2012 CSO Control Program Review Report

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King County

Department of Natural Resources and Parks

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Acronyms

AACE	Association for the Advancement of Cost Engineering
AKART	all known available and reasonable technologies
AWWF	average wet-weather flow
BAT	best available technology economically achievable
BCT	best conventional pollutant control technology
BMP	best management practice
BOD	biochemical oxygen demand
CATAD	computer augmented treatment and disposal
CEPT	chemically enhanced primary treatment
CERCLA	Comprehensive Environmental Response, Compensation and Liability Act
CIP	Capital Improvement Program
City	City of Seattle
County	King County
CSL	Cleanup Screening Level
CSO	combined sewer overflow
CSOCP	combined sewer overflow control policies
CSS	combined sewer system
CWA	Clean Water Act
DDT	dichlorodiphenyltrichloroethane
DO	dissolved oxygen
DNR	Washington State Department of Natural Resources
DSN	Discharge Serial Number
EBDRP	Elliott Bay/Duwamish Restoration Program
EBI	Elliott Bay Interceptor
Ecology	Washington State Department of Ecology
EPA	U.S. Environmental Protection Agency
ESA	Endangered Species Act
FOG	fats, oil, and grease
gpad	gallons per acre-day
gpd	gallons per day
GIS	Geographic Information Systems
GSI	green stormwater infrastructure
HPA	Hydraulic Permit Approval
I/I	infiltration and inflow
LDW	Lower Duwamish Waterway
LTA	long-term-average
LTCP	long-term control plan
Metro	Municipality of Metropolitan Seattle
MG	million gallons
MGD	million gallons per day
MHI	median household income
MTCA	Model Toxics Control Act
NEPA	National Environmental Policy Act
NOAA	National Oceanic and Atmospheric Administration
NPDES	National Pollutant Discharge Elimination System
NSA	Northern Service Area
O&M	operations and maintenance
ORP	oxygen reduction potential
PAHs	polycyclic aromatic hydrocarbons
PBDEs	polybrominated diphenyl ethers

PCBs	polychlorinated biphenyls
PCEP	Puget Sound Estuary Program
PFD	Public Facilities District
PLCs	programmable logic controllers
PSRC	Puget Sound Regional Council
QA/QC	quality assurance/quality control
RCE	Residential Customer Equivalent
RCW	Revised Code of Washington
RI/FS	remedial investigation and feasibility study
RWQC	Regional Water Quality Committee
RWSP	Regional Wastewater Services Plan
SACE	Seattle Area Combined Sewer Overflow Evaluator
SACRO	Seattle Area Central Routing Organization
SAP	sampling and analysis plan
SCADA	Supervisory Control and Data Acquisition
SD	storm drain
SDOT	Seattle Department of Transportation
SEPA	State Environmental Policy Act
SMP	Sediment Management Program
SMS	Sediment Management Standards
SPU	Seattle Public Utilities
SQGs	Sediment Quality Guidelines
SQS	sediment quality standards
SR	State Route
SSA	Southern Service Area
SSACRO	South Seattle Area Control Routing Organization
TBL	triple bottom line
TBT	tributyl tin
TM	Technical Memorandum
TMDL	Total Maximum Daily Load
TOC	total organic carbon
TPP	Treatment Plant Policy
TSS	total suspended solids
USFWS	United States Fish and Wildlife Service
WAC	Washington Administration Code
WQA	water quality assessment
WQS	Water Quality Standards
WRIA	Water Resource Inventory Area
WSDOT	Washington State Department of Transportation
WTD	Wastewater Treatment Division
WWSP	wastewater services policies

Executive Summary

This 2012 Combined Sewer Overflow (CSO) Control Program Review Report is a companion to the King County Executive's Recommended CSO Control Plan. This report documents the County's review of its CSO Control Program, which was conducted in accordance with policies and guidelines in the 1999 Regional Wastewater Services Plan (RWSP). It is supported by technical memorandums that can be found at http://www.kingcounty.gov/environment/wastewater/CSO/ProgramReview/plan.aspx#techmemos.

These reports, the supporting technical memorandums, and legislation are being transmitted on June 15, 2012 from the King County Executive to the King County Council for adoption of the recommended amendments to the County's Long-term CSO Control Plan (Plan). The County's Plan was last amended in 1999. Adoption is anticipated by fall of 2012. This transmittal and adoption of the King County Executive's Recommended CSO Control Plan, which includes a 2030 Plan completion date, are intended to meet the requirements of a 2011 Washington State Department of Ecology (Ecology) administrative order.

Report Purpose

King County issues CSO Control Program reviews and updates or amendments to the County's Long-term CSO Control Plan (Plan) approximately every five years to support county decision-making and renewal of the National Pollutant Discharge Elimination System (NPDES) permit for the West Point Treatment Plant. Adopted changes to the County's Plan will be incorporated into the 2012 Long-term CSO Control Plan Amendment to be submitted to Ecology and the United States Environmental Protection Agency (EPA) in fall of 2012. This process is presented in Figure ES-1. This 2012 CSO Control Program Review Report documents the County's most recent review of its CSO Control Program.

Figure ES-1. King County 2012 Long-term CSO Control Plan Amendment Process

Background

CSOs are untreated discharges of wastewater and stormwater into water bodies during heavy rainfall 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 the need for large wastewater facilities and in challenges to the treatment process. To avoid sewer backups into homes, businesses, and streets during heavy rainfall events, combined sewers in the City of Seattle sometimes overflow into Puget Sound, the Duwamish Waterway, Elliott Bay, Lake Union, the Lake Washington Ship Canal, and Lake Washington. Within the King County wastewater service area, CSOs only exist within the City of Seattle. Based on agreements made at the start of the regional system in 1958, both the County and City of Seattle are responsible for CSOs and are working to control them under long-term CSO control plans. Figure ES-2 shows the locations of the County's and City of Seattle's CSOs.

Although the wastewater in CSOs is greatly diluted by stormwater, CSOs may be harmful to public health and aquatic life because they can carry chemicals and disease-causing pathogens. CSO control protects public health and the environment by accomplishing the following:

- Reducing the potential for contact with pathogens and consumption of contaminated fish
- Reducing the potential for chemical exposure to salmon at their most vulnerable life stage
- Contributing to efforts to restore and protect Puget Sound
- Helping to meet the Duwamish Waterway long-term cleanup goals by reducing the volume of CSOs.

Figure ES-2. King County and City of Seattle CSO Locations

The County's Long-term CSO Control Plan (Plan), implemented through the County's CSO Control Program, outlines measures for controlling CSO discharges to surface waters, including controlling pollution at its sources, optimizing flow management, monitoring and modeling flows in the system, and constructing CSO control facilities. The Plan was last amended in 1999 (1999 Plan Amendment) as a component of the County's RWSP. The 1999 Plan Amendment outlines measures for controlling CSOs to comply with federal and state water quality requirements. Ecology requires control of each CSO such that an average of one untreated discharge may occur per year. CSO sites that meet this requirement are classified as "controlled." Those that do not are called "uncontrolled" CSO sites.

Construction of CSO control facilities in the region began in the late 1970s. Thus far, approximately $389 million has been spent to reduce untreated wastewater and CSO volumes from over 2 billion gallons per year in 1980 to 800 million gallons per year (see Figure ES-3).

Today, 16 of the County's 38 CSO sites are controlled to Ecology's standard; 14 CSO sites remain uncontrolled and are the subject of this review. In addition, the County currently has five CSO control projects underway, and three CSO sites are being refined and adjusted to meet the control standard.

Uncontrolled King County CSO Sites

The 14 uncontrolled CSO sites discharge CSOs to Elliott Bay, the Duwamish River (Lower, East, and West Waterways), and the Lake Washington Ship Canal (including the Montlake Cut).

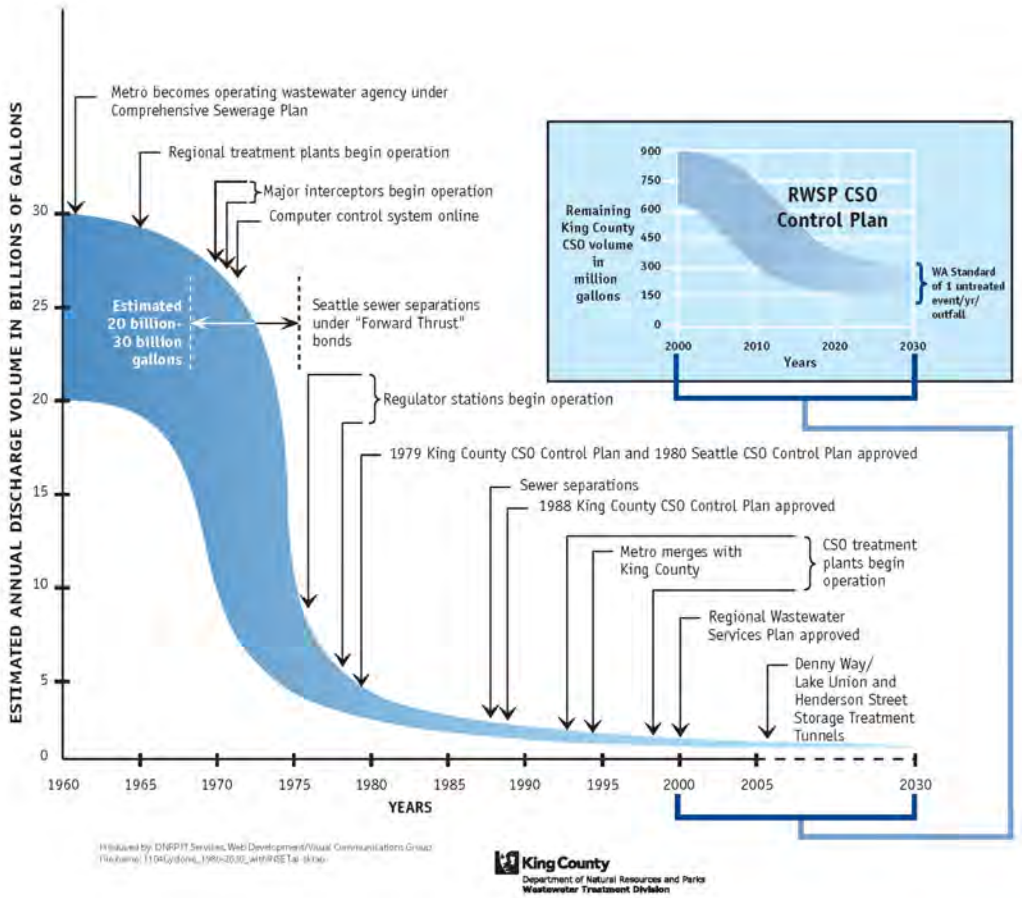

Figure ES-3. Historical Reduction in Volumes Since Construction of the Regional System (1958-79) and CSO Control (1979-Present)

These CSO sites were grouped into areas for evaluation (see Figure ES-4), so that alternatives[3] could be combined to provide control of all uncontrolled CSO sites in a given area:

- Ship Canal – 11th Ave NW, 3rd Ave W, University, and Montlake
- Middle Elliott Bay Interceptor (EBI) – Hanford #2, Lander St, Kingdome, and King St
- Middle EBI – Hanford #1
- South EBI – S Michigan St and Brandon St
- West Duwamish – W Michigan St and Terminal 115
- West Duwamish – Chelan Ave

[3] "Alternative" refers to a planning-level project concept.

Figure ES-4. King County CSO Site and Program Review Areas

CSO Control Program Review Approach

To conduct this most recent review, King County staff gathered and assessed information generated since adoption of the 1999 Plan Amendment. This review identified CSO control alternatives for each of the County's 14 uncontrolled CSO sites and developed an implementation schedule and rate/capacity charge analysis for the recommended preferred alternatives. This review also identified conditions and actions to optimize CSO control facilities that have already been built but for which adjustments are still needed to achieve full control.

This review considered changes in conditions that could impact the type, size, location, sequence, or schedule for the 1999 Plan Amendment adopted alternatives. Changes considered include regulatory and policy changes, new technologies, existing CSO control performance, human and environmental health priorities, hydraulic modeling of the County's combined sewer system, green stormwater infrastructure (GSI) opportunities, site availability, public opinion, and coordination with the City of Seattle and other agencies.

Alternative Evaluation Methodology

The following methodology was used in this review to update the CSO control recommendations from the 1999 Plan Amendment for the 14 uncontrolled CSO sites:

- An initial assessment identified CSO control approaches that are feasible for each uncontrolled CSO site. These are described in Chapter 5 of this report and Technical Memorandum 970, CSO Control Alternatives Development.
- A set of preliminary alternatives was developed from two sources:
  - The 1999 Plan Amendment adopted alternatives
  - New project alternatives developed by using the identified feasible CSO control approaches, new modeling results, changes in available siting, newly identified potential for GSI approaches, or newly identified potential for coordination with the City of Seattle.
- New joint project alternatives were developed and evaluated that would control both King County and City of Seattle CSO discharges where project costs and community impacts might be reduced.
- The preliminary alternatives were screened based on technical considerations, relative cost-effectiveness, community and public health, environmental impacts, land use and permitting, and operation and maintenance implications.

- Preliminary alternatives that were not screened out were further developed into final alternatives by refining the cost, size, and location of the alternatives. A triple-bottom-line analysis[4] of the final alternatives was performed to identify recommended preferred alternatives.
- GSI (or green) alternatives were developed and evaluated in parallel with final conveyance, storage, or treatment alternatives (also referred to as gray alternatives) for uncontrolled CSO basins with potential for GSI retrofit. Runoff volume reduction benefits and planning-level life-cycle costs were estimated. The GSI alternatives deemed cost-effective were identified with the recommended preferred alternatives. The sizes of the gray alternatives were conservatively not reduced to account for the GSI benefit in this review. Future evaluations, including enhanced monitoring and modeling, will quantify and then verify the benefit of GSI techniques prior to gray facility sizing.
- Recommended preferred alternatives were carried forward into the sequence and rate/capacity charge analysis.

Recommended Preferred Alternatives

Table ES-1 presents the recommended preferred alternatives for controlling King County's remaining 14 uncontrolled CSO sites and estimated project cost. Potential GSI alternatives are also described in this table; however, the potential reduction in CSO control volume or CSO peak flow rate that could be achieved by implementing GSI in the CSO basin is not reflected in the costs or sizes of the proposed traditional CSO control facilities (gray facilities). It is anticipated that GSI costs will replace or reduce costs in these estimates. The $711-million-cost projection for the recommended Plan is based on project costs at a planning level of detail[5]. As projects are designed, the costs of the project will be better understood. The general cost of construction will also vary over time depending on conditions at the time projects are bid; however, the County will diligently seek cost efficiencies.

Schedule, Rate Forecasting, and Affordability

This review included an evaluation of project sequence alternatives for implementing the recommended preferred alternatives, as well as schedules with three completion dates (2030, 2035, and 2040). Rate analysis indicated that the sewer rates did not differentiate between alternatives. The project sequence alternatives were then evaluated against the schedule drivers: the ability to complete GSI effectiveness monitoring, prioritizing Duwamish area projects to

[4] A triple-bottom-line analysis evaluates environmental and social, in addition to financial metrics. This analysis is described in this report and Technical Memorandum 970, CSO Control Alternatives Development.

[5] The design status of the alternatives in the recommended Plan is such that the cost estimates are Association for the Advancement of Cost Engineering (AACE) Class 5 estimates. The accuracy range for Class 5 estimates is –50 percent to +100 percent. See Technical Memorandum 620, Cost Estimating Methodology for CSO Control Facilities for details.

coordinate with the river cleanup, and coordination with City of Seattle schedules and other agencies' projects. As a result, a hybrid project sequence was developed and recommended that prioritizes the Duwamish coordination and GSI implementation. The WTD-recommended project sequence is presented in Chapter 7 of this report and Technical Memorandum 1100, Project Sequence.

A rate impact analysis compared schedules for completing the 2011 WTD Recommended CSO Control Plan of 2030, 2035, and 2040, and a No Action Alternative, which assumes no future control projects beyond projects now underway (Puget Sound Beach projects plus the CSO control component of the Ballard Siphon Replacement project.) The rate impact analysis indicated that all the alternative schedules for completing the Plan result in approximately the same level of rate increase, with the extended schedules ending slightly higher than the 2030 schedule but having a slower rate of increase in the earlier years of the schedule. These differences were not considered sufficient reason to change the 2030 completion date. Continuation of the 2030 schedule, as adopted in the 1999 Plan Amendment, was recommended. Under the 2030 schedule, the monthly sewer rate impacts will increase by $7.61 per month (estimated with inflation) due to implementing the Plan by 2030.

To have a better understanding of the impact of implementing the recommended Plan, the County conducted a two-phased analysis of financial capability and affordability. Phase 1 strictly followed guidelines established by EPA, and Phase 2 followed EPA guidelines but included supplemental information to better understand the regional diversity of households. More detail about the financial capability and affordability analysis is provided in Chapter 8.

As highlighted over the past several years, downturns in the economy can happen quickly. Indicators used in the financial capability and affordability analysis, such as median household income and poverty, have all been adversely affected over the past three to five years. The County needs to track these indicators to regularly evaluate the financial capability to implement the recommended Plan and the ability of the ratepayers to pay for the Plan over time.

As part of the required CSO control program reviews completed ahead of the NPDES updates of the Plan, which occur approximately every 5 years, the County will reevaluate the affordability indicators and routinely evaluate financial capability and affordability of the Plan. This will insure that there is a discussion of the ratepayers' ability to pay for the Plan and that the County does not overburden its own finances or those of the community it serves.

Public Review and the King County Executive's Recommended CSO Control Plan

The 2011 WTD Recommended CSO Control Plan was released for public comment in October 2011. Copies of the formal comment letters are presented in Appendix F of this report. Based on input received, including concerns raised by some members of the public about whether dollars spent on CSO control is the best investment in water quality, the King County Executive recommends the following:

- Moving forward with nine CSO control projects to control the remaining 14 uncontrolled CSO sites by 2030. Their estimated project cost is $711 million (2010 dollars). The nine projects are the same as those described in the 2011 WTD Recommended CSO Control Plan.
- Conducting a water quality assessment and monitoring study (study) to inform the next CSO control program review for the 2019 NPDES permit renewal. The Executive believes it is prudent to meet the County's CSO control commitments and also commit resources into completing a comprehensive review of the effects on water quality in the sub-watersheds where CSO discharges occur. Study results could confirm or propose adjustments to the County's Long-term CSO Control Plan to meet water quality standards and ensure that actions by the County and other entities improve water quality, health, and biological outcomes that are well integrated and sequenced to provide the greatest benefit in each CSO discharge watershed. Ecology and EPA will need to review and approve any changes to the Plan that result from the study recommendations.
- Implementing the first projects in the Plan—Hanford #1 and S Michigan St/Brandon St—now. However, the next two projects—3rd Ave W and Chelan Ave—will start in 2017, two years later than stated in the 2011 WTD Recommended CSO Control Plan, to enable study findings and recommendations to confirm or adjust control priorities. Unless changes are recommended in the next Program Review, the CSO control projects recommended in the Plan will be completed by 2030. The Plan continues the commitment to implement Lower Duwamish Waterway projects in coordination with river cleanup, to implement GSI in four CSO basins, and to pursue three joint projects with the City of Seattle. Figure ES-5 shows the sequence and schedule of recommended projects as adjusted to accommodate the water quality assessment and monitoring study.

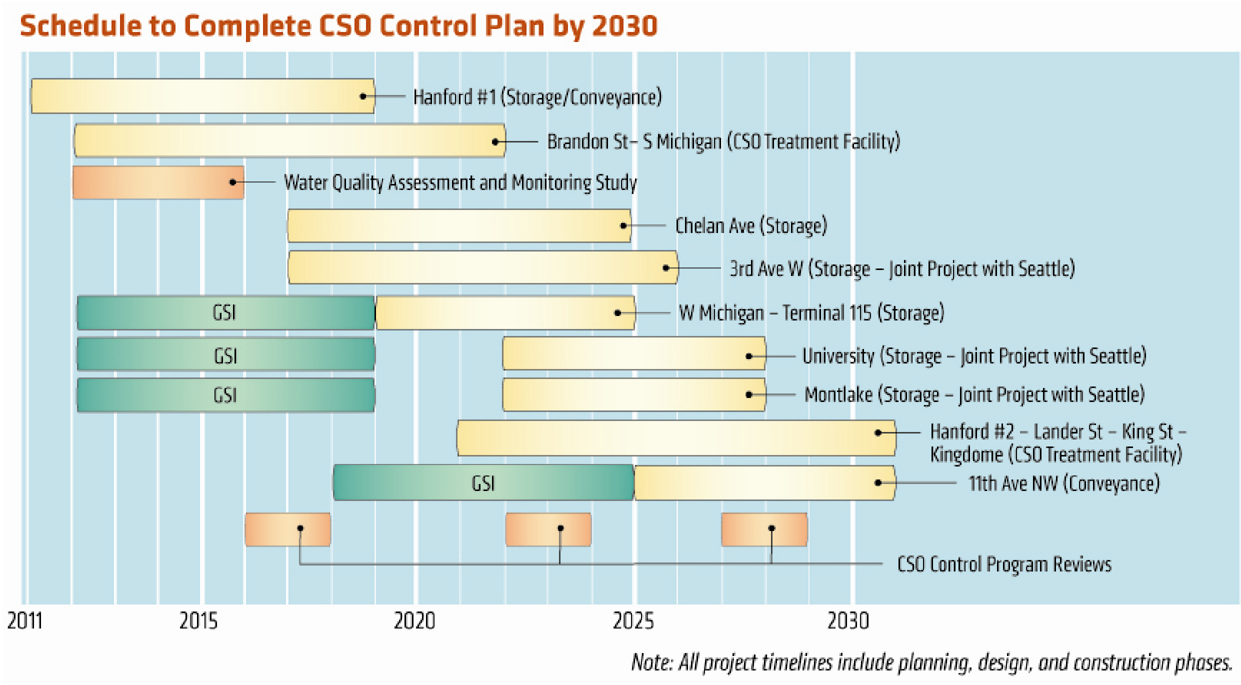

Figure ES-5. Project Sequence and Schedule in King County Executive's Recommended CSO Control Plan

King County Council Review and Long-term CSO Control Plan Amendment Adoption

This 2012 CSO Control Program Review Report and the King County Executive's Recommended CSO Control Plan are being submitted to the King County Council and the public in June 2012. It is expected that the Council will refer the Plan to the Regional Water Quality Committee (RWQC) for initial review and deliberations. The public will be able to comment and provide testimony on the Plan as part of the King County Council's deliberations. Information on how to provide input will be available on the CSO Control Program website at: http://www.kingcounty.gov/csoreview.

The RWQC may recommend changes to the Plan and CSO control policies. The amended Plan is expected to be adopted by the King County Council in fall of 2012. After the King County Council adopts the amended Plan, the County's 2012 Long-term CSO Control Plan Amendment will be finalized and submitted to Ecology and EPA in the fall of 2012. Implementation of projects contained in the adopted Plan will begin immediately.

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Table ES-1. King County Executive's Recommended CSO Control Plan

CSO Control Project and Discharge Serial Number (DSN)[a]	CSO Control Measure(s)	Description	Design Criteria	Performance Criteria in a Typical Year	Critical Milestones[b,c]	Estimated Project Cost in 2010 Million Dollars[d]
2012 King County Executive's Recommended Projects to Control the County's Remaining 14 Uncontrolled CSO Sites						
Duwamish Waterway						
Hanford #1 (DSN 031)	Increased conveyance and storage tank	Increased conveyance to the Bayview Tunnel and storage tank near Rainier Avenue	Up to 0.34 MG of peak CSO storage with conveyance	Reduce to one untreated overflow event per year on a 20-year moving average	Facilities Plan Complete: 2014. Completion of Bidding: 2016. Construction Completion: 2019.	$19.2
Brandon St/ S Michigan St (DSN 041/DSN 039)	CSO treatment	High rate clarification treatment to control CSOs along the East Waterway	Up to 66 MGD of peak CSO treatment and new conveyance system	Treat peak CSOs to state standard of 50-percent total suspended solids (TSS) removal and disinfection; meet state water quality standards.	Facilities Plan Complete: 2015. Completion of Bidding: 2017. Construction Completion: 2022.	$139.7
W Michigan St/ Terminal 115 (DSN 042/DSN 038)	Storage pipe	Storage pipe along West Marginal Way and green stormwater infrastructure (GSI)	Up to 0.32 MG of peak CSO storage. Mitigate up to 24-percent of the impervious area with RainWise and green streets.	Reduce to one untreated overflow event per year on a 20-year moving average	Facilities Plan Complete: 2020. Completion of Bidding: 2022. Construction Completion: 2025.	$14.8[f]
Chelan Ave (DSN 036)	Storage tank	Storage tank near West Duwamish Waterway	Up to 3.85 MG of peak CSO storage on West Duwamish Waterway near Chelan Avenue	Reduce to one untreated overflow event per year on a 20-year moving average	Facilities Plan Complete: 2018. Completion of Bidding: 2020. Construction Completion: 2023.	$51.7
Hanford #2/ Lander St/King St/ Kingdome (DSN 032/DSN 030/DSN 028/ DSN 029)	CSO treatment	High rate clarification treatment facility in South Seattle neighborhood	Up to 151 MGD of peak CSO treatment and modifications to existing conveyance system	Treat peak CSOs to state standard of 50-percent TSS removal and disinfection; meet state water quality standards.	Facilities Plan Complete: 2024. Completion of Bidding: 2026. Construction Completion: 2030.	$270.8

Table ES-1. King County Executive's Recommended CSO Control Plan

CSO Control Project and Discharge Serial Number (DSN)[a]	CSO Control Measure(s)	Description	Design Criteria	Performance Criteria in a Typical Year	Critical Milestones[b,c]	Estimated Project Cost in 2010 Million Dollars[d]
Ship Canal						
3rd Ave W (DSN 008)	Joint city-county storage tank[e] OR *Independent county storage tank*	Storage tank on north side of Ship Canal OR *Storage tank near Seattle Pacific University ($56.4 million)*	Up to 7.23 MG of peak CSO storage OR *Up to 4.18 MG of peak CSO storage*	Reduce to one untreated overflow event per year on a 20-year moving average at one county CSO site and multiple city CSO sites	Facilities Plan Complete: 2018. Completion of Bidding: 2020. Construction Completion: 2023.	$50.3
University (DSN 015)	Joint city-county storage tank[e] OR *Independent county storage tank*	Storage tank near University of Washington campus and GSI OR *Storage tank near University of Washington Campus and GSI ($54.5 million)*	Up to 7.87 MG of peak CSO storage OR *Up to 2.94 MG of peak CSO storage* ______________ Mitigate up to 24-percent of impervious area with RainWise and green streets.	Reduce to one untreated overflow event per year on a 20-year moving average at one county CSO site and multiple city CSO sites	Facilities Plan Complete: 2023. Completion of Bidding: 2025. Construction Completion: 2028.	$45.2[f]

Table ES-1. King County Executive's Recommended CSO Control Plan

CSO Control Project and Discharge Serial Number (DSN)[a]	CSO Control Measure(s)	Description	Design Criteria	Performance Criteria in a Typical Year	Critical Milestones[b,c]	Estimated Project Cost in 2010 Million Dollars[d]
Montlake (DSN 014)	Joint city-county storage tank[e] OR *Independent county storage tank*	Storage tank on south side of Montlake Cut and GSI OR *Storage tank on south side of Montlake Cut and GSI ($102.8 million)*	Up to 7.87 MG of peak CSO storage OR *Up to 6.6 MG of peak CSO storage* ______________ Mitigate up to 19-percent of impervious area with RainWise and green streets	Reduce to one untreated overflow event per year on a 20-year moving average at one county CSO site and multiple city CSO sites	Facilities Plan Complete: 2023. Completion of Bidding: 2025. Construction Completion: 2028.	$95.4[f]
11th Ave NW (DSN 004)	Increased conveyance	Increased conveyance to Ballard Siphon and GSI	Combination of 3,200 feet of up to 84-inch-diameter pipe conveyance and GSI. Mitigate up to 26-percent of the impervious area with RainWise and green streets.	Reduce to one untreated overflow event per year on a 20-year moving average	Facilities Plan Complete: 2026. Completion of Bidding: 2028. Construction Completion: 2030.	$23.7[f]

a. Each CSO outfall is assigned a Discharge Serial Number or DSN through the NPDES permit.
b. "**Completion of Bidding**" means WTD has (1) appropriately allocated funds for a specific CSO control project (or portion thereto); (2) accepted and awarded the bid for construction of the specific CSO control project; and (3) issued a notice to proceed with construction that remains in effect for the specific CSO control project.
c. "**Construction Completion**" means completion of construction and installation of equipment or infrastructure such that equipment or infrastructure has been placed in operation, and is expected to both function and perform as designed, as well as completion of in-situ modified operations and maintenance manuals. This specifically includes all control systems and instrumentation necessary for normal operations and all residual handling systems. For those specified CSO control projects consisting of separate components, "Construction Completion" shall be achieved when the last component is completed.
d. The estimated cost of each recommended CSO control project uses conceptual design information. The project cost estimates are planning-level only, for use in developing long-range capital schedules and budgets. The accuracy of planning-level estimates is -50 to +100 percent. The accuracy will increase as WTD gains more site-specific information during project design. A project budget will be set when design is 30 percent complete.
e. The County is proposing a joint project until the City completes its long-term CSO control plan and project recommendations in 2014. If a joint project is not recommended, the County will implement the identified independent project.
f. Implementation of GSI in the CSO basin is not included in costs, as they are expected to replace and potentially reduce project costs. The sizing of the gray storage facility and GSI will be cost-effectively balanced in future evaluations to achieve the performance standard.

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Chapter 1

Introduction

This 2012 Combined Sewer Overflow (CSO) Control Program Review Report is a companion to the King County Executive's Recommended CSO Control Plan. This report documents King County's review of its CSO Control Program, which was conducted in accordance with policies and guidelines in the 1999 Regional Wastewater Services Plan (RWSP). It is supported by technical memorandums that can be found at http://www.kingcounty.gov/environment/wastewater/CSO/ProgramReview/plan.aspx#techmemos.

The 2011 Wastewater Treatment Division (WTD) Recommended CSO Control Plan and the 2011 Summary of Technical Memorandums (Summary of TMs) were developed to solicit public and agency comment to inform both the King County Executive's Recommended CSO Control Plan and this 2012 CSO Control Program Review Report. Together these two documents recommend amendments to the County's 1999 Long-term CSO Control Plan (1999 Plan Amendment). Adopted changes to the Plan will be incorporated into the 2012 Long-term CSO Control Plan Amendment to be submitted to the Washington State Department of Ecology (Ecology) and the United States Environmental Protection Agency (EPA) in fall of 2012. This transmittal and adoption of a Plan completion date of 2030 are intended to meet requirements in an administrative order established by Ecology in 2011. This process is presented in Figure 1-1.

Figure 1-1. King County 2012 Long-term CSO Control Plan Amendment Process

This chapter gives an overview of the purpose of the program review. It describes the nature and locations of CSOs in the County, the reasons for controlling CSOs, and the County's CSO control strategies.

1.1 Definition of CSOs

CSOs are untreated discharges of wastewater and stormwater into water bodies during heavy 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 the need for large wastewater facilities and in challenges to the treatment process. To protect treatment plants and avoid sewer backups into homes, businesses, and streets during heavy storm events, combined sewers in the City sometimes overflow into Puget Sound, the Duwamish Waterway, Elliott Bay, Lake Union, the Lake Washington Ship Canal, and Lake Washington. Within the King County wastewater service area, shown in Figure 1-2, CSOs only exist within the City. Based on agreements made at the start of the regional system in 1958, both the County and City are responsible for CSOs and are working to control them under long-term CSO control plans. Figure 1-3 shows locations of county and city CSOs. The County, in conjunction with the City, EPA, and Ecology, first developed its CSO Control Plan in 1979. After Ecology developed CSO control rules and regulations in the late 1980s, the County and City developed separate, but coordinated, long-term CSO control plans. The 1988 Plan became the basis for current compliance efforts. Under the Ecology rules the CSO control plan is reviewed and amended with each National Pollutant Discharge Elimination System (NPDES) permit renewal.

1.2 Purpose of the County’s Program Review

In 1993, work began on the RWSP, a revision to the 1958 comprehensive sewer plan for the wastewater service area in King County. Adopted in 1999, the RWSP sets out to integrate long-range planning in all areas of wastewater services and establish priorities for all wastewater programs. One component of the RWSP is an amendment to the 1988 CSO Control Plan that describes the County’s program and schedule to reduce CSOs, referred to as the 1999 CSO Control Plan Amendment (1999 Plan Amendment). The County implements the Plan through the WTD CSO Control Program.

In adopting policies for the RWSP, the King County Council recognized that much can change in five years because science and technology are continually evolving. This new science and technology, as well as changes in conditions and costs, must be considered in planning for CSO control. To this end, RWSP policy requires that the King County Executive review the progress toward completion of the Plan, its priorities and effectiveness, and recommend any Plan changes to the King County Council and Regional Water Quality Committee (RWQC) before finalizing commitments under the NPDES permit.

The County issues two documents in approximately five-year intervals for comprehensive review of the CSO Control Program successes, updates, and future projects. These two documents are CSO Control Program reviews and Plan updates or amendments. Reviews are to support county decision-making and are submitted by the King County Executive to the King County Council for input. Plan updates describe progress in the CSO Control Program over the past five years and commit to the projects for CSO control for the next NPDES permit phase. Amendments modify the Plan with any adopted changes. Plan updates or amendments are submitted as part of the renewal to the NPDES permit for the West Point Treatment Plant. Renewals occur about every five years, and the next renewal will occur in 2014.

The 2006 CSO Control Program Review was completed for King County Council consideration and input. The Plan was updated in 2008 and submitted to Ecology in conjunction with renewal of the NPDES permit for the West Point Treatment Plant. No changes to the Plan were recommended.

This report is being submitted to the King County Council in June 2012 for adoption of the 2012 Plan amendment. This report has been developed with significant public involvement to inform the recommended changes to the Plan. Adopted changes will be incorporated into the 2012 Long-term CSO Control Plan Amendment that will be submitted to Ecology for the 2014 West Point Treatment Plant NPDES permit renewal.

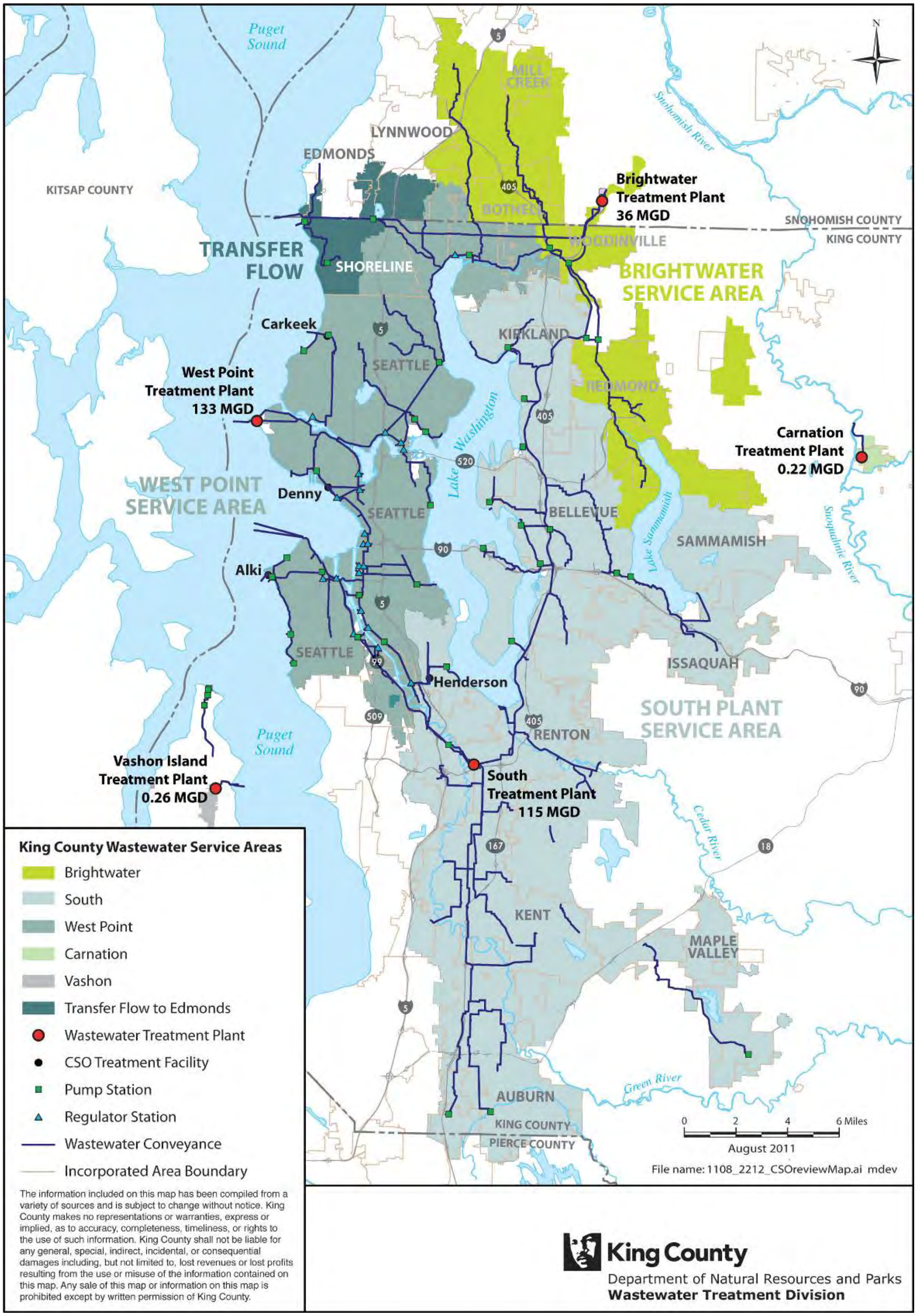

Figure 1-2. King County Wastewater Service Area and System

Figure 1-3. King County and City of Seattle CSO Locations

1.3 King County's Role in Wastewater Management

In 1958, the Municipality of Metropolitan Seattle (Metro) was formed to clean up the waters of Lake Washington and the City of Seattle waterfront. At the time, most wastewater in King County was conveyed from homes and businesses by sewers that discharged the untreated wastewater to the nearest water body. In the 1960s, Metro assumed ownership of the City's wastewater treatment plants and portions of its sewer system and then built large pipes, called interceptors, to carry regional wastewater from many local systems to the treatment plants. Regional improvements in collecting, conveying, and treating wastewater that were made after the formation of Metro continue to be effective despite decades of population growth and development.

In 1994, the County assumed Metro's responsibilities for regional wastewater management. Today, the County's WTD serves 17 cities, 16 local sewer utilities, and 1 Indian tribe in and adjacent to the County (the local agencies). The County operates a "wholesale" utility, providing wastewater conveyance and treatment services to the local agencies or "retailers", who in turn sell wastewater services to area residents and businesses.

The County's wastewater system is the largest in the Puget Sound region (Figure 1-2). The system includes three large regional wastewater treatment plants (the West Point Treatment Plant in the City of Seattle, the South Treatment Plant in the City of Renton, and the new Brightwater Treatment Plant in south Snohomish County), two small wastewater treatment plants (one on Vashon Island and one in the City of Carnation), one community septic system (Beulah Park and Cove on Vashon Island), four CSO treatment facilities (Alki, Carkeek, Elliott West, and Henderson/MLK—all in the City of Seattle), over 350 miles of pipes, 19 regulator stations, 42 pump stations, and 38 CSO outfalls.

The West Point Treatment Plant, South Treatment Plant, and Vashon Treatment Plant provide secondary treatment[1] and disinfection; the Brightwater Treatment Plant and Carnation Treatment Plant use membrane bioreactor systems and disinfection for treatment; the CSO treatment facilities provide CSO treatment (equivalent to primary treatment[1]). Eight of WTD's treatment facilities discharge their treated and disinfected effluent to Puget Sound; the Carnation Treatment Plant discharges to the Chinook Bend wetlands located along the Snoqualmie River.

The county wastewater service area is divided into the East, West, and Brightwater Service Areas. The West Service Area sends a mixture of separated wastewater from north of Lake Washington and both separated and combined sewage flows from the City of Seattle to the West Point Treatment Plant. Approximately 41,000 acres of the 55,000 acres that make up the City are served by combined or partially separated sewers.

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[1] In primary treatment, solids are removed from the wastewater, usually by allowing them to settle to the bottom of large tanks. The wastewater is disinfected, usually with chlorine, and discharged. Secondary treatment includes primary treatment, followed by a biological process to break down organic material, more solids settling, and then disinfection and discharge.

The County owns 38 CSO outfalls, and the City owns 90 CSO outfalls (Figure 1-3). To prevent duplication and conflicts, the County and the City also coordinate their wastewater management programs. In areas served by combined sewers, the City manages stormwater before it enters the county sewers; the County manages the stormwater after it enters the county sewers. In areas served by separated sewers, the City manages most of the stormwater.[2] County policy prohibits construction of facilities to handle "clean" stormwater from separated sewers managed by the City or other agencies.

1.4 Purpose of CSO Control

Although the wastewater in CSOs is greatly diluted by stormwater, CSOs may be harmful to public health and aquatic life because they can carry chemicals and disease-causing pathogens. CSO control protects public health and the environment by accomplishing the following:

- Reducing the potential for contact with pathogens and consumption of contaminated fish
- Reducing the potential for chemical exposure to salmon at their most vulnerable life stage
- Contributing to efforts to restore and protect Puget Sound
- Helping to meet the Duwamish Waterway long-term cleanup goals by reducing the volume of CSOs.

Because of the public health and environmental concerns associated with CSOs, King County has committed to the public to reduce and control CSOs. The County made agreements with the County's regional partners (governments, local agencies and stakeholders in the service area) as part of the RWSP to control the County's remaining uncontrolled CSO sites to Ecology's CSO control standard by 2030.

Regulations, agreements, policies, and public expectations all support the reduction and control of CSOs to protect public health, water quality, sediment quality, and aquatic species in water bodies.

1.4.1 Public Perception and Preferences Regarding CSOs

Since 1958 when the regional wastewater management system was formed, public opinion has been sought on priorities and plans. In recent times, King County's 1999 CSO Water Quality Assessment for the Duwamish River and Elliott Bay included valuable input from regional stakeholders, including regulatory agencies, businesses and environmental groups. The messages heard during this process and during development of the RWSP and subsequent CSO program reviews and control projects—that water quality is a priority to the citizens of the County, that the County should protect and enhance water quality, and that the citizens believe CSOs should

[2] The County is responsible for the stormwater that results from county sewer separation projects; it also accepts contaminated stormwater from industries and charges a fee to recover costs.

be controlled—has been continually reaffirmed through all WTD public involvement activities through this current review. Concern about the costs of CSO control and getting the best environmental benefit for the investment has also been heard. This has led the County to recommend doing a water quality assessment and monitoring study to inform the next Program Review due to Ecology in 2018. Additional information about the study can be found in Section 11.3 of this report.

Regulations that Affect CSO Control Planning

Clean Water Act (CWA)—Adopted in 1972 to eliminate the discharge of pollutants into the nation's waters and to achieve and maintain fishable and swimmable waters.

National Pollutant Discharge Elimination System (NPDES)—The Washington State Department of Ecology (Ecology) implements the CWA by issuing NPDES permits to wastewater agencies and industries that discharge effluent (including CSOs) to water bodies.

Water Quality Standards—To implement CWA, Ecology has developed biological, chemical, and physical criteria to assess a water body's health and to impose NPDES permit limits accordingly.

State CSO Control Regulations—Ecology requires agencies to develop plans for controlling CSOs at the earliest possible date, with control of each CSO such that an average of one untreated discharge may occur per year.

Wet Weather Water Quality Act of 2000—The United States Environmental Protection Agency (EPA) requires agencies to implement Nine Minimum Controls and to develop long-term CSO control plans.

Sediment Quality Standards—Ecology has developed chemical criteria to characterize healthy sediment quality and identify a threshold for sediment cleanup. King County has participated in sediment cleanup at some of its CSO locations.

Endangered Species Act (ESA)—Protection of federally-listed species under the ESA that are at risk of extinction is a primary priority of the CSO Control Program. Seven fish species that use local water bodies where CSOs occur have been listed as threatened or endangered under ESA.

1.4.2 King County CSO Control Policies

King County CSO control policies are included in Appendix A of this report. They are intended to guide the County in controlling CSO discharges, so that all CSO locations meet state and federal regulations. In setting schedules for implementing CSO control projects, the 1999 Plan Amendment gave highest priority to locations with the greatest potential to impact human health, bathing beaches, and species listed under the Endangered Species Act. The policies call for regular reviews of CSO control projects, priorities, and opportunities using the most current studies. Another CSO control policy addresses the cleanup of contaminated sediments near the county CSO sites. The policy directs the County to implement its long-range sediment management strategy and, where applicable, to participate with partners in sharing responsibilities and costs of cleaning up sites such as the Superfund sites in the Lower Duwamish Waterway.

The County's CSO control planning assumptions and policies are listed in Appendix A of this report. The list of assumptions documents the understanding of issues, priorities, and needs at the time of the 1999 Plan Amendment and how they have changed. Those changes may indicate the need for changes in the Plan, so are part of the review described in Chapter 4 of this report. The assumptions and policies continue to guide the CSO Control Program, except where changes are noted or recommended in this 2012 CSO Control Program Review Report.

1.4.3 Applicable Water Quality Regulations

In 1972, the federal Clean Water Act (CWA) 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 NPDES permit program. The second goal is being addressed by developing pollution control programs to meet specific water quality standards for water bodies.

The CWA requires all wastewater treatment facilities and industries that discharge effluent into surface waters to have a NPDES permit. In Washington state, NPDES permits are issued by 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. King County holds NPDES permits for its West Point, South, Vashon, Carnation, and Brightwater Treatment Plants. The West Point Treatment Plant NPDES permit includes the Alki and Carkeek CSO Treatment Plants, Elliott West and Henderson/MLK CSO Treatment Facilities, and all 38 CSO outfalls.

Both the CWA and Washington state regulations define minimum technologies to be used for different wastewater streams. The federal rules define "best conventional pollutant control technology" (BCT), "best available technology economically achievable" (BAT), and other standards while Washington state defines technologies under "all known available and reasonable technologies" (AKART). For example, secondary treatment is defined as BCT and AKART for publicly owned treatment works. Effluent limits defined in NPDES permits reflect implementation of secondary treatment as BCT and AKART.

Effluent limits must protect human health and the environment. To evaluate acceptable water quality and to set protective permit limits, Ecology has put into regulation use-based Water Quality Standards (WQS) (Chapter 173-201A WAC). These standards were "established to sustain public health and public enjoyment of the waters and the propagation and protection of fish, shellfish, and wildlife" (WAC 173-201A-010). The biological, chemical, and physical criteria used to assess a water body's health include bacteria, nutrients, salinity, chlorophyll, solids, dissolved oxygen, temperature, pH, ammonia, turbidity, and a variety of other chemical compounds. These standards apply to the area in a water body that extends beyond a defined mixing zone, an area around a discharge where dilution can be considered in determining compliance with WQS.

When a water body does not meet these WQS, Section 303(d) of the CWA requires that the water body be added to a list of impaired waters called the "303(d) list." This list is prepared and maintained by Ecology for waters classified as category 5[3] under water quality assessment procedures. It is updated every five years. Once listed, the water body must be studied, and controls must be put into place that will correct conditions so that it meets standards. Controls often involve allocating the pollutant load to its sources, such as stormwater runoff and

[3] Category 5 waters have water quality standard violations and require an assessment and pollution allocation called a Total Maximum Daily Load (TMDL).

municipal or industrial discharges, so that the water body can assimilate and still meet the standards. This process is called a Total Maximum Daily Load (TMDL). Most of the water bodies where county CSOs occur are listed as category 5 and may require TMDLs.

1.4.4 CSO Control Regulations

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) 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." This is the control or performance standard. The new regulation also defined standards for treated CSOs, which were essentially technology standards. WAC 173-201A-400(11)(c) defines a mixing zone as an area around a discharge where dilution can be considered in determining compliance with WQS. To align the CSO control standard with WQS, a CSO discharge may be allowed an average of once-per-year exemption to the numeric size criteria and the overlap criteria of a mixing zone. Water quality–based effluent limits also apply to treated CSO discharges.

The renewed NPDES permit for the West Point Treatment Plant, effective July 1, 2009, implemented further interpretation of the performance standard for CSO control. The standard of an average of one untreated discharge per year is now based on a 20-year moving average. The number of untreated discharges that occurred over each of the previous 20 years 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.

EPA's 1994 CSO Control Policy was codified as the Wet Weather Water Quality Act of 2000 (H.R. 4577, 33 U.D.C. 1342(q)). This act requires implementation of Nine Minimum Controls (defined in the act and discussed in Section 3.2.4 of this report) for CSOs and the development of long-term CSO control plans. The purpose of the Nine Minimum Controls is to implement early actions that can improve water quality before the protracted and more expensive capital projects in the control plan are built. EPA has determined that the Nine Minimum Controls represent BAT. The policy also calls for the development of long-term CSO control plans; these plans are similar to Washington state CSO control plans. Agencies must show that water quality standards are met after implementation of their CSO control plan through implementation of a post-construction monitoring plan. The requirements of this act are incorporated in the NPDES permit for the West Point Treatment Plant.

1.4.5 Sediment Quality Regulations

Chemical contamination of aquatic sediments can adversely impact benthic (bottom-dwelling) organisms and can enter the food chain as species feed on each other. Each species, in turn, can suffer adverse impacts. Humans can be affected via direct contact with the chemicals in the sediments through activities such as beach play or hauling fishing nets or via consumption of chemically laden fish and wildlife.

Sediment quality in the Puget Sound region is determined based on Washington standards established by Ecology. The Sediment Management Standards (SMS; Chapter 173-204 WAC) rule outlines specific standards and decision-making processes to protect biological resources and remediation of contaminated sediment. CSO discharges and areas off CSO outfalls must meet these standards. At this time, the SMS includes chemical and biological standards for Puget Sound marine sediments, but lacks standards for freshwater sediments. However, Ecology has established freshwater Sediment Quality Guidelines (SQGs) for developing remediation standards at freshwater sites. SQGs are chemical-specific criteria that designate what is considered healthy sediment quality. Ecology is currently considering revisions to the SMS rule to provide freshwater sediment standards.

Ecology is granted legal authority under the SMS to direct the identification, screening, ranking, prioritization, and cleanup of contaminated sediment sites in the state. The standards include the SQGs and a threshold called the Cleanup Screening Level (CSL) for sediment cleanup efforts (“remediation”). When these chemical criteria are exceeded, toxicity testing may be used to verify the adverse impact. Once a site is ranked and placed on the contaminated sites list, it may then be considered for cleanup. Chapter 173-204 WAC provides for the voluntary cleanup of contaminated sediments with oversight and guidance by Ecology. Alternatively, Ecology or EPA may initiate enforcement actions (including cost recovery) under the Washington Model Toxics Control Act (MTCA) or the federal Comprehensive Environmental Response, Compensation and Liability Act (CERCLA), also known as Superfund.

1.4.6 Endangered Species Act

The Endangered Species Act (ESA) was adopted by Congress to provide extra protections and support to species and populations so greatly impacted that other regulatory control programs, such as the CWA, were not sufficient to protect habitat and increase populations. The act was part of a suite of environmental regulations in the 1970s. It provides for the protection of species, and their habitat, that are becoming extinct. All federal agencies, including EPA, have to consider threatened and endangered species when undertaking any actions, including issuing of permits or certifications for other entities.

In 1999, Puget Sound Chinook salmon and bull trout were listed as threatened species under the ESA. In 2000, NOAA[4] Fisheries adopted a draft protective rule under Section 4(d) of ESA prohibiting the “take” of the listed species.[5] Following the adoption of the rule, WTD began a review of its activities to determine how it should modify its practices, including construction practices and uses of property near water bodies, to stay within the parameters defined in the 4(d) rule.

[4] NOAA = National Oceanic and Atmospheric Administration.
[5] “Take” under ESA means to harass, harm, pursue, hunt, shoot, wound, kill, trap, capture, or collect, or attempt to engage in any such conduct [ESA 3§ (19)].

Southern resident killer whales were listed as endangered in February 2006, and Puget Sound steelhead fish were listed as threatened in May 2007 under the ESA. In April 2010, three species of Puget Sound rockfish were listed under the ESA, including bocaccio as endangered and canary and yelloweye rockfish as threatened.

NOAA stated in the 4(d) rule that it would work with permitting authorities (Ecology) to ensure that permitted discharges do not violate the ESA. NOAA Fisheries, the U.S. Fish and Wildlife Service (USFWS), and EPA have signed a Memorandum of Agreement to work together on integrating CWA standards and ESA requirements. Both NOAA Fisheries and USFWS have the opportunity to review and recommend ESA-protective requirements in NPDES permits.

1.5 King County Efforts to Control CSOs

Strategies for reducing or mitigating the effects of CSOs include pollution prevention through source control, stormwater management, operational controls to transfer as much captured overflow as possible to regional treatment plants, upgrades of existing facilities, and construction of CSO control facilities.

Construction of CSO control facilities in the region began in the late 1970s. So far, $389 million (2010 dollars) has been spent to reduce wastewater and CSO volumes from 2.3 billion gallons per year in 1983 to approximately 800 million gallons per year today (Figure 1-4). WTD currently has an additional $117 million committed to projects under way (these include four Puget Sound Beach projects at $103 million[6] and the CSO component of the Ballard Siphon Replacement project at approximately $14 million, which are described in Chapter 3 of this report).

[6] 2011 Facility Plan estimates.

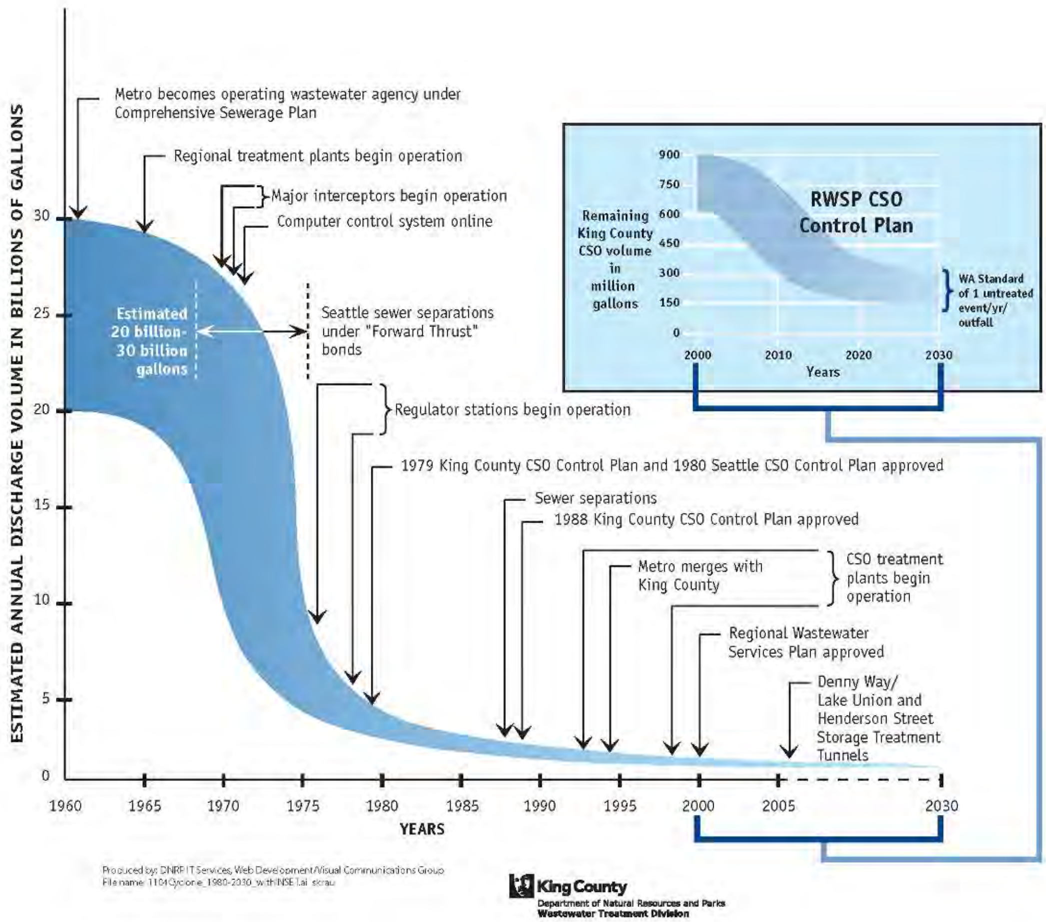

Figure 1-4. Historical Reduction in Volumes Since Construction of the Regional System (1958-79) and CSO Control (1979-Present)

Based on available measured data, the present status of King County's 38 CSO sites is as follows:

- 16 are controlled to Ecology's CSO control standard.
- Three completed projects are being adjusted (Denny Way and Dexter Ave Regulators) or verified (Harbor Ave Regulator) to complete control. See Section 9.0 of Technical Memorandum 970, CSO Control Alternatives Development for information on existing facilities.
- The first four RWSP projects near Puget Sound beaches are in design (S Magnolia, North Beach, Barton St, and Murray Ave) and are scheduled to begin construction at the end of 2013.
- The Ballard Siphon Replacement project is under construction and is expected to control the Ballard CSO site and possibly reduce overflows at the 11th Ave NW CSO site.
- The remaining 14 uncontrolled CSO sites are the subject of current planning. Based on the review to date, WTD recommends that these meet state standards as capital improvement projects that are to be constructed between 2013 and 2030.

Table 1-1 presents all of the County's 38 CSO sites, their control status at the time of this review, and brief descriptions of any projects that are currently underway. More detail is presented in Chapter 3 of this report. The King County Executive's Recommended CSO Control Plan addresses the remaining 14 uncontrolled CSO sites at an estimated cost of $711 million; see Chapter 6 of this report for details about the projects. Current and future recommended projects involve construction of green stormwater infrastructure (GSI), conveyance improvements, storage tanks, and treatment facilities.

Table 1-1. 2011 King County CSO Control Status

CSO Site	CSO Control Status in Current Review[a]	Comments
11th Ave NW	Uncontrolled	Overflow reduction underway with Ballard Siphon Replacement project. Final control project included in King County Executive's Recommended CSO Control Plan.
30th Ave NE	Controlled	
3rd Ave W	Uncontrolled	Control project included in King County Executive's Recommended CSO Control Plan.
53rd Ave SW	Controlled	
63rd Ave SW	Controlled	
8th Ave S/W Marginal Way	Controlled	2010 modeling does not agree with monitoring data. Verification is underway.

Table 1-1. 2011 King County CSO Control Status

CSO Site	CSO Control Status in Current Review[a]	Comments
SW Alaska St	Controlled	Updated monitoring and modeling data indicate that a control project is no longer needed.
Ballard	Uncontrolled	Control project underway.[b]
Barton St	Uncontrolled	Control project underway.[b]
Belvoir	Controlled	
Brandon St	Uncontrolled	Overflow reduction project completed in 2003. Final control project included in King County Executive's Recommended CSO Control Plan.
Canal St	Controlled	
Chelan Ave	Uncontrolled	Control project included in King County Executive's Recommended CSO Control Plan.
Denny Way	Uncontrolled	Control project completed. Full control being achieved by operational adjustment and facility modifications.[c]
Dexter Ave	Uncontrolled	Control project completed. Full control being achieved by operational adjustments and upstream GSI.[c]
Duwamish, E	Controlled	
Duwamish, W	Controlled	
Hanford #1 Hanford@ Rainier Bayview South Bayview North	Uncontrolled	Overflow reduction project completed in 1992. Final control project included in King County Executive's Recommended CSO Control Plan.
Hanford #2	Uncontrolled	Control project included in King County Executive's Recommended CSO Control Plan.
Harbor Ave	Modeling confirmation underway	Control project completed.[b] CSO site appears controlled – Modeling confirmation underway.[c]
Henderson	Controlled	Control project completed.[b]
King St	Uncontrolled	Control project included in King County Executive's Recommended CSO Control Plan.

Table 1-1. 2011 King County CSO Control Status

CSO Site	CSO Control Status in Current Review[a]	Comments
Kingdome (formerly Connecticut)	Uncontrolled	Installation of a storage pipeline in conjunction with street projects in 1994. Partial separation by the Public Facilities District (PFD) in 1999 in conjunction with Safeco Field construction. Final control project included in King County Executive's Recommended CSO Control Plan.
Lander St	Uncontrolled	Control project included in King County Executive's Recommended CSO Control Plan.
Magnolia	Uncontrolled	Control project underway.[b]
Marginal, E	Controlled	
Matthews Park	Controlled	
Michigan, S	Uncontrolled	Control project included in King County Executive's Recommended CSO Control Plan.
Michigan, W	Uncontrolled	Control project included in King County Executive's Recommended CSO Control Plan.
MLK Way	Controlled	Control project completed.[b]
Montlake	Uncontrolled	Control project included in King County Executive's Recommended CSO Control Plan.
Murray Ave	Uncontrolled	Control project underway.[b]
Norfolk	Controlled	Control project completed.[b]
North Beach North Beach Inlet North Beach Wet Well	Uncontrolled	Control project underway.[b]
Pine St, E	Controlled	
Rainier Ave	Controlled	
Terminal 115	Uncontrolled	Control project included in King County Executive's Recommended CSO Control Plan.
University	Uncontrolled	Overflow reduction project completed in 1994. Final control project included in King County Executive's Recommended CSO Control Plan.
Number of Controlled CSO Sites	16 fully controlled; 3 approaching control	3 control projects in final adjustments or confirmations.

Table 1-1. 2011 King County CSO Control Status

CSO Site	CSO Control Status in Current Review[a]	Comments
Number of CSO Sites with Control Projects Underway	5	
Number of CSO Sites with No Control Projects Currently Underway	14	
Total Number of CSO Sites	**38**	

Grey highlighted sites = county CSO sites that are now fully controlled (see Chapter 3 of this report).

a. See Section 3.4 of this report for recent compliance monitoring and modeling data.
b. See Table 3-1 and Table 3-2 in Chapter 3 of this report for details about completed and underway projects.
c. Supplemental compliance plans are described in Section 3.5 of this report and in Section 9.0 of Technical Memorandum 970, CSO Control Alternatives Development.

1.6 CSO Sites Covered by Current Review

The 14 uncontrolled King County CSO sites with no control projects currently underway discharge CSOs to Elliott Bay, the Duwamish River (Lower, East, and West Waterways), and the Lake Washington Ship Canal (including the Montlake Cut). Each CSO site has an associated CSO outfall (numbered by "Discharge Serial Number" or DSN) and a structure where overflows are diverted to the outfall from the combined sewer system. The area contributing combined sewer flow to each CSO site is referred to as a CSO basin.

For this review, it was recognized that some of the uncontrolled CSO sites, because of their system connections and geographic proximity, might be addressed by projects that control more than one CSO site. These CSO sites were grouped into areas for evaluation. Figure 1-5 and Table 1-2 identify the areas, the CSO sites, the DSN for each CSO site, and the name of the associated overflow diversion facility.

Figure 1-5. King County CSO Sites and Areas

Table 1-2. Uncontrolled CSO Sites and Facilities in King County

Area	Uncontrolled CSO Site	DSN	Overflow Diversion Facility	Receiving Water Body
Ship Canal – 11th Ave NW, 3rd Ave W, University, and Montlake	11th Ave NW	004	11th Ave NW Overflow Structure	Lake Washington Ship Canal
	3rd Ave W	008	3rd Ave W Overflow Structure	
	University	015	University Regulator Station	
	Montlake	014	Montlake Regulator Station	
Middle Elliott Bay Interceptor (EBI) – Hanford #2, Lander St, Kingdome, and King St	Hanford #2	032	Hanford St Regulator Station	Duwamish River – East Waterway
	Lander St	030	Lander St Regulator Station	Duwamish River – East Waterway
	Kingdome	029	Kingdome Regulator Station	Elliott Bay
	King St	028	King St Regulator Station	Elliott Bay
Middle EBI – Hanford #1	Hanford #1	031	Hanford@Rainier, Bayview North, and Bayview South Overflow Structures	Lower Duwamish Waterway via Diagonal Storm Drain
South EBI	S Michigan St	039	S Michigan St Regulator Station	Lower Duwamish Waterway
	Brandon St	041	Brandon St Regulator Station	Lower Duwamish Waterway
West Duwamish – W Michigan St and Terminal 115	W Michigan St	042	W Michigan St Regulator Station	Lower Duwamish Waterway
	Terminal 115	038	Terminal 115 Overflow Structure	Lower Duwamish Waterway
West Duwamish – Chelan Ave	Chelan Ave	036	Chelan Ave Regulator Station	Duwamish River – West Waterway

1.7 Relationship Between King County and City of Seattle CSO Control Efforts

Figure 1-3 shows the locations of the City of Seattle and King County CSO outfalls. 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. The City is also amending their long-term CSO control plan. The two agencies communicate frequently and participate in each other’s CSO control planning efforts. The County considers joint CSO control projects with the City if the projects are deemed to be cost-effective for ratepayers, provide a better environmental outcome, or if they have the potential to minimize construction disruption to nearby communities.

The City manages stormwater programs in the combined sewer area. It implements rules governing management of stormwater on private and public property through its stormwater code. The City's NPDES permit, issued in December 2005, requires implementation of stormwater pollution prevention programs in the combined sewer areas (the permit was last modified in December 2010).

The County has responsibility for elements of stormwater management in the few places in the City where it has implemented sewer separation projects. To prevent duplication and conflicts, the County and the City coordinate their stormwater management programs and stormwater NPDES compliance efforts.

1.8 Ecology and EPA Report Requirements

The adopted Long-term CSO Control Plan Amendment will be submitted to Ecology as part of the renewal to the NPDES permit for the West Point Treatment Plant. The amendment complies with the requirements of WAC 173-245-090(2). Each Ecology requirement is listed in Table 1-3, along with the sections of this report where it is addressed. The amendment or update also complies with the requirements of EPA's long-term CSO control plan in accordance with EPA's CSO Control Policy (April 1994). EPA's requirements are listed in Table 1-4, along with the sections of this report where the conclusions of King County's approach are referenced. The County's characterization of its CSOs, control priorities, and methods began in the late 1970s and then aligned with 1987 Ecology regulations (Chapter 173-245 WAC). While the methods used by the County under the Ecology program differ somewhat from those of EPA, the County documents that they are sufficiently similar and lead to equivalent CSO control decisions in this long-term CSO control plan.

Table 1-3. WAC 173-245-040(2) Requirements for CSO Control Plan Update

Requirements	Section Describing King County's Equivalent Approach
(a) Documentation of CSO activity. Municipalities shall complete a field assessment and mathematical modeling study to establish each CSO's location, baseline annual frequency, and baseline annual volume; to characterize each discharge; and to estimate historical impact by:	
(i) Flow monitoring and sampling CSOs. Monitoring and sampling at one or more CSO sites in a group that are in close proximity to one another is sufficient if the municipality can establish a consistent hydraulic and pollutant correlation between or among the group of CSO sites. Sampling may not be required for CSO sites that serve residential basins; and	Section 3.1 and Section 3.2.4
(ii) Developing a rainfall/stormwater runoff/CSO model to simulate each CSO site's activity; and	Section 3.1.4 and Appendix B
(iii) Verifying the model's accuracy with data collected under (a)(i) of this subsection; and	Section 3.1.4, Section 3.4, and Appendix B

Table 1-3. WAC 173-245-040(2) Requirements for CSO Control Plan Update

Requirements	Section Describing King County's Equivalent Approach
(iv) In circumstances where an historical impact may be discernible, observing and sampling the receiving water sediments adjacent to each CSO site or group of sites to establish the presence and extent of any bottom deposits; and	Section 4.1.2 and Section 4.3.1
(v) If the sewer service area upstream of a CSO site includes sanitary sewer sources other than domestic sewage, samples of the sediment deposits shall receive heavy metal analysis and organic pollutant screening. Pending review of results of these analyses, the department may require additional pollutant analyses. If two or more CSO sites serve the same industrial/commercial sources, sediment sampling adjacent to one representative CSO site may suffice.	Section 4.1.2 and Section 4.3.1
(b) To achieve the greatest reasonable reduction at each CSO site, control/treatment alternatives that shall receive consideration include, but are not limited to:	
(i) Use of best management practices, sewer use ordinances, pretreatment programs, and sewer maintenance programs to reduce pollutants, reduce infiltration, and delay and reduce inflow; and	Section 3.2
(ii) In-line and off-line storage with at least primary treatment and disinfection at the secondary sewage treatment facility that is served by the combined sewer; or	Section 5.1.3
(iii) Increased sewer capacity to the secondary sewage treatment facility that shall provide at least primary treatment and disinfection; or	Section 5.1.3
(iv) At-site treatment equal to at least primary treatment, and adequately offshore submerged discharge. At-site treatment may include a disinfection requirement at CSO sites that are near or impact water supply intakes, potentially harvestable shellfish areas, and primary contact recreation areas; or	Section 5.1.3
(v) Storm sewer/sanitary sewer separation.	Section 5.1.3
(c) Analysis of selected treatment/control projects. Municipalities shall conduct an assessment of the treatment/control project or combination of projects proposed for each CSO site. The assessment shall include:	
(i) An estimation of the water quality and sediment impacts of any proposed treated discharge using existing background receiving water quality data, and estimated discharge quality and quantity. The department may require a similar analysis for proposed storm sewer outfalls for basins that drain industrial and/or commercial areas; and	Section 4.2.3
(ii) An estimation of the selected projects' impacts on the quality of effluent from and operation of a municipality's secondary sewage treatment facility. During wet weather flow conditions, a municipality shall maximize the rate and volume of flows transported to its secondary sewage treatment facility for treatment. However, those flows must not cause the treatment facility to exceed the pollutant concentration limits in its NPDES permit; and	Section 4.2.3
(iii) The estimated construction and operation and maintenance costs of the selected projects; and	Chapter 6

Table 1-3. WAC 173-245-040(2) Requirements for CSO Control Plan Update

Requirements	Section Describing King County's Equivalent Approach
(iv) The general locations, descriptions, basic design data, sizing calculations, and schematic drawings of the selected projects and descriptions of operation to demonstrate technical feasibility; and	Chapter 6 and Technical Memorandum 970, CSO Control Alternatives Development
(v) An evaluation of the practicality and benefits of phased implementation; and	Chapter 7 and Chapter 8
(vi) A statement regarding compliance with the State Environmental Policy Act (SEPA).	Section 2.4
(d) Priority ranking. Each municipality shall propose a ranking of its selected treatment/control projects. The rankings must be developed considering the following criteria:	
(i) Highest priority must be given to reduction of CSOs that discharge near water supply intakes, public primary contact recreation areas, and potentially harvestable shellfish areas;	Chapter 7
(ii) A cost-effectiveness analysis of the proposed projects. This can include a determination of the monetary cost per annual mass pollutant reduction, per annual volume reduction, and/or per annual frequency reduction achieved by each project;	Chapter 8
(iii) Documented, probable, and potential environmental impacts of the existing CSO discharges.	Section 3.2.4 and Section 4.2.3
(e) Municipalities shall propose a schedule for achieving "the greatest reasonable reduction of combined sewer overflows at the earliest possible date." (Revised Code of Washington (RCW) 90.48.480.) If the agreed upon schedule exceeds five years, municipalities shall propose an initial five-year program of progress towards achieving the greatest reasonable reduction. Factors that municipalities and the department shall use to determine compliance schedules shall include but not be limited to:	
(i) Total cost of compliance;	Chapter 6
(ii) Economic capability of the municipality;	Chapter 8
(iii) Other recent and concurrent expenditures for improving water quality; and	Chapter 8
(iv) The severity of existing and potential environmental and beneficial use impacts.	Chapter 7

Table 1-4. EPA CSO Control Policy Requirements for Long-term Control Plan

Requirements	Section Where County Approach is Addressed in Report
1. Characterization, Monitoring, and Modeling of the Combined Sewer System. The major elements of a sewer system characterization are described below.	
a. Rainfall Records – The permittee should examine the complete rainfall record for the geographic area of its existing combined sewer system using sound statistical procedures and best available data. The permittee should evaluate flow variations in the receiving water body to correlate between CSOs and receiving water conditions. *King County uses 32 years of rainfall records in characterizing the system. This is also supported by 50 years of system inspection documented in databases and geographic information systems (GIS). Over 20 years of direct monitoring data for volume and frequency has been reported, with modeling available nearly as long. Overflow chemistry has been characterized since the early 1990s. Many water quality studies have been completed as referenced in Appendix E. Completed CSO control measures and planned projects are supported by strong data and science.*	Section 3.1.3, Section 3.1.4, Section 3.2.4. Appendix B
b. Combined Sewer System Characterization – The permittee should evaluate the nature and extent of its 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.	Section 3.1.3 and Section 3.2
c. CSO 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. The monitoring program should include necessary CSO effluent and ambient in-stream monitoring and, where appropriate, other monitoring protocols such as biological assessment, toxicity testing, and sediment sampling.	Section 3.1.3,Section 3.2.4, Section 4.3, and Appendix E
d. Modeling – Modeling of a sewer system is recognized as a valuable tool for predicting sewer system response to various wet weather events and assessing water quality impacts when evaluating different control strategies and alternatives. Use of models should include appropriate calibration and verification with field measurements.	Section 3.1.4, Section 4.2.2, Appendix B, Appendix E, and Technical Memorandum 750, Sediment Deposition and Contamination Potential from Treated CSO Discharges

Table 1-4. EPA CSO Control Policy Requirements for Long-term Control Plan

Requirements	Section Where County Approach is Addressed in Report
2. Public Participation	
The permittee will employ a public participation process that actively involves the affected public in decision-making to select the long-term CSO controls. *King County integrates public involvement for CSO control through its outreach efforts. This is described in the public involvement plan on the CSO Control Program website. The results of public involvement specific to this current Plan amendment are described in Section 4.4 and in Appendix F.*	Section 4.4 and Appendix F
3. Consideration of Sensitive Areas. For such areas, the long-term CSO control plan should:	
a. Prohibit new or significantly increased overflows;	Section 4.3.3
b. Eliminate or relocate overflows that discharge to sensitive areas wherever physically possible and economically achievable, except where elimination or relocation would provide less environmental protection than additional treatment; or where elimination or relocation is not physically possible and economically achievable, or would provide less environmental protection than additional treatment, provide the level of treatment for remaining deemed necessary to meet water quality standards for full protection of existing and designated uses.	Section 4.3.3
c. Where elimination or relocation has been proven not to be physically possible and economically achievable, permitting authorities should require, for each subsequent permit term, a reassessment based on new or improved techniques to eliminate or relocate, or on changed circumstances that influence economic achievability. *CSO control alternatives and sequencing priorities have been developed considering a range of “sensitivities”, and those priorities are reviewed and updated with each NPDES permit CSO control plan amendment. King County had defined its program to meet the Washington state performance standard—studies indicate the water quality benefit of reducing overflows from that standard of one event per year to zero will be minimal and the needed facilities would be extremely large and costly—low benefit to cost does not warrant elimination.*	Section 4.3.3
4. Evaluation of Alternatives. The long-term CSO control plan should adopt one of the following approaches:	
a. “Presumption” Approach. A program that meets any of the criteria below would be presumed to provide an adequate level of control to meet the water quality-based requirements of the CWA, provided that permitting authority determines that such presumption is reasonable in light of the data and analysis conducted in the characterization, monitoring, and modeling of the system and the consideration of sensitive areas. i. No more than an average of four overflow events per year, provided that the permitting authority may allow up to two additional overflow events per year; or ii. The elimination or the capture for treatment of no less than 85 percent by volume of the combined sewage collected in the	Section 4.1.3 and Chapter 5

Table 1-4. EPA CSO Control Policy Requirements for Long-term Control Plan

Requirements	Section Where County Approach is Addressed in Report
combined sewer system during precipitation events on a system-wide annual average basis; or	
iii. The elimination or removal of no less than the mass of the pollutants, identified as causing water quality impairment through the sewer system characterization, monitoring, and modeling effort, for the volumes that would be eliminated or captured for treatment under paragraph ii above. Combined sewer flows remaining after implementation of the nine minimum controls and within the criteria specified should receive a minimum of: • Primary clarification; • Solids and floatables disposal; and • Disinfection of effluent, if necessary, to meet water quality standard, protect designated uses and protect human health, including removal of harmful disinfection chemical residuals, where necessary.	
b. “Demonstration” Approach. A permittee may demonstrate that a selected control program, though not meeting the criteria specified above, is adequate to meet the water quality-based requirements of the CWA. To be a successful demonstration, the permittee should demonstrate each of the following:	
i. The planned control program is adequate to meet water quality standards and protect designated uses, unless water quality standards or uses cannot be met as a result of natural background conditions or pollution sources other than CSOs;	
ii. The CSO discharges remaining after implementation of the planned control program will not preclude the attainment of water quality standards or the receiving waters’ designated uses or contribute to their impairment. Where water quality standards and designated uses are not met in part because of natural background conditions or pollution sources other than CSOs, a total maximum daily load, including a wasteload allocation and a load allocation or other means, should be used to apportion pollutant loads;	
iii. The planned control program will provide the maximum pollution reduction benefits reasonably attainable; and	
iv. The planned control program is designed to allow cost effective expansion or cost effective retrofitting if additional controls are subsequently determined to be necessary to meet water quality standards or designated uses.	
King County has demonstrated that the CSO control plan achieving Washington state’s performance standard of one untreated event per year per outfall will also achieve the presumptive standard of four system events per year. The County has also demonstrated that its system captures more than 85 percent of wet-weather flows and equivalent pollutants now without further control activities.	

Table 1-4. EPA CSO Control Policy Requirements for Long-term Control Plan

Requirements	Section Where County Approach is Addressed in Report
Based on water quality studies completed to date it is expected that post-construction monitoring will demonstrate that remaining untreated CSOs will not cause water quality violations.	
5. Cost/Performance Considerations	
The permittee should develop appropriate cost/performance curves to demonstrate the relationships among a comprehensive set of reasonable control alternatives that correspond to the different ranges specified in Section II.C.4. This should include an analysis to determine where the increment of pollution reduction achieved in the receiving water diminishes compared to increased costs. This analysis, often known as knee of the curve, should be among the considerations used to help guide selection of controls. *Analysis for earlier CSO control plans indicated that the knee of the curve occurred at approximately 65-percent volume control, less than that provided by the Washington state standard. The County's CSO Control Program is designed to achieve the Washington state standard.*	Section 4.2.3 and Technical Memorandum 700, Treatment Technology Selection
6. Operational Plan	
After agreement between the permittee and NDPES authority on the necessary CSO controls to be implemented under the long-term CSO control plan, the permittee should revise the operation and maintenance program developed as part of the nine minimum controls to include the agreed-upon long-term CSO controls. The revised operation and maintenance program should maximize the removal of pollution during and after each precipitation event using all available facilities within the collection and treatment system. For any flows in excess of the criteria specified at II.C.4.a.i, ii, or iii and not receiving the treatment specified in II.C.4.a, the operational plan should ensure such flows receive treatment to the greatest extent practicable. *The County's operation and maintenance program documentation is being organized to show that conveyance storage and treatment facilities are optimizing pollutant removal. The final System Operational Plan, meeting EPA requirements, will be submitted under the conditions of the expected consent decree.*	Chapter 9
7. Maximizing Treatment at the Existing Publicly Owned Treatment Works (POTW) Treatment Plant	
In some communities, POTW treatment plants may have primary treatment capacity in excess of their secondary treatment capacity. One effective strategy to abate pollution resulting from CSOs is to maximize the delivery of flows during wet weather to the POTW treatment plant for treatment. *The West Point Treatment Plant has excess primary capacity and has been approved to provide CSO treatment (equivalent to primary) for flows above the secondary capacity of 300 million gallons per day (MGD) up to 440 MGD. A "no feasible alternatives" analysis was submitted to Ecology during the last NPDES permit renewal.*	Section 3.2.4

Table 1-4. EPA CSO Control Policy Requirements for Long-term Control Plan

Requirements	Section Where County Approach is Addressed in Report
8. Implementation Schedule	
The permittee should include all pertinent information in the long-term control plan necessary to develop the construction and financing schedule for implementation of CSO controls. Construction phasing should consider: a. Eliminating overflows that discharge to sensitive areas as the highest priority; b. Use impairment; c. The permittee's financial capability including consideration of such factors as: i. Median household income; ii. Total annual wastewater and CSO control costs per household as a percent of median household incomes; iii. Overall net debt as a percent of full market property value; iv. Property tax revenues as a percent of full market property value; v. Property tax collection rate; vi. Unemployment; and vii. Bond rating. d. Grant and loan availability; e. Previous and current residential, commercial, and industrial sewer user fees and rate structures; and f. Other viable funding mechanisms and sources of financing. *Prioritization of the CSO control projects is described in Chapter 7. An affordability analysis is discussed in Chapter 8 and provided in Appendix G of this report.*	Chapter 7, Chapter 8, and Appendix G
9. Post-Construction Compliance Monitoring Program	
The selected CSO controls should include a post-construction water quality monitoring program adequate to verify compliance with water quality standards and protection of designated uses as well as to ascertain the effectiveness of CSO controls. This water quality compliance monitoring program should include a plan to be approved by the NPDES authority that details the monitoring protocols to be followed, including the necessary effluent and ambient monitoring and, where appropriate, other monitoring protocols such as biological assessments, whole effluent toxicity testing, and sediment sampling. *A post-construction monitoring plan, as required in the NPDES permit, has been submitted to Ecology and is under review. A copy of this plan is provided in Appendix H of this report.*	Section 11.4 and Appendix H

1.9 Report Outline

This report summarizes extensive work that has been completed for this review. Additional detail on that work is presented in the following technical memorandums:

- King County's Long-term CSO Control Plan Public and Regulatory Agency Participation Plan (December 2011)
- Subtask 911 – Collaborative Opportunities Planned near King County Uncontrolled CSOs Technical Memorandum (July 2011)
- Technical Memorandum, Habitat Project Opportunities (August 2010)
- Technical Memorandum 540, Environmental and Habitat Priorities (November 2010)
- Technical Memorandum 620, Cost Estimating Methodology for CSO Control Facilities (May 2011)
- Technical Memorandum 700, Treatment Technology Selection (June 2011)
- Technical Memorandum 750, Sediment Deposition and Contamination Potential from Treated CSO Discharges (January 2012)
- Technical Memorandum 810, Green Stormwater Infrastructure Alternatives (October 2011)
- Technical Memorandum 970, CSO Control Alternatives Development (October 2011)
- Technical Memorandum 1100, Project Sequence (October 2011)

The content of those technical memorandums is addressed as follows in this report:

- Chapters 1, 2, and 3 provide background information on planning and implementation of the Plan.
- Chapter 4 describes the review process and recent factors that influence CSO control planning. It identifies changes in conditions that may impact the recommended type, size, or location of proposed CSO control facilities or the priority or sequence of the 1999 Plan Amendment adopted alternatives[7] for the remaining uncontrolled CSO sites.
- Chapter 5 discusses the development and evaluation of alternatives for controlling the remaining uncontrolled CSO sites.
- Chapter 6 describes the recommended preferred alternatives, associated costs, potential risks and issues, and additional items to consider in future evaluations.
- Chapter 7 discusses proposed changes to priorities, project sequence, and schedule for implementing the recommended CSO control projects.

[7] "Alternatives" here refers to planning-level project concepts.

- Chapter 8 discusses financing the Plan and presents an affordability analysis for implementing the recommended CSO control projects for the project sequences evaluated.
- Chapter 9 describes the development and maintenance of the System Operational Plan.
- Chapter 10 summarizes the Plan and recommended amendment, including the Plan projects currently underway and the future projects proposed in the King County Executive’s Recommended CSO Control Plan.
- Chapter 11 describes the process that will follow this 2012 CSO Control Program Review Report and the King County Executive’s Recommended CSO Control Plan, including the adoption of the 2012 Long-term CSO Control Plan Amendment. This chapter also discusses implementation of the water quality assessment and monitoring study and Post-Construction Monitoring Plan.
- Appendix A presents the CSO control planning assumptions, policies, and implementation that are intended to guide the County in controlling CSO discharges.
- Appendix B describes the standard operating procedures for modeling sewers in the WTD service area, including the modeling approaches for both the combined and separated portions of the regional conveyance system. The models used for Metro/King County CSO control planning are also described, including previous versions of models and improvements made to attain the version used for this review.
- Appendix C presents a matrix titled “Summary of Review for Change in Uncontrolled CSO Basins.” This matrix lists the adopted alternatives that were presented in the 1999 Plan Amendment and identifies changes since then that triggered a need for reevaluation of adopted alternatives.
- Appendix D includes a summary of the West Point Treatment Plant flow and waste load report.
- Appendix E presents environmental characterization and prioritization that has been completed by the County to date.
- Appendix F presents a summary of the County’s public involvement activities for this review.
- Appendix G presents the County’s methodology to finance planned CSO control projects and the financial capability assessments associated with the King County Executive’s Recommended CSO Control Plan.
- Appendix H presents the Post-Construction Monitoring Plan.

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Chapter 2

History of CSO Control

Planning for CSO control is a dynamic process that must respond to changing regulations and conditions. The first CSO control plan was completed in 1979 to address CSOs into Lake Washington. The 1999 CSO Control Plan Amendment (1999 Plan Amendment) covers all CSOs in the King County system.

This chapter presents a history of CSO control planning in the County before and after adoption of the RWSP and the 1999 Plan Amendment. It also describes updates to the County's Long-term CSO Control Plan (Plan) and reviews scheduled for the near future. Figure 2-1 graphically represents this progression.

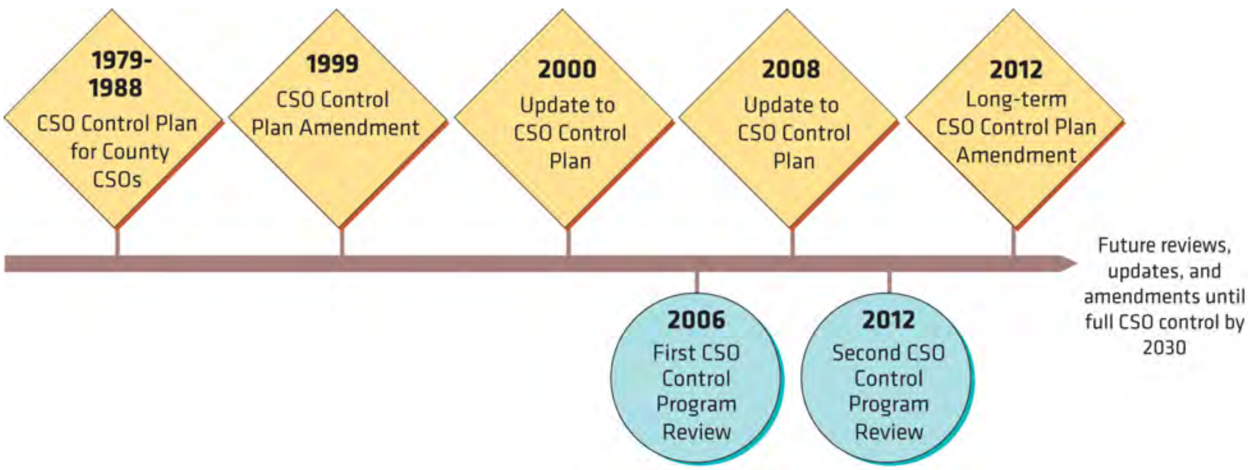

Figure 2-1. Past and Future CSO Control Planning

2.1 CSO Control Planning Prior to the 1999 Plan Amendment

Metro adopted its first CSO control program in 1979, in response to the federal Clean Water Act of 1972. Before projects in the program were fully implemented, Metro decided to integrate CSO control planning into a larger system-wide planning effort that was launched to meet new secondary treatment regulations for wastewater treatment plants.

In 1985, Metro published the integrated 1985 Plan for Combined Sewer Overflow Control. Concurrent with this planning, the state of Washington amended the Water Pollution Control Act (Chapter 90.48 RCW) to require all municipalities with CSOs to develop plans for "the greatest reasonable reduction at the earliest possible date."

In 1986, in response to Chapter 90.48 RCW, Metro issued the Supplemental Plan for Combined Sewer Overflow Control. The supplemental plan evaluated CSO control projects that would achieve 75 and 90 percent volume reductions and documented the results of upgraded computer modeling of the system.

However, in 1987, Washington state published a new CSO regulation that defined the "greatest reasonable reduction" in CSOs (Chapter 90.48 RCW) as "control of each CSO in such a way that an average of one untreated discharge may occur per year" (Chapter 173-245-020 WAC). The CSO regulation required each municipality with CSOs to submit a CSO control plan by 1988 that would specify the means of complying with the new CSO control standard and then to update the plan at the time of NPDES permit renewals, intended to occur every five years.

Metro worked with Ecology to develop a revised CSO control plan under the new regulation—the 1988 Combined Sewer Overflow Control Plan. The Plan established an interim goal of achieving a 75-percent CSO volume reduction system-wide by the end of 2005 and described additional projects intended to achieve the ultimate goal of an average of no more than one untreated discharge per year for each CSO site. To meet the 75-percent volume control target, Metro prioritized projects by overflow volume reduction.

A History of King County CSO Control Plans

1972—The Clean Water Act was established.

1979—Metro adopted its first CSO control plan.

1985 and 1986—The Plan for Combined Sewer Overflow Control and the Supplemental Plan for Combined Sewer Overflow Control were prepared integrating the CSO control plan into a system-wide planning effort

1987—Ecology defined CSO control as "control of each CSO in such a way that an average of one untreated discharge may occur per year."

1988—The 1988 Combined Sewer Overflow Control Plan was prepared to respond to the new regulation.

1995—As part of the renewal to the West Point Treatment Plant NPDES permit, King County prepared an amendment to the 1988 Plan, the 1995 CSO Control Plan Update.

1999—A major plan amendment was completed as part of the RWSP. The 1999 Plan Amendment lists 21 CSO control projects to bring all CSOs into control by 2030.

2000—The Plan was updated for renewal to the West Point Treatment Plant NPDES permit in the CSO Control Plan Year 2000 Update. No changes to the Plan were recommended.

2008—The Plan was updated for the renewal to the West Point Treatment Plant NPDES permit in the 2008 CSO Control Plan Update. No changes to the Plan were recommended.

As part of the 1995 NPDES permit renewal for the West Point Treatment Plant, Metro prepared an amendment to the 1988 Plan. The 1995 CSO Control Update assessed the effectiveness of CSO reduction efforts to date, reevaluated priorities for control of CSO sites, and identified work to be completed on three control projects in 1995–2000: Denny Way/Lake Union, Henderson Street/Martin Luther King, Jr., and Harbor CSO control projects.

2.2 CSO Control Planning in the 1999 Plan Amendment

The RWSP integrates long-range planning for all wastewater services—treatment, conveyance, biosolids reuse, CSO control, and water reuse. The RWSP outlines wastewater projects to be built between 2000 and 2030 to protect human health and the environment, serve population growth, and meet regulatory requirements. It includes the 1999 Plan Amendment, which lists 21 projects to reduce CSOs at each CSO site to one untreated discharge per year on average.

2.2.1 1999 CSO Control Planning Assumptions

Several assumptions guided the development of the 1999 Plan Amendment under the RWSP. These assumptions included conditions around which plans must be developed, such as population and the average amount of rainfall in a year, and values and practices, such as protecting human health and the environment. These assumptions, as well as changes to them since the adoption of the 1999 Plan Amendment, are listed in Appendix A of this report.

The 1999 Plan Amendment was framed by nine CSO control policies approved by the King County Council in 1999. These policies are intended to guide WTD in controlling CSO discharges and in prioritizing planned CSO control projects. These policies institutionalized several values and practices, provided guiding principles, and called for specific tasks to be done. These policies and the status of their implementation are listed in Appendix A of this report.

2.2.2 CSO Control Projects Identified in the 1999 Plan Amendment

The 1999 Plan Amendment recommended CSO control projects for each King County CSO site that was uncontrolled at that time. Those projects are referred to in this report as the adopted alternatives[1]. The adopted alternatives define the type and size of CSO control facility, potential locations, and projected year of control. Details of the adopted alternatives are outlined in the Metro CSO 5-Year Update Task 5 Report and King County CSO 5-Year Update, Task 4.0 Development of Alternatives available in the CSO Control Program website library at: http://www.kingcounty.gov/environment/wastewater/CSO/Library/PlanUpdates.aspx.

The CSO control projects were prioritized according to the CSO control policies. The projects were prioritized based on their protection of public health, the environment, and endangered species. Thus, projects at CSO sites that discharge near beaches on Puget Sound were scheduled for completion first and are currently being implemented. Table 2-1 presents the adopted alternatives in order of priority. The priorities are as follows:

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[1] "Alternative" here refers to a planning-level project concept.

- **Priority 1, CSOs near Puget Sound Beaches.** The current schedule calls for construction of the Barton, Murray, North Beach, and South Magnolia CSO control projects to begin in 2013.
- **Priority 2, University/Montlake CSOs.** These CSO sites are located at the east end of the Ship Canal. The CSO control project was given a high priority because of the high level of boating in that area, which could result in secondary contact with the water.
- **Priority 3, CSOs along the Duwamish River and in Elliott Bay.** The 1999 Plan Amendment designated that nine projects at CSO sites along the Duwamish River and in Elliott Bay be completed by 2027. These projects were given third priority because the Combined Sewer Overflow Water Quality Assessment for the Duwamish River and Elliott Bay indicated that the level of pollution originating upstream of CSOs was high enough to dwarf improvements by CSO control projects.
- **Priority 4, CSOs at the West End of the Ship Canal.** Three projects to control CSOs at the west end of the Ship Canal (Ballard, 3rd Ave W, and 11th Ave NW) are scheduled as the last projects to be completed because significant CSO control had already been accomplished in this area prior to the 1999 Plan Amendment.

Table 2-1. Adopted Alternatives in Order of Priority

Project Name	Project Description	Projected Year of Control	Water Body
S Magnolia	1.3-MG storage tank	2010[b]	Puget Sound
SW Alaska St[a]	0.7-MG storage tank	Controlled	Puget Sound
Murray Ave	0.8-MG storage	2011[b]	Puget Sound
Barton St	Pump station upgrade	2011[b]	Puget Sound
North Beach	Storage tank and pump station expansion	2011[b]	Puget Sound
University/Montlake	7.5-MG storage	2015	Lake Union/East Ship Canal
Hanford #2	3.3-MG storage/treatment tank	2017	Duwamish River
Lander St	1.5-MG storage/treatment at Hanford	2019	Duwamish River
S Michigan St	2.2-MG storage/treatment tank	2022	Duwamish River
Brandon St	0.8-MG storage/treatment tank	2022	Duwamish River
Chelan Ave	4-MG storage tank	2024	Duwamish River
Kingdome (formerly Connecticut St)	2.1-MG storage/treatment tank	2026	Elliott Bay
King St	Conveyance to Connecticut Street treatment	2026	Elliott Bay
Hanford #1 (Hanford@Rainier)	0.6-MG storage tank	2026	Duwamish River

Project Name	Project Description	Projected Year of Control	Water Body
8th Ave S	1.0-MG storage tank	2027	Duwamish River
W Michigan St	Conveyance upgrade	2027	Duwamish River
Terminal 115	0.5-MG storage tank	2027	Duwamish River
3rd Ave W	5.5-MG storage tank	2029	West Ship Canal
Ballard	1.0-MG storage tank (40% King County)	2029	West Ship Canal
11th Ave NW	2.0-MG storage tank	2030	West Ship Canal

a. Updated monitoring and modeling data indicate that the SW Alaska St CSO site is already controlled; thus, the project is no longer needed.

b. In the 1999 Plan Amendment, the Barton St, Murray Ave, North Beach, and S Magnolia CSO control projects were scheduled to be completed in 2010 or 2011. They are now scheduled to be completed in 2015.

2.3 CSO Control Program Review and Plan Updates

2.3.1 2000 CSO Control Plan Update

The 2000 CSO Control Plan Update was included in the June 2000 submission to Ecology of the West Point Treatment Plant NPDES permit renewal application. The update did not recommend any changes to the 1999 Plan Amendment, which was amended only six months before as part of the RWSP.

The 2000 CSO Control Plan Update described King County's progress in implementing its CSO Control Program, documented its compliance with federal and state CSO control requirements, and identified two large CSO control projects—Denny Way/Lake Union and Henderson/Martin Luther King, Jr./Norfolk—for completion in the next five-year NPDES permit cycle.[2]

The update also identified concerns related to historically contaminated sediments near CSO discharge locations; identified some emerging technologies to be considered during predesign of future CSO control projects; and discussed new studies, initiatives, and regulations that affect CSO planning and control. It highlighted the potential impacts of new regulations that could be adopted to meet the requirements of the ESA and to address contaminated sediment concerns.

[2] Both of these projects were completed in May 2005. The remainder of this report uses the names for the completed systems—Mercer/Elliott West and Henderson/Norfolk—rather than the project names.

2.3.2 2006 CSO Control Program Review

To conduct the 2006 CSO Control Program Review, King County staff assessed information generated since adoption of the 1999 Plan Amendment. The review reaffirmed the 1999 Plan Amendment priorities of protecting public health, the environment, and endangered species that shaped the development of the CSO Control Program and the adopted alternatives.

The results of the 2006 CSO Control Program Review were incorporated into the 2008 CSO Control Plan Update.

2.3.3 2008 CSO Control Plan Update

The 2008 CSO Control Plan Update was included in the June 2008 submission to Ecology of the West Point Treatment Plant NPDES permit renewal application. The update described the following:

- King County's progress in implementing its CSO Control Program, its compliance with federal and state CSO control requirements, and CSO control projects in design and construction. The SW Alaska project was removed from the list of Puget Sound Beach projects because CSO monitoring showed it to be controlled. The four remaining CSO sites associated with the Puget Sound Beach projects (S Magnolia, North Beach, Barton St, and Murray Ave) and replacement of the Ballard Siphon were in design.
- The CSO Treatment Technology Pilot Program and other projects. The CSO treatment technology pilot began in 2007. The objective was to test several promising high-rate sedimentation technologies that lacked operational data. Results would be incorporated into the next program review technology assessment to determine if conventional primary CSO treatment should be replaced with a high-rate sedimentation technology.
- A sediment cleanup, initiated in 2001 for the Lower Duwamish Waterway.
- A review of environmental studies, which concluded that the priorities for the CSO control projects listed in the 1999 Plan Amendment were still appropriate.

2.3.4 2012 CSO Control Program Review

The purpose of the 2012 CSO Control Program Review is to update the CSO Control Program priorities, assumptions, and other factors shaping control needs, and recommend an amendment to King County's Plan to meet current conditions if determined necessary. The goal is to select CSO control alternatives that optimize and balance environmental, social, and financial goals to meet current needs, while protecting future opportunities. The review has considered updated scientific information, system hydraulic modeling, changes in applicable regulations, new technologies, coordination opportunities with other agency projects and regional initiatives, and current public opinion about CSO control. Where changed conditions indicated the need for amendments to the 1999 Plan Amendment, changed elements have been developed and proposed.

This review lays the foundation for the County to develop its 2012 Long-term CSO Control Plan Amendment for Ecology and EPA, which is now expected to be submitted in the fall of 2012, ahead of the next West Point Treatment Plant NPDES permit renewal application. The County has completed this review; this document and supporting appendices report the findings and recommendations. The technical memorandums supporting the review and recommendations can be found at:
http://www.kingcounty.gov/environment/wastewater/CSO/ProgramReview/Plan.aspx#techmemos.

2.4 Additional Planning and Environmental Review

King County evaluates and performs any required environmental review of all proposed programs and project alternatives. The current CSO Control Program was presented and evaluated as part of a programmatic review in the RWSP and Draft and Final Environmental Impact Statements. Environmental review for this Program Review and 2012 Long-term CSO Control Plan Amendment is discussed in Chapter 11. As individual CSO control projects are designed, project-specific environmental review of alternative designs for facilities and the impacts of constructing and operating those facilities will occur. The type of environmental review may range from a State Environmental Policy Act (SEPA) Environmental Checklist and Determination of Non-Significance to a National Environmental Policy Act (NEPA) Determination of Significance and Environmental Assessment and ESA Section 7 review.

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Chapter 3
King County's Current CSO Control Program

King County's current CSO Control Program is based on the 1999 Plan Amendment and was last updated in 2008. The County has made significant progress in controlling CSOs during the past two decades. This chapter describes the current CSO Control Program including how computer modeling and direct measurement are used to determine CSO frequency and volume, the County's approach to controlling CSOs, the baseline used for measuring progress; and summarizes the CSO Control Program's effectiveness.

3.1 Measuring Progress in CSO Control

The definition of the control performance standard, how progress is measured, and the control methods currently used in King County's CSO Control Program are described in the following section.

3.1.1 Ecology's CSO Control Performance Standard

The renewed NPDES permit for the West Point Treatment Plant, effective July 1, 2009, implemented a new interpretation of the performance standard for CSO control derived from the state regulatory requirements for "greatest reasonable reduction" as specified in WAC 173-245-022(22). The standard of "an average of one untreated discharge may occur per year" is now based on a 20-year moving average. The average of the number of untreated discharges for each CSO site in each of the previous 20 years is calculated each year to assess compliance with the performance standard for CSOs identified as controlled.

3.1.2 Defining an Overflow Event

A CSO event is defined by the length of the dry period between overflows (the inter-event interval). Discharges are defined as one event, even if they start and stop several times during a storm, as long as the length of time between each discharge is less than the required inter-event interval. The County, in consultation with Ecology, developed and used a 48-hour inter-event interval for the 1999 Plan Amendment modeling, based on its analysis of local rainfall and the wastewater system's response to that rainfall.

Over the years, the inter-event interval used to define a CSO event has changed from 3 hours (1986–1995), to 48 hours (1995–2000), to 24 hours (2000 to present). The change to the 24-hour definition from the 48-hour definition resulted when Ecology decided to apply a single definition for all CSO agencies in the state. This definition of an event reflects the expectation that overflows resulting from a single rainstorm should count as only one overflow. Figure 3-1 gives an example of how events are determined based on a 24-hour inter-event interval.

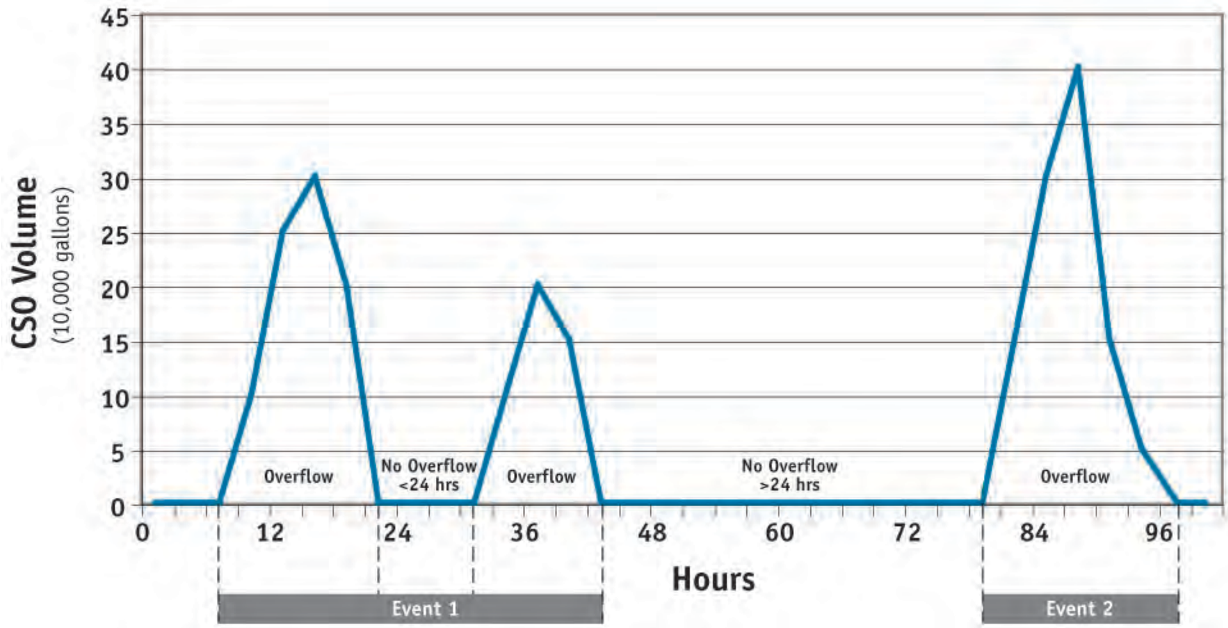

Figure 3-1. Example of Defining CSO Events Using a 24-Hour Inter-Event Interval

3.1.3 CSO and Rainfall Monitoring

King County uses flow monitoring to help assess the frequencies and volumes of CSOs. Monitoring consists of directly measuring overflows with flow meters or measuring the depth or flow level in a pipe with a known geometry and then using the data to calculate flow values.

The County continuously monitors the frequency and volume of overflows at locations where flow control occurs within the wastewater system, such as at regulators or pump stations. Portable monitors, which must be manually downloaded at set time intervals, are used at other locations. Data collected from monitoring actual overflows as they occur is used to determine compliance with Ecology regulations.

CSO Monitoring and Modeling

Flow Monitoring—A combination of flow monitors and a computerized control system tracks the frequency and volume of CSO events.

Modeling—Computerized modeling programs use flow monitoring data and other data, such as rainfall patterns, to predict system behavior and plan for future CSO control facilities

The County measures rainfall at 12 rain gauges maintained across the West Point System. Rainfall duration and quantity is reported for each CSO event from the nearest gauge. Rain gauge data from the City of Seattle and Sea-Tac Airport are also considered in calibrating the hydraulic model. This is described in the Hydraulic Modeling and Monitoring Protocols presented in Appendix B.

3.1.4 CSO Modeling

Because overflows vary with the pattern of rainfall from year to year, it is difficult to use monitored data to assess system capacity and progress in CSO control. One way to achieve consistency is to use a computer model to estimate the average frequency and volume of overflows that would occur under actual rainfall patterns in the service area measured over many years.[1] Modeled data is compared to monitoring data, so that the model is calibrated to provide more accurate predictions for use in CSO Control Program planning and facility design.

WTD uses computer models to simulate stormwater and wastewater flow contributions to the combined sewer system under various conditions. These simulations, combined with field data and engineering judgment, are used in the design and operation of facilities, such as CSO control facilities. The models that WTD has used over the past 30 years are described in Appendix B. The Hydraulic Modeling and Monitoring Protocols are also presented in Appendix B.

For the 1999 Plan Amendment, the types and sizes of CSO control projects were determined using a storm scenario ("design storm") to predict average CSO frequencies and volumes. The design storm represented a storm of a specified volume, duration, and intensity that occurs once per year on average. King County currently uses a "continuous simulation model" that is based on historical long-term rainfall patterns. The continuous simulation model more realistically simulates rainfall variability than previous "event-based" models and provides better long-term predictions of CSOs.

The County completed a 32-year continuous-simulation model run of its combined sewer system for this review in October 2010. The work associated with the October 2010 model run is described in Section 4.2.2 of this report.

3.2 CSO Control Approaches

The CSO Control Program's current approaches to CSO control can be generally categorized as operational controls, CSO treatment, pollution prevention through source control, and implementation of EPA's Nine Minimum Controls. The sections below describe these general approaches.

[1] King County rain gauges indicate that the long-term annual average rainfall in the wastewater service area is 37 inches.

3.2.1 Operational Controls

Operational controls maximize the use of existing conveyance systems and facilities through active management of the facilities. This often includes controls that dynamically operate gates and weirs in response to field measurements of flows and levels. This process directs flows to parts of the system with spare capacity, thus reducing or eliminating CSOs. Maximizing flows in the existing conveyance system requires a thorough understanding of the wastewater conveyance system and how it functions during wet weather. This approach frequently includes a concurrent assessment of the conveyance system and treatment plant operations, so that increased flows do not have adverse consequences, such as back-ups within the system or at the treatment plant.

Since the early 1970s, one of King County's major tools in achieving CSO control has been a Supervisory Control and Data Acquisition (SCADA) system—the County called the original proprietary system CATAD (computer augmented treatment and disposal). The current SCADA system monitors rainfall and conditions in major pipelines and then adjusts in-line regulator gates and pump speeds when flows reach predetermined "set points." The automatic control of the regulator stations significantly reduces CSOs by maximizing storage during a storm and then conveying the flows to the West Point Treatment Plant for treatment when the storm subsides. When needed, the automatic controls can be overridden by experienced certified operators at the West Point Treatment Plant main control center.

The County continually modifies the SCADA system to take into account advances in computer modeling, to incorporate more recent field data, and to reflect modifications to the wastewater system. For example, in 1992, storage levels behind regulator stations were raised to improve the capture of CSOs. SCADA system hardware and software at the West Point Treatment Plant were replaced with a new system to bolster the reliability of monitoring and control of offsite regulator and pump stations. The new hardware includes enough capacity to install and run an optimization and decision support program.

In 2003, WTD embarked on a division-wide effort to improve its operations by developing instrumentation and control standards that would be applied to all of its existing facilities. After developing the standards, Ovation™ by Emerson Process Management was selected as the control system. The control system was designed to enable regional monitoring of pump stations feeding the County's treatment plants, control of processes at each of the treatment plants, and remote and unattended operation of the Brightwater Treatment Plant from the South Treatment Plant at night and during weekends. It is installed to match plant process redundancies, which allow process units to be taken out of service for maintenance without affecting large portions of plant operations. The Brightwater Treatment Plant was designed and constructed using the Ovation control system and Rockwell ControlLogix programmable logic controllers (PLCs). The South Treatment Plant and West Point Treatment Plant are undergoing projects to install the system. It is anticipated that the South Treatment Plant will be on the Ovation control system by the end of 2013, and the West Point Treatment Plant by the end of 2015.

Each treatment plant has offsite conveyance and pump stations that feed flows to the plant. PLC-based control systems at these offsite facilities are connected to the Ovation control system to monitor and, in some cases, control the flow in order to optimize conveyance to the plant for treatment and the use of system storage capacity. In the West Point system this will minimize

CSOs. Critical alarms and process data are communicated to the plant operators using monitoring systems that report data in independent communication pathways from the control system.

The County installed the OSI PI™ process data historian for long-term trending of all key WTD process, operational, and monitoring data (treatment plants, conveyance facilities, CSO control facilities, and offsite pump stations). The system has been in service since 2005.

3.2.2 CSO Treatment

CSO Treatment at West Point Treatment Plant

The West Point Treatment Plant treats some flows that would otherwise discharge at CSO sites. The plant provides CSO treatment for flows between 300 million gallons per day (MGD) and the peak hydraulic capacity of 440 MGD. A "no feasible alternatives analysis" that documents the rationale for continuing this practice was submitted to Ecology for the 2009 NPDES permit renewal. It was approved by Ecology.

The Elliott West CSO Treatment Facility was designed to be the first storage facility to drain when the West Point Treatment Plant has capacity. It also drains when the West Point Treatment Plant is providing full and stable secondary treatment to ensure that necessary solids removals are being provided; this was determined to be when flows are down to 250 MGD. The remaining CSO storage facilities—those resulting from King County projects and City of Seattle projects—that drain to the West Point Treatment Plant will do so after the Elliott West CSO Treatment Facility, receiving full secondary treatment.

Satellite CSO Treatment

King County runs satellite treatment facilities that provide CSO treatment to flows in excess of the capacity of the existing conveyance system. A goal of CSO treatment is to discharge while meeting water quality standards at the edge of applicable mixing zones. A CSO treatment facility must at least provide equivalent to primary treatment and disinfection. A combination of treatment processes may be used to achieve required levels of treatment. High-rate sedimentation processes can be used to provide treatment at rates much higher than can be achieved with conventional primary treatment. Such facilities generally are sited at the shoreline near the outfall. This option requires ongoing sampling and analysis to demonstrate adequate pollutant removal for regulatory compliance: removal of settleable solids and floatables and inactivation of microorganisms.

The County operates four satellite CSO treatment facilities. The Alki and Carkeek CSO Treatment Plants are former primary treatment plants that were converted to CSO treatment facilities after completion of projects to transfer their base flows to the West Point Treatment Plant. These facilities provide storage, primary sedimentation, and disinfection of wet-weather flows during storms. Sodium hypochlorite is used for disinfection; both facilities dechlorinate flows before discharge. The Elliott West and Henderson/MLK CSO Treatment Facilities provide storage and primary treatment in a tunnel and chlorinate (using sodium hypochlorite) and dechlorinate flows before discharge. Details on the operation of county CSO treatment facilities are included in the CSO Control Program 2010 Annual Report. The 2011 Annual Report will be available July 31, 2012 on the County's website at: http://www.kingcounty.gov/environment/wastewater/CSO/Library/AnnualReports.aspx.

3.2.3 Pollution Prevention and Source Control

CSO control strives not only to reduce the volume and frequency of discharges but also to prevent pollutants from entering the combined sewer system and discharging to receiving waters via CSOs. King County's pollution prevention and source control efforts include the Local Hazardous Waste Management Program and the Industrial Waste Program.

WTD administers the multi-agency Local Hazardous Waste Program and funds 17-percent of the program. The goal of the program is to reduce the quantities of hazardous waste generated by households and small businesses and divert these wastes from municipal waste streams and indiscriminate disposal in the environment. Program services include household hazardous waste education and collection; small business education, technical assistance, and compliance assistance; small quantity generator collection and waste handling; an industrial materials exchange; and a hazardous waste library.

The Industrial Waste Program administers the County's industrial waste regulations for local businesses that discharge industrial wastewater to the county sewer system. The County establishes local discharge limits; specific industries are subject to federal pretreatment requirements. Program activities include administration of waste discharge permits, inspections, enforcement, sample collection to determine compliance, and collection of surcharge and monitoring fees. The County also participates in pollution source control activities as part of the Industrial Waste Program, which include the Lower Duwamish Waterway and East Waterway areas. The pollution source control activities are described in the sections below. Additional information can be found in Section 3.2.4 of this report on the EPA Nine Minimum Controls.

Lower Duwamish Waterway Pollution Source Control Activities

EPA listed the Lower Duwamish Waterway as a Superfund site in 2001 because of the presence of contaminated sediments. Before these sediments can be cleaned up, ongoing sources of contaminants must be controlled.

To improve the Lower Duwamish Waterway's health, King County is working with the community to identify and control the sources of pollution that may pose health or environmental problems if they accumulate in the Lower Duwamish Waterway sediments. The goals of the program are to help businesses and property owners meet regulatory obligations and correct issues including hazardous waste storage, spill containment, and removal of potential contaminant sources.

Since 2007, the Industrial Waste Program has been working with other agencies to conduct pollution source control inspections at Lower Duwamish Waterway businesses as part of the Urban Waters Initiative, an interagency coordination effort of Ecology. The initiative provides increased resources to speed up pollution reduction efforts to benefit the waters, sediments, and human and marine inhabitants of the Lower Duwamish Waterway.

The size of this industrial area makes source control challenging. Ecology leads the Source Control Work Group that includes the U.S. Environmental Protection Agency, Seattle Public Utilities (SPU), the King County Industrial Waste Program, the Port of Seattle, the Puget Sound Clean Air Agency, and the City of Tukwila. This group meets monthly to coordinate source control efforts and make it easier for businesses to identify and control pollutant sources. The group's first priority is to address the early action areas identified for sediment cleanup. The group is working on controlling sources of contaminants that may pose health or environmental problems if they accumulate in waterway sediments. More information is available on the group's website at: http://www.ldwg.org/.

Between 2003 and 2006, the County and the City of Seattle, as operators of the local sanitary sewer and stormwater drainage systems, have worked together to inspect more than 1,000 Lower Duwamish Waterway businesses to reduce the amount of pollutants discharged to the Lower Duwamish Waterway. Staff from the following agencies participated in these inspections: the King County Industrial Waste Program, the Local Hazardous Waste Management Program in King County, SPU, Public Health—Seattle and King County, and Ecology.

East Waterway Pollution Source Control Activities

King County is participating in source control activities at the Harbor Island Superfund Site's East Waterway Operable Unit because of the County's CSO discharges to the East Waterway. Since 2008, the King County Industrial Waste Program has participated as a part of a source control technical team, including the Port of Seattle and the City of Seattle, to plan and implement source control activities including business inspections and source control sampling. Currently, the main areas of King County Industrial Waste Program activity include: sediment sampling for CSO characterization, additional sampling for source tracking, ongoing inspections of industrial wastewater dischargers, and assessment of potential sampling sites. Inspections are being conducted as a part of Ecology's Urban Waters Initiative.

3.2.4 EPA CSO Control Policy Nine Minimum Controls

EPA's Nine Minimum Controls were developed to provide early and relatively inexpensive actions to improve water quality without having to wait for completion of more expensive capital projects. When they were published, the Nine Minimum Controls packaged and codified elements, including CSO-specific elements, contained in the operations and maintenance programs of well-run wastewater management programs. Most of them were already standard practice in the King County system. The County's programs and activities in regard to each of the Nine Minimum Controls are as follows:

- **Control 1. Reducing CSOs Through Operation and Maintenance—**Implement proper operation and maintenance programs for the sewer system and all CSO outfalls to reduce the magnitude, frequency, and duration of CSOs. The program must consider regular sewer inspections; sewer, catch basin, and regulator cleaning; equipment and sewer collection system repair or replacement, where necessary; and disconnection of illegal connections.
  - Facility operation is managed by West Point Treatment Plant staff using a SCADA system, which provides monitoring and control capabilities for the treatment plant collection systems. Asset management programs implemented by West Point Treatment Plant, South Treatment Plant, and collection system staff maintain CSO outfalls, regulator stations, and pump stations. Collection system staff inspect sewers on a specified schedule and perform corrective actions when deficiencies are found. Maintenance schedules and records of visits are available for inspection on request.
  - The County is also analyzing the future effects of sea-level rise and the increase in saltwater intrusion based on higher sea levels as a result of climate change. Future CSO control projects will incorporate sea-level rise into facility design.
  - Saltwater and sand that enter the system can cause corrosion and consume capacity. In 2007−2009, meters were installed to better identify areas of intrusion during high tide cycles in dry-weather months, to assess the extent of the problem, and to develop a plan to address it. Data were analyzed in 2010, and a report was completed in 2011.
  - A review indicated that installing permanent backup generators in pump stations that lack reliable dual power feeds could help prevent overflows. The installation process is nearing completion. The last two generators will be installed at Barton and Murray Pump Stations as part of a pump station upgrade project (Barton) and CSO control projects (Murray).
  - The County's Asset Management Program expanded its use of asset management tools, including a more robust standardized inventory system and condition rating systems, and is developing long-range asset replacement and renewal forecasts, including action plans, to avoid failure of critical assets. An update to WTD's 2005 strategic asset management plan was completed in 2010.
- **Control 2. Storing CSOs in the Collection System—**Implement procedures that will maximize use of the collection system for wastewater storage that can be accommodated by the storage capacity of the collection system in order to reduce the magnitude, frequency, and duration of CSOs.
  - Under normal and expected conditions, the SCADA system automatically operates the wastewater system based on programmed level set points and action sequences. Levels in pump station wet wells and at other key points in the conveyance system trigger changes in pump speeds and adjustments of gate positions at pump, regulator, and outfall stations. These adjustments can change the rate and direction of flow through the pipes and optimize storage of flows in the conveyance system. The set points are reviewed when the hydraulic model is recalibrated and when other information suggests that more efficient use of the collection system may be possible.

   - The Plan emphasizes collection system storage projects for CSO control. This emphasis is intended to maximize flow volumes from the combined sewer system that receive secondary treatment at the West Point Treatment Plant.

- **Control 3. Optimizing Pretreatment Program—**Review and modify, as appropriate, the existing pretreatment program to minimize CSO impacts from the discharges from nondomestic users.
   - The County's Industrial Waste Program issues approvals that set limits on the chemical contents of industrial discharges. The program includes monitoring and permit enforcement, education, and technical assistance to businesses on appropriate waste pretreatment and disposal techniques. Local discharge limits are reviewed on a regular basis according to Ecology requirements. The County submits an annual pretreatment report to Ecology detailing education, permitting, monitoring and inspections, and enforcement actions taken during the year.
   - The County administers and helps fund the Local Hazardous Waste Management Program. The Program works to protect and enhance public health and environmental quality in the County by reducing the threat posed by the production, use, storage, and disposal of hazardous materials.
   - Influent quality at the West Point Treatment Plant is assessed for trends that would suggest concurrent changes in CSO discharges. In addition, biosolids quality data from the West Point Treatment Plant are tracked as an indicator of changed loading to the system that could influence CSO quality. The only trends seen are the slow decrease or stability in pollutant concentrations.
   - The County is currently conducting a pollutant analysis to more fully characterize industrial discharges. The results of the analysis will be submitted for the next NPDES permit renewal in 2014.

- **Control 4. Maximizing Flow to Treatment Plant—**Operate the treatment plant at maximum treatable flow during all wet-weather flow conditions to reduce the magnitude, frequency, and duration of CSOs. Deliver all flows to the treatment plant within the constraints of the treatment capacity of the plant.
   - SCADA is used to maximize flow to the secondary treatment plants via operation of regulator and pump stations. The West Point Treatment Plant provides secondary treatment for all base flows (defined by Ecology as 2.25 times the average wet-weather flow (AWWF)) and CSO/primary treatment for flows between 300 MGD and the peak hydraulic capacity of 440 MGD. After receiving primary treatment, CSO flows are mixed with secondary effluent for disinfection, dechlorination, and discharge from the deep marine outfall. The resulting effluent must meet secondary effluent quality limits, with a small reduction in total suspended solids (TSS) percent removal requirements—80 percent removal instead of 85 percent. Ecology permits this treatment and discharge as a "CSO-related bypass."
   - Up to 24 MGD of combined flows are conveyed to the South Treatment Plant from southeast Seattle to receive full secondary treatment. This conveyance minimizes CSOs to the Duwamish River along the Elliott Bay Interceptor.

- Treatment process stability is monitored and optimized to manage flows based on information from automatic sensors and a battery of analytical tests. Process control laboratories at each plant conduct the testing and analysis and then recommend adjustments to the processes if necessary.
- All analyses for CSO control project alternatives include storage and transfer to the secondary and CSO treatment plants.

- **Control 5. Preventing Dry-Weather Overflows—**Dry-weather overflows from CSO outfalls are prohibited. NPDES permit-holders must report each dry-weather overflow to the permitting authority as soon as it becomes aware of the overflow. When it detects a dry-weather overflow, the permit-holder must begin corrective action immediately and inspect the dry-weather overflow each subsequent day until it has eliminated the overflow.
  - The County's CSOs do not occur as a result of inadequate dry-weather flow capacity. The County provides enough capacity in the combined sewer system to transfer 2.25 times the average wet-weather flow to secondary treatment, as negotiated with Ecology. The only overflows seen in the combined sewer system during dry weather result from problems such as power outages, mechanical failures, or human error. These events are rare and are immediately reported to Ecology.
  - Operation and maintenance programs, as described for Control 1, focus on preventing dry-weather overflows and exacerbated CSOs (CSOs that occur during precipitation but are worsened by mechanical failures, power outages, and human error). The conveyance system is monitored through SCADA and direct observation; corrective action is taken immediately if a problem occurs. Equipment problems are immediately reviewed, and repair or replacement is undertaken in a timely manner.
- **Control 6. Controlling Solids and Floatables—**Implement measures to control solid and floatable materials in CSOs.
  - The County engages in the following practices to control solids and floatables:
    - Capturing the "first flush" (maximizing flow to treatment plants), so that most solids and floatables that do enter the sewer are conveyed to the plant for removal and disposal before pipelines reach overflow conditions.
    - Constructing facilities with gates and weirs that retain and minimize the release of solid and floatable materials. Gates are set to maximize flow containment. Baffles are used in front of weirs to help hold back all but the smallest items in the flow that passes over them.
    - Coordinating with the City of Seattle on measures to reduce the washing of street solids and trash into sewers via stormwater and to promote proper disposal of household trash, so that it is not flushed down toilets.
      - → The City's catch basin maintenance program limits the introduction of floatable materials to sewers.
      - → The County developed an information campaign with brochures, TV spots, and a webpage to educate the public that trash should not be

flushed to the sewers. The brochure and webpage (www.kingcounty.gov/environment/wtd/Education/ThingsYouCanDo/Keepwaterclean/Trash.aspx) are offered in English and five other languages.

- □ Building CSO control projects, so that floatables and solids are retained in the sewer.
- □ Encouraging wise water use to reduce unnecessary flows in the sewer that contribute to overflows.
- □ Monitoring the development of new floatable control technologies.

– Observations of the quantity of floatables are noted in logs at each facility and are available for inspection on request. These observations have indicated that additional floatables and solids controls are not needed at this time. Under EPA order, the County began a three-year project in 2009 to observe the floatables in water bodies near nine CSO sites within four hours of an overflow. Observations are compared to photos of each area during summer non-overflow periods. If additional floatables control is found to be needed in the future, the needs will be addressed in the CSO control projects implemented under the County's Plan. The report for the second year was submitted to Ecology and EPA in July concurrent with the 2010 annual report.

- **Control 7. Preventing Pollution—**Implement a pollution prevention program focused on reducing the impact of CSOs on receiving waters.

  – The County has implemented the Industrial Waste Program and has been a major participant in the Local Hazardous Waste Management Program. Both programs serve to reduce discharge to sewers of chemicals and other substances that adversely impact the environment and the wastewater treatment process.

  – The Industrial Waste Program limits the discharge of fats, oil, and grease (FOG) from a petroleum or mineral origin (nonpolar FOG) to 100 milligrams per liter. Industries must use oil/water separators to pretreat oily wastewater to prevent harm to the biological phase of wastewater treatment and must submit plans for the separators to the local sewer utility or to the Industrial Waste Program for review and approval before installing the separators. FOG from an animal or a vegetable origin (polar FOG) can block sewer lines. Although polar FOG has no numerical limit, dischargers are required to minimize free-floating polar FOG and may be required to complete a FOG control plan for the Industrial Waste Program's review and approval.

  – The County also prohibits discharge to the sewer of materials such as ashes, sand, grass, and gravel. Industrial wastewater must contain less than 7 milliliters per liter of solids capable of settling. Food waste, including food-grinder waste, must be capable of passing through a 0.25-inch sieve.

  – Educational materials on controlling trash disposal to sewers are a part of the larger public information program.

- **Control 8. Notifying the Public—**Implement a public notification process to inform the citizens of when and where CSOs occur. The process must include (a) mechanism to alert persons of the occurrence of CSOs and (b) a system to determine the nature and duration of conditions that are potentially harmful for users of receiving waters due to CSOs.

- The County operates a CSO Notification and Posting Program as a joint project with the City of Seattle and Public Health–Seattle & King County. This program includes the posting of signs at publicly accessible CSO locations, an information phone line, websites, a brochure, and other public outreach activities.
- A website providing notification of recent and current CSO discharges went live in December 2007 (www.kingcounty.gov/environment/wastewater/CSOstatus.aspx). In April 2011, the County completed the process to incorporate city real-time overflow information on this site. The webpage presents overflow status for both city and county CSO sites with links to and from each agency's independent website. The community now has access to consolidated information to assist in making choices about use of local waters. Outreach for the joint notification site is being led by the City commencing in summer 2011. An automated e-mail notification system for county CSOs continues to be tested.
- Ongoing community involvement programs help to keep the public informed of CSO-related conditions. Throughout 2010, communities near the Puget Sound Beach projects were actively involved in the decisions for those projects. County staff also solicited input on this review from a wide variety of stakeholders during the year. The public will be given ample opportunity in 2011 to comment on recommendations resulting from the review.

- **Control 9. Monitoring CSO Outfalls—**Monitor CSO outfalls to characterize CSO impacts and the efficacy of CSO controls. This must include collection of data that it will use to document the existing baseline conditions, evaluate the efficacy of the technology-based controls, and determine the baseline conditions upon which it will base the long-term control plan.
  - All county CSOs are monitored for frequency and volume—most using a SCADA system, but a few with portable monitors that must be downloaded manually at intervals. This data is submitted to Ecology monthly and is available in the County's CSO Annual Reports to Ecology—available on-line at www.kingcounty.gov/environment/wastewater/CSO/Library/AnnualReports.aspx. The volume and frequency baseline was set in 1981-83 and is included in Table 3-3.
  - In 1986, the County began a sampling program to characterize each CSO and identify high priority sites for early control. The program included collecting overflow quality data for five CSO sites per year and collecting sediment samples at each site. In the 1990s, sampling was expanded to assess compliance with state Sediment Management Standards. The County's extensive monitoring for its 1999 CSO Water Quality Assessment of the Duwamish River and Elliott Bay found that the majority of risks to people, wildlife, and aquatic life would not be reduced by removal of CSOs because most risk-related chemicals come from sources other than CSOs.
  - Under the renewed NPDES permit for the West Point Treatment Plant, the County developed the Comprehensive Sediment Quality Summary Report for CSO Discharge Locations (December 2009; www.kingcounty.gov/environment/wastewater/CSO/

Library/SedQualSum.aspx)—including a downloadable data file of all CSO and sediment data—and a draft CSO post-construction monitoring plan (submitted July 2010 and discussed in Section 11.4 of this report). The County will submit ambient monitoring data near CSO treatment facility outfalls by June 30, 2013, and will implement additional sediment sampling if required by Ecology.

3.3 Projects to Control CSOs

Projects implemented to directly or indirectly achieve CSO control have reduced the CSO volume from 2,339 million gallons per year (1981-1983 for Ecology planning) to 808 million gallons per year in 2010—a 64-percent reduction since the 1980s. Table 3-1 lists CSO control projects that have been completed or are currently underway. Table 3-2 lists projects done primarily for other reasons, but with CSO control benefits.

Table 3-1. CSO Control Projects Completed or Underway

Project	Description	Year Completed	Status
Ft. Lawton Tunnel	Parallel tunnel to West Point Treatment Plant to provide greater transfer capacity.	1991	Completed.
SCADA (also called CATAD) System Improvements	Improvements to the system that controls flows and maximizes storage in pipelines.	Ongoing	Offsite PLCs have been replaced, SCADA system is being updated to Ovation. After the control system upgrade, options for control enhancements and operator decision support will be evaluated.
Hanford/Bayview w/ Lander Separation & Storage	Partial separation of the Lander and Hanford basins, and reactivation of Bayview Tunnel. (Joint project with the City of Seattle.)	1992	Remaining control will occur under the Plan. Lander stormwater management is ongoing.
Carkeek Transfer/CSO Treatment	Transfer to West Point Treatment Plant of flows up to 9.2 MGD from the Carkeek drainage basin. Treatment of flows above 9.2 MGD at the Carkeek CSO Plant.	Online in 1994; upgrades in 2005; dechlorination began in 2006	Completed.
University Regulator/ Densmore Drain	Separation of Densmore & I-5 stormwater, as well as Green Lake drainage.	1994	Remaining control will occur under the Plan. Densmore stormwater management is ongoing.
Kingdome Industrial Area Storage & Separation	Installation in 1994 of a storage pipeline in conjunction with Seattle and Washington State Department of Transportation (WSDOT) street projects. In 1999, the Public Facilities District (PFD) completed separation between Alaskan Way and 3rd Ave. in conjunction with Safeco Field construction.	1994; 1999	Remaining control will occur under the Plan.

Table 3-1. CSO Control Projects Completed or Underway

Project	Description	Year Completed	Status
Harbor Pipeline	Installation of a pipeline that conveys excess flow from the Harbor regulator to the West Seattle Tunnel for storage.	1996; activated in 2000/01	Completed.
Alki Transfer/CSO Treatment	Transfer to the West Point Treatment Plant of flows up to 18.9 MGD from the Alki drainage basin via the West Seattle Tunnel. Treatment of flows above 18.9 MGD at the Alki CSO plant.	1998; dechlorination began in 2006	Completed.
63rd Ave. Pump Station	Diversion of excess flow to the West Seattle Tunnel or Alki CSO Plant.	1998	Completed.
Denny Way/Lake Union	Storage and primary treatment of Lake Union flows in the Mercer Tunnel with screening, disinfection, and discharge at Elliott West.	2005	Completed (completed system is called Mercer/Elliott West.)
Henderson/MLK/ Norfolk	Storage, primary treatment, and disinfection of Henderson and MLK flows in the Henderson Tunnel; transfer of flows to secondary treatment plants; discharge of excess treated CSOs at Norfolk.	2005	Completed (completed system is called Henderson/ Norfolk.
Barton Street CSO Control Project	Construction of green stormwater infrastructure (GSI) in the Sunrise Heights and Westwood neighborhoods in West Seattle to reduce the amount of peak stormwater flows that would enter the combined sewer system by up to 15 million gallons per day.	2015	Project is currently in design, with construction scheduled for 2013-2016.
Murray Ave CSO Control Project	Construction of an underground storage tank beneath private property across the street from Seattle's Lowman Beach Park. This facility will store approximately one million gallons of peak flows when the Murray Pump Station reaches maximum capacity.	2014	Project is currently in design, with construction scheduled for 2013-2016.
South Magnolia CSO Control Project	Construction of an underground storage tank in the Smith Cove Park/West Yard area south of the Magnolia Bridge. This facility will store approximately 1.8 million gallons of peak flows when the South Magnolia trunk line reaches maximum capacity.	2014	Project is currently in design, with construction scheduled for 2013-2016.
North Beach CSO Control Project	Construction of an underground storage pipeline in the right-of-way of NW Blue Ridge Drive and Triton Drive NW. This facility will store approximately 230,000 gallons of peak flows when the North Beach Pump Station reaches maximum capacity.	2014	Project is currently in design, with construction scheduled for 2013-2016.

Table 3-2. Associated Projects with CSO Control Benefits Completed or Underway

Project	Description	Completion	Status
Renton Sludge Force Main Decommissioning	Before the South Treatment Plant had solids management capability, sludge was pumped via the Elliott Bay Interceptor to the West Point Treatment Plant for processing; decommissioning of the force main may have decreased solids discharge from the Interbay Pump Station at the Denny CSO site.	1988	Completed.
Ballinger and York Pump Stations	Construction of two new pump stations to divert flows to and from the West Point Treatment Plant collection system. Flows are diverted away from the West Point Treatment Plant during the wet season.	1992 (York); 1993 (Ballinger)	Completed.
West Point Treatment Plant Expansion	Increase plant hydraulic capacity from 325 MGD to 440 MGD to enable conveyance and treatment of more flow from the combined sewer system.	1995	Completed.
Allentown Diversion/Southern Transfer	Designed to offset addition of Alki flows to the Elliott Bay Interceptor. Side-benefit of significant volume reduction at Norfolk.	1995	Completed.
North Creek Pump Station	Diverts flow to the South Treatment Plant collection system during wet weather.	1999	Completed.
Ballard Siphon Replacement	Construction of a new 84-inch-diameter siphon pipe under Salmon Bay between the Ballard and Interbay areas to accommodate population growth in North Seattle. Project will control the Ballard CSO site and reduce CSO control requirements at the 11th Ave NW CSO site.	2013	Construction began fall of 2011and will be completed by end of 2013
Barton Street Pump Station Upgrade	Upgrade the existing pump station, including replacement of outdated electrical equipment (variable frequency drives, motor control centers, instruments and controls); pumps and associated equipment; upgrade heating, ventilation and air conditioning; construct a new underground vault to house a new backup generator system and a new odor control system; and construct a new underground valve room and install new valves for the two force mains. Higher pumping will reduce CSOs at Barton such that the remaining control can be achieved using Green Stormwater Infrastructure.	2014	Design is scheduled to be completed by end of 2012, and construction will occur from 2013 through end of 2015

Table 3-2. Associated Projects with CSO Control Benefits Completed or Underway

Project	Description	Completion	Status
Interbay Pump Station Upgrade	Upgrade the Interbay Pump Station, which is more than 40 years old and does not meet current design standards. Upgrades include construction of new generator building to provide emergency power and improve the pump station's reliability; replacement of all three pumps; replacement/upgrade of mechanical, electrical, and controls equipment; upgrade of the HVAC systems; and increase of the pump station capacity from 122 MGD to 133 MGD. While this project maintains the commitment to provide secondary treatment to 2.25 x average wet-weather flow (AWWF), as AWWF slowly increases, it will also provide a very small collateral upstream CSO control benefit.	2015	Construction began in 2011.

3.4 Results of CSO Control Program to Date

The County uses the period between 1981 and 1983 as the baseline for measuring progress in controlling CSOs. Baseline volumes were determined using computer modeling. The model used rainfall data from that period and other parameters, such as system capacity and the amount of permeable and impermeable surfaces in the service area at that time, to define the baseline frequency and volume of CSOs.

The 1981–1983 modeled baseline for the system is a frequency of 471 CSO events per year and a volume of 2,339 MG per year. Long-term-average (LTA) system modeling completed in 2010 indicated a decrease in frequency to 353 events and a decrease in volume to 808 MG. Frequency and volume based on actual measurements for 2008–2010 were lower than modeled LTA estimates—253 events and 691 MG per year on average—possibly because the rainfall for that period was lower than average.

Table 3-3 compares the CSO frequency and volume based on the 2010 LTA modeling, the 1981 – 1983 modeled baseline, and monitoring data (2008 – 2010 for CSO volumes and 20-year average through 2010 for frequency). The results indicate 16 CSO sites as controlled. The Denny Way and Dexter Ave CSO sites are nearly controlled. Monitored and modeled data for Harbor Ave and 8th Ave S/W Marginal Way do not agree, requiring further model calibration and additional monitoring to confirm control. Associated control projects are undergoing operational adjustments, facility modifications, and modeling confirmation.

Table 3-3. Annual Average Frequency and Volume of Untreated CSOs: Monitored CSOs Compared to Modeled CSOs

Station	DSN	Annual Average CSO Volume (MG)			Annual CSO Frequency		
		Monitored (2008–2010)	Modeled Baseline (1981–1983)	Modeled 2010 (LTA)	Monitored 20-Year Average through 2010	Modeled Baseline (1981-1983)	Modeled 2010 (LTA)
11th Ave NW	004	7.7	5	11.5	13.8	16	18
30th Ave NE	049	2.4	0	0	0.0	0	0
3rd Ave W	008	12.4	106	17.1	6.6	17	16.6
53rd Ave SW[a]	052	0.0	0	0.5	0.3	0	2.0
63rd Ave SW	054	1.5	10	0.0	0.4	2	0.2
8th Ave S/W Marginal Way[b]	040	0.0	8	1.8	0.8	6	1.4
Alaska St, SW	055	0.0	0	0.3	0.2	1	0.6
Ballard, with and without New Siphon[c]	003	0.7	90	0.9	4.6	13	0.1
Barton St	057	0.6	8	1.9	3.0	9	5.8
Belvoir	012	0.0	0	0.0	0.6	0	0.0
Brandon St	041	21.6	64	29.9	34.4	36	16.3
Canal St	007	0.0	1	0.35	0.9	0	0.4
Chelan Ave	036	4.4	61	17.2	4.9	7	24.9
Denny Way[d]	027a	0.3	502	6.0	23.9	32	24.0
Dexter Ave[d]	009	8.9	24	1.1	12.1	15	1.8
Duwamish, E	034	0.0	(not modeled)	(not modeled)	0.5	(not modeled)	(not modeled)
Duwamish, W	035	2.0	0	1.3	0.5	0	0.7
Hanford #1 (Hanford @ Rainier)	031a	40.6	378 (total)	6.8	6.6	30 (total)	2.9
Hanford #1 (Bayview South)	031b	(monitoring started in 2011)	(not modeled)	0.1	(monitoring started in 2011)	(not modeled)	0.2
Hanford #1 (Bayview North)	031c	2.2	(not modeled)	3.3	5	(not modeled)	7.5
Hanford #2	032	66.2	266	202.7	15.8	28	19.0
Harbor Ave[e]	037	7.1	36	NA	13.2	30	8.0
Henderson[f]	045	0.0	15	0.0	0.0	12	0.0
King St	028	29.9	55	9.1	16.8	16	7.2
Kingdome	029	4.6	90	195.1	7.9	29	23.8
Lander St	030	297.4	143	92.5	11.6	26	19.5
Magnolia	006	11.9	14	50	20.2	25	50.8
Marginal, E	043	0.0	0	0.0	0.0	0	0.0
Matthews Park	018	0.0	0	0.0	0.0	0	0.0
Michigan, S	039	46.2	190	91.2	7.2	34	24.8
Michigan, W	042	1.0	2	1.1	5.2	5	3.0
MLK Way[f]	013	0.0	60	0.0	0.0	16	0.0
Montlake	014	24.9	32	28.8	5.3	6	10.8

Table 3-3. Annual Average Frequency and Volume of Untreated CSOs: Monitored CSOs Compared to Modeled CSOs

Station	DSN	Annual Average CSO Volume (MG)			Annual CSO Frequency		
		Monitored (2008–2010)	Modeled Baseline (1981–1983)	Modeled 2010 (LTA)	Monitored 20-Year Average through 2010	Modeled Baseline (1981-1983)	Modeled 2010 (LTA)
Murray Ave	056	24.6	6	2.2	4.6	5	6.2
Norfolk[f]	044	0.0	39	0.0	0.0	20	0.0
North Beach Inlet[g]	048a	1.6	6	5.2	9.3	18	22.8
North Beach Wet Well[g]	048b	0.2	(not modeled)	(not modeled)	8.5	(not modeled)	(not modeled)
Pine St, E	011	0.0	0	0.0	0.0	0	0.0
Rainier Ave	033	0.0	0	0.0	0.0	0	0.0
Terminal 115	038	1.7	2	2.4	2.6	4	1.3
University	015	67.9	126	19.4	6.8	13	1.6
TOTAL		**690.5**	**2,339**	**799.8**	**254.1**	**471**	**322.2**

a. The modeled frequency for 53rd Ave SW contradicts the measured frequency for control status, which may be due to the lower capacity of the pump station before the upgrade. Model will be updated in the on-going calibration effort to include pump station upgrade. Calibration for this area is expected by about 2016 for the recommended Chelan project.

b. The modeled frequency for 8th Ave S/W Marginal Way contradicts the measured frequency for control status. Additional meters have been installed in the system to determine what needs to be adjusted in the model.

c. The Ballard siphon replacement project is not yet complete, so monitored volume and frequency of overflows does not include the new siphon. However, the model was updated to include the new siphon, so modeled volume and frequency of overflows includes the new siphon.

d. The Denny Way/Lake Union CSO control project was completed in 2005.

e. Harbor Ave control project was completed in 2000–2001. Monitoring data since project was completed indicates CSO site is controlled; however, modeled pre-project data for 20-year average conflicts and cannot be used to show control. Model will be updated in the on-going calibration effort. Calibration for this area is expected by about 2016 for the recommended Chelan project.

f. The Henderson/MLK/Norfolk CSO control project was completed in 2005. Modeled data was used for pre-project years for estimating the 20-year average.

g. The North Beach Pump Station has two outfalls; baseline is the total for both outfalls combined.

NOTES:

- Shading indicates that a CSO site is controlled to the Ecology standard of an average of no more than one untreated discharge per year.
- Event frequency is based 24-hour inter-event interval.
- See Table 3-1 and Table 3-2 for details about completed and underway CSO control projects

3.5 Supplemental Compliance Plans

The CSO Control Program plans CSO control projects and transfers them to the King County Project Management Unit to initiate project predesign. Staff from the CSO Control Program and from Operations and Maintenance (O&M) participate in the predesign, design, and construction phases of the projects to ensure that project goals and policies are maintained, to monitor facility startup, and to re-institute planning for any capital modifications needed if control cannot be achieved through O&M adjustments and small projects. During startup, there is overlap between the O&M, project management, planning, and NPDES administration groups. Once a CSO control facility has achieved control, the facility is placed under the management of the O&M group in compliance with the NPDES permit.

The seasonal and intermittent operation of CSO control facilities prolongs their commissioning period. The County has found that the startup and tuning of these facilities is an iterative process. Problems and issues may not be identified or confirmed so that modifications can be developed until several wet seasons have occurred. Many modifications to these facilities can only be safely implemented during dry weather. However, the modifications can only be tested in wet weather with rainfall sufficient to operate the facilities several times under a range of conditions, including high flows of significantly diluted wastewater. If problems are apparent only under high flows conditions, then solutions cannot be fully tested until such flows return. If the modifications do not resolve the problems or issues, then another round of planning, implementation, and testing must occur.

Several completed county CSO control projects are currently being adjusted to achieve full control. Some of these projects were developed to control multiple CSO sites. In these cases, the controls are viewed as a system, and control is not fully achieved until the system meets CSO control standards. The Denny Way and Dexter Ave CSO sites are nearly controlled. The Alki CSO Treatment Plant does not yet consistently meet performance standards. Associated control projects are undergoing operational adjustments, facility modifications, and modeling confirmation under supplemental compliance plans to be administered by EPA. Details on the adjustments and modifications that have been implemented or are planned are included in Section 9.0 of Technical Memorandum 970, CSO Control Alternatives Development (found at www.kingcounty.gov/environment/wastewater/CSO/ProgramReview/plan.aspx#techmemos).

Future supplemental compliance plans will be developed on a case-by-case basis for CSOs if projects do not fully achieve control. If needed, they will outline steps to investigate corrections and adjustments necessary to complete control. A schedule will be laid out that considers whether additional consultant or contractor support needs to be procured, whether construction is required, and what types of storm and return frequency provide conditions necessary to test modifications. Based on experience to date, these plans will be iterative. They will be proposed, and their implementation will be reported in annual reports.

3.6 Reporting on CSO Control

King County submits monthly and annual reports on its CSO Control Program to Ecology to fulfill requirements of the West Point Treatment Plant NPDES permit (effective July 1, 2009) and Chapter 173-245-090 WAC. A monthly discharge monitoring report and narrative summary is submitted to Ecology for each CSO treatment facility by the 20th of each month. A separate monthly report includes a summary of discharge volume, duration, and precipitation for all CSO discharge events that occurred during the reporting period. An annual CSO report is submitted to Ecology by July 31st each year. The annual CSO report covers the previous calendar year and meets requirements of WAC 173-245-090(1).

3.7 Control Plan Review and Amendment

Ongoing cycles of review and planning ensure that the CSO Control Program remains current. King County's Plan has required amendments over time to adjust to changes and to incorporate technological advances and opportunities to achieve CSO control more cost-effectively.

Under Washington regulations (Chapter 173-245-090 WAC), the County is required to review and possibly amend its Plan in conjunction with application for renewal of its NPDES permit, which occurs approximately every five years. The review must include the following:

- An assessment of the effectiveness of the CSO reduction plan to date
- A reevaluation of the CSO sites' project priority ranking
- A list of projects to be accomplished in the next five years, based upon priorities and estimated revenues (Ecology may incorporate this schedule into an administrative order or as a compliance schedule in the applicable NPDES permit).

While the regulation explicitly calls only for a review of priorities and funding, it is imperative that a plan be adjusted when information suggests that its components no longer meet needs or that approaches that are better for the environment and the community are available. The County has found that sufficient change occurs to warrant an amendment to the Plan approximately every 10 years. The review and update process is systematic and transparent. Significant stakeholder involvement shapes the effort and the recommendations.

Metro/King County issued its first Plan in partnership with EPA, Ecology, and the City of Seattle in 1979. Secondary treatment implementation required review of the wastewater system as a whole, including CSO control, in 1985 to 1986. This was followed by adjustments to meet new state CSO regulations in 1988. By 1999, sufficient change had accumulated to warrant a major update, resulting in the RWSP, which included the 1999 Plan Amendment. Now 12 years later, review of the Plan against scientific gains and technological advances, development of regional initiatives such as the Duwamish Superfund processes, and new information about city needs, has led to this recommended amendment to the Plan.

The effectiveness of the amended Plan will continue to be monitored and reported to Ecology and EPA in annual reports. Unless unexpected change warrants, the County expects to again review the effectiveness of the Plan in approximately 2018 and will recommend amendments if necessary.

Chapter 4

Factors Considered in Current CSO Control Program Review

As set forth in the following wastewater services policies (WWSP) and combined sewer overflow control policies (CSOCP) from the RWSP, decisions on CSO control must balance several factors, including public health and the environment, regulatory requirements, financial goals, scientific information, and public opinion (Figure 4-1):

> *WWSP-6: King County shall operate and maintain its facilities to protect public health and the environment, comply with regulations and improve services in a fiscally responsible manner.*
>
> *WWSP-11: King County shall design, construct, operate and maintain its facilities to meet or exceed regulatory requirements for air, water and solids emissions as well as to ensure worker, public and system safety.*
>
> *CSOCP-1: King County shall plan to control CSO discharges and to work with state and federal agencies to develop cost-effective regulations that protect water quality. King County shall meet the requirements of state and federal regulations and agreements.*
>
> *CSOCP-2: King County shall give the highest priority for control to CSO discharges that have the highest potential to impact human health, bathing beaches and/or species listed under ESA.*

This chapter describes the following types of factors that were considered for this review:

- Regulatory and county policy factors
- Technical factors
- Human and environmental health factors
- Public opinion
- Coordination with other agencies.

Based on a review of these factors, an assessment was made as to whether changes in each factor warrant a re-evaluation of the 1999 Plan Amendment's priorities, recommended CSO control alternatives for the 14 remaining uncontrolled CSO sites, project sequence, or schedule. The different sections of this chapter explain why each factor is relevant to CSO control planning, assess current conditions related to each factor, and indicate whether those conditions trigger the need to re-evaluate recommendations for the remaining uncontrolled CSO sites. All review technical memorandums referenced in the chapter can be found at http://www.kingcounty.gov/environment/wastewater/CSO/ProgramReview/plan.aspx#techmemos.

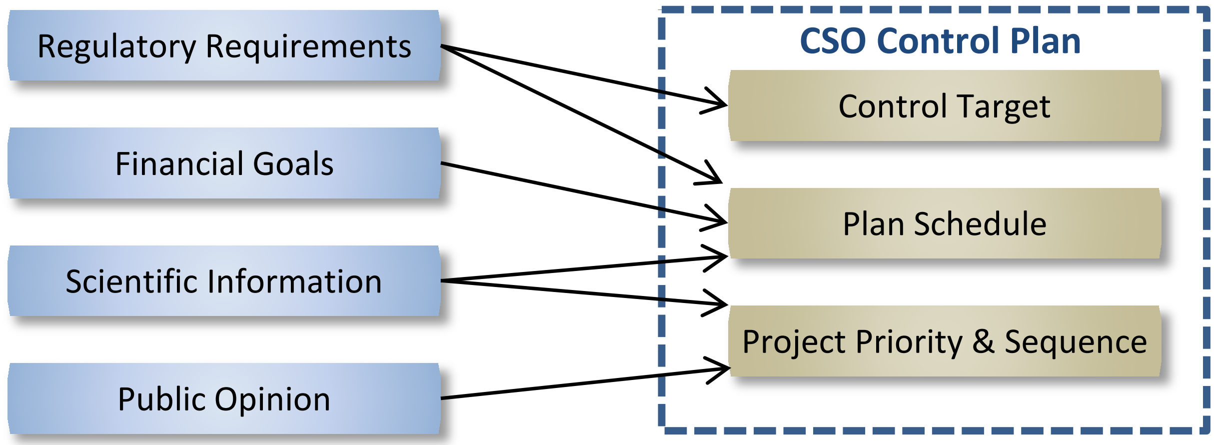

Figure 4-1. Factors that Shape CSO Control Plan Decisions

4.1 Regulatory and County Policy Factors

4.1.1 Water Quality Regulations

Use-Based Water Quality Standards for Protection of Aquatic Species

Under Ecology's former classification-based system of water quality standards, each water body was assigned to one of eight classes: four freshwater classes (Class AA, Class A, Class B, and Lake Class) and four marine classes (Class AA, Class A, Class B, and Class C). In June 2003, Ecology reformatted water uses and criteria to use-based standards rather than classification-based standards. This reflects the latest scientific information and new state and federal requirements that are more specifically aimed at improving the quality of a water body to support uses by humans and aquatic species.

Water-Quality-Based Limits in NPDES Permit

A critical development since the 1999 Plan Amendment is the inclusion of water-quality based limits in the NPDES permit for CSO treatment facilities and changes in the methodologies underlying that permitting. The Alki and Carkeek CSO Treatment Plants were designed to meet technology-based standards for solids control. At the time the plants were converted to CSO treatment, effluent chemical concentration limits to protect aquatic species in the waters receiving the discharges—called water-quality-based limits—were not expected to be applied to the infrequent, intermittent discharges from these plants.

In Washington state, technology-based standards require CSO treatment to be "equivalent to primary," defined as achieving an annual average of 50-percent total suspended solids (TSS) removal and an annual average effluent quality of no more than 0.3 milliliters per liter per hour of settleable solids, with disinfection if needed. When the captured solids are conveyed to the West Point Treatment Plant, the percent of TSS removal for CSOs must be adjusted to account for the losses that occur in the subsequent treatment process. While Alki and Carkeek have always provided disinfection to flows discharged to Puget Sound, the new NPDES permit that became effective January 1, 2004 (as part of the West Point Treatment Plant NPDES permit) includes the requirement to disinfect discharges to meet water-quality-based limits starting January 1, 2006. Dechlorination is now required to meet these limits.

4.1.2 Sediment Management

Washington State's sediment management standards (SMS) present standards and decision-making processes to protect biological resources and remediate contaminated sediments. Implementation of the SMS may have significant implications for CSO control.

Sediment Management Planning

As a part of implementing the 1999 Plan Amendment, WTD is executing a Sediment Management Program (SMP) to remediate contaminated sediments near CSO outfalls. Most sediment contamination occurred in the early to mid-1900s. The SMP assessed areas near seven King County CSOs that were listed on the Washington State Contaminated Sites list. The areas were assessed for their risk, preferred cleanup approach, partnering opportunities, and potential for recontamination after remediation.

The SMP highlighted the growing interest in sediment management as a factor in CSO control planning and the need for more information about CSOs as an ongoing or historical contributor to contamination. The SMP addresses sediment quality issues near CSO discharges and treatment plant outfalls, evaluates and addresses emerging wastewater treatment sediment quality issues, and incorporates sediment quality considerations into comprehensive planning.

The SMP also addresses sediment contamination cleanups that are required under the federal Superfund and state Model Toxic Control Act regulations. The SMP's objectives are to repair potential environmental damage in a timely, efficient, and economical process; to prevent harm to public health; and to limit future liability.

Recent activities have included completing remediation of areas around the Denny Way Regulator and Elliott West outfalls (post-remediation monitoring is underway), completing five years of post-construction monitoring at the Diagonal/Duwamish cleanup site, completing sampling of East Waterway Superfund site sediments to fill in characterization data gaps, continued pollution source control efforts along the East Waterway, and development of sediment transport modeling and risk assessment methodologies. The latter is being used in this review to provide information supporting recommendation of CSO treatment technologies.

The SMP will be updated over the next several years. It will include a new near-field recontamination model which will be used to characterize areas around controlled CSO outfalls.

More information on the County's SMP is available at http://www.kingcounty.gov/environment/wastewater/SedimentManagement.aspx.

Lower Duwamish Waterway Superfund Site

King County continues to work to improve water quality in the Lower Duwamish Waterway. The County's actions focus on reducing CSOs, restoring habitats, capping and cleaning up sediments, and controlling toxicants from industries and stormwater runoff. Since completion of the SMP, the County has been coordinating its sediment management efforts in the Duwamish Waterway with two federal Superfund projects: the Harbor Island and the Lower Duwamish Waterway projects. Superfund is a highly structured approach to managing sediment contamination that could prompt changes in projects, schedules, and budgets in the County's Plan.

The County has been working in partnership with the Port of Seattle since 2003 on the Harbor Island Superfund project. The project will remediate sediments at the County's Lander St and Hanford St CSOs.

The County is partnering with the City of Seattle, the Port of Seattle, and the Boeing Company under a consent agreement with EPA and Ecology to prepare a remedial investigation and feasibility study for the Lower Duwamish Waterway Superfund site.

In 2010, the Lower Duwamish Waterway Draft Final Feasibility Study was issued describing 11 cleanup alternatives being considered for the Lower Duwamish Waterway. EPA will propose a cleanup plan in the summer of 2012 based on the alternatives analyzed in the feasibility study. The cleanup plan and its schedule may influence the County's CSO control decisions.

The County's Industrial Waste Program will coordinate expanded source control work to identify and control the sources of pollution that may pose health or environmental problems if they accumulate in Duwamish Waterway sediments or recontaminate cleanup areas.

More information on the Lower Duwamish Waterway cleanup efforts is available at http://www.kingcounty.gov/environment/wastewater/Duwamish-waterway.aspx.

4.1.3 EPA Policy Compliance

EPA's 1994 CSO Control Policy, codified as the Wet Weather Water Quality Act of 2000 (H.R. 4577, 33 U.D.C. 1342(q)), requires implementation of Nine Minimum Controls for CSOs and the development of long-term CSO control plans. Agencies must show that water quality standards are met after implementation of their CSO control plan. The requirements of this act are incorporated in the NPDES permit for the West Point Treatment Plant. EPA stated in EPA/Ecology Environmental Performance Partnership Agreements from the early 2000s that Ecology's CSO control rule (Chapter 173-245 WAC) was equivalent to EPA's Nine Minimum Controls:

> "Ecology will include requirements to implement Ecology's CSO rule in all NPDES permits to combined sewer overflow (CSO) facilities. Ecology's rule is equivalent to the nine minimum controls outlined in EPA's 1994 CSO Control Policy. NPDES permits for each CSO facility shall also require compliance with an approved CSO reduction plan that includes public notification requirements and post construction compliance monitoring."

A summary of King County's compliance with the EPA Nine Minimum Controls is provided in Section 3.2.4 of this report.

EPA and Ecology have recently stated in the EPA/Ecology Environmental Performance Partnership Agreement (July 1, 2011 to June 31, 2013 4B page 67):

> "Ecology will continue to implement Ecology's combined sewer overflow (CSO) reduction regulation in all NPDES permits issued to facilities that operate a combined sewer system (CSS). Per Ecology's regulation, such permittees have approved CSO Reduction Plans in place. NPDES permits for CSS facilities include requirements for the submission of Annual CSO Reports and a CSO Reduction Plan Amendment at the end of

> each permit cycle. Permits also include a compliance schedule for the implementation of projects during the permit cycle. To comply with EPA's 1994 CSO Control Policy, Ecology will incorporate into NPDES permits the requirements to implement the Nine Minimum Controls (NMC), and Long Term Control Plan (LTCP) elements…"

The County's Plan has been developed and amended over the years based upon assessments and methods similar to those in the EPA Guidance Long-term Control Plan, September 1995. The 2012 Long-term CSO Control Plan Amendment will provide the information in the format called for by EPA to demonstrate equivalency as a long-term control plan. In advance of that the County has identified components of its Plan and this review that meet long-term control plan requirements. These are summarized in Table 1-4 in Chapter 1 of this report.

In early January 2008, EPA began a compliance review of the County's wet-weather management programs. The County has met with EPA several times and has provided information on programs and activities as needed. Highlights are as follows:

- In January 2008, EPA, its contractors, and Ecology conducted inspections of the County's wastewater treatment systems and CSO Control Program over five days.
- In July 2009, EPA issued an order that required submittal of three plans—two related to compliance of the Mercer/Elliott West CSO control system and one calling for a floatables observation study.
- In October 2009, EPA resumed the review focusing on the County's Plan for conformance with the elements of EPA's long-term control plan.
- In May 2010, the County met with EPA and received another request for information.
- In June 2010, EPA requested WTD to resubmit and update information, but EPA did not resume its review because of contractor procurement and funding issues.
- In August 2010, EPA requested specific reports.
- In December 2010, the County presented an analysis of the equivalency of the Ecology performance or control standard to EPA's presumptive standards for system control. The presentation showed the County's CSO Control Program currently meets the 85-percent wet-weather volume and associated pollutant control capture standards, and that upon Plan completion, meeting the Ecology performance or control standard of one untreated discharge per outfall per year on average would achieve EPA's four events over the system per year standard. EPA's consultant reviewed the County's supporting modeling and concurred with the analysis.
- In late 2010, WTD submitted an overview of the process and milestones of its current Program Review and worked with EPA to schedule a meeting in January 2011 with EPA and U.S. Department of Justice lawyers to discuss development of a consent order.
- In mid-2011, EPA and U.S. Department of Justice and the County began discussing potential elements of a consent decree as a start to negotiations.
- Conversations and technical meetings with EPA, its contractor, and the Department of Justice have continued to occur through mid-2012. At the time of this report it appears that EPA has determined that the County's proposed 2012 Long-term CSO Control Plan Amendment meets their requirements. A Clean Water Act Section 308 information

request will be formally made by EPA requiring the submittal of the Plan amendment to provide the mechanism for approval to inform the King County Council's deliberations and adoption. After Plan adoption, the King County Council will be asked to approve the final consent decree.

4.1.4 County Policy Factors

Ordinance 13680, approved by the King County Council in 1999, adopted the 1999 Plan Amendment. It was then codified in the King County Code as Chapter 28.86. The majority of RWSP policies have remained current and required no changes. A few amendments to the ordinance and code have been made since and are included in the King County Code, Chapter 28.86.010 through Chapter 28.86.180. These amendments have included updates to the 1999 Plan Amendment financial policies, conveyance policies, new odor control policies for the County's existing treatment plants and conveyance facilities, and a new section on reporting policies.

Ordinance 15602 (approved in September 2006) adopted 1999 Plan Amendment technical and policy amendments including an update to the policy calling for a CSO control program review to reflect that reviews had been completed for the CSO Control Plan Update due 2005 or after, and streamlining the focus of the review to "assess CSO control projects, priorities and opportunities using the most current studies available." This review responds to this new policy. The text of the changed policy (CSOCP-8) is presented in Appendix A of this report.

4.1.5 1999 Plan Amendment Alternatives Needing Review Due to Regulatory and County Policy Changes

The EPA compliance review indicates that the Ecology performance standard is equivalent to EPA's presumptive standard for King County's system. No change in the performance standard impacts planned projects. Based on the review of regulatory and county policy factors, re-evaluation is needed for the 1999 Plan Amendment's adopted alternatives for the following uncontrolled CSO sites (further details are provided in Appendix C of this report):

- King St (DSN 028)—New water quality standards may affect recommended CSO treatment
- Kingdome (DSN 029)—New water quality standards may affect recommended CSO treatment
- Lander St (DSN 030)—New water quality standards may affect recommended CSO treatment; potential Lower Duwamish Waterway Superfund impacts
- Hanford #2 (DSN 032) —New water quality standards may affect recommended CSO treatment; potential Lower Duwamish Waterway Superfund impacts
- S Michigan St (DSN 039) —New water quality standards may affect recommended CSO treatment
- Brandon St (DSN 041) —New water quality standards may affect recommended CSO treatment

4.2 Technical Factors

Technical factors that could influence CSO control alternatives include new technical analyses and new technologies, the performance of existing facilities, facility siting requirements and availability of sites, and coordination with other asset management needs. This review included the following specific assessments of technical factors:

- A characterization of the King County service area was developed to determine if the treatment capacity strategy developed for the RWSP is still adequate.
- The performance of existing facilities was examined to assess if new approaches and technologies need to be considered for new facilities.
- Hydraulic modeling of the County's combined sewer system was conducted to obtain updated overflow volumes and peak overflow rates. These results were used to determine if the 1999 Plan Amendment's sizing and the type of CSO control facility for the uncontrolled CSO sites need to be updated.
- The County reviewed updated technologies for CSO control for potential application to the proposed CSO control projects, including green stormwater infrastructure (GSI) and new types of CSO treatment.
- Facility siting requirements were reassessed, and the availability of previously proposed sites was re-examined. A preliminary evaluation was also completed to determine if there are any new siting opportunities.
- The County's long-range asset management plans were reviewed to identify any potential overlap with the proposed CSO control projects.

4.2.1 Characterization of the King County Service Area

For CSO control, the key characteristics of the wastewater service area are current and future population, wastewater flow and wastewater pollutant loads, and the volume of CSOs treated at the West Point Treatment Plant. Summary discussions of each are presented in the sections below. A 2004 King County document, Population and Flow Analysis by Wastewater Basin; Supplement to the 2004 Update to the RWSP (2004 Supplement), provides a detailed discussion of the County's service area population and flows (available at www.kingcounty.gov/environment/wtd/Construction/planning/rwsp/Library/CompReview.aspx). The characterization was completed before the Brightwater Treatment Plant came on-line.

Population

King County wastewater service area population and employment forecasts developed in 2003 using data provided by the Puget Sound Regional Council (PSRC) were similar to those generated in 1995 for the RWSP. The RWSP forecast projected a 44-percent increase in total sewered population from 2000 to 2030, and the updated 2003 forecast projected an increase of 40 percent. The 2004 Supplement describes the methodologies used for the two forecasts.

In 2000 (the base year for the 2003 forecasts), residential and industrial populations were similar to those predicted for the RWSP. The number of commercial employees in 2000, however, was 65,000 greater system-wide than predicted for the RWSP. The higher commercial numbers were on the Eastside and in the South Treatment Plant service area. Commercial employment was lower in Seattle than was forecasted for the RWSP.

Figure 4-2 shows 2003 and RWSP total population forecasts for 2000 to 2050 broken down into the seven major sewer basins in the wastewater service area. Figure 4-2 gives the forecasts for the two main treatment plant basins and the total service area, broken down for residential, commercial, and industrial populations. Additional population forecast data is provided in the 2004 Supplement. For most basins, the forecast from the RWSP and the 2003 forecast are similar. Two basins show a significant difference between forecasts. The updated 2003 forecast for the Metro West Side Basin shows a slower growth rate through 2050 than predicted in the RWSP. The 2003 forecast predicts a population of approximately 200,000 fewer than predicted in the RWSP for this basin. The other basin with a significant difference between the RWSP and 2003 forecasts is the Metro East Side basin, which shows a faster growth rate predicted in the 2003 update than predicted in the RWSP.

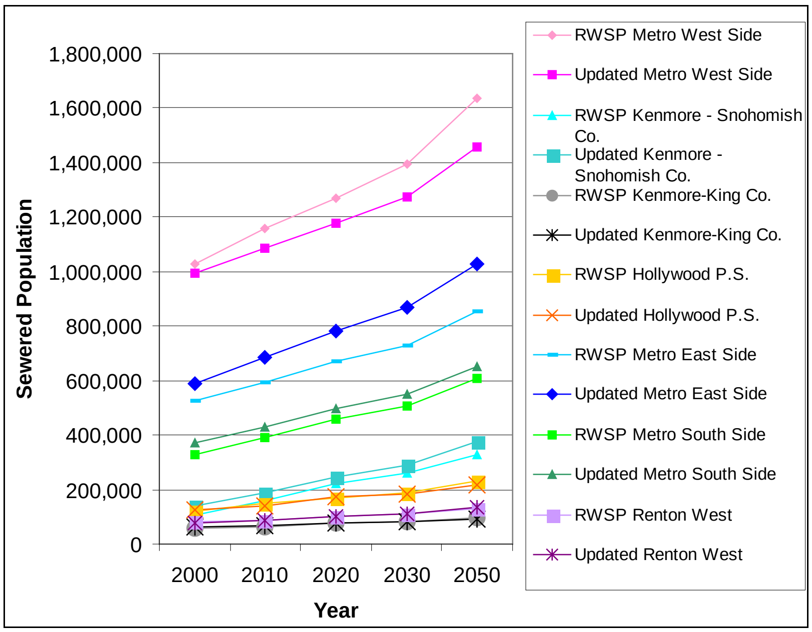

Figure 4-2. Total RWSP and Updated Population Forecasts by Basin (2000 to 2050)

Table 4-1. RWSP and 2003 Updated Population Forecasts (2000 to 2050)

	RWSP Sewered Population				2003 Updated Sewered Population			
Basin	**Res.**	**Comm.**	**Ind.**	**Total**	**Res.**	**Comm.**	**Ind.**	**Total**
2000 Forecasts								
West Point Basin	701,358	556,362	54,439	1,312,159	695,859	527,967	61,061	1,303,042
South Plant Basin	632,561	329,397	98,583	1,060,541	650,516	422,334	86,584	1,159,434
Total Metro System	**1,333,919**	**885,760**	**153,022**	**2,372,701**	**1,346,375**	**950,301**	**147,645**	**2,462,476**

Table 4-1. RWSP and 2003 Updated Population Forecasts (2000 to 2050)

	RWSP Sewered Population				2003 Updated Sewered Population			
Basin	**Res.**	**Comm.**	**Ind.**	**Total**	**Res.**	**Comm.**	**Ind.**	**Total**
2010 Forecasts								
West Point Basin	805,210	656,890	54,855	1,516,955	767,573	609,080	51,780	1,428,433
South Plant Basin	725,840	403,404	93,128	1,222,373	750,449	505,778	84,470	1,340,697
Total Metro System	**1,531,050**	**1,060,294**	**147,984**	**2,739,328**	**1,518,022**	**1,114,858**	**136,250**	**2,769,130**
2020 Forecasts								
West Point Basin	933,000	722,085	49,994	1705,079	868,163	675,845	51,000	1,595,008
South Plant Basin	846,552	464,500	90,045	1,401,096	871,453	601,014	81,272	1,553,739
Total Metro System	**1,779,552**	**1,186,585**	**140,038**	**3,106,175**	**1,739,616**	**1,276,859**	**132272**	**3,148,747**
2030 Forecasts								
West Point Basin	1,017,862	810,781	48,645	1,877,288	962,196	731,610	51,640	1,745,446
South Plant Basin	917,520	531,997	85,115	1,534,632	936,653	692,956	80,841	1,710,450
Total Metro System	**1,935,383**	**1,342,777**	**133,760**	**3,411,920**	**1,898,849**	**1,424,566**	**132,481**	**3,455,896**
2050 Forecasts								
West Point Basin	1,191,270	976,295	44,201	2,211,766	1,113,457	873,503	44,143	2,031,103
South Plant Basin	1,083,672	661,390	76,338	1,821,399	1,082,229	873,478	77,192	2,032,899
Total Metro System	**2,274,941**	**1,637,685**	**120,539**	**4,033,166**	**2,195,686**	**1,746,981**	**121,335**	**4,064,002**

Flows

Projections for average wet-weather flow (AWWF) are the primary basis of planning for treatment capacity. Table 4-2 summarizes AWWF projections through 2050 from the RWSP and from the updated 2003 projections. The projection methodology and details of the projections are presented in the 2004 Supplement.

Table 4-2. RWSP and 2003 Updated Flow Projections (2000 to 2050)

Basin	**RWSP AWWF (MGD[a])**	**2003 Updated AWWF (MGD)**
2000 Projections		
West Point Basin	120	110
South Plant Basin	92	94
Total Metro System	**212**	**205**
2010 Projections		
West Point Basin	132	107
South Plant Basin	105	106
Total Metro System	**237**	**213**
2020 Projections		
West Point Basin	145	118
South Plant Basin	121	128
Total Metro System	**266**	**246**

Table 4-2. RWSP and 2003 Updated Flow Projections (2000 to 2050)

Basin	RWSP AWWF (MGD[a])	2003 Updated AWWF (MGD)
2030 Projections		
West Point Basin	154	126
South Plant Basin	130	137
Total Metro System	**283**	**263**
2050 Projections		
West Point Basin	169	138
South Plant Basin	143	150
Total Metro System	**312**	**288**

a. MGD = million gallons per day

The RWSP projected that the AWWF for the service area would reach the system capacity of 248 MGD in 2013 and that King County would need an additional 64 MGD of capacity by 2050. The Brightwater Treatment Plant provides 36 MGD of new capacity to help accommodate the new demand and to provide peak flow relief in the north end of the service area. Another capacity increment may be provided with expansion of the South Treatment Plant in 2029 and, if needed, a further expansion of the Brightwater Treatment Plant in 2040 to 54 MGD.

The current Brightwater Treatment Plant capacity includes flows redirected from the West Point system. Prior to Brightwater, those flows were managed at the West Point Treatment Plant only during the summer but were sent to the South Treatment Plant at Renton during the winter to provide more capacity to manage combined flows. As a result, the West Point system will not experience further benefit from Brightwater.

The treatment capacity strategy developed for the RWSP (Figure 4-3) appears to still be appropriate under the 2003 projections. Successful infiltration and inflow (I/I) control may reduce peak flow, but its effectiveness will not be known until studies are completed. Increases in water conservation outside the City of Seattle could change the need and sizing for facilities that are scheduled to manage non-peak flows now that the Brightwater Treatment Plant is online.

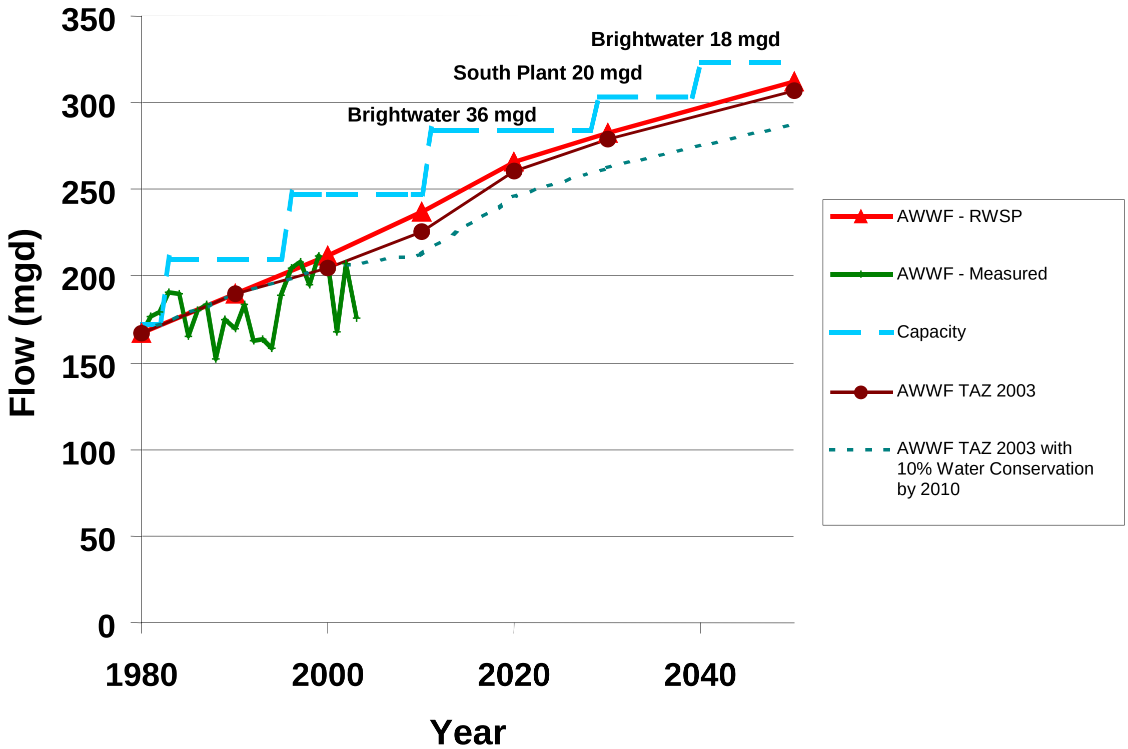

Figure 4-3. Original RWSP and 2003 System-wide AWWF Projections

This assessment indicates that the facilities planned in the RWSP, including those for CSO control, are adequate to manage the impacts of growth.

Waste Load Analysis

Ecology requires that the County conduct an assessment of its treatment plant influent flow and waste load and then submit a report with its application for NPDES permit renewal. Report requirements are presented in Appendix D of this report, along with key data from the flow and waste load study submitted for the 2009 renewal, which covered the period from January 2004 through April 2008. Table 4-3 summarizes influent loading of biochemical oxygen demand (BOD) and TSS for that period.

Table 4-3. West Point Influent Loading Rates from Flow and Waste Load Study

	Influent Loading (Pounds/Day)	
	BOD—168,000 Average Annual Design; 254,000 Max Month	TSS—181,000 Average Annual Design; 274,000 Max Month Design
2004	147,200	168,300
2005	138,000	163,500
2006	150,200	177,500
2007	144,400	158,600
Jan—April 2008	145,900	178,700

At no time during that period did either BOD or TSS monthly average influent loadings exceed 85 percent of the maximum month design limits, the point at which planning for increased capacity is required to begin. The maximum month BOD loading was 168,400 lb/day (June 2007); the 85-percent value of maximum month design is 215,900 lb/day. The maximum month TSS loading was 202,000 lb/day (November 2006); the 85-percent of maximum month design is 232,900 lb/day. BOD loadings during this permit period were 14.0 percent less than in the period covered by the previous report, and TSS loadings were 5.3 percent less, excluding data from the partial years covered by the two periods—2000 and 2008.

This assessment indicates that flows and wasteload from the West Point service area, including the combined system areas, remain within the planned design for system facilities.

CSO Treatment at West Point

In addition to providing secondary treatment for 300 MGD of base wastewater flows, the West Point Treatment Plant is approved to use excess primary capacity to provide 140 MGD of CSO treatment. Table 4-4 shows the volume of CSOs treated at the West Point Treatment Plant from 2007 through 2010.

Table 4-4. CSO Treatment at West Point Treatment Plant

Period	Volume (MG)	Event Range
June 2007—May 2008	228.2	Over parts of 16 days
2008[a]	81.6	Over parts of 13 days
2009	257.8	Over parts of 27 days
2010	387.7	Over 18 events

a. Reporting requirement change from wet-season-orientated to calendar year; January to May 2008 is repeated in this table.

In RWSP Treatment Plant Policy (TPP)-2, King County reserved capacity at the West Point Treatment Plant for any unexpected circumstances, including CSO control needs:

> "…The potential for expansion at the West Point Treatment Plant and South Treatment Plant should be retained for unexpected circumstances which shall include, but not be limited to, higher than anticipated population growth, new facilities to implement the CSO reduction program, or new regulatory requirements."

While there may be unanticipated opportunities to cost-effectively manage CSOs by transfer for CSO treatment at the West Point Treatment Plant, the current system configuration and recommended control projects appear unlikely to increase the practice beyond what is currently occurring.

4.2.2 Size and Type of CSO Control Facility from Hydraulic Modeling

King County completed a continuous-simulation model run of its combined sewer system in October 2010. Overflow rates and volumes from this model run were reviewed to determine if the 1999 Plan Amendment project sizing and project definitions for the uncontrolled CSO sites need to be updated.

Work associated with the modeling included recalibration of selected basins and associated pipe systems, based on flow data provided by the County and Seattle Public Utilities (SPU) from in-station meters and portable flow meters. Recalibration consisted of building up a basin and pipe model, providing a dry-weather flow pattern based on meter data, and then using a calibration tool to change selected basin parameters until model output was as close as possible to the meter data for selected storms.

The recalibrated models were run using City of Seattle rain gauge information and applying the County's quality assurance/quality control (QA/QC) procedures described in Appendix B of this report. The 32-year period of rain data available from the City defined the 32-year continuous-simulation model period for this CSO Control Program Review: from January 1, 1978 to January 1, 2010. The modeling provided the following project definition parameters:

- **CSO Control Volume**—Overflow volume with one-year recurrence frequency. CSO control volume is used to size storage facilities, so that CSO sites average no more than one untreated discharge per year[1].
- **CSO Peak Flow Rate**—Overflow rate with one-year recurrence frequency. CSO peak flow rate is used to size CSO treatment facilities and conveyance facilities, so that CSO sites average no more than one untreated discharge per year[1].
- **Maximum Peak Overflow Rate**—Maximum peak overflow rate of events less than and equal to one-year recurrence frequency by volume. Maximum peak overflow rate is used to size conveyance to storage facilities, so that wet-weather flows can be conveyed to storage facilities, and CSO sites average no more than one untreated discharge per year[1].

The values for each parameter are summarized in Table 4-5 for each uncontrolled CSO site. The values were reviewed to determine if they would impact the size and type of CSO control facility identified in the 1999 Plan Amendment's adopted alternatives for the County's uncontrolled CSO sites.

- **Size of CSO Control Facility –** Reevaluation of alternatives was required for all uncontrolled CSO sites where the modeling values changed by more than 10 percent.

[1] As described in Section 4.1.3 of this report, EPA has indicated that implementation of CSO control to Ecology's performance standard of one untreated discharge per year per outfall on average is equivalent to EPA's presumptive control standards for the County's system.

- **Type of CSO Control Facility –** Reevaluation of alternatives was required where the type of CSO control facility had changed based on hydraulic modeling (e.g., storage may no longer be feasible due to increased volume requirement and inability to drain before next storm event).

The new modeling and the different models that the County has used over the past 30 years are described in Appendix B of this report, including how the types and sizes of CSO control projects were determined for the 1999 Plan Amendment.

Table 4-5. Key Results from October 2010 Modeling Run

Uncontrolled CSO Site	CSO Control Volume (MG)	CSO Peak Flow Rate (MGD)[a]	Maximum Peak Overflow Rate (MGD)
11th Ave NW (DSN 004)			
Existing Conveyance	1.85	32.2	N/A
Increased Conveyance to Ballard Siphon[b]	0.00	0.3	0.3
3rd Ave W (DSN 008)	4.18	29.3	61.3
Montlake (DSN 014)	6.6	93.5	148.5
University (DSN 015)	2.94	74.9	94.7
King St (DSN 028)	2.63	29.6	56.0
Kingdome (DSN 029)	34.22	87.0	227.4
Lander St (DSN 030)	17.69	47.9	324.7
Hanford #1 (DSN 031)			
Hanford@Rainier Overflow Structure	1.02	17.8	31.0
Bayview North Overflow Structure	0.77	28.9	55.5
Bayview South Overflow Structure	0.00	0.0	0.0
Hanford #2 (DSN 032)	43.78	94.9	188.0
Chelan Ave (DSN 036)	3.85	25.7	38.4
Terminal 115 (DSN 038)	0.05	3.8	4.6
S Michigan St (DSN 039)	18.6	66.1	161.4
Brandon St (DSN 041)	6.52	35.2	106.5
W Michigan St (DSN 042)	0.27	3.0	3.6

a. MGD = million gallons per day
b. A scenario with increased conveyance to the Ballard Siphon was modeled for the 11th Ave NW CSO site to assess whether conveyance improvements alone could control this site; the work was performed as part of the screening of preliminary alternatives described in Chapter 5 of this report.

4.2.3 Performance of Existing CSO Controls and Changes in CSO Treatment Technologies

The use of conventional primary clarification to treat CSOs has been challenging. Designed to meet solids removal permit limits as an annual average, compliance is dependent on the number of treatment events that occur as well as the intensity pattern of the storm flows. Very high and dilute flows contain small amounts of solids, and have little time to achieve settling. These rapidly changing flows have also proven difficult to disinfect using hypochlorite and bisulfate.

Descriptions of adjustments and modifications made to maintain these facilities in full compliance are included in Section 9.0 of Technical Memorandum 970, CSO Control Alternatives Development. The lessons of a decade and a half operating these facilities contribute to King County's decision to reassess the use of conventional primary treatment and chlorine disinfection, and to evaluate new technologies. Accordingly, new technologies that could be used to treat CSO discharges were identified and evaluated for this review. These treatment technologies were considered for large outfall locations where storage and/or flow reduction is not expected to be sufficient for CSO control, including the County's Duwamish CSO treatment projects.

The 1999 Plan Amendment recommended that the County use conventional primary clarification for CSO treatment. It also recommended that the County continue to evaluate new technologies, including alternative high-rate treatment technologies, based on the experience of other agencies. This was done as part of the 2000 CSO Plan Update and the 2006 CSO Control Program Review, and is being updated again for this review. The 2006 CSO Control Program Review identified several promising approaches that lacked operating data, so it recommended pilot testing. The County completed testing of high-rate clarification technologies at the West Point Treatment Plant in 2009. The final report was issued in June 2010. Information from the pilot testing was included in this Program Review.

The goals of the treatment technology review were to gather the latest information on treatment technologies and their performance; better define the design conditions and operational issues associated with the technologies; and identify technologies for incorporation into alternatives development for this review. At a minimum, the treatment technologies must be capable of meeting the following requirements, as well as applicable water quality and sediment quality standards:

- Treatment Technology Permit Requirements
  - Comply with Chapter 173-245 Washington Administrative Code (WAC)
  - Annual average solids removal ≥ 50 percent
  - Annual average effluent settleable solids ≤ 0.3 milliliters per liter per hour, as well as a daily maximum limit set in some permits
  - Disinfection: fecal coliform < 400 colony-forming units per 100 ml
  - A single event may be excluded from solids limit calculations as the one untreated event per year

- Discharge Requirements
  - Meet acute water quality standards at the edge of an approved mixing zone (Chapter 173-201A WAC)
  - Meet sediment quality standards (Chapter 173-204 WAC).

The evaluation started with a list of 14 CSO treatment technologies. Based on an evaluation of considerations including performance, siting requirements, cost, and staffing requirements, this list was narrowed to five technologies. These five technologies were evaluated for compatibility with disinfection technologies being considered. The evaluation resulted in two CSO treatment processes being selected for consideration in this review:

- **Chemically Enhanced Primary Treatment (CEPT) with Lamella Plates—**This process improves on conventional primary clarification by providing chemical feeds to enhance coagulation, flocculation, and removal of suspended solids. Inclined plates increase the sedimentation basin's effective settling area. A schematic of the process is shown in Figure 4-4.
- **Ballasted Sedimentation—**This process uses CEPT with lamella plates in combination with a ballast material (microsand or recirculated sludge) to optimize settling and provide the best potential treatment within the smallest footprint. A schematic of the process is shown in Figure 4-5.

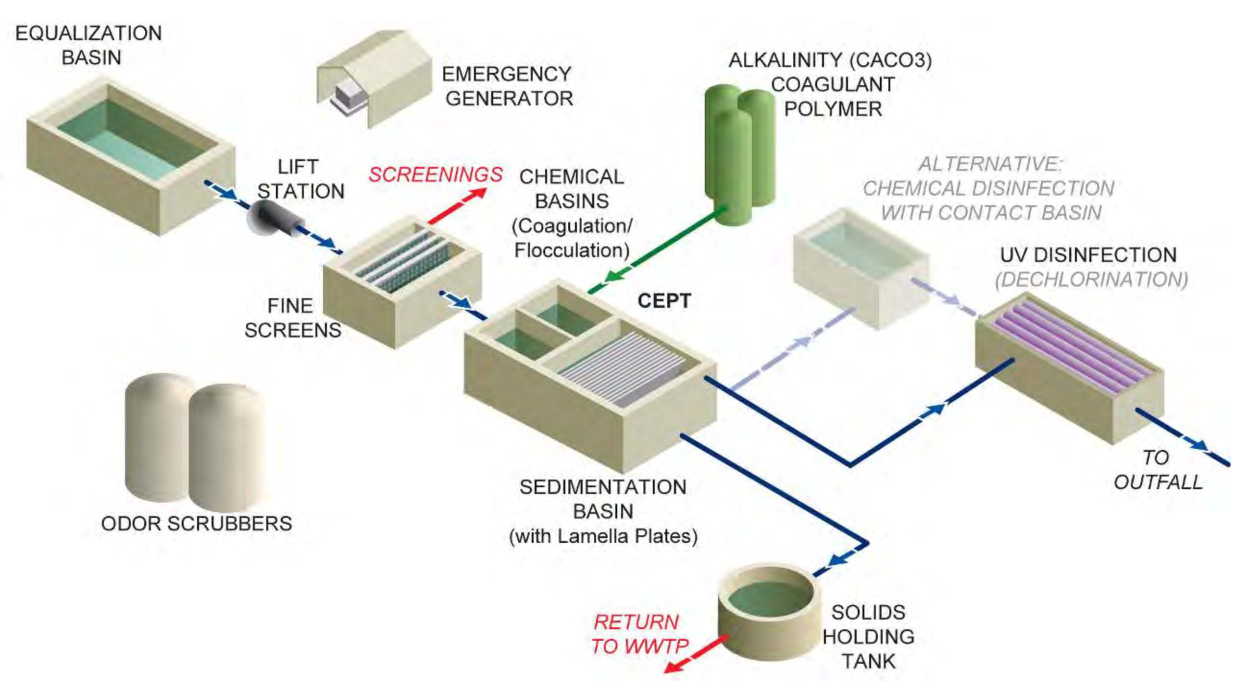

Figure 4-4. Sample Process Flow Schematic for CEPT with Lamella Plates

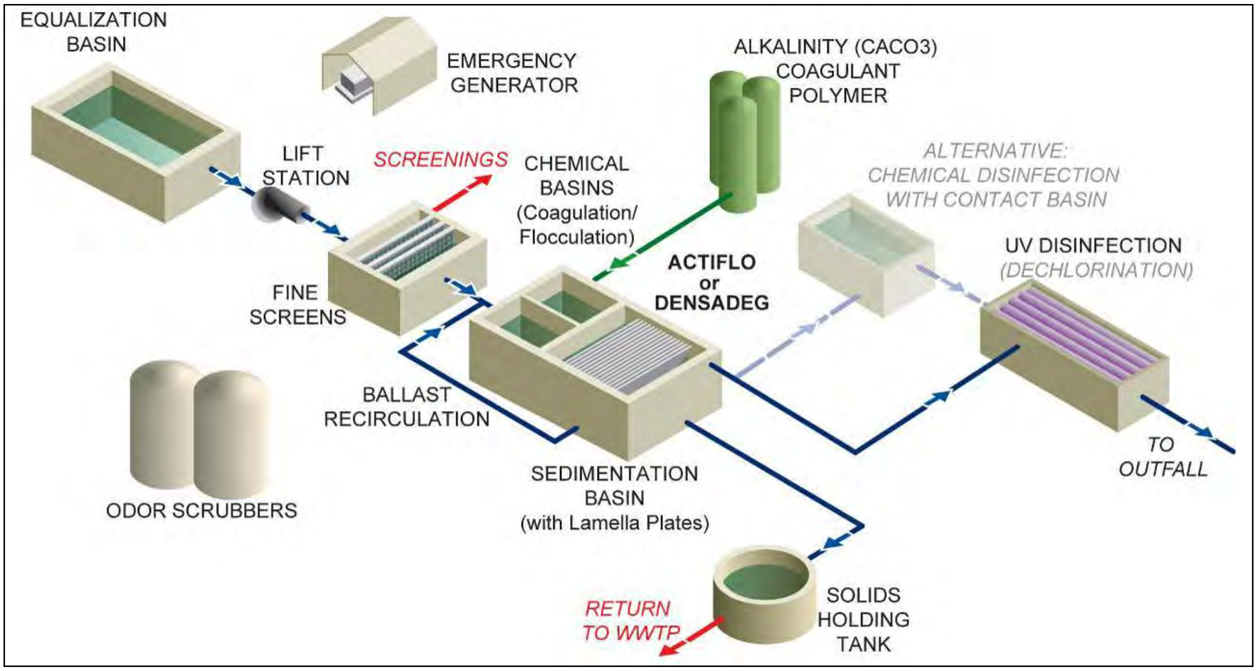

Figure 4-5. Sample Process Flow Schematic for Ballasted Sedimentation

For both of these processes, treatment alternatives in this review include an equalization basin to reduce peak flow rates to the treatment process and improve treatment effectiveness. Flows from the combined sewer system will be pumped to the treatment facility, and flows exceeding the hydraulic capacity of the treatment process will be stored in the equalization basin prior to treatment. The treatment process will operate at maximum capacity until the equalization basin is emptied. This will help ensure that all CSOs are treated and that the equalization basin is used only during events that exceed the treatment facility's design capacity.

The potential for the CSO effluent to deposit sediment and create an area exceeding Washington state's sediment quality standards (SQS) was evaluated using the Environmental Fluid Dynamics Code computer model. Both selected CSO treatment processes appear to have relatively high levels of TSS removal, reducing the loading rate of solids relative to existing CSO discharges. The expected loading rates from both processes were sufficiently low that no sediment quality exceedances were predicted for any conditions modeled. The sediment modeling results can be found in Technical Memorandum 750, Sediment Deposition and Contamination Potential from Treated CSO Discharges.

The selection of these two CSO treatment processes and equalization of peak flows required a reevaluation of land requirements and cost estimates for uncontrolled CSO sites where treatment has been identified as the preferred method of control.

The treatment technology evaluation and selection process is further described in Technical Memorandum 700, Treatment Technology Selection. Key design criteria for CSO treatment facilities and equalization basins are provided in Appendices F.1, F.3, and F.4 of Technical Memorandum 970, CSO Control Alternatives Development.

4.2.4 Green Stormwater Infrastructure (GSI)

GSI has evolved as a CSO control technology since the 1999 Plan Amendment. It reduces peak flows and volumes and provides water quality treatment of stormwater runoff from developed areas using infiltration, evapotranspiration, or stormwater reuse. GSI practices are intended to be decentralized, small-scale techniques, and can be used alone or in combination with traditional CSO control technologies.

In combined sewer basins, GSI practices are used to intercept and manage stormwater before it reaches the combined sewer system, thereby, increasing capacity in the system and reducing the potential for CSOs. The County plans to consider GSI wherever it can cost-effectively decrease the size of planned traditional CSO control facilities, or where it provides other benefits to the community or the environment. GSI techniques include:

- **Bioretention or rain gardens** involve dispersed small-scale landscape features designed to attenuate and treat stormwater. These features are typically vegetation-filled areas, such as planted areas and swales, often located in parking lots, median strips, or streets.
- **Permeable pavement** allows rainfall to penetrate through pavement into a porous material that retains stormwater before it enters a combined sewer, limiting or removing the effects of the stormwater on the sewer system.
- **Roof downspout disconnection** removes water that flows from a roof through a downspout to a combined sewer and redirects it to some other location. It is not considered a GSI technique but may be combined with GSI techniques such as rain gardens.
- **Green roofs or eco-roofs** consist of shallow layers of growing medium, low-growing vegetation, subsurface drainage, and a waterproof membrane installed on building roofs.
- **Trees or tree boxes** retain some rain in their canopies and take up a portion of the rain that infiltrates to the soil.
- **Rainwater harvesting** consists of the use of rain barrels and cisterns to capture, detain, or reuse stormwater for irrigation or flushing toilets.

Key factors that affect the potential success of GSI retrofit projects as they pertain to CSO control objectives are provided below:

- **Sufficient area of impervious surface connected to the combined sewer system**. GSI practices are used in conjunction with disconnection strategies; areas that drain to the combined sewer system are redirected to GSI practices, thereby increasing capacity in the combined sewer system. Therefore, the potential benefits of GSI practices are directly related to the amount of impervious surface which may be feasibly disconnected.
- **Space in the urban landscape for GSI retrofits**. Surface vegetated GSI techniques, such as bio-retention, require sufficient open space. Siting opportunities include, but are not limited to, existing planting strips, parking lots, and landscaped areas on private parcels.

- **Site suitability for infiltration practices**. Infiltrating GSI practices often provide the highest level of CSO control. Infiltration is not appropriate for areas near steep slopes or landslide hazard areas, areas underlain by high groundwater, or areas of contaminated soils or groundwater. Opportunities are highest where slopes are relatively flat and soils are permeable.
- **Re-infiltration of stormwater to the combined sewer system**. For GSI practices that rely on infiltration of stormwater, it is necessary to understand the fate of the infiltrated water. If there is a potential for re-infiltration of this water back into sewer laterals on private property or mainlines in the right-of-way, steps must be taken to eliminate these re-infiltration pathways. Methods can include pipe rehabilitation or replacement, trench water stops, and horizontal setbacks between infiltrating practices and sewer pipes.
- **Supporting conveyance infrastructure for large storm events**. In order to accommodate storms beyond design capacity, it is often necessary to direct excess flows back into the combined sewer system.
- **Community support for GSI projects**. Community understanding of GSI projects and support for their implementation is necessary for the success of this approach.

Of the fourteen uncontrolled CSO basins, the following ten CSO basins were further evaluated to identify GSI opportunities based on the factors listed above: 11th Ave NW, 3rd Ave W, University, Montlake, W Michigan St, Brandon St, S Michigan St, Chelan Ave, and Hanford #1 and Hanford #2[2]. These CSO basins were included due to the predominant land use categorization (i.e., less built-out areas with retrofit opportunities) or the degree of connection to the combined sewer system (i.e., probable opportunities for disconnection).

A reevaluation of alternatives, priority, and sequence or schedule is required for the remaining uncontrolled CSO basins where GSI opportunities have been identified. Where possible, the County will seek to collaborate with the City of Seattle. It should be noted that the sizes of the alternatives for the traditional CSO control facilities (gray alternatives) were conservatively not reduced to account for the GSI benefit (green alternatives) in this review. Sizing for those gray facilities reported is an “up to” volume or flow rate pending verification of projected stormwater diversion. Future evaluations will quantify the GSI benefit prior to final sizing of CSO control facilities. Additional information on the GSI evaluation is included in Technical Memorandum 810, Green Stormwater Infrastructure Alternatives.

4.2.5 Siting of CSO Control Facilities

The 1999 Plan Amendment’s adopted alternatives identify potential locations for CSO control facilities. Using the updated hydraulic modeling values and corresponding project sizing, the potential locations identified in the 1999 Plan Amendment were reviewed to determine if they are still available and practical for the proposed CSO control facilities. A preliminary evaluation was also completed to determine if there are any new siting opportunities. The siting process was divided into the following phases:

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[2] The Hanford #1 and Hanford #2 CSO Basins were evaluated as a single basin for GSI and are also referred to as the “Hanford” CSO Basin in the GSI evaluation.

- **Geographic Information Systems (GIS) Analysis—**GIS maps based on King County Tax Assessor data were created for each basin showing government-owned property, industrial-owned lands, parks, land for sale, properties over two acres, and underdeveloped properties. The following criteria were used to prioritize potential areas of interest:
  - Underdeveloped private industrial/commercial properties are the most desirable types of properties to accommodate CSO control facilities.
  - Government-owned (non-park) property may be viable depending on the size and use of the property.
  - Use of street right of way was considered for storage tanks and conveyance pipes but not for CSO treatment facilities due to the size of the area needed.
  - Residential property may be considered if industrial or government-owned lands are not suitable.
  - Use of City of Seattle Parks was considered lower priority due to potential impact to public use of open spaces and to city regulations.
  - Use of private parks and open space was not considered because it is very limited inside the City.
- **Brownfield Coordination—**Staff met with the County's Brownfield Program to identify any potential opportunities for cleanups with CSO control projects. No opportunities were identified, but this could be re-visited when the CSO control projects are further developed.
- **Windshield Surveys—**Windshield surveys of all uncontrolled CSO basins were conducted to evaluate the availability of the 1999 Plan Amendment's identified sites; compile additional information about properties near existing CSO facilities; and understand potential siting challenges and opportunities in each CSO basin. The windshield surveys confirmed the use of industrial private land as a valid consideration for cost estimating and identified potential sites. Many of the 1999 Plan Amendment sites were no longer available because they had been recently developed for another use.
- **Coordination with Stakeholders—**During this review's technical analysis, specific sites appeared to be potential candidates. If the site was owned by an agency, meetings were held to explore coordination opportunities. These meetings did not yield any information to influence project scheduling and prioritization, but the information will be transferred to the design teams for follow up in the future.

4.2.6 Asset Management

King County reviewed its long-range asset management needs and annual asset management plans to identify any potential overlap with the proposed CSO control projects that could impact schedule or priority. The County did not identify any major asset needs for the uncontrolled CSO sites that would impact schedule or priority. Asset management needs will be reviewed again during preferred alternative development and will be incorporated into projects as feasible.

4.2.7 1999 Plan Amendment Alternatives Needing Review Due to Technical Factor Changes

Based on the review of other technical factors, re-evaluation is needed for the 1999 Plan Amendment's adopted alternatives for all uncontrolled CSO sites (further details are provided in Appendix C of this report):

- The size of CSO control facility for the following CSO sites has changed significantly based on hydraulic modeling:
  - 3rd Ave W (DSN 008)
  - Montlake (DSN 014)
  - University (DSN 015)
  - King St (DSN 028)
  - Kingdome (DSN 029)
  - Lander St (DSN 030)
  - Hanford #1 (DSN 031)
  - Terminal 115 (DSN 038)
  - S Michigan St (DSN 039)
  - Brandon St (DSN 041)
  - W Michigan St (DSN 042)
- The type of CSO control facility for the following CSO sites has changed based on new model control volume needs:
  - 11th Ave NW (DSN 004)
  - Chelan Ave (DSN 036)
  - Brandon St (DSN 041)
- The recommended CSO treatment process for the following CSO sites (where treatment is being considered) has changed:
  - King St (DSN 028)
  - Kingdome (DSN 029)
  - Lander St (DSN 030)
  - Hanford #2 (DSN 032)
  - S Michigan St (DSN 039)
  - Brandon St (DSN 041)

- GSI opportunities identified in CSO basin may reduce the size of CSO control facilities needed for the following CSO sites (further verification is required):
  - 11th Ave NW (DSN 004)
  - 3rd Ave W (DSN 008)
  - Montlake (DSN 014)
  - University (DSN 015)
  - Hanford #1 (DSN 031)
  - Hanford #2 (DSN 032)
  - Chelan Ave (DSN 036)
  - S Michigan St (DSN 039)
  - Brandon St (DSN 041)
  - W Michigan St (DSN 042)
- Proposed facility locations for the following CSO sites are no longer feasible or new site locations have become available:
  - 11th Ave NW (DSN 004)
  - 3rd Ave W (DSN 008)
  - King St (DSN 028)
  - Kingdome (DSN 029)
  - Hanford #1 (DSN 031)

4.3 Human and Environmental Health Factors

King County develops the CSO Control Program and projects based on the most recent assessments of water and sediment quality and of risks posed to human health and the environment. The schedule for implementing CSO control projects gives priority to discharges that pose the greatest risk to human health, particularly at bathing beaches, and to environmental health, particularly those that threaten species listed under the ESA.

4.3.1 Recent Science

King County has conducted or participated in ecological and water quality studies to shape its wastewater management decisions, including those around CSO control. The history, content, and conclusions of scientific assessments done in support of CSO control decisions are summarized in Appendix E of this report. For this review Technical Memorandum 540, Environmental and Habitat Priorities presents an evaluation of current environmental and habitat science related to control of CSOs in the County developed since the 1999 Plan Amendment was adopted. The evaluation helped to prioritize where control efforts will occur next. The environmental and habitat priorities identified are based on a review of existing studies produced by the County and other entities. Those studies cover a variety of subjects related to ecological and human health in the Puget Sound region, including sediment quality, water quality, threatened and endangered species, climate change, and habitat improvement. The County updated these topics in the 2006 CSO Control Program Review and 2008 CSO Control Plan Update; however, Technical Memorandum 540, Environmental and Habitat Priorities addresses scientific developments since the 1999 Plan Amendment was published.

Human Health

Risks to human health in the Duwamish River/Elliott Bay, Lake Washington Ship Canal, and Montlake Cut include pathogen and chemical exposure from a variety of sources.

CSOs can release pathogens (contained in fecal matter) that can cause infections and diseases such as dysentery, hepatitis, and leptospirosis. CSOs also release a variety of chemicals that can cause several forms of cancer (e.g., skin, organ, gastrointestinal) or other, non-carcinogenic effects on humans (e.g., liver toxicity, kidney toxicity, immunotoxicity, neurological impairment). The most significant pathogen and chemical exposure route to humans is by incidental ingestion during direct water contact activities, such as swimming, scuba diving, windsurfing, recreational seafood collection, boating, etc. Also, people can be exposed to pathogens or chemicals through shellfish consumption, which is considered an indirect exposure.

Risks associated with pathogen exposure were the primary driver for prioritizing control of CSOs near Puget Sound beaches. Pathogen exposure and chemical exposure are no longer priority drivers for control of CSOs in the Duwamish River/Elliott Bay because, given the risks from sources other than CSOs, control of CSOs would do little to reduce the ongoing risk. The same may be true for the Lake Washington Ship Canal and Montlake Cut, although there is a lack of studies to assess risks associated with baseline conditions in those waterways.

CSO discharges contribute low levels of the harmful chemicals found in contaminated sediments, compared to industrial and other historical contributors to sediment contamination. Risk assessments conducted by King County for the Duwamish River and Elliott Bay identified cancer risks associated with direct exposure (net fishing and swimming) and indirect exposure (seafood consumption), with or without the influence of CSOs. Similar risk assessments have not been conducted for the Lake Washington Ship Canal, Montlake Cut, or Lake Union. Because removal of CSOs does not reduce risk of cancer from chemical exposure, there is no scientific driver to prioritize control in one water body over the other. However, sediment remediation and source control efforts are underway in the Lower Duwamish Waterway, which presents an institutional driver for prioritizing control of CSOs in this water body.

Water Quality

CSOs degrade water quality by contributing harmful bacteria, nutrients, dissolved heavy metals and harmful chemicals. However, because of the infrequent occurrence of CSOs, their effect on water quality is much less than that of other, largely uncontrolled sources, such as stormwater runoff.

Existing water quality conditions establish no clear priority for CSO control in one area over another. The Duwamish River, Lake Washington Ship Canal, and Montlake Cut are all of moderate water quality under established criteria and are known to have harmful concentrations of fecal coliform, nutrients, and dissolved oxygen. Each of these water bodies receives high volumes of pollutants from other sources (especially stormwater) that degrade water quality on a more consistent basis; therefore, removal of CSOs is not expected to have a substantially greater benefit in one water body than in another. Furthermore, the input of pollutants from other sources is heightened at the same time as CSO discharge events, when runoff rates are high, further reducing the relative effect of input from CSOs. Additional studies will be necessary to define whether any water bodies have significantly worse water quality than others due to pollutant loading from sources other than CSOs.

King County implements a monitoring program for local waters. WTD monitors for trends that may be related to CSOs and control decisions. Seasonal increases in bacteria are measured whether CSOs occur or not. Interactive monitoring maps and data, as well as technical summary reports for marine areas, are available at http://green.kingcounty.gov/marine/. The annual Marine Water Quality reports were one vehicle for reporting ambient monitoring data required in past NPDES permits to Ecology. Similar interactive maps, data, and technical reports are available for major lakes, including Lake Washington and Lake Union, at http://green.kingcounty.gov/lakes/. A summary of the current monitoring program is included in Appendix E of this report.

Climate Change

Climate change, as defined by the Intergovernmental Panel on Climate Change, includes any statistically significant change in climate persisting for an extended period. The effects of climate change are expressed in terms of temperature, precipitation, and sea-level rise; increases in these parameters could have several effects on CSO sites and other wastewater facilities in low-lying areas:

- Increased rate of river flooding and undermining of nearby sewer pipes and facilities
- Increased infiltration into pipes, resulting in higher water tables
- Increased possibility of inflow of river and estuary water into the combined sewer at outfalls
- Increased inflow into sanitary and combined sewers from overloaded stormwater systems.

These effects may cause a need for larger facilities (e.g., pump stations and storage facilities), higher facility elevations relative to water bodies, increased pumping, or enhanced flood and storm surge protections.

The effects of climate change establish no clear priority for CSO control in one area over another. However, sea-level rise attributed to climate change could have less of an effect on CSOs in the Lake Washington Ship Canal and Montlake Cut because the locks maintain a consistent and higher surface water elevation in these water bodies relative to Elliott Bay and the Lower Duwamish River.

Sediment Quality

Historical and current land uses have resulted in contamination of sediments in the Duwamish River, Elliott Bay, and Lake Union. Typical sources of contamination are raw wastewater, industry, stormwater, and CSOs. Current high priority efforts to remediate sediment contamination and eliminate ongoing sources of contamination in the Lower Duwamish Waterway present an institutional driver for prioritizing control of CSOs in the Duwamish

River/Elliott Bay. Sediment remediation efforts are not yet underway in Lake Union, so the Lake Washington Ship Canal and Montlake Cut area are of lower priority for control.

An ongoing question has been to what extent CSOs can contaminate sediments after they have been remediated, and whether it makes sense to control CSOs prior to remediation efforts. Based on sediment monitoring, some recontamination of sediments is occurring at the Norfolk and Diagonal/Duwamish CSO sites, but evaluations do not strongly link it to uncontrolled CSO sites. This is a factor to be considered in planning control for the Hanford #1 CSOs as they ultimately discharge to the Diagonal/Duwamish CSO site. Similar studies have not been conducted in the Lake Washington Ship Canal or Montlake Cut because remediation has not occurred in these water bodies. Therefore, it is difficult to prioritize CSO control in one water body over the other based on scientific factors related to sediment quality.

The SMP update will include a new near-field recontamination model which will be used to characterize areas around controlled CSO outfalls. The additional information from this tool is not expected to change the waterbody prioritization for CSO control.

Ecological Health

The ecological health of the Duwamish River, Elliott Bay, Lake Washington Ship Canal, and Montlake Cut is based on the status of key species that could be affected by CSOs. These include aquatic and wildlife species that have a primary association with aquatic habitat. Of all threatened and endangered species in the vicinity of CSO sites, salmonids (Chinook, steelhead, and bull trout) are most likely to be affected by CSOs because they migrate through the water bodies where CSOs occur (e.g., Duwamish River, Lake Washington Ship Canal, Montlake Cut), and are more closely associated with shoreline habitats where CSOs occur.

Based on potential exposure in proximity to outfalls, CSO sites in the Duwamish River/Elliott Bay area should receive a higher priority for control than the Lake Washington Ship Canal and Montlake Cut. CSOs occur predominantly over a period extending from October through April. During this time, juvenile Chinook salmon in the Duwamish River and adult Chinook salmon in the Lake Washington Ship Canal/Montlake Cut are most likely to come in contact with CSOs. Control of CSO sites in the Duwamish River/Elliott Bay has potential to have more of an effect on Chinook salmon survival and recovery than control of sites in the Lake Washington Ship Canal/Montlake Cut for the following reasons:

- The higher frequency and volume of CSOs in the Duwamish River can cause more harmful exposure of juvenile Chinook salmon to pollutants than adult Chinook salmon exposure in the Lake Washington Ship Canal/Montlake Cut.
- Juvenile Chinook salmon reside in the Duwamish River for a longer duration than adult Chinook salmon reside in the Lake Washington Ship Canal/Montlake Cut.
- Juvenile Chinook salmon are more susceptible than adult Chinook salmon to adverse effects caused by pollutants.

However, the potential adverse effects of pollutants from CSOs on juvenile Chinooks may not be distinguishable from the effects of high volumes of similar pollutants from other sources, especially stormwater. The input of pollutants from other sources is heightened during CSO discharge events when runoff rates are high, further reducing the relative effect of input from CSOs.

4.3.2 Habitat Restoration

In 2010, King County identified habitat-related programs and planned habitat projects that could occur in the future within the basins of the 14 uncontrolled CSO sites. Four major programs that provide an opportunity for habitat restoration could overlap with future CSO control projects:

- The Salmon Habitat Plan for Water Resource Inventory Area 9 (WRIA 9)
- The Duwamish Superfund Cleanup
- The Natural Resource Damage Assessment for the Lower Duwamish River
- The Port of Seattle's Lower Duwamish Habitat Program.

These programs include numerous habitat plans and conceptual projects adjacent to the uncontrolled CSO basins. Based on the research, it appears that the habitat projects could have schedule and scope implications or provide a coordination opportunity only for the Brandon St CSO Basin. Potential habitat programs and projects identified for each uncontrolled CSO basin are summarized in Table 4-1 of the Habitat Project Opportunities Technical Memorandum.

4.3.3 Sensitive Areas

EPA requires prioritization of CSO control efforts based on analysis of sensitive areas. The approach is organized differently from King County's approach under Ecology control planning, but ultimately considers the same kinds of factors. To assist EPA's compliance review of the County's CSO Control Program, prioritization is presented using a sensitive areas analysis.

Examples of sensitive areas presented in EPA's 1994 CSO Control Policy (codified as the Wet Weather Water Quality Act of 2000, H.R. 4577, 33 U.D.C. 1342(q))) and in EPA's CSO Control Guidance for Long-term Control Plan (September 1995) include designated Outstanding National Resource Waters, National Marine Sanctuaries, waters with threatened or endangered species and their habitat, waters supporting primary contact recreation (e.g., bathing beaches), public drinking water intakes or their designated protection areas, and shellfish beds. The awareness of sensitive areas might guide the development and selection of control alternatives, as well as the identification of priorities for project implementation.

Under Ecology's program, all CSOs are to be regulated through NPDES permits and are to be controlled. Under Chapter 173-245-040 WAC, each municipality shall propose rankings of its selected treatment/control projects based on the following criteria:

- Highest priority must be given to reduction of CSOs that discharge near water supply intakes, public primary contact recreation areas, and potentially harvestable shellfish areas.
- A cost-effectiveness analysis of the proposed projects can include a determination of the monetary cost per annual mass pollutant reduction, per annual volume reduction, or per annual frequency reduction achieved by each project.
- Documented, probable, and potential environmental impacts of the existing CSO discharges.

The County's CSOs do not discharge into designated Outstanding National Resource Waters, National Marine Sanctuaries, or waters supporting public drinking water intakes or their designated protection areas. For this evaluation three different categories of sensitive areas were evaluated: human uses (including primary contact areas and shellfish beds), habitat (including endangered species and their habitat), and regulatory concerns.

Recognizing that the spatial extent of these various sensitive areas varied in space and time, the County's sewer service area was divided into zones to aid the analysis. A total of five zones were created, and the number of sensitive areas within each zone, or the presence or absence of certain types of sensitive areas, was noted. Zones were defined as follows and detailed descriptions are provided in Appendix E of this report:

- Zone 1 – North Sound
- Zone 2 – Central Sound/Elliott Bay/Duwamish
- Zone 3 – Duwamish Head to Fauntleroy
- Zone 4 – Lake Union Ship Canal
- Zone 5 – Lake Washington

Appendix E of this report provides detail on zone/area characteristics as well as qualitatively comparing the zones. Because this analysis did not consider each individual outfall but rather the characteristics of the zone into which the outfalls discharge, priority within an environmental zone should consider additional factors rather than those of this analysis alone.

Assuming a qualitative ranking of 3 for high exposure/risk sensitivity to 0 for negligible exposure/risk sensitivity, rankings were assigned to the zones as presented in Table 4-6.

Table 4-6. Summary of Sensitive Area Rankings

Zone	Human Primary Contact/Fish Consumption Risk Sensitivity	Human Secondary Contact Risk Sensitivity	Habitat /Endangered Species Risk Sensitivity	Water Quality Impairment Sensitivity	Total
1	3	3	3	0	9
2	2	1	3	3	9
3	3	3	3	1	10
4	2	3	1	1	7
5	3	3	3	2	11

Prioritization based on these qualitative sensitive areas rankings results in Lake Washington having highest priority for CSO control, South Sound and Elliott Bay/Duwamish areas tied for second priority, the North Sound being third and the Ship Canal being fourth. With control of county CSOs completed in Lake Washington and the Puget Sound Beach projects underway, uncontrolled CSO sites in Zone 3 (Duwamish Head to Fauntleroy) should be the priority for the King County Executive's Recommended CSO Control Plan. The similarity of the rankings also gives support to the assessment of Technical Memorandum 540, Environmental and Habitat Priorities—there was little science-based differentiation between the remaining areas needing

CSO control. Instead, Technical Memorandum 540 identified the benefit of coordinating with the regional initiative to clean up the Duwamish River as a sufficient reason to prioritize CSO control in the Duwamish River sooner. Appendix E of this report provides more detail on this assessment.

4.3.4 CSO Control Priority Conclusions

Previous studies have concluded that there would be limited improvement of conditions for aquatic life, wildlife, and people if CSO discharges are controlled. However, CSOs are one contributor to poor water and sediment quality, which has adverse effects on ecological and human health.

According to NPDES permit requirements, all remaining uncontrolled CSO sites need to be controlled. The County identified that this would be completed by 2030 in the 1999 Plan Amendment. The County must prioritize the next phase of CSO control projects in the Duwamish River/Elliott Bay, Lake Washington Ship Canal, or Montlake Cut.

According to the 1999 Plan Amendment, the next highest priority for CSO control efforts are the University and Montlake CSO sites because of the amount of boating in the area, which could result in secondary contact with the water. However, based on the evaluation of environmental priorities presented in Technical Memorandum 540, Environmental and Habitat Priorities, secondary contact with water from boating is a low risk, and there does not appear to be an overall consensus for prioritizing control of CSOs in one water body over the other based on scientific drivers. However, current efforts to remediate sediment contamination and eliminate ongoing sources of contamination in the Lower Duwamish Waterway (LDW) represents an institutional driver for controlling CSOs, which applies to sediment quality and human health environmental priorities. Table 4-7 summarizes CSO control priority decisions based on an evaluation of environmental priorities.

Table 4-7. CSO Control Area Priority Based on Evaluation of Environmental Priorities

Environmental Priority	CSO Control Area Priority Status				Qualifiers		
	Duwamish River/ Elliott Bay Priority	Lake Washington Ship Canal Priority	Montlake Cut Priority	No Difference in Priority	Scientific Driver	Institutional Driver	Insufficient Data/ Imbalance of Data
Water Quality				X			X
Sediment Quality	X					X	X
Human Health							
Pathogens (incidental ingestion)				X			X
Chemicals (fish consumption)	X					X	X
Ecological Health	X				X		X
Climate Change				X			

4.3.5 1999 Plan Amendment Alternatives Needing Review Due to Human and Environmental Health Factor Changes

Based on the review of human and environmental health factors, re-evaluation is needed for the 1999 Plan Amendment's adopted alternatives as follows (further details are provided in Appendix C of this report):

- Environmental factors have changed CSO control priority for all uncontrolled CSO sites except 11th Ave NW (DSN 004) and 3rd Ave W (DSN 008)
- Changes in the water quality of the receiving water body affect CSO control alternatives for Hanford #1 (DSN 031).

4.3.6 Change Following 2011 WTD Recommended CSO Control Plan Public Involvement

Concerns raised by some members of the public about whether dollars spent on CSO control is the best investment in water quality have prompted the King County Executive to recommend conducting a water quality assessment and monitoring study to inform the next CSO control program review for the 2019 NPDES permit renewal. Additional information about the study can be found in Section 11.3 of this report.

4.4 Public and Regulatory Agency Participation

King County seeks to provide an integrated public and agency information and involvement process. CSO control outreach is carried out within the County's CSO Control Program to ensure equity and social justice. Information on the equity and social justice program can be found at http://www.kingcounty.gov/exec/equity.aspx. The King County Community Outreach Guide can be found on the "tools and resources" tab of this web page.

The County's West Point Treatment Plant and all of its combined sewer facilities are located within the City of Seattle, and so the City is both a stakeholder and a partner in the County's CSO Control Program. The County and the City have a role in each other's long-term CSO control efforts and their associated public and agency participation plans. The focus of the role varies with the program component as described in the County's Long-term CSO Control Plan Public and Regulatory Agency Participation Plan, which is available on the County's CSO Control Program website at http://www.kingcounty.gov/environment/wastewater/CSO/ProgramReview/plan.aspx#techmemos.

Throughout this review, the county staff solicited input on the CSO Control Program from a wide variety of individuals and organizations. The effort offered numerous opportunities to listen to the questions, concerns, and priorities of these organizations, and to incorporate their suggestions wherever possible. County staff met with and interviewed individuals working for different interest groups and agencies, made presentations to different organizations, and hosted public workshops focusing on the science and technology of CSO control.

Public involvement activities for this review continued following the issuance of the 2011 WTD Recommended CSO Control Plan. The County again heard both support for the Plan and concern about costs and environmental benefit. Copies of the formal comment letters are presented in Appendix F.

The following are key findings from the discussions conducted to date:

- CSO control is important to stakeholders. They understand the water quality impacts of overflows and want to see this problem addressed. They also understand the regulatory pressures at the state and local levels to bring CSOs under control.
- Some stakeholders are concerned with the "bigger picture" of stormwater management. They assert that if stormwater were better contained and kept out of surrounding water bodies, the need to also control CSOs would be significantly reduced.
- King County/City of Seattle coordination on possible CSO solutions is viewed as highly important.
- There is strong recognition that continued evaluation of scientific data is important. For example, stakeholders are supportive of prioritizing CSO control projects along the Duwamish River due to environmental and public health concerns.
- There is strong support for the more advanced technologies that the County is proposing to use for CSO treatment at its new CSO treatment facilities.
- GSI is an area of increasing interest, and stakeholders hope this control alternative is employed as often and as effectively as possible. Stakeholders also recognize, however, that GSI can be controversial in neighborhoods where residents are likely to lose parking or have other concerns about street-side rain gardens and other GSI facilities.
- Both support and concerns were raised about a possible Ship Canal tunnel alternative that has continued to be developed. Stakeholders tended to support the potential alternative since it could reduce the impacts of other alternatives on their communities. Some stakeholders recognized that GSI might not be considered useful to reduce the size of such a large and complex facility.
- The introduction of more CSO control projects throughout the City has increased the overall level of public awareness about CSO issues, but has also generated some controversy. Stakeholders urge that greater care be taken to ensure comprehensive public information and involvement around these projects, and recommend that both the City and the County engage the public as extensively as possible in siting decisions, with the desired outcome being enhanced public support of projects.
- Stakeholders caution that CSO control approaches need to be balanced against cost considerations and hope that costs will be kept in mind to maintain a reasonable rate structure for the public.

The public will be able to comment on the King County Executive's Recommended CSO Control Plan as part of the Council's deliberations. Information on how to participate in their deliberations will be available on the CSO control program website at: http://www.kingcounty.gov/environment/wastewater/CSO/ProgramReview/PublicInvolve.aspx.

The adopted amendment to the Plan will be available for comment during Ecology's NPDES permit process in 2013 and 2014. A summary of the 2010-11 public involvement activities is included in Appendix F of this report. A detailed list of contacts made up to the publication of this report is included in the County's Long-term CSO Control Plan Public and Regulatory Agency Participation Plan.

4.4.1 1999 Plan Amendment Alternatives Needing Review Due to Public and Regulatory Agency Participation Changes

Based on public and regulatory agency input received during this review, re-evaluation is needed for the 1999 Plan Amendment's adopted alternatives as follows (further details are provided in Appendix C of this report):

- Stakeholders view coordination between King County and the City of Seattle as important. Potential joint projects have been identified for the following CSO sites:
  - 11th Ave NW (DSN 004)
  - 3rd Ave W (DSN 008)
  - Montlake (DSN 014)
  - University (DSN 015)
  - King St (DSN 028)
  - Hanford #1 (DSN 031)
  - S Michigan St (DSN 039)
  - Brandon St (DSN 041)
- Stakeholders are supportive of prioritizing control of CSOs in the Duwamish River. Prioritizing Duwamish CSO sites sooner impacts the following CSO sites:
  - Montlake (DSN 014)
  - University (DSN 015)
  - King St (DSN 028)
  - Kingdome (DSN 029)
  - Lander St (DSN 030)
  - Hanford #1 (DSN 031)
  - Hanford #2 (DSN 032)
  - Chelan Ave (DSN 036)
  - Terminal 115 (DSN 038)
  - S Michigan St (DSN 039)
  - Brandon St (DSN 041)
  - W Michigan St (DSN 042)

- Stakeholders have indicated that implementing GSI as much as feasible is important. GSI opportunities have been identified for the following CSO sites:
  - 11th Ave NW (DSN 004)
  - 3rd Ave W (DSN 008)
  - Montlake (DSN 014)
  - University (DSN 015)
  - Hanford #1 (DSN 031)
  - Hanford #2 (DSN 032)
  - Chelan Ave (DSN 036)
  - S Michigan St (DSN 039)
  - Brandon St (DSN 041)
  - W Michigan St (DSN 042)

4.5 Coordination with Other Agencies

4.5.1 City of Seattle's CSO Control Program

King County provides wastewater services for 17 cities, 16 sewer districts, and one Indian tribe. By contractual agreement with these local agencies, the County owns and operates the regional conveyance facilities downstream of all local agency sewer basins that combine to serve an area of 1,000 acres or more. The County conveys these local agency flows through its regional conveyance system to one of its wastewater treatment/reclamation plants. Local agencies, such as the City of Seattle, own the sewer collection systems in the basins contributing to the regional system.

Since the County's and the local agencies' systems are connected, one agency's system may impact another's system. This is particularly true with the City because a large part of the City's system is combined sewer, with highly variable wet-weather flows that require complex flow control facilities and operations.

The City's wastewater collection system consists of combined, partially separated, and separated areas. Approximately two-thirds of the City is served by a combined or partially separated sewer system (971 miles of sewer). Most Seattle wastewater is conveyed to county sewers for conveyance to treatment facilities. The City has controlled overflows from 50 of its 90 CSO outfalls. The remaining uncontrolled CSO sites must be controlled by 2025, which is five years earlier than the County's CSO control date.

Although the County and the City are distinct governments with different legislative bodies, responsibilities, regulatory requirements, and financial requirements, the two agencies recognize that they must work together to serve citizens and protect the region's water quality. The County and the City have coordinated over the years to explore CSO control projects that benefit both agencies, the environment, and the communities served.

In recent years, coordination has increased significantly, with meetings and planning efforts occurring at least monthly, and with staff communication at least weekly. Both agencies have provided information relevant to each other's project areas – the City's waterfront, Diagonal, Windermere, Genesee, and Henderson projects, and the County's Puget Sound Beach projects – including GIS data, rain gauge data, supervisory control and data acquisition (SCADA) data, portable flow monitoring data, and pump station performance data. Each agency has allowed the other to place meters at its facilities. Significant time has been spent sharing and translating hydraulic modeling efforts and supporting the City's development of its system model. The City has shared its experience with GSI to support the County's Puget Sound Beach projects. In 2011, the County incorporated the City's real-time data into its on-line notification website to provide the public more comprehensive information.

Through all of this coordination, it became clear that a more systematic analysis of potential joint CSO control projects would benefit both agencies. In early 2009, the County proposed a joint CSO control alternatives analysis effort, with parallel development of independent and joint alternatives. The first meeting occurred to outline the process on May 27, 2009.

Joint opportunities identified for some of the County's uncontrolled CSO sites could impact the project definition, sequences and schedule, or priority of alternatives. A reevaluation of CSO control approaches is required for these sites.

The coordination process proceeded in steps, with decisions to proceed occurring at key milestones. Viable joint alternatives were developed and then compared with independent alternatives, so that each agency could develop an optimal implementation plan. A decision to advance joint alternatives into sequence and schedule development was made jointly by each agency's management. Recommended joint alternatives were planned to integrate with each agency's independent project sequences and schedule, and those sequences were then assessed for rate impacts by each agency (see Chapters 6, 7, and 8 of this report for more information). If sequences meeting each agency's regulatory and financial goals are identified, then the joint alternatives and sequences and schedule will be incorporated into each agency's long-term CSO control plan amendments. The city decisions for their long-term CSO control plan is on a different schedule from the County's due to differing NPDES permit application dates. The King County Council will consider the proposed Plan changes over the summer of 2012, with adoption anticipated by the fall. The City will not be able to firmly commit to joint projects until their council adopts them in 2014. Until then, the County is committed to pursuing cost-effective joint projects with the City. If the City's remaining planning leads them to decisions that independent alternatives better serve their interests, the County will pursue their independent alternatives that are nearly equivalent. These are described in Technical Memorandum 970, CSO Control Alternatives Development.

The history of coordination between the County and the City is further described in Section 1.5 of Technical Memorandum 970, CSO Control Alternatives Development (found at http://www.kingcounty.gov/environment/wastewater/CSO/ProgramReview/plan.aspx#techmemos).

4.5.2 Other Agencies

Coordinating CSO control projects with other agency and community projects could help avoid conflicts, streamline permitting and implementation, and minimize community impacts. For this review, King County contacted the following entities for information on future project needs in the vicinity of the County's uncontrolled CSO sites:

- Lower Duwamish Waterway Group
- Port of Seattle
- Seattle Center
- Seattle Department of Transportation (SDOT)
- Seattle Department of Parks
- Seattle Department of Neighborhoods
- Seattle Housing Authority
- Seattle Public Schools
- Seattle Public Utilities Drainage and Wastewater Unit
- Seattle University
- Sound Transit
- University of Washington
- Washington State Department of Transportation (WSDOT)
- Woodland Park Zoo

Efforts to contact large commercial or industrial developments were not successful. Subtask 911 – Collaborative Opportunities Planned near King County Uncontrolled CSOs Technical Memorandum identifies the uncontrolled CSO sites for which any coordination opportunities have been identified, along with the status of coordination activities.

4.5.3 1999 Plan Amendment Alternatives Needing Review Due to Agency Coordination Changes

Based on the review of coordination opportunities with other agencies, re-evaluation is needed for the 1999 Plan Amendment's adopted alternatives for the following uncontrolled CSO sites (further details are provided in Appendix C of this report):

- 11th Ave NW (DSN 004)
- 3rd Ave W (DSN 008)
- Montlake (DSN 014)
- University (DSN 015)
- King St (DSN 028)

- Hanford #1 (DSN 031)
- S Michigan St (DSN 039)
- Brandon St (DSN 041)

4.6 Summary of Need for Alternative Re-Evaluation

Based on the review of factors and changes, a reevaluation of alternatives, priority, sequence, and schedule is required for all 14 uncontrolled CSO sites. The change matrix in Appendix C of this report identifies which changes triggered the need for a reevaluation for each uncontrolled CSO site. The matrix also includes a brief description for each previously identified adopted alternative site, projected year of control, CSO control volume, and CSO peak flow rate. Updated 2010 CSO control volume and CSO peak flow rate from recent hydraulic modeling are also included.

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Chapter 5

Alternatives Development, Evaluation, and Selection

Based on the review of factors described in Chapter 4 of this report, a reevaluation of 1999 CSO Control Plan Amendment (1999 Plan Amendment) alternatives[1], priority, sequence, and schedule was required for all 14 uncontrolled CSO sites. This chapter summarizes the alternatives development, evaluation, and selection processes used, from preliminary alternatives through final alternatives for this review. Recommended preferred alternatives were selected for each uncontrolled CSO site. Details of this process are presented in Technical Memorandum 970, CSO Control Alternatives Development. All review technical memorandums can be found at http://www.kingcounty.gov/environment/wastewater/CSO/ProgramReview/plan.aspx#techmemos.

5.1 Evaluation Overview

5.1.1 Terminology

The following are definitions for the alternatives terminology used in this report:

- **Alternatives**—Planning-level project concepts.
- **Adopted alternatives—**Recommended CSO control projects for each CSO site from the 1999 Plan Amendment.
- **CSO control approaches—** General types of technology for CSO control; this review identified feasible CSO control approaches for each uncontrolled CSO site.
- **Preliminary alternatives—**All of the adopted alternatives plus new alternatives developed for this review based on updated conditions since the 1999 Plan Amendment was adopted. The new preliminary alternatives use the CSO control approaches identified as feasible for each uncontrolled CSO site.
- **Final alternatives—**Those alternatives remaining after a screening of preliminary alternatives.
- **Recommended preferred alternatives**—The final set of alternatives identified as the best combination of CSO control projects, at this planning-level stage, to provide control for all uncontrolled CSO sites evaluated in this review.

[1] "Alternative" is used here to describe a planning-level project concept.

- Preliminary, final, and recommended preferred alternatives consist of several types of alternatives:
  - **Site alternatives—**Those alternatives that would control a single CSO site.
  - **Consolidated alternatives—**Those alternatives that would control multiple CSO sites.
  - **Independent alternatives—**Site or consolidated alternatives that would contribute to control of CSOs only in the King County combined sewer system or only in the Seattle Public Utilities (SPU) system. Flow transfers from SPU that did not measurably increase the size of county facilities, but would have operations and maintenance impacts, were considered county independent alternatives. These transfers would decrease the size and cost of City of Seattle projects.
  - **Joint alternatives—**Consolidated alternatives that would contribute to control of CSOs in both the county combined sewer system as well as the SPU system. Flow transfers from SPU that increased the size of county facilities and would ultimately be managed by county facilities, such as CSO treatment plants, were evaluated as joint alternatives. These transfers would decrease the size and cost of city projects.
- **Area alternatives—**Combinations of site and/or consolidated alternatives that provide control of all uncontrolled CSO sites in a given geographic area (see Section 1.6 of this report for the definition of areas). Final alternatives were grouped into area alternatives for the triple-bottom-line analysis and selection of recommended preferred alternatives. See Section 5.5.2 of this report for development of area alternatives.
- **Green Stormwater Infrastructure (GSI) or green alternatives—**Low-impact measures implemented to reduce stormwater runoff to the combined sewer system from a neighborhood or area. This review evaluated GSI alternatives separately from the evaluation of alternatives using other CSO control approaches. Where GSI is predicted to allow a reduction in the size of a traditional CSO control facility (gray facility), the facility size is not reduced in this review. Future evaluations, including enhanced monitoring and modeling, will quantify, and then verify, the benefit of GSI techniques prior to gray facility sizing.
- **Gray alternatives—**These are traditional CSO control facilities (non-GSI alternatives) that would include conveyance improvements, storage facilities, and CSO treatment facilities.

5.1.2 Evaluation Process

All alternatives were specified to provide control capacity to meet the Ecology performance or control standard of “an average of one untreated discharge may occur per year”, which EPA has indicated is equivalent to their presumptive standards for system control.

Alternatives development of traditional CSO control facilities (gray facilities) and GSI facilities (green facilities) occurred in parallel. The sizes of the gray alternatives were conservatively not reduced to account for the GSI benefit in this review. Sizing for those gray facilities reported is an “up to” volume or flow rate pending verification of projected stormwater diversions. Future evaluations will quantify the GSI benefit prior to final sizing of the gray facilities. After the GSI reductions have been validated, the most cost-effective balance between gray and green facilities will be established during predesign, and the combination will achieve the CSO control performance standard. Additional information on the GSI evaluation is included in Technical Memorandum 810, Green Stormwater Infrastructure Alternatives. GSI alternatives are also discussed in Section 5.7 and summarized in Table 5-12.

The following methodology was used to update the CSO control recommendations from the 1999 Plan Amendment for the uncontrolled CSO sites (see Figure 5-1):

- An initial assessment prior to this review identified CSO control approaches that are feasible for each uncontrolled CSO site.
- A set of preliminary alternatives was developed from two sources:
  - Adopted alternatives
  - New alternatives developed for this review using the identified feasible CSO control approaches.
- The preliminary alternatives were screened based on technical considerations, relative cost-effectiveness, community and public health, environmental impacts, land use and permitting, and operation and maintenance implications. Alternatives that were not screened out moved forward as final alternatives.
- Screened preliminary alternatives and alternative variations identified after the preliminary screening were developed into final alternatives by refining the cost, size, and location. A triple-bottom-line analysis of the final alternatives, which assesses environmental and social metrics in addition to financial, was performed to identify recommended preferred alternatives. See Section 5.5 of this report for more information.
- GSI (or green) alternatives were developed and evaluated in parallel with final gray alternatives for uncontrolled CSO basins with potential for GSI retrofit. Runoff volume reduction benefits and life-cycle costs were estimated. The GSI alternatives deemed cost-effective were identified with the recommended preferred alternatives. The sizes of the gray alternatives were conservatively not reduced to account for the GSI benefit in this review. Future evaluations, including enhanced monitoring and modeling, will quantify and then verify the benefit of GSI techniques prior to gray facility sizing. See Section 5.7 of this report for more information.

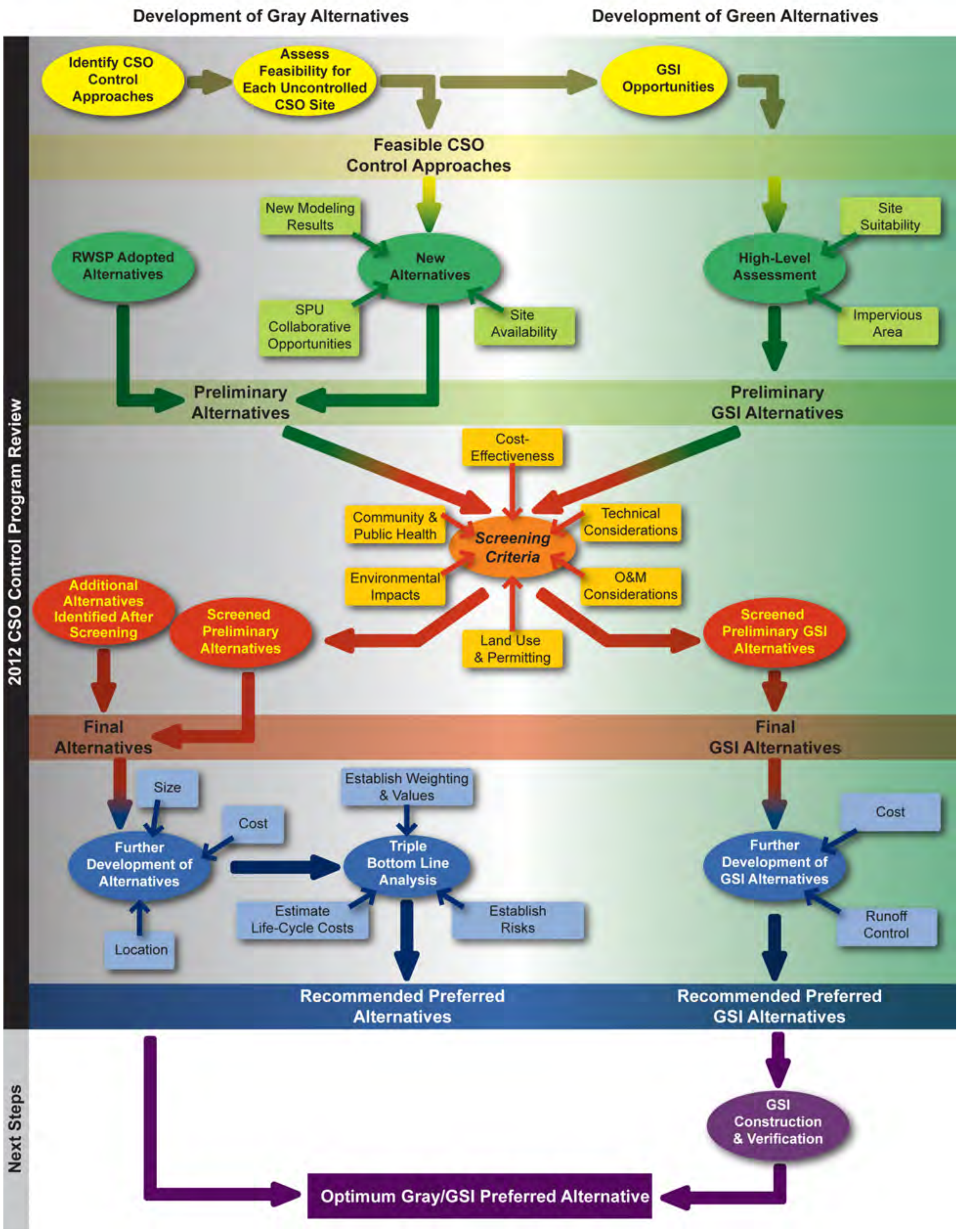

Figure 5-1. Identification and Evaluation of CSO Control Alternatives

5.2 Feasible CSO Control Approaches

A broad range of CSO control approaches was identified for initial consideration in this review. Each was assessed for its feasibility as a control measure for King County's uncontrolled CSO sites. Table 5-1 summarizes the approaches selected for consideration and CSO sites where the control measure may be feasible.

Table 5-1. Feasibility Assessment for CSO Control Approaches

Description	Advantages	Disadvantages	CSO Sites Feasible
Sewer Separation[a]			
Reroute stormwater running off streets, parking lots, and roofs from the combined sewer system to an existing or newly constructed separated stormwater system.	Reduces the frequency or magnitude of CSO events. Permanently removes stormwater from the combined sewer system. Low operation and maintenance requirements in comparison to other CSO control approaches. Provides steadier flow to treatment plant. Separation and stormwater conveyance can be combined with other road improvements projects.	Does not eliminate contamination associated with separate stormwater discharges (oil, grease, floatables, heavy metals, and organics). Requires treatment for stormwater discharges that impact water quality in a receiving water body. May require new stormwater collection and conveyance facilities in already crowded or restricted utility corridors. Significant community disruption.	Brandon St
Green Stormwater Infrastructure[b]			
Reduce runoff through infiltration, small-scale detention, evaporation, or beneficial reuse.	Can assist in reducing the size of high-cost downstream control measures. Can be effective in small areas or neighborhoods if the soil and groundwater conditions are suitable. Can provide a neighborhood amenity.	Generally only effective for CSO control in combination with other measures. Not effective in areas with impermeable soils and/or high groundwater conditions. May reduce parking in neighborhood. May not be appropriate in areas of contaminated soils.	All *except* King St, Kingdome, Lander St, and Terminal 115

Table 5-1. Feasibility Assessment for CSO Control Approaches

Description	Advantages	Disadvantages	CSO Sites Feasible
Increased Conveyance[a]			
Transfer excess flows from a basin with limited capacity to a downstream system or facility with available capacity via a new line or upsizing an existing line.	Reduces the frequency or magnitude of CSO events. May maximize use of existing facilities. May result in fewer facilities requiring operations and maintenance.	Potential impact on downstream system elements. Can require costly new conveyance pipes in already restricted utility corridors. Moves impacts from one neighborhood to another. Seattle Department of Transportation street use permits may be costly.	11th Ave NW, Hanford #1
Offline Storage[a]			
Tanks, pipes, or tunnels offline from the combined sewer system that fill when a specific elevation is exceeded in the system and empty when downstream conveyance capacity becomes available.	Provides detention to reduce the peak flow that downstream pipes and pump stations must convey during wet-weather events. Below-ground storage facility reduces visual impact. Allows for capture of settleable solids and floatables. Depending on the location in the system, flows may drain to the secondary treatment plant.	Land area requirement limits siting options in urban areas. Property acquisition, permitting, cost, and time requirements. Large pipelines to convey volumes to and from the storage facility require deep and wide excavation areas. Odor control requirements. Maintenance of mechanical equipment. Limited by the downstream capacity available to receive flows from draining the storage facility after a wet-weather event.	11th Ave NW, 3rd Ave W, University, Montlake, Chelan Ave, King St, Hanford #1, W Michigan St, Terminal 115

Table 5-1. Feasibility Assessment for CSO Control Approaches

Description	Advantages	Disadvantages	CSO Sites Feasible
CSO Treatment[a]			
Provide treatment for combined sewer flows prior to discharge.	Removes flow from the combined sewer system. May consolidate operation and maintenance at a single site. Can be designed to treat a wide range of flow rates from different size wet-weather events. Capable of treating back-to-back wet-weather events. Continues to provide treatment after a storage tank (sized for one-year recurrence frequency by volume) would be full, reducing the volume of the one untreated discharge per year.	Requires ongoing sampling and analysis to demonstrate adequate pollutant removal for regulatory compliance. Land area requirement limits siting options in urban areas. Challenging staffing to manage intermittent operation; certified treatment plant operators required. Operations may not be considered appropriate for residential areas. Public impacts (odor, noise, traffic, visual aesthetics). Permitting process, including environmental review. High operation and maintenance costs for water quality monitoring and operating plant. Continuing discharge of treated effluent in near-shore areas.	King St, Kingdome, Lander St, Hanford #2, Brandon St, S Michigan St

a. Gray facility or approach.

b. GSI (or green) facility or approach.

5.3 Preliminary Alternatives

5.3.1 Identification of Preliminary Alternatives

Preliminary alternatives for this review were developed from two sources:

- The adopted alternatives from the 1999 Plan Amendment for the 14 uncontrolled CSO sites.
- New alternatives based on information or circumstances that have changed since the 1999 Plan Amendment; these alternatives use the feasible CSO control approaches identified in Section 5.2 of this report. The primary drivers are as follows:
  - New hydraulic modeling results—Updated hydraulic modeling provides the most current design criteria for selecting the best type of CSO control approach as well as for sizing the selected approach.

- Consolidation of King County projects—This review considers how CSO control approaches for each uncontrolled CSO site could realize cost or performance benefits by being combined with control approaches for another CSO site or with some other planned county project.
- Coordination with SPU—This review identifies potential joint projects that address the CSO control needs of both the County and SPU. Joint projects will the preferred alternative when they are technically feasible, and when they are more cost-effective, provide a better environmental outcome, or minimize neighborhood impact.

The 47 preliminary alternatives developed for this review are summarized in Section 5.2 of Technical Memorandum 970, organized by area and CSO site.

Consolidated Alternatives

For the consolidated alternatives, some flow is transferred from an uncontrolled CSO basin to another basin by actions such as installing new conveyance pipes, parallel pipes, or flow controls such as gates. Consolidation can minimize the number of sites necessary for CSO control facilities, provide more cost-effective control of CSOs, reduce community impacts, reduce operation and maintenance activities, and reduce the risk of isolated, intense events yielding overflows. However, consolidation can require greater conveyance capacity to accommodate peak flow events.

Inter-basin flow transfer was considered only where flows can be routed to an adjacent CSO basin by gravity or by back-flowing gravity pipes (reverse flow). Transfers that require a new pump station and interconnecting force main were not considered. Such transfers would require protective features such as standby generators, standby pumps, and bypass pumping to provide uninterrupted flow transfer under wet-weather emergency conditions. These features typically result in higher capital costs.

Joint Alternatives

Joint alternatives address CSO control needs for both King County and the City of Seattle. Forty joint alternative concepts were identified at workshops between the two agencies held in 2009. The development of these concepts into preliminary alternatives was divided between agencies, based on which agency was developing similar independent alternatives for facilities that could be modified to receive the other agency's flows. The agency sending flows to the joint facilities would then develop the necessary conveyance components. The following procedures were established for developing joint alternatives:

- The two agencies agreed to use similar cost estimating methodologies.
- The County provided the City design targets, so that city upstream CSO control projects could be sized to drain when conveyance capacity would be available in the County's system. SCADA would be developed to provide real-time control signals for draining.
- Generally, the agency with the larger CSO control volume led the development of the alternative; the other agency independently developed cost estimates for conveying its flows to the CSO control facility proposed in the alternative.

- Project costs for shared facility components were assigned to each agency based on the percent of CSO design flow contribution from each agency (control volume for storage or peak flow rate for conveyance or treatment). Costs for facilities to be used by only one agency were not shared.
- Joint opportunities found to be cost-effective for both agencies or meeting other social or environmental criteria would be considered for integration into the schedule and rate analysis.
- In cases where the County accepts flow transfers that do not significantly change the size of a facility, but increase operational costs, the City would reimburse those costs.

5.3.2 Screening of Preliminary Alternatives

Screening Criteria

Criteria to screen preliminary alternatives were refined through meetings with King County. The 16 screening criteria are organized into six categories.

- Technical considerations
  - Technical complexity
  - Flexibility/adaptive management
  - Constructability
  - Implementation schedule
  - Siting
  - Coordination with other King County projects
- Cost effectiveness
  - Relative life-cycle costs
- Community and public health
  - Construction impacts
  - Potential community impacts
  - Human health
  - Environmental/social justice
- Environmental impacts
  - Overall environmental
  - Sustainability
- Land use and permitting
  - Permitting complexity

- Operations and maintenance
  - Operations and maintenance
  - Employee safety.

Each criterion has associated definitions to be used in rating alternatives as low, medium, or high for that criterion (e.g., “A low rating is applied for alternatives that…”). A full list of screening criteria, including corresponding high, medium, and low rating descriptions, is included in Appendix D of Technical Memorandum 970.

Screening Process

The screening criteria were reviewed for each preliminary alternative, and the rating for each criterion that best fits the alternative (high, medium, or low) was assigned. Ratings are presented in Appendix E of Technical Memorandum 970. The criteria ratings did not indicate major flaws in any of the preliminary alternatives; further development of the alternatives, including cost estimates, was required before removing any from consideration. Ultimately, 16 preliminary alternatives did not advance to final alternative development; these alternatives were eliminated based on the following considerations:

- King County determined that alternatives for this review should identify potential project areas based on engineering assumptions rather than specific sites. There is uncertainty associated with the availability of sites and future development plans, particularly when some of the CSO control facilities are not anticipated to be constructed for 10 years or more. Because of this decision, preliminary alternatives that differed only in the site identified for the project were merged, and the alternative description was modified to exclude identification of a specific site.
- Joint alternatives with SPU were removed if SPU determined that conveyance to the joint CSO control facility would not be cost-effective compared to an SPU independent alternative or if the SPU flow contributions were considered too small to warrant a separate alternatives evaluation.
- Updated modeling of the 11th Ave NW CSO site with increased conveyance demonstrated that control of this CSO site could be achieved with conveyance alone, without the need for any storage. Therefore, the conveyance-plus-storage alternative for this CSO site was modified to remove the storage component and add potential GSI opportunities, and the conveyance-plus-GSI alternative was eliminated as a separate alternative.
- The Montlake-University consolidated preliminary alternatives were removed because they were determined to be cost-prohibitive due to higher Montlake CSO control volumes based on the most recent modeling results. Higher volumes would require conveyance to the storage facility across the Montlake Cut via a new parallel Montlake Siphon.

Table 5-2 of Technical Memorandum 970 lists all preliminary alternatives that did not move forward to final alternative development. Preliminary alternatives that advanced to final alternative development are listed in Appendix A.2 of Technical Memorandum 970. As a result of site-specific hydraulic modeling, five alternative variations were developed and moved forward to final alternative development in addition to the screened preliminary alternatives, as described in Section 5.4 of Technical Memorandum 970.

5.4 Final Alternatives

Each final alternative was further developed before an evaluation was performed to identify recommended preferred alternatives. The additional development included refining the size, location, and cost information.

5.4.1 Description of Final Alternatives

Final alternative descriptions are summarized in Table 5-2. Detailed final alternative descriptions are presented in Section 6.3 and Appendix G of Technical Memorandum 970.

Table 5-2. Final Alternatives Evaluated for This Review

CSO Location	CSO Control Alternatives
Ship Canal—11th Ave NW, 3rd Ave W, University, and Montlake Area	
11th Ave NW	1.85-MG storage tank. GSI component will be further evaluated.
	Conveyance to Ballard Siphon (3,200 feet of 84-inch-diameter pipe); elimination of CSO discharge point. GSI component will be further evaluated.
3rd Ave W	4.18-MG storage tank on south side of Ship Canal. GSI component will be further evaluated.
	Joint county-city 7.23-MG storage tank project on north side of Ship Canal. GSI component will be further evaluated.
Montlake	6.60-MG storage tank on south side of Ship Canal. GSI component will be further evaluated.
	Joint county-city 7.87-MG storage tank project on south side of Ship Canal. GSI component will be further evaluated.
University	2.94-MG storage tank. GSI component will be further evaluated.
	Joint county-city 5.23-MG storage tank project. GSI component will be further evaluated.
Consolidated project	Joint county-city 21.4-MG storage and conveyance tunnel under Ship Canal to control 11th Ave NW, 3rd Ave W, Montlake, and University county CSOs and seven city CSOs. GSI component will be further evaluated.
Middle Elliott Bay Interceptor—Hanford #2, Lander St, Kingdome, and King St Area	
King St	2.63-MG storage tank.
Kingdome	48-MGD CSO treatment facility.
Hanford #2	68-MGD CSO treatment facility. GSI component will be further evaluated.
Lander St	23-MGD CSO treatment facility.

Table 5-2. Final Alternatives Evaluated for This Review

CSO Location	CSO Control Alternatives
Consolidated projects	56-MGD CSO treatment facility for King St and Kingdome.
	94-MGD CSO treatment facility for Hanford #2 and Lander St. GSI component will be further evaluated.
	139-MGD CSO treatment facility for Hanford #2, Lander St, and Kingdome. New conveyance to facility. GSI component will be further evaluated.
	151-MGD CSO treatment facility for Hanford #2, Lander St, Kingdome, and King St. New conveyance to facility. GSI component will be further evaluated.
	151-MGD CSO treatment facility for Hanford #2, Lander St, Kingdome, and King St. Route flows through existing conveyance (interceptor) to facility. GSI component will be further evaluated.
Middle Elliott Bay Interceptor—Hanford #1 Area	
Hanford #1	One 1.79-MG storage tank to control Hanford #1 and Bayview N. GSI component will be further evaluated.
	Two storage tanks (1.02 MG and 0.77 MG) to control Hanford #1 and Bayview N. GSI component will be further evaluated.
	Conveyance improvements to send more flow to Bayview Tunnel with reduced 0.34-MG storage volume at Hanford #1. GSI component will be further evaluated.
South Elliott Bay Interceptor Area	
Brandon St	24-MGD CSO treatment facility. GSI component will be further evaluated.
	Brandon area sewer separation. GSI component will be further evaluated.
S Michigan St	40-MGD CSO treatment facility. GSI component will be further evaluated.
Consolidated projects	66-MGD CSO treatment facility to control S Michigan St and Brandon St. New conveyance to facility. GSI component will be further evaluated.
	66-MGD CSO treatment facility to control S Michigan St and Brandon St. Route flows through existing conveyance (interceptor) to facility. GSI component will be further evaluated.
West Duwamish—W Michigan St and Terminal 115 Area	
Terminal 115	0.05-MG storage pipe.
W Michigan St	0.27-MG storage pipe. GSI component will be further evaluated.
Consolidated project	0.32-MG storage pipe to control W Michigan St and Terminal 115. GSI would likely be included. GSI component will be further evaluated.

Table 5-2. Final Alternatives Evaluated for This Review

CSO Location	CSO Control Alternatives
West Duwamish—Chelan Ave Area	
Chelan Ave	3.85-MG storage tank near Chelan Ave Regulator Station. GSI component will be further evaluated.
	Two deep storage tanks (3.85 MG total) at West Seattle Pump Station site. GSI component will be further evaluated.
	Transfer to Alki Tunnel and CSO Treatment Plant (upgrade 63rd Ave Pump Station and Alki CSO Treatment Plant). GSI component will be further evaluated.

5.4.2 Planning-Level Design Criteria

Planning-level design criteria were developed for three general types of CSO control facilities: CSO storage tanks, CSO storage pipes, and CSO treatment facilities. The planning-level design criteria were used to determine the following for each final alternative (see Section 6.1 of Technical Memorandum 970 for further detail:

- **Sizing—**Planning-level sizing focused on estimating the overall facility footprint (required land area). Representative footprint sizes for each alternative are used to indicate how large a site may need to be acquired and to estimate property costs.
- **Location—**Specific project sites were not identified for this review because of uncertainties associated with the availability of sites and future development plans. Instead, an approximate boundary of potential sites was developed for each alternative, based on construction issues (such as preferred maximum depth of excavation) and hydraulic performance requirements (such as the preference that flow be conveyed to CSO control facilities by gravity rather than by pumping). The approximate boundary is intended for planning purposes only and does not represent all potential site locations.
- **Cost—**Planning-level cost estimates are used as one component of the triple-bottom-line analysis of gray alternatives. The planning-level cost estimating methodologies used for this evaluation are described in detail in Technical Memorandum 620, Cost Estimating Methodology for CSO Control Facilities. To be conservative, potential reduction in CSO control volume or CSO peak flow rate that could be achieved using GSI techniques is not reflected in costs and sizes of proposed gray CSO control facilities in this review; more in-basin monitoring and modeling needs to be completed to quantify the benefit of the GSI approach before gray facility sizing is reduced.

5.5 Triple-Bottom-Line Analysis Process

A triple-bottom-line (TBL) analysis is a method used by organizations to consider factors other than fiscal in alternatives selection processes. It was performed to select recommended preferred alternatives for each geographical area (as defined in Section 1.6 of this report) by comparing final alternatives based on environmental, social, and financial metrics. A TBL analysis identifies the optimal balance between financial, social, and environmental concerns. Project risks are also identified in the comparisons. TBL analysis can be a useful tool in public involvement, from drawing criteria and their values from public discussions, to providing an understandable communication of the basis by which alternatives were recommended.

Other local entities, such as the City of Seattle, have used TBL analysis for some time and have found it useful, so WTD decided to pilot the use of the method for this Program Review. More commonly applied to design projects, the approach was modified for application to this planning project. For the financial aspect of the analysis, the cost of each alternative is estimated based on conceptual design information. Planning-level cost estimates are typically developed based on cost curves of data from completed projects and do not specify cost component detail.

As described in Technical Memorandum 620, Cost Estimating Methodology for CSO Control Facilities (available at: http://your.kingcounty.gov/dnrp/library/wastewater/cso/docs/ProgramReview/2012/WTDRec/TechMemos/TM620_CSOCostEstimating,May2011.pdf), planning-level cost estimates are Advancement of Cost Engineering (AACE) Class 5 with an accuracy range of -50 percent to +100 percent, and the life-cycle costs used in the analysis are not fully developed. For example, replacement costs for alternative components (e.g., the electrical systems in a regulator) may not be extractable from cost curve data from the total regulator cost. WTD recommends that replacement costs be neglected in comparing similar alternatives if they are likely not to differentiate the alternatives. As a result, planning-level life-cycle cost estimates cannot be viewed as “complete” costs, but as indicators for TBL analysis use only.

For the social and environmental aspects of the analysis, benefits are analyzed using a technique called “value modeling.” Each alternative is qualitatively evaluated for the extent to which it meets project criteria, and the criteria are weighted according to how the criteria differentiate between alternatives. Risk is also ranked qualitatively.

GSI (or green) alternatives were not part of the TBL analysis. GSI alternatives were developed and evaluated in parallel with final gray alternatives for uncontrolled CSO basins with potential for GSI retrofit. Runoff volume reduction benefits and planning-level life-cycle costs were estimated, and GSI alternatives deemed cost-effective during this parallel evaluation were identified with the recommended preferred alternatives. The sizes of the gray alternatives were conservatively not reduced to account for the GSI benefit in this review. Future evaluations, including enhanced monitoring and modeling, will quantify and then verify the benefit of GSI techniques prior to gray facility sizing.

5.5.1 Steps in Triple-Bottom-Line Analysis

The steps of the TBL analysis were applied as follows for this review (see Section 7.1 and Appendix H.1 of Technical Memorandum 970 for further detail):

- **Develop Criteria—**The criteria used for the TBL analysis are the same as the criteria established for the screening of preliminary alternatives (see Section 5.3.2 of this report), with one exception: the criterion "relative life-cycle cost" was not included because life-cycle costs were used as an independent metric for the final alternative TBL analysis. Removing this criterion prevents double accounting for cost-effectiveness. However, the criteria were applied to more highly-developed alternatives than in the initial screening, resulting in more informed and focused rankings.
- **Establish Criteria Weighting—**Weighting was established for each criteria category, and all criteria within each category received the same weighting factor. The purpose of the weighting is to differentiate alternatives from each other. The weighting does not imply importance. Categories for which alternatives receive a wide range of value scores are given greater weight. Categories for which all alternatives are given similar value scores are less useful in differentiating the alternatives. The following weighting factors were assigned:
  - Technical Considerations: Weighting Factor = 20
  - Community and Public Health: Weighting Factor = 20
  - Environmental Impacts: Weighting Factor = 10
  - Land Use and Permitting: Weighting Factor = 10
  - Operations & Maintenance: Weighting Factor = 35
- **Develop Alternatives—**Section 5.4 of this report describes the development of alternatives from preliminary to final. Combinations of the final alternatives were used to create area alternatives, as described in Section 5.5.2 of this report.
- **Produce Cost Estimates—**Planning-level life-cycle cost estimates[2] of final alternatives were developed. As noted earlier, these serve only to differentiate in the selection process.
- **Evaluate Alternatives—**The final alternatives were evaluated in the TBL analysis.
- **Perform Value Modeling—**The screening of preliminary alternatives assigned ratings of high, medium, or low to each alternative for each criterion (see Appendix E of Technical Memorandum 970). For the TBL analysis, the ratings were converted to value scores: High = 3, Medium = 2, and Low = 1. The weighting factors developed for the criteria categories were applied to the value scores, and the weighted value scores were totaled.

[2] The planning-level life-cycle costs differ slightly in this chapter from those shown in Technical Memorandum 970 as the life-cycle cost model was updated after completion of Technical Memorandum 970—those reported here reflect updated estimates. This update did not change which alternatives were recommended as preferred alternatives.

Appendix H.2.1 of Technical Memorandum 970 presents the value scores and weighting of final alternatives. Value scores were calculated for each area alternative by summing and weighting the value scores for each site or consolidated final alternative that it includes, based on the CSO control volume for storage and conveyance alternatives or the CSO peak flow rate for treatment alternatives. For example, the value score would be calculated as follows for an area alternative consisting of two storage site alternatives:

$$\text{Area Alternative Value Score} = \frac{(\text{Site 1 Value Score} * \text{Site 1 CSO Control Volume}) + (\text{Site 2 Value Score} * \text{Site 2 CSO Control Volume})}{\text{Site 1 CSO Control Volume} + \text{Site 2 CSO Control Volume}}$$

- **Identify Risks—**Qualitative risks, not quantitative, were used for the risk analysis because of the limited information available and level of development at this planning stage. All qualitative risks were considered to be of equal weight. The following risks were included in the risk analysis (see Appendix H.2.2 of Technical Memorandum 970 for details):
  - Constructability
  - Equipment failure
  - Complex controls
  - Permitting of new outfall
  - Property availability
  - Staff availability
  - Coordination with other projects
  - Regulatory agency approval
  - Construction cost and bid overruns
  - Stakeholder pressure
  - Changes in volume or flow parameters
  - Downstream system impacts.
- **Risk Analysis—**Each qualitative risk was scored for each alternative based on its likelihood and consequence, using the risk assessment framework presented in Figure 5-2. Mitigation of risks could be considered in reviewing the results. The results (see Appendix H.2.2 of Technical Memorandum 970) were converted to a risk score for each final alternative. The risk score was calculated as the number of critical risks multiplied by three plus the number of high risks. For area alternatives, risk scores were summed and weighted based on the CSO control volume for storage and conveyance alternatives or CSO peak flow rate for treatment alternatives for each contributing CSO site. Based on the risk scoring, each alternative was assigned one of the following colors (unrelated to the colors in Figure 5-2):
  - Blue (relatively low risk): Risk Score Range = 0 to 2
  - Orange (relatively medium risk): Risk Score Range = 3 to 7
  - Red (relatively high risk): Risk Score Range = 8 to 11

- **Review Results and Identify Preferred Alternatives**—Alternative "screening brackets" were created for each area evaluated in this review. Figure 5-3 shows an example of the alternative screening bracket for the W Michigan St and Terminal 115 area. These brackets graphically depict how site and consolidated alternatives were screened and combined to form area alternatives that were compared to select a recommended preferred alternative for each area. They include site and consolidated alternatives considered for the area, with corresponding value scores and life-cycle costs. Additional details for this step are presented in Section 5.5.2 of this report.

	Impact				
Likelihood	Insignificant	Minor	Moderate	Major	Extreme
Almost certain	M	M	H	C	C
Likely	M	M	H	C	C
Possible	L	M	M	H	H
Unlikely	L	L	M	H	H
Rare	L	L	M	M	M

L	Low
M	Medium
H	High
C	Critical

Figure 5-2. Risk Assessment Framework

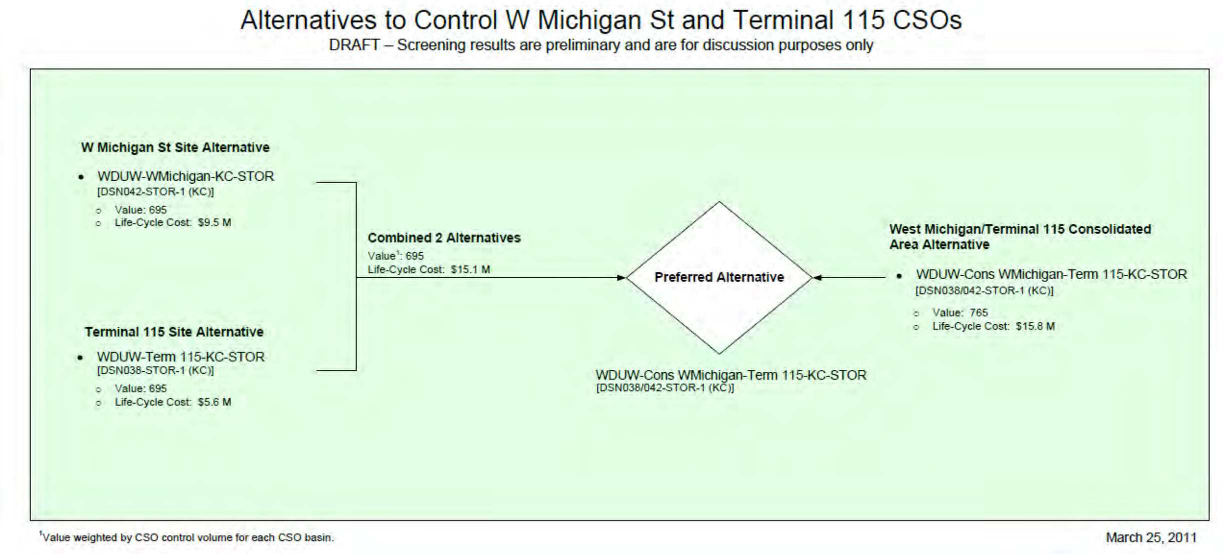

Figure 5-3. Example of Alternative Screening Bracket (W Michigan St and Terminal 115)

5.5.2 Identification of Preferred Alternatives

Identifying Preferred Site Alternatives

Site alternatives are those that would control a single CSO site. Screening yielded a set of planning-level site alternatives. Each final site alternative was evaluated by the TBL analysis to establish its planning-level life-cycle cost, value score, and color-coded risk category. A preferred site alternative was then identified as follows for each uncontrolled CSO site:

- For uncontrolled CSO sites with only one site alternative, that alternative is the preferred site alternative.
- For uncontrolled CSO sites with multiple site alternatives, the estimated life-cycle cost and value score were plotted on scatter graphs, and the points for each alternative were color-coded to indicate its risk category. If any alternative had the lowest cost, highest value score, and lowest risk, it was chosen as the preferred site alternative. Otherwise, the results were qualitatively assessed to identify a preferred site alternative. In the sample scatter graph shown on Figure 5-4, for example, one alternative has a higher value score and lower life-cycle cost, but a higher risk category. Selection of a preferred alternative would qualitatively balance the undesirable higher risk against the desirable low cost and high value score.

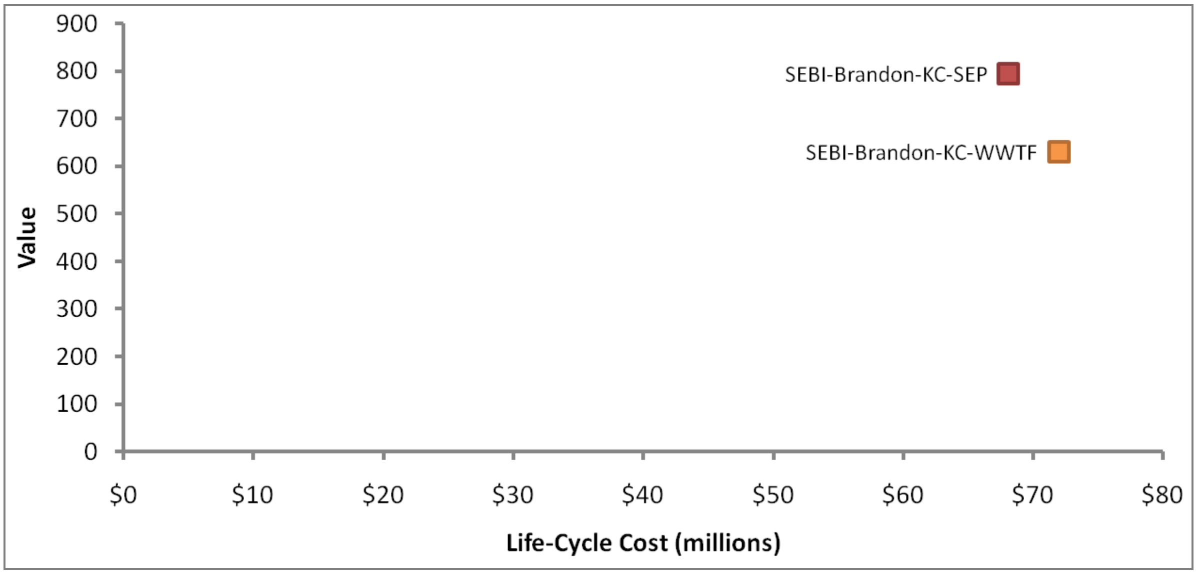

Figure 5-4. Sample Scatter Graph for Identifying Preferred Site Alternative

Identifying Preferred Area Alternatives

Area alternatives are any groupings of alternatives to be compared to another that provide control of all uncontrolled CSO sites in a given geographical area. After preferred site alternatives were identified for each uncontrolled CSO site, area alternatives were developed as follows:

- For areas that include only one uncontrolled CSO site, each site alternative is also an area alternative. For example, this occurs in the Middle EBI—Hanford #1 area.
- For areas that include more than one uncontrolled CSO site:
  - The combination of preferred site alternatives for every uncontrolled CSO site in the area represents an area alternative. For example, this occurs in the Ship Canal—11th Ave NW, 3rd Ave W, University, and Montlake area, where the four preferred site alternatives are combined as an area alternative.
  - Any consolidated alternative that would control all uncontrolled CSO sites in the area represents an area alternative. For example, this occurs in the Ship Canal—11th Ave NW, 3rd Ave W, University, and Montlake area, where the tunnel alternative controls all uncontrolled sites in the area and therefore represents an area alternative.
  - A consolidated alternative that would control some of the uncontrolled CSO sites in the area, combined with another consolidated alternative or site alternatives for the remaining uncontrolled CSO sites in the area, represents an area alternative. For example, this occurs in the Middle EBI—Hanford #2, Lander St, Kingdome, and King St area, where multiple area alternatives are formed by combining consolidated alternatives and site alternatives to control all uncontrolled CSO sites in the area.

The TBL analysis process was used to determine life-cycle cost, value score, and color-coded risk category for each area alternative. These were then plotted for each area on scatter graphs to identify the recommended preferred alternative for the area in the same way as described above for the preferred site alternatives.

5.6 Recommending Preferred Alternatives

Appendix H.3 of Technical Memorandum 970 presents the results of this detailed TBL analysis conducted for this review, including all scatter graphs and alternative screening brackets. The results for each area are summarized in the following sections.

After the alternative selection process, King County decided to make modifications to the life-cycle cost analysis in how operations and maintenance costs were escalated over time. The life-cycle costs presented in this section have been updated to reflect those changes, and so differ from those presented in Technical Memorandum 970. This update did not change which alternatives were selected as recommended preferred alternatives.

It should be noted that late in this analysis the City of Seattle identified potentially greater CSO control volume needs at their Ballard and Delridge CSO sites that might influence joint project options. Their confirmation of CSO control volume needs will not be complete before this 2012 CSO Control Program Review Report and King County Executive’s Recommended CSO Control Plan are submitted.

5.6.1 Ship Canal—11th Ave NW, 3rd Ave W, University and Montlake

Evaluation of Site Alternatives

Site alternatives for each uncontrolled CSO site in this area are conceptually shown in Figure 5-5. Table 5-3 summarizes the TBL analysis of site alternatives and indicates the preferred site alternative for each.

Evaluation of Area Alternatives

The area alternatives for the Ship Canal-11th Ave NW, 3rd Ave W, University, and Montlake area are as follows (area alternatives are shown conceptually in Figure 5-6):

- Combined Preferred Site Alternatives (from Table 5-3)
- Consolidated Alternative—SC-Cons Tunnel-Collab-STOR (Storage Tunnel with SPU)

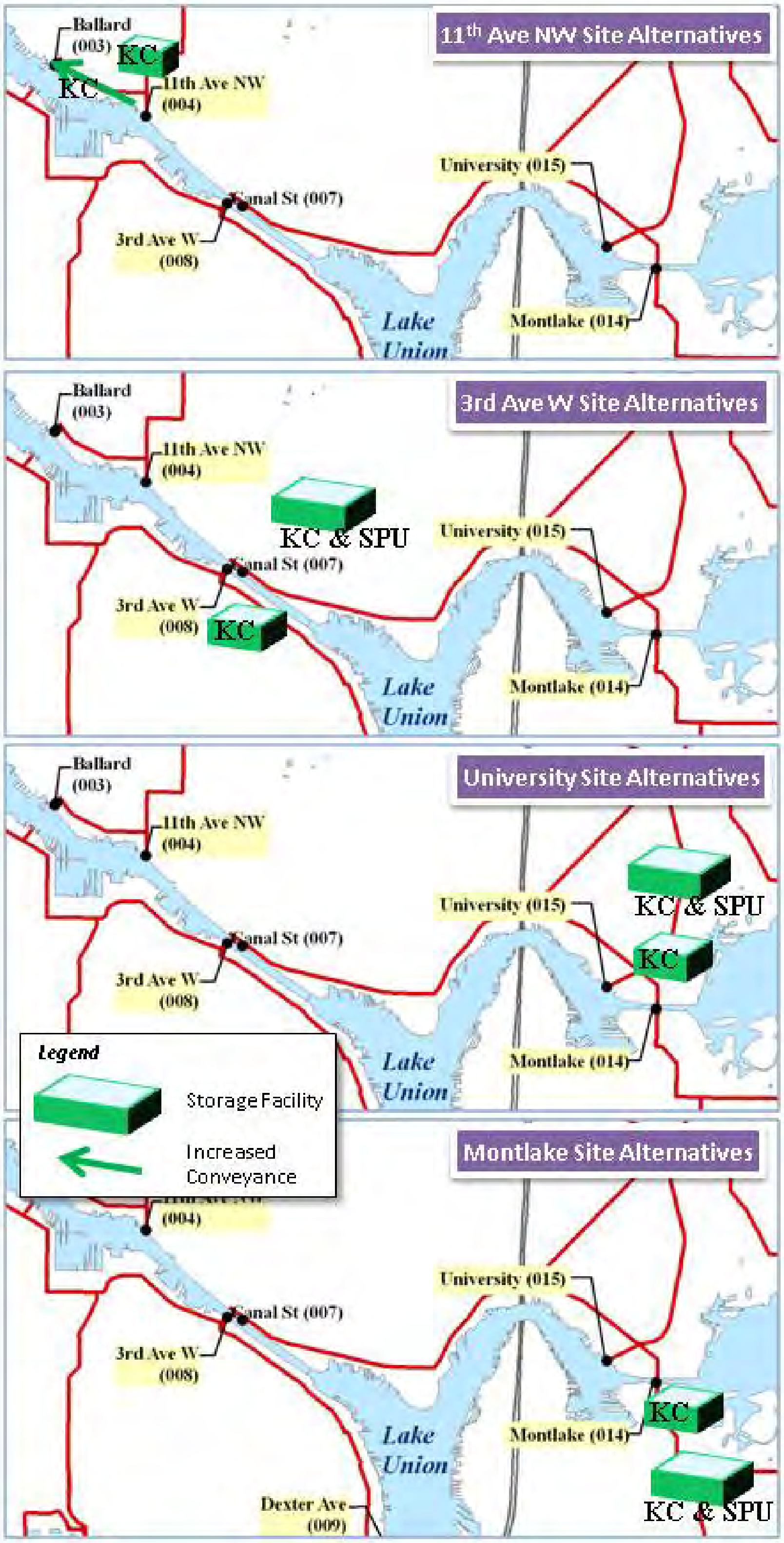

Figure 5-5. Site Alternatives for Ship Canal—11th Ave NW, 3rd Ave W, University, Montlake

Table 5-3. Triple-Bottom-Line Analysis of Site Alternatives for Ship Canal—11th Ave NW, 3rd Ave W, University, and Montlake

Alternative	Description	Planning-Level Life-Cycle Cost[a] (2010 $; millions)	Value Score	Risk Color (Category)	Preferred Site Alternative
11th Ave NW Site Alternatives					
SC-11th Ave NW-KC-STOR	1.85-MG storage tank	$32.3	675	Blue (low)	
SC-11th Ave NW-KC-Conv	3,200 feet of 84-inch-diameter conveyance pipe	$21.9	670	Blue (low)	X
3rd Ave W Site Alternatives					
SC-3rd Ave W-KC-STOR	4.18-MG storage tank south of Ship Canal; King County only	$59.0	620	Orange (medium)	
SC-3rd Ave W-Collab-STOR 2 (includes flow transfer from City of Seattle's CSO Basin 60)	7.23-MG storage tank north of Ship Canal; with SPU	$50.3	650	Orange (medium)	X
University Site Alternatives					
SC-University-KC-STOR	2.94-MG storage tank; King County only	$54.9	615	Orange (medium)	
SC-University-Collab-STOR (may include flow transfer from City of Seattle's Windermere project)	5.23-MG storage tank; with SPU	$47.4	595	Orange (medium)	X
Montlake Site Alternatives					
SC-Montlake-KC-STOR	6.60-MG storage tank; King County only	$104.6	630	Orange (medium)	
SC-Montlake-Collab-STOR	7.87-MG storage tank; with SPU	$97.5	610	Orange (medium)	X

a. Life-cycle cost model was updated from Technical Memorandum 970; portion of planning-level life-cycle cost allocated to King County.

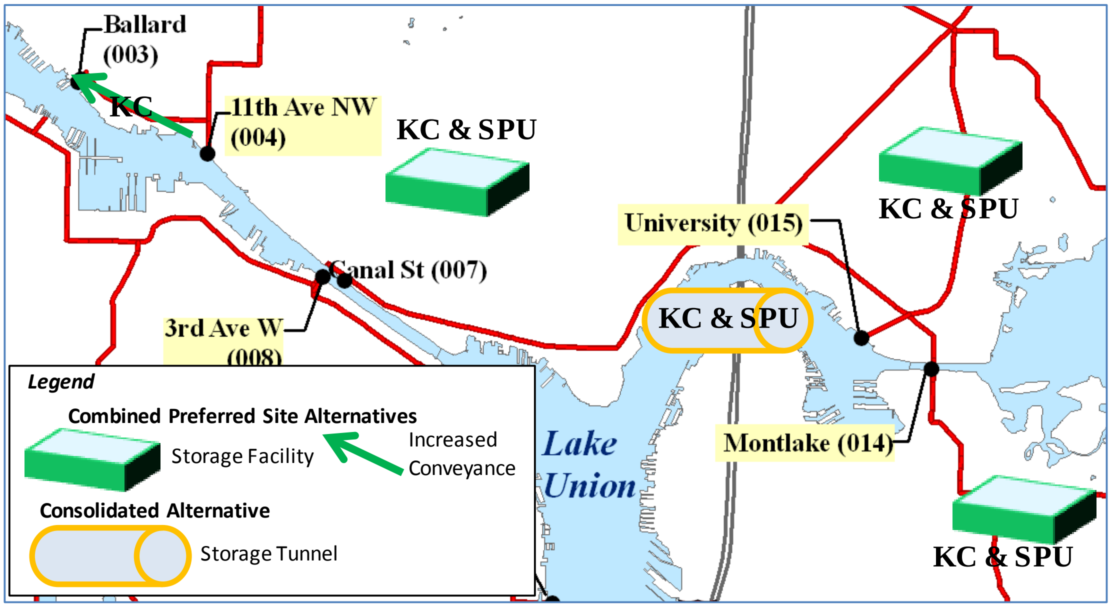

Figure 5-6. Area Alternatives for Ship Canal—11th Ave NW, 3rd Ave W, University, Montlake

Table 5-4 summarizes the TBL analysis of the area alternatives and indicates the recommended preferred alternative for this area. The combined preferred site alternatives have a slightly lower value score, but they also have lower risk and lower estimated life-cycle cost. Therefore, the **combined preferred site alternatives** are the recommended preferred alternative for the Ship Canal—11th Ave NW, 3rd Ave W, University, and Montlake area.

Table 5-4. Triple-Bottom-Line Analysis of Area Alternatives for Ship Canal—11th Ave NW, 3rd Ave W, University, and Montlake

Alternative	Description	Planning-Level Life-Cycle Cost[a] (2010 $; millions)	Value Score	Risk Color (Category)	Recom-mended Preferred Alternative
Combined Preferred Site Alternatives					
SC-11th Ave NW-KC-Conv	3,200 feet of 84-inch-diameter conveyance pipe	$217.0	625	Orange (medium)	X
SC-3rd Ave W-Collab-STOR 2 (includes flow transfer of City of Seattle's CSO Basin 60)	7.23-MG storage tank north of Ship Canal; with SPU				
SC-University-Collab-STOR (may include flow transfer from City of Seattle's Windermere project)	5.23-MG storage tank; with SPU				
SC-Montlake-Collab-STOR	7.87-MG storage tank; with SPU				

Table 5-4. Triple-Bottom-Line Analysis of Area Alternatives for Ship Canal—11th Ave NW, 3rd Ave W, University, and Montlake

Alternative	Description	Planning-Level Life-Cycle Cost[a] (2010 $; millions)	Value Score	Risk Color (Category)	Recom-mended Preferred Alternative
Consolidated Alternative					
SC-Cons Tunnel-Collab-STOR	21.4-MG storage tunnel along the Ship Canal; with SPU	$221.3	635	Red (high)	

a. Life-cycle cost model was updated from Technical Memorandum 970; portion of planning-level life-cycle cost allocated to King County.

5.6.2 Middle Elliott Bay Interceptor (MEBI)—Hanford #2, Lander St, Kingdome, and King St

Evaluation of Site Alternatives

All four of the uncontrolled CSO sites in this area have only one site alternative (King St has a storage alternative and Kingdome, Lander St, and Hanford #2 each have a CSO treatment alternative), so the site alternatives are the preferred site alternatives. Ballasted sedimentation is the CSO treatment process assumed for the TBL analysis.

King St CSO control facilities would include a flow transfer from SPU's south waterfront CSO sites. Hanford #2 CSO control facilities would include flow transfers from SPU's CSO Basin 107 and their Genesee project.

Evaluation of Area Alternatives

The area alternatives for the Middle EBI-Hanford #2, Lander St, Kingdome, and King St area are as follows (area alternatives are shown conceptually in Figure 5-7):

- Alternative A—Three Independent CSO Treatment Facilities + Storage:
  - Alternative MEBI-Kingdome-KC-WWTF, which includes a 48-MGD CSO treatment facility to control Kingdome CSOs.
  - Alternative MEBI-Lander-KC-WWTF, which includes a 23-MGD CSO treatment facility to control Lander St CSOs.
  - Alternative MEBI-Hanford-KC-WWTF, which includes a 68-MGD CSO treatment facility to control Hanford #2 CSOs.
  - Alternative MEBI-King-KC-STOR, which includes a 2.63-MG storage tank to control King St CSOs.

- Alternative B—Two Independent CSO Treatment Facilities:
  - Alternative MEBI-Cons Kingdome-King-KC-WWTF, which includes a 56-MGD CSO treatment facility to control King St and Kingdome CSOs.
  - Alternative MEBI-Cons Hanford-Lander-KC-WWTF, which includes a 94-MGD CSO treatment facility to control Hanford #2 and Lander St CSOs.
- Alternative C—Two Independent CSO Treatment Facilities + Storage:
  - Alternative MEBI-Kingdome-KC-WWTF, which includes a 48-MGD CSO treatment facility to control Kingdome CSOs.
  - Alternative MEBI-Cons Hanford-Lander-KC-WWTF, which includes a 94-MGD CSO treatment facility to control Hanford #2 and Lander St CSOs.
  - Alternative MEBI-King-KC-STOR, which includes a 2.63-MG storage tank to control King St CSOs.
- Alternative D1—One Independent CSO Treatment Facility, with New Conveyance to CSO Treatment Facility:
  - Alternative MEBI-Cons Hanford-Lander-King-Kingdome-KC-WWTF (New Conveyance), which includes a 151-MGD CSO treatment facility, with new conveyance from the four regulator stations to the treatment facility, to control Hanford #2, Lander St, Kingdome, and King St CSOs.
- Alternative D2—One Independent CSO Treatment Facility, with EBI Modifications as Conveyance to CSO Treatment Facility:
  - Alternative MEBI-Cons Hanford-Lander-King-Kingdome-KC-WWTF (EBI Modifications), which includes a 151-MGD CSO treatment facility, with modifications to the EBI to divert flows to the treatment facility, to control Hanford #2, Lander St, Kingdome, and King St CSOs.
- Alternative E—One Independent CSO Treatment Facility + Storage:
  - Alternative MEBI-Cons Hanford-Lander-Kingdome-KC-WWTF, which includes a 139-MGD CSO treatment facility to control Hanford #2, Lander St, and Kingdome CSOs.
  - Alternative MEBI-King-KC-STOR, which includes a 2.63-MG storage tank to control King St CSOs.

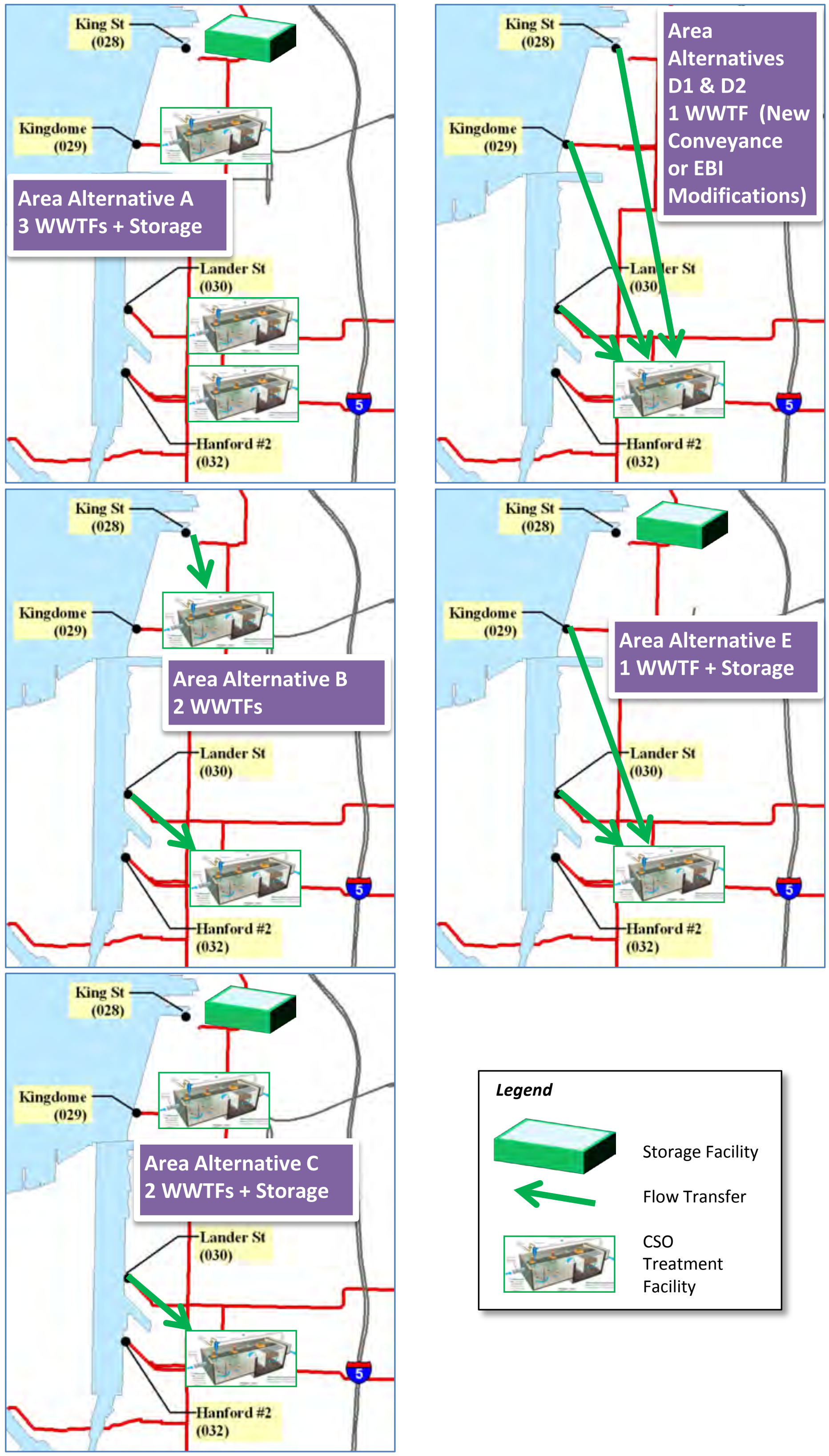

Figure 5-7. Area Alternatives for Middle EBI—Hanford #2, Lander St, Kingdome, King St

Table 5-5 summarizes the TBL analysis of the area alternatives. All of the area alternatives have high risk scores due to the complexity of the alternatives and difficult siting. Alternatives D2, D1, E, and B have comparable life-cycle costs and comparable values. These four alternatives reduce the number of CSO control facilities from four to one or two. Alternative D2 **(MEBI-Cons Hanford-Lander-King-Kingdome-KC-WWTF (EBI Modifications))** has the highest value and lowest life-cycle cost and is the recommended preferred alternative for the Middle EBI—Hanford #2, Lander St, Kingdome, and King St area.

Table 5-5. Triple-Bottom-Line Analysis of Area Alternatives for Middle EBI—Hanford #2, Lander St, Kingdome, and King St

Alternative[a]	Description	Planning-Level Life-Cycle Cost[b] (2010 $; millions)	Value Score	Risk Color (Category)	Recom-mended Preferred Alternative
Alternative A—Three Independent CSO Treatment Facilities + Storage					
MEBI-Kingdome-KC-WWTF	48-MGD CSO treatment facility	$386.8	593	Red (high)	
MEBI-Lander-KC-WWTF	23-MGD CSO treatment facility				
MEBI-Hanford-KC-WWTF	68-MGD CSO treatment facility				
MEBI-King-KC-STOR	2.63-MG storage tank				
Alternative B—Two Independent CSO Treatment Facilities					
MEBI-Cons Kingdome-King-KC-WWTF	56-MGD CSO treatment facility	$316.8	620	Red (high)	
MEBI-Cons Hanford-Lander-KC-WWTF	94-MGD CSO treatment facility				
Alternative C—Two Independent CSO Treatment Facilities + Storage					
MEBI-Kingdome-KC-WWTF	48-MGD CSO treatment facility	$328.3	606	Red (high)	
MEBI-Cons Hanford-Lander-KC-WWTF	94-MGD CSO treatment facility				
MEBI-King-KC-STOR	2.63-MG storage tank				
Alternative D1—One Independent CSO Treatment Facility, with New Conveyance to CSO Treatment Facility					
MEBI-Cons Hanford-Lander-King-Kingdome-KC-WWTF (New Conveyance)	151-MGD CSO treatment facility, with new conveyance	$302.0	640	Red (high)	
Alternative D2—One Independent CSO Treatment Facility, with EBI Modifications as Conveyance to CSO Treatment Facility					
MEBI-Cons Hanford-Lander-King-Kingdome-KC-WWTF (EBI Modifications)	151-MGD CSO treatment facility, with modifications to the EBI	$287.9	660	Red (high)	X

Table 5-5. Triple-Bottom-Line Analysis of Area Alternatives for Middle EBI—Hanford #2, Lander St, Kingdome, and King St

Alternative[a]	Description	Planning-Level Life-Cycle Cost[b] (2010 $; millions)	Value Score	Risk Color (Category)	Recom-mended Preferred Alternative
Alternative E—One Independent CSO Treatment Facility + Storage					
MEBI-Cons Hanford-Lander-Kingdome-KC-WWTF	139-MGD CSO treatment facility	$322.8	641	Red (high)	
MEBI-King-KC-STOR	2.63-MG storage tank				

a. Alternatives include SPU flow transfers.

b. Life-cycle cost model was updated from Technical Memorandum 970; portion of planning-level life-cycle cost allocated to King County.

5.6.3 Middle Elliott Bay Interceptor—Hanford #1

Because this area has only one uncontrolled CSO site (three flow inputs into a single discharge location via the Diagonal storm drain), each site alternative is also an area alternative. The site/area alternatives are shown conceptually in Figure 5-8. Table 5-6 summarizes the TBL analysis of site/area alternatives and indicates the recommended preferred alternative. The conveyance and storage alternative (**MEBI-Han-Rain-BV-KC-CONV/STOR)** has the highest value and lowest life-cycle cost and is the recommended preferred alternative for the Middle EBI—Hanford #1 area.

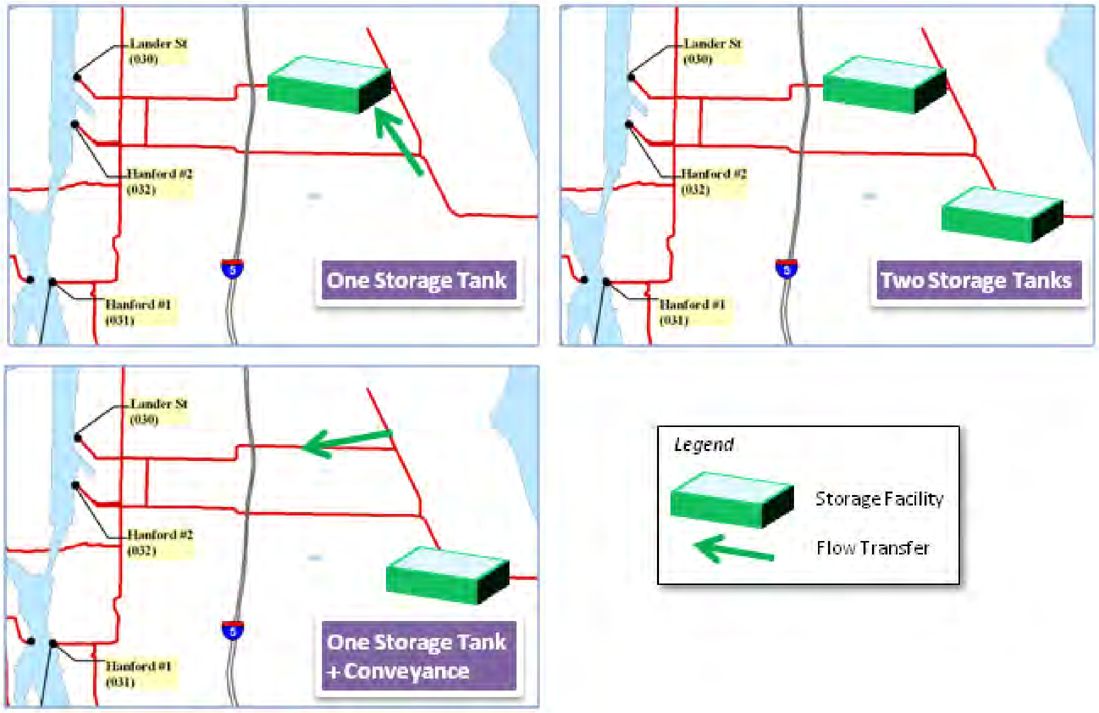

Figure 5-8. Site/Area Alternatives for Middle EBI—Hanford #1

Table 5-6. Triple-Bottom-Line Analysis of Site/Area Alternatives for Middle EBI—Hanford #1

Alternative	Description	Planning-Level Life-Cycle Cost[a] (2010 $; millions)	Value Score	Risk Color (Category)	Recom-mended Preferred Alternative
MEBI-Han-Rain-BV-KC-STOR 1	1.79-MG storage tank	$48.9	725	Blue (low)	
MEBI-Han-Rain-BV-KC-STOR 2	1.02-MG and 0.77-MG storage tanks	$39.0	595	Blue (low)	
MEBI-Han-Rain-BV-KC-CONV/STOR	0.34-MG storage tank and conveyance improvements to use Bayview Tunnel	$18.3	755	Blue (low)	X

a. Life-cycle cost model was updated from Technical Memorandum 970; portion of planning-level life-cycle cost allocated to King County.

5.6.4 South Elliott Bay Interceptor

Evaluation of Site Alternatives

Table 5-7 summarizes the TBL analysis of site alternatives for the two uncontrolled CSO sites in this area and indicates the preferred site alternative for each. Only one site alternative was developed for the S Michigan St CSO site because the large volume to be controlled could not be managed by other control measures, and that is the preferred site alternative. The TBL analysis was used to select a preferred site alternative from the two Brandon St CSO site alternatives (see Figure 5-9). For the CSO treatment alternatives at both CSO sites, it was assumed that ballasted sedimentation would be used.

Table 5-7. Triple-Bottom-Line Analysis of Site Alternatives for South EBI

Alternative	Description	Planning-Level Life-Cycle Cost[a] (2010 $; millions)	Value Score	Risk Color (Category)	Preferred Site Alternative
S Michigan St Site Alternative					
SEBI-SMichigan-KC-WWTF	40-MGD CSO treatment facility	$105.0	630	Orange (medium)	X
Brandon St Site Alternatives					
SEBI-Brandon-KC-WWTF	24-MGD CSO treatment facility	$71.8	630	Orange (medium)	
SEBI-Brandon-KC-SEP	New separated sanitary sewer system; convert the combined sewer system to a storm drain system	$67.6	795	Red (high)	X

a. Life-cycle cost model was updated from Technical Memorandum 970; portion of planning-level life-cycle cost allocated to King County.

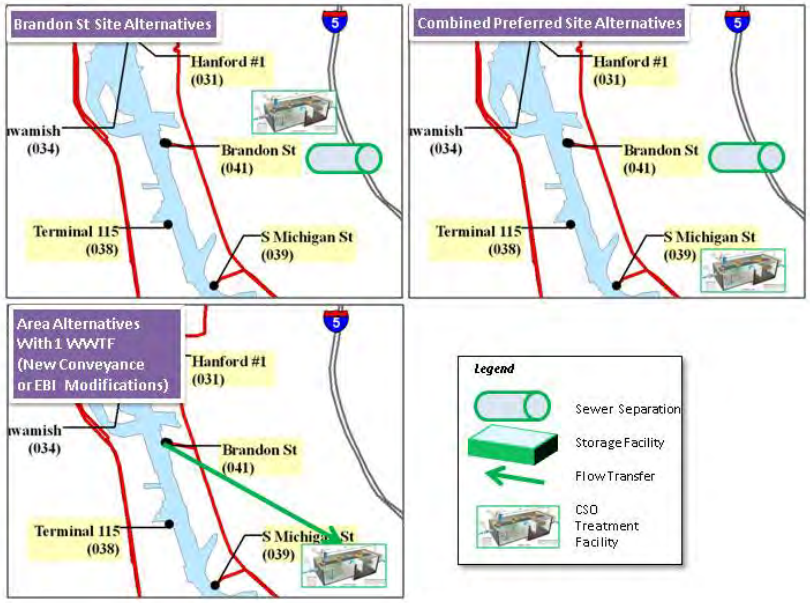

Figure 5-9. Brandon St Site Alternatives and South EBI Area Alternatives

Evaluation of Area Alternatives

The area alternatives for the South EBI area are as follows (area alternatives are shown conceptually in Figure 5-9):

- Combined Preferred Site Alternatives (from Table 5-7)
- Treatment with New Conveyance—SEBI-Cons Brandon-SMichigan-KC-WWTF (New Conveyance)
- Treatment with Modifications to the EBI—SEBI-Cons Brandon-SMichigan-KC-WWTF (EBI Modifications)

Table 5-8 summarizes the TBL analysis of the area alternatives and indicates the preferred area alternative. The consolidated treatment alternative with new conveyance (**SEBI-Cons Brandon-SMichigan-KC-WWTF (New Conveyance)**) is lower in risk and life-cycle cost and only slightly lower in value than the treatment alternative with EBI modifications and therefore is the recommended preferred alternative for the South EBI area.

Table 5-8. Triple-Bottom-Line Analysis of Area Alternatives for South EBI

Alternative	Description	Planning-Level Life-Cycle Cost[a] (2010 $; millions)	Value Score	Risk Color (Category)	Recom-mended Preferred Alternative
Combined Preferred Site Alternatives					
SEBI-SMichigan-KC-WWTF SEBI-Brandon-KC-SEP	40-MGD CSO treatment facility New separated sanitary sewer system; convert the combined sewer system to a storm drain system	$172.6	687	Orange (medium)	
Treatment with New Conveyance					
SEBI-Cons Brandon-SMichigan-KC-WWTF (New Conveyance)	66-MGD CSO treatment facility and new conveyance	$147.0	620	Orange (medium)	X
Treatment with Modifications to the EBI					
SEBI-Cons Brandon-SMichigan-KC-WWTF (EBI Modifications)	66-MGD CSO treatment facility and modifications to the EBI to divert flows	$156.8	640	Red (high)	

a. Life-cycle cost model was updated from Technical Memorandum 970; portion of planning-level life-cycle cost allocated to King County.

5.6.5 West Duwamish—W Michigan St and Terminal 115

Evaluation of Site Alternatives

For both uncontrolled CSO sites in this area, only one site alternative, a storage alternative, was developed, so the storage alternatives are the preferred site alternatives.

Evaluation of Area Alternatives

The area alternatives for the West Duwamish—W Michigan St and Terminal 115 area are as follows (area alternatives are shown conceptually in Figure 5-10):

- Combined Preferred Site Alternatives:
  - WDUW-WMichigan-KC-STOR (W Michigan St Storage)
  - WDUW-Term 115-KC-STOR (Terminal 115 Storage)
- Consolidated Storage—WDUW-Cons W Michigan-Term 115-KC-STOR.

Table 5-9 summarizes the TBL analysis of the area alternatives and indicates the preferred area alternative. The consolidated alternative reduces the number of CSO control facilities from two storage pipes to one, and King County determined that the additional cost was warranted by the benefit of consolidating two storage pipes into a single storage pipe. Therefore, the consolidated storage alternative (**WDUW-Cons W Michigan-Term 115-KC-STOR**) is the recommended preferred alternative for the West Duwamish—W Michigan St and Terminal 115 area.

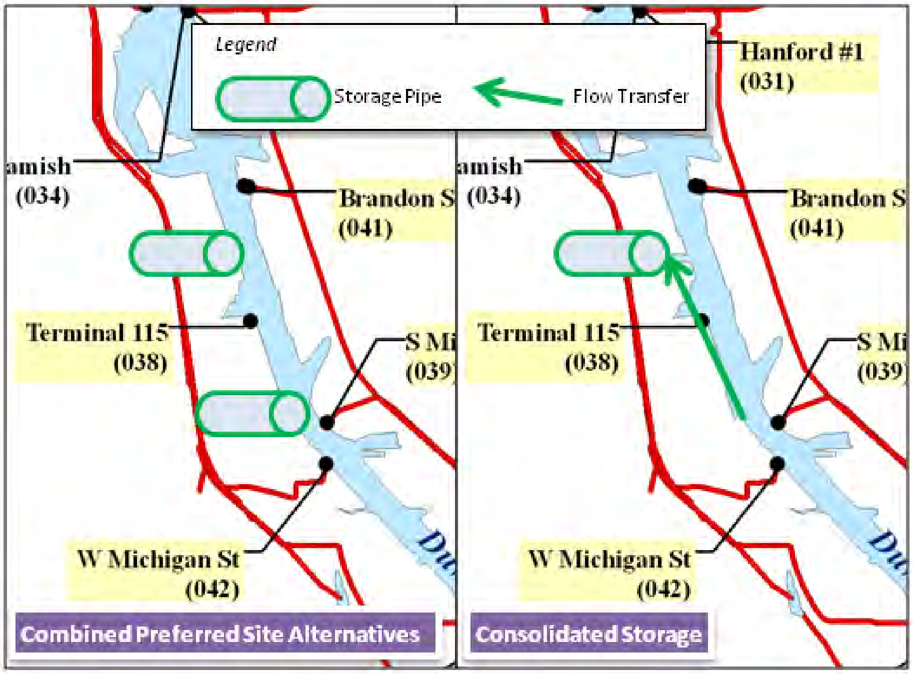

Figure 5-10. Area Alternatives for West Duwamish—W Michigan St and Terminal 115

Table 5-9. Triple-Bottom-Line Analysis of Area Alternatives for West Duwamish—W Michigan St and Terminal 115

Alternative	Description	Planning-Level Life-Cycle Cost[a] (2010 $; millions)	Value Score	Risk Color (Category)	Recom-mended Preferred Alternative
Combined Preferred Site Alternatives					
WDUW-WMichigan-KC-STOR	0.27-MG storage pipe	$19,2	695	Blue (low)	
WDUW-Term 115-KC-STOR	0.05-MG storage pipe				
Consolidated Storage					
WDUW-Cons W Michigan-Term 115-KC-STOR	0.32-MG storage pipe	$15.2	765	Blue (low)	X

a. Life-cycle cost model was updated from Technical Memorandum 970; portion of planning-level life-cycle cost allocated to King County.

5.6.6 West Duwamish—Chelan Ave

Only site alternatives are compared in this area. The alternatives are conceptually shown in Figure 5-11. Table 5-10 summarizes the TBL analysis of site/area alternatives and indicates the recommended preferred alternative. The storage alternative near the Chelan Ave Regulator Station has the lowest risk, lowest life-cycle costs (15 percent less than the next lowest cost alternative), and highest value. This alternative also is less complex than the other two alternatives because upstream diversions are not required. Therefore, the storage near the Chelan Ave Regulator Station alternative (**WDUW-Chelan-KC-STOR 1)** is the recommended preferred alternative for the West Duwamish—Chelan Ave area.

Table 5-10. Triple-Bottom-Line Analysis of Site/Area Alternatives for West Duwamish—Chelan Ave

Alternative	Description	Planning-Level Life-Cycle Cost[a] (2010 $; millions)	Value Score	Risk Color (Category)	Recom-mended Preferred Alternative
WDUW-Chelan-KC-STOR 1	3.85-MG storage tank	$55.1	745	Blue (low)	X
WDUW-Chelan-KC-STOR 2	Two 90-foot-diameter caissons, conveyance improvements	$59.6	705	Orange (medium)	
WDUW-Chelan-KC-CONV	46-MGD upgrade to 63rd Ave Pump Station and Alki Treatment Facility, conveyance improvements	$95.2	640	Red (high)	

a. Life-cycle cost model was updated from Technical Memorandum 970; portion of planning-level life-cycle cost allocated to King County.

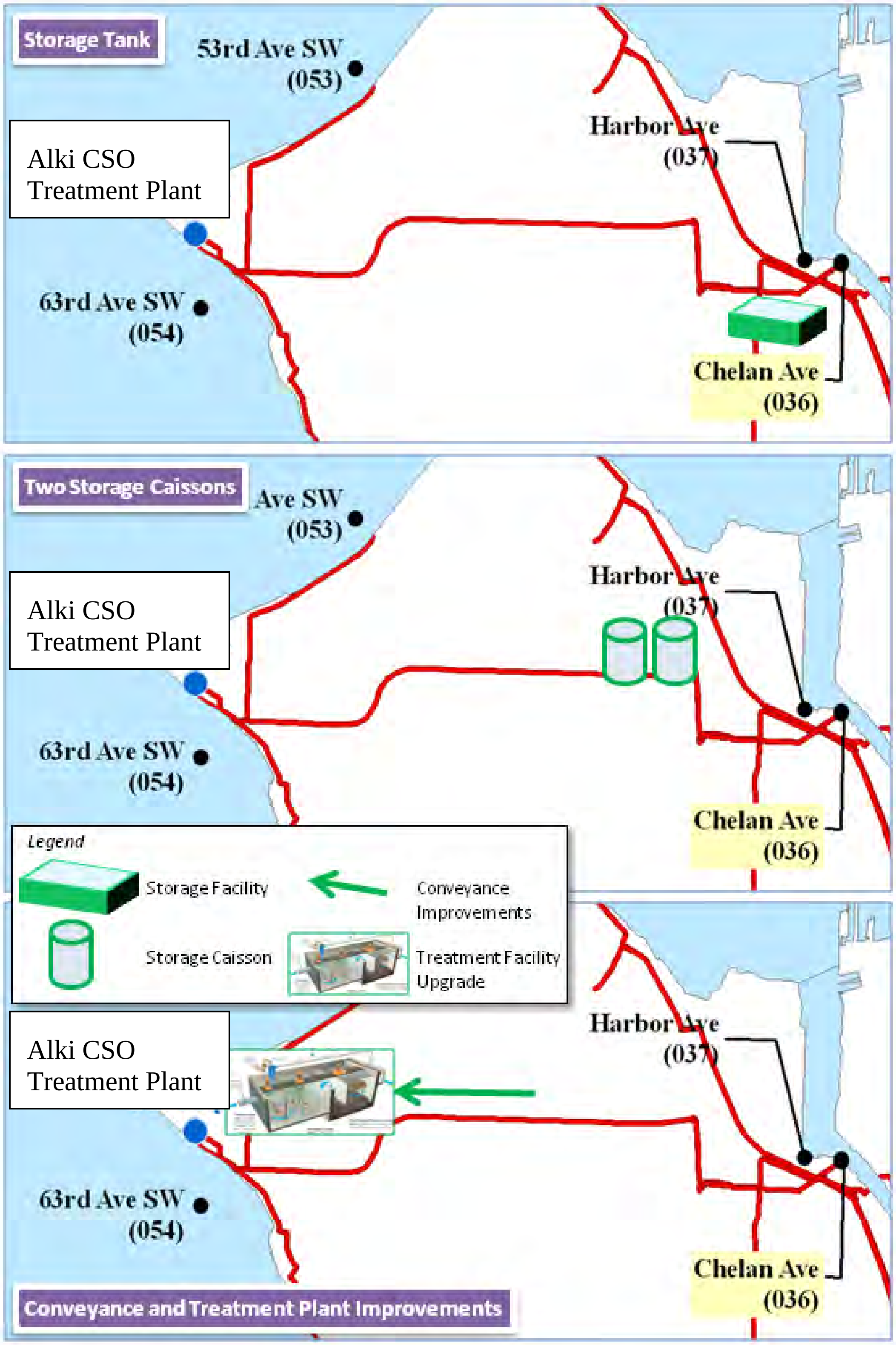

Figure 5-11. Site/Area Alternatives for West Duwamish—Chelan Ave

5.7 Green Stormwater Infrastructure Evaluation

GSI (or green) alternatives were developed and evaluated in parallel with final gray alternatives for uncontrolled CSO basins with potential for GSI retrofit. GSI alternatives were analyzed for each of the 14 uncontrolled CSO basins. Evaluation of the alternatives began with a high-level assessment based on the key factors required for GSI feasibility described in Section 4.2.4 of this report. This assessment eliminated the following basins from further consideration: Lander St, Kingdome, King St, and Terminal 115 CSO Basins. These CSO basins were excluded from this evaluation due to insufficient space in the urban landscape for GSI retrofits (i.e., highly built-out areas with few retrofit opportunities) or insufficient impervious surface connected to the combined sewer system (i.e., few opportunities for disconnection).

The ten CSO basins selected for further evaluation included 11th Ave NW, 3rd Ave W, University, Montlake, W Michigan St, Brandon St, S Michigan St, Chelan Ave, and Hanford #1 and Hanford #2[3]. GSI alternatives were developed and evaluated for these CSO basins. Technical Memorandum 810, Green Stormwater Infrastructure Alternatives presents the development and review process for planning-level GSI alternatives. This process consisted of the following steps:

1. Select uncontrolled CSO basins for evaluation based on potential for GSI retrofit (the remaining ten CSO basins listed above).
2. Generate estimates of impervious surface connected to the combined sewer system using geographic information systems (GIS).
3. Perform initial GIS screening to estimate the portion of connected basins suitable for infiltration practices.
4. Perform a more detailed GIS analysis to identify areas suitable for specific GSI practices.
5. Conduct targeted windshield surveys to validate GIS results and assess technical constraints to GSI implementation not captured in GIS evaluation, such as existing site improvements and infrastructure, available space in the right of way, and drainage patterns.
6. Calculate impervious basin areas likely manageable using GSI based on an assessment of technical constraints and anticipated participation.
7. Estimate total impervious area removed from the control volume.
8. Evaluate runoff volume reduction benefits based on the areas mitigated and the effectiveness of the respective GSI practices.
9. Estimate planning-level life-cycle cost of GSI retrofit alternative.

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[3] The Hanford #1 and Hanford #2 CSO Basins were evaluated as a single basin for GSI and are also referred to as the “Hanford” CSO Basin in the GSI evaluation.

Six of the remaining ten CSO basins that were evaluated for GSI feasibility were not recommended at this time for a GSI component to the traditional gray project. The CSO basins that were not recommended include 3rd Ave W, Hanford #1 and Hanford #2[4], Chelan Ave, Brandon St, and S Michigan St. Table 5-11 summarizes the reasons that GSI was not recommended for these CSO basins. Figure 5-12 presents the CSO basins that King County evaluated for GSI, the CSO basins (and sub-basins) that are recommended for GSI, and the CSO basins that the City of Seattle is recommending for GSI.

Table 5-11. Summary of CSO Basins not Recommended for GSI

CSO Basin	Reason For Not Recommending GSI
3rd Ave W	CSO basin consists of mainly steep slopes. The potential for GSI is limited to cisterns. GSI implementation in this CSO basin would not be cost-effective and would produce minimal reductions in runoff volumes.
Hanford #1 and Hanford #2	GSI opportunities are limited to the highly urbanized areas, where streets are narrow with minimal planter width. GSI would produce minimal reductions in runoff volumes.
Chelan Ave	The majority of the CSO basin is deemed unsuitable for infiltration. The most connected impervious area was in the Delridge area where the City of Seattle is recommending GSI.
Brandon St and S Michigan St	The recommended alternative for these basins is a CSO treatment facility. It is unknown if GSI is cost-effective in conjunction with a treatment facility.

[4] The Hanford #1 and Hanford #2 CSO Basins were evaluated as a single basin for GSI and are also referred to as the “Hanford” CSO Basin in the GSI evaluation.

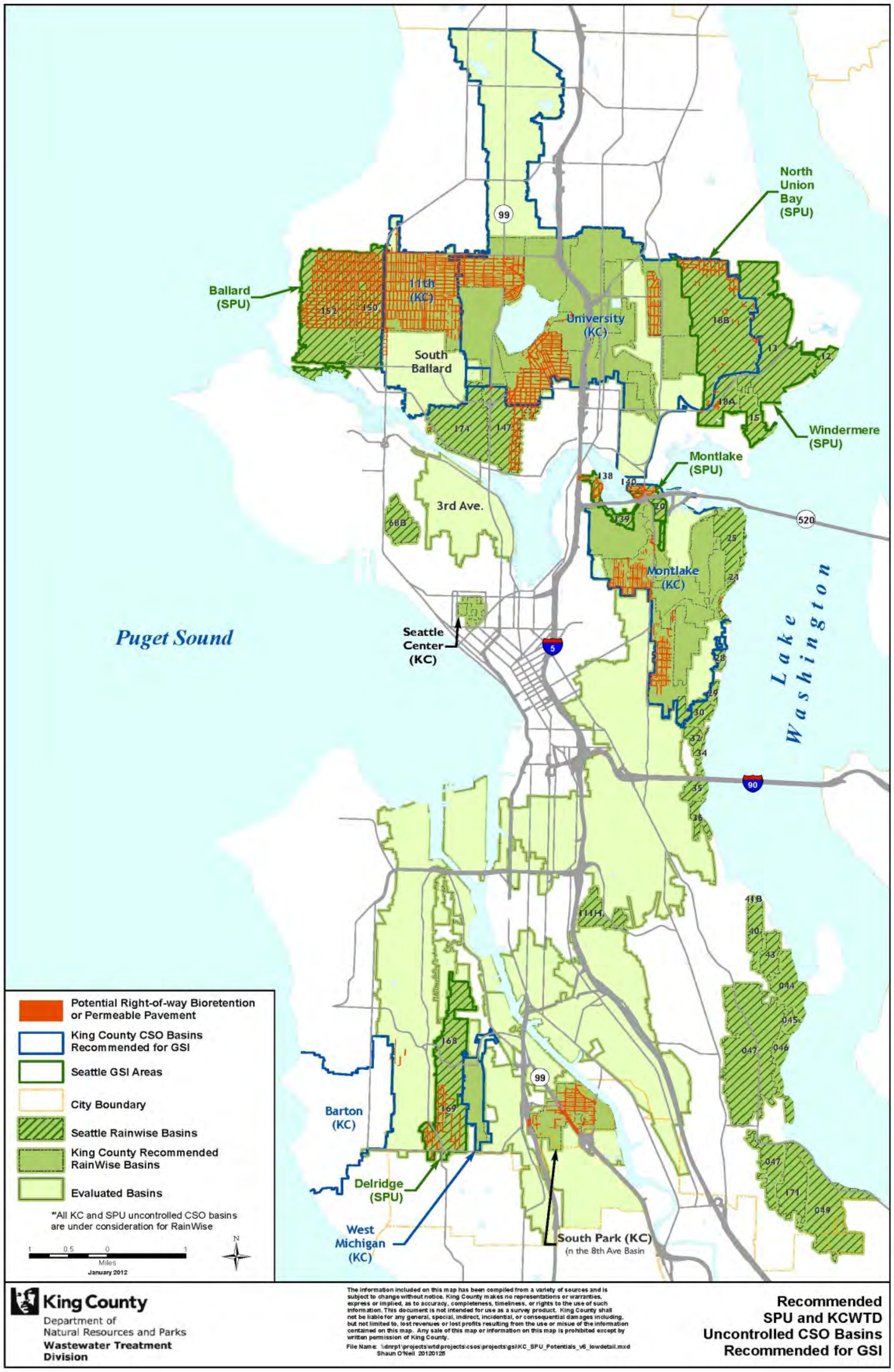

Figure 5-12. Uncontrolled CSO Basins Recommended for GSI

The GSI techniques considered in the remaining four uncontrolled CSO basins include:

- **Green Streets—**Green street practices considered in this evaluation include roadside rain gardens and green alleys (permeable pavement) in rights of way.
- **Seattle RainWise Program—**This program encourages private property owners to reduce the stormwater volume that must be managed in the combined sewer system. It is a voluntary, incentive-style program that offers rebates to reimburse residential property owners who implement GSI projects on their properties. More information about the RainWise Program can be found at: http://www.seattle.gov/util/about_spu/drainage_&_sewer_system/greenstormwaterinfrastructure/residentialrainwiseprogram/.

  The County will partner with SPU to implement these programs in uncontrolled CSO basins. The County intends to extend the RainWise Program to commercial and industrial properties. The RainWise practices considered in this evaluation include parcel-scale rain gardens, detention cisterns, and green roofs. Green roofs were considered for commercial and industrial properties.

Table 5-12 summarizes the recommendations from the analyzed GSI strategies. Specifically, the following are provided:

- The GSI alternative components by CSO basin (e.g., green streets, RainWise, and other key opportunities).
- The range of GSI feasibility from low to high based on the current understanding of connectivity and feasibility.
- The estimated percent of basin impervious surface connected to the combined sewer system that could be managed by GSI, so that it contributes no flow to the combined sewer system during the 1-year storm.
- The estimated reduction in runoff to the combined sewer system during the 1-year storm due to the GSI retrofit. This does not correlate to the CSO control volume, but is an estimate of stormwater runoff.
- The planning-level construction and life-cycle costs for GSI alternatives. For rate assessment purposes, these costs are assumed to be a dollar-for-dollar reduction in the traditional CSO control project (or gray project).

The recommended GSI alternatives (potential opportunities of reducing the gray facility sizes) are included as a component of the recommended preferred alternatives described in Chapter 6. However, the sizes of the gray facilities were not reduced to account for the GSI benefit in this review; more in-basin monitoring and modeling needs to be completed to quantify the benefit of the GSI approach before reducing the gray facility size. Future evaluations will quantify the GSI benefit prior to final sizing of gray facilities, and the most cost-effective balance of green and gray projects will be identified. Together, the two controls will achieve the performance standard. Where possible, the County will seek to collaborate with the City on implementing GSI opportunities.

Additional information on the GSI evaluation is included in Technical Memorandum 810, Green Stormwater Infrastructure Alternatives.

Table 5-12. GSI Alternative Summary Table

CSO Basin	Total Area (Acres)	GSI Alternative Components	GSI Scenario	Total Connected Impervious Area (Acres)	GSI Feasibility				GSI Benefits		GSI Costs	
					Residential RainWise Facility Area[d]	Green Streets / Alleys Facility Area[d]	Impervious Area Managed		Runoff Volume Reduction for 1-Year Storm[c]		Total Construction in 2010 Million Dollars	Planning-Level Life Cycle Costs (Present Value) in 2010 Million Dollars
					(Acres)	(Acres)	(Acres)	%	(MG[a])	%		
11th Ave NW	1,366	Residential RainWise and Green Streets/Alleys	High	691	5	60	182	26%	5.2	23%	$19.4	$21.0
			Low	632	NA	NA	28	4%	0.7	3%	$2.0	$2.2
University	6,172	Residential RainWise and Green Streets/Alleys	High	2,963	28	261	701	24%	16.6	16%	$61.0	$65.9
			Low	2,876	NA	NA	147	5%	2.9	3%	$5.9	$6.4
Montlake	2,212	Residential RainWise and Green Streets/Alleys	High	883	17	76	171	19%	3.3	11%	$10.6	$11.6
			Low	819	NA	NA	36	4%	0.7	2%	$1.2	$1.3
W Michigan St (Including 8th Ave[b])	493	Residential RainWise and Green Streets/Alleys	High	201	3	45	48	24%	1.5	8%	$5.2	$5.7
			Low	188	NA	NA	15	8%	0.4	2%	$0.8	$0.9

a. MG = million gallons
b. The 8th Ave CSO Basin is controlled. This basin is upstream of the W Michigan St CSO Basin, so it was evaluated for GSI to target larger areas of connected impervious. Further modeling is needed to confirm the contribution of this CSO basin to the overflows at the W Michigan St CSO Outfall.
c. The estimated runoff volume reduction does not correlate to the CSO control volume of the gray facility. This volume cannot be directly subtracted from the CSO control volume to determine the size of a reduced gray facility if the recommended GSI alternatives were implemented.
d. The GSI techniques installed in the facility areas can manage stormwater from a larger area of impervious surface than only the footprint of the GSI technique. Therefore, the sum of the acreage for the facility areas is less than the impervious area managed.

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5.8 Agency Approval

On April 5, 2011, the WTD Director and SPU Drainage and Wastewater Division Director met to discuss the following joint alternatives:

- SC-3rd Ave W-Collab-STOR 2: 7.23-MG storage tank north of Ship Canal; with SPU; recommended preferred alternative
- SC-University-Collab-STOR: 5.23-MG storage tank; with SPU; recommended preferred alternative
- SC-Montlake-Collab-STOR: 7.87-MG storage tank; with SPU; recommended preferred alternative
- SC-Cons Tunnel-Collab-STOR: 21.4-MG storage tunnel along the Ship Canal; with SPU.

Both directors agreed to advance the recommended preferred alternatives (SC-3rd Ave W-Collab-STOR 2, SC-University-Collab-STOR, and SC-Montlake-Collab-STOR) into the rate and schedule analysis. Both directors also agreed that the County and the City of Seattle should further develop and define the tunnel alternative.

SPU will be unable to give preliminary confirmation of the joint alternatives until it issues State Environmental Policy Act documentation during the first quarter of 2014. The City of Seattle Mayor and Council will adopt the Long-term CSO Control Plan during the fourth quarter of 2014. After Mayor and Council adoption, a memorandum of agreement for the joint alternatives can be drafted and executed between the County and SPU. If the City determines that independent alternatives are better serve their interests than joint alternatives, the County will implement their independent alternatives that are similar to the joint alternatives as described in Technical Memorandum 970.

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Chapter 6

Recommended Preferred Alternatives

Chapters 4 and 5 of this report summarize analyses and factors evaluated as part of this review. This chapter summarizes the recommended preferred alternatives[1] for controlling the County's remaining 14 uncontrolled CSO sites selected through the triple-bottom-line analysis. It also presents potential risks, issues, and additional items to consider in future evaluations during the predesign phase. All review technical memorandums can be found at: http://www.kingcounty.gov/environment/wastewater/CSO/ProgramReview/plan.aspx#techmemos.

Table 6-1 presents a summary of the recommended preferred alternatives, organized by geographic area, with construction and property acquisition costs and project costs. Figure 6-1 shows the geographic areas and CSO sites. Appendix A.3 of Technical Memorandum 970, CSO Control Alternatives Development presents a summary comparison of the adopted alternatives in the 1999 Plan Amendment and the recommended preferred alternatives from this review, including a discussion of cost differences between the 1999 Plan Amendment and this review.

[1] "Alternative" here refers to a planning-level project concept.

Figure 6-1. King County CSO Site and Areas

Table 6-1. Summary of Costs for Recommended Preferred Alternatives

Alternative	Costs Allocated to King County (2010 $ millions)[a]	
	Construction and Property Acquisition Costs	Project Costs
Ship Canal—11th Ave NW, 3rd Ave W, University, and Montlake		
SC-11th Ave NW-KC-Conv; with GSI[a]	$11.7	$23.7
SC-3rd Ave W-Collab-STOR 2[b]	$27.4	$50.3
SC-University-Collab-STOR; with GSI[a, b]	$24.4	$45.2
SC-Montlake-Collab-STOR; with GSI[a, b]	$52.1	$95.4
Total	**$116**	**$215**
Middle Elliott Bay Interceptor—Hanford #2, Lander St, Kingdome, and King St		
MEBI-Cons Hanford-Lander-King-Kingdome-KC-WWTF (EBI Modifications)	$138	$271
Middle Elliott Bay Interceptor—Hanford #1		
MEBI-Han-Rain-BV-KC-CONV/STOR	$9.5	$19.2
South Elliott Bay Interceptor		
SEBI-Cons Brandon-SMichigan-KC-WWTF (New Conveyance)	$72.3	$140
West Duwamish—W Michigan St and Terminal 115		
WDUW-Cons W Michigan-Term 115-KC-STOR; with GSI[a]	$7.1	$14.8
West Duwamish—Chelan Ave		
WDUW-Chelan-KC-STOR 1	$27.2	$51.7
Total	**$370**	**$711**

a. Implementation of green stormwater infrastructure (GSI) in the CSO basin is not included in costs, as they are expected to replace and reduce project costs. The sizing of the gray storage facility and GSI will be cost-effectively balanced in future evaluations to achieve the performance standard.

b. The City of Seattle cannot commit to joint projects until their Plan update process progresses. If the City does not select joint projects, King County will implement the independent versions of these projects discussed in Chapter 5 of this report.

6.1 Ship Canal—11th Ave NW, 3rd Ave W, University, and Montlake

6.1.1 Recommended Preferred Alternative

The recommended preferred alternative for the Ship Canal—11th Ave NW, 3rd Ave W, University, and Montlake area consists of the preferred site alternatives for this area:

- 11th Ave NW Conveyance—Alternative SC-11th Ave NW-KC-Conv, which includes approximately 3,200 feet of up to 84-inch-diameter conveyance pipe to increase the conveyance capacity from the 11th Ave NW Overflow Structure to the Ballard Regulator Station to control King County CSOs. GSI would likely include implementation of the

RainWise Program in up to 5 acres of residential properties and installing up to 60 acres of green streets/alleys.

- 3rd Ave W Storage with SPU North of Ship Canal[2]—Alternative SC-3rd Ave W-Collab-STOR 2, which includes an up to 7.23-MG storage tank on the north side of the Ship Canal to control county and City of Seattle CSOs.
- University Storage with SPU[2]—Alternative SC-University-Collab-STOR, which includes an up to 5.23-MG storage tank near the University Regulator Station to control county and city CSOs. GSI would likely include implementation of the RainWise Program in up to 28 acres of residential properties and installing up to 261 acres of green streets/alleys.
- Montlake Storage with SPU[2]—Alternative SC-Montlake-Collab-STOR, which includes an up to 7.87-MG storage tank near the Montlake Regulator Station to control county and city CSOs. GSI would likely include implementation of the RainWise Program in up to 17 acres of residential properties and installing up to 76 acres of green streets/alleys.

See Appendix G.1 of Technical Memorandum 970 for details regarding these site alternatives.

6.1.2 Potential Risks, Issues, and Additional Considerations

Potential Risks

Potential risks ranked critical and high for the recommended preferred alternatives were identified during this review based on planning-level information. Many of the risks are associated with potential changes to the projects as more detailed information and site-specific conditions become known. Risk management planning may be required. Potential risks include the following, organized by CSO site:

- 11th Ave NW
  - Construction complexity associated with installing a new up to 84-inch-diameter conveyance pipe along Shilshole Avenue Northwest and Northwest 45th Street could result in major design/construction changes.
- 3rd Ave W
  - King County flows are diverted to the storage tank from a diversion point upstream of the 3rd Ave W Overflow Structure, so predictive controls are required to determine when diversion is needed to prevent CSOs. Complex controls could result in the CSO site not being controlled or the proposed facility operating more frequently than planned.
  - Siting difficulties associated with acquiring property large enough for a storage tank could cause schedule delays or significant project changes.

[2] The City of Seattle cannot commit to joint projects until their Plan update process progresses. If the City of Seattle does not select joint projects, the County will implement the independent versions of these projects discussed in Chapter 5 of this report.

  - County flows are diverted from the North Interceptor upstream of the 3rd Ave W Overflow Structure; modeling has not been completed to determine if the size of the storage will increase based on the upstream diversion location. Potential increase in storage volume could result in a change in design and increase in cost.
- University and Montlake
  - Construction complexity associated with possibility of microtunneling being required to install influent gravity sewer could result in major design/construction changes when more site-specific geotechnical information is known.
  - Siting difficulties associated with acquiring property large enough for a storage tank could cause schedule delays or significant project changes.
  - Community stakeholders could press for a specific project site, resulting in schedule delays or change in alternative.

Potential Issues

Potential issues identified for the 3rd Ave W storage tank include uncertainties with the SPU-defined project, such as siting, storage volume, and cost estimates. SPU is leading the development of this alternative and has not yet selected a preferred alternative; King County has only included a representative alternative recommended by SPU to include in the analyses.

The University storage tank may receive flow transfers from SPU's Windermere area, which has not yet been modeled.

For the joint storage tanks (3rd Ave W, University, and Montlake), operation and maintenance implications need to be understood since they will have design implications.

Additional Considerations

For the Montlake storage tank, there may be additional coordination opportunities with the Washington State Department of Transportation (WSDOT) and its State Route 520 improvements project. It is also likely that SPU will send less flow to this joint storage tank than was assumed in the evaluation (SPU will likely only send flows from the Madison Park CSO Basin and Montlake CSO Basin). King County is also considering evaluating other types of storage facilities, such as a storage pipe or tunnel, for this CSO site due to the potential siting difficulties.

For the storage tank site alternatives, the volumes of the CSO storage tanks were not reduced based on potential storage capacity in the influent gravity sewers. Depending on the hydraulics of the proposed system, additional storage capacity may be available in the influent gravity sewers.

Though not recommended as a preferred alternative, there does not appear to be enough information to select the storage tunnel alternative (Alternative SC-Cons Tunnel-Collab-STOR described in Chapter 5 of this report) as the preferred alternative—or screen it out from consideration at this time. The storage tunnel could reduce siting risks associated with the four county preferred site alternatives and City of Seattle independent alternatives, as well as reduce the number of facilities to be operated and maintained. However, the tunnel alternative would need to site portals and shafts, which may pose similar siting risks. The County and City will continue to evaluate and refine the storage tunnel alternative. The County will evaluate the operation and maintenance requirements and potential issues, including safety, and contact other agencies around the nation that currently operate and maintain large-diameter CSO storage tunnels. The City will strengthen the project definition and refine the costs for this alternative.

The storage tunnel alternative is being developed by the City, and it appears that the current planning-level design is conservative with excavation depth assumptions (current assumption is that the tunnel would be constructed 40 feet below the Fremont Siphon). However, other costs may be inadequately accounted for, including odor control and air management associated with tunnel operation. If costs and risks are reduced with refinement of the design, this alternative may be reconsidered.

Potential risks ranked critical and high identified during this review for the storage tunnel alternative were based on planning-level information. Many of the risks identified below are associated with potential changes to the project as more detailed information and site-specific conditions become known. Risk management planning may be required. Potential risks include the following:

- Construction complexity associated with deep excavation of tunnel portals and tunnel construction could result in major design/construction changes.
- Four county and four or five city CSO sites would be controlled by this storage tunnel, so complex controls would be needed to ensure that each CSO site is controlled to its regulatory requirement. Complex controls could result in the CSO sites not being controlled or the proposed facility operating more frequently than planned.
- Siting difficulties associated with acquiring easements and property for the west and east tunnel portals could cause schedule delays or significant project changes.
- Limited trained staff is available to operate and maintain the storage tunnel. Operation and maintenance issues need to be further defined and resolved to ensure a proper design and adequately trained staff. Coordination with the City could impact the schedule and project definition. Coordination with the City needs to be further defined in later stages of development to ensure cost and schedule compliance.
- Community stakeholders could press for a specific site alignment and portal locations of the tunnel or press for another alternative, resulting in schedule delays or changes in the alternative.

Another alternative that should be considered in future evaluations is possibly sending only the 3rd Ave W, University, and Montlake CSOs to the joint storage tunnel and controlling 11th Ave NW CSOs with the increased conveyance site alternative. Based on the costs developed as part of this review, the construction cost to convey 11th Ave NW CSOs to the tunnel is similar to the construction cost of the increased conveyance site alternative ($10.58 million versus $11.66 million, respectively). Controlling 11th Ave NW CSOs separately from the tunnel may allow the tunnel to move east of the Fremont Siphon, so it would avoid crossing it, possibly allowing the tunnel to be constructed shallower.

It should be noted that late in this analysis the City identified potentially greater CSO control volume needs at their Ballard CSO site that might influence joint project options with the storage tunnel alternative. Their confirmation of CSO control volume needs will not be complete before this 2012 CSO Control Program Review Report and King County Executive's Recommended CSO Control Plan are submitted.

6.2 Middle Elliott Bay Interceptor—Hanford #2, Lander St, Kingdome, and King St

6.2.1 Recommended Preferred Alternative

The recommended preferred alternative for the Middle EBI—Hanford #2, Lander St, Kingdome, and King St area is Alternative D2, which consists of Alternative MEBI-Cons Hanford-Lander-King-Kingdome-KC-WWTF (EBI Modifications) to control Hanford #2, Lander St, Kingdome, and King St CSOs. This alternative includes an up to 151-MGD CSO treatment facility (assuming the use of a ballasted sedimentation treatment process) near the Hanford St Regulator Station and modifications to the Elliott Bay Interceptor (EBI) to divert flows to the CSO treatment facility. See Appendix G.3.8 of Technical Memorandum 970 for details regarding this alternative.

6.2.2 Potential Risks, Issues, and Additional Considerations

Potential risks ranked critical and high identified during this review for the recommended preferred alternative were based on planning-level information. Many of the risks identified below are associated with potential changes to the project as more detailed information and site-specific conditions become known. Risk management planning may be required. Potential risks include the following:

- Construction complexity associated with a large gate and bypass structure and diversion structure along the 96-inch-diameter EBI, as well as a new CSO outfall, could result in major design/construction changes.
- Complex controls could result in the CSO sites not being controlled or the proposed facility operating more frequently than planned. Complex controls are required to determine when the EBI gate closes to cause backflow flows to the CSO treatment facility at Hanford #2 and control four CSO sites. Proper controls are critical to ensure that the CSOs are controlled.
- A new CSO outfall that conveys large treated discharges to the Duwamish River may face regulatory challenges and delay or complicate the alternative.
- Siting difficulties associated with acquiring property for a CSO treatment facility of this size could cause schedule delays or significant project changes.

Complexities and risks associated with backflowing the EBI will be further explored in a future workshop with experts. The County will also complete additional modeling of this alternative. Depending upon the outcome of the workshop, identification of fatal flaws, possible reduction in risks, and refined modeling evaluations, Alternative D1, MEBI-Cons Hanford-Lander-King-Kingdome-KC-WWTF (New Conveyance), is a potential alternate choice.

The recommended preferred alternative may include minimal flow transfers from City's CSO Basin 107, Genesee, and south waterfront areas to the proposed CSO treatment facility.

6.3 Middle Elliott Bay Interceptor—Hanford #1

6.3.1 Recommended Preferred Alternative

The recommended preferred alternative for the Middle EBI—Hanford #1 area is Alternative MEBI-Han-Rain-BV-KC-CONV/STOR, which includes an up to 0.34-MG storage tank near the Bayview North Overflow Structure and conveyance improvements to use available capacity in the Bayview Tunnel. See Appendix G.4 of Technical Memorandum 970 for details regarding this alternative.

6.3.2 Potential Risks, Issues, and Additional Considerations

No critical or high risks were identified during this review for this recommended preferred alternative.

This alternative would include a complex storm drain crossing with a drop structure, and the new conveyance pipe would need to be installed by microtunneling due to deep excavation.

The conveyance upgrade would increase flows to the Hanford and Lander Street Regulator Stations. Additional modeling will be required to determine the impact of the increased flows on the downstream regulator stations and proposed CSO control facilities. For this planning stage, it is assumed that the increased flows from the Bayview North Overflow Structure would minimally impact the size of the proposed CSO control facilities for the Hanford and Lander St Regulator Stations.

The recommended preferred alternative may include minimal flow transfers from the City of Seattle to the proposed storage facility.

6.4 South Elliott Bay Interceptor

6.4.1 Recommended Preferred Alternative

The recommended preferred alternative for the South EBI area is Alternative SEBI-Cons Brandon-SMichigan-KC-WWTF (New Conveyance) to control S Michigan St and Brandon St CSOs. This alternative includes an up to 66-MGD CSO treatment facility (assuming the use of a ballasted sedimentation treatment process) near the S Michigan St Regulator Station and new conveyance from the Brandon St Regulator Station to the CSO treatment facility. See Appendix G.5.3 of Technical Memorandum 970 for details regarding this consolidated alternative.

6.4.2 Potential Risks, Issues, and Additional Considerations

Potential risks ranked critical and high identified during this review for the recommended preferred alternative were based on planning-level information. Many of the risks are associated with potential changes to the project as more detailed information and site-specific conditions become known. Risk management planning may be required. Potential risks include the following:

- Equipment failure associated with the influent pump station during peak event could lead to increased overflows.
- The new CSO outfall that conveys large treated discharges to the Duwamish River may face regulatory challenges that could delay or complicate the alternative.
- Siting difficulties associated with acquiring property for a CSO treatment facility of this size could cause schedule delays or significant project changes.
- Community stakeholders could press for a specific location for the CSO treatment facility, resulting in schedule delays or change in alternative.

6.5 West Duwamish—W Michigan St and Terminal 115

6.5.1 Recommended Preferred Alternative

The recommended preferred alternative for the West Duwamish—W Michigan St and Terminal 115 area is Alternative WDUW-Cons W Michigan-Term 115-KC-STOR, which controls W Michigan St and Terminal 115 CSOs with an up to 0.32-MG storage pipe near the Terminal 115 Overflow Structure. GSI would likely include implementation of the RainWise Program in up to 3 acres of residential properties and installing up to 45 acres of green streets/alleys. See Appendix G.6.3 of Technical Memorandum 970 for details regarding this consolidated alternative.

6.5.2 Potential Risks, Issues, and Additional Considerations

No critical or high risks were identified during this review for this alternative; however, conflicts with the South Treatment Plant effluent transfer system should be avoided in design.

Due to the small storage volume associated with this storage pipe, it may be possible to construct a single storage pipe between the W Michigan St Regulator Station and Terminal 115 Overflow Structure instead of installing a new conveyance pipe to convey W Michigan St CSOs from the W Michigan St Regulator Station to the Terminal 115 Overflow Structure.

Overall, the combined preferred site alternatives have costs, values, and risks similar to those of the consolidated area alternative. Future evaluations should consider evaluating both alternatives.

6.6 West Duwamish—Chelan Ave

6.6.1 Recommended Preferred Alternative

The recommended preferred alternative for the West Duwamish—Chelan Ave area is Alternative WDUW-Chelan-KC-STOR 1, which includes an up to 3.85-MG storage tank near the Chelan Ave Regulator Station and modifications to the Alki Trunk. See Appendix G.7 of Technical Memorandum 970 for details regarding this alternative.

6.6.2 Potential Risks, Issues, and Additional Considerations

The only high risk identified during this review for this alternative is potential siting difficulty associated with acquiring property for storage of this size. Property in the vicinity of the Chelan Ave Regulator Station is primarily owned by the Port of Seattle, with some scattered private property owners. Early discussions with the Port of Seattle and coordinating activities would be required to explore siting possibilities.

If property is difficult to acquire near the Chelan Ave Regulator Station, the storage alternative at the West Seattle Pump Station (Alternative WDUW-Chelan-KC-STOR 2) could be reconsidered as an alternate choice. The proposed facilities are located on property that is owned by King County, adjacent to the West Seattle Pump Station. Potential risks ranked critical and high identified during this review for Alternative WDUW-Chelan-KC-STOR 2 include the following (risk management planning may be required):

- Construction complexity associated with construction of two 90-foot-diameter caissons (approximately 70 feet deep) adjacent to West Seattle Pump Station could result in major design/construction changes.
- County flows would be diverted to the storage facility upstream of the Chelan Ave Regulator Station, so predictive controls would be required to determine when diversion is needed to prevent CSOs. Complete controls could result in the CSO sites not being controlled or the proposed facility operating more frequently than planned.
- Potential increase in storage volume could result in a change in design and increase in cost. County flows would be diverted upstream of the Chelan Ave Regulator Station along the Delridge Trunk; modeling has not been completed to determine if the size of the storage would increase based on the upstream diversion location.
- Potential operations and maintenance issues are associated with cleaning of deep, round storage structures.

It should be noted that late in this analysis the City of Seattle identified potentially greater CSO control volume needs at their Delridge CSO site that might influence joint project options. If further development indicates a joint project with the County's Chelan project would provide a better alternative for both agencies, then the County will consider a joint Delridge/Chelan project with SPU. However, the City's confirmation of CSO control volume needs will not be complete before this 2012 CSO Control Program Review Report and King County Executive's Recommended CSO Control Plan are submitted.

Chapter 7

Project Sequence Evaluation

This chapter presents an evaluation of alternative project sequences for implementing the recommended preferred alternatives[1]. The project sequence development is further described in Technical Memorandum 1100, Project Sequence (found at: http://www.kingcounty.gov/environment/wastewater/CSO/ProgramReview/plan.aspx#techmemos).

7.1 Project Sequence Evaluation

7.1.1 Project Sequence Definition

Project sequence is the order in which the recommended preferred alternatives (described in Chapter 6 of this report) will be implemented from today through completion of control. The project sequence affects utility rates, coordination with other agencies, resource allocation, and local and regional construction impacts. Evaluation of the project sequence included all the recommended preferred alternatives. In addition, a project sequence alternative was evaluated that includes a single storage tunnel instead of individual storage tanks for the University, 3rd Ave W, and Montlake CSO basins. The sequence alternatives include green stormwater infrastructure (GSI) projects for the Montlake, University, 11th Ave NW, and W Michigan St/Terminal 115 (Duwamish) CSO basins.

Project Sequence Drivers

Drivers identified for the project sequence evaluation are those that impact the timing, order, or implementation feasibility of the projects, either individually or collectively. The following drivers were identified for the project sequence evaluation:

- **GSI Project Monitoring—**GSI projects must be implemented early to allow for monitoring to determine the flow reduction achieved.
- **Duwamish Area Projects—**Projects in the Duwamish area should be scheduled to coordinate with a large regional effort underway to clean up and restore the area.
- **Rate Impact—**Sewer rates will need to be increased by King County to implement the CSO control projects. Projects should be spread out to flatten the rate increase. This required implementing the two expensive CSO treatment facilities at opposite ends of the schedule.

[1] "Alternatives" is used here as a planning-level project concept.

- **Workload Impact—**Project impact on county staffing needs to be considered. CSO treatment facilities will likely require additional operation and maintenance staff.
- **King County 2030 Compliance**—Projects need to be implemented by the target of 2030 established in the 1999 Plan Amendment.
- **SPU 2025 CSO Control Schedule**—Projects implemented jointly with SPU must be completed in time to comply with SPU's requirement to control CSOs by 2025.
- **Opportunities and Conflicts with Other Agencies' Projects**—Coordination with other agency projects may result in cost savings or may be necessary to avoid construction conflicts.

7.1.2 Project Implementation Building Blocks

Selecting the right project sequence requires an understanding of the components of work ("building blocks") to be done for each type of project. The duration of each building block, based on historical project implementation timeframes, is used in evaluating the overall timeline for the project sequence (see Figure 7-1). The assumed building blocks for storage tank and CSO treatment projects are as follows:

- Problem definition (two years total):
  - Flow monitoring and modeling to refine project sizing (two years)
  - Existing facility inspection (one year)
  - Existing facility condition and capacity verification (one year)
- Predesign and design (three years)
- Construction (three years for storage tanks; five years for CSO treatment facilities)
- Flow verification and control adjustments if needed (two years for storage tanks; two to three years for CSO treatment facilities).

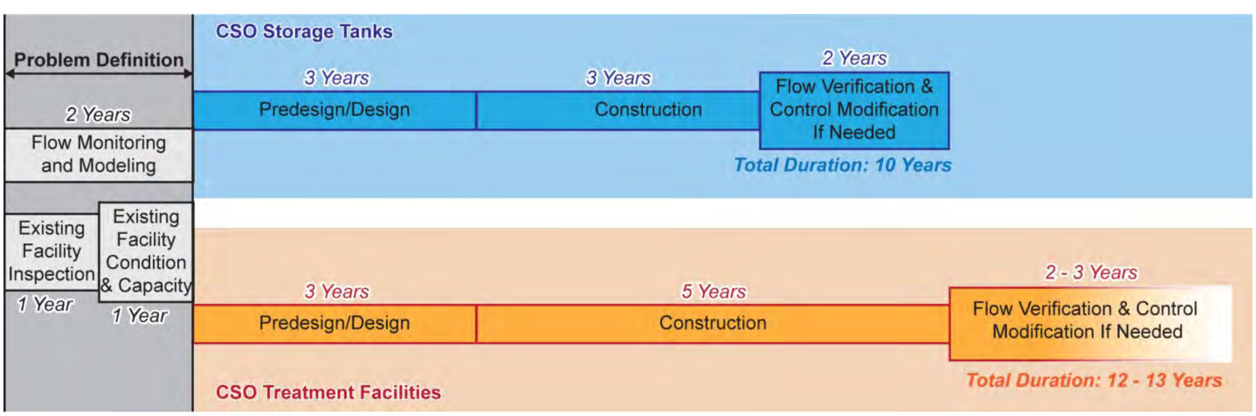

Figure 7-1. Assumed Timelines for Project Building Blocks

The assumed building blocks for GSI projects are as follows:

- Problem definition (two years total):
  - Flow monitoring and modeling performed in the first year of the problem definition for storage or treatment projects will determine the GSI sizing.
  - GSI design will begin in the second year of the problem definition period.
- Construction (two years).
- Verification of flow reduction by flow monitoring for two wet seasons (two to three years depending on weather conditions).

GSI projects will begin before the affected storage or treatment projects, in order to affirm or adjust facility sizing during design. The time between GSI construction and the beginning of design for the storage or treatment project will be driven by the 2030 county compliance date.

7.1.3 Initial Project Sequence Alternatives

Four initial project sequence alternatives were evaluated:

- The **Duwamish River Cleanup Coordination Alternative** (see Figure 7-2) emphasizes completion of projects in the Duwamish area to coordinate with the cleanup schedule of the Lower Duwamish Waterway. Key features of this alternative are as follows:
  - At the recommendation of stakeholders the first CSO treatment facility to be implemented is the Brandon St/S Michigan St facility in the Lower Duwamish Waterway.
  - The Hanford @ Rainier and W Michigan St/Terminal 115 storage projects are completed before the University, Montlake, and 3rd Ave W storage projects.
  - GSI precedes and informs storage and treatment projects.
  - Separate storage projects are implemented for University, 3rd Ave W, and Montlake.
  - The Montlake project could be completed earlier and the Chelan project later if coordination is required with Seattle Parks or Washington State Department of Transportation (WSDOT).
  - Early control is provided for Seattle CSO transfers to King County for treatment.

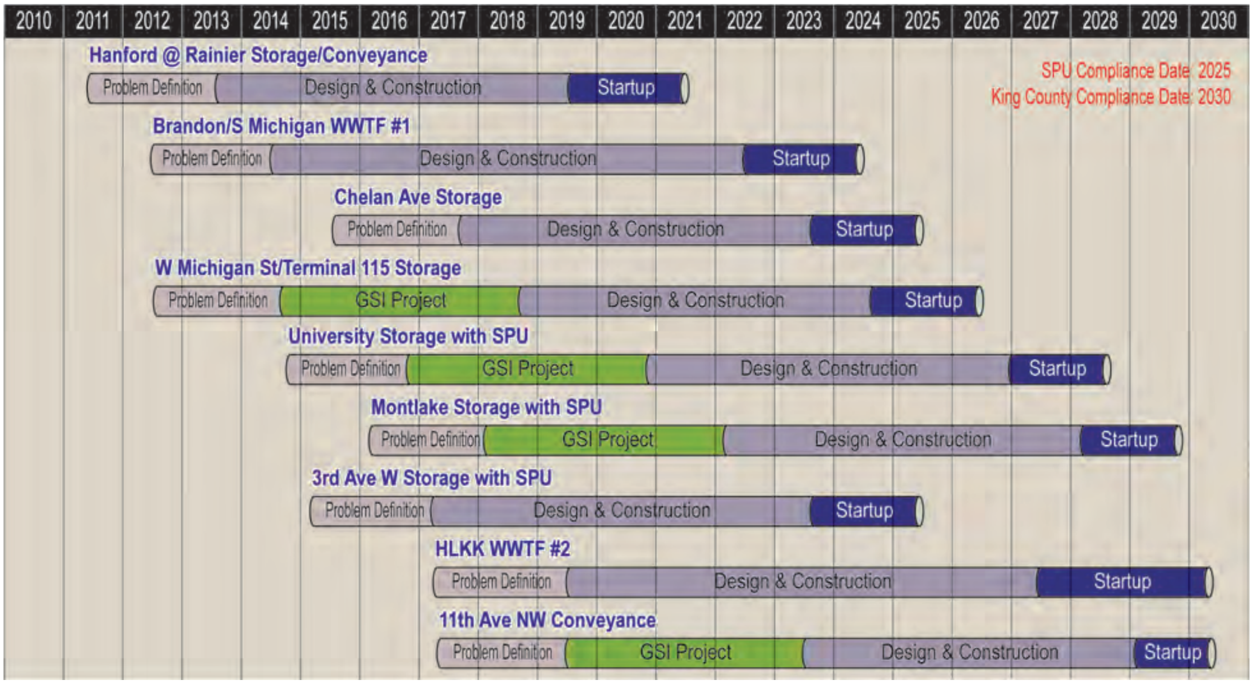

Figure 7-2. Duwamish River Cleanup Coordination Project Sequence Alternative

- The **GSI-First Alternative** (see Figure 7-3) emphasizes the early completion of GSI projects, so that their effectiveness can be measured and used in the design of storage and treatment projects. Key features of this alternative are as follows:
  - All GSI projects are implemented early in the program.
  - Separate storage projects are implemented for University, 3rd Ave W, and Montlake.
  - GSI evaluations overlap the design of storage and treatment projects, so that the SPU CSO control compliance date of 2025 can be met; because of the overlap, the sizing of affected storage or treatment projects is less certain, and will be based more on modeling and less on monitoring.
  - CSO treatment facility construction is spread over a longer time for reduced rate impacts.
  - Start dates for design of storage and treatment projects are staggered to reduce impacts on rates and resources.
  - The start date for the Montlake project is delayed to allow time for coordination with WSDOT on State Route (SR) 520 in the Montlake CSO Basin.
  - This sequence coordinates with the cleanup schedules of the Lower Duwamish Waterway by implementing the Brandon St/S Michigan St CSO treatment project and W Michigan St/Terminal 115 GSI project early in the sequence.

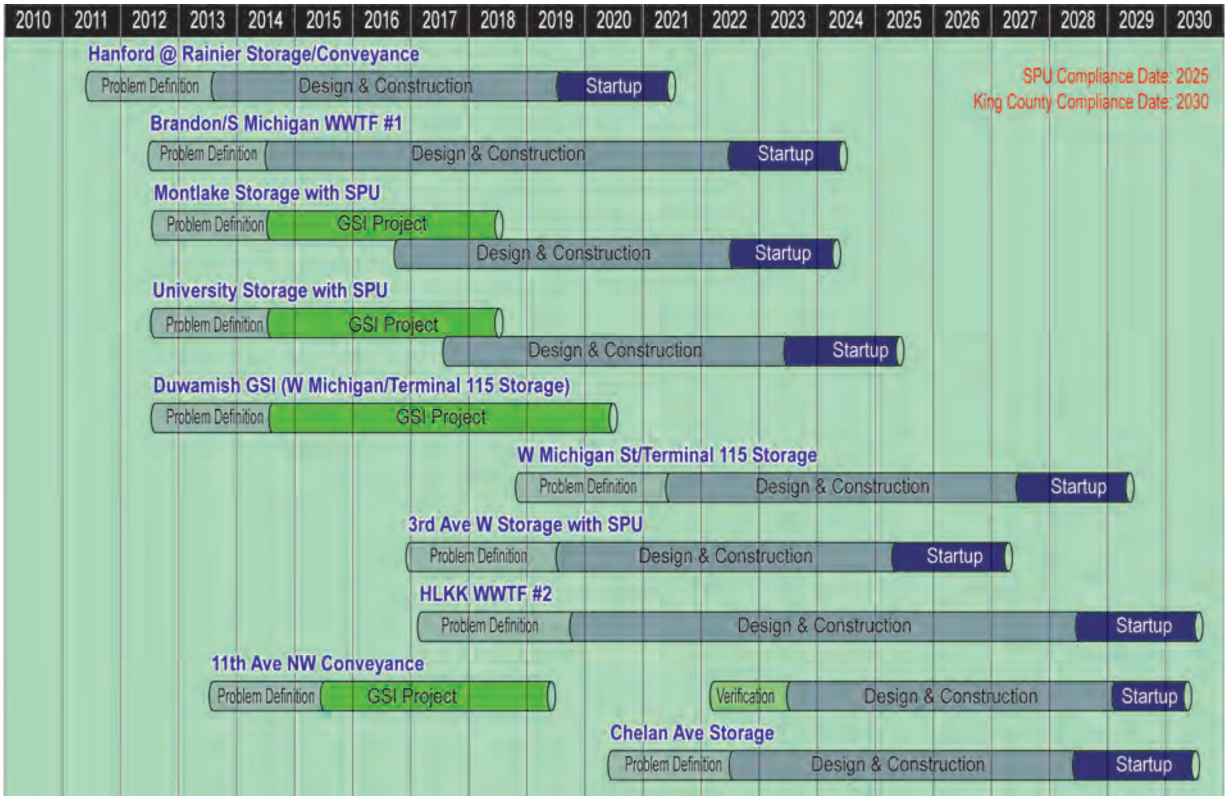

Figure 7-3. GSI-First Project Sequence Alternative

- The **Meet-SPU-2025 Compliance Schedule Alternative** (see Figure 7-4) emphasizes meeting the SPU CSO control compliance date of 2025. It is similar to the GSI-First Alternative; however, it includes GSI design/build projects to be performed by SPU, and it delays the start date of the 11th Ave NW GSI project until after SPU's Ballard GSI projects are operational. Key features of this alternative are as follows.
  - Separate storage projects are implemented for University, 3rd Ave W, and Montlake.
  - GSI evaluations overlap the design of storage and treatment projects, so that the SPU CSO control compliance date of 2025 is met; because of the overlap, the sizing of affected storage or treatment projects is less certain.
  - CSO treatment facility construction is spread over a longer time for reduced rate impacts.
  - Start dates for design of storage and treatment projects are staggered to reduce impacts on rates and resources.
  - The start date for the Montlake project is delayed to allow time for coordination with WSDOT on SR 520 in the Montlake Basin.
  - This sequence addresses public health concerns at University/Ship Canal early.
  - This sequence coordinates with the cleanup schedules of the Lower Duwamish Waterway by implementing the Brandon St/S Michigan St and W Michigan St/Terminal 115 projects early.

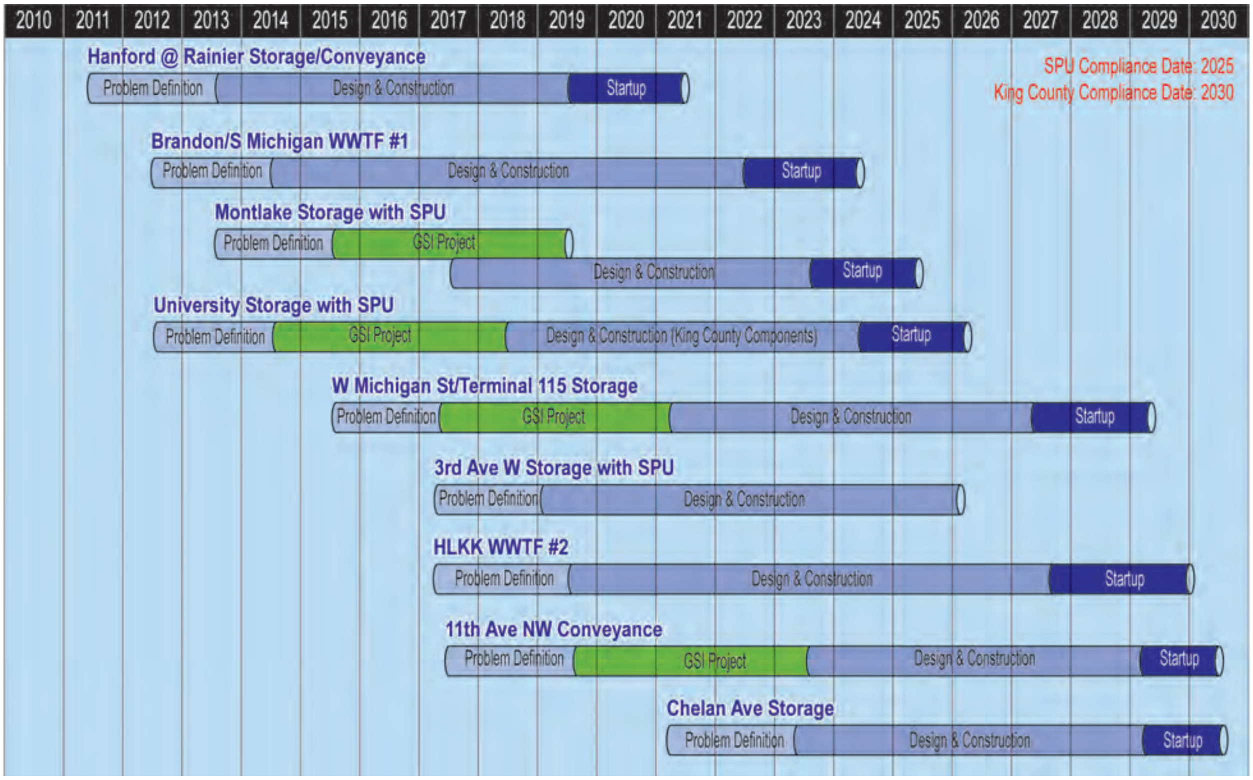

Figure 7-4. Meet-SPU-Schedule Project Sequence Alternative

- The **Joint-Tunnel Alternative** (see Figure 7-5) would provide CSO control in the basins near the Ship Canal (University, 3rd Ave W, and Montlake) using a storage tunnel developed jointly with SPU rather than the individual storage projects for each basin. Key features of this alternative are as follows.
  - This sequence meets SPU CSO control compliance date of 2025 for joint projects.
  - A single tunnel project is implemented for University, 3rd Ave W, and Montlake. This is similar to the storage tunnel final alternative for all four Ship Canal CSO basins evaluated in Chapter 5 of this report, but it excludes the 11th Ave NW CSO Basin, which would be managed by an individual conveyance project.
  - CSO treatment facility construction is spread over a longer time for reduced rate impacts.
  - GSI precedes and informs storage and treatment projects where feasible.
  - Start dates for design of storage and treatment projects are staggered to reduce impacts on rates and resources.
  - A three-year geotechnical feasibility study on the joint tunnel would overlap with the first year of predesign of the tunnel.

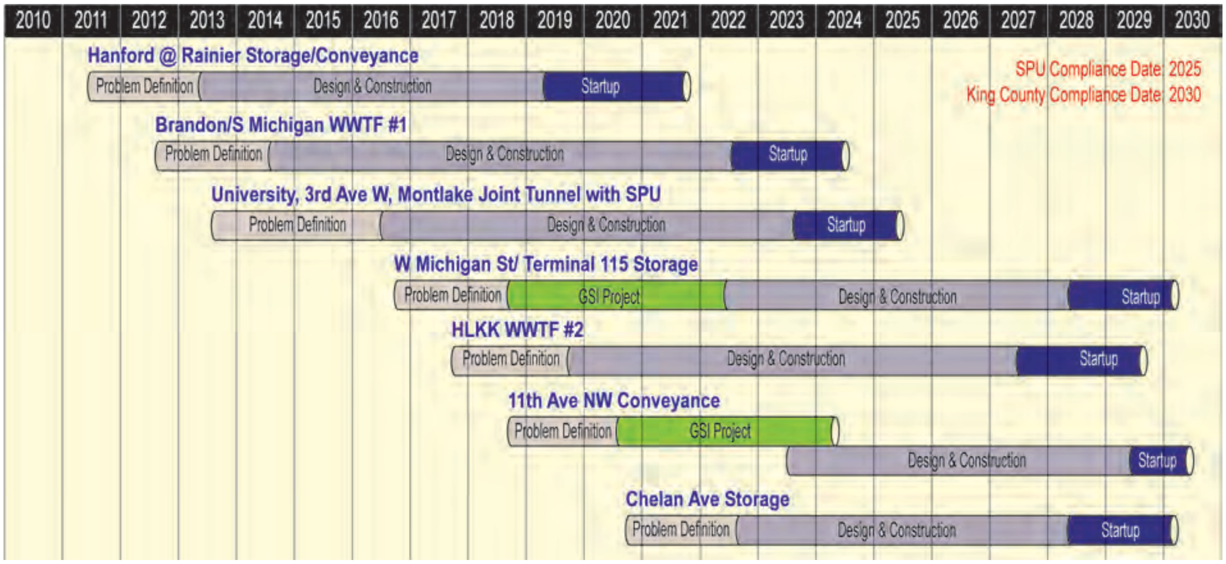

Figure 7-5. Joint-Tunnel Project Sequence Alternative

7.1.4 Evaluation Process

A rate analysis performed for each of the four project sequence alternatives, as described in Chapter 8 of this report, indicated that the sewer rates did not differentiate between the alternatives. The four project sequence alternatives were evaluated against the schedule drivers. Table 7-1 summarizes the results, where “x” indicates the criterion is met.

Table 7-1. Ability of Project Sequence Alternatives to Meet Schedule Drivers

Schedule Drivers	Duwamish River Cleanup Coordination Alternative	GSI-First Alternative	Meet-SPU-Schedule Alternative	Joint-Tunnel Alternative
GSI Project Monitoring	X	X		
Duwamish Area Projects	X			
Rate Impact	X	X	X	X
Workload Impact	X	X	X	X
King County 2030 Completion	X	X	X	X
SPU 2025 Completion		X	X	X
Conflicts with Other Agencies’ Projects	X	X	X	X

Workshops were held with county construction management, SPU, Duwamish stakeholders, and county management to solicit input on the project sequence alternatives. The following input received at the workshops was used to recommend a preferred project sequence:

- Delay the University and Montlake projects in order to avoid construction conflicts with WSDOT improvements planned for SR 520.
- Develop a project sequence that emphasizes both the Duwamish and GSI drivers.
- Increase the GSI verification process to three years to obtain data from two wet seasons and validate the CSO reduction effectiveness.
- Eliminate startup time as a unique phase from the project schedules.

7.1.5 2011 WTD Recommended CSO Control Plan Project Sequence

As a result of the evaluations and workshops, WTD developed and recommended a hybrid project sequence that prioritizes both the Duwamish cleanup coordination and GSI schedule drivers. Figure 7-6 shows the WTD-recommended project sequence. This schedule was included in the 2011 WTD Recommended CSO Control Plan issued for public review and comment in October 2011.

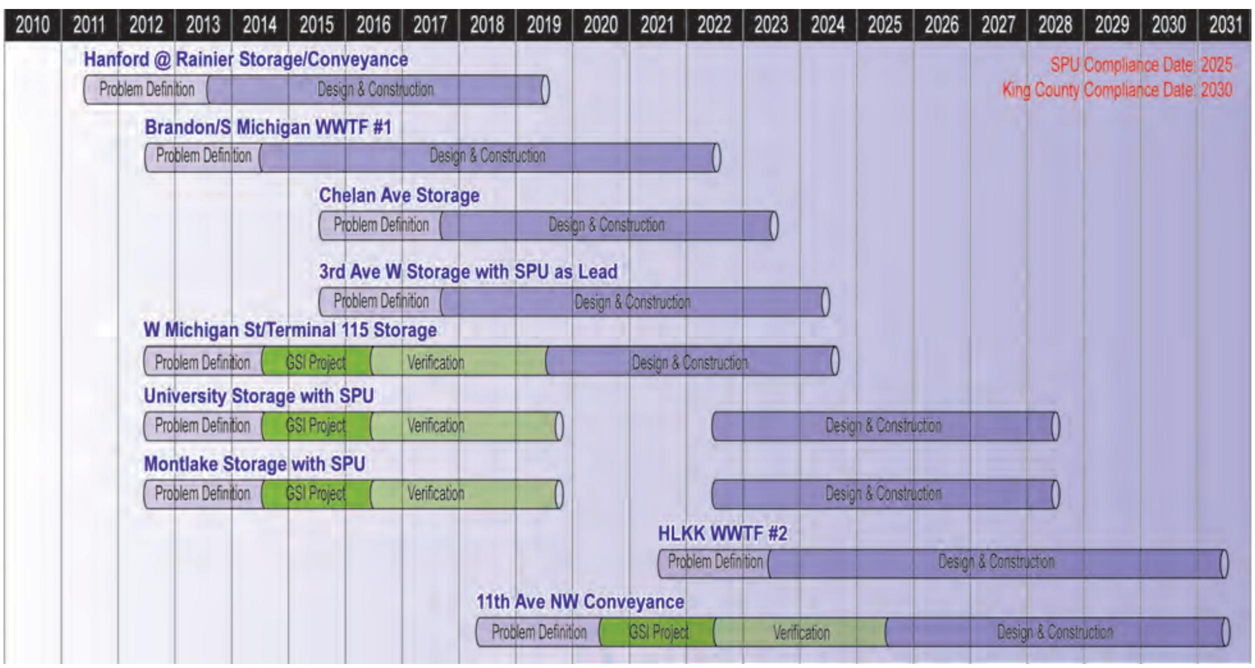

Figure 7-6. WTD-Recommended Project Sequence

The key changes from the initial alternatives are as follows:

- Startup time is not called out as a unique phase.
- The duration of GSI projects (excluding Problem Definition) was refined from four years to five years: two years of design/build and then three years for verification (instead of two years).

The key features of this alternative are as follows:

- Brandon St/S Michigan St would be the first CSO treatment facility to be designed and constructed.
- The W Michigan St/Terminal 115 project would be implemented before the Ship Canal projects.
- GSI monitoring time to gather data for project sizing is maximized by extending to three years.
- Chelan GSI would be done by SPU and timed to inform King County's sizing for the Chelan storage facility.
- The Chelan storage project could be moved earlier and the Montlake project moved later to prioritize the Duwamish.

7.1.6 King County Executive's Recommended CSO Control Plan Project Sequence and Water Quality Assessment and Monitoring Study

Concerns raised by some members of the public about whether dollars spent on CSO control is the best investment in water quality have prompted the King County Executive to recommend conducting a water quality assessment and monitoring study (study) to inform the next CSO control program review for the 2019 NPDES permit renewal. The King County Executive believes it is prudent to meet the County's CSO control commitments and also commit resources into completing a comprehensive review of the effects on water quality in the sub-watersheds where CSO discharges occur.

The purpose of the water quality assessment and monitoring study (study) is to provide information to guide integration and sequencing of CSO control projects with other actions to improve water quality, health, and biological outcomes in watersheds receiving CSO discharges. Study results could confirm or propose adjustments to the County's Long-term CSO Control Plan to meet water quality standards. Additional information about the study can be found in Section 11.3 of this report.

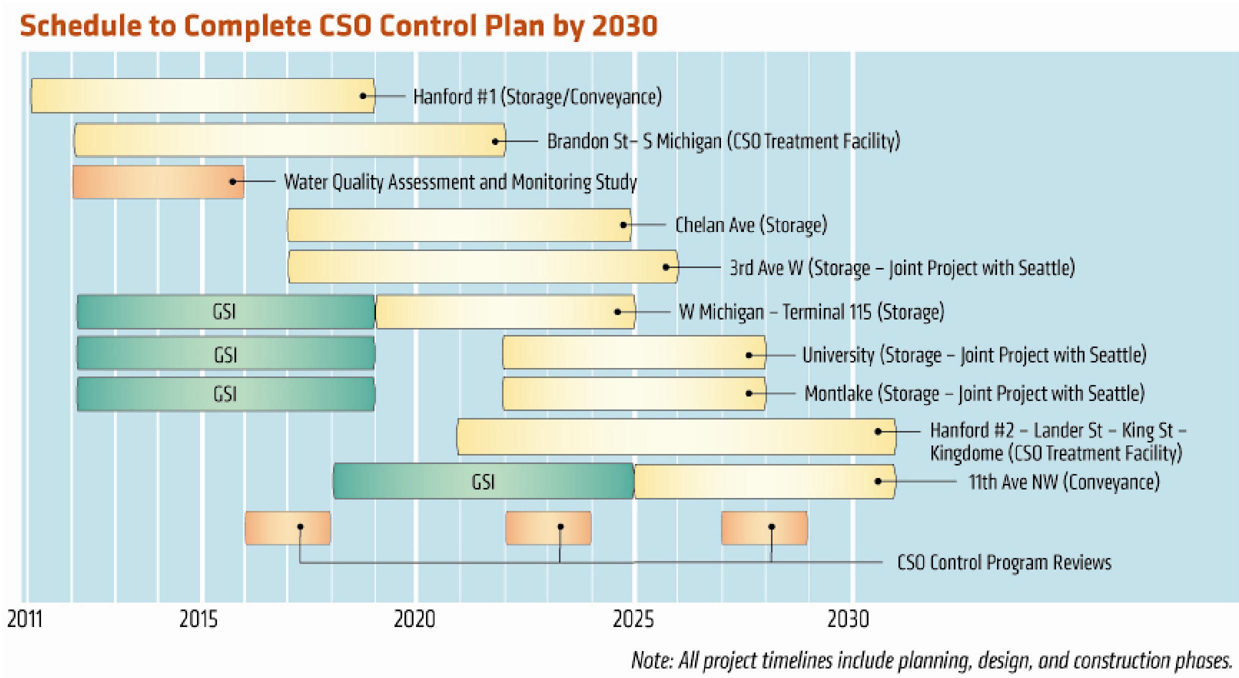

Figure 7-7. King County Executive's Recommended Project Sequence and Schedule with Water Quality Assessment and Monitoring Study

Chapter 8

Rate Analysis and Financing the Plan

King County's Long-term CSO Control Plan (Plan) must be funded using sound and sustainable financial approaches and must be affordable to rate payers. A key consideration in recommending Plan project sequences and schedules is their impact on sewer rates. The County seeks to minimize and distribute rate increases over time. This chapter describes the process to assess potential sequences and schedules, how the recommended Plan will be funded, and the financial impacts on the community.

The County's Capital Improvement Program (CIP), which includes planned CSO control projects, is funded through a mix of proceeds from revenue bond sales, short-term borrowing, capacity charge revenues, and transfers from the operating fund. The operating fund derives the majority of its revenue from monthly charges to customers that are collected by the County's local agencies. Transfers from the operating fund to the CIP are the result of the financial policy requirement of maintaining a debt service coverage ratio greater than 1.15 for all debt service payments. This means the monthly sewer rate is set such that operating revenues will exceed debt service and operating expenses by an amount equal to at least 15 percent of the total debt service expense. This buffer reduces the risk to bond holders and at the end of the year provides the County with funds to reduce the amount of borrowing necessary to finance the CIP. In addition, the County pursues alternative low-cost financing for specific capital projects. As a result, some capital projects are funded by grants or low-interest loans. However, grant funding tends not to be available today. Appendix G of this report provides more detail on the County's funding and financing mechanisms.

This chapter compares the estimated annual expenditures and sewer rate impacts for the four initial project sequence alternatives, for the Wastewater Treatment Division (WTD) recommended project sequence with three Plan completion dates, and for the King County Executive's recommended project sequence; project sequences are described in Chapter 7 of this report. This chapter concludes with a summary of an analysis of the affordability of the Plan and the County's capability to finance it.

8.1 Methodology for Rate Impact Analysis

As discussed in Chapter 7 of this report, King County evaluated four initial project sequence alternatives for completing nine CSO control projects at a total project cost of $711 million (2010 dollars). These alternatives are the Duwamish River Cleanup Coordination Alternative, GSI-First Alternative, Meet-SPU-2025 Compliance Schedule Alternative, and Joint-Tunnel Alternative, which also meets the SPU CSO control compliance schedule. The evaluation resulted in the recommendation to implement a hybrid of the Duwamish River Cleanup Coordination and GSI-First Alternatives.

The Joint-Tunnel Alternative includes a large tunnel project that would replace three individual projects in the Lake Washington Ship Canal area and would be jointly funded by the County and the City of Seattle. The County does not recommend the tunnel project at this time because initial cost estimates are higher than the three individual projects. However, it was felt that the concept needs to be developed further. The County and City are continuing to evaluate the project and will make a recommendation to their respective leadership when complete.

Several factors were considered in the evaluation, including the rate impact analysis described in this chapter. The rate impact analysis first compared estimated annual expenditures and rates for the four initial project sequence alternatives. The analysis assumed a completion date of 2030 for the Plan. A similar analysis was then conducted on the WTD-recommended project sequence to compare three alternative schedules for completing the Plan: 2030, 2035, and 2040. No alternative financing is assumed in the analysis of rate impacts from the recommended CSO control projects.

The 2011−2012 county monthly sewer rate charged to local agencies is $36.10 per single family home, or Residential Customer Equivalent (RCE). Commercial customers, including multi-family buildings, are charged the same rate based on metered water use. (1 RCE = 750 cubic feet per month.)

The rate impacts of alternative sequences and schedules were compared to the No Action Alternative, which assumes no future CSO control projects beyond projects now underway. The No Action Alternative includes four CSO control projects in the 2012 CIP that are scheduled for final design and permitting in December 2012 plus the CSO control component of the Ballard Siphon Replacement project (Table 8-1).

Table 8-1. CSO Control Projects Now Under Way

Current CSO Control Projects	2011−2017 Expenditures ($ x 1M)[a]
Puget Sound beach projects (North Beach, S Magnolia, Murray, Barton)	103
Ballard Siphon CSO component	14
Total	**117**

a. Estimated project spending based on predesign information.

8.2 Comparison of Initial Project Sequence Alternatives

The following sections describe the results of the comparison of annual expenditures and rate impacts of the four initial project sequence alternatives.

8.2.1 Annual Expenditures

In order to evaluate the long-term rate impacts of the initial project sequence alternatives, the project sequences were translated into annual capital and operations and maintenance (O&M) expenditures. Once completed, CSO control facilities incur ongoing O&M costs for electric power, chemicals, staff time for operating and monitoring the facilities, and periodic maintenance.

Capital Costs

Figure 8-1 summarizes the annual capital expenditures in 2010 dollars of the four initial project sequence alternatives. All sequences assumed a Plan completion date of 2030. The Duwamish River Cleanup Coordination Alternative, GSI-First Alternative, and Meet-SPU-2025 Compliance Schedule Alternative have similar cash flow patterns. In addition to the higher cost of the tunnel alternative, cash flows for this sequence are more heavily weighted toward the early years of the 2011−2030 time period—this is in part due to having a schedule that meets SPU's earlier CSO control compliance date. If the tunnel concept is selected, sequences that spread the tunnel cost differently could be developed.

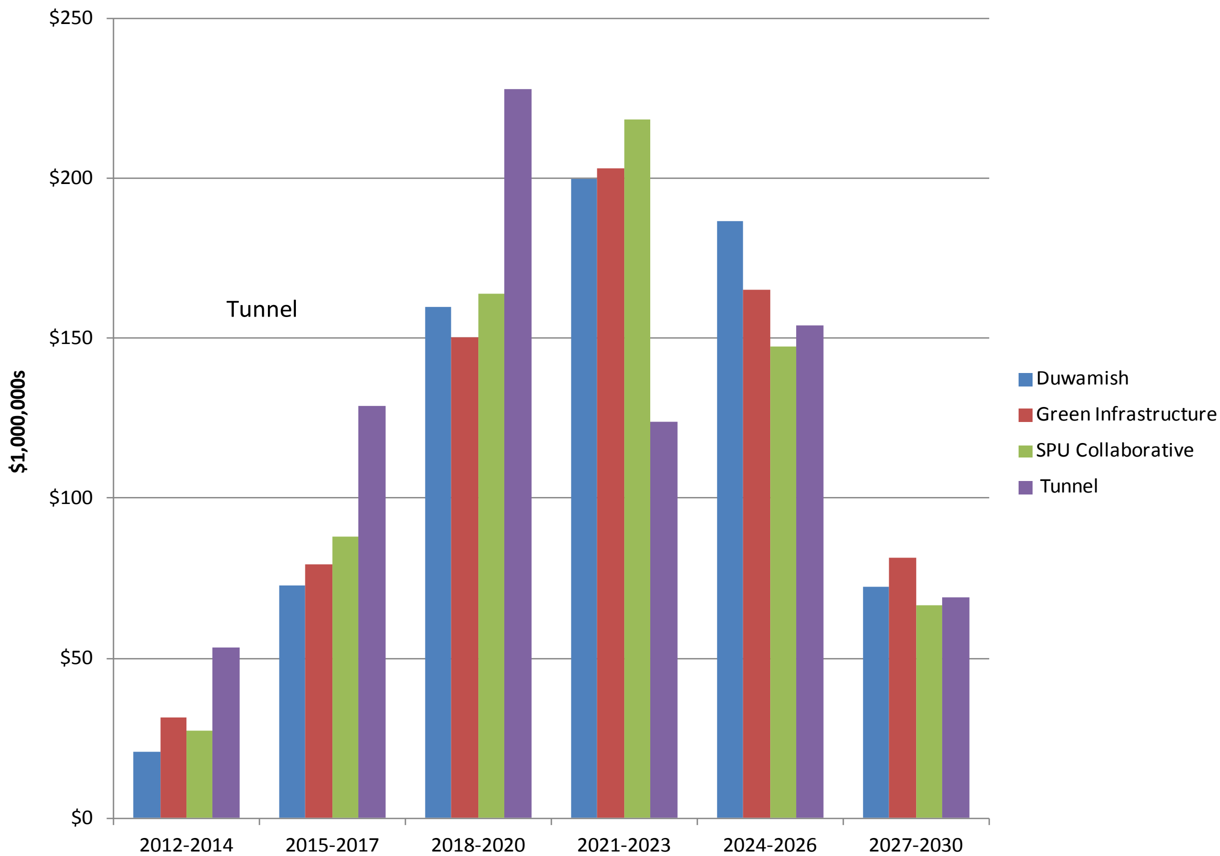

Figure 8-1. Annual Capital Expenditures for Initial Project Sequence Alternatives (2010 Dollars)

Operation and Maintenance Costs

Differences among the four initial project sequence alternatives were not great enough to cause a significant variation in O&M costs. The average cost of the Duwamish River Cleanup Coordination Alternative, GSI-First Alternative, and Meet-SPU-2025 Compliance Schedule Alternative is approximately $3.0 million per year during 2021−2030 (2010 dollars). The average cost of all four alternatives is slightly higher at $3.5 million per year because of the more complex O&M costs for the Joint-Tunnel Alternative than for the simpler operations of three individual storage tanks that the tunnel would replace.

8.2.2 Rate Impacts

Under the No Action Alternative, the monthly sewer rates per single family residence are forecast to increase from $36.10 in 2012 to approximately $43.00 in 2015 (including inflation) as the final costs of the Brightwater Treatment Plant are fully realized, and then to increase gradually to $48.74 by 2030. For the initial project sequence alternatives, the increase would occur at a more sustained rate to an average of $56.41 by 2030.

There are small differences in rate impacts among the four initial project sequence alternatives (Figure 8-2 and Figure 8-3; Table 8-2 and Table 8-3). The rate impacts in 2030 range from $7.52 to $7.85, including inflation. In 2010 dollars, the average rate increase over the 2011−2030 period ranges from $1.99 for the Duwamish River Cleanup Alternative to $2.41 for the Joint-Tunnel Alternative. The average rate increase for the Joint-Tunnel Alternative is somewhat higher because the estimated total cost of the alternative is higher, and the project expenditures take place more quickly than for the other alternatives.

Because the rate analysis showed little difference among the four initial project sequence alternatives, the alternatives were evaluated against other schedule drivers as described in Chapter 7 of this report. As a result of the evaluation, the hybrid Green-Duwamish-First sequence was the WTD-recommended project sequence.

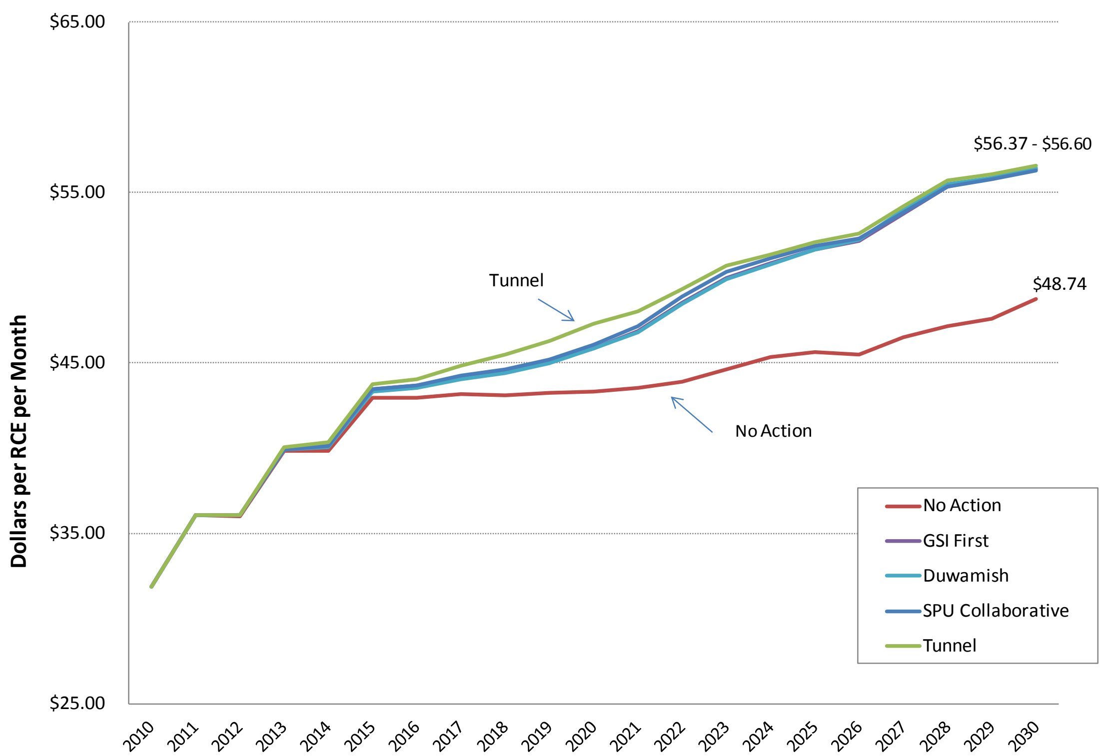

Figure 8-2. Comparison of Monthly Sewer Rates Associated with Initial Project Sequence Alternatives and the No Action Alternative (with Inflation)

Table 8-2. Comparison of Monthly Sewer Rates with Initial Project Sequence Alternatives and the Increase over the No Action Alternative (with Inflation)

		Monthly Rate Increase Over No Action Alternative[a]	
Project Sequence Alternative	2030 Monthly Rate with Inflation	2030 with Inflation	2011-2030 Average (2010 dollars)
No Action	$48.74		
Duwamish River Cleanup Coordination	$56.39	$7.65	$1.99
GSI-First	$56.37	$7.62	$2.03
Meet-SPU-2025	$56.27	$7.52	$2.09
Joint-Tunnel	$56.60	$7.85	$2.41

a. The 2011-2030 average rate increases are computed as levelized rates. Levelized rates recognize the higher value of more immediate costs and revenues, which can be invested and earn interest when compared to costs and revenues that are further in the future. The assigned interest (discount) rate is 6 percent, including inflation.

Table 8-3. Comparison of Amount Added to Monthly Sewer Rate by the Project Sequences (2015−2030, with Inflation)

Project Sequence Alternative	2015	2020	2025	2030
Duwamish River Cleanup Coordination	$0.34	$2.47	$6.07	$7.65
GSI-First	$0.49	$2.53	$6.06	$7.62
Meet-SPU-2025	$0.45	$2.71	$6.30	$7.52
Joint-Tunnel	$0.77	$3.98	$6.51	$7.85

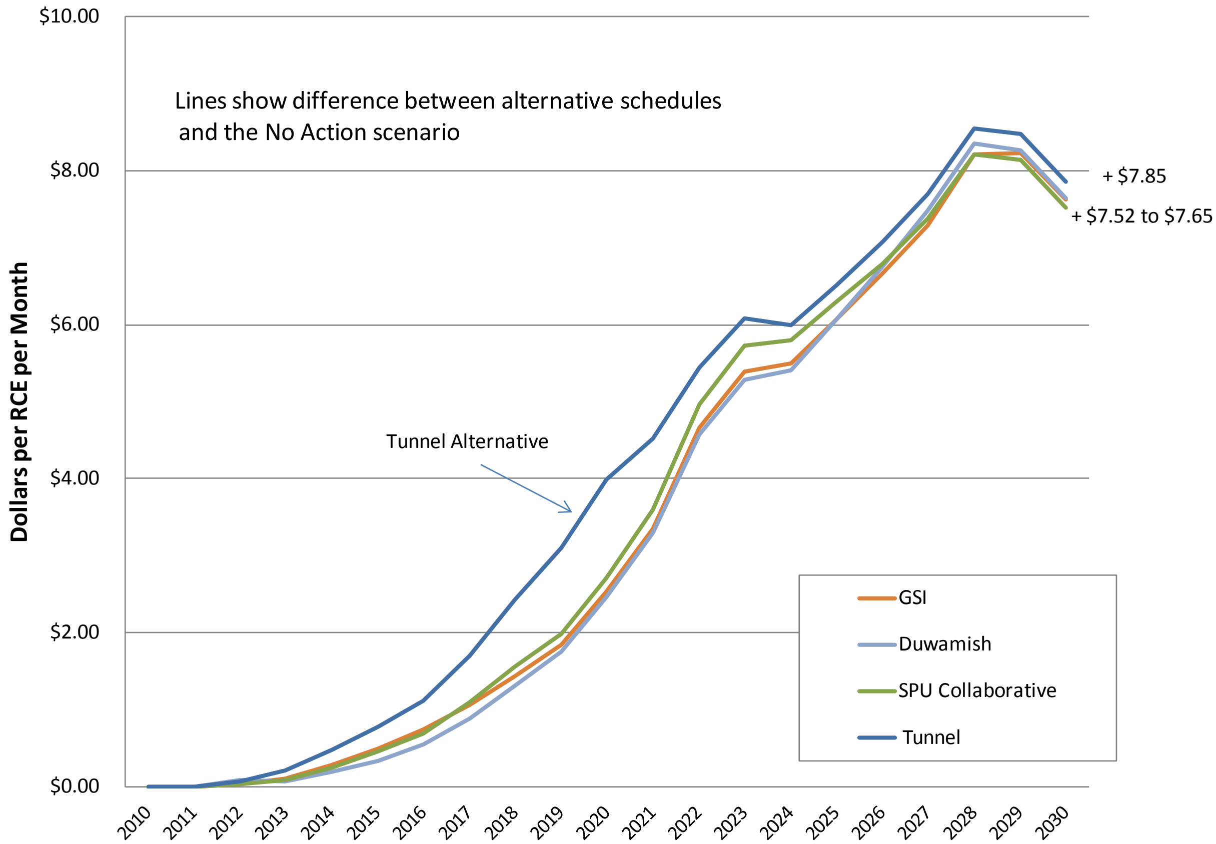

Figure 8-3. Comparison of Amount Added to Monthly Sewer Rates (No Action Alternative) by the Initial Project Sequence Alternatives (with Inflation)

8.3 WTD-Recommended Project Sequence with Three Alternative Completion Dates

After completing an assessment of the four initial project sequence alternatives, and in response to public concerns about cost impacts and the rate of spending on sewer rates, King County compared the annual expenditures and rate impacts of the WTD-recommended project sequence for three alternative completion dates for the Plan: 2030, 2035, and 2040. The 2035 and 2040 options extend the time frame for design and construction of some projects until after 2030. The purpose of this exercise was to measure the rate impacts that result from spreading capital expenditures over a longer period. The start and end dates for all control projects under each of the Plan completion dates are shown in Figure 8-4.

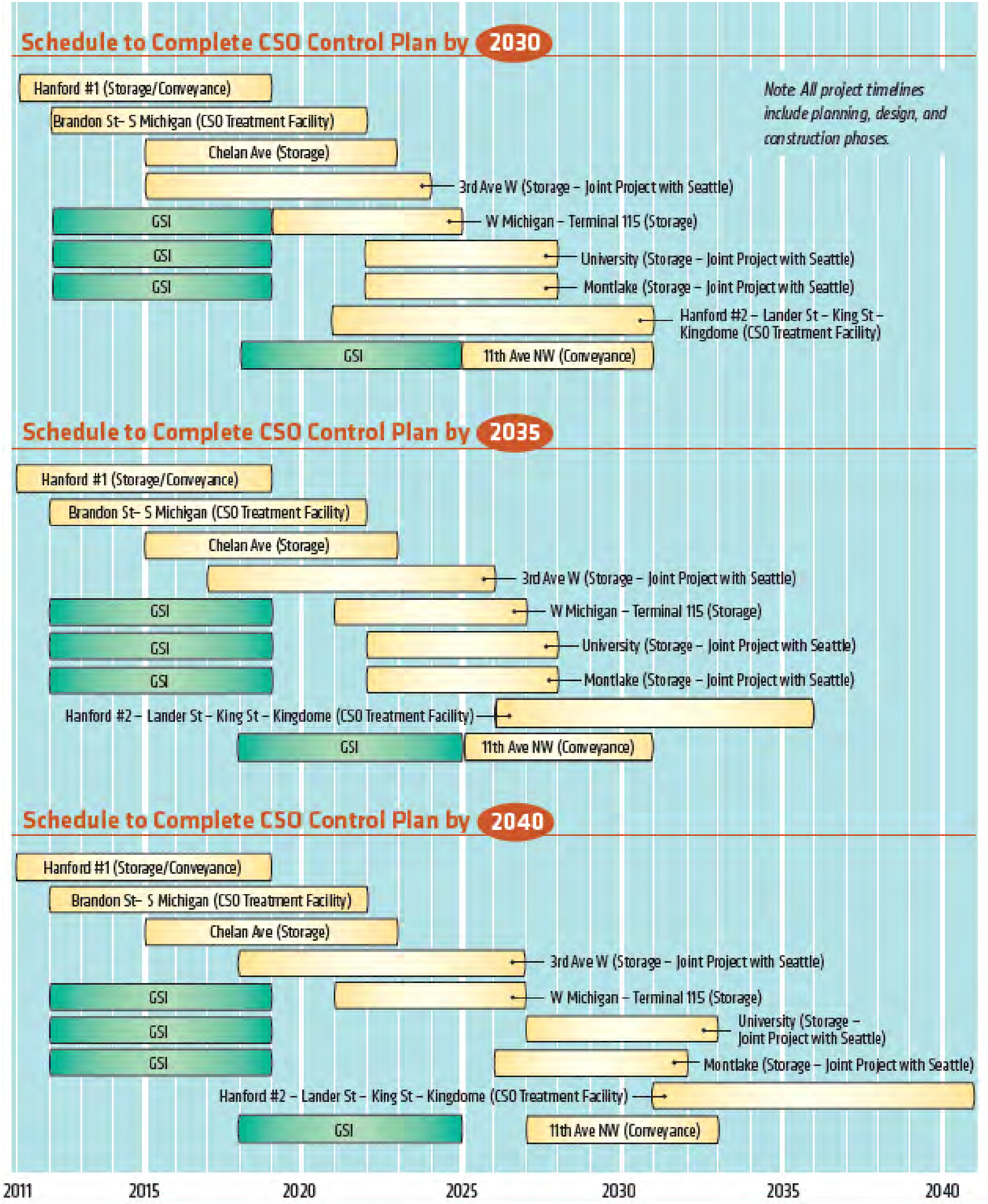

Figure 8-4. WTD-Recommended Project Sequence with 2030, 2035, and 2040 Long-term CSO Control Plan Completion Dates

8.3.1 Annual Expenditures

Capital Costs

Figure 8-5 compares the annual cash flows in 2010 dollars of the WTD-recommended project sequence to the extended schedules. The 2035 and 2040 schedules extend the time frame for design and construction of some projects until after 2030 to spread the capital expenditures and resulting rate impacts over a longer period. In the 2035 option, $192 million in capital expenditures is deferred until the 2031-2035 time period. In the 2040 option, $122 million is deferred until 2031-35, and $192 million is deferred until 2036-2040.

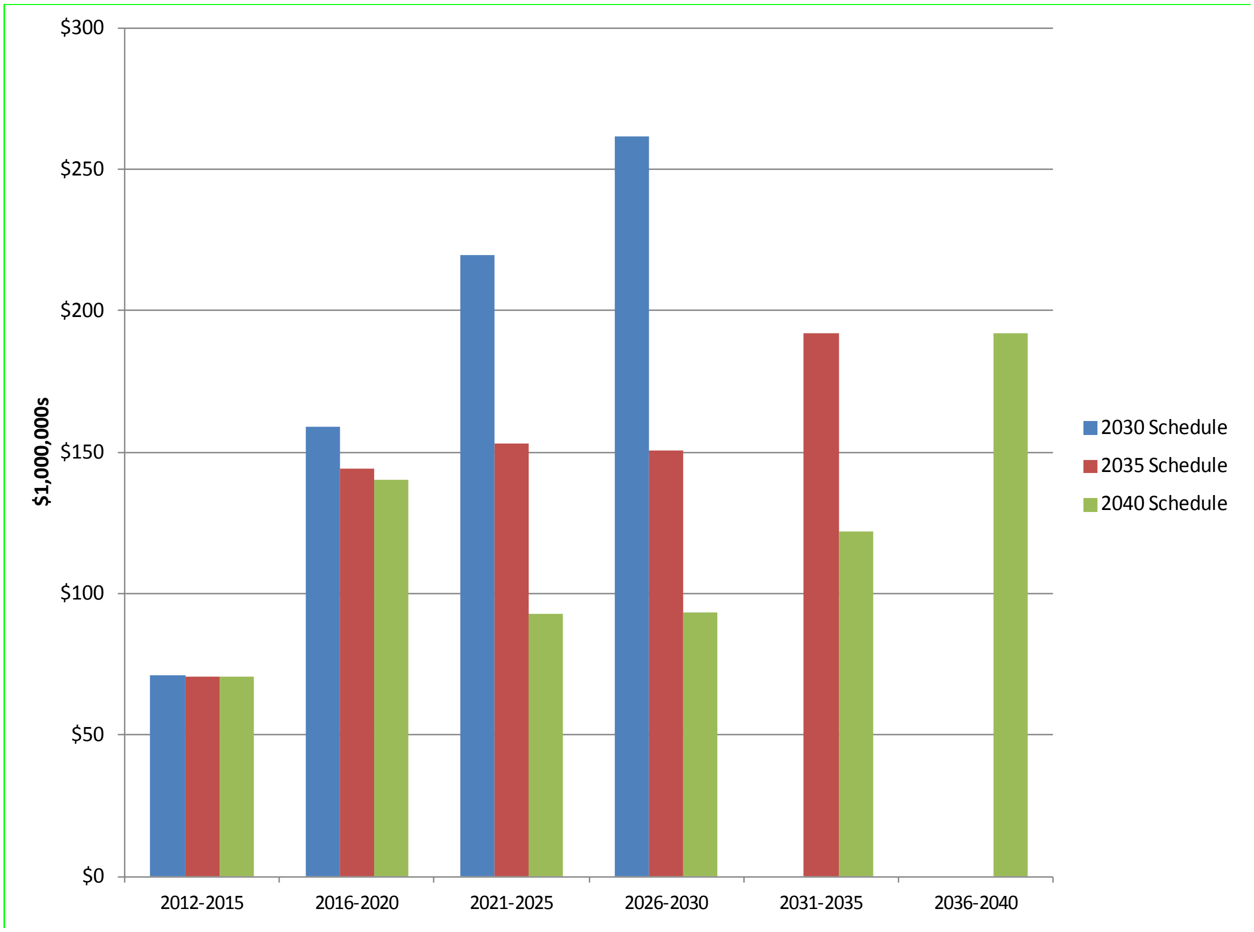

Figure 8-5. Comparison of Annual Capital Expenditures for 2030, 2035, and 2040 Long-term CSO Control Plan Completion Dates for WTD-Recommended Project Sequence (2010 Dollars)

Operation and Maintenance Costs

Average annual O&M costs are lower for the 2035 and 2040 schedules because CSO control projects with higher O&M costs are brought on-line later, requiring fewer years of O&M support during the 2021-2040 time period. The recommended Plan requires an average annual O&M cost of $2.9 million (2010 dollars) during the 2021-2040 time period compared to $2.5 million for the 2035 schedule and $1.9 million for the 2040 schedule.

8.3.2 Rate Impacts

The rate impacts of extending the 2011 WTD Recommended CSO Control Plan schedule are presented in Figure 8-6 and Table 8-4.

The 2030 schedule increases the sewer rate by $7.61 in 2030 (including inflation) compared to the No Action Alternative. The rate impact declines to $7.00 in 2040 as growth in the total customers reduces the cost of debt repayment on a per customer basis.

Extending completion of the Plan beyond 2030 would more gradually phase in the rate impact of the Plan's capital expenditures. The 2035 and 2040 schedules reduce the rate impact in 2030 to $5.47 and $4.07, respectively. The rate impacts of the extended schedules in 2040 are somewhat higher than the 2030 schedule—$7.63 and $8.11 for the 2035 and 2040 schedules, respectively, compared to $7.00 for the 2030 schedule. The higher rate impacts in 2040 are caused by the effect of inflation on capital costs for projects that are delayed. Rates climb more slowly in the extended schedules compared to the 2030 schedule and continue to climb over a longer time period.

The main difference between the schedules is when the rate of increase occurs. They all end at approximately the same level, with the extended schedules slightly higher than the 2030 schedule. These differences do not provide sufficient reason to change the 2030 completion date. WTD is recommending that the County continue with the 1999 Plan Amendment commitment to complete CSO control by 2030.

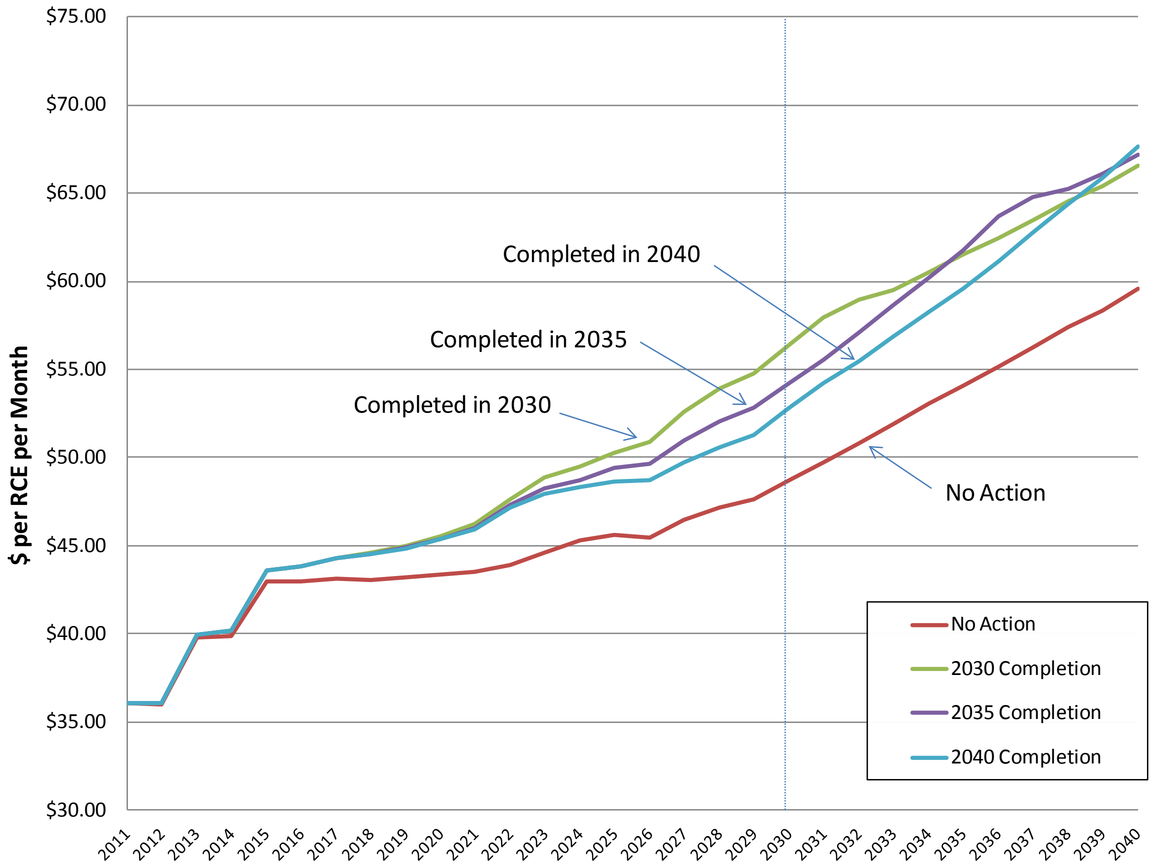

Figure 8-6. Comparison of Monthly Sewer Rates for 2030, 2035, and 2040 Alternative Long-term CSO Control Plan Schedules with WTD-Recommended Project Sequence and No Action Alternative (with Inflation)

Table 8-4. Comparison of Monthly Sewer Rates with 2030, 2035, and 2040 Alternative CSO Control Program Schedules and Increase over the No Action Alternative (2015−2040)

Alternative	2015	2020	2025	2030	2035	2040
Monthly Rate (with Inflation)						
No Action	$42.98	$43.35	$45.60	$48.74	$54.10	$59.55
2030 Completion	$43.62	$45.56	$50.30	$56.35	$61.48	$66.54
2035 Completion	$43.62	$45.42	$49.41	$54.21	$61.77	$67.18
2040 Completion	$43.62	$45.38	$48.66	$52.81	$59.59	$67.66
Monthly Rate Increase over the No Action Alternative (with Inflation)						
2030 Completion	$0.64	$2.21	$4.70[a]	$7.61	$7.38	$7.00
2035 Completion	$0.64	$2.07	$3.81	$5.47	$7.67	$7.63
2040 Completion	$0.64	$2.03	$3.06	$4.07	$5.49	$8.11
2011−2040 Average Increase[b] (2010 Dollars)						
2030 Completion	$2.21					
2035 Completion	$1.95					
2040 Completion	$1.62					

a. The forecast rate in 2025 is $1.37 lower for the WTD-recommended project sequence compared to the Duwamish River Cleanup Coordination Alternative discussed earlier in this chapter. The reduction is due to changes in the scheduling of projects that resulted in a greater share of capital expenditures occurring after 2025. The 2030 rate for the WTD-recommended project sequence is very close to the 2030 rates for the four initial project sequence alternatives.

b. The 2011-2040 average rate increases are computed as levelized rates. Levelized rates recognize the higher value of more immediate costs and revenues, which can be invested and earn interest when compared to costs and revenues that are further in the future. The assigned interest (discount) rate is 6-percent, including inflation.

8.4 King County Executive's Recommended Project Sequence with 2030 Completion Date

The WTD-recommended project sequence (Figure 8-4, 2030 completion date) was released for public comment in October 2011. Concerns raised by some members of the public about whether dollars spent on CSO control is the best investment in water quality have prompted King County to recommend conducting a water quality assessment and monitoring study (study) to inform the next CSO control program review for the 2019 NPDES permit renewal. The King County Executive believes it is prudent to meet the County's CSO control commitments and also commit resources into completing a comprehensive review of the effects on water quality in the sub-watersheds where CSO discharges occur. Additional information about the study can be found in Section 11.3 of this report.

The first projects in the Plan—Hanford #1 and S Michigan St/Brandon St—will proceed according to the schedule in the 2011 WTD Recommended CSO Control Plan (Figure 8-4, 2030 completion date), but the next two projects—3rd Ave W and Chelan Ave—will start two years later to enable study findings and recommendations to confirm or adjust control priorities. Unless changes are recommended in the next Program Review, the Plan will still be completed by 2030. Figure 8-7 shows the sequence and schedule of recommended projects as adjusted to accommodate the water quality assessment and monitoring study. Any future updates or amendments to the County's Plan resulting from the study are subject to EPA and Ecology approvals.

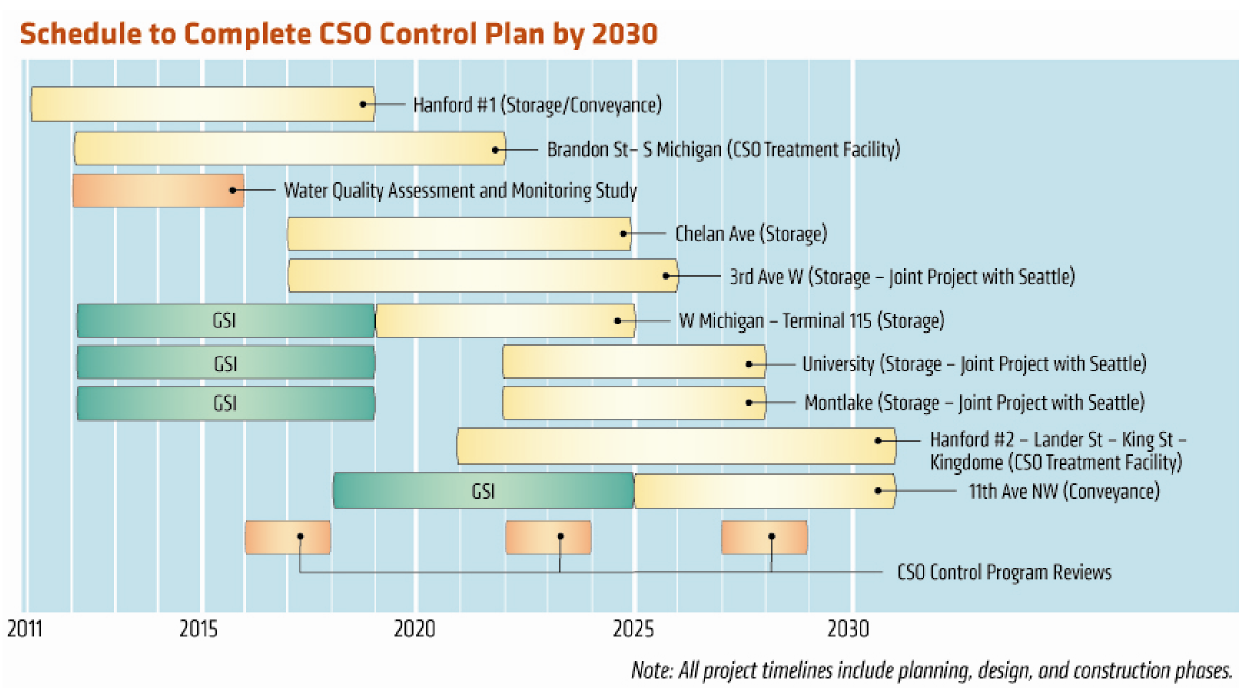

Figure 8-7. King County Executive's Recommended Project Sequence and Schedule

8.4.1 Rate Impacts

The King County Executive's Recommended CSO Control Plan will have two projects—3rd Ave W and Chelan Ave—start two years later to enable study findings and recommendations to confirm or adjust control priorities. The rate impacts were reviewed by the County and were determined to have minimal impact on rates compared to the 2011 WTD Recommended CSO Control Plan. The King County Executive's Recommended CSO Control Plan increases the monthly sewer rate by $7.61 in 2030 (including inflation) compared to the No Action Alternative.

8.5 Affordability of King County Executive's Recommended CSO Control Plan and Financial Capability to Fund the Plan

King County conducted a two-phased analysis of financial capability and affordability of the King County Executive's Recommended CSO Control Plan to gain a better understanding of the cost of implementing the Plan. This section summarizes the analysis. More detail is provided in the King County CSO Financial Capability Assessment and Schedule Development Phase 1 Report and King County CSO Financial Capability Assessment and Schedule Development Phase 2 Report, provided in Appendix G of this report.

The analysis was divided into two phases:

- Phase 1 strictly followed guidelines established by EPA. EPA guidelines consider the following:
  - Estimating median household income (MHI) for the whole service area
  - Unemployment rate measured against the national unemployment rate
  - The financial strength of the County to issue bonds
  - Household cost as a function of the costs to treat wastewater
- Phase 2 followed EPA guidelines but included supplemental information to better understand the regional diversity of households. Phase 2 considered the following:
  - MHI for each census block and percentage of census blocks in the identified income range for different communities and different income groups within the County's service area
  - Poverty rate of each census block and communities
  - Household costs for wastewater services based on both regional and local sewer rates

The Phase 2 analysis included supplemental information to Phase 1, using the same datasets but applying them more locally than regionally and using a similar scoring of households of high, medium, or low burden. This analysis still used the terms and census data that EPA recommends in its guidance.

One component of this rating is a residential indicator that rates an agency’s financial burden. According to the EPA rating system, the financial burden is considered:

- Low if the charges for wastewater treatment are less than 1.0 percent of the MHI of the agency’s customers
- Medium if charges for wastewater treatment are between 1.0 percent and 2.0 percent of the MHI of the agency’s customers
- High if the charges for wastewater treatment are greater than 2.0 percent of the MHI of the agency’s customers.

With Plan implementation, county sewer rates would equal 0.59 percent of the MHI for the county service area based on the EPA guidance. However, if the rates charged by component agencies and the average impact of the County’s connection charges are included, the impact of wastewater services would be much higher—an estimated 0.95 percent of the MHI of non-city households and 1.23 percent of MHI of city households. Therefore, implementation of the Plan would be a medium burden to city households using EPA’s rating system.

As an additional step in evaluating affordability, the County completed an analysis of geographic sub-areas in the service area where wastewater charges are more than 2.0 percent of the MHI. The analysis concluded the financial burden was greater than 2.0 percent in 7.8 percent of the census blocks across all of the County’s service area; see Appendix G of this report for the Phase 2 analysis.

8.5.1 Economic Indicators

The following sections detail individual economic indicators and compare the results of the two phases:

- Median household income (MHI)
- Cost per household and rates
- Poverty rate
- King County’s financial capability

Median Household Income

King County used the EPA guidance to establish a common language for determining financial capability and affordability of implementing the Plan. The EPA guidance uses data from census block groups and regional information on MHI. MHI is the midpoint household income level that divides household income distribution into two equal groups, half with income above that amount and half with income below that amount.

The EPA guidance uses the MHI as representative for each household in the entire service area, which means that the impact of rates to the half of the population below MHI is not considered. MHI in the county region is high due to wealthier suburbs. Figure 8-9 shows the distribution of MHI over the county service area. For comparison, the county MHI in 2000 was $79,863 and the City of Seattle MHI is $60,212. The MHI calculated by the Phase 1 analysis is $72,006; see Appendix G of this report for the Phase 1 analysis. This amount was derived by taking the median income information from each census block within the county service area and averaging them together.

Cost per Household and Rates

The EPA guidance suggests a calculation of the cost per household. The cost per household is a calculated number based on O&M costs, debt service, projected costs, and the CSO Control Program costs. This number is then calculated based on the residential share of monthly sewer rates (eliminating commercial and industrial share and not considering the capacity charge). The result of this analysis for the region was $423 per household per year.

The EPA guidance yields a single incomplete estimate of $423 per household per year, on average, for all households in King County's service area. The County's long-term rate forecast fully considers all costs and capital funding for regional wastewater service, including costs covered by the capacity charge. The resulting forecast is $474 per year. This estimate includes planned future expenditures but not those expenditures included in the King County Executive's Recommended CSO Control Plan.

Since the County is the regional wholesale provider, ratepayers also pay a local utility to convey their wastewater to the County. This additional rate was not considered in the Phase 1 analysis in order to strictly follow EPA's guidance. To more accurately represent the wastewater costs households actually have to pay, the Phase 2 analysis supplemented the Phase 1 costs to include local wastewater collection costs as well as the regional capacity charge for new connections to the system. This was done by using an average of the local wastewater collection rates charged by the 13 largest wastewater utilities in the County's service area. When this was done, the cost to households increased to $730 per year. Since the City of Seattle is implementing its own CSO control program, their costs were considered separately and city ratepayers would pay $738 per year for a baseline (without the King County Executive's Recommended CSO Control Plan). See Table 8-5 for the estimates of future annual sewer rates with and without the King County Executive's Recommended CSO Control Plan.

To understand affordability, the baseline rates were compared to the long-term CSO control plan costs for the County and City. The regional rate rises to $502 per year, the combined rate including local utilities rises to $758 per year, and the city rate is $766 per year including the two long-term CSO control plan costs as of August 2011; see Appendix G of this report for the Phase 2 analysis.

Table 8-5. Estimates of Future Annual Sewer Rates with and without King County Executive's Recommended CSO Control Plan

Phase 1: Average Annual Rate per Household per EPA Guidance (2011−2030)		
Average annual wastewater- and CSO-related costs per household using EPA guidance methodology		$423
Phase 2: Average Annual Rate per Household (2011−2030)		
	Baseline – No New CSO Control Projects	**With King County Executive's Recommended CSO Control Plan**
Regional rate only	$474	$502
Non-City of Seattle combined rate	$730	$758
City of Seattle's combined rate	$738	$766

Poverty Rate

Strict adherence to the EPA guidance does not consider the poverty rate of the service area impacted by implementing the Plan. King County added the poverty rate into the Phase 2 analysis to better understand the equity and social justice issues inherent in implementing county-wide programs.

The number of individuals with incomes below the poverty level is a good indicator of the community's capacity to bear additional financial burdens. In particular, it provides insight into the likelihood that imposition of higher rates to cover anticipated CSO control costs would result in families having to move out of their homes and depend on the overall community for housing and other social services.

According to a recent article in *The Seattle Times*[1] discussing census data from U.S. Census Bureau American Community Survey, poverty rates have increased in the County. Specifically, the poverty rate in the City of Seattle has increased from 10.6 percent in 2009 to 14.7 percent in 2010. In addition, the poverty rate in the City of Kent has increased from 13.5 percent in 2009 to 24.6 percent in 2010. Figure 8-8 shows the distribution of the poverty rate for the county service area.

The poverty rate should be a key indicator of affordability and sensitivity to the areas with higher poverty rates such as the City of Seattle and south King County. The burden of affordability is especially important for the City as not only do the ratepayers have to fund the County's long-term CSO control plan, but also the City's long-term CSO control plan.

[1] Broom, Jack & Mayo, Justin, (September 21, 2011). Census: More residents sinking into poverty. The Seattle Times, http://seattletimes.nwsource.com/html/localnews/2016279575_census22m.html.

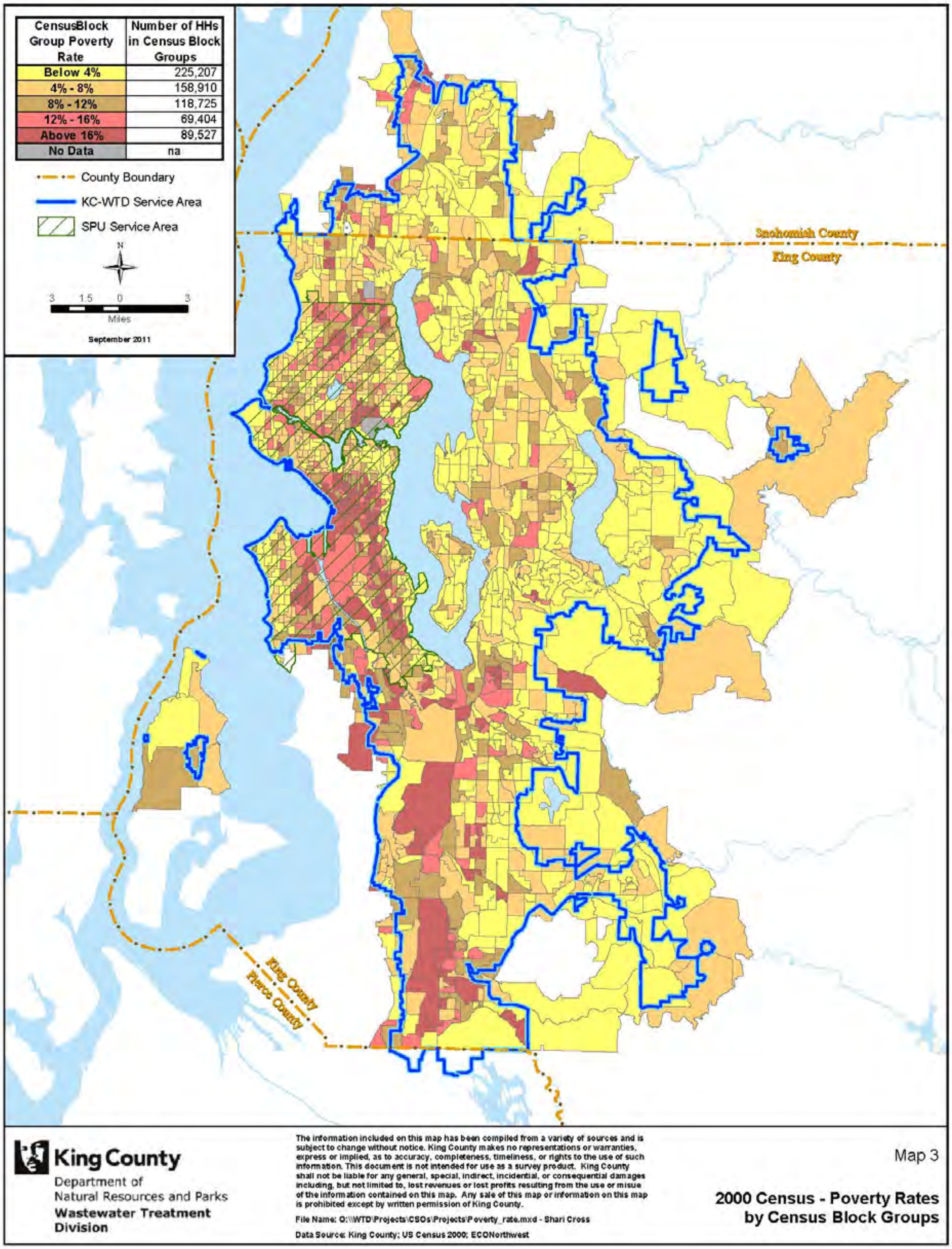

Figure 8-8. Distribution of the Poverty Rate by Census Blocks in King County Service Area

Financial Capability

The EPA guidance prescribes two indicators to describe the debt burden and the capacity to issue additional debt to cover CSO control costs. King County's most recent general obligation bond rating is used to describe the financial conditions at the community level and the most recent revenue bond rating to describe the financial conditions of the wastewater utility. The second indicator looks at the overall net debt to be repaid by property taxes in the County's service area as a percent of full market property value. The percentage indicates the property tax-related debt burden on residents within the service area and the capacity of local governments to issue new debt.

The County currently has a strong financial capability because of low overall debt and high bond ratings. However, the County has incurred debt to expand treatment capacity by building the Brightwater Treatment System. In comparison to the rate collected, the County's debt is high. The EPA guidance does not account for utility debt, only jurisdictional debt in comparison to property values for the region.

It is possible that other regulatory requirements placed on the County may have significant costs and increase the County's overall debt. Changes in water quality requirements and implementing more advanced treatment at wastewater treatment plants would carry both a high capital cost and a regulatory schedule that could have the upgrades being implemented over a short period of time. This is a key indicator to track as the region as a whole makes more investments in replacing aging infrastructure and environmental cleanup.

8.5.2 Other Considerations

This affordability analysis focused primarily on the cost per household and the sewer rate based on a single-family home although the census data does not differentiate between multi-family households and single-family households. Understanding the rate impacts to multi-family homes is difficult because commercial rates are charged by King County, and, therefore, the rate charged varies greatly.

Single-family residences bear the burden of rate increases more than a renter or condominium owner because of the market influence on setting rents, and affordability of housing is not predominantly influenced by utilities.

Multi-family affordability depends on the cost of renting. Rents are determined by the market for the area and the vacancy rate. A typical landlord will pay property taxes, maintenance, management fees, and mortgage, and will therefore have to fold these costs into the rental fee. The mortgage is approximately 65 to 75 percent of the rental charge[2]. The costs of utilities

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[2] National Association of Realtors *Metropolitan Median Prices 2nd Quarter 2011*, http://www.realtor.org/research/research/metroprice.

(water, sewer, gas, garbage) are a smaller portion of the rental charge, and other utilities are paid directly by renters (phone and electricity).

The King County Office of Performance, Strategy and Budget tracks housing affordability and provides the trends in data. In this analysis, MHI has decreased by approximately 3.0 percent, and the average rent for the area has decreased to less than 1.0 percent between 2008 and 2009[3].

After completing the Phase 2 analysis of affordability, the Census Bureau released updated household income data that was based on the 2010 Census American Community Survey. As an additional step in evaluating affordability, WTD used the updated income data to conduct an analysis using income distribution data for the regional wastewater service area (service area).

WTD was concerned that using census block data based on MHI under represented the households making less than the MHI. Half of the population makes less than MHI, which in 2010 was $66,174, and the projected rates for wastewater services could represent a much higher percentage of the annual income in those households that fall below MHI.

To determine what the financial burden was for households, the EPA guidelines for affordability were used to determine high and medium financial burden for households. Households where at least 2 percent of the annual income was spent on wastewater services were considered to have a high financial burden; households spending at least 1 percent but less than 2 percent of the annual income were considered to have a medium financial burden. Based on the sewer rate analysis for the service area, the projected annual rate would rise to an average of $762 per year for city and non-city ratepayers. A household within the service area with annual income less than $35,000 per year would carry a high financial burden, and a household with annual income between $35,000 and $75,000 would carry a medium financial burden.

As compared to using MHI to determine financial burden, WTD believes this analysis reflects a more accurate estimate of the percentage of households that would spend 2.0 percent or more of their annual income on wastewater services.

Based on this analysis an estimated 26 percent of households (204,830 out of 787,809 households) in the service area will have a high financial burden for wastewater services to implement the King County Executive's Recommended CSO Control Plan. The distribution of income and the percentage of households with a high, medium, or low financial burden of paying for wastewater services are shown in Table 8-6.

[3] King County Office of Performance Strategy and Budget, Benchmark Program, http://www.kingcounty.gov/exec/PSB/BenchmarkProgram/AffordableHousing/AH27_TrendHousingCost/TrendHousingTable.aspx.

Table 8-6. King County Annual Income Distribution, 2010[4]

Household Annual Income	Percent of Households
Less than $10,000	6 percent
$10,000 to $14,999	4 percent
$15,000 to $24,999	8 percent
$25,000 to $34,999	8 percent
High Burden (< $35,000)	***26%***
$35,000 to $49,999	12 percent
$50,000 to $74,999	18 percent
Medium Burden (< $75,000)	***30%***
$75,000 to $99,999	13 percent
$100,000 to $149,999	17 percent
$150,000 to $199,999	7 percent
$200,000 or more	7 percent
Low Burden (< $75,000)	***44%***

[4] Based on U.S. Census Bureau American Community Survey.

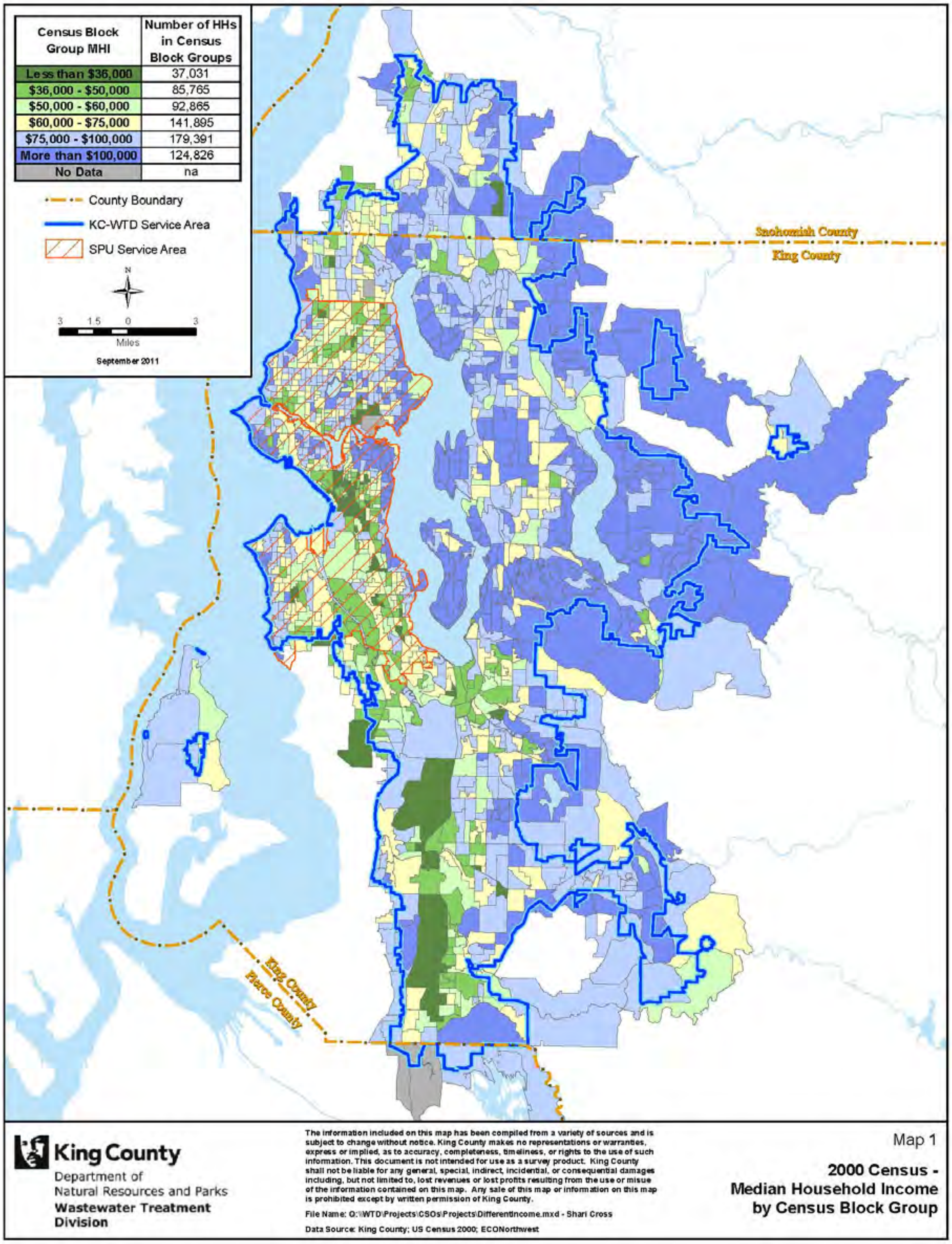

Figure 8-9. Median Household Income by 2000 Census Block Group in King County Service Area

Table 8-7 summarizes the information used for this affordability analysis and compares results of the strict adherence to EPA's guidelines with WTD's supplemental information.

Table 8-7. Comparison of Results of Phase 1 Strict Adherence to EPA Guidance Methodology to Phase 2 Supplemental Information

Indicator	Phase 1: Strict Adherence to Guidance	Phase 1 Result	Phase 2: Supplemental Information	Phase 2 Result	
				Household Income	**% of Households**
Median household income (MHI)	The estimate of MHI in the service area represents the median income from each 2000 census block averaged for the whole service area and inflated to 2010.	$72,006	Income distribution King County 2010 American Community Survey	<$15,000	10%
				$15,001 - $25,000	8%
				$25,001 - $35,000	8%
				$35,001 - $50,000	12%
				$50,001 - $75,000	18%
				$75,001 - $100,000	13%
				$100,001 - $150,000	17%
				>$150,001	14%
Unemployment rate	Service area compared to national average	0.7%, below national average	2000 Census Blocks	20% of the census blocks in the service area are twice the national average	
Poverty rate	Not Used	N/A	2000 Census Blocks	8.2% of the service area population below Poverty Rate	
Cost per Household	Calculated based on King County expenditures and debt service	$423	Rate plus capacity charge	$502	
			King County Sewer Rate + component agency's rate	$758 (non-City of Seattle) $766 (City of Seattle)	
Affordability (ratepayers ability to pay)	Based on MHI for Service Area	Low Burden	By Household based on 2010 income distribution	*26% of **households'** sewer rate is a **high burden**.* *30% of **households'** sewer rate is a **medium burden**.* *44% of **households'** sewer rate is a **low burden**.*	
Bond rating	S&P Moody's	AA+ AAA	Same as Phase 1	Same as Phase 1	

Table 8-7. Comparison of Results of Phase 1 Strict Adherence to EPA Guidance Methodology to Phase 2 Supplemental Information

Indicator	Phase 1: Strict Adherence to Guidance	Phase 1 Result	Phase 2: Supplemental Information	Phase 2 Result
Financial Capability (utilities ability to fund Plan)		Strong	Same as Phase 1	Same as Phase 1

Another consideration for affordability is the County's Equity and Social Justice Initiative. The County has established a principle of equity and social justice. The elements of equity and social justice are embedded in goals, objectives, and strategies through the countywide strategic plan. As part of this initiative, equity and social justice impacts in decision making are considered. This analysis does not cover all elements of equity and social justice but does provide information on the impact to low-income families.

8.5.3 Conclusions

As highlighted over the past several years, downturns in the economy can happen quickly. Indicators used in the financial capability and affordability analysis such as MHI and poverty rate have all been adversely affected over the past two to three years. King County needs to track these indicators to regularly evaluate the financial capability to implement the Plan and the ability of the ratepayers to pay for the Plan over time.

MHI is declining in the service area. It is also a poor indicator of affordability for many income groups and communities in the County's service area. There is a significant income disparity across different communities; for example, the City of Seattle has a lower MHI than the rest of the County and will have a higher burden of sewer rates when paying for implementation of the County's Plan and its own long-term CSO control plan. Within the service area, the income ranges vary between the eastside communities, such as Redmond and Bellevue, and southern communities, such as Kent and Auburn. If this trend continues, the financial burden to ratepayers will change year to year. The wastewater utility financial burden will increase from the 1.0- to 2.0-percent MHI range to the greater than 2.0-percent MHI range as sewer rates increase during implementation of the Plan.

Tracking local poverty rates and programs available to low-income families will determine the ability of specific populations to afford implementation of the Plan.

The costs of implementing the Plan may also change over time as more detailed information becomes available, design progresses, and baseline costs are established for each capital project in the Plan. Any changes in regulatory requirements for treating wastewater would also impact the rate. Additional treatment requirements (such as nutrient removal at the two regional treatment plants) would necessitate a review of capital project reprioritization. Improvements necessary to meet a new regulatory standard would be expensive and would require the County to reevaluate the priority of CSO control in relation to meeting a new regulatory standard.

The $711 million cost projection for the King County Executive's Recommended CSO Control Plan is based on project costs at a planning level of detail[5]. As projects are designed, the costs of the project will be better understood. The general cost of construction will also vary overtime depending on conditions at the time projects are bid.

Lastly, borrowing rates and debt service will impact the long-term cost of implementing the Plan. Any negative changes in the bond ratings or in the bond market will place additional burden on county rates to fund the Plan and could result in higher burdens to the ratepayers.

Based on these conclusions, as part of the required NPDES permit updates of the Plan, which occur approximately every 5 years, the County will reevaluate the indicators mentioned above and routinely evaluate financial capability and affordability of the Plan. This will ensure that there is a discussion of the ratepayers' ability to pay for the Plan and that the County does not overburden its own finances or those of the community it serves.

[5] Cost estimates for the alternatives in this review are classified as Class 5 estimates based on the Association for the Advancement of Cost Engineering (AACE) classification types. The accuracy range for Class 5 estimates is -50 percent to +100 percent. More information can be found in Technical Memorandum 620, Cost Estimating Methodology for CSO Control Facilities.

Chapter 9

System Operational Plan

The United States Environmental Protection Agency (EPA) 1994 CSO Control Policy requires municipalities that are responsible for managing combined sewer systems to develop a "System Operational Plan." King County's current version of equivalent system operational planning and procedures includes separate manuals and sections on the County's intranet site. County personnel access the intranet site for this information; hard copies are rarely relied upon in situations requiring rapid responses.

A separate hard copy of the system operational plan is being developed to include the most pertinent information from the County's intranet site. It describes the intranet documentation in the form of a plan, providing links to the on-line material. The document will be reviewed and updated; however, internet and intranet information may be updated more frequently, so the most current information will be available on-line. Some of the electronic links start with the following address and are only accessible from within the County's secured system: http://wtdweb/www/wtd/.

The System Operational Plan will be submitted to EPA and Ecology under the schedule to be set in the expected consent decree.

The County has identified the following system operational plan objectives[1] in order of priority:

1. Allow the system to operate on its own, as designed; intervene manually when needed to meet objectives.
2. Protect and maintain plant equipment and biological system.
3. Prevent overflows to the street or buildings.
4. Meet West Point Treatment Plant NPDES permit requirements.
5. Capture and convey all dry-weather flows.
6. Capture and convey separated system flows (Lake City tunnel).
7. Capture and convey the maximum volume of wet-weather flows.
8. Use storage for maintenance diversion.
9. Minimize energy use.
10. Minimize odors.
11. Minimize sedimentation/settling in tunnels and siphons.

[1] These objectives were developed by a team of WTD O&M and CSO Control Program staff.

The elements making up the County's system operational plan provide guidance on how to operate the collection system, CSO control facilities, and the West Point Treatment Plant together to provide maximum capture, conveyance, and treatment of combined sewer flows. The system operational plan provides guidance on activities to be carried out during dry-weather flows and to prepare for, manage, and follow-up on wet-weather flow episodes. It can be used in basic and refresher training for WTD personnel, as well as a reference to be consulted when unusual situations must be managed.

The County will modify the system operational plan to incorporate the recommended CSO control approaches and system strategies discussed in this 2012 CSO Control Program Review Report—after design of each planned CSO control project but ahead of each project being brought online. Similarly, the County will work with the City of Seattle to plan for and incorporate their CSO control projects into the larger system operational plan, including SCADA sharing and communication protocols.

The system operational plan will be a "living" document that is updated as new projects are brought online. Updates to the system operational plan will be submitted with annual reports prior to start-up of new county and city facilities and will be updated to reflect actual experience after two to three years of new facility operation.

Chapter 10

King County's Long-term CSO Control Plan and Recommended Amendment

10.1 Planned Projects Currently Underway

The following four projects adopted under the 1999 Plan Amendment are currently in design: North Beach, Magnolia, Murray, and Barton. One project that had been scheduled toward the end of the Plan schedule—Ballard—has been accelerated in conjunction with the Ballard Siphon replacement asset management project. By increasing the size of the new siphon, full control at the Ballard CSO site and CSO reduction at the 11th Ave NW CSO site will be achieved early. Table 10-1 summarizes the key elements of these projects.

10.2 Future Projects in the King County Executive's Recommended CSO Control Plan

The 2011 WTD Recommended CSO Control Plan was released for public comment in October 2011. Copies of the formal comment letters are presented in Appendix F of this report. King County heard both support for the Plan and concern about costs and whether dollars spent on CSO control is the best investment in water quality. The King County Executive believes it is prudent to meet the County's CSO control commitments and also commit resources into completing a comprehensive review of the effects on water quality in the sub-watersheds where CSO discharges occur. As a result, the King County Executive recommends that the County conduct a water quality assessment and monitoring study (study) to confirm or propose adjustments to the Long-term CSO Control Plan to meet water quality standards and ensure that actions by the County and other entities improve water quality, health, and biological outcomes that are well integrated and sequenced to provide the greatest benefit in the sub-watersheds where the County's CSOs discharge. This study will be completed concurrently with the first projects in the Plan to inform the next CSO control program review for the 2019 NPDES permit renewal. Ecology and EPA will need to review and approve any future updates or amendments to the County's Plan that result from the recommendations. Additional information about the study can be found in Section 11.3 of this report.

The King County Executive recommends that projects move forward as indicated in the 2011 WTD Recommended CSO Control Plan—nine projects to control the remaining 14 uncontrolled CSO sites at a total project cost of $711 million. To accommodate the timing of the study, two projects—Chelan Ave and 3rd Ave W—will start two years later than recommended in the 2011 WTD Recommended CSO Control Plan after the findings of the study and any implications for the Plan become clear. The results of the study will not change the 2030 Plan completion date. The King County Executive's Recommended CSO Control Plan continues the commitment to implement CSO control projects in the Lower Duwamish River, so that completion of these projects coincides with the cleanup schedules of the Superfund sites, to implement GSI in four CSO basins, and to pursue three joint projects with the City of Seattle. Figure 10-1 presents the King County Executive's recommended project sequence and schedule as adjusted to accommodate the water quality assessment and monitoring study. Table 10-1 summarizes each of the nine recommended CSO control projects, including project description, design and performance criteria, critical milestones, and planning-level project cost estimate. This is the table of projects attached to the legislation that the King County Executive has transmitted to the King County Council.

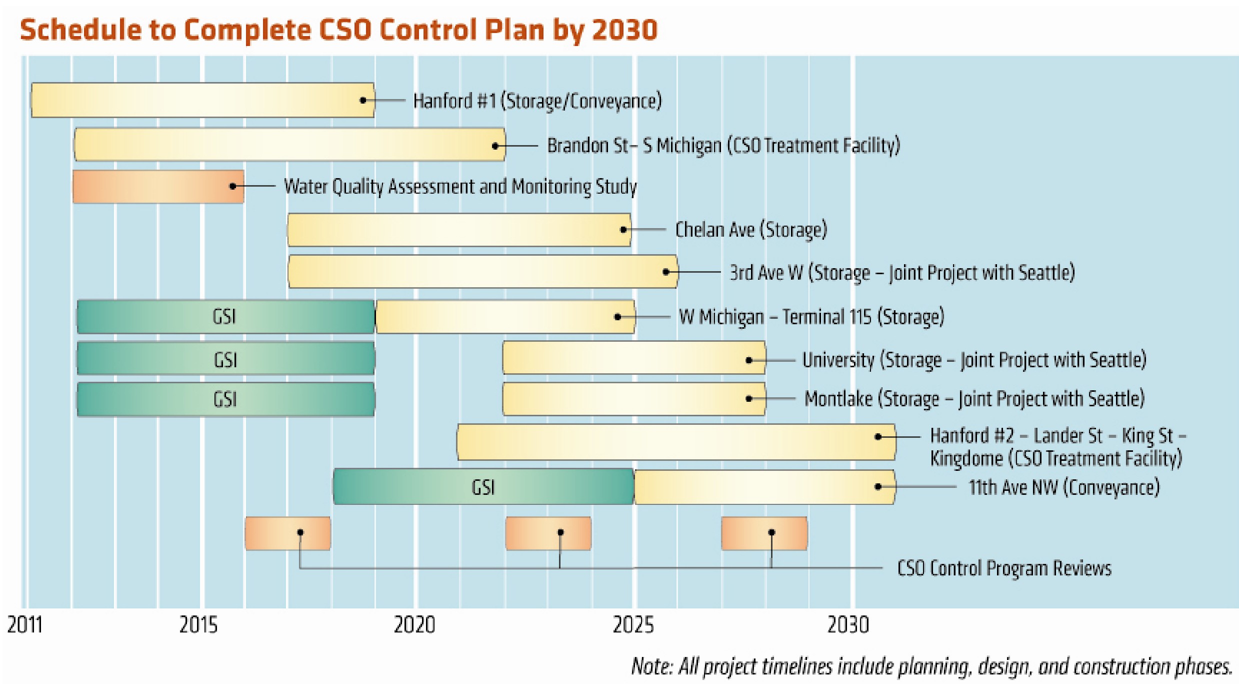

Figure 10-1. King County Executive's Recommended Project Sequence and Schedule

Monthly sewer rates under the King County Executive's Recommended CSO Control Plan will increase by $7.61 per month (estimated with inflation) by 2030.

Table 10-1. King County Executive's Recommended CSO Control Plan

CSO Control Project and Discharge Serial Number (DSN)[a]	CSO Control Measure(s)	Description	Design Criteria	Performance Criteria in a Typical Year	Critical Milestones[b,c]	Estimated Project Cost in 2010 Million Dollars[d]
2012 King County Executive's Recommended Projects to Control the County's Remaining 14 Uncontrolled CSO Sites						
Duwamish Waterway						
Hanford #1 (DSN 031)	Increased conveyance and storage tank	Increased conveyance to the Bayview Tunnel and storage tank near Rainier Avenue	Up to 0.34 MG of peak CSO storage with conveyance	Reduce to one untreated overflow event per year on a 20-year moving average	Facilities Plan Complete: 2014. Completion of Bidding: 2016. Construction Completion: 2019.	$19.2
Brandon St/ S Michigan St (DSN 041/ DSN 039)	CSO treatment	High rate clarification treatment to control CSOs along the East Waterway	Up to 66 MGD of peak CSO treatment and new conveyance system	Treat peak CSOs to state standard of 50-percent total suspended solids (TSS) removal and disinfection; meet state water quality standards.	Facilities Plan Complete: 2015. Completion of Bidding: 2017. Construction Completion: 2022.	$139.7
W Michigan St/ Terminal 115 (DSN 042/ DSN 038)	Storage pipe	Storage pipe along West Marginal Way and green stormwater infrastructure (GSI)	Up to 0.32 MG of peak CSO storage. Mitigate up to 24-percent of the impervious area with RainWise and green streets.	Reduce to one untreated overflow event per year on a 20-year moving average	Facilities Plan Complete: 2020. Completion of Bidding: 2022. Construction Completion: 2025.	$14.8[f]
Chelan Ave (DSN 036)	Storage tank	Storage tank near West Duwamish Waterway	Up to 3.85 MG of peak CSO storage on West Duwamish Waterway near Chelan Avenue	Reduce to one untreated overflow event per year on a 20-year moving average	Facilities Plan Complete: 2018. Completion of Bidding: 2020. Construction C0mpletion: 2023.	$51.7
Hanford #2/ Lander St/King St/ Kingdome (DSN 032/DSN 030/DSN 028/ DSN 029)	CSO treatment	High rate clarification treatment facility in South Seattle neighborhood	Up to 151 MGD of peak CSO treatment and modifications to existing conveyance system	Treat peak CSOs to state standard of 50-percent TSS removal and disinfection; meet state water quality standards.	Facilities Plan Complete: 2024. Completion of Bidding: 2026. Construction Completion: 2030.	$270.8
Ship Canal						
3rd Ave W (DSN 008)	Joint city-county storage tank[e] OR *Independent county storage tank*	Storage tank on north side of Ship Canal OR *Storage tank near Seattle Pacific University ($56.4 million)*	Up to 7.23 MG of peak CSO storage OR *Up to 4.18 MG of peak CSO storage*	Reduce to one untreated overflow event per year on a 20-year moving average at one county CSO site and multiple city CSO sites	Facilities Plan Complete: 2018. Completion of Bidding: 2020. Construction Completion: 2023.	$50.3

Table 10-1. King County Executive's Recommended CSO Control Plan

CSO Control Project and Discharge Serial Number (DSN)[a]	CSO Control Measure(s)	Description	Design Criteria	Performance Criteria in a Typical Year	Critical Milestones[b,c]	Estimated Project Cost in 2010 Million Dollars[d]
University (DSN 015)	Joint city-county storage tank[e] OR *Independent county storage tank*	Storage tank near University of Washington campus and GSI OR *Storage tank near University of Washington Campus and GSI ($54.5 million)*	Up to 7.87 MG of peak CSO storage OR *Up to 2.94 MG of peak CSO storage* ______________ Mitigate up to 24-percent of impervious area with RainWise and green streets.	Reduce to one untreated overflow event per year on a 20-year moving average at one county CSO site and multiple city CSO sites	Facilities Plan Complete: 2023. Completion of Bidding: 2025. Construction Completion: 2028.	$45.2[f]
Montlake (DSN 014)	Joint city-county storage tank[e] OR *Independent county storage tank*	Storage tank on south side of Montlake Cut and GSI OR *Storage tank on south side of Montlake Cut and GSI ($102.8 million)*	Up to 7.87 MG of peak CSO storage OR *Up to 6.6 MG of peak CSO storage* ______________ Mitigate up to 19-percent of impervious area with RainWise and green streets	Reduce to one untreated overflow event per year on a 20-year moving average at one county CSO site and multiple city CSO sites	Facilities Plan Complete: 2023. Completion of Bidding: 2025. Construction Completion: 2028.	$95.4[f]
11th Ave NW (DSN 004)	Increased conveyance	Increased conveyance to Ballard Siphon and GSI	Combination of 3,200 feet of up to 84-inch-diameter pipe conveyance and GSI. Mitigate up to 26-percent of the impervious area with RainWise and green streets.	Reduce to one untreated overflow event per year on a 20-year moving average	Facilities Plan Complete: 2026. Completion of Bidding: 2028. Construction Completion: 2030.	$23.7[f]

a. Each CSO outfall is assigned a Discharge Serial Number or DSN through the NPDES permit.

b. "Completion of Bidding" means WTD has (1) appropriately allocated funds for a specific CSO control project (or portion thereto); (2) accepted and awarded the bid for construction of the specific CSO control project; and (3) issued a notice to proceed with construction that remains in effect for the specific CSO control project.

c. "Construction Completion" means completion of construction and installation of equipment or infrastructure such that equipment or infrastructure has been placed in operation, and is expected to both function and perform as designed, as well as completion of in-situ modified operations and maintenance manuals. This specifically includes all control systems and instrumentation necessary for normal operations and all residual handling systems. For those specified CSO control projects consisting of separate components, "Construction Completion" shall be achieved when the last component is completed.

d. The estimated cost of each recommended CSO control project uses conceptual design information. The project cost estimates are planning-level only, for use in developing long-range capital schedules and budgets. The accuracy of planning-level estimates is -50 to +100 percent. The accuracy will increase as WTD gains more site-specific information during project design. A project budget will be set when design is 30 percent complete.

e. The County is proposing a joint project until the City completes its long-term CSO control plan and project recommendations in 2014. If a joint project is not recommended, the County will implement the identified independent project.

f. Implementation of GSI in the CSO basin is not included in costs, as they are expected to replace and potentially reduce project costs. The sizing of the gray storage facility and GSI will be cost-effectively balanced in future evaluations to achieve the performance standard.

Chapter 11

Next Steps

11.1 2012 CSO Control Program Review Report and King County Executive's Recommended CSO Control Plan

This 2012 CSO Control Program Review Report and the King County Executive's Recommended CSO Control Plan are being submitted to the King County Council and the public in June 2012. It is expected that the King County Council will refer the Plan to its Regional Water Quality Committee (RWQC) for initial review and deliberations. The public will be able to comment and provide testimony on the King County Executive's Recommended CSO Control Plan as part of the King County Council's deliberations. Information on how to participate in the King County Council's deliberations will be available on the CSO Control Program website at: http://www.kingcounty.gov/csoreview.

The RWQC may recommend changes to the Plan and CSO control policies to the King County Council. The County anticipates that the amended Plan will be adopted by the King County Council in fall of 2012.

11.2 2012 Long-term CSO Control Plan Amendment

After the King County Council adopts the amended Plan, the County's 2012 Long-term CSO Control Plan Amendment will be developed and submitted to Ecology and EPA in the fall of 2012, ahead of the 2014 renewal of the West Point Treatment Plant NPDES permit. Implementation of projects contained in the Plan and adopted by the King County Council will begin immediately. The adopted amendment to the Plan will then be available for comment during Ecology's NPDES permit process in 2013 and 2014.

11.3 Implementation of Water Quality Assessment and Monitoring Study

The purpose of the water quality assessment and monitoring study (study) is to provide information to guide integration and sequencing of CSO control projects with other actions to improve water quality, health, and biological outcomes in watersheds receiving CSO discharges. The study should utilize the new EPA integrated planning framework to allow integration and sequencing of projects to ensure that investments in CSO control projects are well-planned and timed to optimize water quality improvements in the sub-basins to which King County's CSOs discharge. Furthermore, the study should emphasize and support value-engineering efforts to refine projects and reduce the costs of constructing CSO infrastructure. This should include opportunities to pursue complementary or combined projects with the city of Seattle or other entities, if it is cost-effective for King County ratepayers.

Major elements of the study include: (1) analyzing and synthesizing findings of existing studies, (2) collecting new information and filling data gaps through additional monitoring and sampling where identified as necessary, (3) assessing factors affecting water quality in the sub-basins and water bodies where King County CSOs discharge, and (4) recommending integration and sequencing of projects to meet current federal and state water quality standards and improve water quality.

EPA has developed guidance for local municipalities to integrate CSO control planning with stormwater controls. This study will use EPA's integrated planning framework to guide the work program and meet objectives established by EPA and Ecology.

The study commits resources into completing a comprehensive review of the effects on water quality in the sub-watersheds where CSO discharges occur. The study will occur in parallel with implementation of the first capital projects of the amended long-term CSO control plan. The results of the assessment may change the sequencing or prioritization of the CSO projects but shall not alter the County's legal obligations to complete the remaining CSO projects.

11.4 Post-Construction Monitoring and Compliance with Water Quality Standards

King County's post-construction monitoring plan is designed to assess, document, and report on the effectiveness of its CSO Control Program in achieving performance requirements and complying with state water and sediment quality standards.

All CSO locations will be monitored for onset, duration, and volume of the discharge. In addition, discharge locations that provide CSO treatment will be monitored for influent and effluent quality. Sampling of the wet-weather discharges will be done in the NPDES permit. In addition to this monitoring, the County will continue to collect precipitation data at an equivalent level to the existing network of rain gauges and will continue its ongoing ambient monitoring program. Pre- and post-construction sediment monitoring will be performed at each CSO control project location as laid out in the approved sampling and analysis plans.

The County submitted a draft post-construction monitoring plan to Ecology for review and approval in July 2010 in accordance with the current NPDES permit requirements. Ecology provided comments on the draft, and the County revised the plan and resubmitted it to Ecology in February 2012. Ecology is currently reviewing the final draft. The final draft is included in Appendix H. The technical appendices are available on-line at: http://www.kingcounty.gov/environment/wastewater/CSO/ProgramReview/Plan.aspx#techmemos.

Appendices

Appendix A. CSO Control Planning Assumptions, Policies, and Implementation

Appendix B. Hydraulic Modeling and Monitoring Protocols, Model History

Appendix C. Change Matrix from 1999 Plan Amendment: Summary of Review for Change in Uncontrolled CSO Basins

Appendix D. West Point Treatment Plant Flow and Waste Load Report Summary

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Appendix F. Summary of 2010-11 Public Involvement Activities

Appendix G. Rate Forecasting and Affordability

Appendix H. Post-Construction Monitoring Plan

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Appendix A

CSO Control Planning Assumptions, Policies, and Implementation

CSO Control Planning Assumptions

Following is the list of assumptions used for combined sewer overflow (CSO) control planning in the 1999 CSO Control Plan Amendment (1999 Plan Amendment), included as part of the Regional Wastewater Services Plan (RWSP). These assumptions are still valid except where noted as being updated in this 2012 CSO Control Program Review Report.

- During 1997 RWSP public involvement process, citizens ranked CSO control as a top priority.
- King County shall design, construct, operate, and maintain its facilities in accordance with standards established by regulatory agencies and manuals of practice for engineering, so as to meet or exceed regulatory requirements for air, water, and solids emissions, as well as ensure worker, public, and system safety.
- The County will meet the state CSO control standard of one untreated overflow per year on average, recognizing that this may become more stringent in the future due to the Endangered Species Act (ESA).

  2012 Update*: Washington State Department of Ecology (Ecology) modified the definition of average to be a 20-year moving average in the 2009 National Pollutant Discharge Elimination System (NPDES) permit.*

- The City of Seattle has controlled all its CSOs, and no further deterioration in its system is expected.

  2012 Update*: The City is actively developing a 2015 Long-term Control Plan. The control approach chosen by the City is to employ Green Stormwater Infrastructure (GSI) wherever cost-effective and to optimize conveyance and store flows for later transfer to the County for treatment at the West Point Treatment Plant. The County and the City have rigorously explored joint opportunities and are proposing three joint projects in the King County Executive's Recommended CSO Control Plan.*

- The 1999 Plan Amendment includes storage tanks and on-site treatment. Investigation is needed to determine if a roof drain disconnection program conducted by homeowners would be cost-effective before it is used for control.

***2012 Update**: GSI is a significant element of the King County Executive's Recommended CSO Control Plan.*

- The County shall give the highest priority for control to CSO discharges that have the highest potential to impact human health, bathing beaches, and/or species listed under the ESA.

  ***2012 Update**: The regional effort to clean up the Duwamish River is now a major factor in shaping the King County Executive's Recommended CSO Control Plan.*

- The County will develop CSO control programs and projects based on assessments of water quality and contaminated sediments.

- Although the County's wastewater collection system is impacted by the intrusion of clean stormwater, conveyance and treatment facilities shall not be designed for the interception, collection, and treatment of clean stormwater.

  ***2012 Update**: GSI will be implemented wherever feasible and cost-effective to reduce the size of CSO control facilities.*

- The County will develop a contaminated sediment management plan.

  ***2012 Update**: An update to the 1999 Sediment Management Plan is under way.*

CSO Control Policies and Implementation

The CSO control policies are intended to guide King County in controlling CSO discharges. Highest priority for controlling CSO discharges is directed at those CSO sites that pose the greatest risk to human health, particularly at bathing beaches or where there is significant fish harvest, and environmental health, particularly those that threaten species listed under the ESA. The County will continue to work with federal, state, and local jurisdictions on regulations, permits, and programs related to CSOs and stormwater. The County will also continue its development of CSO control programs and projects based on assessments of water quality and contaminated sediments.

CSO Control Policies	How is Policy Being Implemented? 2008–2012
CSOCP-1: King County shall plan to control CSO discharges and to work with state and federal agencies to develop cost-effective regulations that protect water quality. King County shall meet the requirements of state and federal regulations and agreements.	The County continues to implement the 1999 Plan Amendment to meet the Ecology standard of no more than an average of one untreated discharge per year at each CSO site. In 2007, predesign began on four CSO control projects: South Magnolia, North Beach, Barton Street, and Murray Avenue. The plan proposed in this report amends the 1999 Plan Amendment CSO control projects (adopted alternatives).

CSO Control Policies	How is Policy Being Implemented? 2008–2012
CSOCP-2: King County shall give the highest priority for control to CSO discharges that have the highest potential to impact human health, bathing beaches, and/or species listed under the ESA.	The current CSO control schedule aligns with the priorities outlined in CSOCP-2. An emerging factor shaping the proposed plan is also the regional effort to clean up the Duwamish River and concerns about health impacts due to consumption of fish with high tissue concentrations of chemicals of concern.
CSOCP-3: Where King County is responsible for stormwater as a result of a CSO control project, the County shall participate with the City of Seattle in the municipal stormwater NPDES permit application process.	This policy was developed with the Lander and Densmore separated drainage basins in mind. In accordance with memoranda of agreements, the County and the City jointly manage stormwater discharges in the Lander and Densmore drainage basins that occur as the result of county sewer separation projects. In addition, the County is a co-permittee with the City for the Densmore NPDES municipal stormwater permit. The County and City continue to discuss how to address stormwater pollution prevention and enforcement needs.
CSOCP-4: Although King County's wastewater collection system is impacted by the intrusion of clean stormwater, conveyance and treatment facilities shall not be designed for the interception, collection, and treatment of clean stormwater.	The County remains committed not to build facilities to collect or treat new separated stormwater but is actively exploring GSI options to manage stormwater ahead of facilities with the intent that the facilities can be smaller and more cost-effective. Four proposed CSO control projects have potential for GSI to be effective.
CSOCP-5: King County shall accept stormwater runoff from industrial sources and shall establish a fee to capture the cost of transporting and treating this stormwater. Specific authorization for such discharge is required.	The King County Wastewater Treatment Division's (WTD's) Industrial Waste Program coordinates the approvals of and cost recovery for such discharges. Source control has become a large element of this program.
CSOCP-6: King County, in conjunction with the City of Seattle, shall implement stormwater management programs in a cooperative manner that results in a coordinated joint effort and avoids duplicative or conflicting programs.	To prevent duplication and conflicts, the County and City coordinate on their stormwater and wastewater management programs. The County and the City are coordinating in implementing the Rainwise program and some GSI project alternatives.

CSO Control Policies	How is Policy Being Implemented? 2008–2012
CSOCP-7: King County shall implement its long-range sediment management strategy to address its portion of responsibility for contaminated sediment locations associated with County CSOs and other facilities and properties. Where applicable, the County shall implement and cost share sediment remediation activities in partnership with other public and private parties, including the County's current agreement with the Lower Duwamish Waterway Group, Ecology and the U.S. Environmental Protection Agency (EPA), under the federal Comprehensive Environmental Response, Compensation and Liability Act. *(Ordinance 15602 amended CSOCP-7 to reflect that a sediment strategy has been developed and is in place.)*	The County continues to work to improve water quality in the Lower Duwamish Waterway through actions such as reducing CSOs, restoring habitats, capping and cleaning up sediments, and controlling toxicants from industries and stormwater runoff. WTD has partnered with the City, the Port of Seattle, and the Boeing Company under a consent agreement with EPA and Ecology to prepare a remedial investigation and feasibility study for the Lower Duwamish Waterway Superfund Site. The feasibility study and proposed clean-up solutions are currently out for public review. The County participated in two early action sites—the Diagonal/Duwamish CSO/Storm Drain and Slip 4 CSO. The cleanup at Diagonal/Duwamish was completed in February 2004. In 2006, EPA approved a cleanup plan for Slip 4 CSO sediments. Sediments with the highest contamination will be removed, and the remaining sediments will be capped. The County is in the process of updating its 1999 Sediment Management Plan in coordination with new requirements for characterization and Post-Construction Monitoring.
CSOCP-8: King County shall assess CSO control projects, priorities, and opportunities using the most current studies available, for each CSO control plan update as required by Ecology in the NPDES permit renewal process, which is approximately every five to seven years. Before completion of an NPDES permit required CSO control plan update, the Executive shall submit a CSO control program review to the King County Council and Regional Water Quality Committee (RWQC). Based on its consideration of the CSO control program review, the RWQC may make recommendations for modifying or amending the CSO Control Program to the King County Council. *(Ordinance 15602 updated this policy to reflect current information.)*	CSO control plan updates are due to Ecology every five years–-the updates are done in coordination with the NPDES permit renewal for the West Point Treatment Plant. New CSO treatment technologies that offer some promise for greater cost-effectiveness were pilot tested between 2007 and 2009. The results were considered in this program review, leading to the recommendation to use high-rate sedimentation processes and ultra-violet disinfection in the Duwamish CSO treatment facilities. Scientific studies implemented since the RWSP were reviewed in updating CSO control priorities for this review. Recommendations were to prioritize the Duwamish projects next to coordinate with the cleanup of the river, and to protect juvenile chinook salmon. WTD is considering the impacts of climate change on CSO treatment facilities and developing adaptation strategies for existing and new CSO control facilities.

CSO Control Policies	How is Policy Being Implemented? 2008–2012
CSOCP-9: Unless specifically approved by the King County Council, no new projects shall be undertaken by the County until the CSO control program review has been presented to the council for its consideration. CSO control project approval prior to completion of CSO control program review (beyond those authorized in this subsection) may be granted based on, but not limited to, the following: availability of grant funding; opportunities for increased cost-effectiveness through joint projects with other agencies; ensuring compliance with new regulatory requirements; or responding to emergency public health situations. The council shall request advice from the RWQC when considering new CSO control projects. King County shall continue implementation of CSO control projects underway as of the effective date of this section, which are the Denny Way, Henderson/Martin Luther King, Jr. Way/Norfolk, Harbor and Alki CSO treatment plants.	This policy has been fully implemented. The CSO control program review referred to in this policy was submitted to the King County Council in April 2006. No new projects were initiated prior to the submittal of the CSO control program review.

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Appendix B

Hydraulic Modeling and Monitoring Protocols, Model History

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King County
Wastewater Treatment Division

Hydraulic Modeling and Monitoring Protocols, Model History

May 2012

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Mission Statement

The King County WTD Modeling Group provides cost-effective analyses and predictions of the quality and quantity of water as it moves through sewers, rivers, lakes, estuaries and Puget Sound.

The Modeling Group predicts water quality and quantity using field measurements and mathematical models; these predictions enhance/support capital project planning, design and operating decisions/strategies that affect the protection and improvement of public health and the environment.

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1.0. INTRODUCTION

This manual documents standard operating procedures for modeling sewers in the King County Wastewater Treatment Division's (WTD) service area. This manual covers the modeling approaches for both the combined and separated portions of the regional conveyance system in the service area and indicates when and how the approaches differ. Both approaches are structured to arrive at the pertinent information for meeting regulatory requirements.

The sections in this chapter briefly describe the County's conveyance system, the types of modeling performed by WTD, and the content and organization of this manual.

1.1 King County Conveyance System

The over 355 miles of pipelines in King County regional conveyance system are part of two different types of systems: separated and combined. The separated system, which carries wastewater and stormwater in separate pipes comprises about 85 percent of the system (colored basins in Figure 1-1). Most flows from the separated portion of the service area are treated either at the South Treatment Plant in Renton or the Brightwater Treatment Plant in south Snohomish County.

The remaining 15 percent of the regional system consists of pipes that carry both wastewater and stormwater. This combined system lies in the city of Seattle and sends its flows to the West Point Treatment Plant in the city's Discovery Park (black and white basins in Figure 1-1). The West Point service area also includes a separated system in the north end that sends its flows through the combined portion of the service area prior to arriving at West Point Treatment Plant. This separated portion is roughly one-third of the West Point service area.

During heavy storms, flows in excess of the capacity of the pipes in the combined sewer system and the capacity of the West Point plant overflow at 38 outfalls into water bodies in the Seattle area. Stormwater runoff contributes most of the flow that overflows. The conveyance system in the area that includes these combined sewage overflow (CSO) locations contains portions that have been separated or partially separated over the years by directing street runoff to separate storm sewers.

Washington state requires CSO programs to limit the number of overflow events to an average of one event per year at each location over the long term. The Washington State Department of Ecology (Ecology) states that compliance will be measured using a 20-year rolling average.

1.2 WTD Modeling Services

Modeling Services are provided by WTD modelers in the Modeling & GIS group in in the Planning, Inspection, Modeling, Monitoring & Mapping Unit (PIM3) of the Program Planning & Development Section (Appendix A). The modelers analyze field data and simulate physical, chemical, and biological processes and conditions using computer simulation models. The results are used to evaluate existing conditions and simulate possible future scenarios.

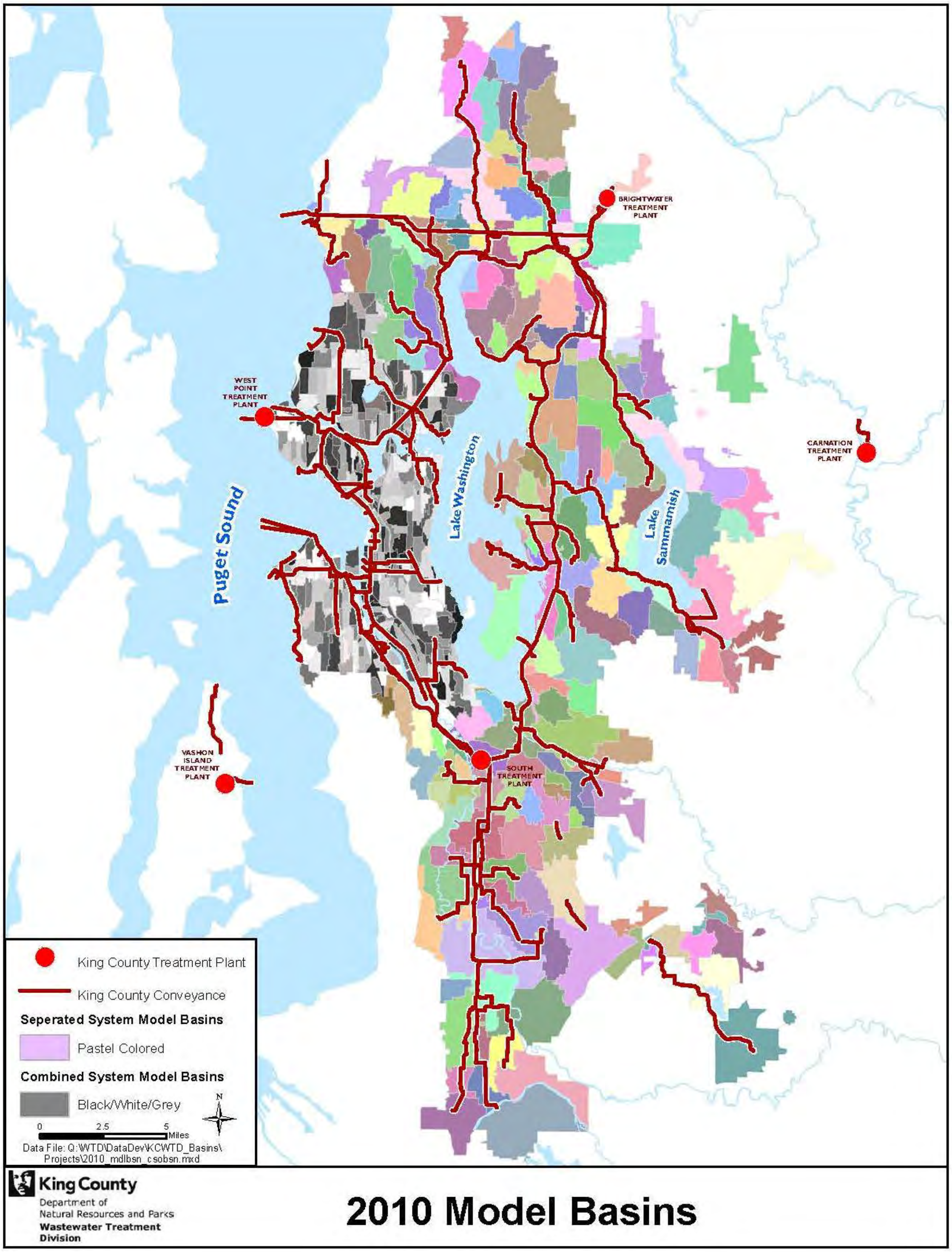


Figure 1-1. Separated and Combined Sewer Model Basins

The Modeling group performs sewer modeling of local wastewater collection systems and the King County regional wastewater conveyance system. The data from these simulations supports the selection, sizing, and timing of most wastewater conveyance and treatment components in the King County wastewater system, including components that will bring the combined sewer system into the state-mandated control of no more than one overflow per year on a long-term average from each CSO location.

In addition to modeling sewers, the Modeling group performs two other services:

- **Water quality modeling.** Simulating the quantity and quality of water in the region's major lakes, rivers, bays, and Puget Sound.
- **Control system modeling.** Providing input on control strategies for WTD conveyance and storage facilities.

Table 1-1 lists many of the services provided by WTD's Modeling Group.

Table 1-1. Services Provided by King County WTD Modeling Group

Collection and Conveyance System Modeling	• Performing hydrologic and hydraulic analyses • Modeling King County conveyance system • Quantifying existing flows and overflows • Quantifying inflow and infiltration (I/I) in the separated sewer system • Estimating future wastewater flows and timing of need for new pipes, pump station upgrades, and treatment capacity • Determining benefits of possible I/I reduction programs • Estimating effectiveness of I/I reduction projects • Conducting storm frequency analyses to establish basis for design • Conducting flow frequency analyses • Analyzing CSO storage/separation alternatives • Optimizing CSO control schemes • Sizing tunnels and pipes for conveyance and storage • Determining storage requirements to delay or avoid adding parallel conveyance facilities • Calculating discharge volumes to local bodies of water and corresponding return frequencies • Determining pipe slope and configuration requirements to meet WTD's maintenance criteria • Troubleshooting unexpected events in the collection system • Making flow monitoring recommendations • Analyzing impacts of collection system alterations on CSOs • Evaluating results of worst-case scenarios during design efforts
Water Quality Modeling	• Predicting the transport and fate of contaminants of concern for water quality assessments • Evaluating impacts of CSOs, treated effluent, and stormwater • Evaluating potential outfall sites • Evaluating Lake Sammamish, Lake Washington, and Lake Union water quality; • Evaluating Green/Duwamish River/Elliott Bay water quality; • Analyzing the hydrographic and ecological character of estuaries, lakes, and rivers • Evaluating the possible sources and fate of sediment contamination; • Providing written reports that assess modeling efforts and characterize hydrographic and ecological responses

	• Providing professional services when assessing how conveyance systems may be influenced by hydrodynamic conditions in estuaries, lakes, and rivers • Assisting the design and implementation of monitoring and sampling programs
Control System Modeling	• Updating and tuning the control program for West Point collection system to optimally use in-line storage and reduce CSOs • Testing new control strategies for pump stations and regulator stations • Providing input on design requirements • Troubleshooting control and sensor problems • Helping with off-site computer upgrades to ensure flow calculations are working properly and data is archived appropriately • Improving flow calculations • Evaluating flow management strategies to minimize the risk of overflows during major storm events • Working with design teams to ensure that adequate data transfer and control capabilities are provided with new projects

1.3 Content and Organization of this Manual

The chapters in this manual provide the following information:

- Chapter 2 presents on overview of the data that is collected and analyzed and the models, tools, and processes that are used.
- Chapter 3 documents how current and peak flows are estimated.
- Chapter 4 shows how future peak flows and required CSO control volumes are estimated.
- Chapter 5 shows how the existing system capacity is analyzed, when peak flows will exceed the capacities, and how the current level of service is computed for each conveyance facility in the separated system. It describes the process of developing planning-level capital projects to address identified capacity shortfalls in the system and how cost estimates are prepared for projects in the planning phase.

The remaining chapters present a list of references, a glossary, and a list of acronyms and abbreviations. Supporting information is included in the appendices.

2.0. MODELS AND MODELING PROCESS

Sewer modeling is the simulation of wastewater flows that enter and travel through the conveyance system to a treatment plant or to an overflow location. Flows consist of base sewage flows that follow a diurnal pattern and additional flows that enter either from direct stormwater connections (inflow) or from the groundwater via infiltration. Modeling attempts to simulate the relationship between sewer flow and the rainfall that falls over a collection area (hydrologic basin).

WTD models the regional conveyance system for three primary purposes: (1) to conduct hydrologic analyses (simulating peak flows composed of base flow plus rainfall-derived infiltration and inflow), (2) to conduct hydraulic analyses (performance of the conveyance system during normal and peak flow events); and (3) to test and optimize control strategies.

Using rainfall as an input, a model is calibrated to accurately simulate the hydrologic response of the system. The model is then used to simulate the routing of this flow throughout the conveyance system. After calibration, a long-term rainfall record is used to determine the system response to a variety of storm conditions, to estimate where and when capacity will be exceeded, and to establish long-term overflow statistics and control requirements.

2.1 Models Used by WTD

King County regional conveyance system modeling began in 1986 with use of the Runoff/Transport and UNSTDY (pronounced “unsteady”) models obtained from Colorado State University to simulate the hydrologic and hydraulic responses in the combined sewer system:

- The Runoff/Transport model simulates wastewater and surface runoff that enter sewers, including those in local agency systems, during rainfall events. The hydrologic response in the combined system is dominated by direct stormwater inflow, which the system was designed to handle. The Runoff/Transport model was improved in the early 1990s to simulate variable infiltration, which is the primary cause of peak flows in the separated system.
- UNSTDY, a hydraulic routing model, simulates the flow of wastewater through the County’s conveyance system (pipes, pumps, and storage facilities).

The models were customized over the years to include all the control structures and strategies in the West Point and South plant collection systems.

In support of King County’s Infiltration and Inflow (I/I) Program in 2000–2004, WTD purchased the MOUSE model (MOdeling of Urban SEwers), produced by Danish Hydraulics Institute, to replace the Runoff/Transport and UNSTDY models. The MOUSE model was developed for continuous simulation of rainfall-dependent I/I and for quantifying the I/I entering separated sewer system basins. It is user friendly and allows the County and local agencies to share modeling data, analyses, and results. Conversion from the Runoff/Transport model to the MOUSE RDII hydrologic model is complete, although further calibration of the MOUSE RDII model is ongoing; conversion from the UNSTDY model to the MOUSE HD hydraulic model is complete for the separated system .

To standardize the platform and increase accessibility by Seattle Public Utility (SPU) and consultants, King County decided in 2009 to migrate the combined system model to MOUSE. So far, the hydrologic response of many of the basins in the combined system has been calibrated. Further monitoring and calibration will be done in 2012 and 2013. The migration of the combined system from UNSTDY to MOUSE HD is still under way.

For WTD's 2012 CSO Control Program update, a mix of hydrologic models was used to estimate CSO control sizing needs. Extensive collaborative efforts had been under way by King County, SPU, and consultants to calibrate basin models for King County and SPU. King County used the MOUSE model to calibrate most of the service area for CSO modeling. SPU and consultant modelers used SWMM5 to calibrate several areas tributary to SPU CSO planning basins and calibrated the InfoWorks model for certain areas for SPU CSO control project purposes.

King County used model outputs that it deemed to provide the best (most reliable) information:

- The MOUSE model output was used for areas where the model had been calibrated to recently collected data.
- For some areas where MOUSE had not been calibrated, SPU provided hydrographs generated by the SWMM model.
- For some areas not calibrated by either model, SPU provided InfoWorks model output.
- Where no recent model calibration had been done, the King County's Runoff/Transport Model was used for simulating the hydrologic response in the basins.

Hydrographs from the four models were placed into King County's UNSTDY model in the appropriate locations so that the hydraulic response in King County's conveyance system could be simulated and CSO control volumes could be estimated. Figure 2-1 shows the models that contributed to the 2012 CSO Control Program Review. Figure 2-2 shows the progress that has been made in calibrating the MOUSE model since the 2012 CSO Control Program Review.

Appendix B provides detail in the history of CSO modeling in King County.

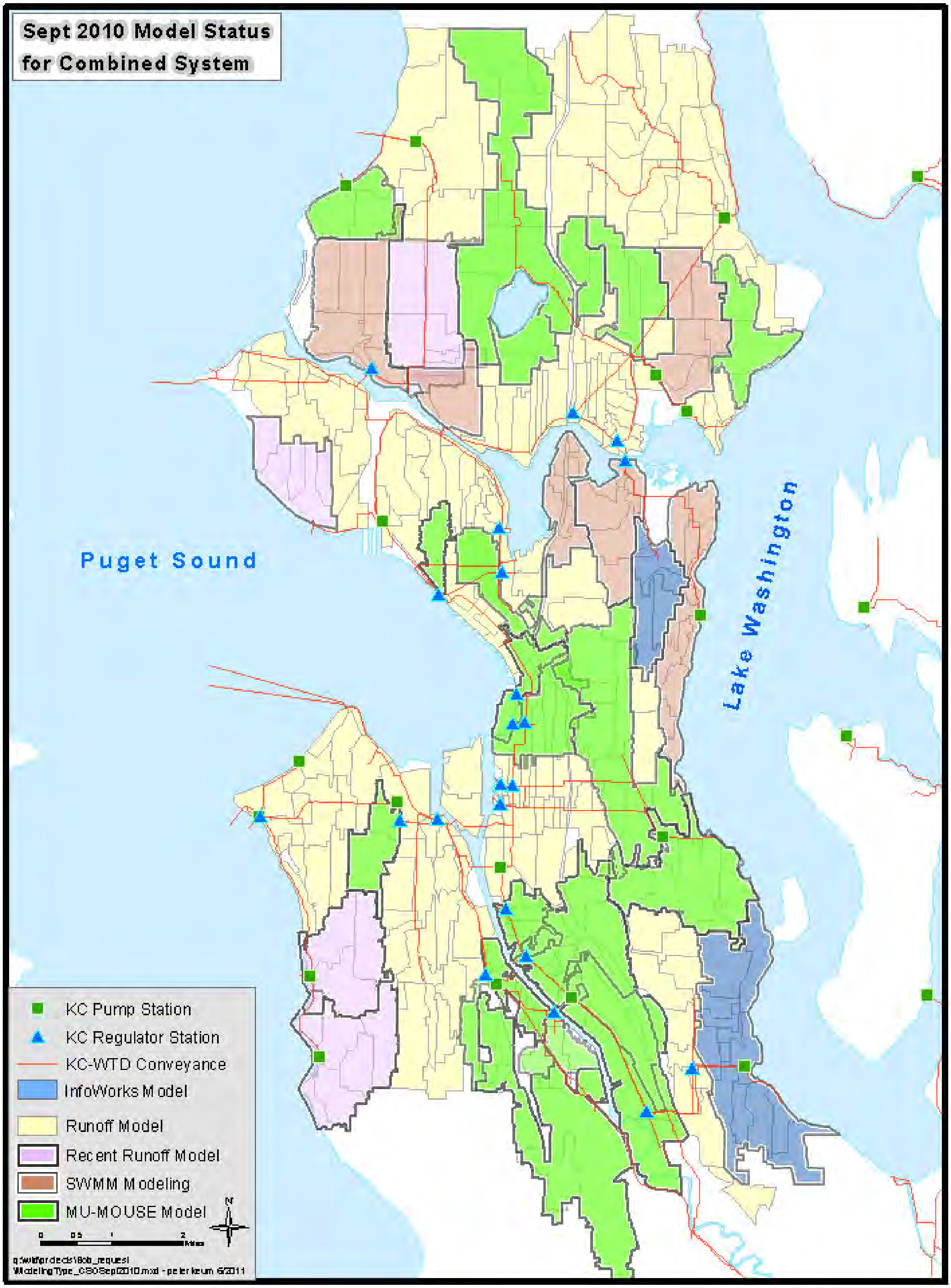


Figure 2-1. Hydrologic Models used in King County's 2012 CSO Control Program Review

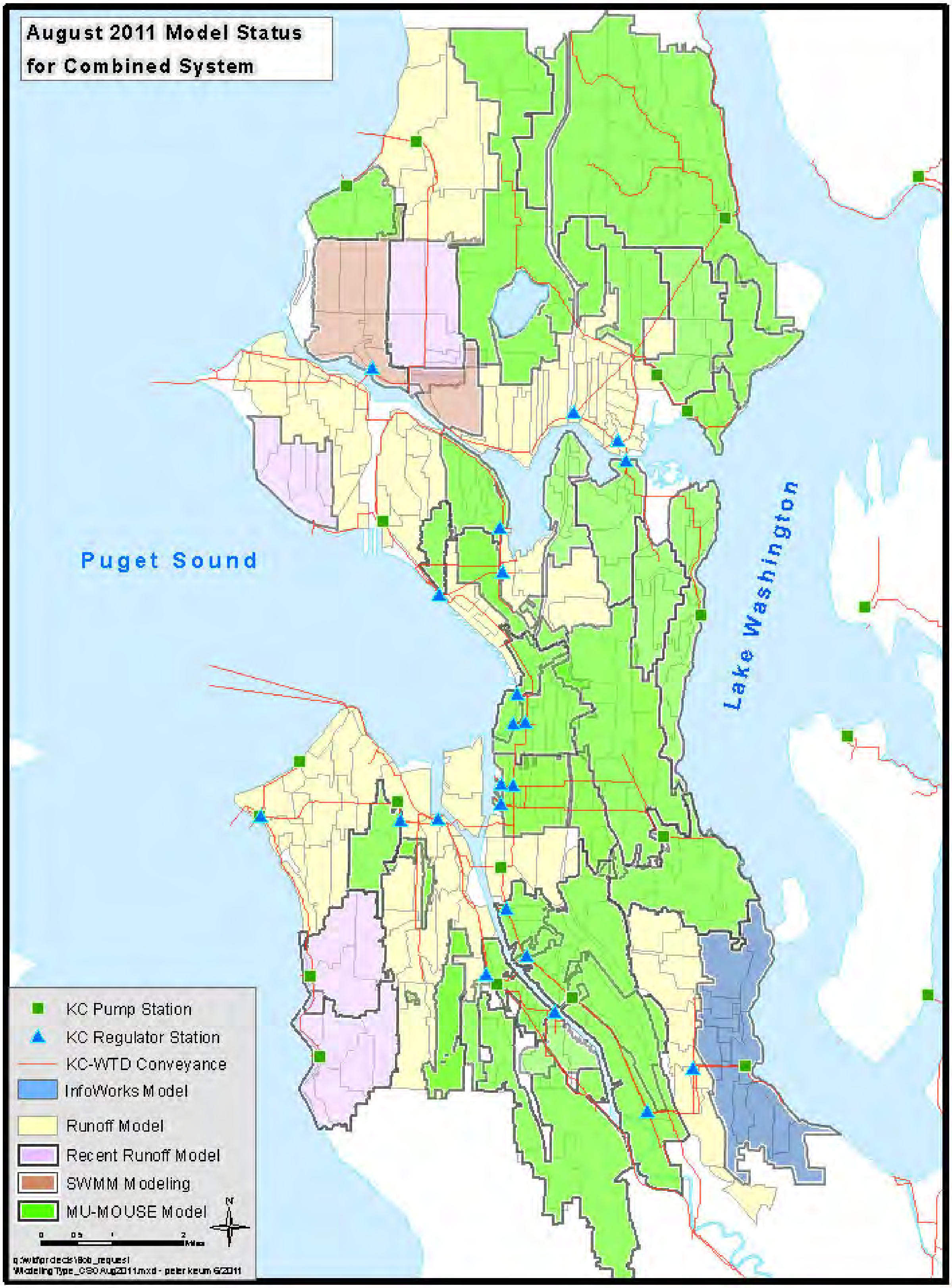


Figure 2-2. Hydrologic Models used in King County's CSO Modeling

2.2 Modeling Processes for Combined and Separated Systems

The process for modeling the combined and separated portions of the service area is generally the same. It consists of three main steps:

1. Simulate base sewage and basin hydrologic responses to estimate current 1-year (combined system) or 20-year (separated system) peak flow demands. The simulation establishes a baseline that represents how the system currently performs under peak flow conditions. The year that flow monitoring data are collected and used for model calibration becomes the current, or baseline, condition for estimating peak flow conditions. Sometimes models are calibrated by project area and other times for a large portion of the system.
2. Project peak flows by decade through 2050 for the regional conveyance system using sewered area, population, and employment projections. For hydrologic purposes, the areas served by most of the separated system are assumed to be built out by 2050 and the areas served by the combined system and the majority of the separated system that flows to the West Point plant are assumed to be fully developed. However, as pipes age and deteriorate, the potential exists for increased flows.
3. Identify peak overflow rates and volumes associated with bringing CSOs down to the required one-per-year level. Identify capacity constraints in the separated system based on when the peak flows exceed the capacity of the existing regional conveyance.

There are notable differences between modeling the combined and separated sewer systems related to the data used, the specific model components used for simulating hydrologic responses, and the primary objectives of the modeling. The following sections describe how the process is applied to the combined and separated sewer systems.

2.2.1 Combined System

Figure 2-3 depicts the modeling process for the combined system.

Flow monitoring in the combined system occurs at all regulator and pump stations and is recorded in the West Point supervisory control and data acquisition (SCADA) system. Portable flow monitors are placed at overflow weir locations for reporting purposes and in the sewers for model calibration purposes. Additional monitoring occurs in specific areas when upcoming CSO projects are in the project definition phase.

Modelers use the flow monitoring data to estimate the volume and frequency of CSOs at all CSO locations. For locations that need to be controlled to the one-per-year standard, the modelers conduct long-term simulations to determine the peak flow and volume that must be controlled. They then evaluate alternative solutions, such as green stormwater infrastructure, storage, treatment, and conveyance, to provide planners and designers with pertinent information for comparing alternatives.

When CSO projects are brought on-line, modelers frequently evaluate how to optimize the control system to obtain the full potential benefit of the CSO facility and conduct expanded evaluations of adjustments and corrections if project performance does not achieve the control target or drifts out of control as a result of system changes.

SPU conducted extensive flow monitoring of the combined system in 2006–2011. The data from this monitoring was added to the long-term data collected by King County. This data became the basis for calibrating the MOUSE model for the combined systemin order to establish the baseline or current condition for estimating peak flows. The calibrations are repeated using new monitored data at intervals of 5−10 years, or when new information suggests it is needed

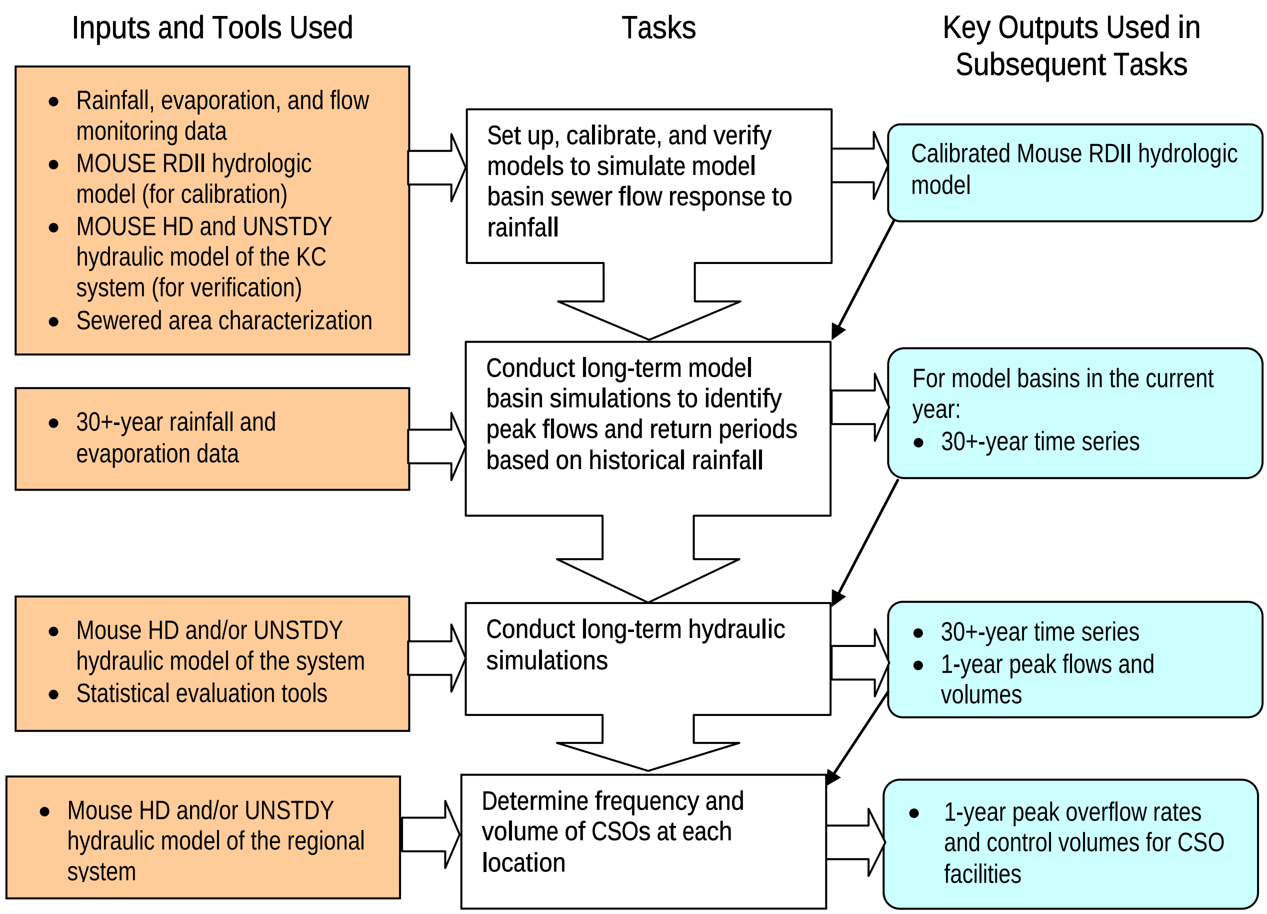


Figure 2-3. Process and Inputs for Identifying CSO Control Facility Needs in King County's Combined Conveyance System

2.2.2 Separated System

Two major questions must be answered in developing the capital projects needed to address capacity shortfalls in the separated conveyance system:

- Where are the capacity shortfalls (needs) in the regional system and when do the shortfalls occur?
- What can be done in the way of capital conveyance improvements to address those shortfalls and how much will the improvements cost?

Extensive flow monitoring of the separated system is performed every 10 years. The data from each of these decennial flow monitoring (DFM) effort is used to update the calibration of the basin models. The updated calibration becomes the basis for the “current year,” which is the year the monitoring occurs. The most recent DFM was completed in 2011.

King County has adopted a 20-year peak flow capacity standard for King County conveyance facilities in the separated portion of the service area that transport wastewater from local agencies to County treatment plants (KCC 28.86.060). To meet this standard, facilities must have capacity for peak flows of a magnitude that can be expected on an average of once every 20 years (20-year return interval). This return interval corresponds to a 5 percent chance that such flows or higher would occur in any given year and a 63 percent chance that such flows would occur in any 20-year period (Table 2-1).

Table 2-1. Estimated Probability of Observing an Event Having a 20-Year Return Interval

Years of Observation	Probability of One Event or More (%)
1	5
5	22
10	39
20	63

For the design of pump stations in the separated system, a five-year peak flow is used to set the firm pumping capacity (all pumps, except the largest unit, are operating).

Figure 2-4 depicts the modeling process for the separated system.

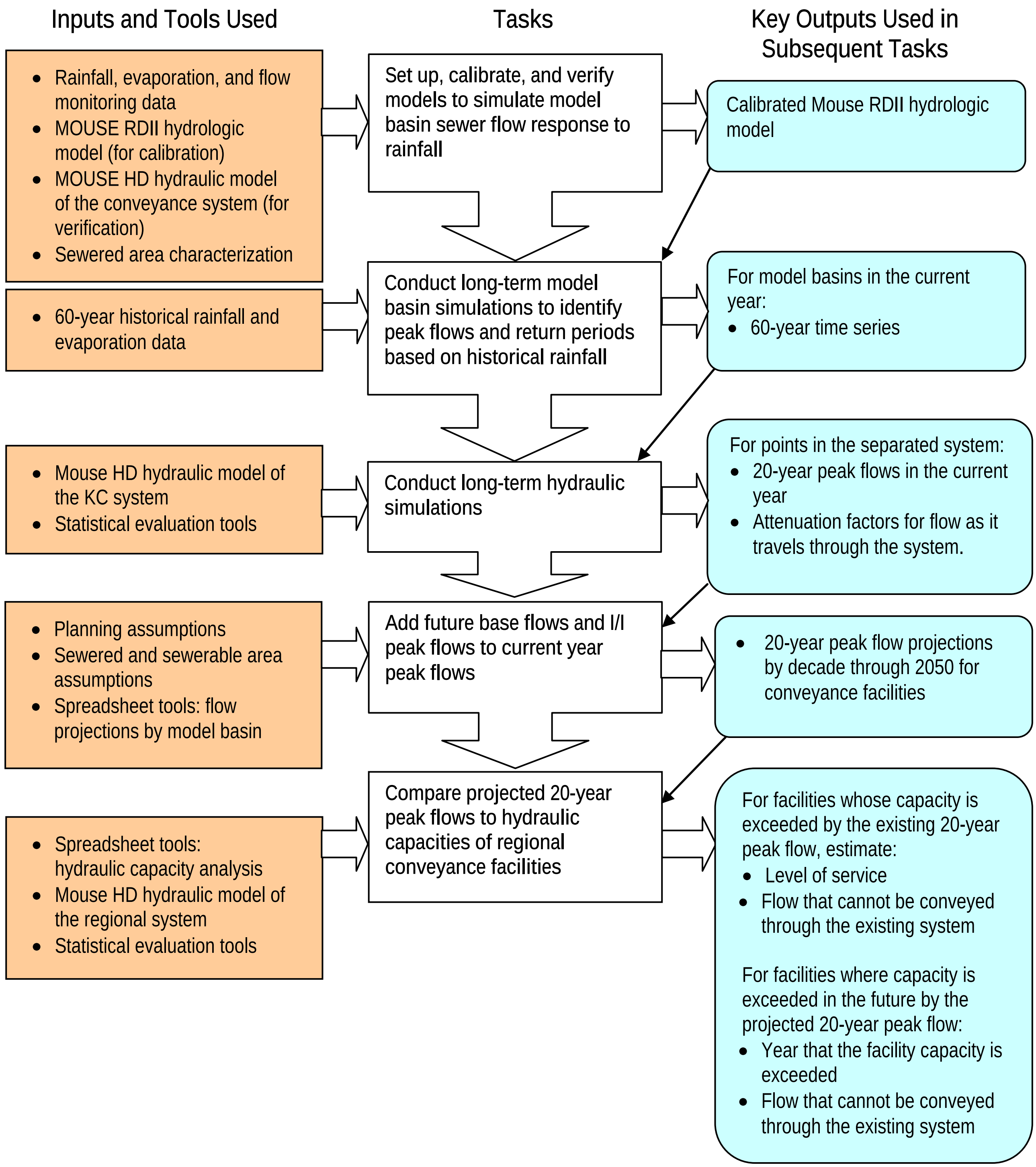


Figure 2-4. Process and Inputs for Identifying Capacity Needs in King County's Separated Conveyance System

3.0. ESTIMATING CURRENT PEAK FLOWS

Peak wastewater flows consist of base flow (wastewater) and I/I. Base flow is primarily a function of how many households and businesses are connected to the sewer system. I/I is primarily a function of the extent of sewers or the developed area served by the wastewater system and on the system's response to rainfall and groundwater conditions.

The current year is defined as the year of the most recent model calibration based on comprehensive flow monitoring. This chapter describes the model calibration and other procedures used to estimate current year peak flow.

3.1 Overview of Procedures

WTD uses a method to estimate current peak flows that takes into account varying geographic coverage, antecedent conditions, and impacts from successive rainfall events, all of which are common in this region. Many traditional methods, such as the "design storm approach," equate rainfall probability to flow probability. These methods become unreliable when flow of a given magnitude can result from a range of rainfall events. As antecedent conditions become more significant in determining flow response, it becomes increasingly difficult to correlate flow to a single rainfall event. An additional consideration is the sensitivity of flows resulting from rainfall received over successive days, weeks, or even months. It is unlikely, therefore, that an event that exactly matches a particular design standard will be measured during a short monitoring period; in fact, it is difficult to tell just from looking at the rainfall and flow data whether such an event has been measured.

The method for estimating peak flows consists of the following tasks (Figure 3-1):

- **Obtain Input Data.** The following data are entered into the MOUSE RDII hydrologic model: basin boundary and sewered/unsewered area, SCADA (combined system), rainfall, evaporation, and sewer flow monitoring data.
- **Calibrate Hydrologic Model.** Using the data, the MOUSE RDII hydrologic model is calibrated to simulate flow response to rainfall in each model basin for the calibration period. Model calibration consists of matching dry-weather flow patterns first. Then model parameters are adjusted until a good match between measured flow and modeled flow is achieved for several rainfall events and groundwater conditions (different seasons). MOUSE has options for simulating runoff from impervious areas:
    - King County uses Model A, which is a unit hydrograph method, to simulate flows from impervious areas in the separated portion of the service area. The impervious area connected to sewers is usually very small (on the order of 1−2 percent of the basin).
    - Model B is a kinematic wave model that is used when modeling the combined system. This model uses hydraulic equations to simulate the overland flow response, which is the dominant component of flow in the combined system. Calibration efforts are prioritized to areas with upcoming control projects.
- **Verify Model Accuracy.** To verify model accuracy, modeled flows (both base flow and I/I) for individual basins are grouped and input into a hydraulic model (MOUSE HD or

UNSTDY) to compare them with measured flows at places where meters collected data from several basins. Where discrepancies are noted, the area is evaluated to determine if the model needs to be adjusted or if flow monitoring needs some corrections.

- **Conduct Long-Term Simulations.** Once good calibrations are achieved (model results closely approximate metered data), peak flows are identified for each basin by performing long-term historical simulations using the longest available rainfall records available for the combined and separated systems:
  - For the combined system, a record of over 30 years of minute-by-minute rainfall data is used along with monthly average evaporation values.
  - For the separated system, a 60-year extended time series of hourly precipitation and monthly evaporation is used.
- **Estimate Current Year Peak Flows.** Once the hydrologic and hydrologic models are calibrated, long-term simulations are run with the hydraulic model to estimate peak flow demands for the current year:
  - For the combined system, a system model is used that incorporates all the existing controls of the regulator and pump stations and simulates overflows from the system. These simulations of overflows are ranked to find the CSO volume with a one-year return frequency. The overflow hydrographs are also evaluated to determine the peak overflow rate associated with a one-year return frequency for use in design of CSO treatment facilities.
  - For the separated system, peak flows identified from the long-term simulation are ranked in order of intensity and plotted using basic statistical methods to determine which peak flows occurred on average every 20 years in each basin and then to estimate the 20-year peak flows for each basin in the separated portion of the King County conveyance system.

The following sections provide more detail on these procedures, describing the data used in the models and analyses, the determination of geographic areas contributing to flow, the model calibration and verification processes, and the long-term peak flow simulations.

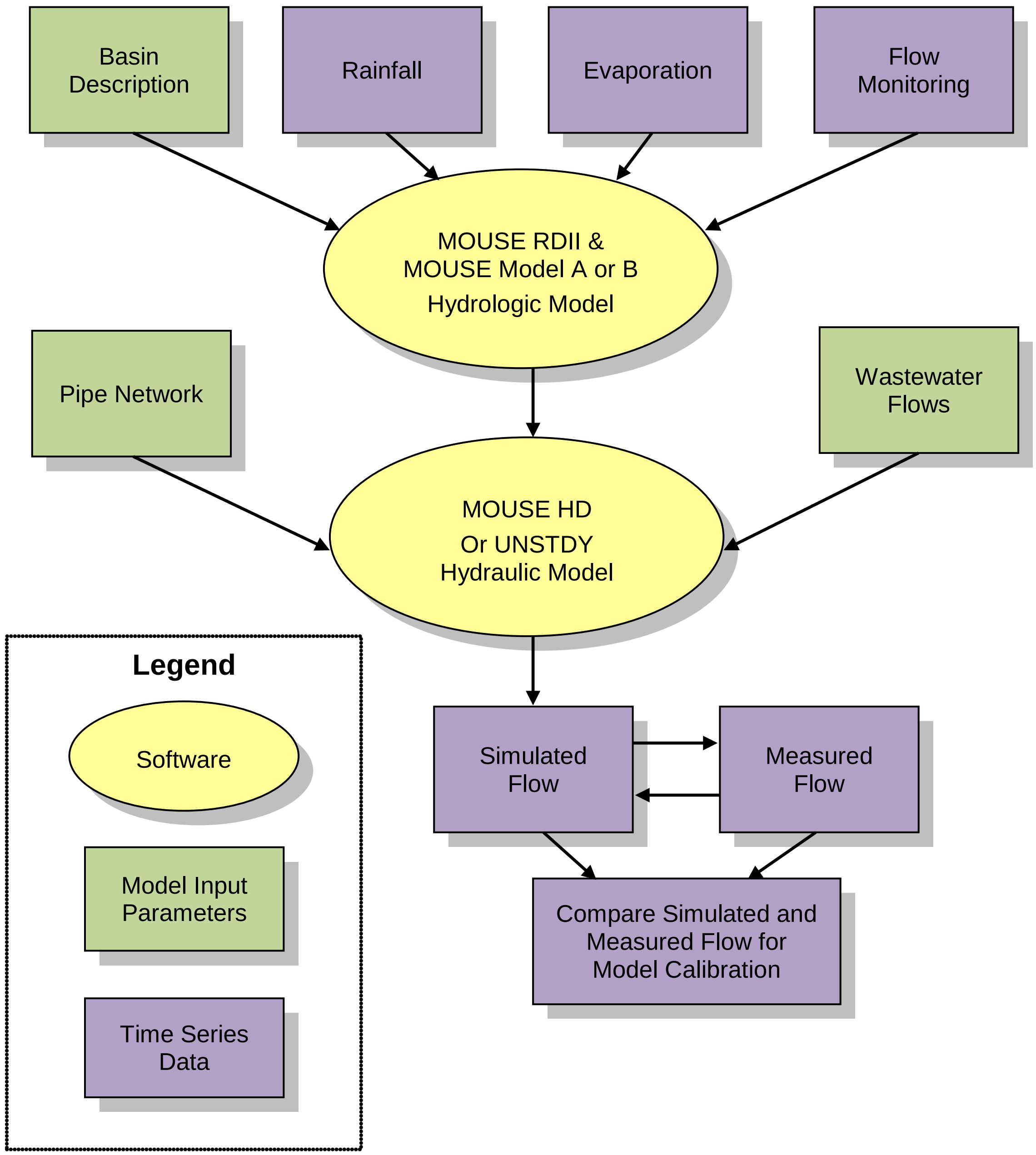


Figure 3-1. MOUSE Hydrologic and Hydraulic Model Components

3.2 Hydrologic Model Input Data

3.2.1 Model Basin Delineation

Model basins are delineated to help quantify flow contributed by local sewer systems to various portions of the King County conveyance system. Basins are delineated such that all important control structures can be simulated appropriately.

A number of data sources, including sewer comprehensive plans, GIS databases, aerial photographs, and available maps of local sewers, are used to determine the area tributary to each modeling flow meter. Because the model basins are used for projecting future flows, the boundaries of the basins encompass the future basin limit under eventual buildout conditions, not just the currently sewered area. King County GIS parcel coverage serves as the basis for geographically defining basin boundaries. Local agency representatives are consulted to verify information and to establish eventual boundaries within the local service area.

Model basins in the separated portion of the service area, as delineated during the I/I Control Program flow monitoring effort, are shown in Figure 3-2. The basins average 1,000 acres and are subdivided into 775 mini-basins (averaging 150 acres).

The model basins used in the combined system are shown in Figure 3-3. The basin definitions are the result of a cooperative effort between King County and SPU. Both agencies compared their basin delineations. SPU then investigated flow direction in about 50 complex areas and communicated the results to King County modelers. The effort resulted in delineation of 344 model basins, each about 350 acres or less. Basin information entered in the hydrologic model include SPU and King County control structures and storage pipes/tanks.

3.2.2 Service Area Classification in the Separated System

Various sources of information, including sewer comprehensive plans, local sewer maps, aerial photography (2000), and parcel data, are used to determine boundaries and classifications of sewered and unsewered areas in the separated sewer area. Sewered areas are input into the MOUSE RDII hydrologic model and are also used in quantifying I/I in terms of gallons per acre per day (gpad). Unsewered areas are divided into two categories—potentially sewerable and not sewerable. The potentially sewerable areas are key in estimating how much new sewered area will be contributing to future flows. These three service area classifications are described in Appendix D.

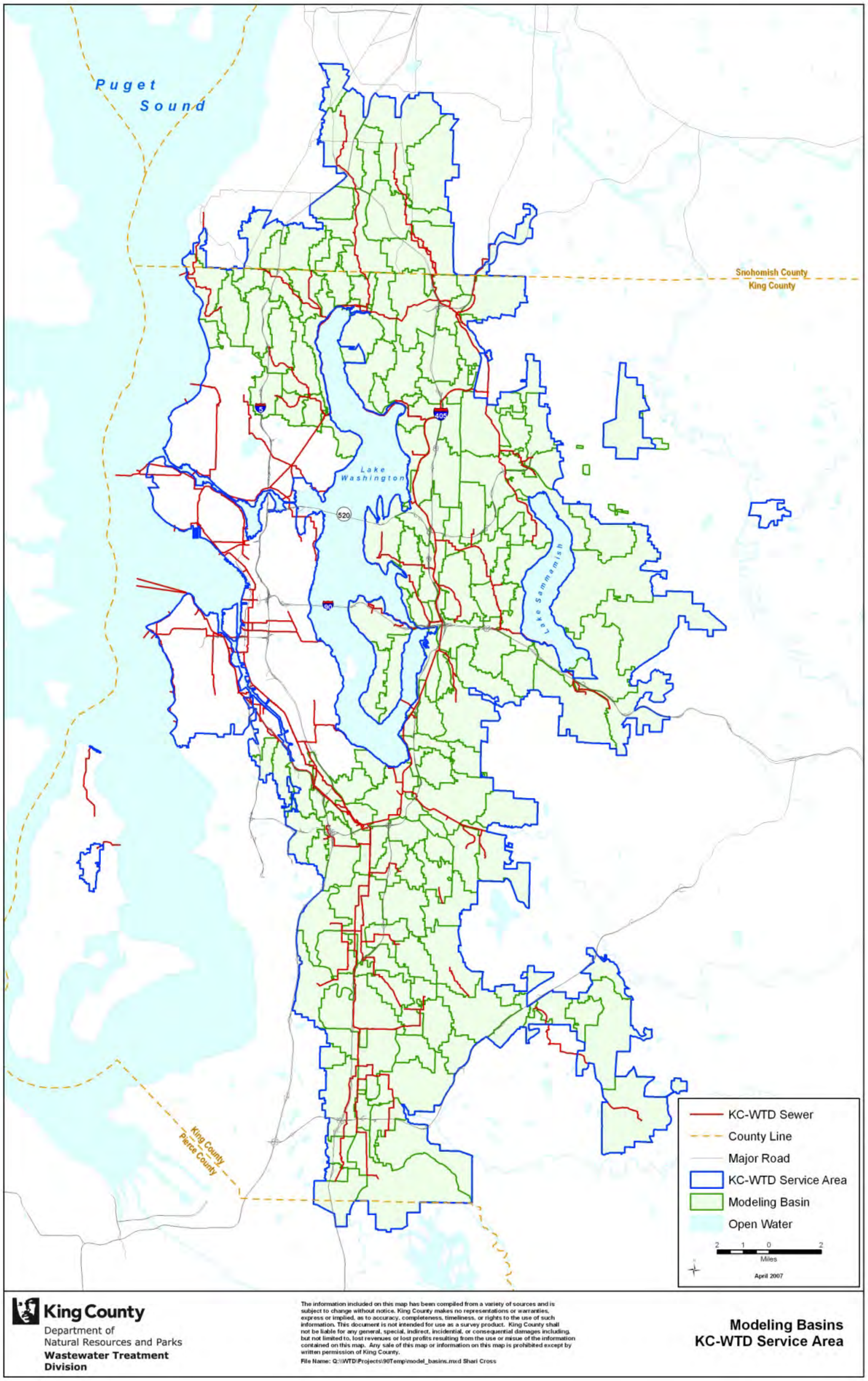


Figure 3-2. KC-WTD Modeling Basins in Separated Portion of Service Area

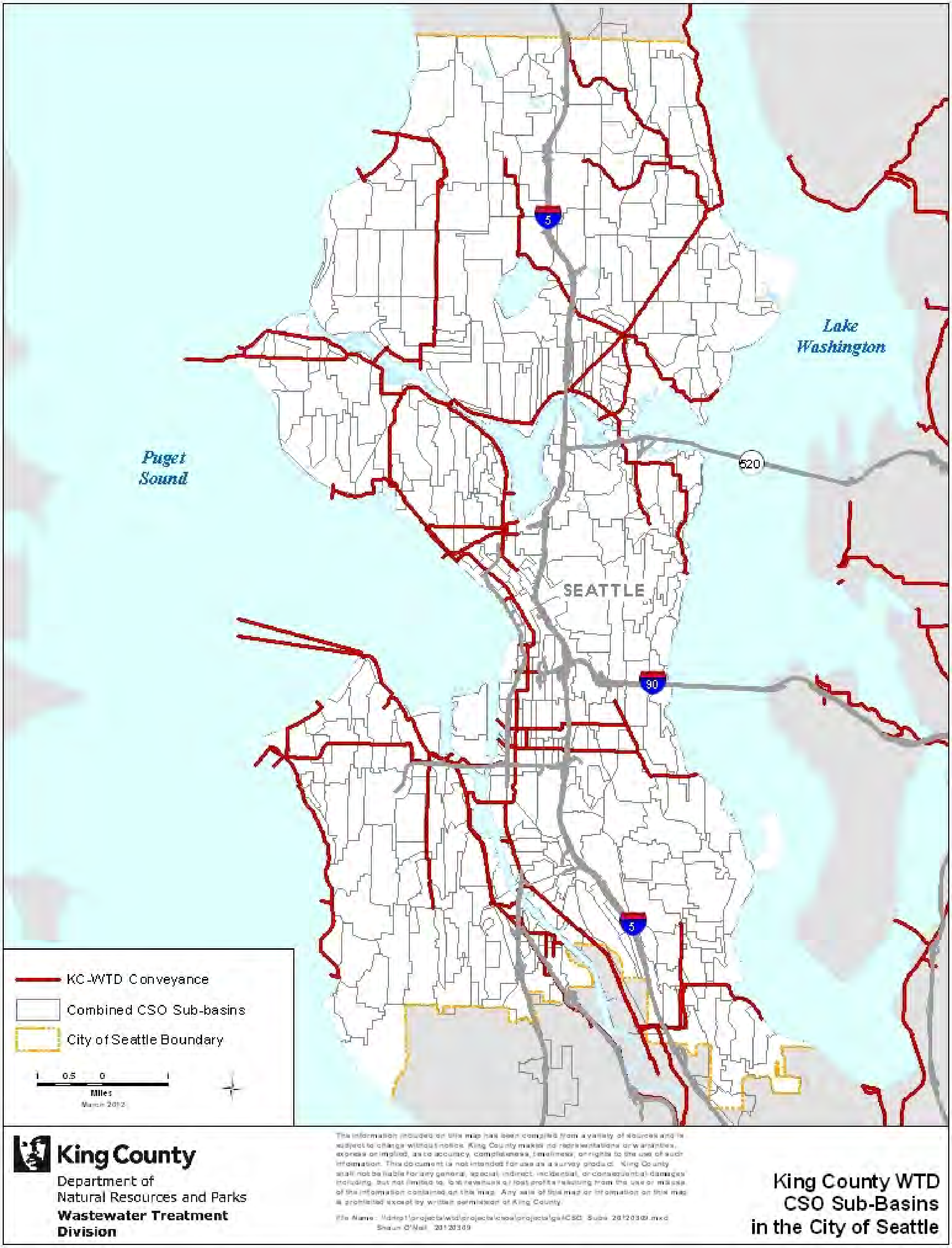


Figure 3-3. KC-WTD Modeling Basins in Combined Portion of Service Area

3.2.3 Flow Monitoring Data

King County installs portable flow meters and collects flow data during dry- and the wet-weather conditions. Meter locations define the service area or basin that is being measured by the meter.

The County's standard operating procedures for flow monitoring (2011, Appendix E) describe the procedures for properly installing, maintaining, calibrating, verifying, and removing meters.

Flow data is checked twice a week to ensure the meters are working properly. Field staff correct obvious problems identified through the data checks. These checks and corrections minimize the time when unreliable data is collected such as when a velocity sensor is covered by a rag or when a battery is running low.

Meters are verified at least twice a year. These verifications involve measuring the depth of flow and comparing it to meter readings, followed by velocity profiles taken with a hand-held velocity probe. Meters are adjusted if the readings are outside the allowable limit. Meter readings may also be adjusted at the end of the monitoring period to reflect the information gained during the monitoring period.

Flow monitoring must collect data on a sufficient number of storms:

- For the combined system, a minimum of 10 storms is desired for calibration to varying conditions. Approximately nine model parameters are typically adjusted in calibrating the hydrologic response of the system. Calibrating to at least 10 events increases the likelihood that the model will be able to simulate the variety of storm events that will be encountered over a long period. At least two storms should have rainfall intensities with return intervals of approximately one to two years or larger, because that is the range of flow that must be controlled to meet the state standard CSO control standard.
- For the separated system, portable meters are in place at least two wet seasons to collect a variety of ground moisture and storm combinations. Preferably a storm greater than or equal to a five-year event can be captured to provide the opportunity to calibrate to a large event.

In some cases, modelers add or subtract flow data to isolate specific sewer basins. Upstream and downstream measured flow hydrographs are compared, and adjustments are made to account for flow travel time and any other effects. For example, data from the upstream meter can be routed through the pipe to the next meter. This simulated flow can then be subtracted from the downstream meter. The resulting flow reflects the flow that is generated in the sewered area between the meters. The final subtracted data is averaged over a 30−40-minute moving interval. When calibration relies on addition or subtraction of data, the data are considered valid only for time periods when reliable data was collected at all required meters. For example, if an upstream meter ceases to function, there will not be enough data to calibrate the model for the basin between the two meters.

When this method fails to provide an adequate flow time series for a basin, the flow time series for subareas of the basin (mini-basins) are scaled up to provide a time series suitable for calibration of the basin. For example, if reliable data was collected from three mini-basin meters in the upstream area of a basin representing 80 percent of the basin's sewered area and the basin flow meter did not provide reasonable flow data, then the flow from the three upstream meters would be added together and factored up by 25 percent to represent an area equivalent to the total sewered area of the model basin. This approach assumes that the downstream portion of the basin is similar in I/I response to the upstream portion. The resulting scaled-up model is simulated and the flows are checked with downstream meters to ensure a good match continues to be achieved.

Appendix E explains how data is analyzed, how it is assessed for accuracy, and how it may be edited to correct for certain errors. It also explains what the patterns in the depth vs. velocity relationship reveal regarding the hydraulic responses at the meter site.

3.2.4 SCADA Data

Level data, gate positions, and flow calculations are obtained for King County regulator stations, which are located in the combined portion of the service area. The water surface elevation is generally measured by a bubbler. Maintenance staff regularly check the bubblers. During model calibration periods, the accuracy of level data in regulator stations is checked by two methods:

- The depth of flow is measured at the regulator and compared with the bubbler reading.
- Level data is checked when the weir elevation is exceeded. The shape of the level vs. time curve begins to level off when the weir elevation is reached, and it steepens when the level goes down past the weir level after a storm. Checking whether these indicators occur at the appropriate weir elevation can tell the modeler if the bubbler is reading the correct level or if the level should be adjusted. Operations staff will locate and correct any problems that are causing errors in the bubblier readings. If the level needs to be adjusted, the associated flow calculations through the gates and over the weirs are adjusted accordingly.

Pump stations record wet well levels and flow meter data. The accuracy of the data are checked during calibration periods:

- Checks on the bubbler readings are made by measuring down from weir levels and by comparing wet well levels during overflow events, as is done at regulator stations.
- Flow meter data is checked by doing fill-and-draw pump tests. The time to fill the wet well and the known wet well volume between each wet well level are used to compute flow that is pumped during the drawdown period. The volume estimate obtained from recording the level information over several drawdown cycles is compared with the flow meter readings during the drawdown periods. This comparison yields a good estimate of meter accuracy, which is useful in the calibration process.

3.2.5 Rainfall Data

Rainfall data is used to calibrate the hydrologic model and establish storm flow patterns to identify peak flows and their return intervals. Model calibration relies primarily on local rainfall data. Identification of peak flow intensities and return intervals relies on a continuous time series of rainfall data.

Figure 3-4 shows the location of the 17 City of Seattle rain gauges and the 72 King County rain gauges used to provide data for model calibration. The City of Seattle gauges are managed by SPU. The King County gauges are managed either by the Water and Land Resources Division (WLRD) or by WTD.

Rainfall data is checked to make sure that it is consecutive and that the highest values appear valid. Unreasonable values are flagged for further investigation. Notes by SPU staff are checked to see what was done to correct or replace erroneous data. Daily rainfall totals from all the gauges are graphed next to each other to reveal where rain gauges were not functioning or were giving unreasonably high values. In such cases, the data for a period may be replaced by the data from a nearby gauge.

Combined System Rainfall Data

City of Seattle gauges are used for calibration of the combined system. Within the city, there are more city (17) than county gauges (11). Rainfall records are obtained from the city and compared with data collected at WTD facilities to check for any major malfunctions of the gauges. The city has easily accessible rainfall records that date back to February 1978. Accessible county rainfall records date back to about 1998. The city record sets the maximum long-term simulation that can be performed for the combined system (up to 34 years now).

Figure 3-5 shows the location of the 17 City of Seattle rain gauges, with the associated Thiessen polygons indicating which gauges are used for each model basin.

Separated System Rainfall Data

King County's 72 rainfall gauges throughout the service area provide data for calibrating the separated system. For calibrating the model as a part of the I/I Control Program, the County used CALAMAR (*calcul de lames d'eau a l'aide du radar*, translated as "calculating rain with the aid of radar"). CALAMAR is a technology that uses both the County's network of rain gauges and radar images from the National Weather Service NEXRAD radar. The CALAMAR process allows a finer resolution in geographic coverage than is economically obtainable with rain gauges alone. However, using the nearest rain gauges only, or averaging between them, or using a Thiessen polygon method for allocating rainfall over a model basin has proven to be adequate in most cases, especially in regard to the frontal systems that dominate significant storm events in the Puget Sound Lowland. The County currently uses the nearest gauge for calibrating the MOUSE model and checks other nearby gauges if the sewer flow response appears inconsistent with the rain gauge data.

For prediction of the 20-year peak flow in the separated system, a 60-year rainfall record was used as a reasonable approximation of future rainfall frequency and intensity. The 60-year record is an extended time series (ETS) based on Seattle-Tacoma (Sea-Tac) International Airport precipitation records. The ETS is based on the longest continuous record of rainfall data for the area. For modeling, it was assumed that the ETS represents future rainfall patterns that are likely to occur in the service area. Such a record is valuable because of the strong influence that antecedent conditions have on I/I entering a pipe. The most effective way to simulate antecedent conditions is to use a model simulation that relies on an actual series of measured rainfall.

One of the primary features of the ETS rain data is that it contains scaled rainfall datasets based on zones of mean annual precipitation (MAP Zones). This allows the model to account for locations with no long-term rainfall record that have greater rainfall than Sea-Tac. A series of statistical scaling functions was used rather than a single scaling factor. The scaling functions provide for scaling rainfall amounts at the 2-hour, 6-hour, 24-hour, 72-hour, 10-day, 30-day, 90-

day, and annual durations.[1] Figure 3-6 shows the MAP Zones and their mean annual precipitation in the separated portion of the service area.

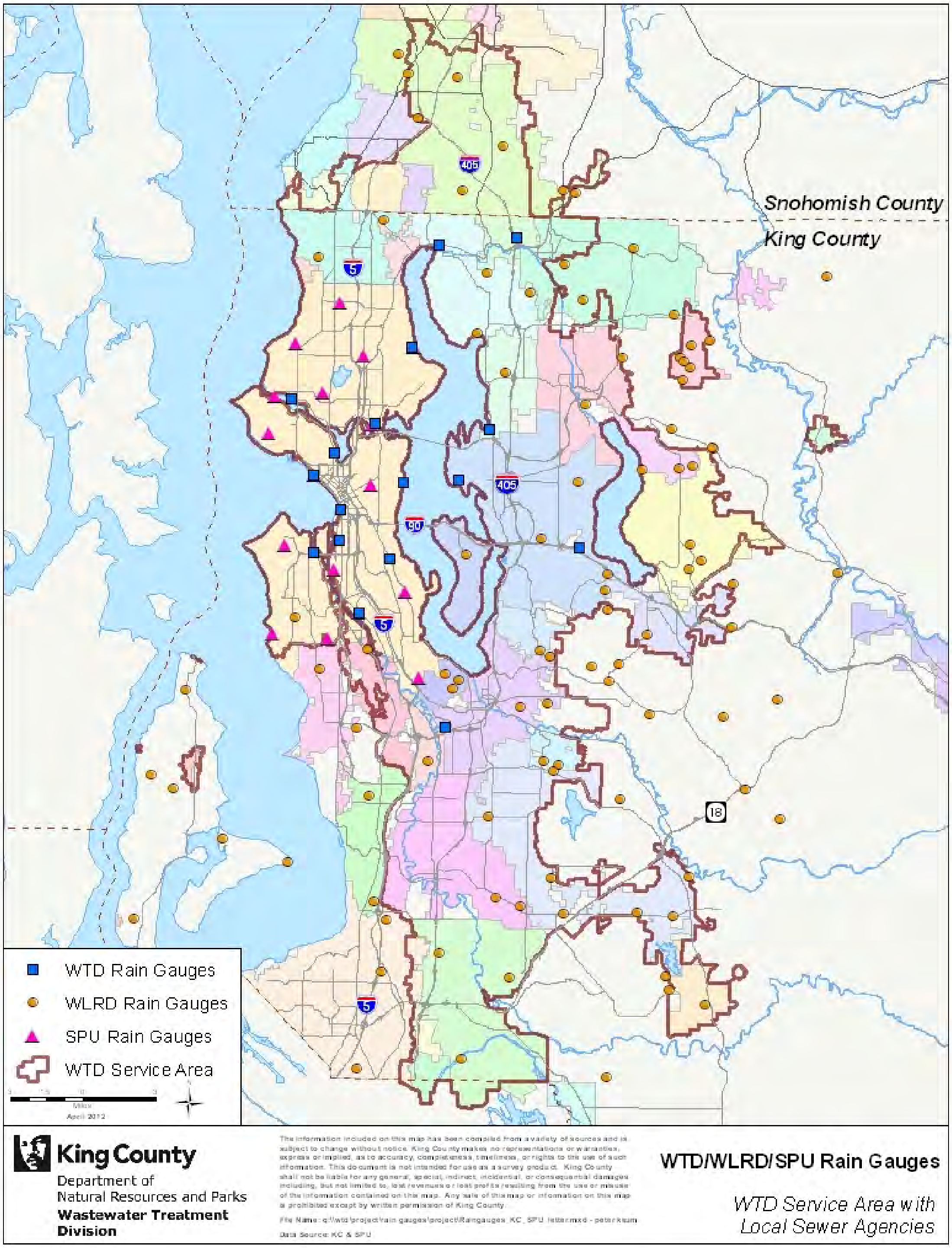


Figure 3-4. King County and City of Seattle Rain Gauge Locations

[1] For more information on the ETS and its development, see http://www.mgsengr.com/precipfrq.htm.

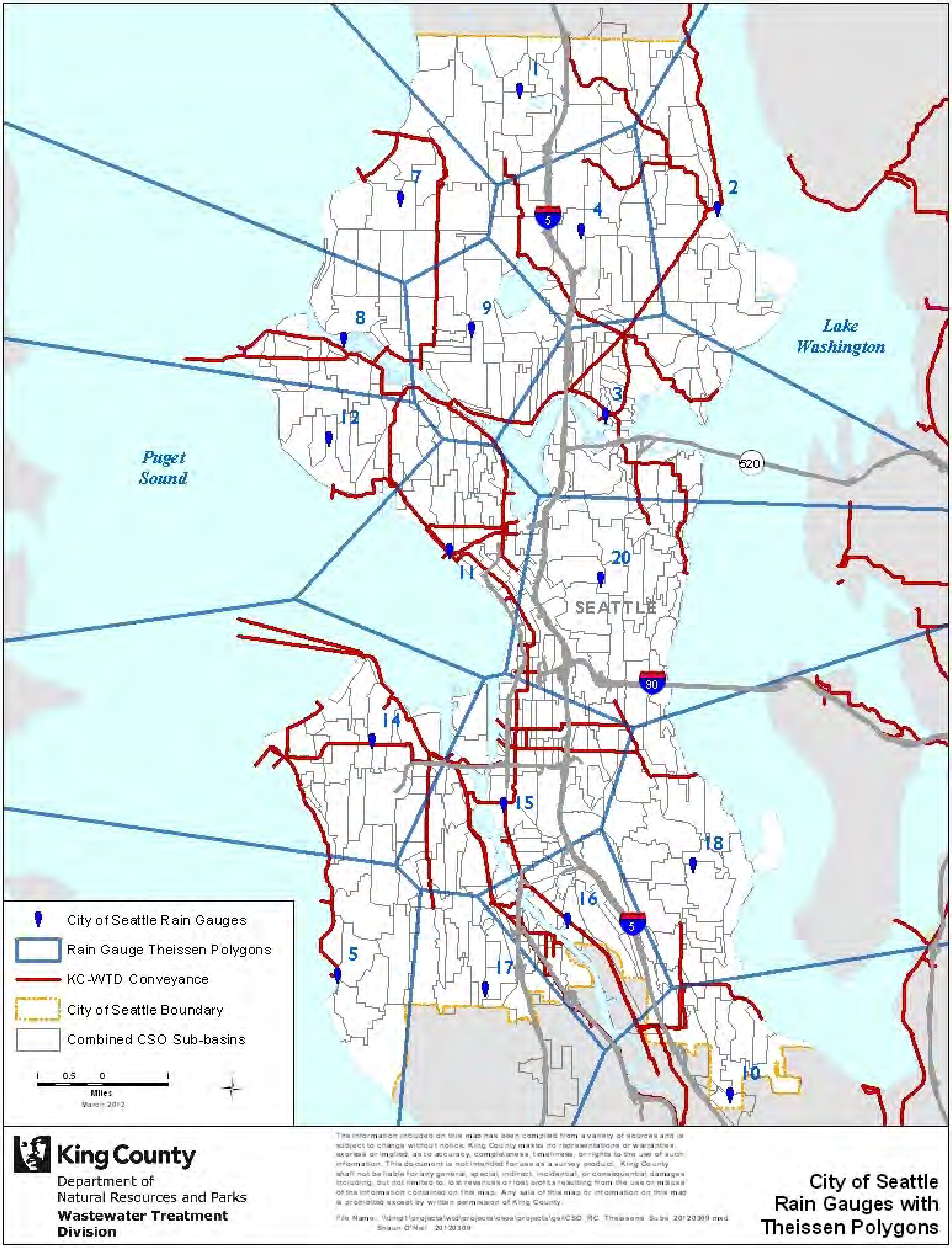


Figure 3-5. City of Seattle Rain Gauges with Corresponding Thiessen Polygons

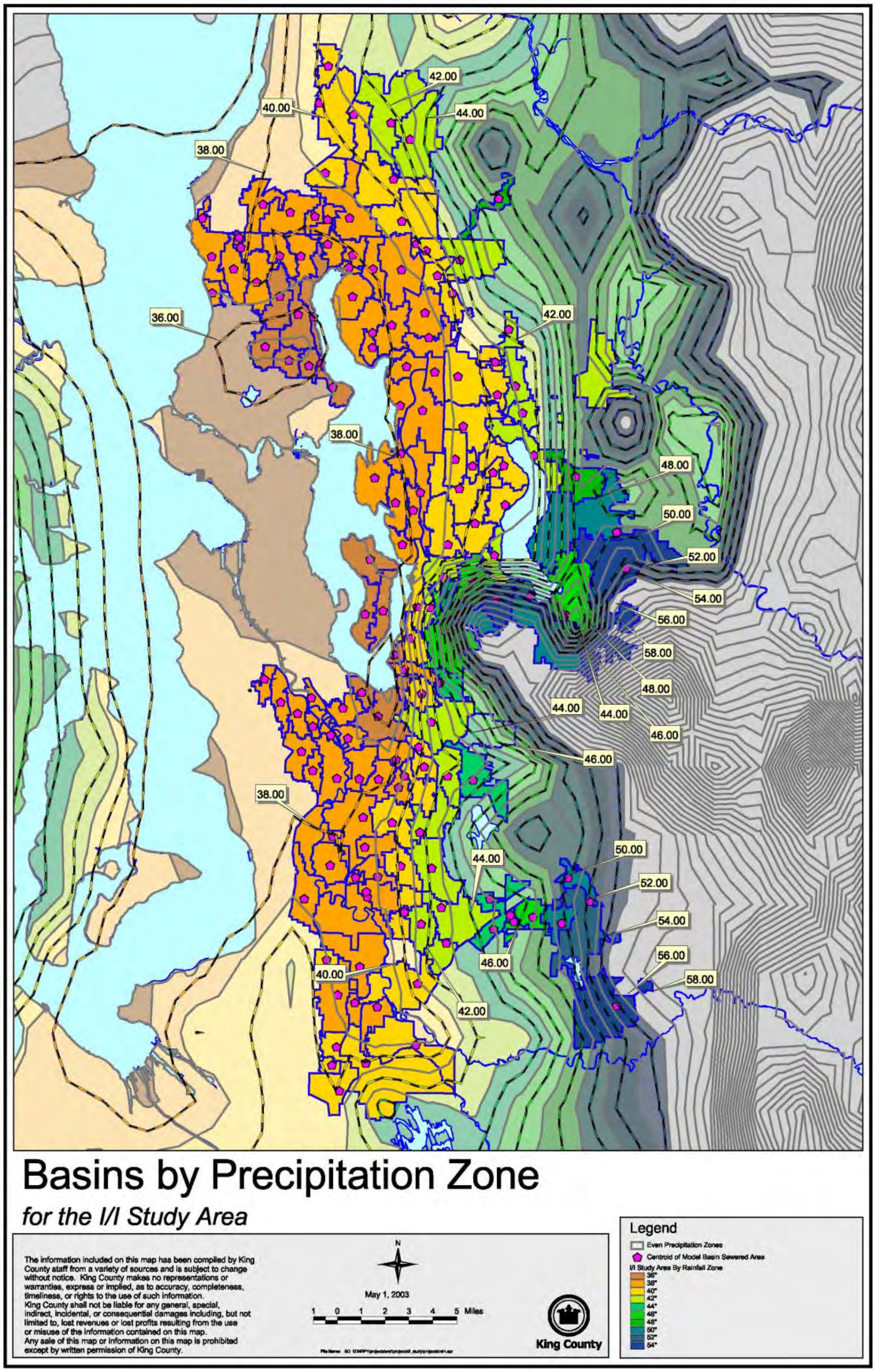


Figure 3-6. Mean Annual Precipitation Zones for the Separated System

3.2.6 Evaporation Data

For calibration of the MOUSE model in both the separated and combined systems, average monthly evaporation rates are used.

Daily evaporation data obtained from the Washington State University Experimental Field Station in Puyallup is used as model input for hydrologic model calibration. Data from this site are commonly used for continuous hydrologic modeling in the Puget Sound area, because evaporation does not vary greatly in the Puget Sound lowlands. This site is the closest location with a long-term evaporation record and, therefore, it is deemed to be a good source of evaporation data for the modeling effort.

For the long-term simulations, evaporation data is supplied with the rainfall files and is generated based on long-term Puyallup weather station data.

3.3 Calibrating the Hydrologic Model

Model calibration is an iterative process of finding a set of model parameters that optimize statistical measures of fit between observed data and modeled data. An initial model parameter set is obtained from a general set recommended by the model developer, literature, or a previous model having similar basin characteristics.

MOUSE RDII is a continuous deterministic, lumped-parameter, conceptual hydrologic model. It uses a conceptual characterization of the physical processes involved in the transformation of inputs (basin characteristics, rainfall, and evaporation) to outputs based on the various parameters in the model. During calibration, the values of non-measurable parameters are adjusted to satisfy the input/output relationship of the modeled system. To do this, the model is run using incremental iterations of values for one or more of the unknown parameters.

Basin calibration entails adjusting the model parameters that control the magnitude and shape of simulated stormwater/groundwater flows. For example, when peak flows are highly correlated with rainfall intensity, as in a combined system, then the impervious area connected to the sewer is the primary parameter used in calibration. When a slower response is indicated by the metered flow, then the rainfall-dependent I/I parameters become the focus in order to match the slower rise and fall of sewer flow during and after a storm. The outputs from successive model iterations are compared with measured values for the output parameters (namely, flow). When the modeled output closely and consistently matches the measured flows, the model is considered calibrated and ready to use in long-term simulations. A match of modeled to measured peak flows within 5 percent is desirable, although not always achievable for all storm events. When all storm flows are not matched exactly, a balance of overestimating some storms and underestimating others is preferable to always overestimating or always underestimating the hydrologic response.

The procedure for selecting parameter values to calibrate each flow component is complex. It requires a detailed understanding of the relationship between parameter values defined in MOUSE RDII and the resulting simulated flow response. The calibration procedure begins by defining the less variable components of flow, such as dry-weather flow. Initial steps involve comparing and calibrating model simulations to flow records collected during periods of dry weather. After dry-weather calibration is completed, the effort focuses on matching simulation results to recorded wet-weather flows. In general, the procedure involves targeting particular periods of the observed flow record to match hydrograph volume, then matching peak flow and shape.

The following sections provide detail on the various steps in the basin calibration process.

3.3.1 Dry-Weather Calibration

Dry-weather calibration helps determine which portion of the measured flows is a result of rainfall and which portion is a result of day-to-day water use patterns. Flows measured during an extended dry period of the monitoring timeframe (preferably in the summer) are used to define and calibrate dry-weather flow input into the model in both the combined and separated portions of the service area. Population can provide an estimate of the wastewater contribution in the absence of flow data collected over dry periods.

Dry-weather flows are represented in MOUSE using three components (Figure 3-7):

- The diurnal flow pattern above the daily minimum flow
- The portion of the daily minimum flow estimated to be wastewater
- The portion of the daily minimum flow estimated to be dry-weather infiltration (base infiltration)

Dry-weather diurnal patterns are established for weekdays, Saturdays, and Sundays for each of the basins based on observed flow data, which varies depending on the mix of commercial and residential land use in the model basin.

Base infiltration is considered a component of I/I that is related to groundwater and that could include leaking water lines, leaking plumbing fixtures, and springs. It may be a seasonal phenomenon because rainfall affects groundwater levels, but generally remains relatively steady over weeks and months. WTD uses the Stevens/Schutzbach equation (1.1) for estimating base infiltration for each basin. This method uses a curve fitting technique to estimate base infiltration.

$$BI = \frac{0.4 * MDF}{1 - 0.6 * \left(MDF / ADDF \right)^{ADDF^{0.7}}} \qquad (1.1)$$

Where:

BI = base infiltration
ADDF = average flow
MDF = minimum flow of the dry-day hydrograph

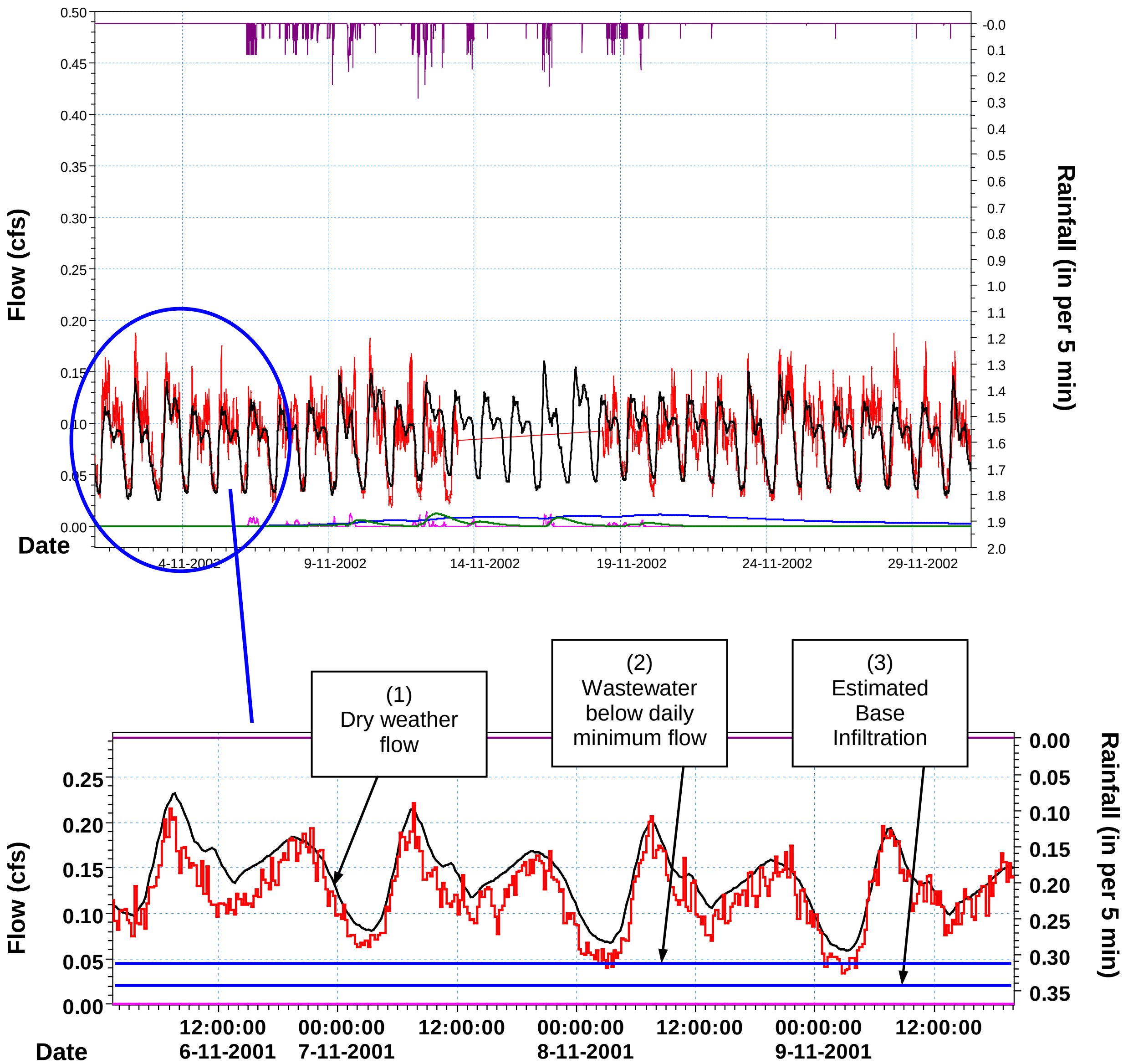


Figure 3-7. Dry Weather Flow Calibration for Combined and Separated Systems

3.3.2 Wet-Weather Calibration

MOUSE wet-weather I/I components can be grouped into three distinct responses: fast response, rapid infiltration, and slow infiltration. Table 3-1 presents each of the three response types and the components in the MOUSE RDII model used to characterize each response. The model can be calibrated using an automated optimization program or done by "trial and error." The automated process is preferred because it usually reduces the time to arrive at a good calibration. Basins are first calibrated using the optimization program and then manually to provide a better visual fit or a better fit to the most pertinent storm events.

Table 3-1. Types of Flow Response to Rainfall

Response Type	Flow Characteristics in Response to Rainfall	Suspected Sources	MOUSE RDII Model Component
Fast response	Sudden increase in flow; highly correlated with rainfall intensity	**Inflow:** catch basins, roof drains, or other direct connections **Infiltration:** sources that respond rapidly to rainfall, such as shallow side sewers	Surface Runoff: Model B for combined system; Model A for separated system
Rapid infiltration	Increase in flow during a rainfall event, with gradual reduction in flow over a relatively short period after the event	**Infiltration:** shallow sources such as laterals, side sewers, and foundation drains; manholes and mains to a lesser extent	Overland Flow
Slow infiltration	Slow increases in flow during a storm; increased flow may take several days or weeks to decline after a storm	**Infiltration:** deep sources, such as manholes and mains; reflects a rising groundwater level	Interflow and Groundwater Flow

Automated Calibration

King County uses the Model-Independent Parameter Estimation (PEST) computer optimization code, fifth edition (Doherty, 2004), for automated calibration. PEST is a freeware program that implements a gradient search method to find the optimum parameter set that minimizes the sum of the square of the residuals (R^2). PEST is widely used in groundwater modeling to optimize spatial variations in hydraulic conductivity (Doherty, 2003; Dubus et al., 2004; and Keating et al., 2003).

PEST has several options for constraining parameters to a given set of rules; these constraints also improve stability in the optimization routine. After several uses, the most appropriate constraining option appears to be the estimation routine. In estimation mode, the program maintains a specified parameter constraint (relation) unless a better fit can be obtained by deviating from the constraint; PEST imposes a penalty for deviating from the parameter constraint. The penalty adds the deviated amount (difference between used parameter value and that specified in the constraint, ΔP). PEST optimizes on the combined errors ($\Delta P + R^2$, where R^2 is the sum of the squares of the residuals). As long as the sum ($\Delta P + R^2$) continues to decrease with increasing ΔP, PEST will continue to deviate from the imposed constraint. This condition implies that the final optimized parameter is justified because the deviation would not be imposed unless an improvement in fit occurred (Doherty, 2004).

If parts of the meter data do not match as well as others, the modeler can adjust weightings associated with different flow ranges. For example, most of the meter data may match but the peak flows do not match as well. Since the duration of high flows is usually much shorter than the duration of lower flows, the errors associated with not matching the higher data may not carry much weight in the optimization process. The weightings of the high flows, therefore, are usually raised so that PEST will give more value to matching the higher flows. (PEST will increase the penalties associated with the errors in the high flow region of the meter data.)

Manual Calibration

Once the automated calibration is completed, the modeler reviews the results to ensure that a good fit to most of the flow data has been obtained. If significant discrepancies exist between the model output and the flow data, the modeler may manually adjust parameters to improve the calibration. During the process, each wet-weather flow component is individually “tuned” (partially calibrated) from the slow infiltration response to the fast response and then an overall final tuning is performed:

- **Slow infiltration response tuning**. Tuning for the slow infiltration response is done by matching the diurnal dry-weather flow pattern to the flow data before and after storm events and at the end of the monitoring period. When the slow infiltration response component is adjusted, the dry-weather flow pattern matches the flow data between the storm events. This approach is a way of separating the slow infiltration response component into flows that primarily depend on the addition of slow infiltration.
- **Rapid infiltration response tuning.** Tuning for the rapid infiltration response component is done by matching storm event volumes and shapes, paying particular attention to matching the flow recession of the storm events. The rapid infiltration component is primarily responsible for the recession limb of the storm event. Measured flow responses to all available storms are used for calibration.
- **Fast response tuning.** The last component to be tuned is the fast response component. The fast response component is tuned to match storm peaks. Both the shape and peak of the hydrographs should be matched; this effort involves fine-tuning the rapid response. When there is difficulty matching the flow responses in all the storms, more emphasis is placed on matching flow during large, rather than small, storms. In the combined sewer areas, storms of approximately the one-year and two-year return periods are given more weight when all storm responses cannot be matched.
- **Final tuning.** After all components are tuned, they are adjusted together until the best model-to-flow data “fit” is achieved. Reduced emphasis is placed on periods with unreliable or inconsistent diurnal wastewater flow patterns (such as holidays).

Figure 3-8 presents a plot of simulated flow versus measured flow. Rainfall is included on the reverse second Y-axis for reference. Also included for reference are the wet-weather I/I components: fast response, rapid infiltration, and slow infiltration. Figure 3-9 displays a “close-up” view of a one-week period with the modeling components making up the total modeled flow in a combined system. Figure 3-10 displays the same information for a separated system, which has a smaller fast response component than a combined system, because less surface runoff is directly connected to the sewer system.

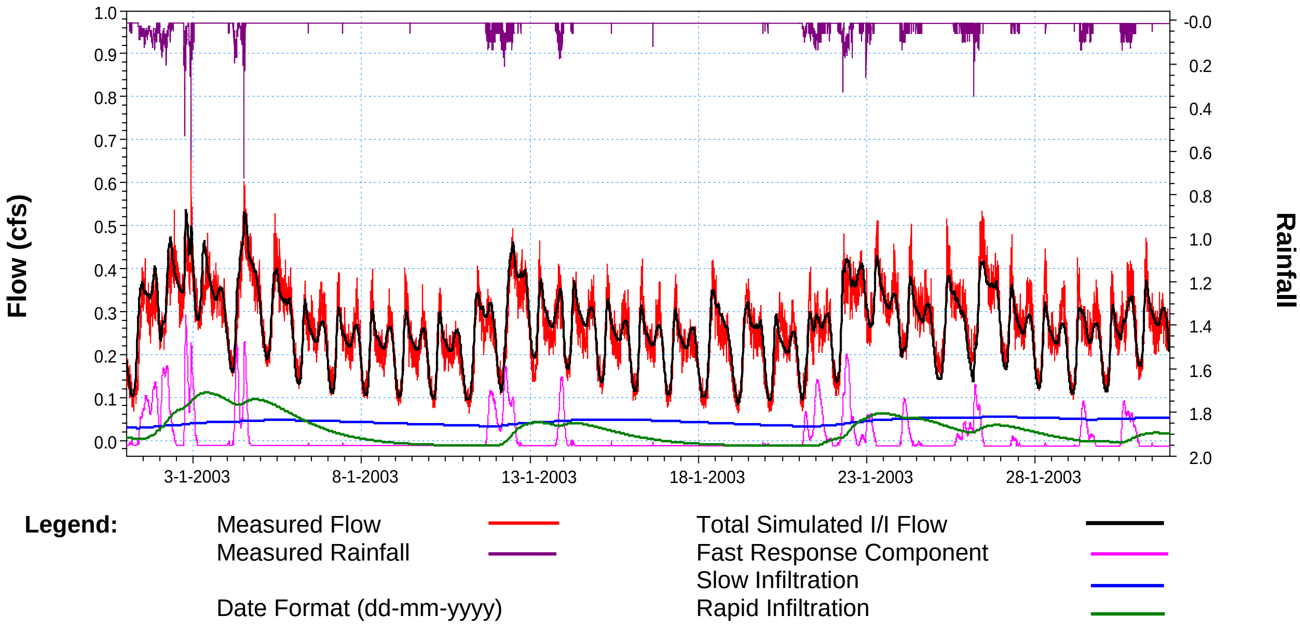


Figure 3-8. Comparison of Modeled Flow Data to Measured Flow Data

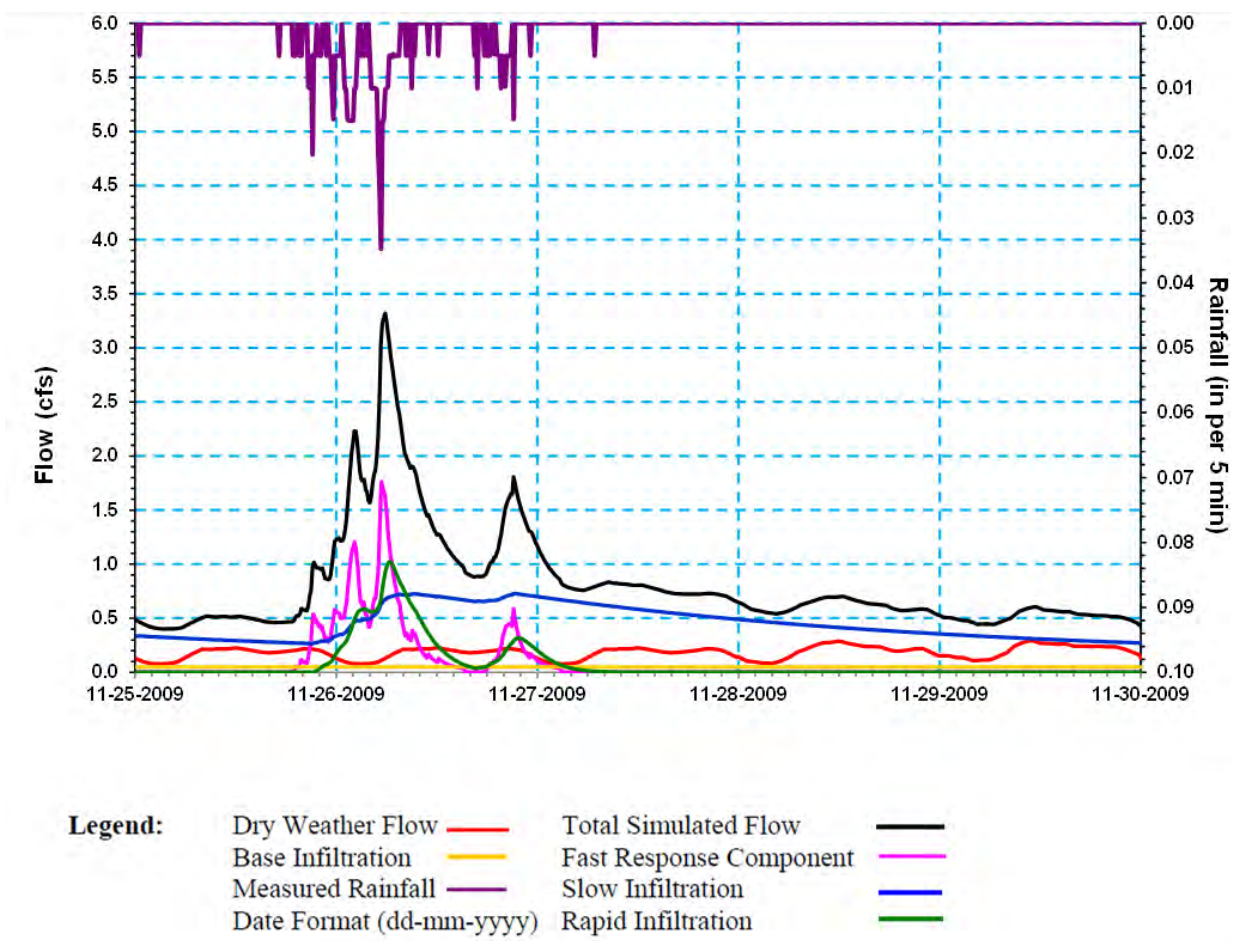
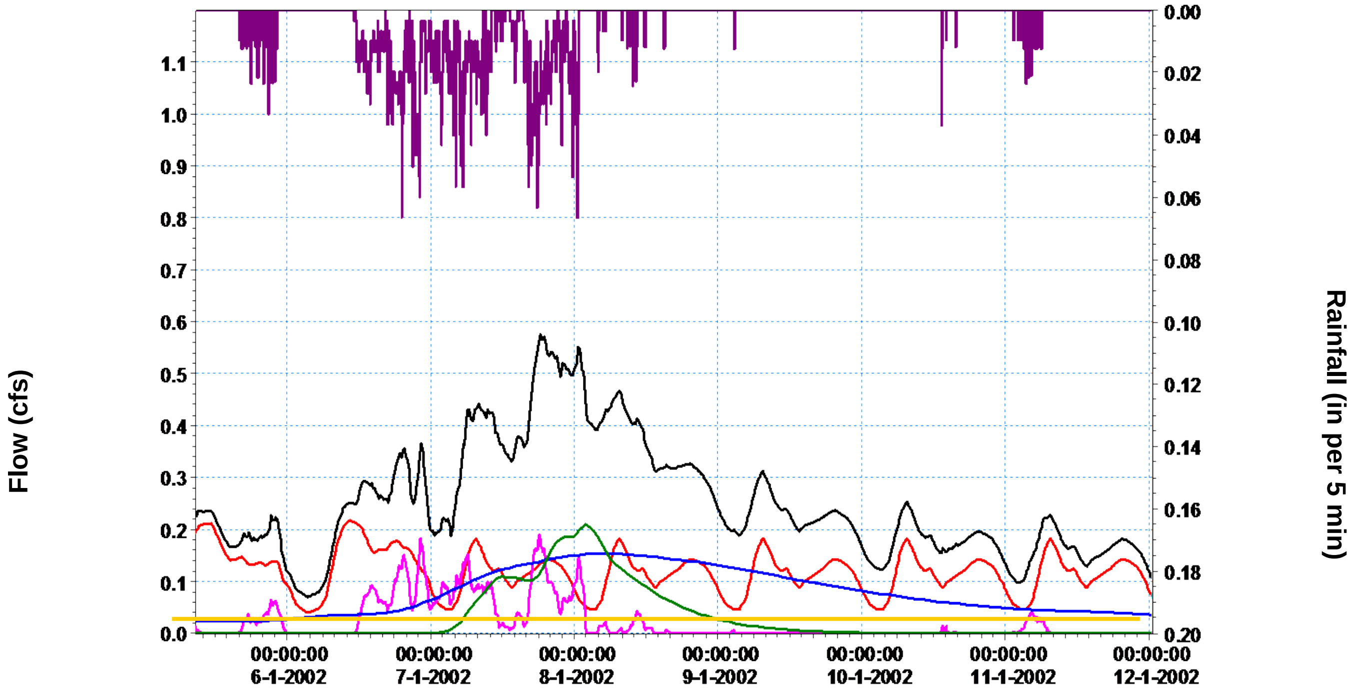


Figure 3-9. Simulated Flow Components in a Combined System



Legend:

Dry Weather Flow (red)	Total Simulated Flow (black)
Base Infiltration (yellow)	Fast Response Component (magenta)
Measured Rainfall (purple)	Slow Infiltration (blue)
Date Format (dd-mm-yyyy)	Rapid Infiltration (green)

Figure 3-10. Simulated Flow Components in a Separated System

Measuring How Well the Model Matches the Flow Data

Four statistical measures of fit are used to quantify how well the model matches the measured flow data for basin modeling in King County:

$$R^2 = \sum \left(q_{obs} - q_{mdl} \right)^2 \tag{1.2}$$

$$b = \frac{1}{N} \sum \left(\frac{q_{mdl} - q_{obs}}{q_{obs}} \right) \tag{1.3}$$

$$wr^2 = \begin{cases} |m| r^2 & \text{for} \quad m \le 1 \\ |m|^{-1} r^2 & \text{for} \quad m > 1 \end{cases} \tag{1.4}$$

$$|b| = \frac{1}{N} \sum_i \left| \sum_{M_i} \frac{q_{mdl} - q_{obs}}{q_{obs}} \right| \tag{1.5}$$

Where:

R^2 = sum of the squares of the residuals
q_{obs} = observed flow
qmdl = simulated flow
b = normalized bias
N = total number of observations
wr^2 = weighted coefficient of determination (r^2)
m = line slope between q_{obs} verses q_{mdl}
|b| = absolute value of the group bias for the i events[2]
M_i = number of observations in each storm event

The sum of the residuals (R^2) is the optimization function used in linear regression and is the minimization function used by the optimization program. The weighted coefficient of determination (wr^2) is an overall good estimator of fit but should be used with other estimators of fit (Krause et al., 2005). Visual inspections are also part of the calibration process.

3.4 Verify Calibrations

After simulating basin peak flow responses with the hydrologic model and calibrating the output for each basin, King County uses the MOUSE HD hydraulic model to spot-check the original basin calibrations by comparing combined flows from more than one basin to flow measurements in the regional conveyance system. To do this, basin flows (generally depicting flow response from local agency systems) are placed at appropriate locations into the hydraulic model. Connections to the conveyance system model (generally depicting county conveyance pipes) vary from a single point to as many as nine points per basin.

Comparing these measured flows allows the County to (1) make adjustments to both base wastewater flow and I/I model parameters to better simulate the base wastewater and I/I contributions to the system and (2) check for metering or modeling problems that need to be investigated.

3.5 Simulate Long-Term Flow Response in Basins

After the hydrologic model is calibrated so that parameters describing each basin represent the processes that transform rainfall to I/I, the model is used to simulate flow response from a long-term rainfall time series that includes large infrequent and smaller more frequent rainfall events.

An over 30-year rainfall record is used for the combined system to determine CSO responses over a wide variety of rainfall conditions and over a large number of years. The resulting output provides annual statistics, which are used for estimating one-year CSO volumes and one-year peak flow rates.

A 60-year hourly rainfall record is used to simulate a time series of flows from each separated system basin outlet. This long-term hydrograph is used to determine flow frequency, including the 20-year peak I/I flow from each basin. A plot can be made of peak flow magnitude versus return period such as the one shown in Figure 3-11. A best-fit curve is used to interpolate between plotted points with a return period greater than one year. The estimated 20-year peak

[2] |b| is an important parameter for propagating model calibration errors into estimated storage requirements (Schock, 2006b).

flow from each basin is determined by selecting the flow from the plotted best-fit curve with a return period of 20 years.

A flow value that exceeds the dry-weather diurnal peak flow is selected as a threshold for evaluating the return intervals. All peak flows, not just the annual peaks, above this threshold are included in determining the return period for flows. The resulting selection of peak flows is termed a “partial duration series.”

Analysis that compared subtracted peak I/I from peak flow with the same return period revealed that the 20-year peak flow is the sum of the peak 20-year I/I plus 1.3–1.35 times the average base wastewater flow. This 1.35 value is referred to as the “base flow peaking factor” and is used to estimate future peak flows.

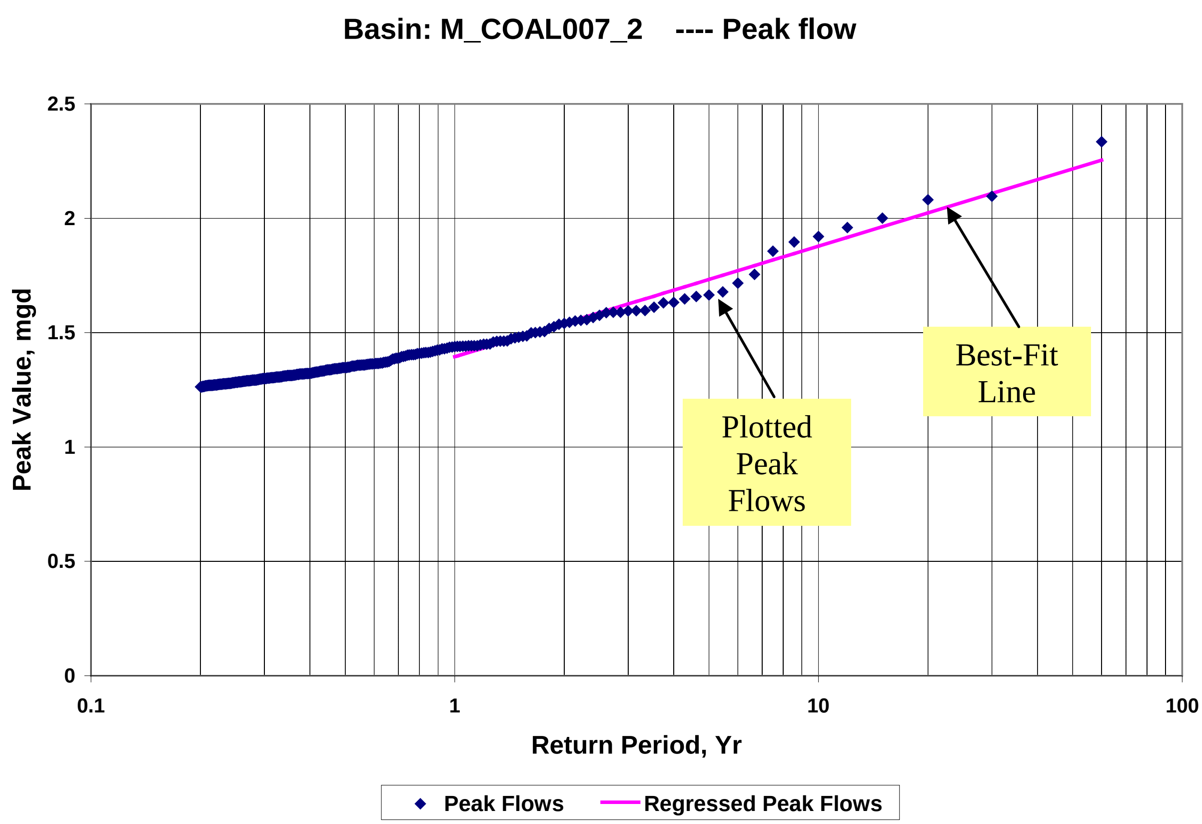


Figure 3-11. Assigning Return Intervals to Simulated Peak Flows

3.6 Estimate Current-Year Peak Flows

Once the hydrologic and hydraulic models are calibrated, long-term simulations are run with the hydraulic model (MOUSE HD) to estimate 20-year and 1-year peak flow demands on the system in the current year.

3.6.1 Combined System

For the combined system, a long-term run is performed with the longest rainfall record available in the combined system. City of Seattle rainfall data, recorded minute-by minute, is available at city gauges beginning February 1978, so as of 2012, approximately 34 years are now available for the long-term runs.

The results of the long-term runs reveal the number and sizes of overflows in each year. The average frequency of CSOs is computed and the volume needed to bring the CSO location into one-per-year control is obtained, as explained in subsequent paragraphs . Peak overflow rates are analyzed similarly to the separated system analysis such that flows are plotted with associated return intervals as in Figure 3-11. Peak overflow rates associated with each CSO event are analyzed so that conveyance can be sized appropriately to capture all the overflow volume associated with all storms smaller than a 1-year CSO event.

3.6.2 Separated System

For the separated portion of the system, the 60-year output from each basin is condensed into a shorter timeframe to simulate roughly 200 storm events through the system. Care is taken in selecting the timeframes to ensure that all back-to-back storm events are included but that the system can adequately drain and come to normal conditions when extended dry weather precedes subsequent storms. The output from this long-term simulation is analyzed to determine the flow versus return interval curve at all parts of the separated conveyance system.

The MOUSE HD model simulates attenuation factors for flow as it travels through the King County system. These attenuation factors are used to adjust the cumulative model basin 20-year peak flows in the base year (e.g., 2010) to match the 20-year peak flows from MOUSE HD. This attenuation accounts for the following:

- Travel time along trunks
- Non-coincidence of peaks arriving from adjoining trunks
- Temporal variation of the 20-year peak flow event occurring within the 60-year rainfall record (that is, not all basins’ 20-year peak flows were caused by the same storm

4.0. ESTIMATING FUTURE PEAK FLOWS AND REQUIRED CSO CONTROL VOLUMES

CSO control volumes are estimated using long-term continuous modeling and evaluating the results to achieve the desired level of control. A hydraulic model is set up to simulate the existing system, with all pertinent controls programmed in. The resulting CSOs can be controlled using different methods, including the following:

- Diverting overflow to a storage facility
- Disconnecting basin areas that produce overflow
- Diverting overflows into a high-rate treatment facility
- Implementing basin modifications that attenuate the flow

The CSO storage or treatment analysis is done for each type of CSO control being considered.

4.1 Assumptions Regarding Future Flows

King County and SPU are working together to optimize the control of the combined system so that new CSO facilities and controls do not adversely affect the other agency's system performance and that optimally sized facilities are constructed. Modeling will likely play a key role in determining the most effective CSO control strategies.

For modeling future peak flows, WTD assumes that I/I will not increase. The combined system is designed to receive a large percentage of the surface runoff, which is the dominant factor contributing to peak flow and to CSOs. Degradation of pipes will not increase the amount of surface runoff entering the pipes.

WTD also assumes that the current condition reflects the ultimate buildout condition in the combined sewer area. The reasons for this assumption are as follows:

- The city of Seattle is completely developed.
- Water conservation has lowered water consumption rates, even when population has increased.
- Seattle's Stormwater Ordinance requires stormwater detention when impervious area is added or a sizeable impervious area is redeveloped.

Although peak flows may decrease in the future because of the stormwater ordinance, WTD takes a conservative stance and assumes that future peak flows will be similar to current peak flows. During each CSO control project design, WTD will assess the potential impacts of planned redevelopment or planned "retrofit" work on SPU's collection system in the basin. For example, if SPU plans to clean pipes that are mostly blocked with sediment, WTD will assess whether the cleaning will affect flows to the county system. Fixing improperly functioning hydrobrakes in the SPU system could also affect flows.

4.2 Entering Data into the Hydraulic Models

The physical description of the combined sewer system is entered into hydraulic models:

- Pipe sizes, lengths, diameters, invert elevations, and other features are entered into the UNSTDY input file from as-built drawings. The same information is entered into the MOUSE HD input files from WTD's GIS database, also populated from as-built drawings. The plan and profile views in MOUSE HD allow the modeler to quickly find gross errors in the data. For instance, an adverse slope in a gravity pipe section alerts the modeler to check the as-built drawings to ensure the data is correct or to find and input the correct data.
- Regulator gate dimensions, sill inverts, outfall gate information, and weir locations and lengths are obtained from as-built drawings. Weir and gate coefficients are obtained from the West Point flow calculation program. Weirs are placed in the MOUSE HD and UNSTDY models in different pipe sections than the regulator and outfall gates to minimize effects of model instability.
- Control elevations such as trunk and interceptor set points are placed into the UNSTDY and MOUSE HD input files. These set points are obtained from the West Point control system. A dll (dynamic link library) is being written to control the gates in MOUSE HD to provide flexibility in simulating all the control features in WTD's conveyance system.
- Pump wet well operating levels are also obtained from the SCADA system. They are input into the hydraulic models to simulate pump stations operations as closely as possible.

4.3 Estimating Storage Volumes

4.3.1 Calculating Storage Volumes

Storage size or volume is based on controlling a portion of flows that otherwise would overflow the conveyance system.

In situations where there is a fixed downstream capacity, overflow volumes are computed when the total basin flow exceeds that downstream capacity. The Hanford @ Rainier basin, for example, has a long trunk (the Hanford Tunnel) with a fixed capacity located just downstream of the overflow point. Figure 4-1 shows the resulting overflow during one storm at a location that has this characteristic.

Other CSO locations may contain regulator gates that restrict the flow into the interceptor when the interceptor is nearly full. In such a case, as along the Elliott Bay Interceptor, flows from the basin are totally cut off from the downstream interceptor and overflows occur when the upstream in-line storage volume of the trunk is exceeded.

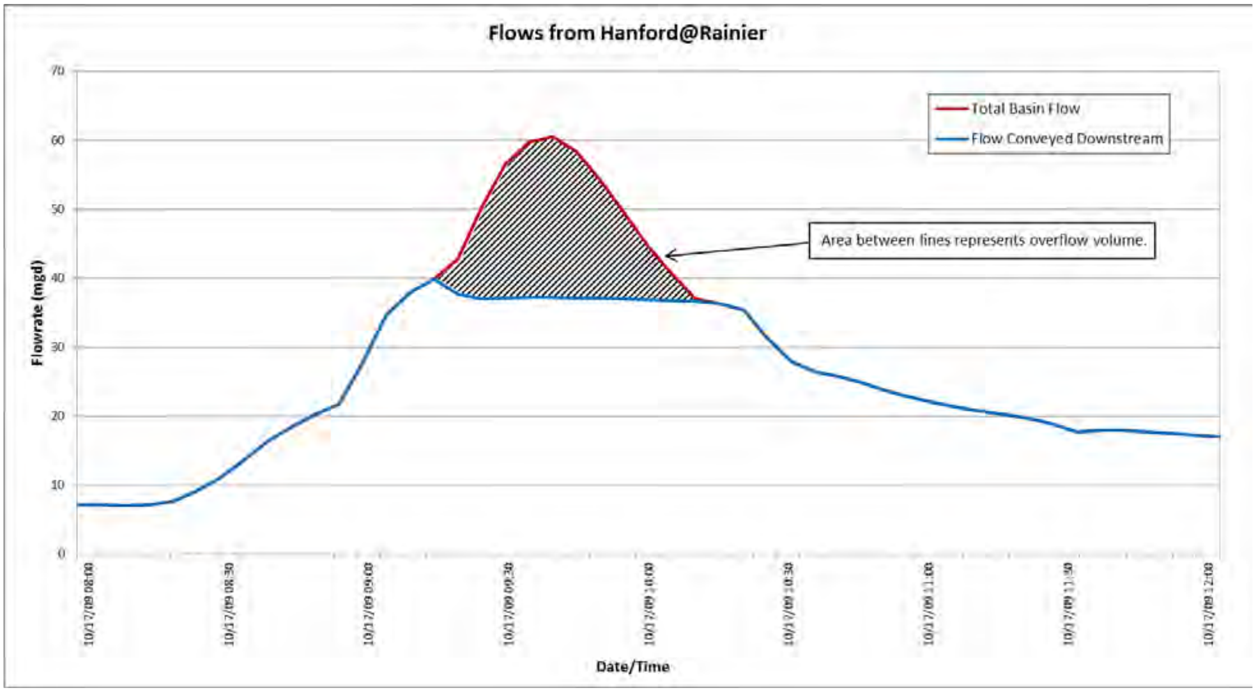


Figure 4-1. CSO Storage Volume Example

4.3.2 Ranking Storage Volumes

The hydraulic model simulates the flow in the trunks and interceptor system, and a long-term time series of overflows is marked for further analysis. In accordance with Ecology guidance, the overflow events in this long-term record are separated so that there is at least 24 hours between overflow events. Overflows that occur within 24 hours of a previous overflow are aggregated and considered part of the previous overflow event. The overflow volumes are then ranked from largest to smallest and return intervals for each event are calculated. The return interval is calculated as follows:

$$RI = M/R$$

Where:

RI = return interval
R= rank
M = number of years

Figure 4-2 is an example graph of the return intervals associated with each control volume.

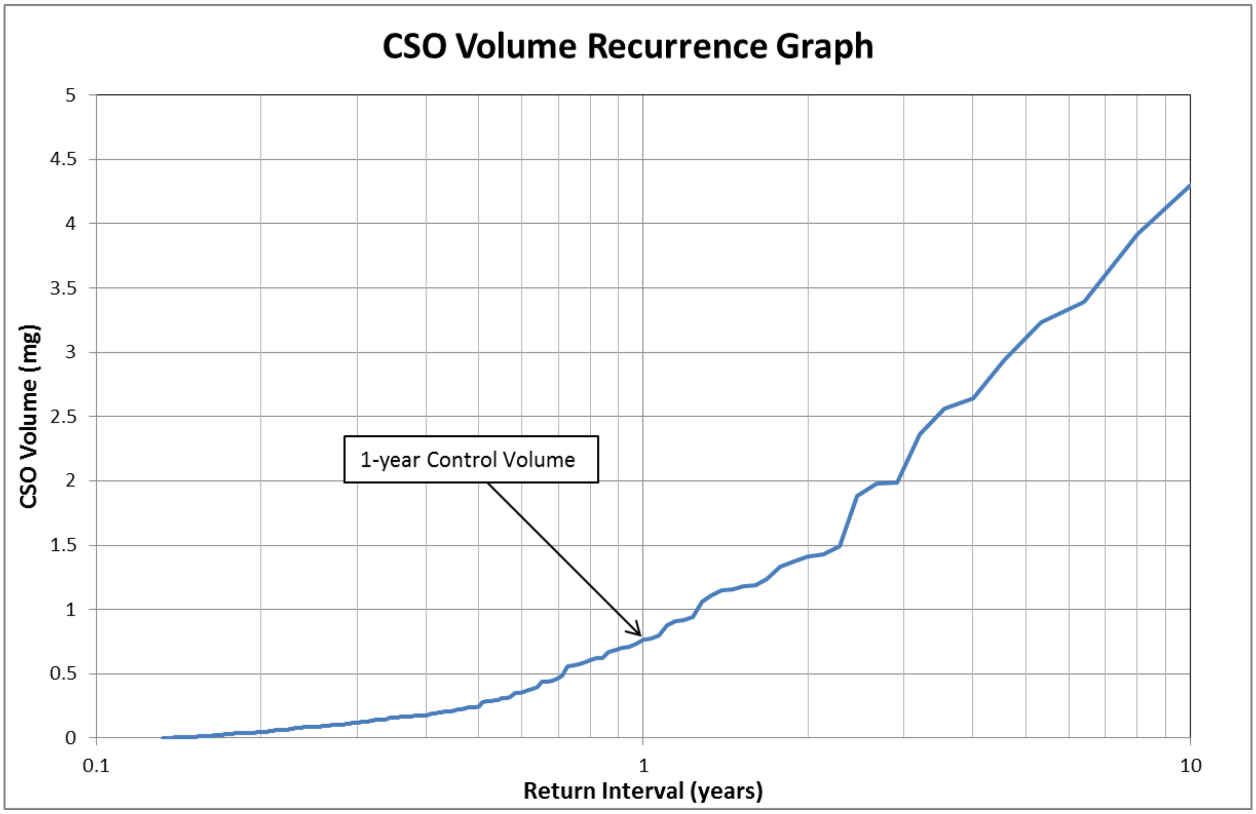


Figure 4-2. CSO Storage Volume Return Graph

Analysis is done to determine the size of storage needed to meet an average one-untreated-discharge-per-year criteria over the long-term simulation and in any given 20-year period during the over 30-year simulation. Since downstream conveyance capacity often affects the size of required storage facilities, model output information can be formatted to display this relationship. For example, a graph of the required CSO storage volume for one configuration of the South Magnolia CSO Project is presented in Figure 4-3. The relationship between storage size required and the HDD (conveyance) capacity is shown both for the long-term average and for the worst 20-year period in the simulation. The 20-year moving average is how compliance is measured in meeting the one-untreated-discharge-per-year regulatory requirement.

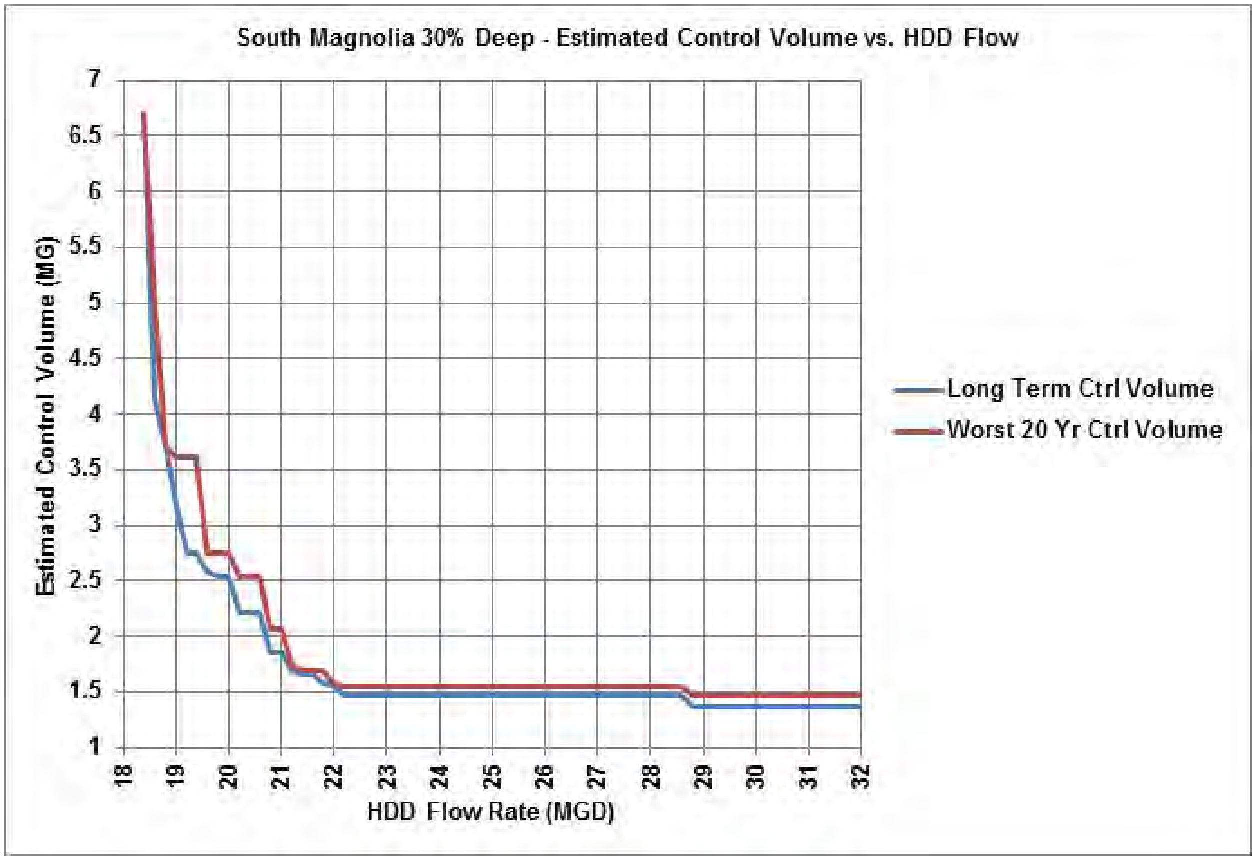


Figure 4-3. CSO Storage vs. Downstream Conveyance (HDD) Capacity

4.3.3 Considering Conveyance Capacity in Sizing Storage Facilities

To achieve a one-year level of control over the long-term, the one-year CSO volume is selected for initial sizing of the CSO storage facility. Modelers also provide the peak overflow rate associated with each overflow volume in the long-term record. Some storms with smaller volumes than the one-year CSO volume may have peak overflow rates that are higher than the storm resulting in the one-year CSO volume. Therefore, when sizing a storage tank, it is important to determine the peak flow rate of all storms equal to or less than the one-year control volume so that sufficient conveyance can be provided to capture all the smaller storms. If conveyance to the CSO storage facility is long, it may be more cost effective to increase the size of storage to capture larger CSO events than to try to convey the maximum flow of all storms smaller than the one-year storm by volume.

4.3.4 Determining Final Storage Size

Estimated one-year storage volume is used for initial screening of project alternatives. After narrowing the number of alternatives to two to four, two storage estimates are provided that includes the following:

- The long-term one-year CSO volume (over 30 years).
- The storage volume required to limit overflows to 20 untreated CSO events in the worst 20-year period.

The project manager for a CSO control project will present a preferred alternative and the range of sizes to the WTD Capital Systems Team (CST) for approval. The following information is provided to CST for each of the final alternatives to facilitate the decision-making process:

- Reliability of flow monitoring data
- Site constraints
- Availability of alternatives for off-site flow reduction
- Opportunities to cost-effectively phase development of storage
- Potential risks of storage sizing on overflows at other sites

The CST decides on the preferred project alternative and specifies the project size to be carried forward into predesign and final design.

4.4 Estimating CSO Treatment Sizes

4.4.1 Determining Treatment Plant Flow Rates

CSO treatment facilities are sized based on peak flow rates expected at the treatment plant site. Treatment must accommodate the peak flow with a one-year return interval. This peak flow is determined by plotting the peak flow return interval curve (as in Figure 3-11) and selecting the flow with the one-year interval. The entire flow could be treated at the CSO treatment facility or through a storage/treatment combination where the peak flow is attenuated by upstream equalization storage. The storage/treatment facility combination reduces the required size of the treatment facility by treating the one-year peak flow but not the instantaneous peak flow.

A curve of storage volume vs . peak treatment rate is generated for proposed CSO/treatment facilities. The analysis assumes that flow will be conveyed to the treatment facility until capacity is reached and that flow in excess of the treatment capacity will fill the storage volume.

Figure 4-4 shows the relationship between required treatment capacity for equalization storage volumes provided for a South Michigan CSO Treatment facility. This information, generated from the long-term modeling simulation, is then used by design engineers to determine the optimum combination (usually least-cost) of treatment facility and storage volume.

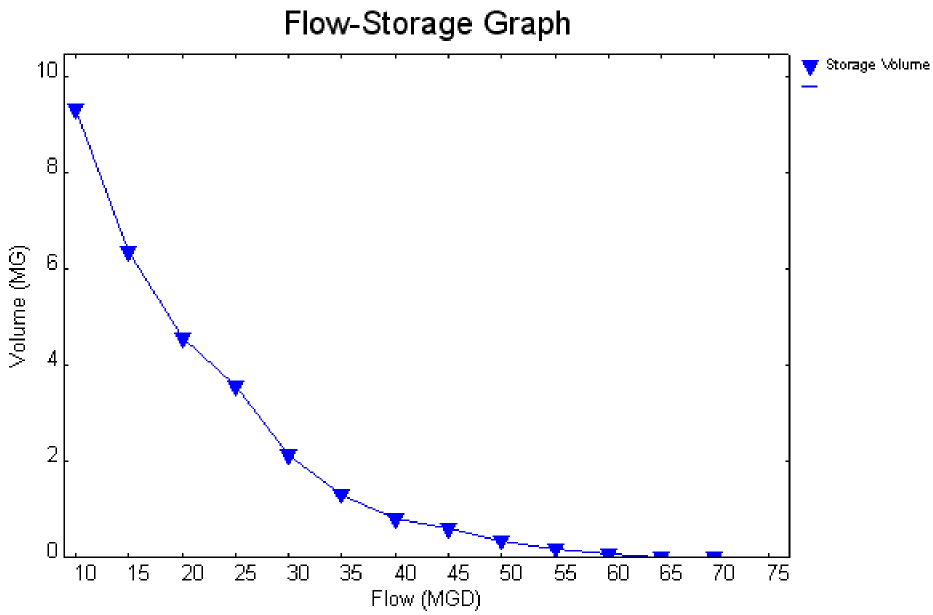


Figure 4-4. Storage/Treatment Flow Relationship for a South Michigan CSO Treatment Facility

4.5 Green Stormwater Infrastructure and/or Stormwater Separation

The impact of removing stormwater from the combined sewer system can also be estimated by removing impervious area in the model from the basins upstream of a CSO location. A curve can be generated showing the resulting required CSO volume vs. the acreage of impervious area removed from the combined system. The model can also be used to determine the amount of area that must be separated in order to eliminate or minimize the need for CSO storage.

Green Stormwater Infrastructure (GSI) is evaluated by simulating a portion of a basin in a model that has GSI simulation capabilities, such as EPA SWMM5. The model is set up to simulate existing conditions and then GSI conditions. The difference in the two hydrographs is subtracted from the corresponding MOUSE model basin flows. The resulting flows will reflect the effects of GSI.

Detailed modeling of GSI features, such as infiltration basins, is currently being conducted by consultants as part of the design process, with review provided by King County modelers. This detailed modeling is not currently done in-house, and standard modeling procedures for this effort has not been written for performing the work in-house.

5.0. ESTIMATING FUTURE PEAK FLOWS AND CAPACITY CONSTRAINTS IN THE SEPARATED SYSTEM

Existing conveyance facilities in the separated system are evaluated for their ability to accommodate the 20-year peak flow through the 2050 planning horizon. Conveyance facilities considered in the analysis include gravity pipes, force mains, inverted siphons, and pump stations. Overflow facilities and outfalls are evaluated when changes are proposed to existing facilities.

After estimating 20-year peak flows, modelers identify capacity constraints in the system by conducting an initial hydraulic capacity analysis using spreadsheet tools followed by hydraulic modeling using MOUSE HD. Modeling plays an important role in developing and selecting alternatives.

5.1 Estimating Future 20-Year Peak Flows

The following approach is used to project 20-year peak flows in 10-year increments through 2050 for each basin in the separated system:

- The projected population and employment for the basin are added to existing population and employment and then factored to calculate the expected base wastewater flow.
- New construction I/I assumptions are applied to additional land that is expected to be sewered.
- I/I in the previous 10-year increment is increased by a 7 percent degradation factor for sewered areas.
- The future peak 20-year I/I is added to the 1.35 peaking factor times the base wastewater flow.

The 20-year peak flows for each basin are placed into an Excel spreadsheet (conveyance.xls) containing all the King County pipe segments in the separated system. The peak flows from each basin are summed up using attenuation factors derived using the MOUSE HD hydraulic model simulations. The resulting peak flows are the 20-year peak flows associated with each King County pipe segment.

Figure 5-1 presents a graphical representation of the flow projection for one basin.

Appendix D contains a detailed description of the assumptions used in projecting flows for the separated portion of the service area.

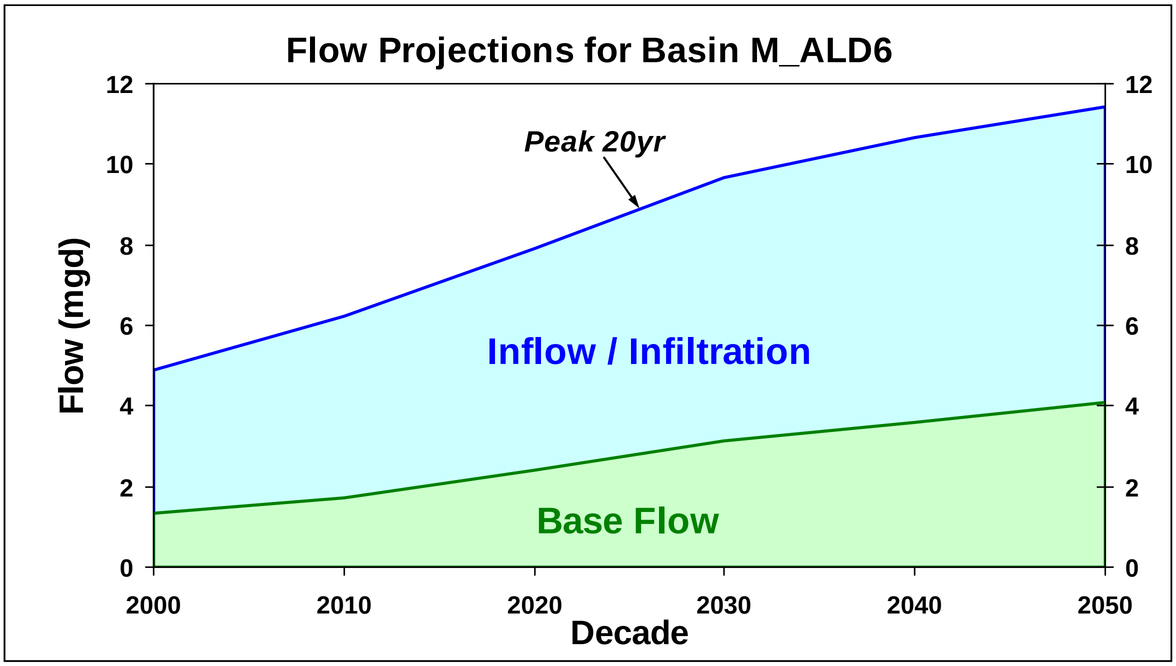


Figure 5-1. Base and Peak Flow Projection for Basin M_ALD6

5.2 Initial Hydraulic Capacity Analysis

The Excel spreadsheet conveyance.xls is used to compare existing capacities with projected 20-year peak flows by decade. The spreadsheet depicts winter conveyance routes for existing conditions and proposed flow redirections. These attenuation factors have been retained within the spreadsheet to attenuate flows in subsequent decades. Attenuation factors mimic the flow attenuation simulated in the MOUSE HD model.

Capacity for gravity pipes is assessed by grouping adjacent pipes into hydraulically representative pipe reaches. These consist of trunk lines of contiguous pipes of a common diameter located between major connections. The use of pipe reaches to assess capacity means that local surcharging experienced in individual pipes would be allowed as long as the overall pipe reach is not surcharged.

Pipe reach capacity is calculated from Manning's equation for pipes flowing full under steady, uniform flow conditions. For use in this equation, a representative gradient is derived as the vertical difference between the upstream and downstream inverts of the pipe section divided by the sum of the individual pipe lengths in the pipe section. Force main capacities are calculated as the product of the cross sectional area for a pipe flowing full and a maximum velocity of 8 feet per second (fps). Specifications for peak pump station capacities are documented in the 1999 WTD Offsite Facilities publication.[3] Updated pump station capacities based on subsequent testing and analyses are used where available.

[3] The Offsite Facilities brochure (last revised 1999) is available online at http://www.kingcounty.gov/environment/wtd/About/System/OffsiteFac.aspx.

5.3 Hydraulic Modeling

Subsequent modeling of existing pipelines is performed to refine the initial conveyance capacity estimate. This subsequent modeling evaluates local head losses at pipe bends, expansions and contractions, and parallel pipe bifurcations and convergences, as well as hydraulically complex facilities such as inverted siphons, low-head crossings and drop structures. This analysis also provides valuable information for pipe sections with varying slopes. The supplemental modeling uses the MOUSE HD hydraulic model and is performed for all trunks identified as having a capacity constraint, whether existing or at some point in the future. New assessments of pipe section capacities are derived from this modeling effort, and the extent of surcharging in each pipe reach is assessed.

This analysis may result in raising or lowering the capacity estimates in many sections, which in turn, results in smaller or larger projects that are required later or sooner. It may reveal that some projects are not actually needed, if for example, a minimal amount of surcharging (water above the crown of the pipe) provides enough capacity to accommodate the saturation peak flow Figure 5-2 shows a pipe profile without surcharging of the sewer. Figure 5-3 shows a pipe profile with the hydraulic grade line in a pipe that is surcharged.

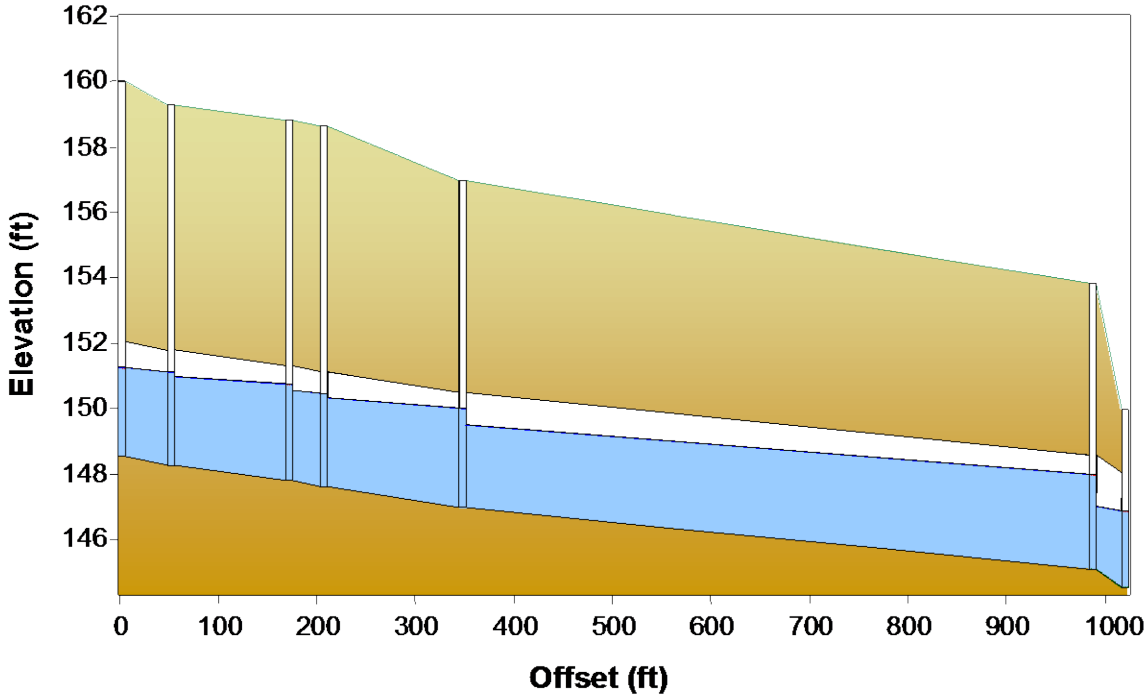


Figure 5-2. MOUSE Profile Without Surcharging

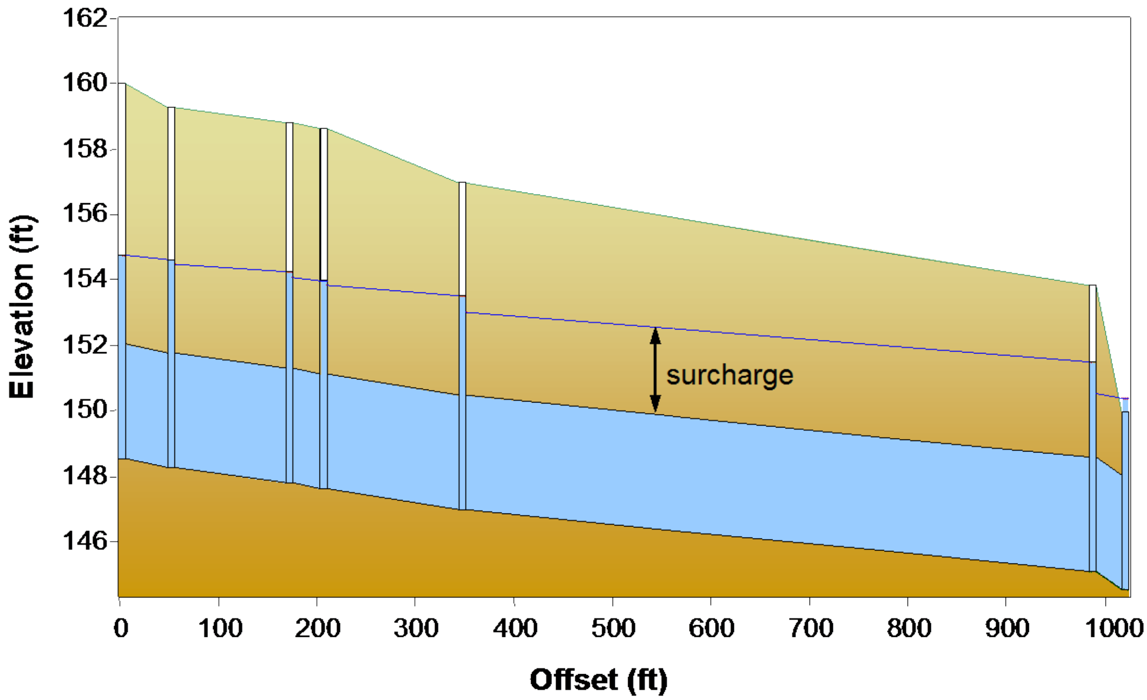


Figure 5-3. MOUSE Pipe Profile With Surcharging

5.4 Determining Capacity Exceedance and Level of Service

5.4.1 Pipelines

Available capacity is compared to projected 20-year peak flow demand by decade. For facilities determined to be exceeded, the year when flow demand exceeds capacity is determined by linearly interpolating between projected flows at the start of the decade (Figure 5-4).

If the flow at 2050 exceeds capacity by less than 5 percent, then no new facility is required. It is assumed that this exceedance will be addressed by limited surcharging and that the pipe can accommodate greater than 15-year peak flows without surcharging (Figure 5-5).

All the pipe capacities are compared with each corresponding flow demand by decade through 2050. All of the pipes in which the capacity is exceeded prior to 2050 are listed and shown in Chapter 3 of the Conveyance System Improvement Program Update, May 2007, and Section 2 of the Regional Conveyance System Needs Technical Memorandum, March 2007. The pipes where capacity is or will be exceeded are highlighted in colors corresponding to the decade in which their capacity is expected to be exceeded by the 20-year peak flow.

For facilities that cannot convey a 20-year peak flow without surcharging and/or overflowing under current conditions, the level of service (LOS) that the facility provides in the current year is determined. The LOS is defined as the return interval of peak flow that can be conveyed through the facility without significant surcharging (for gravity pipes). This information is used along with other criteria in prioritizing CSI projects that need to be constructed in the near future.

The LOS for conveyance facilities is determined by plotting the peak flow vs. return interval (see Figure 3-11), comparing the resulting curve with the facility's capacity, and identifying the return interval that corresponds to the facility's capacity.

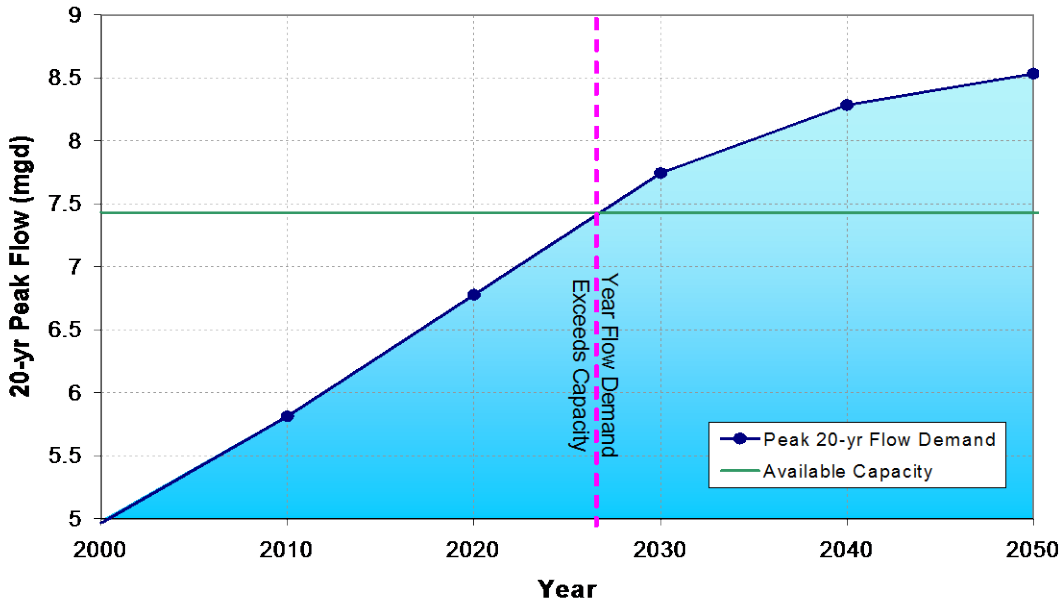


Figure 5-4. Determination of Exceedance and Year Exceeded

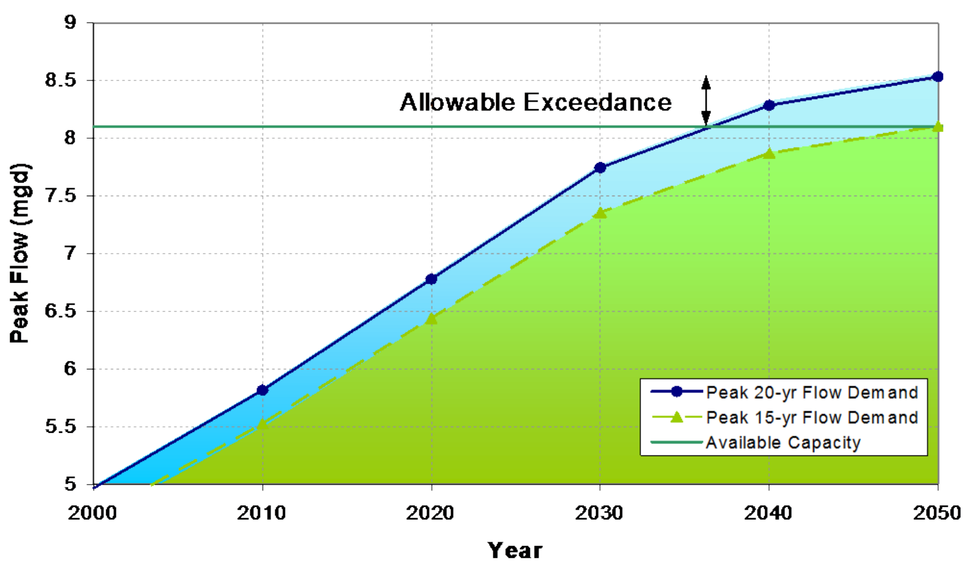


Figure 5-5. Allowable Exceedance at 2050 Saturation Flow Demand

5.4.2 Storage

There are serious drawbacks to sizing storage using a design storm, because of the variable antecedent soil moisture and the magnitudes, durations, and timing of storm flows. The size of a storage facility depends not only on the estimated 20-year peak flow volumes, but also on the capacity of downstream conveyance and the shape, length, and timing of the storm hydrographs.

To address these drawbacks, King County uses long-term simulations of the calibrated models to derive 60-year hydrographs at pertinent parts of the conveyance system, as is done to estimate peak flows. Figure 5-6 shows an example output from part of a long term simulation. In addition to peak flow statistics, the volume of events is also processed. The result of the analysis is the derivation of storage-capacity curves that are used to properly size storage facilities to satisfy the 20-year return period conveyance requirement.

All flows significantly above the diurnal peak daily flow are evaluated for potential storage requirements. Any flow with a return interval of less than 20 years that is above the downstream pipe capacity is “shaved” and stored during the event and released when the event is over. The size of storage increases as the downstream capacity decreases because there is more volume to shave for an event.

The hydrograph volumes above the downstream capacity are computed and ranked by volume. Figure 5-7 shows a typical plot of return periods for various event volumes for a pipe reach.

The third peak volume in the 60-year simulation represents the storage required to satisfy the 20-year peak flow design criterion. This volume is highlighted in Figure 5-7. This storage-capacity curve applies to this location and the specified downstream capacity only. If another downstream capacity were an option, then a new storage-capacity curve would be required for that option.

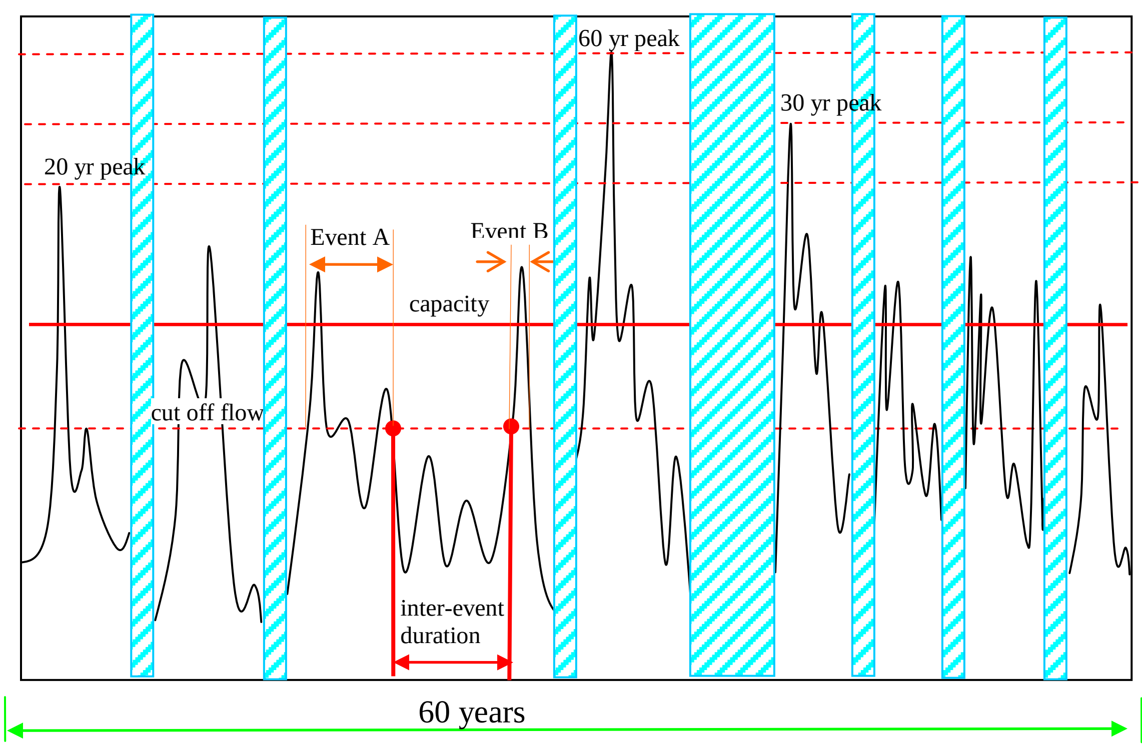


Figure 5-6. Schematic of a 60 year hydrograph

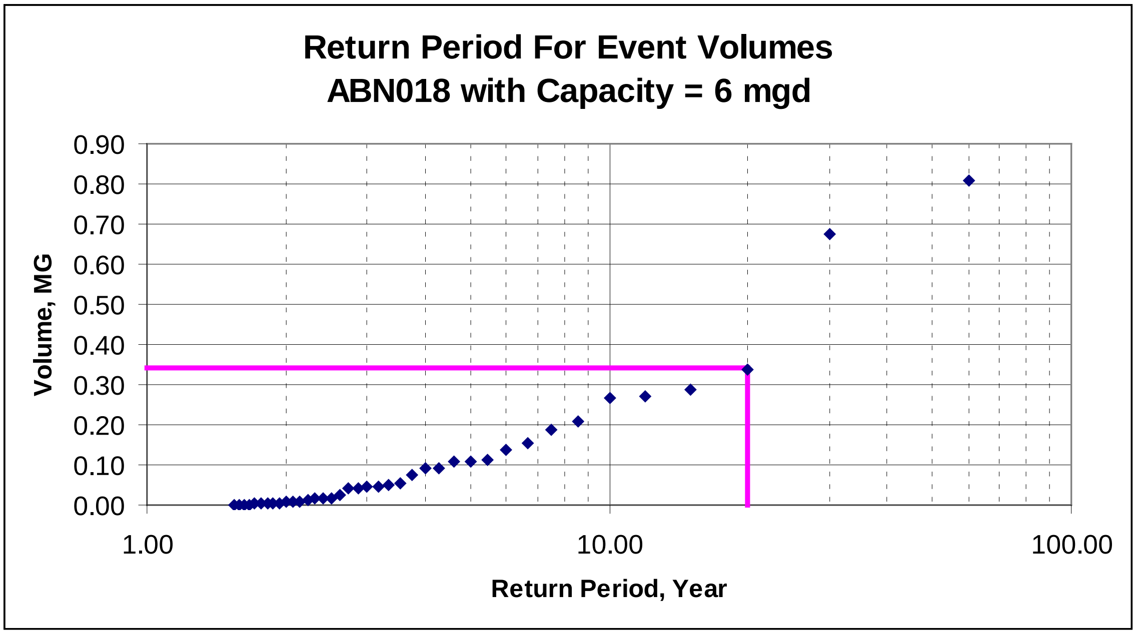


Figure 5-7. Volume vs. Return Period Curve

5.5 Developing Alternatives to Address Capacity Constraints

Generally, there are seven ways to solve capacity constraints in the King County conveyance system:

- Parallel pipes
- Replacement pipes
- Storage to shave peak flows
- Upgrades to pump stations
- Replacement of pump stations
- Flow diversions to other conveyance facilities
- I/I reduction

The first six options are used to develop a list of projects that will meet all the projected conveyance needs for CSI updates. This list is considered a "baseline" against which any I/I reduction effort can be evaluated.

Cost estimates for proposed CSI facilities can be obtained using King County's cost-estimating tool Tabula 3.0. "Tabula Rasa," developed for use by King County staff and consultants, provides conveyance costs estimates at the planning level. It integrates information gathered through analysis of historical costs and other cost planning curves to provide budgetary planning estimates in a consistent and reproducible manner.

Tabula can be found on the internet at the following King County web site: http://www.kingcounty.gov/environment/wastewater/CSI/Tabula.aspx.

5.5.1 Steps in Evaluating Alternatives

The general information used and steps taken to develop new alternatives are as follows (Figure 5-8):

1. Existing pipe and pump station capacities are compared with projected peak 20-year flows by decade through 2050.
2. The year when new capacity is needed to achieve/maintain 20-year flow capacity is determined. This occurs when the 20-yr peak flow projection exceeds the current capacity of the pipe/pump station.
3. An assessment is made as to whether it would be better to parallel or replace an existing pipe in the area of restricted capacity. Factors that are considered include:
    - Condition of pipe (end of useful life?)
    - Pipe material
    - Age of pipe
    - Room in corridor for parallel pipe (this information is not often available at this level of planning)
    - Number of existing pipes

    For example, if it appears that a pipe or pump station is nearing the end of its useful life, it is assumed that it would be replaced. If there are already multiple pipes within a corridor and all of them have many years of useful life left, then it is assumed that one of the smaller pipes will be replaced with a larger one to meet the forecasted demand. The other existing pipes could be used to convey flow while the smaller/older pipe is being replaced.
4. After deciding whether to parallel or replace the pipe, the estimate of peak 2050 flows to convey through new pipe is made along with an appropriate pipe size. The CSI Plan Update pipes have a safety factor of 25 percent applied to the projected 2050 20-year peak flows.
5. Possible routes for new pipes are investigated. Aerial photos, parcel information, and topography are used to determine potentially suitable routes for new pipelines.
6. The following are some factors that are considered in evaluating possible routes:
    - Stream crossings (microtunneling)
    - Major street crossings and culvert crossings (jack and bore)
    - Wetlands
    - Public Rights of Way
    - Topography
    - Water bodies
    - High water tables

    Generally, stream and wetland crossings are avoided if possible and major street crossings are minimized. Public rights-of-way are preferred to private property routes.

7. Tabula is used for estimating construction costs for planned facilities according to likely route/location. Sales tax, allied costs, and contingency are then applied to derive planning-level project cost estimates for each identified conveyance project.
8. If the condition of the pipes indicate they will not need replacing, then a check is made to determine if storage or diversion will be less expensive than paralleling downstream pipes. Generally, storage will be more cost-effective when it can preclude paralleling long stretches of downstream pipe. The amount of flow that needs to be "shaved" from the peak flow determines how much storage is required. The smaller the amount of flow that needs to be shaved, the more likely that storage will be cost-effective. Flow diversions can also be an effective way to minimize conveyance costs.
9. If storage or diversion appears to be a less expensive option in the analysis, it is assumed that the CSI project will be storage or diversion instead of paralleling.
10. Storage projects can provide flow relief for multiple pipe reaches downstream. Therefore, if storage is selected to meet the needs for a particular project, the downstream benefits from providing storage are evaluated. Sometimes an iterative process is used to find the optimal combination of storage, diversion, and downstream parallel/replacement costs.
11. Possible locations of new storage facilities are then evaluated. In general, it is better to place a storage facility where the flow enters and exits by gravity to avoid the need for pumps and associated electrical and mechanical equipment. An assessment is also done to determine whether "box" storage or underground pipe storage is preferred. Generally, using large pipes as underground storage is less expensive than box storage.
12. Once a draft list and cost estimates for proposed facilities are completed, local agency officials are consulted regarding particular issues in their communities. Plans for future road and/or utility projects are obtained and evaluated for coincident benefit. Local agency representatives can provide valuable input regarding problems with proposed sites/routes and can provide suggestions on how or where to locate facilities. This input is used to modify the proposed facility list and update cost estimates.

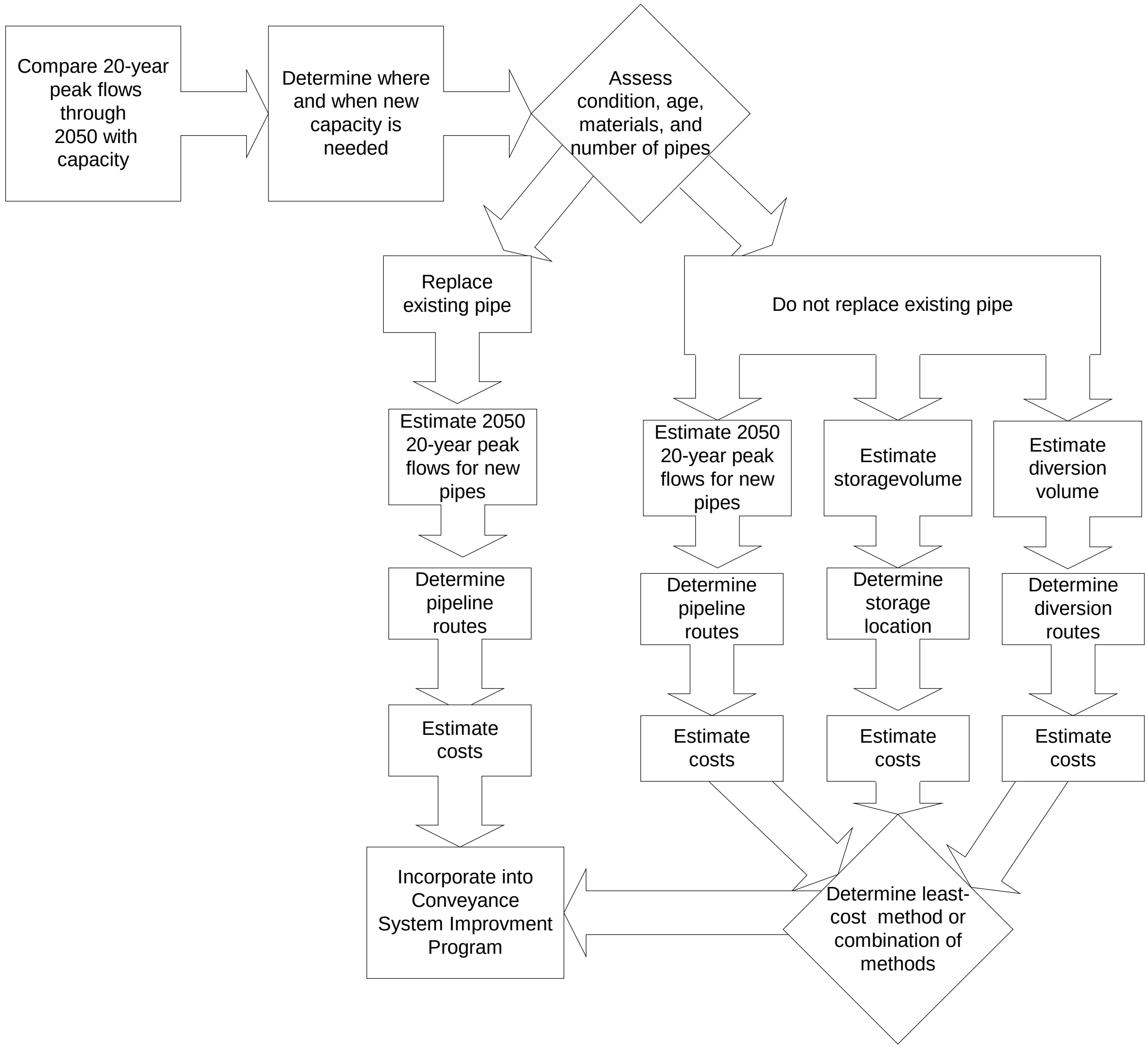


Figure 5-8. Flow Chart for Preliminary Conveyance System Improvements Projects

6.0. REFERENCES

Schock, Kevin, 2006b. Draft- Error Propagation through a calibrated hydrologic model. King County – DNRP.

Krause, P., D.P. Boyle, and F. Base, 2005. Comparison of different efficiency criteria for hydrologic model assessment. Advances in Geosciences, 5: 89-97.

Doherty, John, 2003. Ground water model calibration using pilot points and regularization. Ground water, Vol, 41, No.2:170-177.

Dothery, John, 2004. Model-Independent Parameter Estimation: Users Manual, 5th Edition. Watermark Numerical Computing.

Dubus, Igor G., 2004. Inverse modeling for estimating sorption and degradation parameters for pesticides. Pest Manag. Sci. 60:859-874.

Keating, Elizabeth H., Velimir V. Vesselinov, Edward Kwicklis, and Zhiming Lu, 2003. Coupling basin and site scale models of the Espanola Aquifer. Ground water, Vol.41, No. 2:200-211.

Dieck, Ronald H., 1997. Measurment uncertainty: methods and applications 2nd Ed. Instrument Society of America.

Schock, Kevin, 2006c. Paradigm for Estimating Storage Capacity Based on Expected Exceedences. King County – DNRP.

7.0. GLOSSARY

7.1 Definitions of I/I Terms

Base flow	Wastewater that enters sewers during dry weather in the absence of I/I.
Combined sewer	A pipe designed to carry both stormwater and wastewater.
Infiltration	Groundwater that seeps into sewers through holes, breaks, joint failures, defective connections, and other openings.
Inflow	Stormwater that rapidly flows into sewers via roof and foundation drains, catch basins, downspouts, manhole covers, and other sources.
I/I control	Policy, administrative, financial, and technical measures aimed at limiting future increases in I/I flow.
I/I reduction	Sewer system rehabilitation or replacement projects that are constructed to reduce I/I flows and alleviate immediate downstream capacity constraints.
Lateral sewer	The portion of a building's sewer pipe that is in the public right-of-way.
Separated sewer	A pipe designed to transport household, industrial, and commercial wastewater and to exclude stormwater sources.
Side sewer	The portion of the sewer pipe that extends from a building to the public right-of way.
Peak flow	The highest combination of base flow and I/I expected to enter a wastewater system during wet weather at a given frequency that treatment and conveyance facilities are designed to accommodate.

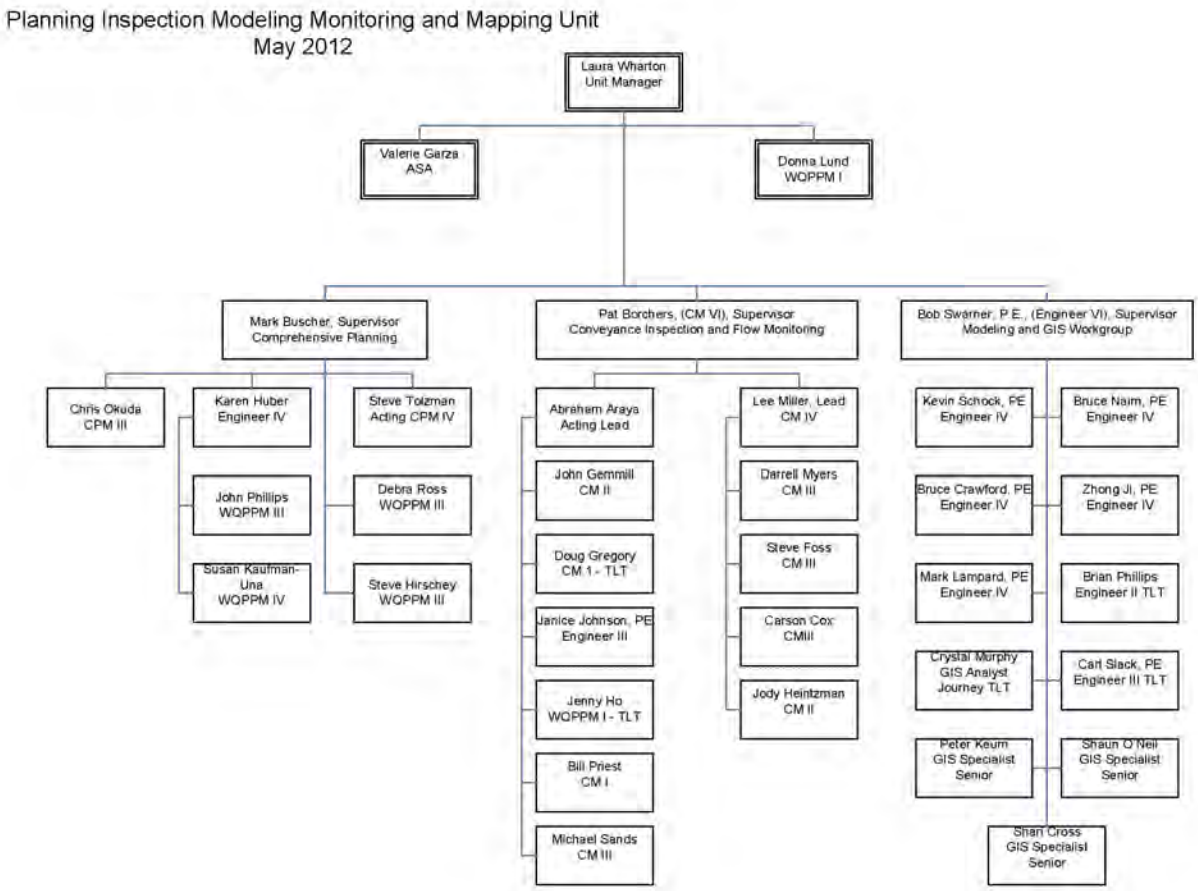
7.2 Definitions of Modeling Terms

Base flow	Wastewater that enters sewers during dry weather in the absence of I/I.
Hydrologic model	A model used to numerically simulate the physical process of rainfall becoming I/I.
Hydraulic model	A model of the actual pipes that convey the wastewater and I/I generated by the hydrologic model. The hydraulic model outputs flow depths and velocities in specific pipe segments and allows for the evaluation of system performance under existing and future demands.
Basin	A geographic area that contributes flow to a specific location, usually a flow meter or a facility. The two primary types of basins used in the assessment are **model basins** and **mini basins**.
Model calibration	The process of adjusting model parameters so that the model output matches the measured sewer flow for the same time period.

8.0. ACRONYMS AND ABBREVIATIONS

AWWF	Average Wet Weather Flow
CSO	Combined Sewer Overflow
FAZ	Forecast Analysis Zone
FTE	Full Time Equivalent
GIS	Geographic Information System
I/I	Infiltration & Inflow
MOUSE	Sewer Modeling Software (MOdeling of Urban SEwers) by Danish Hydraulics Institute
MOUSE HD	Hydraulic Routing module of the MOUSE model
MOUSE RDI	Infiltration module of MOUSE model
NEXRAD	RADAR information used for estimating rainfall over service area
PSRC	Puget Sound Regional Council
RTC	Real Time Control
SACRO	Program used in the 1980's to evaluate Metro's CSO needs
SCADA	Supervisory, Control and Data Acquisition??
SPU	Seattle Public Utilities
SSACRO	Program used in the 1980's to evaluate Metro's CSO needs
TAZ	Traffic Analysis Zones
UGA	Urban Growth Area
UGB	Urban Growth Boundary
UNSTDY	Hydraulic routing model used for Metro's CSO evaluations
WSDOT	Washington Department of Transportation

Appendix A
Organization Chart



Appendix B
Description of Models Used for Metro/ King County CSO Planning

King County's approach to modeling has changed over time. This has resulted from improvements in the science of modeling and available models, as well as improved information about the conveyance system. The history of this effort is summarized in Table 1. A description of each modeling effort follows.

1979 CSO Control Program

In this program, models specifically developed for the 1976 Metro 201 Facilities plan were used. These included a model known as HYDRO to generate runoff from storms.

HYDRO used a synthetic unit hydrograph technique to calculate surface runoff from rainfall. The synthetic unit hydrograph is a triangular hydrograph of the flow that would result from one inch of rain in a ten-minute period. Unit hydrograph shape was dependent on the shape of the area from which runoff was being calculated. Two sets of independent calculations were performed for impervious and pervious surfaces.

Sanitary sewage flows were represented in the 1979 modeling by diurnal hydrographs adjusted in magnitude based on the land use of individual tributary areas. A base infiltration factor (usually 1,100 gpad, but adjusted for measured flows) was added to compute base sewage flow. Runoff computed by the unit hydrograph technique was then added to base wastewater flows.

The total flow hydrographs computed in each basin of the system were routed through Metro's interceptors using a model known as "NETWORK." NETWORK was a specially developed model using a kinematic wave approximation to the full equations of motion. The kinematic wave approximation does not fully account for backwater effects from pump stations and regulator gates, or any other downstream flow restriction. Thus, a complete description the system operation was not available (the actual impact of throttling back on the Interbay pump station could not be precisely simulated for example). Because flows from the north end of the system were not large, these were simulated as a constant value in development of the 1979 plan.

Table 1. History of Hydraulic Models Used for and by King County

Decade	Models: Hydrologic (surface runoff and local system flows)	Models: Hydraulic (Metro/KC trunks and interceptor flow)	Brief Description of Capabilities
1970s	HYDRO		Used synthetic unit hydrograph method for runoff due to rainfall from 58 NSA* basins and 62 SSA** basins.
1970s		NETWORK	Used kinematic wave approximation for simulating flow through Metro trunks and interceptors.
1980s	LCHYD		Used diurnal base flow and constant infiltration to generate hydrographs from separated areas. Linear rainfall/inflow relationship.
1980s	HYDRO72		Used synthetic unit hydrograph method for 19 basins in NSA*.
1980s	HYD72		Used synthetic unit hydrograph method for 62 basins in SSA**.
1980s		LCPRE	Lagged the hydrographs from LCHYD to put into SACRO.
1980s		SACRO	A mass balance model that simulated flow through the NSA. (Kept track of flow but didn't solve hydraulic equations for levels.)
1980s		SSACRO	A mass balance model that simulated flow through the SSA.
1980s		EBIPRE	Lagged the hydrographs from HYD72 to put into SSACRO.
1980s		SACE	Estimated total system overflows based on rainfall only.
1990s — 2000s	RUNOFF		Kinematic wave simulation of runoff due to rainfall from > 400 basins. Variable inflow and infiltration based on rainfall and soil conditions. A physically based model.
1990s — 2000s		UNSTDY	A fully dynamic simulation of flow through King County trunks and interceptors. Computes flows, depths, and velocities in all pipes in the system. Simulates backwater effects, flow reversals, gravity waves, surcharges, etc. Simulates automatic operation of regulator and outfall gates and pump stations. Also, simulates Predictive Control, a computer program that controls the regulator gates to optimize the use of in-line storage. Used seven design storms in early 90s to estimate annual overflows. Moved to a continuous 11-year simulation to estimate annual averages in the late 90's.
2012 Program Update	RUNOFF MOUSE (M_U)	UNSTDY	The most recent calibrations of the hydrologic models were used. Calibrations were performed by KC staff, SPU staff, and by consultants hired by SPU.
2012 Program Update	EPA SWMM5 InfoWorks	UNSTDY	Hydraulic model had capabilities listed above. 32-year long-term simulations were performed to obtain 1-year volumes and peak flow rates.

*NSA = Northern Service Area (North of the Ship Canal)
**SSA = Southern Service Area (South of the Ship Canal)

1986–1988 CSO Control Plan

In the modeling effort for the 1986–1988 CSO Control Plan, consultants used different programs to generate inflow hydrographs from the separated and combined portions of the service area. For the separated sewer area (upstream of the Lake City Regulator) the program LCHYD was used to generate flows from nine sub-basins. A diurnal base flow (e.g., showing two peaks within the same day) hydrograph was developed based on domestic/commercial and industrial populations. A linear relationship was assumed between rainfall and inflow, up to a maximum amount. Infiltration was assumed to be constant for the wet season. A maximum inflow value of 500 gallons per acre per day (gpad) was used for simulating future flows from currently non-sewered areas that were expected to develop and include sewers in the future.

The program LCPRE was used to take into account that peak flows do not occur at the same time in all parts of the system. This lag was incorporated into the simulation.

For the combined system, the program HYDRO72 was used to generate hydrographs from 19 basins in the Northern service Area (NSA). This was a modification of the HYDRO program used in the 1979 CSO control program. Several of the basins in the HYDRO simulation were combined for use in the HYDRO72 model. Furthermore, the length of simulation was increased from24 hours to 72 hours for HYDRO72, which allowed for longer storm events to be simulated.

The same basin parameters from the 1979 CSO Control Program effort were used in the 1986 effort. Despite concerns about the model, a decision was made to continue using the model for continuity with past planning. Five design storms were used to estimate annual CSO volumes and frequencies under existing (at that time) conditions and under future conditions.

The input hydrographs were then used as input to the SACRO (Seattle Area Central Routing Organization) simulation. SACRO simulated the routing of flow through the northern service area (NSA) of the wastewater system. It was designed to give reasonable estimates of the volume of flow through the NSA system. The flow from Interbay Pump Station was assumed to remain the same throughout the study period (1982–2030).

For the wet season, it was assumed that infiltration would remain the same as in the 1981-83 model calibration, at 1100 gpad. HYD72 (similar to HYDROT2) was used to generate synthetic unit hydrographs from 62 basins in the SSA. Seven design storms of varying length and intensities were used to estimate annual CSO frequencies and volumes for the SSA.

The Southern Service Area (SSA) large pipe flow was simulated using SSACRO (South Seattle Area Control Routing Organization). It was developed using primarily SACRO and some of NETWORK. It is based on level pool storage routing concepts and therefore does not accurately represent dynamic wave storage or routing. The program only calculated how the different input hydrographs travel through the system – combining sewer junctions, splitting at diversions, etc. It did not simulate the restriction of flows at the Interbay Pump Station due to flows at the West Point treatment plant exceeding its setpoint, which at that time was 325 million gallons per day.

SSACRO and SACRO basically added up all flows into a particular node (regulator, pump station, etc.), subtracted away that which could be hydraulically conveyed away from the node, and if anything was left, it was either stored or called an overflow. They are mass balance models, and do not compute water surface elevations in the collection system.

The program EBIPRE was developed to simplify and reduce the time involved in routing flows through the Elliott Bay Interceptor. It lagged inflow hydrographs and then combined them to be used in the routing model SSACRO. It also accounted for some of the City of Seattle CSOs and storage projects.

SACE (Seattle Area Combined Sewer Overflow Evaluator) was written to allow rapid testing of alternatives and to determine recurrence periods of overflows for design events. It calculated annual overflows for the wastewater system for the 1942-84 period. The SACE program simply assigned portions of each rainfall event to (l) system capacity; (2) system storage; and (3) rainfall that couldn't get into the sewer. The amount of available storage was increased during inter-event periods to reflect the draining of wastewater from storage. For each rainfall event, the wastewater entering the sewer that could not be contained in “system capacity” or “system storage” was considered to be CSO. There was no simulation of the flow as it proceeded toward the treatment plant.

CATAD Program Improvements—Predictive Control Program Begins

In 1986, a different approach was begun to model the West Point (combined) system, leaving behind the previous model. The effort was to support the development of an optimized real-time control program for the West Point collection system. The Predictive Control Program was to allow the Computer Augmented Treatment and Disposal System (CATAD) to automatically operate regulator gates and optimize in-line storage throughout the entire collection system to minimize CSOs.[4]

As part of this new approach, two new programs were developed to simulate flow through the West Point system. A kinematic wave runoff program was developed to simulate overland flow resulting from rainfall. Flow over both pervious and impervious areas that enters the sewer system was simulated. The West Point system was divided into over 400 basins to simulate this overland flow. This flow was then routed through a kinematic wave transport program, which effectively simulates the lagging and attenuation of flows through the local sewer pipes. The program also computes depths and velocities of flows in each pipe, and is a good approximation of actual conditions as long as there are no backwater effects or hydraulic transients (e.g., hydraulic phenomenon that are short in duration). Unlike previous programs used to model the wastewater, the runoff/transport program is a physically-based model that attempts to directly simulate the flow mechanics of the local sewer system. The program simulates a diurnal base domestic flow and a constant groundwater leakage. Inflow from rainfall induced hydrographs were simulated and input into the appropriate pipes for routing.

Over 70 flowmeters were installed to calibrate the runoff/transport model in the late 1980s.

The model UNSTDY was obtained in 1986 from Colorado State University to simulate the routing of runoff/transport flow hydrographs through the Metro/King County trunks and interceptor system. UNSTDY is a complex, fully dynamic simulation that computes flows, depths, and velocities in all pipes in the system. The full hydraulic equations are solved

[4] Automatic control by CATAD was implemented in 1974. Predictive Control optimizes it.

implicitly which enables it to simulate backwater effects, flow reversals, and gravity waves effectively. This sophistication was required to accurately simulate the in-line storage being utilized throughout the collection system. The model was enhanced to simulate the operation of the regulator gates and pump stations.

These two models can be envisioned as being like a tree or dendritical system with Runoff/Transport forming the leaves and outer branches and UNSYDY forming the inner branches and trunk.

UNSTDY was programmed to simulate the regulator system using local control (manual control), the existing Automatic Control, and the new Predictive Control. In early 1992 it was discovered that several of the level sensors (bubblers) were reading incorrectly, and probably had been since installation. The UNSTDY simulation was modified to be able to simulate control structures as they would have been operated if the sensors were reading incorrectly, as well as if they were reading correctly. This option (which simulates flow assuming errors in the levels sensors) is used when simulating conditions under “baseline” (1981 -83) conditions.

The runoff/transport program was enhanced in the early 1990s to include rainfall-induced infiltration into the sewer system. This infiltration can be the largest component of I/I during large storms in the separated portion of the County sewer system. This modification allows King County to simulate the flow from the northern part of the West Point service area much more accurately than had been possible previously.

The 1995 and 2000 CSO Control Plan Updates

For the 1995 CSO Control Update the same seven design storms used in the 1988 plan were used to estimate annual CSO volumes. For the 2000 CSO Control Update, 11-year continuous simulations were used to estimate CSO frequencies and volumes. As each flow transfer or CSO project is constructed, UNSTDY is modified to include that facility. For example, the Hanford/Lander Separation Project is included for simulations past 1990. The Carkeek flow transfer was included beginning in 1994. The Allentown Diversion was included in 1996. The Alki Flow transfer was included in 1998 as was the University CSO Project (Densmore Pump Station). The Denny Way CSO facility, the Harbor CSO transfer to the West Seattle Tunnel, and Henderson/Martin Luther King Way CSO facility are being simulated for 2005 and beyond.

SCADA Hardware and Software Upgrades

Computer hardware at West Point was been replaced in 2004–2005 for the offsite facilities. Software upgrades were also installed for operating the offsite facilities and for collecting, storing, and retrieving their data.

2012 CSO Control Program Review

Part of the work associated with the 2012 CSO Program Review has been recalibration of selected basins and associated pipe systems using DHI MOUSE/Mike Urban. This recalibration has been performed in some areas where King County has large CSOs to control. The MOUSE model (within the MIKE/Urban shell) was selected because MOUSE is being used for the entire separated portion of King County’s service area. This model was selected during a process in

2001-2002 that evaluated several models for use in King County's Infiltration and Inflow (I/I) Program. The model has proved to be successful in simulating various kinds of inflow and infiltration responses in both combined and separated sewer systems and can provide a good match between model results and metering data. King County is in the process of standardizing the modeling of their entire service area using MOUSE. (DHI now only provides the MOUSE modeling engine within a software shell named MIKE Urban. Both names are used interchangeably in this document.)

In addition, Seattle Public Utilities (SPU) has been doing calibration of basin/pipe models in areas where they have CSO concerns. SPU has been moving from the Infoworks model to the EPA SWMM model for its work. Those areas SPU modeled sometimes overlap areas where the County has CSOs.

Time series used in the hydraulic model (UNSTDY) to estimate the CSO storage and flow requirements were generated by both the County and SPU for the areas that have been recalibrated. Those recalibrated time series replaced the Runoff/Transport time series in areas where the recalibrated hydrographs were available. Other areas continued to use the Runoff/Transport time series as input to the hydraulic model.

The overall model runs can be envisioned as being like a tree or dendritical system with portions of the leaves, outer and inner branches pruned back and MOUSE, Infoworks and SWMM model data grafted on in their place. However, UNSTDY is used to simulate the inner branches and trunk.

The models used to generate long-term hydrographs for the 2012 CSO Control Program Review for each basin group in the CSO service area are presented in Table 2. Figure 1 displays the hydrologic models that were in the 2012 CSO Control Program Review. All these models should be capable of simulating the hydrologic response of the basins, provided enough good quality flow data was available for calibration. Not all areas had equivalent data to work with, but the output from each respective model was considered the best available model data at this time.

Basins were recalibrated based on flow data from in-station meters and portable flow meters provided both by the County and SPU. SPU provided flow and level data at many locations. An important step in using this data was to perform QA/QC on the meter data. The SPU consultant provided QA/QC on all the flow data that they provided.

The County method for calibrating basins consisted of building up a basin and pipe model, providing a dry weather flow pattern based on dry weather meter data and then using a calibration tool called PEST to change selected basin parameters until model output was as close as possible to the meter data for selected storms. PEST is a Model-independent Parameter Estimation computer optimization code. The 5th edition of the code was used. After the best-fit parameters were generated using PEST, each modeler could adjust parameters to try to get a better overall fit. Effort was made such that both peak flows and volumes from the model matched the metered data and were not generally underestimated.

The results of these calibrations were reviewed by a team of modelers and further suggestions were provided for reworking the calibrations until they were judged to be acceptable based on review of hydrographs and the associated statistical data.

Table 2. Hydrologic Models used in 2012 CSO Control Program Review

Location	Hydrologic Model Used
8th Ave	MOUSE
Terminal 115	MOUSE
Harbor	MOUSE
Chelan	Runoff/Transport
S Michigan	MOUSE
Brandon	MOUSE
Hanford2	Runoff/Transport
Kingdome	MOUSE
King	MOUSE
Denny Local	MOUSE
Denny Lake Union	
Portage Bay	EPA SWMM5
Balance of Denny Lake Union	Runoff/Transport
Dexter	MOUSE (MU)
University	
Windermere	MOUSE (MU)
Green Lake/Densmore	MOUSE (MU)
Ravenna	MOUSE
North Union Bay	EPA SWMM5
Balance of University	Runoff/Transport
Montlake	
East Pine PS (Leschi)	EPA SWMM5
Madison Valley	InfoWorks/HSPF
Madison Park	EPA SWMM5
West Montlake	EPA SWMM5
Balance of Montlake	EPA SWMM5
Lander	Runoff/Transport
3rd Ave W	
Fremont	EPA SWMM5
Wallingford	EPA SWMM5
Balance of 3rd Ave W	Runoff/Transport
Rainier PS	MOUSE
Bayview	MOUSE
Hanford @ Rainier	MOUSE
11th Ave NW	Runoff/Transport
Alki (including Barton, Murray & 53rd PS)	Runoff/Transport
S Magnolia	Runoff/Transport
Ballard West (City Weirs)	SWMM
West Michigan	MOUSE
Balance of North Interceptor	Runoff/Transport
Henderson Pump Station	InfoWorks
Rainier@ Henderson	InfoWorks
Upstream of Matthews Park PS	Runoff/Transport

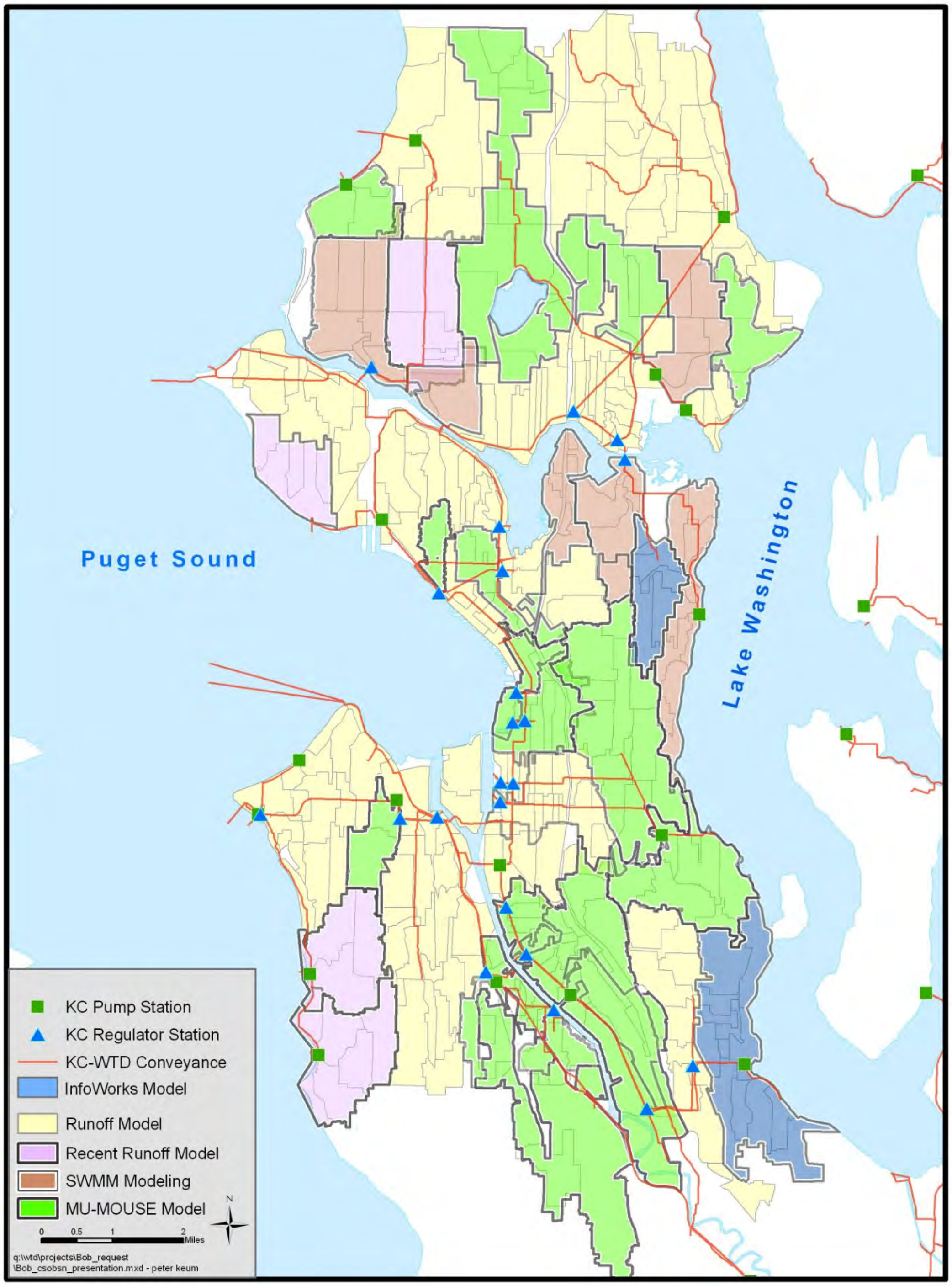


Figure 1 – Models used for hydrologic simulations for 2012 CSO Control Program Review

Once the basin calibrations were complete, a long term model run was performed and a downstream time series was generated to graft into the original models as noted above.

The County models were run using City of Seattle rain gauge information, with County QA/QC applied, to feed the basin models. The City models utilized similar data, but with City processing applied. This data was available and formed the long-term model period from January 1st, 1978 to January 1st, 2010. That is a 32-year time period. The hydrologic model runs started in 1977, using SeaTac data in order to simulate appropriate ground moisture conditions at the start of 1978. The UNSTDY hydraulic model run began a few days prior to 1978 and extended into 2010 to allow the model to initialize and stabilize at the start and to terminate at the end outside of this 32-year period. CSO statistics were generated for the period noted above.

Once the 32-year simulations were performed, statistics were generated to obtain the 1-year peak CSO volumes and the 1-year peak flow rates for use in the 2012 CSO Control Program Review.

Appendix C
Service Area Classification in the Separated System

For modeling purposes, the separated service area is classified according to sewered and unsewered areas. Various sources of information, including sewer comprehensive plans, local sewer maps, aerial photography (2000), and parcel data are used to determine the proper boundaries and classifications.

Sewered area is an input parameter to the MOUSE RDII hydrologic model and is also used in quantifying I/I values in terms of gallons per acre per day (gpad). Unsewered areas are divided into two major categories—potentially sewerable and not sewerable. The potentially sewerable areas are key in the flow projection process to estimate how much new sewered area will be contributing flows in the future. These three major service area classifications are described below and in Table 1.

- **Sewered Area.** An area served by a sanitary or combined sewer collection system. Can be entire parcels or portions of large parcels. Includes the area served by the combined system and areas served by separate sewers.
- **Potentially Sewerable Areas.** Land areas (developed or undeveloped) that could potentially be sewered in the future. Includes vacant parcels and areas currently served by on-site sewage systems (OSS) and portions of parcels where part of the parcel is considered sewered but another portion is not sewered.
- **Not Sewerable Areas.** Includes publicly owned parklands, sensitive areas (such as steep slopes), freeway rights-of-way, and water bodies where development is not expected to occur.

As with delineation of the model basins, parcel boundaries are used primarily as the basis for delineating sewered and unsewered areas. Distinguishing between potentially sewerable areas and not sewerable areas is somewhat subjective. For parcels served by sewers, the entire parcel is considered sewered unless the size of the parcel is greater than 1.5 acres (approximately 60,000 square feet). If a parcel greater than 1.5 acres contains open space that would not contribute to I/I, the open space is designated as unsewered.

For developed areas containing many small parcels, a threshold of 1.5 acres is also used to differentiate between classifying areas as sewered or not sewered. For example, if an area of small parcels (each less than 1.5 acres) is generally developed and sewered, then all the parcels are classified as sewered. However, if a group of small parcels totaling at least 1.5 acres appears undeveloped or unsewered, the area is designated either potentially sewerable or not sewerable.

The sewered area in the model basin is the area used in the model as the model basin area.

Table 1. Sewer Service Area Classifications

Code	Type	Description
		Sewered
S	Sewered	Areas adjacent to sewer lines or with sewer lines running through them that contain at least one building and are served by the sanitary sewer system. These may be entire parcels or portions of parcels. Also includes roads that have sewer lines in them. Sewer lines traversing properties that are not sewered (without connections) will be buffered 5 feet on either side; this buffer will be considered sewered.
		Potentially Sewerable
U	Undeveloped	Undeveloped but potentially sewerable.[a] Parcels that are listed as vacant or showing no improvement value in the King County Assessor's data and appear to be vacant in the 2010 aerial photo. The U classification only applies to entire parcels or groups of parcels that are undeveloped and not sewered.
D	Developed	Not sewered area that is developed and may be sewered in the future.[a] Typically these are older residential areas that are served by individual on-site sewage disposal systems (OSS or septic tank and drainfield systems). The D classification only applies to entire parcels or groups of parcels that are developed and not sewered.
Y	Potentially sewerable area that is not sewered.	Y can be used to designate areas as potentially sewerable, without breaking down parcels or groups of parcels as U (undeveloped) or D (developed). Y is also used in undeveloped areas where development may be less dense than underlying zoning because of site constraints. If a parcel (or group of parcels) is partially sewered, Y is applied to the remainder of the parcel if vacant and potentially sewerable.
AGY	Agricultural	Parcels or portions of parcels currently in agricultural use. Includes parcels that are in State of Washington Current Use Taxation programs. These programs discourage development through tax penalties; however, the land that is still potentially developable.
		Not Sewerable
A	Airfield	Portions of airports that are not sewered. The portions of airports connected to the sanitary sewer system, such as control towers and buildings associated with maintenance or administration, are considered sewered.
AGZ	Agricultural	Fields under cultivation or which may potentially be cultivated. The AGZ designation only applies to areas that are in King County Agricultural Production Districts (APD). It does not include Current use Taxation Parcels that are in agricultural use outside of APD (see AGY in Sewerable). Farmhouses and buildings related to the processing of farm products that may be connected to the sanitary sewer system are considered sewered
C	Cemetery	Cemetery grounds that are not sewered. Developed portions of cemeteries, such as administration buildings, that are connected to the sanitary sewer system are considered sewered.
FY	Freeway	Transportation corridors and associated right-of-way of major freeways and highways
G	Golf Course	Portions of golf courses that are not sewered. Clubhouses, restaurants, and other buildings that are connected to the sanitary sewer system are considered sewered
P	Private Park	Open space that is not likely subject to further development and is not publicly owned. This includes common areas associated with plats, multifamily complexes, and other commercial developments. These areas often have other constraints to development that may otherwise prevent them from being developed. In the case of multifamily and commercial development, the portions of the parcels connected to the sanitary sewer system are considered sewered.
PP	Public Park	Public parks and public open space identified by King County Assessor's information. Includes publicly owned parcels that are not developed such as water tower areas. Developed portions associated with restrooms and other buildings connected to the sanitary sewer system are considered sewered.

Code	Type	Description
PR	Park & Ride	Publicly owned Park & Ride lots on separate parcels.
R	Recreational	Visually discernable recreational facilities including baseball diamonds, football fields, running tracks, and tennis courts, associated with public schools.
RUR	Rural Areas	Areas on the rural side of the urban growth boundary (UGB). There are some minor exceptions to this rule because of permitted uses and sewer service provided prior to establishment of the UGB.
RD	Retention / Detention Ponds	Retention and detention ponds. Stormwater control facilities identified by aerial photographs and/or King County Assessor's data.
SB	Stream Buffer	Undeveloped areas adjacent to stream corridors. Varies with stream classification.
SS	Steep Slopes	Undeveloped areas having an average slope of 40% or greater over 10 feet of elevation, as determined using the steep slope coverage generated by WTD GIS. The WTD GIS staff used United States Geological Survey (USGS) maps at 20-foot contours along with Digital Elevation Model (DEM) coverage to create the steep slopes coverage. A 40% slope over 10 feet of elevation is the King County Sensitive Areas standard for steep slopes. Some of these steep slope sensitive areas are included in other unsewerable areas such as parks and therefore have not been noted. Areas that are developed (D) or sewered (S) and lie within the SS coverage are assigned their respective code, D or S.
W	Water Body	Freshwater lakes, estuaries, lakes, and the lower portions of rivers wide enough to have been included in the county's Water Body coverage. Edge of the water body is considered to be the King County Shorelines coverage. This coverage may not follow parcel lines or the image of the water's edge in the aerial photograph.
WF	Wetland/ Floodplains	Undeveloped parcels in wetlands and floodplains as designated in King County GIS coverage used for this project.
Z	Not sewerable parcels that are not covered by other definitions	Includes limited access publicly and privately owned parcels (some city rights-of-way, railroad rights-of-way, etc.)

[a] Not sewered areas that are potentially sewerable can be coded as U, D, or Y. U and D indicate whether there is any current development on the property. However, in some cases, Y is used to reduce the effort required to delineate the differences between developed and undeveloped areas that are not sewered.

Appendix D
Projecting Future Peak Flows in the Separated Service Area

After estimating current-year peak flows, future demand for conveyance facilities through 2050 are estimated by projecting future peak flow for each basin.

Future conveyance demands in the separated portion of the service area are derived not only from information gained during the current-year peak flow analyses but also from information obtained from local agency comprehensive plans, population and employment growth projections from the Puget Sound Regional Council, existing land uses, local agency sewer comprehensive plans, topography, water consumption data, and modeling. Projecting peak flows also necessitates making assumptions about future conditions.

Section 1 describes the planning assumptions used in projecting future flows and Section 2 shows how these assumptions are used to project peak flows in the separated system.

1. Planning Assumptions

Table 1 lists the assumptions used to model future flows and the timing and sizing of projects to accommodate these flows. The table indicates whether the assumptions are applied in flow projections or planning level design processes. The text that follows describes each assumption and how the assumptions are used to project future peak flows.

Table 1. Planning Assumptions

Category	Assumption	Application
Extent of eventual service area	Urban Growth Area within the wastewater service area	Flow projections
Future population	Puget Sound Regional Council forecasts allocated to sewer basins	Flow projections
Water conservation	10% reduction between 2000 and 2010; no additional reduction after 2010	Flow projections
Septic system conversion	90% of potentially sewerable area sewered by 2030, 100% sewered by 2050 (assumes that combined sewer area is already 100% sewered)	Flow projections
I/I degradation (separated system only)	Increase of 7% per decade up to a maximum of 28 % (over four decades)	Flow projections
New system I/I (separated system only)	1,500 gallons per acre per day with degradation applied	Flow projections
Design flow	20-year peak flow (separated system); 1-year peak flow (combined system)	Estimating need and timing for and sizing of planned projects

Category	Assumption	Application
Sizing of planned facilities	20-year peak flow in 2050 with 25% safety factor (separated system); 1-year peak flow (combined system)	Determining facility sizing
Planning horizon (buildout)	2050	Application of design standard to determine facility sizing

Note: King County and the Metropolitan Water Pollution Abatement Advisory Committee (MWPAAC) Engineering and Planning (E&P) Subcommittee collaborated on formulating planning assumptions for use in modeling future facility needs for the separated system. Except where noted otherwise, these assumptions are also applied to modeling for the combined system,.

Extent of eventual service area

Throughout the planning process the assumed extent of the planning area is the sewerable area within urban growth areas of King, Snohomish, and Pierce Counties where King County WTD has sewage disposal contracts. Figure 1 displays the King County service area, the urban growth areas (outlined with the blue line), and component sewer service providers.

Future Population

It is assumed that new capacity at the West Point Treatment Plant and in the combined sewer system will not be needed to accommodate population growth. Although the City of Seattle is physically built out, redevelopment will increase population density over time. City regulations that require stormwater management, however, will offset the effects of wastewater flows contributed by greater population densification. New conveyance facilities in the separated sewer system are designed to handle peak flows expected to occur from a 20-year peak flow from projected populations in 2050 when buildout is expected to occur. CSO control facilities, such as storage or satellite treatment, are built to manage 1-year peak flows in 2050.

The Puget Sound Regional Council (PSRC) forecasts population for the Puget Sound region out to 2030. The maximum sewer system service area population is a straight line extrapolation of the growth rate between 2020 and 2030 out to 2050. The PSRC produces geographically distributed population projections by dividing the area into two types of zones: (1) Forecast Analysis Zone (FAZ) and (2) Transportation Analysis Zone (TAZ). FAZ boundaries are derived from census tracts. There are approximately 219 FAZs in the regional study area. Preliminary FAZ level forecasts undergo extensive review by local governments, public agencies, and others before FAZ level forecasts are released. PSRC then develops forecasts for TAZs, which are smaller than FAZs and provide greater specificity on where population is currently located and where it is expected to grow. Because TAZ information is generated from FAZ information, the TAZ forecasts also reflect information that has undergone local review. More information about the PSRC population projections and their methods is available at http://www.psrc.org/.

WTD uses the TAZ data for wastewater flow projection in the service area because of their greater specificity. Because TAZ boundaries do not coincide with the basin boundaries used for flow projections, population forecasts are allocated to specific basins. The process involves using GIS tools to assign existing population and growth to both current and future sewered areas in each basin. The initial GIS work is performed and then adjusted, if necessary, according to specific information in each TAZ and basin, such as the location of major employers.

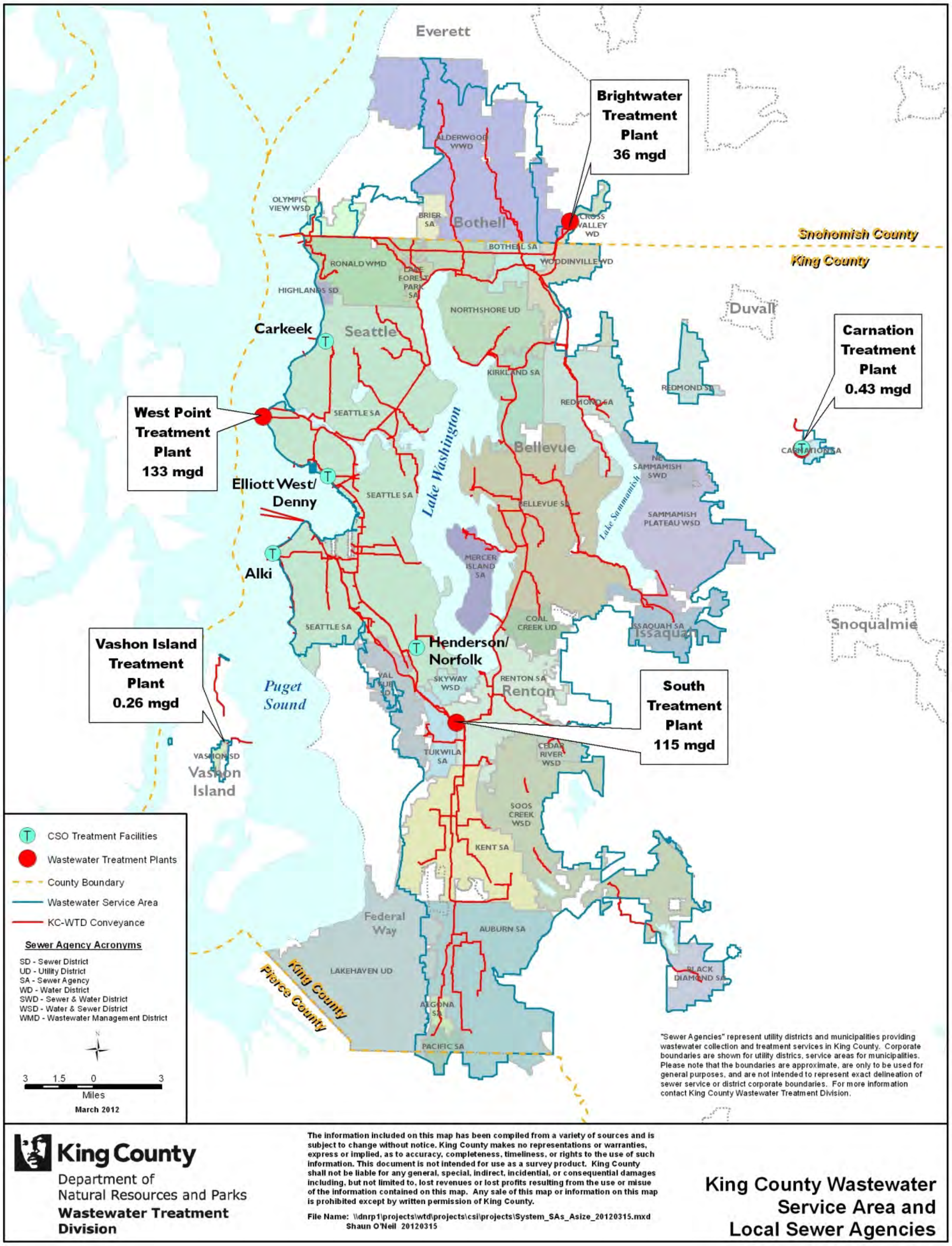


Figure 1. King County Service Area and Local Sewer Agencies

Water Conservation

Indoor water consumption for the months of November through February are used to estimate base wastewater flow. This information is collected from Seattle Public Utilities (SPU) and other water purveyors in the WTD service area to estimate flows from residential, commercial, and industrial users.

The Regional Wastewater Services Plan (RWSP) assumed the following rates of indoor water consumption (wastewater generation) through the 2030 planning horizon:

- Residential: 60 gallons per capita per day (gpcd)
- Commercial: 35 gallons per employee per day (gped)
- Industrial: 75 gped

Water conservation efforts in the region led to lower water usage than the RWSP projections, as evident in the indoor water consumption data provided by SPU in 2000:

- Residential: 56 gpcd in Seattle and 66 gpcd outside Seattle
- Commercial: 33 gped
- Industrial: 55 gped[5]

Data from 2003 show additional reductions:

- Residential: 52.1 gpcd in Seattle and 62.4 gpcd outside Seattle
- Commercial: 32.4 gped in Seattle and 30–33 gped outside Seattle
- Industrial: no data

To accommodate reductions in water consumption, the county assumes a 10 percent reduction in per day consumption from the 2000 levels by 2010, with no additional reduction thereafter (Table 2). Water consumption rates will be updated near the end of 2010.

Table 2. Projected Water Consumption

Type of Consumption	2000 (gallons per capita or employee per day)	2010 and Beyond) (gallons per capita or employee per day)
Residential (Seattle)	56	50
Residential (non-Seattle)	66	60
Commercial	33	30
Industrial	55	50

[5] King County's Industrial Waste Section provided information that the permitted industrial process flow was 22 gped, which was added to the commercial water consumption rate (33 gped) to arrive at a total industrial usage of 55 gped.

Septic System Conversion

The RWSP projected that 100 percent of the potentially sewerable area will be converted from on-site septic systems by 2020. The current planning assumption is that 90 percent of the potentially sewerable area (in 2000) will be sewered by 2030 and that 100 percent of this area will be sewered by 2050.

As of 2000, approximately 43,000 houses in the regional wastewater service area were estimated to be on septic systems. Most are located in the north, east, and south edges of the service area. The Growth Management Act restricts sewer services to parcels in urban growth areas. As the population urban growth areas grows, land values rise. This leads to redevelopment of areas in the urban growth area served by septic systems. Many of the parcels served by septic systems are larger lots that can be subdivided for further development and converted from septic to sewer.

Other information on the service area in 2000 includes:

- Total developable parcels: 300,500
- Total sewered parcels: 246,500
- Vacant developable parcels: 11,000

I/I Degradation

Degradation—cracked pipes; pulled joints; deteriorated pipes, joints, and connections at manholes; construction and/or traffic damage to manholes—is the slow decline in the condition of a collection system and the associated increase of I/I flows in the system. Illicit connections to the sanitary sewer system can also increase I/I. It is assumed that this increase in I/I occurs only in the separated sanitary sewers because combined sewers are designed to accept stormwater runoff.

There are little data documenting how fast and how much I/I degradation occurs in a collection system. WTD currently assumes that degradation will occur at a rate of 7 percent per decade starting in 2000, with a limit of 28 percent over a 40-year period. For example, if a basin's I/I is 1,000 gallons per acre per day (gpad) in 2000, it will increase 7 percent to 1,070 gpad by 2010.

Using a fixed percentage acknowledges that newer systems degrade less (on a total I/I basis) than older leakier systems. For example, a newer system may have 1,000 gpad of I/I and an older one may have 10,000 gpad. Seven percent of 1,000 gpad is 70 gpad, and 7 percent of 10,000 gpad is 700 gpad. For new construction, the degradation assumption of 7 percent per decade will start after the decade of construction. (For example, new construction in the 2000 – 2010 decade will be assumed to have a peak I/I rate of 1500 gpad in 2010. By 2020, that rate is assumed to increase to 1605 gpad.)

Results of the recent Decennial Flow Monitoring (DFM) project (2009–2011) and subsequent modeling will be compared with the 2001–2003 I/I Program flow monitoring and modeling to develop estimates of I/I changes over a decade.

New System I/I

The amount of I/I into the regional system from new sewer facilities impacts system flows and capacity needs. In the past, WTD included an allowance of 1,100 gpad for future sewered areas in the design flow for both the conveyance and treatment of wastewater in the regional system.

Flow monitoring during the wet seasons of 2001–2002 and 2002–2003 showed that the measured amount of peak hourly I/I found in new systems ranges from 270 to 11,200 gpad. Several new systems had less than 800 gpad of peak I/I. The county is now using an assumption of 1,500 gpad for new system I/I.

Design Flow

King County adopted a 20-year peak flow capacity standard for the separated portion of its regional conveyance system when it adopted the RWSP in 1999. The combined system is under a separate state regulation to limit overflows to an average of one untreated event per year on a long-term average. For the combined system, a 1-year peak flow is used for sizing CSO control facilities.

The 20-year peak flow standard is based on the Federal Clean Water Act, which does not permit overflows from the separated conveyance system. Accordingly the county’s adopted 20-year peak flow standard is the design target for conveyance facilities intended to eliminate conveyance system overflows. The 20-year peak flow for the “current year” (baseline) acts as the trigger for identifying and planning for needed improvements in the conveyance system. The current year for modeling the separated system is 2000. The current year will be redefined when the results of the DFM project are used to recalibrate the model.

The 20-year peak flow in 2050 is the design standard for upgrades of pipelines and pump stations. However, mechanical and electrical equipment may be sized for a shorter expected lifetime. The project team decides on the target year for the equipment life and capacity. The 5-year peak flow is used to determine the firm capacity of a pump station, which is defined as the capacity with the largest pump out of service.

A “design storm” approach, while used in the 1990s and previously, was considered but rejected because building a system based solely on the amount of rain from a 20-year storm or 1-year storm does not take into account the antecedent storm and moisture conditions. Antecedent moisture is the buildup of groundwater over time that affects total I/I during a particular storm event. The higher computing power available for modeling enables the shift away from design storm modeling to long-term continuous modeling.

Planning Horizon

WTD currently uses a time horizon through 2050 for planning purposes. It is assumed that “saturation” population and sewered area conditions will occur by then in the urban growth area. For pump station equipment with less than a 40-year lifespan, design capacities may be based on a shorter time horizon.

Size of Planned Facilities

Projects are planned for the separated portion of the service area to convey the saturation peak flows plus a 25 percent safety factor (explained in Section 4.1.9). The sizes of particular projects depend on the ultimate capacity needs and on an assessment of whether the existing facility likely needs to be replaced. For conveyance pipes, the saturation flow is used, as described in Section 4.6. A safety factor is applied to the saturation peak flow to derive the size of a new facility. If the existing facility is likely to remain in place, then the saturation peak flow plus the safety factor is used to size the new facility. If the existing facility likely needs replacing in the next few decades, then a replacement facility is sized to be able to convey the entire future demand including the safety factor. For electrical and mechanical equipment in a pump station, the size of the equipment for a 30-year horizon is generally assumed.

When projects are in the pre-design phase, WTD management makes the decision on whether the safety factor will be used in sizing the new conveyance facility.

For combined system CSO projects, the long-term one-year return volume is assumed for sizing. During Facility Planning, WTD management decides if a safety factor will be used in sizing the facility.

Safety Factors

It is common practice and sound engineering to add a contingency or safety factor for sizing facilities to handle unforeseen circumstances. Adding a contingency factor helps ensure that the conveyance system can accommodate higher peak flows without overflows or other unwanted consequences.

The County and E&P Subcommittee agreed in March 2004 to use a safety factor of 25 percent of additional capacity for completing analyses for the Regional I/I Control Program . This assumption has been carried over to the Conveyance System Improvements (CSI) Update and other planning work for the separated system. The increase for a 25-percent contingency factor in flow results in roughly a 5-percent increase in cost in WTD conveyance facilities.

The Capital Systems Team will decide how much of a safety factor will be used when the project goes to predesign and/or design.

Some of the uncertainties that support developing safety factors are listed in the following section.

Uncertainties Affecting Facility Sizing

There are several factors that are not known precisely when projecting peak wastewater flow into the future. Some of these uncertainties are described in the following paragraphs.

Existing Peak Flow Estimates

There are a number of potential sources of error in estimating existing peak flow from monitored data. Due to inaccuracies in rainfall monitoring, flow monitoring, and modeling, it is not always possible to predict peak flows with a high level of certainty. While models are calibrated using the best information and technology available, the peak flows that serve as the basis for facility sizing are estimates and are not perfectly accurate.

Possibility for Sewering Outside Urban Growth Area

Sewers are expected in urban growth areas and these areas are the source of wastewater system flows. However, on occasion, sewers are needed, and built, outside urban growth area for environmental and/or public health reasons. This can lead to increased peak flows.

“Four to One” Policy for Development along Urban Growth Boundary

Chapter 3 of the County’s *Comprehensive Plan* contains a “Four to One” development policy along the Urban Growth Boundary. This policy states that 1 acre of Rural Area land may be added to a city's Urban Growth Area in exchange for a dedication to the County of 4 acres of permanent open space. Addition of these added urban areas increases the sewered flow above what is generated in the current urban area. It is not known how much this four-to-one development will add to the urban area and resulting sewer flow over time.

Economic and Population Changes

The local economy represents another possible impact on peak flows, since economic surges tend to bring new industries, companies, and population growth, all of which increase flows in the regional system. Some of this growth is already accounted for in the PSRC population forecasts, but these forecasts change over time.

Climatic Changes

Global climate change may impact the frequency and severity of rainstorms in the future. There is indication that storms will increase in intensity due to global warming. If this comes about, peak 20-year flows may be larger than predicted using a historical rainfall record.

2. Approach for the Separated System

For the separated system, projections are done in 10-year increments through 2050 for each basin using the following approach:

- The additional population and employment projected for the basin is added to existing population and employment and factored to derive the expected base wastewater flow.
- New construction I/I assumptions are applied to projected additional sewered land and I/I in the previous 10-year increment for sewered areas is increased by the 7 percent degradation factor to estimate the future 20-year peak flow.
- The future peak 20-year I/I is added to the 1.35 peaking factor times the base wastewater flow to obtain the 20-year peak flow.

The 20-year peak flows for each basin are placed into an Excel spreadsheet ("conveyance.xls") containing all the King County pipe segments in the separated system The peak flows from each basin are summed up, using attenuation factors derived using the MOUSE HD model simulations, such that the resulting peak flows are the 20-year peak flows associated with each King County pipe reach.

Figure 2 presents a graphical representation of the flow projection for one basin.

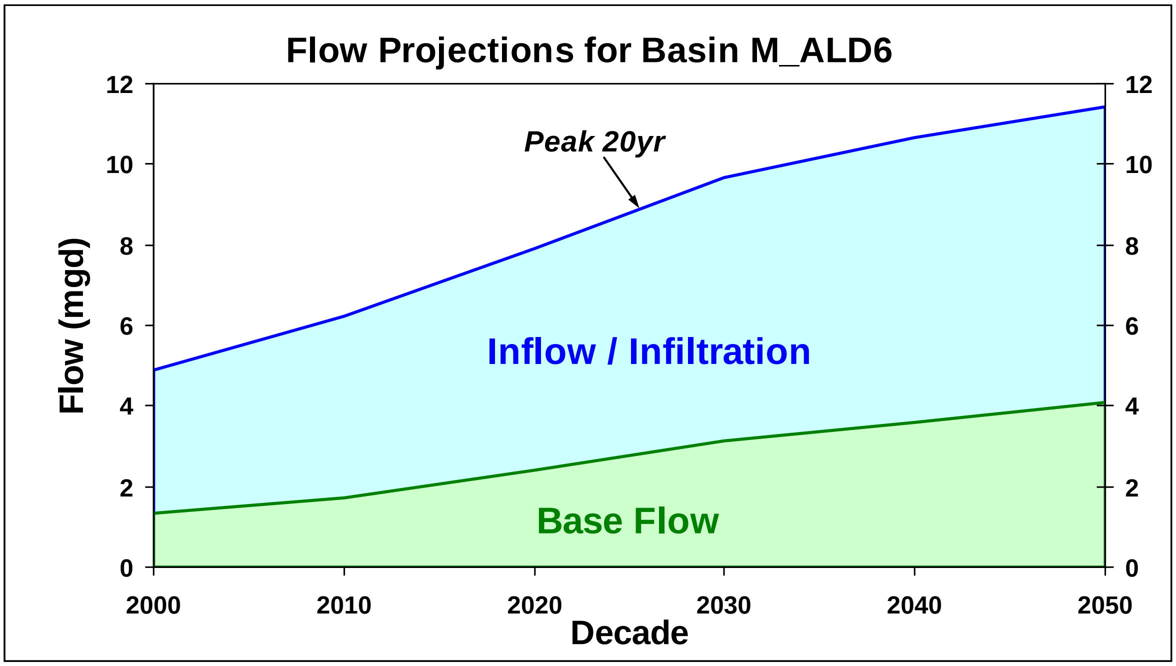


Figure 2. Base and Peak Flow Projection for Basin M_ALD6

Appendix E
Standard Operating Procedures
Flow Monitoring

(October 18. 2011)

Standard Operating Procedures
Flow Monitoring

(October 18. 2011)

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Introduction

The purpose of having Standard Operating Procedures (SOPs) is to:

- To standardize procedures followed by the flow monitoring team in order to make data collection and troubleshooting more productive;
- To allow new personnel to implement procedures and actions such as meter installation and data collection with relative ease;
- To collect high quality data;
- To avoid unnecessary data loss;
- To serve as reference documents for any future audit by end users (of the flow data) or other interested parties;
- To make data review and analysis more efficient and minimize the time lag between data collection and data review/analysis, and
- To support training of new and current employees in flow monitoring.

Supporting documentation

During flow data collection there are several things that need to be documented in order to appropriately interpret the collected data and troubleshoot any observed and/or potential problems. The need for documentation cannot be over emphasized especially when dealing with flow data that may not be easily interpreted and/or requires more detailed analysis. It is not uncommon for data analysts and end users to review previously collected flow data in order to evaluate the data quality and clear any observed inconsistencies. It will be very difficult to support or justify any changes/corrections that may need to be applied to the data without proper documentation completed at the time of data collection. Documentation will be stored in the office and out in the field.

Documentation that must be completed and in some cases updated regularly includes the following:

Site report

The site report must include information on the monitoring site including

- Monitoring site location- street address and/or intersections and close by land marks
- Safety and traffic conditions
- Date of investigation.
- Manhole and pipe information including manhole depth, manhole condition cover size, and pipe size, shape, and type

- ❖ Meter type, serial number, data collection method, level calibrations, sensor offset, velocity multiplier, ultrasonic offset, and pressure sensor offset
- ❖ Initial field verifications
- ❖ Connections - drop, slope, grade etc.
- ❖ Hydraulics - flow conditions in the pipe (ripples/waves, uniform, laminar etc)
- ❖ Surcharge and/or backwater evidence
- ❖ Area (access) map and manhole cross-section drawings

Daily site visit and service log

The daily site visit and service logs need to include the following information and digital copies of daily logs are provided to the Data Analyst (and the original kept with the field crew):

- ❖ Date and time of site visit
- ❖ Site name and meter/sensor serial number
- ❖ Real time depth and velocity readings
- ❖ Manual depth and velocity readings if field verification is performed along with +/- of field reading
- ❖ Battery level
- ❖ Silt level
- ❖ Summary of on-site data review
- ❖ Problems and site conditions observed and services performed

Site Master List

This document contains an inventory of all King County-owned flow monitors and sensors, a list of all calibrations performed at each site, a list of all sites, and maintenance needed at each site, and a collection schedule for all manual collect monitors. This list is maintained in the King County server and is updated regularly by the flow monitoring field crew. Updates to the Master List must be done by the designated Filed Crew, and all other users must make a copy on their respective local drives/computers.

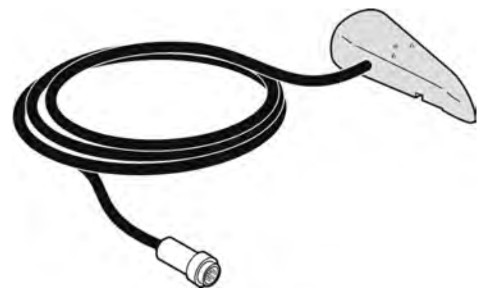
SOP I – Safety Procedures

The field crews install flow meters in manholes and down load data from these meters on a weekly/bi-weekly basis and perform field verifications (requiring manhole entry) every two-three months or as necessary. Some of these activities require Confined Space entry and traffic control set ups.

Any entry into a manhole requires testing for toxic air, wearing Personal Protective Equipment (PPE), safety equipment set up, etc and would be covered under the WTD Confined Space program and must be conducted by personnel certified to make entries, with the necessary equipment. The WTD Safety Program has also hardcopies available. You will want to verify that anyone entering manholes or acting as topside attendant has had training that is documented in the WTD Employee Information System. If it is necessary to block the road or conduct traffic control activities in conjunction with the entry at least one person on the crew must hold a valid flaggers' card and follow the Washington State Department of Transportation (WSDOT) Work Zone Traffic Control Guidelines (M 54-44). Additionally, to review and continually update safety requirements, and track resources, a list of safety equipment must be compiled, maintained, and updated as necessary.

SOP II - Flo-Tote Model 3000 (FT3)

The Model 3000 Flo-Tote Flow meter (FT3) is by Marsh-McBirney/Hach. The main new features of this meter include a disconnectable sensor and an interchangeable data logger (with the Flo-Dar flow meters).



FT3 Installation and Site Setup

Prior to performing the site set up and sensor installation procedures, gather the necessary items on the list below:

- 5 gallon Bucket
- Filled Water Jug
- Properly functioning Gas Meter and a spare
- Confined Space Retrieval Equipment
- Computer with a charged Battery
- Communication Cable
- Flow meter (and a spare)
- Drill with charged batteries
- Mounting hardware (including spring band and scissor band to fit pipe)
- Measuring stick (for manual depth confirmation)
- Portable Velocity Meter (for independent field verification)

The site set up and sensor installation procedures for the FT3 include the following steps:

- ❖ Establish a monitoring location and create a location information or Site setup file for storing the monitor configuration and information (e.g. pipe height and width, sensor offsets, selected devices, data collection rates, and silt level). This step may be performed at the office.
- ❖ Install the sensors and monitor in the manhole
- ❖ Activate the meter
- ❖ Take real time (instantaneous) readings and compare them to manual readings to verify the sensor readings and perform system diagnostics.

The steps are described in more detail below.

1. Once you have arrived at the site, set up and put all of the safety equipment in place, including traffic control.
2. Open Flo-ware on laptop
3. Connect communication cable to computer (9 pin port) and to Flow monitor--
4. Click on Flo-Tote 3 under Options
5. Click on Communications (as shown in Figure 2-1)
6. After the screen has changed you will be in the site setup screen. Figure 2-2
7. Begin by filling in the appropriate Site ID (The site name should already have been chosen. If not the trunk line or town and manhole number will suffice - example, RainierTrunkMHR1853)
8. The location should be the physical address or the two closest cross streets
9. Units will remain in MGD unless other wise requested by the end user or data analyst.

Figure 2-1 Flo-Tote 3 setup window

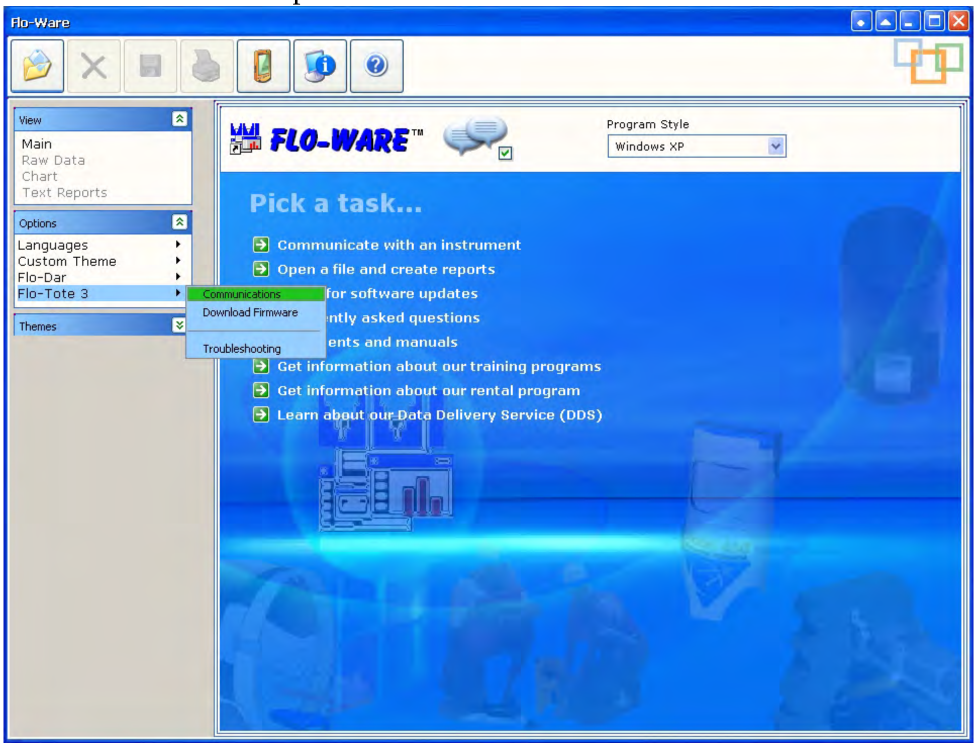
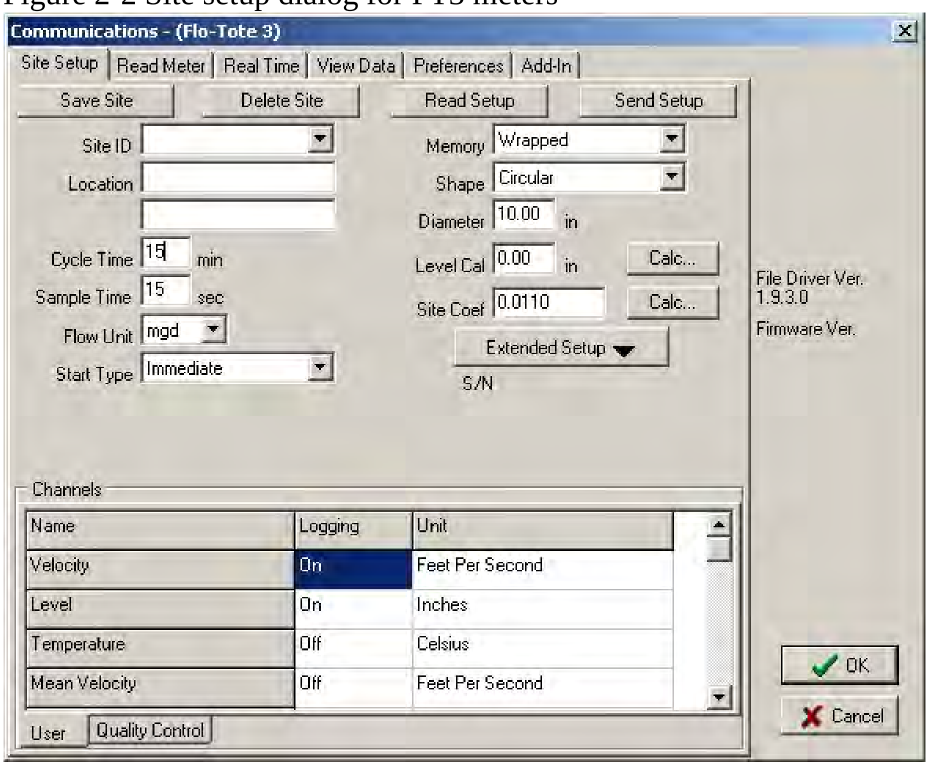
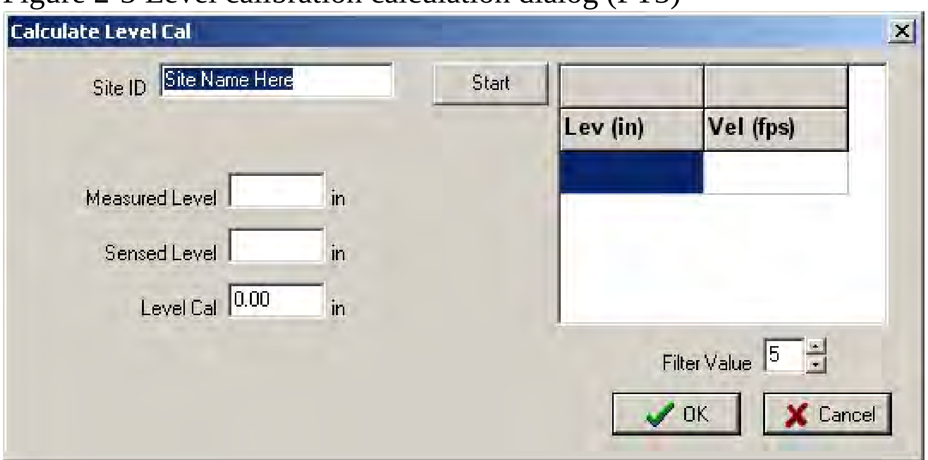


Figure 2-2 Site setup dialog for FT3 meters



10. Sample time will be 15 Seconds
11. Cycle time will remain 15 Minutes unless otherwise requested by the Data analyst or the engineer requesting data
12. Start Type is set to "Immediate" or to "delayed" if requested (Start Date and Time will be given by Data analyst or engineer)
13. Use the pull down menu to choose the way the monitor stores data from Fixed to wraparound. (This ensures that the monitor will continue to collect data after the memory is full)
14. Use the pull down menu to choose the shape of the pipe that you are installing. (most pipes are circular, If not contact supervisor or lead for further instruction)
15. Measure the pipe diameter with a ruler or tape measure and record information in this box.
16. Fill Bucket to ~8" of water and put sensor end at bottom of bucket (Let sensor stay at the bottom of the bucket and do not move the bucket around or put on an uneven surface)
17. Level Cal. – Adjusts the calibration in the level measurement system. The difference between manually measured level and sensed level will be calculated and displayed as the Level Cal.
18. Press Calc Button and a Smaller screen will popup (Figure 2-3)

Figure 2-3 Level calibration calculation dialog (FT3)



19. Once the screen has popped up click on the start button and the monitor will start measuring depth
20. Once there a sufficient number of readings have been taken (usually 4 to 5 will suffice), Click on the stop button.
21. Take a measurement from the bottom of the bucket to the top of the water and record this depth in the Meas. Level Box
22. Type the average of the readings from the monitor and type them into the Sensed Level Box

23. Once this is completed the Level Cal. Box should change from 0.00 to the level cal number for this monitor
24. Click on the OK button and the screen will go away and you will be back at the main setup screen again. (Figure 2-2)
25. Make sure to check that the level cal box has the same number as the previous screen.
26. Enter the manhole and insert the sensor in the pipe with either a springband or a scissorband. Verify that the sensor is on the bottom of the pipe and install the flow meter (sensor/logger assembly) following the recommended methods in the Marsh McBirney Sensor Installation Manual for Open Channels"- P/N 100 BAND.
27. Level Offset – When the sensor is installed, it may not sit exactly at the bottom of the pipe due to significant silt/sediment accumulations at the bottom of the channel. Under such conditions, the sensor is mounted at an offset position and the Level Offset compensates for this situation. Since the sensor's Level port doesn't rest directly on the bottom of the pipe, but 0.4 inches above it, for standard installations where the sensor is mounted at the bottom of the channel, the default Level Offset is 0.4 inches.

a. Click on the Level Offset button under the Extended Setup (Figure 2-4) dropdown list and an additional screen will pop-up (Figure 2-5)

Figure 2-4 Level Offset under the Extend Setup dropdown (FT3)

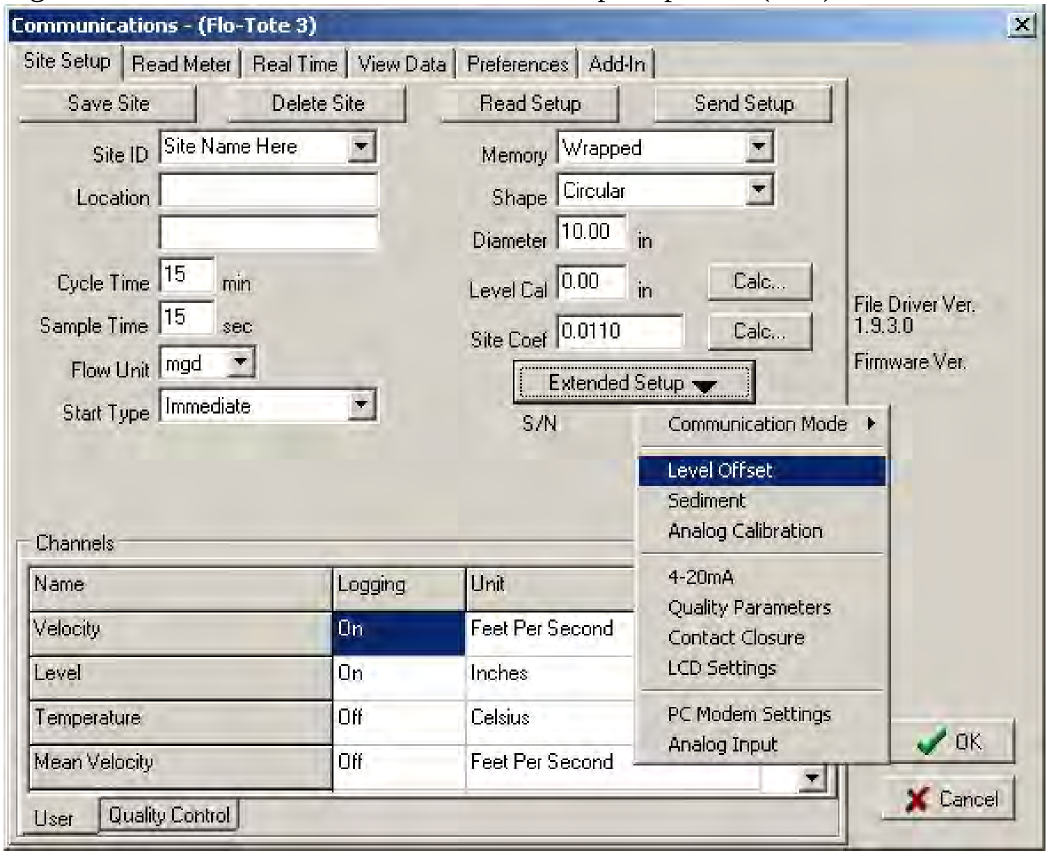
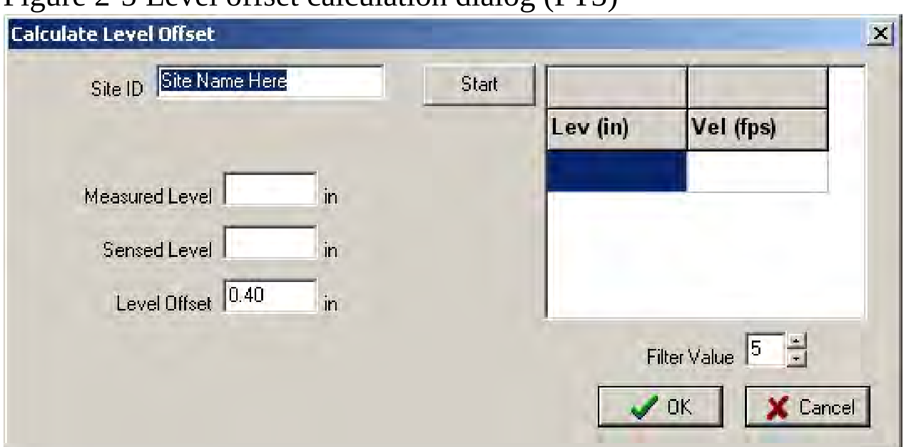


Figure 2-5 Level offset calculation dialog (FT3)



b. Click on Start button to start readings.

c. Once you have 4 to 5 readings click on the stop buttons

d. Type in the readings into the sensed level box

e. Take a measurement and record the depth of flow in the Meas. Level Box

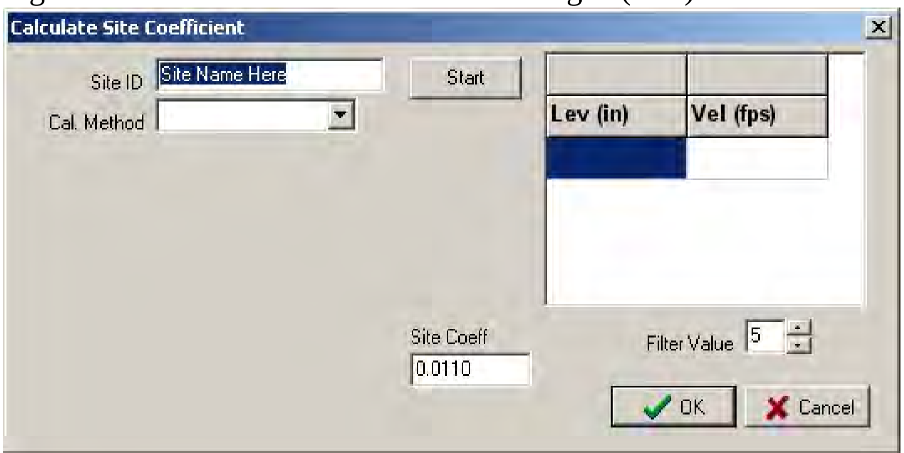
f. Your Level offset will be automatically calculated for you.

g. Press the OK button to return to the Site Setup Main Screen

29. Setting up the Site Coefficient

Click on the Site Coeff. Button and another screen will pop up again (Figure 2-6)

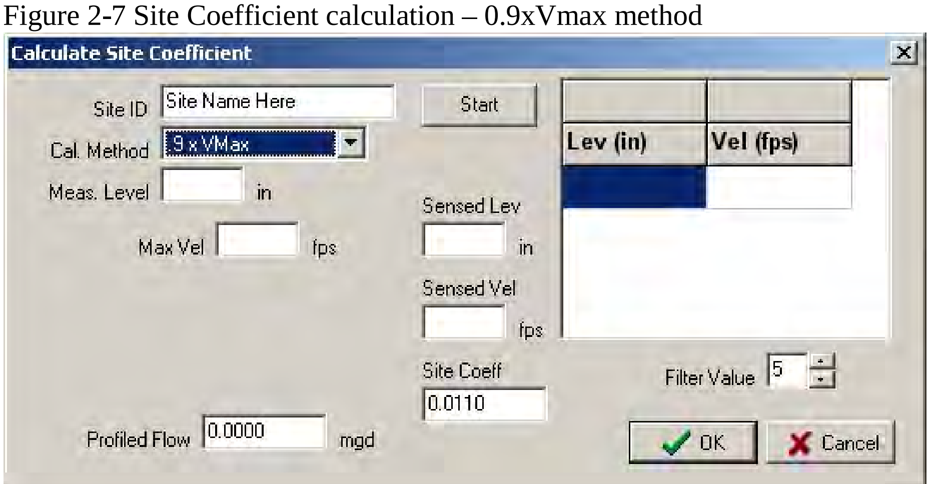
Figure 2-6 Site Coefficient calculation dialogue (FT3)



Choose Cal. Method

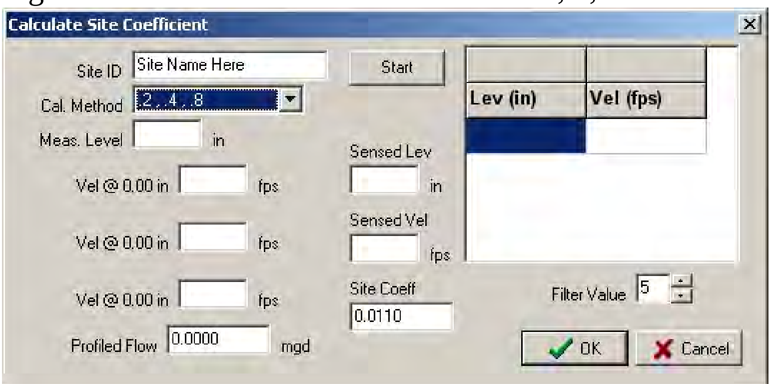
1. Use the pull down menu to choose a cal method. (For flows under 5 inches use .9/Vmax, for flows over 5 inches will use the .2, .4, .8 Method)
2. After choosing the appropriate Cal method proceed to step 3 if .9/Vmax and step 9 if .2/.4/.8 method. Measurements should be taken from the bottom up.
3. After choosing the .9/Vmax method the screen will change and look like Figure 2-7

Figure 2-7 Site Coefficient calculation – 0.9xVmax method



4. Click the start button to start taking real time readings from the monitor. After you have 4 – 5 consistent readings click the stop button.
5. Record your readings in the sensed level and Velocity boxes
6. Take a manual measurement with a ruler or tape and record your value in the Meas. Level box
7. Take a manual Velocity reading the portable velocity meter and record the maximum value read in the Max. Vel. Box.
8. Got to step 13
9. After choosing the .2/.4/.8 method your screen will change and look like Figure 2-8

Figure 2-8 Site Coefficient calculation – .2,.4,.8 method



10. Take a manual Depth Measurement with a ruler or tape and record the depth value in the Meas. Level box.
11. Flo-Ware will calculate the depths at which you should take you readings with the portable velocity meter.
12. Once the Max. velocity has been found with the portable V-meter at the depth specified, record the value in the appropriate box
13. Once all manual readings have been recorded click the start button to start real-time
14. Fire the sensor until you get 4-5 consistent readings
15. Click on the stop button and record the values in their respective boxes
16. Flo-Ware will calculate the coefficient for you automatically.
17. Click on the OK button and you will return to the Site Setup Main Screen
18. Click on Save Site in the Main Screen in the upper left corner, viable in Figure 2-4.
19. After the site has been saved the site will appear in the Site ID pull down menu.
20. After verifying the site has been saved you can press OK to exit the Screen and return to the Flo-Ware Main screen.
21. Once the meter has been installed take a manual depth and velocity measurement followed by a real time. Repeat this twice so that three sets of manual measurements and real times are

recorded. After confirming that the meter is functioning properly and accurately, re send the site setup before leaving the site only if any parameters have been changed.

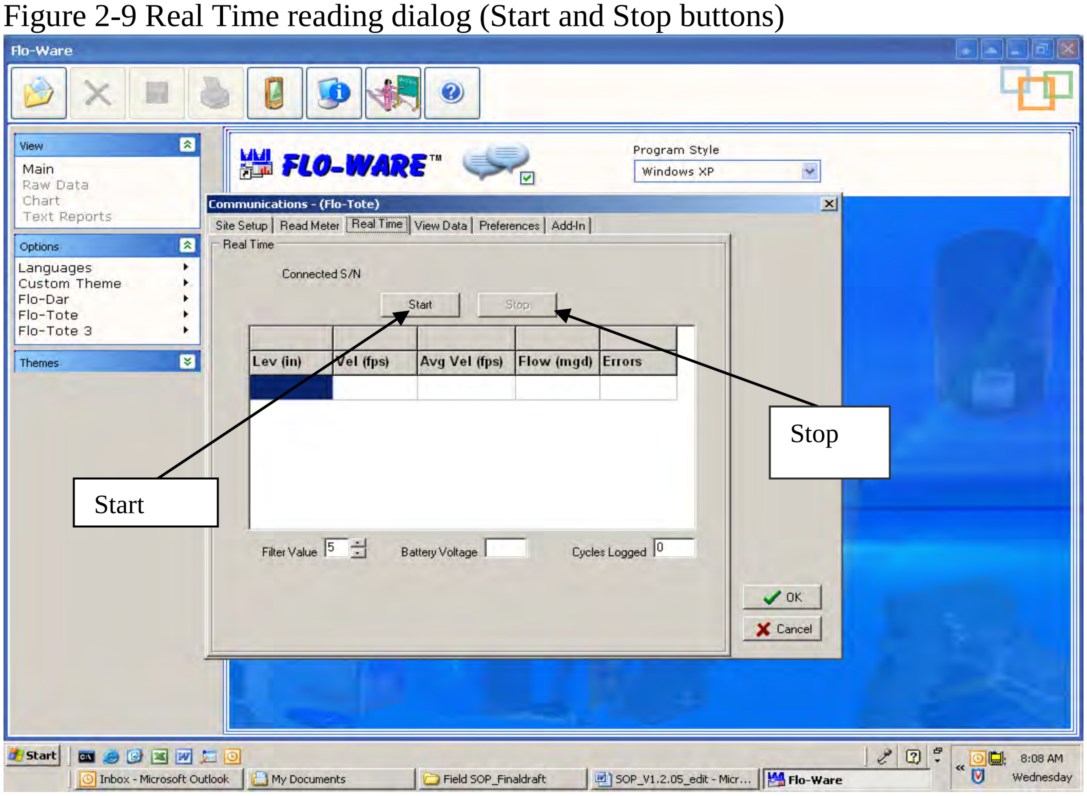
22. Return the next day to verify meter is working properly.

FT3 Data Collection and Review

Once the Flo-Ware program is open, click the Flo-Tote 3 option and select Communications.

1. Once you have arrived at the site, set up and put all of the safety equipment in place, including traffic control.
2. Open Flo-ware on laptop
3. Connect communication cable to computer (9 pin port) and to Flow monitor
4. Hover over Flo-Tote 3 under Options
5. Click on Communications (as shown in Figure 2-1)
6. After the screen has changed you will be in the site setup screen. Figure 2-2
7. Select the read meter tab. (The screen will change to look like Figure 2-9)
8. After the screen has changed click on the Start button to begin reading meter.

Figure 2-9 Real Time reading dialog (Start and Stop buttons)

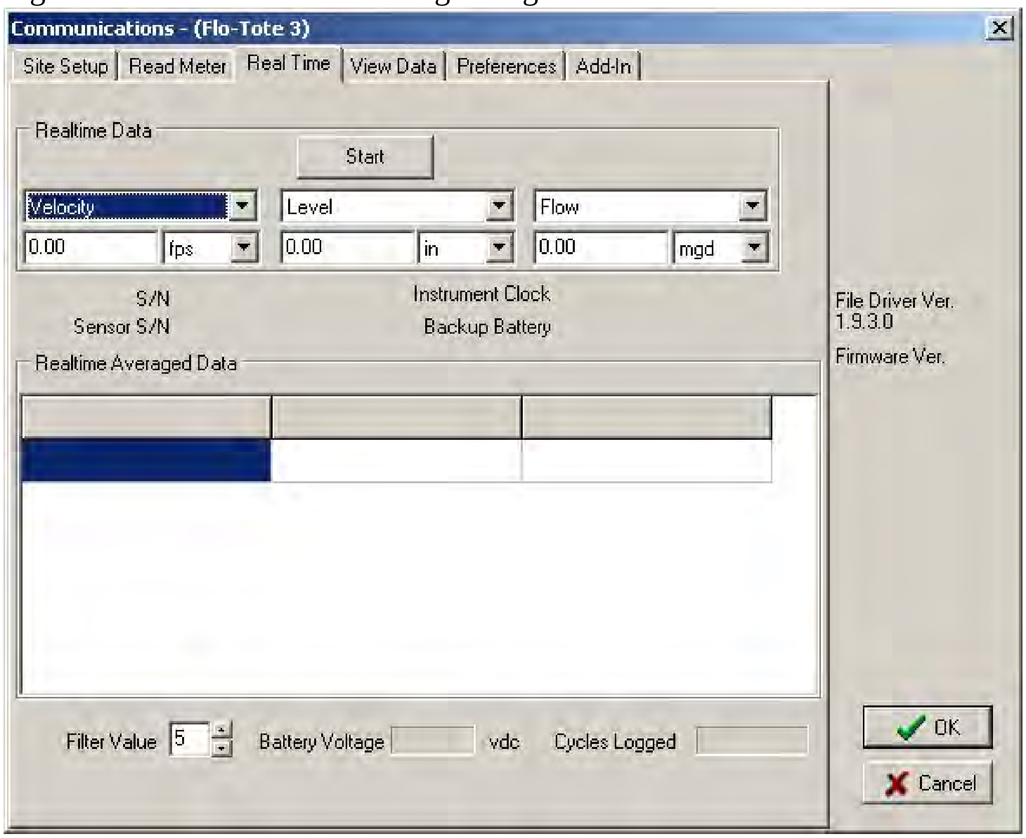


9. Once the download is complete you will get a message indicating that the data has been saved to your computer. Click on O.K. to remove this box from your screen.

10. In the new window select the real-time tab and click on it.

11. After the screen changes click on the Start button to begin firing readings. Figure 2-10)

Figure 2-10 Real time data reading dialog



12. After the monitor has recorded three consistent readings, record all data in the site visit log (as seen in Table 2.1 below)

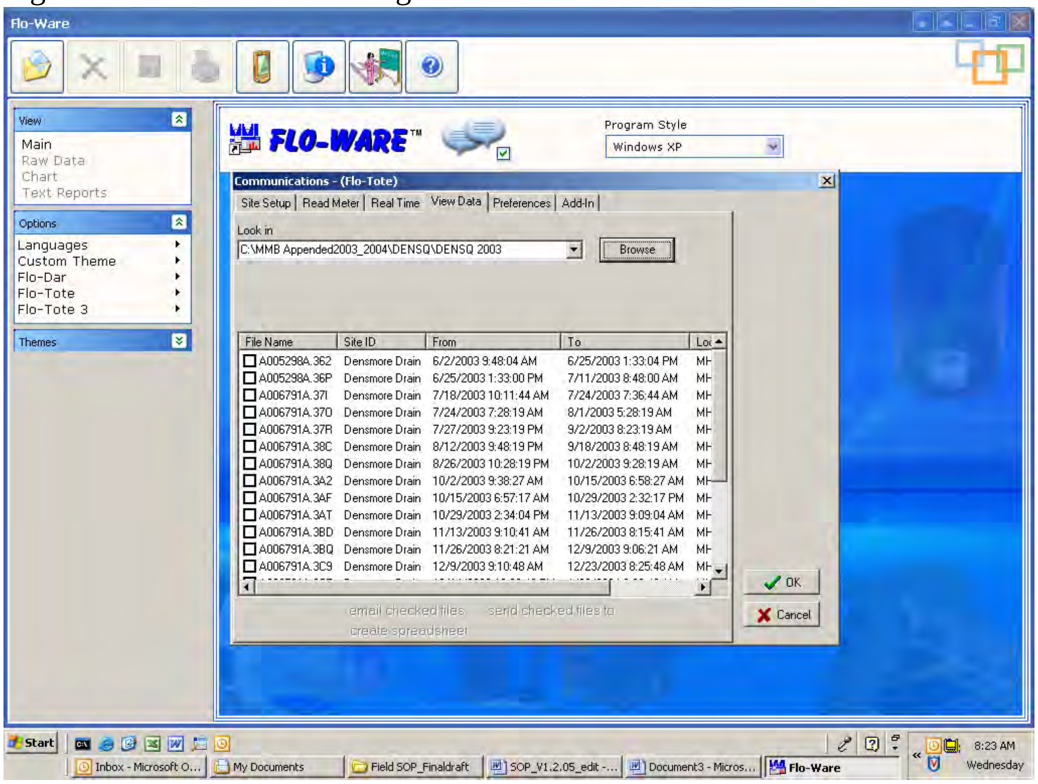
Table 2.1

Northwest			Date of visit					Downloaded:		
Location	Serial Number	Time	Real Time Depth	Real time Vel.	Field Depth	Field Velocity	Battery	Measured pipe dimensions	Measured silt	Additional Comments
HIDCSO	MMI 790									

13. After the information has been recorded in the site visit log, click on the View Data tab.

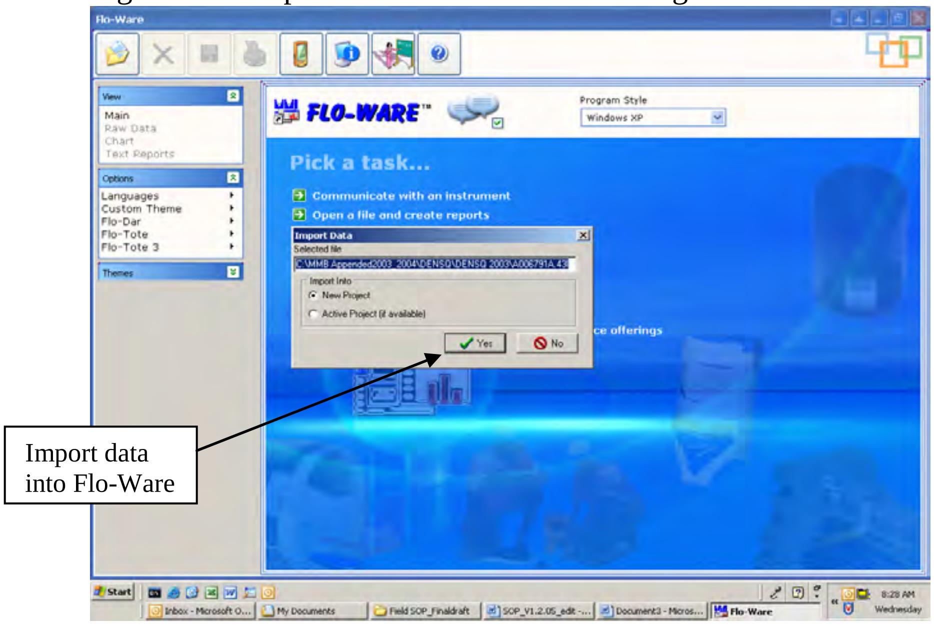
14. Scroll down the list and select the site you have just downloaded. (Figure 2-11)

Figure 2 - 11 View Data dialog



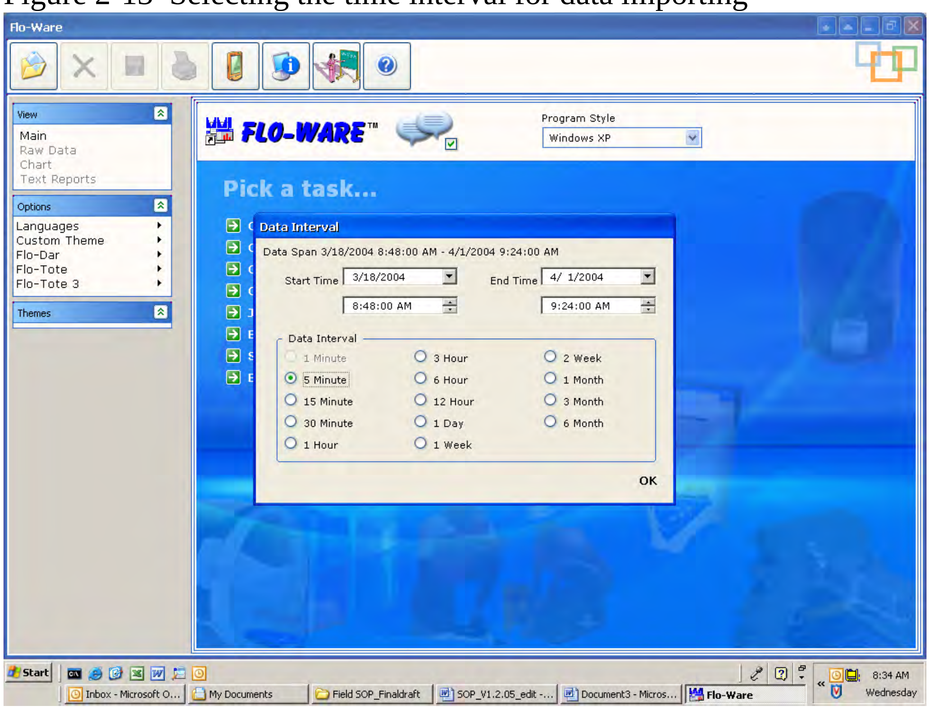
15. Once you have selected the appropriate site select the O.K. Button. (after you have selected the OK button the communications screen will close and a new screen will pop-up as shown in Figure 2-12)

Figure 2-12 Import Data in to Flo-Ware dialog



16. Select the New Project Radio Button and click OK.
    A new screen will pop up to select the data span and time average (Figure 2-13)

Figure 2-13 Selecting the time interval for data importing



Select the lowest number available and click the O.K. button

A new screen with two tabs at the bottom will appear (Figure 2-14)

Click on the Chart tab to view the Hydrograph. (Figure 2-15)

The scattergraph may be viewable via the far right button indicated by a chart with data points. ([Figure 2-16](#)

Figure 2-14 Raw Data view of imported data

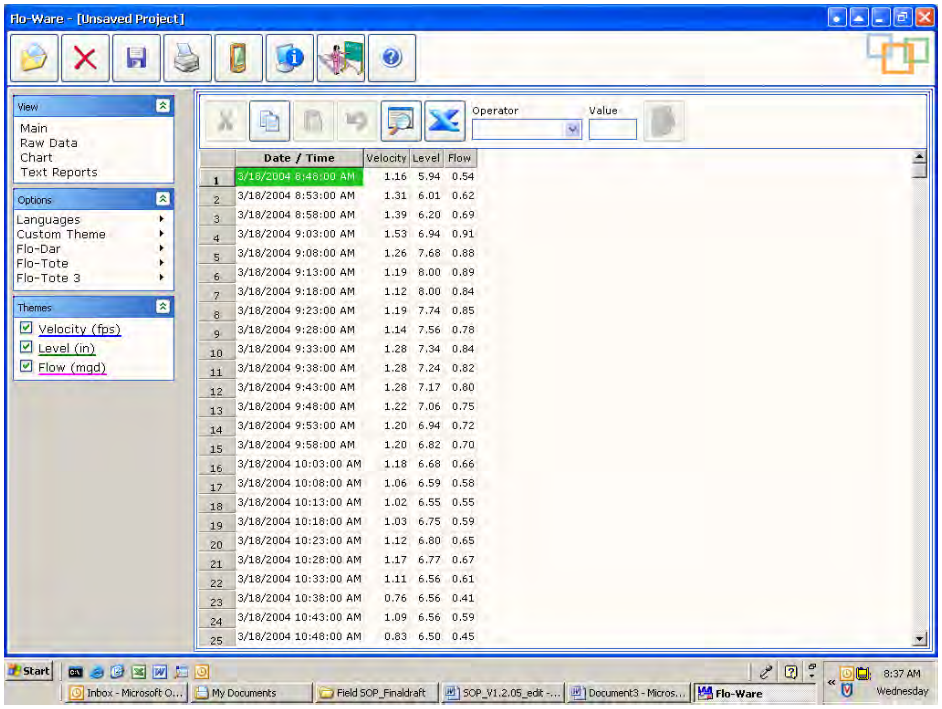


Figure 2-15 Chart view of imported data

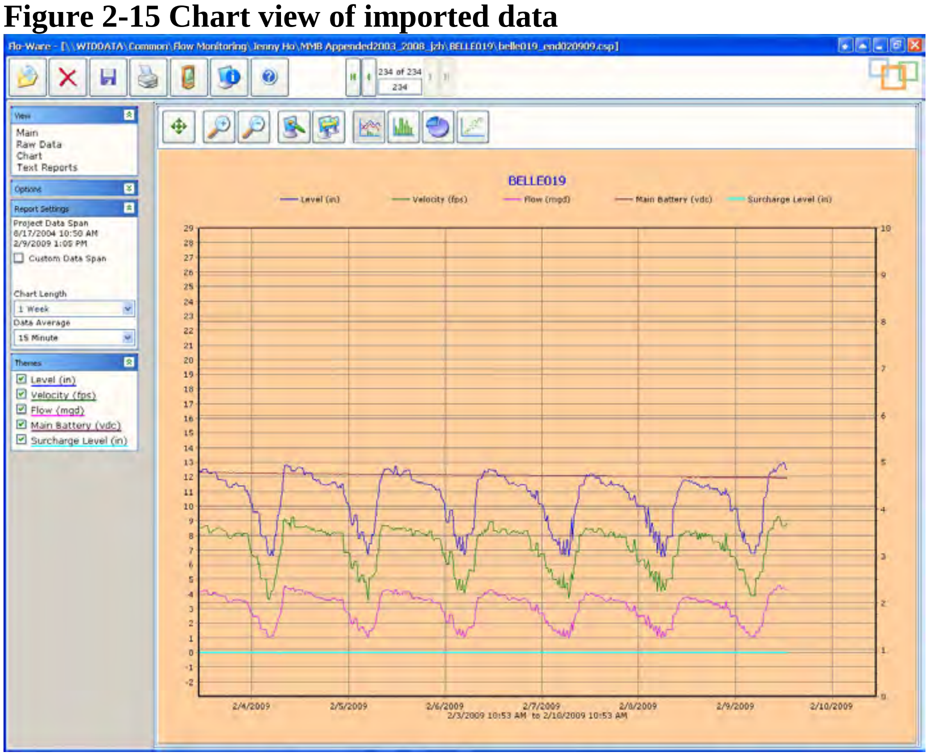
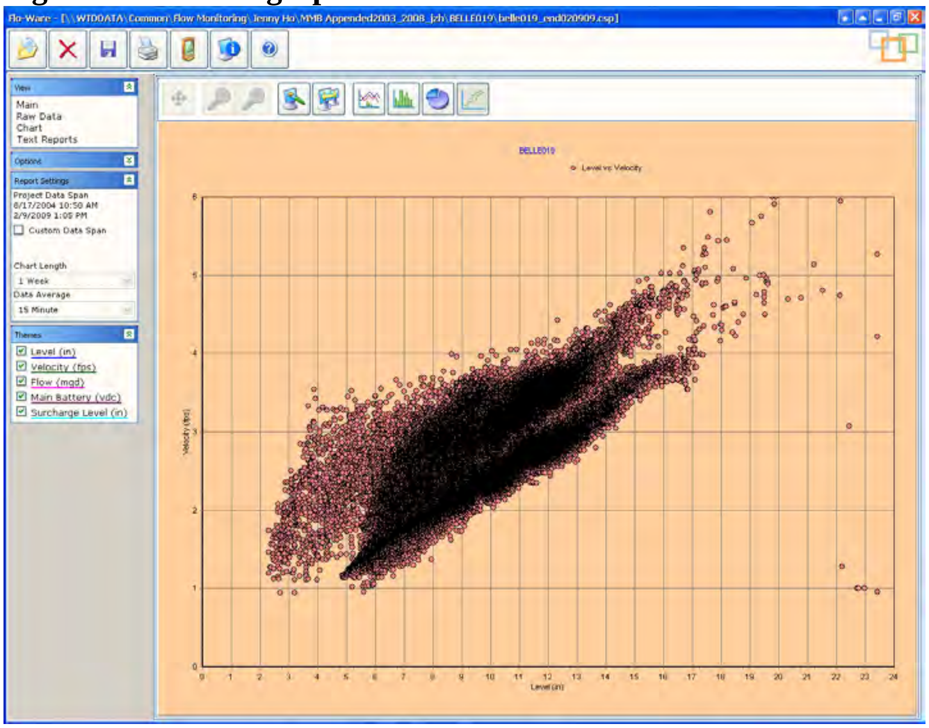


Figure 2-16 Scattergraph



If abnormalities are observed in the data which includes: data loss, flat lining, data drops, odd patterns and other suspicious data proceed below to troubleshooting the FT3.

<u>FT3 Sensor Troubleshooting and Replacement</u>

Once it has been established that the depth and/or velocity data quality is poor or suspicious, the Data Analyst will send out a Maintenance Request form to the field crew to troubleshoot. The field crew may perform the following (MMB suggested solutions to some typical problems):

Level measurements stuck at zero or full scale may be indicative of damage to the internal level transducer. Replace the sensor assembly and verify operation of sensor while onsite and record results. If this doesn’t work, replace the monitor and read depth using the old sensor assembly. If this works, then replace the monitor. If this doesn’t work, replace the old sensor assembly with a new/spare sensor assembly and read depth (with the new/spare monitor). If this works, then replace both sensor assembly and monitor.

If level measurements are wrong or values are drifting, check for moisture in the Atmospheric Pressure Reference (APR) tube. Replace the desiccant (or APR filter) cartridge and dry out the sensor and

verify proper operation of the sensor. If this doesn't work, replace the sensor and verify proper operation.
Sudden drops in Velocity may be caused by debris covering the velocity electrodes. In such cases clean the sensor, check the sensor installation for possible problems and verify proper operation of the sensor.

When velocity electrodes are dry (for extended period of time) and/or the velocity electrodes are covered by debris, a "conductivity lost" error message may appear. In such instances, check the water level and if it's less than one inch for long periods, a low-flow dam may need to be constructed. The sensor may also need cleaning.

A noisy velocity, when the sensor is clean, may be an indication of electrical noise in the monitoring channel (or pipe). Identifying and eliminating the source of the interference may alleviate this problem. It may also be necessary to construct a grounding sleeve around the sensor. If the velocity is still noisy, replace the sensor and verify proper operation of the sensor. If the problem persists, it may be necessary to move the site.
Data gaps and communication problems (with the Flo-Tote) may result if battery voltage is 10V or lower. Check battery voltage and replace if necessary.

Incorrect or odd dates: reset the time and date when visiting the site. When down loading a new set up to the Flo-tote, verify and synchronize the instrument clock with the current date and time. If the Flo-tote was told the correct date and time, but didn't accept it, then the meter may need to be sent out for service.

To check and verify the reliability of the flow data, the functionality of the sensor for level and velocity readings must be checked. To do this, a bucket test needs to be performed. The following is a procedure suggested by MMB.

- Take a 5 gallon (or larger) plastic bucket
- Fill with water about 8 to 10 inches. Take a measurement (using a ruler) to verify the actual level.
- Place the sensor in the bucket
- Let the sensor sit for a couple of hours for the charge on the sensor and the water to equalize (equilibrate) before taking the first reading

- View the data in real time. The velocity readings should be zero and the level readings should be the amount of water in the bucket. Take readings periodically and record the depth (and velocity) values. If at all possible, let the meter take readings overnight (or for a few hours during the daytime) while in the bucket. This will help to determine whether the level measurements are drifting or not.
- If the instrument reads the correct velocity and depth (level) readings then the sensor is working (or functioning) properly.
- If the instrument reads the incorrect velocity, clean the sensor and check again. If the velocity readings are still incorrect, then replace the sensor and perform the test again. If the instrument readings are still incorrect, then the meter will need to be repaired.
- If the instrument reads the incorrect level, an adjustment to the level can be done as long as it is in the valid range (+2 to –4 inches). If it's out of range, then the meter will need to be repaired.

For instrument and related error codes, and preventative maintenance, please refer to the Flo-Tote 3 error codes, and Flo-Tote Preventative Maintenance. The error code documents are compilations of error codes from Marsh McBirney web site and may not be complete. If the error code is not in these documents, then contact Technical support personnel at Marsh McBirney for detailed explanation. 1-800-368-2723

FT3 Firmware Upgrade

Marsh McBirney Inc. periodically updates the embedded software that runs inside the Flo-Tote 3 (i.e. the Firmware) in order to enhance features and functions. The firmware is embedded within the file driver which can be downloaded from the Marsh McBirney Download Center. Updating the firmware clears the entire flash memory and some or all logged data including site setup may be lost. Therefore, it's critical that the meter be READ before performing any updates. Also, there may be project specific limitations that may not allow firmware update at a particular time. The lead field person and Data Analyst will decide on the timing of firmware updates and scheduling sites for update.

Summary for updating firmware

Download the latest file driver (and thus latest firmware) to your computer.

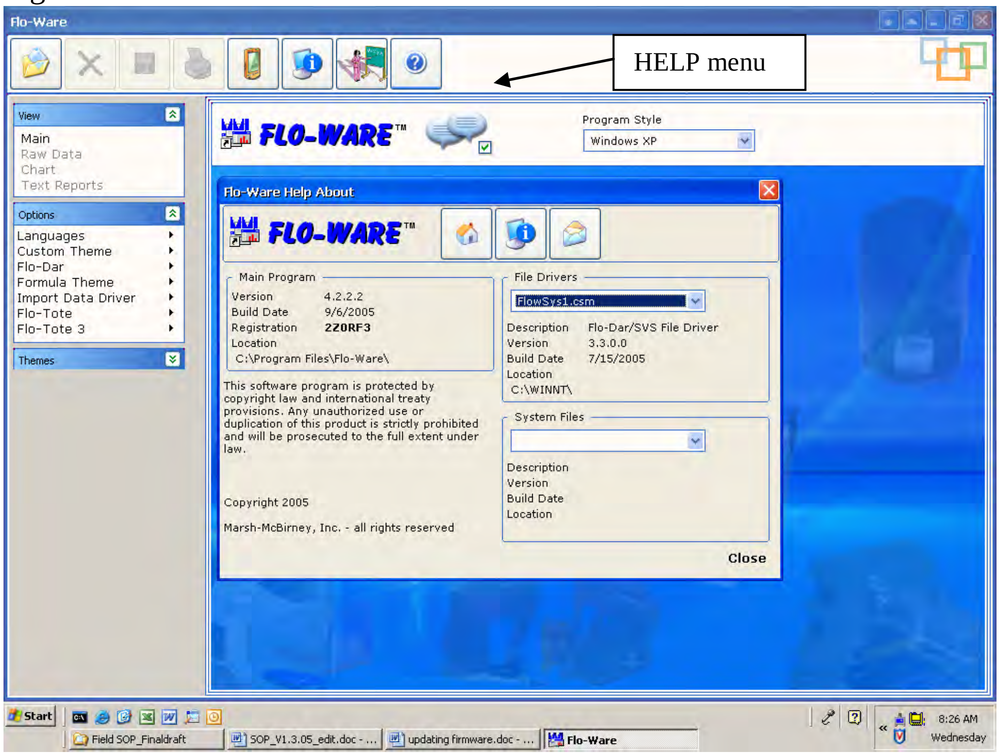
Download/read data from connected meter following procedures outlined for the specific meter (Flo-Tote 3 or Flo-Dar)

In the Flo-Ware main menu choose Options> Flo-Dar (or Flo-Tote3)>download firmware. For the Flo-Dar sensors you will be asked to select the firmware you want to down load (i.e. regular Flo-dar or SVS sensor). You will be prompted to a series of warning/instructive messages. Please read these carefully before proceeding to the next step. Proceed through the process following instructions and prompts from Flo-Ware until the firmware is successfully installed.

Verify that you have the latest version. Open Flo-Ware and double click on the "Help" icon (Figure 2-17). Under the "File Drivers" drop down menu you will be able to see the file driver version for each meter type.

Flowsys1.csm: Flo-Dar file driver
Tote3.csm: Floe-Tote 3 file driver

Figure 2-17



SOP III - Flo-Dar Model 460

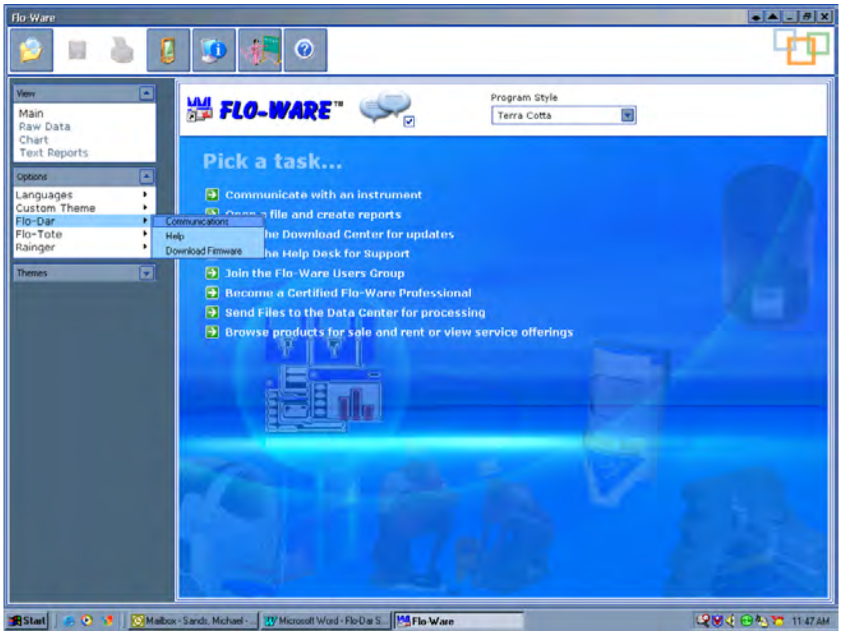
Flo-Dar Installation

1. Ensure that you have the following items before leaving the office:
   Properly functioning Gas Meter and a spare
   Confined Space Retrieval Equipment and Forms
   Computer with a charged Battery
   Communication Cable
   Flow monitor and sensor (and spares)
   Drill with charged batteries
   Mounting hardware with necessary tools
   Measuring stick (for manual depth confirmation)
   Portable Velocity Meter (for independent field verification)
   Spare batteries for all equipment

2. Once you have arrived at the site and all of the safety equipment has been put in place. Turn On the computer.

3. After the computer has booted up start the Flo-Ware program. Once the program has started put your cursor on options, Flo-Dar, and click on Communications. As seen in Figure 3-1

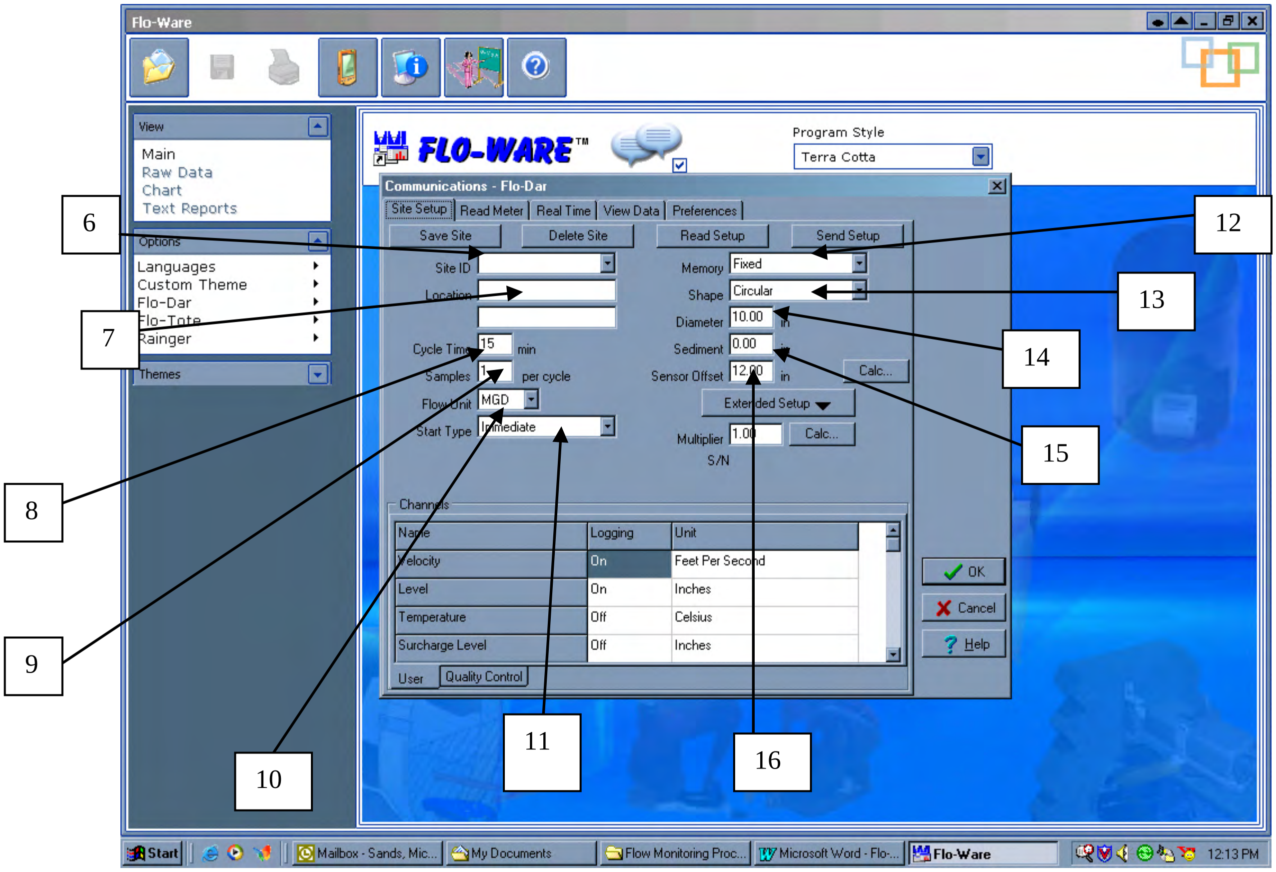
Figure 3 - 1 Flo-Dar Communications window



4. Once you have clicked on Communications the screen will change to look like Figure 3-2

5. Follow in order and input the site information in the program for the site setup.

Figure 3 - 2 Flo-Dar Site setup dialog

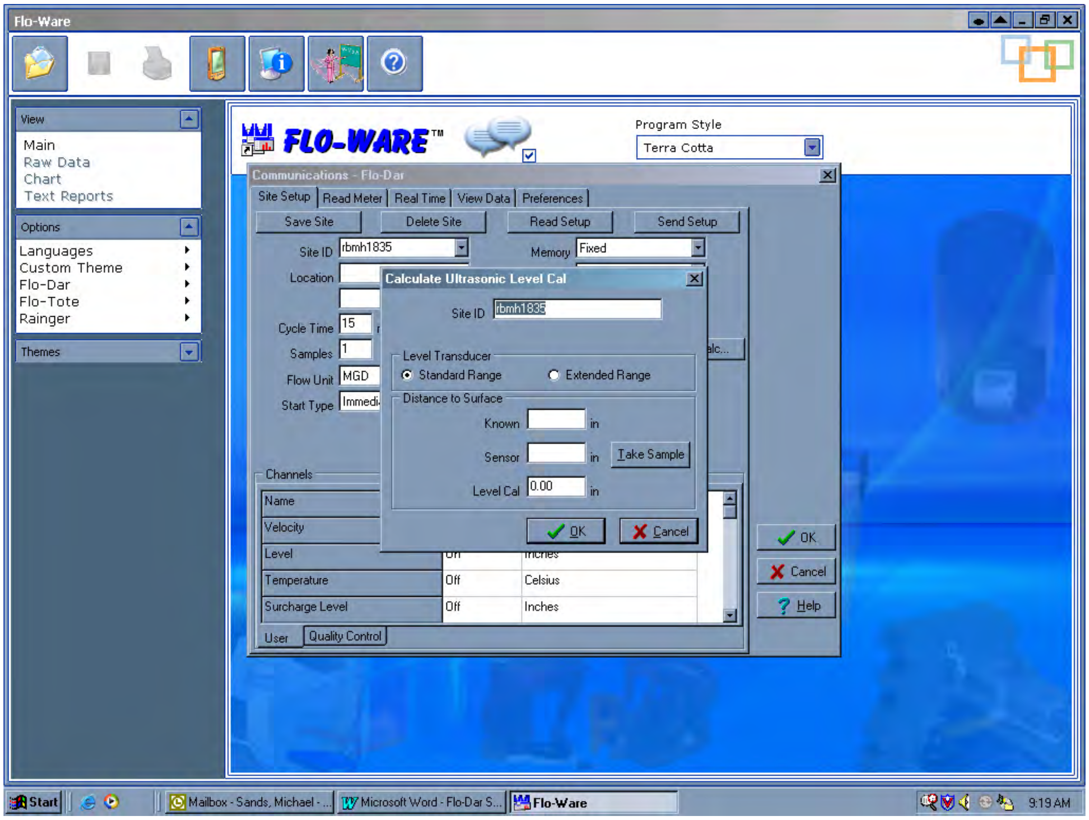


6. Enter **Site ID** (This should have been predetermined before installing the site)
7. Enter the **location** (Normally the address or cross streets)
8. **Cycle time** (usually 5 or 15 minutes, but may vary depending on the engineer or end user requesting data) Cycle Time is how often the meter will take readings
9. **Samples -** This is the number of readings the meter will take when it goes through the cycle. (Normally left at 1)
10. **Flow Unit** will be left at MGD (Million gallons per day) unless other wise told to change it
11. **Start type** can be either **immediate** or **delayed**. Immediate will start the collect cycle immediately where a delayed will be used in cases where a specific start time is desired.
12. **Memory** should be **wrapped**. (Use the pull down menu to select **wrapped**)
13. **Shape** is the shape of the pipe (normally circular)
14. **Diameter** is the measured height of the pipe
15. **Sediment** is how much silt or debris is in the bottom of the pipe.
16. The **sensor off set** is the distance from the bottom of the channel you are monitoring to the top of the frame where the sensor is mounted. (The frame needs to be installed before you can get this measurement)
17. Fill out the corresponding boxes in the site setup sheet while entering the data into the computer.

18. After entering/inputting all of the information into the program, the sensor will need to have the ultrasonic sensor calibrated. (This is to be done on the topside before the sensor is put into the ground)

19. Click on the **extended setup** button and choose Ultrasonic level cal (Figure 3-3)

Figure 3 - 3 Ultrasonic Level calibration dialog

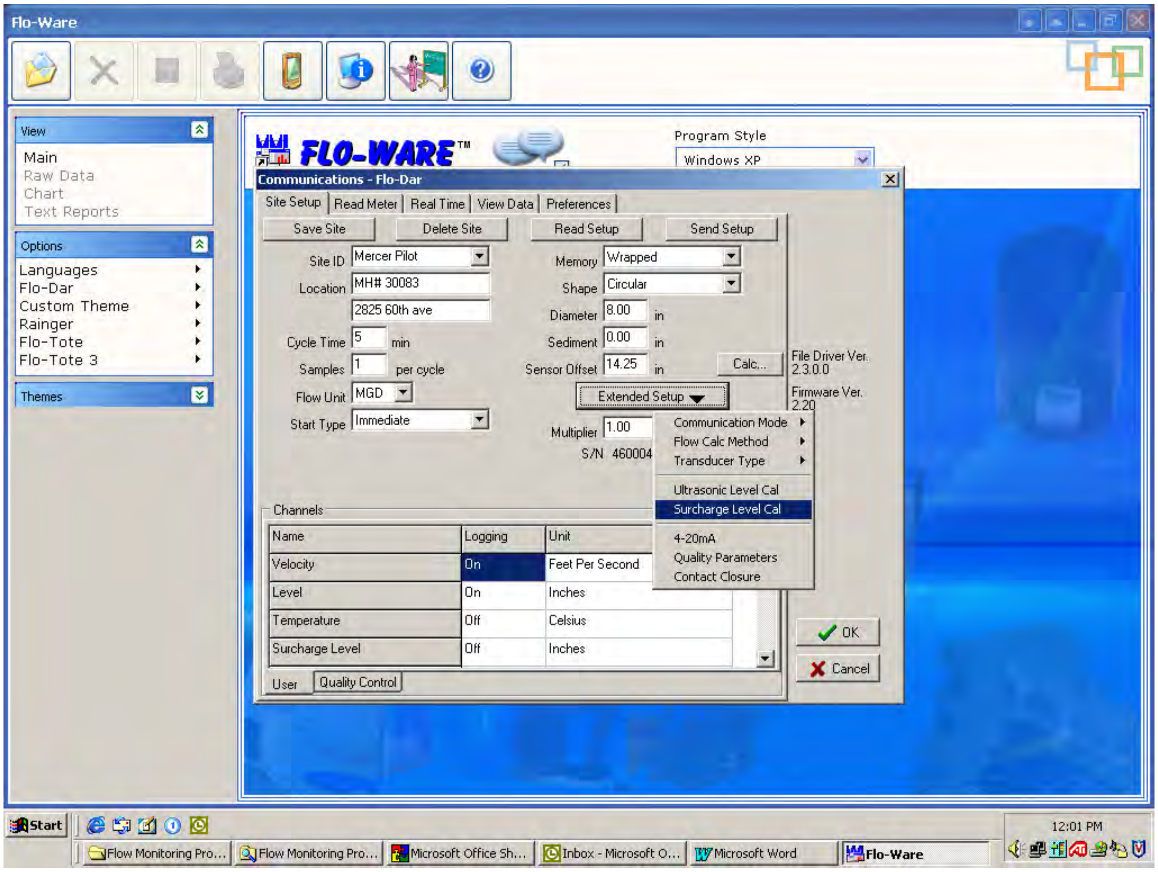


20. Place the sensor at a known distance (measure about 8 inches away from a flat surface)
21. Enter the distance in the **known distance** box.
22. Fire the sensor and the monitor will calculate the level cal for you.
23. When you are finished click the **OK** button. This will set the offset for the ultrasonic sensor.
24. **Surcharge Level Calibration -**

    The Surcharge Level Sensor measures the depth of flow during surcharged conditions and needs to be calibrated for increased accuracy. The following steps are performed to calculate the Surcharge Level Calibration. Details can be found in **Flo-Dar System Manual (Marsh McBirney P/N 105004701).**

    a) Select the Flo-Dar communications option in Flo-Ware, and select the site (of interest)
    b) left-click on the Extended Setup option and choose the Surcharge Level Cal option (Figure 3-4)

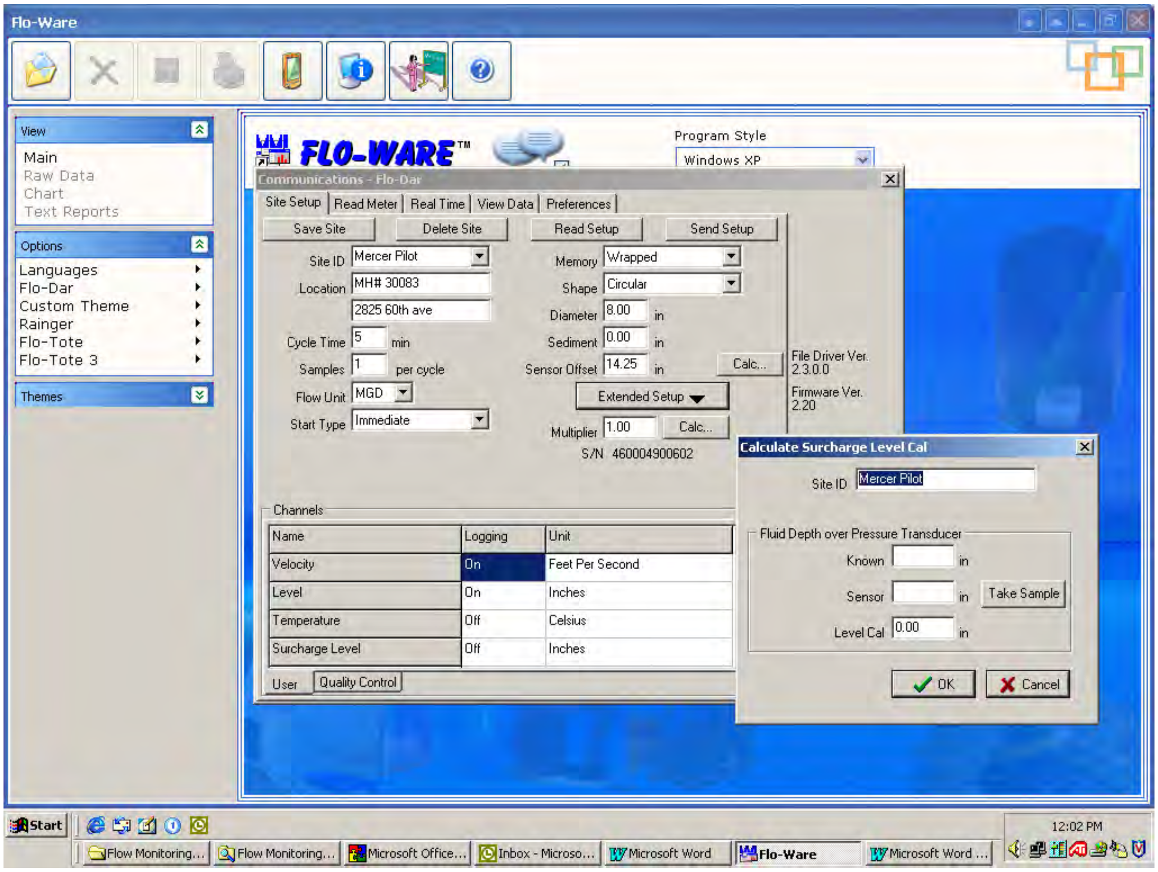
Figure 3 - 4 Surcharge Level calibration dialog



c) Place the sensor in a large bucket of water, measure the depth from debris filter covering the sensor opening to the surface of the water, and enter the value in the **Known** edit box (Figure 3-5)

d) Click **Take Sample** (Figure 3-5) and take a reading. The sensed value will appear in the **Sensor** edit box. The **Surcharge Level Cal**. Edit box will display the difference between the measured level and sensed level

Figure 3 - 5 Surcharge Level calibration calculation dialog



25. Selecting a Flow Calculation Method

a) Direct Method - an advanced algorithm that directly converts the surface velocity to an average velocity

b) Multiplier method - a default value of 1 is used, but can be adjusted performing a velocity profile (**see Velocity Profile - Verification**)

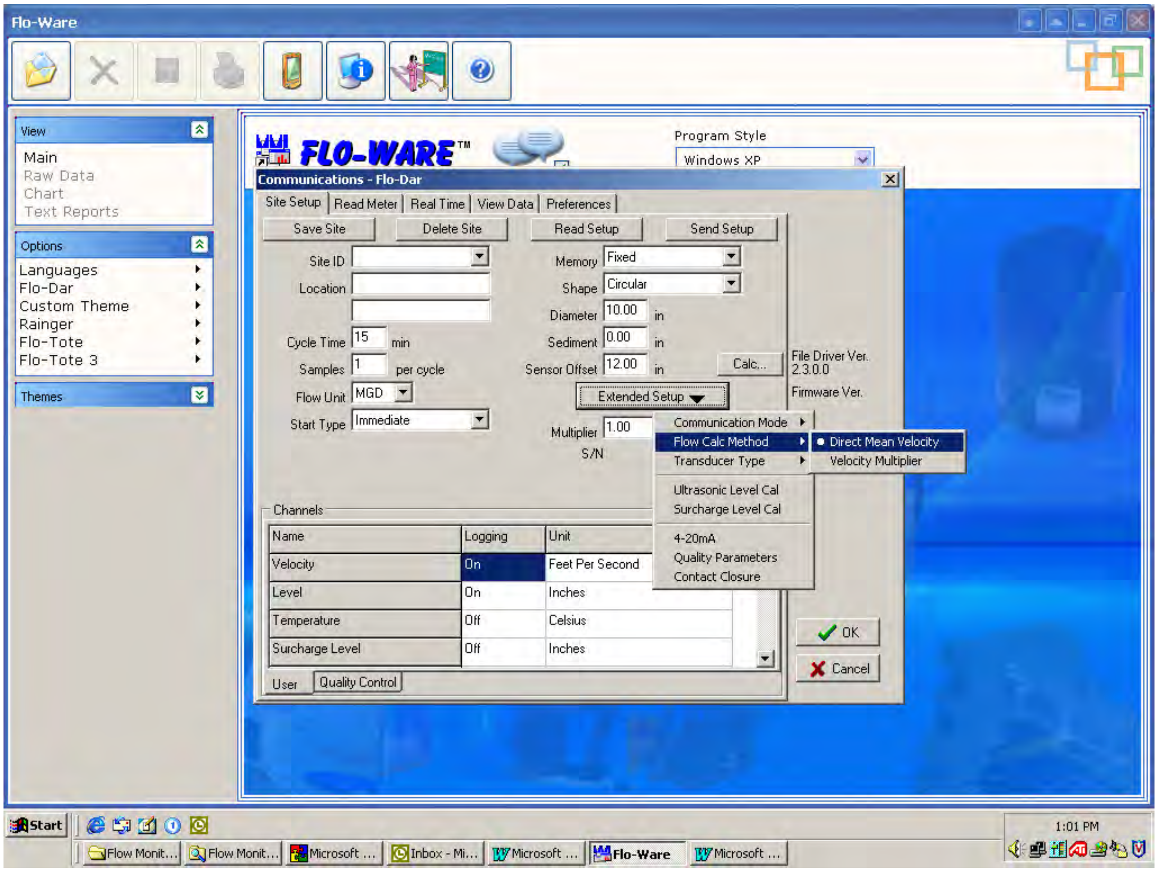
To select the appropriate method, left-click the **Extended Setup** button, choose **Flow Calc Method**, and select either the **Direct Mean Velocity** or the **Velocity Multiplier** options (for pipe diameters 50 inches or greater (Figure 3-6). Data analyst may also determine the appropriate method before hand.

26. Install the meter (and the mounting bracket and hardware) following the recommended procedures/steps in **Model 460 Portable Flo-Dar Installation Manual (Marsh McBirney P/N 105004601).**

27. Obtaining a Velocity multiplier

a) Once the flow calculation method is selected, left-click the Calc button next to the Multiplier edit box (Figure 3-7)

Figure 3 - 6 Selecting a flow calculation method

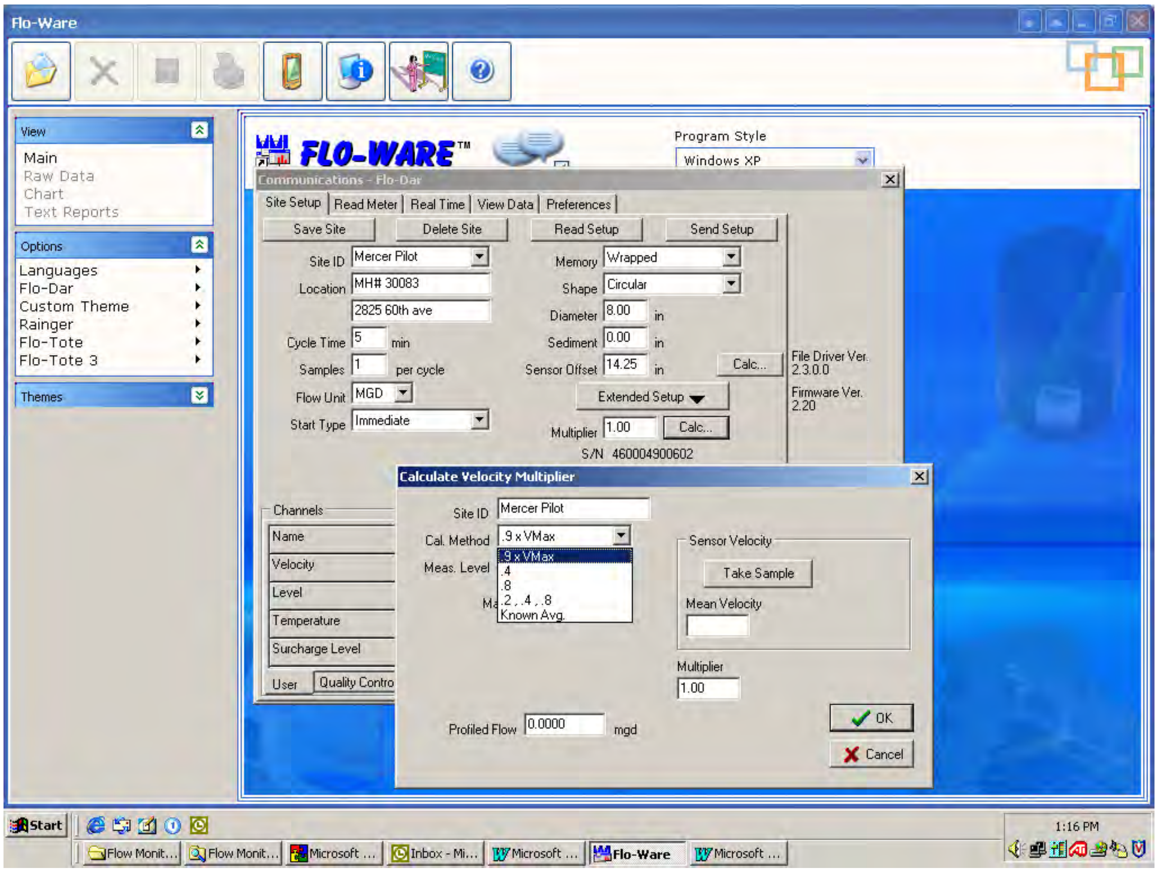


b) Left-click the on the Cal. Method and choose the profiling method from the drop-down menu in the **Calculate Velocity Multiplier window**

c) Perform velocity profiling following the Cal methods described for the Flo-Tote meters in SOP II Choosing Cal Method or as described in detail in **Flo-Dar System Manual (Marsh McBirney P/N 105004701)**

28. Once the meter has been installed take a set of three manual depth and velocity measurements, and three samples in the real time mode. After confirming that the meter is functioning properly and accurately, re send the site setup before leaving the site.

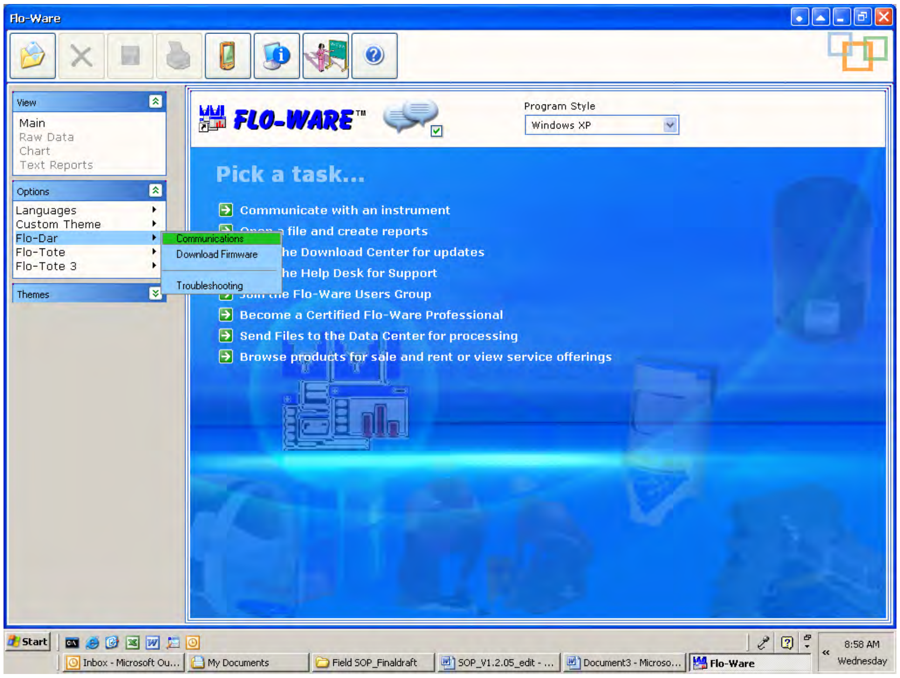
Figure 3 - 7 Velocity Multiplier calculation (.9 x Vmax velocity profiling) dialog



<u>Flo-Dar Data collection and review</u>

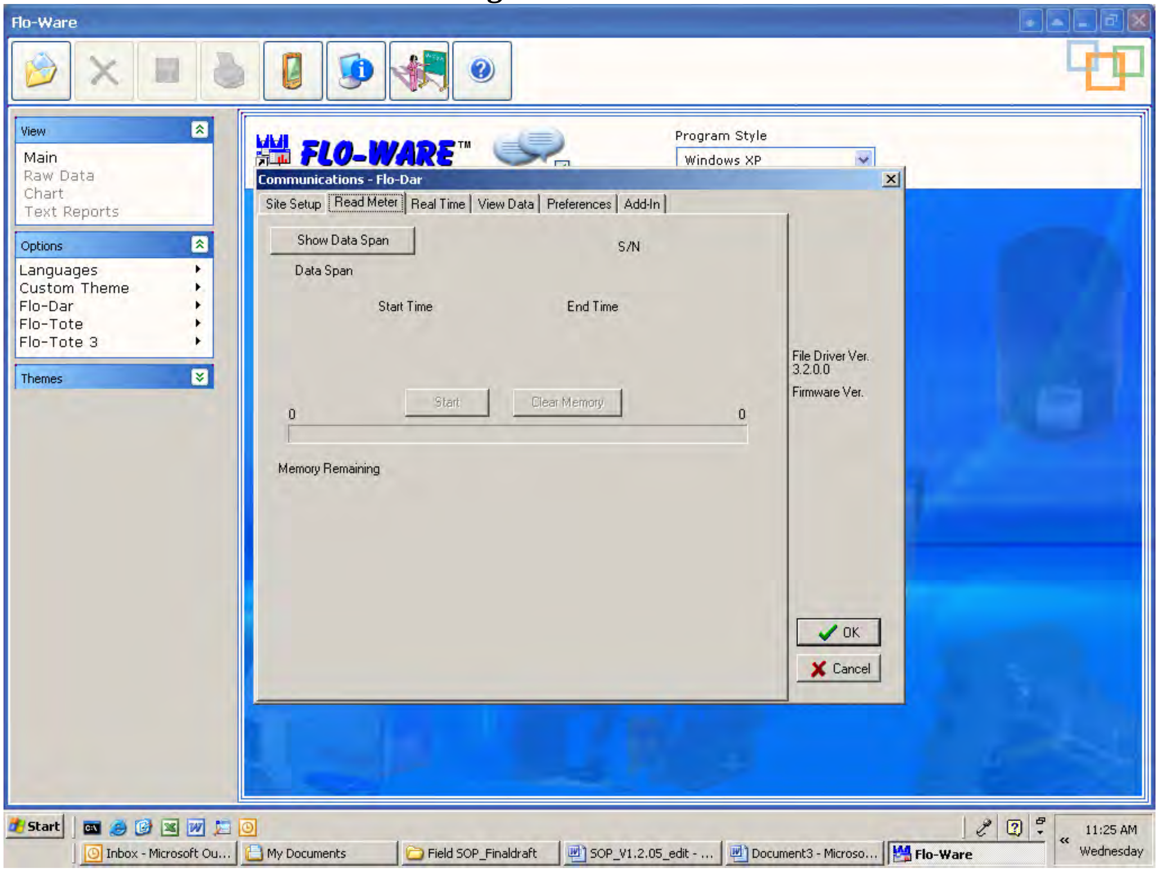
1. Turn Computer on.
2. Connect Flo-Dar Communications cable to the computer (9pin Port) and the monitor
3. Start Flo-Ware Program (Double click on Flo-Ware Icon)
4. Move cursor to **Options** at top of screen and click once to keep drop down box open
5. Select **Flo-Dar** by clicking the cursor once on the highlighted box
6. Select **Communications** by clicking once on the highlighted box (Figure 3-8)
7. Once you have selected communications a new screen will be seen.

Figure 3 - 8 Flo-Dar Communications window



8. After the screen has changed click on the **Show Data span** tab (Figure 3-10)

Figure 3 - 10 Flo-Dar Read Meter dialog



9. Once the **Start** and **End** times have appeared on the screen, Click on the **Start** button to begin data collection.

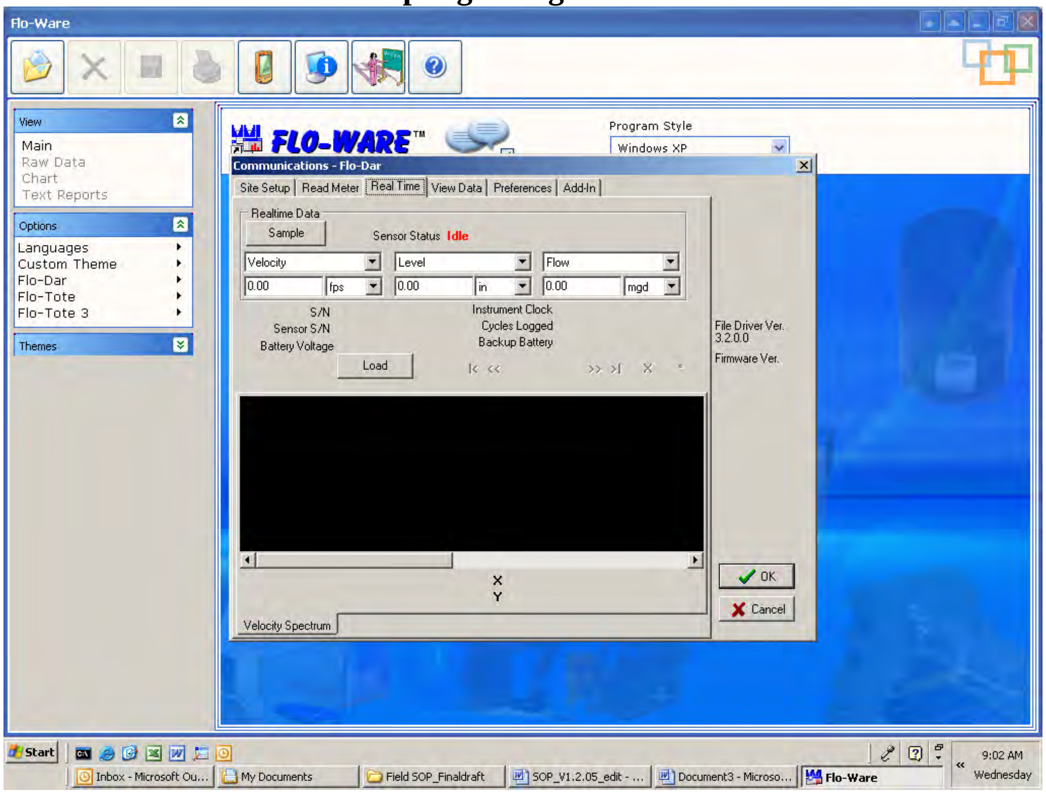
10. A **Save as** screen will popup to save the file you are reading from the monitor. The file will be saved in this format: **SiteNamemmddyy**

11. Once the download is complete you will get a message indicating that the data has been saved to your computer. Click on **O.K.** to remove this box from your screen.

12. In the new window select the **real-time** tab and click on it.

13. After the screen changes click on the **Sample** tab to begin readings. (Figure 3-9)

Figure 3 - 9 Flo-Dar Real Time sampling dialog



14. After the sample has fired, record all data in the site visit log (as seen in Table 5.1)

Table 5.1

Northwest			Date of visit					Downloaded		
Location	Serial Number	Time	Real Time Depth	Real time Vel.	Field Depth	Field Velocity	Battery	Measured pipe dimensions	Measured silt	Additional Comments
HIDCSO	MMI 790									

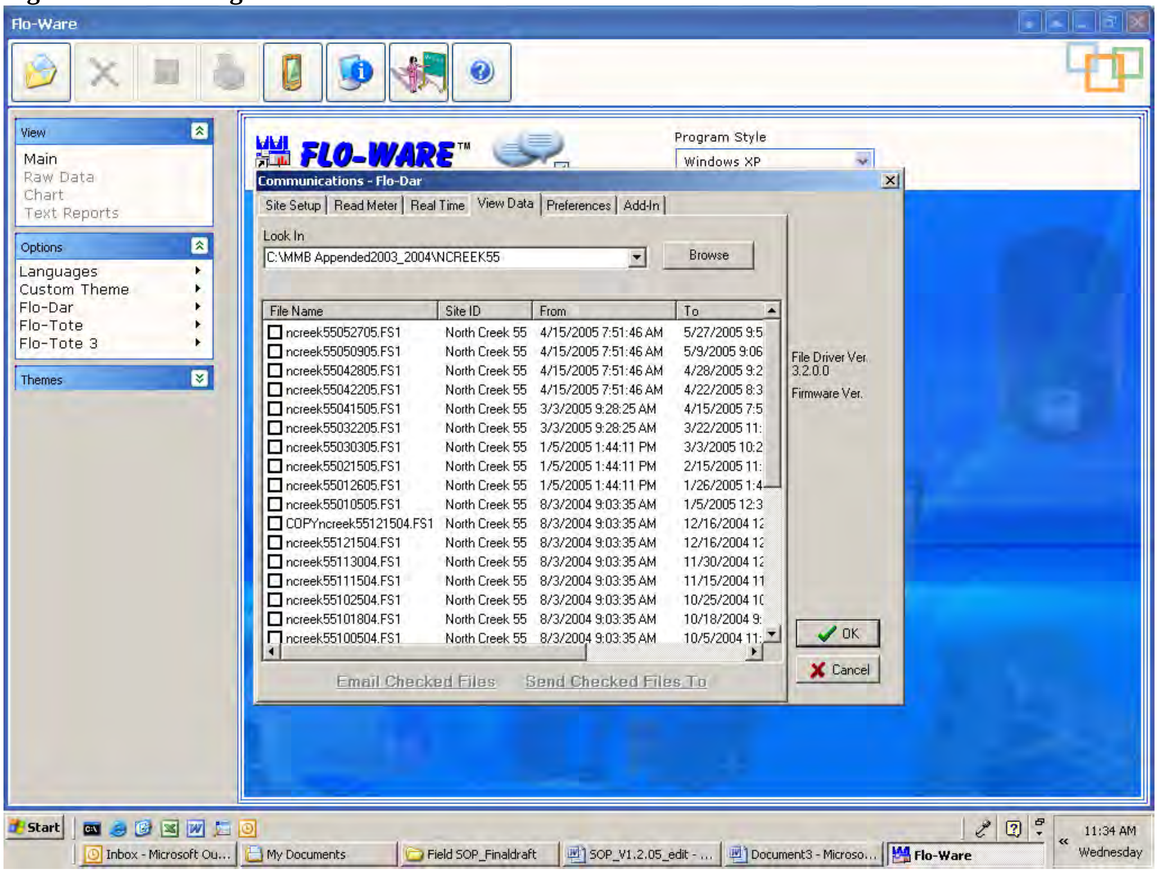
15. After the information has been recorder on the site visit log, click on the **Read meter** tab. (The screen will change to look like Figure 3-10)

16. Repeat steps 13 through 15 and get another Real-time Reading.

17. After the recording the data has been completed click on the view data tab. (The screen will change once again and look like Figure 3-4)

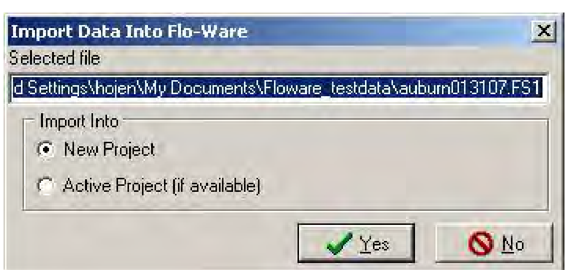
18. Scroll down to the bottom of the list and select the site you have just downloaded. (Figure 3-4)

Figure 3 - 1 Selecting site for data review



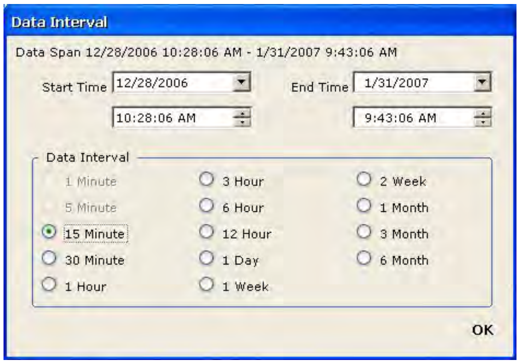
19. Once you have selected the appropriate site select the O.K. Button. (after you have selected the OK button the communications screen will close and a new screen will pop-up as shown in Figure 3-5)

Figure 3 - 2 Importing Raw Data into Flo-Ware



20. Select the New Project Radio Button and click OK.
21. A new screen will pop up to select the time average for viewing (Figure 3-6)

Figure 3 - 3 Selecting the time interval for viewing



22. Select the lowest number available and click the O.K. button
23. A new screen with two tabs at the bottom will appear (Figure 3-7)
24. Click on the Chart tab to view the Hydrograph. (Figure 3-8)

Figure 3 - 4 Raw Data View of imported data

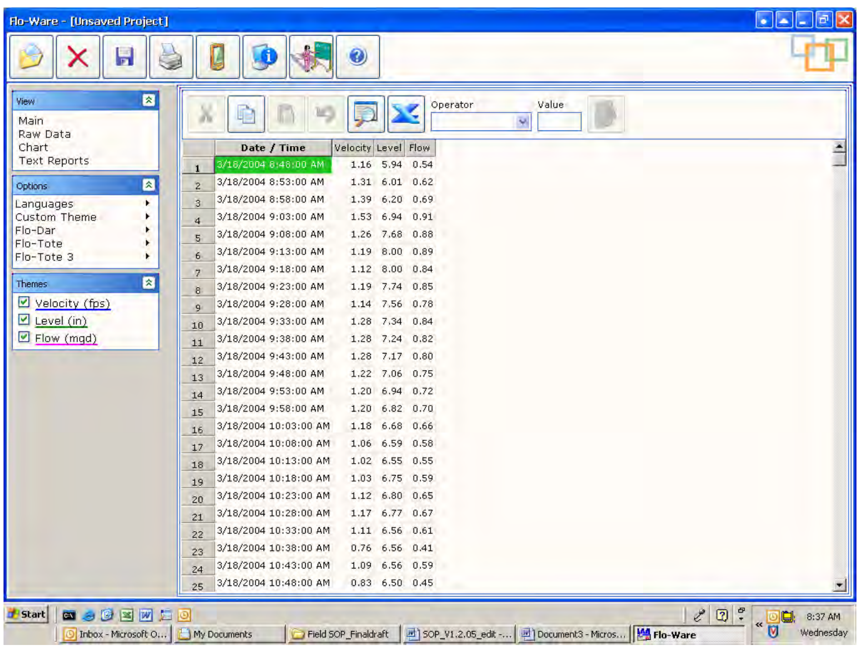


Figure 3 - 5 Chart View of imported data

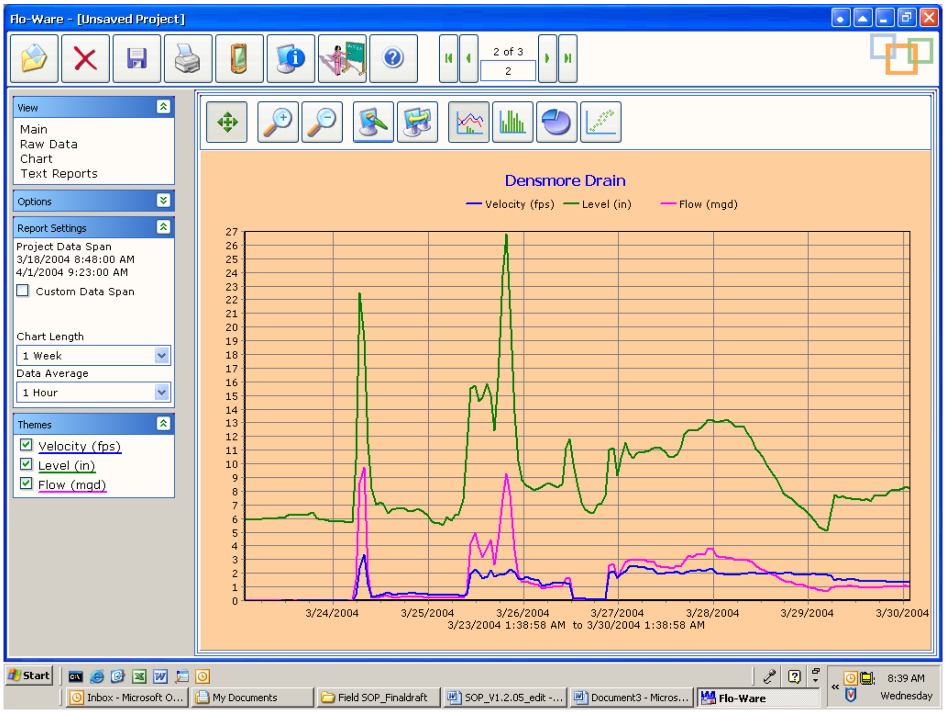
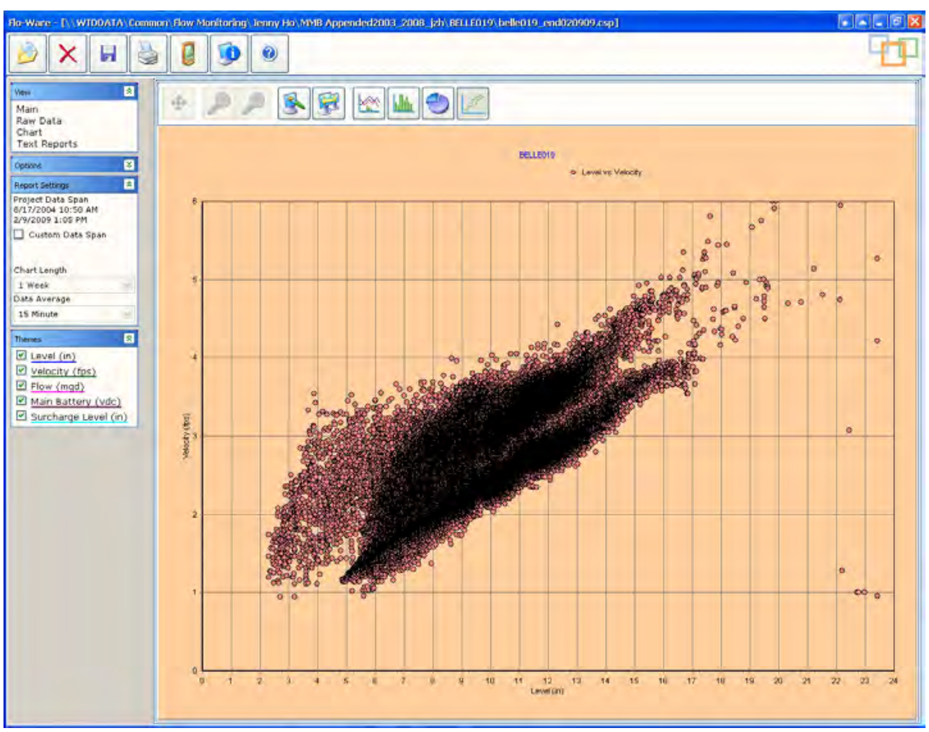


Figure 3 - 9 Scattergraph



Flo-Dar Sensor Troubleshooting and replacement

There are no customer-serviceable parts in the Flo-Dar system except battery swaps, replacement of desiccant or desiccant cartridge (for the Pressure transducer), and replacing sensor cables. If the sensor and/or the monitor are not functioning properly, they need to be replaced as soon as possible. When the sensor is replaced a verification (SOPVII) must be completed because the site setup has changed.

Sensor cleaning: The Flo-Dar sensor is not submerged in the flow and as a result may not require cleaning. However, the sensor may be covered during surcharge conditions and may need to be cleaned. To clean the sensor, please follow the detailed instruction described in Chapter 6 of the Installation and Operation manual for the "Flo-Dar System- Open Channel Non-Contact Radar Flow meter Model 460 (P/N 105004601)."

Replacing sensor cable: Replace any faulty or frayed sensor cable following the procedure outlined in Chapter 6 of the installation and operation manual (see above).

Replacing Desiccant cartridge: The desiccant protects the Atmospheric Pressure Reference (APR) port of the pressure sensor. When half of the desiccant the desiccant turns pink, replace with a fresh cartridge (blue colored). If you do not have a fresh replacement, DO NOT take out the depleted desiccant cartridge and expose the APR to the harsh sewer environment.

For instrument and related error codes, please refer to the Flo-Dar error codes and Flo-Dar Model 460/464 Set up and Maintenance documents. The **Flo-Dar error codes** document is a compilation of error codes from Marsh McBirney web site and may not be complete. If the error code is not in this document, then contact Technical support personnel at Marsh McBirney for detailed explanation. For sensor upgrade consult field lead.

Flo- Dar Firmware Upgrade

Marsh McBirney Inc. periodically updates the embedded software that runs inside the Flo-Dar (i.e. the Firmware) in order to enhance features and functions. The firmware is embedded within the file driver which can be downloaded from the Marsh McBirney Download Center. Updating the firmware clears the entire flash memory and some or all logged data including site setup may be lost. Therefore, it's critical that the meter be READ before performing any updates. Also, there may be project specific limitations that may not allow firmware update at a particular time. The lead field person and Data Analyst will decide on the timing of firmware updates and scheduling sites for update.

Summary for updating firmware

Download the latest file driver (and thus latest firmware) to your computer

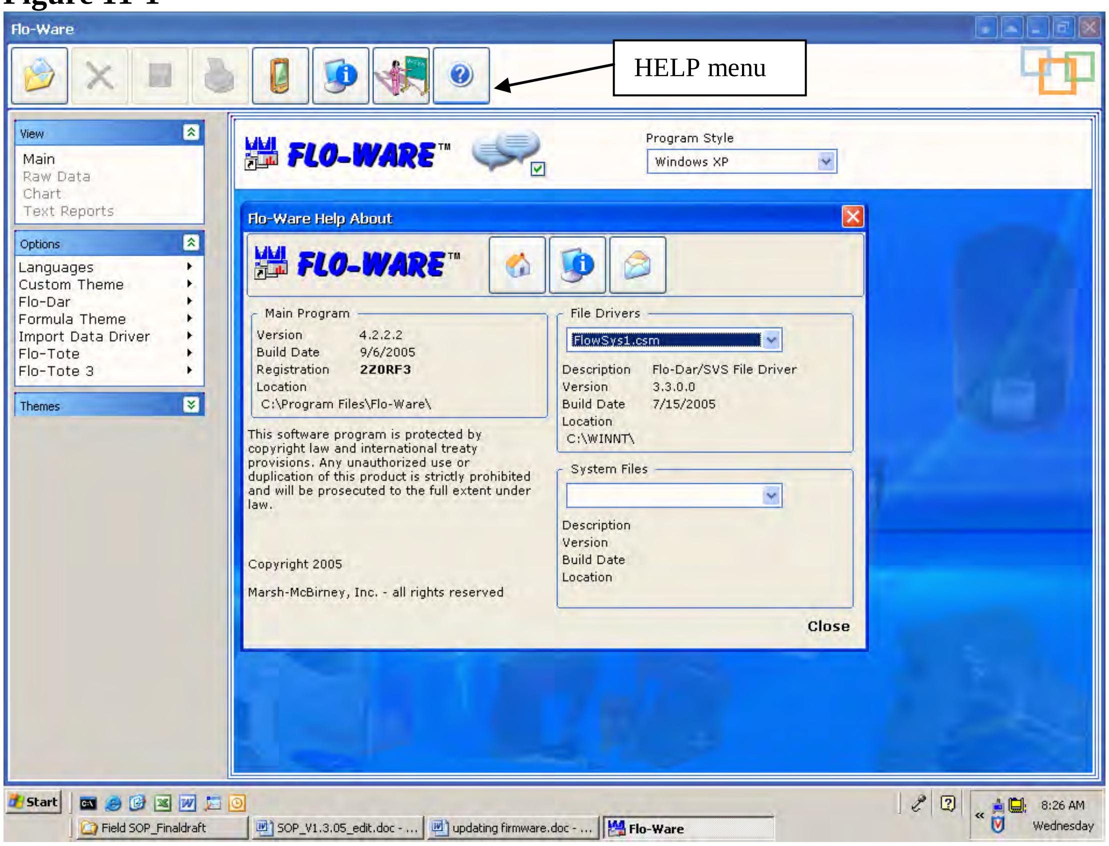
Download/read data from connected meter following procedures outlined for Flo-Dar

In the Flo-Ware main menu choose Options> Flo-Dar (or Flo-Tote3)>download firmware. For the Flo-Dar sensors you will be asked to select the firmware you want to down load (i.e. regular Flo-dar or SVS sensor). You will be prompted to a series of warning/instructive messages. Please read these carefully before proceeding to the next step. Proceed through the process following instructions and prompts from Flo-Ware until the firmware is successfully installed.

Verify that you have the latest version. Open Flo-Ware and double click on the "Help" icon (Figure 11-1). Under the "File Drivers" drop down menu you will be able to see the file driver version for each meter type.

Flowsys1.csm: Flo-Dar file driver
Tote3.csm: Floe-Tote 3 file driver

Figure 11-1



Summary for updating the Flo-Dar sensor firmware

Make sure you have the latest file driver (and thus latest firmware) in your computer
The process of updating the Flo-Dar sensor will erase all data in the memory. Therefore it is critical that all the data be downloaded before updating the sensor firmware.
Connect your laptop computer to the logger and make sure the sensor is still connected to the logger. DO NOT START FLO-WARE. Instead, double click the "Flo-Dar Sensor Updater" icon on your computer to run the program that will update the sensor firmware. If you do not have this program loaded on your computer, please contact your lead or the Data Analyst. You will be prompted to a series of warning/instructive messages. Please read these carefully before proceeding to the next step. Running the updater program will automatically install the updated firmware in the sensor. Please note that this particular update only affects the surcharge level sensor.

FL900 Series Flow Logger

Link to the FL900 Series Flow Logger Manual.

SOP IV – ADS Model 3601

ADS Model 3601 Installation and Site Setup

1. Ensure that you have the following items before leaving the office:
   Properly functioning Gas Meter (and a spare)
   Confined Space Retrieval Equipment
   Computer with a charged Battery
   Communication Cable
   Flow monitor and sensor (and spares)
   Drill with charged batteries
   Mounting hardware

Measuring stick (for manual depth verification)
Portable Velocity Meter (for independent field verification)

2. The set up for the ADS model 3601 flow meters include the following:

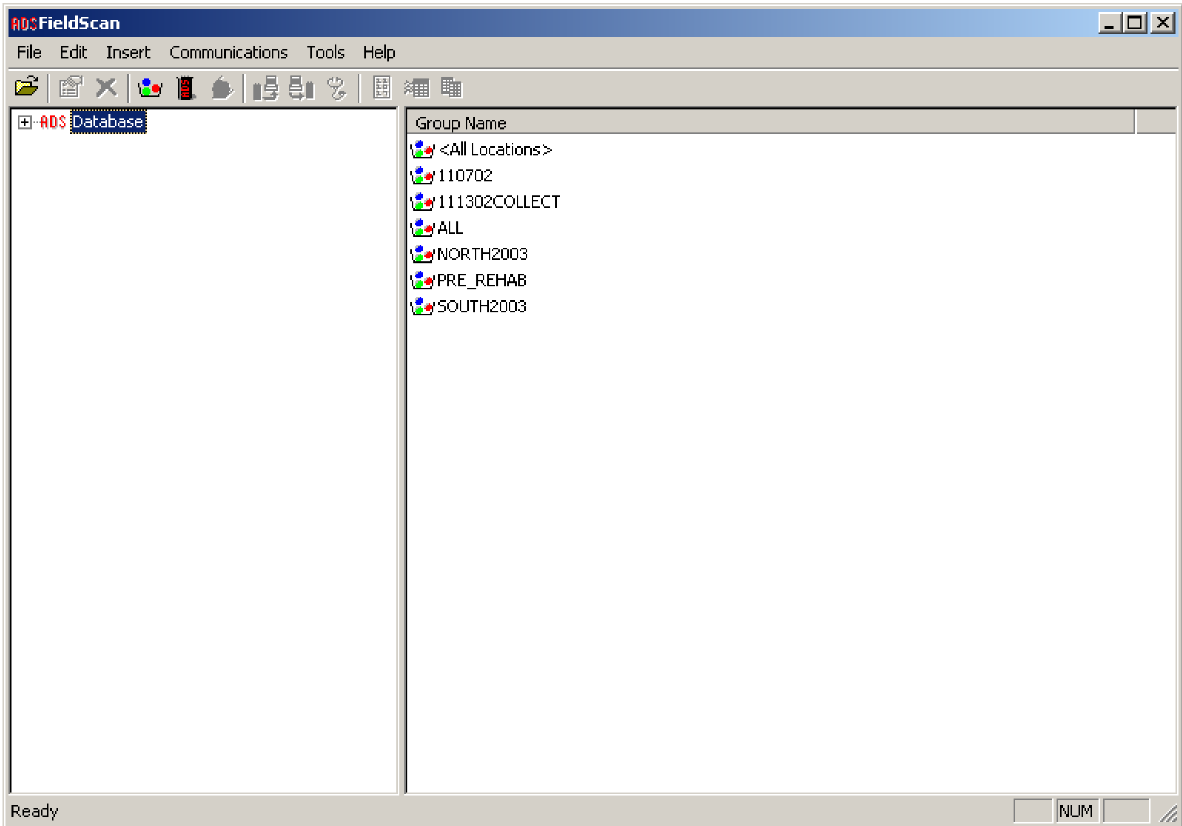
- Establishing a monitoring location and creating a Location Information File (LIF) for storing the monitor configuration and information (e.g. pipe height and width, sensor offsets, selected devices, data collection rates, and silt level). <u>This step can be performed at the office.</u>
- installing the sensors and monitor in the manhole
- activating the meter
- selecting and editing devices (velocity and depth sensors), and
- Taking real time (instantaneous) readings and compare them to manual readings to verify the sensor readings and perform system diagnostics.

3. Once you have arrived at the site, set up and put in place all of the safety equipment including traffic control.

4. Follow the recommended method in the **(ADS) 3600 Flow Monitor Operation and Maintenance DOC No. 530002A2, May 1998)** for ring, sensor, and monitor installation and activation. *Hard copies available - check with the Field crew lead or the Data Analyst.*

5. After the install is completed, turn on the field computer and start the Field Scan program to create the LIF (if it has not already been done at the office), activate the monitor, and conform (verify) the sensors. The configuration and activation procedures are outlined below. Please refer to the **(ADS) Field Scan User's Guide (document No. 950021A1)** for detailed instructions. The field crew will have this document at hand at all times. *Hard copies available - check with the Field crew lead or the Data Analyst.*

Figure 6 - 1 Field Scan Main Menu



Creating the Location Information File

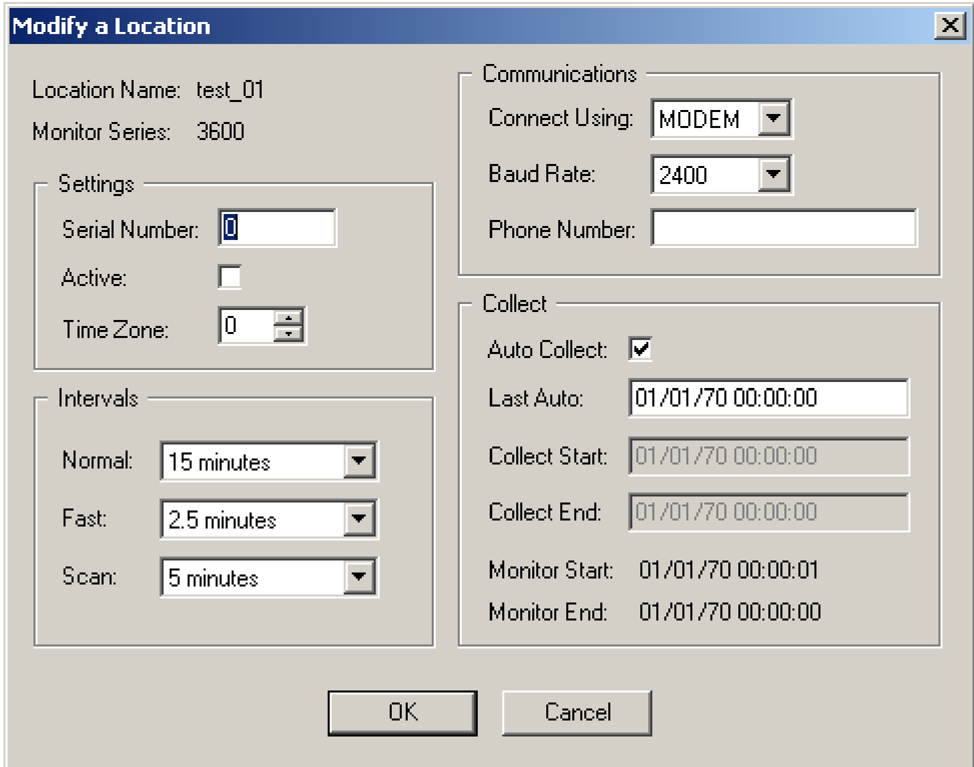
Establishing a new monitoring location

a) Select **INSERT>Location** from the main menu (Figure 6-1)

Figure 6 - 2 Create a Location dialog

Enter the monitor name in **the Location Name** field and select the monitor type (3600 for the 3601 meters) from the **Monitor Series** (Figure 6-2) drop-down list and select **OK**. A LIF is created and the **Modify a Location** dialog is displayed (Figure 6-3)

Figure 6 - 3 Modify a Location dialog



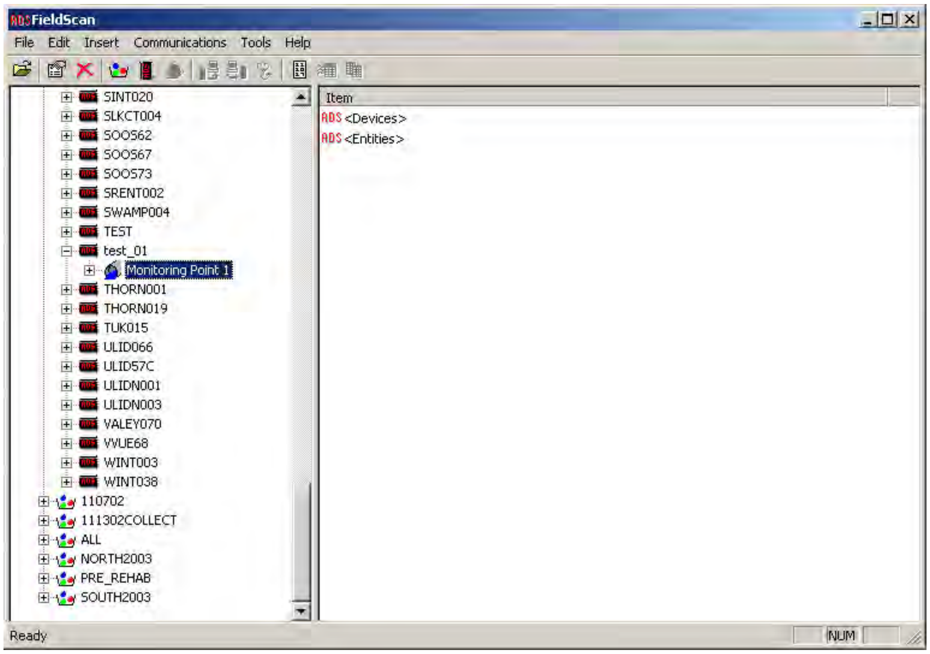
Complete this dialog by entering the appropriate information

- Serial number of the monitor
- Check if the monitor has already been activated
- Enter zero for Time Zone
- Enter the data collection interval (leave the default values for the "fast" and "scan" rates)
- Method of connection (modem or serial). Select **SERAIL** for manual collection
- Baud rate (9600 for serial communication)
- Select **Auto collect.**
- Select **OK** after completing the **Modify a Location** dialog

Create a pipe table: an installation table must be created for a monitoring point so that the monitor calculates depth and quantity accurately.

Select the monitoring point from the main screen (Figure 6-4) and select **Edit>Properties. This will display the Modify a Monitoring Point dialog (Figure 6-5)**

Figure 6 - 4 Selecting the monitoring point from the main menu



Complete this dialog with the appropriate information including the devices to be used and the geographic address of monitoring point, select "pipe" from the drop-down menu and select **Edit**. The Edit Pipe Installation will then be displayed (Figure 6-6).

Figure 6 - 5 Modify a Monitoring Point dialog

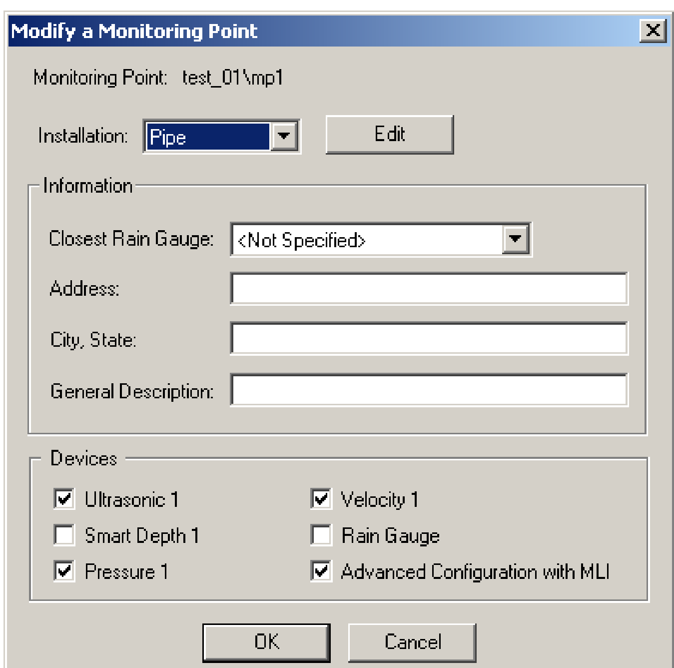
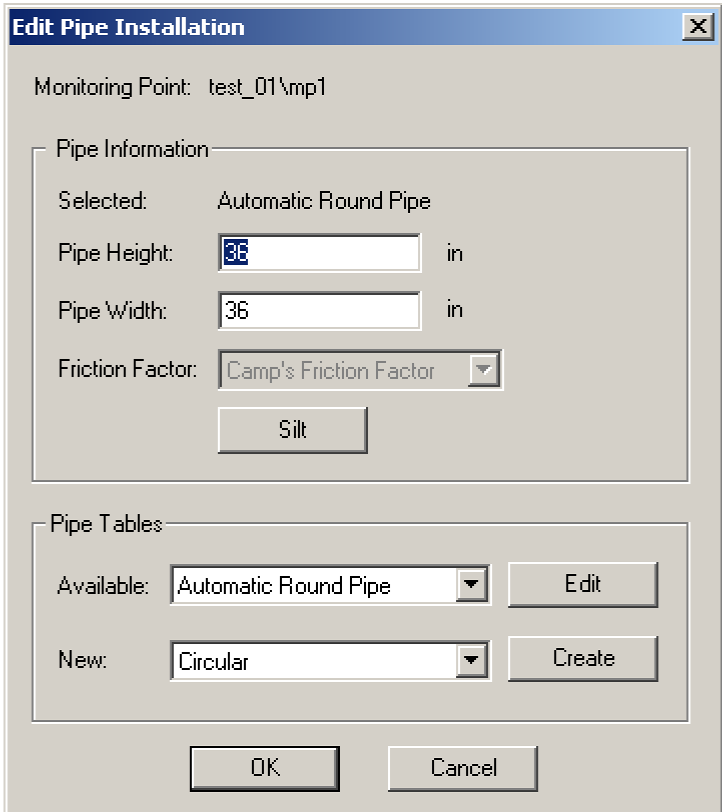


Figure 6 - 6 Edit pipe installation **dialog**



Complete this dialog with the appropriate information.

Selecting and editing devices

To ensure that the monitor collects the desired data (depth and velocity), the proper devices need to be selected. Go to the main screen and select **Edit>Properties**. The devices are selected in the **Modify a Monitoring Point** dialog (Figure 6-5).

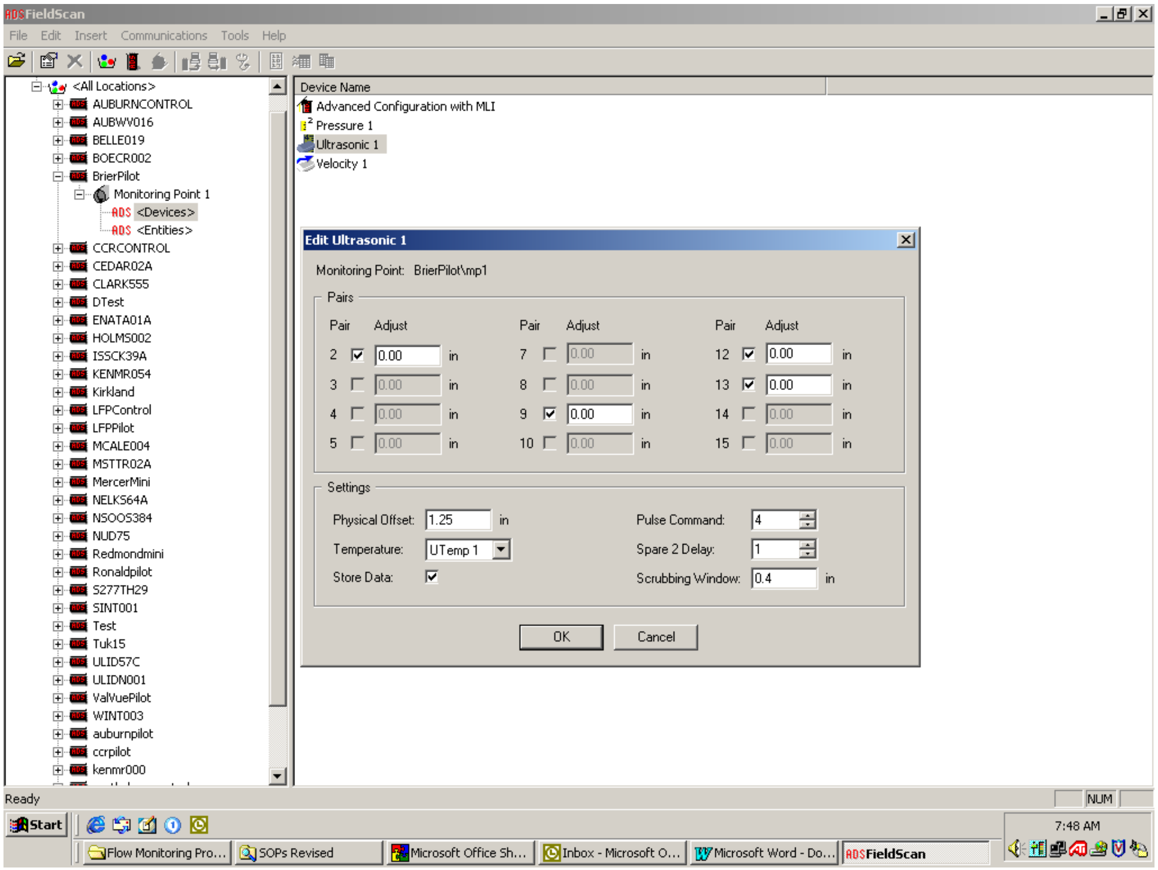
The Ultrasonic, Pressure, and Velocity sensors are edited as follows:

Ultrasonic Sensor

- Select the **Ultrasonic 1 device** from the Field Scan Main screen and go to **Edit > Properties** (Figure 6-7)
- Keep the default-selected pairs. These can be changed after sensor confirmation
- Measure and enter the **Physical offset** (the distance from the crown of the pipe to the face of the sensor) and leave the default value for the other entities (**Pulse command**, **Spare 2 delay** etc). These values can only be changed by the Data Analyst if necessary at all

➢ The **Store Data** option may remain checked for short term monitoring, but may be deselected for long term projects. The selection of this option allows the monitor to log Upairs in addition to Unidepth (the average of the selected Upairs)

Figure 6 - 7 Field Scan main menu - Editing Ultrasonic Sensor



<u>Pressure Sensor</u>

➢ Select the **Pressure 1 device** from the Field Scan Main screen and go to **Edit > Properties** (Figure 6-8)

➢ Enter the sensor serial number

➢ Measure and enter the **Physical offset** (the distance from the invert of the pipe to the level of the sensor - for sites with silt problems, the sensor may be installed offset from the bottom of the pipe).

➢ The **Store Data** option may remain checked for short term monitoring, but may be deselected for long term projects.

- Retrieve the pressure coefficients for the specific pressure sensor being used at the monitoring site. The pressure coefficients should have been downloaded to a local directory (in the field computer) or saved in a floppy disk for easy retrieval. Pressure coefficients are downloaded from the ADS website http://www.adsenv.com/default.aspx?id=113

Velocity Sensor

- Select the **Velocity 1 device** from the Field Scan Main screen and go to **Edit > Properties** (Figure 6-9)
- Leave the default value for all entities. For sites with flows regularly below 1.5 feet per second, the **Flow** option may be changed to **Slow.** The Data Analyst may, at a later time, change some of the entities depending on the data quality and site hydraulics.
- The **Store Data** option must remain checked.
- Select the **Edit Gain** button and apply the default value of 0.9 (Figure 6-9). The Data Analyst may change this value at a later time based on field verifications.

Once all the necessary information is entered and the LIF created, the monitor must be activated and sensor confirmation must be performed.

Activating the monitor

- Select the site and go to **Communications>Activate** (Figure 6-10) and click on **Go**.
- The monitor may also be activated using the Field Scan diagnostics tools (Refer to Chapter 6 in **(ADS) Field Scan User's Guide (document No. 950021A1 Page 3-42 to 3-45).** Hard copies available - check with the Field crew lead or the Data Analyst.

Figure 6 - 8 Editing Pressure device (sensor)

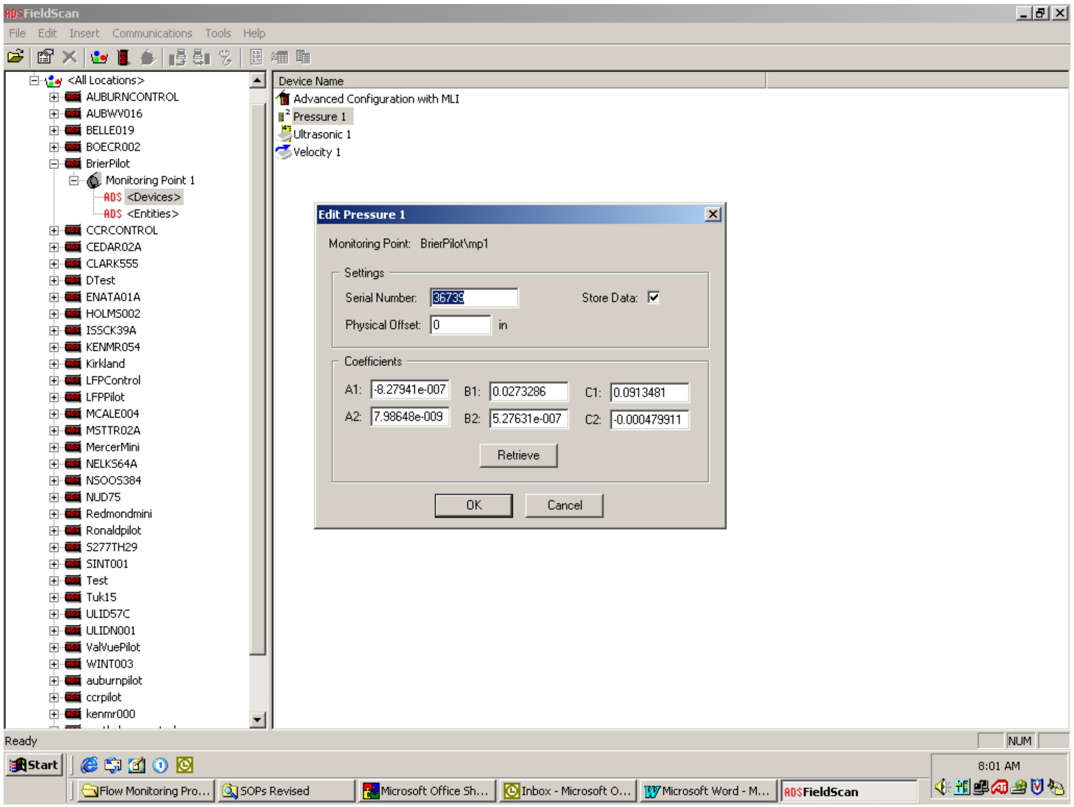


Figure 6 - 9 Velocity editing dialog

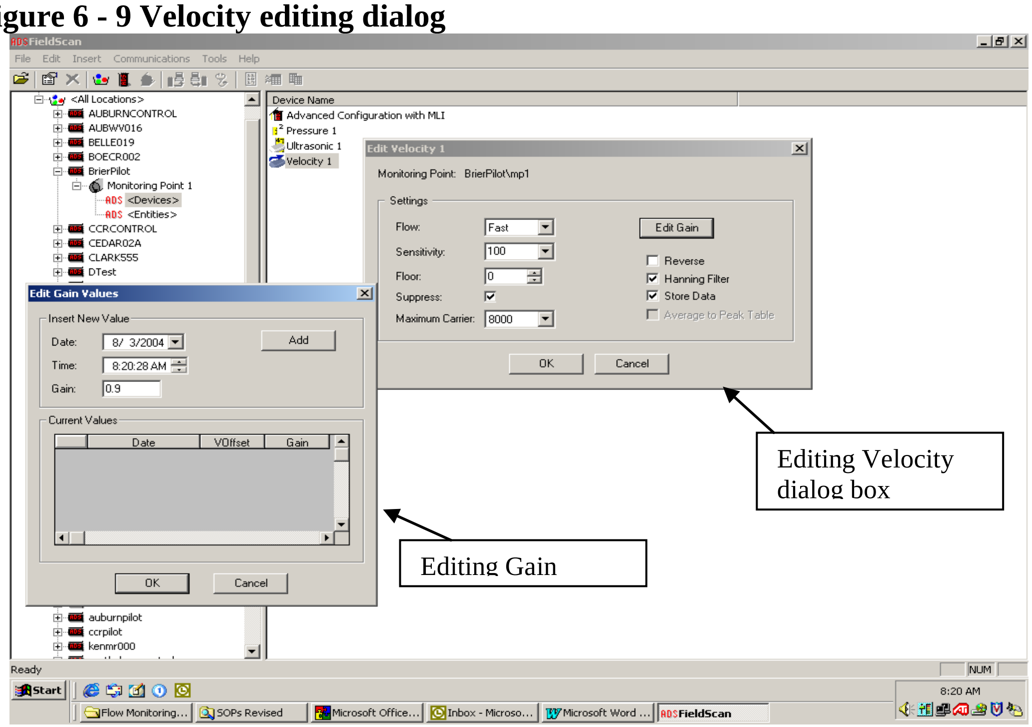
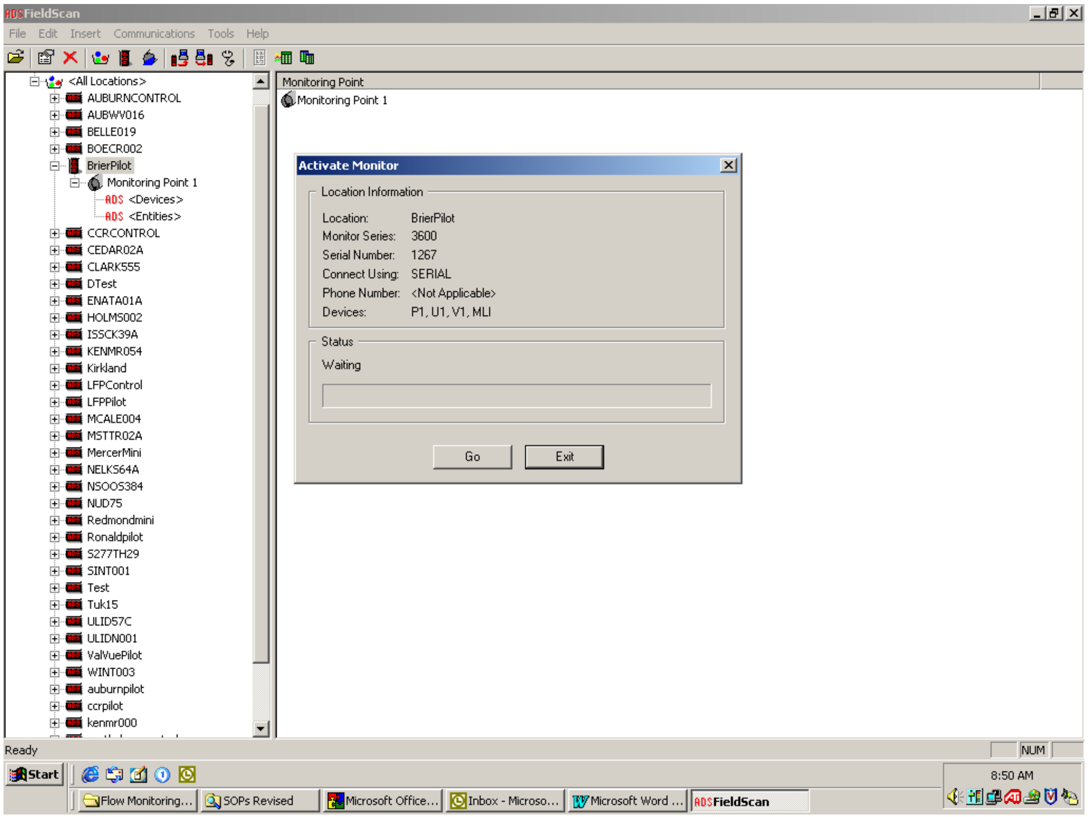


Figure 6 - 10 Monitor activation



Sensor Confirmation

➢ Sensor confirmation involves using the Field Scan software to compare depth and velocity measurements taken manually (by the field crew) to measurements obtained from the meter. This procedure is similar to the field verification procedure(s) detailed in this SOP. You may use the Status Check List worksheet to document sensor status and confirmations. Please refer to the **(ADS) Field Scan User's Guide (document No. 950021A1 Page 3-46 to 3-55)** - *Hard copies available* - *check with the Field crew lead or the Data Analyst. For detailed instructions. Please consult with the lead field person or the Data Analyst before performing sensor confirmations.*

Setting Monitor Time

➢ The user can set the time for a single site or a group of sites after monitor activation. Select the site and go to **Communications>Set Time** and select either the **Current** button to set the time for the currently displayed site or **Group** to set the time for the sites in the group (See Figure 6-11 A and Figure 6-11 B). Each monitor clock that was successfully set will display **YES** in the **DONE** field. Please refer to the **(ADS) Field Scan User's Guide (document No. 950021A1 Page 3-56 to 3-57)** for detailed instructions.

Figure 6 - 11 A - Setting monitor time

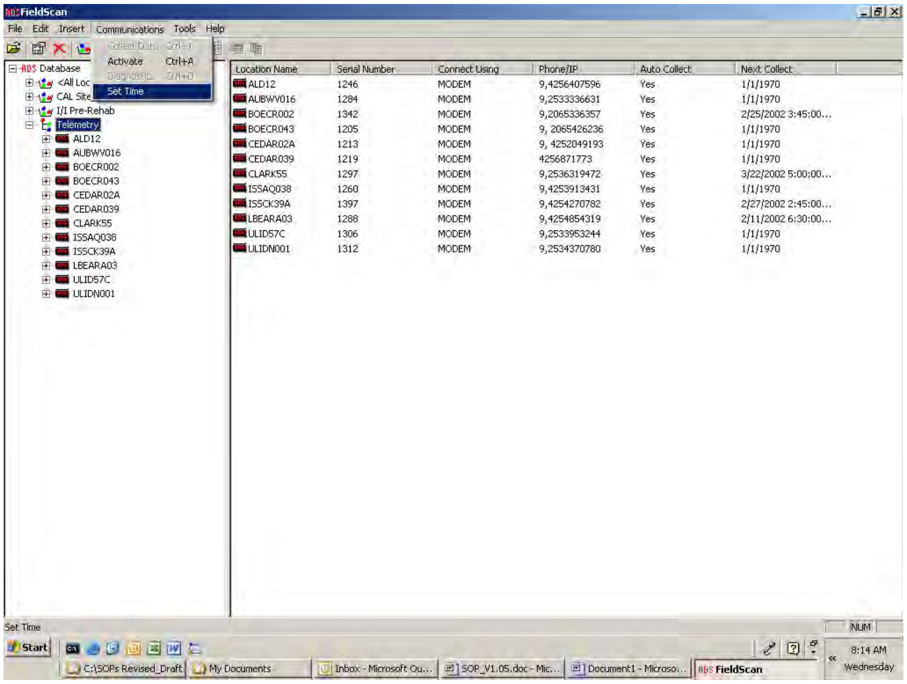
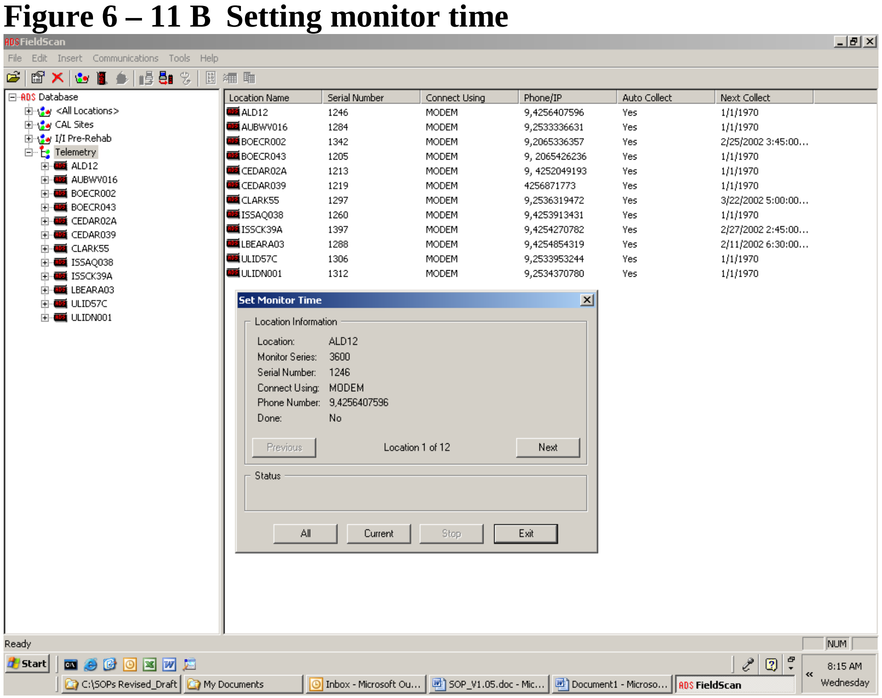


Figure 6 – 11 B Setting monitor time



Advanced Configuration

- This section is detailed in Chapter 4 in the **(ADS) Field Scan User's Guide (document No. 950021A1)** and provides features that enhance the capabilities of the Field Scan software and the quality of the data. Among the features included are Event Notification/Alarms, Sampling, Dual Data Rates and SCADA. *Currently we do not set our flow monitors with these advanced features, but if it becomes necessary, the lead Field person and/or Data Analyst will perform the configuration.*

ADS Model 3601 Data collection and review

Stored data is collected from the monitors using Field Scan or Profile. Flow and system data are collected at set intervals (for example weekly for projects such as Inflow and Infiltration project, and bi-weekly or every three weeks for long-term sites. Data collection is done either remotely (via telemetry using the ADS software Profile), or onsite (manually) using Filed Scan.

Onsite data collection

- Select a site from the Field Scan main screen and select **Communications>Collect Data.** This will display the **Monitor Data Collection dialog window** (Figure 7-1)
- Verify the information on the **Monitor Data Collection dialog** window including the **Collect Start** and **Collect End** date/Time and select the **Go** button. If the Start and End date/Time needs to be changed, edit the site Properties in the main Field Scan menu (Pages 5-2 to 5-4 in **(ADS) Field Scan User's Guide (document No. 950021A1**). *Hard copies available - check with the Field crew lead or the Data Analyst.*

Onsite data review

The data collected must be reviewed onsite. This will allow timely maintenance and help prevent unnecessary data loss. The field crew may be able to diagnose potential problems if the data show abnormal diurnal patterns and/or if either the depth or velocity sensor patterns show signs of sensor fouling. The field crew must communicate with the Field lead person and the Data Analyst if such problems are encountered. The onsite data review servers as the “First Line of Defense” from data loss. The **Data Viewer** tool in

Field Scan allows the user to view data in both graphical and tabular formats. To view data follow these steps

- Select the site (and monitoring point) from the main menu and go to **Tools > Data Viewer** (<u>Figure 7-2</u>)
- Select the start and end date/time of interest, entities (depth, velocity etc) and the type of display - Hydrograph, Scatter graph, or table (<u>Figure 7-3</u>). You have the option to print or export data. For details, please refer to Pages 5-7 to 5-11 in <u>**(ADS) Field Scan User's Guide (document No. 950021A1)**</u>.

Figure 7 - 1 Monitor Data Collection dialog

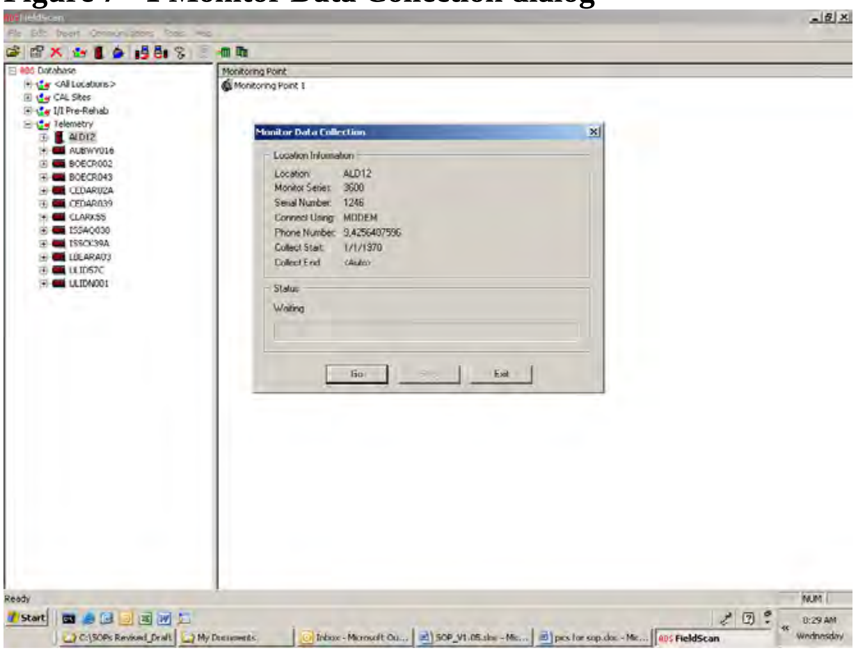


Figure 7 - 2 Data Viewer dialog

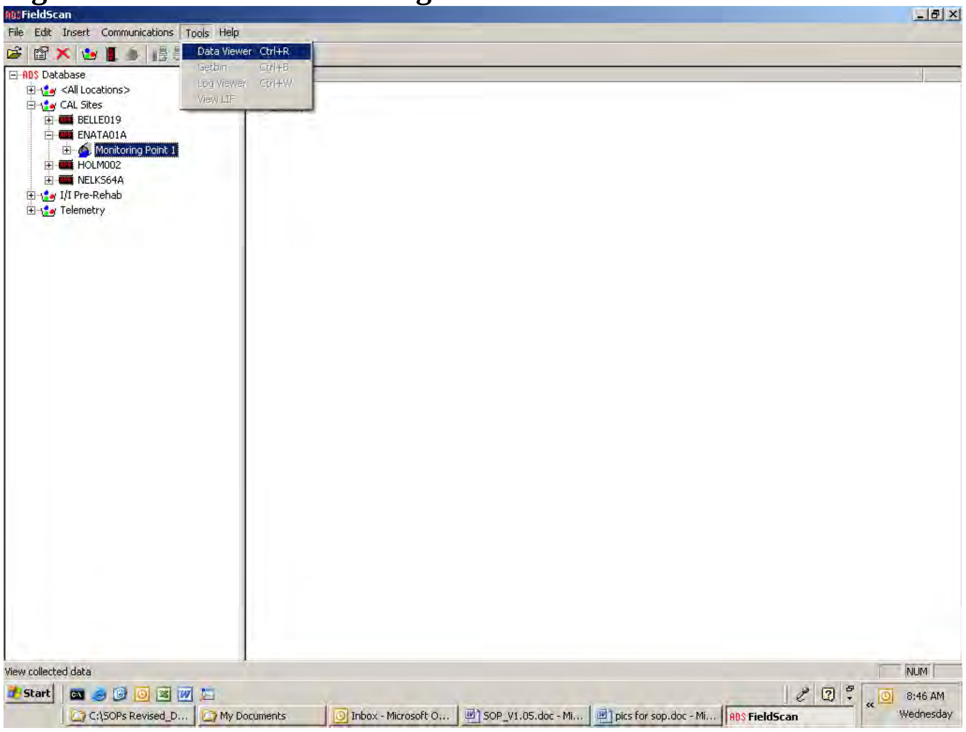
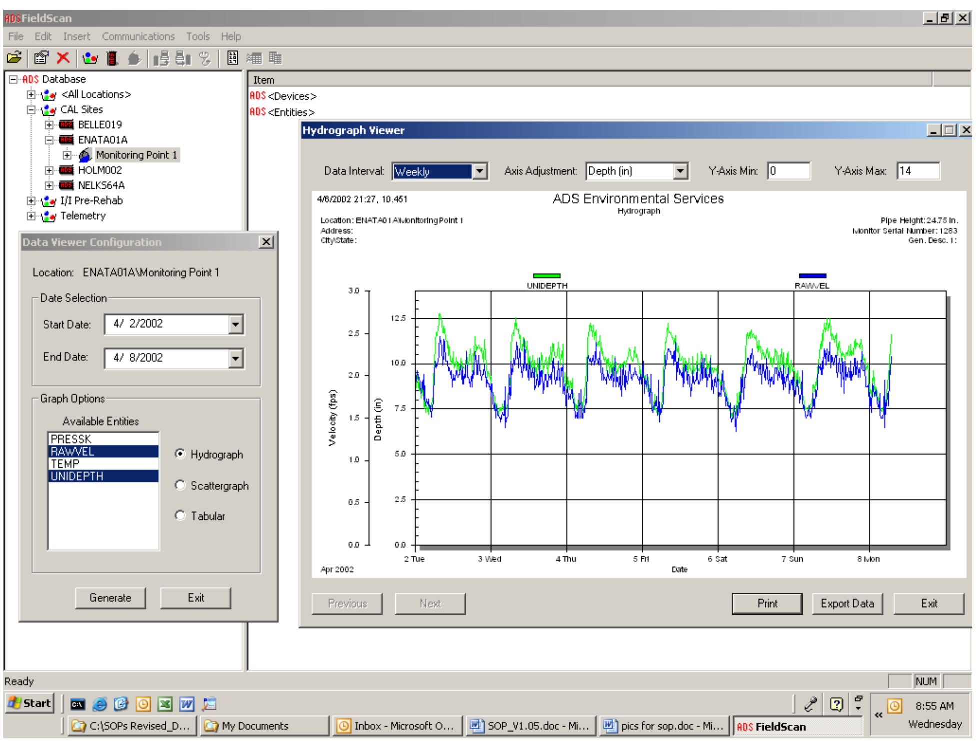


Figure 7 - 3 Data viewer configuration and graphic display dialogs



ADS Model 3601 Sensor troubleshooting and replacement

Ultrasonic sensor

Once it has been established that the depth data quality is poor or suspicious, the Data Analyst will send out a Maintenance Request to the field crew to troubleshoot. The field crew will perform the following:

1) Clean the ultrasonic sensor, make sure it is level, ensure that all (cable) connections are tight, and fire all pairs to evaluate the performance of the sensor.
2) If the sensor has at least 6 good pairs, select the pairs to be used and activate the monitor.
3) If the sensor has less than 4 good pairs and/or the readings are not good (or do not closely match), disconnect the sensor and check (sensor and chassis connectors) for moisture, dry it out (if wet), reconnect, and fire pairs.
4) If sensor still doesn't work, connect a new sensor and fire the sensor off of a flat surface (of known distance from the sensor). Pair readings that are close to each other and to the known distance will indicate that the new sensor is working. In such cases replace the old sensor with the new one (that was just tested) and perform depth confirmation. Check (the following day) whether the new sensor is functioning properly.
5) If the tested (new) sensor didn't work (pairs not reading close to the known distance in step 4), then connect the old sensor to a new monitor, create a test LIF, activate the new monitor with the test LIF, and fire the ultrasonic 2 or 3 times. If the readings are good, then replace the old monitor with the new monitor, update the site LIF and reactivate the (new) monitor. Collect data the following day to evaluate the functionality of the new meter.
6) If the readings weren't good in step 5, replace the old ultrasonic sensor with a new one and test fire (using a test LIF) to evaluate the performance of the new ultrasonic sensor. If the new monitor works with the new ultrasonic sensor, then replace both the old monitor and old ultrasonic sensor and reactivate meter with an updated (site) LIF.
7) If the field crew makes any changes (for example change ultrasonic pairs, or the pipe height), such changes must be recorded in the Site Visit log so the Data Analyst can be aware of the changes.

Velocity sensor

Once it has been established that the velocity data quality is poor or suspicious, the Data Analyst will send out a Service Request Form (SRF) to the field crew to troubleshoot. The field crew will perform the following:

1) Check if the sensor is out of the flow or buried under silt (or debris).
2) Clean sensor, dry out connectors (if wet), ensure that all (cable) connections are tight, and fire sensor. Take velocity readings using a hand held velocity meter and compare the results. If the two readings (meter and manual) are with in 10%, then the firing can be characterized as being successful. Perform two to three reading comparisons (Field Vs Monitor).
3) Collect 5 velocity spectrums if the Data Analyst requests it.
4) If the average depth of flow is greater than 5 inches, you may perform a PVD or Velocity Profile. When performing a PVD or a Velocity Profile, use the forms prepared for such activities.
5) The Data Analyst and/or the field crew will adjust velocity parameters to conform to the flow at the site (for example changing the Fast/Slow algorithm or the Max Carrier). If any change has been made on site, the changes need to be documented in the Site Visit log so the Data Analyst can be aware of these changes.
6) If, after cleaning and drying out any moisture from connectors, the velocity sensor still doesn't work, replace it with a new sensor. Reinstall ring-sensor assembly and test fire the velocity sensor.
7) Return the following day and make sure that the velocity sensor is functioning properly.
8) If the new velocity sensor didn't work, then the velocity board may be faulty. In such cases, replace the (old) monitor with a new/spare monitor and test fire the old sensor. If the sensor works then replace the monitor only. If the old sensor doesn't work, replace it with a new sensor and test fire again. If this works, then replace both velocity sensor and monitor and have the old monitor repaired.

Pressure sensor

Once it has been established that the pressure depth data quality is poor or suspicious, the Data Analyst will send out a Service Request Form (SRF) to the field crew to troubleshoot. The field crew will perform the following:

1) Clean the sensor, dry out the connector (if wet), ensure that all (cable) connections are tight, and make sure that the dryer tube has blue desiccant in it.
2) Test fire the sensor. Check the pressure Temperature Sensor.
3) If, after steps 1 and 2, the sensor doesn't work, replace the pressure sensor with a new one. Change the serial number in the LIF and retrieve the pressure coefficient for the new sensor. Pressure

coefficients may be retrieved from the ADS web site (if not already saved in the field/office computer or disks).

4) Put the sensor in the flow and test fire it. If the new sensor works, securely attach it to the ring, and reactivate the meter with the new pressure serial number and coefficients.
5) If the pressure sensor doesn't work replace the old monitor with a spare/new monitor and test fire the old sensor. If the sensor works, then replace the (faulty) old monitor. If it still doesn't work, replace the sensor and test fire the new sensor with the spare/new monitor. If it works, then replace both monitor and sensor.

If necessary, field diagnostics/trouble shooting procedures will be performed in coordination with the Data Analyst.

ADS Model 3601 Troubleshooting communication problems

Problem: The monitor doesn't answer a telephone call

Possible causes:
1) EMU or monitor battery is low
2) Modem switch settings are incorrect
3) Modem, communication board, or processor board is faulty
4) Telephone line is noisy or has been cut
5) Connectors are loose

Possible solutions:
A) check the voltage of the pair of phone cables is approximately 48 Vdc on hook
B) Check connection
C) Replace EMU modem and check if the modem is the problem
D) Replace the monitor and check if the monitor is faulty

Problem: Busy signal when calling the monitor

Possible causes:
1) shorted or cut telephone line
2) Moisture in or at the telephone connector
3) Faulty modem
4) Low modem/EMU battery

Possible solutions:
A) check for a shorted phone line
B) Check the area for a cut telephone line
C) Check connectors and dry if moist
D) Call another number (from the site phone connection). If the line works, then the monitor is faulty

For more details, Please refer to the ADS manual for Installation and Operation Manual for the 3600/3601 model flow meters. *Hard copies available – check with Field crew leader or Data Analyst.*

SOP V – ADS FlowShark

ADS FlowShark Installation and Site Setup

Assembling the Ring

The flow sensors mount to a stainless steel ring that is installed in the pipe. Several ring sizes exist, and each ring is adjustable within about 3 inches to fit pipes of different diameters.

1. Insert the spreader mechanism screw through the hole in the center of the ring stabilizer. Ensure that the head of the screw fits into the countersink hole.
2. Slide the open end of the ring (end without the welded metal band) through the flanges in the ring stabilizer, making sure the flanges face the outside of the ring and the spreader mechanism screw faces the inside of the ring.
3. Slide the ring stabilizer all the way around the ring until it is about 4 inches from the welded metal band at the other end of the ring.
4. Position the ring with the downstream edge (edge with the holes) facing you.
5. Slide the ultrasonic sensor mount onto the open end of the ring with the back of the ultrasonic mount (side with the slots) facing the outside of the ring.
6. Move the ultrasonic sensor mount around the ring. [Steps 7 and 8 apply to overlapping rings. Proceed directly to step 9 for non-overlapping rings.]
7. Slide the open end of the ring through the slot in the welded band of the ring until it overlaps about 4 inches.
8. Spread the ring sections apart so that you can slide the ring stabilizers with the spreader mechanism screw into the gap.
9. Perform the following based on the ring type:

Overlapping- Insert the spreader mechanism screw completely through the hole at the open end of the ring.

Non-Overlapping- Insert a spreader mechanism screw through the hole at the left end of the ring so that the end of the screw extends inside the ring.

10. Places the ring on a flat surface with the spreader mechanism screw facing up.
11. Orient the ring with the downstream edge (edge with small holes) facing you.
12. Lay the spreader mechanism across the inside if the ring with the downstream end of the mechanism (end with the large welded nut) facing you, the four spreader bars facing toward the inside of the ring, and the shoulder bolts pointed outside the ring.
13. Place a washer and then the downstream, left spreader bar over the spreader mechanism screw.
14. Places the upstream, left spreader bar into the same screw.
15. Lightly turn the hex nut onto the screw, ensuring that it passes through the holes in the end of the spreader bar.

    Note: Steps 16-18 apply only to overlapping rings. For a non-overlapping ring, proceed to step 19.
16. Turn the ring until the spreader mechanism is in the 12:00 position.
17. Align the spreader mechanism screw so that the head is visible through one of the ring adjustment holes.
18. Tighten the screw through the hole using the Phillips-head screwdriver while holding the hex nut with a ½ inch nut driver.
19. Insert the second spreader mechanism screw through the following hole based on ring type:

    Overlapping- Appropriate ring size adjustment hole on the outside of the ring.

    Non-Overlapping- Last hole on the other free end of the ring (inserting the screw from the outside of the ring)
20. Slip the large washer into the screw on the inside of the ring.

<u>Mounting the Ultrasonic Depth Sensor</u>

1. Slide the sensor into the groves on the sensor mount (at the top of the ring) from the upstream end of the mount until the sensor contacts the backstop. The sensor cable should exit the downstream edge of the ring. Orient the sensor with the four transducers facing downwards towards the inside of the ring (flow surface).
2. Verify that the ultrasonic mounts to the ring at the crown of the pipe.

<u>Mounting the Doppler Velocity Sensor</u>

1. Use two 4-40 x 5/16-inch stainless steel screws (do not substitute any other screws) to mount the sensor at the bottom of the ring opposite the ultrasonic depth sensor with the beveled edge of the sensor facing upstream.
2. Secure the sensor cable to the ring.

Mounting the Pressure Depth Sensor

1. Orient the ring so that the ultrasonic depth sensor is directly on top.
2. Use two 4-40 x 5/16-inch stainless steel screws to mount the pressure depth sensor on the bottom inside of the ring with the pointed end of the sensor facing upstream. Mount the pressure depth sensor about 2 inches to the left of the velocity sensor.
3. Secure the sensor cable to the ring.

Securing the Cables to the Ring

1. Starting at the appropriate sensor location, begin securing the sensor cable with 4-inch x 0.08-inch cable ties through the pre-drilled holes along the downstream trailing edge of the ring up the side of the ring. Run the cable up the side of the ring opposite the spreader mechanism (the left side of the ring when facing the downstream edge of the ring).

   Note: When securing both a pressure depth sensor and a Doppler velocity sensor cable to the ring, place the velocity cable on top of the pressure cable and secure both together.
2. Continue securing the cables until the ultrasonic depth sensor or the top of the pipe.
3. Pull the ties until they are taut. Do not over tighten the cable ties or kink the sensor cables. The pressure depth cable sheathes two components: the electrical cables that operate the sensor and an air tube that ventilates the sensor. Over-tightening the ties or kinking the cable can damage or restrict the sir tube, causing incorrect pressure depth readings. In addition, make sure the connector-end of the sensor is not kinked, does not contain moisture, and includes an attached dryer tube filled with active blue desiccant.

Installing the Ring in the Pipe

The ring must fit securely in the pile with the sensors properly positioned to ensure the most accurate monitoring results.

1. Examine the pipe for possible obstructions to the flow or inhibitors to ring installation.
2. Adjust the ring size to slightly less then the pipe diameter before placing the ring in the pipe diameter before placing the ring in the pipe by turning the spreader mechanism adjustment nut clockwise.
3. Place the ring in the input pipe at least 12 inches upstream from the manhole or edge of the pipe with the sensors facing upstream toward the oncoming flow. It must be located for

enough upstream from the manhole to minimize the effect of the draw-down caused by a possible drop in the manhole invert.

- ✓ Make sure the ultrasonic depth sensor is at the top of the pipe, the Doppler velocity sensor is the bottom of the pipe above any silt present and below the flow surface (during minimum flows), and the pressure depth sensor is near the bottom.
- ✓ If necessary, temporarily clear away silt to install the ring, and restore the silt after fully securing the ring.
- ✓ Make sure the ring is flat (flush) against the inside wall of the pipe to avoid obstructing the flow or catching debris.

4. Expand the ring by turning the spreader mechanism nut counter-clockwise with the crank handle or socket. However, do not tighten the ring against the pipe completely at this point.
5. Use a carpenter's level and orient the ultrasonic depth sensor at the top of the pipe so that the sensor face is parallel and level (from the side to side) with the flow surface and pipe crown. If necessary, adjust the level:
    a. First remove the ultrasonic depth sensor from the mount.
    b. Loosen the ring slightly to allow the plate to move on the ring.
    c. Tap the sensor mount to the right or left with a rubber mallet till it is level.
    d. Reattach the sensor to the mount and recheck the level.
6. Fully tighten the ring until it fits securely and completely flush against the pipe of the wall.
7. Restore any slit moved to its pervious level and confirm that the Doppler velocity sensor is still above the silt level.
8. Measure the physical offsets for the ultrasonic and pressure depth sensors.
   Ultrasonic Offset- Measure the distance from the crown (top) of the pipe to the face of the ultrasonic depth sensor
   Pressure Offset- Measure the vertical distance from the bottom of the pressure depth sensor to the bottom, center of the pipe.
9. Secure the sensor cables from the ring to the future monitor location in the manhole.

<u>Creating a Monitor Location</u>

1. Select the All Locations group located under the database level
2. Next select Edit > New > Location option or the New Location toolbar button
3. Enter the new Location Name and new location Description
4. Select the appropriate method of communication from the Connect Using drop-down list.
5. Enter the monitor location Telephone Number or the IP Address for wireless connection.
6. Enter the monitor serial number.

7. Enter all the numbers of hours difference between your location (or the location of the computer on which the database resided) and the location of the monitor in the Time Zone field. There should be no difference.
8. Select the rate at which you want the monitor to log data from the Normal drop-down list.
9. Select the increased rate at which you want the monitor to log data for the duration of an event from the Fast drop-down list.
10. Select OK to create a LIF for the location in the database and exit the dialog.

Creating an Installation Table

1. Select the monitoring point for which you want to create the installation.
2. Select Tools > Installation Generator from the main menu or click on the Installation Generator toolbar button on the Profile main screen.
3. Select the New radio button and then click on the Next button.
4. Select the Pipe radio button and then click on the Next button.
5. Select the type or shape from the drop-down list and then click on the Next button.
6. Enter the proper pipe dimensions in the corresponding fields and then click on the Next button.
7. Enter an appropriate name for the installation in the text field, and then click on the Next button.
8. Review the installation table selection summary and then click on the Finish button. Select the Back button to return to the pervious dialogs to edit any of the existing selections.
9. Click on the Yes button to save the installation table to the Profile database for the selected location.
10. Select File > Exit to close the Installation Generator.

Selecting and Editing Devices

1. Select the location for selecting/editing devices from the database.
2. Expand the location contents and then select Devices.
3. Select the Edit > Properties option or the Properties toolbar button.
4. Select the monitoring point to which you want the assign the devices from the Monitoring Point drop-down list.
5. Select the checkboxes corresponding to the devices you want to assign to the designated monitoring point from the Available Devices selection box. A checkmark must display beside a device in the Monitoring Point Devices section to ensure Profile includes the device in the

LIF. Deselect the checkboxes corresponding to the devices you want to remove from association with the selected monitoring point from the Available Devices section.
Note: Profile selects the Ultrasonic 1, Velocity 1, Pressure 1, and MLI 1 devices for the FlowShark monitor by default. The MLI device is not associated specifically with a sensor. It represents special software included in the monitor firmware that supports activities such as water quality sampling and event notification.

6. Repeat steps 4 through 5 to assign devices to Monitoring Point 2 when applicable.
7. As necessary edit the parameters specific to each device as follows:
8. Once you have edited the devices as necessary, select the OK button the save the devices to the LIF.

Editing the Ultrasonic Device

Use Defaults- Select this check box to apply the default parameters to the ultrasonic device. Deselecting this option enables the parameter fields for editing.

Physical Offset- Enter the physical distance between the face of the ultrasonic depth sensor and the top (crown) of the pipe.

Pipe Height- The field represents the height of the pipe in which the sensor is installed. The parameter is not editable from this location.

Editing the Pressure Device

Serial Number- Enter the serial number listed on the pressure depth sensor. Note: Make sure you have the latest coefficients on your hard drive. The latest pressure coefficients are downloadable from the ADS website. www.adsenv.com. Select Environmental Services > Support > Client Services and the link on Download pressure coefficients…link to save to the desired location.

Physical Offset- Enter the vertical distance from the bottom of the pressure depth sensor to the bottom center of the pipe. ADS recommends measuring this distance manually during the monitor installation or verification process. Profile defaults to 0 inches.

Setting the Communication Parameters

1. Select a monitor location from the Profile main screen and then select **Tools** > **Diagnostics** from the main menu or click on the Diagnostics toolbar icon.
2. Select **Communication Parameters** from the functions dropdown list and click on the Perform button.
3. Select or enter the communication parameters as necessary :
   a) **Modem name-** Select the modem you want to use during modem communication from the drop-down list.

b) **Modem Port-** Select the proper port for modem communication from the drop-down list.

c) **Serial Port-** Select the proper port for serial communication from this drop-down list.

d) **DMI Port-** Select the proper port for communications using the DMI from this drop-down list.

e) **Timeout-** Enter the number of seconds you want your local computer to wait for a response from the monitor once communications has been initiated.

f) **Retires-** Enter the number of times you want your local PC to request data from the monitor following failed attempts while the monitor is still on line. This is usually set to 3.

g) **Low temperature-** Enter the temperature reading from the monitor, ultrasonic depth sensor, and pressure depth sensor above which you want Profile to provide notification.

h) **High Temperature-** Enter the temperature reading from the monitor, ultrasonic depth sensor, and pressure depth sensor above which you want Profile to provide notification.

i) **Log Communications-** Select this checkbox to record all communication activities with the monitor communications are established.

j) **Low Modem Battery TCP/IP-** Enter the voltage below which you want Profile to provide notification for the wireless communication unit. This should be 8.0V.

k) **Low Signal Strength TCP/IP-** Enter the voltage below which you want Profile to provide notification for the wireless communication unit. This should be -100 IP strength.

l) **Low Battery FlowShark-** Enter the voltage below which you want Profile to provide notification for FlowShark monitors. This should be 8.0V.

4. Select OK.

Activating the Monitor

Note: If reactivating an existing site, make sure that all data is collected before activation because all logged data stored in the monitor memory must be deleted before reactivating a FlowShark monitor. Profile will automatically detect if the devices in the LIF differ from the active devices in the FlowShark monitor and delete

1. Select the monitor location for activation from the Profile main screen, and then click on the **Diagnostics** toolbar button.
2. Select the **Connect** button to establish communications with the monitor. Profile initiates communication with the monitor and establishes a connection.
3. Select **Activate** from the **Functions** drop-down list and then select the **Perform** button.
4. Click on the **disconnect** button once activation is successful (in the Results section) and complete

5. Click on the **Close** button to exit the Monitoring Diagnostics dialog.

ADS FlowShark Data Collection and Review

1. Select the monitor location from which you want to collect data and then select Tools > Diagnostics from the main menu or click on the Diagnostics toolbar button.
2. Select the Connect button to establish communication with the monitor. Profile initiates communication with the monitor and establishes a connection.
3. Select Collect from the Functions drop-down list and the select the Perform button.
4. Designate the range of data you want to collect from the monitor by editing the Start and End Time fields in the Collect Information in the section. Edit these fields directly by selecting the portion of the date or time stamp you want to change and then entering the appropriate designation or using the arrows to scroll up and down in the range.
5. Select the Collect button. The Results section displays the status of the collect. Profile collects all entity data from the monitor for the selected time/date range and stores it in the currently selected database.
6. Click on the Next button
7. Review the data in the hydrograph and then click on the Next button. Under optimal conditions the depth and velocity should reflect a constant diurnal pattern.
8. Review the data in the scattergraph and then click on the Next button. Under optimal conditions the data on the graph should reveal velocity increasing with depth.
9. Review an issues identified and the suggested actions and then click on the Finish button.
10. Click on the Close button.

ADS FlowShark Maintenance and Troubleshooting

<u>Replacing the Pressure Depth Sensor Dryer Tube (Desiccant)</u>

Replace the pressure depth sensor’s dryer tube on a regular basis. Make sure the desiccant in the tube is still blue. Pink desiccant indicates that it will not longer absorb moisture. If appears more than half way pink replace the desiccant.

1. Clip the cable ties securing the dryer tube to the monitor.
2. Cut the clear flexible tubing running from the dryer tube to the pressure depth sensor connector at the location close to the brass barbed fitting on the dryer tube.
3. Place the dryer tube with the used desiccant aside, but do not discard.

4. Attach a new dryer tube to the pressure depth sensor inserting the brass fitting into the open end of the plastic tubing running from the sensor connector. Make sure the tubing seats firmly against the fitting to prevent air or moisture transfer.
5. Secure the new dryer tube to he monitor.
6. Remove the black end cap before reinstalling the monitor in the manhole.

Running device Diagnostics

Profile's diagnostics tool enables the user to verify the proper operation for sensors, obtain current readings and status, adjust settings, and identify, diagnose, and troubleshoot potential problems with ultrasonic, velocity, and pressure devices.

1. Select the monitor location for which you want to run diagnostics on a device from the Profile main screen, and then select Tools > Diagnostics or click on the Diagnostics toolbar button.
2. Select the Connect button to establish communication with the monitor.
3. Ultrasonic/Velocity/Pressure Device Diagnostics-
   a. Select the Ultrasonic 1/Velocity 1/ Pressure 1 device from the Diagnose Device drop-down list, and then select the Diagnose button.
   b. Click on the Fire button.
   c. Click on the Advance button to view more detailed diagnostic information.
   d. Verify the accuracy, consistency, and quality of the readings and edit the configuration parameters as necessary.
   e. Select Store to save any changes made in the device parameters to the LIF in the database.
   f. Next select Close button to exit the device dialog and return to the Monitor Diagnostics dialog.
4. Select Activate from the Functions drop-down list, and then select the Perform button. Refer to Activating the Monitor for more details.
5. Select the Disconnect button to discontinue communication with monitor when finished running diagnostics on the system devices.

General Monitor Problems

Problem: Monitor does not answer a telephone call.

Possible Causes:

Telephone connection at monitor may be damaged, loose or leaking.
Telephone cable many be noisy, damaged, or dead.
Lightning protection module may be damaged.
Battery pack may be dead or below minimum voltage requirement.
Monitor may be defective.

Modem in office or field computer may be defective.
Telephone service may not be working.

Possible Solutions:

Make sure phone cable connection at monitor base is secure and dry.
Check telephone cable for damage.
Use voltmeter to check voltage on telephone cable and at lightning protection module. Voltage should be approximately 48 Vdc on hook.
Replace 12-volt battery packs if below 8.0 volts.
Contact telephone company to check service.
Replace the monitor.

Problem: Monitor does not answer through wireless communication.

Possible Causes:

Signal strength to the modem may be insufficient.
Battery pack may be dead or below minimum voltage requirement.
Monitor may be defective.
Modem in monitor may be defective.
Internet connection in the office or field computer may be down.
Port 2100 may be blocked by IT department.

Possible Solutions:

Direct connect to monitor on site and request the signal strength. If the signal strength falls between -51 and -91 communication should be available. If it reads below -91 relocate antenna and if relocation is not an option consider installing a landline or have the site be manually collected.
Replace the 12-volt battery pack if below 8.0 volts.
Replace the monitor.
Restore internet connection.
Restore/establish permission to pass TCP/IP traffic via port 2100.

Problem: Bust signal occurs when calling the monitor.

Possible Causes:

Someone else may be communicating with monitor.
Telephone cable may be damaged or shorted.
Modem in monitor may be damaged.
Telephone service may not be working.

Possible Solutions:

Wait for a few minutes and attempt to communicate with monitor again.
Connect at the site using the serial cable, and try to communicate with monitor.
Use voltmeter to check voltage on telephone cable. Voltage should be approximately 48 Vcd on hook. If it is not, disconnect phone line at the lightning protection module and check the voltage at the network interface box.
Make sure telephone cable is not damaged or severed and repair or replace if necessary .
Check the telephone connector for moisture.
Contact the telephone company to report service is not working
Replace the monitor.

Problem: Monitor establishes a connection but does not respond to any message.

Possible Causes:

Cabling may be loose.
Lightning protection module may be damaged.
Modem in monitor may be faulty.

Possible Solutions:

Listen for noise at the site using a phone connection. If noise is present inspect the wirings and replace wiring of necessary.
Replace the lightning protection module.
Contact telephone company.
Collect the data for the monitor onsite using the serial cable and replace monitor if defective.

Problem: Time stamp on the collected data is incorrect.

Possible Causes:

PC clock may read incorrect time.
Monitor clock may be faulty.

Possible Solutions:

Verify the time in the PC clock and correct of necessary.
Reactivate the monitor to enable the clock (remember to collect data before reactivation)
Collect the data from the monitor and replace monitor if defective.

Problem: You receive a Device Time Out message in Profile.

Possible Causes:

Analog board may be faulty.

Possible Solutions:

Re-attempt communication with monitor.
Replace the monitor if defective.

Problem: Gap exists within the collected data.

Possible Causes:

Monitor time may be incorrect.
Monitor firmware or variable file may be corrupt.

Possible Solutions:

Check monitor time and reset clock if necessary.
Attempt to collect data within the gap.

Problem: Data is missing at the beginning or end of the date range following data collection.

Possible Causes:

Monitor activation may have failed.
Monitor time may be incorrect.
Monitor’s firmware or variable file may be corrupt.

Possible Solutions:

Verify whether the monitor has been activated and activate if necessary.
Check monitor time, and rest clock if necessary.
Run diagnostics in Profile to verify whether a firmware problem may exist.

SOP VI – HACH Sigma Model 930/930T

Model 930T

HACH Sigma 930/930T Installation and Site Setup

Mounting Rings and Bands- Mounting bands are used to hold a probe in a particular place within pipe. They can compress for installation and then expand to the diameter of the pipe to hold the probe into place. *Be sure that the probe is calibrated correctly before attaching it to the mounting bands and inserting it into the pipe.*

1. Securely fasten the probe to the bottom of the mounting ring. Do not tighten the screws as it will damage the probe.
2. Use cable ties to attach the cord up the side of the mounting ring. Be sure not to strain the cable or the connection with the probe.
3. If possible, manually install the ring by slightly compressing the edges so it fits into the pipe. Once it is in position let go of the ring so it can expand to the diameter of the pipe.

<u>Sectional Mounting Bands</u>-

1. Snap the bands together to fit the pipe diameter
2. Securely fasten the probe to the bottom of the mounting bands. Do not tighten the screws as it will damage the probe.
3. Attach the scissor jack assembly to the two ends of the mounting band. Compress the scissor jack to make the mounting band smaller and easier to fit to the pipe.
4. Insert the mounting band into the pipe and expand the scissor jack so it fits tightly in the pipe.

In-Pipe Ultrasonic Sensor

The in-pipe ultrasonic sensor is used in pipes where level measurement near the top of the pipe is desired. Te sensor will read the level until liquid reaches the bottom of the sensor housing. The pipe sensor is not recommended for weir of flume applications due to limited range, but may be desirable in some applications.

1. Mount the sensor over the center of the flow stream where the surface turbulence is minimized.
2. Mount the sensor 2m (82 in.) away from obstructions located in front of the in-pipe sensor to prevent inaccurate liquid level readings.
3. Level the sensor using the built-in bubble level.
4. Ensure the isolation gasket is in place ad the mounting bracket thumbscrews are finger-tight to avoid sensor ringing.
5. Install the sensor within 4.08(13.4ft) of the lowest expected level (minimum range of the sensor).

   Note: Beam Angle- The narrow beam of sound that emanates from the bottom of the in-pipe ultrasonic sensor spreads out at an angle of +/- 12 degrees (-10 dB) as it travels away from the sensor. This means that if the sensor is mounted too high above a narrow channel, the beam may be too wide when it reaches the bottom of the channel. This may cause false echoes from the sides on the channel walls.

Calibrating the In-Pipe Ultrasonic Sensor

Calibrate the in-pipe sensor each time the sensor is installed at a new site. Calibrate the in-pipe via one of two methods; Liquid Depth or Sensor Height. Each method has its own advantages and disadvantages. Liquid Depth calibration is the recommended calibration method; use the sensor height method only when Liquid Depth calibration is not an option. An Invisible Range can also be set which allows the transducer to ignore reflections from obstructions between the sensor and the water surface, such as ladder rungs, channel side walls, ect.

Temperature Calibration

The speed of sound in air varies with the temperature of air. The in-pipe sensor is equipped with temperature compensation to help eliminate the effect of temperature variation under normal site conditions. Enter the ambient air temperature at the transducer location. For optimal results allow enough time to ensure that the sensor is at equilibrium with the surrounding air temperature.

Liquid Depth Calibration (preferred method)

Liquid depth calibration requires knowing the level or depth of the liquid in the channel that is contributing to flow. Liquid depth calibration is the recommended calibration method for the in-pipe sensor. Take a physical measurement of the liquid depth and enter the value into the software. For a dry channel enter 0 depth.

Sensor Height Calibration

Sensor Height calibration is generally used when access to the primary device is difficult (such as confined space entry in a manhole) or when that is not liquid flowing during the installation of the flow meter. This calibration method requires knowing the distance between the zero flow point and the bottom of the sensor. In a round pipe the zero flow point is typically the invert or bottom of the pipe. Further, compensation is required for the invisible range (internal deadband) in the sensor housing. Measurement uncertainty increases to 1.07 am (0.035 ft) fro a +/- 30 am (+/-1 ft) change in level from the calibration point. Use this method only if the Liquid Depth is not an option.

Invisible Range/Deadband

The 930 flow meters are equipped with an invisible range feature to prevent false echoes from tops of channel walls, ladder rungs, shelves, etc. A user-selected range is defined that is invisible to the flow meter. Do not extend that invisible ranged to where it meets or overlaps the highest expected level in the channel.

Measure the distance between the bottom of the sensor housing and the object that is to be excluded from the level measurement. Add 18cm (7.09 in.) to the measured distance to obtain the total invisible range (deadband). Enter the total invisible range value into the application software.

> Note: Keep the sensor and the reflector free of grease and dirt. Since the logger ‘listens’ for the relatively faint sound of the returning echo, a heavily coated sensor will not be able to detect the echo well and may not provide accurate level measurements.

Submerged Area/Velocity Sensor

The submerged Area/Velocity Sensor contains a pressure transducer for level measurement and a pair of ultrasonic transducers for velocity measurement. These two measurements are used to calculate flow in open channels. The flow meter measures the pressure of the water and converts it into a level reading. The ‘wetted area’ of flow stream is then calculated using the level reading and the user-entered channel geometry. The flow meter then measures the Doppler shift in returned ultrasound and converts it into a velocity reading. The ‘wetted area’ multiplied by the velocity equals the flow rate.

Some guidelines for installing a Submerged Area/Velocity Sensor:

- Do not install more than one sensor at a time in pipes less than 61 cm (24inches). Multiple sensors in smaller pipes can create turbulent or accelerated flows near the sensors that may cause inaccurate measurements.
- Mount the sensor as close as possible to the bottom of the pipe invert to most accurately measure low velocity levels.

- Do not monitor sites as far from inflow junctions as possible to avoid interference caused by combined flows.

Zeroing the Submerged Area/Velocity Sensor

The sensor has been factory-calibrated and compensated for temperature. The sensor needs to be zeroed during each installation, but does not require calibration. The sensor should be zeroed when moving it from one flow meter to sample to another.

1. Install InSight version 5.7 or greater and start the program.
2. From the InSight software menu, select Remote Programming.
3. From the Real Time Operations list, select sensor to be calibrated.
4. Remove the probe from the liquid and place the sensor flat on the table or floor with the sensor (the plate with the holes) facing down onto the surface.
5. Press OK on the dialog box when complete.

Connecting the Sensor to the Mounting Bands and In the Pipe

1. Attach the sensor to the spring ring. Mounting bands come with pre-drilled holes for direct mounting of the sensor to the band.
2. To reduce the likelihood of debris collecting on the cable and mounting band, route the cable along the edge of the band and fasten the cable to the mounting band with wire ties. The cable should exit the tied area at, or near, the top of the pipe to keep it out of the flow stream.
3. Point the angle-face of the sensor into the flow. The manufacturer recommends placing the sensor with the arrow pointing with the flow. Slide the mounting band as far into the pipe as possible to eliminate draw down effects near the end of the pipe. Locate the sensor at the bottom-most point in the channel. If excessive silt is present on the bottom of the pipe, rotate the band in the pipe until the sensor is out of the silt.

Performing a Level Adjustment

The manufacture recommends doing a level adjustment whenever a sensor is fart installed into a flow stream. This adjustment accounts for the various physical tolerance stack-ups in the system.

1. With the sensor installed in the flow, use a PC of display to monitor Current Status.
2. Take a physical reading measurement of the water depth by measuring the distance from the top of the pipe to the surface of the water and subtracting this number from the pipe diameter. The resulting number is the water depth.
3. Enter that physically-measured water depth into the software using the Adjust Level Function.

Configuring the 930/930T Flow Meter Parameters Using InSight

1. Connect the RS232 cable (Cat. No. 1727) from the RS232 port to a personal computer.

2. Start InSight. Program the flow meter using the Remote Programming feature to configure the flow meter alarms and fixed-settings and data log. Refer to the InSight Help menu or the InSight Manual for more information.

Configuring 930T Communication Settings Using Telogers™

1. Make sure Telogers is configured to communicate with a local connection.
2. In Telogers select Setup>Options>Communications. Check Enable Local Comm and indicate the local comm port.
3. During initial configuration, collect data on the instrument to add it to the database.
4. Then settings can be modified.
5. Connect the Telogers Cable (Cat. No. 6242300) from the RS232 port on the 930T to a personal computer.
6. From Telogers, select Setup>Options. Select the Communications tab to display the communications dialog.
7. Customize the default settings for the specific computer. Refer to Configuring the Operating
8. Parameters in the Telogers for Windows Software Manual, Cat. No. 6242518.

Communication Options

The 930 Flow Meter can be installed to retrieve data via direct connection to the RS232 serial port, DTU II, or through an internal telephone modem. Data can be retrieved from the 930 Flow Meter using a PC and InSight® Data Analysis Software. Refer to the InSight Software Manual or the Online Help System for more information.

The user can program or retrieve real-time data from the 930T flow meter via RS232, landline telephone or wireless 1XRTT modem. Data can be retrieved from the 930T Flow Meter using a portable or remote host computer and Telogers® for Windows software. Refer to the Telogers for Windows Software Manual or the Online Help System for more information. Insight can also be used with the 930T flow meter.

Modem Communications

The 930 can be configured with a 14,400 baud, cellular capable internal telephone modem (Cat. No. 4872). These advanced, very low power modems let you communicate with Hach loggers over long distances using public telephone lines or a cellular phone. The 930 modem communicates at speeds from 300 to 14,400 baud.

The 930T can be configured with a 9600 baud or 2400 baud M-324 landline modem.

Ultrasonic Sensor

One Ultrasonic Sensor can be attached to each ‘U-SONIC’ receptacle. Loggers that use more than one ultrasonic sensor have ultrasonic receptacles labeled ‘U-SONIC A’, ‘U-SONIC B’, etc. Each sensor may be assigned in the software as the primary sensor or as one or more secondary sensors. The primary sensor is used for all flow calculations in InSight software.

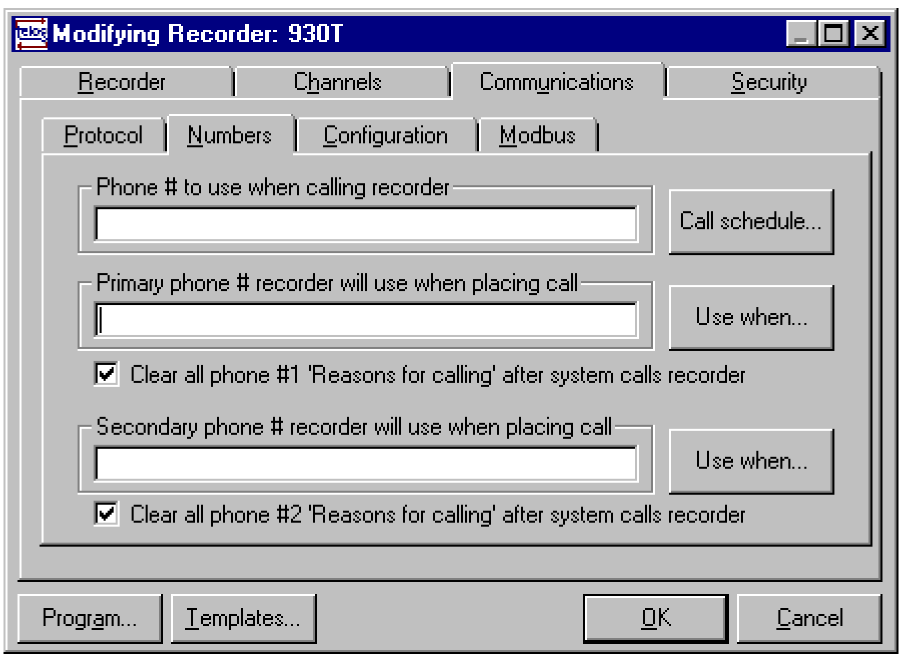
Test Communications (930T ONLY)

The tamper button is used to determine if the phone connection is working for a newly installed 930T Flow Meter.

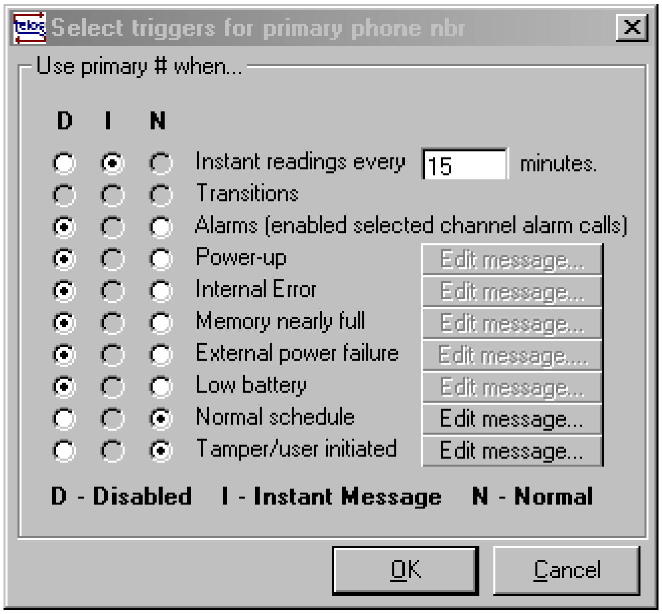
1. Connect the Tamper Box Cable to the RS232 port.

2. Use Telogers to configure the instrument to use the tamper box.

a. Select Setup>Recorders. Click on **MODIFY**. Select the Communication and Numbers tab.



b. Enter the phone number of the computer and click on **USE WHEN...** to display a list of reasons and select the “Tamper/user initiated” option. Click on **OK**.



3. Hold down the tamper button for one second. The 930T will attempt to place a call to the programmed number.

4. Call the office to ask a co-worker to review the View>Log Files>Alarm Log. If the call was made, it is listed in the Alarm log.

HACH Sigma 930/930T Data Collection and Review

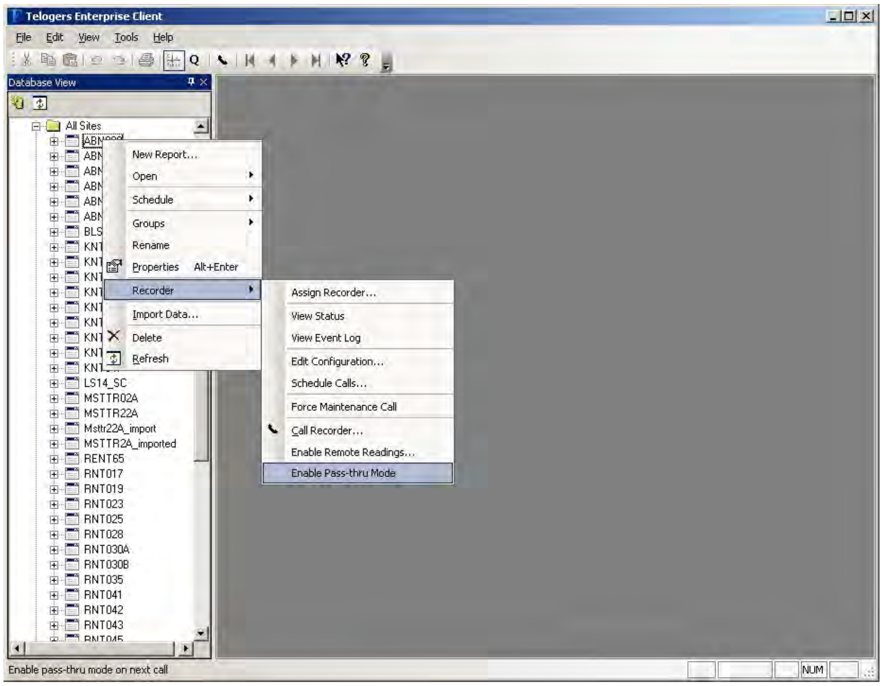
Sigma 930T will be downloaded from the designated office computer telemetry. For Sigma 930 and other manual sites:

1. Connect to the site via Local Recorder.
2. Download data and the data will be automatically stored in a database.
3. View the data by clicking on ‘View DB’ and select the site along with the data properties (eg. The desired time span).
4. Click OK and data will be graphed on the left and tabular data will appear on the right.

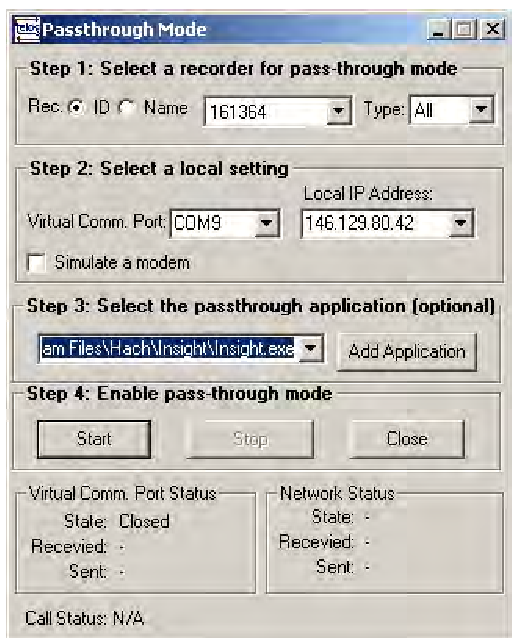
<u>How to Use Pass through Mode:</u>

1. In TEC single right click on site

2. Go to Recorder and click on the Enable Pass-through mode



3. Select the port under the Virtual Comm Port- we selected port 9. Optional: point the in the Step 3: box to the application you want to initialize at the same time pass-through mode starts (in your case it was Insite software)



4. Click Start.

The communication should start in 60 seconds from starting the mode. You can verify that using the TRM View Progress tab. Once the mode is on you can proceed with using flowmeter software as if you were connected to it using a RS232 cable.

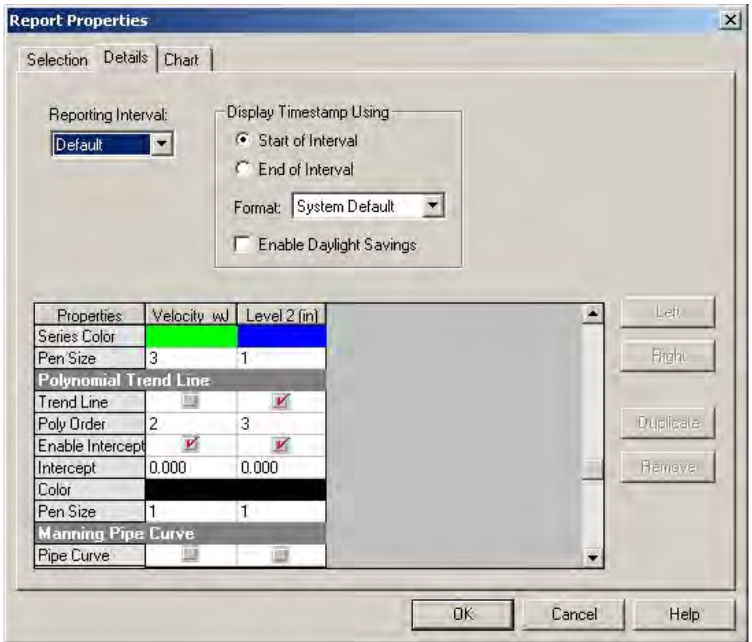
Insight Data into Enterprise

1. Locate the (########.X__) file for the site. This file will be exported by the field crew after each time they download a meter from Insight.
2. Import the file into Insight. The data will be added to the Insight database. Close Insight.
3. Navigate to C:\Program Files\Hach\Insight\DATA\MERGE and locate the 000File. Copy the 000File.
4. Navigate to C:\Program Files\Hach Company\Flo-Center\Site Files and paste the 000File into this folder.
5. Open Flo-Center and Import the file in.
    a. "Insight Binary Site File Format" radio button
    b. Hit Browse to select the 000File and hit OK
    c. Then highlight the Site File and hit Finish. The data will be brought into Flo-Center.
6. While still in Flo-Center, click on the Site Files button.
7. Select the imported site and hit "Add to Database" and hit OK. When finished Cancel to get out.
8. Next click the Export button and check the site you wish to export.
9. Expand the site and uncheck Rain.
10. Under the Channels tab change the Units on Input 5 to V (for volts) and the Units on flow 1 to MGD.
11. Under the 'Misc…' tab uncheck all the boxes.
12. Under the Export Destination tab hit Change and select where you wish to export the file to.
13. Hit Finish and the site data will be exported from Flo-Center. Close Flo-Center.
14. Open Enterprise.
15. Create a new site along with the site's measurements if the site being imported in is new to the database. For existing sites, create new measurements under the site with an identifiable name (eg. Level 1_import). Make sure the measurement type (eg. Meter Level) and the Units are correct.
16. Right click on the site and select "Import Data…"
17. Navigate to the file you exported from Flo-Center and click Open.
18. Enterprise will load the csv file. At the top, match the Measurement 2-6 with the correct Measurement in the column. The drop down menus will enable you to select the newly created measurements you just created (eg. Level 1_import). When done hit OK.
19. Lastly refresh the site in Enterprise.

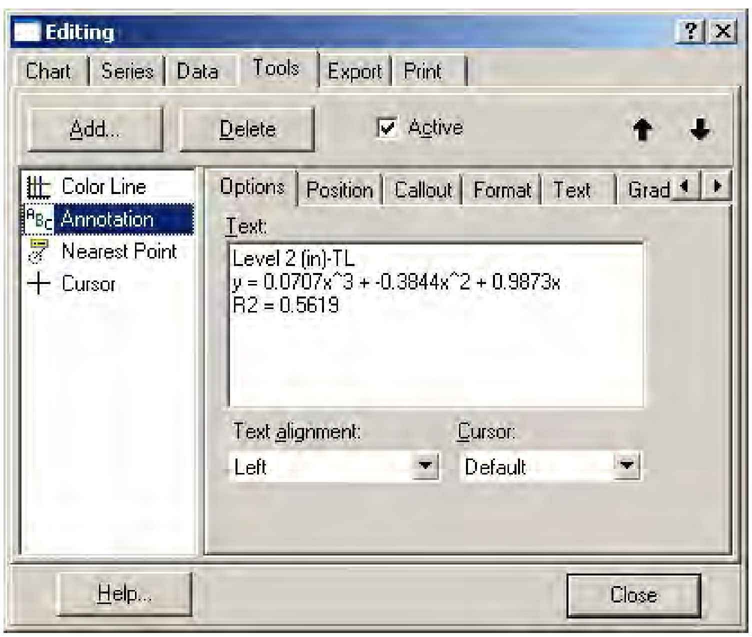
Snapping to Curve in Enterprise

1. Create a polynomial for Velocity (Velocity 1) based on Level and Vraw by first choosing the time the polynomial statement represents the data the best.

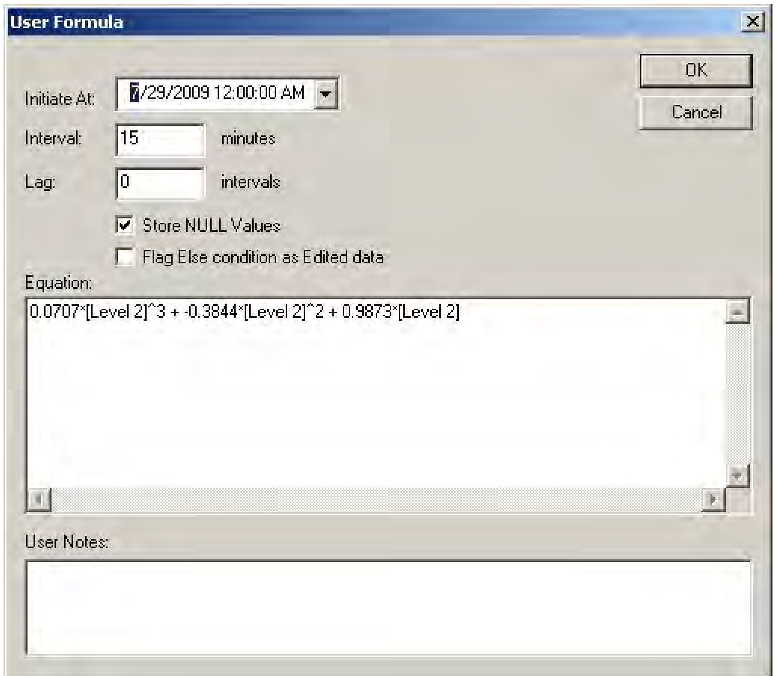
2. Next create the polynomial in the ideal range selected in step 1. Go the Properties of the site and in the **Details tab** locate the **Polynomial Trend Line**. Check the Trend Line box in the right hand column and change the poly order to at least **3**. Choose a higher poly order if you would like the polynomial line to fit more tightly.



3. In the scattergraph right hand click and navigate to the Tech Chart Editor. Under the Tools tab highlight Annotations. This is where you can extract the y value of the polynomial line. Copy and paste this into a temporary word document or text file.



4. Create a computed measurement that will create Polynomial Velocity (Vpoly). In the new user formula paste in the generated polynomial from step 3. It should have a form like: 0.0707*[Level 2]^3 + -0.3844*[Level 2]^2 + 0.9873*[Level 2] where in this case we selected Level 2 as the Raw level.



5. Based on the knowledge of the site determine Velocity value that would define what data would be outside of acceptable range of Vpoly: (eg. +/-0.70 of the polynomial line).

6. OPTIONAL: To flag the data that is outside of the range use create a computed measurement using following formula:

IF (
ABS([Velocity 1] - [Vpoly]) / [Vpoly] < 0.XX,
[Velocity 1],
[Velocity 1]
)

Ensure that new measurement is checked to "Flag Else Condition as edited Data".

7. To replace the data that is outside of the range use following formula in a new measurement:

IF (
ABS([Velocity 1] - [Vpoly]) / [Vpoly] < 0.XX,
[Velocity 1],
[Vpoly]
)

Ensure that new measurement is set to "Flag Else Condition as edited Data" to view the edited data.

HACH Sigma 930/930T Sensor Troubleshooting and Replacement

Cleaning the Sensor (Oil-filled and Standard)

Clean the transducer port when:
• Unexpected increase or decrease in flow or level trend occurs

• Level data are missing or incorrect but velocity data are valid.

• Excessive silt has deposited between the transducer and its protective cover.

Cleaning the Sensor (Oil-filled and Non-oil)
Important Note: Do NOT interchange an oil-filled protective cover plate with a non-oil cover plate. This will adversely affect level readings.

Important Note: When cleaning the transducer, use the gentlest technique possible. Do not use sharp or pointed objects to remove sediment from the face of the transducer. If you nick or dent the transducer, it will break!

1. Soak the sensor in soapy water
2. Remove the screws from the protective cover.
3. Remove the cover and gasket.
4. Carefully swirl the sensor in an appropriate cleaning solution to remove soil. Use a spray or squeeze bottle to wash away heavier deposits.
5. Clean the gasket and cover. Replace the gasket if it is torn or damaged.
6. Level readings will be adversely affected if the gasket is damaged or not installed.
7. Reattach the gasket and cover. Tighten the screws until the gasket starts to compress.
8. If using an oil-filled sensor, continue to Step 9.

   The manufacturer recommends inspecting the oil in the sensor for large air bubbles during the customer-scheduled service duty cycle, and prior to every installation. Small bubbles (less than ¼ inch in diameter) of air within the oil do not affect performance. Larger bubbles may minimize the anti-fouling benefit of the oil.
9. If the sensor is new, remove the yellow tape on the sensor.
10. Remove any debris from the sensor.
11. Load the oil cartage into the dispensing gun.
12. Twist the feed tube onto the cartage and attach the syringe tip to the feed tube.
13. Press the dispenser gun handle to purge any air bubbles from the syringe tip.
14. Remove the set screw in the transducer cover with the supplied 0.035 hex wrench. Retain set screw.
15. Slowly insert the syringe tip into the set screw hole and dispense the oil. Which dispensing the oil, hold the probe at an angle to allow the air to be pushed out the side port. Continue to dispense the oil until all the air bubbles are removed.

Note: Slowly insert the syringe tip and do not dispense oil during insertion or damage to the transducer may occur if too much pressure is applied.

16. Continue to dispense the oil while removing the syringe from the set screw hole to prevent air bubbles. Replace the set screw until it is flush with transducer cover and remove any excess oil around the screw hole or on the sensor.
17. Clean the entire probe and place

How to Enable Dual Data Rate in Sigma 930T

Enabling the dual data rate will allow for dynamic sampling during higher level conditions. The programming will tell the meter when the level rises to certain point, the meter should sample at a different rate to capture more accurate data and when the level drops below a certain point, the meter will return to its pervious sampling rate.

In the wet season we will be recording in 5 minute intervals with the threshold at 85% of the pipe's capacity to record at 1 minute intervals. In the dry season, meters will be recording at 15 minute intervals.

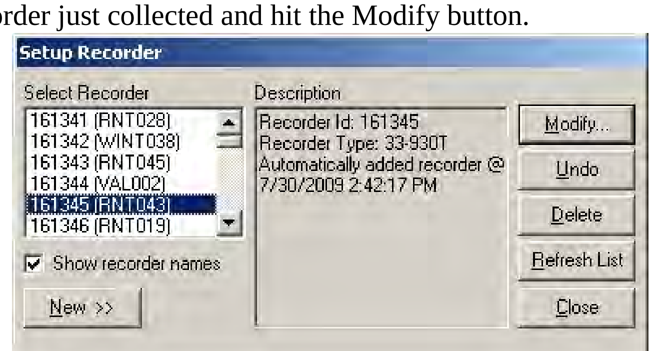
Going from 15 minutes to 5 minute sampling rate with 85% capacity threshold…

1. Connect through the sampling port with the TELOG cable and open Telogers for Windows. **Make sure your padlock is down (locked).**

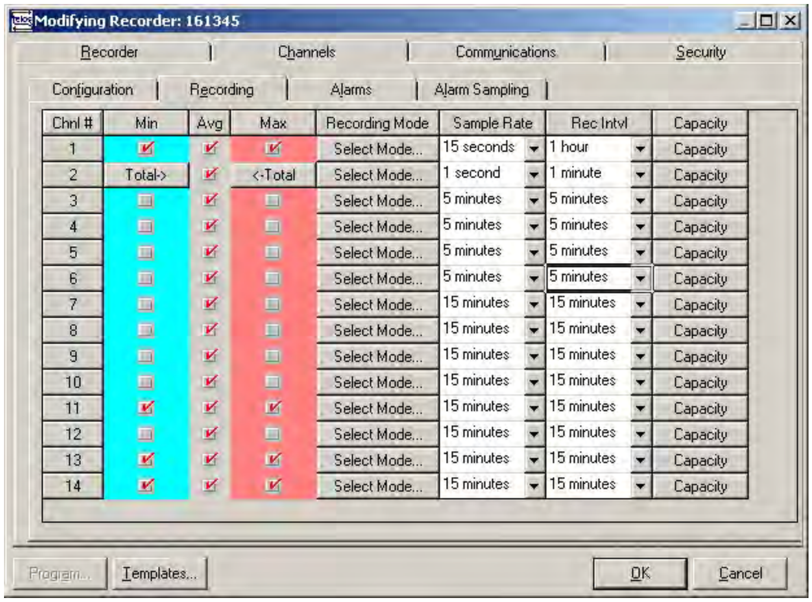
2. Under the Communicate menu select 'with local Recorder' and proceed to collect the data and hit Start. This process will also the recorder to your local database. Write down the recorder ID (161###) shown in the status bar in the site visit log. This helps identify the meter in step 4.

3. When the data is done collecting open the Setup menu and select 'Recorders…'

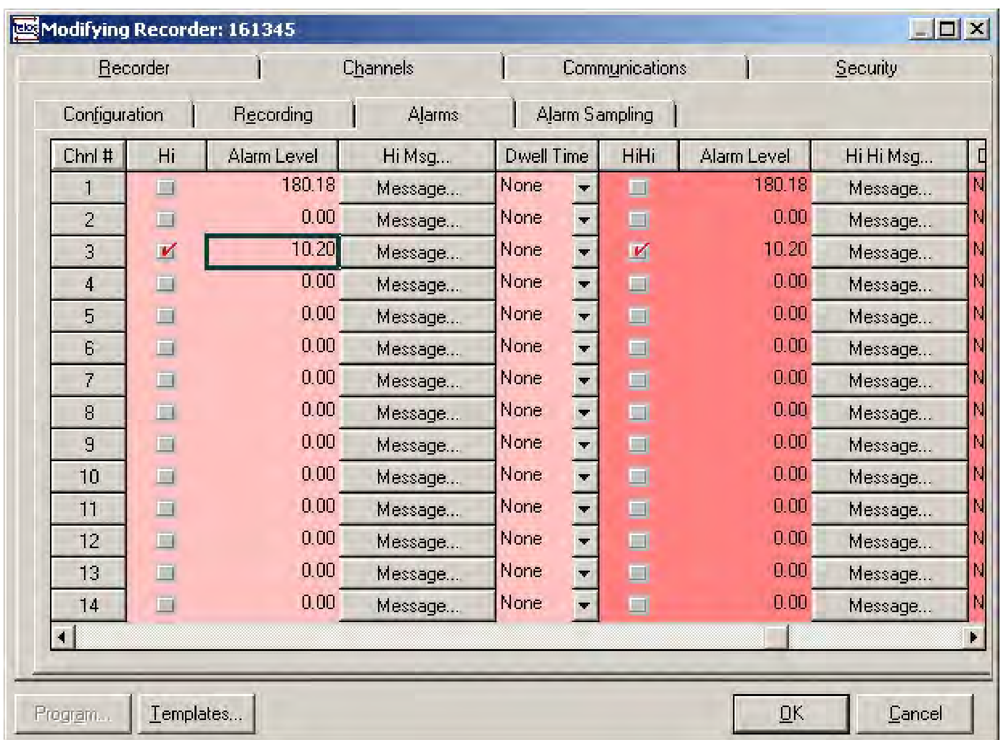
4. Navigate the recorder just collected and hit the Modify button.



5. Under the Channels tab go to the Recording tab and change the Sampling Rate and Sampling Interval of channels 3 through 6 to 5 minutes.

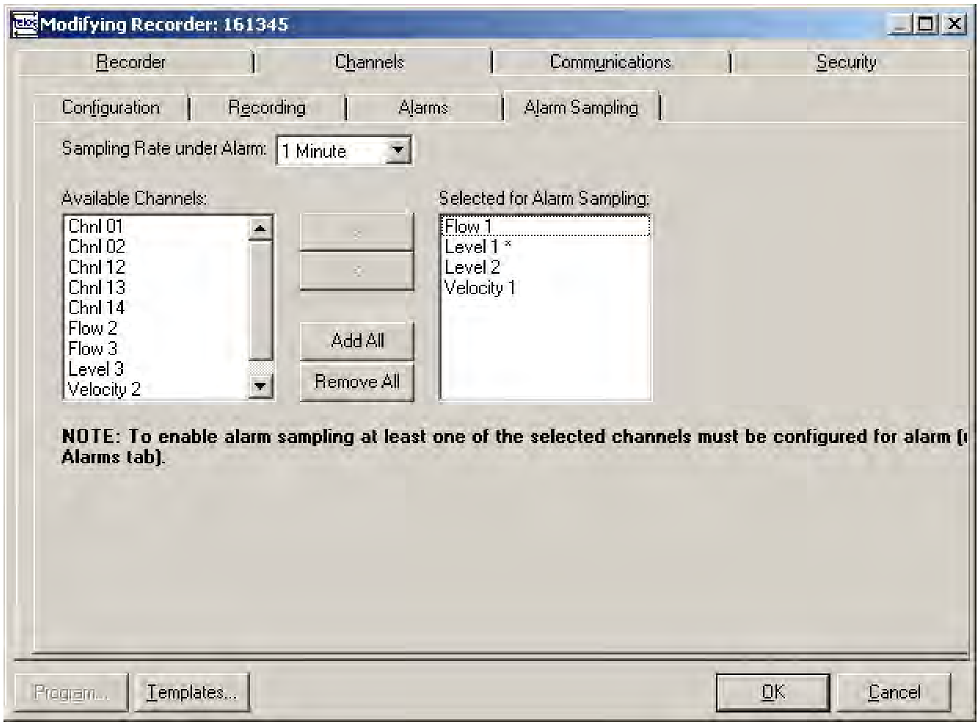


6. Under the Alarms tab scroll the far right. In the channel 3 row, type in the level that equates to 85% of the pipe's diameter in the alarm level under Hi and the Hihi, and also check the boxes adjacent to your newly entered levels. (Note: enter in the Hihi level first)



7. Next navigate to the Alarm Sampling tab. Set the Sampling Rate under Alarm to 1 Minute.

8. In the Available Channels add Level 1, Level 2, Velocity 1 and Flow 1 to the right hand side. (Note: Sometimes the names will not show, if that is the case add channels 3 through 6 to the right hand side)



9. Click OK to accept all changes made and close the Setup Recorder box.

10. Open the padlock (unlock it) and connect to the meter once more. The configurations made should be pushed to the meter. **Call DA.** Inform the DA what changes have been made to the recorder. If in the future the DA connects to the meter, the DA needs to have the exact configuration or else the DA may accidentally overwrite the new changes.

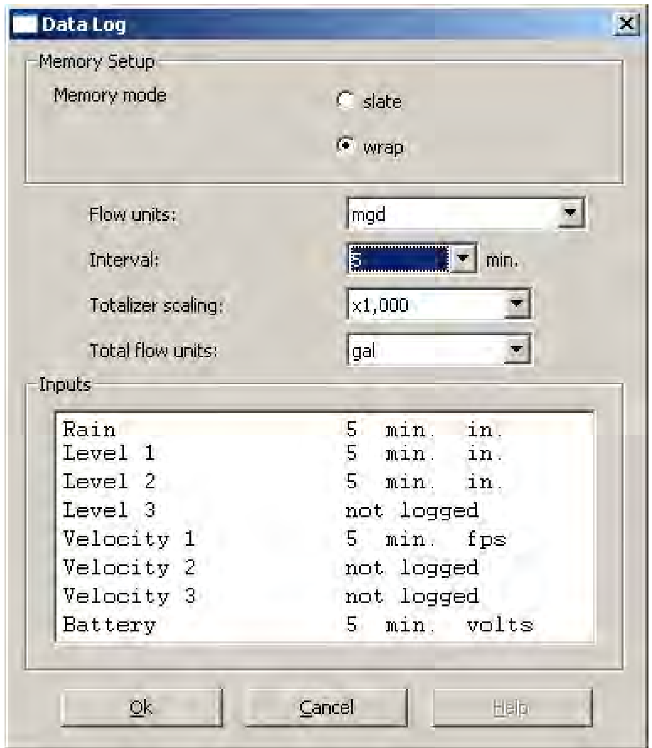
11. When the call ends **lock the padlock**.

12. To make sure the configurations were pushed into the meter, collect the data once again with the padlock down. During this call configurations from the meter will be pushed to your computer and you may view the meter's configurations after the call has finished. The Telog side is now setup.

13. Check to see that on the SIGMA side of the meter is recording in 5 minute intervals.

14. Connect through Insight and download the data.

15. In Remote Programming click on Data Log and change the Sampling Rate to 5 minutes. When asked about resetting the logger click ok, you collected the data moments ago therefore we have the most correct data.



16. Operation Successful screen should appear. Programming on Insight side is done and 5 minutes sampling with dual data rate is complete.

HACH Sigma 930/930T Troubleshooting Communication Problems

Telogers for Windows Troubleshooting

Preparation for the Unit Under Test (UUT)

1. Connect the Communications and Auxiliary cables.
2. Start Telogers software and verify the communication port is configured to allow for local communication. Start Telogers for Windows.
3. To prevent your local configuration of the recorders from overwriting the setting in the RTU
4. In the main menu bar navigate to Setup -> Options -> Communications tab
5. Check the ‘Enable Local Comm’ box and from the Local Port drop down menu select the Com port used by the PC to communicate with RTU.
6. Click OK to apply changes.
7. To prevent your local configuration of the recorders from overwriting the settings in the RTU keep the lock on the Telogers control panel in the lock position.

8. Verify the firmware version of the recorder. If the firmware is below 2.0 will work with Telogers 3.4x. If the firmware is above or equal to 2.0 use at least Telogers 3.6.3.

Event Log Messages and Description

Error Messages in Event Log	**Description / Possible Solution**
Call Setup Failed: Not registered and not searching	Check the antenna and all connections
Call setup Failed: No Carrier	Failed to connect to Telog Server. Verify the server is running.
Unsuccessful outgoing call using Ph# 1 with system address; 59542	Call was never completed look for other error messages in the log, from the destination server
External Power Failure: A low external DC supply condition detected.	Message was originated to do the low battery power detached-correct the external power supply problem. This message is not related to communications. It is a warning that the external battery is low. An alarm may be set to force a call during this condition.
Low external battery condition detected.	Call was originated do to the low battery power detected-replace the battery if necessary. This message is not related to communications. It is a warning that the external battery is low. An alarm may be set to force a call during this condition.
Initiating call to system using Ph#1 [Reasons: Cold Start]. Reason mask: 1	Call was originated do to the system cold start. Determine the reason for the cold start.
Detected installation of RS-232 module.	Message appears after power up or when module is installed.
Power Up: A cold-start detected; all data lost.	Call was originated to do the system cold start or battery replacement. Determine the reason for the cold stat. This message is not related to communications. It is a warning that the external battery is low. An alarm may be set to force a call during the condition.
Clock adjustment by 1 second. Recorder was fast.	After recorder communicated with Telogers system the system dictated the time adjustment to the recorder.
Script Device Type: EM3 1xRTT+CDMA, Version: 14	Verify that the device type is identical with the one installed in the recorder. Compare the script version recorder is using with the version located on the destination server. Script version 14 listed in the message.
Script XXX, Version 14	To Identify the latest version of the script available for each devise type in the current version of Telogers (TCC) go to Help -> About… -> Script.
Script Device Type: EMIV 1xRTT+CDMA, Version 2	The event log does not have sufficient history to say anything except that the script 2 is used in EM4. Verify that the device is identical with the one installed in the recorder. Compare the script version recorder is using with the version located on the destination server.
Call setup failed: Timed out while waiting for 'CONNECT' from the modem, 20	The call wasn't completed problem connecting the wireless network. Attempt call after 45 minutes. If still not successful contact Telog.

Call setup failed: Timed out while waiting for 'CALL' from the modem, 20	The call wasn't completed problem connecting the wireless network. Attempt call at a later time. If still unsuccessful contact Telog.
Call setup failed: Timed out while waiting for 'PPP' from the modem.	The call wasn't completed problem connecting the wireless network. Attempt call at a later time. If still unsuccessful contact Telog.
Unsuccessful outgoing call using Ph#2 with system address: 65535	Verify the destination number or the IP for the secondary system.
Unsuccessful outgoing call using Ph#1 with system address: 65536	Verify the destination number or the IP for the primary system.
Modem Type: Unknown [-1]	Modem configuration could not be accessed. No power to the modem, cabling failure, modem failed. Cold start the unit.
Call setup failed: Device did not respond	Modem configuration could not be assessed. No power to the modem, cabling failure, modem failure. Cold start the unit.
Call setup failed: Unrecognized event logged: 45	The latest version of the software will display: (Possible Reasons: Inactive Account or invalid account information in the modem)
Phone number: 9542706267	Verify that MIN and MDN numbers belong to the correct recorder
Signal Strength 3,99	Low signal strength, consider testing the site for locating better location for antenna- contact Telog to acquire the signal strength test kit. Install directional antenna. Replace antenna.
Signal Strength 0-5	Signal strength is very low. Unlikely the modem will work in this area. Check Burial antenna to be sure tile (dark) side is facing up.
Signal Strength 6-11	Signal strength is low. Modem may work through there may be some sporadic outages.
Signal Strength 12-15	Signal strength is good. Modem should work fine in this range.
Signal Strength >16	Signal Strength is very good. Should not have any problems in this range.
Signal Strength 99,99	Check the antenna and all connection: there is no signal.
Local comm activity detected.	The RTU woke up due to some activity on the local RS232 port.
Initiation call to system using Ph#1 [Reasons: Tamper Pressed]. Reason mask: 4.	The recorder's tamper button was pushed down for at least one second. If tamper messages follow close to one another in the log check for the possibility of the short on the board or send unit for service.
Modem Type: iPort EM4	Modem type set in the software. Verify hardware modem and software modem match.
Tamper detected	The recorder's tamper button was pushed down for at least one second. If tamper messages follow close to one another in the log check for the possibility of the short on the board or send unit for service.
Call setup failed: Failed to set the IP and Port to call	Incorrect IP address or Port entered in the recorder's configurations; change the configuration
Phone configuration was modified.	Recorder configuration was changed after communication session. If connection fails try

Review Configuration

To view the configuration of the recorder you can select one of the two methods: review the Summary of Recorder Status or review the Configuration screens. The latter one is more common way to review the settings.

The summary pare provides an excellent place to view the configuration of the recorder. To view the information go to VIEW -> RECORDER STATUS -> from the dropdown menu select RTU name or ID. The configuration is available in the summary pane to the left; each configuration can be selected and examined on the right side of the page. Page provides tools to view the Event Log and for the Raw Data stored during the communication.

Configuration Screens

Configuration screens not only store the configuration but they allow for making changes the setting to access it go to SETUP -> RECORDERS and select the name or ID and click MODIFY. All parameters in the recorder are modified from this menu.

Log Files

The content of system and error logs on the field computer can be accessed through the VIEW -> LOG FILES menu. However you con copy the files in the entirety and forward them to the troubleshooting team when necessary; they are stored in the Telogers folder on the drive that hosts the installation. The default location is C:\Program Files\Telog Instruments\Telogers.

SOP VII – Field Verifications

The process of field verification includes manually measuring depth, velocity, and flow quantity at the monitoring site and comparing these readings with real time readings from the meter. Field verifications are used to independently verify the accuracy of the flow meters and generate depth-velocity relationships and variables that would be used in flow calculations (e.g. **Site Coefficients** for Marsh McBirney Flo-Tote meters, **Velocity Multipliers** for Flo-Dar meters, and **Average to Peak ratios** (Av/Pk) for ADS meters). Field crews descend into the manhole to take the manual measurements.

Field verifications must be scheduled and performed as follows:

1) During meter installation
2) Two to three weeks after the meter has been installed
3) After the first two verifications (above), the site will be verified regularly based on a schedule put together by the Data Analyst and Field Crew Lead and/or as requested by the Project Manager for a specific project.
4) A monitoring site must be verified any time a sensor is replaced or any change has been made to the site set up or sensor configuration

5) Field verification is required if a significant change in depth and or velocity is observed for an extended period of time (more than a few days) at the monitoring site. Reasons for the observed change need to be documented

6) At the end of the monitoring period when the meter is removed.

Any variation to the above schedule must be approved by the Data Analyst and Field Crew Lead. In case of equipment failure (including manual velocity meters, sensors, or computer) or if the comparison between the meter and manual readings are large and unreasonable (e.g. if the manual readings are showing 2 inches of flow and the meter is reading 10 inches), the Field Crew Lead and/or the Data Analyst must be notified and briefed immediately. If such problems arise at the end of the monitoring period and the meter is scheduled for removal, **DO NOT** remove the meter without first consulting with the Field Crew Lead and the Data Analyst. A meter must not be pulled out without performing field verification unless it is approved by the Field Crew Lead and the Data Analyst.

It may not be possible to verify some sites. For example heavily pump station influenced sites or very low flowing (less than ½ inch) sites pose verification problems, and it may only be possible to verify the depth and not the velocity at these sites. If a site cannot be verified, the reason must be stated and an alternative way of verifying the flow must be devised by the flow monitoring group or the site should be removed to a better location.

The crew should consult with Field Crew Lead and/or Data Analyst when there is doubt regarding a procedure or action to be taken. Incorrect assumptions may result in data loss and low up time percentage.

The type of field verification performed depends on the monitoring site conditions. A complete **Velocity profile** is performed at sites where depth of flow is greater than 5 inches, it remains relatively constant, and flow is stable. For sites with depths of flow between 2 and 5 inches, **Peak Velocity and Depth (PVD)** verifications are performed. **Weir verifications** are performed at sites where depth of flow is less than 2 inches. Flow quantities are verified using a volumetric weir.

The following tools are required for performing field verifications:

- Portable velocity meter
- Calibrated volumetric Weir
- Measuring stick (folding Carpenter's Rule)
- Flash light
- Safety equipment including Traffic Control equipment, Confined Space Entry equipment, and Gas meters

Peak Velocity and Depth (PVD) Verifications

1. Turn the Field Computer On
2. Connect the proper communication cable to computer and Flow Monitor

3. Start either Flo-Ware or Field Scan by double clicking on the appropriate icon
4. Refer to the data collection and review procedure for the respective meter type and collect data (After reviewing the data DO NOT CLOSE THE PROGRAM OUT) After the data has been collected you can begin performing the field verifications
5. Follow confined space entry procedures and safety protocols and have crew member enter the manhole
6. Once crew member is in the monitoring manhole, send down the measuring stick, portable velocity meter, and a flashlight
7. Go to the appropriate screen in the flow monitoring program (Real-time for Flo-Dars and Flo-Totes, and Diagnostics for ADS Monitors, Figure 10-1 and Figure10-2 respectively)

Figure 10 - 1 Flo-Tote & Flo-Dar meters Real Time dialog

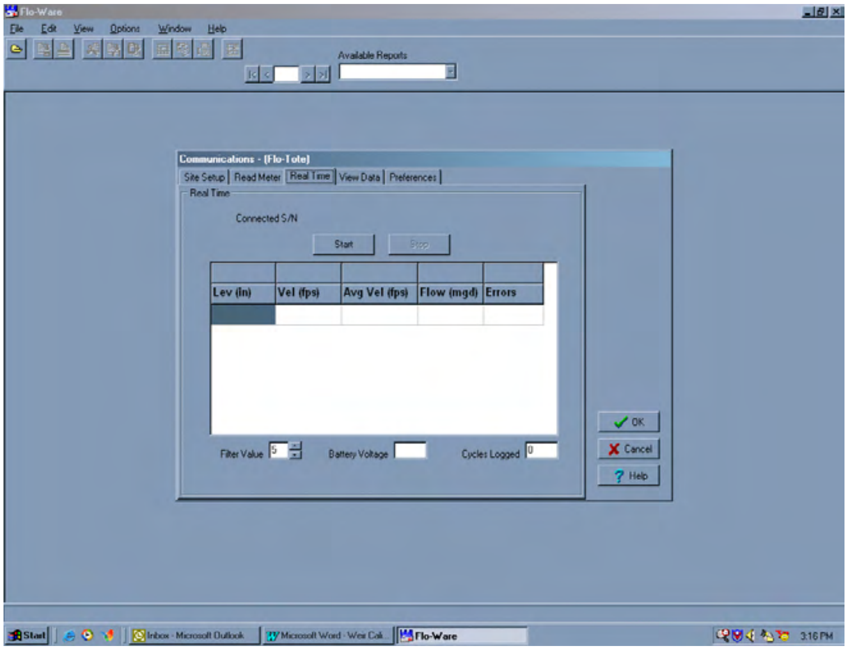
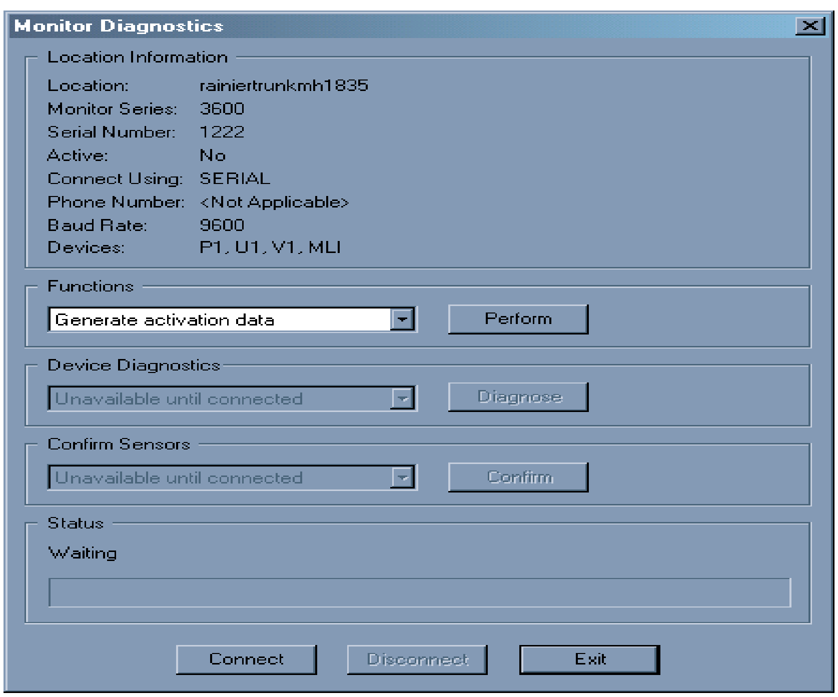


Figure 10 - 2 ADS meters Diagnostics dialog



8. Once in the program, read sensors and log the results on the **Site calibration/verification form**. Ensure that the form is completely filled out with the correct information including Date and time, Site Name, depth of flow (DOF), velocity, and all other applicable fields

9. Perform the manual measurements as follows:

- Position your self where the flow is not obstructed and measure the depth (where the flow is the deepest) to the eighth (1/8) of an inch. The depth can be measured in two ways:
  - a) Directly by placing the measuring stick or ruler in the flow at the appropriate location in relation to the pipe and the sensor and taking the readings (**DOF**), or
  - b) By placing the measuring stick (or ruler) at the face of the ultrasonic sensor (for ADS meters and Flo-Dars) or at the crown of the Pipe and measuring the air gap from these locations down to the water surface (**Air DOF**).
  - c) For sites with sediment/silt accumulation, measure and record the depth of silt. Measuring the silt level is very important as any sediment in the pipe will displace the flow (artificially raising the DOF) and skew the flow calculations.

- Once the depth measurement is taken, peak velocity is measured by scanning through the flow with a portable velocity meter (**Marsh McBirney Flo-Mate Model 2000 or the Model OSS PC1 Pygmy current meter manufactured by Hydrological Services PTY. Ltd**.)
- The manually measured depth and velocity results from the portable velocity meters are recorded in the Site calibration form along with the sensor/meter real-time measurement.
- A set of three manual and real-time measurements are to be taken per site (verification) visit

Velocity Profile (Verifications)

A velocity profile allows the determination of average velocity to calculate Average to Peak ratios (ADS meters), Site coefficients (Flo-Tote 2 and 3), and Velocity Multipliers (Flo-Dar) to be used in flow calculations. When performing a velocity profile, velocity readings are taken with a portable velocity meter at set depths of flow. The following general steps are performed during a velocity profile:

- Take a Peak velocity and depth (PVD) reading before performing a velocity profile
- Using a portable velocity meter, measure the velocity at 20% depth (from the surface) at the left-half centerline and record the values.
- Measure the velocity at 20% depth (from the surface) at the center and record the values.
- Measure the velocity at 20% depth (from the surface) at the right-half centerline and record the values.
- Measure the velocity at 60% depth (from the surface) at the left-half centerline and record the values.
- Measure the velocity at 60% depth (from the surface) at the center and record the values.
- Measure the velocity at 60% depth (from the surface) at the right-half centerline and record the values.
- Measure the velocity at 80% depth (from the surface) at the center and record the values.

- Take a Peak velocity and depth (PVD) reading after completing the velocity profile
- Calculate the Average to Peak (Av/Pk) ratio using the values from the velocity profile.

Weir Verifications

Weir verification is performed at flow flows where manual velocity readings are difficult or impossible due to the shallow DOF. The THEL-MAR Volumetric weir is used to verify flow quantity at shallow depths. The THEL-MAR Volumetric weir is a compounded weir that incorporates the advantage of a 90^o V-notch for measuring flow. The V-notch section measures from 57 to 3700 gallons per day (GPD). The rectangular portion of the weir is capable of measuring (in GPD) up to 35% of pipe capacity (see THEL-MAR Company brochure). Flow rates are indexed on each side of the weir and the calibration lines are in 2-mm (0.0787 inches) increment. Instantaneous flow rates are read where the flow surface intersects the calibration lines. The steps taken during weir verification are outlined below:

a) Follow steps 1 through 8 described in the Peak Velocity and Depth (PVD) verification section. In step 6 of this section, add the volumetric weir to the list of items. If the DOF is less than 2 inches, the portable velocity meter may not be needed.
b) Take a manual DOF reading and peak velocity (for flows > 2 inches) before installing the weir, and record the readings and the time these readings were taken
c) Install the weir, and level it using the bubble level mounted at the top of the weir's faceplate.
d) Wait for five to ten minutes for water to back up behind the weir and flow is uniform and stabilized
e) Read the flow rate from both the right and left sides of the calibrated weir and record readings in the Site Calibration/Verification form
f) Wait 2 to 4 minutes and check the readings. Record these readings. If the flow keeps rising, check the readings at a 2 minute interval until it stabilizes
g) Remove the weir, allow the flow to return to "normal" and take sensor/meter readings and record findings.
h) Take a manual DOF reading and peak velocity (for flows > 2 inches) and record the readings and the time these readings were taken.
i) Repeat the above steps two more times to get three sets of readings for valid calibration/verification.

SOP VIII – Data Review and Analysis

Raw data collected from flow meters are reviewed and edited as necessary. Field verifications and site finalization procedures are performed to finalize the data and calculate flow quantity. An overview of the process can be viewed in this flow chart.

Field verifications are used to independently verify the accuracy of the flow meters and generate depth-velocity relationships and variables that would be used in flow calculations.

The process of site finalization includes re-measuring the pipe dimensions, measuring any silt accumulation in the pipe, reviewing any unusual hydraulic conditions at a monitoring site, and reviewing and evaluating velocity parameters including Gain, Average to peak ratios, Site coefficients, and velocity multipliers. Measuring the silt level is very important as any sediment in the pipe will displace the flow (artificially raising the DOF) and skew the flow calculations.

The quality and reliability of depth and velocity readings from the flow meters determine the accuracy and reliability of the resulting calculated flow quantity. Depth and velocity sensors may be affected by local hydraulic conditions at the monitoring site and may give erroneous or invalid readings. Some of the factors contributing to poor quality depth and/or velocity data include

a) slow and sluggish flows (2 feet/sec velocity) contributing to sensor fouling,
b) downstream blockage and possibly related upstream surcharges contributing to sensor fouling,
c) shallow and fast flows where slight increase in depth may cause the flow to spray off of the sensor/ring assembly and splash on to the ultrasonic sensor (mounted at the crown of the pipe) giving erroneous depth data,
d) non-uniform and poor velocity profiles (in the pipe) resulting in erroneous calculation of average to peak ratios, gain values, or velocity multipliers
e) not properly functioning depth and/or velocity sensors,
f) very shallow flow conditions where the sensors are unable to sense velocity during such low flow conditions (velocity is forced to zero), and
g) incorrect site setups during meter install or reactivation.

Erroneous data include depth and/or velocity "pops" and "drop outs", depth and velocity not showing matching diurnal patterns during normal open channel flow, and shift in depth indicating a backwater condition but not accompanied by drop in velocity. Erroneous or invalid data are identified using a scatter graph (x-y plot of depth versus velocity) and hydrograph (time series plot of depth and velocity).

Editing data involves removing and/or correcting unreliable or invalid depth and velocity data. Based on review and analysis of field confirmations, field crew observations during site visits, and historical trend and data consistency with site hydraulics, some of the invalid data may be reconstituted or flagged. Flagging is a term applied to removing the invalid data from being used in flow calculations. The terms data "reconstitution," "reconstruction," or "snapping" refer to the process of generating depth-velocity relationships using good quality and valid data to reconstruct poor/erroneous velocity (and in some cases depth) data. These terms are used interchangeably in this report. Reconstituted or snapped data are used in flow quantity calculations.

Using Scatter graphs and hydrographs to review and edit data

An x-y plot is used to graph depth and velocity data from meter readings and results from field verifications. This scatter graph technique of data evaluation and reconstitution is based on a definable depth-velocity relationship and the theoretical Manning pipe curve which predicts that, in open channel gravity flows, there is a predictable velocity for every depth of flow. For a properly functioning meter, the depth and velocity readings should fall on or around the pipe curve. Depth and velocity field confirmations are plotted on the depth-velocity scatter graph and compared to meter readings to verify that the meter is functioning properly.

Hydrographs are time series plots showing depth and velocity (and flow quantity if desired). Hydrograph plots can be used to identify and edit erroneous/invalid depth and/or velocity data.

Scatter graph and hydrograph plots can show repeatability of the measured data, provide information on the steadiness of the flow, and show significant hydraulic changes such as backwater conditions and flow increase due to rain events. Scatter graphs and hydrographs can also be used to reconstruct or snap erroneous/invalid data when supported by field confirmations and well established depth-velocity relationships, or to flag erroneous/invalid data when there is not enough justification to reconstruct or snap the data.

The following examples show how invalid data are identified, flagged, and in some cases snapped (to curve) using hydrograph and scatter graph plots. An example showing how changes in hydraulic conditions are identified using a combination of hydrograph and scatter graph plots is also given below.

A - Invalid depth data

Figure A.1 illustrates how invalid depth is identified and flagged on a hydrograph. Depth and velocity show repeated diurnal pattern with velocity increasing with increase in depth. Around 11/25/03, depth values kept spiking without any significant and matching increase in velocity. There were no rain events on 11/26 and 11/27, but the depth of flow spiked to depths of flow close to that observed during the significant rain events on 11/18 and 11/19/03. Even though there was a rain event on 11/28, the effect is masked by the invalid depth data before and after this rain event. The invalid data are flagged and are not used for flow quantity calculation.

Figure A.1- Hydrograph of invalid depth data due to sensor fouling

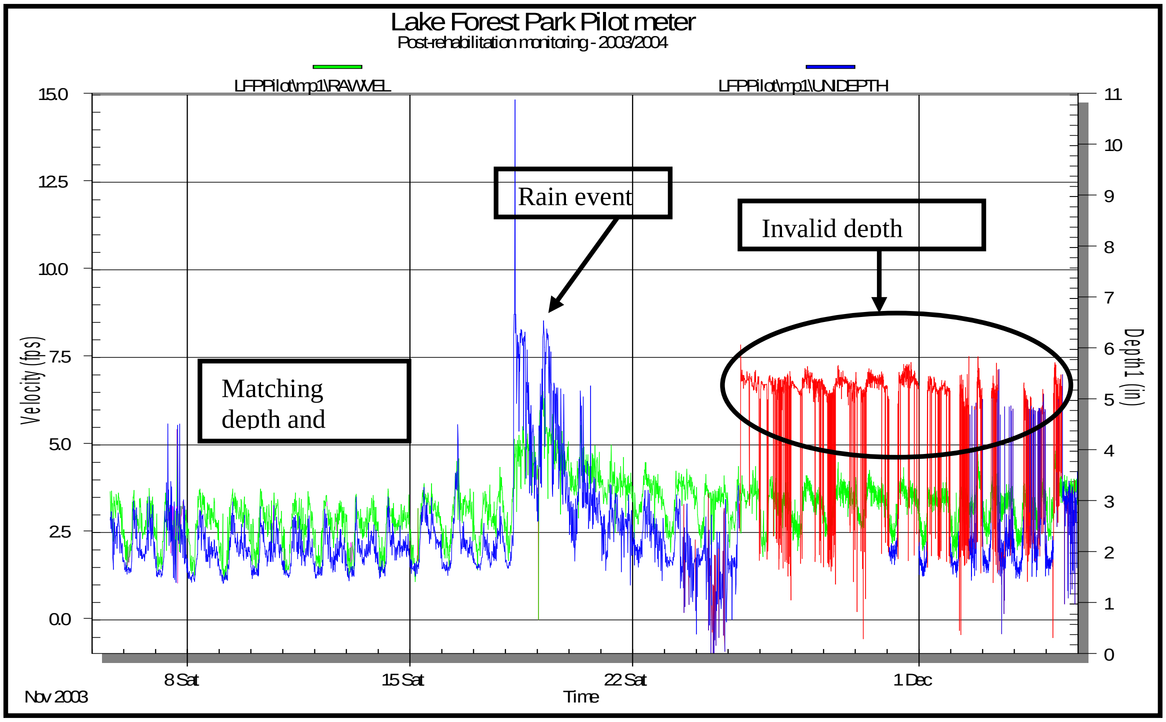


Figure A.2 is a scatter graph showing invalid and flagged velocity data. In this graph there are some depth data that show ultrasonic depth values at full or near full pipe heights. During such periods where the ultrasonic depth sensor indicates surcharge conditions, depth data from the pressure sensor is used to calculate flow quantity. Figure A.3 is a scatter graph plot with velocity on the X- axis and depth on the Y-axis showing the flagged depth data illustrated in Figure A.1. Field verification data are also plotted on this scatter graph.

Figure A.2 - Scatter graph of Invalid velocity showing open channel flow and backwater and surcharged conditions.

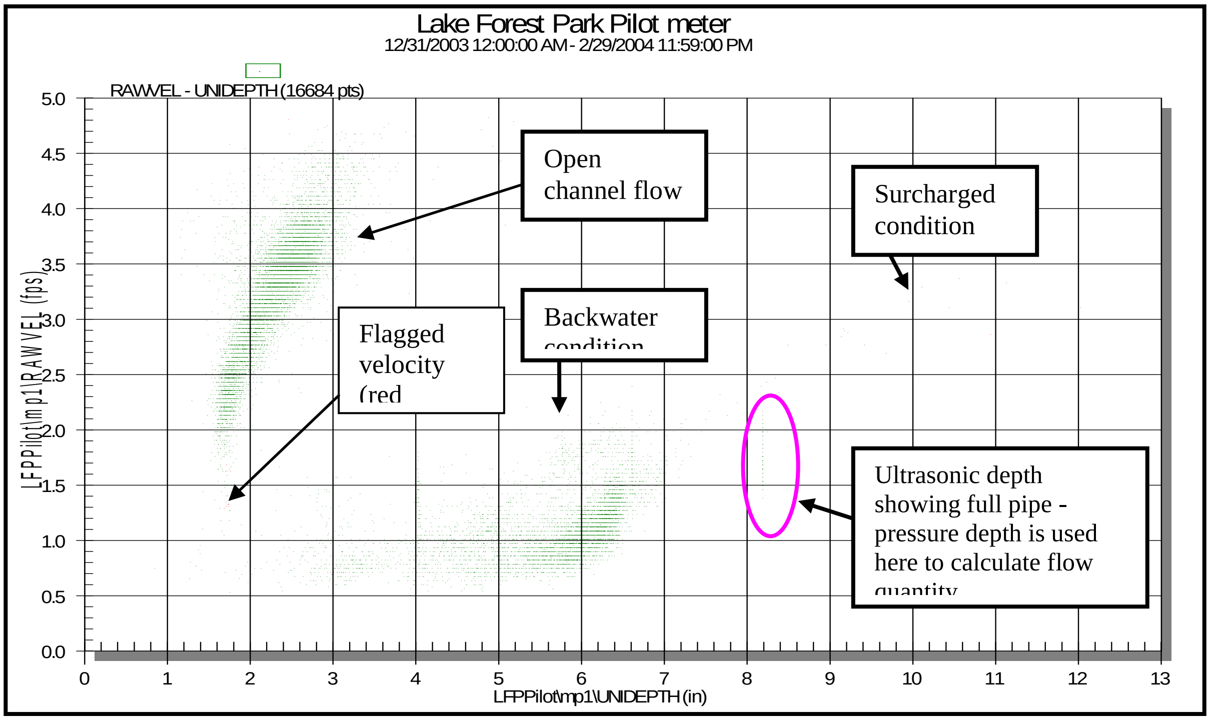
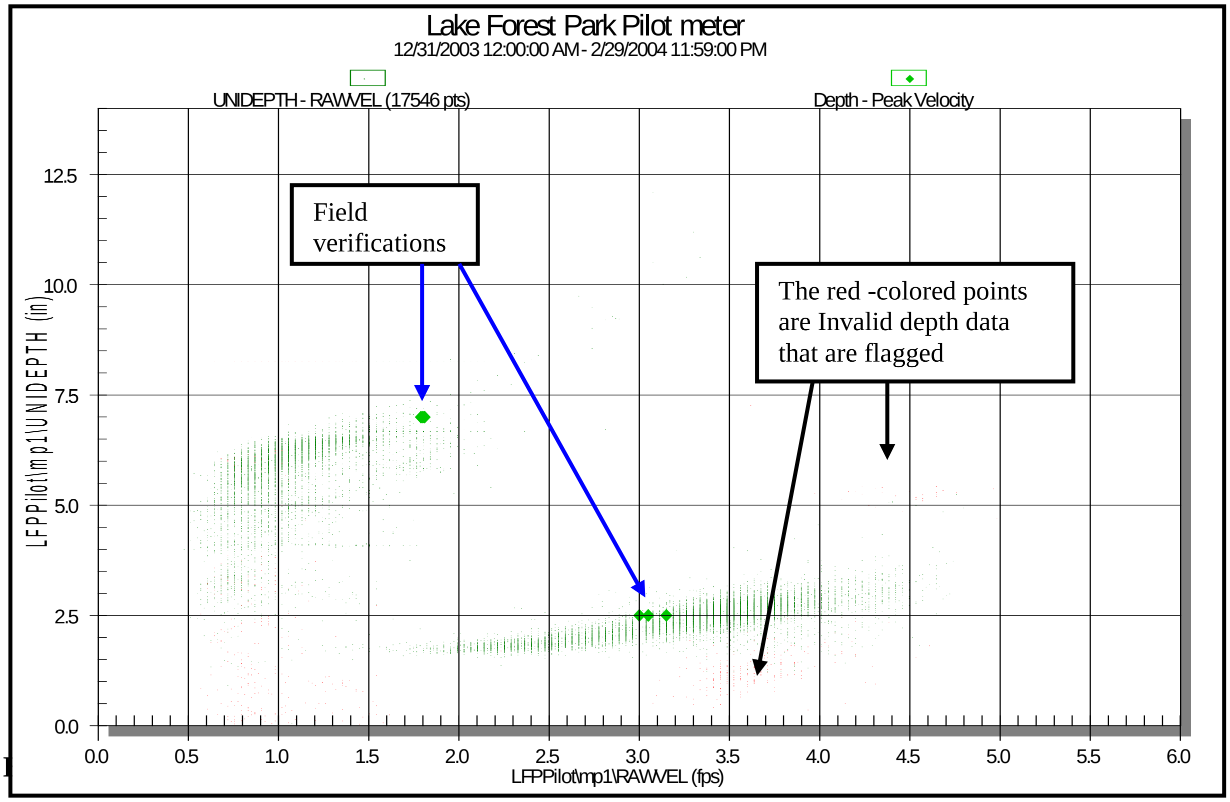


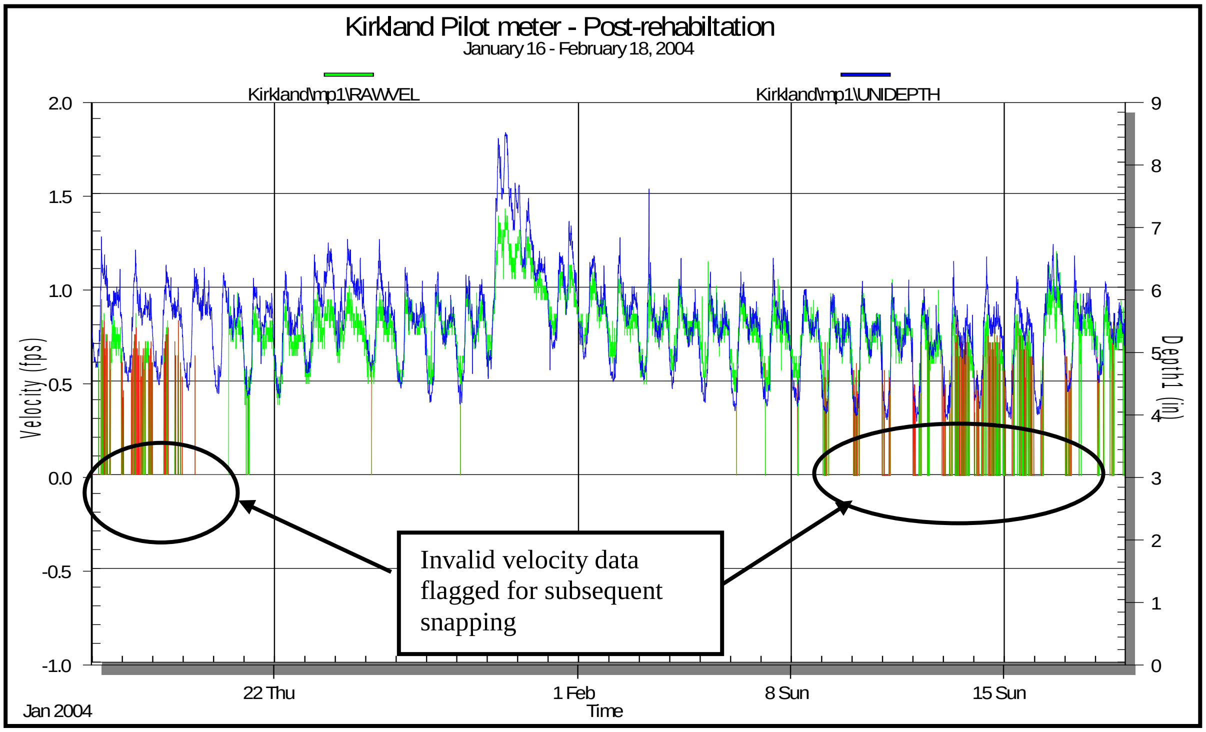
Figure A.3 - Scatter graph of Invalid depth data



Figures B.1 - B.4 illustrate how invalid velocity data are identified, selected, flagged and reconstituted. Figure B.1 shows good depth and velocity data with some velocity data dropping to zero occasionally. This is a relatively deep (4-6 inches DOF) and slow (< 1 fps for the most part) site. There are no corresponding depth dropouts to the observed velocity dropouts. The velocity dropouts could be the result of debris covering the sensor.

Once the invalid velocity data had been identified, these data points can either be flagged (i.e. removed from further flow quantity calculation) or reconstituted based on a well-developed depth-velocity relationship at the monitoring site. The hydrograph in Figure B.1 and scatter graph in Figure B.2 indicate that the depth-velocity data at this site are repeatable and regular (open channel flow) satisfying the main requirement of the data reconstitution (or reconstruction) process. As shown in Figure B.2, a best-fit curve is drawn through the depth-velocity data and tolerance limits are set.

Figure B.1 - Hydrograph of Invalid velocity data



Invalid velocity data is selected (blue box in Figure 4.5) and reconstituted based on the tolerance limit and location of the invalid data (above and/or below, or with in the tolerance limit). In the example given in Figure B.2, invalid data only below the tolerance limit were reconstituted (or snapped to curve). Figures B.3 and B.4 show the reconstituted velocity data in hydrograph and scatter graph plots respectively. Reconstituted velocity data are presented as magenta colored data points on these graphs.

Figure B.2 - Scatter graph of Invalid velocity data, best-fit curve, and tolerance limits set for data reconstitution

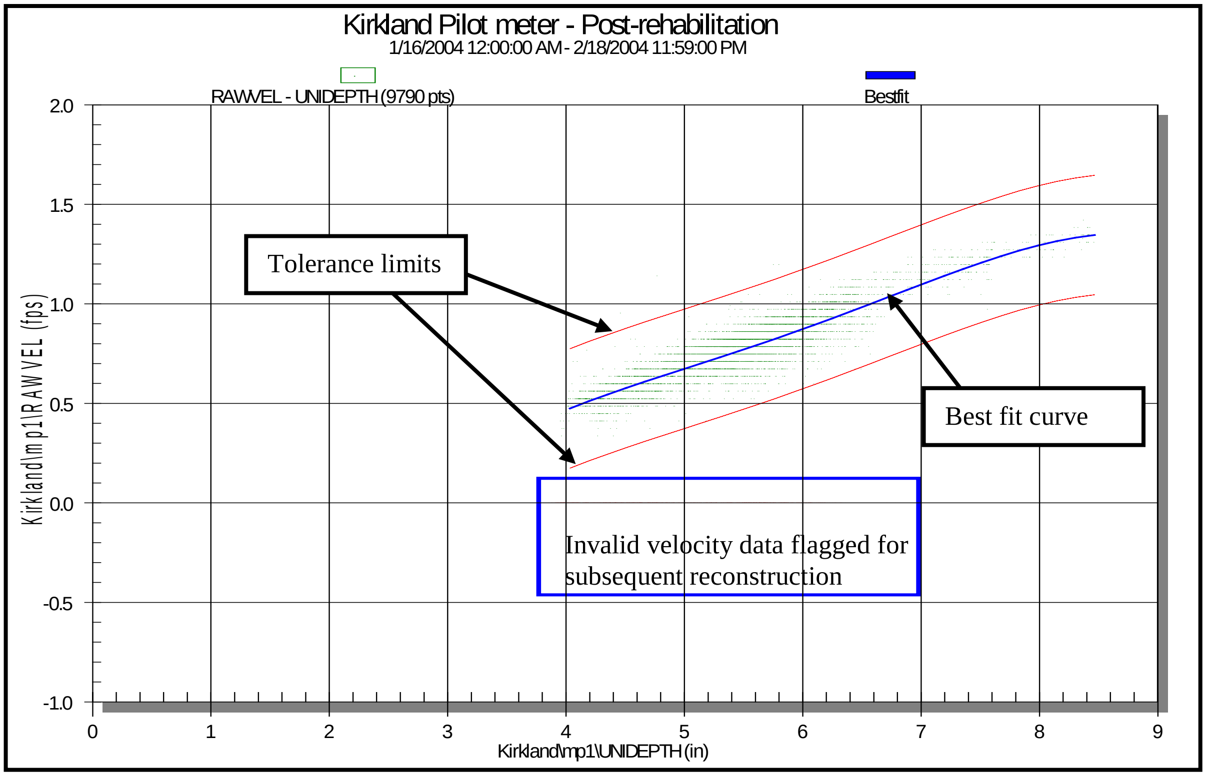


Figure B.3 - Hydrograph of reconstituted velocity data

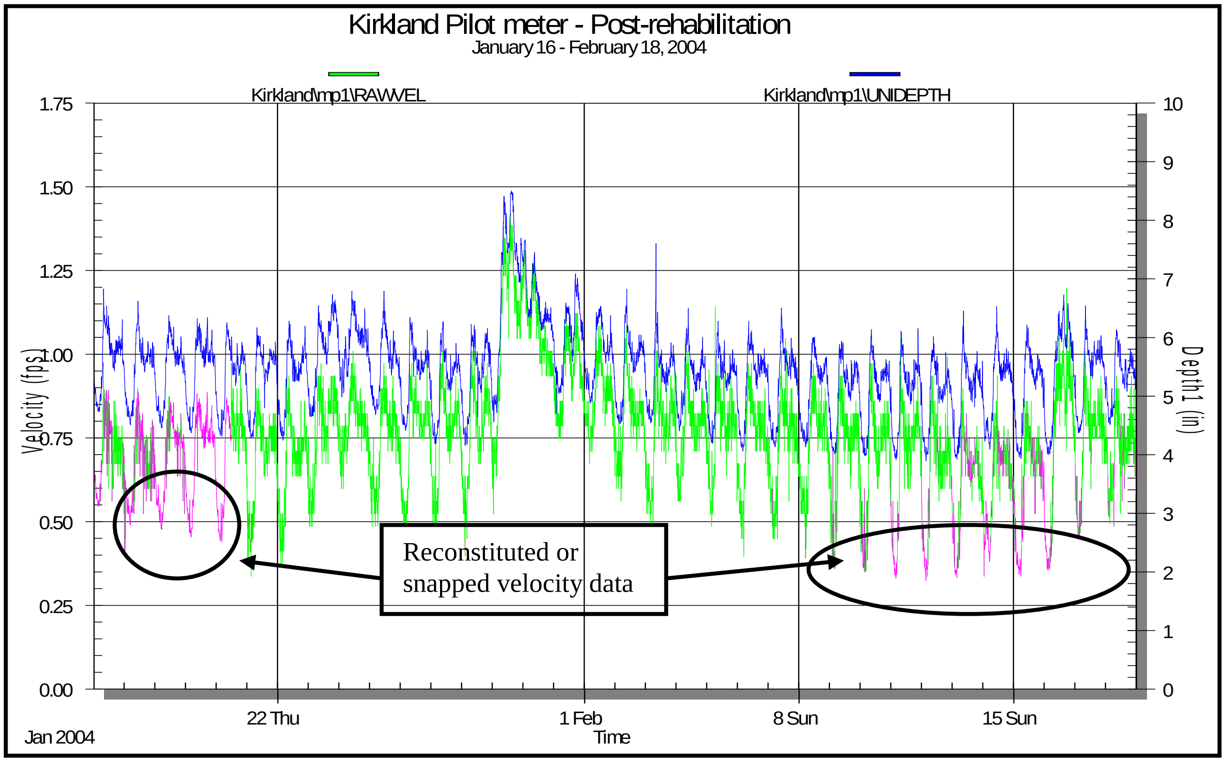
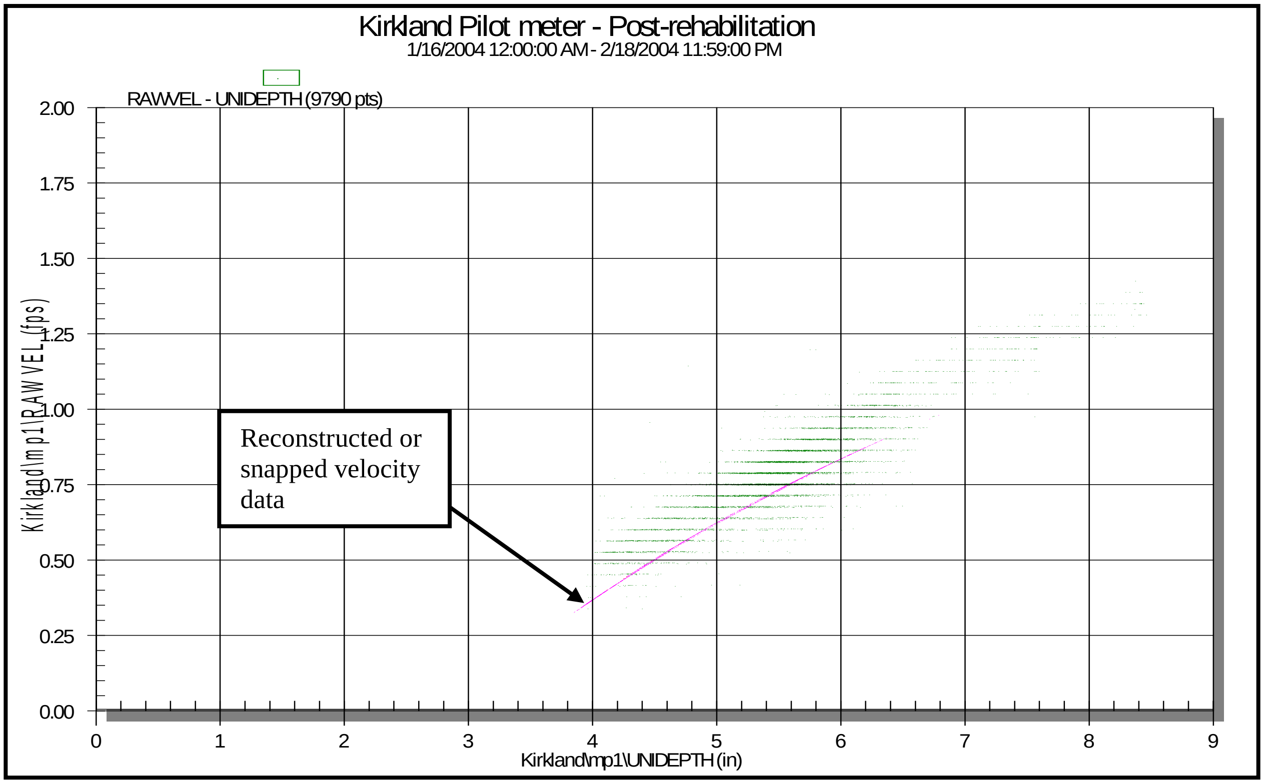


Figure B.4 - Scatter graph of reconstituted velocity data



C - Identifying unusual hydraulic (non-open channel flow) conditions

In addition to identifying and editing invalid depth and velocity data, hydrograph and scatter graph plots can be used to identify unusual hydraulics or changes in hydraulics at a monitoring site.

Figures C.1 and C.2 illustrate how changes in hydraulic conditions are identified using a combination of hydrograph and scatter graph plots.

For example, when the raw flow data from this site were reviewed, it was noticed that the flow has changed significantly around 1/27/04. Prior to 1/27/04, depth and velocity patterns showed a regular and repeatable pattern where increase or decrease in depth was accompanied by increase or decrease in velocity. Depth values ranged from 1.5 to 2 inches and velocity varied from about 2 to 4 feet per second during the dry day periods. After 1/27/04, the site became deeper (4 to 7.5 inches) and slower (velocity < 2 feet/second). Depth and velocity varied inversely. The field crew performed a manhole investigation on 2/19/04 and found that there was a huge accumulation of trash and rags blocking the flow in the downstream side of the pipe. This temporary blockage had backed up the flow increasing the depth and decreasing the velocity. Field verification was performed during the high flow condition, then the crew removed the blocking debris. Flow returned back to normal open channel flow.

Figure C.1 - Hydrograph illustrating backwater conditions due to temporary debris blockage and invalid depth data (in red).

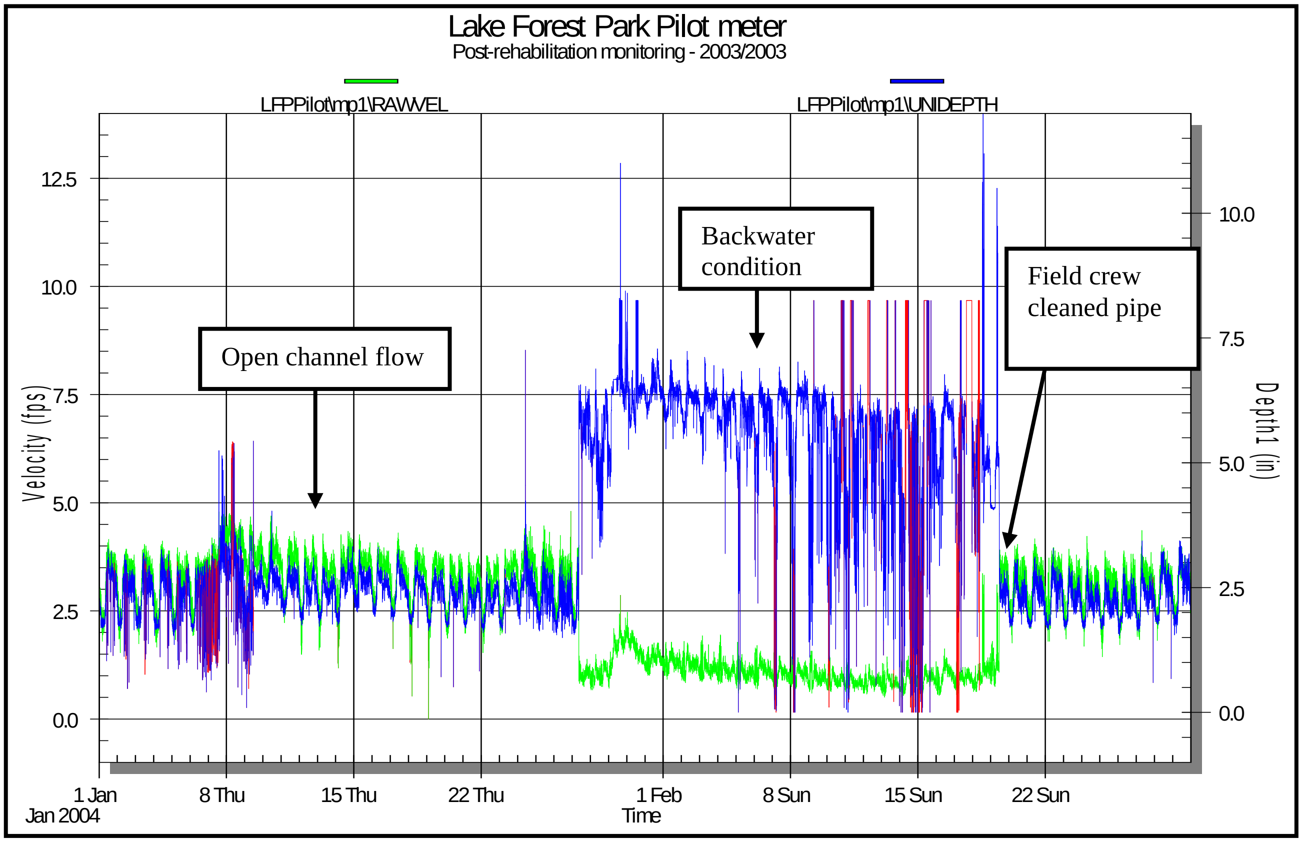
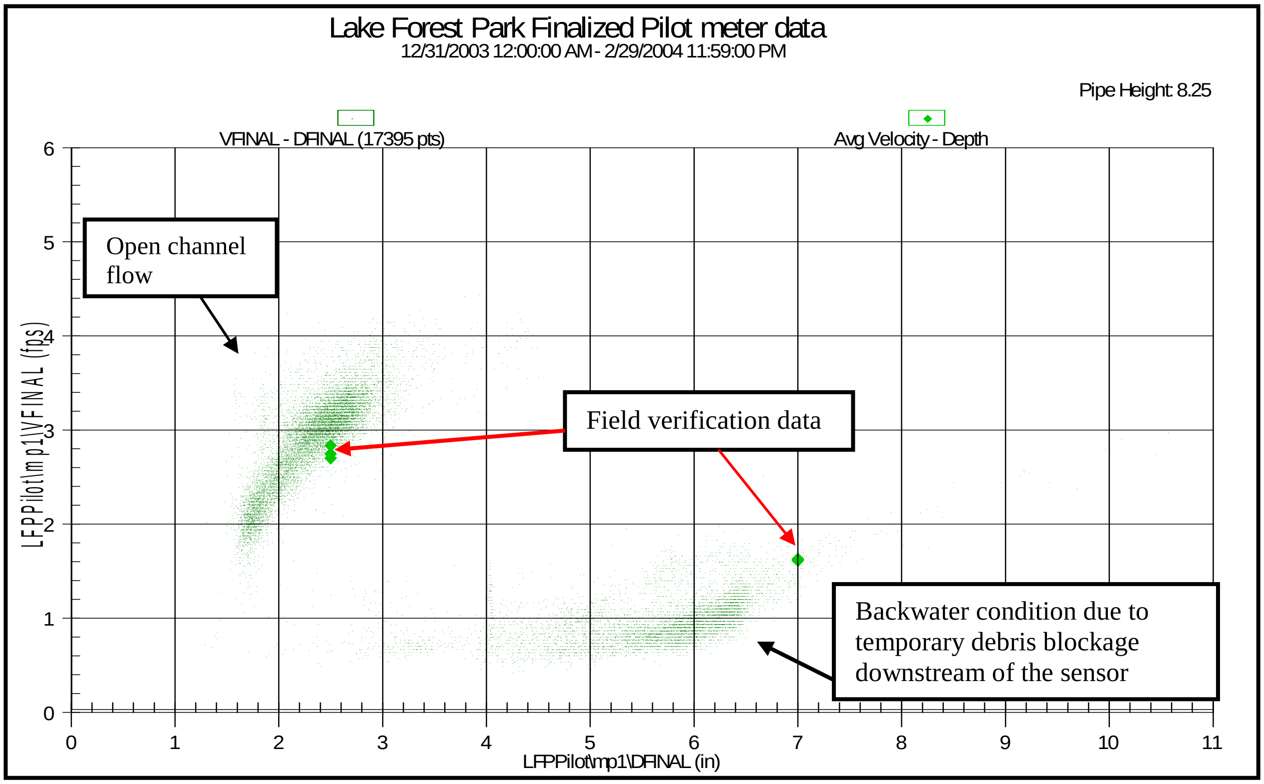


Figure C.2 - Scatter graph illustrating backwater conditions due to temporary debris.



Appendix C

Change Matrix from 1999 Plan Amendment: Summary of Review for Change in Uncontrolled CSO Basins

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King County 2012 Combined Sewer Overflow Control Program Review

Change Matrix from 1999 Plan Amendment: Summary of Review for Change in Uncontrolled CSO Basins

Revised: 5/7/2012

Alternative Information From 1999 Plan Amendment								Regulations	Size of Facility Based on Hydraulic Modeling	Type of Facility Based on Hydraulic Modeling	CSO Treatment Process	Green Stormwater Infrastructure Opportunities	Site Availability	Environmental and Habitat Priorities	Receiving Water Quality	Public Opinion	Coordination with KC or Other Agency Projects	Change from 1999 Plan Amendment	
CSO Discharge Serial Number	**CSO Facility Name**	**Alternative Description**	**Year of Control**	**CSO Control Volume (MG)**	**CSO Peak Flow Rate (MGD)**	**2010 Modeling Results - CSO Control Volume (MG)**	**2010 Modeling Results - CSO Peak Flow Rate (MGD)**	**Do regulatory changes require a change in control target?**	**Has the size of CSO control facility changed significantly (>10%) based on hydraulic modeling?**	**Has the type of CSO control facility (e.g., storage, treatment, etc.) changed based on new model control volume needs?**	**Has the CSO treatment process changed based on review?**	**Have green stormwater infrastructure opportunities been identified in the CSO basin? Can these reduce the size of CSO control facilities needed for the CSO basin?**	**Are the sites proposed in the 1999 Plan Amendment unavailable or impractical? Have any new sites become available?**	**Have environmental factors (climate change, habitat restoration projects, human health considerations) changed CSO control priority or schedule for the CSO basin?**	**Are there any changes in the water quality of the receiving water body?**	**Has public opinion changed in the area?**	**Have opportunities for coordination with other King County projects or other agency projects (e.g., SPU control needs) been identified?**	**Change from Alternative Identified in 1999 Plan Amendment and Re-evaluation Required?**	**Comments**
004	11th Ave NW	2.0-MG storage tank West Point Peak Flow Set Point: 440 MGD Potential Sites: Underneath NW 45th Street or adjacent private property	2030	1.7	20.0	1.85	32.20	No	No	Yes	N/A	Yes	Yes	No	No	Yes	Yes	Yes	**Reasons for Change from 1999 Plan Amendment Alternative and Re-evaluation:** -Hydraulic modeling determined that the CSO control volume at 11th Ave NW can be eliminated by increasing conveyance capacity from the 11th Ave NW overflow structure to the Ballard Siphon. -Potential GSI opportunities are available in the basin (high potential). -Storage tank located underneath 45th Street would be located adjacent to a building that could increase construction risks. -Coordination with the Ballard Siphon project may have reduced the CSO control volume at 11th Ave NW even without upgrading conveyance capacity. -Collaborative opportunities with SPU may be available, which may require the schedule to be modified. -Stakeholders view GSI and coordination with City of Seattle as important. Opportunities for both have been identified for this CSO site. **Notes:** Control volume and peak flow rate presented assume no increase in capacity of the downstream conveyance system to the Ballard Siphon.
008	3rd Ave W	5.5-MG storage tank West Point Peak Flow Set Point: 440 MGD Potential Sites: Underneath the extension of W Ewing St east of 3rd Ave W adjacent to Ship Canal - possible Burke-Gilman Trail extension	2029	5.5	37.0	4.18	29.3	No	Yes	No	N/A	Yes	Yes	No	No	Yes	Yes	Yes	**Reasons for Change from 1999 Plan Amendment Alternative and Re-evaluation:** -Size of proposed CSO control facility has decreased by more than 10% since 1999 Plan Amendment based on hydraulic modeling. -Potential GSI opportunities are available in the basin (low potential). -1999 Plan Amendment site may not be feasible due to irregular shape and small size of site. -Collaborative opportunities with SPU may be available, which may require the schedule to be modified. -Stakeholders view GSI and coordination with City of Seattle as important. Opportunities for both have been identified for this CSO site.
014	Montlake	7.5-MG storage tank to control University and Montlake CSOs at University. West Point Peak Flow Set Point: 440 MGD Potential Sites: 1 to 6 potential sites have been identified in University of Washington campus area	2015	0.8	27.0	6.6	93.5	No	Yes	No	N/A	Yes	No	Yes	No	Yes	Yes	Yes	**Reasons for Change from 1999 Plan Amendment Alternative and Re-evaluation:** -Hydraulic modeling determined that there is not enough capacity in the Montlake Siphon to convey flows from Montlake to University to control Montlake CSOs. A smaller storage tank at Montlake, a new siphon, or GSI opportunities will need to be evaluated with the joint University/Montlake storage tank to control Montlake and University CSOs. -Size of proposed CSO control facility has increased by more than 10% since 1999 Plan Amendment based on hydraulic modeling. -Potential GSI opportunities are available in the basin (high potential). -Prioritizing control of CSOs in the Duwamish River and Elliott Bay could be more beneficial to ecological and human health when compared to control of CSOs in Lake Washington Ship Canal, Lake Union, and the Montlake Cut. -Collaborative opportunities with SPU may be available, which may require the schedule to be modified. -Stakeholders view GSI and coordination with City of Seattle as important. Opportunities for both have been identified for this CSO site.
015	University	7.5-MG storage tank to control University and Montlake CSOs at University. West Point Peak Flow Set Point: 440 MGD Potential Sites: 1 to 6 potential sites have been identified in University of Washington campus area	2015	6.6	124.0	2.94	74.90	No	Yes	No	N/A	Yes	No	Yes	No	Yes	Yes	Yes	**Reasons for Change from 1999 Plan Amendment Alternative and Re-evaluation:** -Hydraulic modeling determined that there is not enough capacity in the Montlake Siphon to convey flows from Montlake to University to control Montlake CSOs. A smaller storage tank at Montlake, a new siphon, or GSI opportunities will need to be evaluated with the joint University/Montlake storage tank to control Montlake and University CSOs. -Size of proposed CSO control facility has decreased by more than 10% since 1999 Plan Amendment based on hydraulic modeling. -Potential GSI opportunities are available in the basin (high potential). -Prioritizing control of CSOs in the Duwamish River and Elliott Bay could be more beneficial to ecological and human health when compared to control of CSOs in Lake Washington Ship Canal, Lake Union, and the Montlake Cut. -Collaborative opportunities with SPU may be available, which may require the schedule to be modified. -Severe construction conflicts are predicted in the area at time of construction. -Stakeholders view GSI and coordination with City of Seattle as important. Opportunities for both have been identified for this CSO site.
028	King St	Conveyance to 2.1-MG storage/treatment tank to control King Street and Kingdome CSOs at Kingdome (primary treatment). West Point Peak Flow Set Point: 400 MGD Potential Site: On the Kingdome site beneath a parking area north of S Royal Brougham Way	2026	2.2	24.2	2.63	29.6	Yes	Yes	No	Yes	No	Yes	Yes	No	Yes	Yes	Yes	**Reasons for Change from 1999 Plan Amendment Alternative and Re-evaluation:** -King County is evaluating the possibility of consolidating King Street, Kingdome, Lander, and Hanford #2 into one CSO treatment facility using existing infrastructure (e.g., backflow in EBI). This alternative will need to be evaluated with the 1999 Plan Amendment alternative. -King County's existing and new treatment facilities have changed regulatory targets related to disinfection. Also, the change from classification-based water quality standards to use-based has made the water quality standard targets more stringent. -Size of proposed CSO control facility has increased by more than 10% since 1999 Plan Amendment based on hydraulic modeling. -Update of current treatment technologies has resulted in revisiting footprint requirements and cost estimates for treatment options. -A building is now located on the proposed storage/treatment tank location, Parcel 7666204876 (Qwest Exhibition Hall), so new potential sites need to be identified. -Prioritizing control of CSOs in the Duwamish River and Elliott Bay could be more beneficial to ecological and human health when compared to control of CSOs in Lake Washington Ship Canal, Lake Union, and the Montlake Cut. -Collaborative opportunities with SPU may be available, which may require the schedule to be modified. -Stakeholders view coordination with City of Seattle and prioritizing Duwamish River CSOs as important.

CSO Discharge Serial Number	CSO Facility Name	Alternative Description	Year of Control	CSO Control Volume (MG)	CSO Peak Flow Rate (MGD)	2010 Modeling Results - CSO Control Volume (MG)	2010 Modeling Results - CSO Peak Flow Rate (MGD)	Do regulatory changes require a change in control target?	Has the size of CSO control facility changed significantly (>10%) based on hydraulic modeling?	Has the type of CSO control facility (e.g., storage, treatment, etc.) changed based on new model control volume needs?	Has the CSO treatment process changed based on review?	Have green stormwater infrastructure opportunities been identified in the CSO basin? Can these reduce the size of CSO control facilities needed for the CSO basin?	Are the sites proposed in the 1999 Plan Amendment unavailable or impractical? Have any new sites become available?	Have environmental factors (climate change, habitat restoration projects, human health considerations) changed CSO control priority or schedule for the CSO basin?	Are there any changes in the water quality of the receiving water body?	Has public opinion changed in the area?	Have opportunities for coordination with other King County projects or other agency projects (e.g., SPU control needs) been identified?	Change from Alternative Identified in 1999 Plan Amendment and Re-evaluation Required?	Comments
029	Kingdome	2.1-MG storage/treatment tank to control King Street and Kingdome CSOs at Kingdome (primary treatment). West Point Peak Flow Set Point: 400 MGD Potential Site: On the Kingdome site beneath a pakring area north of S Royal Brougham Way	2026	9.2	55.1	34.22	87.00	Yes	Yes	No	Yes	No	Yes	Yes	No	Yes	No	Yes	**Reasons for Change from 1999 Plan Amendment Alternative and Re-evaluation:** -King County is evaluating the possibility of consolidating King Street, Kingdome, Lander, and Hanford #2 into one CSO treatment facility using existing infrastructure (e.g., backflow the EBI). This alternative will need to be evaluated with the 1999 Plan Amendment alternative. -King County's existing and new treatment facilities have changed regulatory targets related to disinfection. Also, the change from classification-based water quality standards to use-based has made the water quality standard targets more stringent. -Size of proposed CSO control facility has increased by more than 10% since 1999 Plan Amendment based on hydraulic modeling. -Update of current treatment technologies has resulted in revisiting footprint requirements and cost estimates for treatment options. -A building is now located on the proposed storage/treatment tank location, Parcel 7666204876 (Qwest Exhibition Hall), so new potential sites need to be identified. -Prioritizing control of CSOs in the Duwamish River and Elliott Bay could be more beneficial to ecological and human health when compared to control of CSOs in Lake Washington Ship Canal, Lake Union, and the Montlake Cut. -Stakeholders view prioritizing Duwamish River CSOs as important.
030	Lander St	1.5-MG storage/treatment tank to control Lander Street CSOs at Hanford #2. West Point Peak Flow Set Point: 400 MGD Potential Sites: Industrial private property, corner of Occidental Ave S and Lander St.	2019	15.2	54.0	17.69	47.90	Yes	Yes	No	Yes	No	No	Yes	No	Yes	No	Yes	**Reasons for Change from 1999 Plan Amendment Alternative and Re-evaluation:** -King County is evaluating the possibility of consolidating King Street, Kingdome, Lander, and Hanford #2 into one CSO treatment facility using existing infrastructure (e.g., backflow the EBI). This alternative will need to be evaluated with the 1999 Plan Amendment alternative. -King County's existing and new treatment facilities have changed regulatory targets related to disinfection. Also, the change from classification-based water quality standards to use-based has made the water quality standard targets more stringent. -Update of current treatment technologies has resulted in revisiting footprint requirements and cost estimates for treatment options. -Prioritizing control of CSOs in the Duwamish River and Elliott Bay could be more beneficial to ecological and human health when compared to control of CSOs in Lake Washington Ship Canal, Lake Union, and the Montlake Cut. -Stakeholders view prioritizing Duwamish River CSOs as important.
031	Hanford #1 (Hanford@Rainier) and Bayview North	0.6-MG storage tank West Point Peak Flow Set Point: 400 MGD Potential Sites: Ballfield adjacent to Rainier Ave S and S Winthrop St, one block north of S Hanford St or pipe storage in Rainier Ave from S Hanford St to S Bayview St.	2026	0.6	16.0	Hanford #1 1.13 Bayview North 0.77	Hanford #1 17.8 Bayview North 28.9	No	Yes	No	N/A	Yes	Yes	Yes	Yes	Yes	Yes	Yes	**Reasons for Change from 1999 Plan Amendment Alternative and Re-evaluation:** -Modeling has identified possibility of Bayview North overflows occurring, changing volume and location needs for Hanford #1 and Bayview North. -Size of proposed CSO control facility has increased by more than 10% since 1999 Plan Amendment based on hydraulic modeling. -Potential GSI opportunities are available in the basin (medium to high potential). -Potential site identified (Parcels 0003600026 and 0003600059) is used as a football field and track for Franklin High School. -Remediation activities have changed the conditions of the CSO discharge location; sediment quality has become a driver at this location. -Collaborative opportunities with SPU may be available, which may require the schedule to be modified. -Stakeholders view GSI, coordination with City of Seattle, and prioritizing Duwamish River CSOs as important.
032	Hanford #2	3.3-MG storage/treatment tank (primary treatment) West Point Peak Flow Set Point: 400 MGD Potential Sites: Industrial private property, corner of Occidental Ave S and Lander St.	2017	18.8	89.0	43.78	94.90	Yes	No	No	Yes	Yes	No	Yes	No	Yes	No	Yes	**Reasons for Change from 1999 Plan Amendment Alternative and Re-evaluation:** -King County is evaluating the possibility of consolidating King Street, Kingdome, Lander, and Hanford #2 into one CSO treatment facility using existing infrastructure (e.g., backflow the EBI). This alternative will need to be evaluated with the 1999 Plan Amendment alternative. -King County's existing and new treatment facilities have changed regulatory targets related to disinfection. Also, the change from classification-based water quality standards to use-based has made the water quality standard targets more stringent. -Update of current treatment technologies has resulted in revisiting footprint requirements and cost estimates for treatment options. -Potential GSI opportunities are available in the basin (low potential). -Prioritizing control of CSOs in the Duwamish River and Elliott Bay could be more beneficial to ecological and human health when compared to control of CSOs in Lake Washington Ship Canal, Lake Union, and the Montlake Cut. -Stakeholders view GSI and prioritizing Duwamish River CSOs as important.
036	Chelan Ave	4.0-MG storage tank West Point Peak Flow Set Point: 400 MGD Potential Site: Site of existing West Seattle Pump Station.	2024	4.0	33.0	3.85	25.70	No	No	Yes	N/A	Yes	No	Yes	No	Yes	No	Yes	**Reasons for Change from 1999 Plan Amendment Alternative and Re-evaluation:** -King County is evaluating the possibility of transferring flows to the West Seattle Tunnel and Alki CSO Treatment Plant to control Chelan Ave CSOs. This alternative will need to be evaluated with the 1999 Plan Amendment alternative. -Potential GSI opportunities are available in the basin (high potential). -Prioritizing control of CSOs in the Duwamish River and Elliott Bay could be more beneficial to ecological and human health when compared to control of CSOs in Lake Washington Ship Canal, Lake Union, and the Montlake Cut. -Stakeholders view GSI and prioritizing Duwamish River CSOs as important.
038	Terminal 115	0.5-MG storage tank West Point Peak Flow Set Point: 400 MGD Potential Site: 2 potential sites located on Glacier NW property	2027	0.5	N/A	0.05	3.80	No	Yes	No	N/A	No	No	Yes	No	Yes	No	Yes	**Reasons for Change from 1999 Plan Amendment Alternative and Re-evaluation:** -Size of proposed CSO control facility has decreased by more than 10% since 1999 Plan Amendment based on hydraulic modeling. -Prioritizing control of CSOs in the Duwamish River and Elliott Bay could be more beneficial to ecological and human health when compared to control of CSOs in Lake Washington Ship Canal, Lake Union, and the Montlake Cut. -Stakeholders view prioritizing Duwamish River CSOs as important.
039	S Michigan St	2.2-MG storage/treatment tank (primary treatment) West Point Peak Flow Set Point: 400 MGD Potential Site: 1 potential site located on private property that is currently a parking lot.	2022	13.1	75.1	18.60	66.10	Yes	Yes	No	Yes	Yes	No	Yes	No	Yes	Yes	Yes	**Reasons for Change from 1999 Plan Amendment Alternative and Re-evaluation:** -King County is evaluating the possibility of consolidating S Michigan St and Brandon St into one CSO treatment facility. This alternative will need to be evaluated with the 1999 Plan Amendment alternative. -King County's existing and new treatment facilities have changed regulatory targets related to disinfection. Also, the change from classification-based water quality standards to use-based has made the water quality standard targets more stringent. -Size of proposed CSO control facility has decreased by more than 10% since 1999 Plan Amendment based on hydraulic modeling. -Update of current treatment technologies has resulted in revisiting footprint requirements and cost estimates for treatment options. -Potential GSI opportunities are available in the basin (high potential). -Prioritizing control of CSOs in the Duwamish River and Elliott Bay could be more beneficial to ecological and human health when compared to control of CSOs in Lake Washington Ship Canal, Lake Union, and the Montlake Cut. -Collaborative opportunities with SPU may be available, which may require the schedule to be modified. -Stakeholders view GSI, coordination with City of Seattle, and prioritizing Duwamish River CSOs as important.

CSO Discharge Serial Number	CSO Facility Name	Alternative Description	Year of Control	CSO Control Volume (MG)	CSO Peak Flow Rate (MGD)	2010 Modeling Results - CSO Control Volume (MG)	2010 Modeling Results - CSO Peak Flow Rate (MGD)	Do regulatory changes require a change in control target?	Has the size of CSO control facility changed significantly (>10%) based on hydraulic modeling?	Has the type of CSO control facility (e.g., storage, treatment, etc.) changed based on new model control volume needs?	Has the CSO treatment process changed based on review?	Have green stormwater infrastructure opportunities been identified in the CSO basin? Can these reduce the size of CSO control facilities needed for the CSO basin?	Are the sites proposed in the 1999 Plan Amendment unavailable or impractical? Have any new sites become available?	Have environmental factors (climate change, habitat restoration projects, human health considerations) changed CSO control priority or schedule for the CSO basin?	Are there any changes in the water quality of the receiving water body?	Has public opinion changed in the area?	Have opportunities for coordination with other King County projects or other agency projects (e.g., SPU control needs) been identified?	Change from Alternative Identified in 1999 Plan Amendment and Re-evaluation Required?	Comments
041	Brandon St	0.8-MG storage/treatment tank (primary treatment) West Point Peak Flow Set Point: 400 MGD Potential Site: 1 potential site located on private property that is partially a parking lot for equipment rental.	2022	4.5	25.1	6.52	35.20	Yes	Yes	Yes	Yes	Yes	No	Yes	No	Yes	Yes	Yes	**Reasons for Change from 1999 Plan Amendment Alternative and Re-evaluation:** -An interim project to upsize the Brandon St Regulator pipe may have decreased the frequency and volume of CSO discharges. -King County's existing and new treatment facilities have changed regulatory targets related to disinfection. Also, the change from classification-based water quality standards to use-based has made the water quality standard targets more stringent. -Size of proposed CSO control facility has increased by more than 10% since 1999 Plan Amendment based on hydraulic modeling. -King County is evaluating the possibility of consolidating S Michigan St and Brandon into one CSO treatment facility and evaluating sewer separation in Brandon. These alternatives will need to be evaluated with the 1999 Plan Amendment alternative. -Update of current treatment technologies has resulted in revisiting footprint requirements for treatment options. -Potential GSI opportunities are available in the basin (high potential). -Prioritizing control of CSOs in the Duwamish River and Elliott Bay could be more beneficial to ecological and human health when compared to control of CSOs in Lake Washington Ship Canal, Lake Union, and the Montlake Cut. -Collaborative opportunities with SPU may be available, which may require the schedule to be modified. -Stakeholders view GSI, coordination with City of Seattle, and prioritizing Duwamish River CSOs as important.
042	W Michigan St	Conveyance Upgrade: Decommission existing 24-inch-diameter outfall gate. Upgrade diversion pipe that routes flows to the West Duwamish Interceptor (Section 2) from 10 inches to 30 inches in diameter. Construct a new junction chamber prior to station and rebuild existing diversion manhole. West Point Peak Flow Set Point: 400 MGD	2027	0.1	2.0	0.27	3.00	No	Yes	No	N/A	Yes	No	Yes	No	Yes	No	Yes	**Reasons for Change from 1999 Plan Amendment Alternative and Re-evaluation:** -Size of proposed CSO control facility has increased by more than 10% since 1999 Plan Amendment based on hydraulic modeling. -Potential GSI opportunities are available in the basin (high potential). -Habitat improvements were constructed next to CSO discharge location since 1999 Plan Amendment. -Stakeholders view GSI and prioritizing Duwamish River CSOs as important.

Note: The following CSO basins have been controlled since 1999 Plan Amendment based on hydraulic modeling and CSO monitoring or are anticipated to be controlled with project(s) in design or construction.

Ballard (003)
Dexter Ave (009)
8th Avenue S/West Marginal Way (040)
North Beach (048)
SW Alaska Street (055)
Murray Street (056)
Barton Street (057)

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Appendix D

West Point Treatment Plant Flow and Waste Load Report Summary

Flow and Waste Load Report Requirements

The Washington State Department of Ecology (Ecology) requires that King County conduct an assessment of its treatment plant influent flow and waste load and submit a report as part of the County's application to renew its National Pollutant Discharge Elimination System (NPDES) permit for the plant. The report must contain the following:

- An indication of compliance or noncompliance with the permit effluent limits
- A comparison between the existing and design monthly average dry-weather and wet-weather flows, peak flows, biochemical oxygen demand (BOD), and total suspended solids (TSS) loadings
- The percentage change in these parameters since the previous report.

The report must also state the present and design population or population equivalent, projected population growth rate, and the estimated date upon which the design capacity is projected to be reached, according to the most restrictive of these parameters.

Summary of Report Results

Recorded Flows and Loads

The flow and waste load study submitted for the 2009 West Point Treatment Plant NPDES permit renewal covered the period from January 2004 through April 2008. Table D-1 presents the flow rates from the flow and waste load study.

Average annual flow for this period was under the design value of 142 million gallons per day (MGD). The flows decreased compared to the report for the previous period, which covered the period from January 1996 through March 2000; annual flows during that period ranged from 117.0 MGD and 129.4 MGD.

Table D-1. Flow Rates from Flow and Waste Load Study

	Flow Rate (MGD)				
	Average Annual (Jan to Dec)	Dry Season (May to Oct)	Wet Season (Nov to Apr)	Peak Day[a]	
				Secondary	CSO
2004	99.7	91.7	107.8	305	358
2005	96.8	85.8	108.0	277	327
2006	117.4	87.9	147.4	286	335
2007	98.1	84.1	112.4	299	401
Jan – April 2008	100.0		100.0		202

a. Peak day is the maximum flow day during the year; not an instantaneous maximum. Separate measurements are made for flows receiving secondary treatment and combined sewer overflow (CSO) flows receiving only primary treatment.

Table D-2 summarizes influent loading for the period from January 2004 through April 2008. At no time during that period did either BOD or TSS monthly average influent loadings exceed 85 percent of the maximum month design limits. The recorded maximum-month BOD loading was 168,400 lb/day (June 2007), compared to the 85-percent-of-design maximum-month flow of 215,900 lb/day. For TSS, the recorded maximum-month loading was 202,000 lb/day (November 2006), compared to the 85-percent-of-design maximum-month load of 232,900 lb/day.

Table D-2. Influent Loading Rates from Flow and Waste Load Study

	Influent Loading (Pounds/Day)	
	BOD	TSS
Average Annual Design Load	***168,000***	***181,000***
Maximum-Month Design Load	***254,000***	***274,000***
Recorded Average Annual, 2004	147,200	168,300
Recorded Average Annual, 2005	138,000	163,500
Recorded Average Annual, 2006	150,200	177,500
Recorded Average Annual, 2007	144,400	158,600
Recorded Average, Jan – April 2008	145,900	178,700

BOD loadings during this permit period decreased by 14.0 percent from the period covered by the previous report; TSS loadings decreased by 5.3 percent. The percentage change was calculated using the average of the annual loading data from only the whole years. The data from the partial years, 2000 and 2008, were not included in this analysis.

Projected Flows and Loads

Population projections are used to make flow projections, and the flow projections are used in combination with actual 2007 and Jan - Mar 2008 loadings to project influent loadings. Table D-3 shows the report's projections for population in the West Point service area for 2008, 2010, 2011, and 2013. The projections for 2008 and 2010 take into account planned changes in apportionment of flows between the West Point and South Treatment Plants (flow from some pump stations can be sent to either West Point or South). The projects assumed that the Brightwater Treatment Plant would come on line in early 2011, removing some population from the West Point service area.

Table D-3. Population, Flow and Load Projections from Flow and Waste Load Study

	Projections – West Point Service Area				
Year	Total Population	Percent Increase	Flow	BOD Loading	TSS Loading
2007	1,325,000		98.1 [a]	144,4003[a]	158,600[a]
2008	1,337,000	0.91%	111	157,800	178,700
2010	1,362,000	1.02%	110	160,000	180,900
2011	1,199,000	12.0%	96	136,800	161,500
2013	1,217,000	1.5%	97	138,500	163,100

a. Flow, BOD loading, and TSS loading are actual 2007 figures.

The projected TSS loading for 2010 is nearly equal to the average annual design load of 181,000 lbs/day, apparently due to significantly more inert solids from street wash-off than anticipated in the design of the West Point Treatment Plant secondary process. However, demand on the capacity at the West Point Treatment Plant will be reduced with diversion of some flows previously treated at the West Point Treatment Plant during the summer to the Brightwater Treatment Plant.

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Appendix E

Environmental Characterization and Prioritization

King County's Long-term CSO Control Plan (Plan) and amendments are founded upon the most current scientific information available related to public health, water quality, environmental protection, recovery of endangered species, and climate change. When information has not been available, the County has initiated or participated in special studies to develop the needed information. Each review of the County's CSO Control Program and Plan amendment has considered new information developed since the last review, as well as trends over time. The summary of these reviews and new information can be found in the following sections of past planning reports:

- 1979 CSO Control Plan – Chapter 6
- 1985-6 Final Supplemental Plan for CSO Control – Chapter 3
- 1988 CSO Control Plan – Appendix F
- 1995 CSO Control Plan Update – Chapter 4
- 1999 Plan Amendment – Companion to the 1998 CSO Water Quality Assessment for the Duwamish and Elliott Bay and the 1999 Sediment Management Plan
- 2000 CSO Control Plan Update – Chapters 4 and 6
- 2011-12 Program Review – Chapter 4 of 2012 CSO Control Program Review Report and Technical Memorandum 540, Environmental and Habitat Priorities

Foundational Studies

These reviews include environmental and health characterization information from certain "foundational studies". These studies have shaped King County's decisions on CSO control over the years. These studies and their conclusions are summarized in Table E-1. Details of the studies can be found at the end of this appendix.

Table E-1. Foundational Studies and CSO Control Program Implications

Year	Study	CSO Control Program Implications
1958	Metropolitan Seattle Wastewater and Drainage Study	This regional study recognized that providing better wastewater management would result in the most environmental improvement. As a result, the regional wastewater agency, Metro (predecessor to King County WTD), was formed to put the new wastewater system in place. The study recommended a program, comprised of a three-stage schedule of projects, including sewer separation and storage, to control

Year	Study	CSO Control Program Implications
		overflows in the City of Seattle.
1978	Areawide Section 208 Water Quality Plan	Two years of investigation was done under Section 208 of the federal Clean Water Act (CWA). Toxic chemicals were identified as one of the five main water quality problems facing the Seattle–King County region. The plan recommended public and private actions to control pollutants entering regional waters. The plan recommended CSO control as part of improved wastewater management and identified the need for increased understanding of the toxic impacts of CSOs.
1979-1984	Toxicant Pretreatment Planning Study	Metro, with the support of the United States Environmental Protection Agency (EPA) and the Washington State Department of Ecology (Ecology), initiated a 5-year, $7 million (1979 dollars) study—the Toxicant Pretreatment Planning Study—to develop a better understanding of toxic chemicals in the environment and in wastewater, and of their impacts and treatability. A scientific advisory panel provided advice, oversight, and review during the study. Recommendations of the study included the following: • Develop an action plan to clean up toxicants in Elliott Bay. • Strengthen Metro's industrial pretreatment program to meet increasing emphasis on toxicant control at the source. • Continue source control programs and promote a general “source control attitude.” • Implement Metro's adopted facilities plans. • Focus on continued toxicant research. • Include CSO control as part of a coordinated Elliott Bay Action Plan, and prioritize source control, including enhancing Metro’s pretreatment program.
1983	Water Quality Assessment of the Duwamish Estuary	In 1982 the Duwamish Waterway was identified as having one of the four worst water quality problems in the state. Metro was awarded a grant to inventory pollutants entering and impacting the waterway and to develop a strategy for pollution control. Major impacts to beneficial uses were attributed to ammonia, residual chlorine, copper, lead, mercury, polychlorinated biphenyls (PCBs), and polycyclic aromatic hydrocarbons (PAHs). Temperature, dissolved oxygen, nitrite, cadmium, dichlorodiphenyltrichloroethane (DDT), pathogens, and sediments were considered to produce only minor impacts. CSOs were identified as a minor contributor to the larger pollution problem; control was recommended as a part of the solution.
1988	Draft Elliot Bay Action Plan	The Urban Bay Action Program, an element of the Puget Sound Estuary Program, developed the 1988 action plan for the Elliott Bay Action Program. It identified and ranked environmental indicators and problem areas. Control of direct discharges and stormwater source control were identified as the greatest needs; these controls were expected to improve CSO discharge quality. Metro’s Denny Way and Michigan CSOs were identified as priorities for control.
1988-1996	Metro Receiving Water Monitoring Program	Metro was instructed to develop and implement a plan for monitoring receiving waters in the vicinity of its primary treatment plants—West Point, Alki, Carkeek, and Richmond Beach—and in other point source discharge areas. Monitoring was to occur quarterly to biennially at a range of stations near the treatment plants and nearby shorelines. These monitoring efforts affirmed that CSO control was a minor to moderate part of a larger wet-weather problem, and that while CSO control was

Year	Study	CSO Control Program Implications
		part of the solution, it would not bring the largest benefit.
1988-1997	Metro/King County CSO Discharge and Sediment Characterization Study	In approving Metro's 1988 CSO Control Plan, Ecology required characterization of CSOs and sediment quality. The purpose of the characterization was to set site control priorities and a control project schedule. Analysis showed that the variability between different samples at a site was generally greater than variability among sites. Sediment sampling confirmed that sediments had been significantly impacted by pollution and that the contamination resulted from many sources. The Denny Way CSO site was slightly higher in pollutant concentrations than other CSO sites, affirming it as a priority site for control; chemistry at other overflows did not greatly influence their control priority.
1999	CSO Water Quality Assessment for the Duwamish River and Elliott Bay	King County completed the water quality assessment with support from a large stakeholder group and a peer review panel. The water quality assessment reviewed the health of the Duwamish River and Elliott Bay estuary and the effects of CSO discharges. The assessment affirmed that CSO pollution is a very small part of a larger problem; it recommended CSO control to meet state regulations and helped determine the priority of the CSO control projects for the 1999 Plan Amendment.
1999	Sediment Management Plan	The Sediment Management Plan assessed areas near seven county CSOs that were listed on the Washington State Contaminated Sites list. Contamination of sediments with chemicals such as PCBs was identified as resulting mainly from historical inputs. The plan, therefore, recommended that sediment remediation near CSOs proceed ahead of CSO control (except near the Denny Way CSO site where control should come first). It recommended coordinated efforts to solve phthalate pollution problems.

These foundational studies shaped CSO control through the 1999 Plan Amendment. With one exception, they repeatedly indicated that CSO discharges were a small part of the water quality problem, but that control played a role in the larger solution. However, information indicated that the Denny Way CSO site should be a priority for control due to its high volume, chemistry, and sediment contamination, so its control project was already underway before the 1999 Plan Amendment and was completed in 2005. Beyond that priority, receiving water and overflow chemistry did not differentiate the priority for control of the other CSO sites. Volume control had set the priority under the 1988 CSO Control Plan to meet agreements with Ecology to achieve 75-percent volume reduction by 2006, but the studies did not support it as a primary prioritization factor. Pathogen exposure risk and the importance of protecting public health made control of CSOs along recreational beaches where primary contact occurred a high priority, so the 1999 Plan Amendment prioritized CSO sites along Puget Sound next for CSO control projects. The potential for secondary contact from sculling, kayaking and canoeing along the east end of the Ship Canal prioritized control of the University and Montlake CSO sites as second priority projects. The Duwamish River with its net fishing was prioritized third, and the west end of the Ship Canal was identified for control last in the schedule.

2006 CSO Control Program Review and 2008 CSO Control Plan Update

For the 2006 CSO Control Program Review, King County took a fresh look at existing information, reviewed new information, and completed studies to assess—both quantitatively and qualitatively—the health benefits to the public, environment, and endangered species of CSO control. The assessment drew from studies done in support of the Superfund processes in the Duwamish River and on those done in support of protecting endangered species. It built on the findings of the foundational studies.

Duwamish Waterway Superfund Initiatives as of 2006

Since completion of the Sediment Management Program (SMP), King County has been coordinating its sediment management efforts in the Duwamish Waterway with two federal Superfund projects: the Harbor Island and the Lower Duwamish Waterway projects. Superfund is a highly structured approach to managing sediment contamination that could prompt changes in projects, schedules, and budgets in the County's Plan.

The County has been working in partnership with the Port of Seattle since 2003 on the Harbor Island Superfund project. The project will remediate sediments at the County's Lander St and Hanford CSO sites.

In 2001, EPA added approximately five miles of the Lower Duwamish Waterway (LDW) to its list of Superfund cleanup sites. Nine county CSOs are located in this stretch of the waterway. The County, the Port of Seattle, the City of Seattle, and Boeing voluntarily became involved early in the process before the site was listed under Superfund, entering into an Administrative Order on Consent in December 2000 with EPA and Ecology for the site and initiating work in support of the remedial investigation and feasibility study (RI/FS).

Phase 1 of the RI/FS examined existing data on the risks to human health and the environment from sediment-associated chemicals in the LDW. As a result of the Phase 1 study, EPA identified seven early action sites. Two of the seven early action sites were near the County's Norfolk and Diagonal/Duwamish CSO sites. Sediment near the Norfolk CSO site had already been remediated in 1999; remediation of the Diagonal/Duwamish sediment was completed in 2004. Both projects were completed by the County, the City of Seattle, and the Elliott Bay/Duwamish Restoration Program.[1]

Phase 2 of the RI/FS generated additional data and estimated risks that will remain after completion of early remedial actions. The draft RI/FS was circulated for public review in November 2007. Some key findings are as follows:

[1] The Elliott Bay/Duwamish Restoration Program administers projects funded under a 1990 settlement of litigation by the National Oceanic and Atmospheric Administration (NOAA) for natural resource damages from Seattle and King County CSOs and storm drains.

- The waterway contains a diverse assemblage of aquatic and wildlife species and a robust food web that includes top predators.
- Much of the sediment contamination resulted from historical releases that are now generally buried under cleaner more recently deposited sediment. Almost all new sediment that enters the waterway comes from the Green River.
- In general, high concentrations of chemicals, including PCBs, were detected in surface sediment in localized areas—frequently called “hot spots”—separated by larger areas of the LDW with lower concentrations. Relatively high surface sediment contamination is present in some areas as a result of a number of processes, including low net sedimentation rates in a few areas with primarily historical contamination or because of the presence of ongoing localized sources.
- The highest risks to people are associated with consumption of fish, crabs, and clams, with lower risks associated with activities that involve direct contact with sediment, such as clamming, beach play, and net fishing.
- Most of the human health risk is from PCBs, arsenic, cPAHs, and dioxins and furans.
- Ecological risks to fish and wildlife were relatively low, with the exception of risks to river otter from PCBs.
- Sediment contamination in approximately 75 percent of the LDW is estimated to have no effect on the benthic invertebrate community; approximately 7 percent of the surface sediment has chemical concentrations exceeding the higher of the two state standards associated with potential adverse effects to the benthic invertebrate community. The potential for effects in the remaining 18 percent of the LDW is more uncertain. Most of the state sediment standard exceedances were for PCBs and phthalates, although 41 different chemicals had at least one exceedance.

The draft RI/FS included two recommendations in its key findings:

- The control of local sources of toxics is critical to the long-term success of specific remedial actions in the LDW.
- Continued coordination of cleanup actions and source control will be necessary to ensure that any actions taken are not unduly impacted by local sources.

Studies to Protect Endangered Species as of 2006

CSOs occur in the lower reaches of each of the two primary watersheds in King County’s wastewater service area. These watersheds—called Water Resource Inventory Areas (WRIAs)—are the Lake Washington/Cedar/Sammamish watershed (WRIA 8) and the Green/Duwamish and Central Puget Sound watershed (WRIA 9).

In WRIA 8, the county CSOs into Lake Washington are controlled, but CSOs in the Lake Washington Ship Canal and the nearshore area near Carkeek Park are not yet controlled. Three Chinook salmon populations migrate in and out of the watershed through the lakes, Ship Canal, and Locks. Juveniles rear in the marine nearshore areas of Puget Sound before heading into the ocean. Studies indicate that all three populations are at extremely high risk of extinction. The

Cedar River population is at highest risk, followed by North Lake Washington and then Issaquah populations.[2]

In WRIA 9, the county CSOs are located in the LDW from the turning basin to the mouth, in Elliott Bay, and along the Alki shoreline. There are no county CSOs in the Green River. Eight county CSOs in WRIA 9 were controlled, and the Denny Way project was completed. However, Denny Way is undergoing adjustments to achieve full control. Discharges to the Duwamish Waterway have been reduced over time. The Alki CSO Treatment Plant, and the Elliott West and Henderson/MLK CSO Treatment Facilities discharge treated effluent into WRIA 9. The Green River/Duwamish Waterway system has not experienced the same decline in Chinook salmon as has occurred in other systems. Overall, Green River Chinook salmon are considered resilient and have survived the effects of large-scale production of hatchery fish, high harvest rates, and habitat alteration.[3]

Given the varied life history strategies of bull trout and the limited information regarding the species, the U.S. Fish and Wildlife Service assumes the presence of bull trout everywhere in their historical range unless proven otherwise. Bull trout are likely to occur in the same water bodies, except for Lake Washington, as outmigrating juvenile chinook (which bull trout prey on).

Salmon Conservation Plans: Strategies for Improving Habitat

A Salmon Conservation Plan was published for WRIA 8 in July 2005 and for WRIA 9 in August 2005.[4] The plans describe long-term habitat conservation and recovery actions in WRIA 8 and WRIA 9 that take an ecological approach but concentrate on the needs of the ESA-listed species of chinook salmon and bull trout. They include strategies, policies, and recommended projects to address factors that limit salmon habitat in the watersheds.[5]

Both WRIA plans recommend actions in the lower reaches of the watersheds that should be considered in CSO control planning. One of the many recommended actions is to increase efforts to protect sediment and water quality, especially near commercial and industrial areas where there is the potential for fuel spills, discharge of pollutants, and degraded stormwater quality. While CSOs were not considered as a major concern in the plans, CSOs were perceived as contributing to the degradation of water and sediment quality in salmon habitat. This perception is linked with a larger concern about impacts from stormwater.

Habitat quality in the transitional areas of the estuaries is a priority. The WRIA 8 plan recommends the creation of pocket estuaries in the Lake Washington Ship Canal near the Hiram

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[2] September 2001, Salmon and Steelhead Habitat Limiting Factors Report for the Cedar-Sammamish Basin (Water Resource Inventory Area, Washington Conservation Commission, Olympia, WA.

[3] December 2000, Habitat Limiting Factors and Reconnaissance Assessment Report, Green/Duwamish and Central Puget Sound Watersheds, Water Resource Inventory Area 9 and Vashon Island, King County and the Washington Conservation Commission, Seattle and Olympia, WA.

[4] February 25, 2005, WRIA 8 Steering Committee, Proposed Lake Washington /Cedar/Sammamish Watershed Chinook Salmon Conservation Plan. August 2005, Making our Watershed Fit for a King, Salmon Habitat Plan, Green/Duwamish and Central Puget Sound Watershed Water Resource Inventory Area 9.

[5] These habit-limiting factors were documented in the Washington Conservation Commission's 2000 and 2001 reports cited earlier.

M. Chittenden Locks in order to enlarge the estuarine transition zone; the WRIA 9 plan recommends enlargement of the Duwamish estuarine transition zone habitat by expanding the shallow water and slow water areas. The WRIA 9 plan specifically recommends that area projects be leveraged to create improved habitat. Future CSO control projects may be viewed as opportunities to make needed habit improvements. A summary of the information considered in this review follows.

Climate Change and Sea-Level Rise as of 2006

On October 27, 2005, King County Executive Ron Sims called together experts from across the country in a conference to discuss the latest information on global warming and climate change and to begin a conversation on their implications to providers of public services in the Pacific Northwest. Despite differing opinions on the details and climate models, there is broad scientific consensus that climate change is occurring; that human actions, especially through the creation of greenhouse gases from burning fossil fuels, are contributing to these changes; and that steps need to be taken to both prepare for the expected effects of climate change and to possibly prevent them from worsening.

Sea-level rise and changes in storm patterns and intensity may occur from climate change. A rise of 6 to 50 inches by 2100 is projected for Puget Sound.[6] Low-lying areas may be at risk. Risks are greatest in southern Puget Sound because this area is sinking at up to 0.08 inch per year, or about an inch every 12 years, as the result of subsidence (sinking) as tectonic plates converge (move toward or under one another). The convergence of plates may cause uplift on the Washington coast, offsetting the effects of sea-level rise caused by climate change.

WTD will monitor the growing information on climate change and sea-level rise. The design of new CSO control facilities or of modifications to existing facilities will consider climate impacts and sea-level change anticipated during the life of the facility. Possible accommodations could include increased sizing, higher facility elevations with respect to nearby water bodies, increased pumping, and enhanced flood and storm surge protections. Decisions as to when to implement these design features will be made based on when it would be most cost-effective to do so while still meeting the need.

Implications for the 2008 CSO Control Plan Update

The review of scientific developments between the 1999 Plan Amendment and the 2006 CSO Control Program Review did not change the prioritization of the Plan control projects. No changes were recommended to the Plan at the time. The Plan progress was updated and King County committed to implementing the Puget Sound Beach projects over the next NPDES permit cycle.

[6] Mote, P., Petersen A., Reeder, S., Shipman, H., and Whitely Binder, L. 2008. Sea Level Rise in the Coastal Waters of Washington State. Report prepared by the Climate Impacts Group, University of Washington, Seattle, Washington, and the Washington Department of Ecology, Lacey, Washington. http://cses.washington.edu/db/pdf/moteetalslr579.pdf

Consideration of Sensitive Areas for CSO Control

EPA requires prioritization of CSO control efforts based on analysis of sensitive areas. The approach is organized differently from King County's approach under Ecology control planning, but ultimately considers the same kinds of factors. To assist EPA's compliance review of the County's CSO Control Program, prioritization is presented using a sensitive areas analysis.

Examples of sensitive areas presented in EPA's 1994 CSO Control Policy (codified as the Wet Weather Water Quality Act of 2000, H.R. 4577, 33 U.D.C. 1342(q))) and in EPA's CSO Control Guidance for Long-term Control Plan (September 1995) include designated Outstanding National Resource Waters, National Marine Sanctuaries, waters with threatened or endangered species and their habitat, waters supporting primary contact recreation (e.g., bathing beaches), public drinking water intakes or their designated protection areas, and shellfish beds. The awareness of sensitive areas might guide the development and selection of control alternatives, as well as the identification of priorities for project implementation.

County CSOs do not discharge into designated Outstanding National Resource Waters, National Marine Sanctuaries, or waters supporting public drinking water intakes or their designated protection areas. For this evaluation three different categories of sensitive areas were evaluated: human uses (including primary contact areas and shellfish beds), habitat (including endangered species and their habitat), and regulatory concerns. The following categories of sensitive areas and uses were catalogued:

- Swimming beaches (#)
- Scuba diving (Y/N)
- Wind surfing (Y/N)
- Shellfish growing area (Y/N)
- Fishing piers (#)
- Boat ramps (#)
- Upland play areas (#)
- Parks (#)
- Marine Protected Areas (#)
- Salmon Migration (# species)
- Wetland/streams (# parcels)
- Eelgrass beds (Y/N)
- Salt-tolerant marshes (Y/N)
- Endangered species critical habitat (Y/N)

- Outstanding Natural Resource Waters (Y/N)
- Section 303(d) of the Clean Water Act (CWA) water, sediment, and tissue impairments both by media and by contaminant type.

Recognizing that the spatial extent of these various sensitive areas varied in space and time, the County's sewer service area was divided into zones to aid the analysis. A total of five zones were created and the number of sensitive areas within each zone, or the presence or absence of certain types of sensitive areas, was noted. Table E-2 and Table E-3 tabulates the zone/area characteristics and qualitatively compares the zones based on Human Primary Contact/Fish Consumption Risk Sensitivity, Human Secondary Contact Risk Sensitivity, Habitat /Endangered Species Risk Sensitivity, and Water Quality Impairment Sensitivity. Because this analysis did not consider each individual outfall but rather the characteristics of the zone into which the outfalls discharge, priority within an environmental zone should consider additional factors rather than those of this analysis alone. Zones were defined as described in the following sections.

Zone 1 – North Sound

Zone 1 (North Sound) includes the area from the West Point Treatment Plan northwards along the eastern half of Puget Sound to Richmond Beach.

There is one King County CSO (control project in progress) and one CSO treatment plant located in this zone. The north Puget Sound is characterized by few recreational beach/shoreline access points due to steep bluffs and railroad rights of way along the immediate shoreline. There are a few known scuba diving areas but the preponderance of human exposure is from boating activities originating at Shilshole Marina/Boat ramp and summertime beach activities at Golden Gardens Park just north of the Marina. Zone 1 has eelgrass beds which are a Washington Department of Fish and Wildlife and Puget Sound Partnership priority habitat. None of this zone is categorized as an Outstanding National Resource Water, and there are only three impaired waterbody listings under Section 303(d) of the CWA, two for water quality and one for sediment quality. These regulatory listings are for fecal coliform bacteria, polychlorinated biphenyls (PCBs), and sediment bioassay failures.

Zone 2 – Central Sound/Elliott Bay/Duwamish

Zone 2 (Central Sound/Elliott Bay/Duwamish) includes the area from the West Point Treatment Plant southwards along the Seattle shoreline into the Duwamish River as far upstream as the Norfolk CSO site, thence along the southwestern portions of Elliott Bay to Duwamish Head.

There are eighteen King County CSOs (ten uncontrolled/one near control/one with a project in progress) and two CSO treatment plant discharges in this zone, and the Elliott Bay/Duwamish River zone is characterized by few natural habitats. The shoreline is predominantly developed except for public park beaches at the northwestern and southwestern margins of Elliott Bay. Almost the entire Duwamish waterway is industrialized. Consequently, there are fewer natural habitats potentially impacted by CSOs in this zone. Instead, there are the seven marinas and boat ramps, three fishing piers, and one of the largest numbers of park parcels (seven) in the zone.

Like the other marine water zones, this area supports scuba diving, shellfish growing, and threatened and endangered species such as Chinook salmon and Orca whales. The unusual feature of this zone is the relatively large number of impaired waterbody listings (48) under Section 303(d) of the CWA for sediment contamination. These listings are partially due to the extensive information from sampling and studies completed in the Duwamish Waterway as part of the Comprehensive Environmental Response, Compensation and Liability Act (CERCLA) investigation occurring. These regulatory listings are for fecal coliform bacteria, multiple metals, a wide variety if polycyclic aromatic hydrocarbons (PAHs), PCBs, and other contaminants like phthalates as well as sediment bioassay failures.

Zone 3 – Duwamish Head to Fauntleroy

Zone 3 includes the area from the Duwamish Head west and south along the Puget Sound shoreline to Barton Street.

There are five King County CSOs (two with projects in progress) and one CSO treatment plant located in this zone which extends from Alki Point southwards to just south of Lincoln Park at the Barton Street Pump Station emergency overflow. This zone is characterized by large reaches of publically accessible beach/shoreline, many play areas, scuba diving, wind surfing, shellfish beds, eelgrass beds, and parks among other human- and habitat-oriented resources. Similar to Zone 1, Zone 3 has some of the lowest numbers of waterbody impairment listings under Section 303(d) of the CWA. Zone 3 has one regulatory listing for fecal coliform bacteria, no sediment listings, and three tissue listings for PCBs and other chlorinated compounds.

Zone 4 – Lake Union Ship Canal

Zone 4 (Lake Union Ship Canal) includes the area from the Ballard Locks upstream through Lake Union to Point Webster in Lake Washington.

There are nine King County CSOs in this zone (four uncontrolled/one near control/one with a project in progress). Zone 4 is characterized by extensive watercraft-oriented development with marinas and small shipyards comprising the majority of the shoreline. There are two large parks with limited water access on the north and south sides of Lake Union and many smaller public access points along both the ship canal and Lake Union. As an entirely freshwater urban area, Zone 4 has no swimming beaches, marine protected areas, fishing piers, sensitive areas, salt marshes, eelgrass beds, or Outstanding Natural Resource Waters. Zone 4 includes five waterbody impairment listings under Section 303(d) of the CWA. These regulatory listings are for fecal coliform bacteria, lead, a chlorinated pesticide aldrin, phosphorus, and sediment bioassay failures.

Zone 5 – Lake Washington

Zone 5 has five King County CSOs (all controlled) and is comprised of Lake Washington and its tributaries. As an entirely freshwater area, Zone 5 has no marine-protected areas, fishing piers, sensitive areas, salt marshes, eelgrass beds, or Outstanding Natural Resource Waters. Zone 5 has a large number of swimming beaches, play areas, and boat ramps, and the majority of the shoreline is either publically owned park or single family residences. Zone 5 has ten waterbody impairment listings under Section 303(d) of the CWA, which is second behind Zone 2 in total listings. These regulatory listings are for fecal coliform bacteria, PCBs, and four additional persistent chlorinated pesticides, phosphorus, sediment bioassay failures, and phosphorus.

Summary

Each of the zones above has a variable number of King County CSOs within it, and these are at various stages of control. Each area of consideration has more or less of a variety of types of sensitive areas. Most areas have at least some of each attribute although there are some noteworthy differences between areas. Human use of Zone 5 (Lake Washington) is very high between the predominantly residential and public shoreline, and many access points and uses. This contrasts with Zone 2, which is heavily industrialized and bulkheaded with relatively few public access points but a large regulatory concern with many contaminated sediment listings under Section 303(d) of the CWA.

One consideration is the relative persistence of environmental problems described by each 303(d) listing. In general, PAH listings and fish tissue listings are indicative of more persistent environmental problems than fecal coliform bacteria, which attenuate days to weeks after release compared to the years and decades for PAHs and chlorinated pesticides. Qualitatively, this might weigh the water quality impairment risk higher.

Assuming a qualitative ranking of 3 for high exposure/risk sensitivity to 0 for negligible exposure/risk sensitivity, rankings were assigned to the zones as presented in Table E-2.

Table E-2. Summary of Sensitive Area Rankings

Zone	Human Primary Contact/Fish Consumption Risk Sensitivity	Human Secondary Contact Risk Sensitivity	Habitat /Endangered Species Risk Sensitivity	Water Quality Impairment Sensitivity	Total
1	3	3	3	0	9
2	2	1	3	3	9
3	3	3	3	1	10
4	2	3	1	1	7
5	3	3	3	2	11

Prioritization based on these qualitative rankings results in Lake Washington having highest priority for CSO control, South Sound and Elliott Bay/Duwamish areas tied for second priority, the North Sound being third, and the Ship Canal being fourth. With control of county CSOs completed in Lake Washington and the Puget Sound Beach projects underway, this reflects the prioritization of the 2011 WTD Recommended CSO Control Plan. The similarity of the rankings also gives support to the assessment of Technical Memorandum 540, Environmental and Habitat Priorities—there was little science-based differentiation between the remaining areas needing

CSO control. Instead, Technical Memorandum 540 identified the benefit of coordinating with the regional initiative to clean up the Duwamish River as a sufficient reason to prioritize CSO control in the Duwamish River next.

Table E-3. Summary of Sensitive Area Metrics

Outfall Discharge Serial Number	Name	Zone	Control Status	Human Use								Habitat						Section 303(d) of CWA Listing within Zone								
				Swim-ming Beach-es (#/ zone)	Scuba Div-ing, 1=yes	Wind surf-ing 1=yes	Shell-fish grow-ing area 1=yes	Fishing piers (#/ zone)	Boat ramps (#/ zone)	Upland Play areas (#/ zone)	Parks (#/ zone)	Marine protect-ted areas (#)	Salmon-id migra-tion (# species)	Wetlands/ streams (# parcels/ zone)	Eelgrass beds 1=yes	Salt-toler-ant marshes 1=yes	Endang-ered species critical habitat 1=yes	Outstand-ing Natural Resource Waters 1=yes	303(d) water listing	303(d) sedi-ment listing	303(d) tissue listing	Bacteria	Metals	PAHs	PCBs and Chlori-nated pest-icides	Other, e.g. phtha-lates
048	North Beach	1	Project in progress	2	1	1	1	1	3	2	3	2	1	5	1	0	1	0	2	1		1			1	1
047	Carkeek CSO Treatment Plant	1	Controlled	2	1	1	1	1	3	2	3	2	1	5	1	0	1	0								
006	Magnolia	2	Project in progress	1	1	0	1	3	7	5	7	1	4	6	1	0	1	0	3	48	2	3	6	22	8	14
027a	Denny Way (& Interbay PS Emergency Overflow)	2	Near control	1	1	0	1	3	7	5	7	1	4	6	1	0	1	0								
027b	Elliott West CSO Treatment Facility	2	Controlled	1	1	0	1	3	7	5	7	1	4	6	1	0	1	0								
028	King St	2	**Uncontrolled**	1	1	0	1	3	7	5	7	1	4	6	1	0	1	0								
029	Kingdome	2	**Uncontrolled**	1	1	0	1	3	7	5	7	1	4	6	1	0	1	0								
030	Lander St	2	**Uncontrolled**	1	1	0	1	3	7	5	7	1	4	6	1	0	1	0								
031	Hanford #1	2	**Uncontrolled**	1	1	0	1	3	7	5	7	1	4	6	1	0	1	0								
032	Hanford #2	2	**Uncontrolled**	1	1	0	1	3	7	5	7	1	4	6	1	0	1	0								
034	E Duwamish	2	Controlled	1	1	0	1	3	7	5	7	1	4	6	1	0	1	0								
035	W Duwamish	2	Controlled	1	1	0	1	3	7	5	7	1	4	6	1	0	1	0								
036	Chelan Ave	2	**Uncontrolled**	1	1	0	1	3	7	5	7	1	4	6	1	0	1	0								
037	Harbor Ave	2	Being verified	1	1	0	1	3	7	5	7	1	4	6	1	0	1	0								
038	Terminal 115	2	**Uncontrolled**	1	1	0	1	3	7	5	7	1	4	6	1	0	1	0								
039	S Michigan St	2	**Uncontrolled**	1	1	0	1	3	7	5	7	1	4	6	1	0	1	0								
040	8th Ave S/W Marginal Way	2	Controlled	1	1	0	1	3	7	5	7	1	4	6	1	0	1	0								
041	Brandon St	2	**Uncontrolled**	1	1	0	1	3	7	5	7	1	4	6	1	0	1	0								
042	W Michigan St	2	**Uncontrolled**	1	1	0	1	3	7	5	7	1	4	6	1	0	1	0								
043	E Marginal	2	Controlled	1	1	0	1	3	7	5	7	1	4	6	1	0	1	0								
044	Norfolk	2	Controlled	1	1	0	1	3	7	5	7	1	4	6	1	0	1	0								
044b	Henderson/ Norfolk CSO Treatment Facility	2	Controlled	1	1	0	1	3	7	5	7	1	4	6	1	0	1	0								
051	Alki CSO Treatment Plant	3	Controlled	2	1	1	1	0	6	6	4	3	1	1	1	1	1	0	1	0	3	1	0	0	3	0
053	53rd Ave SW	3	Controlled	2	1	1	1	0	6	6	4	3	1	1	1	1	1	0								
054	63rd Ave SW	3	Controlled	2	1	1	1	0	6	6	4	3	1	1	1	1	1	0								
055	SW Alaska St	3	Controlled	2	1	1	1	0	6	6	4	3	1	1	1	1	1	0								
056	Murray Ave	3	Project in progress	2	1	1	1	0	6	6	4	3	1	1	1	1	1	0								
057	Barton St	3	Project in progress	2	1	1	1	0	6	6	4	3	1	1	1	1	1	0								

Outfall Discharge Serial Number	Name	Zone	Control Status	Human Use								Habitat						Section 303(d) of CWA Listing within Zone								
				Swim-ming Beach-es (#/ zone)	Scuba Div-ing, 1=yes	Wind surf-ing 1=yes	Shell-fish grow-ing area 1=yes	Fishing piers (#/ zone)	Boat ramps (#/ zone)	Upland Play areas (#/ zone)	Parks (#/ zone)	Marine protect-ted areas (#)	Salmon-id migra-tion (# species)	Wetlands/ streams (# parcels/ zone)	Eelgrass beds 1=yes	Salt-toler-ant marshes 1=yes	Endang-ered species critical habitat 1=yes	Outstand-ing Natural Resource Waters 1=yes	303(d) water listing	303(d) sedi-ment listing	303(d) tissue listing	Bacteria	Metals	PAHs	PCBs and Chlori-nated pest-icides	Other, e.g. phtha-lates
003	Ballard	4	Project in progress	0	0	1	1	0	10	3	6	0	1	0	0	0	1	0								
004	11th Ave NW	4	**Uncontrolled**	0	0	1	1	0	10	3	6	0	1	0	0	0	1	0								
007	Canal St	4	Controlled	0	0	1	1	0	10	3	6	0	1	0	0	0	1	0								
008	3rd Ave W	4	**Uncontrolled**	0	0	1	1	0	10	3	6	0	1	0	0	0	1	0	4	1	0	1	1	0	1	2
009	Dexter Ave	4	Near control	0	0	1	1	0	10	3	6	0	1	0	0	0	1	0								
012	Belvoir	4	Controlled	0	0	1	1	0	10	3	6	0	1	0	0	0	1	0								
014	Montlake	4	**Uncontrolled**	0	0	1	1	0	10	3	6	0	1	0	0	0	1	0								
015	University	4	**Uncontrolled**	1	1	1	0	5	18	13	6	0	2	3	0	0	1	0								
049	30th Ave NE	4	Controlled	1	1	1	0	5	18	13	6	0	2	3	0	0	1	0								
011	E Pine St	5	Controlled	1	1	1	0	5	18	13	6	0	2	3	0	0	1	0								
013	MLK Way	5	Controlled	1	1	1	0	5	18	13	6	0	2	3	0	0	1	0								
018	Matthews Park	5	Controlled	1	1	1	0	5	18	13	6	0	2	3	0	0	1	0	1	3	6	1	0	0	5	4
033	Rainier Ave	5	Controlled	1	1	1	0	5	18	13	6	0	2	3	0	0	1	0								
045	Henderson	5	Controlled	1	1	1	0	5	18	13	6	0	2	3	0	0	1	0								

Ongoing Water and Sediment Monitoring Programs

To maintain vigilance in identifying environmental and public health needs and to support decision-making about the wastewater management system, including the CSO Control Program, King County regularly monitors wastewater treatment plant effluent, marine waters, beaches, major lakes, and streams. The biological, chemical, and physical parameters used to assess a water body's health under Washington State Water Quality Standards include fecal coliform bacteria, dissolved oxygen, temperature, pH, ammonia, turbidity, and a variety of chemical compounds.

In addition to ongoing water and sediment quality monitoring, the County conducts special intensive investigations, such as pre- and post-construction monitoring for capital projects and for sediment remediation projects near CSO outfalls.

Interactive monitoring maps and data, as well as technical summary reports for marine areas, are available at http://green.kingcounty.gov/marine/. The annual Marine Water Quality reports were one vehicle for reporting ambient monitoring data required in past NPDES permits to Ecology. Similar interactive maps, data, and technical reports are available for major lakes, including Lake Washington and Lake Union, at http://green.kingcounty.gov/lakes/.

Table E-4 summarizes the current monitoring program. Maps of monitoring stations are available at the above website.

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Table E-4. Summary of King County Water Quality Monitoring Programs in 2010

Program	Media and Locations	Parameters	Methods	Sampling Frequency	Program Purpose	Duration
Ongoing Monitoring						
Marine monitoring	Water in areas of Puget Sound near and away from King County treatment plant and CSO outfalls Water, sediment and shellfish (butter clams) at Puget Sound beaches Phytoplankton community assessment at 3 sites	Water: temperature, salinity, clarity, DO, TSS, turbidity, nutrients, pH, chlorophyll, PAR, and bacteria Beach water: temperature, salinity, nutrients, and bacteria Beach sediment: metals, organics, and physical properties Shellfish: lipids, metals, and PBDEs Phytoplankton: species composition, chlorophyll, and nutrients (nitrogen only)	Discrete water samples and water column profile data collected at multiple depths, ranging from 1 to 200 m In situ automated water monitoring systems at various depths, dependent upon location Sediment corer for intertidal sediments[a] Shellfish: shovel Phytoplankton: Niskin bottles	Water: monthly; in situ systems every 15 minutes at 3 sites Beach sediment: every 5 years Shellfish: semi-annually Phytoplankton: bi-weekly April through September (October at 1 site)	To assess potential effects to water quality from point and nonpoint pollution sources and to compare quality to county wastewater sources	Ongoing
Marine NPDES sediment monitoring	Sediments in Puget Sound near treatment plant outfalls	Grain size, solids, sulfides, ammonia-nitrogen, oil and grease, TOC, metals, organic compuounds, and (at South and West Point plants) benthic infauna	Sediment samples in a grid pattern as defined in the SAP approved by Ecology	Sediment samples at outfalls once per permit cycle (about every 5 years)	NPDES permit requirement	No work in 2010. Next sampled in 2011
Major lakes monitoring	Water in Lakes Washington, Sammamish, and Union at ambient locations	Water: temperature, DO, pH, conductivity, clarity, and nutrients. Fecal coliform on Lake Union only.	Water samples collected at incremental depths depending on the site Sediment: surface, petite ponar[b]	Water samples: biweekly from March through October; monthly during the rest of the year	To document status and trends of lakes	Ongoing
Swimming beach monitoring	Lake Washington, Lake Sammamish, and Green Lake	Bacteria; microcystin and anatoxin (algal toxins)	Water samples at swimming beaches	Weekly, in the summer from Memorial Day through end of September	To evaluate human health risks and necessity for beach closures	Ongoing
Small lakes monitoring	Volunteers monitor 12 small lakes in King County within city limits	Precipitation, lake level, temperature, Secchi depth, phosphorus, nitrogen, chlorophyl-a, phytoplankton	Single-point and vertical profiles	Rainfall & lake level: daily Temperature & Secchi depth: weekly Other parameters: every 2 weeks May to October	To characterize and identify trends in water quality	Ongoing

Table E-4. Summary of King County Water Quality Monitoring Programs in 2010

Program	Media and Locations	Parameters	Methods	Sampling Frequency	Program Purpose	Duration
Rivers and streams monitoring	Water quality samples from 20 rivers and streams of both watersheds; emphasis on mouths of major rivers and tributaries Streamflow and temperature data from 35 stream locations	Routine samples collected monthly: TSS, pH, temperature, conductivity, DO, nutrients, bacteria	Descrete grab sample collection for water quality samples Streamflow and temperature: continuous data recorders; direct measurements 6–12 times per year	Monthly routine sampling	To keep a minimum number of long-term stations to document the status and long-term trends of targeted streams and rivers	Ongoing
Benthic macroinvertebrate monitoring	Wadeable stream subbasins	Size and distribution of aquatic macroinvertebrate populations	Samples collected with a Surber stream bottom sampler	Annually	To establish a baseline for identifying long-term trends	Ongoing
Precipitation monitoring	Rainfall measured at 70 locations in King and Snohomish Counties, and at 2 meteorologic stations	Rainfall, air temperature, wind speed, air pressure, calculated transpiration/evaporarion	Continuous data recorders		To analyze infiltration to wastewater conveyance system and to model stormwater	Ongoing
Brightwater Outfall Studies	Water, eelgrass, and intertidal biota for the Brightwater outfall site	Water: temperature, salinity, clarity, DO, nutrients, suspended solids, light transmission, chlorophyll, PAR, and bacteria Eelgrass and intertidal biota: distribution and relative abundance	Water column samples collected at multiple depths, from 1 to 175 m Eelgrass survey: underwater video collected by SCUBA divers and an ROV Intertidal biota survey: transect/quadrat method	Water: monthly Eelgrass: annual survey over the course of the study that began in 2004 and goes through 2014 Intertidal biota: annually for 5 years (project ends in 2010)	To meet HPA and DNR outfall lease requirements and to compare outfall pre-construction eelgrass abundance and distribution to post-construction data	Through 2014
Brightwater Construction NPDES Stormwater Monitoring	Stormwater and surface water	Water: DO, pH, turbidity, temperature, rainfall, and chemical parameters as required by permit, variable with discharge location.	Field measurements and laboratory analysis.	Intensive and dependent on rainfall.	To meet NPDES Construction Stormwater permit	Through 2012
Elliott West/Denny Way CSO sediment monitoring	Sediment near the new Denny Way Regulator and Elliott West CSO Treatment Facility outfalls and in sediment cleanup areas associated with the old Denny Way CSO discharge site	Benthic communities, sediment chemistry	Sediment samples per approved SAP	Variable	To meet U.S. Army Corps of Engineers permit requirements and an Ecology cleanup order	Through 2021
Duwamish/Diagonal post-remediation sediment monitoring	Sediment near the Seattle Diagonal storm drain (includes city and county CSO outfalls) and the county's Duwamish CSO outfall	Sediment chemistry, cap surveys	Sediment samples per approved SAP	Annual	Under an EPA/Ecology Consent Order	Through 2014

Table E-4. Summary of King County Water Quality Monitoring Programs in 2010

Program	Media and Locations	Parameters	Methods	Sampling Frequency	Program Purpose	Duration
Wetland monitoring for Carnation Treatment Plant	Water quality in discharge wetland, existing tributaries, and outflow Sediment quality in wetland pond	Water: metals, organics, nutrients, bacteria Sediment: metals, organics and physical parameters	Water column Surface sediments	Variable	Project completed in 2010; purpose was to determine conditions before and after treatment plant discharge. No further monitoring.	2006–2010
Quartermaster Harbor Nitrogen Management Study	Groundwater quality Streamwater quality Streamflow and temperature (done as part of another project) Marine water quality (see ambient marine monitoring above)	Groundwater: alkalinity, nutrients, TSS, bacteria, DO, pH, specific conductance, temperature, turbidity, ORP Streamwater: same as groundwater, except for addition of mircrobiology and deletion of TSS and ORP	Groundwater: monitoring wells with dedicated sampling equipment Streamwater: various sampling methods	Groundwater: Annually Streams: Monthly Streamflow: continuously at 5 sites; every 2 years at 22 sites	Recommend policy changes for nitrogen management in the King County Comprehensive Plan	2009–2012
Stormwater Permit Monitoring	Stormwater quality Stomwater quantity Chemical loadings MS4 outfalls BMPs (sand filter, pond)	Organics, metals, conventionals. bod Flow	Autosamplers	Storm-driven	NPDES stormwater permit	Ongoing
Stormwater Retrofit Plan for WRIA 9	Streams in WRIA 9, including some previously existing sites	Streamflow, water temperature, turbidity, specific conductance	Continuously recording data loggers and sondes	15 minute data recording	Calibrate models used to plan stormwater retrofits for EPA grant	Through October 2011
Vashon Groundwater Quality	Groundwater water quality	Nutrients including nitrate; conventionals including chloride, and selected metals including arsenic.	Nine monitoring wells with dedicated sampling equipment and 15 long-term sampling locations	Annually	Long term trend of environmental indicators (nitrate- chloride and arsenic) and assessment of water qualty within different aquifers on VMI.	Ongoing

BMP = best management practices; CSO = combined sewer overflow; DNR = Washington State Department of Natural Resources; DO = dissolved oxygen; Ecology = Washington State Department of Ecology; EPA = U.S. Environmental Protection Agency; HPA = Hydraulic Permit Approval; m = meter; NPDES = National Pollutant Discharge Elimination System; ORP = oxygen reduction potential; PAR = photosynthetically active radiation; PBDEs = polybrominated diphenyl ethers; SAP = sampling and analysis plan; TOC = total organic carbon; TSS = total suspended solids.

a Intertidal zone is the area that is exposed to the air at low tide and submerged at high tide; subtidal zone is the area below the intertidal zone that is always covered by water.

b Petite ponar is a type of grab sampler that can easily be carried by one person in the field and can be deployed without the use of a winch or crane recommended for larger samplers.

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Foundational Studies

King County, and its predecessor agency Metro, have consistently considered scientific information in making wastewater management decisions. When information has not been available, they have initiated or participated in special studies to develop the needed information. This section describes the foundational studies that have shaped the County's decisions on CSO control through submittal of the 2000 CSO Control Plan Update. Studies conducted since the 2000 update are described in the body of the report.

1958 Metropolitan Seattle Wastewater and Drainage Study

Beginning with the 1958 Metropolitan Seattle Wastewater and Drainage Study, regional agencies have collaborated on studies to identify major environmental protection needs and to identify and prioritize corrective actions. This study recognized that providing better wastewater management would result in the most environmental improvement. As a result, the regional wastewater agency, Metro, was formed to put the new wastewater system in place.

CSO Implication: As part of the larger three-stage schedule of projects, the study recommended a program of sewer separation and storage, as needed, to control overflows in the City of Seattle.

1978 Areawide Section 208 Water Quality Plan

As early as 1974, Metro recognized the need to consider the presence and fate of toxic chemicals in its planning and management activities. The initial focus was on characterizing treatment plant and combined sewer discharges for heavy metals. Investigation of sediment conditions near Metro outfalls was a component of these first efforts. The scope of later studies was expanded to assess organic compounds (notably pesticides and PCBs) and the complex interaction of chemical contamination, biological impairment, and source identification and control strategies.

Two years of investigation was done under Section 208 of the federal Clean Water Act. Toxic chemicals were identified as one of the five main water quality problems facing the Seattle–King County region. The plan recommended public and private actions to control pollutants entering regional waters.

CSO Implication: The plan recommended CSO control as part of improved wastewater management and identified the need for more understanding of the toxic impacts of CSOs.

1979–1984 Toxicant Pretreatment Planning Study

In 1979, Metro, with the support of the United States Environmental Protection Agency (EPA) and the Washington State Department of Ecology (Ecology), initiated a 5-year, $7 million (1979 dollars) study—the Toxicant Pretreatment Planning Study—to develop a better understanding of toxic chemicals in the environment and in wastewater, and of their impacts and treatability. A scientific advisory panel provided advice, oversight, and review during the study.

Recommendations of the study included the following:

- Develop an action plan to clean up toxicants in Elliott Bay.
- Strengthen Metro's industrial pretreatment program to meet increasing emphasis on toxicant control at the source.
- Continue source control programs and promote a general “source control attitude.”
- Implement Metro's adopted facilities plans.
- Focus on continued toxicant research.

Table E-5 lists the reports produced as a part of the Toxicant Pretreatment Planning Study. Information from the study and from two complementary studies, Household Hazardous Waste Disposal and Toxicants in Urban Runoff, became a basis for the policy decisions in the 1980s.

CSO Implication: The Toxicant Pretreatment Planning Study recommended that CSO control should be part of a coordinated Elliott Bay Action Plan and that source control, including enhancing Metro’s pretreatment program, should be a priority.

Table E-5. Documents Produced as Part of the Toxicant Pretreatment Planning Study

Title	Topics
Toxicant Pretreatment Planning Study Summary Report	Synthesis of all study and related project information, problem definition, conclusions and recommendations.
Al: Treatment Plant Evaluation	Occurrence of toxicants in wastewater treatment plants, removals, mass loadings, and balances. Alum addition and the impacts of Renton sludge.
A2: Collection System Evaluation	Occurrence of toxicants in various land use types, estimates of total loadings by land use types, toxicants in CSO's, and evaluation of a Duwamish satellite treatment plant.
A3: Industrial Waste Characterization	Occurrence of toxicants at selected industrial locations, identification of total industrial loads of toxicants to West Point and Renton (South plant).
A4: Source Controls—Pretreatment Evaluation	Industrial pretreatment program review and recommendations plus other toxicant control options.
Technical Report B: Pilot Plant Studies	Occurrence of toxicants, mass loadings, and balances of pilot-scale studies on alum-assisted primary treatment, secondary treatment of West Point wastewater, and anaerobic digestion. Bench-scale alum and powdered activated carbon studies.
C1: Evaluation of Toxicant Transport and Fate	Occurrence of toxicants in receiving waters, sources of toxicants, transport, and deposition.
C2: Puget Sound Benthic Studies and Ecological Implications	Analysis of biological testing of bottom sediments in Puget Sound and correlation with toxicant loadings.
C3: Lake Washington Benthic Studies and Ecological Implications	Analysis of biological testing of bottom sediments in Lake Washington and correlation with toxicant loadings.

1983 Water Quality Assessment of the Duwamish Estuary

Because of the potential conflict between uses of the Duwamish Waterway, EPA and Ecology classified the estuary as a high priority study area. In the 1982 state/EPA agreement, both agencies identified the Duwamish Waterway as having one of the four worst water quality problems in the state. As the designated water quality management agency for the Green/Duwamish basin, Metro was awarded a grant to inventory pollutants entering and impacting the waterway and to develop a strategy for pollution control. The 1983 Water Quality Assessment of the Duwamish Estuary (also known as the Harper-Owes Study) documented this work. It overlapped Toxicant Pretreatment Planning Study activities in some areas.

The assessment synthesized the findings of the many Duwamish studies performed through July 1982 in order to identify data strengths, deficiencies, and gaps requiring further investigation. Public input and interagency task force review comments were considered in developing a ranked list of beneficial uses of the estuary. Mass balances were performed for 20 parameters to identify impacts to beneficial uses. Upstream sources were found to contribute more than two-thirds of the total sediment, iron, and mercury load, as well as much of the organic carbon and pesticides. Major impacts to beneficial uses were attributed to ammonia, residual chlorine, copper, lead, mercury, PCBs, and PAHs. Temperature, dissolved oxygen, nitrite, cadmium, DDT, pathogens, and sediments were considered to produce only minor impacts.

The Renton Treatment Plant (now called South Treatment Plant) was found to contribute nearly 80 percent of the total ammonia load. The anticipated diversion of the Renton Treatment Plant effluent out of the Duwamish River in 1986 was expected to result in marked reductions in ammonia, chlorine, dissolved oxygen, nitrite, and cadmium impacts. CSOs were found to be a source of all pollutants measured—but only a small source. One exception was fecal coliform bacteria. An estimated 80 percent of the total pathogens released to the estuary was estimated to originate from CSOs. While concentrations of toxicants were found to be relatively high in CSOs, the small annual volume made them a minor source.

The most significant finding was that the majority of metal and organic toxicants could not be attributed to documented sources, which shifted attention to the heavy industrial and commercial activity along the river. Future conditions were projected to adversely impact beneficial uses. Temperature, sediment, pathogens, copper, lead, mercury, PCBs, and PAHs were identified as the greatest contributors to future adverse impacts.

The study made 11 recommendations:

- Flow augmentation
- River bank shading
- Erosion controls
- Maintenance dredging
- CSO controls
- Paving of a contaminated parking area on Harbor Island

- Control of shipyard emissions
- Additional investigations
- Good housekeeping measures
- Preservation of local wildlife habitat
- Improved river access

CSO Implication: CSOs were identified as a minor contributor to the larger pollution problem; CSO control was recommended as a part of the solution.

1988 Draft Elliot Bay Action Plan

In 1985, the Puget Sound Estuary Program (PSEP) was formed to minimize toxic chemical contamination of Puget Sound and to protect its living resources. The Urban Bay Action Program, an element of the PSEP, developed the 1988 action plan for the Elliott Bay Action Program. Its objectives were as follows:

- Identify specific toxic areas of concern in the bay and the Duwamish Waterway based on chemical contamination and associated adverse biological effects
- Identify historical and ongoing sources of contamination
- Rank toxic problem areas and sources (to the extent possible) in terms of priority for development of corrective actions
- Implement corrective actions to reduce or eliminate sources of ongoing pollution and restore polluted areas to support natural resources and beneficial uses.

The plan described actions that had been completed and actions to be completed in the future. It identified and ranked environmental indicators and problem areas. Problem areas included the following:

- Seattle South Waterfront
- North Harbor Island I
- North Harbor Island II
- West Waterway I
- West Waterway II
- Denny Way CSO Area

Problem stations included the following:

- EW-05 (center of East Waterway between Terminals 25 and 30)
- AB-01 (east of Duwamish Head)
- KG-01 (near mouth of Slip 1 across from the southern end of Kellogg Island)
- KG-05, KG-06 (north of Kellogg Island)

- DR-12 (in Slip 3)
- DR-15 (in Slip 2)
- DR-16 (north of Terminal 115 on west side of waterway)

Early accomplishments of the Elliott Bay Action Program included more than 175 inspections at 102 sites, identification of 42 unpermitted discharges, and development of permits and best management practices for shipyards. Fifteen contaminated upland sites were identified for cleanup; two cleanups and negotiation of cleanups for twelve additional sites were completed. By September 1987, enforcement actions included 36 notices of violation, 22 administrative orders, and 28 fines totaling $44,500 (1988 dollars).

Through these efforts, most known direct industrial discharges to the bay and river were ended or routed to the municipal sewer system under permits. In addition, the effluent discharge from the Metro Renton Treatment Plant was relocated from the Duwamish River to Puget Sound off Duwamish Head in 1987. The remaining ongoing contaminant sources were believed to include contaminated groundwater, storm drains, CSOs, and a few unidentified direct discharges.

To characterize contaminant inputs from CSOs and storm drains, sediment was collected from the downstream end of 7 CSOs, 20 storm drains (SDs), and 15 combination CSO/storm drains. These inline sediments were compared to offshore sediments to evaluate CSO and storm drain contributions to the contamination in priority areas and stations. Ten priority drainages were identified for source control activities. Six of these drainages discharged to priority problem areas and were considered high priority:

- SW Lander CSO/SD (Seattle 105)
- SW Hanford CSO/SD (Seattle 162)
- SW Florida CSO/SD (Seattle 098)
- Fox S CSO/SD (Seattle 116)
- Michigan CSO (Metro W039)
- Michigan SD (Seattle)

Four of the drainages were outside of priority problem areas:

- Slip 4 CSO/SD (Seattle 117)
- Duwamish SD (Seattle)
- Slip 6 SD (Seattle)
- S 96th Street SD (Seattle)

Site-specific action plans were then developed. Potential sources, status, actions, responsible entities, and implementation dates were compiled. Recommended actions included underground tank removal, upland soil and aquatic sediment remediation, rerouting of discharges to the sewer system, enhanced permitting by Metro’s Industrial Waste Program and by Ecology, stormdrain and CSO outfall cleaning, CSO control, implementation of BMPs, and further investigations.

CSO Implication: Control of direct discharges and stormwater source control were identified as the greatest needs; these controls were expected to improve CSO discharge quality. Metro's Denny Way and Michigan CSOs were identified as priorities for control. Although the Denny Way CSO was not identified as a candidate for source control activities, it was determined that controlling the site would benefit the Denny Way "problem area."

1988–1996 Metro Receiving Water Monitoring Program

In Administrative Order number DE-84-577, Ecology instructed Metro to develop and implement a plan for monitoring receiving waters in the vicinity of its primary treatment plants—West Point, Alki, Carkeek, and Richmond Beach—and in other point source discharge areas. (The Renton plant provided secondary treatment.) The proposed plan included water column surveys of fecal coliform and enterococcus bacteria; subtidal sediment surveys including benthic taxonomy, amphipod bioassays, and analysis of conventional constituents (particle size distribution, total organic carbon, oil, and grease), metals, and extractable organic priority pollutants (plus a survey); intertidal monitoring of water for bacteria and of sediments for metals and extractable organic priority pollutants; and clam and algae tissue samples for analysis of bacteria, metals, and extractable organic priority pollutants. Monitoring was to occur quarterly to biennially at a range of stations near the treatment plants and nearby shorelines.

This "point source" monitoring program was approved by Ecology on April 5, 1988, in a first amendment to Administrative Order DE-84-577. Data were reported to Ecology as QA/QC was completed and were summarized in annual water quality status reports for marine waters. The monitoring program was implemented until discontinued after issuance of the 1996 NPDES permit for the West Point plant, which was upgraded to provide secondary treatment, and after closure of the Richmond Beach plant. After 1996, Metro focused its monitoring program on collecting data on key parameters that could be used in long-term trend assessments. This monitoring continues under ongoing programs described later in this appendix. In parallel, an ambient monitoring program was implemented to provide background data that could be compared to the point source monitoring data. The comparison would help identify impacts related to Metro discharges and ensure that water quality improvements were not undermined.

CSO Implication: These monitoring efforts affirmed that CSO control was a minor to moderate part of a larger wet-weather problem and that while CSO control was part of the solution, it would not bring the largest benefit.

1988–1997 Metro/King County CSO Discharge and Sediment Characterization Study

In approving Metro's 1988 CSO Control Plan, Ecology required characterization of CSO and sediment quality. The purpose of the characterization was to obtain additional information to be used in setting site control priorities and a control project schedule. Because some sampling had already been done, the approved monitoring plan called for taking four discharge samples at five active overflow sites per year until all sites had been sampled. The sampling was completed in 1994. Sediment sampling was also completed for all sites at the rate of five sites per year. When the state promulgated the Sediment Management Standards and attendant testing protocols, additional sediment sampling was done to fully meet these requirements. This additional sampling was completed in 1997. This data, along with data collected since that time, is available at http://www.kingcounty.gov/environment/wastewater/CSO/Library/SedQualSum.aspx.

Analysis of overflow samples showed that the variability between different samples at a site was generally greater than variability among sites. Sediment sampling confirmed that sediments had been significantly impacted by pollution and that the contamination resulted from many sources. Recognizing that further understanding of sediment contamination was needed, King County made it a focus of both the 1999 CSO Water Quality Assessment of the Duwamish and Elliott Bay and the 1999 Sediment Management Plan.

CSO Implication: The Denny Way CSO, containing overflow from the Elliott Bay Interceptor via the Interbay Pump Station, was slightly higher in pollutant concentrations than the other CSOs, affirming it as a priority site for control; chemistry at other overflows did not greatly influence their control priority.

1999 Combined Sewer Overflow Water Quality Assessment for the Duwamish River and Elliott Bay

King County completed the 1999 CSO Water Quality Assessment of the Duwamish and Elliott Bay (WQA) with support from a large stakeholder group and a peer review panel. The WQA reviewed the health of the Duwamish River and Elliott Bay estuary and the effects of CSO discharges. A computer model was developed to predict existing and future water and sediment quality conditions, and a risk assessment was undertaken to identify risks to aquatic life, wildlife, and human health. Findings identified during the course the WQA were taken into account during development of the RWSP CSO control program.

The WQA identified some risks to fish, wildlife, and humans in the estuary and predicted limited improvement if CSO discharges were eliminated from the estuary (Table E-6).

Table E-6. Water Quality Assessment Findings Regarding CSOs

Risk Target	Risk	CSO Control Benefit
Water column–dwelling aquatic organisms; salmon by direct or dietary exposure	None identified	No benefit
Sediment-dwelling organisms; salmon via dietary exposure	Potential risk from PCBs, TBT, bis(2-ethylhexyl) phthalate, mercury, PAHs; low risk from 1,4-dichlorobenzene	Slightly reduced risk[a] ; slight decrease in loadings of bis(2-ethylhexyl) phthalate, mercury, PAHs, and 1,4-dichlorobenzene
Wildlife	Low-to-high risks, depending on the species, from PCBs, lead,	Slight decrease in loadings of lead, copper, and zinc

Risk Target	Risk	CSO Control Benefit
	copper, and zinc	
Humans – chemical exposures	Significant risk from exposure to arsenic and PCBs from fish consumption; potential risk from exposure to arsenic and PCBs when netfishing, swimming, windsurfing, and SCUBA diving	No benefit; the identified risk is not related to CSOs
Humans – pathogen exposures	Potential risk from fecal coliform, giardia, and viruses. People should avoid water contact during and for 48 hours after overflows.	Reduced risk; any benefit from reduced fecal coliform would not be apparent because inputs from other sources are so high

[a] CSOs were not believed to be a significant source of PCBs or tributyl tin (TBT), but were considered a moderate source of 1,4 –dichlorobenzene.

CSO Implications: The findings of the WQA affirmed that CSO pollution is a very small part of a larger problem, mainly because of the low pollutant concentrations in CSOs and the brief and infrequent exposure to CSOs. It recommended the continuation of CSO control to meet state regulations and helped determine the priority of the CSO projects in the RWSP. It recommended that locations with greater potential for human contact—the Puget Sound beaches—be controlled first. Locations in the Duwamish Waterway were set later in the schedule because of the perceived lower human health and environmental benefit from CSO control at these sites. It identified sediment contamination as the largest risk in the river environment.

1999 Sediment Management Plan

The Sediment Management Plan assessed areas near seven King County CSOs that were listed on the Washington State Contaminated Sites list. The areas were assessed for their risk, preferred cleanup approach, partnering opportunities, and potential for recontamination after remediation (Table E-7). The remediation schedule for these areas, shown in Table E-7, is being implemented.

The Sediment Management Plan highlighted the growing interest in sediment management as a factor in CSO control planning and the need for more information about CSOs as an ongoing or historical contributor to contamination. The sediment management program was formed to implement the plan and any new projects developed after the plan in the broader context of wastewater planning. The program addresses sediment quality issues near CSO discharges and treatment plant outfalls, evaluates and addresses emerging wastewater treatment sediment quality issues, and incorporates sediment quality considerations into comprehensive planning.

CSO Implications: Contamination of sediments with chemicals such as PCBs was identified as resulting mainly from historical inputs. The plan, therefore, recommended that sediment remediation near CSOs proceed ahead of CSO control (except near the Denny Way CSO where control should come first). It recommended coordinated efforts to solve phthalate pollution problems.

Table E-7. Recommended Projects in Sediment Management Plan

Nearby CSO and Water Body	Cleanup Priority	Recommended Cleanup Approach	Partnering Opportunity	Cost (million $)[a]	Scheduled to be Completed
Duwamish/ Diagonal[b] (Duwamish River)	High	Dredging and capping	King County under direction of EBDRP[c]	8.90[d]	Completed 2004
King Street (Puget Sound, Elliott Bay)	High	Capping	WSDOT and Seattle	2.60	2008
Hanford (Duwamish River)	Medium/ High	Dredging and confined aquatic disposal	Port of Seattle	15.49	2007
Lander (Duwamish River)	Medium/ High	With Hanford	U.S. Army Corps of Engineers	3.45	2007
Denny A & B[e] (Puget Sound)	Medium	Dredging and capping		2.23	2006
Denny C & D (Puget Sound)	Medium	Capping		0.90	2009
Chelan Ave. (Puget Sound, Elliott Bay)	Low/ Medium	Dredging and confined aquatic disposal		2.80	2010
Brandon St. (Duwamish River)	Low	Capping		0.50	2012

[a] These costs are given in 2005 dollars (the original estimates, given in 1998 dollars, escalated by 3 percent per year).
[b] This project was added after the SMP.
[c] These costs were not included in the SMP; it was assumed that they would be paid by the Elliott Bay/Duwamish Restoration Program (EBDRP).
[d] EBDRP administers projects funded under a 1990 settlement of litigation by the National Oceanic and Atmospheric Administration (NOAA) for natural resource damages from City of Seattle and King County CSOs and storm drains.
[e] This is a City of Seattle storm drain; King County's Hanford No. 1 CSO uses this outfall.

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Appendix F

Summary of 2010-11 Public Involvement Activities

Overview

Throughout 2010 and 2011, staff from King County's Department of Natural Resources and Parks solicited input on the County's CSO Control Program Review from a wide variety of individuals and organizations. This review, scheduled for completion in 2012, is a comprehensive evaluation of the CSO control projects that are anticipated to be built by 2030. The consultant/county team is looking at available data to determine if these upcoming projects have been sized and located appropriately, if they are prioritized correctly, and if the estimated costs to construct them are accurate. Because the City of Seattle is also responsible for some of the CSO outfalls in the system, both entities are also coordinating closely to determine where there might be opportunities for greater system wide efficiencies.

Public involvement is a critical component of the Program Review. The County has actively sought the opinions and perspectives of interest groups and agencies as it evaluated the CSO Control Program. The public involvement effort has been designed to offer numerous opportunities to listen to the questions, concerns, and priorities of these organizations, and to incorporate their suggestions, wherever possible.

To date, county staff has:

- Presented at more than 40 meetings, reaching approximately 100 organizations and agencies.
- Facilitated multiple meetings (from two to five) with deeply-involved groups and agencies.
- Created detailed informational and response-form Web pages. Plan documents are available in numerous area libraries.
- Coordinated with City of Seattle presentations about proposed joint CSO control projects that have supplemented county outreach efforts.
- Participated in three workshops hosted by others where information has been shared about the CSO Control Program with some 400 attendees.
- Sponsored and hosted two of its own workshops, with 80 people in attendance. The first of these workshops, held on September 29, 2010, focused on updates to environmental science that the County is using for the Program Review. The second workshop, held on November 17, 2010, focused on technology updates related to CSO control.

In October 2011, the King County Wastewater Treatment Division (WTD) issued the 2011 WTD Recommended CSO Control Plan for public review and comment. An informational open house was held on November 9, 2011 and focused on the recommended Plan, its options, and costs. The website was expanded to include nine technical memorandums, the 2011 Summary of Technical Memorandums document, and an interactive map where users could select a CSO and find maps, control alternative details, and cost estimates for the final alternatives. Additional briefings were provided to agencies and community groups. Comment means were provided through mailer cards on the document, online comment forms, and formal letters.

Written comments were received from Goslyn, Washington State Department of Ecology, Garden Cycles, University of Washington, People for Puget Sound, Cari Simson, Ballard Stormwater Consortium, Andrea Faste, and the Metropolitan Water Pollution Abatement Advisory Committee **(**MWPAAC). These letters are attached at the end of this report.

A complete list of all of the organizations engaged in the discussions is included at the end of this report.

Prevalent Themes

What follows is a brief summary of the discussions conducted to date. Detailed notes on the interviews and presentations are also available upon request.

1) CSO control is important to stakeholders. They understand the water quality impacts of overflows, and want to see this problem addressed. They also understand the regulatory pressures from both the state and local levels to bring CSOs under control.
2) While CSO control is important, some stakeholders are concerned that the “bigger picture” of stormwater management is not being fully addressed. They assert that if stormwater was better contained and kept out of our surrounding water bodies, the need to also control CSOs would be significantly reduced; they view CSOs, in effect, as a subset of a larger stormwater program. These stakeholders believe more regulatory and programming emphasis should be placed on holistic stormwater controls, and that organizational responsibility should not inhibit the effort.
3) Another broad theme relates to King County/City of Seattle coordination. Because the two systems are linked, those interviewed want to make sure the two entities are collaborating as closely as possible on CSO solutions. There are some concerns that this coordination is not as robust as it should be.
4) There is strong recognition that the continued evaluation of scientific data is important. For example, stakeholders are supportive of the fact that the County will move control projects along the Lower Duwamish Waterway higher in the priority rankings, and that these projects will be built earlier than originally anticipated. This is particularly important to interest groups in the Duwamish area, because people consume fish from the river and because the lower Duwamish is a superfund cleanup site. Data on the possible effects of CSOs on fish populations and habitats, as well as fish consumption, was not available during previous program reviews, and has been a beneficial addition to the 2012 analysis.
5) Likewise, there is strong support for the more advanced technologies that the County is proposing to use for CSO treatment and effluent disinfection at its new CSO control facilities. There is broad recognition that these technology upgrades are essential to

effective control and treatment, given the volume of flows and the number of contaminants present in uncontrolled CSOs and the sensitivity of the Duwamish River.

6) Green Stormwater Infrastructure (GSI) is an area of increasing interest, and stakeholders hope this control alternative is employed as often and as effectively as possible. There is a growing interest in using every available opportunity to build CSO control facilities as community amenities, and GSI offers the landscaping and aesthetic elements that can help to achieve this goal. Stakeholders also recognize, however, that GSI can sometimes be controversial in neighborhoods where residents are likely to lose parking or have other concerns about streetside raingardens and other GSI facilities. Moving forward, additional regulatory policies may be required in order to ensure that GSI systems can be employed as effectively as possible.
7) The introduction of more CSO control projects throughout the City, whether they are city-generated or county-generated, has increased the overall level of public awareness about CSO issues, but has also generated some controversy. Some neighborhoods have been dismayed to learn that CSO control facilities will be located in their area. Stakeholders urge that greater care be taken to ensure comprehensive public information and involvement around these projects. Stakeholders understand that significant water quality improvements will be achieved through greater CSO control, and recommend that both the City and County engage the public as extensively as possible in siting decisions, with the desired outcome being enhanced public support and acceptance of these important projects.
8) We heard concern that the County would consider extending the Program completion date beyond 2030, as had been set in the 1999 CSO Control Plan amendment. This concern was very strong from the regulatory community.
9) Although stakeholders are supportive of meeting the regulatory mandate of one CSO per outfall per year, and although GSI has a great deal of appeal, stakeholders also caution that CSO control approaches need to be balanced against cost considerations. They are mindful of the many regional investments currently being proposed for public infrastructure improvements, and hope that costs will be kept in mind in order to maintain a reasonable rate structure for the public. They are concerned that we make the best investments for water quality.

Public Involvement for the 2012 King County Executive's Recommended CSO Control Plan

Legislation adopting the King County Executive's Recommended CSO Control Plan and the 2012 CSO Control Program Review Report is being transmitted to the King County Council and Regional Water Quality Committee in mid-June 2012. The King County Council welcomes public comment by letter and at their meetings. Schedules and agendas can be found on the King County Council's website at: http://www.kingcounty.gov/council/committees.aspx. Meetings can also be watched live or by video—information on the other ways to interact is also available on their website.

Copies of the Plan and supporting documents, including information in English, Spanish, Korean, Chinese, and Vietnamese, are available for download at the CSO Control Program website: http://www.kingcounty.gov/environment/wastewater/CSO.aspx.

Copies of the documents are available at the following libraries—King County Library System's Bellevue, Burien, Fairwood, Federal Way, Redmond, and Shoreline libraries; the Seattle Public Library's Central Library; and the Ballard Neighborhood Service Center.

Public involvement Activities for the 2012 CSO Control Plan Review, 2010 – December 2011

Presentation(s) to meetings of, or to representatives of:	
36th District GOP	People for Puget Sound
Antioch University students	Puget Sound Partnership
Ballard District Council	Puget Soundkeepers' Alliance
Ballard Chamber of Commerce	Port of Seattle
Ballard Landmark Residents Association	Queen Anne Chamber of Commerce
Ballard Place Condominiums	Queen Anne Help Line
Ballard Rotary Club	Queen Anne/Magnolia District Council
Canal Station Condominium Association	Seattle Police Department
City of Seattle DOT	Seattle-King County Dept. of Public Health
City of Seattle Parks and Recreation	Seaview Neighborhood Association
Crown Hill Neighborhood Association	Seattle Floating Homes Association
Design Build Association of America- Northwest	Seattle Planning Commission
Duwamish River Cleanup Coalition	Seattle University
ECO-NET	Shilshole Liveaboard Association
Environmental Coalition of South Seattle	Sunset Hill Community Association
ERDA Environmental Services Inc.	Sunset West Condo Association
Georgetown Community Council	Sustainable Ballard
The Green Party	Sustainable Magnolia
Friends of Burke Gilman Trail	Sustainable West Seattle
Groundswell NW	Suquamish Tribe
Interbay P-Patch	U.S. Army Corps of Engineers
King County staff	U.S. EPA Region 10
Landmark Inn	University Sunrise Rotary Club
Lower Duwamish Waterway Source Control Work Group	University of Washington staff
Lower Duwamish Waterway Source Control Work Group stakeholder group	University of Washington students
Magnolia Community Club	Uptown Alliance
Magnolia Community Council	Urban Horticulture Center
Magnolia/Queen Anne District Council	Water Resource Inventory Areas (WRIAs) 8 and 9
Manufacturing Industry Council	Washington State Dept of Ecology
Montlake Landfill Oversight Committee	Washington State Dept of Health
Muckleshoot Tribe	Washington State Dept of Transportation
National Oceanic and Atmospheric Administration	Waste Action Project
North Seattle Industrial Association	West Crown Hill Sidewalks
Norwegian Commercial Club	Whittier Heights Community Council
Olympic Manor Community Club	U.S. EPA
	WA State Dept of Ecology

Presentations at events, including:	King County Wastewater Treatment Division presentations including CSO information:
EOS Alliance: Urban Green Infrastructure Forum Port of Seattle Waterfront Workshop: Environmental Leadership, Stewardship and Collaboration King County CSO Control Program: Environmental Priorities Workshop King County Treatment Technologies Workshop 2011 Western WA Regional Short School Lynnwood Seattle Public Utilities Sounding Board Sustainable West Seattle Community Forum City of Seattle Restore Our Waters 2011 Seattle Watersheds Forum	Throughout King County - Educational events and treatment plant tours explaining wastewater system and CSOs *Including:* Ballard Seafood Festival, Seattle Duwamish River Festival, South Park Fremont Fair, Seattle Environmental Health Fair, South Park

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Comment Letters Received on the 2011 Wastewater Treatment Division Recommended CSO Control Plan

EMAIL:
From: Glenn Martin [mailto:gmartin@greasetrap.ca]
Sent: Friday, October 21, 2011 7:30 PM
To: CSO, Review
Subject: King County's clean-water utility is seeking public review
Dear Dana,
My CSO suggestions.
This process must start at the root ... and continue to improve

1. Grease Trap Ordinances
2. Enforce them.
3. Ban grease trap additives, chemicals, and bacterias.
4. Encourage grease recovery devices

Better grease recovery
Grease is recycled
No more sewer and pump costs.
Restaurants save money in the long run.

Glenn Martin
Goslyn Ontario
www.greasetrap.ca
416 377 0906

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STATE OF WASHINGTON
DEPARTMENT OF ECOLOGY
PO Box 47600 • Olympia, WA 98504-7600 • 360-407-6000
711 for Washington Relay Service • Persons with a speech disability can call 877-833-6341

November 29, 2011

Ms. Pam Elardo
Director, Wastewater Treatment Division
King County, Dept. of Natural Resources and Parks
KSC-NR-0501
201. S. Jackson Street, Room 501
Seattle, WA 98104-3855

Re: *Recommended Combined Sewer Overflow Control Plan, October 2011*

Dear Ms. Elardo:

The Washington State Department of Ecology (Ecology) recently received the King County (County) Wastewater Treatment Division's *Recommended Combined Sewer Overflow Control Plan (October 2011)*. In this document, the County requested public input regarding the proposed combined sewer overflow (CSO) control plan with received comments to be shared with King County Executive Dow Constantine. The purpose of this letter is to provide comments on the County's proposed CSO control plan to the County's Department of Natural Resources and Parks and to the King County Executive.

King County is required under State regulation (WAC 173-245-020[22]), to reduce CSOs on average to no more than one untreated discharge per outfall per year. On September 13, 2011, Ecology and the County jointly agreed via Administrative Agreed Order 8724 to ensure that CSOs from all of the County's CSO outfalls are reduced on average to no more than one untreated discharge per outfall per year by December 31, 2030. However, the County's recently issued *Recommended CSO Control Plan* lists three different schedules for CSO correction projects with end dates in years 2030, 2035, and 2040. Ecology views CSO correction end dates that extend beyond December 31, 2030, as unacceptable and in direct conflict with the recently signed Administrative Agreed Order. In addition, CSO correction project end dates in years 2035 and 2040 do not meet the State law (RCW 90.48.480) requirement of "the greatest reasonable reduction of combined sewer overflows at the earliest possible date". For the above reasons, Ecology would not be able to approve the County's CSO control plan if it contains construction completion end dates beyond December 31, 2030. A County CSO control plan that goes beyond the established completion construction date in the Administrative Agreed Order 8724 could not, on its face, be approved by Ecology and I am dismayed by King County's statements in the *Recommended CSO Control Plan* which are in direct conflict with the Agreed Order.

The *Recommended Combined Sewer Overflow Control Plan* lists joint projects with the City of Seattle. As you are aware, the City of Seattle has an Agreed Administrative Order to meet the requirements of WAC 173-245-020(22) by December 31, 2025. The schedules contained in the County's plan for joint projects with the City extend beyond the date for the City to be under control. Ecology advises the County to revise joint project timelines to meet the City's end date for CSO correction. Otherwise, the County's proposed joint project timelines puts another entity at legal risk.

We appreciate this opportunity to comment on the County's *Recommended Combined Sewer Overflow Control Plan* and we anticipate that the final *Combined Sewer Overflow Plan* will be a document consistent with all governing documents such as Agreed Order 8724 . If you have any questions or concerns, please contact Mark Henley, Interim Municipal Unit Supervisor, at 425-649-7103.

Sincerely,

Kelly Susewind, P.E., P.G.
Water Quality Program Manager

Enclosure: Agreed Order 8724

Cc: Mr. Dow Constantine, King County Executive
Ms. Christie True, Director, Dept. of Natural Resources and Parks
Ms. Trish Rhay, Seattle CSO Program Director
Mr. Robert Grandinetti, EPA
Mr. Kevin Fitzpatrick, WQ Section Manager, NWRO
Mr. Mark Henley, Interim Municipal Unit Supervisor, NWRO
Ms. Amy Jankowiak, Compliance Specialist, NWRO

EMAIL:

From: Steven Richmond [mailto:gardencycles@hotmail.com]
Sent: Tuesday, December 13, 2011 10:16 AM
To: CSO, Review
Subject: CSO suggestions

Hello King County Executive Dow Constantine:

I'm sure KC's CSO plan solidly addresses stormwater, but I want to ask that you analyze what I consider to be the low-hanging fruit of stormwater mitigation, that is, forest health, including soil health. In Seattle at least, the urban forests are primarily deciduous, and this doesn't intercept much rain in winter. And the funding mechanisms of the Green Seattle Partnership dictate that restoration is acre-by-acre, using manual grubbing methods that promote erosion and reinfestation of invasives. It's an inefficient use of diminishing monies when we should be addressing survival rings for ivy that continues to choke city trees, and we need to get evergreen conifers growng ASAP. 2/3rds of densely-polluted city forest remain unplanted with conifers, but watersheds upstream need reforestation as well, particularly lands surrounding the Green River.

Also, much of our needed tree canopy is on private land, so we need to motivate landowners to increase tree/shrub canopy, reduce invasive seed sources, and manage their roof runoff with raingardens and cisterns. This could be done by applying the Public Benefit Rating System to properties of all sizes to offer owners opportunities to reduce property taxes to offset increases in stormwater/utility fees.

Thank you for your consideration.

Steven Richmond / Garden Cycles
GARDEC*932JF; http://gardencycles.com
(206) 650-9807; FAX (206) 763-0144

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UNIVERSITY OF WASHINGTON

OFFICE OF REGIONAL AND COMMUNITY RELATIONS
Aaron Hoard, Deputy Director

December 22, 2011

Dana West
King County Wastewater Treatment Division
KSC-NR-0505
201 S. Jackson St.
Seattle WA 98104-3855

RE: University of Washington Comments on the King County WTD Recommended CSO Control Plan

Dear Ms. West:

The University supports King County's goal of reducing combined sewer overflow events into Lake Washington and elsewhere. We appreciate your willingness to brief us on these plans early and your interest in exploring Green Stormwater Infrastructure to mitigate the need for these facilities.

The proposed boundaries for locating the University CSO Storage Tank include significant portions of University property. As you can image, locating such a facility in this area is something we would prefer not happen. However, if there is no other place to put it, there are a number of issues King County must consider if a tank is located on this property.

Montlake Landfill Area

A significant portion of the area identified for locating the University CSO Storage Tank was operated by the City of Seattle as a municipal garbage dump from 1926 through 1964. This landfill received between 40% and 60% of the city's garbage and biodegradable and non-biodegradable debris during its operation. Garbage depths are up to 12.2 meters in places with a cap of soil over the top of approximately 0.61 meters. Underneath the garbage is a significant layer of peat that ranges between 6.1 and 12.2 meters in depth. The water table also presents challenges in this area is it lies within 0.6 meters or less of the surface over a large portion of the landfill. Please see ***Attachment 1*** (Montlake Landfill Report, 1999) for more details and estimated landfill boundaries.

Numerous factors will need to be taken into consideration if a CSO storage tank is built in this area, including, but not limited to:

1. Structures built on the landfill or peat will need to be placed on pilings to avoid settlement issues.
2. Digging into the landfill will require proper disposal of the garbage, including contaminated soil or groundwater which may need to be disposed of as hazardous waste. Workers will need to have HAZWOPER training to work with this material.
3. Because of the high water table, dewatering issues will need to be considered for any structures built underground.
4. Methane mitigation will also need to be factored into the design. Please see ***Attachment 2*** (Montlake Landfill Methane Action Plan, 2008) for more information about this topic.

University Current and Planned Uses

There are a number of facilities and areas within the CSO storage tank planning area that support University educational and athletic activities. These include the Ceramic and Metal Arts Buildings, Union Bay Natural Area, Environmental Safety Buildings, Golf Driving Range, Intramural Activities (IMA) Building, IMA sports fields, soccer field, and Chaffey Field. Please see ***Attachment 3*** (Campus Map) for locations. Access and use of these facilities must be accommodated both during construction and after. Odor control will need to be included to minimize impacts on these areas.

The University has permits in hand to build a new Track and Field facility just north of the soccer fields in 2012. Its placement necessitates construction of a new Intramural Activities Field just east of the Golf Driving Range. This relocated IMA field will be lighted and have synthetic turf. Please see ***Attachment 4*** (IMA/Track Replacement Map, 2011) for specific locations. There has been a significant loss of IMA field space over the years, so it will be important to preserve the remaining field space to support ongoing student outdoor sports activities and events.

Special consideration will need to be given to the Emergency Helistop located just south of the Golf Driving Range. This helistop is a critical facility that serves both the University Medical Center and Children's Hospital. 24-hour access must be maintained to this facility and it cannot be moved or altered.

King County should also be aware of the numerous underground utilities that run under campus. ***Attachment 5 (a-g)*** contains maps showing many of these utilities.

A significant portion of the CSO storage tank planning area includes the University's E1 parking lot. This lot provides parking for daily university operations, as well as much needed parking for football and basketball games. Revenues from this lot support the university's transportation operations such as UPASS and Intercollegiate Athletics on game days. If this parking lot is selected for the tank location, the University must be compensated for any lost revenues as a result of construction or long-term parking loss. It is the University's preference that any construction activities be timed so as not to impact University operations. This might be accomplished by limiting construction to the period of time between graduation in June and the first football game in the fall.

Union Bay Natural Area

The CSO storage tank planning area also includes a significant portion of the Union Bay Natural Area. This is a public wildlife area, natural restoration laboratory, and an important habitat next to Lake Washington. At 74 acres, with 4 miles of shoreline, it is the second largest natural system left on the lake. Considered one of the best bird-watching sites in the city of Seattle, over 200 species of birds have been sighted here.

If this area is selected for the storage tank, King County will need to work closely with the UW College of the Environment, School of Forest Resources, and UW Botanic Gardens to make sure that research and recreational opportunities are not impacted by the tank's construction and operation. The Washington State Department of Transportation is also proposing to make improvements to this area as mitigation for the SR 520 Bridge Replacement and HOV Program. It will be important to make sure that the storage tank does not impact this mitigation work.

Due to potential disruption by the construction, compensation should be considered for the activities of recreation, research, and teaching.

Please see the Union Bay Natural Area and Shoreline Management Guidelines (***Attachment 6***) for more information.

Storage and Conveyance Tunnel beneath Lake Union

The University would like to thank King County for not moving forward with Alternative N-3a (Joint SPU/King County Storage and Conveyance Tunnel from University Regulator to 3rd Avenue West Regulator; Storage and Conveyance Tunnel beneath Lake Union). The University has strong concerns about the impact this project would have on Husky Stadium and the UW Medical Center. This alternative's proposed construction start date would happen just after this area of campus has already undergone years of impacts from Sound Transit construction, the stadium rebuild and SR-520 replacement. The University would not welcome lengthening the period of time when heavy construction occurs in this area. Further, there will be a number of new facilities and structures in the area that will be difficult to build around. In short, the University does not want to see this alternative move forward and is thankful that it is not in the recommended plan.

Thank you again for allowing us to comment on this plan. If you have any further questions, please feel free to contact me directly. I can also arrange additional meetings with UW faculty and staff if that would be helpful.

Sincerely,

Aaron Hoard
Deputy Director
UW Regional & Community Relations

CC: Montlake Landfill Oversight Committee

Attachments:

1) Montlake Landfill Report, 1999
2) Montlake Landfill Methane Action Plan, 2008
3) UW Campus Map
4) IMA/Track Replacement Map, 2011
5) Campus Utilities Maps
    a. Utilities Record Composite Plan (1-7)
    b. Utility Tunnels
    c. Methane Mitigation System
    d. Montlake Landfill with Settlement Stations
    e. Street Lighting (1-7)
    f. Irrigation Systems (1-6)
    g. Montlake Landfill Methane Monitoring
6) Union Bay Natural Area and Shoreline Management Guidelines, 2010

PEOPLE
F O R
PUGET
SOUND
pugetsound.org

December 28, 2011

Karen Huber
CSO Control Program Manager
King County Wastewater Treatment Division
201 South Jackson Street
KSC-NR-0512
Seattle, WA 98104-3856
Via Email: karen.huber@kingcounty.gov, review.cso@kingcounty.gov

RE: King County 2011 Wastewater Treatment Division (WTD) Recommended Combined Sewer Overflow (CSO) Control Plan

Dear Karen,

Thank you for the opportunity to provide comments on the *King County 2011 Wastewater Treatment Division (WTD) Recommended Combined Sewer Overflow (CSO) Control Plan*, dated October 2011, and associated documents. We also appreciate the extensive amount of outreach you have conducted with us and other stakeholders.

People for Puget Sound is a nonprofit, citizens' organization whose mission is to protect and restore the health of Puget Sound and the Northwest Straits.

Background
Combined sewer overflow (CSO) systems are designed to discharge untreated wastewater and stormwater directly from CSO outfall pipes into water bodies during heavy rainstorms when sewage treatment plants are overwhelmed. Fifteen percent of King County's service area has combined sewers. The outfalls all are located in the City of Seattle. King County owns 38 and the City of Seattle owns 90 CSO locations. On average over the long term, about 350 overflows occur from King County CSOs each year with a total average annual volume discharged of about 800 million gallons.

Proposal
King County plans to control all King County CSO locations to an average of no more than one overflow per year at each location at a cost of $711 million (in 2010 dollars) over 20 years. To meet this goal, they propose constructing nine projects in the Lake Washington Ship Canal area and in industrial areas near the Duwamish River. They are recommending that the projects in the Duwamish River area be finished first to support ongoing regional efforts to clean up the river. They are recommending that the projects incorporate green stormwater infrastructure where possible and that they meet the schedule recommended in previous plan updates to complete all projects by 2030.

Our comments follow:

- **Overall plan.** We commend King County for your leadership in addressing CSOs in an aggressive manner. We also appreciate your effort to save money by working with the

City of Seattle on joint projects, where possible, over time. People For Puget Sound supports reducing pollution to Puget Sound by reducing inputs from CSOs. Although toxic loading studies to the Sound show that CSO do not contribute large amounts of toxic chemicals to the Sound when viewed as a whole estuary, locally CSO are a major problem. Toxic chemicals associated with CSO outfalls have accumulated in the sediment at numerous toxic cleanup sites, often in environmental justice communities. Unfortunately, this ongoing source recontaminates areas where we are investing hundreds of millions of dollars to conduct sediment cleanup. In the King County CSO flows, numerous persistent bioaccumulative chemicals occur at significant levels. These chemicals come from the industrial users in the system as well as from households and street runoff.

- **Green infrastructure.** People For Puget Sound strongly supports the use of green infrastructure to control pollutants associated with stormwater, including that contributing to CSOs. We hope that King County will continue to push the envelope in developing green infrastructure techniques and incorporating those in the CSO areas. There is ample evidence that green infrastructure is more cost effective over the long-term.

- **Source reduction.** We do not feel that the County has been aggressive enough in helping reducing sources of toxic pollutants to CSOs (and to the wastewater system).

    - We believe there should be more comprehensive sampling of the entire system in order to better determine locations with higher levels of toxic chemicals.
    - King County could be more of a partner in product investigations and subsequent product regulatory or policy work to reduce these chemicals at the state level. King County <u>has</u> been a leader in the effort to reduce medicine/pharmaceuticals, but we have not seen a similar level of effort for other chemicals of concern for Puget Sound.

- **Advanced treatment.** We applaud King County for doing rigorous studies of advanced techniques to treat CSO discharges and incorporating this into your plan.

- **Duwamish first.** We support the change in schedule so that the Duwamish projects will be constructed earlier in the sequence. Given the huge amount of resources directed towards the Superfund cleanup, it is imperative that these CSOs be controlled soon.

- **Ship Canal.** We believe that the Ship Canal will be the focus of significant cleanup efforts starting within the next decade and therefore it is important to control those CSOs as soon as possible.

Thank you for your consideration. You can reach me at (206) 382-7007 (X172) or htrim@pugetsound.org.

Sincerely,

Heather Trim
Director of Policy

From: West, Dana
Sent: Wednesday, December 28, 2011 5:49 PM
To: Huber, Karen; Phillips, John
Subject: FW: Comments on CSO Control Program Review

I think our mail system for the CSO review email address is working fine.
Dana

From: CSO, Review
Sent: Wednesday, December 28, 2011 1:15 PM
To: West, Dana
Subject: Comments on CSO Control Program Review

Submitted from:
http://www.kingcounty.gov/environment/wastewater/CSO/ProgramReview/CommentForm.aspx
Submitted at 1:15:40 PM, on Wednesday, December 28, 2011

My comment:

comment: Thank you for the opportunity to comment on the CSO plan.
As a past staff person for the Duwamish River Cleanup Coalition, and current adjunt faculty in the Antioch University - Seattle B.A. Environmental Studies program, I am keenly aware of Seattle's environmental health issues regarding stormwater and CSOs. I am going to have my students read the plan during Winter quarter, and even though it's too late to comment officially, they can still send comments to you with their ideas.

I support your decision to recommend putting the Duwamish River projects first, to be on track with the ongoing Superfund cleanup of the river's sediments. I also highly support your decision to include Green Stormwater Infrastructure where possible, and that you complete the projects by 2030.

GSI systems should also be included in the shoreline areas targeted by the WRIAs for shoreline restoration (bioretention areas mimicing marshes, roadside swales, etc.) especially in neighborhood areas (such as South Park, University, Montlake, Ballard) to use as public demonstration sites.
Also, the proposed treatment plants and other built structures should also employ GSI technologies to the buildings themselves (green roofs, bioretention swales in parking areas, etc.) on all the impervious surfaces, and use these as educational sites (much as how the other treatment facilities also have educational components).
The City of Seattle has also been updating their shoreline master plan, and the County's CSO plan should be aware of the opportunities presented to site or not site facilities, based on that process.
The WTD should also support the addition of GSI systems through incentives, for other efforts within the basins, such as by businesses, municipalities, NGOs or groups of citizens.

As far as the costs, I think that the added $2.06 per month average (2010 dollars) added to ratepayers' bills is a fair increase, considering that the improvements will have a cumulative effect with other improvements (reduction of chemicals and other contaminants going into the system, citizen awareness and education about their role in reducing toxins to the environment, and community supported grants and other programs to improve water quality).

People want to be involved in making decisions about improvements to where they live. Maybe if you show the rate increase in the form of comparable costs (a morning latte, a gallon of gas, a loaf of bread, etc.) and also the longterm economic and environmental improvements to the food chain that will come from this added expense (easy-to-understand cost-benefit analysis), might help frame the improvements in a way that average citizens can understand. A

$4.00 latte or gallon of gas does nothing for the environment, but the same amount spent on future built environmental upgrades will have far-reaching improvements. People need to see this displayed visually.

Thank you again for the chance to comment and add suggestions.

first_name: Cari

last_name: Simson

e-mail: crsimson@gmail.com

User IP Address:184.78.162.6
User Software Client:Mozilla/5.0 (Windows NT 6.1) AppleWebKit/535.7 (KHTML, like Gecko) Chrome/16.0.912.63 Safari/535.7

Ballard Stormwater Consortium

Comments on King County Wastewater Treatment Division's 2011 Recommended Combined Sewer Overflow Control Plan

December 30, 2011

Thank you for this opportunity to provide comments on King County Wastewater Treatment Division's 2011 Recommended Combined Sewer Overflow Control Plan. We appreciate the effort that King County is making to engage the public in addressing Seattle's CSO problems.

We are submitting comments on behalf of the Ballard Stormwater Consortium. We are a committee of Ballard residents who are concerned about the impacts of stormwater and combined stormwater/sewer systems upon Salmon Bay and Puget Sound. Our focus is primarily on watersheds in the geographic area of Ballard and North Beach. We are offering our comments based on our review of the Wastewater Treatment Division's October 2011 Recommendations, particularly as they relate to those watershed areas. Our comments are also based on our recent review of the City of Seattle's Combined Sewer Overflow alternatives. Two of the City of Seattle's three alternatives involve partnering with King County.

General Comments

- We strongly believe that an integrated approach is needed in addressing Ballard's CSO and stormwater problems. The agencies and programs within agencies that work on these issues should be working together and planning together. Some parts of Ballard are managed by Seattle Public Utilities; other parts are managed by King County. The combined sewer overflows (and the stormwater from non-combined systems) all end up in the same place---Salmon Bay and Puget Sound. Because of this, King County and the City of Seattle should work together to address these problems. A coordinated effort by both agencies can only enhance each other's efforts.
- King County is to be commended for doing a thoughtful review of possible options and recommendations, and for inviting input on all 32 options that were considered. However, we are disappointed that King County's final recommendations do not include the consolidated Ship Canal storage tunnel that is one of Seattle's main alternatives, nor does the timing of King County's collaborative projects (2030 at the earliest) align with the City of Seattle's timing for the joint County-City alternatives (2025). Although both issues are noted in the Recommendations document (pages 10 and 12), we think King County's final recommendations should clearly state that the recommendations are based on current information and that King County will continue to work with the City of Seattle to evaluate the joint consolidated tunnel project.
- We take issue with use of the term "green infrastructure" to differentiate raingardens, green roofs and other "natural drainage" systems from other methods of reducing or eliminating combined sewer overflows (e.g., storage, CSO treatment, conveyance, sewer separation). From our perspective, any of these methods is green if proper implementation results in reducing/eliminating contamination of Puget Sound, Salmon Bay and other water bodies.
- Based on our own experience with the Ballard Roadside Raingardens, we are concerned that many factors affect and limit the use of "green infrastructure" and "natural drainage" strategies**.** While appealing in concept, this strategy has potential pitfalls given the geographic/geologic/soil conditions throughout the City of Seattle (e.g., mostly glacial till throughout Ballard) and many groundwater/perched water unknowns. These conditions vary from block- to-block. In addition, many questions exist as to the cost effectiveness of this approach and how such decentralized facilities will be maintained over time. We are glad to see that King County recommends assessing the potential of GSI, rather than assuming that it will reduce planned CSO control volumes.

Response to Specific Questions

1. **Should we reconsider one of the alternatives evaluated earlier but not recommended?**

   Yes. We are pleased to see that several of the Ship Canal/Montlake Cut area options involve collaboration between King County and the City of Seattle. We think that you should also seriously consider recommending the joint County-City conveyance tunnel under the Ship Canal to control 11th Avenue NW, 3rd Avenue NW, Montlake and University CSO's and seven city CSOs. We ask that this joint tunnel be revised to include some or all of the CSO overflow that is projected from the Ballard area (from Ballard CSO pipes 150/151 and 152.)[1] At a minimum, make a formal footnote that commits King County to continuing to evaluate and pursue this option with the City of Seattle. Failure to do so will render Seattle's EIS process moot.

2. **Should we change the sequence of projects?**

   We would like to see Ballard's CSO issues addressed by 2025, as proposed by the City of Seattle. However, we can support addressing the Duwamish area first, provided that the Ship Canal CSOs including Ballard are addressed no later than 2030.

3. **Which CSO control plan schedule should we use?**

   We support King County's recommendation to control the CSO's in its service area by 2030, although we would prefer to see the CSO's controlled by 2025 given the public health and environmental contamination associated with them. We are not supportive of extending the completion time beyond 2030.

4. **Did we overlook something important?**

   Addressing CSO's is largely a stormwater management problem. The summary documents that we have reviewed do not clearly describe this inter-relationship. Perhaps this has to do with the division of responsibilities between the City of Seattle and King County. From the standpoint of concerned watershed residents, however, it is important to:
   - Address CSO and stormwater drainage issues in an effective integrated manner;
   - Look for ways to treat stormwater as well; and
   - Maximize coordination with the City of Seattle in addressing both stormwater and CSO issues.

We encourage King County to commit to integrated planning, coordination, and project implementation.

Thank you for considering our comments.

Sincerely,

Liz Tennant

Chair, Ballard Stormwater Consortium
7557 28th Avenue NW
Seattle, WA 98117

and the following Ballard Stormwater Consortium members:

Sharon Costello
Kim McDonald
Dana L. Rasmussen
Lynda K. Rockwood
Deb Willard

---

[1] We made the same request to Seattle Public Utilities in our "Comments on the Scope of Seattle Public Utilities' Programmatic EIS for the Combined Sewer Overflow Long Term Control Plan," submitted November 1, 2011.

From: West, Dana
Sent: Tuesday, January 03, 2012 8:13 AM
To: Huber, Karen; Phillips, John
Cc: Peterson, Erika
Subject: FW: Draft Comments on King County's 2011 Recommended CSO Control Plan

Karen-I had sent a background email to you about the Ballard Stormwater Consortium presentation.
Please let me know this morning if that is a helpful accompaniment if/when you forward this as needed, or if you need more information.

Karen and John, if I cannot be present at any discussions about this (I will be there tomorrow and the next day of this week and am here today), please be sure to let me know about discussions that take place regarding this feedback so that I can best work with you.

Erika, we have discussed this.
Dana

From: Andrea Faste [mailto:amfaste@comcast.net]
Sent: Friday, December 30, 2011 4:35 PM
To: West, Dana; Elardo, Pam; Constantine, Dow
Cc: LizTennant@AOL.com
Subject: Re: Draft Comments on King County's 2011 Recommended CSO Control Plan

Thank you for the opportunity to comment on the 2011 WTD's recommended CSO Control Plan.
I recognize the many hours of work that people in your WTD program have spent compiling the technical Memos, their summaries and their recommendations. As a mere college graduate with rather sketchy scientific background, it is impossible for me to comment on the details. I do urge a full, hard look at options provided by Seattle's SPU people regarding their suggested options for the Ballard/Fremont/Montlake areas. As I glanced through the documents, the attachments, and Liz Tennant's very detailed response for which she offered comments, it struck me overall that I could only comment on the presentation itself. The concern for me is that by focusing on costs, cost benefits, and timeline, and telling the public what the cost to them as citizens and property owners might be, there are certain things being overlooked.

This project of containing toxics ought to be addressing the root cause, the toxics in what we put into our bodies, the toxics that increased traffic puts into our roadways. Even more for Puget Sound Country, the reality is that climate change is coming to us in the form of much more intense rain in batches, less and less following the usual gentle drizzle we consider "normal" with extended dry periods in between. This means for storm water and CSO's, the corrections have to be both scientific and also educational. Like flash floods, our water run-off will be intense in big bursts, and the overflows may become more common. Mitigating the problem can also be addressed with education like West Seattle's Toxick program. Children getting a

glimpse of the
future can begin adapting now. If they take the message home to their parents that reinforces the
importance of washing cars in car washes, better yet, riding bikes, that eating less processed
foods and more organic ones, not throwing prescription drugs into the toilet, and helping make
rain gardens we will be miles ahead. We can attack this issue from both sides. This for me is that
unscientific, unmeasurable part of the "triple bottom line" as I understand it. Looking holistically
at the big, big picture and recognizing that mother nature is calling most of the shots these days.

I value my home in Ballard, I love my neighbors, my community and my involvement with
Groundswell NW and Sustainable Ballard. We are trying hard to make Ballard a blueprint for
cooperation, inclusion and awareness of the issues effecting us all. There are people here who
have installed rain gardens, are making a business of using cisterns, and are building homes with
the tiniest footprints imaginable. We also know that Seattle Public Utilities has solutions that
seem more suited to the Ship Canal and Ballard, and are anxious that the County and the City
are really cooperating, not just jostling to be the winners in whose alternative gets selected, or
that worries over money, who pays and how much is really the main factor driving your
decisions. A healthy ecosystem is priceless, we all want it, let's figure out a way that will work
for all of us.
On Dec 28, 2011, at 8:40 PM, LizTennant@AOL.com wrote:

Dear Ballard Neighbors and Friends,

As you may recall, King County Wastewater Treatment Division is asking for public comment on its 2011
Recommended Combined Sewer Overflow Control Plan. John Phillips spoke about this at the December
14th meeting of the Ballard District Council. Public comments received by December 31, 2011 will be
transmitted to County Executive Dow Constantine.

I have drafted the attached comments which I plan to finalize and submit on Friday December 30th.
Please let me know if you have any comments that you would like me to add to this letter and/or
whether you would like me to list you as a signatory.

If you would like to delve into additional details about the King County plan, see the e-mail below from
Dana West of King County Wastewater Treatment Division.

I am anticipating having at least several of you agree to sign this letter, in which case I will replace "I am
submitting" with "We are submitting comments..."

Thanks in advance for your time and your consideration. Please feel free to contact me if you have any
questions.

Best regards,

Liz

Liz Tennant
Chair, Ballard Stormwater Consortium
7557 28th Avenue NW
Seattle, WA 98117

-----Original Message-----
From: West, Dana <Dana.West@kingcounty.gov>
To: West, Dana <Dana.West@kingcounty.gov>
Cc: West, Dana <Dana.West@kingcounty.gov>
Sent: Mon, Dec 12, 2011 1:38 pm
Subject: Update on King County's Long-term CSO Control Plan
Your comments are invited on King County's Long-term CSO Control Plan documents:
The 2011 Summary of Technical Memorandums (Summary), completed Nov. 30, 2011 is a companion to the King County 2011 Wastewater Treatment Division Recommended Combined

Sewer Overflow (CSO) Control Plan issued in October 2011. The Summary, supported by eight
technical memorandums, explains the detail that WTD's recommended CSO Control Plan is
based on.
These were developed to solicit public and agency comment to inform the future 2012 Executive's Preferred CSO Control Plan and 2012 CSO Control Program Review Report.
Together these will recommend changes to the County's Long-term CSO Control Plan and will
be submitted to the King County Council and the public in the spring of 2012.
Resulting adopted changes to the Long-term CSO Control Plan will be incorporated into the 2012
Long-term CSO Control Plan Amendment to be submitted to the Washington State Department
of Ecology and the United States Environmental Protection Agency in fall of 2012.
Learn more:
*   ?Our staff, documents and web pages are available to provide detailed information about the proposed
projects.
*   ?You can also go to selected King County and Seattle libraries and the Ballard Neighborhood Service
Center to read the documents in print. Libraries also have computers to use to read the document online.
For more information scroll down the following Web page:
www.kingcounty.gov/environment/wastewater/CSO/ProgramReview/Plan/Commenting.aspx
*   ?Information about this project is also available in Spanish, Korean, Chinese and Vietnamese. See contact
information below.

Please let us know your thoughts and opinions about our recommended plan. Comments received
by Dec. 31, 2011, will be used to help shape Executive Constantine's recommendation to the County
Council.
*   ?Our Web pages highlight how you can comment and become more involved.

<image001.jpg>

Thank you for your interest in this information.

Dana West
King County Wastewater Treatment Division
Community Services and Environmental Planning
206-684-1097

www.kingcounty.gov/CSOReview

<Draft_Comments_on__King_County_CSO_Plan_Update_12.28.11.doc>

"In the end we will conserve only what we love. We love only what we can understand. We will understand only what we are taught." -- Baba Dioum, 1968

MWPAAC

Metropolitan Water Pollution Abatement Advisory Committee

King Street Center, 201 South Jackson Street, MS KSC-NR-0512
Seattle, WA 98104 206-263-6070

April 4, 2012

Pam Elardo, P.E., Director
Wastewater Treatment Division
King County Department of Natural Resources
KSC-NR-0501
201 South Jackson Street
Seattle, WA 98104-3855

Dear Ms. Elardo:

The Metropolitan Water Pollution Abatement Advisory Committee (MWPAAC) offers the following comments on the King County Wastewater Treatment Division's (WTD) Recommended Combined Sewer Overflow (CSO) Control Plan released in October 2011. Two concerns that MWPAAC has are the viability of Green Stormwater Infrastructure (GSI) and the rate impacts associated with the compliance deadline.

We reviewed the selection of nine projects to control overflows at 14 CSO control locations. MWPAAC supports the recommended project sequence that prioritizes the Duwamish River/Elliott Bay area projects first and the potential implementation of GSI projects before building CSO storage or treatment facilities. In addition, MWPAAC supports the concept of joint CSO projects with the City of Seattle, but requests that WTD ensure appropriate and equitable cost allocation between the City and WTD, including future obligations and liabilities. Also, WTD should develop a better definition of future GSI financial and operational responsibilities with MWPAAC's input.

With respect to GSI projects, MWPAAC has reservations given that GSI is a relatively new technology and as such lacks a proven history. Prior to full-scale implementation of GSI, WTD should carefully evaluate whether the technology is viable at the proposed location given the specific geological conditions. The cost effectiveness of GSI is potentially a concern. Therefore, it is important that there be an accurate estimate of lifecycle costs associated with GSI projects and also an evaluation of the effectiveness of GSI based on the cost of operations and maintenance. When selecting a preferred alternative, WTD should consider the wider range of uncertainties in costs with GSI (e.g., decreasing performance, operations and maintenance, future liabilities, etc.).

MWPAAC recommends that WTD reconsider the completion date of 2030 for CSO projects, which is current policy and required for compliance by the Washington State Department of Ecology. Rate impacts vary with the completion date and MWPAAC would like WTD to re-evaluate extending the compliance date from 2030 in order to lessen the sewer rate impacts recognizing the other demands to fund water quality projects in the region. MWPAAC acknowledges the regulatory agencies may oppose such an extension for completion of the CSO projects. However, the Puget Sound region can only afford so much and funds should be prioritized to allow for investments in other water quality projects in the region. Jurisdictions across the country have negotiated extensions of compliance dates for CSO control programs based on affordability. MWPAAC recommends WTD explore extending the 2030 compliance date with the regulators.

In summary, MWPAAC supports WTD's recommended CSO Control Plan Update, but urges caution regarding the potential use of GSI until the technology is proven to be cost effective and also recommends extension of the 2030 compliance date to allow for the best investments to improve water quality with finite resources.

Sincerely,

Scott Thomasson
Chair

cc: MWPAAC Members

Appendix G

Rate Forecasting and Affordability

King County Wastewater Treatment Division (WTD) maintains models of revenue and financing requirements for forecasting near-term and long-term sewer rates and scenarios. These models were used to develop the forecast scenarios for the project sequences and schedules presented in Chapter 7 and Chapter 8 of this report. The financial and rate impacts were determined by comparing the rates forecast for the No Action Alternative (no future CSO control projects beyond those that are currently underway) to various scenarios with additional CSO control projects. A recommended project sequence and schedule was selected from this analysis.

This appendix describes how additional CSO expenditures affect capital funding and operating costs which, in turn, affect WTD's future sewer rates. For simplicity, the description explains changes for the King County Executive's Recommended CSO Control Plan for two years: 2016 and 2025. In 2016, the impacts of the County's Long-term CSO Control Plan (Plan) are relatively modest. In 2025, the cumulative impacts of the Plan are closer to the full impact realized at the completion of the Plan in 2030. This appendix also summarizes assumptions used for the rate forecast for variables such as capital expenditures, customer growth, and interest rates.

Sources of Capital Funding

The estimated project cost of the Plan ($711 million) will be initially funded by a combination of additional borrowing and direct funding of the added capital expenditures via increases in the sewer rates that WTD charges 35 component agencies for wastewater treatment and conveyance services.

WTD's principal form of borrowing is issuance of revenue bonds. The tax exempt bonds are backed solely by the revenues of the WTD as an Enterprise of King County. Ratings on the most recent WTD revenue bond issue (October 2011) were AA+ by Standard & Poor's and AAA by Moody's. The forecast assumes a term of 40 years for repayment of debt service on the bonds.

Table G-1 illustrates the effect of the recommended Plan on WTD's capital funding needs. In 2016, additional Plan capital expenditures of $23.1 million result in $25.1 million in total uses of funds after including debt issuance costs and a deposit to the bond reserve. The added costs are required for $24.1 million in additional revenue bonds. Additional funds are provided through a $1.0-million transfer from the WTD operating fund.

These revenue sources also fund the cost of issuing bonds and a $1.6-million deposit in WTD's bond reserves. As a protection to holders of municipal debt, public agencies that issue bonds backed by customer revenues agree to maintain bond reserves equal to the annual debt service on the revenue bond issues. Additional requirements governing the amounts of the transfers from the WTD operating fund are discussed in the following section (Determination of Rate Impacts).

The components of CSO capital funding are similar for the year 2025. An additional $79.6 million in capital expenditures result in $85.5 million in total uses of funds after including debt issuance costs and a deposit to the bond reserve. The added costs support funding from $69.2 million in additional revenue bonds. Other funding sources include $6.7 million from an operating fund transfer and $9.6 million from a variable rate bond issue. WTD follows a policy of maintaining a level of variable rate debt equal to 15 percent of outstanding debt on revenue and general obligation bonds.

The County has other sources of financing than those listed above. Included in these alternative sources of funding are:

- Limited Tax General Obligation bonds. These bond issues are backed by both the County's general taxing authority and WTD revenues. Future use of general obligation bonds depends on the County's total capacity additional debt obligations and the potential savings from slightly lower interest rates on general obligation bond issues. The scenarios do not assume any future use of general obligation bonds.

- Grants and low interest loans from the Washington State Revolving Fund or Public Works Trust Fund. These alternatives have been and will likely continue to be important capital funding sources for WTD. However, given the competitive process and uncertainty regarding their availability, amounts, and timing, no further funds from these sources have been assumed in the scenarios.

Table G-1. Long-term CSO Control Plan Capital Funding, 2016 and 2025

Changes to the Construction Fund	2016 ($ x 1M, with Inflation)	2025 ($ x 1M, with Inflation)
Uses of Revenues		
Capital Expenditures	($23.1)	($79.6)
Debt Issuance Costs	($0.5)	($1.4)
Deposit to Bond Reserves	($1.6)	($4.5)
Total Uses of Revenues	($25.2)	($85.5)
Revenue Sources		
Revenue Bonds	$24.1	$69.2
Variable Bonds		$9.6
Transfers from Operating Fund	$1.0	$6.7
Total Revenues	$25.1	$85.5

Determination of Rate Impacts

The additional costs associated with future CSO control projects under the King County Executive's Recommended CSO Control Plan will be ultimately recovered through increases in the sewer rate, which account for approximately 80 percent of WTD's total revenues. Other sources of revenue include interest income and surcharges on high strength industrial waste discharges. Changes in interest income associated with the CSO control alternatives have a limited indirect effect on the sewer rate. WTD's other revenue sources including the capacity charge levied on new connections to the system, which contribute no additional funding for future CSO control projects.

Table G-2 illustrates the impact of the Plan on revenues that must be recovered from the WTD sewer rate. There are three major elements to the rate impacts including:

- Costs of operating and maintaining the new CSO control facilities (operations and maintenance costs); the first CSO control project is completed by 2020, and a sufficient number of CSO control facilities are completed by 2025 to add $2.3 million to WTD's annual operating costs.
- Debt service on bonds issued to pay for the cost of building CSO control projects. Bond-funded CSO capital expenditures are sufficient to increase debt service to $7.1 million in 2016 compared to the No Action Alternative. By 2025, the CSO capital program has added $37.7 million to WTD's debt service.
- An increase in the transfer of funds from operating revenues to the construction fund. The increase in the transfer to construction is due to bond covenants established for revenue bonds that commit WTD to setting rates high enough to keep operating revenues equal to at least total debt service plus 15 percent, also referred to as a coverage ratio of x1.15. Revenues must also meet a coverage ratio requirement of x1.25 on debt service for revenue and general obligation bonds (excluding debt service on subordinate bonds). Total debt service on all Plan capital expenditures results in a $5.7-million increase in the required construction fund transfer in 2025.

In addition to the main elements, additional bond reserves required for revenue bonds issued to fund CSO control projects generate additional investment income. In 2025, the additional interest earnings reduce total revenue requirements by $2.8 million.

The rate impact of the additional revenues needed to support the Plan is computed by dividing the Plan expenditures by Residential Customer Equivalents (RCEs), the unit of measure (equal to 750 cubic feet per month) for the WTD monthly sewer rate. By 2025, CSO expenditures will require an additional $4.70 per RCE, including inflation.

Table G-2. Long-Term CSO Control Plan Cost Rate Impacts, 2016 and 2025

Changes to the Operating Fund	2016 (with Inflation)	2025 (with Inflation)
Operating Expense		$2.3 M
Debt Service	$7.1 M	$37.7 M
Transfers to Capital	$1.0 M	$6.7 M
Total Uses of Revenues	**$8.1 M**	**$46.7 M**
Less: Investment Income	($0.7 M)	($2.8 M)
Increase in Rate Revenues	$7.4 M	$43.9 M
Increase in the WTD Monthly Sewer Rate	$0.86	$4.70

Forecast Assumptions

The WTD rate forecast requires forecast assumptions for inputs such as operating expenditures, customer equivalents, and interest rates. The version of the rate model used for the CSO rate forecast is the June 2011 budget submittal forecast for the 2012 proposed budget. Key inputs and assumptions for this forecast for the key variables can be summarized as follows:

- *Operating Expenditures:* The forecast assumes that WTD's proposed 2012 budget for operating expenditures escalates at 4.0 percent during 2013-2017 and 3.0 percent after 2017. The rate forecasts include the planned operations and maintenance (O&M) costs for the various Plan alternatives while the No Action Alternative excludes O&M costs associated with future CSO control projects.
- *Capital Expenditures*: Sources and assumptions for capital expenditures are as follows:
  - Capital Improvement Program (CIP) expenditures during 2011-2017 are from the 2012 proposed budget submittal in June of 2011.
  - CIP expenditures after 2017 includes planned projects from the 2006 conveyance system improvement plan update, current assumptions for asset management capital expenditures, and completion of a 20-MGD re-rating and expansion of the South Treatment Plant in 2030.
  - Planned projects not currently underway are excluded from the rate forecast for the No Action Alternative. CIP expenditures associated with the recommended project sequence for CSO control projects are then included in the rate forecast for each scenario.
- *RCEs*: WTD uses demographic and employment forecasts from the Puget Sound Regional Council and assumptions about water use trends to develop a long-term forecast of single-family residential units and multi-family and commercial/industrial customer equivalents. Short-term updates to the long-term RCE forecast are completed semi-

annually to incorporate recent customer trends and the current regional economic outlook. Due to the continuing outlook for a very weak economic recovery, the June 2010 forecast update anticipates a total growth in RCEs during 2010-2017 of only 2.4 percent, an average annual increase of 0.3 percent. The long-term RCE forecast for 2017-2030 is an average annual growth rate of 1.0 percent. Annual RCE growth declines to 0.6 percent during 2031-2040 as the WTD service area becomes fully developed.

- *Capacity Charge Revenues:* Future capacity charge revenues are determined by annual increases in the capacity charge and the number of new customers connecting to the WTD regional sewer system. This revenue source accounts for an average 15 percent of operating revenues during 2011-2030. Under King County's current policies and rate methodology for the capacity charge, CSO expenditures have little or no effect on the capacity charge. Therefore, this revenue source does not contribute to changes in rates among the various Plan alternatives.
- *Interest Rates and Bond Term*: The assumed bond term for revenue bond issues is 40 years, and interest rate assumptions are presented in Table G-3 below.

Table G-3. Interest Rate Assumptions

Description	2011	2012	2013	2014	2015-2040
Revenue Bonds	4.90%	5.50%	5.65%	5.75%	5.75%
Variable Rate Bonds	1.25%	1.25%	2.25%	3.00%	4.00%
Interest on investments	0.55%	0.55%	1.46%	2.49%	3.50%

Affordability of King County Executive's Recommended CSO Control Plan and Financial Capability to Fund the Plan

To have a better understanding of the cost of implementing the Plan, WTD conducted a two-phased analysis of financial capability and affordability of the King County Executive's Recommended CSO Control Plan.

Phase 1 strictly followed guidelines established by the United States Environmental Protection Agency (EPA). The EPA guidelines consider the following:

- Estimating median household income (MHI) for the whole service area
- Unemployment rate measured against the national unemployment rate
- The financial strength of the County and WTD to issue bonds
- Household cost as a function of the costs to treat wastewater

Phase 2 followed EPA guidelines but included supplemental information to better understand the regional diversity of households. Phase 2 considered the following:

- MHI for each census block and percentage of census blocks in the identified income range for different communities and different income groups within WTD’s service area
- Poverty rate of each census block and communities
- Household costs for wastewater services based on both regional and local sewer rates

The Phase 1 and Phase 2 analyses are attached.

King County CSO Financial Capability Assessment and Schedule Development

Phase 1: Apply Current EPA CSO Financial Capability Assessment Guidance to WTD's Long Term CSO Control Plan

***** DRAFT DOCUMENT*****

August 2011

ECONorthwest
ECONOMICS • FINANCE • PLANNING

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For More Information

This report was prepared by Ernie Niemi, Tom Souhlas, and Paul Thoma of ECONorthwest, which is solely responsible for its content.

ECONorthwest specializes in economics, planning, and finance. Founded in 1978, we're one of the oldest independent economic consulting firms in the Pacific Northwest. ECONorthwest has extensive experience applying rigorous analytical methods to examine the benefits, costs, and other economic effects of environmental and natural resource topics for a diverse array of public and private clients throughout the United States and across the globe.

For more information about ECONorthwest, visit our website at http://www.econw.com.

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Acknowledgements

We very much appreciate the assistance we've received from Mark Buscher, Shari Cross, Greg Holman, Tom Lienesch, John Phillips, and Dave White in securing and interpreting the data required to complete this memorandum.

Glossary

CPI	Consumer price index (All Urban Consumers – CPI-U, as reported by the U.S. Bureau of Labor Statistics)
CSO	Combined sewer overflow
CSO Guidance	EPA. 1997. *Combined Sewer Overflows–Guidance for Financial Capability Assessment and Schedule Development.* EPA 832-B-97-004. February.
Ecology	Washington Department of Ecology
EPA	U.S. Environmental Protection Agency
MHI	Median household income
NPDES	National Pollutant Discharge Elimination System, a permit program authorized by the Clean Water Act that the controls water pollution by regulating point sources that discharge pollutants into waters of the United States.
WTD	King County, Wastewater Treatment Division.
WWT	Wastewater treatment

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APPENDIX: FINANCIAL CAPABILITY ASSESSMENTS COMPLETED BY OTHER JURISDICTIONS A-1

I. INTRODUCTION AND BACKGROUND

King County Wastewater Treatment Division (WTD) is currently completing a review of its Combined Sewer Overflow (CSO) Control Plan, an exercise it must complete every five years to secure renewal of its permit to discharge treated wastewater under the Clean Water Act. The review will satisfy requirements established by the U.S. Environmental Protection Agency (EPA) and the Department of Ecology (Ecology), under the provisions of the National Pollution Discharge Elimination System (NPDES) elements of the Clean Water Act. The review examines the assumptions and rationale underlying the plan, including the impacts implementation of the plan would have on ratepayers and an assessment of their financial capability to bear these impacts. This memo describes these potential impacts and presents a financial capability assessment based on guidance (*CSO Guidance*) provided by the U.S. EPA.[1] The memo has these components:

Section II describes the steps required to complete the financial capability assessment following EPA's *CSO Guidance*.

Section III describes approaches other communities across the U.S. have taken to estimate the impact of their CSO plans on ratepayers and assess their financial capability.

Section IV presents the estimates of ratepayer impacts and the Financial Capability Assessment associated with King County WTD's current CSO Control Plan.

II. DESCRIPTION OF EPA'S CSO GUIDANCE

This section describes the approach EPA prescribes in its *CSO Guidance* for preparing a Financial Capability Assessment of a CSO Control Plan. Although the document provides only guidance and is not an official rule, WTD anticipates that EPA and Ecology will want to review a report completed in accordance with the guidance as they develop the 2012 CSO Program Review and 2013 CSO Program Update.

The *CSO Guidance* describes a two-phase approach for assessing financial capability. The first phase examines the financial impact CSO controls would have on the residential ratepayers served by an NPDES permittee, such as King County WTD. Specifically, this phase involves calculating the expected costs of implementing a CSO Control Plan as a percentage of the median income of households in the area covered by the plan. This statistic called the Residential Indicator. The second phase examines how the CSO costs would affect the financial status of the NPDES permittee and the community it serves. This phase involves developing several Permittee Financial Capability Indicators, which evaluate the debt, socioeconomic conditions, and financial management conditions that affect the permittee's financial capability to implement its CSO Control Plan. EPA's *CSO Guidance* indicates that the second phase may not be warranted if the Residential Indicator indicates the CSO costs would equal less than 1.0 percent of the median household income in WTD's service territory. The *CSO Guidance* (p. 19) indicates that, in

[1] U.S. Environmental Protection Agency. 1997. *Combined Sewer Overflows – Guidance for Financial Capability Assessment and Schedule Development. EPA-832-B-97-004. February.*

such circumstances, only "significant weaknesses in a permittee's financial and socioeconomic conditions" would warrant extending the schedule for implementing CSO controls.

EPA's *CSO Guidance* also contains instructions for converting each indicator into a general score: "Low," "Mid-Range," or "High" for the Residential Indicator; "Weak," "Mid-Range," or "Strong" for the Permittee Financial Capability Indicators. When entered into a matrix provided by the *CSO Guidance,* these general scores become the basis for consolidating all the indicators into an overall, Financial Capability Indicator, that characterizes the financial burden of implementing CSO controls on the permittee and the community it serves. The overall indicator characterizes the financial impacts in three categories: "Low Burden," "Medium Burden," or "High Burden." The *CSO Guidance* indicates that EPA and Ecology will use this representation of financial burden to assess the reasonableness of alternative schedules for implementing CSO controls. In general, the higher the financial burden, the greater the likelihood that they will approve a longer implementation schedule. If the results from applying EPA's *CSO Guidance* show that King County WTD's CSO Control Plan would result in a "Low Burden," EPA and Ecology generally would expect WTD to implement CSO projects with a high priority on a normal engineering and construction schedule. If the results show a "Medium Burden" they generally would expect an implementation schedule of up to 10 years might be appropriate. With a "High Burden," they would expect an implementation schedule up to 15 years might be appropriate, although they might negotiate an implementation schedule up to 20 years for an unusually high burden.

Table 1 presents a summary of all the indicators and their respective thresholds for determining their general score.

EPA acknowledges that the financial indicators it specifies in its *CSO Guidance* might not present the most complete picture of a permittee's financial capability to fund CSO controls. The indicators represent the general financial capability of residential ratepayers and the overall community served by a permittee to bear the costs associated with wastewater treatment and CSO controls. The formulas specified by EPA for calculating the indicators are generalized to apply equally across all permittees. As a consequence, they do not capture important differences from one community to the next that affect the actual impacts of CSO controls on a permittee's cash flow, the community's ability to bear these actual costs, or the actual level of residential rates. Accordingly, EPA encourages each permittee to submit documentation, beyond the results from applying the *CSO Guidance*, to create a more accurate and complete picture of its financial capability. It leaves to the permittee the task of determining what documentation is appropriate.

A. The Residential Indicator

The Residential Indicator intends to measure the financial impact on residential consumers of the wastewater treatment (WWT) and CSO costs anticipated by the CSO Control Plan. To calculate the indicator, the *CSO Guidance* calls for using a standardized approach to estimate the average annual costs associated with current and projected

WWT and CSO controls.[2] This amount is multiplied by an estimate of the share of total wastewater flows attributable to residential water users and divided by the total number of households in the service area to calculate the average anticipated WWT and CSO costs per household. This amount, divided by the median household income (MHI) yields the annual WWT and CSO control costs per household, as a percent of MHI.

Table 1. Indicators of Financial Capability Required by EPA's *CSO Guidance*

Residential Indicator		**Financial Impact Thresholds**		
		Low	**Mid-range**	**High**
Annual WWT and CSO Control Costs per Household as a Percent of Median Household Income		< 1%	1% – 2%	> 2%
Permittee Financial Capability Indicators		**Benchmark Thresholds**		
		Weak	**Mid-range**	**Strong**
Debt Indicators	Bond Rating (Moody)	Ba, B, Caa, Ca, C	Baa	Aaa, AA, A
	Bond Rating (Standard and Poor)	BB, B, CCC, CC, C, D	BBB	AAA, AA, A
	Overall Net Debt as a Percent of Full Market Property Value	> 5%	2% – 5%	< 2%
Socioeconomic Indicators	Unemployment Rate (relative to national rate)	> 1% above	Within 1%	> 1% below
	Median Household Income (local relative to national)	> 25% below	Within 25%	> 25% above
Financial Management Indicators	Property Tax Revenues as a Percent of Full Market Property Value	> 4%	2% – 4%	< 2%
	Property Tax Collection Rate	< 94%	94% – 98%	> 98%
Overall Financial Capability Indicator (Based on a formula developed by EPA to consolidate the average scores of individual Permittee Financial Capability Indicators)		< 1.5	1.5 – 2.5	> 2.5

Source: EPA. 1997. *CSO Guidance.*

The top section of Table 1 shows EPA considers that WWT and CSO costs to residential consumers of less than one percent, between one and two percent, and more than two

[2] Actual costs will vary from this estimated amount.

percent of MHI would have a "Low," "Mid-Range," and "High" financial impact, respectively. In its *CSO Guidance*, EPA indicates that a permittee having a low residential indicator score (less than 1.0 percent of median household income) is unlikely to receive approval for an implementation schedule longer than the minimum, unless it can demonstrate significant weaknesses in its financial and socioeconomic conditions.

EPA recognizes that its Residential Indicator might not provide a full and adequate representation of the potential financial impacts of CSO costs on residential consumers. Hence, it states (p. 19 of *CSO Guidance*) that, where a permittee believes there are "unique circumstances" it "may submit documentation of its unique financial conditions" in support of its efforts to receive approval for a longer implementation schedule.

B. Permittee Financial Capability Indicators

EPA's *CSO Guidance* recommends that these indicators be considered only if the Residential Indicator shows that the residential portion of WWT and CSO costs would exceed 1.0 percent of median household income. It identifies six Permittee Financial Capability Indicators. It also includes a method for consolidating them into an Overall Permittee Financial Capability Indicator.

1. Individual Indicators

The *CSO Guidance* splits the six individual indicators into three groups:

- **Debt Indicators.** Intended to assess the current debt burden of the permittee or the communities within the permittee's service area, and their ability to issue additional debt to finance CSO controls.
  - Bond ratings (for general obligation and/or revenue bonds)
  - Overall net debt (debt to be repaid by property taxes in the permittee's service area) as a percent of full market property value in the area

  EPA's *CSO Guidance* prescribes two Debt Indicators to describe the permittee's debt burden and its capacity to issue additional debt to cover CSO control costs. One looks at the most recent bond ratings for the permittee and the communities in its service area. It considers the most recent general obligation bond rating, to describe the financial conditions at the community level, and the most recent revenue bond rating, to describe the financial conditions of the wastewater utility. The other looks at the overall net debt to be repaid by property taxes in the permittee's service area as a percent of full market property value. The percentage indicates the property tax-related debt burden on residents within the permittee's service area and the capacity of local governments to issue new debt.

- **Socioeconomic Indicators.** Intended to assess the general economic well-being of residential ratepayers in the permittee's service area.
  - Unemployment rate, relative to the national average
  - Median household income, relative to the national average

The *CSO Guidance* prescribes two Socioeconomic Indicators: the unemployment rate and the median household income, relative to the national levels for each variable. An unemployment rate lower, or a median income rate higher than the corresponding national average indicates a higher general level of economic well-being, and the reverse indicates a lower level. The *CSO Guidance* also suggests providing other data, e.g., the poverty rate or employment projections, that may shed additional light on the economic well-being of residents in the service area. Where appropriate, the *CSO Guidance* suggests providing circumstantial discussion of past, present, and projected future factors influencing either of the Socioeconomic Indicators.

- **Financial Management Indicators.** Intended to evaluate the permittee's overall ability to manage financial operations.
  - Property tax revenue collection rate
  - Property tax revenues as a percent of full market property value

  The *CSO Guidance* prescribes two Financial Management Indicators to assess the permittee's capacity to manage its finances. One describes the property tax burden, estimated as property tax revenues as a percent of full market property value within the permittee's service area. It represents the permittee's funding capacity based on the wealth of its residents, as indicated by the value of their homes. The other describes the property tax revenue collection rate, to describe the efficiency of the permittee's tax collection system and equals the ratio of property tax revenue collected to property taxes levied.

The *CSO Guidance* suggests that, although the calculation of values for the six financial capability indicators reflects current conditions, a permittee should consider pending changes may affect the values in the future.

2. Overall Permittee Financial Capability Indicator

The middle section of Table 1 shows each of the individual indicators and the benchmark thresholds for assigning them a general, financial capability score: "Weak," "Mid-Range," or "Strong." The *CSO Guidance* assigns numerical values to each of the individual indicators, based on its general score. A "Weak" score receives a value of 1, a "Mid-Range" score receives a value of 2, and a "Strong" score receives a value of 3. The Overall Permittee Financial Capability Indicator equals the average value for the six indicators.

C. Financial Capability Matrix

The *CSO Guidance* specifies a "Financial Capability Matrix" as the tool for integrating the Residential Indicator and the Overall Permittee Financial Capability Indicator and determining if the CSO controls may impose a "Low," "Medium," or "High" financial burden on the permittee. Table 2 contains the Financial Capability Matrix. The *CSO Guidance* indicates (p. 39) that a permittee, EPA, and Ecology will use the level of burden indicated by the matrix "to establish reasonable and workable CSO control implementation schedules." It also states (p. 46-47) that a permittee in the "Low Burden" category would be expected to follow "a normal engineering and construction schedule," but it does not indicate how many years that might entail. A permittee in the "Medium Burden" category might have up to 10 years to implement the CSO controls. A permittee in the "High Burden" category might have up to 15 years (and, in some extreme cases, up to 20 years) to implement the CSO controls.

Table 2. Financial Capability Matrix (Worksheet 10)

Financial Capability Indicator	Residential Indicator		
	Low (< 1%)	Mid-range (1% – 2%)	High (> 2%)
Weak (< 1.5)	Medium Burden	High Burden	High Burden
Mid-range (1.5 – 2.5)	Low Burden	Medium Burden	High Burden
Strong (> 2.5)	Low Burden	Low Burden	Medium Burden

Source: EPA. 1997. *CSO Guidance.*

The *CSO Guidance* states (p. 46) that these burden categories and their scheduling implications do not predetermine the actual schedule for implementing CSO controls: they "are not intended to replace the negotiations and deliberations necessary to balance all of the environmental and financial considerations that influence the site specific nature of the controls and implementation schedules." Instead, they provide a starting point from which the permittee (WTD), EPA, and state authorities (Ecology) should negotiate the schedule.

In addition to the results from the Financial Capability Assessment, the *CSO Guidance* describes several other factors for consideration during the negotiations. These include giving the highest priority to eliminating combined sewer overflows to sensitive areas and high priority to reversing any impairment of use of receiving waters that experience recurring adverse impacts of CSOs on aquatic life, human health, or aesthetics. It also lists three financial factors that are secondary to the assessment of financial capability determined through the calculations specified in the *CSO Guidance*. These include the availability of grants and loans, sewer user fees, and other viable funding mechanisms (such as the establishment of special assessment districts), an increase in user fees, the imposition of or increase in taxes, and the privatization of wastewater treatment. EPA states (p. 47) that "these considerations normally do not have a significant impact on the length of time needed to implement CSO controls."

III. Review of Financial Capability Assessments Prepared by Other Permittees

This section describes the Financial Capability Assessments completed by eleven permittees outside King County:

- Allegheny County, Pennsylvania, Sanitary Authority (2002)
- City of Atlanta, Georgia, Department of Public Works (2002)
- City of Indianapolis, Indiana (2006)
- City of Newport, Rhode Island (2009)
- City of Omaha, Nebraska (2009)
- City of Toledo, Ohio (2009)
- District of Columba Water and Sewer Authority (2002)
- Franklin County, Ohio Division of Sewerage and Drainage (2005)
- Kansas City, Missouri, Water Services Department (2009)
- Louisville and Jefferson County, Kentucky, Metropolitan Sewer District (2009)
- Philadelphia, Pennsylvania, Water Department. (2002)

Overall, each permittee followed the *CSO Guidance* in calculating and presenting the indicators for the Financial Capability Assessment. Three permittees, Allegheny County, the City of Newport and Kansas City, provided only information required to complete the calculations called for in the *CSO Guidance*. The other eight permittees, however, provided additional analyses and discussions clarifying several issues regarding socioeconomic conditions in their respective service areas and the potential impact of CSO costs on households. The following sub-sections describe their additional analyses, arguments, and presentations. Due to extended periods of negotiations with EPA over consent decrees, the extent of the influence that these Financial Capability Assessments have on the period of compliance remains unclear. Results from earlier negotiations, however, indicate that some permittees received relief from EPA due to the results of their Financial Capability Assessments.

A. City of Atlanta, Georgia, Department of Public Works

In 2002, the City of Atlanta, Department of Public works published its *CSO Remedial Measures Plan*. The department generally followed the prescriptions in EPA's *CSO Guidance*, with two exceptions.

- In its calculation of the Residential Indicator, the department concluded (p. 8) that its CSO program "is of such magnitude" that the provisions in the *CSO Guidance* for calculating debt service on the basis of a single debt issue "is inconsistent with requirements for financing a long-term capital program of [this] magnitude." The department substituted a cash flow analysis that assumed bonds, with both fixed and variable rate debt, would be issued every other year, with funds managed in accordance with the City's Strategic Financial Planning model. This approach reduced the Residential Indicator from 2.30 percent of median household income (with the *CSO Guidance* methods) to 2.08 percent. The department argued (p. 9) that, even with this adjustment, the Residential Indicator fell into the "High" financial impact category, "reinforcing the conclusion" that the CSO Control Plan "represents a "High Burden" for the City of Atlanta."

In addition to the core analysis called for in EPA's *CSO Guidance,* the department submitted additional information regarding the Residential Indicator:

- The department calculated the Residential Indicator for the entire service area as well as for households in the service area in the lowest quartile of household income. The results showed (p. 9) the financial burden of anticipated WWT and CSO costs on these households "will more significantly affect poverty and low income families in Atlanta." The department concluded (p. 9) that "This impact on low income ratepayers is a unique financial condition warranting special consideration … as provided in the EPA Guidance (page 10, fifth paragraph and page 36, second paragraph)."

The department has submitted three iterations of their Financial Capability Assessment to the EPA. Despite documenting a "high burden", especially for low-income households that comprise 25 percent of the service area's population, EPA has not extended the department's schedule.[3]

B. City of Indianapolis, Indiana

In 2006, the City of Indianapolis published its *Long Term Control Plan Report*. The city made this adjustment to the methods prescribed in EPA's *CSO Guidance*:

- In addition to calculating the Residential Indicator for the entire service area, the city also calculated the indicator for communities within the service area having relatively low household incomes. The city concluded (p. 6-9) that the anticipated residential portion of the WWT and CSO costs would constitute high burden for residents in these areas.

The city also provided additional information supporting its claim that the results from applying the *CSO Guidance* did not fully reflect the community's financial ability to bear the costs of CSO controls:

- The city provided information (p. 6-14) suggesting that unemployment likely would remain unusually high because of recent closures and downsizing for some key employers and sectors.
- The city explained (p. 6-15) how recent court rulings and actions by the state legislature have resulted in "a real decline in both assessed value and property tax revenue" affecting its financial capability to bear WWT and CSO costs.

[3] National Association of Clean Water Agencies. 2005. *Financial Capability and Affordability in Wet Weather Negotiations*. October.

Based upon this analysis, the city developed a 20-year implementation schedule, which. was approved by the Indiana Department of Environmental Management under the consent decree in 2007[4].

C. City of Omaha, Nebraska

In 2009, the City of Omaha published its *Long Term Control Plan for the Omaha Combined Sewer Overflow Control Program.* The city completed the calculations called for in EPA's *CSO Guidance* assuming that implementation of CSO controls would result in constant annual costs of $100 million. Based on this assumption, the calculations showed that the controls would have a "mid-range" financial impact on residents in the city's service area. In light of this finding, the city discussed three additional issues that may influence the actual burden experienced by residents in the service area:

- In reality, CSO costs would not remain constant, at $100 million per year, but, instead, would fluctuate, with the potential for higher than "mid-range" impacts on ratepayers in years with higher than average costs.
- The recent recession has affected several variables used in calculating many of the financial capability indicators (e.g., costs of bond financing, property tax revenues) that may alter the level of the financial burden resulting from WWT and CSO costs.
- Uncertainty in future financial stability, costs of goods, services and energy make it difficult to project rates into the future, with or without CSO control costs.

For each of these issues, the city described how deviations from the core assumptions it used in accordance with EPA's *CSO* Guidance would affect its findings. The city also discussed existing plans for non-CSO control expenditures that likely would impact future rates, attempts to obtain grants and loans to finance some of these WWT and CSO projects, and the availability of other funding mechanisms for financing CSO controls.

The city expressed (p. 6-5) this overall conclusion: "The [Long Term Control Plan] may meet the affordability criteria as they exist now, but the criteria are flawed and the economy is so unpredictable that all that can be said is that the City should be able to implement the plan through at least 2014. Adaptive management and periodic re-evaluation of financial capability will be necessary in order to determine whether the overall program timeline as currently envisioned can be achieved without external funding."

Omaha's Long Term Control Plan was approved in 2009 and has a 15-year schedule, to complete all projects by 2024.

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[4] City of Indianapolis *Raw Sewage Overflow Long Term Control Plan and Water Quality Improvement Report* September 2006; Approved January 2007

D. City of Toledo, Ohio

In 2009, the City of Toledo published its *Long Term Control Plan Report*. The city modified its calculation of the Residential Indicator and discussed other issues associated with the potential impact of CSO compliance on households in the service area:

- To adjust MHI to current dollars, the city described a method specific to the region (rather than using average change in the Consumer Price Index (CPI), which the CSO Guidance recommends). The city stated that historical data from the U.S. Census Bureau have shown that MHI in Toledo grows less rapidly than the national CPI would suggest. Therefore, the city estimated the current MHI of households in the service area by applying a Toledo-specific adjustment factor to the most recent MHI estimates from the U.S. Census Bureau.
- The city provided a discussion of the potential impact of CSO control costs on low-income populations. The city identified the number of households living below the poverty level in the service area and estimated the Residential Indicator for those households.

The city concluded (p. 16-16) with this statement: "The City of Toledo is a large City in a part of the country where large cities have declining population and households. As a result the costs of the program will be borne by a decreasing number of citizens at the same time as the total costs are increasing rapidly. Total rate increases to fund this program over a period of 13 years are more than double the rates at the beginning of the program. While the EPA affordability criteria identifies the project as a medium burden for the City, the City remains concerned about the impacts of these rates on the citizens and the major industrial users that fuel the economy. "

The consent decree for Toledo allows it to petition US EPA and Ohio EPA to change the compliance schedule if it experiences significant adverse changes to its financial capabilities[5].

E. District of Columbia Water and Sewer Authority

In 2002, the District of Columbia Water and Sewer Authority published its *Combined Sewer System Long Term Control Plan*. The agency described several potential alternatives, with different implementation costs, for meeting CSO regulations. The agency included analyses and discussions on several issues related to income distribution in the service area and the effect of the agency's existing programs on its capacity to finance CSO controls:

- In calculating projected WWT costs, the agency annualized the value of projects outlined in its 10-year Capital Improvement Program. Since the agency's plan evaluated several potential alternatives for controlling CSOs, they used a range of potential CSO control costs ($0, $100 million, $500 million, $1 billion, and $2 billion).

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[5] *USA v. City of Toledo* 3:91:CV7646 United States District Court for the Northern District of Ohio

- The agency summarized its calculations for the Residential Indicator for each of the potential CSO control costs in a table, providing a range of potential Residential Indicators.
- The agency went beyond the prescriptions of the CSO Guidance and calculated the Residential Indicator for low-income households. Household income in the agency's service sector does not follow a normal statistical distribution, but, instead, clusters at low- and high-income levels. To consider the potential impact on the cluster of households in the low-income group, the agency conducted a separate analysis and calculated the Residential Indicator for these households assuming a household income of $18,000 (20 percent of households in the service area have household incomes less than $18,000).
- The agency included a section describing how its current bond rating is higher than the rating of the most recent bonds issues (which the CSO Guidance considers).
- In summarizing the Financial Capability Indicators, the agency provided results from the service area as a whole, as well as results associated with the 20 percent of households with the lowest incomes.
- The agency presented the Financial Capability Matrix categories for each of the potential CSO control costs assessed for the entire service area as well as for the 20 percent of households with the lowest incomes. The agency identified threshold levels of CSO costs that would shift the service area as a whole and the 20 percent of households with the lowest incomes from one financial-burden category to another.
- The agency provided a short critique of the CSO Guidelines. The agency suggested that a more accurate and complete assessment of financial capability must consider the total cost associated with water services as well as WWT and CSO controls, and the distribution of the impacts on different economic groups. To assess these factors, the agency provided a table showing the annual bill in FY 2003, the projected annual bill in FY 2018, and the average annual rate increase over the 15 year period for a baseline scenario, assuming no CSO controls and four scenarios including CSO controls (15-year, 20-year, 30-year, and 40-year implementation periods). In addition to this table, the agency provided a figure showing the annual percentage increase in household water bills for the baseline scenario and the several alternatives. It concluded that extending the implementation schedule would reduce the financial impact on customers, especially those with low incomes.
- The agency pointed out several areas of uncertainty in its analysis. The uncertainty is centered on its assumptions regarding: water consumption, cost estimates, interest rates, and future regulatory requirements. For each of these variables, the agency described the potential impact on forecasted rates that would occur if the projections deviate from the agency's core assumptions.

After negotiating with EPA, the agency's decree included provisions allowing it to petition for a time extension, in the future, in the event that additional, capital-intensive mandates materialize during implementation or if any of the economic indicators used in the Financial Capability Assessment become more negative in the future.

F. Franklin County, Ohio, Division of Sewerage and Drainage

In 2005, the Franklin County Division of Sewerage and Drainage (providing service to Columbus, Ohio and other surrounding areas) published its *Wet Weather Management Plan*. The division calculated the Residential Indicator and the Financial Capability Indicators based on three potential implementation periods (20 years, 30 years, and 40 years). In addition, the division discussed several other characteristics specific to the service area:

- The division used data on household income from 2005, converted to 2000 dollars.
- The division also described other pertinent socioeconomic information in the service area that may provide a better context from which to consider the potential burden of CSO control costs. Among the variables it discussed were: uncertainty of trends in household income, the potential impact on the poorest 10 percent of residents in the service area, on low-income communities, and on the housing costs of elderly households. It showed (p. V-11) that the peak annual financial impact on the poorest 10 percent of the population would peak at 4.2–5.6 percent of this group's household income, with "catastrophic" outcomes. It also showed (pp. V-11 & -12) that the annual impact on three low-income communities would peak 2.53–6.14 percent of their median household income.
- The division discussed uncertainty regarding future unemployment trends in light of potential increases in costs of doing business (due to increased utility costs), and the existing burden on renters and homeowners of rental and mortgage commitments. It provided information indicating that weakness in the area's labor-market creates uncertainty about the agency's ability to bear the CSO-related financial burden. It found that the anticipated CSO costs would potentially limit access to mortgage financing for 22,600 to 30,900 households, with the greatest impact occurring with the shortest implementation schedule for CSO controls.
- The division presented evidence indicating that anticipated increases in rates to cover CSO costs would increase the incidence of rate-payments delinquencies and contribute to the number of people living below the poverty line. The anticipated increase in delinquencies also would increase the division's administrative and operations costs associated with collections and service shut-offs. It also found that the anticipated increase in delinquencies would increase its administrative and operations costs associated with collections and service shut-offs.
- The division concluded (pp. V-16 & -17):

  "While there are relatively minor impacts in compressing the schedule from a 40- to 30-year period, compressing the schedule from 30 to 20 years could result in significant impacts. A 20-year program could significantly increase the costs of the program as defined in this report. Compression of the program schedule to a 20-year time frame will likely result in program cost increases due to the following factors:

  - Tunnel Contractor Availability/Competition.
  - Tunnel Construction Overlap/Coordination.
  - Surety Bonding & Insurance.
  - Utility/Sewer Contractor Availability/Competition.
  - Construction Labor Import.
  - Disruption/Congestion/Truck Traffic.
  - General Public Health & Safety.
  - City Bond Rating/Impact on Economic Development.
  - WWTP Operations Disruption/Accelerated Staffing.
  - Bond Administration.
  - Increased Risk/Claims & Change Orders.
  - Design/Project Management.
  - Increased Reliance on Consultants vs. In-House Staff."

- The division elaborated on these conclusions, observing that implementing the CSO control plan over 20 years would require concurrent construction of several tunnels and other major projects, overwhelming the capacity of regional contractors. It then stated that, "A 20-year plan would be characterized by a rapid ramping, peaking and falling of activity. The marketplace would trail in its reaction to this and additional costs, disruptions and delays would be experienced as the contracting community tries to keep pace. A minimum 30-year plan would be required to adequately flatten out the peaking nature and offer a more linear approach as the market would be set up for consistency. A reasonable estimate of impact for a third project bidding simultaneously with two ongoing projects, during a 20-year and 30-year program, would be 10 percent of the total cost over a more competitive situation. An additional 15 percent might be expected if a fourth project were to be bid with three others under construction. In this case, competition would be virtually eliminated.
- The division also observed that the construction program under the 20-year schedule would impose large costs on the local economy by disrupting transportation, and increasing traffic congestion and delays. It also would increase construction-related risks generally, as well as specific risks from potential additional costs associated with change orders and claims.
- The division completed its presentation (p. V-20) stating that the analysis "confirms that a 30-year schedule is more detrimental to the community than a 40-year schedule. … The question then becomes are these catastrophic economic impacts off-set by a commensurate environmental benefit? In order to answer that question, the City conducted an analysis of the environmental benefits of the 30- and 40-year implementation periods. … Overall, the difference in environmental benefits between the 30- and 40-year schedule is very minor. Significant progress in reducing untreated volumes is made on either schedule during the period from present to 2025. Critical components of the untreated discharges are addressed either identically or with minor differences."

A 40-year plan submitted in 2005 and approved in 2009 calls for additional financial analysis by 2015 to project the rate impact of implementing the projects sooner, by 5, 10 and 15-years.

G. Louisville and Jefferson County, Kentucky, Metropolitan Sewer District

In 2009, the Louisville and Jefferson County Metropolitan Sewer District (MSD) published its *Integrated Overflow Abatement Plan.* The district provided only a summary, with little detail, describing how it calculated each of the Financial Capability Indicators. It also briefly discussed distributional issues associated with the CSO controls:

- The district compared the percent of households in the service area that would pay more than 2 percent of MHI under the baseline scenario (no CSO control costs) with the percent of households that would do so under a scenario with CSO costs. The district concluded that 10 percent of households would pay more than 2 percent of the current MHI under the baseline scenario, whereas 20 percent of households would pay more than 2 percent of the current MHI under a scenario with CSO controls. The district briefly described efforts, such as a discount program for low-income households, to mitigate the potential increase in rates.

MSD agreed to a 15-year schedule and a total cost of $843 million (2009) and provided some financial relief to low-income ratepayers. It also looked at charging residential costumers based on winter consumption rates and at monthly billing.[6]

H. Philadelphia Water Department

In 2002, the Philadelphia Water Department (PWD) published its *Combined Sewer Overflow Long Term Control Plan Update.* In addition following to the approach prescribed by EPA's *CSO Guidance* suggests, the department presented information from several separate analyses and additional discussions on other issues associated with the potential impact of CSO compliance on households in the service area:

- In its plan, the department calculated an annual Residential Indicator for 20 years (2009-2029) using the MHI for two groups: of all households in the service area, and the 20 percent of households with the lowest incomes. The analysis showed that, over time, the Residential Indicator for both populations would increase, primarily due to anticipated increases in wastewater rates higher than projected increases in household incomes.
- The department presented a geographic representation of the percent of income households would pay for a typical sewer bill.
- In its plan, the department calculated the Financial Capability Indicators in compliance with the CSO Guidance. It also described the residential tax burden in more detail. The department stated that while residents in the service area pay

[6] Louisville and Jefferson County, Kentucky, Metropolitan Sewer District (MSD), 2008, *Vision for MSD's Integrated Overflow Abatement Plan*

property taxes, revenues from property taxes account for a small percentage (about 6 percent) of Philadelphia's operating revenues relative to other large cities. The department suggested that the CSO Guidance, by not considering the overall tax burden on households fails to adequately consider households' actual disposable incomes. It reached a similar conclusion regarding other factors, e.g. the cost of living, not included in the CSO Guidance.

The department described socioeconomic trends in the service area that may provide a better context from which to consider the potential burden of CSO control costs. Among the variables it considered were: trends in the overall population, trends in minority populations, trends in the age of the population, trends in the number of households and the composition of households, trends in income levels, and trends in employment. For each of these trends, the department described how projections and potential deviations from those projections would impact the economic burden identified by the Financial Capability Assessment.

PWD negotiated and signed a Consent Decree in June 2011. It calls for $1.2 billion in improvements over a 25-year period rather than the 20-year period proposed by EPA. EPA agreed to the 25-year period in response to PWD's concerns regarding a high burden to rate payers[7].

I. Summary of Review of Financial Capability Assessments Conducted by Other Permittees

Each of the Financial Capability Assessments reviewed contains an affordability assessment in accordance with the analytical prescriptions in EPA's *CSO Guidance*. The jurisdictions also included additional information, analysis, and discussion to help provide a better context from which to consider the potential financial impacts of CSO controls. The nature and extent of the additional analysis and information vary considerably, but, as a whole, the jurisdictions took one or more of these steps:

- Calculated the Residential Indicator for low-income residents in the service area, rather than for all residents
- Calculated the Residential Indicator, annually, using projected annual WWT and CSO costs over the duration of implementation
- Calculated the Residential Indicator for a range of potential CSO costs
- Projected the MHI specific to the region using regional changes in MHI over time
- Displayed the spatial distribution of the Residential Indicator across different communities in the service area
- Discussed tax burdens specific to the service area, taking into consideration other types of taxes as well as property taxes

[7] City of Philadelphia, 2009, *Green City; Clean Water, City of Philadelphia's Program for Combined Sewer Overflow Control,* Approved June 2011

- Determined the financial burden from the Financial Capability Matrix for a range of assumptions
- Discussed additional factors not included in the Financial Capability Assessment, including trends in overall population, trends in minority populations, trends in the age of the population, trends in the number of households and the composition of households, trends in income levels, and trends in employment
- Discussed the potential impact of additional factors on the future burden of CSO costs on residents in the service area
- Discussed the uncertainty in the precision and accuracy of projections of CSO costs, socioeconomic variables, and other inputs used in calculating the assessment's indicators
- The impacts of Financial Capability Assessments on the negotiations of final consent decrees are mixed. For example, Toledo obtained some relief by being allowed to open the consent decree if financial indicators changed drastically. Other communities, such as Philadelphia, made good arguments for schedule extensions but did not secure additional time to implement CSO programs.

IV. Financial Capability Assessment of WTD's Long Term CSO Control Plan

This section presents the results of calculations, conducted in accordance with the *CSO Guidance*, of the Financial Capability Assessment for WTD's proposed CSO controls. The presentation mirrors the structure of the *CSO Guidance*, showing the line-by-line individual data entries and calculations for these three components of the assessment:

A. Residential Indicator

B. Permittee Financial Capability Indicators

C. Financial Capability Matrix

A. Residential Indicator

The Residential Indicator is intended to measure the financial impact on residential water users of the anticipated total costs for WWT and CSO controls. Calculating the Residential Indicator involves two worksheets. The first summarizes current and projected future WWT and CSO costs per household. Worksheet 1 contains the details requested by the *CSO Guidance*, in 2011 dollars. The top portion shows WTD's estimates of current WWT costs. The middle section shows WTD's projections for future WWT and CSO costs. The projections embody several assumptions. The estimate of annual debt service of projected WWT and CSO costs (Line 104), assumes an interest rate of 5.75 percent and a bond term of 40 years. The estimated residential share of total WWT and CSO costs (Line107), assumes the household share of wastewater flow at 61% of total wastewater flow in the service area.[8] Both the residential share of total WWT and CSO costs (Line 107) and the total number of households in the service area (Line 108) include households in single-family and multi-family homes. The cost per household (Line 109) is about $423.

Worksheet 2 uses the results from Worksheet 1 to calculate the annual WWT plus CSO control costs per household as a percent of adjusted MHI. The estimate of MHI in the service area, represents the results from first using the 2000 Census to calculate the median household income for each block-group that at least partially intersects WTD's service area's boundary. Each of these MHIs was then adjusted to 2011 dollars. dollars using the average annual change in CPI as described in the *CSO Guidance* The median value of these block-group level MHIs (Line 203) is $72,006. The average cost per household (Line 109) divided by this number yields the Residential Indicator for WTD's service area: 0.59 percent. The *CSO Guidance* (p. 19) places this Residential Indicator into the **Low** Financial Impact Category.

[8] Swarner, Bob. 2011. Personal Communication with Bob Swarner. May 17,2011.

Worksheet 1 - Cost per Household		
Current WWT Costs	**Data/Calculation**	**Line Number[1]**
Annual O&M Expenses[1]	$111,116,000	Line 100
Annual Debt Service[1]	$184,200,000	Line 101
Subtotal	$295,316,000	Line 102
Projected WWT and CSO Costs		
Estimated Annual O&M Expenses[2]	$10,370,000	Line 103
Annual Debt Service[2]	$153,544,079	Line 104
Subtotal	$163,914,079	Line 105
Total Current and Projected WWT and CSO Costs	$459,230,079	Line 106
Residential Share of Total WWT and CSO Costs[3]	$280,130,348	Line 107
Total Number of Households in Service Area[4]	662,373	Line 108
Cost Per Household	$422.92	**Line 109**

[1] Holman, Greg. 2011. Personal Communication with Greg Holman, Financial Services Administrator, King County. May 5, 2011.

[2] Holman, Greg. 2011. Personal Communication with Greg Holman, Financial Services Administrator, King County. August 29, 2011.

[3] Swarner, Bob. 2011. Personal Communication with Bob Swarner. May 17,2011.

[4] King County WTD with data from U.S. Census Bureau. P16. Population in Households in 1999.

Worksheet 2 - Residential Indicator		
Census Year MHI[1]	$53,646	Line 201
MHI Adjustment Factor[2]	1.34	Line 202
Adjusted MHI	$72,006	Line 203
Annual WWT and CSO Control Cost per Household	$442.92	Line 204
Residential Indicator (Annual WWT and CSO Control Costs per Household as a Percent of MHI)	0.59%	Line 205

[1] King County WTD with data from U.S. Census Bureau. P53. Median Household Income in 1999.

[2] ECONW with data from the U.S. Bureau of Labor Statistics. Consumer Price Index, All Urban Consumers – (CPI-U), U.S. City Average. Retrieved on May 24, 2011 from ftp://ftp.bls.gov/pub/special.requests/cpi/cpiai.txt.

B. Permittee Financial Capability Indicators

The Permittee Financial Capability Indicators are intended to measure the financial capacity of WTD and the community it serves. The indicators are split into three groups: Debt Indicators, Socioeconomic Indicators, and Financial Management Indicators. This section, briefly describes the calculation of each indicator and shows how it relates to the benchmarks defined in the *CSO Guidance.* The discussion concludes by consolidating the indicators and calculating the Permittee Financial Capability Indicators Score.

1. Debt Indicators

The Debt Indicators in the *CSO Guidance* describe the community's public debt burden and capacity to issue additional debt. The first Debt Indicator is based on recent bond ratings. Worksheet 3 contains the details requested by the *CSO Guidance*. Both the most recent general obligation bond rating and the most recent revenue bond rating for King County were evaluated in 2010. According to the benchmarks defined in the *CSO Guidance*, this information places WTD in the **STRONG** category for this indicator.

Worksheet 3 – Bond Rating

Most Recent General Obligation Bond Rating[1]		
Date	June 2010	
Rating Agency	Standard & Poor's	
Rating	AA+	Line 301
Most Recent Revenue Bond[2]		
Date	December 2010	
Rating Agency	Moody's Investor Services' Ratings	
Bond Insurance	No	
Rating	Aaa	Line 302
Summary Bond Rating	Aaa	Line 303

[1] King County Budget Office. 2010. King County Credit Rating. Retrieved on May 18, 2011, from http://www.kingcounty.gov/operations/Budget.aspx.

[2] Moody's Investor Services' Ratings. 2011. King County, Washington, Sewer Revenue and Refunding Bonds, 2010. CUSIP: 495289VW7

The second Debt Indicator shows overall net public debt for the community served by WTD as a percent of full market property value. Worksheet 4 contains the details requested by the *CSO Guidance*. Because of limitations in the available data, WTD is unable to acquire data specific to just the properties lying within its service territory, which includes most of King County and small portions of Snohomish and Pierce County. Consequently, it uses data for King County as a whole. This approximation is reasonable, as more than 90 percent of the households in WTD's service area reside in King County, about 90 percent of the households in King County reside in the service area, and the difference between the data presented in Worksheet 4 and the data specific to just the service area is likely negligible. The overall net debt as a percent of full market property value (Line 405) is 2.01 percent. According to the benchmarks defined in the *CSO Guidance*, this number places WTD in the **MID-RANGE** category for this indicator.

Worksheet 4 - Overall Net Debt as a Percent of Full Market Property Value		
Direct Net Debt[1]	$1,201,054,542	Line 401
Debt of Overlapping Entities[1]	$5,284,695,915	Line 402
Overall Net Debt[1]	$6,485,750,457	Line 403
Market Value of Property[2]	$322,870,276,270	Line 404
Overall Net Debt as a Percent of Full Market Property Value	2.01%	Line 405

[1] King County Financial Services. 2011. Draft Official Statement for Upcoming King County General Obligation Bond Issue.

[2] King County Department of Assessments. 2011. Account Statistics 2010 Tax Roll. Retrieved on May 18, 2011, from http://www.kingcounty.gov/Assessor/Reports/AnnualReports/2010.aspx.

2. Socioeconomic Indicators

The Socioeconomic Indicators in the *CSO Guidance* describe the well-being of residents in WTD's service area. The first Socioeconomic Indicator looks to the rate of unemployment in WTD's service area relative to the national average. Worksheet 5 contains the details requested by the *CSO Guidance*. The average unemployment rate in the counties in WTD's service area, weighted by the percentage of WTD's households in each county, (Line 502) in 2010 was 8.9 percent. The average unemployment rate at the national level in 2010 was 9.6 percent. According to the benchmarks defined in the *CSO Guidance*, these numbers place WTD in the **MID-RANGE** benchmark category for this indicator.

Worksheet 5 - Unemployment Rate		
Unemployment Rate – Permittee	N/A	Line 501
Source	N/A	
Unemployment Rate - County	8.9%	Line 502
Source: U.S. Bureau of Labor Statistics. 2011. Labor Force Data by County. Retrieved on May 18, 2011, from http://www.bls.gov/lau/. Average for King, Snohomish, and Pierce, weighted by the percentage of WTD's households in each county.		
Average National Unemployment Rate	9.6%	Line 503
Source: U.S. Bureau of Labor Statistics. 2011. Labor Force Statistics from the Current Population Survey. Retrieved on May 18, 2011, from http://data.bls.gov/timeseries/LNU04000000?years_option=all_years&periods_option=specific_periods&periods=Annual+Data		

The second Socioeconomic Indicator compares the MHI in WTD's service area to the national MHI. Worksheet 6 contains the details requested by the *CSO Guidance*. The data show that the MHI in the service area is 27.75 percent higher than the MHI at the national level. According to the benchmarks defined in the *CSO Guidance*, this relationship places WTD in the **STRONG** benchmark category for this indicator.

Worksheet 6 - Median Household Income		
MHI – Permittee	$72,006	Line 601
Source	King County WTD with data from U.S. Census Bureau. P53. Median Household Income in 1999.	
Census Year National MHI	$41,994	Line 602
MHI Adjustment Factor	1.34	Line 603
Adjusted National MHI	$56,366	Line 604
Source	U.S. Census Bureau. P53. Median Household Income in 1999. Summary File 3.	

3. Financial Management Indicators

The Financial Management Indicators in the *CSO Guidance* describe WTD's capacity to manage its finances. The first Financial Management Indicator is based on property taxes and property value. Worksheet 7 contains the details requested by the *CSO Guidance*. Worksheet 7 uses data from King County to represent WTD and assumes that King County's financial management appropriately represents the capabilities of Snohomish and Pierce Counties, which contain a small amount of WTD's service area. In 2010, total property tax revenue for all local governments equaled 1.10 percent of full market property value in King County. According to the benchmarks defined in the *CSO Guidance*, this percentage places WTD in the **STRONG** category for this indicator.

Worksheet 7 - Property Tax Revenues as a Percent of Full Market Property Value		
Full Market Value of Real Property[1]	$322,870,276,270	Line 701
Property Tax Revenues[2]	$3,544,925,219	Line 702
Property Tax Revenue as a Percent of Full Market Property Value	1.10%	Line 703

[1] King County Department of Assessments. 2011. Account Statistics 2010 Tax Roll. Retrieved on May 18, 2011, from http://www.kingcounty.gov/Assessor/Reports/AnnualReports/2010.aspx.

[2] Hendrickson, Mary. 2011. Personal Communication with Mary Hendrickson, Systems Coordinator, King County Treasury Operations. May 17, 2011. TRB500-2 YE10.

The second Financial Management Indicator compares tax revenues levied with tax revenues collected. Worksheet 8 shows the results for King County. In 2010, King County collected 98.06 percent of the property taxes levied in the county. According to the benchmarks defined in the *CSO Guidance*, this percentage places WTD in the **STRONG** benchmark category for this indicator.

Worksheet 8 - Property Tax Revenue Collection Rate

Property Tax Revenue Collected[1]	$3,476,125,683	Line 801
Property Taxes Levied[1]	$3,544,925,219	Line 802
Property Tax Revenue Collection Rate	98.06%	Line 803

[1] Hendrickson, Mary. 2011. Personal Communication with Mary Hendrickson, Systems Coordinator, King County Treasury Operations. May 17, 2011. TRB500-2 YE10.

4. Permittee Financial Capability Indicators Score

The *CSO Guidance* provides rules for converting each of these indicators into a Permittee Financial Capability Indicators Score, which involves assigning a numerical value to each of the individual indicators, based on its benchmark category. An indicator in the "Weak" benchmark category receives a value of 1, an indicator in the "Mid-Range" category receives a value of 2, and an indicator in the "Strong" receives a value of 3. Worksheet 9 shows the results for WTD: its Permittee Financial Capability Indicators Score (Line 907) equals 2.67.

Worksheet 9 - Summary of Permittee Financial Capability Indicators and Permittee Financial Capability Indicators Score

Financial Capability Indicator	Actual Value	Benchmark	Score	
Bond Rating	Aaa	Strong	3	Line 901
Overall Net Debt as a Percent of Full Market Property Value	2.01%	Mid-Range	2	Line 902
Unemployment Rate	0.70% below	Mid-Range	2	Line 903
Median Household Income	27.75% above	Strong	3	Line 904
Property Tax Revenues as a Percent of Full Market Property Value	1.10%	Strong	3	Line 905
Property Tax Revenue Collection Rate	98.06%	Strong	3	Line 906
Permittee Financial Capability Indicators Score			**2.67**	**Line 907**

C. Financial Capability Matrix

The *CSO Guidance* provides a matrix that dictates how to derive an overall, Financial Capability Matrix Score from the Residential Indicator (Line 205) and the Financial Capability Indicators Score (Line 907). Worksheet 10 shows the results. According to the rules and thresholds defined in the *CSO Guidance*, the calculations place WTD and the community it serves, in the **Low Burden** category (Line 1003).

Worksheet 10 - Financial Capability Matrix Score		
Residential Indicator Score	0.59%	Line 1001
Financial Capability Indicators Score	2.67	Line 1002
Financial Capability Matrix Score (Category)	Low Burden	Line 1003

V. CONCLUSIONS

The results of WTD's Financial Capability Assessment, as prescribed by EPA's *CSO Guidance*, suggest that the costs of implementing CSO controls proposed by WTD would impose a "Low Burden" on the households and taxpayers of its service area. Discussion in the *CSO Guidance* recommends that EPA and Ecology use this result in negotiations with WTD to press for implementation of the controls as quickly as possible, subject to the requirements of normal design and construction schedules.

WTD has concluded, however, that the calculations prescribed by the *CSO Guidance* do not capture the actual, full financial burden would accompany implementation of the proposed CSO controls, nor do they adequately represent the community's financial capability to bear those costs. Accordingly, it has begun efforts, consistent with the terms of the *CSO Guidance*, to provide additional, supplementary information.

APPENDIX: FINANCIAL CAPABILITY ASSESSMENTS COMPLETED BY OTHER JURISDICTIONS

Financial Capability Assessments Included in this Appendix
City of Toledo, Ohio
District of Columbia Water and Sewer Authority
Philadelphia Water Department

FINANCIAL CAPABILITY ASSESSMENT: CITY OF TOLEDO, OHIO

CHAPTER 16 AFFORDABILITY ANALYSIS

16.1. Introduction

This report presents an evaluation of the financial impacts to the residential customers in the Toledo sewer system service area for the construction of combined sewer overflow control facilities. The determination of the level of financial hardship to residential customers is a critical element in the development of an implementation schedule for the construction of the long-term CSO Control Program.

16.2. US EPA Guidance Document

In 1997 the US EPA published the "Combined Sewer Overflows (CSO) – Guidance for Financial Capability Assessment and Schedule Development" for the purpose of providing a mechanism for evaluating the financial resources of a municipality to determine an implementation schedule for the construction of required CSO controls.

The financial capability indicators to be used in this evaluation include:

- Total annual wastewater and CSO control cost per household as a percent of median household income.
- Bond ratings
- Overall net debt as a percent of full market property value
- Unemployment rate
- Median household income
- Property tax revenue collection rate
- Property tax revenues as a percent of full market property value

16.3. Affordability Analysis

The CSO guidance document presents a two-phased approach to assessing the community's financial capability. Phase One determines a residential indicator and Phase Two develops financial capability indicators. The results of the two phases are combined into a financial capability matrix to give an overall assessment of the City's financial capability.

The following is an evaluation of the two phases of the affordability analysis. The line numbers correspond to the lines of the financial capability assessment worksheets that are presented in Figure 16.3 and Figure 16.4.

16.3.1. Phase One:

Determination of a residential indicator. The residential indicator is the City's average cost per household for wastewater treatment and CSO controls as a percentage of the local median household income (MHI). It is a reflection of the residential share of current and projected WWT and CSO controls need to meet the consent decree and NPDES permit requirements.

To get an accurate indication of the financial hardship the implementation of a long-term CSO control plan will have on residential customers, it is important to evaluate both current and future conditions. By evaluating future conditions, variables such as the projected number of residential customers and median household incomes can result in a more accurate assessment than what is shown under existing conditions. Therefore, the Phase One worksheets attached in Figure 16.3 include both current and future (Year 2016) evaluations.

Cost per Household

Line 100: Sewer system operating costs are presented in the City of Toledo 2004 Annual Information Statement. Total operating expenses were $24,287,000, comprised of personal services ($11,829,000), contractual services ($8,406,000), materials and supplies ($1,746,000) and utilities ($2,306,000). Depreciation costs are not included.

The evaluation of project year 2016 conditions includes no distinction between current and projected wastewater treatment and CSO costs. Therefore, no costs are included under this line item.

Line 101: The current annual debt service associated with wastewater treatment costs include an annual debt service of $5,254,166 for sewer bonds, the City's aggregate annual loan payments on Ohio Water Development Authority Loans of $3,802,803, and a 10% coverage on existing debt of $905,680 for a total annual principal and interest payments of $9,962,480.

As discussed under Line 100, no projected 2016 costs are included under this line item.

Line 102: The sum of Lines 100 and 101 are presented on Line 102 at $34,249,480 is the current wastewater costs as prescribed in the EPA financial capability guidance document.

All costs projected under the year 2016 evaluation are included in lines 103 through 106.

Line 103: The estimated annual O&M expense is based on 15% of the estimated annual debt service (Line 104) plus an additional $9,000,000 of replacement funds. The total estimated annual O&M cost is $15,534,481.

Line 104: Projected debt service costs are based on estimated capital improvement projects totaling $450 million. An estimated 20% of these costs will be financed through the Ohio Water Pollution Control Loan Fund Program (OWPCLFP). The remaining 80% of the costs will be funded with open market bond funds. For the purpose of this analysis and average interest rate for OWPCLFP loans will be 3.8% over a 20 year period and an interest rate of 7% over 20 years will be used for the open market bond financing.

Also included in Line 104 is a 10 percent debt coverage as it is the policy of the City of Toledo. A total of $43,563,205 is included in Line 104, which is comprised of the following:

Annual Debt Service on OWPCLFP Loans: $9,397,137

Annual Debt Service on Open Market Bonds:	$30,205,777
10% Debt Coverage	$3,960,291
Total	$43,563,205

Line 105: Projected O&M and debt service increases total projected wastewater costs of $59,097,686.

Line 106: Total current wastewater costs of $34,249,480 (Line 102) and the projected wastewater cost increases of $59,097,686 (Line 105) equal total wastewater costs of $93,347,166.

The total projected annual wastewater costs in the year 2016 are estimated to be $113,793,510 (with 10% coverage). These costs are based on the assumptions presented in the financing modeling included below.

Line 107: Of the approximate 112,000 sewer system users, 93% or 103,917 are residential customers. Based on user volume the residential portion of the total annual volume is 59.41%. The following is a breakdown of the user volume in 2003:

Table 16.1: Water Usage Statistics

Category	**User Volume (in thousand cubic feet)**
Residential	1,031,418
Commercial	278,055
Industrial	412,588
Governmental	14,145
Total	1,736,206

Therefore, the residential share of the total projected annual wastewater costs are estimated at $55,457,551 under current conditions and $67,604,724 under projected year 2016 conditions.

Line 108: As stated in Line 107 the total number of residential users of the sewer system is 103,917, representing 93% of the total users.

U.S. Census data has shown a reduction in the number of households in the City of Toledo between 1990 and 2000. The Toledo Metropolitan Area Council of Governments projects the population of the City to continue to decrease over the next 30 years. By projecting out to the year 2016 on the basis of the assumption of a continued trend, the number of residential customers within the sewer service area is projected to be 101,340 in the year 2016.

Line 109: Dividing the residential share of the total projected wastewater costs as stated in Line 107 by the number of residential customers from Line 108, results in an annual cost per household of $534 if the entire project were constructed at once and $667 under projected year 2016 conditions (with phased implementation).

Residential Indicator

Line 201: The median household income for the Toledo sewer service area in the year 2000 is estimated to be $34,748. Since the service area includes more than one community, it is necessary to develop a weighted MHI for the entire service area. This is done by prorating the portions of the total users by each community and applying that portion to the MHI for each community. The following is the calculation of the MHI for the Toledo sewer service area.

Table 16.2: Median Household Income Comparison

Community	2000 MHI	Users	Weighted MHI
Toledo	$32,546	94,951	$29,738
Ottawa Hills	$100,000	1,505	$1,448
Northwood	$51,071	539	$265
Rossford	$43,776	2,074	$874
Walbridge	$40,234	940	$364
Washington Twp.	$50,268	865	$418
Springfield Twp.	$47,389	131	$60
Sylvania Twp.	$61,146	1,784	$1,050
Lake Twp.	$42,726	228	$94
Perrysburg Twp.	$50,488	900	$437
Total		103,917	$34,748

As shown in Table 16.2, the MHI for the City of Toledo ($32,546) is well below that of any other community with customers within the sewer system service area. The residential customers within the City of Toledo comprise approximately 93% of all residential customers within the service area. Therefore the greatest financial burden for constructing the proposed CSO control program will be placed upon City residents. To get a more accurate reflection of the financial impact to residential customers, the City of Toledo residents will be evaluated separately from the entire service area.

To evaluate the financial impact to City residents the MHI for the City is used in the Phase One Worksheets attached in Figure 16.3 and Figure 16.4.

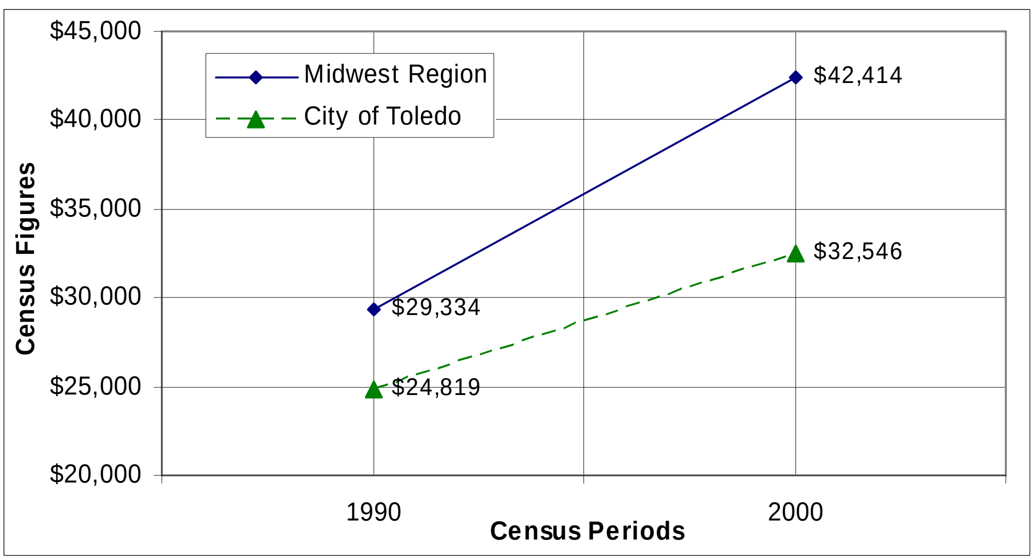
Line 202: To determine a projected MHI for the City of Toledo, the variables to be considered include the historic trend from 1990 to 2000 census data, comparisons between Midwest and Toledo income changes and Wage Earner Consumer Price index figures since the 2000 census.

A rough calculation to determine the current and future MHI for the City of Toledo can be made by making a straight-line projection between 1990 and

2000 census figures. This methodology does not account for the economic conditions that have impacted income levels since the year 2000.

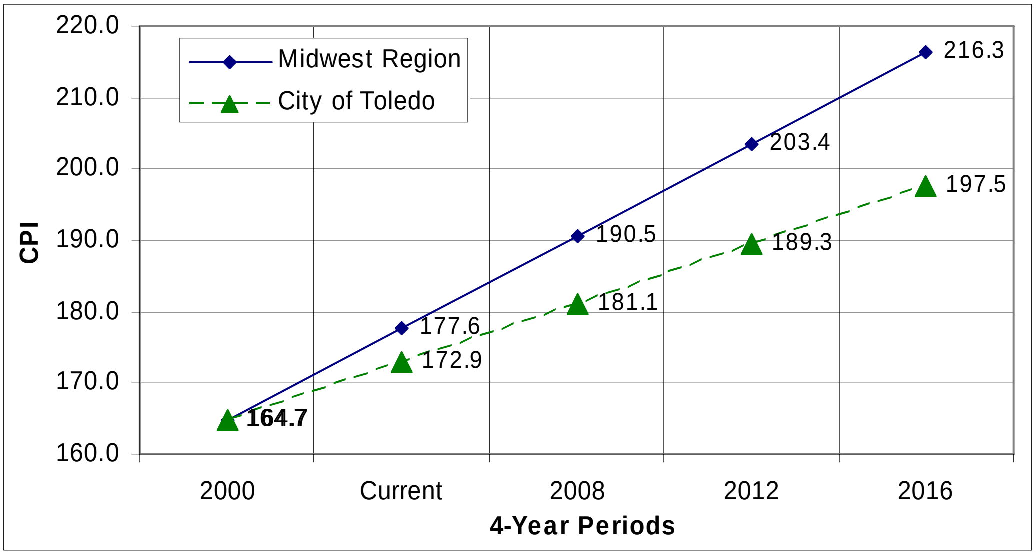
To accommodate economic variables since the year 2000 an application of wage earner consumer price index figures is appropriate. Consumer price index figures are only available down to a level of the Midwest Region. To adjust Toledo MHI figures by the Midwest Region CPI would be stating that Toledo MHI levels are increasing at the same rate as all of the Midwest. In fact, it is known that Toledo MHI levels are increasing at a much lower rate than the midwest as a whole. One way to quantify this lower level of increase is to compare historic data for both the city of Toledo and the Midwest Region that is available from the same data source. MHI data from the 1990 and 2000 census are available for both areas and have been used for this analysis.

Figure 16.1: Median Household Income Comparisons



By the application of the different rates of MHI increases between the City and the Midwest Region to the projected CPI figures for the Midwest Region would reflect a more accurate MHI for the City of Toledo for years after the year 2000.

Figure 16.2: Wage Earner Consumer Price Index Adjustments



The MHI adjustment factors are determined by the increases over the CPI for the year 2000 for the City of Toledo. Table 16.3 shows this computation.

Table 16.3: City of Toledo MHI Adjustment Factor

Year	2000 MHI	CPI	Adj Factor	Adj MHI
2000	$32,546	164.7	1.000	$32,546
Current	**$32,546**	**172.9**	**1.050**	**$34,166**
2008	$32,546	181.1	1.100	$35,787
2012	$32,546	189.3	1.149	$37,407
2016	**$32,546**	**197.5**	**1.199**	**$39,028**

Figure 16.1 and Figure 16.2 and Table 16.3 show the steps taken to compute the current and year 2016 adjustment factors. The MHI adjustment factors would therefore be 1.050 for current conditions and 1.199 for the year 2016.

Line 203: Adjusting the weighted 2000 MHI for the Toledo sewer service area by the adjustment factor from Line 202 results in an estimated MHI of $37,458 for current conditions. The adjusted MHI for the City of Toledo is estimated to be $34,173 currently and $39,023 in the year 2016.

Line 204: The projected annual cost per household as determined in Line 109 is $534 under current conditions and $667 in the year 2016.

Line 205: The projected annual cost per household from Line 204 represented as a percent of the estimated MHI of the City of Toledo is shown to be 1.56 percent under current conditions and 1.71 percent in the year 2016. Both of these percentages fall into the Mid-Range financial impact classification.

Table 16.4: Meadian Household Income Index

Financial Impact Classification	Residential Indicator (CPH as % of MHI)
Low	< 1.0% of MHI
Mid-Range	1.0% to 2.0% of MHI
High	> 2.0% of MHI

Although this residential indicator shows that the cost of constructing the proposed CSO control facilities would result in a high hardship on the typical residential customer in the City of Toledo, the hardship imposed on the lower income residents of Toledo would be much greater. According to the 2000 US Census 17.9% of the population of Toledo lives below the poverty level. This percentage is much higher than both the State of Ohio and national percentages. The following table illustrates these comparisons.

Table 16.5: Poverty Level Comparison

Population*	**USA**	**Ohio**	**Toledo**
Total	273,882,232	11,046,987	306,933
<50% of Poverty Level	15,337,408	530,076	25,943
50% to 74% of Poverty Level	8,510,306	304,847	14,584
75% to 99% of Poverty Level	10,052,098	335,775	14,376
Total Below Poverty Level	33,899,812	1,170,698	54,903
Percentage Below Poverty Level	12.38%	10.60%	17.89%

1 – Based on 2000 Census data.

In Toledo the average persons per household is 2.38, according to the year 2000 US Census. The poverty rate at this size of household is estimated to be $13,140 per year. This rate is calculated by interpolating a value between the 2000 median household income for two and three person per household poverty threshold levels. The median household adjustment factor from Line 202 (1.078) was also included in the calculation.

At the poverty level the projected annual cost per household would be approximately 3.61 percent of the adjusted median household income under current conditions and 3.96 percent in the year 2016. These percentages increase significantly for households with even lower incomes. The EPA guidance document states that an annual wastewater treatment and CSO cost per household greater than 2 percent of the adjusted median household income is considered to be a high financial burden to residential customers. Considering that nearly one half (47.3%) of the households in Toledo living in poverty have incomes less than 50 percent of the poverty threshold level, the projected annual cost per household would create an excessively high burden on these Toledo residents.

16.3.2. Phase Two

Financial Capability Indicators. Under Phase Two selected indicators are assessed to evaluate the City's debt burden, socioeconomic conditions, and financial operations. The debt indicators will assess the City's current debt burden and its ability to issue additional debt for the construction of the proposed CSO controls. Socioeconomic indicators will assess the general economic well-being of residential customers of the sewer system service area. Financial management indicators will assess the City's overall ability to manage financial operations.

Bond Rating

Line 301: The City of Toledo received a Moody's Aaa general obligation bond rating on July 15, 2004.

Line 302: The City of Toledo received a Moody's Aaa revenue bond rating on July 1, 2003. No bond insurance was purchased.

Line 303: Based on the most recent bond ratings, the City of Toledo has received a strong rating level for this evaluation.

Overall Net Debt as a Percent of Full Market Property Value

Line 401: As reported in the 2003 "Comprehensive Annual Financial Report", the City of Toledo's direct debt as of December 2003 was $125,978,000, excluding double-barreled bonds.

Line 402: Also reported in the 2003 "Comprehensive Annual Financial Report" is the debt from overlapping entities, including Lucas County, and the Cities of Toledo, Sylvania, Ottawa Hills, Springfield, and Washington School Districts, and the Sylvania Area Joint Recreation District. Total overlapping debt is totals $182,621,000.

Line 403: The total overall net debt is $308,599,000.

Line 404: The Real Property market value of the City of Toledo for the year 2004 was $10,722,242,000.

Line 405: The overall net debt as a percent of the full market property value is 2.878 percent. Communities with values between 2 and 5 percent are considered to be a mid-range impact to residential customers.

Unemployment Rate

Line 501: According to the February 2005 Bureau of Labor Statistics for Toledo Metro Area, the unemployment rate for the City of Toledo was 8.1 percent.

Line 502: Unemployment statistics are available for the City of Toledo, therefore evaluating unemployment statistics for Lucas County are not necessary.

Line 503: According to the February 2005 Bureau of Labor Statistics for the United States, the national unemployment rate was 5.4 percent. A community with an unemployment rate more than one percentage point above the national average is considered weak in this financial capability study. In February 2005 the City of Toledo's unemployment rate was 2.7 percentage points higher than the national average. Therefore, the employment rate in the City of Toledo is considered extremely weak.

Median Household Income

Line 601: As shown in Line 203 the estimated MHI for the City of Toledo, including a consumer price index adjustment is $34,173.

Line 602: According to the 2000 US Census the MHI for the United States was $41,994.

Line 603: The consumer price index for US cities appreciated at a greater rate than for Midwest cities since the 2000 Census. The MHI adjustment factor to be applied the national MHI is 1.092.

Line 604: The adjusted national MHI is estimated to be $45,857. The adjusted MHI for residents of the City of Toledo is calculated to be approximately 25.5% below the adjusted national MHI. The mid-range rating extends from 25 percent below the adjusted national MHI to 25 percent above the national MHI. At 25.5 percent below the national MHI the City of Toledo is considered to be a Weak rating.

Property Tax Revenues as a Percent of Full Market Property Value

Line 701: The full market value of real property as reported on Line 404 is $10,722,242,000.

Line 702: Property tax revenues for the year 2003 in the City of Toledo were $14,835,000. A more accurate evaluation of revenues collected measured against the full market value of real property would be to include income tax and special assessment revenues as well. Together these sources of revenues totaled $188,608,000 in the year 2003.

Line 703: The tax revenues as a percentage of the full market value equal 1.76 percent. This shows a strong financial management position in the City of Toledo. When comparing all general revenues for the City of Toledo in the year 2003 to the full market value of the City, the percentage increases to 2.66 percent. This level shows a Mid-range burden to the residents of Toledo.

Property Tax Revenue Collection Rate

Line 801: For the year 2003 the City of Toledo collected $14,189,000 in property taxes by the due date for payment. An additional $646,000 in delinquent taxes from City residents were ultimately collected by the City.

Line 802: For the year 2003 the City of Toledo levied $15,047,000 in property taxes.

Line 803: By the due date for payment of property taxes in the 2003, the City of Toledo collected 94.3 percent of the property taxes levied. After all delinquent taxes were collected the overall percentage increased to 98.6%.

16.4. Financial Capability Matrix Summary

Phase One of the Financial Capability Analysis is a determination of the Residential Indicator score. The annual wastewater treatment and combined sewer overflow control costs per household as a percentage of the adjusted median household income for the City of Toledo is 1.56 percent currently and 1.71 percent in the year 2016. Scores falling between one and two percent are considered a Mid-Range financial burden, and over 2% is a High financial burden to residential users.

According to US Census figures, in the year 2000 17.9 percent of individuals in the City of Toledo were living below the poverty level. As stated previously, at the poverty level the projected annual cost per household would be 3.61 percent of the adjusted median household income. Therefore 17.9 percent of all Toledo residents would be paying more than 3.61 percent of the adjusted MHI. This percentage increases significantly for households with even lower incomes.

Table 16.6: Financial Capability Matrix

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

16.5. USER RATE ALTERNATIVES

The City of Toledo's rate consultant ran the rate model to inform the City about the likely impact from implementation of the LTCP. See Appendix L for additional details. Various assumptions incorporated in the model are identified in Table 16.7.

Table 16.7: Rate Model Assumptions

Item	Assumption
Capital Expenditures Source	WPCLF loan funds 20% of costs 2006 – 2008 Balance bond funded.
Loan Source Interest Rates	WPCLF: 4.15% (2005), with annual increase of 0.25% Bonds: 2.96% (2005), with annual increase of 0.25% through 2013, 25 year amortization.
Rate Coverage Requirements	1.10
Operating Expenses Growth Rates	3.5% in 2005 – 2007; 5.0% in 2008 and thereafter, plus $400,000 in 2009, less $1.4 mill. energy savings

The rate increases for the years 2003 through 2006 were set through City Council action in 2003 at 9.75%. Projected rate increases for the remaining duration of CSO plan implementation are projected as shown in Table 16.8.

Table 16.8: Projected Rate Increases

Year	Increase	Cumulative Increase
2003	9.75%	10%
2004	9.75%	20%
2005	9.75%	32%
2006	9.75%	45%
2007	10.75%	61%
2008	10.75%	78%
2009	10.75%	97%
2010	8.75%	114%
2011	6.99%	129%
2012	8.16%	148%
2013	7.28%	166%
2014	7.56%	186%
2015	6.95%	206%
2016	6.08%	225%

16.6. CONCLUSIONS

The City of Toledo is a large City in a part of the country where large cities have declining population and households. As a result the costs of the program will be borne by a decreasing number of citizens at the same time as the total costs are increasing rapidly. Total rate increases to fund this program over a period of 13 years are more than double the rates at the beginning of the program. While the EPA affordability criteria identifies the project as a medium burden for the City, the City remains concerned about the impacts of these rates on the citizens and the major industrial users that fuel the economy.

Figure 16.3: Affordability Analysis Worksheet Number 1

		Column 1	Column 2
PHASE ONE:		City of Toledo	City of Toledo
	Worksheet 1 - Cost per Household	**Current Conditions**	**Year 2016**
	Current WWTP Costs		
Line 100	Annual O&M Expenses (Excl. Depreciation)	$24,287,000	
Line 101	Annual Debt Service (P&I)	$9,962,480	
Line 102	Subtotal	$34,249,480	
	Projected WWT & CSO Costs (Current dollars)		
Line 103	Estimated Annual O&M Expenses (excl. depreciation)	$15,534,481	
Line 104	Annual Debt Service (P&I)	$43,563,205	
Line 105	Subtotal	$59,097,686	
Line 106	Total Current & Projected WWT & CSO Costs	$93,347,166	$113,793,510
Line 107	Residential Share of Total WWT & CSO Costs	$55,457,551	$67,604,724
Line 108	Total number of Residential Customers in Service Area	103,917	101,340
Line 109	Cost per Household	$534	$667
	Worksheet 2 - Residential Indicator		
	Median Household Income (MHI)		
Line 201	Census year MHI	$32,546	$32,546
Line 202	MHI Adjustment Factor	1.050	1.199
Line 203	Adjusted MHI	$34,173	$39,023
Line 204	Annual WWT & CSO Control Cost per household (CPH)	$534	$667
	Residential Indicator		
Line 205	Annual WWT & CSO CPH as a % of Adj MHI	1.56%	1.71%
		Mid-Range	Mid-Range
PHASE TWO:	**Worksheet 3 - Bond Rating**		
	Most recent General Obligation Bond Rating		
	Date	7/15/2004	
	Rating Agency	Moodys	
Line 301	Rating	Aaa	
	Most recent Revenue (Water/Sewer or Sewer) Bond		
	Date	7/1/2003	
	Rating Agency	Moodys	
	Bond Insurance (yes/no)?	no	
Line 302	Rating	Aaa	
Line 303	Summary Bond Rating	Aaa	
	Worksheet 4 - Overall Net Debt as a Percent of Full Market Property Value		
Line 401	Direct Net Debt (GO bonds excl. Double-Barreled Bonds)	$125,978,000	
Line 402	Debt of Overlapping Entities (proportional share of multijurisdictional debt)	$182,621,000	
Line 403	Overal Net Debt	$308,599,000	
Line 404	Market Value of Property	$10,722,242,000	
Line 405	Overall Net Debt as a % of Full Market Property Value	2.878%	

Figure 16.4: Affordability Analysis Worksheet Number 2

Worksheet 5 - Unemployment Rate

Line 501	Unemployment Rate - Permittee	8.1%
	Source	BLS
Line 502	Unemployment Rate - County (if no permittee rate)	N/A
	Source	
	Benchmark	
Line 503	Average National Unemployment Rate	5.4%
	Source	BLS

Worksheet 6 - Median Household Income

Line 601	MHI - Permittee	$34,173
	Source	2000 US Census
	Benchmark	
Line 602	Census Year National MHI	$41,994
Line 603	MHI Adjustment Factor	1.0920
Line 604	Adjusted National NHI	$45,857
	Source	2000 US Census

Worksheet 7 - Property Tax Revenues as a Percent of Full Market Property Value

Line 701	Full Markey Value of Real Property	$10,722,242,000
Line 702	Property Tax Revenues	$188,608,000
Line 703	Property Tax Revenue as a % of Full Market Property Value	1.76%

Worksheet 8 - Property Tax Revenue Collection Rate

Line 801	Property Tax Revenue Collected	$14,835,000
Line 802	Property Taxes Levied	$15,047,000
Line 803	Property Tax Revenue Collection Rate	98.6%

Worksheet 9 - Phase Two Summary of Permittee Financial Capability Indicators

		Column A: Actual Value
Line 901	Bond Rating	strong
Line 902	Overall Net Debt as a % of Full Market Property Value	mid-range
Line 903	Unemployment Rate	mid-range
Line 904	MHI	mid-range
Line 905	Property Tax Revenues as a % of Full Market Property Value	strong
Line 906	Property Tax Revenue Collection Rate	strong
Line 907	Permittee Indicators Score	

Worksheet 10 - Financial Capability Matrix Score

Line 1001	Residential Indicator Score	1.56%
Line 1002	Permittee Financial Capability Indicators Score	2.33
Line 1003	Financial Capability Matrix	Medium Burden

16.7. 2009 Addendum to the December 2005 LTCP

The November 2005 affordability analysis has been revised and updated to address comments received from the U.S. EPA and the U.S. Department of Justice. All data included in the 2005 analysis have been evaluated and the most recent available data have been used in this update.

The most significant changes to the 2005 analysis include the use of updated data sources, evaluation of financial impacts on the entire sewer service area, and the removal of all project costs associated with storm water related projects. Data used for this updated analysis were primarily provided from the *City of Toledo 2007 Annual Information Statement* and the *City of Toledo Comprehensive Annual Financial Report for the Year Ended December 31, 2006*. In the 2005 analysis the residential sewer customers within the City of Toledo were the focus of the financial impact evaluation because they accounted for over 91% of the total service area residential customers, and over 22% were living below the poverty level. This update evaluates the impact to the residential customers of the entire sewer service area.

The following is a summary of the worksheet line items where methodology revisions were made to the affordability analysis section of the City of Toledo Long Term Control Plan, followed by revised CSO Control Program Affordability Study Worksheets.

Worksheet 1 – Cost per Household

- Line 100 – Current O&M: In 2005 the best available documentation came from the 2004 Annual Information Statement (AIS) ($24,287,000). The 2008 Update includes actual figures from the 2008 Sewer Operating Budget ($35,173,346).
- Line 101 - Current Annual Debt: The 2005 analysis included information from the 2004 AIS ($9,056,969 plus 10% coverage). Information obtained from the 10/2007 City of Toledo Sewer System Cash Flow Model was used for the 2008 update. Data from the Cash flow model for the year 2004 was very comparable to the 2004 AIS data. The major difference between the two analyses was the

annual debt payments on loans increased significantly, by approximately $14.7 million between the years 2004 and 2008.

- Line 103 – Projected O&M: An estimate of 15% was applied to the projected annual debt service (line 104) to determine the projected O&M expense for both analyses. Included in the 2005 study was a $9 million payment to replenish the replacement fund. A reevaluation during the preparation of the 2008 update resulted in a determination that a replacement fund payment is not appropriate for the purpose of this analysis.
- Line 104 - Projected Annual Debt: The methodology used in the 2005 study included an estimated $450 million in capital costs, assuming $130 million to be funded with WPCLF loans and $320 million with open market bonds. A 10% coverage amount was also added to the annual debt service. A revised methodology used for the 2008 update included a breakdown of the specific projects from the City of Toledo Capital Improvements Plan (CIP), which included $250,850,007 for long term control plan project costs and $213,232,163 for wastewater treatment related projects. Also included are $60 million for additional long term compliance plan projects not included on the CIP. Of the total $524 million in capital costs, an estimated 30% or $157 million are estimated to be financed with WPCLF loans, and the remaining 70% or $367 million with open market bonds.
- Line 108 – Residential Customers: The number of residential customers included in the 2005 study was provided from the 2004 AIS. Since that time the City of Toledo replaced their statistical computer program, from a CIS format to a SAP format. The current number sewer customers is now 100,007, which show a slight decline since 2004, as would be expected.

Worksheet 2 – Residential Indicator

- Line 201 - Census Year MHI: The basis of the affordability analysis was changed between the 2005 study and the 2008 update from the MHI for the City of Toledo to the MHI for the entire sewer service area. The MHI for the residential customers from each community served by the City of Toledo sewer system were weighted in accordance with the guidelines provided in the U.S. EPA published document "Combined Sewer Overflows (CSO) – Guidance for Financial Capability Assessment and Schedule Development". The estimated MHI for the sewer service area was $34,827 in the year 2000.

- Line 202 – MHI Adjustment Factor: The 2005 study included a MHI adjustment factor of 1.05, which was determined by the use of 2000 Census figures and projected forward to the year 2004 by the use of historical census data and consumer price indices. Since that time the US Census Bureau prepared the 2006 American Community Survey (ACS), which produced updated population, demographic and housing unit estimates for the City of Toledo. The ACS showed that the MHI for the City of Toledo in 2006 was $33,691. At this level the MHI was shown to be increasing at a slower rate than estimated in 2005. However, the data provided in the ACS is more accurate than the methodology implemented in the 2005 study. The adjustment factor was determined by calculating the difference between the 2006 and 2000 MHI amounts and prorating for an additional year. This adjustment factor (1.041) was then applied to the 2000 MHI figures for each of the communities in the sewer service area.

Table 16.9: Financial Capability Matrix (Revised 16.6)

Phase Two Permittee Financial Capability Indicators Score (Socioeconomic, Debt and Financial Indicators) Score = 1.83	Phase One Residential Indicator (Cost Per Household as a % of MHI) Score = 1.75%		
	Low (Below 1.0%)	Mid-Range (Between 1.0 & 2.0%)	High (Above 2.0%
Weak (Below 1.5)	Medium Burden	High Burden	High Burden
Mid-Range (Between 1.5 & 2.5)	Low Burden	**Medium Burden**	High Burden
Strong (Above 2.5)	Low Burden	Low Burden	Medium Burden

Figure 16.5: Affordability Analysis Worksheet Number 1 (Revised 16.3)

PHASE ONE:

	Worksheet 1 - Cost per Household	City of Toledo Sewer Service Area
	Current WWTP Costs	
Line 100	Annual O&M Expenses (Excl. Depreciation)	$35,173,346
Line 101	Annual Debt Service (P&I)	$24,471,927
Line 102	Subtotal	$59,645,273
	Projected WWT & CSO Costs (Current dollars)	
Line 103	Estimated Annual O&M Expenses (excl. depreciation)	$6,899,084
Line 104	Annual Debt Service (P&I)	$45,993,891
Line 105	Subtotal	$52,892,975
Line 106	Total Current & Projected WWT & CSO Costs	$112,538,248
Line 107	Residential Share of Total WWT & CSO Costs	$63,494,079
Line 108	Total number of Residential Customers in Service Area	100,007
Line 109	Cost per Household	$635

	Worksheet 2 - Residential Indicator	
	Median Household Income (MHI)	
Line 201	Census year MHI (2000)	$34,827
Line 202	MHI Adjustment Factor	1.041
Line 203	Adjusted MHI	$36,255
Line 204	Annual WWT & CSO Control Cost per household (CPH)	$635
	Residential Indicator	
Line 205	Annual WWT & CSO CPH as a % of Adj MHI	1.75%
		Mid-Range

PHASE TWO:

	Worksheet 3 - Bond Rating	
	Most recent General Obligation Bond Rating	
	Date	
	Rating Agency	Moodys
Line 301	Rating	Aaa
	Most recent Revenue (Water/Sewer or Sewer) Bond	
	Date	
	Rating Agency	Moodys
	Bond Insurance (yes/no)?	no
Line 302	Rating	Aa
Line 303	Summary Bond Rating	Aa
		Strong

	Worksheet 4 - Overall Net Debt as a Percent of Full Market Property Value	
Line 401	Direct Net Debt (GO bonds excl. Double-Barreled Bonds)	$126,683,000
Line 402	Debt of Overlapping Entities (proportional share of multijurisdictional debt)	$164,750,000
Line 403	Overal Net Debt	$291,433,000
Line 404	Market Value of Property	$12,329,491,000
Line 405	Overall Net Debt as a % of Full Market Property Value	2.364%
		Mid-Range

Figure 16.6: Affordability Analysis Worksheet Number 2 (Revised 16.4)

Worksheet 5 - Unemployment Rate

Line 501	Unemployment Rate - Permittee (9/2007)	8.2%
	Source	BLS
Line 502	Unemployment Rate - County (if no permittee rate)	N/A
	Source	
	Benchmark	
Line 503	Average National Unemployment Rate (9/2007)	4.8%
	Source	BLS
		Weak

PHASE TWO (cont.):

Worksheet 6 - Median Household Income

Line 601	MHI - Permittee	$36,255
	Source	2000 US Census
	Benchmark	
Line 602	Census Year National MHI (2000)	$41,994
Line 603	MHI Adjustment Factor (2007)	1.1794
Line 604	Adjusted National NHI	$49,528
	Source	2000 US Census
		Weak

Worksheet 7 - Property Tax Revenues as a Percent of Full Market Property Value

Line 701	Full Market Value of Real Property	$12,329,491,000
Line 702	Property Tax Revenues	$203,836,000
Line 703	Property Tax Revenue as a % of Full Market Property Value	1.65%
		Strong

Worksheet 8 - Property Tax Revenue Collection Rate

Line 801	Property Tax Revenue Collected	$15,889,000
Line 802	Property Taxes Levied	$17,305,000
Line 803	Property Tax Revenue Collection Rate	91.8%
		Weak

Worksheet 9 - Phase Two Summary of Permittee Financial Capability Indicators

		Column A: Actual Value	Column B: Score
Line 901	Worksheet #3 - Bond Rating	strong	3
Line 902	Worksheet #4 - Overall Net Debt %	mid-range	2
Line 903	Worksheet #5 - Unemployment Rate	weak	1
Line 904	Worksheet #6 - MHI	weak	1
Line 905	Worksheet #7 - Property Tax Revenues %	strong	3
Line 906	Worksheet #8 - Property Tax Collection Rate	weak	1
Line 907	Phase 2 - Permittee Indicators Score		**1.83**

Worksheet 10 - Financial Capability Matrix Score

Line 1001	Residential Indicator Score	**1.75%**
Line 1002	Permittee Financial Capability Indicators Score	**1.83**
Line 1003	Financial Capability Matrix	**Medium Burden**

FINANCIAL CAPABILITY ASSESSMENT: DISTRICT OF COLUMBIA WATER AND SEWER AUTHORITY

Section 12
Financial Capability

12.1 INTRODUCTION

Financing CSO programs in a fair and equitable manner without placing an unreasonable burden on ratepayers is one of the most challenging aspects facing CSO communities. CSO control costs can be one of the largest single expenditures made on a public works project for many communities. No dedicated grant programs currently exist to fund CSO control programs. As a result, a detailed affordability analysis is necessary to assess the impact of CSO control costs on the fiscal health of a community. A procedure for assessing financial capability is described in EPA's Guidance Document, *Guidance for Financial Capability Assessment and Schedule Development* (EPA, 1997). This procedure was used to perform the financial capability assessment for WASA.

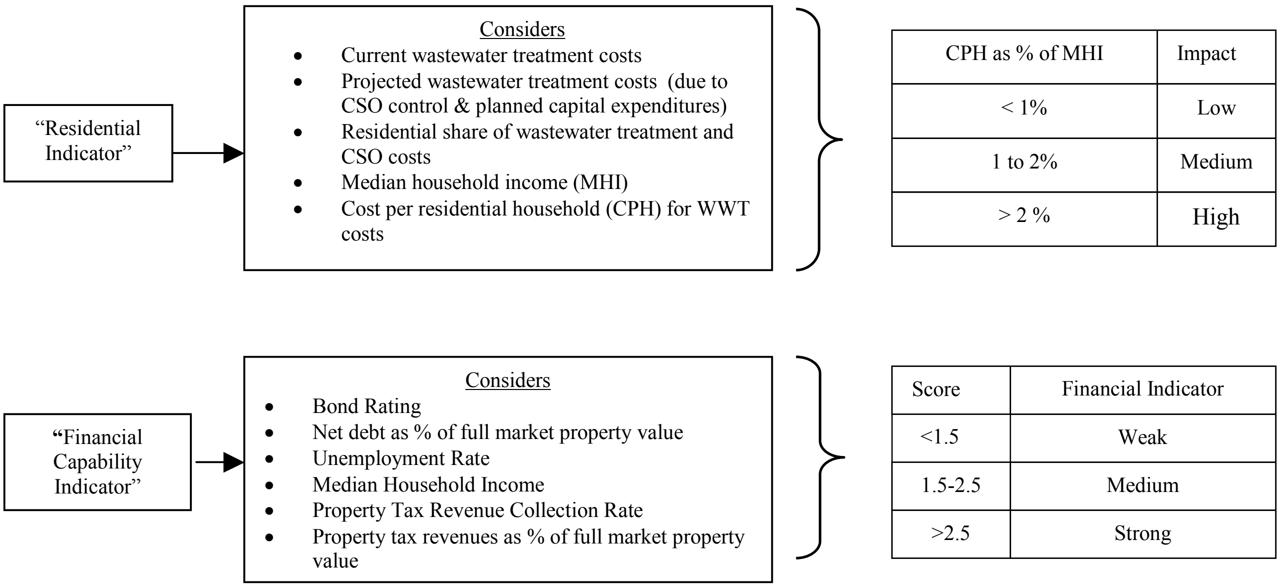
Regulatory agencies are allowed to consider other factors that will have an impact on the ability of a community to finance CSO controls. As a result, this evaluation also considers the District's income distribution, the ability of the District to remain competitive in the greater Washington area, and the effect of WASA's existing capital improvement program on the ability to finance CSO controls.

12.2 METHODOLOGY

In EPA's guidance document, assessment of financial capability entails a two-phase approach. The first phase consists of the calculation of a "Residential Indicator", which measures the financial impact of current and proposed CSO controls on residential users. The residential indicator is calculated by estimating the cost per household (CPH) for current and proposed wastewater treatment and CSO control costs. The CPH is used in conjunction with the median household income (MHI) to estimate residential impacts. Residential impacts are considered by EPA to be 'low' if the CPH is less than 1% of the MHI, 'medium' if the CPH is between 1% and 2% of the MHI, and 'high' if the CPH is greater than 2% of the MHI. Note that the CPH is not strictly equivalent to a monthly or annual sewer user fee. The CPH does not take into account all factors that are included when developing a sewer bill such as project scheduling, industrial vs. residential rates and other factors.

The second phase of the assessment involves calculation of a "Financial Capability Indicator", which assesses the overall financial health of the community. This indicator examines bond rating, debt burden, unemployment rate, property tax collection rates, MHI and other factors to develop a numerical score. The financial capability is considered by EPA to be low if the score is less than 1.5, medium if the score is between 1.5 and 2.5, and strong if the score is greater than 2.5. Figure 12-1 summarizes the development and scoring of the residential and financial capability indicators.

Figure 12-1
EPA's Residential and Financial Capability Indicators



Once the residential and financial capability indicators are calculated, they are combined into a financial capability matrix. The matrix provides EPA's assessment of the overall burden associated with funding CSO controls. This is summarized in Table 12-1.

Table 12-1
EPA's Financial Capability Matrix

Financial Capability Indicator	Residential Indicator (Cost per Household as % of Median Household Income)		
	Low (Below 1.0%)	Medium (Between 1.0% and 2.0%)	High (Above 2.0%)
Weak (Below 1.5)	Medium Burden	High Burden	High Burden
Medium (Between 1.5 and 2.5)	Low Burden	Medium Burden	High Burden
Strong (Above 2.5)	Low Burden	Low Burden	Medium Burden

12.3 RESIDENTIAL INDICATOR

12.3.1 Median Incomes

The CPH for wastewater treatment (WWT) and CSO controls was developed using a three-step process. First, WASA's total WWT and CSO costs were calculated by adding current costs for existing wastewater treatment operations and projected costs for proposed WWT facilities and CSO controls. Next, the residential share of total WWT and CSO costs was calculated. The final step consists of calculating the CPH by dividing the residential share of total WWT and CSO costs by the number of households in the District.

Current WWT costs consist of current annual wastewater operating and maintenance (O & M) expenses, plus current annual debt service (principal and interest). Planned WWT capital costs were obtained from WASA's ten year Capital Improvement Program (CIP) (WASA, 2000b). The CIP amounts to $1.6 billion for the ten-year period FY2000 through FY2009, of which about $564 million are attributable to wastewater treatment for WASA customers within the District. The remainder of the CIP is attributable to water system improvements or to expenditures to be borne by others such as the surrounding counties whose wastewater is treated at Blue Plains.

The affordability analysis was conducted for a range of CSO control plan capital costs between $100 million and $2 billion in year 2001 dollars. Five cost levels were selected to compute the CPH: $0 million, $100 million; $500 million; $1 billion; and $2 billion. Each of the foregoing CSO control cost levels was assumed to occur in FY2001 to establish a common implementation year for all assumed CSO control cost scenarios as a benchmark for their comparison.

WASA's Board of Directors has adopted financial policies that require maintenance of 140 percent debt service coverage, and maintenance of cash reserves of 180 days O&M expenses, currently approximately $91 million. The present analysis factored in WASA's debt service coverage requirement. CSO control O&M costs will add substantially to the reserve requirement. An interest rate of 7% and a term of 30 years were used in the analysis to determine the capital recovery factor, which are consistent with WASA's assumptions for debt issuance for the CIP (WASA, 2002a). An interest rate of 2.6% was used as a present value adjustment factor based on the past 5 year average annual increase in the Consumer Price Index (CPI) from the Bureau of Labor Statistics (U.S. Bureau of Labor, 2000).

The residential share of total annual WWT and CSO costs is computed by multiplying the percent of total wastewater flow attributable to residential users by the total costs. For FY 1999, the residential share of wastewater flow within the District boundaries was 50% (WASA, 2000c).

The latest median household income (MHI) for the District estimated by the Census Bureau for 2000 is $38,752 (U.S. Census Bureau, 2002). This was adjusted upward to year 2001 using an inflation adjustment factor resulting in an adjusted MHI of $39,760. Dividing this amount by total annual WWT and CSO control costs per household (CPH) yields the Residential Indicator and the financial impact on residential customers.

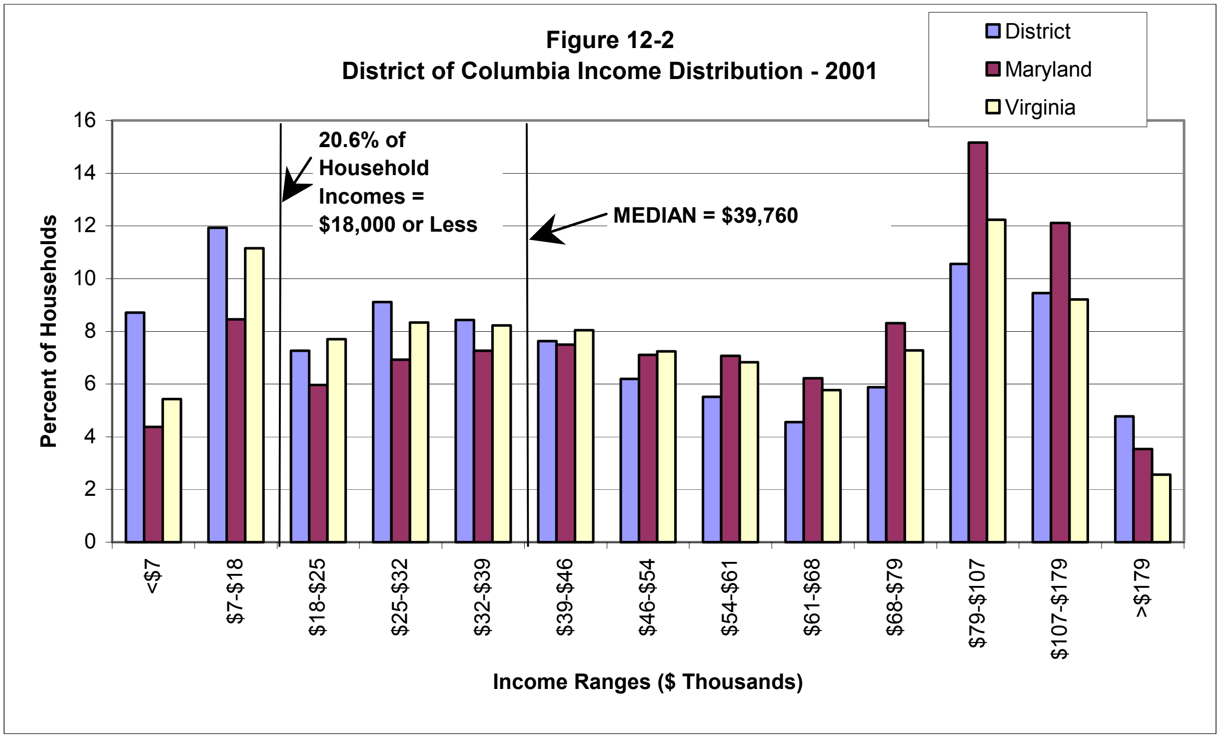
The annual cost per household and the residential indicator are summarized in Table 12-2.

Table 12-2
Projected Cost Per Household and Residential Indicator
Median Income Households

Category	*CSO Control Costs in Year 2001 (ENR=6383)*					*Line No. from EPA Worksheet*
	$0	*$100 Million*	*$500 Million*	*$1,000 Million*	*$2,000 Million*	
Current WWT Costs:						
Annual O&M Expenses	$88,059,582	$88,059,582	$88,059,582	$88,059,582	$88,059,582	100
Annual Debt Service (P&I)	$17,111,944	$17,111,944	$17,111,944	$17,111,944	$17,111,944	101
Subtotal (Line 100 + Line 101)	$105,171,526	$105,171,526	$105,171,526	$105,171,526	$105,171,526	102
Projected WWT Costs: Annual O & M Expense	$0	$0	$0	$0	$0	103a
Projected CSO Costs: Annual O & M Expense	$0	$1,500,000	$7,500,000	$15,000,000	$30,000,000	103b
Projected WWT & CSO Costs: Annual Debt Service (P&I)	$58,110,933	$69,107,129	$113,091,910	$168,072,887	$278,034,842	104
Subtotal (Lines 103a + 103b+ 104)	$58,110,933	$70,607,129	$120,591,910	$183,072,887	$308,034,842	105
Total Current & Projected WWT & CSO Costs (Line 102 + Line 105):	$163,282,459	$175,778,655	$225,763,436	$288,244,413	$413,206,368	106
Residential Share of Total WWT & CSO Costs:	$81,641,230	$87,889,327	$112,881,718	$144,122,207	$206,603,184	107
Total No. of Households in District:	248,338	248,338	248,338	248,338	248,338	108
Annual Cost per Household (Line 107 / Line 108):	**$329**	**$354**	**$455**	**$580**	**$832**	**109**
Median Household Income (MHI) for Census Year 2000	$38,752	$38,752	$38,752	$38,752	$38,752	201
MHI Adjustment to Year 2001	1.026	1.026	1.026	1.026	1.026	202
Adjusted MHI (Line 201 x Line 202)	$39,760	$39,760	$39,760	$39,760	$39,760	203
Annual WWT & CSO Control Costs per Household (CPH) (Line 109)	$329	$354	$455	$580	$832	204
Residential Indicator: CPH as % MHI) (Line 204 / Line 203 x 100)	**0.83%**	**0.89%**	**1.14%**	**1.46%**	**2.09%**	**205**
Financial Impact:	**Low**	**Low**	**Mid-Range**	**Mid-Range**	**High**	

12.3.2 Lower Incomes

The financial impact of wastewater treatment and CSO control costs on residential customers in the District is not fully measured by the foregoing method. Because of the demographics of the District, income does not follow a normal statistical distribution, or bell curve, among households across the full range of incomes. In the District, there is a distinct clustering of household incomes at the lower and upper extremes of the income spectrum. This creates a ‘u’ shaped or upside down income distribution which is shown on Figure 11-2.



Because of the disproportionate number of low income households in the District, the impact of wastewater treatment and CSO control costs on the most well off households in the lowest 20% of income distribution in the District was calculated. The most well off households in this category have incomes of approximately $18,000 per year. The results are presented in Table 12-3, which shows a high impact on this segment of the population for all assumed levels of CSO control costs.

Table 12-3
Projected Cost Per Household and Residential Indicator
Lower 20% of Household Incomes

Category	*CSO Control Costs Year 2001 (ENR=6383)*					*Line No. from EPA Worksheet*
	$0	*$100 Million*	*$500 Million*	*$1,000 Million*	*$2,000 Million*	
Highest Household Income of Lower 20% of Income Range:	$18,000	$18,000	$18,000	$18,000	$18,000	201a
Annual WWT & CSO Control Costs per Household (CPH) (Line 109)	$329	$354	$455	$580	$832	204
Residential Indicator: CPH as % MHI) (Line 204 / Line 203 x 100)	**1.83%**	**1.97%**	**2.53%**	**3.22%**	**4.62%**	**205a**
Financial Impact:	**Mid-Range**	**Mid-Range**	**High**	**High**	**High**	

12.4 FINANCIAL CAPABILITY INDICATORS

12.4.1 General

The permittee's financial indicator score was determined by evaluation of selected factors that portray WASA's and the District's debt burden, socioeconomic conditions, and financial operations. WASA's current debt burden was assessed as well as its ability to issue new debt to finance CSO controls by determining bond ratings and overall debt as a percentage of full market property value in the District. Socioeconomic conditions in the District were evaluated by assessing its unemployment rate and median household income (MHI). The District's ability to manage financial operations were evaluated by determining the property tax collection rate and property tax revenues as a percentage of full market property value. A value range for each of these indicators characterizes whether WASA's residential users are in a "Weak", "Mid-Range" or "Strong" position to bear WASA's WWT and CSO control costs relative to national benchmarks according to the EPA guidance document.

12.4.2 Bond Ratings

Ratings of WASA's Public Utility Revenue Bonds, Series 1998, have been upgraded since their issuance by Moody's, Standard & Poors and Fitch IBCA to A1, A, and A+, respectively. Continued compliance with the Board of Directors' 140 percent debt service coverage and 180 day O&M expense cash reserves policies has been critical to these bond rating upgrades. This will ultimately result in lower interest rates on future WASA debt issuance.

When WASA was first created in 1996, it was an unrated utility. WASA started operations with the negative cash position left by its predecessor agency, the Water and Sewer Utility Administration (WASUA). In barely two years WASA reached its 180 day O & M cash reserve goal, 11 months ahead of schedule. Without strong cash reserves and debt service coverage policies, WASA's bond ratings would be significantly lower and its cost of capital significantly higher. WASA has worked hard to implement these policies and achieve their goals. They must be maintained in order to ensure WASA's long-term financial viability and not be compromised by unaffordable new projects.

According to criteria in the guidance document, the rating of the most recent bonds to be issued either by the District or WASA is to be used to determine a bond rating indicator for WASA. Consequently, a rating of Baa1 for the District's General Obligation Bonds (Series 1999A) and General Obligation Bonds (Series 1999B) by Moody's Investor Service has been used, corresponding to a "Mid-Range" indicator rating (WASA 2002a).

12.4.3 Summary of Financial Capability Indicators

An average score for the indicators determined in this phase of the financial capability assessment was calculated. The indicators are compared to national benchmarks to form an overall assessment of the financial capability and its effect on implementation schedules in the long-term CSO control plan. Each indicator is scored using the following rating scale:

Indicator Ratings	**Score**
Weak	1
Mid-Range	2
Strong	3

The average score for the indicators was calculated by dividing the sum of the scores by the number of entries. The average score is given on line 907 of Table 12-4 and the overall financial capability rating is given at the bottom of the table. According to this procedure, WASA's overall financial capability corresponds to a "Mid-Range" rating. However, because of the disproportionate number of lower income households in the District previously described, an alternative score is presented using the income of the most well off households in the lowest 20% of income distribution in the District instead of the MHI. This score results in a "Low" overall financial capability rating.

Table 12-4
Financial Capability Indicators

Indicator(Line No. from EPA Worksheet)	*Value*	*Indicator Rating*	*Score Using Median Household Incomes*	*Score Using Lower 24% of Household Incomes*	*Line No. from EPA Worksheet*
Bond Rating (Line 303):	Baa1	Mid-Range	2	2	901
Overall Net Debt as a Percent of Full Market Property Value (Line 405):	7.30%	Weak	1	1	902
Unemployment Rate (Line 501):	5.1	Weak	1	1	903
Median Household Income (Line 601):	$39,760	Mid-Range	2	0	904
Highest Household Income of Lower 20% of Income Range (Line 601a):	$18,000	Weak	0	1	904a
Property Tax Revenues as a Percent of Full Market Property Value (Line 703):	1.31%	Strong	3	3	905
Property Tax Revenue Collection Rate (Line 803):	86.89%	Weak	1	1	906
Permittee Indicators Score (Sum of Scores/ Number of Entries):			1.67	1.50	907
Financial Capability:			**Mid-Range**	**Low**	

12.5 COMBINED RESIDENTIAL AND FINANCIAL INDICATORS

The Residential Indicator and the Financial Capability Indicators were combined in the Financial Capability Matrix to evaluate the level of financial burden that CSO controls might impose on WASA. The Residential Indicator score is given on line 1001 and the Financial Capability Indicator score is given on line 1002 of Table 12-5.

Table 12-5
Financial Capability Matrix Overall Score

	CSO Control Costs in Year 2001 (ENR-6383)					*Line No. from EPA Worksheet*
	$0	*$100 Million*	*$500 Million*	*$1,000 Million*	*$2,000 Million*	
For Median Incomes						
Residential Indicator Score (Line 205):	0.83%	0.89%	1.14%	1.46%	2.09%	1001
Financial Capability Indicators Score (Line 907 Column B):	1.67	1.67	1.67	1.67	1.67	1002
Financial Capability Matrix Category:	**Low Burden**	**Low Burden**	**Medium Burden**	**Medium Burden**	**High Burden**	**1003**
Lower 20% of Household Incomes						
Residential Indicator Score (Line 205a):	1.83%	1.97%	2.53%	3.22%	4.62%	1001a
Financial Capability Indicators Score (Line 907 Column C):	1.50	1.50	1.50	1.50	1.50	1002a
Financial Capability Matrix Category:	**Medium Burden**	**Medium Burden**	**High Burden**	**High Burden**	**High Burden**	**1003a**

Based on EPA's approach, it would appear that CSO control programs costing between $500 million and $1 billion would impose a "Medium Burden" and a CSO control program costing $2 billion would impose a "High Burden" on WASA and its residential customers.

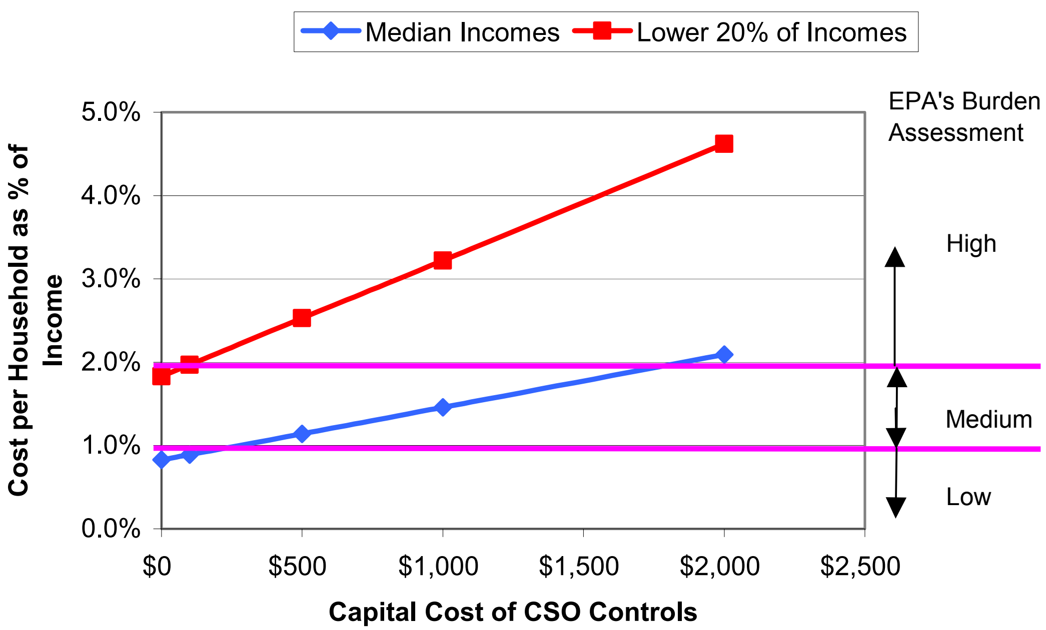
This method of determining a Financial Capability Matrix category for WASA understates the impact of CSO controls on the disproportionately large number of low income households in the District. Therefore, the Financial Capability Matrix Score was also calculated for the most well off households in the lowest 20% of income distribution. This score presents a very different picture of the impact of CSO control costs, indicating that any program above approximately $100 million would impose a "High Burden" on this segment of the population.

Additional analyses were performed to determine the CSO control cost levels that would trigger each of the financial burden categories established by EPA. The results suggest that for median income households, the threshold CSO capital cost for rising into EPA's 'high' burden level is about $1.85 billion. For the upper end of the lower 20% income range, this threshold is only $125 million. These results are summarized in Table 12-6 and on Figure 12-3.

Table 12-6
Summary of CSO Control Cost Impacts on Residential Customers
(Year 2001 Dollars)

EPA's Burden Assessment	*Median Income Households*			*Low Income Households (Income of 18,000)*		
	CPH as a % of MHI	*Wastewater & CSO CPH*	*CSO Control Plan Cost*	*CPH as a % of Income*	*Wastewater & CSO CPH*	*CSO Control Plan Cost*
No Additional CSO Controls (Baseline Condition)	0.83%	$329	$0	1.83%	$329	$0
Medium Burden Threshold	1.0%	$399	$280 million	1.0%	$180	$0
High Burden Threshold	2.0%	$794	$1.85 billion	2.0%	$360	$125 million

Figure 12-3
Impact of CSO Controls on Cost Per Household



12.6 OTHER FACTORS

12.6.1 Baseline Rate Impacts Facing WASA's Rate Payers

The financial assessment and affordability analysis presented in the previous sections uses EPA's standard methodology to assess the financial capability of the Authority and its customers relative to the proposed LTCP. The assessment using EPA's approach results in a finding of an overall "medium impact" on the Authority and its customers; the impact is high when applied to the over 51,000 households that have incomes of less than $18,000. These households approach the medium impact with WASA's existing capital program and financial plan; including CSO costs, their wastewater costs will fall in the very high range. A more accurate and complete picture of the financial capability of the Authority and its customers to fund the proposed LTCP must take into consideration the total cost of wastewater treatment and CSO controls, the rising cost of drinking water services, and, as pointed out earlier, the disparate impact on low income residents of the District of Columbia.

This analysis reflects several important analytical conventions that differ from the analysis presented in earlier sections.

- This rate impact analysis focuses on a typical residential customer with metered water consumption of 100 ccf per year. The EPA approach documented in earlier sections uses the number of households and cost per household (CPH) to evaluate financial capability. Note the two methods are not strictly equivalent. The CPH does not take into account all factors that are included in retail rate making such as project scheduling, varying consumption levels, etc.

- The EPA approach uses cost estimates in current dollars. The plan reflects 2001 values for all cost estimates. This analysis of rate impacts uses "year-of-expenditure" values which reflect the inflationary impact of time on costs and rates.

In January 2002, the Authority adopted a 10-year financial plan that provides for operations, maintenance and capital expenditures for the period of FY 2001 to FY 2010. This 10-year plan continues the Authority's current $1.6 billion water and wastewater capital improvement program (CIP).

Approximately 24 percent of the CIP is for mandated improvements that will enable the Authority to meet its current regulatory requirements. The balance of the program reflects the age and condition of the system and historical disinvestment in the system's infrastructure by predecessor agencies.

- Over half of WASA's pumping stations were constructed before 1940 and are not operating at optimal capacity.
- Half of WASA's pipes were built prior to 1930.
- Preventive maintenance expenditures were extremely low from 1980 to 1996.
- Virtually no technology existed in the Authority's operations prior to 1997.
- Prior to WASA's creation in 1997, annual capital spending averaged less than $40 million per year on total plant in service of over $1.3 billion.

Between FY 2003 and FY 2007, in the peak years of this capital program, WASA's annual capital investments in water and wastewater infrastructure (before consideration of the LTCP) exceed $200 million, a fivefold increase from the average investment only five years ago.

Even with significant capital funding from wholesale customers and grants – about 13% of the CIP's funding will come from EPA grants and 28% from wholesale customers – WASA will need to issue approximately $775 million in new debt between FY 2001 and FY 2010 to finance 47% percent of the program. As a result debt service costs will increase by more than $50 million per year by 2010 over current levels. This rising trend is equivalent to average annual increases of 11% in annual debt service costs.

The majority of the burden of this capital investment falls on the District's retail rate payers. Annual increases in retail rates of approximately 6.5% to 7.0% through FY 2008 followed by 6% annual increases from FY 2009 through FY 2012 will be required to finance the Authority's existing capital program. This projection is consistent with the policy adopted by WASA's Board of Directors to use steady rate increases as a way to mitigate the impacts of rising and mandated costs to customers. The Board established this policy after implementing a critically-needed 42% rate increase in 1997.

Over the long-term, the Authority is projecting that future necessary infrastructure investment will continue to require steady rate increases of at least 5% per year. This longer-term outlook is consistent with national infrastructure studies that document the need for doubling of rates over 20 years for infrastructure investment (see Clean and Safe Water for the 21st Century, Water Infrastructure Network, Washington, D.C.).

Under this "baseline" scenario, in which customer rates are affected by the water and wastewater capital program and routine inflationary increases in the cost of doing business, the annual cost for water and wastewater costs for a typical residential customer with metered consumption of 100 CCF per year prior to consideration of the CSO LTCP will increase from $290 to $617, a 113% increase, in fifteen years.

12.6.2 Substantial Rate Increases Required to Fund LTCP

Implementation of the LTCP will result in substantial additional rate increases and higher costs to the Authority's customers over and above the increases needed to fund the baseline capital program. Through analysis of a range of LTCP implementation schedules WASA has determined that the only rates impacts that are feasible (without substantial outside funding) are those associated with the longest possible implementation schedules. Shorter implementation schedules create too high a burden on the Authority's rate payers in terms of rapid escalation of the cost of wastewater services.

If WASA implemented the proposed LTCP over a 40-year period, a typical residential customer with annual metered water consumption of 100 CCF will see their annual wastewater costs rise from $290 to $722 in 15-years; an increase of 150%. This figure is $105 per year more than the annual bill in the baseline case without any CSO program.

Any shortening of the implementation schedule to less than 40 years will significantly increase the impacts on WASA's rate payers of the CSO controls. A fifteen-year LTCP implementation schedule would result in a more than tripling of wastewater bills to $1002 in fifteen years, and would require multiple peak increases within the next 5 to 10 years exceeding 15%, as described further below. A twenty-year program also has similar peaking impacts during the first 10 years.

Table 12-7 displays the impacts for a 100 CCF customer over 15 years for the baseline and for several LTCP implementation schedules.

Table 12-7
Summary of Rate Impacts of the CSO LTCP on 100 CCF Residential Customer

	FY 2003 Annual Bill	*Annual Bill in 15 Years*	*Average Annual Rate Increases Over 15 Years*
Baseline – No LTCP	$290	$617	6.0%
Baseline Plus LTCP – 40 Years	$290	$722	7.2%
Baseline Plus LTCP – 30 Years	$290	$795	8.0%
Baseline Plus LTCP – 20 Years	$290	$942	9.4%
Baseline Plus LTCP – 15 Years	$290	$1,002	9.9%

12.6.3 True Affordability Measure -- Impacts on Annual Household Budgets

A key indicator of the affordability of the proposed LTCP is the impact on the annual household budgets for District ratepayers as measured by the timing and extent of the required annual rate increases.

The 15 and 20-year LTCP implementation schedules would require a large number of consecutive "double-digit" rate increases when the costs of those programs are added to the demands imposed by the baseline investment in water and wastewater infrastructure. The 15-year program is projected to require 8 consecutive increases over 10% per year. Such rate increases would outpace expected growth in household incomes by two to three times, therefore eroding household resources for other items .

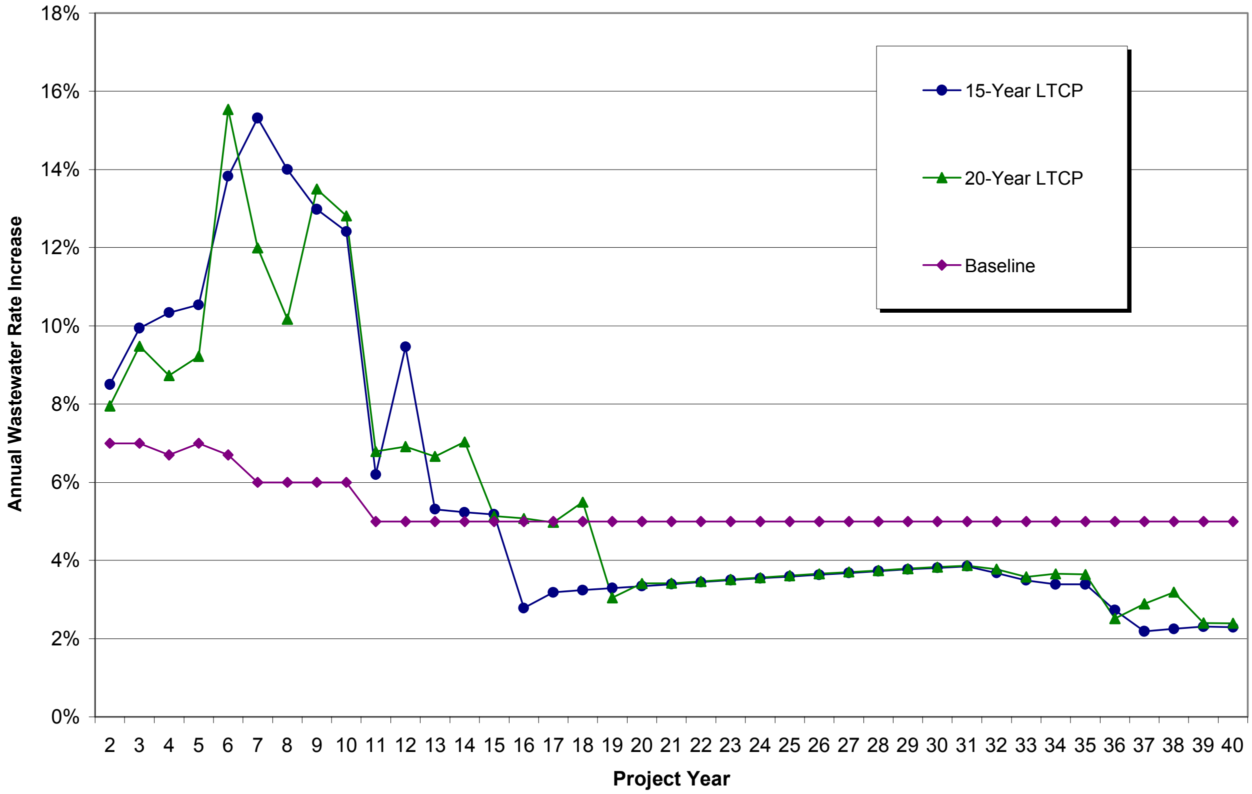
In addition to the extreme peaking of rate increases, the disparity between the rising costs that would be borne by District of Columbia residents and national experience is illustrated by the difference between 9.9% average annual increases associated with the 15-year program and the 3.6% annual rate of growth in consumer expenditures for water and sewer maintenance reported by the Bureau of Labor Statistics (BLS from January 1992 to January 2002.

These burdens will make it increasingly difficult for the District to remain competitive on a "cost of living" or "cost of doing business basis" compared to neighboring jurisdictions or other major cities that are not faced with the same capital investment burden. Currently the Authority's rates are generally competitive with the wastewater rates paid in neighboring jurisdictions in Maryland and Virginia but none of these jurisdictions is faced with the burden of an expensive CSO LTCP. The impact of this program will reduce the ability of the District to attract and retain residents and businesses relative to other locations in the area.

Nationally, a survey conducted by Memphis Gas, Light and Water Division of residential wastewater bills for rates in effect in 2001 found the monthly wastewater bills for residential customers in the District were the sixth highest out of 28 cities surveyed. All of the future rate increases associated with the baseline infrastructure investment needs and the CSO will likely further reduce the District's competitiveness on a cost of living and cost of doing business basis relative to other major cities that do not have the same burdens.

Figure 12-4 shows the annual increase in wastewater rates required for the 15 and 20-year programs as well as the baseline case.

Figure 12–4
Annual Rate Increases Required for 15 and 20-Year LTCP Plans



Another important measure is the total increase in revenue requirement added in each fiscal year, as shown in Figure 12-5. This measure demonstrates the intense peaking requirements of the CSO program as well. A 15-year program would require approximately $20 million of annual rate increases solely for CSO in five out of six years at the height of the program. The highest annual increase in revenue requirement would be approximately $33 million when the total needs of the baseline infrastructure program and the CSO are taken together.

Longer implementation schedules that range from 30 to 40 years greatly minimize peak rate increases: the 15-year schedule required eight consecutive annual increases in excess of 10 percent, while a 40 year schedule will only require one increase that is greater than 10 percent. Fewer peak increases under longer-term implementation schedules minimize the near-term impact on customers, particularly the 51,000 households with incomes less than $18,000 per year, allowing them to plan for more gradual rate increases that are in line with projected salary and other income increases. Figure 12-6 displays the annual rate increases required for 30- and 40-year implementation programs.

Figure 12-5
Annual Increase in Revenue Requirement for 15-Year LTCP and Baseline Needs

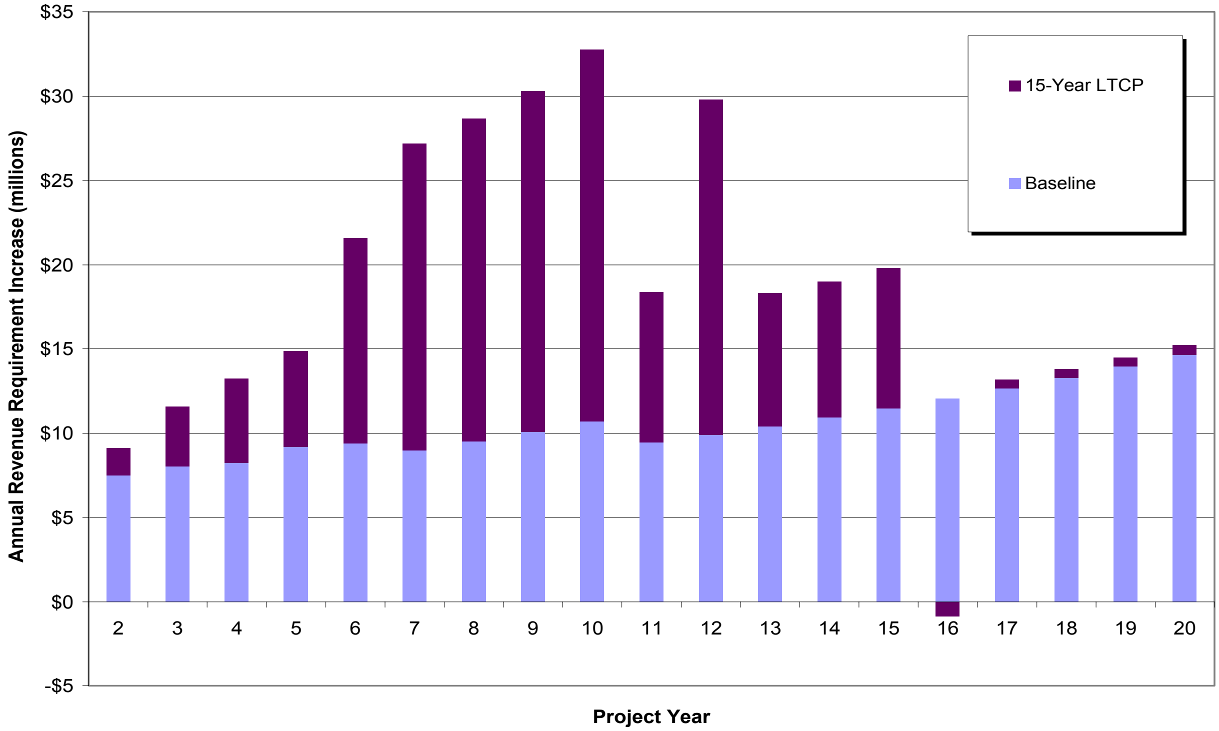
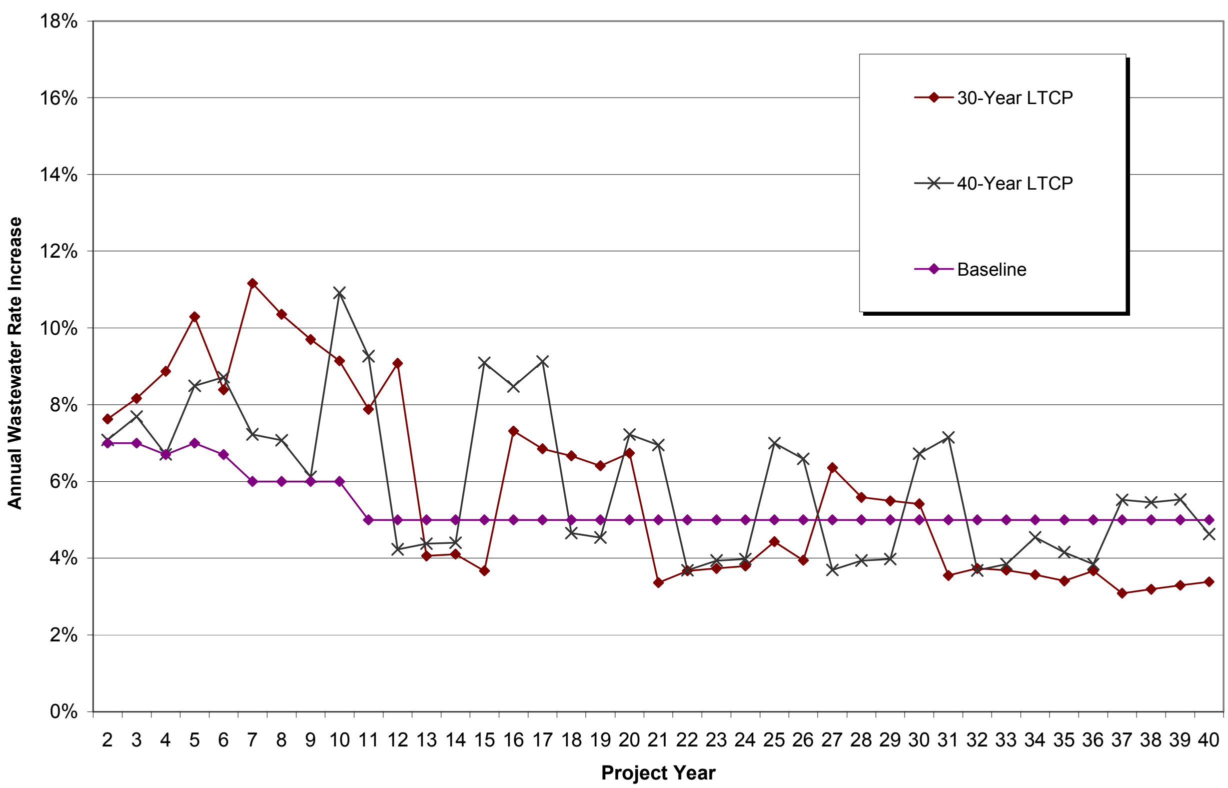


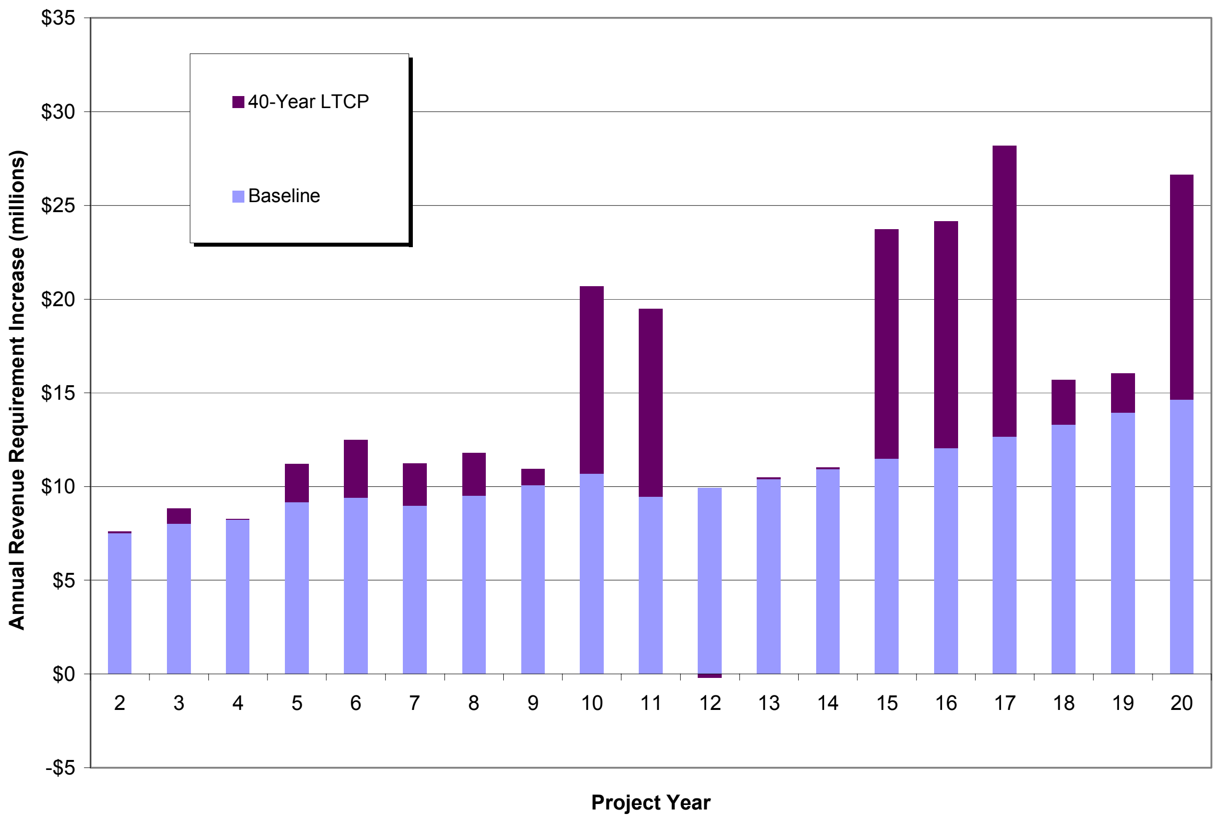
Figure 12-6
Annual Rate Increases Required for 30 and 40-Year LTCP Plans



Although there are still burdensome peaks, in general the 40-year program requires less annual increases in rate revenues for CSO. As shown in Figure 12-5, a 15-year program will require annual rate revenue increases in excess of $20 million for five out of fifteen years. Figure 12-7 shows that a 40-year schedule will require only one increase in excess of $20 million during the first fifteen years of implementation. This illustrates the minimizing effect of a longer term program on WASA's customers, particularly low income customers.

Figure 12-7

Annual Increases in Revenue Requirements for 40-Year Program



12.6.4 High Degree of Uncertainty in Rate Impacts Should Be Considered

In formulating its rate impact analysis WASA focused on a "most probable" approach to key assumptions that represent the economic and demographic conditions during the foreseeable future in a manner appropriate for this planning document. Nevertheless, the economic and demographic conditions that actually materialize on a year-to-year basis may differ from those associated with the forecast. Some of these considerations are described below:

- <u>Water Consumption</u> - The analysis of rate impacts has assumed that metered water consumption is maintained at current levels over the long-term. Water consumption has declined over the past 2 decades due to technological improvements and shifts in consumer behavior. Although WASA has taken steps to maintain a high level of meter accuracy and to reduce unbilled water, it is possible that water consumption will continue to decrease over the long-term, particularly in response to increasing rates. It is not unreasonable to expect that the 150% increase in rates over 15 years associated with the 40-year LTCP program will result in some level of reduced consumption. Any reduction in consumption will result in higher impacts have to be offset with further rate increases on the balance of the water sold by the Authority. There exists the potential to initiate a vicious cycle that would be particularly hard on low income households.

- Cost Estimates -The rate impact analysis reflects the cost estimates prepared for this planning document. These costs estimates have a level of confidence of minus-15% to plus-40%. It would be equally likely that the final cost estimates in today's dollars are 40% greater or 15% less than the cost estimates included in this plan. These estimates reflect the level of planning and engineering completed to date on each alternative which is only a portion of the work needed to complete the project. It is very likely that the costs will be higher due to the complexity of the project and the unique risks involved with a mega-project. In recent months many high-profile mega-projects of this type have seen bid amounts far exceed preliminary estimates. Several examples within the Washington region are the Woodrow Wilson Bridge replacement and the I-495/I-395 interchange (the "Mixing Bowl") project. Unlike those projects however, any cost increases or contract overruns would be borne by a relatively small population of wastewater rate payers in the District of Columbia. These are very real risks that should be considered as part of the financial capability assessment.

- Interest Rates - This rate impact analysis assumes that the Authority will be able to borrow for future CSO costs at the same interest rates as it currently pays for its utility revenue debt. Any increase in interest rates due to market conditions will need to be absorbed by WASA's retail customers and will increase the financial burden of all LTCP schedule options. The Authority's future credit rating and the structure of future bond issues could also have negative impacts on the revenue requirements. These risks should also be considered in the financial capability analysis.

- Future Regulatory Requirements - The rates impact analysis reflects the current regulatory horizon that the Authority has used to develop its current capital improvement program and the LTCP for its combined sewer system. The analysis does not provide for additional costs that may be mandated to cover future regulations such as Total Maximum Daily Loads (TMDLs) or additional nitrogen removal requirements at Blue Plains. While the baseline analysis provides substantial capital funding for future reinvestment in infrastructure, any extraordinary capital costs related to future regulation (e.g., disinfection by-products) or critical infrastructure replacement needs would further increase rates for the Authority's rate payers.

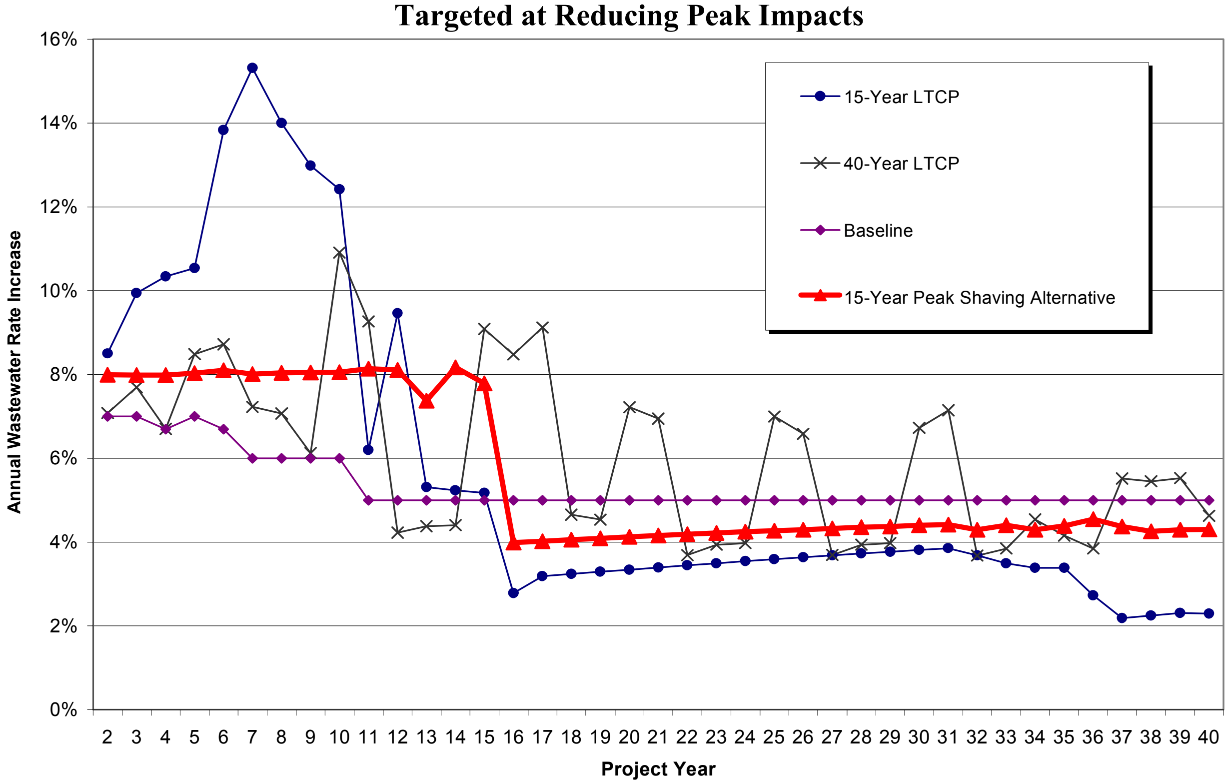
12.6.5 Effect of Federal Funding on Rate Increases

There are two ways to reduce the rate impacts of a shorter LTCP implementation schedule, external funding assistance and deferral of other water and wastewater capital expenditures.

External assistance targeted at limiting peak rate increases can reduce the severe impacts of high annual rate increases associated with the shorter programs. External assistance of 62% of the capital cost of the program could keep rate increases to 8% per year as shown in the following chart. The additional annual revenue required would gradually increase to $11.2 million by year 15.

Total external capital assistance under this scenario would be $960 million over 15 years. The external assistance in this case is targeted at the peaking impacts on wastewater rates and varies from year to year as necessary to limit rate increases to 8% or less. In any case, it is important for external assistance to reflect year-of-expenditure values or the actual "cost to complete" the project. If external assistance is determined on current dollars or on an amount per year, the cost to complete and inflation risks are shifted to ratepayers.

Figure 12-8
Rate Increases for a 15-Year LTCP Plan with External Assistance Targeted at Reducing Peak Impacts



FINANCIAL CAPABILITY ASSESSMENT: PHILADELPHIA WATER DEPARTMENT

11 FINANCIAL CAPABILITY

11.1 INTRODUCTION

The United States Environmental Protection Agency (US EPA) suggests that a financial capability assessment should be included in the CSO Long Term Control Plan (LTCP) in order to establish the burden of compliance on both ratepayers and the permittee. The assessment in this section follows the guidelines and methodology as described in the US EPA's "Combined Sewer Overflows – Guidance for Financial Capability Assessment and Schedule Development," published February 1997. The purpose of the financial capability assessment is twofold.

First, the affordability process contemplates balancing the pace of environmental improvement with the financial and economic capability of the permittee. The process allows flexibility in scheduling completion of CSO compliance measures, based on the financial capability of the area served. Second, a financial capability can support the determination of funding needs by agencies providing loan and grant monies for capital projects.

The financial capability assessment is a two phased process. The residential indicator is the percentage of median household income (MHI) expended on wastewater management. The financial capability indicator is an assessment of the permittee's debt burden, socioeconomic conditions, and financial operations. These two measures are subsequently entered into a financial capability matrix, suggested by US EPA, to determine the level of financial burden that the existing wastewater management system and the CSO control measures will place on residential customers and the permittee. The US EPA matrix appears in Table 11-8 at the end of this section.

In addition to following guidelines for these two measures, US EPA encourages inclusion of any information that would have a financial impact on CSO compliance by the permittee in the capability report. This assessment, therefore, includes extensive discussion of socioeconomic trends in the Philadelphia area because of the financial challenges that the City and the region faces.

11.2 PHASE 1 - CALCULATION OF THE RESIDENTIAL INDICATOR

PWD has projected future revenue requirements and associated rates, taking into account current and future costs to operate, maintain, and replace the PWD's system, currently outstanding debt service, and future debt service resulting from anticipated and identified capital improvements. The focus for evaluating the impact of the residential indicator is the next 20 years (FY 2029)[1], however it is anticipated that elements of the LTCPU implementation program will continue well beyond this 20 year timeframe.

PWD has developed its financial projections consistent with the manner in which it develops rate projections, with expenses, revenues and capital costs stated in future year dollar terms

[1] The City of Philadelphia's fiscal year runs from July 1st through June 30th.

(*i.e.*, inflated to the future year). Thus, household bills in 2015 (for example), reflect what PWD estimates households are projected to pay in that year. For purposes of the affordability analysis, these future household rates are compared to projected household incomes (also projected to future year dollars) in those specific years. The approach keeps all cost figures on a consistent basis and provides PWD with a realistic picture of actions required to raise needed revenue and comply with its ultimate requirements.

In developing these projections, PWD has sought to estimate the future burden of the LTCPU in addition to the full utility system's long term needs for wastewater and water service, as currently understood. Although PWD provides both water and wastewater (including stormwater) service, they have traditionally maintained separate water and wastewater rates, in accordance with standard cost-of-service criteria. PWD has evaluated the impact of the LTCPU by estimating those capital and operation and maintenance (O&M) costs in conjunction with an estimate of other costs anticipated to be incurred by the utility over the next 20-plus years. The associated rates for wastewater and stormwater are then estimated on an average household basis. The residential indicator is based on that average annual cost per household relative to projected MHI for each year over the forecast period.

11.2.1 Key Assumptions

The key assumptions used to develop these projections are:

- The combined sewer area is located within the City limits of Philadelphia, therefore the determination of the residential indicator is based on the retail cost of wastewater service for households in the City of Philadelphia served directly by PWD. The cost of contract sales to wholesale customers outside of the City is anticipated to increase in response to increased costs of service for non-LTCPU related activities
- The projected average growth in MHI is 2.29%. Since 1989, MHI in Philadelphia has grown at a rate which is below both those of the state (2.94%) and national (3.18%) levels. This appears to be a consistent and long-term trend resulting from structural elements of the Philadelphia's demographic and economic makeup, rather than just being the result of cyclical or outlying occurrences. Metered sales (for water/wastewater customers) and associated billable discharges to the wastewater system have been trending downward (*e.g.*, billed water consumption declined approximately 5.4% for FY 2000 to FY 2008). To provide for a conservative estimate, the residential indicator projections assume that consumption will stabilize at current levels
- Costs associated with O&M (including labor and materials) are anticipated to grow at rates experienced in recent years. The costs for O&M of PWD's existing wastewater system are estimated to increase at 4.7% per year throughout the planning period. The inflation rate for the O&M costs for LTCPU related projects is projected to be 3.87%
- Future costs for capital projects are inflated at an annual rate of 3.87%. For the most recent 10 year period, the Engineering News Record City Cost Index – Philadelphia construction cost index and the building cost index have increased at an average annual rate of 4.1% and 3.9% respectively

- The PWD's capital improvement program for non-LTCPU related projects reflects continued investments in facility upgrades and replacements throughout the entire system. The estimated costs for the non-LTCPU capital improvements are approximately $3.7 billion (water and sewer - 2009 dollars) through Philadelphia's FY 2029 (ending June 30, 2029). The primary capital expenditures generally consist of the following: improvements to water and wastewater treatment plants; rehabilitations and replacement of water mains; rehabilitation and replacement of old sewers and construction of new sewers to relieve unsanitary conditions; and construction of new storm flood relief sewers and storage tanks
- PWD assumes the funding for its capital program will be financed primarily through the issuance of revenue bonds through the municipal bond market, supplemented through PennVest financings. PWD will also utilize pay-as-you-go funding and, to the extent available, miscellaneous grants. Best practices vis-à-vis the municipal bond market requires that PWD's capital debt be structured with various interest rates and maturities. Therefore, rather than specifying an assumed interest rate and bond duration, PWD's Financial Capability analysis utilizes long term experience in defining an annual cost per unit of principal borrowed. PWD has determined that a capital cost factor of 8.059% is appropriate. Costs of O&M associated with the LTCPU were synchronized with the implementation schedule and with escalation factors generally resembling historical cost escalation for PWD's overall O&M program
- Revenue projections for this financial capability assessment rely on PWD's existing cost-of-service based rate structure with forecast revisions reflecting the proportional increase in wastewater and stormwater costs due to implementation of the LTCPU as well as a continuation of the non-rate revenues the City currently generates

As detailed in Section 10 of this report, PWD is proposing green infrastructure with targeted traditional infrastructure as its preferred alternative. The recommended plan seeks to reduce CSO frequency and volume through a range of land-based stormwater management techniques or source controls. As described in previous sections, this option will be implemented in stages through 2029. The total capital need for the LTCPU program is $902 million (Table 11-1), and the total O&M need through 2029 for the LTCPU as it is implemented is $98 million, both stated in 2009 dollars.

The LTCPU capital program will be implemented within the context of PWD's overall capital improvement program, also summarized in Table 11-1. Total capital expenditures through 2029 of approximately $4.6 billion (2009 dollars) for improvements to the water and wastewater systems are projected. Of these projected capital expenditures, around $3.4 billion or 73 % are projected for wastewater and wet weather; including $902 million for the implementation of the recommended LTCPU through 2029. The remaining projected wastewater expenditures go towards system renewal, replacement, rehabilitation and improvements necessary for adequate and compliant services.

PWD assumes the continuation of its ongoing program related to water main and sewer rehabilitation and replacement and treatment plant upgrades throughout the 20 year period. PWD will also pursue an aggressive storm flood relief program that is intended to be completed within the next decade. The cost of that program is not included in the estimate

Table 11-1 PWD Capital Improvements Program (in billion $) 2010-2029

Capital Program	Present Dollar Value (2009 Dollars)
Water Treatment and Distribution	$1.22
Wastewater Treatment and Collection	$2.12
Storm Flood Relief	$0.36
Long Term Control Plan	$0.90
Total Capital Cost	**$4.60**

for the LTCPU, although it is expected to have a beneficial impact on the City's ability to manage wet weather flows in the future.

11.2.2 Projected Revenue Requirements and Rate Impacts

For FY 2009 through FY 2029, the annual revenue requirement for PWD's wastewater system is expected to increase by about $720 million, from approximately $350 million to $1.07 billion in 2029. Annual wastewater system debt service in 2029 is projected to be approximately $366 million. This amount compares to current (2009) annual wastewater system debt service costs of approximately $130 million.

PWD is empowered and required under the Philadelphia Home Rule Charter to establish rates for water, wastewater and stormwater at levels that provide sufficient revenue to meet all operating expenses of the water, wastewater and stormwater systems, including interdepartmental charges for services provided to the PWD, and debt service requirements on all obligations issued for the PWD, including specific bond ordinance covenants.

PWD estimates that the typical household in the City currently pays approximately $400 annually for wastewater services, including stormwater. The most recently available U.S. Census data for MHI in Philadelphia is $35,431 for 2007. Based upon the projected annual MHI growth of 2.29%, the estimated 2009 MHI would be $37,072. PWD customers are currently (2009) paying approximately 1.10% of their income for wastewater charges. In addition to the general rates, special rates are applicable to certain properties or customer groups as prescribed by ordinance. Charges are also administered for municipal fire protection and private fire protection and for industrial dischargers of high strength wastewater. Service to customers located outside the City is on a wholesale basis through contracts with various municipalities, authorities and townships. Each wholesale contract has been negotiated on a case-by-case basis, and has a different cost structure and variations in the method for adjusting those wholesale charges to reflect changes in their cost of service.

Under the US EPA guidance, a key measure of affordability is the residential indicator: the ratio of the wastewater cost per household to MHI. The residential indicator is compared to US EPA-defined criteria to determine whether costs impose a low, mid-range, or high impact on residential users. Table 11-2 shows US EPA's residential indicator criteria, which define a "low" impact as a cost per household less than 1.0% MHI, a "mid-range" impact between 1.0 and 2.0%, and "high" impact as greater than 2.0% of MHI.

Table 11-2 US EPA Residential Indicator

Residential Indicator	Cost per Household
Low	Less than 1.0% of MHI
Mid-Range	1.0-2.0% of MHI
High	Greater than 2.0% of MHI

Implementation of the PWD's LTCPU projects along with other necessary wastewater system capital improvements require wastewater system rates to be increased at an annualized rate of approximately 6.18%. The cumulative effects of these increases are shown graphically on Figure 11-1. The primary measure of the affordability (wastewater cost as percent of MHI), the residential indicator, is currently around 1.1%. The residential indicator is expected to rise to approximately 2.27% by 2029); based upon projected average annual household wastewater costs of approximately $1,321 and a projected MHI of approximately $58,305. As may be noted in Figure 11-1, the cost, demographic and economic trends will result in continued increases in the percentage of household income to be expended on wastewater services well beyond 2029.

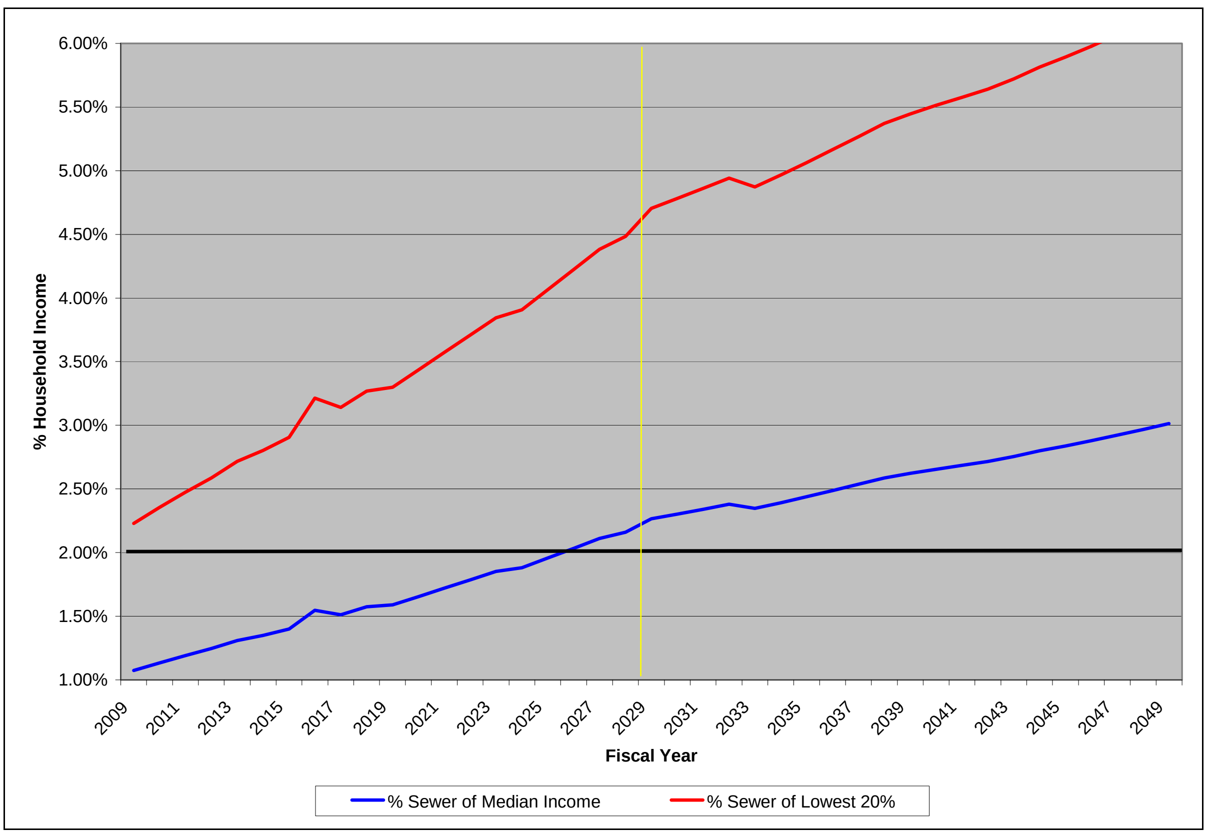


Figure 11-1 Residential Indicator, 2009-2029 Recommended Plan, 2009-2020 Implementation

US EPA's residential indicator is based upon the City's MHI. By definition, one half of the households (approximately 279,000) have household incomes that are less than the current $37,072 median and will be less than the $58,305 MHI that is projected for 2029. At an average of approximately 2.5 residents per household, the lower half of the MHI population for the City would total approximately 698,000. Therefore, a group that would comprise the 16th largest cities within the U.S., (exceeding major cities such as Boston, Baltimore, Washington D.C., and Seattle), would be paying more than 2.27% of their incomes for wastewater services in 2029.

The financial impact of the LTCPU implementation and other LTCPU costs on the lower income population of Philadelphia will be significant. The projected 2029 MHI for the lowest 20% MHI group is less than $38,000. This group would be paying between 3.5% of their MHI (upper limit of the second quintile) to 7.0% MHI (first quintile) in 2029. This group includes around 158,000 households representing a population of around 396,000. This number is larger than the populations of major cities such as Cincinnati, Minneapolis, Honolulu, Pittsburgh, and Toledo. The disparate impact of the implementation of the LTCPU and other necessary wastewater capital improvements upon the City's varying income areas is shown on Figure 11-2. The map shows the projected Residential Indicators for the 368 census tracts within the City of Philadelphia in 2029.

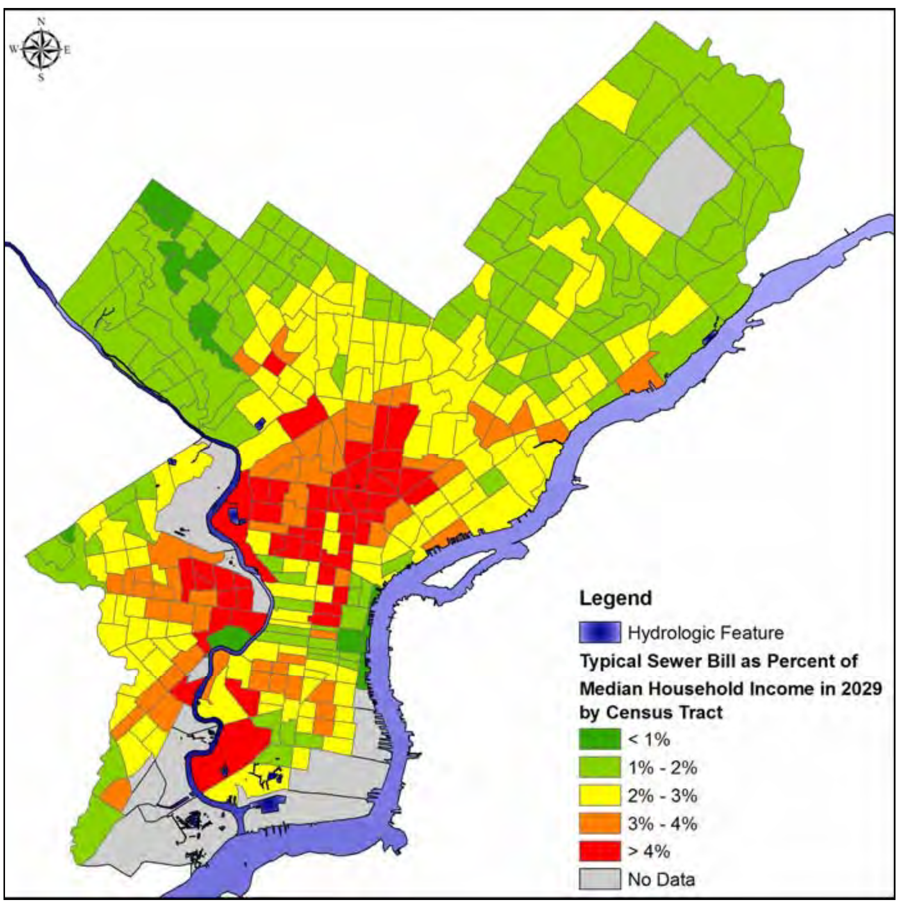


Figure 11-2 Projected Residential Indicator by Census Tract (2029)

11.2.3 Financing Assumptions

The projections of burden and the residential indicator are sensitive to assumptions regarding debt financing. PWD has traditionally funded its capital programs with a combination of traditional debt (revenue backed bonds), existing reserve funds, grant funding (when available), and the state revolving fund (PennVEST). Although this combination of funding mechanisms may continue to be available, it is assumed that the predominant funding source will be traditional debt (revenue bonds issued through the municipal bond market) supplemented by pay as you go funding and limited grants.

11.2.4 Grant Availability

Although PWD will pursue available grant programs, the financial analysis does anticipate grant funding for CSO controls. The amount of grant funding that may become available is expected to be relatively minor in comparison to the projected capital expenditures for the LTCPU.

11.3 PHASE 2 - CALCULATION OF PERMITTEE FINANCIAL CAPABILITY INDICATORS

The second phase of the financial capability assessment - calculation of the financial capability indicator for the permittee – includes six items that fall into three general categories of debt, socioeconomic, and financial management indicators. The six items are:

- Bond rating
- Total net debt as a percentage of full market real estate value
- Unemployment rate
- MHI
- Property tax revenues as a percentage of full market property value
- Property tax revenue collection rate

Each item is given a score of three, two, or one, corresponding to ratings of strong, mid-range, or weak, according to US EPA-suggested standards. The overall financial capability indicator is then derived by taking a simple average of the ratings. This value is then entered into the financial capability matrix to be compared with the residential indicator for an overall capability assessment). Table 11-3 contains the six criteria and the ratings that categorize the permittee as strong, mid-range, or weak in each category. Shaded areas of this table indicate the City of Philadelphia's position in each category. Indicators with shading in two ratings such as the bond rating category reflect a score between the two ratings. A discussion of each item follows.

Table 11-3 US EPA Permittee Financial Capability Indicator Benchmarks

Indicator	Strong	Mid-Range	Weak
Bond rating	AAA-A (S&P) or Aaa-A (Moody's)	BBB (S&P) Baa (Moody's)	BB-D (S&P) B-C (Moody's)
Overall net debt as a percent of full market property value	< 2%	2% to 5%	> 5%
Unemployment rate	> one percentage point below the national average	± one percentage point of national average	> one percentage point above the national average
MHI	More than 25% above adjusted national MHI	± 25% of adjusted national MHI	> 25% below adjusted national MHI
Property tax revenues as a percent of full market property value	< 2%	2% to 4%	> 4%
Property tax collection rate	> 98%	94% to 98%	< 94%

(Blue areas indicate City of Philadelphia ratings)

Bond Rating – Indicator 1

General obligation debt, which is debt backed by the full faith, credit, and taxing power of the City of Philadelphia, has been rated by Moody's Investors Service at Baa1, by Standard & Poor's Corporation at BBB, and by Fitch Investors Service at BBB+.

The PWD issues debt pursuant to the City's Restated General Water and Wastewater Revenue Bond Ordinance of 1989 ("General Ordinance"), which superseded the General Water and Wastewater Revenue Bond Ordinance of 1974 ("Prior Ordinance"). PWD's debt is a special obligation of the City, secured along with previously issued water and wastewater revenue bonds, by a pledge of and security interest in all project revenues established in various funds and accounts, all as defined in the General Ordinance.

PWD's debt is currently rated as A3 by Moody's Investors Service, A by Standard and Poor's and A- by Fitch.[2] Based on the current credit rating of the City and PWD the overall bond rating is between strong and mid-range.

Net Debt as Percent of Full Market Value – Indicator 2

Total net debt includes overlapping debt, which is the indebtedness of the School District of Philadelphia and the City of Philadelphia General Bonded Debt in addition to the City of Philadelphia. School District debt totaled $2,634 million and bonded debt totaled $4,136 million on June 30, 2008, for total overlapping debt of $6.77 billion. The percent of total net debt to full market value was 37.30%. The calculation of the above percentage is based on a deduction of $255.7 million in sinking fund monies from outstanding debt. Self-sustaining debt (*i.e.*, revenue-backed bonds) are also excluded from total debt outstanding. Overall net debt as a percent of full market property value places the City of Philadelphia in the weak range on this measure.

[2] Source: OFFICIAL STATEMENT relating to $140,000,000 City of Philadelphia, Pennsylvania Water and Wastewater Revenue Bonds, Series 2009A (page 59)

Unemployment Rate – Indicator 3
The unemployment rate for the City of Philadelphia was 7.2% in 2008. The unemployment rate for the Commonwealth of Pennsylvania in 2008 was 5.4%, and the national rate for 2008 was 5.8%.

According to US EPA guidelines, a local variance of greater than 1% from the national rate indicates a weak financial capability. Philadelphia maintained an unemployment rate greater than 1% of the national average for the year 2008. Most recent data from the Department of Labor, Bureau of Labor Statistics shows the unemployment rate for Philadelphia to be as high as 9.7% in March 2009, its highest rate since 1993 and remaining ahead of the state and national averages.

MHI – Indicator 4
The most recent data (2007) from the Census Bureau estimate Philadelphia's MHI to be $35,431. US EPA guidelines suggest that a variance of greater than 25% below the national MHI figure constitutes a weak rating. Pennsylvania's MHI estimate was $47,913 and the national estimate was $50,007 over the same period of time, percent differences of nearly 32 and 36%, respectively.

Property Tax Revenues as a Percent of Full Market Property Value – Indicator 5
The City of Philadelphia assessed valuation is 29.22% of the full market value of real estate. A tax of 33.05 mills is levied on the assessed valuation. Therefore, the property tax levy is 3.305% of assessed valuation, or approximately 1.0% of full market value set by the State Tax Equalization Board. The projected full market value for 2008 was $41.67 billion. The result shows current year real estate collections to be approximately 0.85% of full market value. Table 11-4 shows assessed valuation, full markets value, tax levy and current year tax collections for real estate taxes.

The US EPA financial capability assessment makes no provision for measuring a local tax burden other than the real estate tax. This gives Philadelphia an artificially strong rating in the property tax revenues as a percent of full market value category.

However, the City of Philadelphia is somewhat unique in that real estate collections are not its primary source of income. The earned income tax levied by the City comprised 23% of the operating revenues in FY 2008, while the property tax only accounted for 6% of revenue. The City's current earned income tax rate is 4.22% of residents' wages. Although real estate taxes are comparatively low, Philadelphia taxpayers are heavily burdened by other local levy, including a Philadelphia sales tax.

Analysis by a Pew Foundation study[3] documents that the total tax burden per household in Philadelphia are about double the average for comparable large cities. For a family of three earning $50,000 annually, the tax burden in Philadelphia is 17.3% compared to the large city average of 8.8%. The total tax burdens for ten cities in the Pew study are shown on Table 11-5.

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3 Philadelphia 2009 – The State of The City. The Pew Charitable Trusts – Philadelphia Research Initiative; page 13 (http://www.pewtrusts.org)

Table 11-4 City of Philadelphia, 2003-2008 Adjusted Real Estate Valuation, Real Estate Taxes Levied, and Collection Rates (in millions $)

Year	Total Taxable Assessed Valuation	Full Market Value based on State Tax Equalization Board	Adjusted Gross Real Estate Taxes Levied	Amount Collected in Year of Levy	Current Year Property Tax Revenue Collection Rate	Real Estate Tax Collected as Percent of Full Market Value
2008	12,175	41,667	391.1	355.901	91.0%	0.85%
2007	11,615	39,696	391.1	347.5	88.9%	0.88%
2006	11,431	39,600	385.6	339.6	88.1%	0.86%
2005	11,032	37,153	373.5	350.3	93.8%	0.94%
2004	10,946	36,856	372.5	340.9	91.5%	0.92%
2003	10,621	35,384	359.4	326.8	90.9%	0.92%

Source: Pennsylvania State Tax Equalization Board, FY 2008 CAFR, and City of Philadelphia Yearly Supplemental Reports

Table 11-5 Comparison of Large City Tax Burdens (Family of Three with $50,000 Income)

City		Tax Burden	% Income
1	Philadelphia	$8,629	17.3
2	Baltimore	$7,105	14.2
3	Detroit	$6,180	12.4
4	Columbus	$5,589	11.2
5	Houston	$4,398	8.8
6	New York	$4,259	8.5
7	Boston	$3,892	7.8
8	Washington	$3.590	7.2
9	Chicago	$3,547	7.1
10	Phoenix	$3,403	6.8
	Average	**$4,423**	**8.8**

Source: Philadelphia 2009 – The State of The City The Pew Charitable Trusts – Philadelphia Research Initiative; page 13 (http://www.pewtrusts.org)

The residential indicator is a national screening parameter and does not account for localized factors which erode the effective household income. The high total tax burden facing Philadelphia households reduces their effective household income. Consequently, measuring the household burden imposed by wastewater costs as a percentage of the MHI (estimated in 2009 to be $37,072 and projected to be $58,305 in 2029) may underestimate the financial burden of the projected wastewater costs per household. As was noted in an analysis of the impacts of CSO controls in the Boston region:

> *"The greater are the costs of other necessities as a share of MHI, the greater will be the economic burden associated with sewer charges equal to a given percent of MHI."* [4]

4 Assessment of the Economic Impact of Additional Combined Sewer Overflow Controls in the Massachusetts Water Resource Authority Service Area (page 13) prepared by Robert N. Stavins, Genia Long, and Judson Jaffee. Analysis Group Incorporated, August 2004.

The impacts of the tax burden in Philadelphia are further exacerbated by the relatively high cost of living in Philadelphia. The American Chamber of Commerce Researchers Association Cost of Living Index for Philadelphia was 1.249 in 2006[5] (*i.e.*, the cost of living in Philadelphia is approximately 25% higher than the national average). The estimated U.S. MHI in 2009 is approximately $52,500 or 41% higher than the Philadelphia MHI. Thus, the household at the median Philadelphia income faces costs of living that are 25% higher than the national average while earning an income that is about 71% of the national median income.

Property Tax Collection Rate – Indicator 6
Real estate tax collections had shown a pattern of increase since the rate was lowered to 34.74 mills on assessed valuation in 2003, however, the collection rate dropped below 90% for 2006 and 2007. The US EPA criterion for a strong rating in this category is a collection rate of more than 98%. Philadelphia's rate is estimated to be 91%, which places it in the weak range for real estate tax collections.

Summary of the Six Municipal Financial Capability Indicators
The City of Philadelphia received a financial capability rating of 1.58, according to the scores on the six items included in the assessment. This is based on a strong-to-mid-range rating of "2.5" on its bond rating; weak ratings of "1" on overall net debt as a percent of full market property value, unemployment rate, MHI, and property tax collection rate; and the strong rating of "3" on its property tax revenues as a percent of full market value of real estate. The 1.58 rating represents the simple average of those scores.

11.4 ADDITIONAL SOCIO-ECONOMIC TRENDS IN THE PWD SERVICE AREA

In addition to following US EPA guidelines for completion of the financial capability assessment matrix, a discussion of socioeconomic trends in the PWD service area is essential to the consideration of scheduling and compliance levels with CSO guidelines. Approximately 70% of the service area population consists of City of Philadelphia residents, and neighboring counties served are limited in the flows that can be sent to PWD's wastewater treatment plants. Therefore, this discussion includes socioeconomic trends in Bucks, Delaware, and Montgomery Counties, but it is focused primarily on demographic and employment conditions and projections for Philadelphia.

Philadelphia's Demographic and Economic Trends
This section advances an analysis of demographic and economic changes that have taken place in Philadelphia and the surrounding suburban counties during the years 1980 to 2008 and for the forecast period of 2010 to 2035. Emphasis is placed upon demographic and economic changes as they impact Philadelphia County. Demographic and economic trends that are analyzed include population, age of population, the number of households, household composition, and income levels.

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5 American Chamber of Commerce Research Association Cost of Living Index, http://www.coli.org.

Population

Population levels are a significant indicator in any analysis of demographic and economic changes. Philadelphia's population is depicted in Table 11-6 for the historic period 1980 through 2007 and the forecast period of 2010 through 2035. During the period 1990 to 2000, the population of Philadelphia decreased significantly from 1,585,577 to 1,517,549, a 4.5% decline. As illustrated in Table 11-6, the Delaware Valley Regional Planning Commission (DVRPC) has projected a small increase in the City of Philadelphia's population for the forecasted period 2010-2035. However, most recent census data indicates that the City's population has continued its dramatic decline with a currently estimated population of 1,454,382. Therefore, unless there is a reversal of this trend, the estimated projections for the year 2035 would need to be adjusted significantly downward. In this event, the PWD would anticipate a reduction in the number of residential customers and a corresponding increase in the burden on the remaining households. The Philadelphia County population trend is a reasonable basis for predicting that residential demand for wastewater service in Philadelphia County is not likely to increase significantly during the forecast period.

Table 11-6 Philadelphia County Population Levels 1980-2035

1980 Census	1,688,210
1990 Census	1,585,577
2000 Census	1,517,549
2005 – 2007 Census Estimate	1,454,382
2010 Forecast	1,475,613
2020 Forecast	1,474,268
2030 Forecast	1,478,065
2035 Forecast	1,480,023

Source: DVRPC, Analytical Data report "Regional, County, and Municipal Population and Employment Forecasts, 2005-2035," July 2007

Minority Population

The proportion of minority population in the PWD service area varies between 8.9% in Bucks County and 57.3% in Philadelphia based on most recent Census data. Philadelphia's minority population is over 31% higher than the national average and over 41% higher than the state average. A portion of that population experiences lower incomes, slower growth in income, and greater difficulty meeting the increased burden of utility costs.

Age of Population

The age of the local population is also a significant factor in this analysis. In this regard, it should be noted that in 1980, approximately 14% of all Philadelphians were 65 years of age or older (elderly), and in 1990 the number rose to 15.2%. In 2000, the percentage of elderly in the local population decreased to 14.1%, and the most recent data estimate a 13.0% elderly population. The national average is estimated to be 12.5%, so despite the decrease in elderly population within the City, it still remains above average.

An increase in the elderly population is evident in the suburban counties served by the permittee. The elderly population in the surrounding counties increased from 13.8% to

14.3% during the 1990 to 2000 time period. According to the DVRPC[6], based on population forecasts and the current age distribution, the percent of elderly within Philadelphia and its surrounding communities will increase to roughly 19% of the population by 2025. The DVRPC estimates that the elderly population within Philadelphia will be around 15%, and as high as 22% in Bucks County. As the baby boomer generation ages, the percentage of elderly should increase dramatically.

This trend of the locally aging population is alarming since there appears to be a historic positive correlation in Philadelphia between the percentage of the elderly population and the percentage of the population living in poverty. This is evident in Philadelphia County, based upon population and demographic trends observed between 1970 and 2000. Along with the increased percentage of elderly population, the number of residents living in poverty went from just less than 12% to more than 22%.[7]

It can be reasonably projected, based on the foregoing, that the permittee's customer base will consist of an increasing number of elderly persons, who in many instances are living on limited incomes. Further, an aging customer base indicates limits on future economic expansion.

Number of Households

Another significant factor in this analysis of demographic and economic trends is the number of established households in Philadelphia County. In 1980, 1990, and 2000, there were 634,665, 600,740, and 590,238 households in Philadelphia, respectively. Most recent Census data estimates 557,985 households. The consistent decrease in the number of households is not surprising given the general decline in Philadelphia's population. However, this trend is more alarming when viewed in conjunction with the changes in local household composition, addressed in the following section. These factors suggest that significant income growth in Philadelphia will be unlikely during the forecast period.

Household Composition

Family households in Philadelphia numbered 352,331 in 2000, compared to 378,048 in 1990 and 415,891 in 1980. In 2000, 189,291 such households were headed by two parents, compared to 227,187 in 1990 and 280,619 in 1980. The number of female-headed households in this mix was 131,332 in 2000, compared to 122,370 in 1990 and 113,489 in 1980. This is significant because two parent households tend to have higher incomes than non-family households and family households headed by single parents[8]. Illustrative of this point is in the 12 months prior to the last census estimates, 34% of female-headed families in Philadelphia were below the poverty line compared to only 8.5% of married couple families.

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6 DVRPC, "The Aging of the Baby Boomers: Elderly and Near-Elderly Population Characteristics," January 2007.

7 In this same context, it should be noted that a significant percentage of children in Philadelphia County live in poverty. In 2006, roughly 35 percent of all children in Philadelphia lived in poverty. This is also an indicator that many households served by the permittee operate under severe economic constraints at present.

8 US Census Bureau, "Income, Poverty, and Health Insurance Coverage in the United States: 2007."

As noted previously, recent trends reflect a drop in total number of households, which includes an 18% decrease in family households. However, most recent census data estimates that the decrease in the number of married couple families is over 16% since 2000, while the female-headed households have barely dropped 10%. Combined with an increase in non-family households of nearly 17%, the result is a proportional increase in households with historically lower earning potential.

Taken together with the above average population of elderly in the service area, these household composition trends do not forecast significant income growth. An examination of the historical and recent income levels further illustrates this point.

Income Levels
Personal income per capita in Philadelphia decreased from $17,430 in 1990 to $16,509 in 2000, compared to a regional increase from $18,383 to $27,789 over the same period of time. Recent census estimates show that Philadelphia's per capita income has increased to $19,875, still significantly lower than the regional and national per capita income estimates of $34,019 and $26,178, respectively. Despite the increase in per capita income, 16.5% of the families in Philadelphia, including 136,277 households, must sustain themselves on incomes below $15,000.

As shown in Figure 11-3, MHI in Philadelphia has significantly lagged behind the national level since the 1970s. Since 1989, MHI in Philadelphia has grown at a rate which is below both those of the state (2.94%) and national (3.18%) levels. This appears to be a consistent and long-term trend resulting from structural elements of the Philadelphia's demographic and economic make-up, rather than being the result of cyclical or outlying occurrences. It is reasonable to expect that this trend in income levels and growth will continue into the future.

From 1990 to 2000, the percentage of all persons with incomes below the poverty level in Philadelphia increased from 20.3% to 22.9%. This trend has continued with the most recent census figure at 24.5%. Given the local increase in unemployment due to the recent economic climate, it is possible that in the near future the number of Philadelphians living in poverty could increase dramatically.

Employment Trends in Philadelphia
Future income growth in Philadelphia is dependent upon prospective economic trends, driven in large part by employment. The affordability of PWD's LTCPU is tied to such economic trends.

The data assembled by the DVRPC in their study entitled "Regional, County, and Municipal Population and Employment Forecasts, 2005-2035", indicates that Philadelphia will experience minimal growth in employment during the forecast period. This estimate focuses on long-term trends and assumptions, and should be evaluated with actual data as available to address any potential long-term shifts that may occur due to the current economic climate and eroding job market. The projected changes in job numbers by employment sector for Philadelphia appear in Table 11-7.

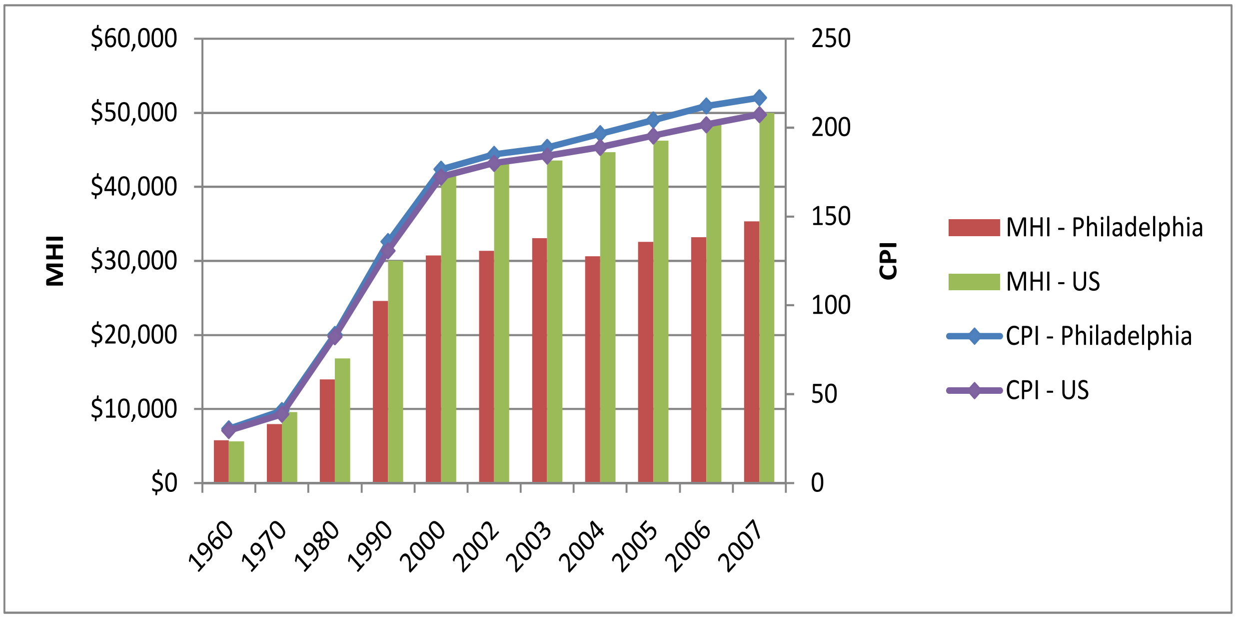

Figure 11-3 MHI Trends and Comparisons

Employment composition in Philadelphia is also not substantially changed in any employment sector during the forecast period, as shown in Table 11-7, although small increases and decreases are shown in some job sectors. Total job forecasts and employment sector forecasts indicate a reversal of past trends, in which employment levels dropped overall. It bears emphasis, however, that Philadelphia County has yet to experience the sizable upward employment trend projected in the above data and the current uncertainty in the job market will negate short-term growth estimates and may potentially hinder long term employment level growth.

11.5 The Financial Capability Matrix

It was established previously in the Phase One (Residential Indicator) analysis that Philadelphia's residential indicator is projected to fall into the high-range category on the financial capability matrix. The Phase two analysis on the assessment of the financial capability indicators placed Philadelphia in the mid-range category for current conditions. The intersection of these two ratings on the EPA financial capability matrix places the City of Philadelphia in the category of high financial burden, as shown on Table 11-8.

In addition to these strictly numerical measures, socioeconomic trends in the Philadelphia area require careful consideration as level and scheduling of CSO control expenditures are determined.

11.6 Conclusions and Implications

PWD will be implementing the innovative approach to combined sewer overflow controls detailed elsewhere within this document within the context of its financial and demographic reality. This reality may be summarized by the unprecedented needs for capital reinvestments in the City's water and sewer systems juxtaposed with structural economic and

Table 11-7 Philadelphia County Employment Forecasts by Sector

Sector	2005	2010	2015	2020	2025	2030	2035
Agriculture & Mining	977	919	866	848	806	765	764
Construction	24,172	20,895	20,302	21,436	21,022	20,504	20,557
Manufacturing	50,335	50,077	48,118	49,208	47,549	45,819	45,805
Transportation / Utilities	33,892	33,515	32,770	31,995	31,502	30,941	31,026
Wholesale	23,505	22,881	22,373	22,092	21,706	21,261	21,275
Retail	97,010	91,230	89,277	87,867	86,642	85,260	85,365
FIRE	61,588	54,847	53,678	53,644	53,217	52,406	52,767
Services	318,831	335,615	346,195	342,303	351,950	360,385	361,570
Government	117,048	112,106	110,674	117,046	116,745	116,015	116,454
Federal/Military	677	715	709	700	692	683	685
Total	**728,035**	**722,800**	**724,962**	**727,139**	**731,831**	**734,039**	**736,268**

Source: DVRPC Employment Forecasts by Sector, based on 2009 economic model run by DVRPC.

Table 11-8 The Financial Capability Matrix at Year 2029

Permittee Financial Capability Indicators Score (Socioeconomic, Debt and Financial Indicators)	Residential Indicator		
	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

(Blue areas indicate City of Philadelphia ratings)

demographic changes that will continue to erode both PWD's ability to finance required capital investments and the citizen's ability to afford them.

As noted above, PWD's current capital improvements for its water and sewer systems total $4.6 billion through 2029. This includes $3.7 billion for its current systems required to maintain current levels of service and regulatory compliance; and approximately $900 million (2009 dollars) in new capital expenditures for the implementation of the LTCPU recommended alternatives.

The anticipated tripling of the PWD's annual wastewater system revenue requirements from approximately $350 million in 2009 to over $1 billion in 2029 will be paid for by a rate base whose income is projected to increase by less than 60% during the same period. The results of this will be burden measured as the residential indicator of 2.27% of the median income. A population equivalent to cities larger than Boston, Washington D.C., Baltimore and Seattle will pay more than 2.27% of their household income for wastewater services. The lowest quintile of the households, a population larger than cities such as Cincinnati, Minneapolis, Pittsburgh or Toledo will face annual wastewater costs totaling between 3.55 to upwards of 7% of their household incomes.

It is reasonable to expect that an implementation schedule (through 2029) imposing residential burdens well above 2.27% for populations the size of major American cities is untenable. The municipal financing market likely would agree with such a conclusion. PWD might face insurmountable difficulties in financing their capital needs as outlined above.

These realities suggest an implementation schedule extending beyond the 2029 deadline. Indeed, through its Green Infrastructure approach to CSO control, PWD fully intends to continue to expand the green features within the City so that control levels will increase and improve well beyond 2029. PWD's Green Infrastructure approach is uniquely suited for incremental and modular implementation and the scheduling context is a completely different paradigm than that of a traditional infrastructure control strategy. A storage and conveyance tunnel, for example, would be of little or marginal benefit before it is fully constructed and operated. CSO control and the resulting water quality benefits would not occur until initiation of operation of at least large portions of the program. In such cases, the regulatory and environmental imperatives might push towards a discrete short term (ten to twenty) year timeframe. PWD's approach however provides for immediate compliance and water quality benefits that will grow annually. The proposed implementation schedule will allow the City of Philadelphia and its watersheds to achieve these benefits within the constraints that the nation's changing economics and demographics have dealt it.

King County CSO Financial Capability Assessment and Schedule Development

Phase 2: Comprehensive Analysis of Regional Affordability and Implications for WTD's Long Term CSO Control Plan

***** DRAFT DOCUMENT*****

September 2011

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Glossary

CPI	Consumer price index (All Urban Consumers – CPI-U, as reported by the U.S. Bureau of Labor Statistics)
CSO	Combined sewer overflow
CSO Guidance	EPA. 1997. *Combined Sewer Overflows–Guidance for Financial Capability Assessment and Schedule Development.* EPA 832-B-97-004. February.
Ecology	Washington Department of Ecology
EPA	U.S. Environmental Protection Agency
MHI	Median household income
Permittee	An entity, such as King County, Wastewater Treatment Division, that must secure a permit, under the Clean Water Act, to discharge treated wastewater
WTD	King County, Wastewater Treatment Division.

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Appendix A. Past, Present, and Proposed Projects Included in Baseline Scenario **A-1**

I. Introduction and Background

King County Wastewater Treatment Division (WTD) is currently completing a review of its Combined Sewer Overflow (CSO) Control Plan to secure renewal of its permit to discharge treated wastewater. The review will satisfy requirements established by the U.S. Environmental Protection Agency (EPA) and the Department of Ecology (Ecology), under the provisions of the National Pollution Discharge Elimination System (NPDES) elements of the Clean Water Act. The review examines the assumptions and rationale underlying the plan, including the impacts implementation of the plan would have on ratepayers and an assessment of their financial capability to bear these impacts.

EPA has provided guidance (*CSO Guidance*)[1] for describing these impacts and ratepayers' ability to bear the costs. It uses three metrics:

- The Residential Indicator. The *CSO Guidance* prescribes a method for developing an estimate of CSO and other wastewater-related costs as a percentage of the median household income (MHI) for all households in the service area for concluding that the overall financial impact on residential customers would be Low, Mid-Range, or High. The *CSO Guidance's* approach does not account for actual impacts on residential rates, as a whole, or for the impacts on low-income households.
- The Permittee Financial Capability Indicators Score. The *CSO Guidance* requires measuring the local unemployment rate relative to the national rate, as well as several other variables that characterize the community's capacity to finance CSO costs.[2] It then specifies criteria for concluding if each variable indicates WTD's financial capability is Weak, Mid-Range, or Strong, and prescribes a method for calculating an overall score.
- Overall Financial Burden. The *CSO Guidance* prescribes a method for combining the first two metrics and specifies criteria for concluding that the costs of implementing CSO controls would impose a **Low Burden, Medium Burden,** or **High Burden** on WTD and the community.

Table 1 summarizes some of the results of the analysis using the *CSO Guidance*. The overall financial burden—**Low Burden**—determined for WTD using the *CSO Guidance* will be useful in discussions between WTD and Ecology over the schedule for implementing the CSO controls. The *CSO Guidance* generally anticipates that, unless site-specific environmental and financial conditions warrant a schedule extension, permittees in the **Low Burden** category will implement CSO controls "based on a normal engineering and construction schedule," permittees in the **Medium Burden** category will follow an implementation schedule of up to 10 years, and permittees in the **High Burden** category will follow an implementation schedule of up to 15–20 years.

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[1] U.S. Environmental Protection Agency. 1997. *Combined Sewer Overflows – Guidance for Financial Capability Assessment and Schedule Development*. EPA-832-B-97-004. February.

[2] The variables include bond rating, net public debt as a percent of full market property value, unemployment rate relative to the national rate, MHI relative to the national average, property tax revenues as a percent of full market property value, and the collection rate for property taxes.

Table 1. Summary of Results Using *CSO Guidance*

Average annual WWT- and CSO-related costs per household (2011-2030)[a]	$423
Average annual costs per household as a percentage of the 2010 MHI - $72,006 for the WTD's overall service area (the Residential Indicator)	0.59%
WTD's Financial Capability Indicators Score	2.67 (vs. maximum of 3)
Overall Financial Burden	Low Burden

Source: Niemi, E., T. Souhlas, and P. Thoma. 2011. *King County CSO Financial Capability Assessment and Schedule Development. Task 1: Apply Current EPA CSO Financial Capability Assessment Guidance to WTD's Long Term CSO Control Plan*. ECONorthwest.

[a] Estimate derived by applying the *CSO Guidance's* methodology. Includes only WTD's WWT- and CSO-related costs, with no accounting for the timing of the costs associated with individual projects and actions. Does not include related costs of WTD's component agencies.

EPA recognizes, however, that the *CSO Guidance's* approach may not fully represent the economic impacts of CSO costs and the financial capability of the communities WTD serves to bear those costs. Accordingly, it encourages the submission of supplemental information. Permittees elsewhere in the U.S. have concluded that the results from applying the *CSO Guidance* fail to fully describe their financial capability and the burden that CSO costs would impose on their ratepayers. Accordingly, they have submitted supplemental information describing circumstances specific to their communities that they believe affect their financial capacity to bear CSO costs. For example, some permittees have provided supplemental information showing the actual impacts on all ratepayers, on ratepayers in some neighborhoods, and on low-income ratepayers will exceed the impacts determined using the approach prescribed by EPA's *CSO Guidance*.[3]

This report contains supplemental information to provide a more complete picture of WTD's financial capability to fund its Recommended CSO Control Plan. Specifically, it presents supplemental information that shows:

- **Actual anticipated expenditures and rate impacts** are higher than those estimated using the *CSO Guidance*.
- **Impacts on low-income households** are higher than indicated by the *CSO Guidance's* approach.
- **Past expenditures** demonstrate WTD and its ratepayers already have taken accelerated actions to reduce the environmental impacts of wastewater and borne costs that are not accounted for in the *CSO Guidance's* approach.
- **Current and anticipated economic conditions** have diminished the financial capacity of WTD and its ratepayers in ways that the *CSO Guidance's* approach does not take into account.

[3] For more information about supplemental information submitted by permittees elsewhere, see Niemi, E., T. Souhlas, and P. Thoma. 2011. *King County CSO Financial Capability Assessment and Schedule Development. Task 1: Apply Current EPA CSO Financial Capability Assessment Guidance to WTD's Long Term CSO Control Plan*. ECONorthwest.

II. ACCOUNTING FOR ACTUAL ANTICIPATED EXPENDITURES AND RATE IMPACTS

The analytical approach prescribed by the *CSO Guidance* for estimating the impacts of CSO costs on households, permittees, and communities embodies several standardized assumptions, applicable over different communities across the U.S. Using the *CSO Guidance's* approach, analysis indicates that, with implementation of the Long Term CSO Control Plan by 2030, households in WTD's service area would realize costs for WWT and CSO services averaging $423 per year (in 2011 dollars) over the 20-year period.[4] This figure reflects just WTD's current costs for existing WWT operations plus its projected costs for proposed WWT and CSO controls. It does not incorporate the related costs of WTD's component agencies or capacity charges[5] incurred by new developments. Adding these costs into the calculation shows that, in reality, households would experience costs higher than those indicated by applying the *CSO Guidance's* analytical approach.

This section shows the actual anticipated expenditures on WWT and CSO controls, and the full rate impacts on households. The analysis considers projections of wastewater collection rates, over the next 20 years, under two scenarios. The first scenario (Baseline – No New CSO) includes costs associated with all past, current, and planned non-CSO projects, as well as all past and current CSO projects, but it assumes no new CSO capital projects. Appendix A provides a complete list of the projects included in the Baseline – No New CSO scenario, with financial information. The second scenario (Recommended CSO Control Plan) includes all the projects in the Baseline scenario as well as all future CSO capital projects recommended by WTD, assuming a 2030 completion date. The rates under both scenarios include the anticipated average future capacity charges, per household.

For each of the two scenarios, we present projections for three categories of rates:

- **Regional wastewater collection rate** (regional rate) is the rate WTD charges the various component agencies in its service area.
- **Non-Seattle combined regional and local wastewater collection rate** (non-Seattle combined rate) is the average rate component agencies outside Seattle charge households in their respective service areas.
- **Seattle's combined regional and local wastewater collection rate** (Seattle's combined rate) is the combined rate for households in Seattle's service area.

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4 This amount is the sum of expected costs for each of the 20 years divided by 20. It does not reflect considerations about the timing of the costs of projects and actions, which economists typically represent using a process called discounting to account for preferences that favor incurring costs in the more distant future rather than in the near term, all else equal. To facilitate comparison with the findings from applying the *CSO Guidance*, we similarly overlook the effects of timing in our presentation of supplemental information.

5 King County WTD collects fees from capacity charges on new developments. For our analysis, King County WTD has projected these capacity charges over the next 30 years and has distributed them evenly across all households in the service area to estimate the average capacity charge per household per year.

Table 2 summarizes our findings regarding the actual anticipated rate impacts.[6] It shows the estimated amounts for each of the three rates described above, for three analyses. The top of the table shows the estimates resulting from applying the *CSO Guidance's* approach. Because that approach considers only WTD's costs, it yields just a single estimate, $423 per household per year, on average, for all households in WTD's service area. The middle of the table shows the estimates for the Baseline – No New CSO scenario. Here, the regional rate rises to $474 per household, the non-Seattle combined rate equals $730, and Seattle's combined rate equals $738 per household per year, on average. The bottom portion of Table 2 shows the anticipated rates under the Recommended CSO Control Plan scenario, with average annual rates per household of $502 for the regional rate, $758 for the non-Seattle combined rate, and $766 for Seattle's combined rate.

Table 2. Summary of Estimates of Average Regional and Combined Rates per Household, 2011-2030

Results from *CSO Guidance*	Regional Rate	Non-Seattle Combined Rate	Seattle's Combined Rate
Average annual rate, per household	$423	Did not calculate	Did not calculate
Average annual rate as a percentage of WTD service area's 2010 MHI - $72,006	0.59%	Did not calculate	Did not calculate
Burden category for WTD's service area	Low Burden	Did not calculate	Did not calculate
Baseline – No New CSO	**Regional Rate**	**Non-Seattle Combined Rate**	**Seattle's Combined Rate**
Average annual rate, per household	$474	$730	$738
Average annual rate as a percentage of the relevant area's 2010 MHI[a]	0.66%	0.91%	1.19%
Burden category for WTD's service area	Low Burden	Low Burden	Low Burden
Recommended CSO Control Plan	**Regional Rate**	**Non-Seattle Combined Rate**	**Seattle's Combined Rate**
Average annual rate, per household	$502	$758	$766
Average annual rate as a percentage of the relevant area's 2010 MHI[a]	0.70%	0.95%	1.23%
Burden category for WTD's service area	Low Burden	Low Burden	Low Burden

Source: ECONW with data from King County WTD.

[a] Since each of the three rates applies to a different area, we calculate the percentage of MHI using the MHI specific to each area. For the regional rate, we use the MHI for WTD's entire service area, $72,006. For the non-Seattle combined rate, we use the average MHI for the portion of WTD's service area outside Seattle, $79,863. For Seattle's combined rate, we use the MHI for households in Seattle, $62,078.

[6] Throughout this report, we refer to household rates for wastewater collection services. These rates refer to the average rates charged to households living in single-family homes in the service area. They do not necessarily represent the rates for households living in multi-family housing. The rates for households in multi-family housing may be above or below the average rates for single-family homes.

Table 2 also shows the average annual payment per household paying each of the three rates as a percentage of the MHI in the relevant area. For these calculations, the MHI equals $72,006 for WTD's service area as a whole (applicable to the regional rate), $79,863 for WTD's service area excluding Seattle (applicable to the non-Seattle combined rate), $62,078 for Seattle's service area (applicable to Seattle's combined rate). The top of the table shows that the payment calculated using the *CSO Guidance's* approach represents 0.59 percent of MHI across WTD's entire service area. The middle of the table shows higher percentage under the Baseline – No New CSO Scenario, which includes costs that the *CSO Guidance* does not take into account. The bottom portion of the table shows even higher percentages under the Recommended CSO Control Plan scenario: 0.70 percent for the regional rate, 0.95 percent for the non-Seattle combined rate, and 1.23 percent for Seattle's combined rate. In all cases, the percentage falls below 2.0 percent, which, when considered with other variables, EPA's *CSO Guidance* deems to constitute a **Low Burden** on households in the community.

In the remainder of this section, we present more detailed information about the regional rate only and the combined rates outside in inside Seattle.

A. Regional Wastewater Collection Rate

In 2010, the average regional rate, per household, was $383. WTD used rate models to project the average regional rate each year over the period, 2011 through 2030 under two scenarios: the Baseline – No New CSO scenario and the Recommended CSO Control Plan scenario. Table 3 shows the expected range of the annual regional rate, per household, from 2011 to 2030, and the average over the period, for each of the two scenarios. Under the Baseline – No New CSO scenario, the average annual regional rates range from about $421 to about $528, and average $474 per household. Under the Recommended CSO Control Plan scenario, average annual regional rates range from about $473 to about $533, and average about $502 per household. Both scenarios include the same projections for future capacity charges for new development. Average annual rates fluctuate from 2011 to 2015 at which point they peak, under both scenarios, and decrease, annually through 2030.

Table 3. Average Annual Regional Rate per Household, 2011-2030 (in 2011 Dollars)

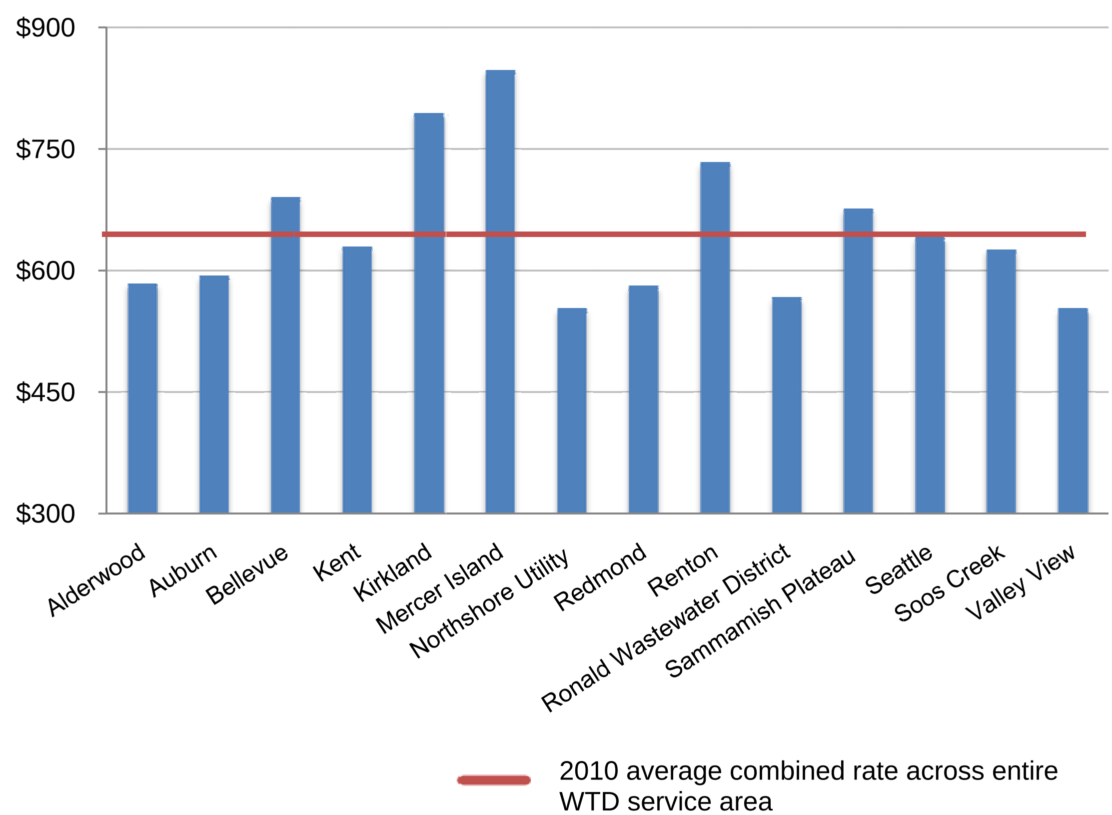
Average household regional rate (2010)		$383
	Baseline- No New CSO	**Recommended CSO Control Plan**
Average annual regional rate (2011-2030)	$474	$502
Range of annual regional rates (2011-2030)	$421-$528	$473-$533

Source: ECONW with data from King County WTD.

B. Combined Local and Regional Wastewater Collection Rates

Households in WTD's service area do not pay WTD directly for wastewater services. Instead, they pay a wastewater collection rate to one of 35 component agencies that operate in WTD's service area. This rate (the combined rate) has two components: (1) the regional rate (the rate WTD charges the component agencies), and (2) the local wastewater collection rate (the rate each component agency charges for the services it provides). Figure 1 shows the average annual combined rate, per household, in 2010 for 14 of the largest component agencies operating in WTD's service area. These component agencies provide wastewater services to over 90 percent of the single-family residences in the service area.[7] In 2010, average annual combined rates, by household, ranged from $553 to $848 across these component agencies. The average annual combined rate (weighted by the number of households in each component agency's service area) was about $640 per household.

Figure 1. 2010 Average Combined Regional and Local Rate per Household, by Component Agency



Source: ECONW with data from King County WTD.

[7] Survey conducted by King County WTD, April 2011.

Table 4 shows the average combined rate, and the range of rates, in 2010, for WTD's service area as a whole, the non-Seattle portion of the service area, and the portion in Seattle.

Table 4. Combined Rates per Household, Average and Range for 2011-2030 (in 2011 Dollars)

	Average Annual Rate	Range of Rates
Combined Rate Across Entire WTD Service Area	$640	$553-$848
Non-Seattle Combined Rate	$640	$553-$848
Seattle's Combined Rate	$638	N/A

Source: ECONW with data from King County WTD.

Table 5 shows the average of the expected annual combined rates for each year during the period, 2011 through 2030, for the non-Seattle portion of the service area under the two scenarios. It also shows the range of the expected annual rates over this period. To estimate the future combined rates for each year, we added WTD's projections for the regional rate with the current average local rate from 13 of the largest component agencies, excluding Seattle.[8] This calculation indicates that, Under the Baseline – No New CSO scenario, the annual non-Seattle combined rate will range over the 2011-2030 period from about $676 to $784 per household, with an average rate of about $730 per household. Under the Recommended CSO Control Plan scenario, the annual rate will range over the 2011-2030 period from about $728 to $789 per household, with an average rate of about $758 per household.

Table 5. Non-Seattle Combined Rate per Household, Average and Range for 2011-2030 (in 2011 Dollars)

	Baseline- No New CSO	Recommended CSO Control Plan
Average annual combined rate (2011-2030)	$730	$758
Range of annual combined rates (2011-2030)	$676-$784	$728-$789

Source: ECONW with data from King County WTD.

Households that pay for WWT and CSO services through Seattle Public Utilities differ from other households in WTD's service area in that their local rates include costs Seattle Public Utilities is incurring for future CSO projects it is planning separate from those WTD is planning. Table 6 shows Seattle's annual combined rates, per household, from 2011 to 2030 under the two scenarios. To project Seattle's future combined rates, we

[8] We assume the local rate will remain unchanged, when expressed in constant 2011 dollars. We included all the component agencies shown in Figure 1, excluding Seattle, which we consider in isolation in the next section. We weighted the local wastewater collection rates by the number of households each one agency serves. This weighted average was about $256 per household in 2010.

added WTD's regional rate projections with Seattle's local rate projections.[9] Under the Baseline – No New CSO scenario, Seattle's average annual combined rates range from about $686 to $791, with an average rate of about $738 per household. Under the Recommended CSO Control Plan scenario, Seattle's average annual rates range from about $738 to $797, with an average rate of about $766 per household.

Table 6. Seattle's Combined Rate per Household, Average and Range for 2011–2030 (in 2011 Dollars)

	Baseline- No New CSO	Recommended CSO Control Plan
Seattle's average annual combined rate (2011-2030)	$738	$766
Range of Seattle annual combined rates (2011-2030)	$686-$791	$738-$797

Source: ECONW with data from King County WTD.

Notes: Combined rates have two components – the regional rate and the local rate. To project Seattle's combined rates, we used WTD's projected regional rates, along with Seattle's projected local wastewater collection rates.

C. Summary of Actual and Anticipated Rates

Table 7 summarizes some of the estimates represented in Tables 2–6 and Figure 1. Section A of the table shows the results of the analysis conducted using the approach described in the *CSO Guidance*. They indicate that, with implementation of the Long Term CSO Control Plan by 2030, households in WTD's service area would realize costs for WWT and CSO services averaging $423 per year (in 2011 dollars) over the 20-year period.[10] Sections B and C of the table show results from analyses that more fully consider the actual, total costs households will bear for these services under the Baseline – No New CSO scenario and the Recommended CSO Control Plan scenario. Using rate models specific to its service area WTD projects regional rates for each year, from 2011 to 2030. These annual estimates often exceed $423 per year per household. The expected annual regional rates, for the period, 2011–2030, average $474 under the Baseline – No New CSO scenario and $502 per household under the Recommended CSO Control Plan scenario. The difference, $28 per household per year, represents the additional costs households, on average, will bear from implementing the Recommended CSO Control Plan.

[9] Seattle Public Utilities provided three sets of projections. We used the "Mid-Range" projection. Furthermore, Seattle's projections run from 2011 to 2025. We assumed that its local rates would increase with inflation from 2026 to 2030.

[10] This amount is the sum of expected costs for each of the 20 years divided by 20. It does not reflect considerations about the timing of the costs, which economists typically represent using a process called discounting to account for preferences that favor incurring costs in the more distant future rather than in the near term, all else equal. Niemi, E., T. Souhlas, and P. Thoma. 2011. *King County CSO Financial Capability Assessment and Schedule Development. Task 1: Apply Current EPA CSO Financial Capability Assessment Guidance to WTD's Long Term CSO Control Plan*. ECONorthwest.

Table 7. Summary of Estimates of Future Rates

A. *CSO Guidance's* Average Annual Rate, per Household (2011-2030)		
Average annual WWT- and CSO-related costs per household using *CSO Guidance* methodology		$423
B. Average Annual Rate, per Household (2011-2030)		
	Baseline – No New CSO	**Recommended CSO Control Plan**
Regional Rate Only	$474	$502
Non-Seattle Combined Rate	$730	$758
Seattle's Combined Rate	$738	$766
C. Range of Annual Rates, per Household (2011-2030)		
	Baseline – No New CSO	**Recommended CSO Control Plan**
Regional Rate Only	$421-$528	$473-$533
Non-Seattle Combined Rate	$676-$784	$728-$789
Seattle's Combined Rate	$686-$791	$738-$791

III. Accounting for Impacts on Low-Income Households

In this section, we examine the potential impacts WWT- and CSO-related costs on low-income households. This effort complements the description of the impacts on households resulting from the analytical approach prescribed in EPA's *CSO Guidance.* That approach represents the potential impact of WWT- and CSO-related costs on households by dividing the average annual value of those costs (per household, from 2011 to 2030) by the MHI of all households in WTD's service area. It also assesses the community's ability to bear WWT- and CSO-related costs by considering the unemployment rate in the entire service area, as well as several other regional variables—such as bond rating, net public debt as a percent of full market property value, and property tax revenues as a percent of full market property value. Applying the methodology and criteria prescribed by the *CSO Guidance* leads to the conclusion that WTD and the communities it serves have a **Strong** ability to bear the anticipated costs of the Recommended CSO Control Plan, and that the plan would impose a **Low Burden** on the area's households.[11] By focusing on the overall service area, however, this conclusion overstates the financial capability of communities with high concentrations

[11] Niemi, E., T. Souhlas, and P. Thoma. 2011. *King County CSO Financial Capability Assessment and Schedule Development. Task 1: Apply Current EPA CSO Financial Capability Assessment Guidance to WTD's Long Term CSO Control Plan*. ECONorthwest.

of low-income households, and understates the financial burden the anticipated increases in WWT and CSO rates would impose on low-income households.

To show more fully how implementation of the plan would affect low-income households and communities, we use Census data, disaggregated at the census-block-group level, to characterize household income, unemployment, and poverty in WTD's service area.[12] This characterization identifies those portions of WTD's service area with the highest concentrations of low-income households and, hence, the lowest financial capability to bear anticipated increases in WWT and CSO rates. In particular, it shows the communities within the service area on which the costs of implementing CSO controls by 2030 would impose financial impacts beyond those calculated using the *CSO Guidance's* methodology.

Table 8 summarizes our findings, which we explain in more detail in the subsequent text. The top line shows that, at the top of its expected range over the 2011-2030 period, the regional rate would, by itself, exceed the **Medium Burden** threshold defined by the *CSO Guidance* for about 1.9 percent of all the households in WTD's service area when compared against the MHI for the different census block groups in the service area. The second line shows that, at the top of its expected range, the non-Seattle combined rate would exceed this threshold for about 1.7 percent of all households in the service area. The third line shows that, at the top of its expected range, Seattle's combined rate would exceed the threshold for about 6.1 percent of all households in the service area. Combining the second and third lines shows that the combined rates would exceed the **Medium Burden** threshold for about 7.8 percent of households in WTD's service area.

Table 8. Summary of Potential Burden on Low-Income Households (Recommended CSO Control Plan Scenario)[a]

	Low Burden	Medium Burden	High Burden
Regional Rate Only	98.1%	1.9%	0.0%
Non-Seattle Combined Rate	58.9%	1.7%	0.0%
Seattle's Combined Rate	33.3%	6.1%	0.0%

Source: ECONW with data from King County WTD.

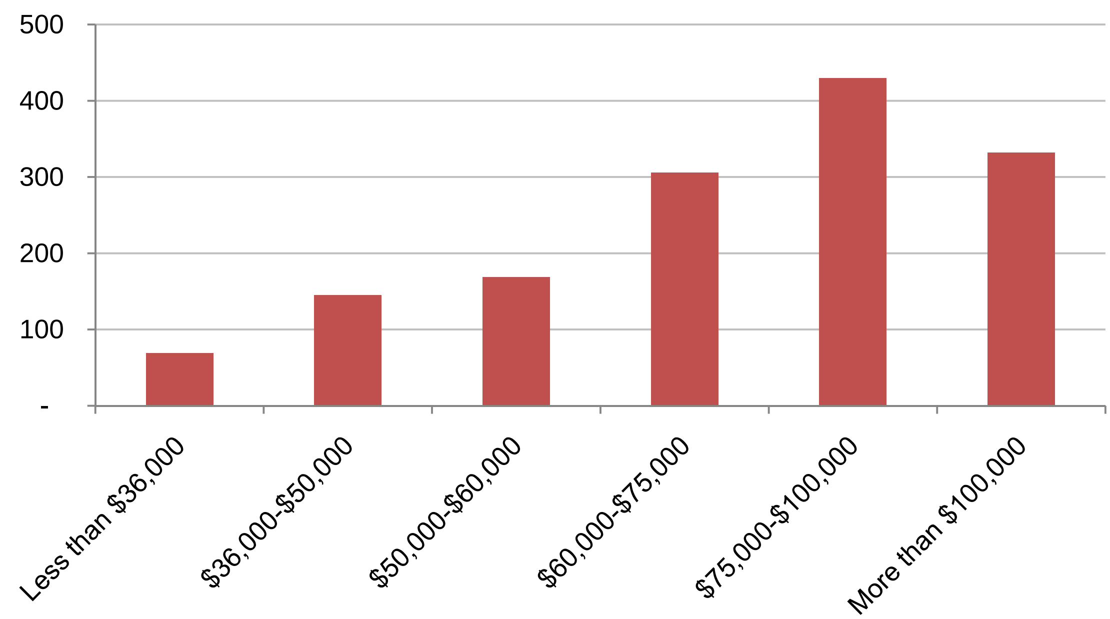
[a] Percentage of households in WTD's service area living in census blocks where the highest expected rate exceeds the thresholds defined by the *CSO Guidance*, when compared against the MHI for each census block group,

A. Household Income

[12] A census block group is one of the units the U.S. Census Bureau uses to group individuals and households. Census block groups typically contain between 600 and 3,000 people. For more information, see: U.S. Census Bureau. 2011. *Cartographic Boundary Files*. Retrieved on August 19, 2011 from http://www.census.gov/geo/www/cob/bg_metadata.html.

Using the methodology described in the *CSO Guidance*, the 2011 MHI for all households in WTD's service area is $72,006 (in 2011 dollars).[13] By definition, half of the area's households have incomes below the median; the other half have incomes above it. In this section, we disaggregate these data to identify different clusters of households, in terms of their incomes and their geography. The U.S. Census calculates MHI at the census-block-group level. We use these data to describe the distribution of household incomes from the lowest to the highest. Figure 2 shows the number of census block groups with MHIs in different ranges. For example, 69 of the 1,451 census block groups in WTD's service area have MHIs below $36,000, 145 have MHIs in the $36,000–$50,000 range, and so on.

Figure 2. Number of Census Block Groups in WTD's Service Area, by MHI (2011 dollars)



Source: ECONW with data King County WTD; U.S. Census Bureau. P53. Median Household Income in 1999; U.S. Bureau of Labor Statistics. Consumer Price Index, All Urban Consumers – (CPI-U), U.S. City Average. Retrieved on May 24, 2011 from ftp://ftp.bls.gov/pub/special.requests/cpi/cpiai.txt.

The number of people living within each census block group is not constant. Using the number of households in each census block group, we estimate the percentage of WTD's service area population in each MHI group. For example, while only 4.6 percent of the census block groups had MHIs below $36,000, these census block groups represent about 5.6 percent of the population in WTD's service area. About 13 percent of households are in census block groups in the $36,000–$50,000 range, 14 percent in the $50,000–$60,000 range, and about 67.4 percent in the $60,000 and higher range.

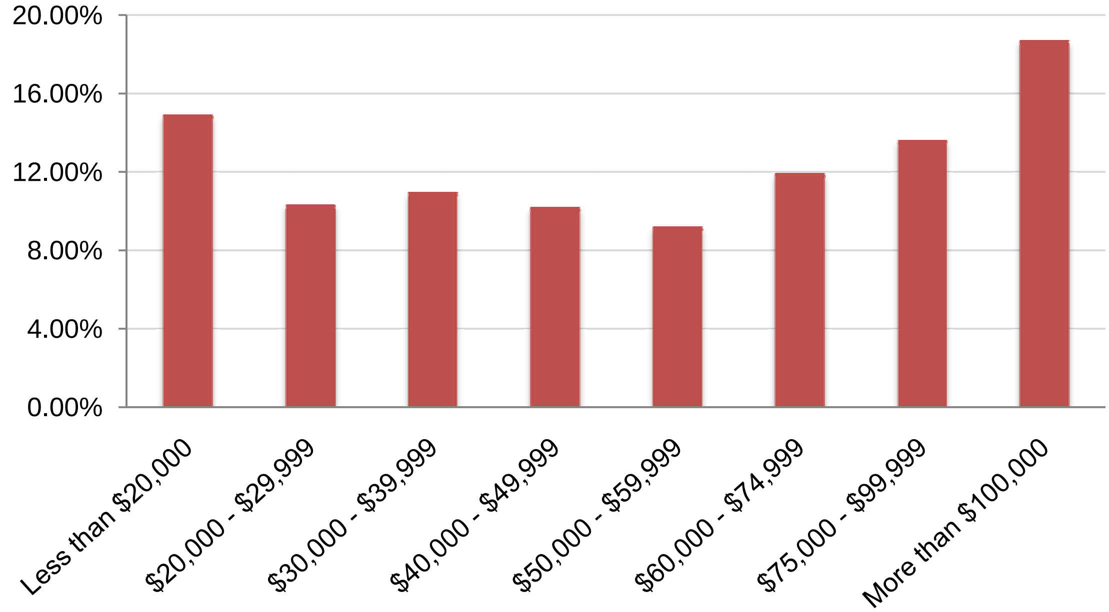
[13] Niemi, E., T. Souhlas, and P. Thoma. 2011. *King County CSO Financial Capability Assessment and Schedule Development. Task 1: Apply Current EPA CSO Financial Capability Assessment Guidance to WTD's Long Term CSO Control Plan*. ECONorthwest.

Map 1 provides a geographic representation of the data in Figure 2. Census block groups with MHIs below $50,000 are concentrated in South Seattle and South King County (around Auburn, Kent, and Pacific), while census block groups in the Eastern and Northern parts of the service area tend to have higher MHIs. The overall MHI in Seattle's service area is about $62,080 and about 11.0 percent of those households are in census block groups with MHIs below $36,000. The MHI across the rest of WTD's service area is about $79,860 and about 2.0 percent of households are in census block groups with MHIs below $36,000. These data, along with the map, indicate that, although CSO control costs will affect low-income households throughout WTD's service area, the impacts will not occur equally but, instead, concentrate in South Seattle and South King County.

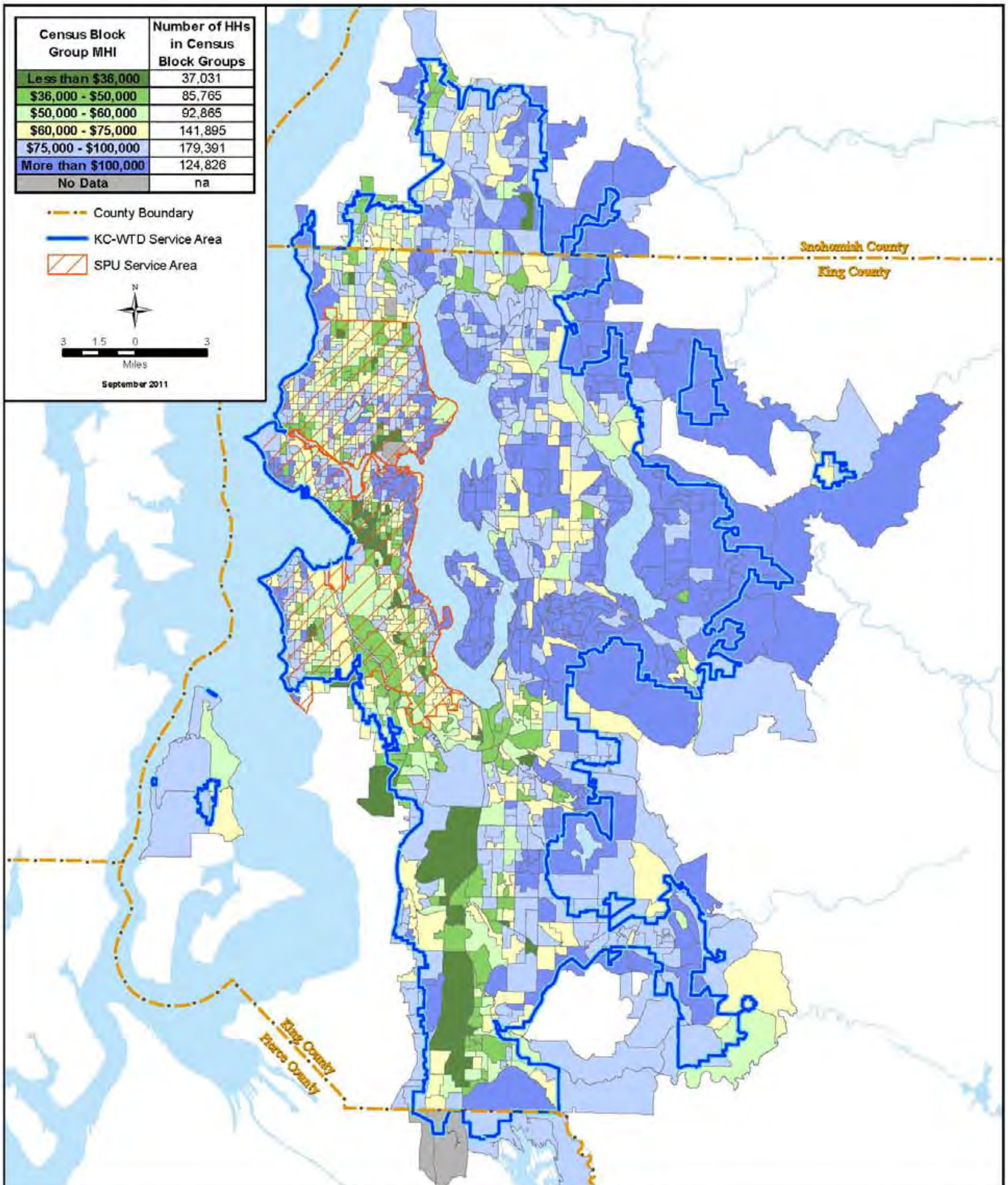
WTD's service area also has many high-income households and these can mask the potentially severe impacts of CSO costs on low-income households. Figure 2 and Map 1 show the percentage of households in different income brackets. Figure 3 provides a clearer picture of the income distribution. Using household-level data from the 2000 Census rather than data at the census-block-group level, it shows a U-shaped distribution of income across King County. About 15.0 percent of households earned less than $20,000 in 1999 and about 18.7 percent of households earned more than $100,000. None of the other income ranges accounted for more than 14.0 percent of the households in King County. For perspective, the 2000 Census showed that many other major cities of the U.S. had a lower incidence of high-income households. In Chicago, for example, about 27 percent of households had incomes less than $20,000 while 7 percent had incomes of more than $100,000. In Philadelphia, 35 percent of households had incomes less than $20,000 while 3 percent had incomes of greater than $100,000.[14]

Figure 3. Percent of Households in Different Income Brackets (1999 dollars)

[14] ECONW with data from U.S. Census Bureau. P52. Household Income in 1999.



Source: ECONW with data from U.S. Census Bureau. P52. Household Income in 1999.



King County
Department of
Natural Resources and Parks
Wastewater Treatment Division

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Data Source: King County; US Census 2000; ECONorthwest

Map 1

2000 Census - Median Household Income by Census Block Group

The potential costs associated with the Recommended CSO Control Plan will, all else equal, consume a higher percentage of the income for households with lower incomes than for households with higher incomes. Table 9 illustrates the greater impacts on low-income households. Specifically, it shows the percentage of pre-tax income[15] that would be consumed for two groups—households with pre-tax income equal to the MHI for the relevant area and households with incomes below one-half this amount.

Table 9. Summary of Average Annual Wastewater- and CSO-Related Rates as a Percentage of Household Income, 2011–2030

	Below Half MHI	MHI
Average annual WWT- and CSO-related costs per household using *CSO Guidance* methodology (MHI=$72,006)	> 1.2%	0.6%

Average Annual Rates as a Percentage of Pre-Tax Household Income (2011-2030)				
	Baseline – No New CSO		Recommended CSO Control Plan	
Wastewater Collection Rate	**Below Half MHI**	**MHI**	**Below Half MHI**	**MHI**
Regional Rate (MHI=$72,006)	> 1.3%	0.7%	> 1.4%	0.7%
Non-Seattle Combined Rate (MHI=$79,863)	> 1.8%	0.9%	> 1.9%	1.0%
Seattle's Combined Rate (MHI=$62,078)	> 2.4%	1.2%	> 2.5%	1.2%

Source: ECONW with data from WTD and Niemi, E., T. Souhlas, and P. Thoma. 2011. *King County CSO Financial Capability Assessment and Schedule Development. Task 1: Apply Current EPA CSO Financial Capability Assessment Guidance to WTD's Long Term CSO Control Plan*. ECONorthwest.

B. Unemployment

In 2010, the average unemployment rate in WTD's service area was 8.9 percent and the national rate was 9.6 percent. By having a rate lower than the national average, the approach prescribed by the *CSO Guidance* leads to the conclusion that WTD and the communities it serves have an above-average financial capability to bear CSO-related costs, all else equal.

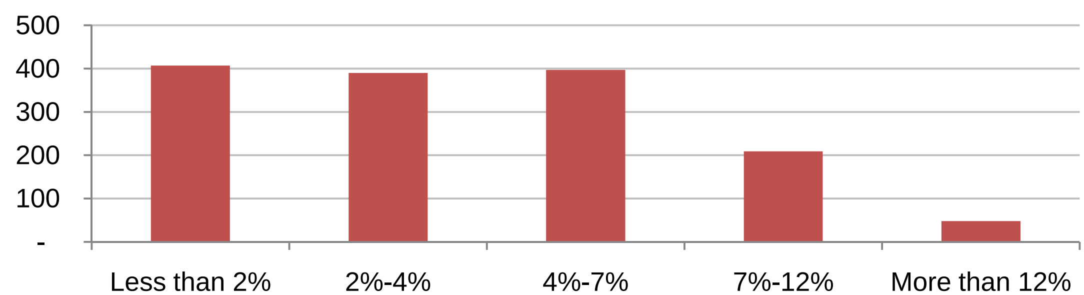
The *CSO Guidance's* approach does not, however, account for communities within WTD's service area with concentrations of unemployment, or for changes in the relationship between regional and national unemployment over time. To illustrate these variations, we examined unemployment rates by census block group. Data on unemployment rates from the 2010 Census, at the census-block-group level, however, are not expected for areas in Washington until later this year, and hence the most recent data at this level of disaggregation come from the 2000 Census. The 2000 Census found

[15] Income data from the U.S. Census Bureau describe pre-tax incomes. Many factors influence the amount of money different households pay in taxes, and any assumptions on these tax levels may inadequately consider the distribution of tax impacts on the communities this report considers.

that the overall unemployment rate for WTD's service area was about 4.5 percent, higher than the national average, 4.2 percent. Figure 4 shows the number of census block groups in WTD's service area with unemployment rates in different ranges. About 57.2 percent of the census block groups in WTD's service area had unemployment rates below the national rate in 2000. About 3.3 percent of the census block groups, however, had unemployment rates above 12.0 percent, and another 14.4 percent of the census block groups had unemployment rates in the 7.0–12.0 percent range. These numbers indicate that unemployment rates can vary widely across the service area, and some census block groups can have unemployment rates far higher then the regional or national averages.

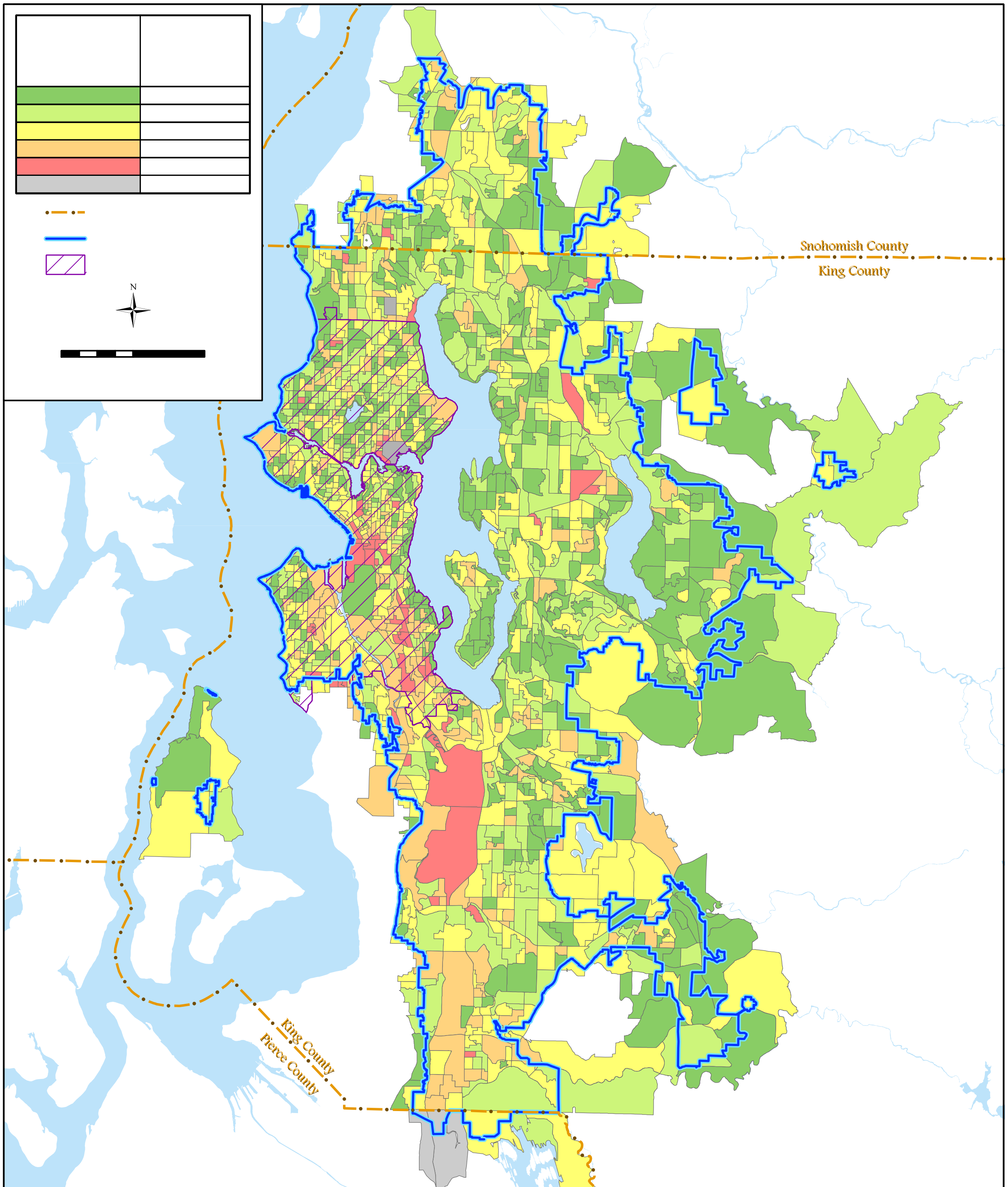
Map 2 provides a geographic representation of the data in Figure 4. Census block groups with high unemployment rates follow the pattern shown in Map 1 of census block groups with low MHIs. Generally, 2000 Census data show that census block groups with high unemployment rates (more than 7 percent) are concentrated in the South Seattle and South King County (around Auburn, Kent, and Pacific) while census block groups in the Eastern and Northern parts of the service area tend to have lower unemployment rates (less than 7 percent). The data shown in Map 2 are from the 2000 Census. The unemployment rate for WTD's service area as a whole has nearly doubled from 4.5 percent in the 2000 Census to 8.9 percent in the 2010 Census. While there are insufficient data to analyze the distribution of this additional unemployment across WTD's service area, unemployment rates likely have increased in most, if not all, census block groups, and with higher unemployment rates, these communities likely face additional burdens in meeting their financial obligations than suggested by the analysis using the *CSO Guidance*.

Figure 4. Number of Census Block Groups in WTD's Service Area by Unemployment Rate (2000 rates)



	2000 Census	2010 Census
Unemployment Rate in WTD's Service Area	4.5%	8.9%
National Unemployment Rate	4.2%	9.6%

Source: ECONW with data from King County WTD and U.S. Bureau of Labor Statistics. 2011. National, State, and Local Unemployment Rates. Retrieved on August 23, 2011 from http://www.bls.gov/bls/unemployment.htm.



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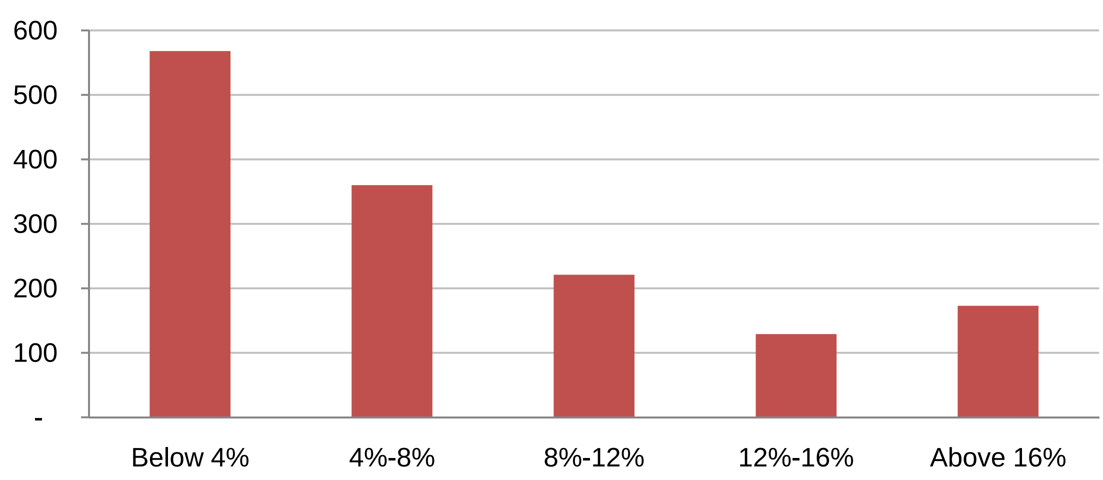
C. Poverty

The methodology prescribed by EPA's *CSO Guidance* does not explicitly consider poverty rates in determining the potential impacts of the Recommended CSO Control Plan on households. Thresholds for poverty level are dependent on household income, and the age and number of individuals in the household.[16] The number of individuals with incomes below the poverty level is a powerful indicator of the community's capacity to bear additional financial burdens. In particular, it provides insight into the likelihood that imposition of higher rates to cover anticipated CSO costs would result in families having to move out of their homes and depend on the overall community for housing and other social services.

Poverty data from the 2010 Census are not expected until later this year, and hence the most recent data come from the 2000 Census. In 2000, about 130,000 residents in WTD's service area (or about 8.2 percent of its total population) had incomes below the poverty level. Across King County, the percentage of the population with incomes below the poverty level increased from 8.0 percent in 1990 to 9.5 percent in 2006.[17] While there are insufficient data to update poverty figures specific to the census block groups in WTD's service area, they likely follow the pattern of the county as a whole. Figure 5 shows the number of census block groups in WTD's service area with poverty rates in different ranges. For example, the right side of the figure shows 173 census block groups had poverty rates above 16 percent, 129 census block groups had rates in the 12–16 percent range, 221 had rates in the 8–12 percent range, 360 had rates in the 4–8 percent range, and 568 had rates below 4 percent.

Figure 5. Number of Census Block Groups in WTD's Service Area by Poverty Rate (2000 rates)



[16] U.S. Census Bureau. 2000. *Poverty Thresholds 2000*. Retrieved on August 10, 2011 from http://www.census.gov/hhes/www/poverty/data/threshld/thresh00.html.

[17] King County Office of Management and Budget. 2008. *The 2008 Annual Growth Report*. November.

Source: ECONW with data from King County WTD.

The number of people living within each census block group is not constant. Using the number of households in each census block group, from the 2000 Census, we estimate the percentage of the total population in WTD's service area in each poverty bracket. For example, while only 11.9 percent of the census block groups had poverty rates above 16 percent, these census block groups represent about 12.4 percent of the population in WTD's service area. Applying the same technique to the other poverty rate ranges, we find that 9.5 percent of the population in WTD's service area lived in census block groups with poverty rates in the 12–16 percent range, 16.9 percent lived in census block groups with poverty rates of 8–12 percent, 23.7 percent lived in census block groups with poverty rates of 4–8 percent, and 37.5 percent lived in census block groups with poverty rates of below 4 percent.

Map 3 provides a geographic representation of the data in Figure 5. Census block groups with high poverty rates follow the geographic patterns shown in Maps 1 and 2 for census block groups with high unemployment rates and low MHIs. Generally, 2000 Census data show that census block groups with high poverty rates (more than 12 percent) are concentrated in South Seattle and South King County (around Auburn, Kent, and Pacific) while census block groups in the Eastern and Northern parts of the service area tend to have lower poverty rates (less than 12 percent). The data shown in Map 3 are from the 2000 Census. The US Census Bureau recently released data showing the poverty rate across the country has reached 15.1 percent. The poverty rate, at the national scale, has increased in each of the past three years, and is currently the highest it has been since 1993.[18] There are insufficient data, however, to determine how the poverty rate in WTD's service area has changed over recent years at the census-block-group level.

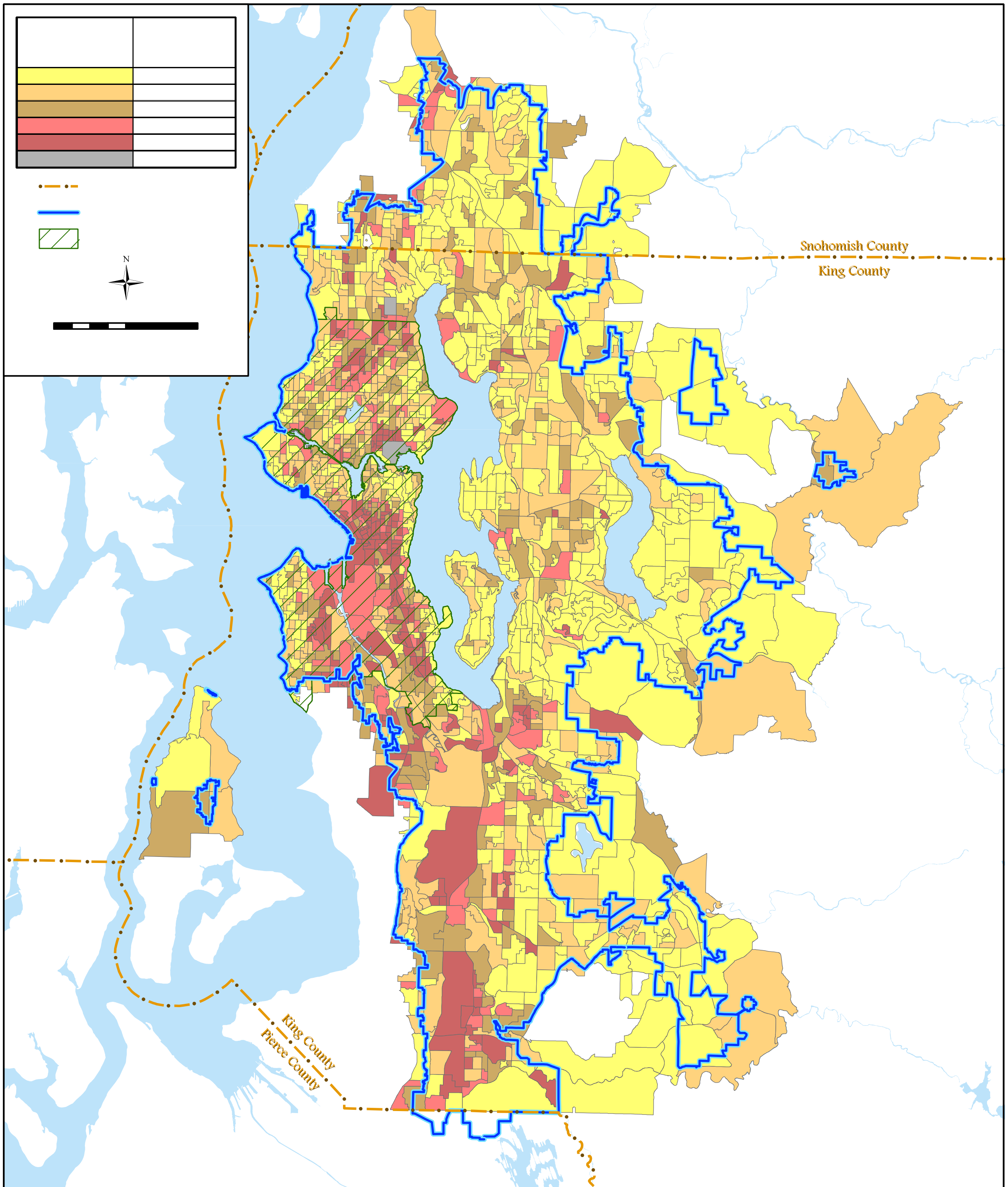
D. Applying the *CSO Guidance* at the Census-Block-Group Level

The analytical approach prescribed by the *CSO Guidance* uses the MHI and unemployment rate, for WTD's overall service area, along with several other variables, to categorize the potential financial impact of CSO controls on WTD and the communities it serves. Applying that approach leads to the conclusion the Recommended Plan would impose a **Low Burden** on WTD and these communities. The *CSO Guidance* suggests permittees provide additional analysis and narrative discussion describing issues specific to their communities that may better describe their financial capabilities. Other permittees have disaggregated their service areas at the census-block-group level to show the distribution of impacts across their service areas, and to assign a burden category to each census block group.[19] Here, we take a similar approach, demonstrating how applying elements of the analytical approach prescribed by the *CSO Guidance* to disaggregated data based on census block groups provides a more complete

[18] US Census Bureau. 2011. *Income, Poverty, and Health Insurance Coverage in the United States: 2010*. September.

[19] For discussion of how other permittees analyzed these issues, see: Niemi, E., T. Souhlas, and P. Thoma. 2011. *King County CSO Financial Capability Assessment and Schedule Development. Task 1: Apply Current EPA CSO Financial Capability Assessment Guidance to WTD's Long Term CSO Control Plan*. ECONorthwest.

picture of the financial burden that would accompany full implementation of CSO controls included in the Recommended Plan by 2030.



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The discussion above, in Section II, shows that application of the *CSO Guidance's* approach leads to the conclusion that impacts on households resulting from implementation of the Recommended CSO Control Plan by 2030 would fall into the **Low** category, as indicated by the Residential Indicator (average costs per household as a percent of MHI for all households in WTD's service area). This approach also leads to the conclusion that the communities in the service area, considered as a whole, have a **Strong** Financial Capability Indicators Score. Together, these two conclusions support a third conclusion: that implementation of the Recommended CSO Control Plan by 2030 would place a **Low Burden** on all households and communities in the service area.

Repeating the major analytical steps prescribed in the *CSO Guidance*, but using MHIs and applicable combined rates at the census-block-group level rather than for the service area as a whole, does not change the Financial Capability Indicator Score for any of the census block groups. It does, however, change some census block groups' Residential Indicator Scores, pushing some census block groups into the **Medium Burden** category. Table 10 shows the percentage of households living in census block groups that fall under each of the *CSO Guidance's* burden categories.[20] The first row shows the results using the *CSO Guidance*, per household from 2011 to 2030, to calculate the burden. The other rows show the results using the maximum annual wastewater collection rates, per household, from 2011 to 2030, under the Recommended CSO Control Plan scenario.

Table 10. Percentage of Households in WTD's Service Area in Census Block Groups Falling Under the *CSO Guidance* Burden Categories

	Low Burden	Medium Burden	High Burden
Percentage of Households in WTD's Service Area Using the Average WWT- and CSO-related costs per household as Defined by the *CSO Guidance*	99.2%	0.8%	0.0%
Percentage of Households in WTD's Service Area Using the Maximum Annual Regional Rate[a]	98.1%	1.9%	0.0%
Percentage of Households in WTD's Service Area Using the Maximum Annual Non-Seattle Combined Rate[b]	58.9%	1.7%	0.0%
Percentage of Households in WTD's Service Area Using Seattle's Maximum Annual Combined Rate[c]	33.3%	6.1%	0.0%

Source: ECONW with data from King County WTD.

[a] To calculate the values in this row, we divided the maximum annual regional rate ($533 per household) by the MHI in each census block group in WTD's service area, weighted each of these census block groups by the number of households they contain, and divided by the total number of households in WTD's service area.

[b] To calculate the values in this row, we divided the maximum annual combined rate ($789 per household) by the MHI in each census block group in WTD's service area (excluding census block groups in Seattle's service area), weighted each of these census block groups by the number of households they contain, and divided by the total number of households in WTD's service area.

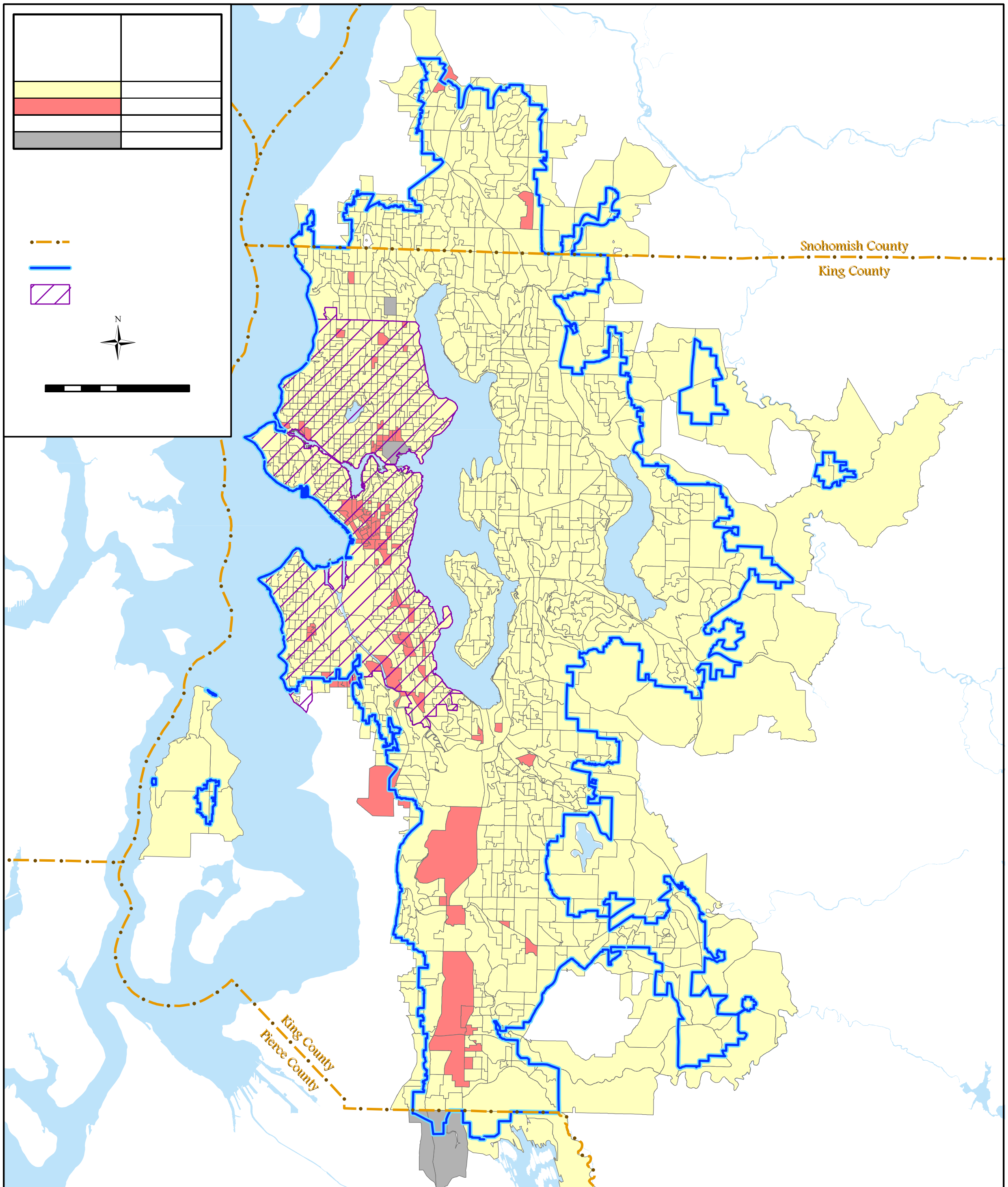
[c] To calculate the values in this row, we divided Seattle's maximum annual combined rate ($797 per household) by the MHI in each census block group in Seattle's service area, weighted each of these census block groups by the number of households they contain, and divided by the total number of households in WTD's service area.

[20] The 2000 Census does not provide the income for each household. If it did, we could estimate the number of households falling under each burden category. Without these household-level data, we rely on census-block-group-level data to identify communities likely containing a high percentage of households in each burden level.

For example, using $423 per household, the average cost estimated using the approach prescribed by the *CSO Guidance*, 0.8 percent of households in WTD's entire service area are in census block groups with MHIs that would place them in the **Medium Burden** category. Using the maximum annual regional rate ($533 per household), 1.9 percent of households in WTD's service area live in **Medium Burden** census block groups. Using the maximum annual combined rate ($797 per household in Seattle's service area and $789 per household in other areas), 7.8 percent of households in WTD's service area live in **Medium Burden** census block groups. The rest of the households (92.2 percent of all households in WTD's service area) live in census block groups that fall into the **Low Burden** category. No households live in census block groups that fall into the **High Burden** category.

Map 4 provides a geographic representation of the data shown in the bottom two rows of Table 10. Census block groups that fall into the **Medium Burden** category follow the geographic patterns shown in Maps 1, 2, and 3 for census block groups with high poverty rates, high unemployment rates, and low MHIs. As shown above, 6.1 percent of all households falling into the **Medium Burden** category (using maximum annual combined rates) are in census block groups within Seattle's service area. About 40,500 households in Seattle's service area (15.5 percent of all households in its service area) are in census block groups falling under the **Medium Burden** category, and are concentrated in South Seattle. Most of the census block groups falling under the **Medium Burden** category outside of Seattle's service area are in South King County (around Auburn, Kent, and Pacific).

Using projected rates and MHI data at the census-block-group level, the percentage of households falling into the **Medium Burden** category is higher than it is using the *CSO Guidance* methodology. An increase in a household's financial burden resulting from implementation of CSO controls will leave it with fewer resources to meet other financial obligations. So, while most of the households in WTD's service area remain in the **Low Burden** category throughout our analysis using disaggregated data for census block groups, we have identified some households for which the impacts of the Recommended CSO Control Plan would be greater. Overall, WTD's service area contains about 661,800 households. The disaggregated analysis indicates that implementation of the CSO control actions in the Recommended Plan by 2030 would impose a **Medium Burden** on about 7.8 percent, or about 51,410 of these households, using maximum annual combined rates in the relevant areas.



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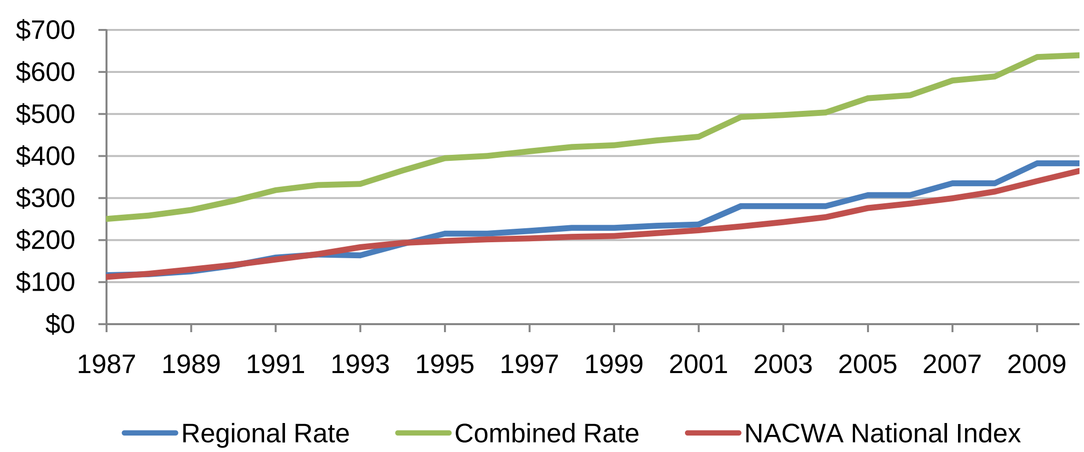
IV. Accounting for Past Expenditures

The true burden of CSO control costs reflect not just by costs anticipated in the future but also by those households have shouldered in the past. To date, WTD has met, complied with, and in many instances exceeded CSO-related regulations. Since 1983, WTD has spent about $506 million (in 2011 dollars) [21] complying with these regulations (some of these compliance measures are listed in Appendix A). The households in WTD's service area have borne these costs, and have paid above-average rates for these WWT and CSO services, relative to communities across the country. If WTD had not made these investments, their future CSO-related costs likely would be higher than those represented for 2011 to 2030 in the Recommended CSO Control Plan scenario.

Figure 6 shows the average annual regional rate (the blue line) and the average annual combined rate (the green line) in WTD's service area, per household, from 1987 to 2010 and the average annual rate, per household, from service areas across the country (the red line).[22] From 1987 to the mid 1990s, WTD's regional rate followed the national average closely. Since the mid 1990s, though, WTD's regional rates have consistently been higher than the national average. Average annual combined rates in WTD's service area have consistently been higher than the national average. From 1987 to 2010, the average annual combined rate in WTD's service area was about $432 per household; nearly double the average annual rate across the country, $220 per household.

Figure 6. Average Annual Wastewater-Related Rates per Household (1987-2010)



Source: ECONW with data from King County WTD and NACWA. 2010. *2010 Service Charge Index*.

Notes: The average combined rate in WTD's service area uses historical regional rates and assumes that local rates

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[21] King County, *Regional Wastewater Services Plan 2009 Annual Report.* This amount reflects the sum of each year's expenditures including costs of the four Puget Sound CSO Beach Projects, expressed in 2011 dollars. It does not reflect the timing of the expenditures, represented by the present value that would weigh expenditures incurred in earlier years more than those incurred in later years.

[22] The regional and combined rates from 1987 to 2010, discussed in this section, do not include additional fees households paid toward capacity charges on new developments. Inclusion of these fees would raise the blue and green lines.

increased by inflation.

V. Accounting for Current and Anticipated Economic Conditions

As described above, the *CSO Guidance* defines a permittee's burden level (**Low, Medium,** or **High**) as a function of WWT- and CSO-related costs, income and wealth characteristics in the service area, and other factors. Recent and anticipated economic conditions have dramatically changed income and wealth characteristics in ways that are not fully captured by applying the *CSO Guidance's* approach, which was developed in the middle of prolonged period of economic growth. These changes, reflecting the recent recession and slow recovery, reduce the financial capabilities of ratepayers and communities in ways not considered by the *CSO Guidance*.

Figure 7 illustrates the change in economic conditions, using as an indicator the nations real, i.e., inflation-adjusted real gross domestic product (GDP). Real GDP is the value of the goods and services produced by labor and property within a country, in real terms (that is, adjusting for price changes tied to inflation and deflation). Real GDP per capita indicates the country's standard of living.[23] The red line shows the actual real GDP for the period, 1951–2011, and the blue line shows the potential real GDP that the nation's economy could produce if it were operating at full employment conditions.[24] Since 1950, actual real GDP has fluctuated above and below potential real GDP. In recent years, however, actual real GDP has dropped markedly below potential real GDP, and has not fully recovered. Since 1950, the real standard of living has grown by about 2.1 percent per year. As real GDP growth slowed from 2007 to 2008 and decreased from 2008 to 2009, real standard of living declined. The cumulative loss in GDP since the recession began is about $2.8 trillion,[25] or about $23,000, on average, for each of the approximately 120 million U.S. households.

Households are facing a different reality now than they were in 1997 when the *CSO Guidance* was written. Back then, historical economic data suggested their standard of living would increase, on average, about 2.1 percent per year, meaning they could expect their wealth to increase from year to year. With more wealth, they could anticipate purchasing more goods and services or purchasing higher quality goods and services than they could previously. These expectations, supported by on-going experience, underlay the willingness and ability of households and communities to bear the costs of CSO controls. Now, both the actual and the forward-looking ability to pay

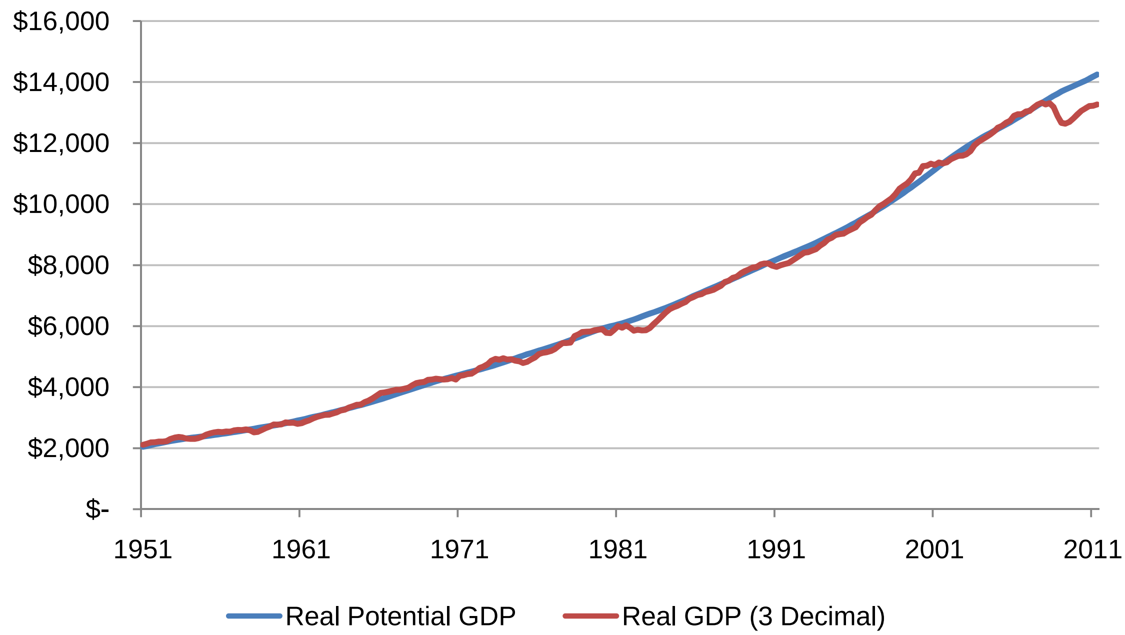
[23] For more details, see: U.S. Bureau of Economic Analysis. 2011. *A Guide to the National Income and Product Accounts of the United States*. Retrieved on August 23, 2011 from http://www.bea.gov/national/pdf/nipaguid.pdf.

[24] Potential real GDP is a measure of an economy's maximum sustainable GDP assuming full employment, in real terms. For more details, see: U.S. Congressional Budget Office. 2011. *A Summary of Alternative Methods for Estimating Potential GDP.* Retrieved on August 23, 2011 from http://www.cbo.gov/doc.cfm?index=5191&type=0.

[25] Krugman, P. 2011. "The Waste." *The Conscience of a Liberal. New York Times.* http://krugman.blogs.nytimes.com/2011/08/11/the-waste/. August 11.

have declined. Due to uncertainty regarding the future growth of income and wealth, the financial capability of households in WTD's service area to pay increasing rates for wastewater services related to CSO costs likely is overstated.

Figure 7. Actual and Potential GDP (Billions of chained 2005 dollars)



Source: ECONW with data from Federal Reserve Bank of St. Louis, Economic Research. Retrieved on August 15, 2011 from http://research.stlouisfed.org/fred2/categories/106.

Notes: Data for Real Potential GDP (Series ID - GDPPOT), data for Real GDP (Series ID – GDPC96).

VI. Analytical Conclusions

Calculations resulting from applying the assumptions and methods of the *CSO Guidance* indicate implementing the Recommended CSO Control Plan with the 2030 deadline would impose a **Low Burden** on households and the overall community WTD serves.[26] Based on these findings, the *CSO Guidance* expresses general scheduling boundaries that, subject to negotiation, expect WTD would implement the CSO controls as quickly as possible, following a normal engineering and construction schedule. Because the *CSO Guidance* incorporates standardized assumptions and analytical methods insensitive to local conditions, however, these findings do not provide a complete, accurate picture of the actual, full financial burden that would accompany implementation of the proposed CSO controls, nor do they adequately represent the community's financial capability to bear those costs.

[26] Niemi, E., T. Souhlas, and P. Thoma. 2011. *King County CSO Financial Capability Assessment and Schedule Development. Task 1: Apply Current EPA CSO Financial Capability Assessment Guidance to WTD's Long Term CSO Control Plan*. ECONorthwest.

The supplemental information presented in this report sheds light on the economic conditions in WTD's service area not considered by the *CSO Guidance*, and supports these conclusions:

1. **If the CSO controls in the Recommended Plan are implemented by 2030, the actual WWT– and CSO–related rate payments by households and the financial impact on households would exceed the estimates resulting from application of the *CSO Guidance's* analytical approach.**
   - Applying the *CSO Guidance's* approach suggests that current and anticipated WWT costs, plus past CSO costs, plus costs in WTD's Recommended CSO Control Plan would results in annual costs of $423 per household over the period, 2011–2030. This amount reflects just the costs borne by WTD and passed to customers.
   - In reality, however, households also will bear WWT– and CSO–related costs from the component agencies. Rate models tailored to WTD and the component agencies shows that the total, combined costs during this period would average $758 per household per year, for all the households in WTD's service area, and $766 per household per year for those in Seattle. These, more realistic estimates of the actual costs borne by households are about 80 percent higher than those that result from applying the *CSO Guidance's* approach.
   - The projected rates from the rate models do not account for the costs households in WTD's service area already have borne because of the steps taken by WTD and its component agencies to reduce the environmental impacts of WWT and CSO. Had WTD not taken these steps, the costs of implementing CSO controls in the Recommended Plan by 2030 would be even higher, leading to higher rates for households in the service area.
   - The projected rates from the rate models indicate that the actual average cost per household likely will exceed 1.0 percent of MHI for all households in WTD's service area, especially when one accounts for the possibility that actual construction costs will exceed current, planning-level estimates. This means that, when evaluated using the criteria expressed in the *CSO Guidance*, the Residential Indicator of the impact on households will fall into the **Mid-Range** category rather than into the **Low** category, which results from applying the *CSO Guidance's* approach.

2. **The financial capability of WTD and the communities it serves to bear the costs of the CSO controls in the Recommended Plan is lower than indicated by applying the *CSO Guidance's* approach.**
   - The *CSO Guidance's* approach does not reveal the potential impacts on low-income households, households living in poverty, and the communities in which these households live. Much of the approach revolves around a single indicator of financial capability: the MHI for WTD's entire service area. This approach overlooks the hardship households with incomes below the MHI can experience with increases in WWT and CSO rates.
   - Examination of disaggregated data from the 2000 Census (the most recent data currently available, from a year when the economy was far more robust

than today) shows that about 36.0 percent of the service area's population lived in census block groups where the incidence of poverty exceeded 8.0 percent.

- Data from the 2000 Census show about 5.0 percent of the service area's population lived in census block groups with MHIs less than one-half the MHI for the service area as a whole.
- The 2000 Census also shows that, even in 2000, a year when the overall unemployment rate was 4.5 percent for the service area and 4.2 percent for the nation, more than 40 percent of the area's census block groups had unemployment rates higher than the national rate.
- Recent and anticipated economic conditions reduce the financial capability of ratepayers and communities in ways not foreseen by the *CSO Guidance*. The recent recession and slow recovery reduce the financial capabilities of ratepayers and communities. By one estimate the downturn since 2007 has reduced cumulative real GDP, a strong indicator of the standard of living, by $23,000 per household.
- Individually and collectively, this information calls into question the conclusion, derived from applying approach prescribed by the *CSO Guidance*, that WTD and the communities it serves have a **Strong** financial capability to bear the costs that would accompany implementation of the CSO controls in the Recommended Plan by 2030.

3. **This supplemental information supports the conclusion that implementing the CSO controls in the Recommended Plan by 2030 would impose more than a Low Burden on WTD and the households and communities it serves.**
    - The burden would be especially high in areas with low MHIs, high unemployment, and high poverty rates, relative to the rest of WTD's service area. These areas are clustered in South Seattle and South King County (around Auburn, Kent, and Pacific).

APPENDIX A. PAST, PRESENT, AND PROPOSED PROJECTS INCLUDED IN BASELINE SCENARIO[27]

RSWP Project Planned for the Future (millions of 2010 dollars)	
	2009 Cost Estimate
Planned conveyance projects	$406
Planned South Plant expansion	$119
Water quality protection	$80
RSWP Projects in Design or Construction (millions of 2010 dollars)	
	2010 Cost Estimates
Total Costs for RWSP Projects in Design/Construction	**$363**
Total Conveyance Projects	**$231**
Bellevue Pump Station Upgrade and Force Main Installation	$37
Kent-Auburn Conveyance System Improvements (Phase A and Phase B pipelines)	$52
Black Diamond Storage	--
North Creek Pipeline	$49
Bellevue Influent Trunk Parallel	$7
Sunset/Heathfield Pump Station Replacement and Force Main Replacement	$81
Decennial Flow Monitoring	$6
Total Treatment and Odor Control	**$10**
West Point Digestion Improvements	$10
Brightwater Treatment & Conveyance	$1,856
Total I/I	**$2**
Sediment Management/Lower Duwamish Superfund	**$61**
Habitat Conservation Plan (HCP)/Programmatic Biological Assessment	**$8**
Reclaimed Water	**$33**
Brightwater Reclaimed Water Backbone	$26
Future Water Reuse	$4
Reclaimed Water Comprehensive Plan	$3
RWSP Planning and Reporting	**$3**
Puget Sound Beach CSO Control Projects	**$176**
Completed RWSP Projects (millions of 2010 dollars)	
	Expenditures as of December 31, 2010
Total completed projects	**$376**
Completed CSI projects, acquisitions, planning	$249
Completed treatment and odor control projects	$64
Completed reclaimed water projects	$7
Completed I/I pilot study projects/program	$40
Completed water quality protection	$16

[27] ECONW with data from King County WTD.

Appendix H

Post-Construction Monitoring Plan

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Post Construction Monitoring Plan for King County CSO Controls

March 2012

FINAL DRAFT

King County

Department of
Natural Resources and Parks
Wastewater Treatment Division

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Summary

King County's post construction monitoring plan is designed to assess, document, and report on the effectiveness of its combined sewer overflow (CSO) control program in achieving performance requirements and complying with state water and sediment quality standards.

Post construction monitoring to be conducted at each CSO is summarized in the following table. All CSO locations will be monitored for onset, duration, and volume of the discharge. In addition, discharge locations that provide CSO treatment will be monitored for influent and effluent quality. Sampling of the wet-weather discharges will be done in coordination with sampling for NPDES permit compliance. In addition to this monitoring, King County will continue to collect precipitation data at an equivalent level to the existing network of rain gauges and will continue its ongoing ambient monitoring program.

Post Construction Compliance Monitoring Plan

Medium	Post Construction Monitoring to be Conducted
CSO discharge	Untreated CSOs controlled to one overflow per year or less: Overflow onset, duration, and volume using SCADA and portable meters Treated CSO discharges: Overflow onset, duration, and volume using SCADA Influent and effluent quality sampling; reasonable potential analysis to assess compliance with water quality standards
Sediment	Sites with adequate characterization and no existing SMS exceedances: No sediment monitoring Sites with existing SMS exceedances or inadequate sediment characterization: Project-specific pre-construction (if needed) and post-construction sediment monitoring used to determine if SMS still exceeded; a site specific cleanup plan if needed
Receiving water	Ongoing ambient monitoring programs and sampling specified in the NPDES permit

SCADA = supervisory control and data acquisition system.

Assumptions used to develop the plan are as follows:

- CSOs controlled to no more than one untreated event per year on average will request and be granted an average once per year exemption to the numeric mixing zone size criteria described in Section 173-201A-400 WAC and will be deemed to comply with receiving water quality standards. Monitoring for these sites focuses on characterizing the quantity and frequency of discharges.
- The effectiveness of the CSO control at treated CSO sites is to be assessed by monitoring their ability to provide the equivalent of primary treatment— at least 50 percent removal of the total suspended solids annually and discharges less than 0.3 mL/L/hr of settleable solids for each event—and on other NPDES permit limits that apply to the effluent.

- King County will evaluate treated CSO compliance with state water quality standards by conducting a reasonable potential analysis based on the treated effluent quality data and existing ambient quality data.
- Data from previous studies and from ongoing monitoring programs are sufficient to characterize ambient water quality in receiving waters.
- At locations where SMS are currently met with an uncontrolled CSO, the activity of reducing the CSO discharge to achieve control will not degrade the existing sediment quality.

Monitoring data and evaluation will be reported to the Washington State Department of Ecology through the monthly discharge monitoring reports, annual CSO reports, and CSO plan updates. The post construction monitoring plan will be updated periodically to reflect changing conditions and requirements.

1 Introduction

King County's wastewater collection and treatment system currently has 38 combined sewer overflow (CSO) locations and 4 CSO treatment plants. Their outfalls discharge to Lake Washington, Lake Union, Lake Washington Ship Canal, Duwamish River, Elliott Bay, and Puget Sound. The county is working toward controlling all its CSO locations by 2030 to meet the Washington State standard of no more than one untreated overflow on average per year at each location. These CSOs are regulated through the National Pollutant Discharge Elimination System (NPDES) permit for the West Point Treatment Plant.

In response to the Clean Water Act of 1972, the Municipality of Metropolitan Seattle (Metro) adopted the *Combined Sewer Overflow Control Program* in 1979. Since adoption of this first program, Metro and then later King County have modified plans to respond to evolving CSO regulations and wastewater system needs. The most recent CSO control plan was adopted in 1999 as part of the county's Regional Wastewater Services Plan (RWSP) and was updated in 2000 and 2008 as a part of the West Point plant's NPDES permit renewal.

This document describes a post construction compliance monitoring plan to measure the effectiveness of CSO controls and to provide information for use in demonstrating compliance with state water and sediment quality standards.

The following sections in this chapter provide background on the impetus for the plan, regulations that guide environmental protection and CSO control, and locations and control status of county CSOs.

A History of CSO Plans

1979—Metro adopted its first *Combined Sewer Overflow Control Program.*

1985 and 1986—The *Plan for Combined Sewer Overflow Control* and the *Supplemental Plan for Combined Sewer Overflow Control* were prepared as part of a system-wide planning effort

1988—The *1988 Combined Sewer Overflow Control Plan* was prepared in response to Ecology's 1987 definition of control as one untreated discharge per year.

1995—As part of the 1995 West Point NPDES permit renewal, King County prepared an update and amendment to the 1988 plan.

1999—A CSO control plan was adopted as part of the Regional Wastewater Services Plan (RWSP). The plan lists 21 control projects to bring all CSOs into control by 2030.

2000—The RWSP CSO control plan was updated as part of the West Point NPDES permit renewal. No changes to the RWSP CSO control plan were recommended.

2006—The first CSO control program review was completed.

2008—The RWSP CSO control plan was updated as part of the West Point NPDES permit renewal. No changes to the RWSP CSO control plan were recommended.

1.1 Background

The U.S. Environmental Protection Agency (EPA) requires CSO communities to conduct a post-construction monitoring program for their controlled CSOs to "verify compliance with water quality standards and protection of designated uses as well as to ascertain the effectiveness of CSO controls" (Section II.C.9 of the CSO Control Policy). In accordance with this requirement, Section 18.K of the West Point NPDES permit requires King County to implement a post construction compliance monitoring program and to prepare a plan that describes the program:

> The Permittee must 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. This water quality compliance monitoring program must include a plan that details the monitoring protocols to be followed, including

> the necessary effluent and ambient monitoring and, where appropriate, other monitoring protocols such as biological assessments, whole effluent toxicity testing, and sediment sampling. The plan must be reviewed and approved by Ecology….The plan should include a discussion of controlled outfalls that may be influenced by other County or City of Seattle uncontrolled outfalls that may adversely influence or interfere with the water quality assessment of controlled outfalls. The Permittee must provide adequate justification for not performing post construction monitoring for controlled CSO outfalls where water quality may be impacted by nearby outfalls.

The post construction monitoring plan described in this document groups CSO controls into two categories to evaluate their effectiveness. One category consists of the implementation of conveyance system improvements, including storage or Green Stormwater Infrastructure (GSI), with the objective of reducing the average number of overflows to no more than one untreated event per year on average as specified in WAC 173-245-020(22). Compliance will be based on a 20-year moving averaging period, including past years and the current year. It is assumed that for CSOs controlled to this standard the County will request and the State will grant the mixing zone exemption described in WAC 173-201A-400 (see "Regulations" below) and the CSO will be deemed to meet the surface water quality standards. Monitoring for these types of controls focuses on characterizing the quantity and duration of discharges, monitoring the condition of the GSI-managed area, as well as the confirmation that there are no exceedances of sediment management standards at the outfall due to the CSO. If the CSO appears to have contributed to existing SMS exceedances, then such contamination will be remediated.

The second type of control consists of a CSO treatment facility that is designed to provide the equivalent of primary treatment and disinfection. Monitoring for this type of control focuses on characterizing the quantity, duration, and quality of both the influent and treated effluent. The effectiveness of the CSO control is to be assessed from the ability to provide the equivalent of primary treatment: at least 50 percent removal of the total suspended solids (TSS) and discharges less than 0.3 mL/L/hr of settleable solids. In addition, the treated effluent must meet any limits defined in the NPDES permit that the reasonable potential analysis identified as being needed.

Monitoring activities designed to demonstrate compliance with water quality standards include effluent and sediment sampling. A reasonable potential calculation is proposed as the methodology to demonstrate compliance with surface water quality standards. Compliance with sediment quality standards will be demonstrated through sediment sampling combined with model predictions.

1.2 Regulations

In Washington State, the planning and design of the CSO controls are required to follow the requirements set out by the Washington State Department of Ecology (Ecology) in Chapter 173-245 WAC, submission of plans and reports for construction and operation of combined sewer overflow reduction facilities. These regulations include requirements for flow monitoring, hydraulic model development and verification, sampling of pollution levels, and sediment sampling if historical contamination may be present.

Once the Ecology-approved designs are constructed, WAC 173-201A-010 requires compliance with Chapter 173-201A WAC, water quality standards for surface waters of the State of

Washington; Chapter 173-204 WAC, sediment management standards; and applicable federal rules. These regulations are described below.

1.2.1 Regulations for Planning and Design of CSO Control Facilities

The plans and specifications developed during project design must conform to the guidance in the *Criteria for Sewage Works Design* (WAC 173-245-050), which states that "compliance with the state water quality standards is a requirement that must always be achieved" (C3-1.2.3). Analyses of how the design will meet applicable criteria are submitted to Ecology prior to project construction as part of a project-specific engineering report or facility plan. The NPDES permit sets conditions and permit limits to assure the goals and requirements are met. Following project completion, post construction monitoring assesses whether the CSO control is operating as designed and complies with state water quality standards.

Regulations Related to CSO Control

Clean Water Act (CWA)—Adopted in 1972 to eliminate the discharge of pollutants into the nation's waters and to achieve and maintain fishable and swimmable waters.

National Pollutant Discharge Elimination System (NPDES)—The Washington State Department of Ecology (Ecology) implements the CWA by issuing NPDES permits to wastewater agencies and industries that discharge effluent (including CSOs) to water bodies.

Water Quality Standards—To implement CWA, Ecology has developed biological, chemical, and physical criteria to assess a water body's health and to impose NPDES permit limits accordingly.

State CSO Control Regulations—Ecology requires agencies to develop plans for controlling CSOs at the earliest possible date so that an average of one untreated discharge per year occurs at each location.

Wet Weather Water Quality Act of 2000—The U.S. Environmental Protection Agency (EPA) requires agencies to implement Nine Minimum Controls and to develop long-term CSO control plans.

Sediment Quality Standards—Ecology developed chemical criteria to characterize healthy sediment quality and identified a threshold for sediment cleanup. King County has participated in sediment cleanup at some of its CSO locations.

Endangered Species Act (ESA)—Some species of fish that use local water bodies where CSOs occur have been listed as threatened under ESA.

1.2.2 Water Quality Regulations

Washington State surface water quality standards, Chapter 173-201A WAC, require meeting quantifiable standards as well as protecting the designated use of a water body. The standards include both numeric and narrative criteria (Appendix A).

Water quality standards must be met at the point of discharge or at the edge of a mixing zone. The standards include language that exempts one CSO discharge per year on average from the numeric water quality standards to align with the state CSO control standard. This exemption applies to both treated and untreated CSO discharges. The exemption is implemented as a mixing zone of unlimited extent in WAC 173-201A-400 (mixing zones) which specifically applies to controlled CSO discharges:

> (11) Combined sewer overflows complying with the requirements of Chapter 173-245 WAC, may be allowed an average once per year exemption to the numeric size criteria in subsections (7) and (8) of this section and the overlap criteria in subsection (9) of this section, provided the discharge complies with subsection (4) of this section.

Referenced subsection (4) reads as follows:

> (4) No mixing zone shall be granted unless the supporting information clearly indicates the mixing zone would not have a reasonable potential to cause a loss of sensitive or important habitat, substantially interfere with the existing or characteristic uses of the water body, result

in damage to the ecosystem, or adversely affect public health as determined by the department.

Treated CSO discharge events, which may occur multiple times per year, are evaluated against water quality standards. The applicability of numeric standards to CSOs are as follows:

- The acute aquatic life numeric standards are applicable because of the intermittent and short duration (typically less than 48 hours) of CSOs.
- The chronic aquatic life standards, intended to be protective of four-day exposure durations (Ecology, 2008, Table VI-4), typically would not be applicable to shorter duration discharges.
- The human health criteria are based on lifetime exposure and are evaluated with the annual/maximum monthly effluent averages (Ecology, 2008, Table VII-1) and are not appropriate for CSO discharges.

Narrative criteria are designed to protect all existing and designated uses and are given in WAC 173-201A-260 (2) for fresh and marine waters (see Appendix A):

(a) Toxic, radioactive, or deleterious material concentrations must be below those which have the potential, either singularly or cumulatively, to adversely affect characteristic water uses, cause acute or chronic conditions to the most sensitive biota dependent upon those waters, or adversely affect public health (see WAC 173-201A-240, toxic substances, and 173-201A-250, radioactive substances).

(b) Aesthetic values must not be impaired by the presence of materials or their effects, excluding those of natural origin, which offend the senses of sight, smell, touch, or taste (see WAC 173-201A-230 for guidance on establishing lake nutrient standards to protect aesthetics).

The 1972 federal Clean Water Act requires states to prepare a list of water bodies that do not meet water quality standards for ensuring the water is healthy for such uses as fish and wildlife habitat and recreation in and on the water. Water bodies identified on the list must attain water quality standards within a reasonable period, either through a water cleanup plan based on total maximum daily loads (TMDLs) or other pollution control mechanisms. Water cleanup plans describe the type, amount, and sources of water pollution in a particular water body; analyze how much the pollution needs to be reduced or eliminated to meet water quality standards; and provide targets and strategies to control the pollution (Ecology, 2002).

Ecology compiles environmental data, including King County’s, into a database named EIM. Violations of water quality standards identified through these data form the basis for the state’s 303(d) list of impaired water bodies. The most recent list was published in 2008 and covers both fresh and marine waters. Subsequent to the 2008 listing, Ecology decided to publish assessments of marine waters and fresh waters in alternating two-year cycles, starting with a marine water assessment in 2010.

All of the receiving water bodies for county CSOs have listings for impairment because of fecal coliform bacteria levels. Water column samples also indicate impairment for dissolved oxygen (Duwamish Waterway), pH (Duwamish River), total phosphorus (Lake Washington and Lake

Union),[1] lead (Lake Washington Ship Canal and Lake Union), and aldrin (Lake Union). The Duwamish Waterway has listings for impairment from a wide variety of chemicals detected in sediment and tissue samples. In addition, there are a few sediment and tissue listings at discrete locations in Lake Washington and Puget Sound.

1.2.3 Sediment Quality Regulations

Regulation of contaminated sediments in the marine environment of Washington State typically falls under the authority of Ecology. In 1991, Ecology adopted the Sediment Management Standards (SMS; Chapter 173-204 WAC) for designating marine sediments that have acute or chronic adverse effects on aquatic organisms. Ecology has begun the process of creating a consistent set of standards for freshwater sediments (Ecology, 2003). Currently, state standards for freshwater sediment quality are determined on a case-by-case basis (WAC 173-204-315).

Three sets of standards were established under the SMS: sediment quality standards, sediment cleanup standards, and source control standards (Ecology, 2007):

- Sediment quality standards (SQS) correspond to a sediment quality that will result in no adverse effects, including acute or chronic adverse effects, on biological resources and no significant health risk to humans. The SQS includes chemical concentration criteria for 47 chemicals. If sediment chemical concentrations exceed SQS criteria, the sediments are designated as potentially having an adverse effect on biological resources and fail the SQS. Sediments failing the SQS may be reevaluated using biological tests described in WAC 173-204-315 to confirm or refute the original designation.
- If sediments exceed the SQS for any one of the 47 listed chemicals, they are subject to sediment cleanup standards set forth in WAC 173-204-520. Cleanup screening levels (CSLs) set the maximum degree of concentration needed to identify a cluster of potential concern, above which the cluster is defined as a cleanup site. Similarly, minimum cleanup levels (MCULs) establish the maximum degree of contamination to be allowed on a site after cleanup and are to be used in the evaluation of cleanup alternatives as specified in the SMS. MCULs are set at the same concentration as CSLs.
- Source control standards define the maximum level of sediment contamination allowed in sediments impacted by permitted ongoing discharges (WAC 173-204-420). Ecology has the ability to designate a zone (sediment impact zone or SIZ) in which contamination above the SQS standards is allowed provided that appropriate source control activities have occurred and the discharge is not expected to create a cleanup site (WAC 173-204-400/410).

1.3 Locations and Control Status of County CSOs

King County CSO outfalls and CSO treatment facilities are shown in Figure 1. Eighteen county CSO locations are reported as controlled to a frequency of, on average, less than one untreated event per year (Table 1). Four of the controlled locations receive treatment equivalent to primary and disinfection. The RWSP CSO control plan lists conveyance system improvements, storage facilities, and treatment facilities to bring the remaining CSOs into control.

[1] King County data indicate that total phosphorus levels do not exceed standards in Lake Washington and the Lake Washington Ship Canal.

The West Point Plant also provides some CSO treatment via a CSO-related bypass. The CSO flows receive primary treatment and then are mixed with secondary treated effluent before disinfection and discharge. The mixed effluent complies with secondary treatment standards.

> **Ongoing Reporting on Status of CSO Control Program**
>
> **Monthly discharge monitoring report (DMR).** Reports on onset, duration, volume, and frequency of discharge events; treated CSO quality; and rainfall.
>
> **Annual CSO control program report.** Compiles and summarizes DMR information for each calendar year.
>
> **CSO control plan update.** Submitted about every five years with renewal application for the West Point NPDES permit. Reports on progress and plans to control all CSOs to the state standard.

As shown in Table 1, no King County outfalls that discharge treated CSO or will discharge treated CSO in the future are near (less than 500 feet) other CSOs. Other CSOs are near 15 untreated county CSOs, either currently controlled or not yet controlled to one overflow per year or less. It is assumed that once untreated CSOs are controlled, they meet state water quality standards with the application of the mixing zone exemption in WAC 173-201A-400, as described above under "Water Quality Regulations." As a result, adjacent discharges will not affect the ability of these CSOs to comply with water quality standards.

1.4 Goals of CSO Control Plan

King County's CSO Control plan is intended to fulfill the mandate encoded in King County Code 28.86.080. Of specific relevance to this PCMP are the CSO control policies 1 and 2:

> CSOCP-1: King County shall plan to control CSO discharges and to work with state and federal agencies to develop cost-effective regulations that protect water quality. King County shall meet the requirements of state and federal regulations and agreements.
>
> CSOCP-2: King County shall give the highest priority for control to CSO discharges that have the highest potential to impact human health, bathing beaches and/or species listed under ESA.

The Washington State requirements in WAC 173-245-015 state:

> All CSO sites shall achieve and at least maintain the greatest reasonable reduction, and neither cause violations of applicable water quality standards, nor restrictions to the characteristic uses of the receiving water, nor accumulation of deposits which: (a) Exceed sediment criteria or standards; or (b) have an adverse biological effect.

where the greatest reasonable reduction is defined in WAC 173-245-020 (22) as:

> "The greatest reasonable reduction" means control of each CSO in such a way that an average of one untreated discharge may occur per year.

The CSO control plan proposes controlling all of King County's CSOs to no more than one untreated discharge per year. The performance of CSO treatment facilities is proposed to meet Washington State requirements of the equivalent of primary treatment, defined by at least a fifty percent removal of the total suspended solids from the waste stream, and less than 0.3 ml/l/hr. of settleable solids in the discharge. Disinfection is proposed for treated discharges.

1.5 Purpose of this Post Construction Monitoring Plan

As outlined in EPA's CSO Control Policy, post construction compliance monitoring is intended to provide data that can be used to:

- Verify the effectiveness of CSO controls
- Demonstrate compliance with WQS, protection of designated uses and sensitive areas

The data gathered under this PCMP is intended to be used to determine if King County is achieving the goals of its CSO Control Plan. The data will first provide an assessment of system performance to determine if the CSO Control Plan has resulted in the system meeting the standard of an average of one or fewer untreated overflows per year and treated discharges receiving the equivalent of primary treatment and disinfection as outlined in WAC 173-245. Next, the data will assess if water quality standards are being met by the CSO discharges. The proposed monitoring reflects the guidance on how to conduct effective post construction compliance monitoring issued in the document "CSO Post Construction Compliance Monitoring Guidance" (EPA, 2011).

Figure 1. King County CSO Locations

Table 1. King County CSO Discharge Locations and Status

DSN No.[a]	Facility	Nearby CSO[b]	Receiving Water	Status
003	Ballard Siphon Regulator		Lake Washington Ship Canal via city Storm Drain	Not controlled
004	11th Avenue NW (also called East Ballard)		Lake Washington Ship Canal	Not controlled
006	Magnolia Overflow	City CSO 064 – 300 feet north	Elliott Bay/Puget Sound	Not controlled[d]
007	Canal Street Overflow	City CSO 174 – 500 feet west County CSO 008 – 500 feet west	Lake Washington Ship Canal	Controlled
008	3rd Ave W and Ewing Street	City CSO 174 – 200 feet north County CSO 007 – 500 feet east	Lake Washington Ship Canal	Not controlled
009	Dexter Avenue Regulator		Lake Union	Not controlled[c]
011	E Pine Street Pump Station Emergency Overflow	City CSO 028 – 350 feet south City CSO 027 – 100 feet west	Lake Washington	Controlled
012	Belvoir Pump Station Emergency Overflow	Shares outfall with County CSO 049 City CSO 018 – 250 feet south	Lake Washington	Controlled
013	Martin Luther King Way Trunkline Overflow	Shares outfall with County CSO 045 City CSO 047 – 125 feet north City CSO 176 – 200 feet south	Lake Washington via storm drain	Controlled
014	Montlake Overflow		Lake Washington Ship Canal	Not controlled
015	University Regulator		Lake Washington Ship Canal	Not controlled
018	Matthews Park Pump Station Emergency Overflows		Lake Washington	Controlled
027b	Elliot West CSO Treatment Facility	County CSO 027a 340 feet inshore	Elliott Bay	Controlled — CSO treatment facility
027a	Denny Way Regulator	County CSO 027b 340 feet offshore	Elliott Bay	Not controlled[c]
028	King Street Regulator		Elliott Bay	Not controlled
029	Kingdome Regulator (replaced Connecticut Street Regulator)		Elliott Bay via the Connecticut storm drain	Not controlled
030	Lander Street Regulator		East Waterway of Duwamish River	Not controlled
031	Hanford #1 Overflow (Bayview N, Bayview S, and Hanford at Rainier)	Shares outfall with county CSO 034 and city CSO 111	Duwamish River via Diagonal storm drain	Not controlled
032	Hanford #2 Regulator		East Waterway of Duwamish River	Not controlled
033	Rainier Avenue Pump Station Emergency Overflow	City CSO 039 – 50 feet NE City CSO 038 – 100 feet SE	Lake Washington	Controlled
034	East Duwamish Pump Station Emergency and Siphon Aftbay Overflows	Shares outfall with county CSO 031 City CSO 111 – 50 feet south	Duwamish River via the Diagonal storm drain	Controlled
035	West Duwamish Siphon Forebay Overflow		Duwamish River	Controlled
036	Chelan Avenue Regulator	City CSO 104 – 300 feet NE	West Waterway of Duwamish River	Not controlled
037	Harbor Avenue Regulator	City CSO 099 – 50 feet north	West Waterway of Duwamish River via a city storm drain	Not controlled[c]
038	Terminal 115 Overflow		Duwamish River via a city storm drain	Not controlled

DSN No.[a]	Facility	Nearby CSO[b]	Receiving Water	Status
039	Michigan Regulator (also called South Michigan Regulator)		Duwamish River	Not controlled
040	8th Avenue S Regulator and West Marginal Way Pump Station Emergency Overflow	Both facilities share the same outfall.	Duwamish River	Controlled
041	Brandon Street Regulator		Duwamish River	Not controlled
042	West Michigan Regulator (SW Michigan Street Regulator)		Duwamish River	Not controlled
043	East Marginal Pump Station		Duwamish River	Controlled
044	Norfolk Outfall and Henderson/MLK CSO Treatment Facility		Duwamish River	Controlled—CSO treatment facility
045	Henderson Pump Station	Shares outfall with county CSO 013 City CSO 047 – 125 feet north City CSO 176 – 200 feet south	Lake Washington via a storm drain	Controlled[c]
046	Carkeek CSO Treatment Facility Outfall		Puget Sound	Controlled—CSO treatment facility
048b	North Beach Pump Station Emergency Overflow (inlet structure)		Puget Sound	Not controlled[d]
048a	North Beach Pump Station Emergency Overflow (wet well)		Puget Sound	Not controlled[d]
049	30th Avenue NE Pump Station	Shares outfall with county CSO 012 City CSO 018 – 250 south	Lake Washington	Controlled
051	Alki CSO Treatment Facility Outfall		Puget Sound	Controlled — CSO treatment facility
052	53rd Avenue SW Pump Station Emergency Overflow		Puget Sound	Controlled
054	63rd Avenue SW Pump Station Emergency Overflow		Puget Sound	Controlled
055	SW Alaska Street Overflow		Puget Sound	Controlled
056	Murray Avenue Pump Station Emergency Overflow	City CSO 090 – 200 feet east	Puget Sound	Not controlled[d]
057	Barton Street Pump Station Emergency Overflow	City CSO 094 – 150 feet east	Puget Sound	Not controlled[d]

[a] DSN = discharge serial number, as set in the NPDES permit.
[b] Distances between outfalls are based on GIS data and may not be exact.
[c] Control project was completed; currently refining system operation and control strategies.
[d] Control project is in design.

2 Existing Data

As part of its CSO Control Program, Metro and then King County have conducted sampling to characterize ambient water quality conditions, untreated CSO quality, treated CSO quality, and sediment quality near CSO discharges. These data are included in Ecology's EIM database.

In the late 1980s, Metro began a sampling program to characterize CSOs to comply with the requirements of Chapter 173-245 WAC and to identify any high priority sites for early control. Overflow quality data were collected for five CSO sites each year, and sediment samples were collected at each site in the West Point service area.[2]

Later, sampling was expanded to assess compliance with state Sediment Management Standards. In parallel to this, the county conducted extensive monitoring and modeling for its 1999 *King County Combined Sewer Overflow Water Quality Assessment for the Duwamish River and Elliott Bay* (King County, 1999).

The following sections describe data from these and other CSO-related monitoring programs.

Findings and recommendations regarding CSO control— 1958–2009 environmental studies

1958 *Metropolitan Seattle Wastewater and Drainage Study* recommended sewer separation and storage, as needed, to control CSOs as part of a larger schedule of projects.

1978 Areawide Section 208 Water Quality Plan recommended sewer separation and storage, as needed, to control overflows.

1979–1984 *Toxicant Pretreatment Planning Study* recommended that CSO control be part of a coordinated Elliott Bay Action Plan and that source control, including enhancement of Metro's pretreatment program, should be a priority.

1983 *Water Quality Assessment of the Duwamish Estuary* identified CSOs as a minor contributor to the larger pollution problem and CSO control as one part of the solution.

1988 *Elliott Bay Action Plan* recommended elimination of direct industrial discharges into the bay and implementation of stormwater source control to improve CSO quality; set Denny Way and Michigan Street as priorities for CSO control.

1988–1996 Metro Receiving Water Monitoring Program affirmed that CSOs were not a major part of larger wet-weather problems and that CSO control would not yield the largest benefit to water quality.

1988–1997 Metro/King County CSO Discharge and Sediment Quality Characterization affirmed the Denny Way CSO as a priority for control based on pollutant concentrations.

1999 *King County Combined Sewer Overflow Water Quality Assessment for the Duwamish River and Elliott Bay* recommended continuation of CSO control to meet state regulations and helped set control priorities.

199*9 Sediment Management Plan* recommended that sediment remediation at CSO sites proceed ahead of CSO control because most contamination was from historical inputs.

2009 *Comprehensive Sediment Quality Summary Report for CSO Discharge Locations.*

2.1 Untreated CSO Quality

Untreated (in-pipe) CSO quality data are usually collected at the regulator or pump station just upstream of the overflow location.

Overflow quality was first characterized in the late 1980s and early 1990s under the CSO sampling plan to meet the requirements of Chapter 173-245 WAC. The data have been supplemented over time through special studies and control project definitions. The untreated CSO quality data were compiled and summarized in the *Comprehensive Sediment Quality Summary Report for CSO Discharge Locations* (King County, 2009a).

These historical untreated CSO sampling data indicate that four chemicals—copper, silver, zinc, and ammonia—could approach or exceed acute marine water quality standards without additional source control or adequate removal in

[2] The service areas for the Carkeek and Alki Treatment Plants were not included in that original sampling plan because they were independent from the West Point system until 1994 (Carkeek) and 1998 (Alki).

treated CSO discharges. Other chemicals for which there are numeric water quality standards were either not detected or detected at sufficiently low concentrations that an exceedance of acute marine water quality standards was not probable.

2.2 Treated CSO Quality

Sampling of treated CSOs is done in accordance with the West Point plant's NDPES permit and includes analysis for priority pollutants (metals and volatile organic, acid extractable, and base neutral compounds). Sampling results are submitted to Ecology with the monthly discharge monitoring reports (DMRs). Ecology maintains a searchable database of these data (Water Quality Permit Life Cycle System, http://www.ecy.wa.gov/programs/wq/permits/wplcs/index.html).

King County's CSO treatment plants provide a hypochlorite-based disinfection followed by dechlorination. Failure of a component of the disinfection system could result in an exceedance of water quality standards for fecal coliform bacteria, total residual chlorine, and/or pH. Limits for these compounds are included in the current NDPES permit (Ecology, 2009).

2.3 Ambient Water Quality

King County conducts ambient water quality monitoring in all water bodies where CSOs discharge. Samples are usually taken monthly and are typically analyzed for parameters such as nutrients, fecal indicator bacteria, dissolved oxygen, temperature, water clarity, turbidity, total suspended solids, pH (fresh water), salinity, and chlorophyll. The monitoring program has produced a comprehensive historical dataset that documents and assess trends in ambient water quality. Information and data can be found at http://green.kingcounty.gov/marine/ and http://www.kingcounty.gov/environment/waterandland/lakes.aspx.

In addition to routine monitoring programs, other monitoring efforts have looked at ambient water quality. In 1996–1997, for the 1999 *King County Combined Sewer Overflow Water Quality Assessment for the Duwamish River and Elliott Bay* (WQA), ambient water quality samples were collected from the Duwamish River and Elliott Bay during periods when CSOs were overflowing for analysis of metals and a number of organic compounds. In 1999–2001, samples were collected from the Central Basin of Puget Sound for analysis for a similar range of parameters, and between 1999 and 2008, quarterly samples were collected from Lake Washington and the Lake Washington Ship Canal. In all studies, metal compounds were detected at concentrations significantly below water quality standards, while most organic compounds were not detected. Organic compounds that were detected also were below water quality standards.

The WQA identified some risks to fish, wildlife, and humans in the estuary, but because CSOs were not found to be a significant source, the WQA predicted limited improvement if CSO discharges were eliminated from the estuary. Risk of infection from direct contact with viruses and *Giardia* in CSO discharges during and soon after CSO events were predicted to be reduced with removal of CSOs throughout the Duwamish River and along the Elliott Bay shoreline. In the immediate vicinity of CSOs, risks to sediment dwelling organisms from organic enrichment, and possibly from 1,4-dichlorobenzene and bis(2-ethylhexyl) phthalate, were predicted to be reduced by removal of CSOs. The WQA concluded that even if CSOs were eliminated from the

Elliott Bay/Duwamish system, minimal to no improvement in water quality would be observed because most pollutants were shown to come from sources other than CSOs.

More information on these studies can be found in the WQA report (King County 1999) and in the *1999/2000 Water Quality Status Report for Marine Waters* (King County, 2001) and *2001 Water Quality Status Report for Marine Waters* (King County, 2002).

In the 2009 West Point NPDES permit renewal specific ambient sampling requirements for areas near West Point and CSO discharges were included. To satisfy these requirements KC will continue to perform existing, longstanding KC ambient monitoring programs described above as well as add 2 new monitoring stations to be more fully representative of CSO discharge areas.

2.4 Sediment Quality

Data on sediment quality around King County's CSO outfalls have been collected for a variety of purposes, including compliance with State Sediment Management Standards (SMS) and as a part of joint efforts such as Superfund projects in the Duwamish Waterway. Sediment quality data are available for most CSOs to help determine whether impacts have occurred and next steps are needed. Data for the other CSOs have not been collected because the sites were in fresh water for which there are no numeric sediment quality standards[3] or because the CSO basin was primarily residential and could be characterized by CSO data for similar residential basins. Existing data are included in the *Comprehensive Sediment Quality Summary Report for CSO Discharge Locations* (King County, 2009a). Table 2 provides a brief summary of the sediment samples that have been collected near CSO discharge locations.

For CSOs discharging into Puget Sound, current sediment quality data show either no exceedances of SQS or a single exceedance of a phthalate compound. For CSOs discharging into Elliott Bay and the Duwamish River, sediment quality data show multiple exceedances of SQS, often including PAHs, total PCBs, phthalate compounds, and some metals. CSOs discharging into Lake Washington and the Ship Canal have multiple exceedances of the freshwater sediment guidelines for metals, total PCBs, PAHs, phthalate compounds, and other organic compounds.

In addition, the county conducts ambient subtidal sediment monitoring in Elliott Bay, the Central Basin of Puget Sound, and three embayments. The latest sampling in 2007 found sediment in these areas to be of good quality with some evidence of minor impacts from human activities in a few locations (King County, 2009b).

King County sediment quality data, along with available QA/QC data, are included in the EIM database.

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[3] The SMS contains a narrative freshwater standard that can be evaluated on a case-by-case basis. There are currently no promulgated numeric standards for freshwater, or for the protection of human health but there are narrative standards.

Table 2. Sediment Samples near CSO Discharge Locations and Status

DSN No.[a]	Facility	Receiving Water	Last date of sediment sample	Number of Stations	SQS Exceedances[b,c] (number)	Status
003	Ballard Siphon Regulator	Lake Washington Ship Canal via city Storm Drain	1989	1	total PCBs, bis(2-ethylhexyl) phthalate	expect area-wide cleanup; characterize following cleanup
004	11th Avenue NW (also called East Ballard)	Lake Washington Ship Canal	1989	1	total PCBs, bis(2-ethylhexyl) phthalate	expect area-wide cleanup; characterize following cleanup
006	Magnolia Overflow	Elliott Bay/Puget Sound	2011 (1996)	6 (6)	pending (previous: none)	Adequately characterized
007	Canal Street Overflow	Lake Washington Ship Canal	--	None		expect area-wide cleanup; characterize following cleanup
008	3rd Ave W and Ewing Street	Lake Washington Ship Canal	2011 (1989)	7 (1)	pending (previous: total PCBs, bis(2-ethylhexyl) phthalate; **total PAHs**)	expect area-wide cleanup; characterize following cleanup
009	Dexter Avenue Regulator	Lake Union	2001	1	DDE, **total PCBs**, bis(2-ethylhexyl) phthalate, **carbazole**, **chromium**, **copper**, **dibenzofuran**, **lead**, **mercury**, nickel, **tributyltin**, **total PAHs**	expect area-wide cleanup; characterize following cleanup
011	E Pine Street Pump Station Emergency Overflow	Lake Washington	2000	2	bis(2-ethylhexyl) phthalate (1), nickel (2)	Inadequate characterization; other contributing sources
012	Belvoir Pump Station Emergency Overflow	Lake Washington	--	None	--	Inadequate Characterization
013	Martin Luther King Way Trunkline Overflow	Lake Washington via storm drain	2000	3	total PCBs (2), bis(2-ethylhexyl) phthalate (3), dibenzofuran(1), dieldrin(1), nickel (2), silver(1), tributyltin(3), **total PAHs** (3), TPH-residual (1)	Inadequate characterization; other contributing sources
014	Montlake Overflow	Lake Washington Ship Canal	2011 (1996)	7 (1)	pending(previous: bis(2-ethylhexyl) phthalate)	Adequately characterized
015	University Regulator	Lake Washington Ship Canal	2011 (1996)	7 (1)	pending (previous: bis(2-ethylhexyl) phthalate)	Adequately characterized
018	Matthews Park Pump Station Emergency Overflows	Lake Washington	--	None	--	Inadequate Characterization
027b	Elliot West CSO Treatment Facility	Elliott Bay	2009	16	total PCBs (7); multiple PAHs (2); benzyl butyl phthalate (3); bis(2-ethylhexyl) phthalate (5); mercury (6)	Adequately characterized

DSN No.[a]	Facility	Receiving Water	Last date of sediment sample	Number of Stations	SQS Exceedances[b,c] (number)	Status
027a	Denny Way Regulator	Elliott Bay	2009	16	see Elliott West (027b)	Adequately characterized
028	King Street Regulator	Elliott Bay	1989	5	multiple PAHs, bis(2-ethylhexyl) phthalate; total PCBs, arsenic, mercury, silver, zinc	remediation planned
029	Kingdome Regulator (replaced Connecticut Street Regulator)	Elliott Bay via the Connecticut storm drain	1996	7	1,4-dichlorobenzene; multiple PAHs; benzyl butyl phthalate, bis(2-ethylhexyl) phthalate; total PCBs; copper	Port of Seattle dredged area in 2005; Inadequate characterization of current condition
030	Lander Street Regulator	East Waterway of Duwamish River				current area-wide cleanup; characterize following cleanup
031	Hanford #1 Overflow (Bayview N, Bayview S, and Hanford at Rainier)	Duwamish River via Diagonal storm drain	2009	23		current area-wide cleanup; early action sediment remediation completed; monitoring ongoing
032	Hanford #2 Regulator	East Waterway of Duwamish River				current area-wide cleanup; characterize following cleanup
033	Rainier Avenue Pump Station Emergency Overflow	Lake Washington	2000	2	total PCBs (1), bis(2-ethylhexyl) phthalate (1), nickel (1), silver (1), tributyltin(2)	Inadequate characterization; other contributing sources
034	East Duwamish Pump Station Emergency and Siphon Aftbay Overflows	Duwamish River				current area-wide cleanup; characterize following cleanup
035	West Duwamish Siphon Forebay Overflow	Duwamish River				current area-wide cleanup; characterize following cleanup
036	Chelan Avenue Regulator	West Waterway of Duwamish River	2011	6	pending	Adequate characterization; No Action Record of Decision
037	Harbor Avenue Regulator	West Waterway of Duwamish River via a city storm drain		None		Inadequate characterization; No Action Record of Decision
038	Terminal 115 Overflow	Duwamish River via a city storm drain		None		current area-wide cleanup; characterize following cleanup
039	Michigan Regulator (also called South Michigan Regulator)	Duwamish River				current area-wide cleanup; characterize following cleanup

DSN No.[a]	Facility	Receiving Water	Last date of sediment sample	Number of Stations	SQS Exceedances[b,c] (number)	Status
040	8th Avenue S Regulator and West Marginal Way Pump Station Emergency Overflow	Duwamish River				current area-wide cleanup; characterize following cleanup
041	Brandon Street Regulator	Duwamish River	2011	6	pending	current area-wide cleanup; characterize following cleanup
042	West Michigan Regulator (SW Michigan Street Regulator)	Duwamish River				current area-wide cleanup; characterize following cleanup
043	East Marginal Pump Station	Duwamish River				current area-wide cleanup; characterize following cleanup
044	Norfolk Outfall and Henderson/MLK CSO Treatment Facility	Duwamish River	2004	4		current area-wide cleanup; early action sediment remediation completed; monitoring completed
045	Henderson Pump Station	Lake Washington via a storm drain	2000	3	total PCBs (2), bis(2-ethylhexyl) phthalate (3), dibenzofuran(1), dieldrin(1), nickel (2), silver(1), tributyltin(3), **total PAHs** (3), TPH-residual (1)	Inadequate characterization; other contributing sources
046	Carkeek CSO Treatment Facility Outfall	Puget Sound	2000	6	None	Adequately characterized
048b	North Beach Pump Station Emergency Overflow (inlet structure)	Puget Sound	2011 (1996)	6 (6)	pending (previous: phenol (1))	Adequately characterized
048a	North Beach Pump Station Emergency Overflow (wet well)	Puget Sound	2011 (1996)	6 (6)	pending (previous: phenol (1))	Adequately characterized
049	30th Avenue NE Pump Station	Lake Washington	--	None	--	Inadequate Characterization
051	Alki CSO Treatment Facility Outfall	Puget Sound	2001	6	none	Adequately characterized
052	53rd Avenue SW Pump Station Emergency Overflow	Puget Sound	2011 (1996)	6 (6)	pending (previous: reference station exceeded Arochlor 1254, benzyl butyl)	Adequately characterized

DSN No.[a]	Facility	Receiving Water	Last date of sediment sample	Number of Stations	SQS Exceedances[b,c] (number)	Status
054	63rd Avenue SW Pump Station Emergency Overflow	Puget Sound	1997	6	None	Adequately characterized
055	SW Alaska Street Overflow	Puget Sound	1997	6	None	Adequately characterized
056	Murray Avenue Pump Station Emergency Overflow	Puget Sound	2011 (1997)	7 (6)	pending (previous: None)	Adequately characterized
057	Barton Street Pump Station Emergency Overflow	Puget Sound	2011 (1997)	6 (6)	pending (previous: benzyl butyl phthalate (2) **dimethyl phthalate** (1)	Adequately characterized

[a] DSN = discharge serial number, as set in the NPDES permit.
[b] Freshwater sediments compared to proposed criteria in November 2011 Draft Revisions Sedment Management Standards
[c] compounds in **bold** exceed Cleanup Screening Levels (CSL)

2.5 Rainfall

King County has a network of 12 rain gauges to measure rainfall across the service area. This network is supplemented by a network of 17 rain gauges operated and maintained by the City of Seattle. Data from the county's network of gauges are archived in the supervisory control and data acquisition (SCADA) system historian and summarized and reported to Ecology as part of the monthly DMRs when a CSO event occurs.

2.6 Discharge Onset, Duration, and Volume

The current program of monitoring CSO onset, volume, and duration has been in effect since the approval of the CSO control plan in 1988. The data are collected from flow meters or water surface gauges upstream of overflow weirs and input to SCADA. They are reported to Ecology as part of the monthly DMRs and are summarized in the annual CSO report. Previous CSO reports can be found at
http://www.kingcounty.gov/environment/wastewater/CSO/Library/AnnualReports.aspx.

3 Post-Construction Monitoring

Post construction monitoring to be conducted at each CSO is summarized in Table 3 and described in the sections that follow.

All CSO locations will be monitored for onset, duration, and volume of the discharge. Discharge locations that provide CSO treatment will also be monitored for influent and effluent quality. Sampling of the wet-weather discharges will be done in coordination with sampling for NPDES permit compliance.

In addition to this monitoring, King County will continue to collect precipitation data at an equivalent level to the existing network of rain gauges and will continue its ongoing ambient monitoring program.

Table 3. Post Construction Compliance Monitoring Plan

Medium	Post Construction Monitoring to be Conducted
CSO discharge	Untreated CSOs controlled to one overflow per year or less: Overflow onset, duration, and volume using SCADA and portable meters Treated CSO discharges: Overflow onset, duration, and volume using SCADA Influent and effluent quality sampling; reasonable potential analysis to assess compliance with water quality standards
Sediment	Sites with no existing SMS exceedances and adequate characterization: No sediment monitoring Sites with existing SMS exceedances or no sediment quality data: Project-specific pre-construction (if needed) and post-construction sediment monitoring used to determine if SMS still exceeded; a site-specific cleanup plan, if needed
Receiving water	Ongoing ambient monitoring programs and sampling specified in the NPDES permit

SCADA = supervisory control and data acquisition system.

Assumptions used to develop the plan are as follows:

- CSOs controlled to no more than one untreated event per year on average will request and be granted the mixing zone exemption described in Section 173-201A-400 WAC and will be deemed to comply with receiving water quality standards. Monitoring for these sites focuses on characterizing the quantity and frequency of discharges.
- The effectiveness of the CSO control at treated CSO sties is to be assessed by monitoring their ability to provide the equivalent of primary treatment— at least 50 percent removal of the total suspended solids annually and discharges less than 0.3 mL/L/hr of settleable solids for each event—and on other NPDES permit limits that apply to the effluent.
- King County will evaluate treated CSO compliance with state water quality standards by conducting a reasonable potential analysis based on the treated effluent quality data and existing ambient quality data.

- Data from previous studies and from ongoing monitoring programs are sufficient to characterize ambient water quality in receiving waters.
- Implementing CSO control measures will not degrade the existing sediment quality. Presumably achieving CSO control will reduce the CSO discharge volume resulting in improved sediment quality.

The post construction monitoring plan is described below in two major subsections that parallel EPA's CSO Post Construction Monitoring Guidance (EPA, 2011) according to the types of monitoring being conducted. Subsection 3.1 discusses monitoring to "verify the effectiveness of CSO controls." Subsection 3.2 discusses effluent and ambient monitoring to gather data to be used in assessing compliance with WQS. Each subsection will focus on the type of monitoring to be done to define what, where, and when monitoring will occur.

3.1 Monitoring to Verify the Effectiveness of CSO Controls

The CSO controls described in the County's CSO Control plan propose to limit untreated CSO discharges to one or fewer events per year on average. Section 3.1.1 describes the flow monitoring the County uses to determine the onset, duration, volume, and frequency of CSO events. Section 3.1.2 describes the effluent monitoring conducted at CSO treatment facilities to evaluate the effectiveness of the CSO treatment and ensure that the discharge is receiving the required level of treatment. Section 3.1.3 describes how post construction monitoring will be implemented for Green Infrastructure projects.

3.1.1 Discharge Frequency

Ecology has directed that the control standard of no more than one untreated event per year be assessed as a 20-year moving average of monitored event data. The standard will be met if there are no more than 20 untreated events in 20 years. Where 20 years of monitored data are not available, such as for a new control facility, the missing years are to be predicted using modeled data.

Metering is proposed at all CSO discharge locations to determine the onset, duration, and volume of each CSO event. Flow metering is implemented with permanent flow meters, portable flow meters, or weirs with level sensors depending upon the CSO. The following sections summarize how flow monitoring is conducted; additional details can be found in the CSO Discharge Flow Measurement Sample and Analysis Plan and Quality Assurance Project Plan included as 0.

3.1.1.1 Methods for Measuring CSO Frequency

Direct monitoring of CSO frequency consists of recording physical data indicating that CSOs have occurred. Meters or sensors that measure CSO discharges as they occur directly monitor overflows at all CSO locations. Depending on the meter type, the data is telemetered directly to the County's SCADA system, telemetered in real time to a centralized data server, or manually downloaded by field personnel and transferred to the data server. Details of the instrumentation can be found in the CSO Discharge Flow Measurement Sample and Analysis Plan and Quality Assurance Project Plan, the most recent plan is attached as 0.

3.1.1.2 Which Outfalls to Monitor

King County currently monitors all of its CSO discharge locations with flow meters to provide estimates of overflow onset, duration, and volume. Real-time depth meters are installed upstream of overflow weirs at 32 CSO overflow points, allowing calculation and documentation of overflow onset, duration, and volume. Two locations are monitored by real-time, permanent flow meters connected to the County's SCADA system. An additional nine locations are monitored via continuously recording flow meters (velocity/depth) that are regularly downloaded. Some discharge points have multiple meters to record all potential overflow pathways.

Under this plan, overflow monitoring will continue at all CSO discharge locations. The locations and/or equipment associated with some monitoring sites may change to accommodate post construction configurations.

3.1.1.3 When and How Often to Monitor

Under this plan, overflow monitoring will be continuous at all CSO discharge locations.

3.1.1.4 Data Collection

At most locations the data will be telemetered and collected and archived as part of King County's control system. When telemetry is not feasible, data will be downloaded on a periodic basis. The data collected will allow an evaluation of whether a CSO has occurred, as well as a determination of the onset, duration, and volume of an overflow. Coincidental precipitation data will also be collected from the County's existing rain gauges (Section 2.5).

3.1.1.5 Data Evaluation

Ecology defines the minimum inter-event period (MIET) as 24 hours. A CSO event is considered to have ended only after at least 24 hours has elapsed since the last measured occurrence of an overflow. This elapsed time will be used in evaluating the overflow data and determining the number, duration, and event volumes of each overflow.

3.1.1.6 Estimating CSO Frequency Using Modeling

King County's fully dynamic, planning-level collection system model will be used for facilities that do not have a 20-year record of CSO overflow events. The model will predict how the new control facility would have performed under the previous 20 years of rainfall conditions. As post construction monitoring data become available, they will replace model results in the rolling 20-year average calculation. King County proposes that a commissioning period be established for each project, after which the monitoring data will be incorporated into the 20-year average. The duration of this commissioning period will be set on a case-by-case basis by Ecology. Allowing for such a period prevents initial startup issues from affecting the analysis of the level of control for the next 20 years.

Details of this collection system model are described in Appendix C of King County's 2008 CSO control plan update (King County, 2008).

3.1.2 Treatment Effectiveness

CSO treatment facilities must achieve a minimum level of treatment to comply with their discharge permit. This section describes the monitoring that will demonstrate if the minimum level of treatment has been achieved. Consistent with EPA's CSO Control Policy and Ecology's regulations for CSO Control Facilities, the CSO Control plan describes the minimum level of treatment as:

- Annual: Primary clarification equivalent to a 50% reduction in TSS and less than 0.3 mL/L/hr settleable solids (Removal of floatables and settleable solids may be achieved by any combination of treatment technologies or methods that are shown to be equivalent to primary clarification);
- Monthly: Settleable solids maximum of 1.9 mL/L/hr.
- Disinfection of effluent, including removal of harmful disinfection chemical residuals, where necessary.

In addition to the prescribed minimum level of treatment, the treated discharge will be required to comply with Washington State water quality standards. Monitoring to verify compliance with water quality standards is described in Section 3.2.

Details of sampling to determine treatment effectiveness can be found in the Treated CSO Sample and Analysis Plan and Quality Assurance Project Plan, the most recent plan is attached as Appendix C.

3.1.2.1 Methods for Determining Treatment Effectiveness

Monitoring of the treated CSO effluent will be done in accordance with the current and future NPDES permits. Current requirements include collection of flow proportional composite samples for both influent and effluent TSS and settleable solids. Total residual chlorine is to be determined from the effluent chlorine analyzer or grab samples, and fecal coliforms is collected by grab samples from the effluent channel after disinfection.

3.1.2.2 Which Outfalls to Monitor

Effluent samples are currently collected at King County's four CSO treatment facilities at Alki, Henderson/MLK, Elliott West, and Carkeek. Additional treatment facilities are proposed in the current control plan for Hanford/Lander, King/Kingdome, Michigan, and Brandon.

3.1.2.3 When and How Often to Monitor

Each CSO event will be monitored, according to the sample collection requirements in the NPDES permit. Flow proportional composites are collected over the entire event duration within the sampling intervals mandated in the permit. Grab samples are also taken at specific time intervals after the discharge begins to the receiving water. These intervals are within the first three hours, within 4-8 hours, within 20-24 hours, and each following 24 hour period.

3.1.2.4 Data Collection

The composite and grab samples will be transported to an accredited laboratory for analysis following the protocols required in the NPDES permit.

3.1.2.5 Data Evaluation

The total removal efficiency for TSS is to be calculated on a mass balance basis as the percent of solids captured at the CSO Treatment Facility and then permanently removed at the West Point Treatment Plant. The reported daily average(s) of TSS% removal efficiency at West Point WWTP, corresponding to the event, are to be used for calculating the total removal efficiency for the CSO Treatment Facility. Compliance with the % TSS removal is based on the yearly average as reported in the annual CSO report, although it is reported on a monthly basis. Likewise, the settleable solids discharge limit of 0.3 mL/L/hr is assessed on the annual average of the per-event flow proportional composite samples.

The disinfection effectiveness is evaluated from the average monthly value for fecal coliform in the effluent, calculated from the geometric mean for the day(s) in which a discharge(s) occurred for Carkeek, Alki, and Henderson/MLK. Non-discharge days are not included in the calculation. At Elliott West, non-discharge days are included at 1.0 CFU/100mL and the average monthly value is calculated from the geometric mean of the entire month. The average monthly value is not to exceed the level prescribed in the NPDES permit, which is either a technology based limit or a water quality based limit, depending on the CSO treatment facility.

Removal of the disinfectant is evaluated from the total residual chlorine concentration in the effluent. The average measurement over a calendar day is not to exceed the limit given for each CSO treatment facility in the NPDES permit. The limit is a water-quality based value calculated by Ecology.

3.1.3 Green Stormwater Infrastructure

Green Stormwater Infrastructure (GSI) improvements that are implemented as part of the CSO Control Plan will include a detailed description of the GSI project as part of the plans and reports submitted to Ecology under the requirements in Chapter 173-245 WAC (see Section 1.2.1). This description will include the performance levels expected to be achieved with the implementation of the GSI project and a description of any post-construction monitoring and modeling to be performed.

GSI projects will have scheduled routine maintenance of the facility. During these maintenance visits, the facility will be inspected for the parameters outlined in the City of Seattle's Green Stormwater Operations and Maintenance Manual (Seattle, 2009). The condition of the vegetation, mulch layer, hardscape and infrastructure components will be monitored through visual inspection and any defects will be corrected. Inspection and maintenance activities will be performed to Service Level A for the first two years of a project, and Service Level B for subsequent years. Projects may include underground infiltration structures, which will have initial and long-term monitoring. This monitoring may depend on the type of structure and location, and will be detailed in the description of the GSI project submitted to Ecology prior to construction.

The CSO Control plan envisions Green Infrastructure will be used as part of a larger CSO control effort. Consequentially, Green Infrastructure will be evaluated in terms of the larger CSO control approach because it is used in conjunction with other control methods. Principally, the net result of the Green Infrastructure projects plus any other CSO control measures will be evaluated on their ability meet the goals of the CSO Control Program (Section 1.4).

3.2 Monitoring to Assess Compliance with Water Quality Standards

As described in EPA's CSO Control Policy, this portion of the post construction water quality monitoring plan is intended to verify compliance with WQS and the protection of designated uses. This section and the relevant appendices detail the monitoring protocols to be followed, including the necessary effluent and ambient monitoring and sediment sampling.

The county will assess compliance with state surface water quality standards by conducting a reasonable potential analysis as described in the permit writer's manual (Ecology, 2010). The analysis will be based on the post construction monitoring of treated effluent quality data and on existing ambient quality data. This analysis is extremely protective of water quality standards. It uses the 95th percent confidence level of the 95th percentile concentration and then combines these concentrations with the 90th percentile concentration of ambient water quality samples and the calculated outfall dilution ratio to estimate a maximum concentration at the point of compliance. The point of compliance is either the discharge point or the boundary of an approved mixing zone. When the maximum reasonable potential concentrations are below state water quality standards, the analysis demonstrates that the treated CSO discharge has met receiving water quality standards. Where a reasonable potential to violate water quality standards at the edge of the mixing zone is predicted, the county will assess whether the maximum measured concentration, which may be less than the reasonable potential concentration, has the potential to violate water quality standards. Where the potential exists to exceed water quality standards, it is assumed that Ecology will set site-specific effluent limits and monitoring requirements to prevent violation.

3.2.1 Effluent Monitoring

Effluent monitoring is intended to characterize the parameters in the treated effluent that will be evaluated in the reasonable potential analysis. As described below and in Appendix C, effluent quality samples are typically collected during one overflow per year as flow proportional composites, or if more appropriate for a parameter, as a grab or continuous measurement. Details of sampling to characterize the treated CSO discharges can be found in the Treated CSO Sample and Analysis Plan and Quality Assurance Project Plan, the most recent plan is attached as Appendix C.

3.2.1.1 What will be Monitored

Monitoring of the treated CSO effluent will be done in accordance with the current and future NPDES permits. Current requirements include measurement of volume, duration, precipitation, BOD_5, TSS, TSS removal, settleable solids, total residual chlorine, fecal coliform, and pH for each discharge event. Measurement of effluent temperature, salinity, alkalinity, oil and grease, hardness, cyanide, total phenols, nutrients, EPA priority pollutants, and some Ecology priority toxic chemicals is required. The current monitoring requirements are detailed in Appendix C, including sampling parameters and methods. Monitoring of the influent to, or the recycle from, the CSO treatment facilities will be conducted to allow estimation of the removal rates of TSS and BOD_5.

King County will continue monitoring the West Point WWTP effluent, including CSO-related bypass durations and volumes and final effluent parameters, as required by current and future NPDES permits. Compliance with secondary permit limits will continue to be reported in monthly DMRs to Ecology.

3.2.1.2 Where Monitoring will be Performed

Samples will be collected from the effluent stream of King County's four CSO treatment facilities at Alki, Henderson/MLK, Elliott West, and Carkeek. Additional treatment facilities are proposed in the current control plan for Hanford/Lander, King/Kingdome, Michigan, and Brandon.

3.2.1.3 When Monitoring will occur

Monitoring will occur for one event per year, or as directed in the NPDES permit.

3.2.1.4 How Monitoring will be conducted

Monitoring of the treated CSO effluent will be done in accordance with the current and future NPDES permits. Current requirements include collection of most parameters in flow proportional composite samples, and grab samples or continuous analyzers for other parameters.

3.2.2 Ambient Water Quality Monitoring

King County conducts extensive monitoring of the ambient water quality in numerous water bodies throughout the County. A subset of this monitoring is relevant to characterizing water quality in locations potentially affected by the combined sewer system.

The County's ongoing ambient monitoring program does not analyze for trace metals or organic compounds, and such analyses are not proposed. King County has analyzed for these constituents multiple times. The most recent sampling occurred to comply with part of the 2009 West Point NDPES permit renewal, in which King County must conduct sampling and submit a receiving water characterization report to Ecology by June 30, 2013, that describes background conditions for use in future reasonable potential calculations. The requirement includes analysis for metals and some organics in the vicinity of each CSO treatment facility. Prior to this, the CSO Water Quality Assessment (King County, 1999) conducted extensive sampling, including wet weather events with CSO discharges. These and previous sampling events show that concentrations of ambient metal and organic compounds are low compared to the acute water quality standards applicable to CSO discharges. With the results of the current analysis, ambient conditions will be well characterized. King County anticipates that sampling for trace metals and organics will be conducted on a periodic basis to verify and document ambient conditions.

The following sections summarize the relevant portion of King County's ongoing ambient monitoring program for post construction monitoring. Additional details can be found in Appendix D, Receiving Water Characterization Study Sampling and Analysis Plan and Quality Assurance Project Plan, Appendix E, Major Lakes Sampling and Analysis Plan, and Appendix F, Freshwater Swimming Beach Monitoring Sampling and Analysis Plan.

3.2.2.1 What will be Monitored

Open water samples will be analyzed for the following parameters:

- Field measurements are taken for dissolved oxygen and temperature
- Fecal Coliforms
- Ammonia-Nitrogen
- Nitrite/Nitrate Nitrogen
- Ortho Phosphorus
- Total Suspended Solids

Marine intertidal (beach) samples will be analyzed for the following parameters:

- Field measurement for temperature
- Fecal Coliforms
- Ammonia-Nitrogen
- Nitrite/Nitrate Nitrogen
- Ortho Phosphorus

Swimming Beach (freshwater) samples will be analyzed for:

- Field measurement for temperature
- Fecal Coliforms

3.2.2.2 Where Ambient Monitoring will be Performed

Ambient monitoring will be conducted at the ambient monitoring stations described below in Table 4.

Table 4. PCMP Ambient Sampling Locations

Description	Locator	East Coordinate	North Coordinate	Type
Point Jefferson	KSBP01	1248062	275439	Open Water (marine)
Dolphin Point	LSNT01	1245197	198653	Open Water (marine)
Elliott Bay	LTED04	1264675	223909	Open Water (marine)
Duwamish River	LTXQ01	1278053	190313	Open Water (marine)
Ship Canal/above Locks	0512	1255339	246408	Open Water (freshwater)
Lake Union/depth profile station, near west shore	A522	1269458	234484	Open Water (freshwater)
Ship Canal / Montlake Bridge	0540	1277624	239584	Open Water (freshwater)

Description	Locator	East Coordinate	North Coordinate	Type
Lake Washington / mid-lake north off Sandpoint	0826	1295117	253655	Open Water (freshwater)
Lake Washington / S of I-90 Bridge	0890	1286489	213199	Open Water (freshwater)
Madrona Park	SD007SB	1282939	225430	Swimming Beach
Mathews Beach Park	0818SB	1285991	257467	Swimming Beach
Alki Beach	LSHV01	1253532	216852	Intertidal (Beach)
Carkeek Park	KSHZ03	1259784	263736	Intertidal (Beach)
Magnolia	KSYV02	1254488	234547	Intertidal (Beach)
Me-Kwa-Mooks Park (Barton CSO)	LSLT02	1251892	209683	Intertidal (Beach)
SAM Sculpture Park Beach (Elliott West)	LTBD27	1264297	228851	Intertidal (Beach)

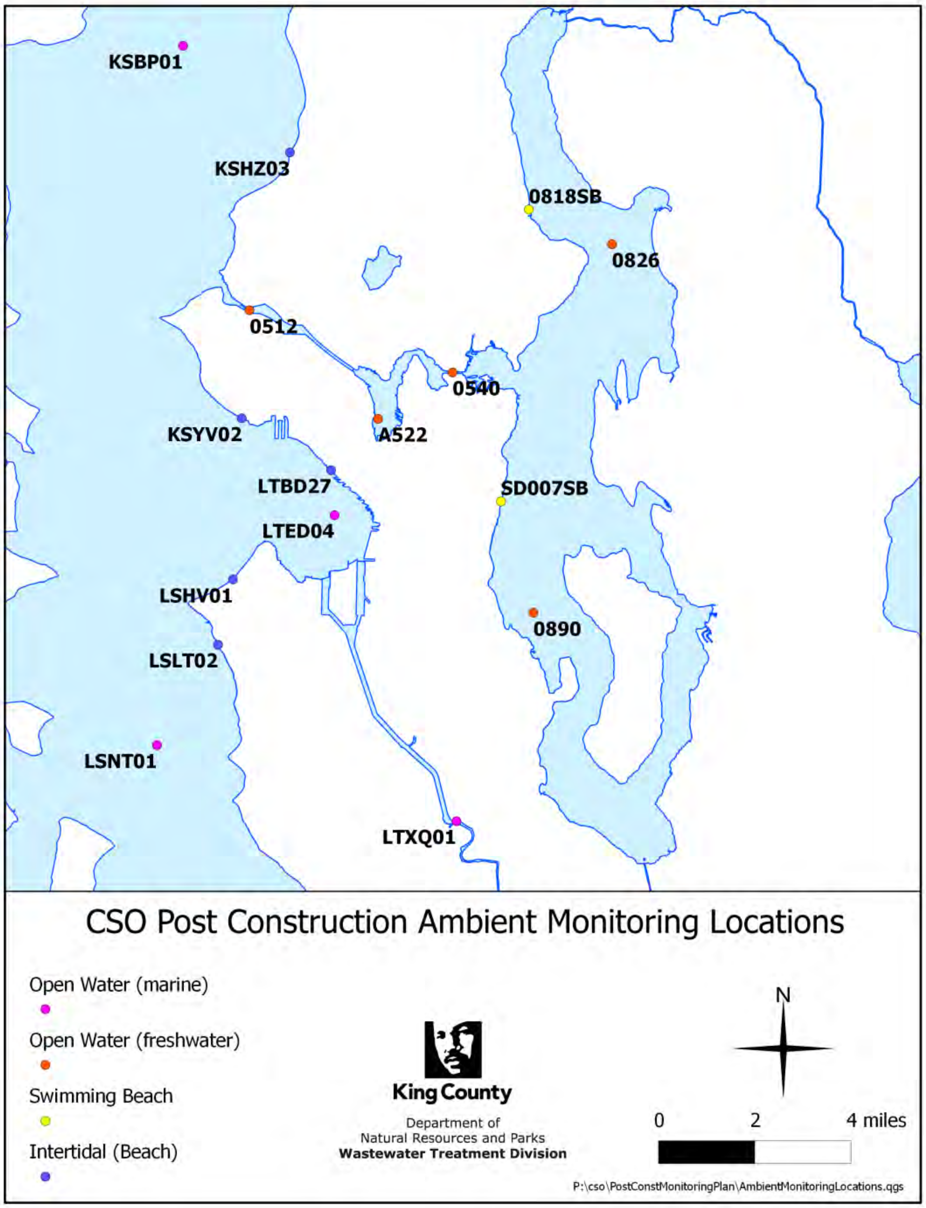

Figure 2. PCMP Ambient Monitoring Locations

3.2.2.3 When Ambient Monitoring will occur

Ambient monitoring at the open water and intertidal stations listed in Table 4 is conducted on a monthly schedule. Sampling may be delayed or cancelled due to weather conditions or equipment problems.

The swimming beach stations in Table 4 (Madrona Park, Mathews Beach Park) are sampled on a weekly basis from mid-May through mid-September by collecting a single grab sample. Time of day of sampling is determined by field and lab requirements. If the bacterial results from the initial sampling at a beach is above the criteria for closing a beach (geometric mean >200 cfu/100ml or single sample >1000 cfu/100ml), an additional sample will be immediately collected from the same location using the same sampling protocols. The rationale for immediate re-sampling is based on lack of statistical sampling power with a single grab and the possibility of collecting a false high count from a small localized source not representative of the overall bacterial water quality or human health concern.

3.2.2.4 How Ambient Monitoring will be conducted

Electronic in situ data are collected at the open water stations using a CTD (conductivity, temperature, depth) sensor array or Hydrolab® instrument deployed from the County's research vessels R/V Liberty or R/V Chinook, with the exception of the Duwamish River station (LTXQ01). Samples from the Duwamish River station are collected using a modified van Dorn-style sampling bottle that is lowered from the bridge mid-channel.

Discrete water samples are collected from between one and seven depths at each offshore station, depending on the total station depth. Laboratory analytes for discrete samples include fecal coliform, suspended solids, and nutrients (ammonia, nitrite/nitrate nitrogen, orthophosphate). Bacteria samples are collected from the surface sampling depth, with the exception of Duwamish River samples. Bacteria samples are collected from two depths at each Duwamish River station. All other laboratory parameters are analyzed on samples collected from every depth.

Intertidal (marine beach) water samples are collected as grab samples by wading into the water to a depth of approximately one meter and collecting a single sample from a depth of approximately one-half meter.

Samples at swimming beach locations are collected as grab samples within one foot of the surface of the water where the swimming area is three to six feet deep. Samples are collected using the dip method.

Additional details are provided in the respective SAP/QAPP attached in the Appendices.

3.2.3 Sediment Monitoring

King County has collected sediment quality data at the majority of its CSO outfall discharge locations, both as part of its NPDES sediment monitoring program and for special environmental studies. Section 2.4 provides a brief overview of the data; results were discussed and provided in King County's comprehensive sediment quality report (King County 2009).

The County's Sediment Management Plan (King County 1999) develops remedial strategies for correcting short- and long-term hazards associated with contaminated sediments near King County CSO sites. Sediment quality data is being collected at 10 CSO discharge locations for the current update to the SMP. This data will be used to calibrate and validate a near-field sediment model developed by the County primarily to evaluate recontamination potential for CSOs, following control and sediment remediation projects. Analysis of the model output will provide one line of evidence to characterize the sediment quality in areas around other County CSOs.

Many of the County's CSOs are situated in areas that will be the subject of an area-wide sediment remediation project. The County expects to participate in these area-wide remediation projects. Following completion of the area-wide remediation, the County will assess if the sediments in the vicinity of its CSO discharges have been adequately characterized, or if additional monitoring or modeling is required.

3.2.3.1 What will be Monitored

Monitoring of sediments near CSO discharges will be done according to the priorities and needs identified by King County's Sediment Management Program. The sediment quality samples at each CSO location will typically involve sampling surficial sediments at three to seven sites (depending on site-specific conditions) for metals and priority pollutants, using methods similar to the Puget Sound protocols. The Sampling and Analysis Plan (SAP) included in Appendix G was developed for sampling sediments around 10 CSO locations for the current SMP update. King County anticipates that the SAPs developed to conduct additional site-assessments around its CSO discharges would be similar to this document in terms of the sampling methodology, analytical parameters and detection limits, data analysis, and QA/QC controls. Individual SAPs will vary by sampling objectives and sample design based on site-specific issues.

3.2.3.2 Where Sediment Monitoring will be Performed

Post Construction sediment monitoring will be conducted at CSO discharge locations that require a site-specific sediment cleanup plan to be developed. Cleanup plans will contain actions required to meet the Sediment Management Standards (SMS) as well as a sampling program to ensure the outcome has been achieved and recontamination is not occurring. No post construction sediment monitoring is proposed at CSO locations that currently meet SMS and are not predicted to have sediment recontamination since the post construction conditions will, by virtue of overflow reduction, be contributing fewer pollutants.

Additional sediment quality sampling is anticipated to characterize specific CSO locations depending upon the CSO control status, existing sediment characterization, and the status of area-wide cleanup projects. The anticipated sampling is discussed below.

No further sediment monitoring is planned at sites that have previously been characterized as not having SMS exceedances and where source conditions have not changed. It is assumed that if there were no exceedances at an uncontrolled CSO, there would be no exceedances after the site is controlled. Thus no additional sediment sampling is proposed at:

- Alki
- Carkeek
- 63rd
- SW Alaska

Additionally, no additional sediment sampling is proposed at the Norfolk Outfall and Henderson/MLK CSO Treatment Facility (one location). Sediment remediation was completed here in 1999, and the post-cleanup sediment monitoring did not indicate sediment recontamination from the CSO discharges. Additional sediment concerns from other contaminant sources at this location will be addressed through the current Lower Duwamish Waterway sediment clean-up.

Sediment sampling being conducted for the current SMP update is expected to provide sufficient data to characterize the following CSO discharge locations:

- Magnolia (DSN 006)

- Montlake (DSN 014)
- University (DSN 015)
- North Beach (DSN 048a, 048b)
- 53rd Ave (DSN 052)
- Murray (DSN 056)
- Barton (DSN 057)

If this data and modeling results do not indicate SMS exceedances, no future sediment monitoring will occur at these sites. If SMS exceedances exist, a site-specific cleanup-plan will be developed.

The SMP update process will use existing samples, near-field modeling, and additional sediment verification samples to evaluate sediment quality at the following controlled CSOs:

- East Pine (DSN 011)
- Belvoir (DSN 012)
- Mathews Park Pump Station Emergency Overflow (DSN 018)
- Rainier Ave Pump Station Emergency Overflow (DSN 033)
- Henderson Pump Station (DSN 045)
- 30th Ave NE Pump Station (DSN 049)

If the data and modeling support an adequate characterization, a site-specific cleanup plan will be developed if SMS exceedances exist. No additional sampling for post construction monitoring will be proposed if the sediments meet SMS standards and there is adequate characterization.

Sediment quality samples will be collected for the remaining locations following completion of the respective CSO control project or of the area-wide cleanup project unless adequate recent data exists.

3.2.3.3 When Sediment Monitoring will occur

When sediment monitoring occurs is described below and summarized in Figure 3. The County expects to participate in area-wide sediment remediation projects that incorporate sediments off CSO discharges. Following completion of the area-wide remediation, the County will assess if the sediments in the vicinity of its CSO discharges have been adequately characterized, or if additional monitoring or modeling is required.

Any in-water work associated with CSO control projects will involve collection of pre-construction and post-construction sediment samples. These samples will serve to document any change in sediment quality from construction activities as well as to characterize the sediment quality.

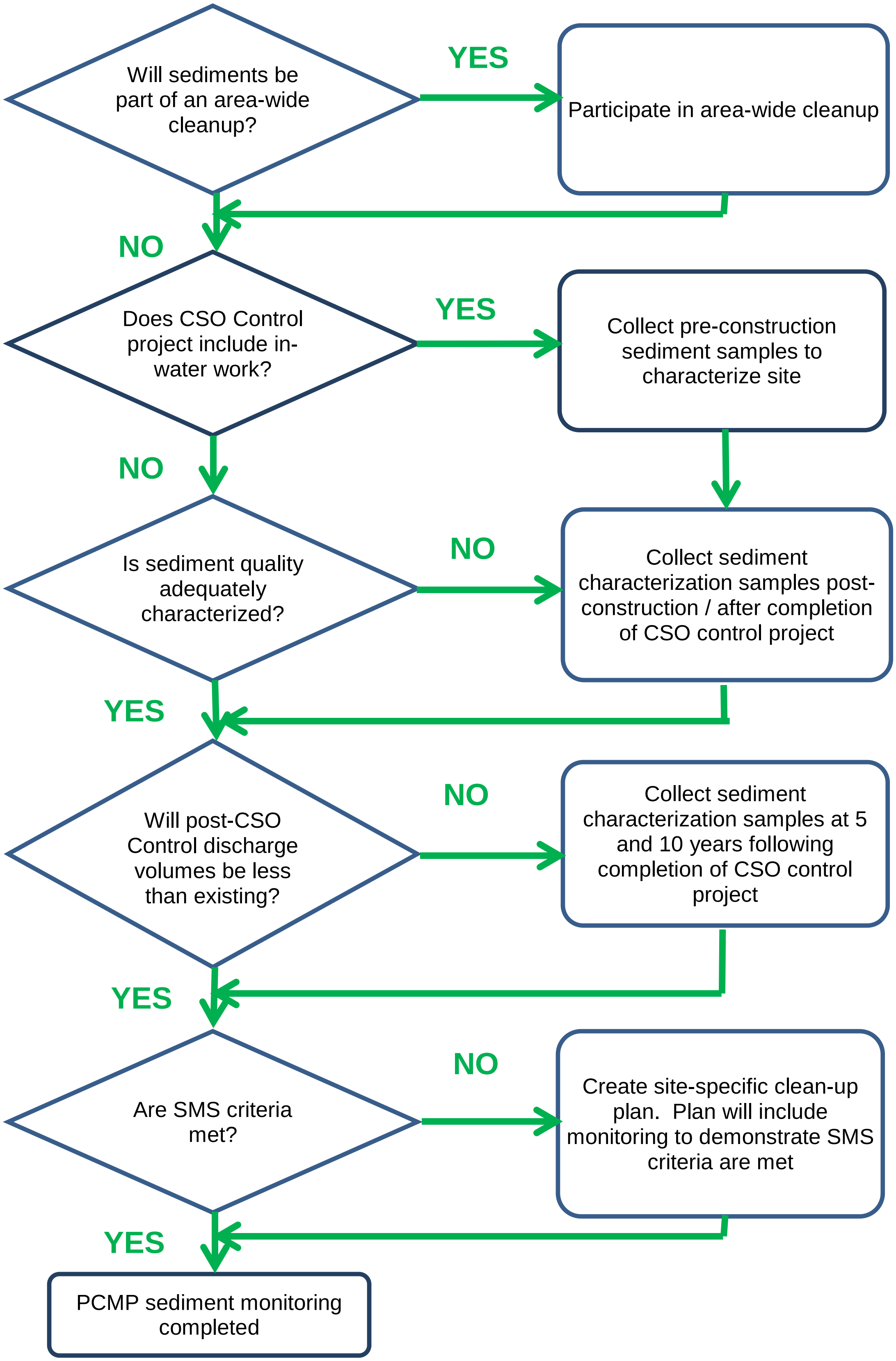

Figure 3. PCMP Sediment monitoring flowchart

For CSO control projects that will reduce the CSO discharge volume, one set of sediment quality samples will be collected to characterize the sediment quality. Sediment quality samples were collected in 2011 for 10 CSO locations (identified in Table 2). If existing samples provide adequate characterization and have no exceedances of SMS standards, no additional samples will be collected. Otherwise, one set of sediment quality samples will be collected following the completion of each CSO control project. If these samples indicate exceedances of SMS standards, a site-specific cleanup plan will be developed. The additional monitoring required as part of the site-specific cleanup plan will be described and documented in that plan. Sediment monitoring associated with any cleanup plan will be designed to demonstrate compliance with SMS.

CSO control projects that create or relocate a discharge location, or increase the volume of CSO discharge (such as combining flows to a CSO treatment facility), sediment quality sampling will happen three times. Initial sampling will occur prior to discharge to provide a pre-discharge characterization of the sediment quality. Sediment monitoring will be repeated at 5 and 10 years after completion of the CSO control project to ensure SMS standards are met. Should SMS standards not be met at the 10 year sampling, a site-specific cleanup plan will be developed.

Sediment remediation and monitoring may be performed prior to the completion of CSO control projects at locations where sediment recontamination modeling indicates that recontamination will not occur under existing conditions. Otherwise, sediment remediation will be performed after the CSO control project is completed.

3.2.3.4 How Sediment Monitoring will be conducted

Prior to sampling at a site, King County will develop a Sampling and Analysis Plan (SAP) for that site. Each SAP will be prepared according to the guidance provided in the Sediment Source Control Standards User Manual, Appendix B: Sediment Sampling and Analysis Plan (Ecology, 2008). The purpose of the plans is to determine whether the sediment at a site exceeds the SMS and, if so, to delineate the exceedances. A SAP from the current CSO sediment sampling is included in Appendix G to illustrate the methods and sampling details typically employed.

3.3 Quality Control and Data Management

Activities under the plan will be implemented with appropriate quality control standards. The county has standard operating procedures (SOPs) in place for CSO outfall flow monitoring and for water and sediment quality sampling. In general, quality control procedures are as follows:

- A dedicated CSO crew manages CSO flow monitoring by following SOPs for maintenance, equipment replacement, data downloads, and associated field activities. A data analyst reviews the flow data for validity and representativeness.
- Trained staff at the county’s certified environmental laboratory performs ambient water and sediment quality sampling. Standard sampling procedures and documentation, including use of chain-of-custody forms and appropriate sample preservation techniques, are a required part of the program.

- Environmental laboratory staff analyze water quality samples, following standard and required methods, protocols, and documentation.
- Rainfall data are recorded and archived by the county's SCADA system. Rain gauge calibration and maintenance are performed every three months, as scheduled and tracked by the county's computerized maintenance management system.

Data on controlled untreated and treated CSO discharges are currently being collected as part of the county's ongoing monitoring program; the post construction monitoring data will be integrated into existing data validation, archival, retrieval, and management tools.

Details on King County's quality control and data management procedures and protocols can be found in the NPDES permit sampling requirements and the sampling and analysis plans included in the Appendices.

4 Data Evaluation and Progress Reporting

King County will evaluate the post construction monitoring data to assess CSO control effectiveness and compliance with water quality standards and will report progress in the annual CSO report. Each CSO control plan update submitted with the West Point NPDES permit renewal application will consolidate the information relevant to each project; document the performance of the fully implemented CSO control measures, both by individual CSOs and systemwide; and provide further assessment of long-term trends.

If a CSO control project has been completed, but has not met performance goals, supplemental compliance plans will be developed as described in 2011 CSO Control Program Review Summary of Technical Memorandum, Section 9.0. On-going monitoring meeting PCMP needs will continue, and any special studies identified to support the review of project effectiveness will be implemented. The schedule for data review, conclusions and reporting will be defined in the supplemental compliance plan.

4.1 Discharge Frequency

Ecology has directed that the control standard of no more than one untreated event per year be assessed as a 20-year moving average of monitored event data. Where 20 years of monitored data are not available, such as for a new control facility, the missing years are to be predicted using modeled data. The model will predict how the new control facility would have performed under the previous 20 years of rainfall conditions. As post construction monitoring data become available, they will replace model results in the rolling 20-year average calculation. King County proposes that a commissioning period be established for each project, after which the monitoring data will be incorporated into the 20-year average. Allowing for such a period would prevent initial startup issues from affecting the analysis of the level of control for the next 20 years.

The modeled data will come from King County's fully dynamic, planning-level collection system model that has been continually refined since its development in the late 1980s. Details of this collection system model are described in Appendix C of King County's 2008 CSO control plan update (King County, 2008). The county will use this model to simulate up to 20 years of overflow events to fill in any missing years of data, using the following steps:

1. Use the model as calibrated and configured during a CSO control project's design phase to run a continuous simulation of CSO discharges for a representative 20-year period.
2. Replace successive years of the model run with monitored post construction CSO discharges, as actual overflow data becomes available.
3. Used this combination of model results and monitored data each year to assess compliance with the control standard.
4. If the modeled average annual overflow frequency is one or less under the mixing zone rules, the CSO will be deemed to be in compliance with Washington State surface water quality standards, Section 173-201A, if an unlimited mixing zone is approved once per year on average.

4.2 Compliance with Surface Water Quality Standards

The county will assess compliance with state surface water quality standards by conducting a reasonable potential analysis as described in the permit writer's manual (Ecology, 2010). The analysis will be based on the post construction monitoring of treated effluent quality data and on existing ambient quality data. This analysis is extremely protective of water quality standards. It uses the 95th percent confidence level of the 95th percentile concentration and then combines these concentrations with the 90th percentile concentration of ambient water quality samples and the calculated outfall dilution ratio to estimate a maximum concentration at the point of compliance. The point of compliance is either the discharge point or the boundary of an approved mixing zone. When the maximum reasonable potential concentrations are below state water quality standards, the analysis demonstrates that the treated CSO discharge has met receiving water quality standards. Where a reasonable potential to violate water quality standards at the edge of the mixing zone is predicted, the county will assess whether the maximum measured concentration, which may be less than the reasonable potential concentration, has the potential to violate water quality standards. Where the potential exists to exceed water quality standards, it is assumed that Ecology will set effluent limits and monitoring requirements to prevent violation.

As part of the 2009 West Point NDPES permit renewal, King County must submit a receiving water characterization report to Ecology by June 30, 2013, that describes background conditions for use in future reasonable potential calculations. The requirement includes analysis for metals and some organics in the vicinity of each CSO treatment facility. With the results of this analysis combined with sampling King County has conducted in marine and fresh waters, ambient conditions will be well characterized and no additional receiving water sampling, other than ongoing ambient monitoring programs, is proposed under this post construction monitoring plan.

In EPA's December 2001 Report to Congress—Implementation and Enforcement of the Combined Sewer Overflow Control Policy, the agency noted :

> In practice, it is often difficult, and in some instances impossible, to link environmental conditions or results to a single source of pollution, such as CSOs. In most instances, water quality is impacted by multiple sources, and trends over time reflect the change in loadings on a watershed scale from a variety of environmental programs.

King County's experience supports this conclusion. Sampling of ambient waters to verify compliance with water quality standards has not proven effective in past monitoring programs. Ambient water conditions at CSO outfalls are dynamically complex, with vertical stratification, wind, and tidal currents that control the location of the discharged effluent plume. Discharge flow rates can vary rapidly, which can affect both effluent dilution and plume location. Concentrations of the parameters of concern also vary significantly over a discharge event. The logistics of boat-based sampling—mobilizing for a limited number of unpredictable events of short duration in poor weather conditions—also works against successful receiving water sampling. Together, these factors create a high likelihood that such sampling would not accurately characterize the discharge's impact on the receiving water.

King County has already documented in the 1999 CSO WQA that the benefits of CSO control in the Duwamish River will be minimal because of the magnitude of pollutant contributions from upstream and other sources (King County, 1999). The WQA found that fecal coliform standards in the Duwamish River and Elliott Bay shoreline were exceeded for nine months or more each year. It was predicted that CSO control would not reduce fecal coliform levels sufficiently to alter the frequency of exceedances, except along the North Elliott Bay shoreline. Thus, post-CSO control receiving water monitoring will not necessarily show that water quality standards have been met. Significant watershed level actions will need to be implemented to achieve that goal.

The WQA found no apparent risk from chemicals to aquatic life in the water column. With the exception of copper, the 90th percentile of ambient concentrations is typically less than 5 percent of the corresponding acute water quality standard. For copper, a 90th percentile concentration is approximately 25 percent of the acute water quality standard. Thus, the reasonable potential calculation is relatively insensitive to the ambient concentrations and additional ambient data collection is unlikely to alter conclusions regarding the ability of treated CSO effluent to meet water quality standards at the edge of mixing zone boundaries.

4.3 Compliance with Sediment Management Standards

Sediment chemistry data will be evaluated by comparison with SMS sediment chemical criteria from Tables I and III of Chapter 173-204 WAC. Sediment data for some organic compounds are generally normalized to organic carbon content for comparison to SMS criteria. Normalization to organic carbon can produce biased results, however, when the organic carbon content of the sample is very low (Ecology, 1992). When the organic carbon content of a sample is near 0.1 or 0.2 percent (1,000 to 2,000 mg/kg dry weight), even background concentrations of certain organic compounds can exceed sediment quality criteria.

If the organic carbon content at any particular station is below 0.5 percent dry weight, then dry weight-normalized results for non-ionizable organic compounds will be compared to Lowest Apparent Effects Threshold (LAET) or Second Lowest Apparent Effects Threshold (2LAET) criteria (EPA, 1988), rather than SMS criteria. The LAET and 2LAET are considered equivalent to the SQS and CSL, respectively.

The chemistry data will be submitted to Ecology in EIM format (latest version), and exceedances of SMS will be summarized in the annual CSO report.

If the sediment sampling confirms exceedances of the SMS, a project-specific sediment cleanup plan will be developed for approval by Ecology. The plan will identify remediation measures and the subsequent sediment monitoring program. It may also include sediment recontamination modeling to assess the potential for recovery or recontamination. The extent and frequency of the subsequent sediment monitoring will depend on the type and extent of existing contamination and the expected recovery or recontamination rate. Sediment monitoring associated with any cleanup plan will be designed to demonstrate compliance with SMS.

4.4 Influence of Other CSOs

In S.18.K.3 of the West Point NDPES permit, Ecology requested that the post construction monitoring plan address the following:

> …a discussion of controlled outfalls that may be influenced by other County or City of Seattle uncontrolled outfalls that may adversely influence or interfere with the water quality assessment of controlled outfalls. The Permittee must provide adequate justification for not

performing post construction monitoring for controlled CSO outfalls where water quality may be impacted by nearby outfalls.

For untreated CSOs controlled to an average of one or fewer events per year, it is assumed that surface water quality standards will have been met by requesting and being granted the once per year unlimited mixing zone. The presence of nearby uncontrolled CSOs will not influence the ability to achieve water quality standards under this scenario. As a result, no additional monitoring other than the post construction monitoring described previously, is proposed to evaluate the influence of nearby CSOs on the control status of King County CSOs.

CSOs that treat and discharge could be impacted by nearby uncontrolled CSOs affecting the ambient water quality conditions. The Elliott West discharge (DSN 027b) is located 340 feet offshore of the Denny CSO (DSN 027a), which is not fully controlled (see Table 1). However, the Elliott West discharge terminates at a depth of 60 feet and primarily mixes with ambient water at depth as it rises to the surface. The Denny CSO discharges at a depth of 20 feet and will reach the surface before it could reach the mixing zone for the Elliott West discharge. As a result, it is unlikely that the Denny CSO would affect compliance with water quality standards at Elliott West. No other treated CSO discharges have a nearby CSO discharge. King County believes that the ambient water quality sampling conducted during its ongoing program and the wet-weather sampling that occurred during the 1999 Duwamish/Elliott Bay WQA are sufficiently comprehensive to include the effects of other discharges, particularly since the reasonable potential analysis uses the 90th percentile ambient concentration (King County, 1999). The WQA includes samples taken during periods of CSO overflow events.

Sediment quality near CSOs can be affected by sediment deposition from historical activities and other sources. Cleanup plans developed to address area-wide sediment quality exceedances will address sediment deposition from all nearby outfalls. In many cases, there is wide spread sediment contamination and cleanup activities are expected to be integrated with an area-wide cleanup.

5 References

Ecology. 1988. *Sediment Quality Values. Refinement: 1988 Update and Evaluation of Puget Sound AET*. Prepared for the U.S. Environmental Protection Agency, Region 10, by PTI Environmental Services. Seattle, WA.

Ecology. 1992. Technical Information Memorandum, Organic Carbon Normalization of Sediment Data. Prepared by Teresa Michelsen for the Washington State Department of Ecology, Sediment Management Unit. Olympia, WA.

Ecology. 2002. *Water Cleanup Plans – Total Daily Maximum Loads.* Publication Number 02-10-038. http://www.ecy.wa.gov/pubs/0210038.pdf.

Ecology. 2003. *Development of Freshwater Sediment Quality Values for Use in Washington State, Phase II Report: Development and Recommendation of SQVs for Freshwater Sediments in Washington State.* Publication Number 03-09-088. Prepared by Avocet Consulting.

Ecology. 2007. *Agreed Order DE 5068, Exhibit D: Sediment Management Standards Interim Action Work Plan: Denny Way Combined Sewer Overflow Site Seattle, Washington.* http://www.ecy.wa.gov/programs/tcp/sites/denny_way/dw_hp.htm.

Ecology. 2008. *Criteria for Sewage Works Design* (Orange Book). Publication Number 98-37. http://www.ecy.wa.gov/biblio/9837.html.

EPA. 2011. *CSO Post Construction Compliance Monitoring Guidance*. Publication Number EPA-833-K-11-001, April 2011.

Ecology. 2009. *National Pollutant Discharge Elimination System Waste Discharge Permit No. WA-002918-1* (West Point Wastewater Treatment Plant), http://www.ecy.wa.gov/programs/wq/permits/permit_pdfs/west_point/2009/WestPointWWTP_Permit.pdf.

Ecology. 2010. *Water Quality Program Permit Writer's Manual.* Publication Number 92-109. originally issued June 1989, revised November 2010. http://www.ecy.wa.gov/biblio/92109.html.

Ecology, 2011. *Draft Revisions Sediment Management Standards (SMS) (Part V and Definitions).* Discussion Materials Prepared for the Sediment Cleanup Advisory Committee. November 2011. http://www.ecy.wa.gov/programs/tcp/regs/2011-SMS/adv-comm/mtg-111209/SMS_Revisions_Advisory_Group_Preliminary%20Draft_Nov_2011.pdf

King County. 1999. *King County Combined Sewer Overflow Water Quality Assessment for the Duwamish River and Elliott Bay*. King County Department of Natural Resources and Parks, Wastewater Treatment Division. Seattle, WA. http://www.kingcounty.gov/environment/wastewater/CSO/Library/WaterQuality.aspx.

King County, 2001. *1999/2000 Water Quality Status Report for Marine Waters*. King County Department of Natural Resources and Parks, Water and Land Division. Seattle, WA. http://green.kingcounty.gov/marine/Reports.aspx.

King County. 2002. *2001 Water Quality Status Report for Marine Waters.* King County Department of Natural Resources and Parks, Water and Land Division. Seattle, WA. http://green.kingcounty.gov/marine/Reports.aspx.

King County. 2008. *Combined Sewer Overflow Program, 2008 CSO Control Plan Update.* King County Department of Natural Resources and Parks, Wastewater Treatment Division. Seattle, WA. http://www.kingcounty.gov/environment/wastewater/CSO/Library.aspx.

King County. 2009a. *Comprehensive Sediment Quality Summary Report for CSO Discharge Locations*. King County Department of Natural Resources and Parks, Wastewater Treatment Division. Seattle, WA. http://www.kingcounty.gov/environment/wastewater/CSO/Library/PlanUpdates.aspx.

King County. 2009b. *Regional Wastewater Services Plan, 2008 Annual Report.* King County Department of Natural Resources and Parks, Wastewater Treatment Division. Seattle, WA. http://www.kingcounty.gov/environment/wtd/Construction/planning/rwsp/Library/AnnualReport.aspx.

King County, 2009c. *King County Surface Water Design Manual.* King County Department of Natural Resources and Parks. Seattle, WA. http://www.kingcounty.gov/environment/waterandland/stormwater/documents/surface-water-design-manual.aspx

Seattle Public Utilities, 2009. *Green Stormwater Operations and Maintenance Manual*, Seattle, WA.

Post Construction Monitoring Plan for King County CSO Controls

March 2012

Appendices

Appendix A. Water Quality Standards

Appendix B. Flow Measurement Sampling and Analysis Plan and Quality Assurance Project Plan

Appendix C. Treated CSO Sampling and Analysis Plan and Quality Assurance Project Plan

Appendix D. Receiving Water Characterization Study Sampling and Analysis Plan and Quality Assurance Project Plan

Appendix E. Freshwater Lakes Sampling and Analysis Plan and Quality Assurance Project Plan

Appendix F. Beaches Sampling and Analysis Plan and Quality Assurance Project Plan

Appendix G. Marine Water Column and Nearshore Sampling and Analysis Plan and Quality Assurance Project Plan

Appendix H. Sediment Sampling and Analysis Plan and Quality Assurance Project Plan

Appendix A. Water Quality Standards

Numeric Standards

Table 240(3). Toxics Substances Criteria

	Freshwater		Marine Water	
Substance	Acute	Chronic	Acute	Chronic
Aldrin/Dieldrin e	2.5a	0.0019b	0.71a	0.0019b
Ammonia	f,c	g,d	0.233h,c	0.035h,d
(un-ionized NH3) hh				
Arsenic dd	360.0c	190.0d	69.0c,ll	36.0d,cc,ll
Cadmium dd	i,c	j,d	42.0c	9.3d
Chlordane	2.4a	0.0043b	0.09a	0.004b
Chloride (Dissolved) k	860.0h,c	230.0h,d	-	-
Chlorine (Total Residual)	19.0c	11.0d	13.0c	7.5d
Chlorpyrifos	0.083c	0.041d	0.011c	0.0056d
Chromium (Hex) dd	15.0c,l,ii	10.0d,jj	1,100.0c,l,ll	50.0d,ll
Chromium (Tri) gg	m,c	n,d	-	-
Copper dd	o,c	p,d	4.8c,ll	3.1d,ll
Cyanide ee	22.0c	5.2d	1.0c,mm	d,mm
DDT (and metabolites)	1.1a	0.001b	0.13a	0.001b
Dieldrin/Aldrin e	2.5a	0.0019b	0.71a	0.0019b
Endosulfan	0.22a	0.056b	0.034a	0.0087b
Endrin	0.18a	0.0023b	0.037a	0.0023b
Heptachlor	0.52a	0.0038b	0.053a	0.0036b
Hexachlorocyclohexane (Lindane)	2.0a	0.08b	0.16a	-
Lead dd	q,c	r,d	210.0c,ll	8.1d,ll
Mercury s	2.1c,kk,dd	0.012d,ff	1.8c,ll,dd	0.025d,ff
Nickel dd	t,c	u,d	74.0c,ll	8.2d,ll
Parathion	0.065c	0.013d	-	-
Pentachlorophenol (PCP)	w,c	v,d	13.0c	7.9d
Polychlorinated				

Biphenyls (PCBs)	2.0b	0.014b	10.0b	0.030b
Selenium	20.0c,ff	5.0d,ff	290c,ll,dd	71.0d, x,ll,dd
Silver dd	y,a	-	1.9a,ll	-
Toxaphene	0.73c,z	0.0002d	0.21c,z	0.0002d
Zinc dd	aa,c	bb,d	90.0c,ll	81.0d,ll

Notes to Table 240(3):

a. An instantaneous concentration not to be exceeded at any time.
b. A 24-hour average not to be exceeded.
c. A 1-hour average concentration not to be exceeded more than once every three years on the average.
d. A 4-day average concentration not to be exceeded more than once every three years on the average.
e. Aldrin is metabolically converted to Dieldrin. Therefore, the sum of the Aldrin and Dieldrin concentrations are compared with the Dieldrin criteria.
f. Shall not exceed the numerical value in total ammonia nitrogen (mg N/L) given by:

For salmonids present:	0.275	+	39.0
	$1 + 10^{7.204-pH}$		$1 + 10^{pH-7.204}$
For salmonids absent:	0.411	+	58.4
	$1 + 10^{7.204-pH}$		$1 + 10^{pH-7.204}$

g. Shall not exceed the numerical concentration calculated as follows:

Unionized ammonia concentration for waters where salmonid habitat is an existing or designated use:

$$0.80 \div (FT)(FPH)(RATIO)$$

where:

RATIO = $13.5;\ 7.7 \le pH \le 9$

RATIO =

$(20.25 \times 10^{(7.7-pH)}) \div (1 + 10^{(7.4-pH)});\ 6.5 \le pH \le 7.7$

FT = $1.4;\ 15 \le T \le 30$

FT = $10^{[0.03(20-T)]};\ 0 \le T \le 15$

FPH = $1;\ 8 \le pH \le 9$

FPH = $(1 + 10^{(7.4-pH)}) \div 1.25;\ 6.5 \le pH \le 8.0$

Total ammonia concentrations for waters where salmonid habitat is not an existing or designated use and other fish early life stages are absent:

$$\text{Chronic Criterion} = \left(\frac{0.0577}{1+10^{7.688-pH}} + \frac{2.487}{1+10^{pH-7.688}} \right) \times (1.45 \times 10^{0.028(25-A)})$$

where: A = the greater of either T (temperature in degrees Celsius) or 7.

Applied as a thirty-day average concentration of total ammonia nitrogen (in mg N/L) not to be exceeded more than once every three years on average. The highest four-day average within the thirty-day period should not exceed 2.5 times the chronic criterion.

Total ammonia concentration for waters where salmonid habitat is not an existing or designated use and other fish early life stages are present:

$$\text{Chronic Criterion} = \left(\frac{0.0577}{1+10^{7.688-pH}} + \frac{2.487}{1+10^{pH-7.688}} \right) \times B$$

where: B = the lower of either 2.85, or 1.45 x $10^{0.028 \times (25-T)}$. T = temperature in degrees Celsius.

Applied as a thirty-day average concentration of total ammonia nitrogen (in mg N/L) not to be exceeded more than once every three years on the average. The highest four-day average within the thirty-day period should not exceed 2.5 times the chronic criterion.

h. Measured in milligrams per liter rather than micrograms per liter.

i. ≤ (0.944)(e(1.128[ln(hardness)]-3.828)) at hardness = 100. Conversion factor (CF) of 0.944 is hardness dependent. CF is calculated for other hardnesses as follows: CF = 1.136672 - [(ln hardness)(0.041838)].

j. ≤ (0.909)(e(0.7852[ln(hardness)]-3.490)) at hardness = 100. Conversions factor (CF) of 0.909 is hardness dependent. CF is calculated for other hardnesses as follows: CF = 1.101672 - [(ln hardness)(0.041838)].

k. Criterion based on dissolved chloride in association with sodium. This criterion probably will not be adequately protective when the chloride is associated with potassium, calcium, or magnesium, rather than sodium.

l. Salinity dependent effects. At low salinity the 1-hour average may not be sufficiently protective.

m. $\leq (0.316)e^{(0.8190[\ln(\text{hardness})] + 3.688)}$

n. $\leq (0.860)e^{(0.8190[\ln(\text{hardness})] + 1.561)}$

o. $\leq (0.960)(e^{(0.9422[\ln(\text{hardness})] - 1.464)})$

p. $\leq (0.960)(e^{(0.8545[\ln(\text{hardness})] - 1.465)})$

q. $\leq (0.791)(e^{(1.273[\ln(\text{hardness})] - 1.460)})$ at hardness = 100. Conversion factor (CF) of 0.791 is hardness dependent. CF is calculated for other hardnesses as follows: CF = 1.46203 - [(ln hardness)(0.145712)].

r. $\leq (0.791)(e^{(1.273[\ln(\text{hardness})] - 4.705)})$ at hardness = 100. Conversion factor (CF) of 0.791 is hardness dependent. CF is calculated for other hardnesses as follows: CF = 1.46203 - [(ln hardness)(0.145712)].

s. If the four-day average chronic concentration is exceeded more than once in a three-year period, the edible portion of the consumed species should be analyzed. Said edible tissue concentrations shall not be allowed to exceed 1.0 mg/kg of methylmercury.

t. $\leq (0.998)(e^{(0.8460[\ln(\text{hardness})] + 3.3612)})$

u. $\leq (0.997)(e^{(0.8460[\ln(\text{hardness})] + 1.1645)})$

v. $\leq e^{[1.005(pH) - 5.290]}$

w. $\leq e^{[1.005(pH) - 4.830]}$

x. The status of the fish community should be monitored whenever the concentration of selenium exceeds 5.0 ug/ l in salt water.

y. ≤ $(0.85)(e^{(1.72[\ln(\text{hardness})] - 6.52)})$

z. Channel Catfish may be more acutely sensitive.

aa. ≤ $(0.978)(e^{(0.8473[\ln(\text{hardness})] + 0.8604)})$

bb. ≤ $(0.986)(e^{(0.8473[\ln(\text{hardness})] + 0.7614)})$

cc. Nonlethal effects (growth, C-14 uptake, and chlorophyll production) to diatoms (*Thalassiosira aestivalis* and *Skeletonema costatum*) which are common to Washington's waters have been noted at levels below the established criteria. The importance of these effects to the diatom populations and the aquatic system is sufficiently in question to persuade the state to adopt the USEPA National Criteria value (36 µg/L) as the state threshold criteria, however, wherever practical the ambient concentrations should not be allowed to exceed a chronic marine concentration of 21 µg/L.

dd. These ambient criteria in the table are for the dissolved fraction. The cyanide criteria are based on the weak acid dissociable method. The metals criteria may not be used to calculate total recoverable effluent limits unless the seasonal partitioning of the dissolved to total metals in the ambient water are known. When this information is absent, these metals criteria shall be applied as total recoverable values, determined by back-calculation, using the conversion factors incorporated in the criterion equations. Metals criteria may be adjusted on a site-specific basis when data are made available to the department clearly demonstrating the effective use of the water effects ratio approach established by USEPA, as generally guided by the procedures in USEPA Water Quality Standards Handbook, December 1983, as supplemented or replaced by USEPA or ecology. Information which is used to develop effluent limits based on applying metals partitioning studies or the water effects ratio approach shall be identified in the permit fact sheet developed pursuant to WAC 173-220-060 or 173-226-110, as appropriate, and shall be made available for the public comment period required pursuant to WAC 173-220-050 or 173-226-130(3), as appropriate. Ecology has developed supplemental guidance for conducting water effect ratio studies.

ee. The criteria for cyanide is based on the weak acid dissociable method in the 17th Ed. Standard Methods for the Examination of Water and Wastewater, 4500-CN I, and as revised (see footnote dd, above).

ff. These criteria are based on the total-recoverable fraction of the metal.

gg. Where methods to measure trivalent chromium are unavailable, these criteria are to be represented by total-recoverable chromium.

hh. The listed fresh water criteria are based on unionized or total ammonia concentrations, while those for marine water are based on total ammonia concentrations. Tables for the conversion of total ammonia to un-ionized ammonia for freshwater can be found in the USEPA's Quality Criteria for Water, 1986. Criteria concentrations based on total ammonia for marine water can be found in USEPA Ambient Water Quality Criteria for Ammonia (Saltwater)-1989, EPA440/5-88-004, April 1989.

ii. The conversion factor used to calculate the dissolved metal concentration was 0.982.

jj. The conversion factor used to calculate the dissolved metal concentration was 0.962.

kk. The conversion factor used to calculate the dissolved metal concentration was 0.85.

ll. Marine conversion factors (CF) which were used for calculating dissolved metals concentrations are given below. Conversion factors are applicable to both acute and chronic criteria for all metals except mercury. The CF for mercury was applied to the acute criterion only and is not applicable to the chronic criterion. Conversion factors are already incorporated into the criteria in the table. Dissolved criterion = criterion x CF

	Metal	CF	
	Arsenic	1.000	
	Cadmium	0.994	

	Chromium (VI)	0.993	
	Copper	0.83	
	Lead	0.951	
	Mercury	0.85	
	Nickel	0.990	
	Selenium	0.998	
	Silver	0.85	
	Zinc	0.946	

mm. The cyanide criteria are: 2.8µg/l chronic and 9.1µg/l acute and are applicable only to waters which are east of a line from Point Roberts to Lawrence Point, to Green Point to Deception Pass; and south from Deception Pass and of a line from Partridge Point to Point Wilson. The chronic criterion applicable to the remainder of the marine waters is l µg/L.

(4) USEPA Quality Criteria for Water, 1986, as revised, shall be used in the use and interpretation of the values listed in subsection (3) of this section.

(5) Concentrations of toxic, and other substances with toxic propensities not listed in subsection (3) of this section shall be determined in consideration of USEPA Quality Criteria for Water, 1986, and as revised, and other relevant information as appropriate. Human health-based water quality criteria used by the state are contained in 40 CFR 131.36 (known as the National Toxics Rule).

(6) Risk-based criteria for carcinogenic substances shall be selected such that the upper-bound excess cancer risk is less than or equal to one in one million.

Narrative Standards

The designated uses of water bodies that King County CSOs discharge into are given in the following two tables. Note that the Duwamish River is listed as freshwater for designating beneficial uses but the marine numeric criteria apply from the mouth to at least river mile 5 due to the presence of saline water.

Designated Uses for the Freshwater Bodies Where King County CSOs Discharge

Water body	Aquatic Life Uses						Recreation Uses			Water Supply Uses				Misc. Uses				
	Char Spawning/Rearing	Core Summer Habitat	Spawning/Rearing	Rearing/Migration Only	Redband Trout	Warm Water Species	Ex Primary Contact	Primary Contact	Secondary Contact	Domestic Water	Industrial Water	Agricultural Water	Stock Water	Wildlife Habitat	Harvesting	Commerce/Navigation	Boating	Aesthetics
Duwamish River from mouth south of a line bearing 254° true from the NW corner of berth 3, terminal No. 37 to the Black River (river mile 11.0)				x					x		x	x	x	x	x	x	x	x
Lake Washington Ship Canal from Government Locks (river mile 1.0) to Lake Washington (river mile 8.6)	x						x			x	x	x	x	x	x	x	x	x
Lake Washington		x	x				x			x	x	x	x	x	x	x	x	x

Designated Uses for the Marine Water Bodies Where King County CSOs Discharge

Water Body	Aquatic Life Uses					Recreation Uses		Misc. Uses				
	Extraordinary	Excellent	Good	Fair	Shellfish Harvest	Primary Contact	Secondary Contact	Wildlife Habitat	Harvesting	Commerce/Navigation	Boating	Aesthetics
Elliott Bay east of a line between Pier 91 and Duwamish Head		x			x	x		x	x	x	x	x
Puget Sound through Admiralty Inlet and South Puget Sound, south and west to longitude 122°52'30"W (Brisco Point) and longitude 122°51'W (northern tip of Hartstene Island).	x				x	x		x	x	x	x	x

Appendix B. Flow Measurement Sampling and Analysis Plan and Quality Assurance Project Plan

The current version of the CSO Flow Monitoring Sampling and Analysis Plan and Quality Assurance Project Plan (SAP/QAPP) is available on-line at: http://www.kingcounty.gov/environment/wastewater/CSO/ProgramReview/Plan.aspx#techmemos.

Appendix C. Treated CSO Sampling and Analysis Plan and Quality Assurance Project Plan

The current version of the Treated CSO Sampling and Analysis Plan and Quality Assurance Project Plan (SAP/QAPP) is available on-line at: http://www.kingcounty.gov/environment/wastewater/CSO/ProgramReview/Plan.aspx#techmemos.

Appendix D. Receiving Water Characterization Study Sampling and Analysis Plan and Quality Assurance Project Plan

The current version of the Receiving Water Characterization Study Sampling and Analysis Plan and Quality Assurance Project Plan (SAP/QAPP) is available on-line at: http://www.kingcounty.gov/environment/wastewater/CSO/ProgramReview/Plan.aspx#techmemos. This SAP/QAPP reflects the protocols and methods used in King County's ambient monitoring program for marine waters, and would apply to the Open Water (marine) stations listed in Table 4 (KSBP01, LSNT01, LTED04, LTXQ01).

Appendix E. Freshwater Lakes Sampling and Analysis Plan and Quality Assurance Project Plan

The current version of the Major Lakes Sampling and Analysis Plan is available on-line at: http://www.kingcounty.gov/environment/wastewater/CSO/ProgramReview/Plan.aspx#techmemos. This SAP includes the quality assurance information for this program and reflects the protocols and methods used in King County's ambient monitoring program for freshwaters and would apply to the Open Water (freshwater) stations listed in Table 4 (0512, A522, 0540, 0826, 0890).

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Appendix F. Beaches Sampling and Analysis Plan and Quality Assurance Project Plan

The current version of the Swimming Beaches Sampling and Analysis Plan is available on-line at: http://www.kingcounty.gov/environment/wastewater/CSO/ProgramReview/Plan.aspx#techmemos. This SAP includes the quality assurance information for this program and reflects the protocols and methods used in King County's ambient monitoring program for freshwater swimming beaches and would apply to the Swimming Beach stations listed in Table 4 (SD007SB, 0818SB).

Appendix G. Marine Water Column and Nearshore Sampling and Analysis Plan and Quality Assurance Project Plan

The current version of the Existing Water Quality Conditions Study Sampling and Analysis Plan is available on-line at: http://www.kingcounty.gov/environment/wastewater/CSO/ProgramReview/Plan.aspx#techmemos. This SAP includes the quality assurance information for this program and reflects the protocols and methods used in King County's ambient monitoring program for marine intertidal beaches and would apply to the Intertidal (Beach) stations listed in Table 4 (LSHV01, KSHZ03, KSYV02).

Appendix H. Sediment Sampling and Analysis Plan and Quality Assurance Project Plan

The current version of the CSO Sediment Quality Characterization Sampling and Analysis Plan is available on-line at: http://www.kingcounty.gov/environment/wastewater/CSO/ProgramReview/Plan.aspx#techmemos. This SAP includes the quality assurance information for this program and reflects the protocols and methods used by King County for sediment characterization.