenance	0.0	0.7	6.9	6.9
Total O&M staff	0.0	1.2	11.0	11.0
Shared Ship Canal Tunnel				
Operations	0.0	0.2	2.0	2.0
Maintenance	0.0	0.2	4.5	4.5
Total O&M staff	0.0	0.4	6.5	6.5

See Chapter 5 Section 5.11 for additional details on the operational plan for the recommended LTCP option.

CHAPTER 5

Selection and Implementation Of Recommended LTCP CSO Control Option

5.1 LTCP Development and Implementation Timeline

On May 29, 2014, the Draft LTCP was issued for public and regulatory (EPA and Ecology) review and comment. Following the comment period and receipt of comments from the public, EPA, and Ecology, additional evaluation was performed to select a recommended option. The process for selecting the recommended option is documented in Section 5.4. Some of the smaller elements of the option have been modified from the Draft LTCP (flow transfers changed to small storage facilities), but the major elements (tanks and tunnels) have remained the same.

In early February 2015, a draft Final LTCP was submitted to EPA and Ecology for review. In March 2015, the Mayor and City Council reviewed and adopted the Final LTCP through a City ordinance process. The Final LTCP was submitted to EPA and Ecology along with an updated Post-Construction Monitoring Plan for approval on May 29, 2015. By the end of 2015, the Final LTCP is anticipated to be approved by EPA and Ecology and LTCP implementation will commence. Under the LTCP Alternative, construction completion of all LTCP CSO control projects will be achieved by December 31, 2025.

The overall LTCP development and implementation schedule is shown on Figure 5-1, along with a detailed schedule for adoption and approval of the Final LTCP.

5.2 Public and Regulatory Agency Participation Program

As part of the process for developing the Draft LTCP and selecting the recommended option, and in accordance with the Consent Decree, the City conducted a comprehensive public and regulatory agency participation program.

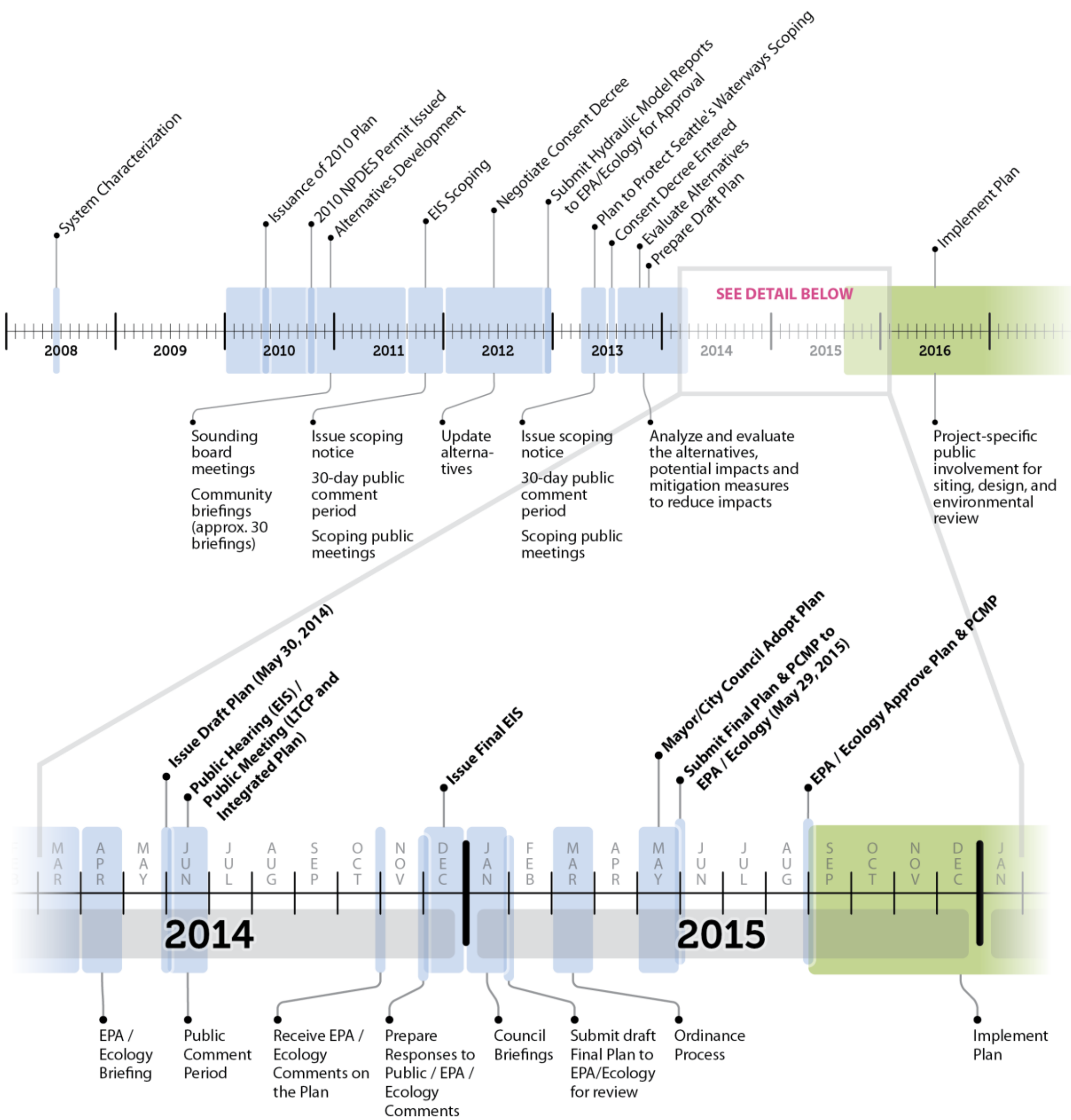

Figure 5-1. LTCP Schedule Summary of Public and Regulatory Participation Process and Approach

A summary of the overall public and regulatory agency participation program activities is presented in Table 5-1. Public and regulatory agency participation was performed jointly for the LTCP, the Integrated Plan, and the Programmatic EIS, which together comprise the City's overall Plan to Protect Seattle's Waterways.

Table 5-1. Final Public and Regulatory Agency Participation Program

Consent Decree requirements (Appendix C, Section A.1-A.5)	Public participation performed
How the City will make LTCP information available for public review.	► Prepared the Community Guide to the Integrated Plan to provide an overview of the three stormwater control projects the City proposes for the Integrated Plan Alternative. ► Placed an article about the Draft EIS release and public hearing in the summer 2014 edition of Seattle Public Utilities' Curb Waste newsletter, which is mailed to approximately 330,000 Seattle residents. Conducted briefings with 13 community organizations and environmental groups: • Ballard District Council (May 14, 2014) • Delridge Neighborhoods District Council (June 18, 2014) • Fremont Neighborhood Council (May 19, 2014) • Friends of Gasworks Park (May 13, 2014) • Groundswell NW (May 20, 2014) • Lake City Neighborhood Alliance (May 8, 2014) • Leschi Community Council (June 4, 2014) • North Seattle Industrial Association (May 27, 2014) • Northwest District Council (May 28, 2014) • Puget Soundkeeper Alliance (May 22, 2014) • South Park Neighborhood Alliance (June 10, 2014) • Sustainable West Seattle (May 5, 2014) • Thornton Creek Alliance (June 26, 2014) The following organizations declined the City's offer to provide a briefing: • Broadview Community Council • Central District Council • Duwamish River Cleanup Coalition • Georgetown Community Council • Greater Duwamish District Council • Madison Park Community Council • Meadowbrook Community Council • Montlake Community Council • North District Council • Puget Sound Partnership • Sustainable Seattle • Thornton Creek Oversight Committee

Table 5-1. Final Public and Regulatory Agency Participation Program

Consent Decree requirements (Appendix C, Section A.1-A.5)	Public participation performed
	• Wallingford Community Council. ► In coordination with the Ballard District Council, the City established the West Ship Canal Stakeholder Advisory Group to represent the interests of stakeholders in Ballard, Fremont, and Wallingford and provide focused input on aspects of the plan that affect these neighborhoods. The City convened two meetings of the West Ship Canal Stakeholder Advisory Group and the West Ship Canal Stakeholder Advisory Group met an additional six times. ► Maintained the CSO program website at www.seattle.gov/CSO. Information about the Plan to Protect Seattle's Waterways is available by clicking Long Term Control Plan.
How the City will solicit public comments on the development of the LTCP	• ► Issued the Draft Plan to Protect Seattle's Waterways and Draft EIS on May 29, 2014, and held a 30-day public comment period that ended on June 30, 2014. Hosted the Draft EIS public hearing and Long Term Control Plan/Integrated Plan public meeting on June 24, 2014. The City accepted comments by mail, email, and in person at the Draft EIS public hearing. The City received 13 sets of comments from the public and agencies. Held public Council Committee meetings in April and May 2015 for the Ordinance to approve the Plan to Protect Seattle's Waterways
Summary of public hearings during LTCP development to provide public with information and to solicit public comments.	► A summary of questions and comments received during the 30-day Draft EIS public comment period is available in the *Draft EIS Public Hearing and Long-Term Control Plan Public Meeting Summary Report* available at www.seattle.gov/CSO.
Program for consideration of comments provided by the public as the City developed the LTCP.	► Issued the Draft Plan to Protect Seattle's Waterways and Draft EIS on May 29, 2014, and held a 30-day public comment period that ended on June 30, 2014. Hosted the Draft EIS public hearing and Long Term Control Plan public meeting on June 24, 2014. The City accepted comments by mail, email, and in person at the Draft EIS public hearing. The City received 13 sets of comments from the public and agencies. ► Issued the Programmatic Final Environmental Impact Statement on December 4, 2014. • Distributed a Notice of Availability of the Programmatic Final EIS • Published a notice of Availability of the Programmatic Final EIS in *The Daily Journal of Commerce* and *the Seattle Times* • Transmitted the Notice of Availability and the Programmatic Final EIS to the Ecology's SEPA Unit • Filed the Programmatic Final EIS with the City's SEPA Public Information Center • Made copies of the Programmatic Final EIS and background materials available for public viewing at the Seattle Public Utilities office in the

Table 5-1. Final Public and Regulatory Agency Participation Program

Consent Decree requirements (Appendix C, Section A.1-A.5)	Public participation performed
	Seattle Municipal Tower, at the Seattle Central Library, and online at www.seattle.gov/CSO • Provided copies of the Programmatic Final EIS to all parties listed in the Programmatic Draft EIS distribution list and all parties that made comments on the Programmatic Draft EIS The appeal period closed without comment on December 19, 2014.
How the City ensured that EPA and Ecology were kept informed of the LTCP development.	► Communicated regularly with EPA and Ecology regarding the LTCP and the Integrated Plan, including the following: • April 23, 2014: Provided a summary presentation on the four volume Draft Plan to Protect Seattle's Waterways. -- Volume 1 Executive Summary -- Volume 2 The Long Term Control Plan -- Volume 3 The Integrated Plan -- Volume 4 Programmatic Environmental Impact Statement. Reviewed the Integrated Plan Post-Construction Monitoring Program and comments from EPA and Ecology on a preliminary draft of Volume 1 Executive Summary (which was provided in advance of the meeting). Reviewed the projected plan schedule. • November 13, 2014: Provided a summary presentation on the recommended CSO control measures and reviewed the schedule for development and submittal of a draft Final and Final Plan • February 2, 2015: Submitted draft Final Plan to EPA and Ecology for review • May 29, 2015: Submitted Final Plan and Post-Construction Monitoring Plan to EPA and Ecology for approval

5.2.1 Summary of Comments on the Draft LTCP

5.2.1.1 Public Comments

During the 30-day comment period for the Draft EIS, the City received several sets of comments:

- Six letters
- Six emails
- One comment form submitted at the Draft EIS public hearing

The following agencies and organizations submitted comment letters:

- Ballard Stormwater Consortium
- City of Seattle Parks and Recreation
- Duwamish River Cleanup Coalition

- King County Wastewater Treatment Division (King County)
- Washington State Department of Archaeology and Historic Preservation (DAHP)
- Washington State Department of Natural Resources (DNR)

A summary of questions and comments received during the 30-day Draft EIS public comment period is in the Draft EIS Public Hearing and Long Term Control Plan Public Meeting Summary Report available at www.seattle.gov/CSO.

5.2.1.2 King County Wastewater Treatment Division Comments

King County submitted comments during the 30-day Draft EIS comment period, including the following observations:

- The LTCP recognizes that all of the options have elements that may impact King County's system and that strong coordination is needed between the City and King County.
- King County will need to reach its own conclusions about the benefits of shared projects as well as implications for the regional wastewater system and to King County's LTCP and Consent Decree. Prior to implementing any shared projects with King County, joint project agreements need to be signed with the City.
- Both King County and the City need to be involved in analyzing the impacts of proposed projects on the downstream system and to agree on an approach to address impacts. Shared project agreements need to be negotiated and signed between the two agencies. Coordination is also necessary on City projects that aren't shared, such as projects that increase flows to King County facilities. The nature of those impacts will need to be analyzed and appropriate compensation to King County negotiated, where applicable. The Programmatic Draft EIS describes the City's commitment to work with King County and the importance of close coordination and shared agreements.

5.2.1.3 Regulatory Agency Comments

The City received 23 LTCP-related comments from Ecology on August 29, 2014. Responses were prepared and submitted to Ecology in February 2015.

The City received conditional approval of the May 2014 Draft LTCP from the EPA on October 31, 2014. On December 6, 2014, the City received a clarification letter that stated:

> *"EPA would like to clarify the letter sent to Seattle dated October 31, 2014. This letter approved the Draft Long Term Control Plan (LTCP) and provided conditional approval of the draft Integration Plan (IP). Both plans will only be considered completely approved when both EPA and Ecology have approved each as final documents. As such, approval of the final LTCP and final IP by the Agencies will require the City to address comments raised by both EPA and the Washington State Department of Ecology's in the next iteration of each."*

5.2.2 Subsequent Public and Regulatory Agency Participation

On February 2, 2015, the City provided EPA and Ecology a draft Final Plan for Protecting Seattle's Waterways for review that identified the Recommended LTCP CSO Control Option and the Recommended Alternative for Protecting Seattle's Waterways. Comments were incorporated into the Final Plan. From March through May 2015, the City Council reviewed and adopted the Final LTCP through a City ordinance process. The ordinance process required open public Council hearings and meetings (April and May 2015) to discuss and approve the Ordinance.

On May 29, 2015, the Final LTCP was submitted to EPA and Ecology for Final Approval. By the end of 2015, the Final Plan is anticipated to be approved by EPA and Ecology and LTCP implementation will commence in late 2015 or early 2016.

Starting in 2016, the City will work with local neighborhoods to select specific sites at which facilities will be built. As part of each project siting process, the City will perform an appropriate, project-specific environmental review. The project-level environmental review will identify project-specific impacts and will help inform decisions regarding site and project-level details. Public meetings for siting, design, and environmental review will continue until the plan is fully implemented.

5.3 Refinement and Evaluation of CSO Control Options

This section describes the additional tasks that were performed between late May 2014 and December 2014 to refine and evaluate the CSO control options. Tasks included incorporating regulatory review comments, evaluating new hydraulic boundary conditions provided by King County for CSO storage release flow rates, performing a detailed evaluation of shared options with King County, preparing independent third-party cost estimates, issuing the Programmatic Final EIS, sponsoring an agency peer review, assessing the potential CSO reduction of proposed City retrofit and green infrastructure program projects, updating the CSO Sensitive Area Study, and reanalyzing the control status of outfalls previously thought to be controlled.

5.3.1 Evaluation of Additional King County Boundary Conditions (No Impact Release Rates)

The hydraulic models used for this analysis were based upon the calibrated Storm Water Management Model, Version 5 (SWMM5), engine update v22. These models were documented in the LTCP Hydraulic Model Reports (Refer to Chapter 2). The models were modified to incorporate the most likely CSO control measures to confirm that the measures would control discharges to an average of no more than one CSO event per year per outfall over a 20-year moving average.

All of the City's CSO basins discharge into the King County system through various facilities. To determine whether the City's CSO control measures would impact the operation of King County facilities, King County identified key locations in their system and, for each location and under varying conditions, specified the maximum flow that could be discharged from the City system without impacting operation of King County facilities. These data, called no-impact release rates (NIRR), provide durations and maximum flow rates for release of stored flow from the City CSO control facilities that would result in minimal or no impact on the operation of King County's facilities.

The City's most likely CSO control measures were also evaluated using the King County NIRR to confirm that the CSO control measures would allow the City to achieve compliance with the Consent Decree requirements. Where necessary, minor modifications were made to the City's CSO control measures to account for the King County NIRR, but the NIRR did not significantly impact any of the City's CSO control measures. The King County NIRR was available only for the period from 1978 through 2009 and thus the analysis was restricted to this period.

Section 5.8 summarizes the results of the evaluation. Appendix L includes the *January 2015 Long Term Control Plan CSO Control Measures Performance Modeling Report,* which provides additional detailed information on the CSO performance modeling.

5.3.2 Joint Evaluation of King County and City Shared Options

The City recognizes the importance of coordination with King County in controlling CSOs in Seattle. All City options have elements that may impact King County's downstream wastewater system. Three of the proposed options include shared City/King County projects along the Ship Canal. Several of the proposed options include sewer system improvements that would convey additional wastewater volume to the downstream King County system. All interagency coordination will be conducted in accordance with commitments included in the City and King County Coordination Plan, signed by both agencies on April 4, 2014. In the Coordination Plan, the City and King County agreed that specific factors will be considered in evaluating and making a recommendation on which CSO projects will be undertaken jointly or independently by either the City or King County. Section 5.4.2 discusses the evaluation factors and the process.

5.3.3 Issuance of Final Programmatic Environmental Impact Statement

The Final Programmatic EIS responded to comments received on the Draft Programmatic EIS, described changes to the alternatives that have occurred since the issuance of the Programmatic Draft EIS, and includes modification and revisions to the analysis as appropriate. Changes to the Draft Programmatic EIS in response to comments received are minor. Consistent with Washington Administrative Code 197-11-560(5) and Seattle Municipal Code 25.05.560.E, the City has prepared an updated fact sheet and an addendum to the Draft Programmatic EIS that includes the comments, responses, and changes to the document since its release. The Final Programmatic EIS was issued on December 4, 2014, and the appeal period closed without comment on December 19, 2014. The Final Programmatic EIS is Volume 4 of the Plan to Protect Seattle's Waterways.

The Final Programmatic EIS provides a comprehensive evaluation of potential impacts associated with implementation of the plan. Site-specific environmental reviews will be conducted during LTCP implementation, when additional information will be available. Environmental elements covered in the EIS include earth, groundwater, air quality, odors, surface water, biological resources, energy, climate change, and environmental health. Noise and vibration, land use, visual quality, recreation, historic and cultural resources, transportation, utilities, and socioeconomics and environmental justice were also evaluated.

Key issues associated with the alternatives and options include potential construction-related impacts, particularly traffic, noise, and other community impacts during construction periods that could range from roughly one year to as many as seven years, depending on the project size. Possible long-term impacts include a potential for odor and noise at storage facilities and potential operational implications for the region's wastewater system. Appropriate design, along with coordination with potentially affected agencies and organizations, will reduce the potential for significant impacts.

5.3.4 Assessment of Control Benefits from the Sewer System Improvement Program

The City has been conducting an ongoing program to identify, design, and construct sewer system improvement projects in CSS areas. These projects are typically small in scope and consist of modifications to existing infrastructure. Examples include raising an overflow or storage weir, removing an existing HydroBrake and replacing it with a motor-operated gate, increasing the capacity of a pump station by replacing the pumps, or modifying the hydraulics of an overflow control structure.

These sewer system improvements are an important part of the City's strategy to reduce CSOs. Each sewer system improvement project is coupled with the in-line or off-line storage projects described in Section 5.6, Development of Design Criteria for Recommended CSO Control Measures. Once the sewer system improvement is implemented, its performance will be evaluated for up to two years to determine what impact the project has had in reducing CSOs. It is expected that these projects will either eliminate the need for a storage project, or reduce the size of the storage project. Table 5-2 presents a summary of the various sewer system improvements being planned. For more details on these sewer system improvements see the Annual CSO Report.

Table 5-2 Summary of Planned Sewer System Improvements

Sewer system improvement project	Description	Schedule
North Union Bay Basin 018	See Section 5.6.3.	See Section 5.9.3
Leschi Basins 026 through 036	Improved operation and maintenance activities, conveyance rehabilitations, weir adjustments, HydroBrake replacements, and a dry-weather flow bypass.	Package 1 completed in 2014 Package 2 to be completed by 2016
Magnolia Basin 060	Replace pumps and increase the capacity of pump station 22 from 0.9 MGD to 3.3 MGD.	To be completed by 2018
Delridge Basin 099	Details yet to be determined.	To be completed by 2017
East Waterway Basin 107	Installation of a check valve between the King County Elliott Bay Interceptor downstream of the Duwamish pump station and Basin 107, preventing backups in the interceptor from causing CSOs in Basin 107.	To be completed by 2018
Duwamish Basins 111B, 111C, and 111H	Overflow structure modifications and weir raises.	Basins 111B and 111C completed in 2014. Basin 111H was analysed, but no sewer system improvement project was identified
Montlake Basins 020, 139, and 140	Improvements for these basins have not yet been selected, but will likely include pump station upgrades.	To be completed by 2018
Portage Bay Basin 138	Details yet to be determined.	Completed by 2018
Delridge Basins 168 and 169	Upgrade existing 1.6 MG storage facilities and associated conveyance infrastructure. Updates include new diversion structures, HydroBrake removal, motor-operated gate installation, and modifications to the hydraulic control chambers.	Construction completion by November 1, 2015 (NPDES wastewater permit requirement)

5.3.5 Assessment of Control Benefits from Green Infrastructure Program

The term green infrastructure describes systems and practices that use or mimic natural processes to infiltrate, evapotranspire, or harvest stormwater on or near the site where it is generated. The City's use of GI may include, but is not limited to, rain gardens, permeable pavement, bioretention facilities, rainwater harvesting, vegetated roofs, detention cisterns, and the retaining and planting of trees. These GI solutions control the sources of pollution by slowing, detaining, or retaining stormwater so that it does not carry runoff into nearby waterways. This reduces the volume and timing of flows into the system. GI facilities are also referred to as natural drainage systems (NDS) and they are a type of low impact development. Examples of GI currently being implemented by the City include:

- Stormwater code – the City requires GI as part of new and replaced development.
- RainWise – City program that provides property owners with rebates for mitigating the impacts of impervious roof surfaces on private property by installing properly sized and constructed GI facilities.
- Roadside rain gardens – Deep-rooted native plants and grasses planted in a shallow depression in the public right-of-way, such as the planting strip adjacent to homes.

The City's goal is to use green solutions to the maximum extent feasible to reduce CSOs. The RainWise program is offered in all of the uncontrolled CSO basins as part of the approach to manage the precipitation uncertainty associated with climate change. The roadside rain garden program focuses on basins with suitable soils where large areas of impervious roadway are connected to the combined sewer, and thus large scale implementation of GI can substantially reduce CSO control volumes as well as help alleviate localized sewer capacity issues. The primary CSO areas where roadside rain gardens can be used to offset CSO control volumes are Ballard, Delridge, Montlake, and North Union Bay.

Toward that goal, several GI projects were identified for early implementation: RainWise, Ballard NDS 2015, and Delridge NDS 2015. The City's 2010-2015 NPDES Waste Discharge Permit includes requirements to begin construction of roadside rain garden projects in the Ballard and Delridge CSO areas by October 31, 2015. Plans for additional future GI projects in the roadside right-of-way and the associated potential for downsizing of storage facilities within any of these basins will be documented in the engineering reports of individual CSO control projects, as discussed in Section 3.6.5.

5.3.5.1 Rainwise Program

Since 2010, RainWise has offered rebates to residents living in prioritized combined sewer areas of Seattle. As of 2014, RainWise rebates are offered in all of the City's uncontrolled CSO basins. Eligible property owners are alerted through mailings, public meetings, and media events. By logging onto the RainWise website at www.rainwise.seattle.gov, property owners can learn about green stormwater technologies and are presented with solutions appropriate to their property. Through this site, they are also able to contact trained contractors. Since program inception, over 500 contractors, landscape designers, and similar professionals have been trained in the program.

Upon completion, installations are inspected by a RainWise inspector and homeowners apply for rebates. RainWise rebates for rain gardens are currently $3.50 per square foot of roof area controlled. The average RainWise installation controls runoff from 1,270 square feet of roof area.

The RainWise program has rebated 584 installations, controlling an impervious roof area of 17 acres.

In spring 2013, a memorandum of agreement with King County made RainWise rebates available to CSO basins within the City of Seattle under King County's jurisdiction. To date King County has rebated 185 installations.

5.3.5.2 Ballard Roadside Raingardens

The City has installed one roadside rain garden project, Ballard Roadside Raingardens Phase 1, and is currently in the design phase for a second project, Ballard Natural Drainage System 2015 (Ballard NDS 2015). The potential for future projects will be evaluated during preliminary engineering of the CSO storage project for the basin.

Ballard Roadside Raingardens Phase 1 built numerous rain gardens in the planting strip area of street rights-of-way and also reduced the amount of impervious surface in the project area by narrowing roadways and replacing that pavement with vegetation. Some of the Phase 1 rain gardens did not drain as quickly as designed because they were built over till soils with infiltration rates lower than the rate generally considered feasible for infiltration as a sole removal strategy. During the construction phase, the City retrofitted the slower-draining rain gardens by installing an underdrain with an orifice to allow any water that couldn't infiltrate fast enough a pathway out of the cell and back to the combined sewer system.

The City completed post project flow monitoring for Ballard Roadside Raingardens Phase 1. The monitoring work had two components: controlled flow tests and continuous flow monitoring. The controlled flow tests, which occurred in September of 2012 and again in the spring of 2013, involved hooking up to a fire hydrant, sending a simulated storm down the streets, and monitoring how well the bioretention facilities perform. The flow going into the rain gardens is known and the amount that leaves them is captured by flow monitors located in the pipe system immediately downstream.

These flow monitors continued to collect data until the middle of 2013. The results of the flow monitoring showed that the infiltrating rain gardens along 30th Ave NW are working as designed and are able to provide the desired reduction in combined sewage volume. The rain gardens along 28th Ave NW, which were retrofitted with an underdrain, demonstrated that they still could provide significant flow reduction. The monitoring showed that they reduced peak flow rates of CSO-size events by 80 to 90 percent, delayed discharge to the combined sewer by 50 to 60 percent, and infiltrated 40 to 50 percent of the annual flow volume to the rain garden.

The second roadside rain garden project in Ballard, Ballard NDS 2015, was initiated in August of 2012, and construction is planned to begin in fall of 2015. Ballard NDS 2015, building on the experience from the first Ballard NDS project, will provide roadside rain gardens on up to 20 blocks. The design includes bioretention within the planting strip and in curb extensions (see Figure 5-2 below). Ballard NDS 2015 is estimated to reduce the total amount of stormwater reaching the City's combined sewer system by 6.5 MG each year and reduce the downstream storage control volume by 150,000 gallons. The project is also improving aesthetics, safety, and walking and biking mobility by overlapping with Seattle Department of Transportation's (SDOT's) proposed Neighborhood Greenway routes and community goals for improving the neighborhood.

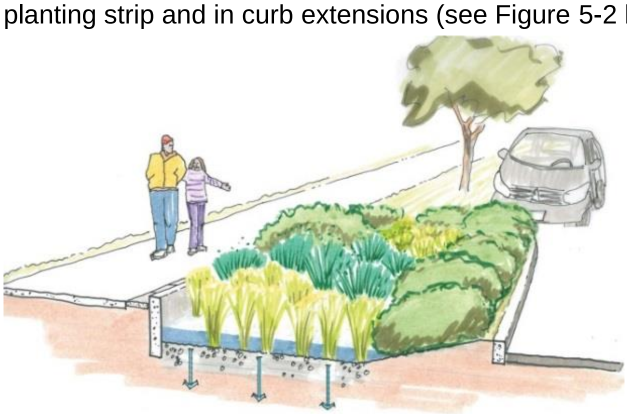

Figure 5-2 Proposed Curb Extension Swale Configuration

5.3.5.3 Delridge Roadside Raingardens

The City began developing and analyzing alternatives for the Delridge NDS 2015 project in August 2012. This project will use roadside rain gardens in the public right-of-way to protect the water quality of Longfellow Creek by reducing CSO volumes discharging to the creek. The City has coordinated with SDOT to integrate locations for roadside rain gardens with neighborhood greenways within the Longfellow Creek basin. Neighborhood greenways are residential streets generally one street over from main arterials. These streets have low volumes of auto traffic and low speeds where people who walk and ride bicycles are given priority.

The City and SDOT conducted joint community engagement to identify the most technically and socially feasible neighborhood greenway east of Delridge Way. The City conducted a survey, worked with a community-based organization and community ambassadors to canvass residents, held three community meetings to identify the best locations for the roadside rain gardens on the neighborhood greenway, and assessed the most promising sites for their geotechnical feasibility.

The Delridge NDS 2015 project is anticipated to provide roadside rain gardens on up to 15 blocks, reduce the total amount of stormwater reaching the City's combined sewer system by 4.4 MG each year, and reduce downstream storage control volume needs by approximately 200,000 gallons. Delridge NDS 2015 performance modeling will be integrated into the Delridge sewer system improvement modeling optimization efforts planned for 2015. The project is currently in design and construction is expected to begin in fall 2015. Additional benefits of the project include improved pedestrian and bicycle safety along the greenway route, improved ADA access, traffic calming, improved vehicular sightlines, and increased tree canopy cover.

5.3.6 Update of CSO Sensitive Area Study

Section 2.5 described an initial prioritization of the assumed uncontrolled CSO basins following the guidelines for screening and ranking in the EPA policy documents. CSO basins included in the initial study were ranked on seven criteria using site-specific information available in December 2012. Each CSO basin received a score for each of the seven criteria. These scores were totalled and the resulting total scores were used to rank the CSO basins.

Subsequent to the April 2013 study, the hydraulic models for the CSO areas and the 20-year moving average overflow frequencies were determined. The 20-year moving average calculations indicated that eight of the CSO basins that were initially considered uncontrolled are now controlled as reported in the 2013 Annual CSO Report. A revised Sensitive Area Study was performed for the remaining uncontrolled CSO basins using the same seven criteria and 2013 Annual CSO Report statistics for the 20-year moving average annual overflow frequency and CSO volumes.

The CSO basins were scored based on the seven criteria and their results were ranked as shown in Figure 5-3. The basins were divided into two categories:

- LTCP Priority Basins (higher priority): These basins are included in the LTCP and are not eligible for deferral as part of the Integrated Plan Alternative. Seven CSO basins from Ballard, Fremont/Wallingford, Delridge, and North Union Bay CSO areas are included in this category.

- Potential Integrated Plan Basins (lower priority): These basins are included in the LTCP and are eligible for deferral as part of the Integrated Plan Alternative. Fourteen CSO basins from the East Waterway, Duwamish, Leschi, Montlake, Portage Bay, Central Waterfront, and Magnolia CSO areas are included in this category.

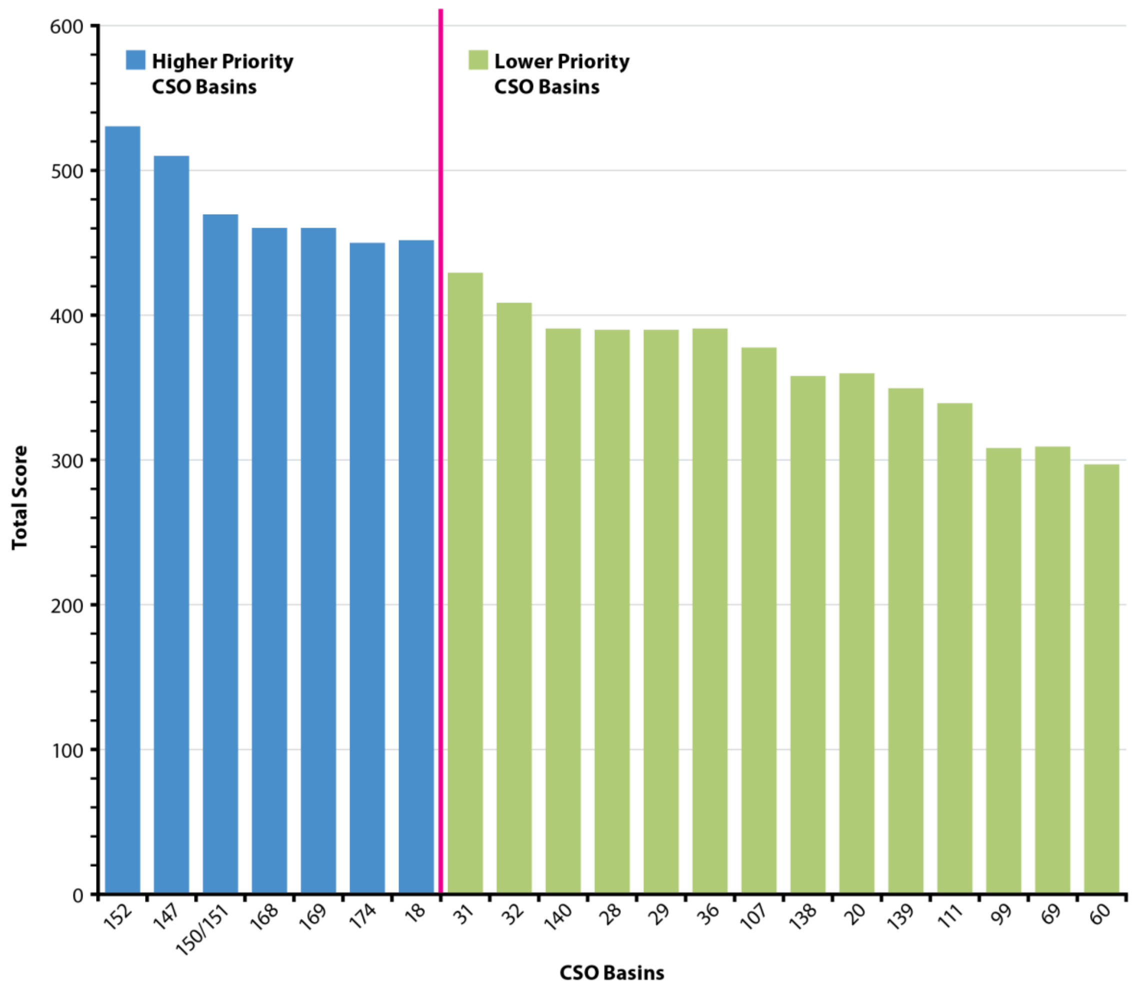

Figure 5-3 Updated Ranking of CSO Basins Based on Sensitive Area Study

5.3.7 Outfall Abandonment

On September 9, 2014, the City formally abandoned Leschi Outfall 026. This reduced the total of managed outfalls to 86.

5.3.8 Reanalysis of Control Status of Outfalls Previously Thought to be Controlled

As required by its NPDES permit, the City monitors all of its 86 CSO outfalls and prepares an annual report describing their performance relative to the once per year discharge standard. It is possible that CSO basins that are currently controlled may in the future become uncontrolled due to changing weather patterns, modifications elsewhere in the system, or other causes. In these cases the City will determine the cause of the exceedance and will develop and implement a supplemental CSO control measure to bring the basin into control. The CSO control measure will depend on the basin and the cause of the exceedance. Supplemental measures may include sewer system improvements, GI, operational changes, or other CSO control measures.

As part of completing the LTCP, the City reanalysed flow monitoring and modeling data for each of the outfalls identified as controlled in the May 2014 Draft LTCP. The reanalysis indicated that Leschi (Basin 034) did not meet the controlled performance standard. Leschi (Basin 034) is hydraulically linked with the other Leschi basins and will be controlled by the North Leschi control measure described in the LTCP. No further action is required.

5.4 Development of Short List and Selection of Recommended Option

5.4.1 Short List of Final Options

Section 4.1.1 described a Multiple Objective Decision Analysis (MODA) process for rating and ranking the Draft LTCP options in accordance with the requirements from the EPA *Combined Sewer Overflows Guidance for Long-Term Control Plan*. The net present values of the costs for the options are Class 4 estimates with an accuracy of minus 20 percent to plus 30 percent, so it is difficult to differentiate among the options based on cost alone. The MODA process considered non-monetary factors as well. The Neighborhood West Ship Canal Tunnel was the highest ranked LTCP alternative option based on the MODA process.

After the May 2014 Draft LTCP was issued for public and regulatory comment, the City and King County commenced detailed evaluation of the three shared options (Shared Storage, Shared West Ship Canal Tunnel, and Shared Ship Canal Tunnel) and the City performed additional evaluation of the Neighborhood Storage (Tanks and Tunnel) options. King County provided hydraulic boundary conditions for the City to determine the allowable CSO storage release rates into the King County sewer system. Additional conceptual engineering was performed, that resulted in the elimination of two shared options and modifications to the third shared option.

The coordination between the sewer system improvement program and the LTCP options was also clarified following the May 2014 Draft LTCP. Several of the storage projects included in the LTCP options were coupled with planned sewer system improvements, as described in Section 5.3.4. Once the sewer system improvements are implemented their performance will be evaluated for up to two years to determine what impact the sewer system improvements have had in reducing CSOs. It is expected that the sewer system improvements will either eliminate the need for storage projects, or reduce the size of the storage projects.

A summary of the additional evaluation process is presented below.

5.4.1.1 Neighborhood Storage Tank Option

This option was retained as a Final LTCP option. There were no changes to the description provided in Section 3.6.1 for the Neighborhood Storage Tank Option.

5.4.1.2 Neighborhood West Ship Canal Tunnel

This option was eliminated for final evaluation because King County indicated an interest in evaluating and potentially pursuing the Shared West Ship Canal Tunnel option. A neighborhood tunnel would present the same challenges and community impacts as a shared tunnel, but the community would face additional construction impacts if the agencies pursued separate projects. There would also be increased operational impacts from having three facilities instead of one. Although cost was not a significant determining factor in selection, this option was the most expensive.

5.4.1.3 Shared Storage

This option was eliminated for final evaluation because it will not meet the Consent Decree completion deadlines of December 31, 2025 for the North Union Bay CSO Basin 018 (King County University Regulator storage) and Montlake CSO Basins 020, 139, and 140 (King County Montlake Regulator). The King County University and Montlake Regulator CSO control measures would not be completed until December 31, 2028.

In addition, the City identified a sewer system improvement project for North Union Bay CSO Basin 018 that utilizes existing storage more effectively and eliminates the need to build additional storage for the basin. The sewer system improvement project has less impact on the community than building a new storage facility. In the Montlake area, joining in a shared project would require construction of extensive conveyance system improvements throughout the basin with their associated community impacts.

The third shared storage CSO control measure was the Fremont/Wallingford and King County 3rd Ave. West project. This project was eliminated for final evaluation because a Shared West Ship Canal Tunnel option as described below presented significantly fewer community impacts for both construction and operation than did building multiple storage tanks.

5.4.1.4 Shared West Ship Canal Tunnel

This option was retained as a Final LTCP option. The City evaluated a Shared West Ship Canal Tunnel including both King County 3rd Ave W and 11th Ave. NW CSO flows. The addition of storage for 11th Ave NW flows and King County's desire to collaborate on a shared project resulted in a significant increase in this option's ranking. Although this option may not be completed until 2025, King County's Consent Decree provides the opportunity to request a modification to the 3rd Ave. W construction completion date (December 31, 2023) to coordinate with the City on a shared project. The joint project analysis resulted in adding conveyance to divert 11th Ave. NW CSO flows into the tunnel and to divert 3rd Ave W flows into the tunnel from the south side of the Ship Canal instead of the north side. The impact of these changes will result in a reduction of the number of constructed facilities and associated community impacts.

Flow diversion for the East Waterway CSO control measure was revised to a neighborhood storage CSO control measure because the King County Hanford, Lander, Kingdome, King St. CSO plant will not be completed until December 31, 2030. Without an operating HLKK CSO plant, the City will not meet its Consent Decree construction completion date of December 31, 2025. Constructing a neighborhood storage CSO control measure will allow the City to meet that date.

Flow diversion for the Magnolia CSO control measure was revised to a neighborhood storage pipe because of hydraulic capacity limitations of the existing King County North Interceptor at the Magnolia CSO discharge location. Constructing a neighborhood storage CSO control measure will allow the City to discharge its CSO flows to the King County interceptor without impacting the King County interceptor hydraulic capacity.

There were no other changes to the option descriptions provided in Section 3.6.2.

5.4.1.5 Shared Ship Canal Tunnel

This option was eliminated from consideration because a third-party review documented in the L, 2014 Cost Review Report LTCP Tunnel Construction Cost Estimate Validation and Schedule Review, Frank Coluccio Construction Co.) of the Shared Ship Canal Tunnel schedule indicated that the tunnel would require six to eight years for construction and it would not meet the City Consent Decree construction completion date of December 31, 2025. In addition, King County, in their 2012 CSO Plan, rated the Shared Ship Canal Tunnel as the lowest ranked option.

5.4.1.6 Final Options for Evaluation

Two options were retained for final evaluation: Neighborhood Storage Tank and Shared West Ship Canal Tunnel. Table 5-3 summarizes the CSO areas and the specific CSO control measures for each option.

Table 5-3. Final Option Descriptions and CSO Control Measures

CSO area	Options	
	Neighborhood Storage Tank	Shared West Ship Canal Tunnel
Ballard	Off-line storage tank	Shared deep tunnel with Fremont/ Wallingford and King County 3rd Ave. W and 11th Ave. NW
Magnolia	Off-line storage pipe	Off-line storage pipe
North Union Bay	Collection system improvement	Collection system improvement
Central Waterfront	Off-line storage pipe	Off-line storage pipe
Fremont/ Wallingford	Off-line storage tank	Shared deep tunnel with Ballard and King County 3rd Ave. W and 11th Ave. NW
Duwamish	2 off-line storage pipes	2 off-line storage pipes
Delridge	3 off-line storage pipes	3 off-line storage pipes
Montlake	3 off-line storage pipes	3 off-line storage pipes
Leschi	3 off-line storage pipes plus 1 off-line storage tank	3 off-line storage pipes plus 1 off-line storage tank
East Waterway	Off-line storage tank	Off-line storage tank
Portage Bay	Off-line storage pipe	Off-line storage pipe

Figures 5-4 and 5-5 show the CSO control measures and control volumes for the two final options.

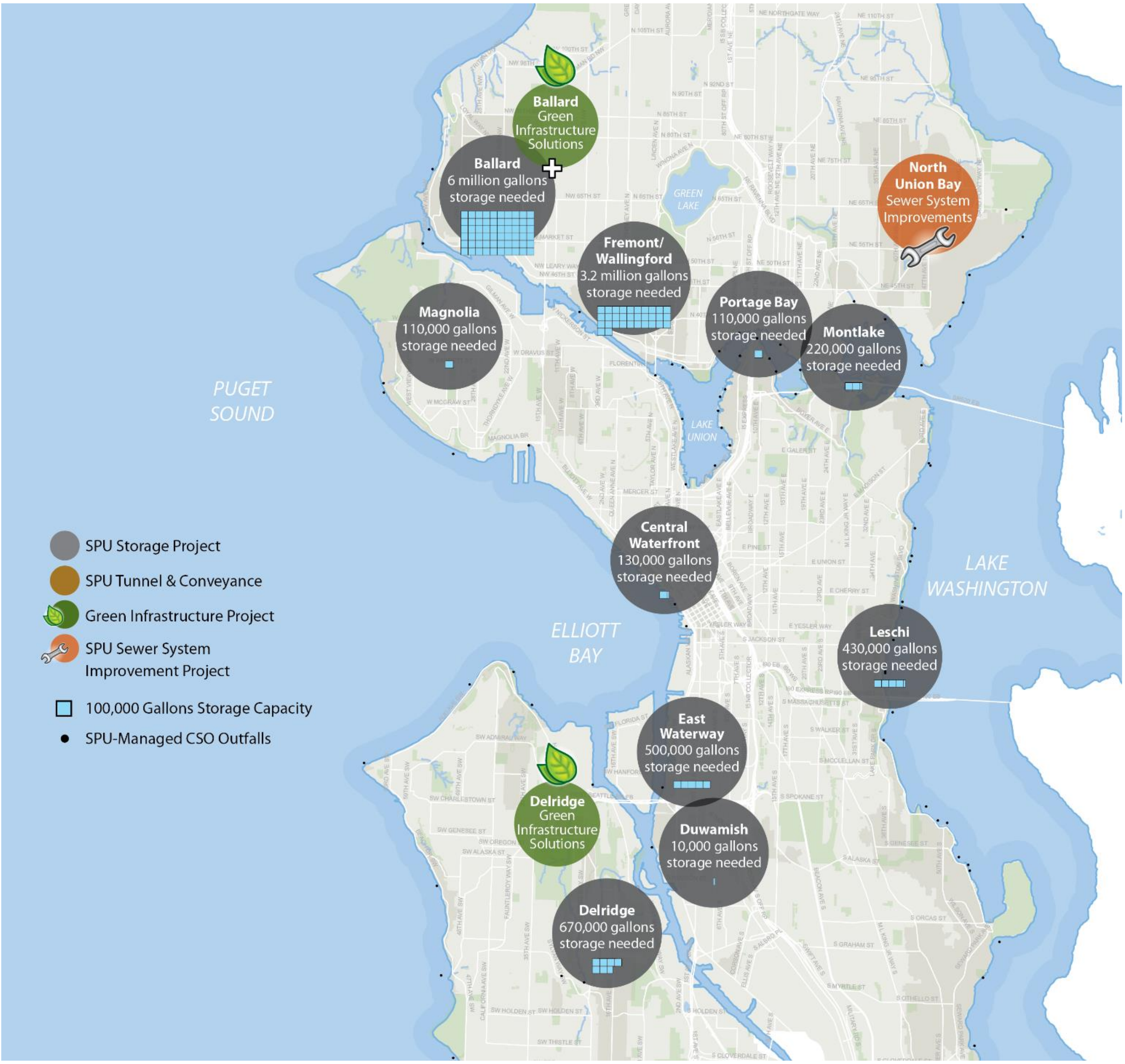

Figure 5-4 Neighborhood Storage Tank Option

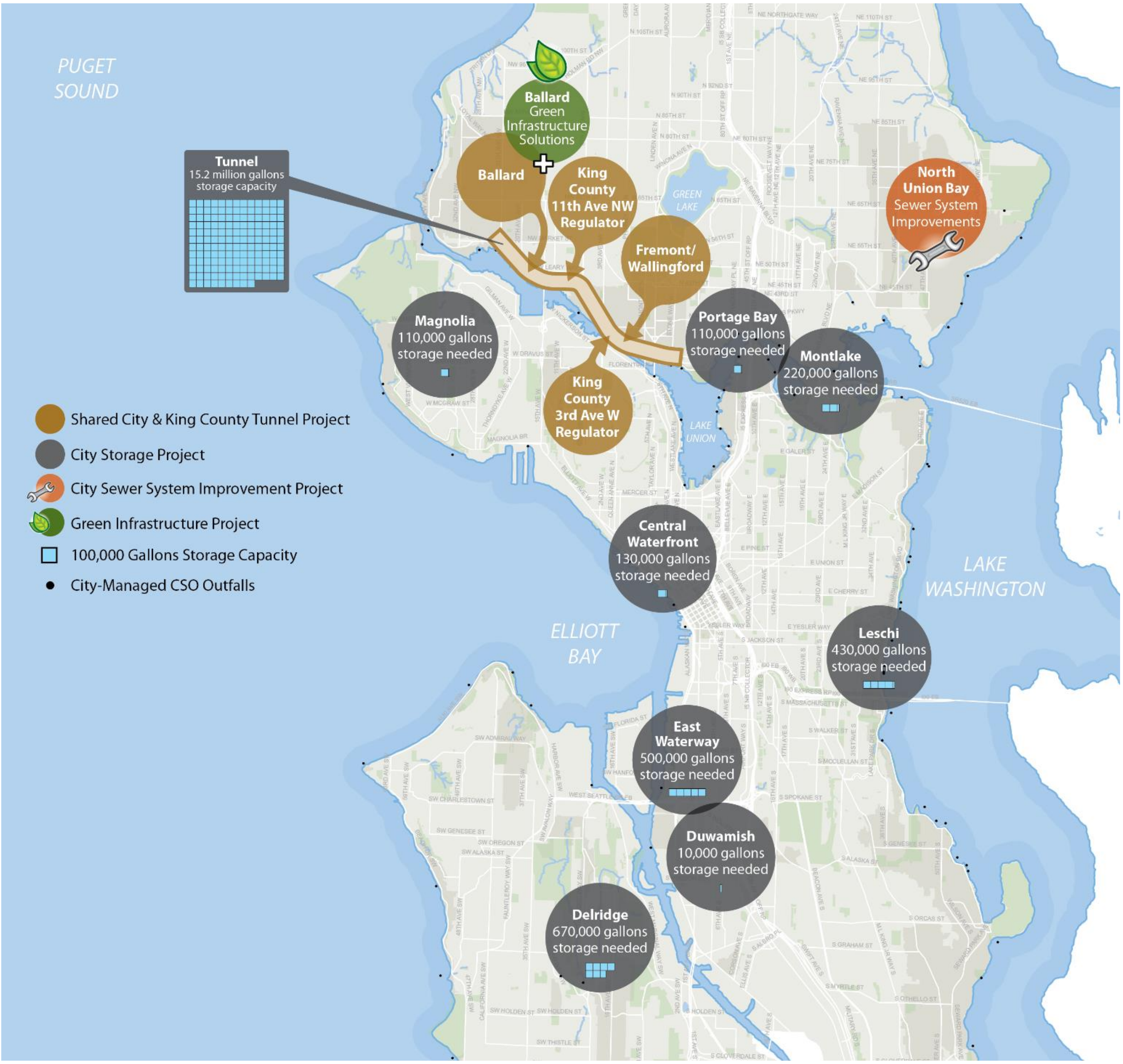

Figure 5-5 Shared West Ship Canal Tunnel Option

5.4.2 Evaluation of Final Two Options

As described in Section 5.3.2, the Coordination Plan between the City and King County identifies factors to be considered in evaluating and recommending which CSO projects will be undertaken jointly or independently by either the City or King County. These evaluation factors are applied to the two final options as described in the subsections below.

5.4.2.1 Financing

In accordance with the agreed-on principles, financial benefits are to be shared by both agencies. Benefits will be realized through economies of scale and other efficiencies from replacing a larger number of independently designed and constructed storage projects with a smaller number of jointly developed storage projects. Financial risks and rewards are to be apportioned for each joint project.

The final two options were compared using an NPV calculation based on a discount rate of 3 percent and a 100-year life cycle that includes salvage value. In addition to initial capital costs and ongoing operating costs, the NPV calculation incorporated future replacements for metering equipment (5-year cycle), electrical and instrumentation components (10-year cycle), mechanical and odor control equipment (25-year cycle), and major structure upgrade (50-year cycle). Replacement values were extracted from construction cost estimates.

A preliminary breakdown of how cost will be shared between the City and King County was developed based on a cost allocation methodology developed by the City and King County, as described in Section 5.7.4. This cost share may change and will be finalized during the development of the Shared West Ship Canal Tunnel project.

The NPV costs are based in August 2014 dollars and include the present-value cost of construction and operations, maintenance, and long-term replacement. The costs include factors such as land costs, contaminated soil mitigation, the potential for loans and grants, private and public park mitigation, and potential negotiated costs (or savings) with King County. It should be noted that the costs shown are planning-level, conceptual costs (Class 4) that are expected to be accurate within minus 20 percent to plus 30 percent. Actual costs will vary depending on many factors. Table 5-4 and Figure 5-6 show the net present values and accuracy range for the two final options.

Table 5-4 Final Option Net Present Values

Option	Total Project NPV, $M	City NPV cost share, $M	City share lower NPV cost range $M (-20%)	City share upper NPV cost range $M (+30%)
Neighborhood storage tanks	$401	$401	$321	$521
Shared West Ship Canal Tunnel	$491	$386[a]	$309	$502

Notes:
NPV = Net Present Value
[a] As a shared project, King County would also contribute funding for the Shared West Ship Canal Tunnel. The cost shown in this table is limited to the City's share of the NPV. See Section 5.7.4 for details on the cost share methodology.

Although cost is of great importance, the level of accuracy of Class 4 estimates makes it difficult to distinguish between the two final options on the basis of cost.

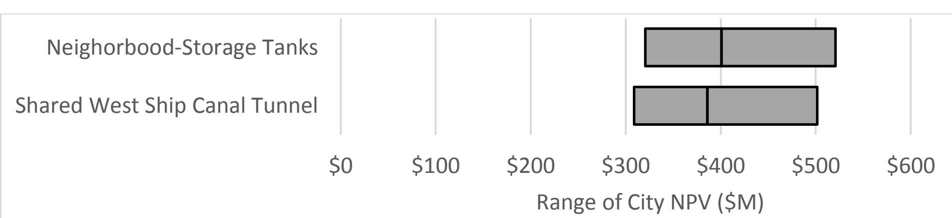

Figure 5-6 Comparison of Cost Range for Final LTCP Options

5.4.2.2 Scheduling

Both the City and King County are subject to consent decrees that set a schedule for completing CSO control projects identified in each agency's LTCP. King County must complete their CSO control projects by 2030; the City by 2025. Additionally, King County's LTCP includes a project sequence that establishes the order in which projects are to be completed. The effect of implementing joint projects on the City's or King County's ability to meet their respective completion schedules and King County's approved project sequence must be considered. Both utilities must agree that a joint project can be managed within their respective schedules before they proceed with it.

Table 5-5 presents the relevant consent decree milestones for the City LTCP CSO basins and the King County 3rd Ave. W and 11th Ave. NW CSO basins. (See Table 5-34 for proposed milestone dates for all projects. When approved, these dates will become the City's milestone dates.)

Table 5-5 Relevant Consent Decree Milestones for the City and King County CSO Basins

Agency	CSO basin	Relevant Consent Decree milestone		
		Facilities plan submittal	Completion of bidding	Construction completion
City	All LTCP CSO basins	TBD	TBD	December 31, 2025
King County	3rd Ave. W	December 31, 2018	December 31, 2020	December 31, 2023
	11th Ave. NW	December 31, 2026	December 31, 2028	December 31, 2030

Both agencies' consent decrees further stipulate that uncontrolled CSO basins must achieve controlled status within one year of the construction completion milestone.

As indicated in Table 5-5, the King County 3rd Ave. W CSO basin has the earliest consent decree milestones of the CSO basins being considered. An assessment was conducted to determine whether the Shared West Ship Canal Tunnel option could meet the Consent Decree milestones for the King County 3rd Ave. W CSO basin. To develop a prudent engineering and construction schedule, the agencies are working together to clarify schedule and project delivery risks to further assess the degree of variance in this schedule. As described in King County's Consent Decree (paragraph 23):

> *WTD may request a modification of the critical milestones set forth in Appendix B for the sole purpose of revising the priority and sequencing of its CSO control measures if WTD demonstrates that the requested modification (1) reflects good engineering practice, (2) is required to coordinate or align with the City of Seattle's stormwater or CSO infrastructure projects, (3) is necessary to attain cost effective and technically sound CSO control measures and (4) will not change, modify, or extend in any way WTD's final Construction Completion of December 31, 2030.*

Since the Shared West Ship Canal Tunnel option deviates from King County's recommended control measures for 3rd Ave W and 11th Ave NW, it may be necessary for King County to request modification to its Consent Decree.

The City will work with King County, EPA, and Ecology to support the modification of King County's Consent Decree.

Although King County's 3rd Ave W facility will be delayed, it should be recognized that the 11th Ave. NW CSO outfall would achieve control status approximately five years earlier than required in King County's Consent Decree if the Shared West Ship Canal Tunnel option is approved.

The Neighborhood Storage Tank Option would allow both agencies to meet all of their consent decree milestones.

5.4.2.3 Community Impacts

Construction of CSO control projects can have temporary adverse impacts on host communities. Once constructed, CSO control facilities can have ongoing community impacts associated with their operation and maintenance. Development of shared CSO control projects presents the opportunity for the City and King County to reduce the total number of CSO control facilities, which can reduce the number of communities impacted by their construction, operation, and maintenance. Conversely, larger shared CSO control facilities could result in larger-scale impacts to host communities. A recommendation regarding whether or not to develop shared CSO control projects in lieu of independent projects needs to consider the number of affected communities and the scale of larger shared CSO control facilities on host communities.

The City evaluated a wide range of community impacts during the course of developing the LTCP and recognized four key factors that make a difference between the Neighborhood Storage Tank Option and the Shared West Ship Canal Option. A summary of the comparison between each option is presented in Table 5-6. As is noted in Table 5-3, the only difference between the Neighborhood Storage Tank Option and the Shared West Ship Canal Option is related to the projects that are to be constructed in the Ballard and Fremont/Wallingford CSO areas. As such, the community impacts described below focus on the impacts to those neighborhoods.

Table 5-6 Comparison of Community Impacts

Community impact	Neighborhood Storage Tank Option	Shared West Ship Canal Tunnel Option
Traffic and air pollution	This option has the most project locations, with dispersed short-term, construction-related air and odor impacts in numerous neighborhoods throughout the city. Impacts are likely to be most noticeable in residential areas. Storage tank construction in the largely residential Ballard and Fremont/Wallingford neighborhoods could last up to five years (Ballard) and three and one-half years (Fremont/ Wallingford). Transportation impacts would be highly visible and would be of concern to local residents, business owners, and commuters in affected neighborhoods. This option would have the most dispersed transportation impacts because it would require roadway lane and sidewalk closures at a number of locations throughout the city.	Construction-related air quality impacts would occur at fewer sites than under the Neighborhood Storage Tank Option but the impacts would be more concentrated at those sites. Construction of the tunnel would require a substantially higher number of truck trips and associated emissions than smaller, independently constructed CSO control facilities in Ballard and Fremont/Wallingford, resulting in more concentrated and longer duration impacts at the tunnel portal sites in these neighborhoods. Overall, this option would result in substantially more truck trips over a longer period in Ballard compared to the Neighborhood Storage Tank Option. The expected construction duration Is three and one-half years. However, this option would eliminate construction truck trips associated with a separate King County 3rd Ave. W CSO

Table 5-6 Comparison of Community Impacts

Community impact	Neighborhood Storage Tank Option	Shared West Ship Canal Tunnel Option
		control project and a separate, independent King County 11th Ave. NW CSO control project between Ballard and Fremont/Wallingford areas. These truck trips and traffic disruptions would be less than what would likely be experienced with independent CSO control projects. Thus, overall impacts would be reduced with this option.
Land use and visual quality	Due to the larger number of distributed CSO storage facilities, this option has the greater number of areas that would experience temporary land use impacts. Construction could intermittently disrupt access to residences, businesses, and institutions. Temporary easements would be needed from some private landowners, depending on the project. Acquisition-related impacts would potentially be greater under this option because it would require the greater number of project locations.	This option would concentrate construction-related land use impacts at fewer but larger project sites in Ballard and Fremont /Wallingford. The tunnel is estimated to require three and one-half years to construct and up to four acres for construction staging. Much of this area could be sold back to private ownership following construction. In addition to land use and visual quality impacts from tunnel portal activity, dispersed impacts and disrupted access from construction of drop shafts and microtunnels and from open-cut construction in roadways throughout the Ship Canal neighborhoods would occur. In addition, the new flow diversion (conveyance line) would introduce minor and temporary land use and visual quality impacts to the 3rd Ave. W area on the south side of the Ship Canal.
Noise and vibration	Construction of projects would result in short-term moderate to substantial increases in noise. This option would have more dispersed noise and vibration impacts throughout the Plan area. Construction would occur in every CSO neighborhood, but would last longest in Ballard, Fremont/Wallingford, and East Waterway, where construction durations would range from one to five years.	Potential construction-related impacts would largely be concentrated at the tunnel portals in the Ballard and Fremont/Wallingford neighborhoods. After initial tunnel portal site construction, most work would occur underground, which would not produce noticeable street-level noise or vibration other than from trucks hauling tunnel spoils on roadways. Potential for vibration impacts along the tunnel routes is likely to be a concern to property owners. Potential impacts in other neighborhoods, including those associated with construction of the new flow diversion (conveyance line) near the 3rd Ave. W CSO area on the south side of the Ship Canal, would be similar to those described for the Neighborhood Storage Tank Option.

5.4.2.4 Regulatory Considerations

All CSO control projects must meet the control standard of no more than one CSO event per outfall per year. As described in the City and King County Coordination Plan, recommendations about whether or not to develop a shared City and King County CSO control project should consider which type of project is most likely to meet compliance standards. The ability to adapt to changing regulations or other external factors like climate change should also play a part in the decision-making.

When considering the overflow frequency requirement, the planning team evaluated the flexibility of the tunnel to control the variability of volumes that will occur in the seven CSO basins from year to year versus the static control volume associated with discrete tanks for each CSO basin under the Neighborhood Storage Tank Option.

An analysis of the 20-year historical record ending with 2014 indicated that both the tunnel and the Neighborhood Storage Tank Option would meet the CSO control standard. However, since weather patterns vary across the City and the Shared West Ship Canal Tunnel is almost three miles long, the tunnel outfalls would not always overflow at the same time. As a result, the tunnel has flexible storage volume that can be used to reduce overflows compared to individual storage tanks.

5.4.2.5 Lead Agency Designation and Responsibilities

Efficient implementation of a shared CSO project may require that either King County or the City is designated as project lead, responsible for leading project design, construction, ownership, and operation. Alternatively, a shared project management structure can be developed for managing the project. The decision to designate a lead agency or create a joint project management structure will be reached collaboratively on a project-by-project basis. In either case, responsibilities of the lead agency or joint management team will be spelled out when the decision is made.

The final recommendation on a joint project will be documented in a joint project agreement. The agencies will need to agree on a schedule that meets each agency’s compliance schedules and project goals.

The City would be the lead agency for the Shared West Ship Canal Tunnel. A draft Term Sheet spelling out the terms of an agreement to be executed between King County and the City has been developed. A joint project agreement is being prepared to define all roles and responsibilities for the construction and operation of the Shared West Ship Canal Tunnel.

5.4.3 Recommended LTCP Option

Based on the evaluations described in Section 5.4.2, the environmental impact statement prepared for the LTCP, and cooperative agreements with King County, the City selected the Shared West Ship Canal Tunnel option as the recommended option.

The Shared West Ship Canal Tunnel option is recommended because, on balance, it is a more flexible means of controlling CSOs in the area of the West Ship Canal and should result in the least long-term impacts to the neighborhoods where the tunnel would be located. Cost difference is not a determining factor in the recommendation because the options considered are within the same cost range. The determining factors in support of the recommendation are as follows:

- The Shared West Ship Canal Tunnel option allows the City and King County to work together to build a single facility to serve multiple common needs. Opportunities to achieve economies of scale and operational flexibility are greater with the shared tunnel than with separate neighborhood storage tanks.
- The West Ship Canal Tunnel option is consistent with terms contained in each jurisdiction's consent decree requiring coordination of the planning, implementation, and operation of CSO control within the Seattle area.
- The Shared West Ship Canal Tunnel option will likely have greater impacts to neighborhoods during construction than the Neighborhood Storage Tank Option. However, once constructed, the Shared West Ship Canal Tunnel will largely be underground. The impact to neighborhoods resulting from hosting permanent facilities is less than the Neighborhood Storage Tank Option.

A summary of the comparison between the two options is presented in Table 5-7, below.

Table 5-7 Comparison of Final Options

Evaluation factors		Option	
Factor	**Items to be considered**	**Neighborhood Storage Tank Option**	**Shared West Ship Canal Tunnel Option**
Financing	Financial benefits are to be realized and shared by both agencies through economies of scale and other efficiencies from replacing a larger number of independently designed and constructed storage projects with a smaller number of jointly developed storage projects.	The construction and long-term operating costs of the two alternatives for the City ratepayers are very similar. The total project cost and NPV of the two alternatives, given the accuracy of project development phase cost estimates, does not indicate a significant cost difference between the two options.	
Scheduling	The effect of implementing joint projects on either the City's or King County's ability to meet their respective consent decree milestone dates and King County's approved LTCP project implementation sequence will be considered. Both utilities must agree that a shared project can be managed within their respective schedules before recommending shared project implementation.	More complicated permitting/regulatory compliance requirements from dispersed large tank construction and operation.	The City's and King County's consent decrees contain identical language requesting the agencies to work together for a regional solution. The tunnel option requires a partnership for a joint project with King County that independent tanks do not require. The Consent Decree milestone for completion of construction for King County's 3rd Ave W facility will have to be changed from December 31, 2023, to December 31, 2025. The agencies are working together to confirm the schedule for construction completion.

Table 5-7 Comparison of Final Options

Evaluation factors		Option	
Factor	**Items to be considered**	**Neighborhood Storage Tank Option**	**Shared West Ship Canal Tunnel Option**
Community impacts	The evaluation of whether to develop shared CSO control projects in lieu of independent City and King County projects needs to consider the number of affected communities and the scale of larger joint CSO control facilities on host communities. Shared CSO control projects present the opportunity for the City and King County to reduce the total number of CSO control facilities to be constructed, which can reduce the number of communities impacted by their construction, operation, and maintenance. Conversely, larger joint CSO control facilities could result in larger-scale impacts to host communities.	There are significantly more short-term construction impacts from major tank construction and more long-term community impacts from land use restrictions and loss of property for dedicated major tank sites.	Community impacts from construction noise, traffic disruption, property consumed and removed from potential other uses, and street disruptions are lower with this option. A large portion of the tunnel construction sites could be sold for private use following the completion of construction.
Regulatory considerations	All CSO control projects must meet the control standard of no more than one CSO event per year. The evaluation of shared or independent CSO control projects should consider which type(s) of project are most likely to meet compliance standards.	The Neighborhood Storage Option will meet the control standards.	The Shared West Ship Canal Tunnel provides greater flexibility to control all seven outfalls due to the ability to optimize storage for each basin depending on the variability of rainfall and flows in each basin. The Shared West Ship Canal Tunnel CSO control measure is estimated to have a 20-year moving average CSO overflow frequency of 0.5 events per year and an annual CSO volume reduction of 80%.

Table 5-7 Comparison of Final Options

Evaluation factors		Option	
Factor	**Items to be considered**	**Neighborhood Storage Tank Option**	**Shared West Ship Canal Tunnel Option**
Local agency designation and responsibilities	Efficient implementation of a joint CSO control project may require the designation of a lead agency or the creation of a joint project management structure will be considered. Key evaluation decisions include which agency will act as lead, and what responsibilities are inherent in a lead agency, or whether a joint project management structure is appropriate and what responsibilities are inherent in a joint project management structure. The final recommendation on a joint project will be documented in a joint project agreement.	Both agencies have recent experience in the construction of large storage tanks. King County has extensive experience in the operation of facilities off-site from their treatment works and has dedicated operators and maintenance staff. The City has constructed and operated numerous pipe storage facilities and two large cylindrical storage tanks. The City is currently constructing new state of the art rectangular tank storage facilities. The Windermere and Genesee CSO storage facilities will be complete in 2015. The City is also performing final design of the Henderson CSO storage facilities which will be completed by 2018.	The City will be the lead agency for a Shared West Ship Canal Tunnel. King County and the City will enter a project-specific agreement to construct and operate the Shared West Ship Canal Tunnel.

5.4.4 Peer Review of Analysis and Recommendations

The City engaged a peer review team to assess the evaluation of the Neighborhood Storage Tank Option and the Shared West Ship Canal Tunnel option that was done by City staff and consultants and to provide their observations on the thoroughness of the monetary and non-monetary evaluation. The peer review members were senior public agency engineering, construction, and operations managers from the following agencies:

- City of Edmonton, Canada: The City of Edmonton is unique in that it operates its own tunnel construction company and currently owns multiple tunnel boring machines.
- Milwaukee Metropolitan Sewerage District (MMSD): MMSD provides wholesale conveyance and treatment services to 28 municipalities, similar to the services King County provides to its wholesale customers. MMSD also operates 21 miles of deep tunnels (15 to 30 feet in diameter), at depths of approximately 300 feet in solid dolomite rock.
- City of Portland, Oregon: The City of Portland has recently completed implementation of its LTCP. There are several operating storage tanks, as well as a tunnel system with vortex drop shafts and a 200-MGD pump station. The tunnels take dry-weather flow as well as wet-weather overflow and have had no

significant odor problems. Tunnel construction involved 10 miles of soft-ground tunnel and several mined tunnels.

- City of Omaha, Nebraska: The City of Omaha is currently involved in implementing its CSO LTCP. Omaha has $300 million of its $2 billion program currently under contract. The LTCP includes the concept of a deep tunnel and also includes two additional tanks. Omaha is now at 90 percent complete on design of a 14-foot-diameter stormwater tunnel that will convey separated stormwater to the Missouri River.

The peer team conclusion was: “The planning and analyses to date have been very good. The three options presented are common techniques and are technically viable. Continued cooperation between the City and King County could lead to a shared tunnel option that may be the best overall long-term, cost-effective solution to significantly reduce overflows and impacts to the area.”

5.5 Environmental Impact of Recommended Option

This section describes the types of social and environmental impacts that could occur within the plan area from the recommended option.

5.5.1 Construction Impacts

CSO reduction projects included under the recommended option – and common to both the LTCP Alternative and the Integrated Plan Alternative – would involve construction of sewer system improvements, flow diversions, and underground storage. Because this is a planning-level evaluation, project details and construction methods have not yet been defined. However, the information in Table 5-8 provides a reasonable estimate of the nature, extent, and duration of anticipated construction activities for the types of projects being considered. Actual construction activities would vary and would be determined during subsequent, project-specific review. It should be noted that for EIS purposes, CSO areas are described in terms of “neighborhoods” to promote better understanding within a broad audience. EIS neighborhoods are generally consistent with CSO basin areas.

Table 5-8. Summary of Recommended Option Construction Impacts

Resource
Earth
Construction of tunnel portals and movement of the tunnel boring machine could result in vibration and ground subsidence. The location of the portals, drop shafts, conveyance lines, and tunnel near liquefiable soils in Fremont, Ballard, and the south side of the Ship Canal could result in soil settling. Geotechnical exploration and testing would be conducted during project design to identify potential hazards along the tunnel alignment. Overall impacts would be reduced under this option because the shared tunnel would reduce the number of City and King County independently constructed CSO control facilities.
Air Quality
Construction of the tunnel would not have a significant impact on air quality in the Seattle area, but may result in moderate localized impacts largely related to vehicle emissions and dust. Impacts under the recommended option would be concentrated at fewer locations. Overall impacts would be reduced under this option because the shared tunnel would replace a number of City and King County independently constructed CSO control facilities with a single, large tunnel.
Surface Water
Construction could include increased pollutants and sediments from site runoff, requiring control measures. The shared tunnel would have reduced potential for impacts associated with site runoff compared to independently constructed City (Ballard and Fremont/Wallingford) and King County (3rd Ave W and 11th Ave NW regulators) CSO control facilities. Portal locations, due to their larger construction footprint, would be the focal point for potential surface water runoff impacts. Deep tunnels have less

Table 5-8. Summary of Recommended Option Construction Impacts

Resource
surface disruption than storage tanks and pipes, but would likely have dewatering impacts. Dewatering water could include contaminants and sediments that could be discharged into local water bodies if not properly managed.
Biological Resources
No direct impacts to aquatic habitats, plants, and invertebrates would occur and only minor indirect impacts are anticipated. Only minor impacts to terrestrial habitat are anticipated because projects are typically located in areas with low habitat value. In general, impacts would potentially be lower with the tunnel because construction will be concentrated at fewer locations with less surface disturbance than other options.
Energy and Climate Change
Construction would not have a significant impact on energy resources in the Seattle area. Construction-related energy consumption and greenhouse gas emissions would be lower than those estimated for the other options. Overall impacts would be reduced under this option because the shared tunnel replaces a number of City and King County independently constructed CSO control facilities.
Environmental Health and Public Safety
Ground excavations and dewatering have the potential to encounter contaminated materials and may require special handling methods. In general, environmental health risks are low, and the potential for the public to encounter contaminated soils or groundwater is low. Potential construction-related impacts would be concentrated at the tunnel portals in the Fremont/Wallingford and Ballard neighborhoods.
Noise and Vibration
Construction would result in short-term moderate to substantial increases in noise, lasting from one to as many as five years, depending on the control project. Potential construction-related impacts would largely be concentrated at the tunnel portals in the Ballard and Fremont/Wallingford neighborhoods (for approximately three and one-half years). After the portals are built, most work would occur underground, which would not produce noticeable street-level noise or vibration other than from trucks hauling tunnel spoils on roadways. The potential for vibration along the tunnel route is likely to be a concern to property owners.
Land Use and Visual Quality
This option would require the acquisition of easements or property for construction access facilities and staging areas. Property might need to be acquired for storage tank locations, although public property would be preferred when available. For storage pipes and flow diversions, construction would occur primarily in street rights-of-way. For the tunnel, property would need to be acquired for tunnel portals. This option would reduce the number of areas affected by construction, but would concentrate construction-related land use impacts at fewer, larger project sites in Ballard and Fremont/Wallingford. The tunnel is estimated to require three and one-half years to construct and up to four acres for construction staging. Much of this area could be sold following construction.
Recreation
Temporary impacts to recreation could occur if a facility is sited within a park, although the City would attempt to avoid siting facilities in parks. If construction or staging areas are located near or adjacent to a park, recreational use of the park could be disrupted by restricted access, noise, dust, and truck trips during peak construction periods.
Historic, Cultural, and Archaeological Resources
Construction could have a potential adverse effect on historic, cultural, or archaeological resources. Because excavation for the tunnel portals would be deeper than geological layers that might contain cultural resources, the tunnel options would have less potential to encounter cultural resources than storage tanks or storage pipes. This option has the potential for temporary impacts to historic properties along the proposed tunnel alignment (vibration, dust, noise, and visual integrity). Historic structures may be more susceptible to damage from vibration.

Table 5-8. Summary of Recommended Option Construction Impacts

Resource
Transportation
Transportation impacts would include increases in traffic volumes due to construction-generated truck trips, commute trips of construction workers, and roadway lane and sidewalk closures where construction activities take place. Impacts from tunnel construction would be concentrated at two tunnel portal locations in Ballard and Fremont/Wallingford. Total truck trips for tunnel construction are expected to be over 34,000 truck round trips (average 33 per day for 3.5 years) for the tunnel, generated primarily in Ballard. Additional truck trips would be generated by construction of conveyance and connection elements (e.g., drops shafts and conveyance lines). This option would eliminate construction truck trips associated with separate King County 3rd Ave. W and 11th Ave. NW CSO control projects. In addition, this option would avoid the need for substantial in-road construction for a storage pipe project, which could result in traffic disruptions in the Fremont/Wallingford area. While construction truck trips and traffic disruptions from separate, independent CSO control projects would be avoided under this option, conveyance and connection elements needed to deliver 3rd Ave. W and 11th Ave. NW flows to the tunnel (drop shafts and a conveyance line) would bring some additional construction truck trips and traffic disruptions to these areas. However, these truck trips and traffic disruptions would be less than what would likely be experienced for independent CSO control projects. Anticipated increase in truck traffic during tunnel construction is relatively low compared to typical background traffic on city arterials and is not expected to adversely affect roadway operations. However, at peak construction times, the truck trips could be noticeable to the public.
Public Utilities
Construction would occur in areas highly constrained by existing underground and overhead utilities, requiring extensive coordination with utilities to avoid conflicts. Deep tunnels tend to be constructed below many underground utilities, reducing the potential for utility conflicts. However, temporary electrical substations to power the tunnel boring machine and construction of tunnel portals and other associated facilities would require utility coordination and reconfiguration.
Socioeconomics and Environmental Justice
Construction could cause a hardship for some residents due to disruptions to access to community resources, businesses, and public transportation in project areas. There could be short-term impacts on existing economic conditions due to construction disturbance and temporary changes in the use of the land during construction. The shared tunnel would replace City (and King County) independently constructed storage facilities in the Ship Canal neighborhoods with a single, large tunnel, and therefore fewer areas would experience construction disturbance and modified access to community resources or businesses. However, it would concentrate impacts at fewer locations in the Ship Canal neighborhoods. The neighborhoods that have the highest potential to be affected include Ballard and Fremont/Wallingford. Disproportionate impacts to minority or low income populations are not expected.

5.5.2 Operational Impacts

Table 5-9 describes the potential effects of the plan after construction has been completed and the plan projects are in operation. Both the LTCP Alternative and the Integrated Plan Alternative would implement one of the four options, although some of these CSO reduction projects would be deferred under the Integrated Plan Alternative. Because CSO reduction facilities under the options would largely be underground, few operational effects to the environment would result from plan implementation. As noted above, for purposes of the EIS, CSO areas are referred to as “neighborhoods.”

Table 5-9. Summary of Recommended Option Operational Impacts

Resource
Earth
With the implementation of site-appropriate design, potential adverse impacts would be avoided and minimized. With the tunnel, there would be fewer storage tanks and pipes potentially at risk during a seismic event. Tunnels are generally designed to avoid other underground utilities and take advantage of stable glacial till layers. Operational effects are anticipated to be minor.
Air Quality
The net operational impacts on air quality and odors would be minor. All facilities would be designed and maintained to minimize emissions of odorous compounds. The large tunnel would replace the need for a number of potential odor-producing storage facilities in the Ballard and Fremont/Wallingford neighborhoods. The large tunnel's greatest potential for odors would be at the downstream tunnel portal (likely located along the Ship Canal in the vicinity of Ballard), which would be controlled by an odor control facility.
Surface Water
The recommended option would substantially reduce pollutant from existing uncontrolled CSO outfalls when compared with the No Action Alternative. Pollutant loadings would be substantially reduced and the outfalls would come into compliance with the Clean Water Act and the requirements of the Consent Decree. The Ship Canal/Lake Union, Lake Washington, Duwamish River, Longfellow Creek, Elliott Bay, and Puget Sound would receive reduced discharges from CSOs.
Biological Resources
The recommended option would result in negligible to minor impacts to biological resources. Instead, there would be long-term beneficial effects on fish and aquatic life from reducing CSOs. Implementation of the LTCP would reduce the volume of untreated sewage and stormwater runoff, thereby reducing the potential for related impacts on aquatic life. Implementation of the LTCP would comply with the Consent Decree as well as other federal and state requirements.
Energy and Climate Change
The recommended option would potentially have a higher electrical requirement than storage tanks because of the electricity needed to pump the deeply stored water. However, overall energy use would still be minor and would be further reduced as this option replaces the need for four City and two King County independently constructed CSO facilities. The GHG emissions produced by operating and maintaining CSO facilities are not expected to cause appreciable climate change. The City has incorporated climate change modeling in its development of the LTCP and would incorporate additional modeling in the design of individual CSO facilities to minimize risks from anticipated changes in precipitation and sea level rise.
Environmental Health and Public Safety
Overall, the recommended option is expected to reduce environmental health risks associated with CSOs by reducing untreated discharges. Reduction of CSO discharges to recreational water bodies, including Lake Union, the Ship Canal, Lake Washington, and the Duwamish Waterway, would reduce the potential for CSO-related environmental health risks in those water bodies.
Noise and Vibration
The net operational effects would be minor. Noise would be intermittently generated by pump stations and odor control facilities. All facilities would be designed and maintained to reduce noise to permissible levels.
Land Use and Visual Quality
Potential land use impacts include conversion of land in residential, commercial, or industrial areas to public utility uses. The tunnel would have less potential for long-term land use impacts than storage tanks since the tunnel would replace the need to site several storage tanks in the Ship Canal neighborhoods (Ballard and Fremont/Wallingford) and less property would need to be retained following construction. In contrast to storage tanks, the City would be able to sell or lease approximately 75 percent of the land needed for construction of the tunnel portal in Ballard for other uses. Approximately one half acre of the launch portal would be retained by the City to house the pump station, odor control, and a permanent shaft for access and

Table 5-9. Summary of Recommended Option Operational Impacts
Resource
maintenance. All of the area used for the smaller, recovery end of the tunnel in Fremont/Wallingford would be retained by the City. Some additional areas would be retained for permanent drop shafts as required to accept flows from each contributing City and King County CSO area.
Recreation
Overall, the operational effects on recreational activities are expected to be minor. Reductions in pollutant loading would benefit long-term water quality and help maintain beneficial uses at area beaches. Water contact recreation in Lake Washington, Portage Bay, the Duwamish River, and Lake Union, in particular, would be enhanced by improved water quality. Locating storage facilities in a park would constrain certain future uses of that area for park purposes. However, there is a potential to provide recreational facilities on top of storage tanks following construction. The tunnel would replace the need to site several storage tanks in the Ship Canal neighborhoods (Ballard and Fremont/Wallingford), thus reducing the potential for recreation impacts.
Historic, Cultural, and Archaeological Resources
Operation of projects implemented under the recommended option is anticipated to have no effect on historic, cultural, and archaeological resources.
Transportation
Overall, the operational effects from vehicle trips generated by facility maintenance under the recommended option are expected to be minor.
Public Utilities
Implementation of the recommended option will require close coordination with numerous utilities, in particular, wastewater and stormwater utilities within the service area. Because the City's collection system network sends wastewater to King County for treatment, coordination with King County will be particularly important. King County's West Point WWTP would receive additional sewage flows as a result of plan implementation. The high variability in flow rates within the sewer system associated with heavy storms could be challenging to manage at the King County West Point WWTP. Based on City modeling, these additional flows will have little effect on the peak loading to King County's West Point WWTP and may potentially reduce peak loading. However, annual average flows will increase, resulting in greater operational and maintenance costs. The City and King County will address the incremental cost of these flows in their sewage disposal agreement. The large shared tunnel under the recommended option would be implemented in accordance with operational agreements between the City and King County. The shared tunnel may reduce the operational complexity of controlling neighborhood storage tanks or shared storage tanks, as it provides one large storage facility for all flows to be managed through a single pump station discharging to King County's West Point WWTP. Close coordination with King County would be needed to optimize operational benefits.
Socioeconomics and Environmental Justice
The operational effects would be minor to moderately beneficial associated with improved water quality in area receiving waters, and there would be no adverse operational effects that would be predominantly borne by minority or low-income populations and underserved communities.

5.5.3 Summary

The construction impacts of the recommended option would be minor to moderate, assuming mitigation measures are implemented. Transportation impacts could be substantial in some neighborhoods. Long-term effects would be beneficial, particularly to water quality, biological resources, and environmental health, and there would be no adverse operational effects that would be predominantly borne by minority or low-income populations and undeserved communities.

5.6 Development of Design Criteria for Recommended CSO Control Measures

5.6.1 Shared West Ship Canal Tunnel

5.6.1.1 CSO Control Measure Description

The recommended CSO control measure for the Ballard and Fremont/Wallingford areas is a Shared West Ship Canal Tunnel that will store CSO flows for two City and two King County CSO areas. Off-line storage will be provided with a deep storage tunnel constructed between the Ballard and Fremont/Wallingford CSO areas, on the north side of the Ship Canal. The Shared West Ship Canal Tunnel will control the Ballard CSO basins (Basins 150, 151, and152), the Fremont/Wallingford CSO basins (Basins 147 and 174), the King County 3rd Ave. West Regulator (Basin 008), and the 11th Ave. NW Regulator (Basin 004). The total control volume for both the City and King County CSO basins is 15.24 MG. Figure 5-7 provides an overview of the project location and components.

The main components of the Shared West Ship Canal Tunnel include the storage tunnel and appurtenances, facilities to convey City and County CSO flows into the tunnel, and a tunnel pumping station effluent line to drain flows away from the tunnel. A description of each component is as follows:

The storage tunnel and appurtenances will include:

- A bored 15.24-MG off-line storage tunnel, 14,000 feet long, with a nominal 14-foot inside diameter
  - The stored volume in the storage tunnel will flow from the Fremont/Wallingford CSO Outfall 147 westward to an effluent pump station located near the Ballard CSO Outfall 152.
  - The tunnel route is planned to be generally in street rights-of-way along the north side of the Ship Canal.
- Six diversion structures for diverting influent CSO flow away from outfalls to the tunnel
- Four drop structures to convey influent CSO flow into storage
- An east tunnel portal housing odor control equipment

A west tunnel portal housing an effluent pump station with a peak capacity of 32 MGD to empty the storage tunnel in approximately 12 hours. Conveyance facilities from City and County CSOs will include:

- Approximately 2,200 linear feet (lf) of 36- to 72-inch diameter gravity sewer line to convey flows from the City's Ballard and Fremont/Wallingford CSO areas (Basins 150/151, 152, 147, and 174 respectively),
- Approximately 900 lf of 48- to 60-inch diameter gravity sewer line to convey flows from the County's 3rd Ave. W. and 11th Ave. NW CSO to tunnel drop structures. Approximately 800 lf of the gravity sewer line will be under the Ship Canal to connect the 3rd Ave. W. diversion structure to the tunnel.

The tunnel pumping station effluent line will consist of an approximately 1,900 lf force main to discharge the stored tunnel CSO flows directly into the existing Ballard Siphon wet-weather barrel forebay.

A new flow diversion structure will be constructed at the 3rd Ave. W CSO Regulator. In addition, an underwater flow diversion conveyance will be constructed beneath the Ship Canal from King County's 3rd Ave. W CSO Regulator north to a new tunnel drop structure located near the Fremont-Wallingford CSO Outfall 174. A new diversion structure near the 11th Ave. NW CSO Regulator and new gravity conveyance pipe to connect to a new tunnel drop structure will also be constructed.

The City will operate the shared CSO tunnel and will be responsible for achieving the CSO control performance standard for the following seven CSO outfalls: Ballard 150, 151 and 152; Fremont/Wallingford 147 and 174; King County 3rd Ave W and King County 11th Ave NW.

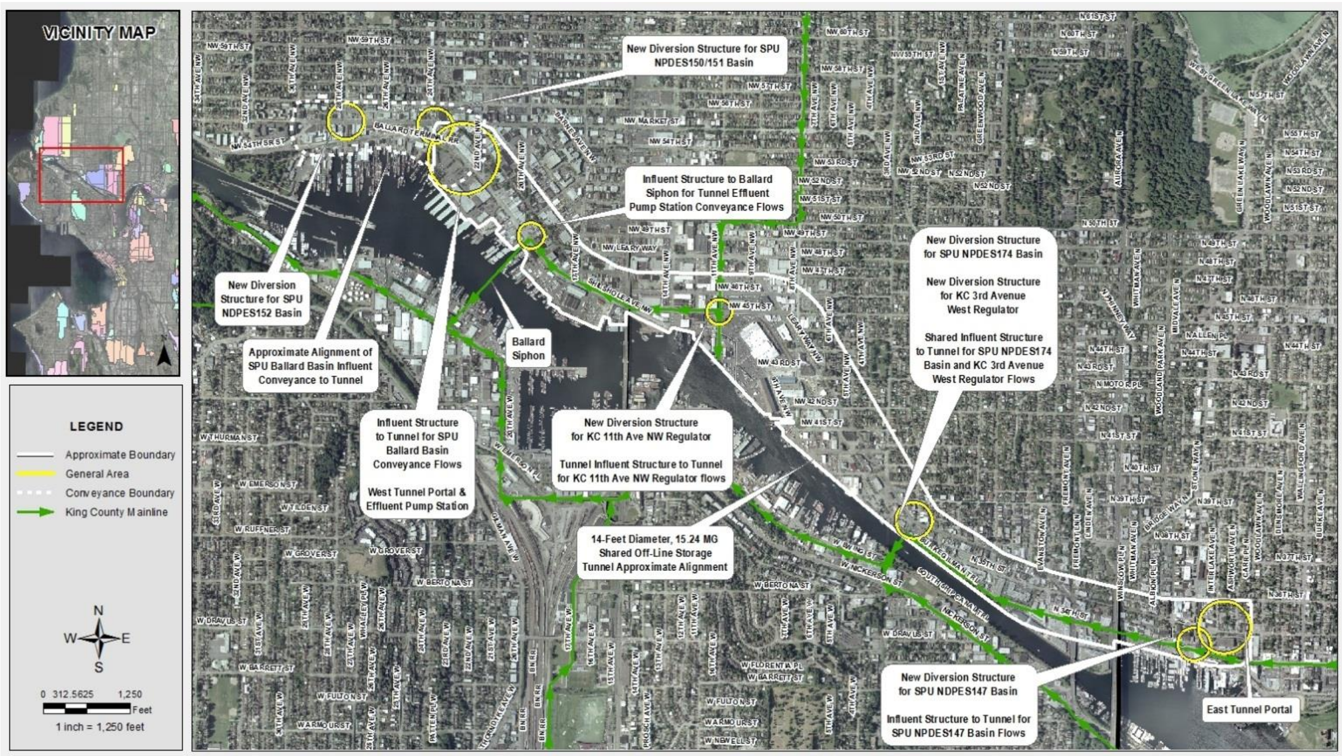

Figure 5-7. Shared West Ship Canal Tunnel Recommended Control Measure

5.6.1.2 CSO Control Measure Design Criteria

The design criteria for the Shared West Ship Canal Tunnel CSO control measures are listed in Table 5-10.

Table 5-10. Shared West Ship Canal Tunnel CSO Control Measure Design Criteria

CSO outfall	Recommended CSO control measure	Average annual overflow frequency after CSO control measure implementation [a]	Peak storage release rate with no impact (MGD) after CSO control measure implementation [a]	Average annual overflow volume after CSO control measure implementation (MG)[a]	Control volume with climate change (MG)
147 (City Fremont-Wallingford)	Shared West Ship Canal Tunnel	0.5	See Storage Release Rate below	1.5	2.15
174 (City Fremont-Wallingford)	Shared West Ship Canal Tunnel	0.5	See Storage Release Rate below	1.0	1.06

Table 5-10. Shared West Ship Canal Tunnel CSO Control Measure Design Criteria

CSO outfall	Recommended CSO control measure	Average annual overflow frequency after CSO control measure implementation a	Peak storage release rate with no impact (MGD) after CSO control measure implementation a	Average annual overflow volume after CSO control measure implementation (MG)a	Control volume with climate change (MG)
150/151 (City Ballard) [b]	Shared West Ship Canal Tunnel	0.4	See Storage Release Rate below	1.0	0.62
152 (City Ballard)	Shared West Ship Canal Tunnel	0.5	See Storage Release Rate below	3.6	5.38
11th Ave NW (King County CSO Outfall 004)	Shared West Ship Canal Tunnel	0.4	See Storage Release Rate below	3.9	4.18 (without Climate Change)
3rd Ave W (King County CSO Outfall 008)	Flow Diversion to Shared West Ship Canal Tunnel	0.5	See Storage Release Rate below	3.1	1.85 (without Climate Change)
Total Tunnel		Not applicable	32 (Storage release rate)	Not applicable	15.24

Notes:
[a] Peak rate of release from storage when allowed by NIRR. NIRR derived from 20-year (1990-2009) long-term simulations with Rainfall scaling =1.0
[b] These outfalls are served by a common discharge pipe and are considered a single point for control volume and frequency purposes.

Additional project design considerations to be evaluated during the design phase are shown on Table 5-11.

Table 5-11. Shared West Ship Canal Tunnel Additional Considerations for Design Phase

CSO outfall	Additional considerations to be evaluated during design phase
150, 151, 152, 147. 174	Validate final CSO control volume based on Annual CSO Reports, additional flow monitoring data, and final design modeling. Determine grit management scheme for flow diverted to storage.
King County 3rd Ave W	Validate final CSO control volume based on future Annual CSO Reports, additional flow monitoring data, and final design modeling. Determine grit management scheme for flow diverted to storage. King County to obtain approval for extending Consent Decree milestone for completion from 2023 to 2025.
King County 11th Ave NW	Validate final CSO control volume based on future Annual CSO Reports, additional flow monitoring data, and final design modeling. Determine grit management scheme for flow diverted to storage.

5.6.2 Magnolia

5.6.2.1 CSO Control Measure Description

The recommended CSO control measure for Magnolia CSO Outfall 060 is shown on Figure 5-8 and includes a new 0.11 MG buried storage pipe that is 6-feet in diameter and approximately 530 feet long. A possible location for the new storage pipe is within the City right-of-way. A new 10-foot diversion structure and approximately 50 feet of influent gravity pipeline will connect to a new 10-foot diameter access structure at the inlet end of the new storage pipe. A new effluent pump station (peak capacity of 0.22 MGD), sized to empty the storage facility within 12 hours, is required and will discharge through approximately 50 feet of force main. A new below-ground facility will house the electrical and standby power generation equipment. A new flap gate will be installed in the existing Magnolia CSO control structure to prevent tidal inflow.

Figure 5-8. Magnolia CSO recommended CSO Control Measure

5.6.2.2 CSO Control Measure Design Criteria

The Final LTCP project definition criteria for the Magnolia CSO control measure are listed in Table 5-12.

Table 5-12. Magnolia CSO Control Measure Design Criteria

CSO outfall	Recommended CSO control measure	Average annual overflow frequency after CSO control measure implementation [a]	Peak storage release rate with no impact (MGD) after CSO control measure implementation [a]	Average annual overflow volume after CSO control measure implementation (MG)[a]	Control volume with climate change (MG)
060	Off-line storage pipe	0.5	0.22	0.15	0.11

Notes:
[a] Peak rate of release from storage when allowed by NIRR. NIRR derived from 20-year (1990-2009) long-term simulations with Rainfall scaling =1.0

Additional project design considerations to be evaluated during the design phase are shown on Table 5-13.

Table 5-13. Magnolia Considerations for Design Phase

CSO outfall	Additional considerations to be evaluated during design phase
107	Validate final CSO control volume based on Annual CSO Reports and flow monitoring data after Magnolia CSO sewer system improvement project implementation.

5.6.3 North Union Bay

5.6.3.1 CSO Control Measure Description

The recommended CSO control measure for North Union Bay CSO Outfall 018 is shown on Figure 5-9 and includes modifying the existing City CSO storage facility (CSO Facility 24) overflow structure to restore the original design capacity for storage and flows. The existing HydroBrake will be replaced with a motor-operated gate (or valve) for CSO Facility 24 to divert additional CSO flows to the downstream King County interceptor.

The motor-operated gate will have the ability to adjust to downstream conditions and upstream storage needs. Both the City and King County have downstream system constraints (capacity of the City's system between CSO Facility 24 and King County's Laurelhurst Trunk and the King County North Interceptor) that an active system will be able to meet by adjusting the discharge. An active system will result in the existing storage capacity being used efficiently to achieve the optimal balance between conveyance and storage.

The new motor-operated gate between the City and King County systems can be adjusted automatically to control flows. King County is planning a large University Regulator CSO project (storage and potential pump station) downstream of CSO Facility 24. Flows from Basin 018 will impact King County's design criteria and it will be advantageous to have the ability to control flows from the City's storage facility.

However, the recommended CSO control measure may result in an increase in the required storage volume for the King County University Regulator CSO storage project. The City performed pre-construction flow monitoring and will be performing up to five years of post-construction flow monitoring to determine the actual impacts upon the future King County University Regulator CSO project. Based on the flow monitoring data, King County and the

City will coordinate conveyance and storage design and operations for both the North Union Bay CSO and King County University Regulator CSO projects.

Figure 5-9. North Union Bay CSO Outfall 018 Recommended Control Measure

5.6.3.2 CSO Control Measure Design Criteria

The Final LTCP design criteria for the North Union Bay CSO control measure are listed in Table 5-14. Additional design considerations to be evaluated during the design phase are shown on Table 5-15.

Table 5-14. North Union Bay CSO Control Measure Design Criteria

CSO outfall	Recommended CSO control measure	Average annual overflow frequency after CSO control measure implementation [a]	Peak storage release rate with No Impact (MGD) after CSO control measure implementation [a]	Average annual overflow volume after CSO control measure implementation (MG)[a]	Control volume with climate change (MG)
018	Sewer system improvement (retrofit)	0.8	Peak flow will increase from 5.5 MGD to 9 MGD to King County	1.6	Not applicable.

Notes:

[a] Peak rate of release from storage when allowed by NIRR. NIRR derived from 20-year (1990-2009) long-term simulations with Rainfall scaling =1.0

Table 5-15. North Union Bay Considerations for Design Phase	
CSO outfall	**Additional considerations to be evaluated during design phase**
018	Validate control status after North Union Bay CSO sewer system improvement project implementation. After implementation, the City may convey additional CSO flows to the proposed King County University Regulator CSO storage tank. If the additional City flows impact the King County CSO storage tank sizing, the City and King County will evaluate the impacts and adjust the King County tank size to accommodate City flows.

5.6.4 Central Waterfront

5.6.4.1 CSO Control Measure Description

The recommended Central Waterfront CSO Outfall 069 control measure is shown on Figure 5-10 and includes a new 0.13 MG buried storage pipe that is 6 feet in diameter and approximately 600 feet long. A possible location for the new storage pipe, which will be located upstream of the existing CSO Outfall 069 control structure, is the existing street right-of-way. A new storage diversion weir will be installed in the existing City CSO facility in MH039-521. Approximately 50 feet of new gravity influent conveyance pipe will be required and will connect to a 10-foot diameter inlet structure of the new storage pipe. Stored CSO flows will be released by a new adjustable control gate installed in a 10-foot diameter outlet structure that will discharge into the existing combined sewer system. A level sensor in the new outlet structure will signal the automatic control gate to open when there is capacity in the existing combined sewer system.

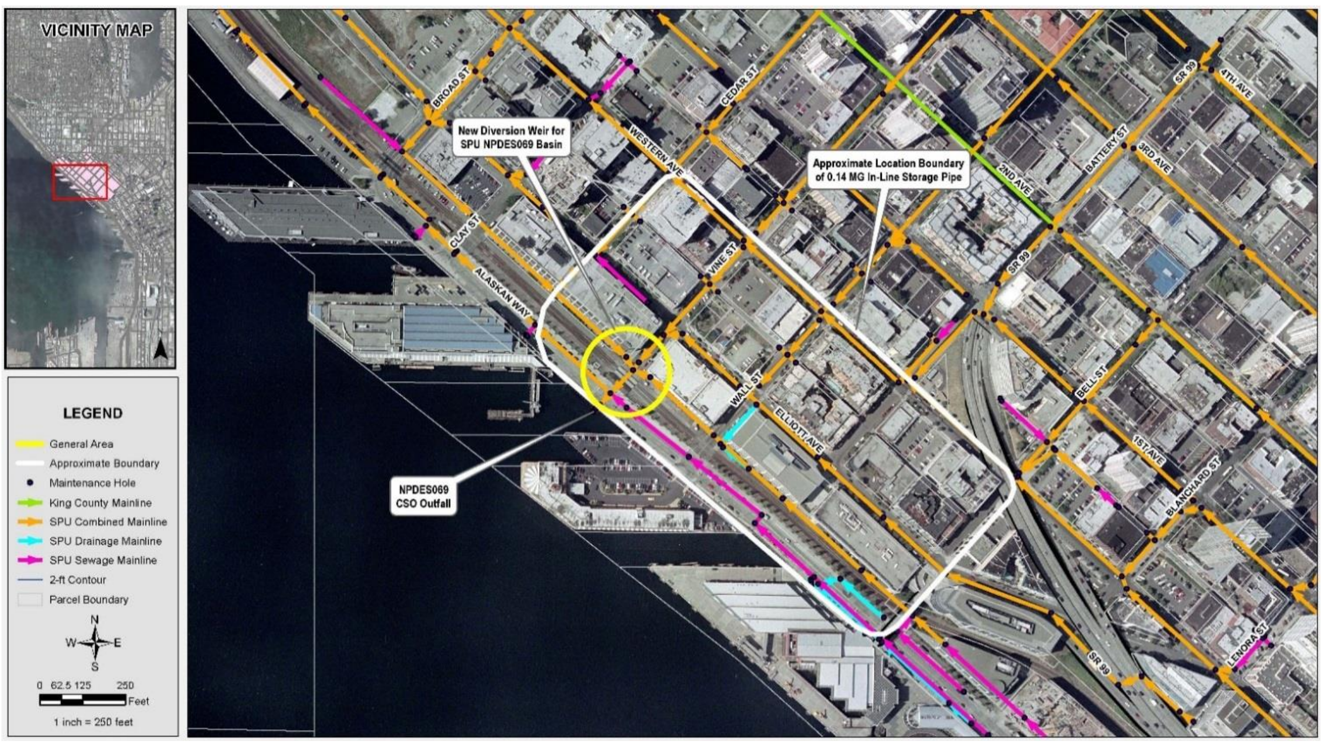

Figure 5-10. Central Waterfront CSO Outfall 069 Recommended Control Measure

5.6.4.2 CSO Control Meausre Design Criteria

The design criteria for the Central Waterfront CSO control measure are listed in Table 5-16.

Table 5-16. Central Waterfront CSO Control Measure Design Criteria

CSO outfall	Recommended CSO control measure	Average annual overflow frequency after CSO control measure implementation [a]	Peak storage release rate with No Impact (MGD) after CSO control measure implementation [a]	Average annual overflow volume after CSO control measure implementation (MG)[a]	Control volume with climate change (MG)
069	Off-line storage pipe	0.7	0.26	0.5	0.13

Notes:
[a] Peak rate of release from storage when allowed by NIRR. NIRR derived from 20-year (1990-2009) long-term simulations with Rainfall scaling =1.0

Additional project design considerations to be evaluated during the design phase are shown on Table 5-17.

Table 5-17. Central Waterfront Considerations for Design Phase

CSO outfall	Additional considerations to be evaluated during design phase
069	Validate final CSO control volume based on future Annual CSO Reports, additional flow monitoring data, and final design modeling. Coordinate construction with the north portion of the Elliott Bay Seawall Project.

5.6.5 Duwamish

5.6.5.1 CSO Control Measure Description

The recommended CSO control measure for Duwamish CSO Outfall 111 is shown on Figures 5-11 and 5-12 and includes improvements to control overflow structures 111B, 111C, and 111H.

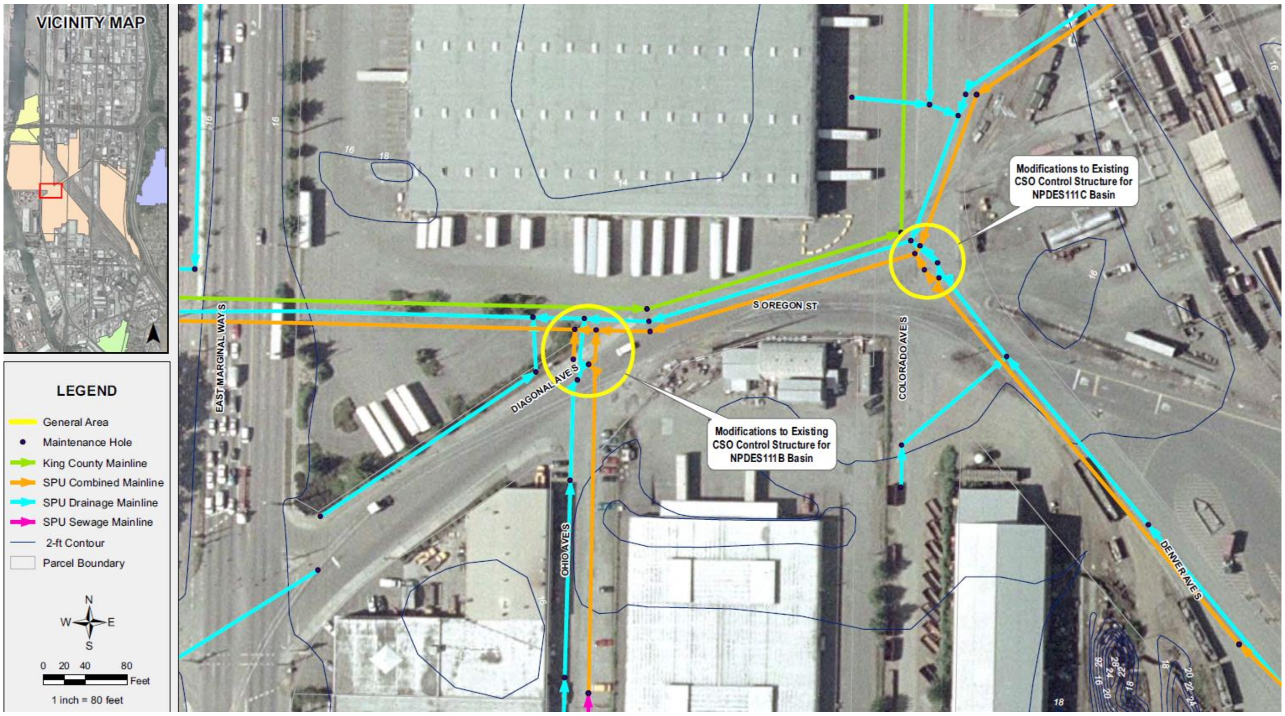

Figure 5-11. Duwamish CSO Sub-basin 111B and 111C Recommended Control Measure

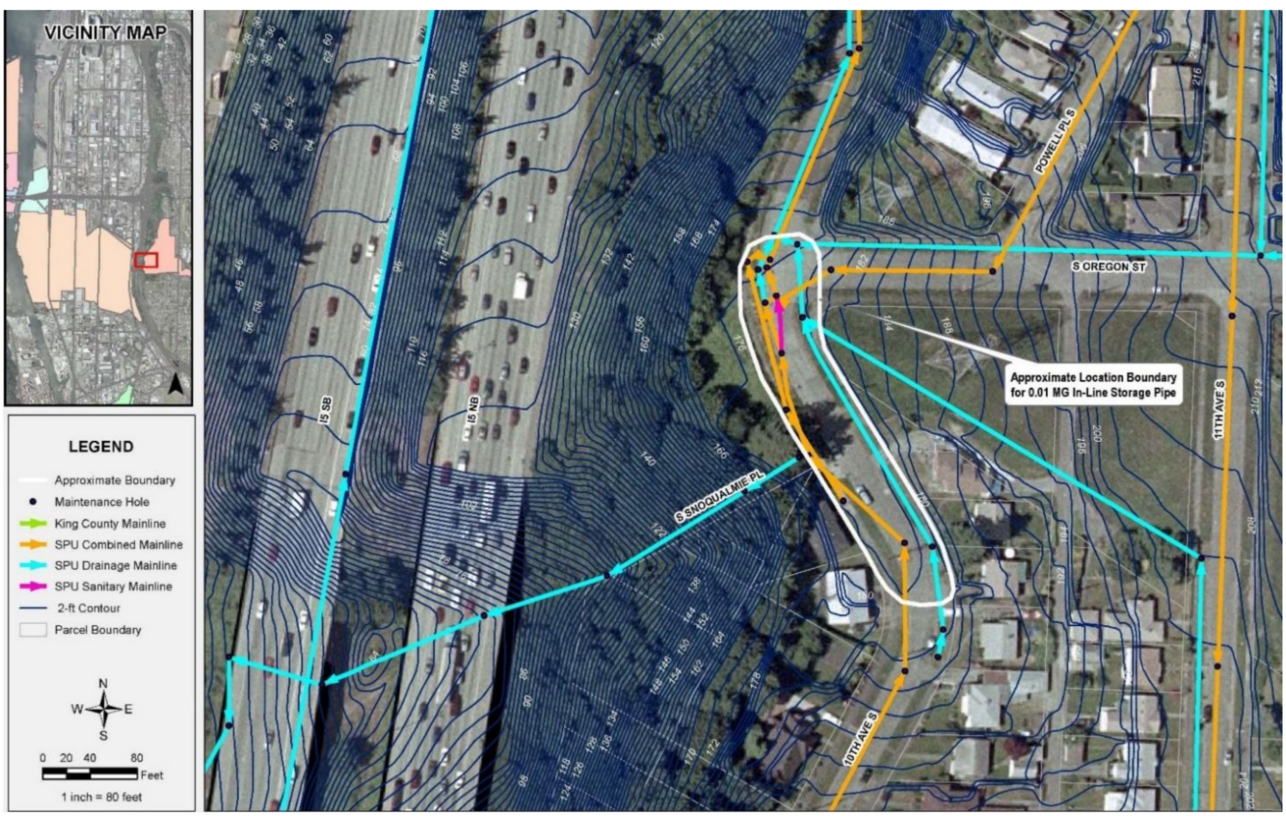

Figure 5-12. Duwamish CSO Sub-basin 111H Recommended Control Measure

The Duwamish 111B and 111C CSO control measure consists of off-line CSO storage upstream of the King County Duwamish pump station which directs flow to the King County Elliott Bay Interceptor. The 0.02 MG storage volume will be provided by modifying two existing control structures and rerouting storm drainage piping to isolate the structures. Two new effluent pump stations (peak capacity of 0.02 MGD), sized to empty the storage facilities within 12 hours, are required as well as approximately 75 feet of force main. A new below-ground facility will house the electrical standby power generation equipment. The storm drainage conveyance system will be rerouted to bypass the overflow control structures for 111C and 111B, and the flap gate currently controlling the outlet of each control structure will be replaced by a new motor-operated control gate. Because the modified storm drainage conveyance system will bypass the control structure, both the storm drainage and CSO control chambers in each control structure will be used to store excess combined sewer flow.

The Duwamish 111H CSO control measure will include a new off-line storage pipe adjacent to the existing CSO Control Facility 35 storage tank. The new 60-inch diameter storage pipe will be approximately 100 feet long. During CSO events, excess combined sewer flows will be diverted from existing CSO Control Facility 35 storage to a new 0.01 MG off-line storage pipe and flow through both the new storage pipe and the existing CSO Control Facility 35 tank to the downstream sewer conveyance system. After a storage event, both the new storage pipe and existing tank will drain together through the existing gravity effluent pipes.

5.6.5.2 CSO Control Measure Design Criteria

The design criteria for the Duwamish CSO control measure are listed in Table 5-18.

Table 5-18. Duwamish CSO Control Measure Design Criteria

CSO outfall	Recommended CSO control measure	Average annual overflow frequency after CSO control measure implementation [a]	Peak storage release rate with no Impact (MGD) after CSO control measure implementation [a]	Average annual overflow volume after CSO control measure implementation (MG)[a]	Control volume with climate change (MG)
111B	Off-line storage pipe	0.4	See 111 (all sub-basins)	0.03	<0.01
111C		0.3		0.03	<0.01
111H	Off-line storage pipe	0.5		0.03	<0.01
111 (all sub-basins)	N/A	0.7	0.04	0.09	0.01

Notes:
[a] Peak rate of release from storage when allowed by NIRR. NIRR derived from 20-year (1990-2009) long-term simulations with Rainfall scaling =1.0

Additional project design considerations to be evaluated during the design phase are shown on Table 5-19.

Table 5-19. Duwamish Considerations for Design Phase

CSO outfall	Additional considerations to be evaluated during design phase
111	Validate final CSO control volume based on Annual CSO Reports and flow monitoring data after Duwamish CSO sewer system improvement project implementation.

5.6.6 East Waterway

5.6.6.1 CSO Control Measure Description

The recommended CSO control measure for East Waterway CSO Outfall 107 is shown on Figure 5-13 and includes a new 0.5 MG storage tank with approximate dimensions of 50 feet wide by 90 feet long with a side water depth of 15 feet. Flows will enter the storage facility during a storm event through a new diversion structure and approximately 500 feet of gravity influent conveyance pipe. The tank will be buried and divided into chambers so that only those chambers required to store the storm event volume will be used. Storage of flows will start in the first chamber. When that chamber reaches capacity, flows will be transferred into subsequent chambers until either the storm event ends or the capacity of the storage facility is reached. The tank will need to be maintained on a scheduled basis and cleaned manually to ensure proper function. A new effluent pump station (peak capacity of 1.0 MGD), sized to empty the storage facility within 12 hours, is required and will discharge into the King County Elliott Bay Interceptor through approximately 1,380 feet of force main . A new below-ground facility will house the electrical, standby power generation, and odor control equipment.

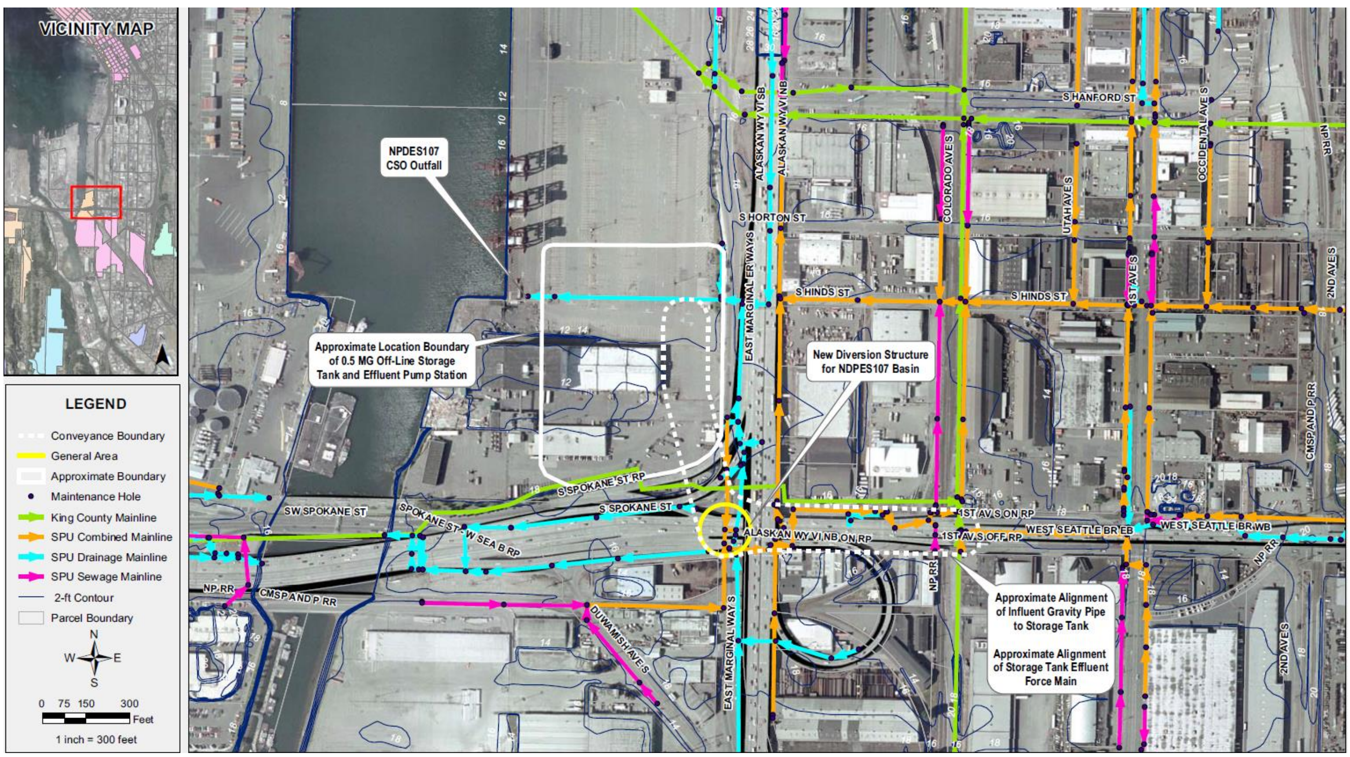

Figure 5-13. East Waterway CSO Outfall 107 Recommended Control Measure

5.6.6.2 CSO Measure Design Criteria

The design criteria for the East Waterway CSO control measure are listed in Table 5-20.

Table 5-20. East Waterway CSO Control Measure Design Criteria

CSO outfall	Recommended CSO control measure	Average annual overflow frequency after CSO control measure implementation [a]	Peak storage release rate with no impact (MGD) after CSO control measure implementation [a]	Average annual overflow volume after CSO control measure implementation (MG)[a]	Control volume with climate change (MG)
107	Off-line storage tank	0.7	1.0	0.01	0.5

Notes:
[a] Peak rate of release from storage when allowed by NIRR. NIRR derived from 20-year (1990-2009) long-term simulations with Rainfall scaling =1.0

Additional design considerations to be evaluated during the design phase are shown on Table 5-21.

Table 5-21. East Waterway Considerations for Design Phase

CSO outfall	Additional considerations to be evaluated during design phase
107	Validate final CSO control volume based on Annual CSO Reports and flow monitoring data after the East Waterway CSO sewer system improvement project implementation. Re-evaluate CSO performance after construction of the King County HLKK CSO Plant.

5.6.7 Delridge/Longfellow

5.6.7.1 CSO Control Measure Description

The recommendations for the Delridge CSO area include three separate CSO control measures for uncontrolled CSO Outfalls 099, 168, and 169 as described below.

5.6.7.1.1 Delridge/Longfellow CSO Outfall 099

The recommended CSO control measure for the Delridge/Longfellow CSO Outfall 099 is shown on Figure 5-14 and includes a new 0.17 MG storage pipe that is 12 feet in diameter and approximately 210 feet long. The new storage pipe will be buried underground within the City right-of-way. Modifications to the existing CSO structure (MH055-447) will be required to divert flow to the new storage pipe. Approximately 80 feet of new gravity influent conveyance pipe will be required and will connect to the inlet end of new storage pipe. A new effluent pump station (peak capacity of 0.34 MGD), sized to empty the storage facility within 12 hours, is required and will discharge through approximately 30 feet of force main. A new below-ground facility will house the electrical, standby power generation, and odor control equipment.

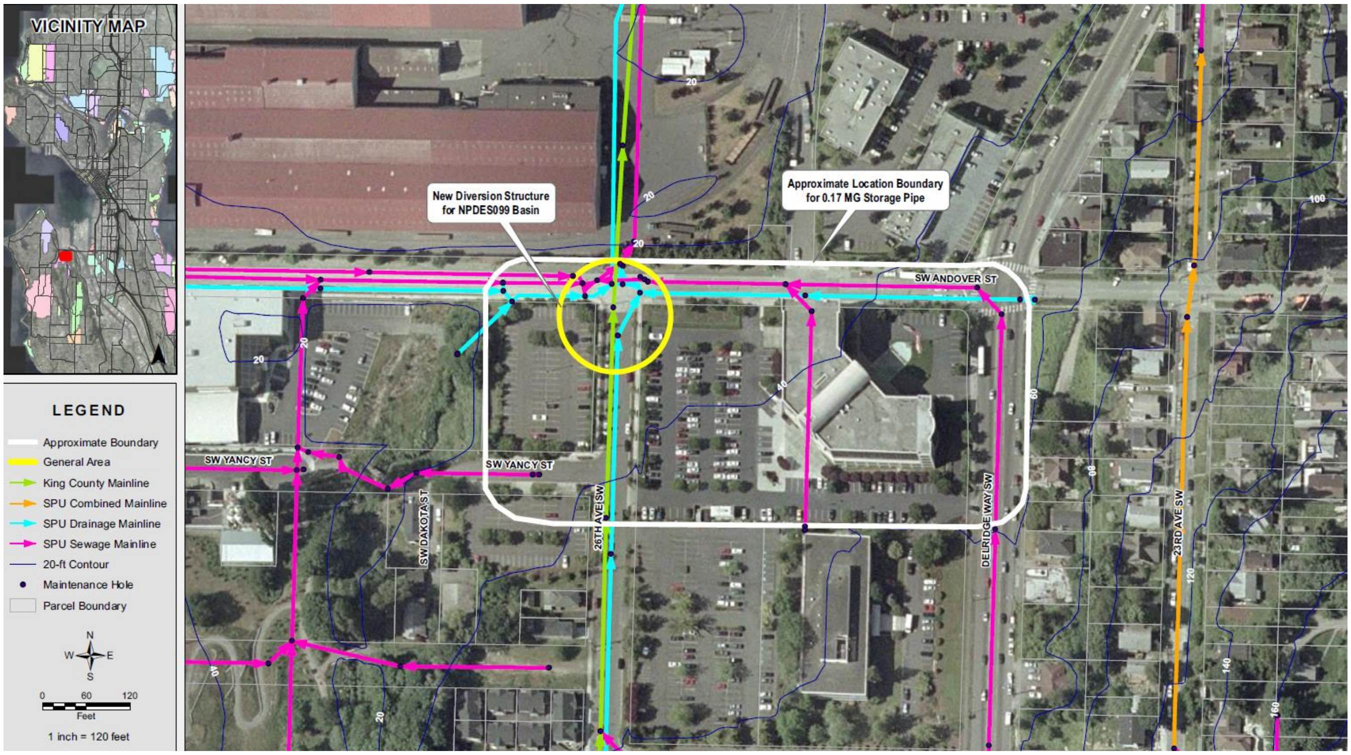

Figure 5-14. Longfellow CSO Outfall 099 Recommended Control Measure

5.6.7.1.2 Delridge/Longfellow CSO Outfall 168

As previously described in Section 5.3.4, the Delridge sewer system improvement project will be operational by October 2015 and is expected to significantly reduce the annual frequency and volume of CSOs discharged from Outfall 168. However, the Delridge sewer system improvement project hydraulic modeling indicated approximately 0.25 MG of additional CSO storage may be required to fully control CSO Outfall 168. The City will conduct post construction flow monitoring and modeling to determine the control volume required for the CSO control measure.

The recommended CSO control measure for Delridge/Longfellow CSO Outfall 168 is shown on Figure 5-15 and includes a new 0.25 MG storage pipe that is 10 feet in diameter and approximately 450 feet long. The new storage pipe will be buried underground within the City right-of-way. Modifications to the existing CSO structure (MH069-428) will be required to divert flow to the new storage pipe. Approximately 100 feet of new gravity influent conveyance pipe will be required and will connect to the inlet end of new storage pipe. A new effluent pump station (peak capacity of 0.50 MGD), sized to empty the storage facility within 12 hours, is required and will discharge through approximately 500 feet of force main. A new below-ground facility will house the electrical, standby power generation, and odor control equipment.

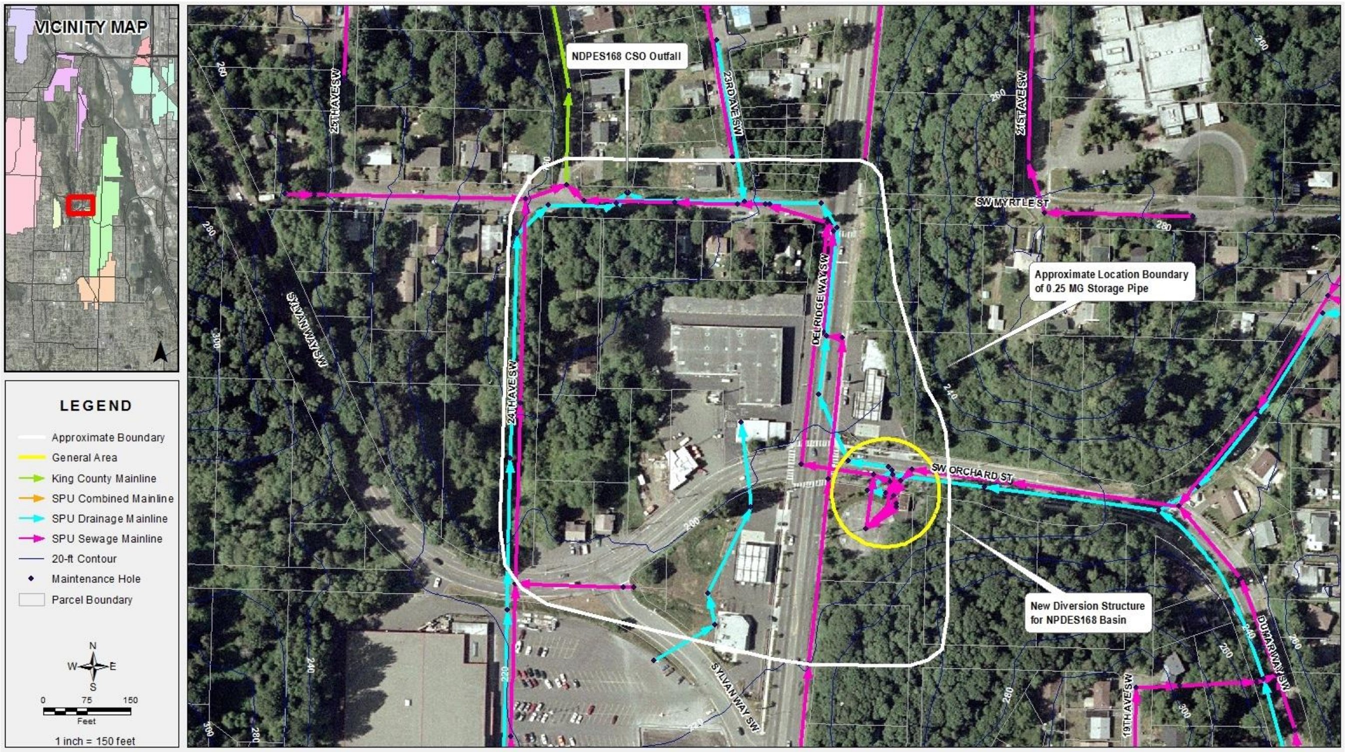

Figure 5-15. Longfellow CSO Outfall 168 Recommended Control Measure

5.6.7.1.3 Delridge/Longfellow CSO Outfall 169

As previously described in Section 5.3.4, the Delridge sewer system improvement project will be operational by October 2015 and is expected to significantly reduce the annual frequency and volume of CSO discharges from Outfall 169. However, the Delridge sewer system improvement project hydraulic modeling indicated approximately 0.25 MG of additional CSO storage may be required to fully control CSO Outfall 169. The City will conduct post construction flow monitoring and modeling to determine the control volume required for the CSO control measure.

The recommended CSO control measure for Delridge/Longfellow CSO Outfall 169 is shown on Figure 5-16 and includes a new 0.25 MG storage pipe that is 9 feet in diameter and approximately 550 feet long. The new storage pipe will be buried underground within the City right-of-way. Modifications to the existing CSO structure (MH076-367) will be required to divert flow to the new storage pipe. Approximately 50 feet of new gravity influent conveyance pipe will be required and will connect to the inlet end of new storage pipe. A new effluent pump station (peak capacity of 0.50 MGD), sized to empty the storage facility within 12 hours, is required and will discharge through approximately 50 feet of force main. A new below-ground facility will house the electrical, standby power generation, and odor control equipment.

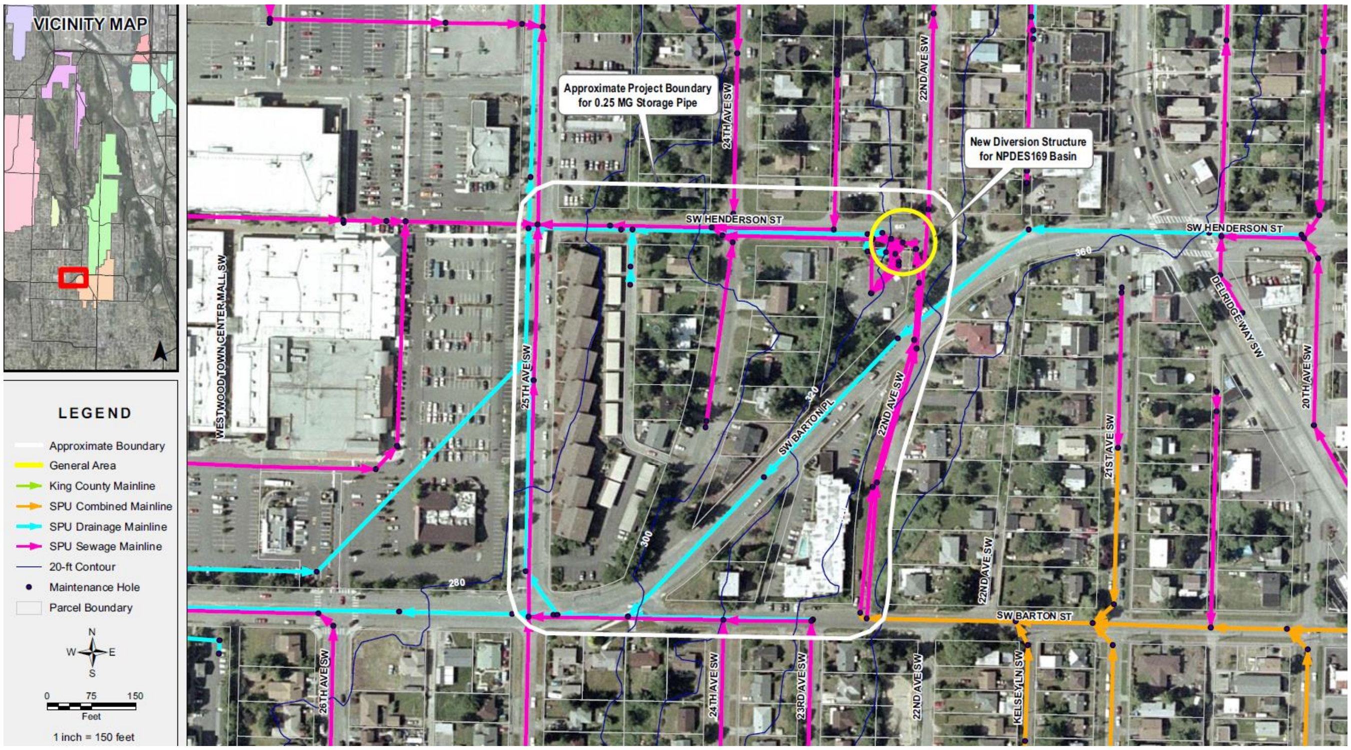

Figure 5-16. Longfellow CSO Outfall 169 Recommended Control Measure

5.6.7.2 CSO Measure Design Criteria

The design criteria for the Delridge/Longfellow CSO control measure are listed in Table 5-22.

Table 5-22. Delridge/Longfellow CSO Control Measure Design Criteria

CSO outfall	Recommended CSO control measure	Average annual overflow frequency after CSO control measure implementation [a]	Peak storage release rate with no impact (MGD) after CSO control measure implementation [a]	Average annual overflow volume after CSO control measure implementation (MG)[a]	Control volume with climate change (MG)
099	Off-line storage pipe	0.8	0.34	0.55	0.17
168	Off-line storage pipe	1.0	Peak outflow rate not increased	2.50	0.25
169	Off-line storage pipe	0.5	Peak outflow rate not increased	0.80	0.25

Notes:
[a] Peak rate of release from storage when allowed by NIRR. NIRR derived from 20-year (1990-2009) long-term simulations with Rainfall scaling =1.0

Additional project definition considerations to be evaluated during the implementation phase are shown on Table 5-23.

Table 5-23. Delridge/Longfellow Considerations for Design Phase

CSO outfall	Additional considerations to be evaluated during design phase
099	Validate final CSO control volume based on future Annual CSO Reports, additional flow monitoring data, and final design modeling.
168	Validate final CSO control volume based on Annual CSO Reports and flow monitoring data after the Delridge CSO sewer system improvement project implementation.
169	Validate final CSO control volume based on Annual CSO Reports and flow monitoring data after the Delridge CSO sewer system improvement project implementation.

5.6.8 Montlake

5.6.8.1 CSO Control Measure Description

Three separate CSO control measures are recommended for Montlake CSO Outfalls 020, 139, and 140, as described below.

5.6.8.1.1 Montlake CSO Outfall 020

The recommended Montlake CSO Outfall 020 control measure is shown on Figure 5-17 and includes a new 0.16 MG buried storage pipe that is 12 feet in diameter and approximately 200 feet long. A possible location for the new storage pipe is within the existing street right-of-way upstream of Pump Station 13. One new diversion structure with two fixed weirs, a motor-operated gate, and approximately 50 feet of new gravity influent conveyance pipe will be required and will connect to the inlet end of new storage pipe. A new effluent pump station (peak capacity of 0.32 MGD), sized to empty the storage facility within 12 hours, is required and will discharge through approximately 50 feet of force main. A new below-ground facility will house the electrical, standby power generation, and odor control equipment.

5.6.8.1.2 Montlake CSO Outfall 139

The recommended Montlake CSO Outfall 139 control measure is shown on Figure 5-18 and includes a new 0.01 MG buried storage pipe that is 5 feet in diameter and approximately 75 feet long. A possible location for the new storage pipe is within the existing street right-of-way upstream of Pump Station 25. One new diversion structure and approximately 25 feet of new gravity influent conveyance pipe will be required and will connect to the inlet end of new storage pipe. After a CSO storage event, a new automatic gate in existing MH031-313 will open and allow the stored CSO flows to be released by gravity into the existing combined sewer conveyance system.

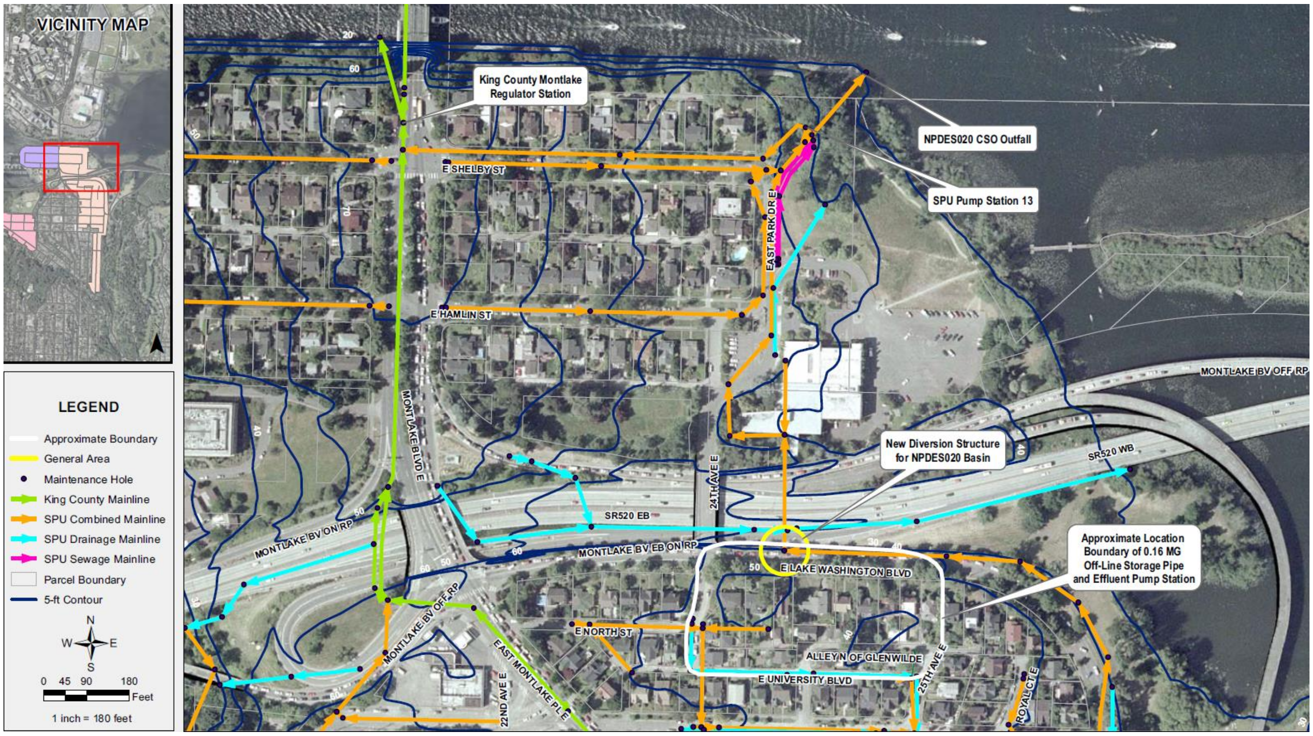

Figure 5-17 CSO Outfall 020 Recommended Control Measure

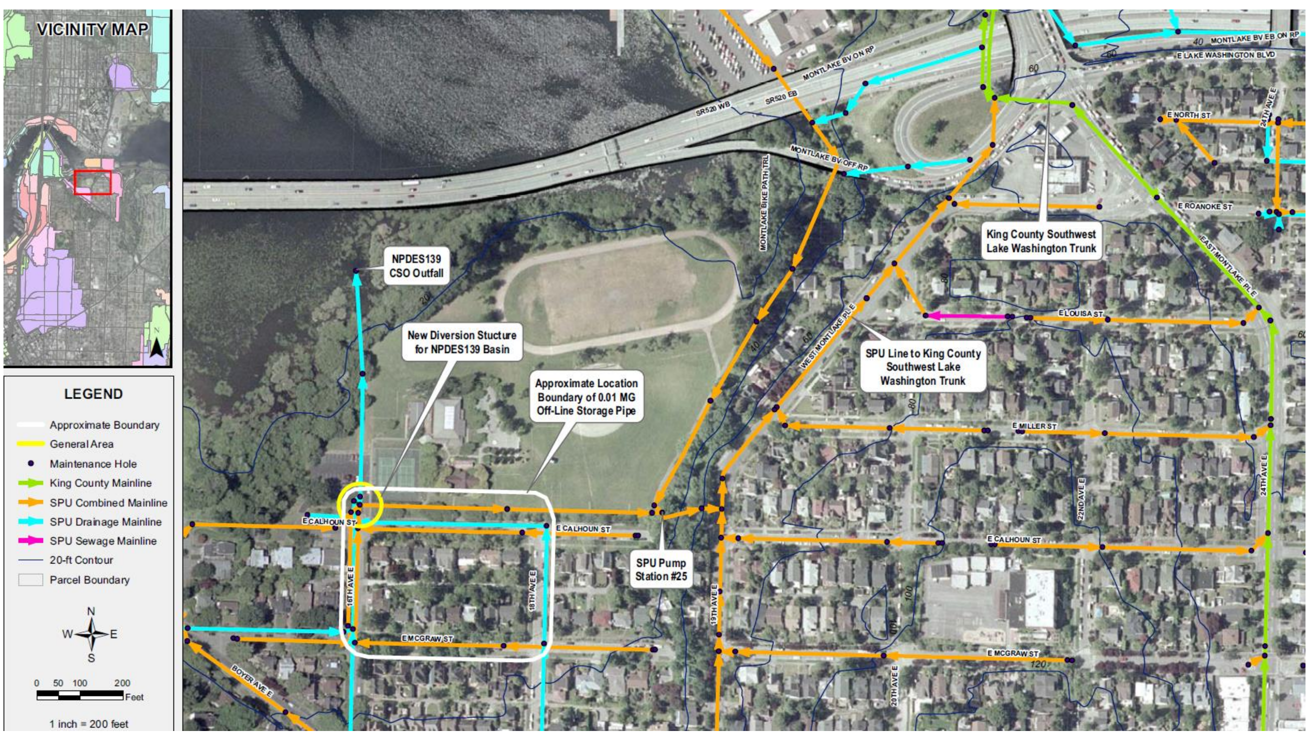

Figure 5-18 CSO Outfall 139 Recommended Control Measure

5.6.8.1.3 Montlake CSO Outfall 140

The recommended Montlake CSO Outfall 140 control measure is shown on Figure 5-19 and includes a new 0.05 MG buried storage pipe that is 8 feet in diameter and approximately 150 feet long. A possible location for the new storage pipe is within the existing street right-of-way, upstream of Pump Station 15 and its existing detention pipe. One new diversion structure and approximately 60 feet of new gravity influent conveyance pipe will be required and will connect to the inlet end of new storage pipe. After a CSO storage event, both the new and existing storage pipe will be emptied by the existing Pump Station 15.

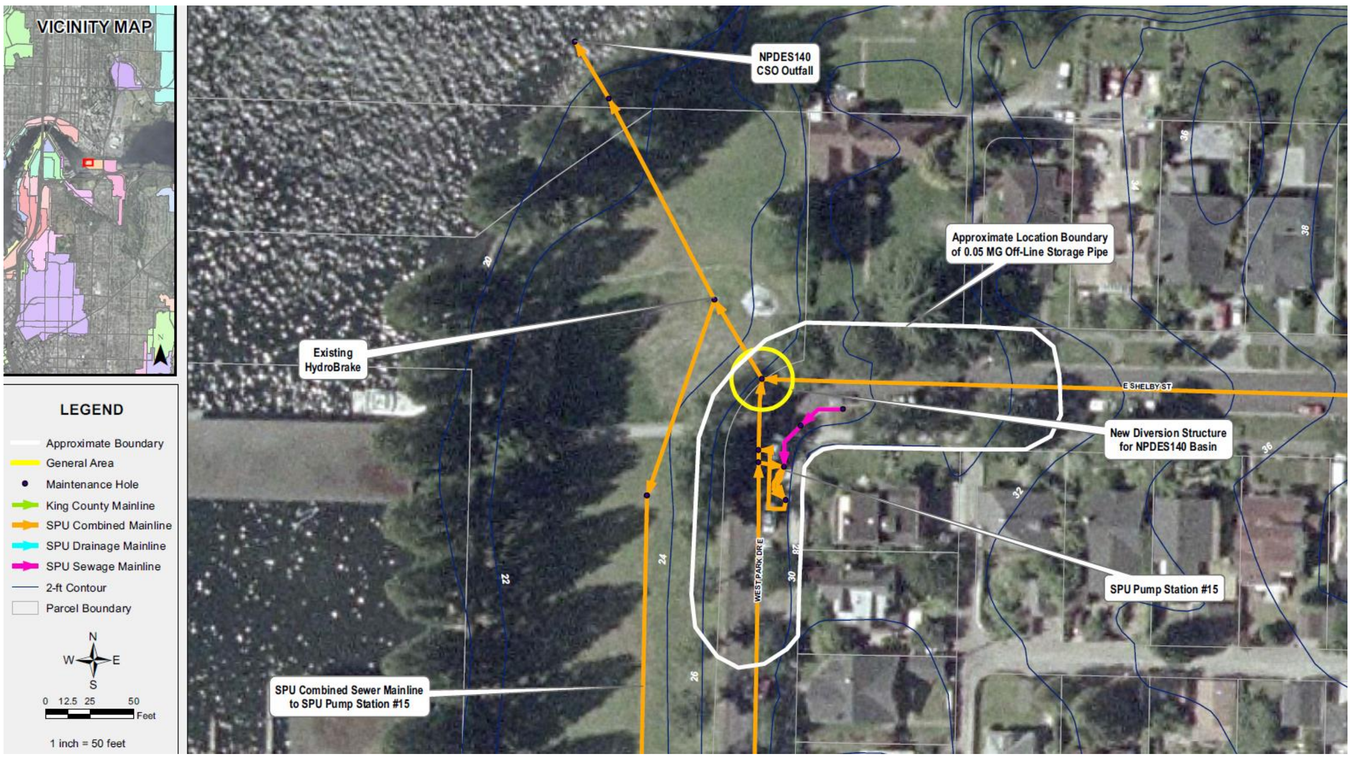

Figure 5-19 CSO Outfall 140 Recommended Control Measure

5.6.8.2 CSO Meaure Design Criteria

The design criteria for the Montlake CSO control measures are listed in Table 5-24.

Additional design considerations to be evaluated during the design phase are shown on Table 5-25.

Table 5-24. Montlake CSO Control Measure Design Criteria

CSO outfall	Recommended CSO control measure	Average annual overflow frequency after CSO control measure implementation [a]	Peak storage release rate with no impact (MGD) after CSO control measure implementation [a]	Average annual overflow volume after CSO control measure implementation (MG)[a]	Control volume with climate change (MG)
020	Off-line storage pipe	0.6	Peak outflow rate not increased	0.40	0.16
139	Off-line storage pipe	0.5	Peak outflow rate not increased	0.02	0.01
140	Off-line storage pipe	0.4	Peak outflow rate not increased	0.08	0.05

Notes:
[a] Peak rate of release from storage when allowed by NIRR. NIRR derived from 20-year (1990-2009) long-term simulations with Rainfall scaling =1.0

Table 5-25. Montlake Considerations for Design Phase

CSO outfall	Project definition considerations to be evaluated during design phase
020	Validate final CSO control volume based on future Annual CSO Reports, additional flow monitoring data, and final design modeling.
139	Validate final CSO control volume based on future Annual CSO Reports, additional flow monitoring data, and final design modeling.
140	Validate final CSO Control Volume based on future Annual CSO Reports, additional flow monitoring data, and final design modeling.

5.6.9 Leschi

5.6.9.1 CSO Control Measure Description

Based on the hydraulic model development work described in Chapter 2, System Characterization, and the Leschi conveyance system configuration, the Leschi CSO area can be hydraulically divided into north and south areas. The north Leschi area includes CSO Basins 026, 027, 028, 029, 030, 031, 032, and 033. The south Leschi area includes CSO Basin 034, 035, and 036. Figure 5-20 shows the Leschi CSO outfall locations and the general area of the recommended CSO control measures. Pumping Station 2 divides the north from the south groups. Basins south of Pump Station 2 drain to Pump Station 2 which pumps flows to the King County East Pine pump station. North of Pump Station 2, all flows drain by gravity to the King County East Pine pump station.

The Leschi basin is an isolated area with no upstream or downstream hydraulic relationship to other City NPDES basins; however, all of the Leschi basins are connected and each basin flows through the numerically lower basin and into the Leschi trunk sewer. All the collected flows discharge from the Leschi CSO area to King County's East Pine pump station for conveyance to the West Point WWTP.

Table 2-23, LTCP Outfall Control Status, indicated that 6 of the 11 NPDES basins in the Leschi CSO area (028, 029, 031, 032, 034, and 036) are uncontrolled and will require action to achieve the performance standard.

Because the basins are hydraulically linked, however, an action to control a single basin runs the risk of forcing adjacent basins out of control.

The recommended CSO control measure for the Leschi CSO area consists of four separate facilities to provide storage volume for the five uncontrolled basins as shown on Figure 5-20 and described in the following sections.

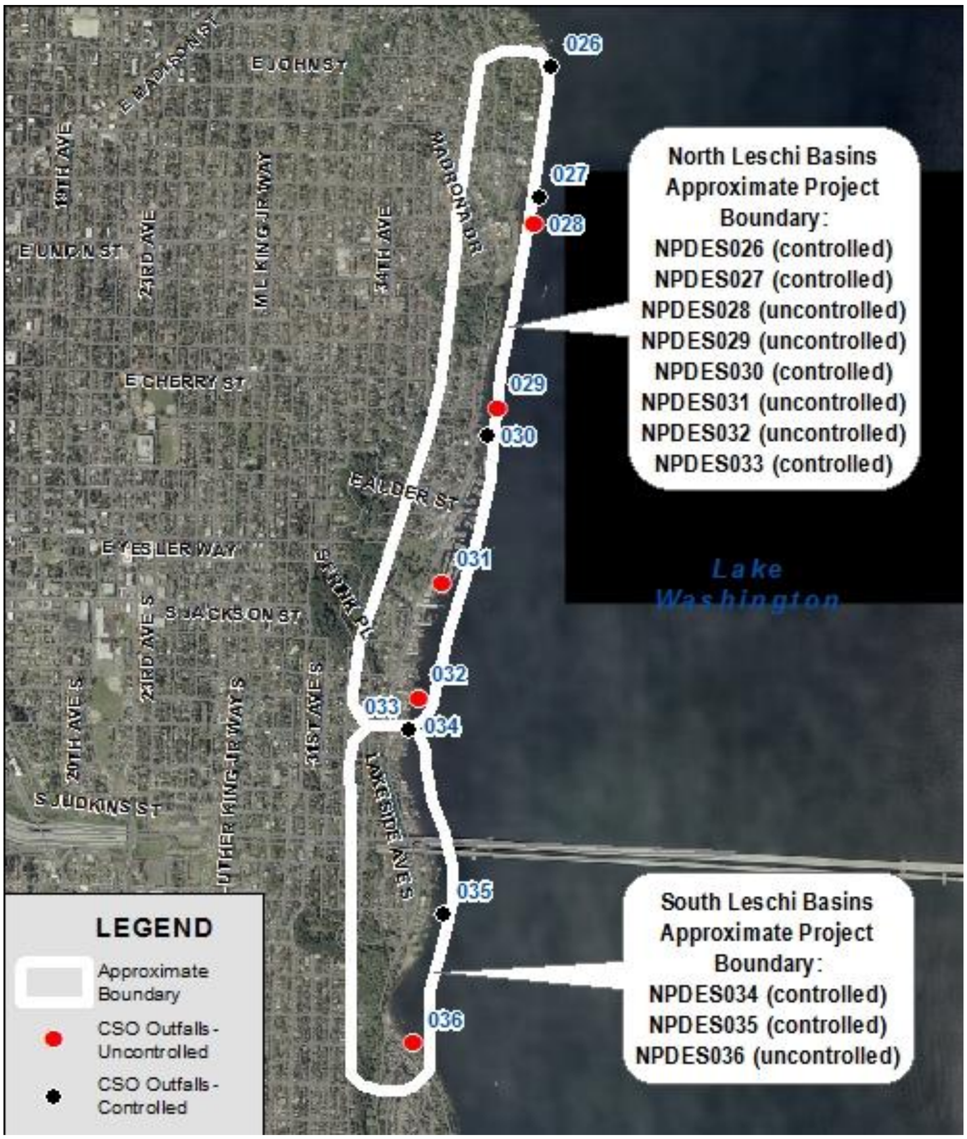

Figure 5-20. CSO Recommended Control Measure

5.6.9.1.1 North Leschi

The recommended measures for the north Leschi area have three separate CSO control measures for uncontrolled CSO Outfalls 028, 029, and 031/032 as described below.

The recommended Outfall 28 CSO control measure is shown on Figure 5-21 and includes a new 0.01 MG buried storage pipe that is 3 feet in diameter and approximately 210 feet long. A possible location for the new storage pipe is within the right-of-way of Lake Washington Blvd. One new diversion weir will be installed in the existing Outfall 028 control structure. Approximately 80 feet of new gravity influent conveyance pipe will be required and will connect to a new 8-foot diameter access structure at the inlet end of the new storage pipe. A new 12-foot diameter access structure at the outlet end of the new storage pipe with a motor-operated gate to allow drainage of the new storage pipe will also be required.

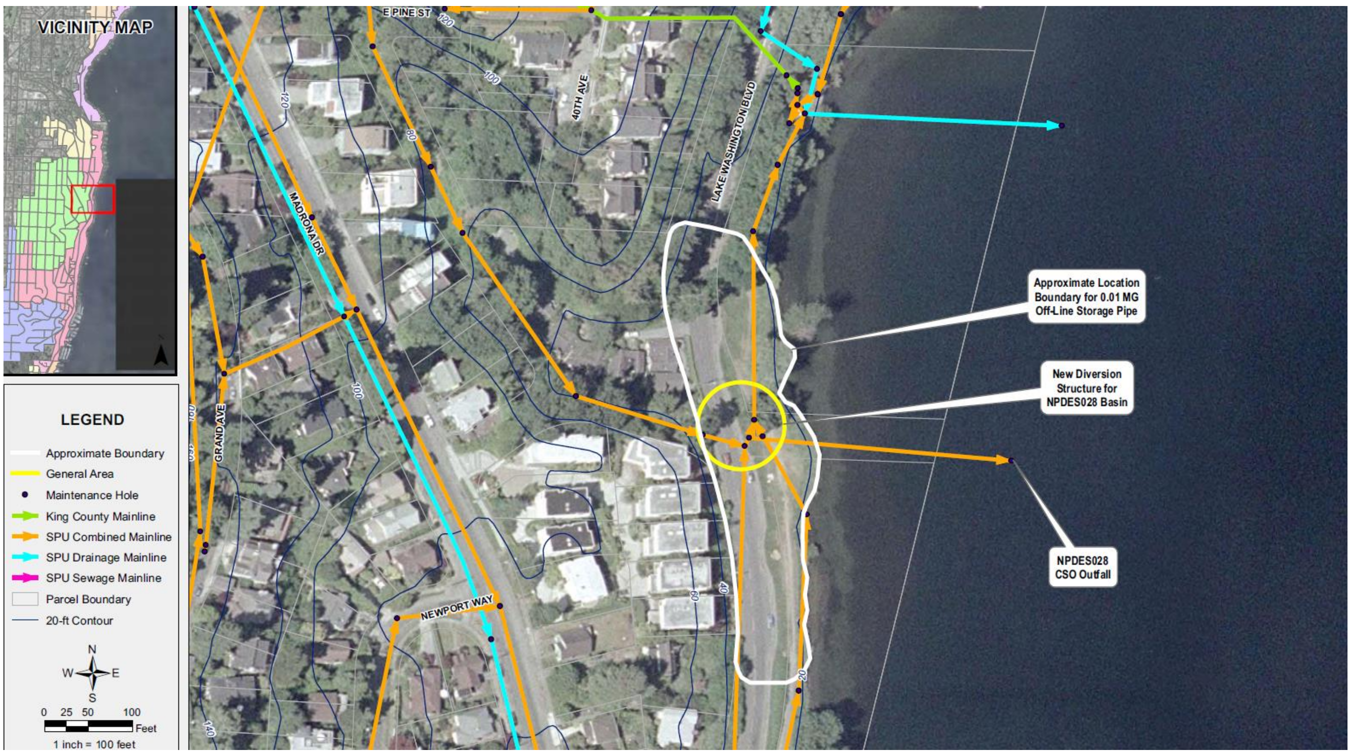

Figure 5-21. CSO Outfall 028 Recommended Control Measure

The recommended Outfall 029 CSO control measure is shown on Figure 5-22 and includes a new 0.02 MG buried storage pipe that is 5 feet in diameter and approximately 150 feet long. A possible location for the new storage pipe is within the right-of-way of Lake Washington Blvd. A new 4-foot diversion structure and approximately 20 feet of influent gravity pipeline will connect to the inlet end of the new storage pipe. A new effluent pump station (peak capacity of 0.04 MGD), sized to empty the storage facility within 12 hours, is required and will discharge through approximately 70 feet of force main. A new below-ground facility will house the electrical and standby power generation equipment. The existing outfall overflow weir will be raised.

Figure 5-22. CSO Outfall 029 Recommended Control Measure

The recommended CSO control measure for Basins 031 and 032 is shown on Figure 5-23 and includes a new 0.33 MG storage tank with approximate dimensions of 60 feet wide by 65 feet long with a side water depth of 15 feet. Based on hydraulic and hydrologic modeling, the storage volume estimates for Basins 031 and 032 are 0.31 MG and 0.08 MG, respectively – a sum of 0.39 MG. However, modeling of the design concept for Basins 031 and 032 indicated that a single 0.33 MG storage facility will be sufficient to control CSOs at Outfalls 031 and 032 to an average of one per year. Flows will enter the storage facility during storm events through a new diversion structure and approximately 50 feet of gravity influent conveyance pipe. The tank will be buried underground and divided into chambers so that only those chambers required to store the storm event volume will be used. Storage of flows will start in the first chamber. When that chamber reaches capacity, flows will be transferred into subsequent chambers until either the storm event ends or the capacity of the storage facility is reached. The tank will need to be maintained and cleaned manually to ensure proper function. A new effluent pump station (peak capacity of 0.66 MGD), sized to empty the storage facility within 12 hours, is required and will discharge through approximately 50 feet of force main. A new below-ground facility will house the electrical, standby power generation, and odor control equipment. Approximately 50 feet of existing 8-inch diameter gravity pipe will need to be increased to 12-inch diameter gravity pipe between MH046-033 and MH046-031. The CSO control measure for Basins 031 and 032 would also control Basin 034.

Figure 5-23. CSO Outfall 031 and 032 Recommended Control Measure

5.6.9.1.2 South Leschi

The recommended CSO control measure for the south Leschi area (Outfall 036) is shown on Figure 5-24 and includes a new 0.03 MG storage pipe that is 7 feet in diameter and approximately 120 feet long. A possible location for the new storage pipe is within the right-of-way of Lake Washington Blvd. One new diversion structure will be constructed upstream of the existing outfall control structure. Approximately 50 feet of new gravity influent conveyance pipe will be required and will connect to a new 8-foot diameter access structure at the inlet end of the new storage pipe. A new 12-foot diameter access shaft to accommodate the effluent pump station (peak capacity of 0.06 MGD), sized to empty the storage facility within 12 hours, is required and will discharge through approximately 50 feet of force main. A new below-ground facility will house the electrical, standby power generation, and odor control equipment.

Figure 5-24. CSO Outfall 036 Recommended Control Measure

5.6.9.2 CSO Measure Design Criteria

The design criteria for the Leschi CSO control measures are listed in Table 5-26.

Table 5-26. Leschi CSO Control Measure Design Criteria

CSO outfall	Recommended CSO control measure	Average annual overflow frequency after CSO control measure implementation [a]	Peak storage release rate with no impact (MGD) after CSO control measure implementation [a]	Average annual overflow volume after CSO control measure implementation (MG)[a]	Control volume with climate change (MG)
026	Outfall is controlled. No CSO control measure required	0.2	Not applicable	<0.01	Not applicable
027	Outfall is controlled. No CSO control measure required	0	Not applicable	0	Not applicable
028	Off-line storage pipe	0.5	0.02	0.02	<0.01
029	Off-line storage pipe	0.5	0.04	0.03	0.02

Table 5-26. Leschi CSO Control Measure Design Criteria

CSO outfall	Recommended CSO control measure	Average annual overflow frequency after CSO control measure implementation [a]	Peak storage release rate with no impact (MGD) after CSO control measure implementation [a]	Average annual overflow volume after CSO control measure implementation (MG)[a]	Control volume with climate change (MG)
030	Outfall is controlled. No CSO control measure required	0.8	Not applicable	0	Not applicable
031	Combined 031/032 Off-line storage pipe/tank	0.5	0.66	0.17	0.31
032		0.4		0.01	0.08
033	Outfall is controlled. No CSO control measure required	0.2	Not applicable	0	Not applicable
034	Outfall is uncontrolled, but will be brought into control from the CSO control measures being implemented in other basins	0.4	Not applicable	0.15	Not applicable
035	Outfall is controlled. No CSO control measure required	0.5	Not applicable	0.01	Not applicable
036	Off-line storage pipe	0.5	0.06	0.06	0.03

Notes:

[a] Peak rate of release from storage when allowed by NIRR. NIRR derived from 20-year (1990-2009) long-term simulations with Rainfall scaling =1.0 Additional design considerations to be evaluated during the design phase are shown on Table 5-27.

Table 5-27. Leschi Considerations for Design Phase

CSO outfall	Additional considerations to be evaluated during design phase
026	Outfall is currently controlled. Validate CSO control status based on Annual CSO Reports and flow monitoring data after Leschi sewer system improvement project implementation. Monitor CSO control status after implementation of all Leschi CSO control measures.
027	Outfall is currently controlled. Validate CSO control status based on Annual CSO Reports and flow monitoring data after Leschi sewer system improvement project implementation. Monitor CSO control status after implementation of all Leschi CSO control measures.

Table 5-27. Leschi Considerations for Design Phase

CSO outfall	Additional considerations to be evaluated during design phase
028	Validate final CSO control volume based on Annual CSO Reports and flow monitoring data after Leschi sewer system improvement project implementation. Monitor CSO control status after implementation of all Leschi CSO control measures.
029	Validate final CSO control volume based on Annual CSO Reports and flow monitoring data after Leschi sewer system improvement project implementation. Monitor CSO control status after implementation of all Leschi CSO control measures.
030	Outfall is currently controlled. Validate CSO control status based on Annual CSO Reports and flow monitoring data after Leschi sewer system improvement project implementation. Monitor CSO control status after implementation of all Leschi CSO control measures.
031 032	Validate final CSO control volume based on Annual CSO Reports and flow monitoring data after Leschi sewer system improvement project implementation. Monitor CSO control status after implementation of all Leschi CSO control measures.
033	Outfall is currently controlled. Validate CSO control status based on Annual CSO Reports and flow monitoring data after Leschi sewer system improvement project implementation. Monitor CSO control status after implementation of all Leschi CSO control measures.
034	Outfall is currently controlled. Validate CSO control status based on Annual CSO Reports and flow monitoring data after Leschi sewer system improvement project implementation. Monitor CSO control status after implementation of all Leschi CSO control measures.
035	Outfall is currently controlled. Validate CSO control status based on Annual CSO Reports and flow monitoring data after Leschi sewer system improvement project implementation. Monitor CSO control status after implementation of all Leschi CSO control measures.
036	Validate final CSO control volume based on Annual CSO Reports and flow monitoring data after Leschi sewer system improvement project implementation. Monitor CSO control status after implementation of all Leschi CSO control measures.

5.6.10 Portage Bay/Lake Union

5.6.10.1 CSO Control Measure Description

The recommended CSO control measure for Portage Bay/Lake Union (Outfall 138) is shown on Figure 5-25 and includes a new 0.12 MG buried storage pipe that is 10 feet in diameter and approximately 210 feet long. A possible location for the new storage pipe is within the City right-of-way. A new diversion structure and approximately 210 feet of influent gravity pipeline will connect to a new 12-foot diameter access structure at the inlet end of new storage pipe. A new non-return valve will be installed in the new 12-foot diameter access structure at the south end of the new storage pipe so storage can be emptied by gravity back into the existing the City sewer system within 12 hours of a wet-weather event. A new below-ground facility will house the electrical and odor control equipment.

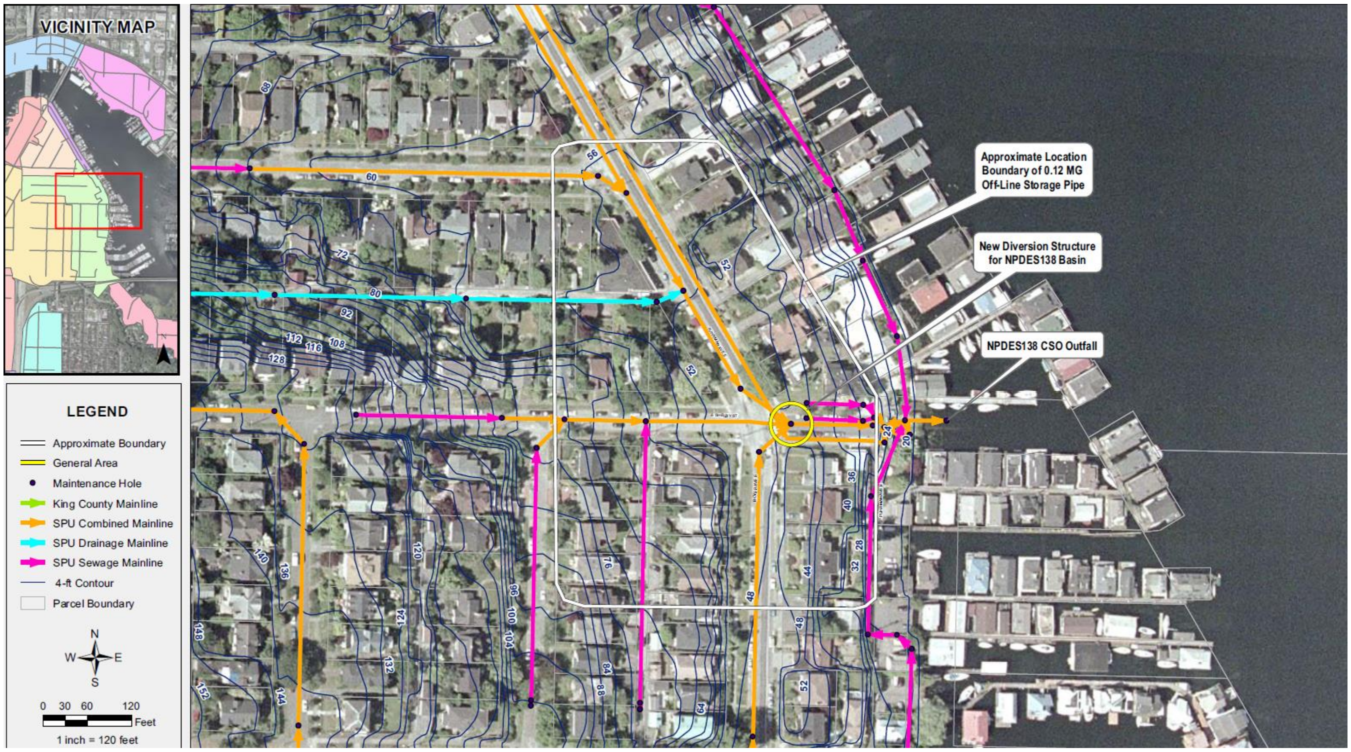

Figure 5-25. Portage Bay/Lake Union CSO Outfall 138 Recommended Control Measure

5.6.10.2 CSO Measure Design Criteria

The design criteria for the Portage Bay CSO control measure are listed in Table 5-28.

Table 5-28. Portage Bay/Lake Union CSO Control Measure Design Criteria

CSO outfall	Recommended CSO control measure	Average annual overflow frequency after CSO control measure implementation [a]	Peak storage release rate with no impact (MGD) after CSO control measure implementation [a]	Average annual overflow volume after CSO control measure implementation (MG)[a]	Control volume with climate change (MG)
138	Off-line storage pipe	0.6	0.22	0.15	0.11

Notes:

[a] Peak rate of release from storage when allowed by NIRR. NIRR derived from 20-year (1990-2009) long-term simulations with Rainfall scaling =1.0

Additional considerations to be evaluated during the design phase are shown on Table 5-29.

Table 5-29. Portage Bay Considerations for Design Phase

CSO outfall	Additional considerations to be evaluated during design phase
138	Validate final CSO Control Volume based on future Annual CSO Reports, additional flow monitoring data, and final design modeling.

5.7 Estimated Costs of Recommended LTCP Option

5.7.1 Overview of Project Costs

The project costs and their net present values were presented in Chapters 3 and 4. Section 5.4 described the process used to identify two final options for long-term CSO control: the Neighborhood Storage Tank Option and the Shared West Ship Canal Tunnel option. Following the short-listing of these two options, the costs of each were updated to reflect the results of ongoing refinement and evaluation. Major areas of cost revision were:

- Previous estimates (expressed in 2013 dollars) were escalated to August 2014 dollars.
- Final control measure modeling resulted in minor changes to control measure sizes and volumes.
- Project schedules were adjusted as appropriate to allow sewer system improvement projects to be completed prior to final design of the control measures. This will allow the City to optimize the size of final control measures, and it resulted in changes to NPVs.
- More detailed analysis of pre- and post-construction monitoring affected that portion of the cost.
- Substitution of storage projects for the proposed flow diversions in the Magnolia and East Waterway neighborhoods affected the overall cost estimates.

For all control measures except Ballard and Fremont/Wallingford, the City used its Conceptual Cost Calculator (3C) to develop estimates of construction cost. Details of the 3C cost model can be found in Section 3.7.1.

Because Ballard and Fremont/Wallingford are the largest basins and are included in a shared project with King County, further refinement of the costs was deemed to be appropriate. King County and the City engaged a third-party cost estimator who was not involved in the development of the conceptual designs of the City's or King County's CSO facilities. This estimator provided an independent project cost estimate for the Shared West Ship Canal Tunnel, the City's Ballard Storage Tank, the City's Fremont/Wallingford Storage Tank, King County's 3rd Ave. W storage tank, and King County's 11th Ave. NW conveyance.

This was done for two primary purposes: to update King County project costs that were dated and prepared under different methods and to ensure that the estimates used to compare the agencies' projects were done on an equivalent basis (the "apples to apples" factor).

5.7.2 Capital Cost

Table 5-30 presents the capital cost of the recommended CSO control measures that are included in the Shared West Ship Canal Tunnel option.

The total project cost shown includes construction costs for major parts of each control measure (conveyance, storage, pump stations, special construction, etc.) as well as estimated soft costs, project contingencies, management reserves, property costs, commissioning, and stabilization period costs. All costs are expressed in August 2014 dollars based on an Engineering News Record Construction Cost Index (CCI) value of 10161.68.

Table 5-30. Recommended CSO Control Measures Total Project Cost (August 2014 $Millions)

CSO area	CSO outfall	Total project cost [a]	Construction cost	Property cost	Soft costs	Project contingency and reserves	Commissioning and stabilization	Baseline flow monitoring
Leschi	028-036	$28.1	$12.0	$1.7	$5.9	$6.8	$1.2	$0.5
Montlake	020/139/140	$13.6	$6.3	-	$3.1	$3.3	$0.6	$0.3
Portage Bay	138	$8.7	$4.1	-	$2.0	$2.1	$0.4	$0.1
Duwamish	111	$4.4	$1.9	-	$0.9	$1.0	$0.2	$0.4
East Waterway	107	$31.1	$13.0	$3.3	$6.4	$7.9	$0.4	$0.1
Magnolia	060	$6.3	$2.9	-	$1.4	$1.6	$0.3	$0.1
Central Waterfront	069	$10.5	$4.9	-	$2.4	$2.6	$0.5	$0.1
Delridge	099	$7.7	$3.6	-	$1.7	$1.9	$0.4	$0.1
	168	$8.9	$4.2	-	$2.0	$2.1	$0.4	$0.2
	169	$8.0	$3.7	-	$1.8	$1.9	$0.4	$0.2
North Union Bay	018	$1.6	$0.6	-	$0.3	$0.3	$0.2	$0.2
Shared West Ship Canal Tunnel	City: 150, 151, 152, 147 and 174; King County: 3rd Ave W and 11th Ave NW	$374.1[b]	$210.0	$2.8[c]	$76.7	$75.2[d]	$8.8	$0.6
Total cost of control measures		$503.0	$267.2	$7.8	$104.6	$106.7[d]	$13.8	$2.9
Anticipated King County contribution [d]		$116.0	$65.1	$0.9	$23.8	$23.3	$2.7	$0.2
City share of total cost of control measures		$387.0	$202.1	$6.9	$80.8	$83.4	$11.1	$2.7

Notes:

[a] *Total Project Cost includes construction, engineering, property, soft costs, sales tax, contingency, management reserve fund, commissioning, stabilization, and baseline flow monitoring.*

[b] *Includes $1.2 M for Art and Sustainability.*

[c] *Property cost of Shared West Ship Canal Tunnel is shown as net capital cost assuming 80 percent of property sold after construction.*

[d] *See Section 5.7.4 for details on the cost share between the City and King County. City and King County negotiations have been conducted using a preliminary total project cost of $366 M (in August 2014 $'s) for the Shared West Ship Canal Tunnel. The difference in cost is due to the inclusion of commissioning, stabilization, and flow monitoring costs, which are assumed to be capitalized instead of operating expenses. The total project cost estimate for the project will continue to be refined as the project is developed.*

Facilities constructed under the LTCP will require commissioning costs beyond those the City typically encounters when completing construction. These include stabilization costs to ensure that the constructed facilities will perform as designed. A project contingency and management reserves were included in the total project costs. These allowances are intended to address the costs of potential construction risks, permit conditions, and site-specific mitigation. During the design, the total project costs will be revised to include site-specific conditions.

The cost estimates for the control measures presented in this LTCP are considered to be Class 4 estimates, as defined by the Association for the Advancement of Cost Engineering (AACE), with an accuracy range of minus 20 percent to plus 30 percent.

The construction costs for the recommended CSO control measures have been reviewed and validated by third-party engineering and construction firms as follows:

- Tunnel construction costs were reviewed by three independent cost reviewers. The tunnel construction schedule was reviewed by a construction contractor.
- Large CSO storage tank cost estimates (3 MG and larger) were reviewed by an independent cost reviewer.
- Smaller pipe and tank storage and conveyance cost estimates were based on recent City construction costs.
- Major conveyance costs were reviewed in an independent cost review.

5.7.3 Operating Cost

The City's non-capital costs include recurring annual operation and maintenance expenses, fees paid to King County for treatment of additional flows, ongoing flow monitoring for system control, and post-construction monitoring to demonstrate consent decree compliance.

An operation and maintenance cost model (Appendix K) was developed for comparing control measures. This cost model incorporated existing City operating experience with storage facilities and conveyance systems augmented by recent monitoring and construction commissioning data.

Table 5-31 presents information on the maintenance costs for the proposed control measures that are included in the options. The table includes anticipated annual costs for maintenance broken down by major activities for each control measure. The operating cost shown includes the expected cost of energy (both the readiness to serve and energy charges).

Table 5-31. Recommended CSO Control Measures Operation and Maintenance Costs (August 2014 $Millions),

CSO area	CSO basins	Annual O&M[a]	Post-construction monitoring
Leschi	028-036	$0.31	$1.20
Montlake	020/139/140	$0.22	$0.64
Portage Bay	138	$0.05	$0.41
Duwamish	111	$0.16	$0.19

Table 5-31. Recommended CSO Control Measures Operation and Maintenance Costs (August 2014 $Millions)

CSO area	CSO basins	Annual O&M[a]	Post-construction monitoring
East Waterway	107	$0.11	$0.13
Magnolia	060	$0.08	$0.30
Central Waterfront	069	$0.05	$0.49
Delridge	099	$0.11	$0.36
	168	$0.13	$0.42
	169	$0.14	$0.37
North Union Bay	018	$0.09	$0.19
Shared West Ship Canal Tunnel	The City: 150/151, 152, 147 and 174 King County: 3rd Ave W and 11th Ave NW	$0.82	$1.76
Annual operating cost		$2.27	$6.46
Anticipated King County contribution [b]		$0.25	$0.55
City share of annual operating cost		$2.02	$5.91

Notes:
[a] *Annual system operating and maintenance costs include maintenance labor, power and chemicals, odor control consumables, meter maintenance costs for permanent flow monitoring, and treatment fees to King County.*
[b] *Based on a preliminary cost share for the Shared West Ship Canal Tunnel. See Section 5.7.4 for details.*

5.7.4 Shared Project Costs

A cost sharing methodology for shared projects was agreed upon by King County and the City. In general, the approach is to share the savings. Each jurisdiction's share of the selected project is based on each jurisdiction's proportionate share of the avoided cost of projects that would otherwise have been built.

This cost sharing approach is applicable to the Shared West Ship Canal Tunnel project for the City (Ballard and Fremont/Wallingford) and King County (3rd Ave. W and 11th Ave. NW) CSO basins. Table 5-32 presents the planning-level cost share that was used for the development of this LTCP based on the methodology agreed to by King County and the City. The actual cost shares will be developed as part of the project-specific agreement to be developed by the agencies.

Table 5-32: Breakdown of Costs Between King County and the City

Agency	Project	NPV of costs	Percent of total NPV of costs
City	Ballard Tank	\$135M[a]	69%
	Fremont/Wallingford Tank	\$106M[a]	
King County	3rd Ave. W Tank	\$90M	31%
	11th Ave W Conveyance	\$20M	
Combined		\$352M	100%

Note:
[a] For comparison with King County projects, the cost of pre-construction and permanent flow monitoring not included in NPV.

5.8 Performance Evaluation of Recommended Option

5.8.1 CSO Performance Standard

This section was prepared in accordance with Appendix C of the July 3, 2013, Consent Decree. The specific requirement is listed in Paragraph C.5(a) as follows:

> *Assessment of CSO Control Measures: In developing the LTCP, the City must conduct or document prior analysis of alternatives for reducing the City's CSOs. The assessment must include, at a minimum, (a) an evaluation of the annual performance capabilities and effectiveness, measured in terms of CSO activation frequencies and overflow volumes, of various CSO control alternatives to meet performance criteria for controlling CSOs, pursuant to WAC 173-245 and RCW 90.48.48.*

5.8.2 Recommended CSO Control Measures Performance

Based on the CSO control measures described in Section 5.6 and the King County No Impact Release Rates described in Section 5.3, the LTCP hydraulic models were used to estimate the 20-year moving average annual overflow frequency and volume for each CSO outfall control measure. The results are shown in Table 5-33, Projected Annual Performance (20-year Moving Average Overflow Frequency and Volume) After Implementation of Recommended CSO Control Measures. All recommended CSO control measures will reduce the annual CSO overflow frequencies to less than one event per outfall per year based on a 20-year moving average.

Table 5-33 Projected Annual Performance (20-year Moving Average Overflow Frequency and Volume) After Implementation of Recommended CSO Control Measures

CSO area	CSO outfall number	Recommended CSO control measure	20-year moving average annual overflow frequency[a]	Average annual overflow volume (MG)[b]	Peak no impact release rate (MGD)[c]	Comments
Shared West Ship Canal (Joint City and King County)						
Fremont/Wallingford	147	15.24 MG deep tunnel storage located north of the Ship Canal	0.5	1.5	n/a	Overflows diverted to tunnel until tunnel is full
Fremont/ Wallingford	174		0.5	1.0	n/a	Overflows diverted to tunnel until tunnel is full
Ballard	150/ 151		0.5	1.0	n/a	Overflows diverted to tunnel until tunnel is full
Ballard	152		0.5	3.6	n/a	Overflows diverted to tunnel until tunnel is full
King County 3rd Ave. W	008		0.5	3.1	n/a	Overflows diverted to tunnel until tunnel is full
King County 11th Ave. NW	004		0.4	3.9	n/a	Overflows diverted to tunnel until tunnel is full
Tunnel performance and Effluent pump station flow rate			Not Applicable	Not Applicable	32	Tunnel Effluent PS discharge rate based on Ballard wet weather siphon NIRR
Off-Line Storage						
Montlake	020	0.16 MG off-line storage tunnel storage pipe	0.6	0.40	0.32	Flows released from storage are passed through existing City Pump Station13 so that peak outflow from the basin is not increased
Leschi	028	0.01 MG off-line storage pipe	0.5	0.02	0.02	
Leschi	029	0.02 MG off-line storage pipe	0.5	0.03	0.04	
Leschi	031	0.33 MG off-line storage tank/pipe	0.5	0.17	0.66	Outflow from common storage tank
Leschi	032		0.4	0.01		

Table 5-33 Projected Annual Performance (20-year Moving Average Overflow Frequency and Volume) After Implementation of Recommended CSO Control Measures

CSO area	CSO outfall number	Recommended CSO control measure	20-year moving average annual overflow frequency[a]	Average annual overflow volume (MG)[b]	Peak no impact release rate (MGD)[c]	Comments
Leschi	036	0.03 MG off-line storage pipe	0.5	0.06	0.06	
Magnolia	060	0.11 MG off-line storage pipe	0.5	0.15	0.22	
Central Waterfront	069	0.13 MG off-line storage pipe	0.7	0.50	0.26	
Delridge/ Longfellow	099	0.17 MG off-line storage pipe	0.8	0.55	0.34	
East Waterway	107	0.5 MG off-line storage tank	0.7	0.01	1.0	
Duwamish	111	0.01 MG off-line storage pipe	0.7	0.09	0.02	
Portage Bay/Lake Union	138	0.11 MG off-line storage pipe	0.6	0.15	n/a	Flows released from storage are passed through the existing City Pump Station 20 so that outflow from the basin is not increased
Montlake	139	0.01 MG off-line storage pipe	0.5	0.02	n/a	Flows released from storage are passed through the existing City Pump Station 25 so that outflow from the basin is not increased
Montlake	140	0.05 MG off-line storage pipe	0.4	0.08	n/a	Flows released from storage are passed through the existing City Pump Station 25 so that outflow from the basin is not increased

Table 5-33 Projected Annual Performance (20-year Moving Average Overflow Frequency and Volume) After Implementation of Recommended CSO Control Measures

CSO area	CSO outfall number	Recommended CSO control measure	20-year moving average annual overflow frequency[a]	Average annual overflow volume (MG)[b]	Peak no impact release rate (MGD)[c]	Comments
Delridge/ Longfellow	168	0.25 MG off-line storage pipe	1.0	2.50	n/a	Peak outflow rate not increased
Delridge/ Longfellow	169	0.25 MG off-line storage pipe	0.5	0.80	n/a	Peak outflow rate not increased
Flow Diversion						
North Union Bay	018	Modifications to CSO control structure 018B	0.8	1.8	n/a	Increase peak flow from 5.5 MGD to 9 MGD to King County

Notes:

[a] *20-year moving average overflow frequency with Rainfall scaling factor of 1.0*

[b] *Estimated volumes less than 5,000 gallons are shown as < 0.01 MG. Volumes of 5,000 to 10,000 gallons are rounded up to 0.01 MG.*

[c] *Maximum discharge rates from storage facilities based on King County provided "no-impact release rates"*

5.9 Implementation Plan for Recommended Option

5.9.1 Overview

The implementation plan describes the approach the City will take to meet design, construction, and operational compliance milestones for each of the CSO control projects. The implementation schedule will affect rates, employment, public and local businesses, agency resource allocation, and other agency projects.

The Consent Decree requires the LTCP to develop an expeditious schedule for the design, construction, and implementation of all CSO control measures. If it is not possible for the City to design and construct all measures simultaneously, the LTCP will include a phased schedule based on the relative importance of each measure with the highest priority given to those projects which most reduce the discharge of pollutants.

5.9.2 Prioritization and Scheduling Criteria

5.9.2.1 Project Scheduling Approach

Project scheduling takes into consideration task durations as well as the relative priorities of the projects. Project duration assumptions are listed in Table 4-12.

The LTCP used two methods to determine the priority of projects which most reduce the discharge of pollutants. The first method followed the EPA guidelines for sensitive areas, which determines which basins have the largest impact on receiving water bodies and human health. The results of the revised sensitive areas analysis were summarized in Figure 5-3. The LTCP will give the highest priority to controlling overflows to the highest ranked sensitive areas.

The second method was then used to rate the results as ranked by the first method to compare the relative cost-effectiveness of each CSO project on a total project cost per gallon of CSO discharge volume reduced. The LTCP will give the highest priority to controlling overflows to the CSO projects with the lowest cost per CSO discharge gallon reduced.

5.9.2.2 Project Phasing

Because the CSO projects vary in construction complexity and project costs, their durations range from 5 years to 11 years based on the City's project implementation experience. In addition, project funding will influence the implementation schedule and require a phased construction approach.

5.9.2.3 Consent Decree Required Milestone Dates

For each CSO control measure, the Consent Decree requires the implementation schedule to specify milestone dates for the following project activities: draft and final engineering report, draft and final plans and specifications, construction start, construction completion, and achievement of controlled status. These required milestone dates have been identified for each recommended CSO control measure and are summarized in Table 5-34 below.

5.9.3 LTCP Option Implementation Schedules

Figure 5-26 presents the overall schedule for the recommended CSO control measure projects. The schedules show the project duration and the Consent Decree milestone dates for construction completion and achievement of controlled status.

In most CSO areas the overall strategy is to first implement sewer system improvements prior to implementing storage facilities. The sewer system improvements are expected to either reduce the need for an additional storage facility, or at the least to reduce the required size of the facility. Once the sewer system improvements have been constructed their ongoing performance will be evaluated, and any impacts on the sizing of required CSO facilities will be assessed.

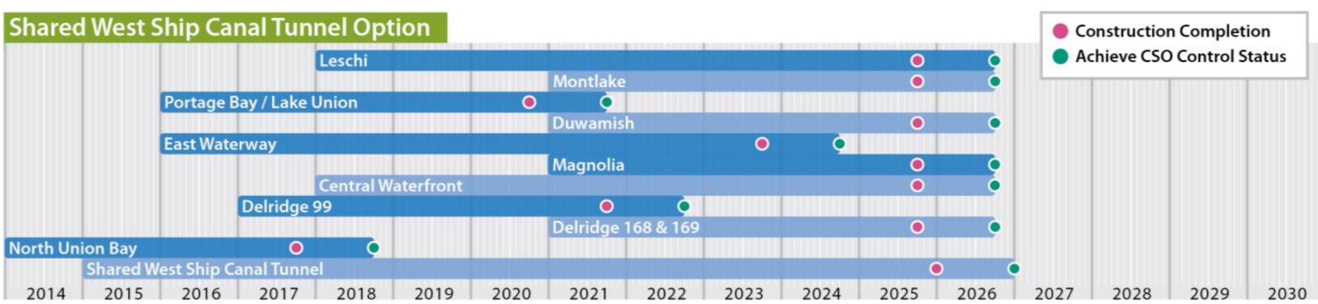

Figure 5-26. Recommended Option Implementation Schedule

The EPA CSO Control Policy indicates that the implementation of CSO projects should be prioritized based on the results of the Sensitive Area Study (see Section 5.3.6). The high priority CSO basins from the City Sensitive Area Study include the following:

- Ballard Basins 150, 151, and 152
- Fremont/Wallingford Basins 147 and 174

- Delridge Basins 168 and 169
- North Union Bay Basin 018

The uncontrolled CSO basins in the Ballard and Fremont/Wallingford CSO areas will be controlled with the completion of the Shared West Ship Canal Tunnel. This CSO control measure is one of the first projects to begin, due to its long duration.

A sewer system improvement project is currently being implemented in Basins 168 and 169 in Delridge, with an NPDES permit deadline to complete construction by November 1, 2015. If post-project performance monitoring indicates that these sewer system improvement projects do not bring the basins into control, an additional CSO control measure will be implemented beginning in 2021.

The CSO control measure for Basin 018 in North Union Bay is currently being implemented, with a scheduled construction completion date of September 30, 2017.

The implementation schedule for the lower-priority CSO basins was based on budget availability and coordination with the sewer system improvement program. In basins where sewer system improvements are being implemented, the CSO control measure is not scheduled to begin until the corresponding retrofit project has been completed and the impact of the sewer system improvement on the control volume has been evaluated.

Table 5-34 shows the Consent Decree milestone dates for the Shared West Ship Canal Tunnel as well as the milestones for the remaining 2010 Plan projects and Consent Decree Early Action Projects that will be completed after 2015.

Table 5-34. Milestone Compliance Dates

	Draft engineering report	Final engineering report	Draft plans and specs	Final plans and specs	Construction start [a]	Construction completion [b]	Achieve controlled status [c]
City-only CSO control measures							
Leschi	6/30/2019	12/31/2019	6/30/2021	12/31/2021	7/1/2022	9/30/2025	9/30/2026
Montlake	6/30/2021	12/31/2021	6/30/2022	12/31/2022	7/1/2023	9/30/2025	9/30/2026
Portage Bay/Lake Union	6/30/2016	12/31/2016	6/30/2017	12/31/2017	7/1/2018	9/30/2020	9/30/2021
Duwamish	6/30/2021	12/31/2021	6/30/2022	12/31/2022	7/1/2023	9/30/2025	9/30/2026
East Waterway	6/30/2017	12/31/2017	6/30/2019	12/31/2019	7/1/2020	9/30/2023	9/30/2024
Magnolia	6/30/2021	12/31/2021	6/30/2022	12/31/2022	7/1/2023	9/30/2025	9/30/2026
Central Waterfront	6/30/2019	12/31/2019	6/30/2021	12/31/2021	7/1/2022	9/30/2025	9/30/2026
Delridge 99	6/30/2017	12/31/2017	6/30/2018	12/31/2018	7/1/2019	9/30/2021	9/30/2022
Delridge 168	6/30/2021	12/31/2021	6/30/2022	12/31/2022	7/1/2023	9/30/2025	9/30/2026
Delridge 169	6/30/2021	12/31/2021	6/30/2022	12/31/2022	7/1/2023	9/30/2025	9/30/2026

Table 5-34. Milestone Compliance Dates

	Draft engineering report	Final engineering report	Draft plans and specs	Final plans and specs	Construction start [a]	Construction completion [b]	Achieve controlled status [c]
North Union Bay	Completed	Completed	Completed	Completed	7/1/2015	9/30/2017	9/30/2018
Shared City/King County West Ship Canal Tunnel CSO control measure							
Shared West Ship Canal Tunnel	3/31/2017	12/31/2017	3/31/2020	12/31/2020	7/1/2021	12/31/2025	12/31/2026

Notes:

[a] Construction Start is defined in the Consent Decree, Section IV. Definitions, Paragraph 9 (j).

[b] Construction Completion is defined in the Consent Decree, Section IV. Definitions, Paragraph 9 (i).

[c] Achieve Control Status will be documented in the City's Annual Report, submitted to EPA and Ecology by March 31 of each year.

5.9.4 LTCP Implementation Plan

5.9.4.1 LTCP CSO Program Management Approach

Implementation of the recommended CSO control measures will managed by the City in coordination with King County. Figure 5-27 provides a preliminary organizational structure for LTCP implementation that describes the roles and functional responsibilities for City and King County staff as well as outside resources.

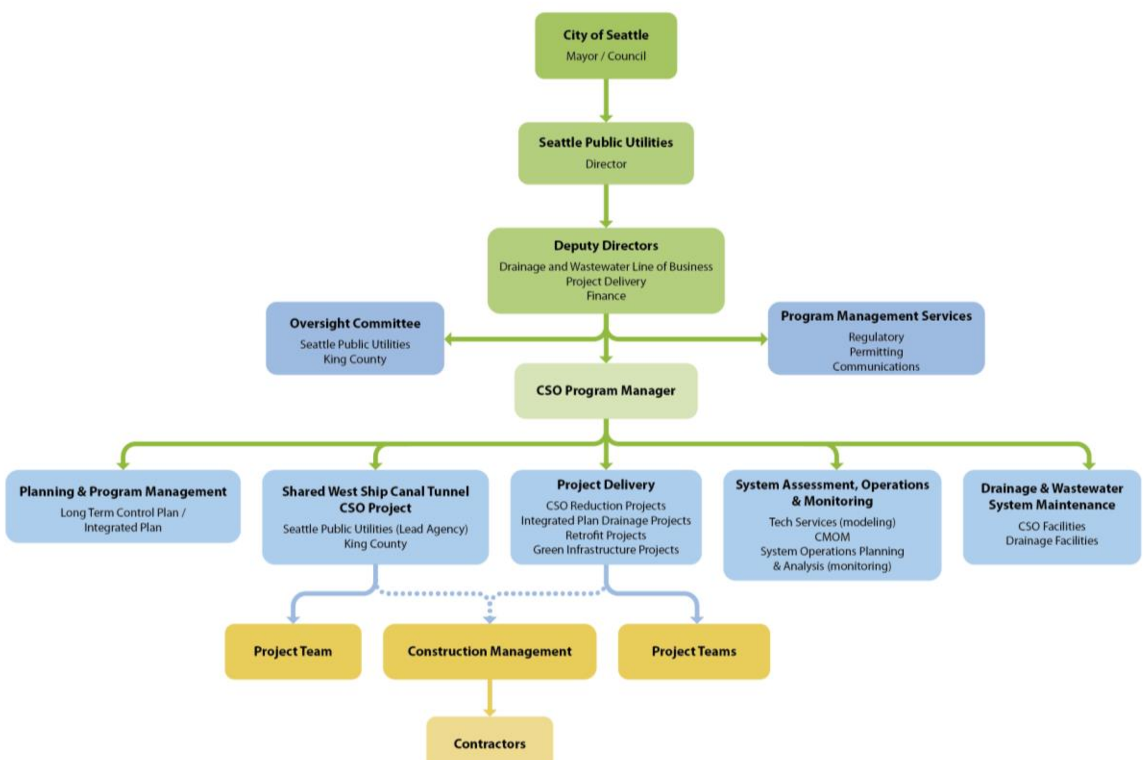

Figure 5-27. Preliminary Organization Structure for LTCP Implementation

5.9.4.2 Shared West Ship Canal Tunnel

The City is the lead agency for the Shared West Ship Canal Tunnel and will be the responsible for project management, design, construction, start-up, and operation. King County and the City will establish a joint project management team with specific roles and responsibilities defined and agreed upon. An oversight committee of the appropriate agency executives will be established to oversee the budget, schedule, configuration, and change management of the project. Roles and responsibilities will be defined by the project-specific agreement to be signed by the agencies.

5.9.4.3 City-Only Neighborhood CSO Control Measures

The City will be responsible for the project management, design, construction, start-up, and operation for all other CSO control measures.

5.9.5 Factors Potentially Affecting Schedule

The LTCP implementation schedule shows the order in which the CSO control measures will be implemented between 2015 and the achievement of control status. The implementation schedule will affect sewer rates, City resource workload, City resources, and local and regional projects. The following major internal and external factors that impact the timing and implementation decisions of the options or individual projects were identified for the LTCP.

5.9.5.1 City Rates

City drainage and wastewater rates will need to be increased to implement the LTCP options. In addition, the City rate payers will also be paying for the implementation of the 2010 Plan CSO projects and the Consent Decree Early Action Projects during the same period (2015 to 2025). LTCP projects may need to be distributed throughout this period to reduce or “flatten” the rate increase. Rate impacts are discussed in detail in Section 4.5, Financial Plan.

5.9.5.2 King County Coordination

5.9.5.2.1 Coordination Strategy

The City and King County both have CSO consent decrees and NPDES Permits with varying compliance dates and priorities that make coordination of shared projects challenging. The City and King County have entered into an agreement for working together on plans, projects, and activities that have the potential to affect both agencies. The City/King County project coordination strategy addresses projects having the potential to impact both agencies and it includes factors for determining joint or independent projects, project coordination levels, and tiered project management and oversight levels. It is expected that this plan will be updated and modified periodically.

King County and the City are each implementing Capital Improvement Programs within the City of Seattle, including independent and joint CSO control, capacity improvements, sanitary sewer overflow control, drainage improvement, and asset management projects. King County has an approved LTCP. The City has prepared a Final LTCP. King County and the City are developing and will implement a Joint System Optimization and Operations Plan. Both agencies will also implement post-construction monitoring plans in the same water bodies. Both agencies agree to assess the cost-efficient level of coordination on all of these projects, and where coordination seems useful, both agencies will work together to develop joint project agreement or detail sheets for each project with the appropriate coordination activities for each project phase.

5.9.5.2.2 Coordination Principles

The purpose of these coordination principles is to provide a foundation for the City and King County to work together on plans, projects, and activities. The principles are summarized below.

- The City and King County will work together on plans, projects, and activities when one agency's plan, project, or activity has the potential to impact the other or when such collaboration benefits the discharge environments, the communities near facilities or discharges each utility serves, or each agency's customers. If either agency identifies potential adverse impacts to the others' systems, projects, operations, community relations, or compliance with regulations, both agencies commit to work together to promptly determine causes and develop preventive actions.
- The relationship of the agencies will be as partners with individual obligations, contracts, and responsibilities.
- Projects and activities will be coordinated with the intent of meeting applicable regulatory standards for treatment, CSO control, and SSO control and drainage.
- Plans, projects, and activities will meet the intent of each agency's Consent Decree and NPDES permit project sequences, schedules, and requirements. Where implementation of plans, projects, or activities would result in conflicts with either agency's Consent Decree and NPDES permit project sequences, schedules, and requirements, the agencies will negotiate together with regulators to resolve the conflict.
- Evaluation of the benefits of plans, projects, and activities to the community and customers will include consideration of financial, social, and environmental criteria.
- Cost sharing opportunities will be determined and reviewed for joint projects. Cost sharing details will be identified for each project and will be consistent with a joint City and King County cost sharing method for joint capital projects.
- Payments or credits for changes in operation and maintenance costs resulting from increased or decreased flows between the City and King County systems will be identified for each project.
- Project scheduling will consider each agency's sequencing and financing priorities.
- Collaboration on projects and activities will consider each agency's unique governmental structures, authorities, legal obligations, and responsibilities, including council structures and processes, financial goals (sewer rates, capacity charge and funding), customers (the City's customers are a subset of King County's customers), the City's drainage responsibilities, and King County's wastewater treatment responsibilities.
- This coordination plan will be reviewed and modified as needed in conjunction with review and amendment of each agency's long-range plans and more frequently by request of either agency.
- Project communications will be developed and agreed upon by the City and King County and will include a discussion of the benefits of joint projects to each agency's customers and stakeholders.
- Decisions on plans, projects, and activities will be made by a joint oversight committee as described in the coordination plan. Conflicts between King County and the City will be resolved in a timely manner by elevating the issues to the joint oversight committee.

5.9.5.3 Opportunities and Conflicts with Other Projects

CSO Basin 107 (East Waterway) will be impacted by the future King County HLKK Project. The proposed HLKK project includes a CSO treatment facility of up to 151-MGD (assuming the use of a ballasted sedimentation treatment process) near the Hanford St Regulator Station and modifications to the Elliott Bay Interceptor to divert wet-weather flows to the CSO treatment facility. The flow diversion may result in decreased CSO control requirements for CSO Basins 107 depending on the final configuration of the HLKK flow diversion from the Elliott

Bay Interceptor to the new CSO plant. The City Consent Decree currently requires that CSO Basin 107 reach construction completion by 2025. Close coordination of the CSO Basin107 project with King County's HLKK project will need to occur to identify the most cost-effective solution and implementation schedule.

5.9.5.4 Central Waterfront and Elliott Bay Seawall Projects

The proposed CSO Basin 069 (Central Waterfront) control measure for all options must be coordinated with the Elliott Bay Seawall (North) Project. The CSO Basin 069 project location will be significantly impacted by the Elliott Bay Seawall (North) project construction which is currently scheduled for 2018 to 2020. The specific construction schedule cannot be finalized until the City obtains funding for the Elliott Bay Seawall (North) project construction. Constructing the CSO Basin 069 project before the Elliott Bay Seawall (North) project would result in additional disruption to the community and significant additional construction costs for the Seawall project to protect the CSO Basin 069 project in place.

5.10 Financial Plan for Recommended Option

5.10.1 Overview

Significant financial investment in CSO control is necessary for the City to comply with regulatory requirements and improve water quality in the City's surrounding receiving waters. This section describes the projected costs for the LTCP from 2015 through 2045 and the associated incremental rate increases that will be necessary to fund the LTCP.

5.10.2 Financial Capability Matrix

A Financial Capability Matrix combines the Residential Indicator (first phase) and Permittee Financial Capability Indicators (second phase) to give an overall assessment of the City's financial capability (Table 5-35). This assessment can be used to help establish an appropriate and reasonable CSO control implementation schedule. Appendix C contains details on the City's financial capability assessment.

Table 5-35. EPA Financial Capability Matrix

Permittee financial capability indicator score	Residential indicator (cost per household as a % of MHI)		
	Low (below 1.0%	Mid-Range (between 1.0% and 2.0%)	High (above 2.0%)
Weak (below 1.5)	Medium burden	High burden	High burden
Mid-range (between 1.5 and 2.5)	Low burden	Medium burden	High burden
strong (above 2.5)	Low burden	Low burden	Medium burden

5.10.3 Baseline Wastewater and Drainage Rates

The monthly baseline rates, not including the costs of the LTCP or Integrated Plan Alternatives, were estimated. The monthly wastewater and drainage rates for the current City Strategic Business Plan were used to estimate the baseline rates from 2015 through 2030. The King County Treatment Wholesale baseline rates also include the King County treatment cost increases provided by King County in June 2013 and the rate impact estimates provided in the King County Executive's Recommended Combined Sewer Overflow Control Plan June 2012. The baseline monthly rates are listed in Table 5-36.

Table 5-36. Baseline Monthly City Wastewater and Drainage Rate Estimate (with Inflation)

Baseline rates	2015	2020	2025	2030
Wastewater [a]	$17.85	$26.84	$35.89	$42.51
Drainage [b]	$29.15	$42.38	$52.65	$58.12
King County treatment wholesale rate [c]	$33.31	$41.42	$39.26	$39.82
Total baseline rate	$80.31	$110.64	$127.80	$140.46

Notes:
[a] The wastewater baseline rate represents the typical residential monthly system rate based on 4.3ccf (100 cubic feet) drinking water consumption per month. All LTCP-related capital costs have been removed.
[b] The drainage baseline rate represents the typical residential monthly rate for the average parcel, which is a residential lot between 5,000-6,999 square feet (Small Residential Tier 3). All LTCP-related capital costs have been removed.
[c] King County charges a wholesale treatment rate to cities and local wastewater districts that send flows to the regional system. The City of Seattle passes through this rate to customers via the treatment component of the sewer rate. This analysis assumes the typical residential monthly bill with drinking water consumption of 4.3ccf.

5.10.4 Project Revenue Requirements and Rate Impacts

5.10.4.1 Assumptions

The assumptions used in this analysis include budget estimates used for the Strategic Business Plan and inflation rates for both capital and non-capital projects. The non-capital projects assume the inflation rate utilized in the Strategic Business Plan through 2020 and then an average for later years. Capital projects utilized the national construction inflation forecast provided by the consulting firm of HIS Global Insight.

King County treatment cost increases assume the most recent forecast (2015 to 2019) provided by King County in June 2013 and the rate impact estimates provided in the King County Executive's Recommended Combined Sewer Overflow Control Plan, June 2012.

5.10.4.2 Projected Rates and Rate Impacts

Based on the planning-level cost estimates and the implementation schedules for each option, the City analyzed how the recommended option may affect monthly City wastewater and drainage rates between 2015 and 2045. Table 5-37 shows the total monthly estimated rates (baseline and including the costs of the recommended option) between 2015 and 2030.

Table 5-37. Monthly Wastewater and Drainage Rates for LTCP Implementation (with Inflation)

Option	2015	2020	2025	2030
Total baseline rate only	$80.31	$110.64	$127.80	$140.46
Recommended shared West Ship Canal Tunnel Option	$81.36	$115.44	$133.15	$145.57

Figure 5-28, Monthly Wastewater and Drainage Rates for Baseline and LTCP Implementation, shows the total monthly rate (Total Baseline Rate and additional LTCP Rates).

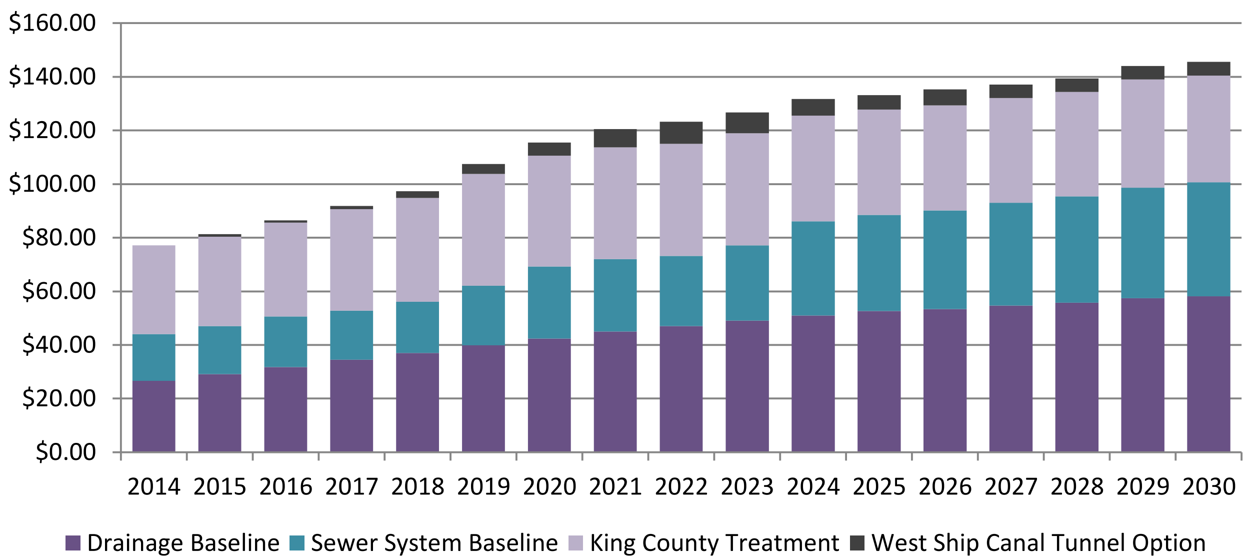

Figure 5-28. Monthly Wastewater and Drainage Rates for Baseline and LTCP Implementation

Given the recommended option, the monthly City wastewater and drainage rates are estimated to increase an additional $5.11 by 2030 as shown in Table 5-37. By comparison, the current baseline City rates without implementing any LTCP projects are estimated to increase by $60.15 during the same period.

5.10.5 Recommended Financial Plan

The estimated costs of the plan will be funded with a combination of additional borrowing and cash funds. The City is recommending funding the LTCP with 75 percent revenue bond funds and 25 percent cash as per the Financial Policies for the Drainage and Wastewater Fund. The line of business maintains a strong rating of Aa/AA with both Moody's and Standard and Poor's rating agencies, and as such, receives favorable interest rates in the bond market. The tax-exempt bonds are backed solely by the revenues of the fund and are typically issued for a term of 30 years. As projected earlier, increases in both the sewer and drainage rates will be used to fund the cost of borrowing and the 25 percent cash contribution.

When available, the City will apply for grant dollars and low-cost loans. These will typically be from the Washington State Revolving Fund or Public Works Trust Fund. However, given the uncertainty regarding availability of grants and loans from these sources, no funds from these sources have been assumed in the rate impact analysis.

5.11 Operation Plan

This section presents the City's general approach to operating the recommended option. The section includes proposed staffing requirements, CSO operating strategies, and system operation coordination with King County.

5.11.1 City and King County Joint Operations and System Optimization Plan

Implementation of the recommended option follows directly from terms of each jurisdiction's Consent Decree which requires coordination of the planning, implementation, and operation of CSO controls within the combined system. The City's Consent Decree includes the following requirement in paragraph 31:

> *No later than March 1, 2016, the City shall submit to EPA and the State for their approval a Joint Operations and System Optimization Plan ("Joint Plan") that the City will work with King County in jointly developing and which satisfies the requirements of Appendix F. This Joint Plan shall be applicable to the City's and King County's respective CSO systems, and (a) be consistent with each entity's operational objectives, (b) ensures the optimal level of coordination and information sharing is maintained, and (c) optimizes system and joint operations.*

During 2014, the City and King County Joint Plan team developed and evaluated operational alternatives in CSO basins where there is the greatest opportunity for operation and system optimization. The second required progress report was submitted to EPA and Ecology in December 2014. The Final Joint Plan to be submitted in March 2016 will include detailed information on the operation of recommended City CSO control measures. For example, the City will design and operate the tunnel in coordination with King County to satisfy the following operating conditions:

- The City CSO facilities will operate within the King County NIRR to protect down-stream King County facilities and ensure regulatory compliance.
- Upgrades to the system, including options analysis and design, to respond to changes in flow from the basins, future regulatory changes, or errors in control volume estimates will be shared in accordance with the cost sharing agreement.
- The design and operation of the tunnel will include grit and debris control to avoid downstream settling and the compromising of system capacity.

Table 5-38 presents an accomplishment matrix summarizing the status and completion date for each of the Joint Plan requirements listed in the Consent Decrees for both agencies.

Table 5-38. Operations and Maintenance Status

Consent Decree item [a]	Status
(a) Overview of those interdependent portions of the King County's regional wastewater, conveyance, and treatment system and the City's wastewater collection system	Completed Q4 2013
(b) Methods to accommodate each agency's operational objectives while complying with their contractual obligations	In progress, anticipated completion date Q4 2015

Table 5-38. Operations and Maintenance Status

Consent Decree item [a]	Status
(c) Shared operational objectives for the King County and the City's combined sewer systems	Completed Q2 2013
(d) Organizational structure	Completed Q3 2013
(e) Modes of operation (dry, wet, transition) for identified CSO facilities	In progress, anticipated completion date Q4 2015
(f) Each agency's operational decision hierarchy	In progress, anticipated completion date Q4 2015
(g) Identified CSO facilities, if any, that may be beneficial to jointly operate and/or monitor	In progress, anticipated completion date Q4 2015
(h) Real-time communication plans/protocols	In progress, anticipated completion date Q4 2015
(i) Emergency and special operations protocols	In progress, anticipated completion date Q4 2015
(j) A process for incorporating the Joint Plan into the design of new capital projects for the combined system, including the King County and City's CSO long-term control plans	In progress, anticipated completion date Q4 2015
(k) A process for updating the Joint Plan every three years	In progress, anticipated completion date Q4 2015

Notes:
[a] Joint Plan components are listed in Appendix D of King County's Consent Decree and in Appendix F of the City's Consent Decree.

5.11.2 Recommended Shared West Ship Canal Tunnel Option Staffing

The City has projected the additional operation and maintenance staffing needed to commission, operate, and maintain the LTCP projects. Specific numbers of full-time equivalent (FTE) employees and staff responsibilities for the recommended option are summarized in Table 5-39 for current (2015), near-term (2020), construction completion (2025), and achievement of controlled status (2030).

The City Operations staff refers to control center operators in the System Operations and System Operations Planning and Analysis (SOPA) sub-groups who will conduct performance monitoring, modeling, post-construction monitoring reporting, facility configuration and control strategies management, and operations data stewardship. Maintenance staff refers to Maintenance sub-group staff who will perform maintenance of the CSO control measure facilities including pump stations, control structures, and CSO storage and conveyance facilities.

Based on the implementation schedules for the recommended option, the first additional LTCP operation and maintenance staff will be required for CSO facility commissioning and acceptance testing by 2020. The total number of additional operations and maintenance staff will be up to 11 FTEs after construction completion in 2025.

Table 5-39. Operations and Maintenance Staffing Needs for Recommended Option

Recommended option	LTCP staffing requirements (FTEs)			
	2015 (current)	2020 (near term)	2025 (construction completion)	2030 (controlled status)
Shared West Ship Canal Tunnel Option				
Operations	0.0	0.5	4.1	4.1
Maintenance	0.0	0.7	6.9	6.9
Total O&M staff	0.0	1.2	11.0	11.0

5.11.3 Maintenance of CSO Control Measures

In general, routine inspection and cleaning activities are established for each asset class and assigned to the appropriate skilled craft as part of the City asset on-boarding process. Conditions are assessed and follow-up activities (such as supplemental cleaning, adjustments, repair, replacement, etc.) are initiated based on internal service-level requirements and industry best practices. Frequency of routine scheduled and event-driven maintenance activities are adjusted according to condition assessment findings and anticipated weather events. The goal is to apply the appropriate, timely, and necessary levels of maintenance that ensure assets perform as designed. Detailed maintenance strategies will be prepared during the LTCP implementation phase for the preventative, corrective, and emergency maintenance procedures.

The City established maintenance procedures for the new Windermere and Genesee CSO storage facilities. These CSO storage facilities are scheduled for startup and commissioning in 2015 and the City maintenance experience will be used to update the procedures for the following CSO facilities:

- Storage pipes and tanks
- Pump systems
- Conveyance pipelines
- Gates, valves, and weirs
- Odor control systems
- SCADA systems
- Automated wash down systems

5.11.4 Facilities and Grounds Operation of CSO Control Measures

Master operating strategies are intended to define protocols for optimizing the operation of multiple CSO facilities Operating strategies presented in this plan are presented in general planning-level detail. Project specific operating strategies will be prepared during the LTCP implementation phase.

Storage will be provided through new in-line storage pipelines, off-line storage tanks, or an off-line deep tunnel storage facility. Existing CSO storage facilities also may need to be used to achieve the CSO performance standard. The general CSO master system operating approach is to provide sufficient real-time flow monitoring for each CSO facility to determine the influent flows, CSO facility performance, CSO overflow, and CSO storage release flows back into the City or King County interceptor system. General operating strategies will be developed for operation between, during, and after CSO events:

- Inter-CSO events occur between CSO storage events. During these periods, operating procedures such as weather forecasting, operational preparation, and control revisions can be performed to prepare the CSO facility for an upcoming CSO storage event.
- During-CSO events are the actual storage events when a storm occurs and the CSO facility receives CSO flows for storage. During these events, operating procedures for flow monitoring, equipment monitoring, CSO storage, and pumping control will be required.
- Post-CSO events include the release of the stored CSO flows into the King County interceptor system. Detailed flow monitoring will be required to not exceed the King County NIRR for each City CSO control facility to minimize downstream impacts to the King County interceptor and West Point WWTP.

5.11.4.1 Automation and SCADA

All LTCP projects will be monitored in real time using the City SCADA system, and each project will be operated by on-site Programmable Automation Controllers. PACs will be programmed to operate gates, pumps, and other mechanical devices. The City Control Center operators will have 24/7 real-time remote access via the SCADA system to monitor and, if needed under unusual circumstances, to override the local PAC control.

5.11.4.2 Monitoring

Each LTCP project will have real-time monitoring instrumentation to monitor levels, mechanical devices, and flows. Data will be available through the City SCADA system in real time to the Control Center and in near real time to other users of the data.

5.11.4.3 Storage Control Strategy

The LTCP projects will generally use automated sluice gates or valves to constrict flow and direct it into storage. Automated control of these devices can be overridden if necessary by a local or remote operator. Flows will be released from storage either by opening flow control gates or valves or by pumping from the storage facility back into the conveyance system.

The City CSO facilities will operate within the King County NIRR to protect down-stream King County facilities and ensure regulatory compliance. Generally, storage flow release will be controlled by the PAC and will take place when monitoring equipment indicates that there is available capacity in the downstream system. Downstream conditions that are assessed in real time may be restricted to just the immediate project vicinity or may include City and King County facilities farther downstream or in nearby basins.

5.11.4.4 Storage Performance Monitoring

Continuous evaluation of the CSO system and each LTCP project will be performed by the City SOPA group. All operational and metrological data is gathered by the SOPA group, and CSO control performance will be closely evaluated after significant CSO and storm events.

Downstream hydraulic limitations resulting from King County interceptor and treatment plant capacity will impact City CSO storage operations and need to be evaluated as part of the overall City operating strategy.

Figure 5-29. Illustrates how the recommended Shared West Ship Canal Tunnel will operate. The tunnel is a 15.24 MG storage facility that will release its stored flows into the King County North Interceptor. King County has provided NIRR for the tunnel effluent pumping to avoid impacting the downstream King County North Interceptor.

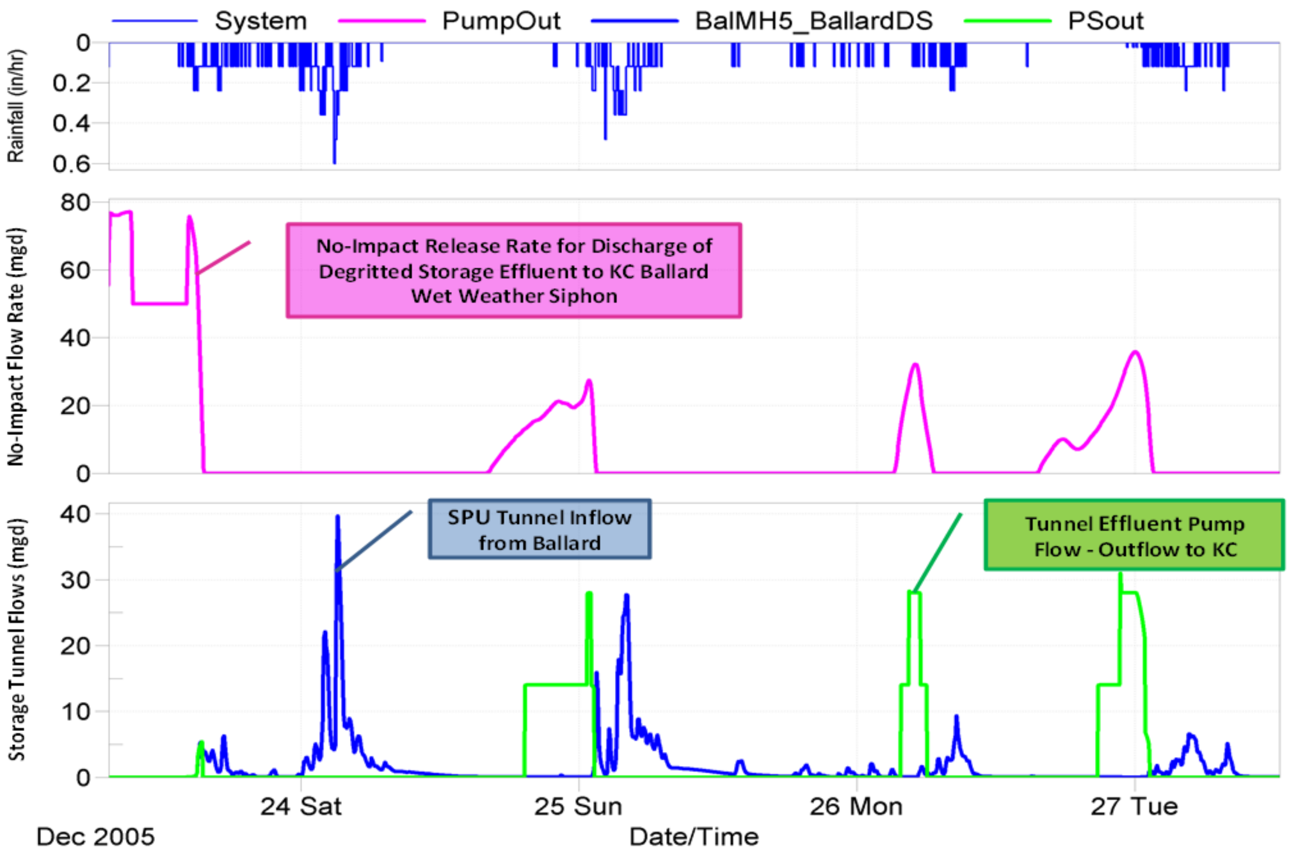

Figure 5-29. Example of Shared West Ship Canal Tunnel Storage Operation During CSO Event

As the rainfall increases (top row, blue column), CSO flows will increase in both the King County and City sewer systems. To prevent CSOs, rain-induced CSO flows (bottom row, blue line) will be diverted into the proposed tunnel to prevent overflows. As rainfall subsides and interceptor capacity is available, stored CSO flows can be released (bottom row. green line) back into the sewer system.

However, since all City stored flows will be released into the King County interceptor system, the King County interceptor and treatment plant capacity are major factors in how the City CSO facilities operate and when the City CSO facilities can release stored CSO flows. This limitation is called the NIRR (middle row, pink line).

The proposed facility will need to release stored CSO flows multiple times during a prolonged CSO event such as the example storm shown. Sufficient flow monitoring and real-time control systems must be provided to determine when and how much CSO flows need to diverted into storage and when the stored flows can be released to the King County interceptor system.

5.12 Measures of Success

The measure of success for the City CSO program will be the successful construction and operation of the recommended LTCP projects by the required critical milestone dates and demonstration, through post-construction monitoring, that the CSO control status is in accordance with the Consent Decree.

5.12.1 Overview

The EPA *Combined Sewer Overflows Guidance for Long-Term Control Plan, 1995* recommends in *Section 1.6.8, Measures of Success*, that

> *As municipalities, NPDES permitting authorities, and the public embark on a coordinated effort to address CSOs, serious consideration should be given to "measures of success." For purposes of this discussion, measures of success are objective, measurable, and quantifiable indicators that illustrate trends and results over time. Measures of success generally fall into four categories:*
>
> 1. *Administrative measures that track programmatic activities;*
> 2. *End-of-pipe measures that show trends in the discharge of CSS flows to the receiving water body, such as reduction of pollutant loadings, the frequency of CSOs, and the duration of CSOs;*
> 3. *Receiving water body measures that show trends of the conditions in the water body to which the CSO occurs, such as trends in dissolved oxygen levels and sediment oxygen demand; and*
> 4. *Ecological, human health, and use measures that show trends in conditions relating to the use of the water body, its effect on the health of the population that uses the water body, and the health of the organisms that reside in the water body, including beach closures, attainment of designated uses, habitat improvements, and fish consumption advisories. Such measures would be coordinated on a watershed basis as appropriate.*

The Consent Decree also states that the performance criteria is the 20-year moving average, which is defined in Section IV. Definitions, paragraph (ee):

> *(ee). "Twenty Year Moving Average" shall mean the average number of untreated discharge events per CSO Outfall over a twenty year period for purposes of compliance with WAC 173-245-020(22). For previously Controlled CSO Outfalls and where monitoring records exist for the past 20 consecutive years, the twenty year moving average shall mean the average number of untreated discharges per CSO Outfall over the 20 year record. On an annual basis, the twenty year moving average will be calculated and includes the current monitored year and each of the previous 19 years of monitored CSO data. For CSO reduction projects and Controlled CSO Outfalls where a complete twenty year record of monitored data does not exist, missing annual CSO frequency data will be generated based on the predicted CSO frequency for a given year as established in the approved engineering report or facility plan. For each CSO reduction project, the engineering report or facility plan shall predict the CSO frequency for each CSO Outfall (s) based on long-term simulation modeling using a 20-year period of historical rainfall data, the hydraulic model,*

the CSO control project design and assuming the CSO control project existed throughout the 20-year period. For CSO reduction projects, the level of control is the number of discharge events per CSO Outfall per year that are estimated to occur based on the designed CSO control project over a 20-year period. The level of control will be estimated for each year for a period of 20 years in the engineering report or facility plan. For the time period between the approval of the engineering report and the CSO reduction project's Construction Completion date, the City shall use the same model for the approved design along with the corresponding rainfall data for this period of time to derive CSO frequencies. This information will be submitted as an amendment to the engineering report or facility plan. For CSO reduction projects, the 20-year moving average will use the approved level of control, on an annual basis, for each of the preceding years for which monitored data does not exist in conjunction with monitored data after the CSO control project has been constructed.

5.12.2 Post-Construction Monitoring Program

The Consent Decree outlines the requirements of a post-construction monitoring program. The Consent Decree outlines three key components of the post-construction monitoring program, as summarized below:

- Achieving Controlled Status: The Consent Decree stipulates that "one year following Construction Completion of each CSO control measure, the City shall document that the associated CSO Outfall has been controlled." In order to determine whether a CSO outfall has achieved controlled status, each completed CSO control measure will undergo post-project performance monitoring. This term, which is not contained in the Consent Decree, is used to describe the flow monitoring, modelling, and analysis that must be conducted by the City in order to determine whether a CSO outfall has achieved controlled status. In general, post-project performance monitoring consists of the following steps:
    - Monitoring flows of the constructed CSO control measure to obtain actual operating and CSO frequency information
    - Revising the approved hydraulic model to incorporate the as-constructed CSO control measure project
    - Calibrating the as-constructed model with actual performance and flow data
    - Calculating the moving 20-year average annual overflow frequency analysis using a combination of flow monitoring data supplemented with computer simulations that assume the constructed CSO control measure has been in operation for 20 years.

The control measure must meet a performance standard of no more than one untreated discharge per CSO outfall per year on a 20-year moving average. The results of each control project's post-project performance monitoring will be included in the following year's annual report submitted to EPA and Ecology in compliance with the consent decree and the NPDES permit.

- Implement the Post-Construction Monitoring Plan (PCMP): As described in the Consent Decree, the City is required to "implement the Post-Construction Monitoring Plan… as conditionally approved by the State… by developing and implementing Quality Assurance Project Plans for each CSO control measure, in accordance with the schedule identified in the LTCP." The purpose of the PCMP is to demonstrate achievement and compliance with the State's water quality standard. This will include the development of sediment sampling and analysis plans for each of the 14 representative outfalls identified in the conditionally approved PCMP. The PCMP was submitted as a separate document for approval on May 29, 2015.

- Submit the PCMP report: As described in the consent decree, the City is required to submit a PCMP report within 120 days after complete implementation of the PCMP.

  The PCMP report will:

  - Summarize the data collected pursuant to the PCMP
  - Analyze whether the completed CSO control measures have met and continue to meet the design criteria and performance criteria specified in the LTCP
  - Show that the City's operation of its CSS complies with the CSO control policy, the CWA and its implementing regulations, all applicable state law and regulations, and the City's NPDES permit.

EPA and Ecology approval of the PCMP report will confirm that the CSO control measure has satisfied the consent decree requirements for post-construction monitoring.

In summary, the City's PCMP consists of two primary components, as summarized in Table 5-40 below.

Table 5-40. Summary of the Post-Construction Monitoring Program

Component	Description/purpose	Applicable deadlines
Post-project performance monitoring	Determine whether an uncontrolled CSO outfall has been brought into control due to the construction of CSO control measures. This program is implemented on a project-by-project basis.	Achieve controlled status one year following construction completion.
Post-project construction monitoring	Demonstrate achievement/compliance with the State's water quality standard. This program is implemented at 14 surrogate outfalls: 013, 018, 028, 047, 063, 068, 071, 095, 099, 111, 147, 151, 169, and 174.	Complete post-construction monitoring for all CSO outfalls except 071, 099, 111, 147, 174, and 151 by December 31, 2028, and the report by December 31, 2029. Complete post-construction monitoring of CSO Outfalls 071, 099, 111, 147, 174, and 151 by December 31, 2035, and the report by April 30, 2036.

5.12.3 City/King County Monitoring and Modeling Memorandum of Agreement

The City and King County have developed flow monitoring and modeling requirements for the purpose of quantifying how much impact, if any, the completed CSO control measures have on downstream King County facilities. In general, these requirements include several years of pre-construction flow monitoring to establish baseline conditions followed by a minimum of five years of post-construction flow monitoring. This data is then used to determine what payments the City will be required to make to King County for increased capital and operational expenses at downstream locations.

These requirements will be finalized with the approval by each agency of the term and detail sheets for each shared project.

5.12.4 Coordination with Other Programs

The Joint Operations Plan is discussed in Section 5.11, Operation Plan. In conformance with the Consent Decree, the final Joint Plan will be issued March 1, 2016.

5.12.5 Data Evaluation and CSO Performance Report

The City is required under its NPDES permit to submit an annual report to Ecology for review and approval by March 30 of each year. The annual report must cover the previous calendar year and report the frequency and volume of all CSO overflows and determine the control status for all permitted CSO outfalls.

The City is also required under the Consent Decree to submit an annual report to EPA and Ecology until the Consent Decree terminates. The first Consent Decree annual report was submitted to EPA and Ecology in October 2013. The second Consent Decree annual report was combined with the annual NPDES permit report and submitted in March 2014. Each subsequent annual Consent Decree report will be submitted by March 30 of the following year as a combined report with the Annual Report.

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