State of Oregon

# Department of Environmental Quality — Memorandum

**Date:** Jan. 28, 2011

**To:** Environmental Quality Commission

**From:** Dick Pedersen, Director

**Subject:** Agenda item C, Action item: City of Portland Post-2011 Combined Sewer Overflow Facilities Plan
February 16-18, 2011, EQC meeting

**Purpose of item**

This item will recommend the approval of the post-2011 CSO Facilities Plan. The plan identifies methods for achieving further reductions in overflow frequency and volume after the expiration of the amended stipulation and final order. The plan is subject to EQC approval under the order.

**DEQ recommendation and commission motion**

DEQ recommends that the commission approve Portland's post-2011 Combined Sewer Overflow Facilities Plan, seen here as attachment A.

**Background and summary**

A large part of Portland is served by a combined sewer system that discharged large quantities of untreated sanitary sewage and stormwater to the Columbia Slough and the Willamette River during most rain events. Sewer overflows are a public health and water quality concern.

In 1991, the commission and the city entered into a legal agreement through a stipulation and final order that established the framework for a twenty-year combined sewer overflow control program that would drastically reduce overflow frequency and volume. The agreement was amended in 1994.

Now in the final year of the program, the city has made significant progress in controlling overflows. All milestones and requirements of the original and amended stipulation and final order have been met.

As the last piece required by the amended stipulation and final order, the city submitted a facilities plan for commission approval that outlines the methods for reducing overflow event frequency and volume of discharges that could result from possible future development activity that increases impervious surface areas within the city. The facilities plan introduced green infrastructure plans to control the stormwater from both existing surfaces and from future development.

Over the course of implementation of the control program, DEQ has maintained close coordination with the city on a host of policy, regulatory and technical matters. DEQ also provides an engineering review of the sewerage facilities constructed as part of the city's program.

**Attachments**

A. Post-2011 Combined Sewer Overflow Facilities Plan-September 2010
B. DEQ fact sheet on Portland combined sewer overflows
C. Post-2011 Combined Sewer Overflow Facilities Plan Executive Summary (City of Portland September 2010)
D. Summary report from the city to accompany the presentation

**Available upon request**

- 1994 ASFO and original 1991agreement
- CSO Management Plan (City of Portland, 1994), or Executive Summary
- CSO Management Plan Update (City of Portland, 2001)
- Numerous engineering and other technical analyses developed as part of the program

**Additional resource**

The city's Bureau of Environmental Services maintains a website about the CSO control program at www.portlandonline.com/bes/

Approved:

Division: ____________________________

Section: ____________________________

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# Post-2011 Combined Sewer Overflow Facilities Plan

**SEPTEMBER 2010**

ENVIRONMENTAL SERVICES
CITY OF PORTLAND
working for clean rivers

# CITY OF PORTLAND
# POST-2011 CSO FACILITIES PLAN

*ASFO WQ-NWR-91-75*

September 2010

## Environmental Services
## City of Portland

REGISTERED PROFESSIONAL ENGINEER
17,666
OREGON
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EXPIRES: 6/30/2011

Prepared by

**CH2MHILL**
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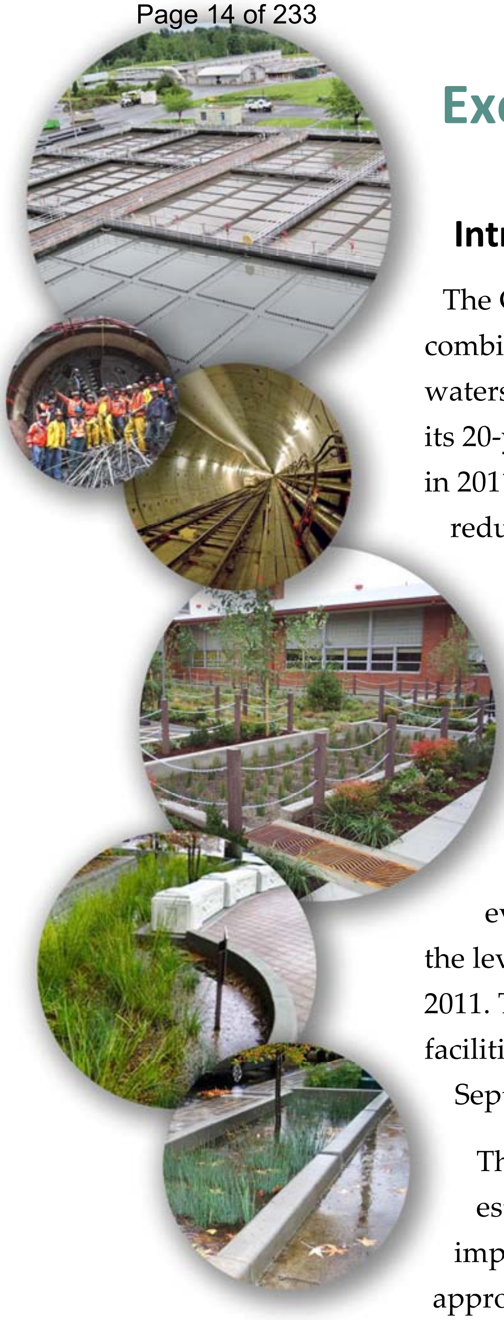
# Acronyms and Abbreviations

| | |
|---|---|
| ºC | degrees Celsius |
| °F | degrees Fahrenheit |
| ASFO | Amended Stipulation and Final Order |
| ATC | Alternative Treatment Configuration |
| avg/evnt | average per event |
| avg/yr | average per year |
| BCC | Balch Consolidation Conduit |
| BES | City of Portland Bureau of Environmental Services |
| BMP | best management practice |
| BOD | biochemical oxygen demand |
| BSBR | basement sewer backup risk |
| CAC | Citizen Advisory Committee |
| CBO | Congressional Budget Office |
| CBR | cost-benefit ratio |
| CBWTP | Columbia Boulevard Wastewater Treatment Plant |
| CBWWTF | Columbia Boulevard Wet Weather Treatment Facility |
| CEPT | Chemically Enhanced Primary Treatment |
| CFR | *Code of Federal Regulations* |
| cfs | cubic feet per second |
| CIP | capital improvement program |
| CMOM | capacity, management, operation, and maintenance |
| COM | commercial |
| CPI | consumer price index |
| CSCC | Columbia Slough Consolidation Conduit |
| CSO | combined sewer overflow |
| CWA | Clean Water Act |
| DEQ | Oregon Department of Environmental Quality |
| EIA | effective impervious area |
| EPA | U.S. Environmental Protection Agency |
| EQC | Environmental Quality Commission |
| ESA | Endangered Species Act |
| FCA | Financial Capability Assessment |
| FR | *Federal Register* |

| | |
|---|---|
| gal | gallon |
| GIS | geographical information system |
| gpm | gallons per minute |
| hp | horsepower |
| hr | hour |
| HYDRA | Hydrologic Data Retrieval and Alarm |
| kV | kilovolt |
| kWh | kilowatt-hour |
| LTCP | long-term control plan |
| $m^3$ | cubic meters |
| MG | million gallons |
| MGD | million gallons per day |
| mg/l | milligrams per liter |
| MHI | median house income |
| ml | milliliter |
| MPN | most probable number |
| NACWA | National Association of Clean Water Agencies |
| NFAA | no feasible alternative analysis |
| NMCs | nine minimum controls |
| NPDES | National Pollutant Discharge Elimination System |
| ODFW | Oregon Department of Fish and Wildlife |
| ODOT | Oregon Department of Transportation |
| OF | outfall |
| O&M | operations and maintenance |
| PBDE | polybrominated diphenyl ether |
| PBOT | Portland Bureau of Transportation |
| PCMP | post construction monitoring plan |
| POTW | publicly owned treatment works |
| RDII | rainfall-derived infiltration and inflow |
| RSF | Rate Stabilization Fund |
| SCADA | Supervisory Control and Data Acquisition |
| SDC | system development charge |
| SFO | Stipulation and Final Order |
| SFR | single family residence |

| | |
|---|---|
| SVI | sludge volume index |
| SWMM | Stormwater Management Manual |
| SWPI | Southwest Parallel Interceptor |
| | |
| TMDL | total maximum daily load |
| TSS | total suspended solids |
| | |
| U.S. | United States |
| | |
| WMP | Watershed Management Plan |
| WRPP | Willamette River Predesign Project |
| WRSTF | Willamette River Stakeholders Task Force |
| WR-WWTF | Willamette River Wet Weather Treatment Facility |



# Executive Summary

## Introduction

The City of Portland is committed to cost-effectively controlling combined sewer overflows (CSOs) to protect the water quality in its watersheds. This commitment is demonstrated by the implementation of its 20-year long-term control plan (LTCP), which is due to be completed in 2011. At that time, CSO annual discharge volume will have been reduced by 96% and the number of events reduced from 50 per year to less than 4.

As agreed in the Amended Stipulation and Final Order (ASFO) between the Oregon Environmental Quality Commission (EQC) and the City of Portland, the Bureau of Environmental Services (BES) has prepared this facilities plan report to outline "methods for achieving further reductions in the frequency and volumes of CSOs after the term of the amended order." The plan evaluates cost-effective approaches to further reduce CSO beyond the level of control specified in the ASFO that Portland will achieve in 2011. The City is required by the ASFO to submit this post-2011 CSO facilities plan to the Department of Environmental Quality (DEQ) by September 1, 2010. The plan is subject to approval by the EQC.

This facilities plan expands on the ASFO requirements by establishing a framework for future system refinements, improvements, and enhancements. A risk-based asset management approach is applied to focus available resources on high-priority, cost-beneficial projects that rely on green infrastructure to provide CSO reduction, watershed benefits, and relieve capacity problems in the combined sewer system.

## Further CSO Reductions—Statement of Understanding

The following questions and answers explain how the concept of "further CSO reductions" is interpreted in the development of this facilities plan.

### How does the ASFO characterize further reductions?

As further reductions of *frequency* and *volume* of CSOs.

### What is the starting point for *further*? Further than *what?*

The starting point for measuring further reductions is the level of CSO reduction required by the ASFO for the Willamette River, which is to be fully achieved by December 2011. The ASFO requires all 42 CSO outfalls on the Willamette River to be controlled to eliminate all CSO events for storms up to a 4-per-winter return frequency and a 3-year summer return frequency.

In contrast, the Columbia Slough system was controlled to the original Stipulation and Final Order (SFO) criteria consisting of 5-year winter and 10-year summer storm frequency. The SFO was amended in 1994 to recognize that the Willamette CSO should be controlled to a lower, more cost-effective level that was equally protective of the Willamette water quality. Because the difference between the two levels was driven by cost-effective CSO control benefits, the ASFO added a requirement that the City outline methods by which further reduction of Willamette CSO discharges beyond the 4-per-winter and 3-year summer frequencies could be cost-effectively achieved.

### To what extent will further reductions be achieved in December 2011 when the East Side CSO Controls become operational, thus completing implementation of the LTCP?

System modeling indicates that the winter overflows may be reduced to as few as two per winter on average compared to the ASFO requirement of four per winter once these facilities are on-line.

### When must the further reductions be achieved?

There is no ASFO requirement for timing of the further reductions. It is expected that further reductions of CSO discharges will be achieved at varying levels throughout the 2011–2050 planning period subject to timing and patterns of infill development and recommended plan implementation rates.

## Are further reductions required by regulations or permits?

No. The ASFO-specified reductions for CSOs meet regulatory requirements, including the draft National Pollutant Discharge Elimination System (NPDES) permit and the Willamette River Bacteria Total Maximum Daily Load (TMDL). The TMDL allocation specifically matches the ASFO level of control. The further reductions being considered by this facilities plan are not required by the EPA CSO Policy, the City's NPDES permit, or the Clean Water Act.

## If further reductions are not required, why are they being evaluated?

Section 23d of the ASFO, adopted in 1994, requires that the City "submit to DEQ no later than September 1, 2010, an approvable facilities plan report outlining the methods for achieving further reductions in the frequency and volumes of CSOs after the term of this Amended Order." Developing the plan and evaluating the methods is required by the ASFO, which was adopted in 1994. At that time, the process of identifying new cost-effective opportunities to reduce CSOs was incorporated into the ASFO because, as stated in Section 9d, "New technology may emerge that will provide more cost effective methods of reducing CSOs than are available today." Moreover, as also stated in the ASFO, "The people of the Portland Region place a high value on the Willamette River and good water quality. The River's importance to the people of Portland and the value of water quality both continue to increase over time." It is in the City's interest to pursue cost-effective further reductions over time.

## Ultimately, how will further reductions be measured?

Further reductions will be most easily measured by the reduced number of overflows per winter into the Willamette River. The number of overflows is a more reliable metric than volume because the volume of each overflow will vary according to the severity of the storm. In addition, winter overflows are expected to occur more frequently than summer overflows. Reduction of CSO in terms of winter overflow events provides a metric that can be evaluated more frequently than allowed by the infrequent summer overflow events.

## Do further reductions need to be cost effective?

Yes. Section 23 of the ASFO states that the City, "the commission, and the Department agree that further reductions in untreated discharges beyond the level to be achieved through the Enhanced Draft Federal Level [four per winter, three-year summer storms]…are desirable **if the reductions can be done in a cost effective manner**." [Emphasis added.] Thus, if CSO reduction measures are not cost effective they are not desirable. Moreover, the City's approximately $1.4 billion investment in CSO controls to address the requirements of the ASFO has significantly affected Portland's monthly sewer rates, which have increased nearly 400% since 1990. It is not tenable to implement reduction measures that are not cost effective and have a program that Portlanders can afford.

### Can further CSO reductions be achieved via green infrastructure?

Yes. Green infrastructure could be developed with sufficient capacity to meet future stormwater removal demand and sustain reduction of winter CSO events achieved in 2011. Preliminary hydrologic and hydraulic modeling of the combined sewer system was performed to confirm this for future (2050) conditions and recommended projects contained in the Combined Sewer System Plan (BES, forthcoming 2010). These projects rely on green infrastructure (also called sustainable stormwater) projects and pipe improvements that address local street flooding and basement sewer backup risk, while also helping to reduce inflow to the CSO tunnel system.

## Implementation of CSO Long-Term Control Plan

### LTCP Implementation History

The City has planned, designed, and implemented a successful 20-year CSO control program. With the adoption of the SFO in 1991, the CSO program officially began. The Cornerstone Projects, designed to divert stormwater runoff away from the combined sewer system through efforts such as the Downspout Disconnection Program, were initiated in 1993. In 1994 the City entered into an Amended SFO (ASFO) which incorporated the LTCP and facilities planning information developed between 1990 and 1993. Portland completed the Columbia Slough CSO projects in 2000 and the West Side Willamette CSO projects in 2006. The East Side CSO projects are on schedule to be completed in 2011.

When the CSO LTCP process began in 1990, the annual CSO volume discharged to the Willamette River and the Columbia Slough was estimated to be approximately 6 billion gallons per year total. With the implementation of LTCP projects, the annual CSO volume has been reduced to approximately 2.1 billion gallons as of 2006. With completion of the East Side CSO projects in 2011, the volume is projected to be reduced to approximately 200 to 300 million gallons per year, which represents a 96% reduction from the 1990 total. The timing of CSO reductions achieved now and in 2011 by Portland's LTCP is shown graphically in Figure ES-1. The dramatic decline illustrates Portland's commitment to CSO reduction. As required by the CSO Policy, the completed LTCP program complies with the water quality standards established by the State of Oregon and the City's NPDES permit requirements.

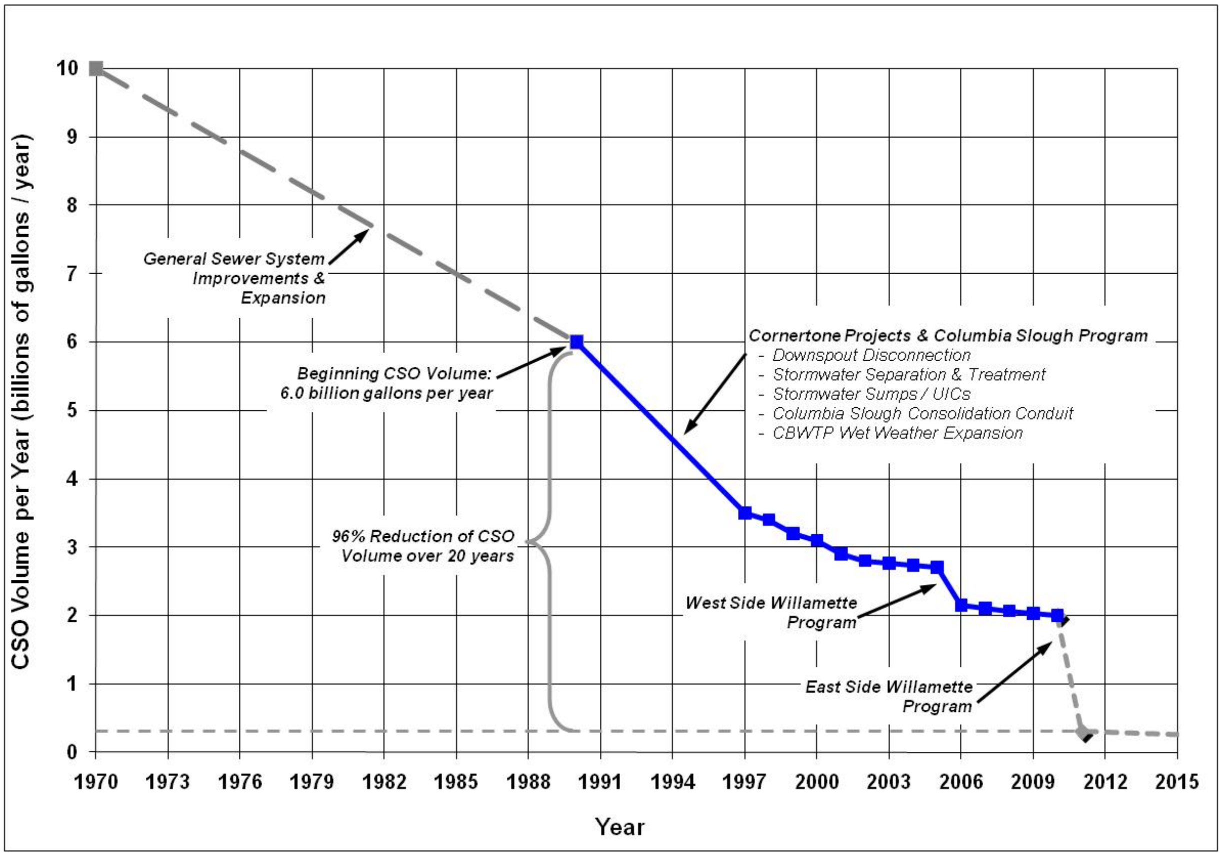



**Figure ES-1**. Overview of Portland's CSO Reductions Since 1970
*CSO LTCP begins in 1991 and concludes in 2011*

## Successful Completion of ASFO Requirements

Throughout the 20-year CSO program, the City has met the SFO and ASFO milestones and CSO control requirements. The final ASFO projects are on schedule to be completed in 2011. As described in the ASFO, annual CSO discharge volumes to the Columbia Slough are reduced 99.5%, and CSO volumes to the Willamette River will be reduced 94%, providing an average system-wide annual reduction of 96%.

The completed Columbia Slough CSO control system is shown in Figure ES-2. This figure also provides a comprehensive view of the implemented Cornerstone Projects. The completed Willamette CSO control facilities and those scheduled for completion in 2011 are shown in Figure ES-3. The CSO outfalls shown in these figures are color coded to indicate their control status.

Monitoring data for the completed CSO control system confirm that the ASFO-required CSO control performance standards are being achieved for the Columbia Slough and the Willamette River outfalls. Modeling projections indicate that with implementation of the final phase of the LTCP the ASFO CSO control requirements will be met at the remaining CSO outfalls. In summary:

- At all 13 Columbia Slough outfalls, the CSOs are eliminated for storms smaller than 5-year winter and 10-year summer design storms.
- At 23 Willamette River outfalls, the CSOs are eliminated for storms smaller than the 4-per-winter and 3-year summer design storms.
- At the remaining 19 Willamette River outfalls, the CSOs will be eliminated as of December 2011 for storms smaller than the 4-per-winter and 3-year summer design storms.

## CSO Volumes, Events, and Service Area Characteristics

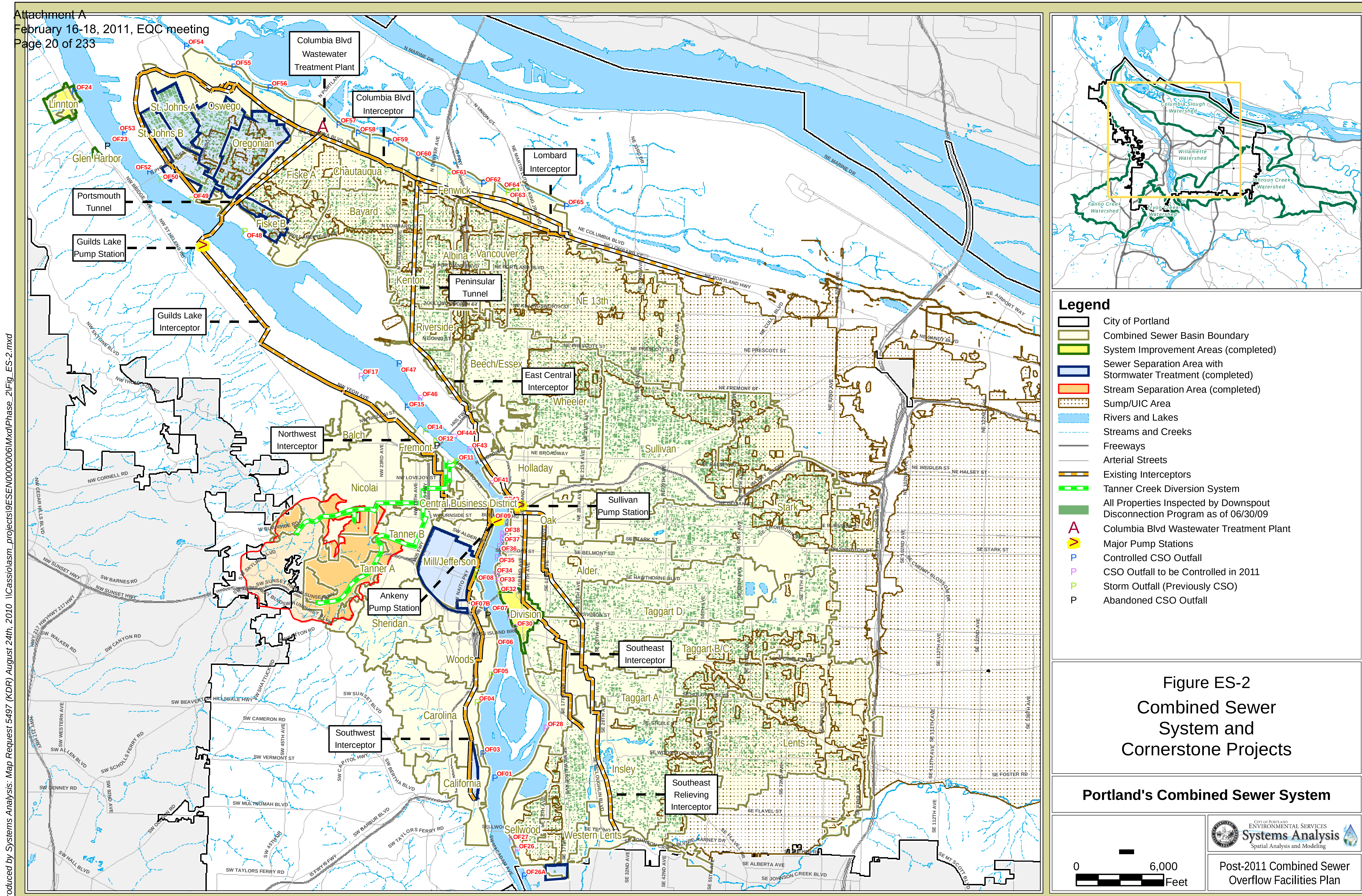
For long-term planning, BES estimated future condition characteristics based on the City's comprehensive planning data. The combined sewer system explicit model was used to simulate how the system will handle future flows under design storm conditions in accordance with the CSO control compliance methodologies approved by DEQ.

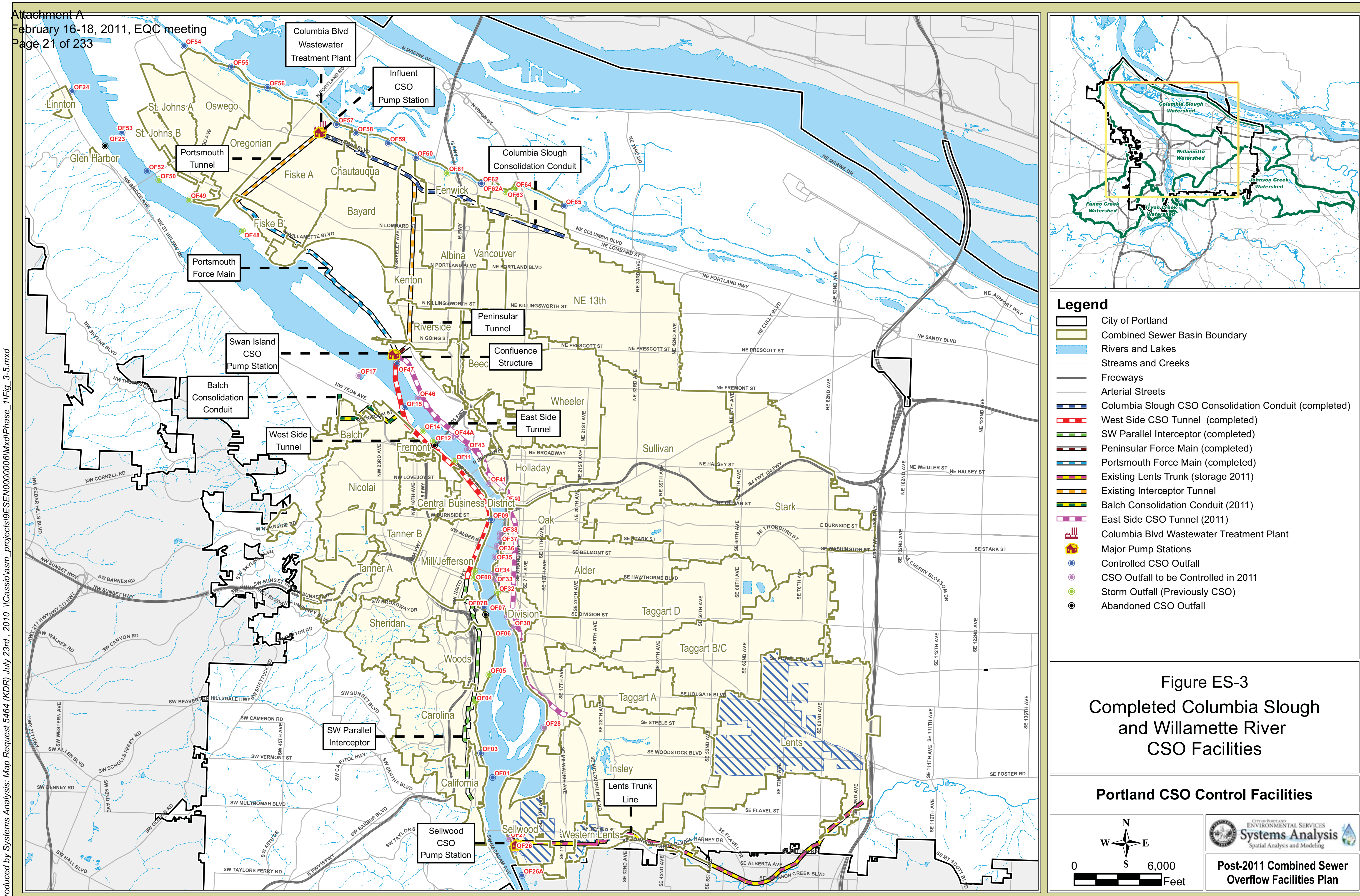
### Development of Future Condition Characteristics

To control CSOs, the City must also control the amount of stormwater entering the combined system. To characterize future (2050) conditions, BES simulated new effective impervious areas that could increase the stormwater volume entering the combined system. BES determined via system-wide hydrologic and hydraulic modeling that under 2050 conditions, new efforts will be needed to control an additional 22.4 million gallons (MG) of stormwater during the 3-year summer storm to sustain the further reductions of CSO achieved in 2011.

### Performance Projections for Future Service Improvements

The 2010 Combined Sewer System Plan, which was developed to address localized street flooding and basement sewer backup risk, integrates green infrastructure stormwater controls to reduce flows into the combined system and consequently help to reduce CSOs. Implementation of these integrated improvements was modeled to demonstrate that the stormwater controls embedded in the proposed projects to relieve local pipe capacity problems can also be effective in reducing CSOs in the long-term. The results showed that the steady implementation of green infrastructure stormwater controls can effectively keep pace with community growth and sustain further CSO reductions. However, not all of the recommended Combined Sewer System Plan projects are cost-beneficial and therefore not all of the embedded stormwater controls will be implemented.


Columbia Blvd Wastewater Treatment Plant
Columbia Blvd Interceptor
Lombard Interceptor
Portsmouth Tunnel
Guilds Lake Pump Station
Guilds Lake Interceptor
Peninsular Tunnel
East Central Interceptor
Northwest Interceptor
Sullivan Pump Station
Ankeny Pump Station
Southeast Interceptor
Southwest Interceptor
Southeast Relieving Interceptor
Linnton
Glen Harbor
St. Johns A
St. Johns B
Oswego
Oregonian
Fiske A
Fiske B
Chautauqua
Bayard
Fenwick
Albina
Vancouver
Kenton
Riverside
NE 13th
Beech/Essex
Wheeler
Balch
Fremont
Holladay
Sullivan
Nicolai
Central Business District
Tanner B
Tanner A
Mill/Jefferson
Oak
Stark
Alder
Division
Taggart D
Taggart B/C
Taggart A
Sheridan
Woods
Carolina
California
Insley
Lents
Sellwood
Western Lents
Legend
City of Portland
Combined Sewer Basin Boundary
System Improvement Areas (completed)
Sewer Separation Area with Stormwater Treatment (completed)
Stream Separation Area (completed)
Sump/UIC Area
Rivers and Lakes
Streams and Creeks
Freeways
Arterial Streets
Existing Interceptors
Tanner Creek Diversion System
All Properties Inspected by Downspout Disconnection Program as of 06/30/09
Columbia Blvd Wastewater Treatment Plant
Major Pump Stations
Controlled CSO Outfall
CSO Outfall to be Controlled in 2011
Storm Outfall (Previously CSO)
Abandoned CSO Outfall
Figure ES-2
Combined Sewer System and Cornerstone Projects
Portland's Combined Sewer System
0
6,000
Feet
City of Portland Environmental Services
Systems Analysis
Spatial Analysis and Modeling
Post-2011 Combined Sewer Overflow Facilities Plan
Produced by Systems Analysis: Map Request 5497 (KDR) August 24th, 2010 \\Cassiolasm_projects\9ESEN0000006\Mxd\Phase_2\Fig_ES-2.mxd


Columbia Blvd Wastewater Treatment Plant
Influent CSO Pump Station
Portsmouth Tunnel
Columbia Slough Consolidation Conduit
Portsmouth Force Main
Peninsular Tunnel
Swan Island CSO Pump Station
Confluence Structure
Balch Consolidation Conduit
East Side Tunnel
West Side Tunnel
SW Parallel Interceptor
Lents Trunk Line
Sellwood CSO Pump Station
Linnton
Glen Harbor
St. Johns A
St. Johns B
Oswego
Oregonian
Fiske A
Fiske B
Chautauqua
Fenwick
Bayard
Albina
Vancouver
Kenton
NE 13th
Riverside
Wheeler
Balch
Fremont
Sullivan
Holladay
Nicolai
Central Business District
Stark
Oak
Tanner B
Tanner A
Mill/Jefferson
Alder
Sheridan
Division
Taggart D
Taggart B/C
Woods
Taggart A
Carolina
Lents
Insley
California
Sellwood
Western Lents
Legend
City of Portland
Combined Sewer Basin Boundary
Rivers and Lakes
Streams and Creeks
Freeways
Arterial Streets
Columbia Slough CSO Consolidation Conduit (completed)
West Side CSO Tunnel (completed)
SW Parallel Interceptor (completed)
Peninsular Force Main (completed)
Portsmouth Force Main (completed)
Existing Lents Trunk (storage 2011)
Existing Interceptor Tunnel
Balch Consolidation Conduit (2011)
East Side CSO Tunnel (2011)
Columbia Blvd Wastewater Treatment Plant
Major Pump Stations
Controlled CSO Outfall
CSO Outfall to be Controlled in 2011
Storm Outfall (Previously CSO)
Abandoned CSO Outfall
Columbia Slough Watershed
Willamette Watershed
Johnson Creek Watershed
Fanno Creek Watershed
Tryon Creek Watershed
Figure ES-3
Completed Columbia Slough and Willamette River CSO Facilities
Portland CSO Control Facilities
N
W
E
S
0
6,000
Feet
City of Portland Environmental Services
Systems Analysis
Spatial Analysis and Modeling
Post-2011 Combined Sewer Overflow Facilities Plan
Produced by Systems Analysis: Map Request 5464 (KDR) July 23rd , 2010 \\Cassio\asm_projects\ESEN00000006\Mxd\Phase_1\Fig_3-5.mxd

## Development and Evaluation of Post-2011 Methods

BES developed and evaluated methods to mitigate the projected increase in stormwater runoff that could not be addressed by existing BES program activities. The following technologies were considered for this facilities plan as specified by the ASFO: sewer separation, upsizing of trunk and interceptor lines for storage, operational enhancements, wet weather treatment improvements, enhanced inflow and pollutant source control, and comprehensive and multi-objective water quality improvement strategies.

As previously discussed, the increased 3-year summer storm volume of stormwater that will need to be controlled by 2050 is estimated to be 22.4 MG or the equivalent of 600 acres of impervious surface in the Willamette River combined sewer service area.

After initial screening, BES evaluated the viable methods for expected cost-effectiveness and risk factors. The evaluation showed that the total number of impervious acres that could be managed by candidate methods exceed the target of 600 acres. Because of this, the methods with the greatest risk could be eliminated from further consideration.

## Recommended Plan for Further Reductions

### Overview

To establish a comprehensive framework for future CSO reductions, BES has developed a combination of policies and methods for implementation in an adaptive management approach.

### Policies

The following policies define the acceptable characteristics for CSO reduction methods:

- Reduce the amount of clean stormwater entering the combined sewer system by maximizing infiltration where practicable.
- Integrate watershed health goals, including restoration of the hydrologic cycle by using stormwater as a resource and not a waste.
- Apply green approaches alongside traditional approaches to stormwater management in the combined sewer system.
- Increase the adaptive capacity of the City's built and natural stormwater systems by developing and maintaining an urban stormwater system that can respond to a range of possible future conditions.
- Implement reduction methods only if they are cost-effective and meet the requirements of a risk-based asset management approach to efficiently achieve

environmental, social, and economic benefits—Triple Bottom Line benefits. Consider a wide array of environmental and social benefits (and external costs) to the community when performing a Triple Bottom Line assessment.

In short, the post-2011 BES approach to CSO reductions emphasizes development of green infrastructure, cost effectiveness, risk-based asset management, and the synthesis of multiple benefits.

## Methods

The recommended methods and candidate methods of the plan are listed in Table ES-1 in order of priority with the corresponding acres of managed impervious area. If, in addition to the recommended methods, all of the candidate methods are implemented, then the grand total of managed effective impervious area is estimated to be greater than 700 acres, which compares favorably with the 2050 goal to manage 600 acres of effective impervious area

**Table ES-1**. Recommended Plan

| Method | Description | Impervious Area Managed (acres) |
|---|---|---|
| **Recommended** | | |
| Existing Program Activities | CIP-Budgeted Cost-Beneficial Combined Sewer System Plan Projects: Implement Maintenance and Reliability projects to address local street flooding and basement sewer backup risk. Associated green infrastructure stormwater controls will provide significant CSO reduction benefits. | 185 |
| | Additional Cost-Beneficial Combined Sewer System Plan Projects: Reassess cost-benefit of additional Combined Sewer System Plan projects to address local street flooding and basement sewer backups and submit for CIP and Operating funds as needed for implementation. Associated stormwater controls will provide significant CSO reduction benefits. | 190 |
| | Portland Bureau of Transportation Stormwater runoff management (pollution reduction and flow control) for roadway improvement projects that involve more than re-paving existing roadways. Assumed to mitigate for an average of 1 impervious acre per year over the 40 year planning period. | 40 |
| Recommended Methods Sub-total | | 415 |
| **Candidate** | | |
| Re-evaluate Stormwater Management Manual (SWMM) Volume Control Effectiveness | Re-evaluate assumption that SWMM stormwater facility designs required by the City at new developments and redevelopments effectively manage 26% of new impervious area for volume control. Recent investigation indicates that the managed impervious area may achieve greater than 40% effective for volume control. Monitor to verify and adjust planning demands. | 110 |

**Table ES-1**. Recommended Plan

| Method | Description | Impervious Area Managed (acres) |
|---|---|---|
| Improve Stormwater Facility Design for Volume Control | Improve design to increase effectiveness of flow volume removal. The flow-through planter is an excellent candidate for improved design because it is currently estimated to remove 25% of the stormwater flow volume it receives and it is frequently implemented to meet SWMM. If the flow-through planter volume removal efficiency could be increased to 40%, this would produce 60 acres of impervious area removal. | 60 |
| Assess Stormwater Water Quality Problem Areas | The tunnel system provides an opportunity to route a portion of the stormwater from densely populated areas to the CBWTP using gates and real time controls. This method achieves water quality benefits while minimizing the increased flow to the CSO control system. | -20 |
| Implement Stormwater Projects at Large Institutions | Manage impervious areas from educational and religious institutions in the East Willamette basins by directing stormwater runoff to vegetated infiltration facilities. | 65 |
| Refine Requirements of SWMM for New Development and Redevelopment | ▪ Increase use of ecoroofs through incentives and grants for ecoroofs throughout the City<br>▪ Review the application criteria for flow-through planters<br>▪ Continue and enhance existing stormwater incentive programs<br>▪ Integrate and enhance urban forestry requirements with the SWMM and target implementation in CSO areas<br>▪ Pursue effective public and private maintenance of installed facilities | 60 |
| Implement Storm-water Projects at Large Commercial Facilities | Manage impervious areas from existing commercial facilities in the East Willamette basins by directing stormwater runoff to vegetated infiltration facilities. | 30 |
| Candidate Methods Sub-total | | 305 |
| **Grand Total** | | **720** |

## Risk Assessment of Recommended Plan

A risk assessment of the recommended plan is summarized in Table ES-2. Monitoring for increased risk in the areas outlined in Table ES-2 is recommended as an adaptive implementation plan activity.

City of Portland Post-2011 CSO Facilities Plan

**Table ES-2**. Risk Assessment and Mitigation Measures

| Plan Element | Risk of Implementation | Mitigation Measures |
|---|---|---|
| **Recommended Methods** | | |
| Existing Program Activities | Volume reduction estimates are overstated through model assumptions or their actual reduction performance | Monitor performance from existing facilities; apply additional stormwater reduction strategies identified in plan |
| | Maintenance of green infrastructure stormwater controls not performed over long term to maintain performance | Apply cost-benefit risk analysis in a business case to justify adequate maintenance budget<br>Commit to investigation of optimal maintenance cycles, work planning, and procedures with monitoring of how maintenance affects facility functionality<br>Consider alternative maintenance delivery methods |
| | Unauthorized public and private stormwater facility modifications diminish performance | Perform periodic inspections to ensure facilities (including disconnections) are intact and functioning properly |
| | Funding not approved for stormwater control facilities on private property | Seek alternative funding and implementation approaches or revise public works projects to incorporate needed control |
| | Participation by private property owners is not sufficient to meet onsite stormwater control targets | Develop outreach, technical assistance, and financial incentive programs<br>Revise public works projects to incorporate needed control |
| | Green streets not feasible | Increase options for onsite stormwater controls through partnering with private properties |
| **Candidate Methods** | | |
| Re-evaluate SWMM Volume Control Effectiveness | Volume reduction estimates are overstated vs. actual reduction performance | Monitor performance from existing facilities<br>Apply additional stormwater reduction strategies identified in plan |
| Improve Stormwater Facility Design | Long-term improvements not realized | Monitor performance from existing facilities, apply results to modified design to achieve greater volume removal |
| | Design improvements are more costly and less attractive to developers | Develop design improvements that are cost conscious |

**Table ES-2.** Risk Assessment and Mitigation Measures

| Plan Element | Risk of Implementation | Mitigation Measures |
|---|---|---|
| Assess Stormwater Water Quality Problem Areas | Real time control requirements increase costs beyond cost effective levels | Include water quality improvements in benefit assessment |
| | Permitting issues regarding Waterfront Park | Apply additional green infrastructure solutions to the areas rather than sending separated stormwater to the tunnel system |
| Implement SWMM Projects at Large Institutions | Resistance from property owners because of lack of design capabilities or concern about facility maintenance commitments | Develop outreach, technical assistance, and financial incentive programs<br>Develop alternative maintenance delivery systems |
| Refine Requirements of SWMM for New Development and Redevelopment | Resistance from property owners, developers, and stormwater facility installers | Develop outreach, technical assistance, and financial incentive programs |
| | Conflict with City developmental policies fostering maximum density and use of property | Increase requirements for ecoroofs and other facilities that provide flow control<br>Evaluate sharing facilities in the public right-of-ways |
| Implement Stormwater Projects at Large Commercial Facilities | Resistance from property owners | Develop outreach, technical assistance, and financial incentive programs |

# Financial Planning

## Funding and Financial Planning Process

BES operations, maintenance, and capital projects are financed with revenues from sewer rates and system development charges, revenue bond debt, or with ending fund balances. Beyond the short-term (5-year) forecast interval, BES financial plans rely on knowledge of longer-term sewer and water quality program costs and estimates of the impacts of potential regulatory requirements over a longer horizon. BES assumes that it will continue to rely on revenue bond financing for capital expenditures (decreasingly over the next 15 years).

## Financial Capability and Affordability

Portland is well positioned to financially manage the future sewer and water quality programs. However, Portland has consistently raised sewer rates to pay for CSO control projects and other capital improvement program (CIP) investments since 1990. The current financial model requires the City to continue to raise rates to retire the substantial debt incurred to finance the CSO control program. Portland ratepayers have shouldered this financial burden and it will continue to grow past 2016 when it is projected that 30% of households will exceed the 2.0% EPA affordability guideline for sewer rates.

Based on EPA's Financial Capability Assessments, Portland's financial burden would be considered in the upper range of a "Medium Burden" on the community. With the anticipated additional costs of pursuing further CSO reductions, the City-wide average affordability index will grow even higher from the currently projected 1.78% toward the 2% threshold for "High Burden."

## Implementation Plan

### Recommended Methods

Initial implementation of the Existing Program Activities will consist of recommended 2010 Combined Sewer System Plan Service Improvements with stormwater removal activities that are already programmed into the CIP. The remaining cost-beneficial Combined Sewer System Plan projects (those not yet in the CIP) are recommended to provide additional stormwater removal. The implementation approach is shown in Figure ES-4. The figure shows the demand for stormwater removal from 2011 to 2050 when growth creates a 22.4 MG demand during the 3-year summer design storm as previously described. The methods to achieve the desired stormwater removal are shown relative to the increasing demand for removal over time.

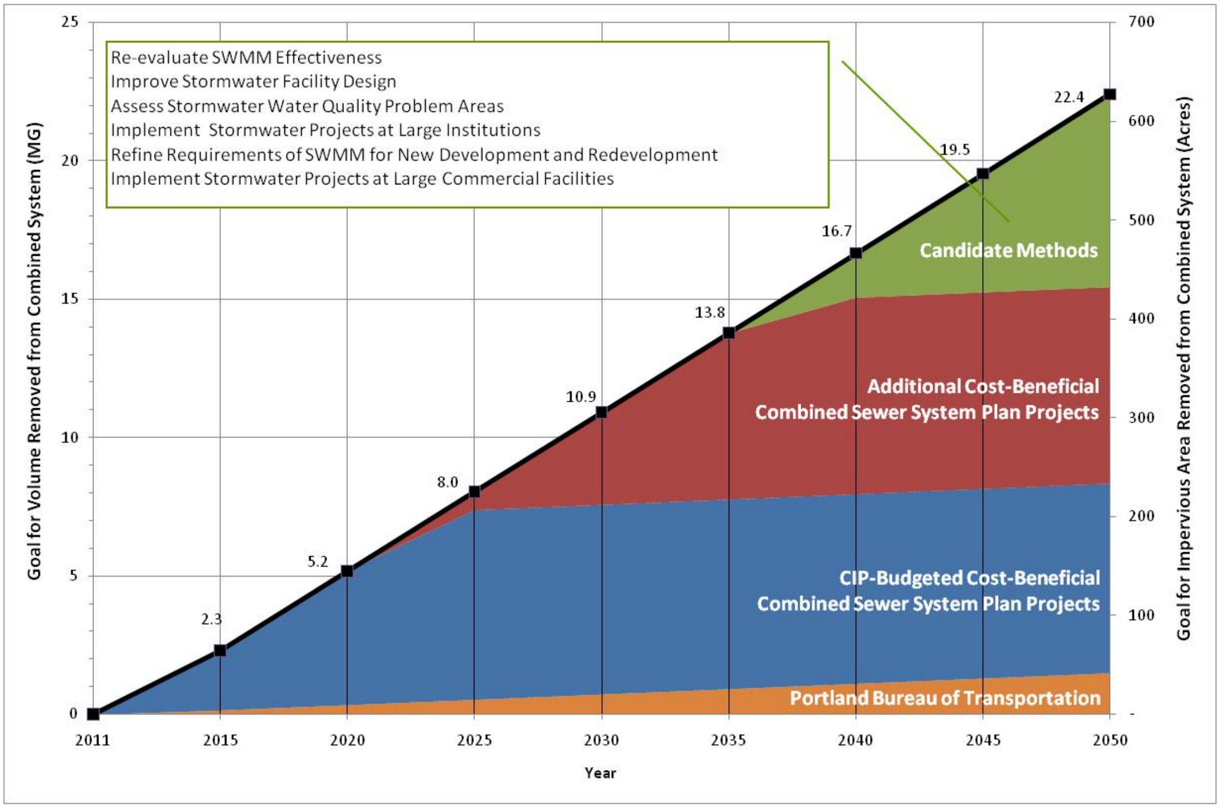



**Figure ES-4**. Post-2011 CSO Implementation Plan for Further CSO Reductions

Figure ES-4 results in the following general conclusions regarding implementation characteristics and timing:

- Portland Bureau of Transportation projects are assumed to remove a 3-year summer storm equivalent of 0.04 MG per year for a total of 1.5 MG by 2050.
- Combined Sewer System Plan projects in the CIP start in 2011 and would need to be implemented at a rate of approximately 0.5 MG or 14 acres of impervious area removal per year through 2025.
- Cost beneficial Combined Sewer System Plan projects not yet in the CIP need to be initiated by 2020 and by 2025 need to remove impervious area at a rate of 0.5 MG/14 acres per year through 2040.

## Candidate Methods

The candidate methods shown in Figure ES-4 and described in the recommended plan are more flexible in their timing relative to the project groups described above. For purposes of this facilities plan, the specific candidate methods are not identified individually but are shown as a group and are to be implemented following the recommended projects starting in 2035 through the end of the planning period in 2050. Their maximum rate of removal is similar to the recommended projects at 0.5 MG/14 acres per year.

Given that some of these methods (e.g., effectiveness and modifications to the application of the SWMM) provide benefit with minimal cost, it is likely, but not certain, that they will be integrated with earlier activities in the implementation period.

## Plan Performance Monitoring and Reporting

### Method for Demonstrating Compliance with Permit Requirements

DEQ approved the design storm method for demonstrating CSO compliance in 2001 for the Columbia Slough system and in 2007 for the West Side CSO system. After the East Side CSO control projects are completed in December 2011, BES will submit to DEQ for approval the method for demonstrating that the ASFO's design storm requirements for eliminating CSOs from the remaining Willamette River outfalls have been achieved.

### Long-Term CSO System Inflow and Overflow Tracking

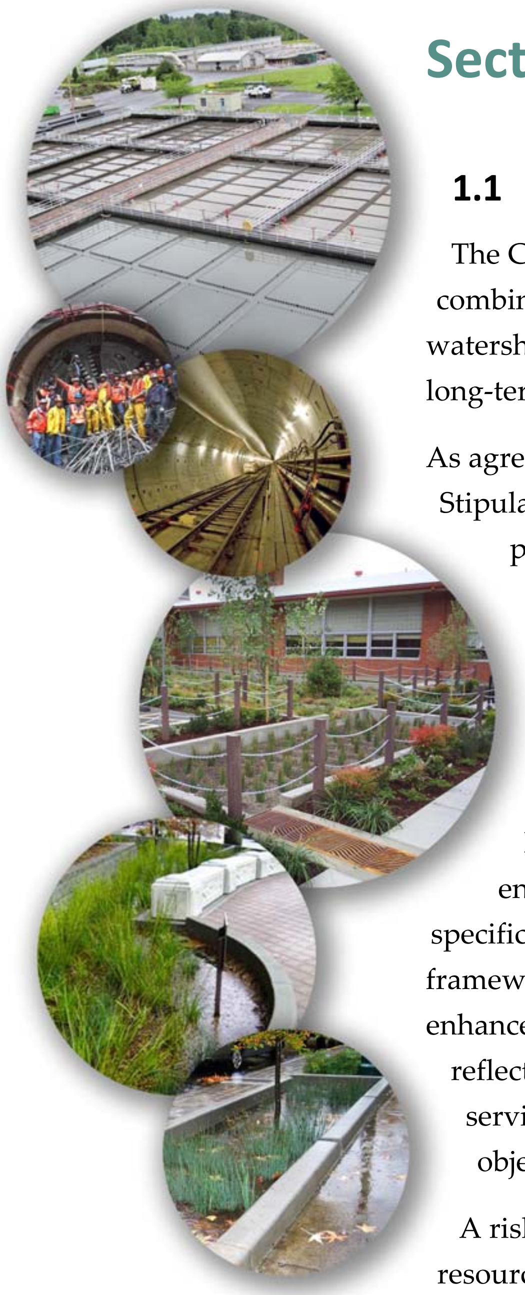
BES developed and submitted a draft *Post-Construction Monitoring Program* to DEQ and EPA Region X in July 2008. That report documents the CSO monitoring and sampling activities that BES will implement to ensure that the CSO Program complies with the City's NPDES permit and water quality standards as required by the permit, CSO Policy, and the Clean Water Act.

Through post-construction monitoring and the CSO event reports that are required by the City's permit, Portland will be able to track the influence of the increased or decreased stormwater inflow on the performance of the CSO system.

## Public Notification, Involvement, and Education

From the beginning, BES has been committed to meaningful public involvement as essential to successful implementation of the CSO LTCP. Initially, programs were developed to raise awareness about CSO issues and support public participation in the formulation of ASFO goals and requirements. They fostered public involvement in the development, evaluation, and selection of preferred alternatives for the City's 20-year CSO LTCP. The public involvement programs were integral to the effective implementation of LTCP project phases and were expanded and adjusted accordingly.

In the future, the City's CSO-related public involvement activities will be developed on a project by project basis as combined sewer service improvements are integrated with sustainable stormwater management projects. Public involvement provides opportunities for Portland's citizens to participate in decision-making, take part in stewardship activities, and help build sustainable community partnerships.



# Section 1: Introduction

## 1.1 Purpose

The City of Portland is committed to cost-effectively controlling combined sewer overflows (CSOs) to protect the water quality in its watersheds. This is demonstrated by the implementation of its 20-year long-term control plan (LTCP), due to be completed in 2011.

As agreed in the Environmental Quality Commission (EQC) Amended Stipulation and Final Order (ASFO), the City has prepared this facilities plan report to outline "methods for achieving further reductions in the frequency and volumes of CSOs after the term of the amended order." This plan looks at ways to cost-effectively exceed the level of control specified in the ASFO for the Willamette River CSO system that will be met by completion of the LTCP projects.

In keeping with the City's vision of sustainability and environmental stewardship, this facilities plan expands on the specific requirements of the ASFO to develop a report that establishes a framework for future system refinements, improvements, and enhancements. The development and evaluation criteria for this plan reflect associated water quality regulatory requirements, customer service commitments, and the City's watershed health goals and objectives.

A risk-based asset management approach is applied to focus available resources on high priority projects and provide guidance for adapting to changes in demand and potential changes in regulatory requirements and community expectations. This facilities plan develops a strategy for further reduction of CSO discharges through sustainable stormwater management that builds on the City's 20-year investment in stormwater inflow controls.

## 1.2 Coordination with Other Current Plans and Reports

In combination with this post-2011 CSO facilities plan, the *City of Portland CSO Program Nine Minimum Controls Implementation Report* (last updated in 2003) is scheduled to be updated in the fall of 2010. This report and Portland's previous CSO reports together document the City's on-going CSO control plans, the requirements of the U.S. Environmental Protection Agency (EPA) CSO Policy (Federal Register, 1994), the associated Oregon Administrative Rules, and the proposed National Pollutant Discharge Elimination System (NPDES) permit.

For more information about CSO treatment facilities planning, refer to the *Columbia Boulevard Wastewater Treatment Plant Facilities Plan* (Brown and Caldwell, 2010). For information about development and evaluation of conveyance and stormwater control alternatives in the combined sewer system basins, refer to the *Combined Sewer System Plan* (BES, 2010).

Although this post-2011 CSO facilities plan anticipates that the CSO reductions stipulated in the ASFO will be achieved by the compliance deadline of December 1, 2011, the term of the ASFO will not be concluded until after BES submits a final compliance report by December 1, 2012 that demonstrates compliance by a means approved by the Oregon Department of Environmental Quality (DEQ).

## 1.3 Intended Readers

This facilities plan was written for the following readers:

- DEQ regulatory staff for review to satisfy the ASFO Section 23d requirement to submit "an approvable facilities plan report outlining the methods for achieving further reductions in the frequency and volumes of CSOs after the term of the amended order," which must be submitted to DEQ no later than September 1, 2010, and is subject to approval by the EQC.
- EQC members to allow their review and approval.
- EPA program development and regulatory enforcement staff to provide information regarding successful implementation of the City's long-term CSO control plan and future approach to protecting human health, improving water quality, and protecting beneficial water uses in the Portland watersheds.
- Managers and staff of BES to document the overall plan for continuing to provide reliable service, meet regulatory requirements, protect public health, protect the environment, and support the long-term goals of the community.

- Interested citizens to provide a better understanding of BES services and responsibilities, ongoing development and implementation of policies, methods, and projects to meet current and future needs and requirements.
- Engineering design teams to support successful project implementation.

## 1.4 Organization of the Document

This facilities plan is organized to clearly meet the requirements of the ASFO (including evaluation of specified technologies) and applicable elements of the DEQ *Guidelines for the Preparation of Facilities Plans and Environmental Reviews for Community Wastewater Projects* (December, 2005).

This plan includes a review of the accomplishments of the City's long-term control plan as it relates to the ASFO (August, 1994) and the EPA Combined Sewer Overflow Control Policy (April, 1994). In keeping with the subsequent *Combined Sewer Overflows, Guidance for Long-Term Control Plan* (EPA, 1995), the plan addresses the nine elements of the LTCP as defined in the guidance document, but since this is not an LTCP, but rather a post-LTCP plan, the plan is not organized to feature those elements.

Overall, the plan is organized to tell Portland's CSO story, which is a history of innovation and progress and a restatement of BES's commitment to exceptional levels of service, protection of public health, watershed management goals, and community values.

# Section 2: Planning Criteria and Policies

## 2.1 Introduction

The primary criteria for development of this CSO facilities plan are defined by the ASFO agreement between the EQC and the City of Portland. This plan was prepared as specified by the ASFO. Additional criteria are defined by the associated EPA CSO Policy and the proposed City of Portland NPDES permit.

These regulatory criteria are supported and supplemented by the City's commitment to sustainability and environmental stewardship as reflected in the BES mission, which includes protecting public health and safety, improving the health of its watersheds, and providing cost-effective sewer service to its customers.

## 2.2 ASFO Requirements

The ASFO requires BES to develop this post-2011 CSO facilities plan to outline methods for achieving *further reductions* in the frequency and volume of CSOs after the level of control stipulated in the ASFO has been achieved. The ASFO directs that when methods for further reductions are evaluated those evaluations must take into account generally accepted technologies, potential innovative technologies, cost effectiveness, and the environmental benefits that could be achieved.

Section 23d of the ASFO deals directly with the development of this post-2011 CSO facilities plan report, which must be approvable and submitted to DEQ no later than September 1, 2010. A copy of the ASFO (No. WQ-NWR-91-75 Multnomah County) is provided in Appendix A for reference. Recognizing that the ASFO does not indicate a specific planning horizon for the report, BES selected a long-term planning horizon of approximately 40 years, consistent with the utility planning history and nature of the efforts required to further reduce CSOs or improve receiving water quality.

### 2.2.1 Stipulated CSO Reduction Requirements

To determine what qualifies as further reductions, the CSO reduction requirements stipulated by the ASFO serve as the benchmark. The previously stated requirements for reduction of the frequency and volume of CSOs are as follows:

- Eliminate all untreated CSO discharges to the Columbia Slough from November 1 through April 30 except during storms greater than or equal to a storm with a 5-year return frequency and eliminate all untreated CSO discharges from May 1 through October 31 except during storms greater than or equal to a storm with a 10-year return frequency.
- Eliminate all untreated CSO discharges to the Willamette River from November 1 through April 30 except during storms greater than or equal to a storm with a four in 1-year return frequency and to eliminate all untreated CSO discharges from May 1 to October 31 except during storms greater than or equal to a storm with a 3-year return frequency.

Using historical rainfall data, the City developed design storms that correspond with the storm frequencies specified by the ASFO CSO reduction criteria. The summer design storms are shown in Figure 2-1; the winter design storms in Figure 2-2. BES applies and DEQ accepts a criteria compliance process wherein these storms are compared with actual storms to determine whether an overflow event was in compliance with the ASFO.

The ASFO Paragraph 23 identifies that further reductions in CSO discharges beyond the 4-per-winter and 1-in-3 summer storm level of control provided by the "Enhanced Draft Federal Level alternative" are desirable if the reductions can be done in a cost-effective manner. Because the Columbia Slough system is already controlled to a higher level (the "SFO Level" which controls the 5-year winter and 10-year summer storms), the focus for "further reductions in CSO discharges" applies only to the Willamette River system of CSO outfalls.

The ASFO also identified specific programs, projects, and activities that were to be implemented by specified deadlines to achieve CSO reductions and water quality improvements. The history of how the City has consistently met the corresponding ASFO CSO reduction milestones is described in Section 3.

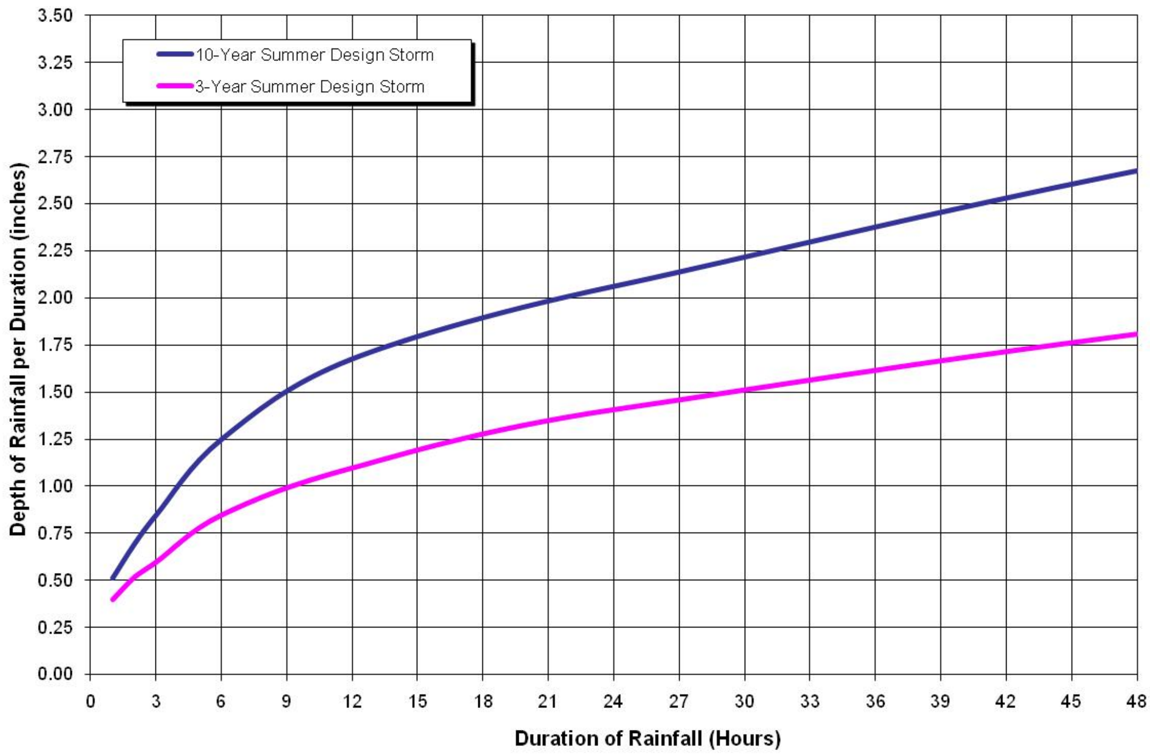



**Figure 2-1.** Depth-Duration Curves for ASFO Summer Storm Criteria

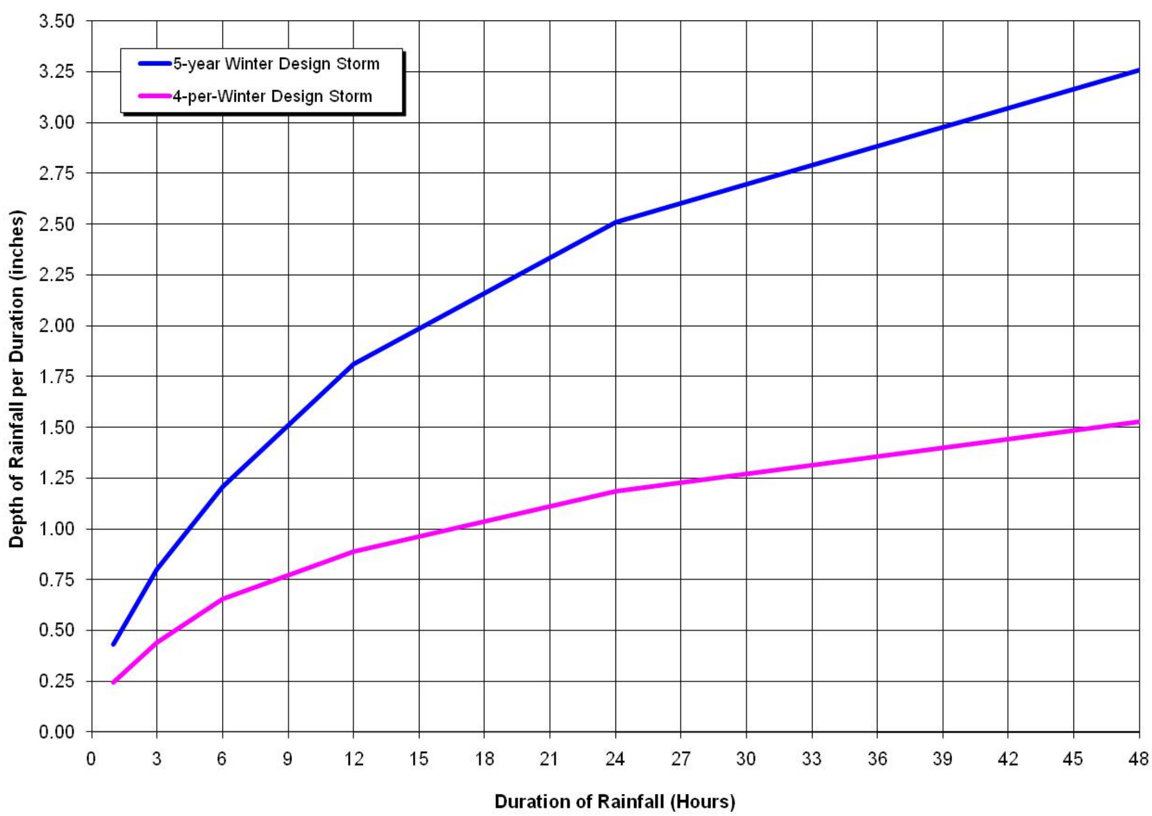



**Figure 2-2.** Depth-Duration Curves for ASFO Winter Storm Criteria

### 2.2.2 Further Reductions

The City is projected to achieve the CSO reduction requirements specified in the ASFO by 2011. Thus, the primary planning criterion for this post-2011 CSO facilities plan is to develop and evaluate potential alternatives for cost-effectively exceeding the ASFO-specified reductions in the frequency and volume of CSOs discharged to the Willamette River in the future.

Although the ASFO requires that a facilities plan report be submitted, the *further* reductions of frequency and volume of CSO being considered by the report are not required by the CSO Policy, the NPDES permit, or an identified impairment under section 303(d) of the Clean Water Act. In fact, the Willamette River Bacteria TMDL allocation specifically matches the ASFO level of control and is therefore identified as the level of CSO that meets water quality criteria for protecting the Willamette River's beneficial uses of "fishable and swimmable."

In lieu of a regulatory basis for establishing further reduction requirements, the facilities plan incorporates a risk-based asset management approach to efficiently achieve environmental, social, and economic benefits—Triple Bottom Line benefits. This approach protects watersheds and public health, delivers high quality sewer service, creates green infrastructure for community amenities, and minimizes life-cycle costs within acceptable levels of risk while meeting the further reduction intent of the ASFO.

### 2.2.3 Demonstrate Compliance with CSO Elimination per Design Storm

The ASFO also requires that within 12 months of the compliance deadline of December 1, 2011, BES demonstrate that the remaining Willamette River CSO outfalls have been controlled to the 4-per-winter and 1-in-3-year summer storm level. The latest date that this report can be submitted is December 1, 2012. The method for demonstrating compliance must be approved by DEQ, as was done in 2001 for the Columbia Slough system and in 2007 for the West Side CSO system. Compliance methods are discussed in Section 8.1.

### 2.2.4 Technologies to Evaluate

The ASFO advises that technologies to be evaluated should include innovative measures, those pioneered by Portland and measures used elsewhere that may be applicable to Portland. The ASFO specifies that at least the following six types of technologies should be evaluated in the post-2011 facilities plan:

1. Separation of sewers in selected basins where determined to be beneficial.
2. Continual replacement of deteriorated trunk and interceptor lines with larger diameter pipes to provide additional inline storage to convey more wastewater for treatment.

3. Implementation of operational enhancements to reduce the quantity of pollutants discharged when overflows do occur (for example, sewer flushing, street cleaning by vacuuming/washing).
4. Addition of further treatment technology to the wet weather treatment facility to further reduce the pollutants being discharged.
5. Enhanced inflow and pollutant source control (for example, organic composting stormwater filters and permeable pavements).
6. Comprehensive and multi-objective water quality improvement strategies in all tributaries to the Willamette River within Portland. Such strategies should include preservation and enhancement of riparian environments and wetland systems, stormwater management, water conservation, implementation of best management practices, source control of roadway runoff including pretreatment facilities, implementation of land use policies and requirements that benefit water quality, development of private property stewardship programs, and other strategies designed to prevent pollutants from reaching the Willamette River.

### 2.2.5 Cost Effectiveness

Cost effectiveness was considered an important criterion in the formulation of the ASFO, as reflected in the following bulleted statements from Section 9d:

- Responsible public policy calls for a cost effective approach to CSO reduction.
- Based on analysis of alternatives presented in the facility plan, CSO control beyond the level achieved with the Enhanced Draft Federal Policy[1] alternative (96% reduction of overflow volume) appears to be very costly for a relatively small increment in water quality improvement.
- New technology may emerge that will provide more cost effective methods of reducing CSOs than are available today.

Read together, these statements illustrate that cost effectiveness is an important factor in determining the advisability of pursuing any proposed CSO reduction measures and that cost effectiveness should be judged in terms of the water quality benefits achieved by further CSO reductions.

This post-2011 CSO facilities plan will examine new opportunities for CSO reduction beyond the Enhanced Draft Federal Policy level for cost effectiveness, and if such opportunities are found to be cost effective, plan to implement them to improve water quality in the Willamette River.

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[1] *Enhanced Draft Federal Policy Level* is early terminology for what eventually became the Willamette River's ASFO level of control: 4-per-winter and 1-in-3 summer storms.

### 2.2.6 Termination of the ASFO

Section 18 of the ASFO states that the order shall terminate 60 days after the respondent demonstrates full compliance with the requirements for CSO overflows on the Columbia Slough and the Willamette River as set forth in Section 12a of the ASFO.

## 2.3 EPA CSO Policy

EPA's CSO Policy, like the ASFO, is focused on cost-effective reduction of the frequency and quantity of untreated combined sewage discharges. The Policy contains three specific requirements for CSO communities:

1. Prohibition of overflows from the CSO system during dry weather; overflows should only be a result of wet weather.
2. Site-specific implementation of the Nine Minimum Control Technologies (NMCs) no later than 1997, consistent with the technology requirements of the Clean Water Act. These requirements are best management practices for operations of CSO control facilities and are not intended to require significant capital construction or continued increases of the size and capacity of capital facilities.
3. Development of an LTCP for cost-effective compliance with the Clean Water Act, which would include but not be limited to the following items identified in the LTCP guidance document (EPA, 1995):
   - Characterization of the system and overflow frequency and impacts
   - Identification of sensitive uses in the receiving water and a plan to control CSO to a higher level where these uses exist
   - Equivalent of primary clarification, solids and floatable control, and disinfection for the captured combined sewage
   - Maximization of the treatment at the existing publicly owned treatment works (POTW)
   - Revision of an Operations Plan to maximize the removal of pollutants during and after each precipitation event using all available facilities within the collection and treatment system
   - Demonstration of attainment with water quality standards when the LTCP has been fully implemented, consistent with the water quality requirements of the Clean Water Act, which includes the CSO Policy
   - Phasing of the implementation schedule to provide control of sensitive areas first and to account for financial capability
   - Post construction compliance monitoring to verify compliance with water quality standards and effectiveness of CSO controls

## 2.4 NPDES Permit Requirements

The NPDES permit is issued by the State of Oregon under federal authorization from EPA. EPA engages in the development and approval of the permit. The permit contains enforceable and specific mass load limits, overflow limits, wet weather effluent limits, special conditions, and monitoring/reporting requirements. Generally, permits have a 5 year life and if more than 5 years are needed to come into compliance, an enforcement order, such as the ASFO, "overlays" the permit to establish a compliance schedule. This is certainly the case with the CBWTP NPDES permit and the ASFO.

Section 3c of the NPDES permit incorporates the CSO control levels established in the ASFO Section 12a and thereby establishes the performance standards under which a CSO is presumed compliant with the permit. The permit states that CSO discharges are to be eliminated for all storms that are smaller than the following return frequency storms:

- Columbia Slough: 5-year winter storm and 10-year summer storms
- Willamette River: Four times per winter storms and 3-year summer storms

The CSO control level established in the permit is also the level required for the Willamette River Bacteria Total Maximum Daily Load (TMDL) allocation and therefore meets the water quality criteria for protecting the designated beneficial uses for the river. The permit also requires full utilization of the facilities including secondary treatment and a 70% TSS removal for primary wet weather CSO treatment.

Future NPDES permits will continue to require compliance with the ASFO overflow limits; the ASFO levels of CSO control are consistent with water quality requirements.

Section 3b of the NPDES permit (draft) requires ongoing operations and maintenance for the combined sewer system. It also requires the submittal of an updated NMCs report during the 5 years of the permit cycle to document the on-going implementation of the NMCs.

The NPDES permit specifically allows for CSO discharges from permitted outfalls after compliance with the ASFO (see section 6 of the permit) as long the discharges are consistent with the frequency performance standards allowed in the permit, the overflow structures are equipped with floatable controls, and the NMCs continue to be implemented. Under these conditions, CSOs are in compliance with the NPDES permit.

## 2.5 BES Mission

As the City agency responsible for sewage and stormwater collection and wastewater treatment, BES serves to protect public health, the environment, and the water quality of

City of Portland Post-2011 CSO Facilities Plan

surface water and groundwater. To address Portland's current and future needs (BES, 2005), it must accomplish the following:

- Meet regulatory requirements within its financial constraints (see ASFO, EPA CSO Policy, and NPDES Permit discussed above)
- Maintain the aging infrastructure with limited financial resources
- Improve watershed health and improve water quality (see Watershed Goals and Objectives discussed below)
- Manage stormwater to reduce sewer overflows and basement flooding (see Reduction of Street Flooding and Basement Sewer Backup Risk discussed below)
- Apply innovative ways to use stormwater and wastewater as a resource
- Ensure that BES has the technical expertise and knowledge to adapt to changing regulations
- Manage projects and programs to meet goals and minimize rate increases

### 2.5.1 BES Watershed Goals and Objectives

The *Portland Watershed Management Plan* (BES, 2005) provides guidance for performance of watershed activities citywide. The goals of this plan are to improve hydrology, physical habitats, water and sediment quality, and biological communities. The watershed health objectives to meet these goals are outlined in Table 2-1. Combined sewer system improvements should be planned and designed to help achieve these objectives.

**Table 2-1.** Watershed Health Objectives

| Goal | Objective |
|---|---|
| Hydrology | ***Stream Flow and Hydrologic Complexity:*** Protect and increase rainfall interception areas, create infiltration and detention areas to normalize stream hydrographs, reduce stormwater flow to sewer systems, and reduce basement flooding.<br>***Channel and Floodplain Function:*** Protect and restore the extent, connectivity, and function of streams, other open drainageways, wetlands, riparian areas, and floodplains to improve bank stability and natural hydrologic functions and reduce risk to development and human safety.<br>***Stormwater Conveyance:*** Maintain stormwater collection and conveyance infrastructure capacity. |
| Physical Habitat | ***Aquatic Habitat:*** Protect and improve aquatic, riparian, and floodplain habitat extent, quality, and connectivity that supports the persistence of native fish and wildlife communities.<br>***Terrestrial Habitat:*** Protect and improve upland habitat extent, quality, and connectivity that support the persistence of native terrestrial communities and connectivity to aquatic and riparian habitat. |
| Water and Sediment Quality | ***Stream Temperature:*** Protect and improve stream temperatures, dissolved oxygen, and pH levels that protect ecological health and achieve applicable water quality standards.<br>***Human Pathogens:*** Maintain and manage sewer infrastructure and stormwater inputs and runoff to limit sewage overflow and the delivery of pathogens to waterways and achieve applicable water quality and sewer design manual standards. |

**Table 2-1.** Watershed Health Objectives

| Goal | Objective |
|---|---|
| | ***Pollutants:*** *Regulate* the sources and transport of stormwater and industrial pollutants and nutrients to limit surface water, groundwater, soil, and sediment contamination to levels that protect ecological and human health and achieve applicable water quality standards. |
| Biological Communities | ***Fish and Other Aquatic Organisms:*** Implement watershed actions to maximize the persistence of native Willamette and Columbia River fish and other aquatic organisms and assist with species recovery and potential population productivity by protecting and improving hydrology, habitat, and water quality.<br><br>***Terrestrial Wildlife and Vegetation:*** Implement watershed actions to restore populations of terrestrial organisms to healthy, self-sustaining levels, protect and restore the composition and structure of native vegetation communities, and reduce populations of non-native plants and organisms to levels that do not compete with native species. |

Source: *Actions for Watershed Health, Portland Watershed Management Plan* (BES, 2005).

### 2.5.2 Reduction of Street Flooding and Basement Sewer Backup Risk

The BES combined sewer system level of service target is to eliminate or significantly reduce street flooding risk and basement sewer backup risk for the 25-year design storm under future (2050) conditions.

### 2.5.3 BES CIP Planning Requirements

Facility planning documents intended to recommend projects for capital improvement program (CIP) funding must satisfy the Capitalization Policy for "engineering analysis," as follows:

1. Identify and characterize the problem(s)
   - Problem identification.
   - Develop criteria for alternative screening & evaluation.
   - Characterize magnitude and areal extent of problems.
2. Develop range of viable alternatives and screen to select alternatives for evaluation
   - Define a range of viable alternatives.
   - Develop and apply a screening process based on selection criteria above as a guide which addresses primary and secondary problems.
   - Select a minimum of two alternatives to go into Evaluation Process. One alternative is always the "null" or "do nothing" option.
3. Perform alternative evaluations
   - Perform analysis of each alternative to quantify the benefits (reduction of primary and secondary problems).

- Quantify the amount of benefit each alternative provides compared to the original problem characterization.
- Estimate costs.
- Compare alternatives for magnitude of benefits, cost-effectiveness of resolving the primary and secondary problems, implementation risks, resource requirements, impacts to parties other than BES.

4. Select recommended alternative based on the evaluation results
   - Project recommendation includes description of benefits expected, how they relate to the magnitude of the total problem (e.g., how much of the total problem will be addressed), costs, and implementation schedule.
   - Include recommendations in a document or plan. This document will be referenced by the Project Request Forms for recommending projects for CIP funding.

## 2.6 BES CSO Facilities Planning Policies

BES developed the following policies to define the acceptable characteristics of Portland's CSO reduction methods:

- Reduce the amount of clean stormwater entering the combined sewer system.
- Integrate the watershed health goals, including restoration of the hydrologic cycle by using stormwater as a resource and not a waste. Implementing infiltration to the maximum extent practicable is a key approach to achieving this policy.
- Implement projects only if they are cost-effective and meet the requirements of a risk-based asset management approach to efficiently achieve environmental, social, and economic benefits—*Triple Bottom Line* benefits. Consider a wide array of environmental and social benefits (and external costs) to the community when performing a *Triple Bottom Line* assessment.
- Apply green infrastructure along with traditional approaches to stormwater management in long-term CSO control plans. Green infrastructure refers to vegetative approaches that help divert, store, and promote infiltration of stormwater to reduce pollution, reduce volume and peak flows, and recharge groundwater. These approaches include tree planting, green roofs, constructed wetlands, and small scale, decentralized, engineered stormwater controls such as vegetated swales, planters, or rain gardens.
- Increase the adaptive capacity of the City's built and natural stormwater systems by developing and maintaining an urban stormwater system that can respond to a range of possible future conditions.

# Section 3: Implementation of CSO Long-Term Control Plan

## 3.1 Overview

Since 1990, the City of Portland has planned, designed, and implemented a successful CSO long-term control plan. The history is summarized as follows:

- 1990—Portland initiates the CSO Management Plan project by hiring CH2M HILL and Brown & Caldwell to develop a comprehensive CSO LTCP.
- 1991—EQC issues the SFO and the 20-year schedule for the CSO Program officially begins.
- 1993—Portland initiates Cornerstone Projects to divert stormwater runoff from the combined sewer system; four components are (1) sump installations, (2) sewer separation, (3) stream diversion, and (4) residential downspout disconnections.
- 1993—Portland completes draft facilities plan, conducts Collaborative Process with EQC and DEQ officials to review alternatives, and selects the level of CSO control for the Columbia Slough and the Willamette River.
- 1994—Portland and EQC sign Amended SFO; Portland finalizes the CSO facilities plan.
- 1995—Portland begins designing the Columbia Slough CSO capture and treatment projects, including upgrades at CBWTP.
- 1996 – System improvements and the Cornerstone Projects effectively control several of the North Willamette CSO outfalls.
- 1996—Construction starts on the Columbia Slough CSO projects and Portland begins predesign for the Willamette River CSO projects.
- 2000—Portland completes construction of the Columbia Slough CSO projects, which reduce CSOs to the slough by more than 99%.
- 2002—Construction begins on the West Side CSO Tunnel and Swan Island Pump Station and Portland begins design of East Side CSO Tunnel.

City of Portland, Post-2011 CSO Facilities Plan

- 2006—West Side CSO projects completed, over 23 CSO outfalls on the Willamette River are now controlled, work starts on East Side CSO projects.
- 2007—Downspout Disconnection Program disconnects its 50,000th downspout, and disconnections are removing more than 1 billion gallons of stormwater annually from the combined sewer system.
- 2011—East Side CSO projects will be completed; all remaining CSO outfalls on the east side of the Willamette River will be controlled.

The development and implementation of this CSO program is described below and followed by conclusions about the success of the program.

## 3.2 Years 1990–1995

### 3.2.1 1990 CH2M HILL/Brown & Caldwell CSO Facilities Plan Contract

Before 1990, City staff contacted national engineering firms and agencies to obtain advice in developing a CSO abatement program to address sewer overflows from the combined sewer system. By the spring of 1990, the City published a Request for Proposals for professional services in developing a CSO Control Facilities Plan. The proposal review process resulted in the selection of a team led by CH2M HILL and Brown & Caldwell. The contract, initiated by October 1990, included services for monitoring, modeling, mapping, CSO characterization, alternatives development, costs estimates, an implementation schedule and a financing plan.

### 3.2.2 1991 Stipulation and Final Order (SFO)

In August 1991, as part of the renewal of the NPDES permit issued by DEQ covering CSO discharges, the Oregon Environmental Quality Commission (EQC) approved the Stipulation and Final Order (SFO), which required Portland to eliminate CSO discharges that exceeded the water quality standards for bacteria within a 20-year schedule that included interim milestones. To meet the bacteria water quality standard, no CSO discharge should occur for storms smaller than a 5-year winter or 10-year summer storm.

Therefore, by 1991, the two major parameters that drive CSO program costs—schedule and level of control—were established by the SFO without the benefit of knowing the costs or actual water quality benefits. For this reason, the SFO included a re-opener clause that would allow evaluation of changes to the SFO based on new and significant information as expected from the CSO Facilities Planning project.

### 3.2.3 1992 CSO Characterization Report

In developing the Draft CSO Facilities Plan, Portland released the 1992 CSO Characterization Report, which quantified the number, volume, and duration of overflow events; impacts on water quality; and other information that could assist the City in preparing a CSO control strategy. This report established the baseline CSO characteristic that annually 6 billion gallons of combined sewage overflowed during 100 days in a typical year through 55 outfalls on the Columbia Slough and the Willamette River. These CSO discharges were determined to exceed water quality standards at their points of discharge. However, data published later also showed that 76% of the annual exceedances of the bacteria standard in the Portland reach of the Willamette River were the result of sources upstream of the City of Portland.

### 3.2.4 1993 Draft CSO Facilities Plan

The June 1993 Draft CSO Facilities Plan provided a variety of planning level benefits and costs for four different levels of CSO control. The draft plan also examined multiple CSO treatment options, and storage and conveyance options for each level of control. The alternatives presented in the draft plan are summarized in Table 3-1.

**Table 3-1.** Alternatives Presented in 1993 Draft Facilities Plan

| Alternative | Event Control Level | | Level of Control Based on 1990 CSO Volume Control (Annual CSO volume of 6 billion gallons) | | Level of Control Based on EP Method for Volume Control (Annual combined sewage generated during wet weather events) | | 1993 Capital Costs ($ million) |
|---|---|---|---|---|---|---|---|
| | Description | # per Year | MG/Year | % of Total | MG/Year | % of Total | |
| No action | 1990 system | 50 | 6,000 | 0% | 13,000 | 0% | $0 |
| Sewer separation | Complete separation | 0 | 0 | 100% | 0 | 100% | $1,400 |
| SFO level | 5-year winter, 10-year summer | 0.3 | 25 | 99.6% | 25 | 99.8% | $1,005 |
| Enhanced draft federal policy | 4-per-winter, 1-in-3 summers | 4.33 | 240 | 96% | 240 | 98.2% | $700 |
| Draft federal policy | Minimum 85% volume control | 9 | 600 | 90% | 600 | 95.4% | $550 |

Data about the alternatives, including costs and potential water quality benefits, were used in the 1993 Collaborative Process to select a preferred level of control and likely configuration of Cornerstone Projects and CSO facilities.

City of Portland, Post-2011 CSO Facilities Plan

### 3.2.5 1993 Collaborative Process

Between October 1993 and January 1994, two members of the Oregon EQC, two members of Portland's City Council, the director of DEQ, and a representative of the Bureau of Environmental Services sat as a collaborative committee and initiated what was called the Collaborative Process. During four public meetings, the committee heard testimony from representatives of the regulatory agencies, businesses, environmental groups, technical experts, and the general public. At the fifth public meeting, the Collaborative Committee came to a preliminary recommendation to amend the 1991 SFO to reflect the Enhanced Federal Level (94% annual volume control) for the Willamette River. The Enhanced Federal Level eliminated overflows for all storms smaller than a 4-per-winter storm and a 3-year summer storm. Recognizing the Columbia Slough as a sensitive water body, it was recommended that the SFO level (99% control) be retained, and that the control schedule be accelerated by 1 year (controlled by December 2000) instead of requiring the installation of temporary floatable control facilities. These recommendations were presented to the public in a series of discussion groups and public workshops in March and April 1994.

### 3.2.6 1994 Amended Stipulation and Final Order (ASFO)

The recommendations from the collaborative process resulted in new performance standards and, in August 1994, the formal adoption of an Amended Stipulation and Final Order (ASFO). Specifically, the ASFO required:

- All 13 Columbia Slough CSO outfalls controlled by December 2000 for storms less than a 5-year winter and 10-year summer storm (99% annual volume reduction)
- All 42 Willamette River CSO outfalls to be controlled to a 4-per-winter storm and 3-year summer storm level according to the following schedule (94% annual volume reduction):
  - 7 Willamette River outfalls controlled by December 1, 2001
  - 16 additional CSO outfalls controlled by December 1, 2006
  - All remaining (19) CSO outfalls controlled by December 1, 2011

To ensure that Portland would continue to strive for Willamette River CSO control above the 94% volume control, the ASFO requires Portland to develop a set of additional CSO reduction measures in a Post-2011 CSO Facilities Plan that is to be submitted to DEQ by September 1, 2010, subject to approval by the EQC.

### 3.2.7 1994 Final CSO Facilities Plan

In December 1994, Portland released the 1994 Final CSO Facilities Plan for reducing CSO discharges into the Columbia Slough and the Willamette River. The plan recommended a two-tier approach:

1. First, implement the Cornerstone Projects — a series of cost-effective, early-action projects to reduce the amount of stormwater entering the combined sewer system.
2. Second, design and construct several major CSO control facilities for capturing, storing, and conveying the balance of the CSO to wet-weather facilities for treatment.

The 1994 CSO Facilities Plan provided this two-tier approach to significantly reduce CSO discharges as early as possible in the program while allowing time for verifying and designing the more complex and expensive large-scale components in a phased manner.

The 1994 CSO Plan also recommended an early schedule for controlling CSOs to the Columbia Slough to the original SFO one-in-10-year summer and one-in-5-year winter frequency control (99% volume reduction). The plan recommended a storage and conveyance facility called the Columbia Slough Consolidation Conduit (CSCC) along the slough to collect and store peak CSO discharges. The captured flows were to be pumped to the Columbia Boulevard Wastewater Treatment Plant and treated via a wet weather treatment facility at that site. The proposed schedule for the Cornerstone Projects and the Columbia Slough CSO control projects were completed by December 2000.

For the Willamette CSO control, the 1994 CSO Facilities Plan recommended a set of storage, conveyance, pumping, and treatment facilities to provide one-in-3-year summer and four overflows per winter frequency control (94% volume reduction). The main facilities included:

1. Storage and conveyance improvements in Southwest Portland
2. Large diameter tunnels on each side of the river to collect, store, and convey CSO flows
3. Pump stations to convey up to 400 million gallons per day (MGD) of CSO flow from the storage tunnels to wet weather treatment
4. Wet Weather Treatment Plant on Swan Island to handle up to 340 MGD of captured CSO flows

The 1994 CSO Plan estimated the cost of the CSO Program to be $700 million (1993 dollars); $190 million for Cornerstone projects, $120 million for major CSO facilities for the Columbia Slough, and $390 million for major CSO facilities for the Willamette River. The implementation schedule included a number of intermediate milestones and showed the program completed by 2011. Also in 1994, BES submitted a report to DEQ documenting compliance with the Nine Minimum Controls and describing site-specific implementation. The Final CSO Facilities Plan was approved by the EQC in April 1995.

City of Portland, Post-2011 CSO Facilities Plan

Questions regarding how CSO would be treated and where the treatment facilities would be located were major factors in the planning and decision-making processes. Three distinct CSO treatment alternatives covering the method and location of treatment were evaluated:

1. CBWTP Alternative ("the Long Tunnel" Alternative):
   - All CSO treatment provided at the CBWTP via a new wet weather treatment facility (CBWWTF)
   - Minimum wet weather treatment rate of 460 MGD, up to a potential 756 MGD
   - Required a 10-mile tunnel to capture and convey CSO along the Willamette River from SE Portland to CBWTP
2. Single Willamette Alternative:
   - Columbia Slough CSO treated at CBWTP via a 75 MGD wet weather treatment facility
   - Willamette River CSO treated at a single 340 MGD wet weather treatment facility (WR-WWTF) located in the Swan Island industrial area
3. Multiple Willamette Alternative:
   - Columbia Slough CSO treated at CBWTP via a 75 MGD wet weather treatment facility
   - Willamette River CSO treated at three wet weather treatment facilities located at:
     - Swan Island industrial area
     - Oregon Museum of Science & Industry (OMSI) site
     - NW Portland ( "Pearl District") site

For the Columbia Slough CSO treatment, the facilities plan recommended a 75 MGD wet weather treatment facility—the CBWWTF, described as "an integrated facility that will provide the additional wet weather treatment capacity required to treat the 75 MGD of the Columbia Slough basin CSOs. In this manner, the ability to maximize the use of existing facilities, one of the nine minimum controls, could be achieved."

For each alternative, the recommended CSO treatment train consisted of screening, primary clarification, disinfection and dechlorination. This recommendation was based on EPA's CSO Guidance and the determination that "equivalent to primary clarification" was expected to be about 15% to 30% TSS removal during peak design storm conditions.

Evaluation of the three alternatives produced the following results regarding environmental benefits, operations & costs, and community considerations:

#### 3.2.7.1 Environmental Benefits

- Metals loading to the Willamette River would be 25 to 60% higher with the Single and Multiple Willamette Alternatives.
- Bacteria control for the Willamette River would be 400 MPN/100 ml for fecal for the Single and Multiple Willamette Alternatives, but would be 12 MPN/100 ml for the CBWTP Alternative.
- For higher levels of CSO control (above 94%), providing treatment at CBWTP was found to be most beneficial for water quality and habitat protection due to higher treatment effectiveness, assimilative capacity of the Columbia River, and no need to construct a new outfall system in the Willamette River.
- A WWTF on the Willamette River and its treated effluent would have higher impacts from nutrients and metals on its receiving stream and would be a challenge to meet water quality standards.

#### 3.2.7.2 Operations & Costs

- Operational reliability and performance estimated to be best for the CBWTP Alternative.
- Capital costs for the CBWTP Alternative were higher, but O&M costs lower.
- Single Willamette River Alternative had the lowest capital and lowest net present worth cost, although the CBWTP Alternative net present worth costs were close.

#### 3.2.7.3 Community Considerations

- Community impacts due to construction and operation are less for the CBWTP Alternative.

Single Willamette River WWTF had most public support as it was considered to be more "environmentally just" in that it treated Willamette CSO in the Willamette community. The North Portland community at that time did not support expansion of the plant to treat CSO from the Willamette basin.

The 1994 CSO Facilities Plan alternative evaluation results showed that it was more beneficial to send CSO to the CBWTP site. However, the difference in costs and the clear lack of public support resulted in the Single Willamette WWTF Alternative being selected and approved by the City Council.

The lack of support from the North Portland community for expanding CBWTP to treat all the CSO changed over the next few years due to the good work started in the 1995 CBWTP Facilities Plan (below) with the Citizens Advisory Committee (CAC) and the actions implemented at CBWTP to be a good neighbor and community partner. When the alternatives evaluation was performed for the 2001 Willamette River CSO Predesign

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(presented below), it was a member of the CAC and a resident of North Portland who led the recommendation to locate all CSO treatment at CBWTP.

## 3.3 Years 1995–2000

In 1995, Portland launched the CSO Management Program and began developing the program and project controls necessary to ensure the ASFO milestones would be accomplished. The immediate needs were to initiate implementation of the Cornerstone Projects and begin the design and construction work for the Columbia Slough CSO Program.

### 3.3.1 Cornerstone Projects Implementation

Before the 1994 CSO Facilities Plan was completed, the City of Portland had begun developing the city code changes and funding mechanisms necessary to launch the Cornerstone Projects. These fundamental projects were intended to remove stormwater from the combined sewer system and infiltrate it into the ground or when necessary, treat the stormwater through water quality facilities and discharge it to the Willamette River. The Cornerstone Projects include:

- Downspout Disconnection Program
- Residential Street Sump/UIC Projects
- West Side Stream Diversion Projects
- Partial Sewer Separation with Stormwater Treatment at Ramsey Lake Constructed Wetlands

Implemented across the majority of the combined sewer system since 1995, this program has reduced the original 1990 estimate of 6 billion gallons of CSO/year by about 35%, and resulted in the control of 15 of the 55 original CSO outfalls. The outfalls effectively controlled early in the program through the Cornerstone Projects and local system improvements include:

- 3 Columbia Slough North Portland Outfalls:
  - St. Johns A – Outfall 54
  - Oswego – Outfall 55
  - Oregonian – Outfall 56
- 12 Willamette River Outfalls:
  - California – Outfall 1B
  - Mill – Outfall 8

- Jefferson – Outfall 8A
- Glen Harbor – Outfall 23
- Linnton/NW 110th – Outfall 24
- Division – Outfalls 29 and 32
- Fiske B – Outfall 48
- St. Johns B – Outfalls 49, 50, 52, and 53

The ASFO required the City to control seven CSO outfalls on the Willamette River by December 2001. The seven outfalls were controlled by the Cornerstone Projects with local system improvements which ensured that CSO discharges would be eliminated. The seven outfalls were sealed off and no longer discharge CSOs. Later during implementation of the program, the Downspout Disconnection Program was extended to additional areas and property types beyond the original Cornerstone Project definition because of the program's success in cost-effectively removing stormwater.

### 3.3.2 1995 CBWTP Facilities Plan

The 1995 CBWTP facilities planning effort identified the facilities and improvements required to support new flow and load projections, accommodate the 1994 CSO Facilities Plan, and address new NPDES requirements. It also identified other necessary items, including how to support the plant's role as a good neighbor in the North Portland community. The CBWTP facilities planning project began in 1994 and concluded in 1995.

The 1995 CBWTP Facilities Plan focused on providing the dry weather primary and secondary facilities necessary to manage the sanitary sewage flow projections shown in Table 3-2. Note that the 1994 average-day dry weather flow of 59 MGD is similar to the average dry weather flow of 55 MGD measured for the 2007–2009 period. Similarly, the 1994 maximum-month dry weather flow of 64 MGD is essentially the same as the 65 MGD maximum-month dry weather flow measured during the 2007–2009 period.

**Table 3-2.** 1995 Sanitary Sewer Flow Projections for Columbia Boulevard Wastewater Treatment Plant (million gallons per day)

| Description | 1994 | 2000 | 2005 | 2010 | 2020 | 2040 |
|---|---|---|---|---|---|---|
| Average-day dry weather | 59 | 75 | 79 | 83 | 92 | 110 |
| Maximum-month dry weather | 64 | 82 | 87 | 92 | 102 | 121 |
| Average-day dry season | 62 | 78 | 82.5 | 87 | 97 | 115 |
| Maximum-month dry season | 74 | 94 | 99.5 | 105 | 116 | 138 |
| Average-day wet season | 80 | 97 | 103 | 109 | 120 | 143 |
| Maximum-month wet season | 96 | 115 | 121.5 | 128 | 142 | 169 |

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The 1995 Plan estimated that secondary treatment expansion would be needed to treat 160 MGD to meet future treatment needs. New secondary capacity would require additional space beyond the current site boundaries. The facilities plan recommended expanding to the Western Site (next to the existing secondary system), and providing the tunnels and piping necessary to operate the old and new facilities together as one system. The facilities plan also suggested considering plug-flow selector and step-feed technologies because they can result in increased capacity where there is limited space for expansion.

The 1995 CBWTP Facilities Plan addressed the full range of peak wet weather flows predicted to arrive at the Columbia Boulevard site:

- 319 MGD from the existing interceptor system, including sanitary flows from Inverness Pump Station
- 75 MGD from Columbia Slough captured CSOs
- 336 MGD from Willamette River captured CSOs

The peak flow predictions were additive so that the total potential total flow could be as high as 730 MGD. At that time, the location of the facility to treat Willamette River captured CSOs was not yet determined. Therefore, it was necessary to develop a contingency plan if the Willamette River CSOs were treated at the Columbia Boulevard site in order to reserve space for potential future facilities.

Six alternatives for treating CSO were examined—three alternatives for treating only the Columbia Slough CSO and three alternatives for Columbia Slough and Willamette River CSO treatment. The facilities plan recommended that the existing eight primary clarifiers be modified to serve as a wet weather-only primary treatment system, while a set of new dry weather primary clarifiers were constructed to provide the best treatment of the most-frequently occurring daily, dry weather flows.

The Plan examined options for treating more captured CSO through the secondary system. One option recommended and implemented was to provide a dewatering system that would enable the wet weather primary clarifiers to be used as initial storage tanks when the secondary capacity was exceeded. The dewatering system would rapidly pump the stored flow back to the dry weather/secondary system when capacity was available. The facilities plan predicted that this would increase the volume of CSO treated through the secondary system by 12 to 24%.

The planned treatment for captured CSO from the Columbia Slough system was recommended to include a new 75 MGD Influent Pump Station to dewater the Columbia Slough Consolidation Conduit; the Main Headworks would provide screening and grit removal, and existing primary clarifiers would be converted to wet weather treatment. Also, a wet weather diversion or flow control structure downstream of the Main Headworks was recommended to divert wet weather flows that exceeded the secondary capacity to the wet weather primaries. Disinfection, effluent pumping, and dechlorination were also planned for the wet weather treatment train.

The facilities plan also recommended installation of a second outfall to the Columbia River with a diffuser system for wet weather primary effluent (Outfall 003). The controlling parameters for designing the system were residual chlorine and metals.

The plan provided for the possibility that the Willamette CSO tunnel would be extended to the plant site. The proposed treatment for the Willamette River CSOs included a new 336 MGD Influent Pump Station (to dewater the deep Willamette CSO tunnel), a new set of wet weather primary clarifiers, disinfection, effluent pumping, a new outfall pipeline, and dechlorination.

The 1995 CBWTP Facilities Plan evaluated primary and secondary treatment alternatives for CSO, and recommended a strategy that would maximize CSO to the existing secondary system, provide initial storage for flows exceeding that capacity, and treat the remaining CSO through wet weather primary clarification, disinfection, dechlorination, and discharge through a diffuser system to the Columbia River. This strategy was implemented and has yielded compliance with effluent limits and water quality standards. Finally, as noted above, the projected increase in dry weather flows from 1995 to 2010 has not occurred, and therefore the City has not expanded secondary treatment beyond the current 100 MGD capacity.

### 3.3.3 Columbia Slough CSO Program Implementation

The Columbia Slough CSO Program, which was accelerated in the ASFO to be completed by December 2000, consisted of new facilities designed to achieve the highest level of control (5-year winter, 10-year summer) to protect the Columbia Slough from CSO.

**Columbia Slough Consolidation Conduit (CSCC)**: A 3-mile-long conveyance and storage conduit was designed and constructed to collect, convey, and store CSO from all ten outfalls east of the plant.

**Influent Pump Station (IPS)**: The Influent Pump Station dewaters the CSCC and is used to modulate the Columbia Slough flows into CBWTP to equalize flows during dry weather and to limit small storm inflows to CBWTP from exceeding the 100 MGD secondary capacity. The IPS was originally designed to pump dry weather (Low) flows and wet weather CSO (High) flows at a maximum of 75 MGD. In 2006, the IPS was upgraded to

135 MGD for new peak (High-High) flows entering the CSCC from the inter-connection between the Peninsular Tunnel carrying Willamette CSO and the CSCC at the Argyle Structure.

**Columbia Boulevard Wet Weather Treatment Facility (CBWWTF)**: The previous dry weather primary clarifiers were refurbished and modified to provide storage and primary treatment of captured CSO flows exceeding the secondary treatment capacity.

**New Outfall & Diffuser**: A new 84-inch diameter, 1-mile long outfall (003) was constructed to discharge into the Columbia River 950 feet upstream of the existing Outfall 001. The outfall includes a 265-foot long diffuser.

### 3.3.4 Revision to Bacteria Water Quality Standards

EPA CSO Policy commits the state and EPA to coordinate the approval of CSO long-term control plans with the review and possible revision of water quality standards to reflect the periods when CSO discharges may occur without impacting other beneficial uses. Consistent with that commitment, the Oregon DEQ initiated the process to review and revise the bacteria water quality standards to address the findings of the Draft CSO Facilities Plan, the Collaborative Process, and the approved ASFO level of control. These findings showed that CSO reduction above the 4-per-winter and 3-year-summer design storm level did not have significant water quality benefits. This conclusion was later confirmed by the bacteria TMDL process for the Willamette River.

DEQ's revised bacteria water quality standard gives authority to the Environmental Quality Commission to approve on a case-by-case basis a Bacteria Control Management Plan which describes the hydrologic conditions under which the numerical bacteria criteria could be waived. These plans are to identify the specific hydrologic conditions, identify the public notification and education processes that will be followed to inform the public about an event and the plan, describe the water quality assessment conducted to determine bacteria sources and loads associated with the specified hydrologic conditions, and describe the bacteria control program that is being implemented in the basin or specified geographic area for the identified sources.

Portland's NPDES permit states that the approved Bacteria Control Management Plan for Portland's combined sewer system consists of ASFO WQ-NWR-91-75 and the 1994 CSO Management Plan, which was approved by the EQC in June 1995.

## 3.4 1997–2001 Willamette River CSO Predesign

Willamette River CSO Predesign Project (WRPP) was initiated in early 1997 to re-visit the basis and technical options to cost-effectively control the Willamette CSOs. The WRPP was performed by an integrated team of city and consulting staff. The project received national expert advice from an Advisory Team, and guidance on local priorities and public review through a Stakeholder Taskforce.

The WRPP examined a full range of technical options to cost-effectively control the Willamette CSOs and continue the steady pace of program implementation by preparing preliminary design documents ready for design. To accomplish these objectives, Portland carried out new and extensive analyses and evaluations of the various elements required in the Willamette CSO control program. Figure 3-1 shows the project scope and approach that resulted in a completely new solution for the Willamette CSO system and changed how and where Willamette CSOs would be treated.

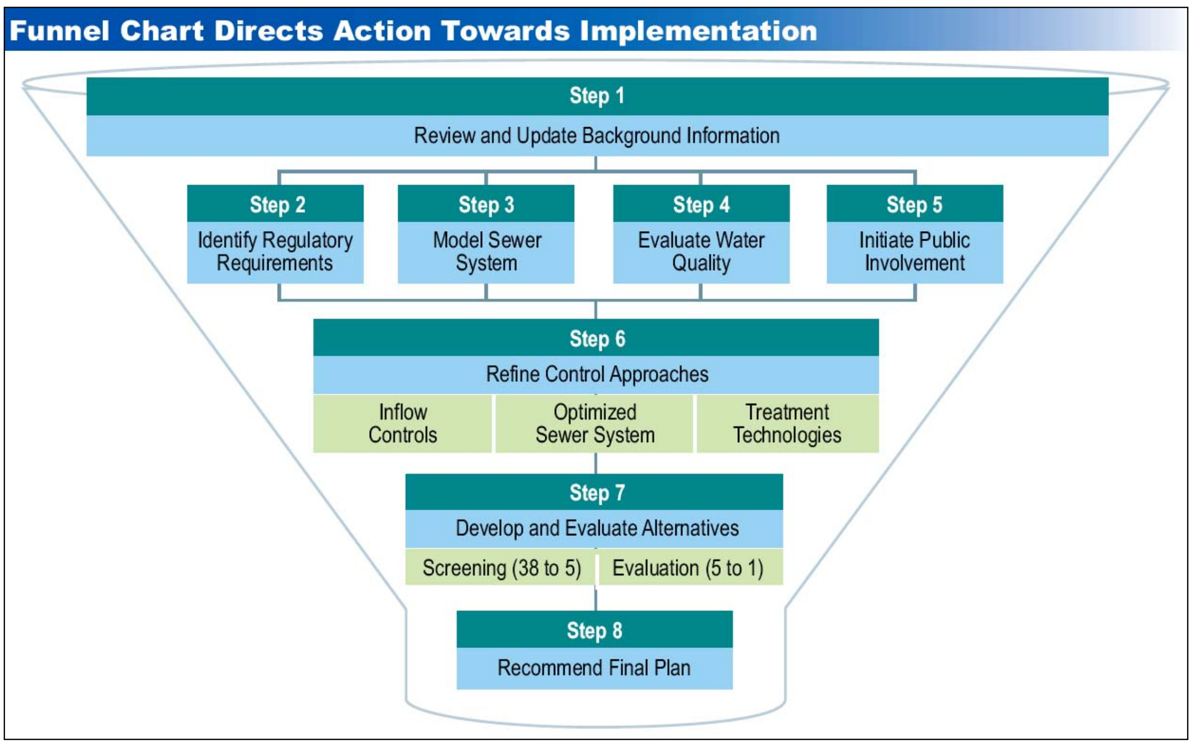


**Figure 3-1.** Scope and Project Approach for the Willamette River CSO Predesign Project

The information provided below summarizes the extensive work performed for this project to determine the most beneficial method for abating the Willamette CSOs. This project, completed in 2001, was the pivot point in the 20-year CSO program that changed the configuration of the CSO control system and demonstrated that CSO flows should be conveyed to and treated at the CBWTP site. The WRPP also increased the areal extent of the

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larger CSO facilities to address flows and loads from the southwest and southeast Portland areas that were found to require much larger CSO facilities than expected in the 1994 Facilities Plan.

### 3.4.1 Willamette River CSO Treatment Alternatives

The CSO treatment processes investigated by the WRPP were divided into two general types for this project—disinfection and solids removal processes. Disinfection would provide treatment for E. coli bacteria while solids removal processes would provide removal of floatable and discrete suspended and/or soluble material attributable to CSO discharges. Acting as stand-alone processes or in combination, these two treatment components were evaluated in considerable detail to provide a level of treatment that would improve the quality of effluent discharged to the Willamette River.

The three disinfection technologies were carried forward to the development of alternatives:

- UV disinfection
- Sodium hypochlorite disinfection with dechlorination
- Gaseous chlorine disinfection with dechlorination

Various solids removal technologies and the disinfection options were combined into specific Alternative Treatment Configurations (ATCs) and then evaluated against water quality impacts criteria. The ATCs were as follows:

1. Coarse Screens/High-Rate Sedimentation (without coagulation addition)/Disinfection
2. Coarse Screens/High-Rate Sedimentation (with coagulant addition)/Disinfection
3. Coarse Screens/Ballasted Coagulation-Sedimentation/Disinfection
4. Coarse Screens/Vortex Separation/Disinfection
5. Coarse Screens/Fine Screens/Disinfection

An example diagram of one of the ATCs or treatment trains evaluated is shown in Figure 3-2.

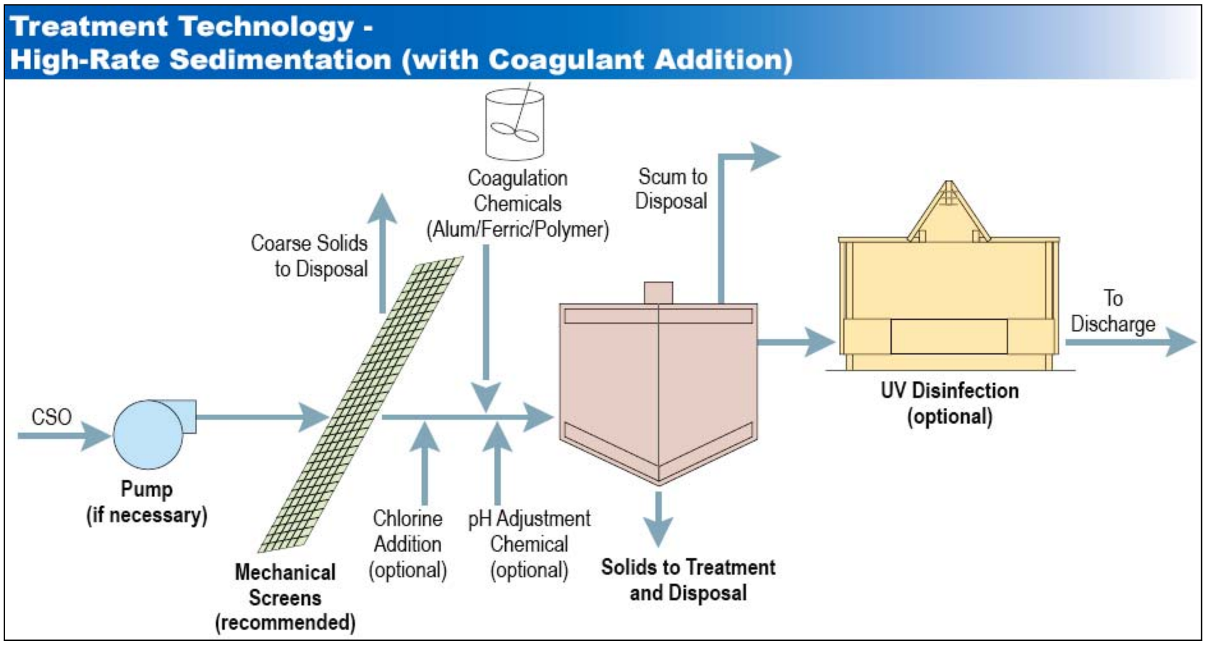


**Figure 3-2.** Example of One Alternative Treatment Configuration for Willamette River WWTF

### 3.4.2 Expanding Secondary Capacity for CSO Treatment

Secondary treatment of CSOs was considered in the 1995 CBWTP Facilities Plan in connection with future dry weather expansion of the CBWTP. The Willamette River CSO Predesign considered including secondary treatment facilities at the Willamette River WWTF site. The idea was to intercept sufficient dry weather wastewater flows for secondary treatment at the WR-WWTF site in lieu of adding similar treatment capacity in the future at CBWTP. This approach would ensure that the Willamette facility was continuously operated by providing secondary treatment for a base sanitary flow during dry weather. During CSO events, the available secondary capacity (about 3 times the average dry weather flow) would be used to treat both sanitary and CSO flows, and the remaining CSO flow in excess of the secondary capacity would be directed to the wet weather treatment train. Overall, providing secondary treatment at the Willamette site was seen as a potential long-range cost-effective alternative that could provide the following benefits:

- Higher quality effluent to the Willamette River for wet weather flows falling within a 3:1peak-to-average dry weather flow capacity and by blending with the secondary treated effluent
- A base staff of operators at the CSO treatment facility year-round rather than intermittent staffing during CSO periods
- Secondary expansion at a Willamette River site rather than at the CBWTP, which might be more acceptable to the public
- Automation of the facility, providing more efficient and effective operation

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The WRPP alternative evaluation process, discussed below, clearly showed that sending all CSO to CBWTP for treatment was the most beneficial. Therefore, the potential secondary treatment plant on the Willamette WWTF site was not pursued.

### 3.4.3 Alternative Solutions for Willamette CSO Control & Treatment

Over 38 alternative configurations were conceived and initially screened to ensure that the best and full range of options to control Willamette CSOs were considered. From the screening of 38 initial alternatives, five major alternatives were proposed for detailed evaluation:

#### *3.4.3.1 Alternative #1: Update the 1994 CSO Management Plan for Willamette CSO Treatment*

- Optimized to improve combined treatment and tunnel costs
- 1994 tunnel diameters would need to upsized from 12 feet to 21 feet
- Wet weather treatment rate reduced to 125 MGD
- Capital costs $595 million, Net Present Worth costs $483 million

#### *3.4.3.2 Alternative #2: Treat Willamette CSO at Swan Island (WR-WWTF)*

- Incorporate upstream collection system improvements including “green” stormwater controls
- Tunnel diameters of 16-feet, WR-WWTF treatment rate of 150 MGD
- Capital cost $534 million, Net Present Worth costs $433 million

#### *3.4.3.3 Alternative #3: Split CSO between Swan Island & CBWTP*

- Northwest route to CBWTP to connect WR-WWTF and CBWWTF
- Tunnel diameters of 10-feet (West) and 15-feet (East), WR-WWTF treatment rate of 150 MGD
- Capital cost $606 million, Net Present Worth costs $505 million

#### *3.4.3.4 Alternative #4: Treat Willamette CSOs at CBWTP – Tunnel Crossing River Route*

- Two options – Northwest (4A) or Northeast (4B) routes to CBWTP
- Tunnel diameters of 18-feet, wet weather headworks required at CBWTP
- Capital cost $478 million, Net Present Worth costs $340 million

#### *3.4.3.5 Alternative #5: Treat Willamette CSOs at CBWTP – East & West Routes, No Tunnel under River*

- Tunnel diameters of 14-feet (West) and 17-feet (East)
- Crossing via force main in the Guilds Lake trench
- Wet weather headworks and additional primary tank required at CBWTP
- Capital cost $489 million, Net Present Worth costs $379 million

Each alternative was modeled and evaluated in detail. Scores were assigned to each alternative based on the benefits they provided according to nine different criteria:

- **Capital Cost** – Includes project management and administration, design, construction management, construction and startup and commissioning.
- **Operation and Maintenance Cost** – Annual cost to operate and maintain the facilities
- **Water Quality Impacts and Permitting** – Related to effluent quality from the facilities, including receiving water impacts, NPDES permit mass load allocation, ESA and Portland Harbor considerations
- **Operational Impacts** – Daily operation of facilities, including staffing efficiencies, number of facilities, chemical transport and storage, truck traffic impacts and solids handling
- **System Flexibility** – Flexibility to operate the facility with existing systems; considers redundant routes for conveying sewage to treatment, and potential for expansion or alteration for changed conditions
- **Implementation Flexibility** – Flexibility in implementation considering ability to provide incremental CSO reduction, reasonable construction schedule, project phasing and construction packaging
- **Constructability** – Construction risks due to geotechnical conditions, size and depth and location of tunnels and pump stations
- **Construction Impacts on Community** – Considers amount of construction activity, number of neighborhoods affected, disruption to commercial and residential areas, opportunity for community/public amenities.
- **Public Acceptance** – Likely acceptance by the public based on environmental equity, long-term impacts (odors, noise, traffic, visual degradation, property valuation), and potential local enhancements.

Figure 3-3 shows the summary of scores and relative ranking of the 5 alternatives (highest score reflects best at achieving the criteria). This figure graphically illustrates that the detailed benefit-cost analysis conducted for the Willamette River CSO Predesign, conclusively determined that conveying the Willamette CSO to the CBWTP site (Alternatives #4 and #5) is significantly more beneficial than any other CSO abatement alternative.

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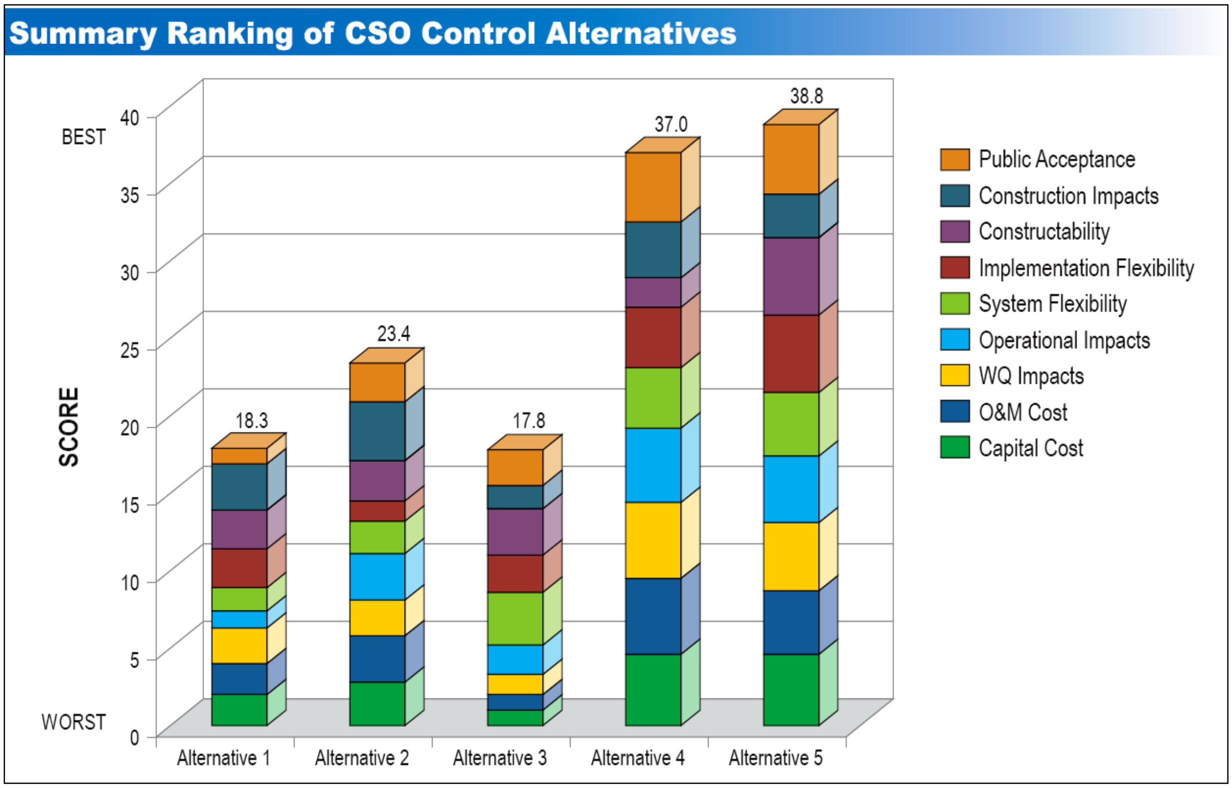


**Figure 3-3.** Willamette River Predesign Alternative Evaluation Results

The specific advantages of Alternative 5 and Alternative 4 (relevant to this report) were identified to include:

- Provide critical redundancy for both the CSO and the combined sewer system, and therefore the two parts of CSO system (West and East) act as a backup in case of a partial failure of either the interceptor system (daily flows) or part of the CSO system (wet weather flows).
- Alternative 5 can be converted to Alternative 4 if necessary, but the reverse is not true. Therefore, Alternative 4 can be held as the reserve alternative.[2]
- Both alternatives allow BES to build facilities according the ASFO schedule, in two phases. In this manner, the benefits of conveying CSO to CBWTP are realized sooner.
- Alternatives 4 and 5 provide for consolidated treatment at one facility (instead of multiple facilities).
- Alternatives 4 and 5 maximize use of the existing conveyance and treatment infrastructure.

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[2] During design of the Northwest Route for Alternative 5, it was determined that the multiple permit approvals needed for a shallow trenched river crossing would be significantly stalled due to the ESA listing of the Willamette River for salmonids, and the possible Portland Harbor Superfund listing. To meet schedule and avoid permitting delays, a deep tunnel crossing was needed, which converted the preferred approach to Alternative 4B.

The project team, internal and external stakeholders (including citizens, DEQ staff and representatives from business and environmental groups) selected Alternative 5 because it had the highest benefit score.

### 3.4.4 Previous CSO Treatment Alternative Evaluations—Convey to CBWTP for Primary Treatment and Maximize Existing Secondaries

The three major CSO treatment planning efforts presented above conclusively demonstrated that conveying the captured CSO to CBWTP for a minimum of primary treatment was more beneficial than other CSO abatement alternatives because:

- The infrastructure Portland is providing to convey CSO to CBWTP provides a redundant system able to capture and convey both dry and wet weather flows safely to the treatment plant if an emergency failure should occur to the collection system, the interceptor system or one of the major pump stations. This is a significant benefit for environmental risk management.
- A higher quality effluent will be achieved for many of the events when secondary capacity is available for treating CSO, including the CSO stored in the onsite wet weather primary clarifiers.
- There are considerable cost-efficient benefits in using existing facilities and sharing future facilities
- The operational reliability provided by a facility that is staffed and in service 24 hours/day is much higher compared to a wet-weather only facility that must be quickly activated to treat CSO.

CBWTP safely discharges into a receiving stream that is most able to accommodate treated effluent and has the least environmental impact without causing exceedances of water quality standards.

### 3.4.5 2001 Updated CSO Facilities Plan

Portland consolidated the major findings from the first 10 years of the program, along with the changes and revised plans for the Cornerstone Program, the Columbia Slough CSO Program and the newly completed Willamette River CSO Predesign into an amendment to the 1994 CSO Facilities Plan. This updated CSO Facilities Plan was submitted to DEQ in December 2001.

## 3.5 Years 2001–2006

### 3.5.1 West Side Willamette CSO Implementation

The CSO Program implementation during this period was dominated by the design and construction of the West Side CSO System, which resulted in the control of 12 more Willamette CSO outfalls. All of these outfalls are located on the west side of the river except for the Riverside Outfall 47. Discharges to this outfall were controlled in 2006 when the outfall pipe was connected into the Swan Island Confluence Structure where the West Side and East Side CSO Tunnels connect. Therefore, although Riverside Outfall 47 is geographically an "east side" outfall, it was controlled early by the West Side Willamette CSO Program.

**The West Side CSO Tunnel**: Is a 14-foot interior diameter tunnel that collects CSO from the West Side outfalls and conveys it under the Willamette River to the Confluence Structure and the Swan Island Pump Station. Five large shafts are used to bring captured CSO into the tunnel, and four of the shafts act as overflow relief points for storms exceeding the design capacity.

**The SW Parallel Interceptor (SWPI)**: Is a 36-inch to 72-inch conduit that parallels the existing SW Interceptor and provides both CSO capture as well as new sanitary conveyance capacity for southwest Portland. The SWPI connects to the West Side CSO Tunnel at the SW Clay Street shaft.

**Swan Island Pump Station & Force Main**: This large 140-foot diameter, 160-foot deep structure was designed and constructed to dewater the West Side (2006) and the East Side (2011) CSO Tunnels. The Phase I implementation completed in 2006 provided 100 MGD pumping capacity and discharges into the Peninsular Tunnel via two force mains for dry and wet weather flows.

### 3.5.2 2003 Nine Minimum Controls Implementation Report

In 2003, BES submitted an updated report to DEQ documenting compliance with the Nine Minimum Controls and describing site-specific implementation.

### 3.5.3 2005 CSO Sizing & Flow Management Predesign

During 2000–2005, Portland's technical staff developed highly detailed explicit models of the combined sewer system that enabled the full simulation of all combined system pipes, the previously implemented Cornerstone Projects, and the incorporation of new green infrastructure stormwater controls. The updated modeling and flow estimates coincided with the need to confirm the sizing of the East Side CSO Tunnel. The new modeling results indicated it would be necessary to increase the size of the East Side CSO Tunnel from the 2001 WRPP proposal of 17-feet to 22-feet diameter. This sizing also accommodates CSO reductions beyond the requirements of the ASFO to address the ASFO's directive to develop and evaluate cost-effective approaches for further reductions in the frequency and volume of CSOs after the term of the ASFO has expired.

This 2005 Predesign also provided a Systems Operation Plan for integrating the operation of the existing combined system with the new CSO facilities.

## 3.6 Years 2006–2011

### 3.6.1 Willamette River Bacteria TMDL: September 2006

As part of the Willamette River Bacteria TMDL approved by EPA on September 29, 2006, the City of Portland received an average wet weather event load allocation for CSO discharges consistent with the level of CSO control specified in the ASFO. These allocations are expressed for winter and summer storms with the return intervals stipulated in the ASFO. This load allocation represents a 93% decrease relative to the TMDL conditions reviewed.

### 3.6.2 Additional West Side Willamette CSO Implementation

The Balch Consolidation Conduit project, which includes 84-inch and 54-inch diameter pipes, will carry combined sewage and stormwater runoff from the Balch Drainage Basin to the West Side CSO Tunnel for conveyance to the CBWTP. Construction began in June 2009 and will be complete by December 2011.

### 3.6.3 East Side CSO Implementation

**The East Side CSO Tunnel**: This 22-foot inside diameter tunnel stretches 6 miles along the east side of the Willamette River from SE Portland to Swan Island. CSO consolidation pipes are being constructed to route CSO to six large shafts. The tunnel will capture, convey and store CSO from 14 outfalls and deliver the flow to the Swan Island Pump Station.

**Swan Island Phase 2**: Phase II of the pump station will increase the pumping capacity to 220 MGD and allow flow to be sent to the Peninsular Tunnel to the east or to the Portsmouth Tunnel to the west through the 54-inch Portsmouth Force Main currently under construction.

**Columbia Boulevard Wet Weather Treatment Facility (CBWWTF) Improvements**: When the East Side CSO system is completed in December 2011, the storm-based flows to the CBWTP will increase from about 330 MGD to a maximum of 450 MGD. New capacity must be added to

City of Portland Post-2011 CSO Facilities Plan

several treatment systems at the CBWTP site in order to meet effluent limits and pollution reduction requirements. This includes the following:

- **New Primary Clarifier**. A new primary clarifier was completed earlier in 2009 as an addition to the existing dry weather primary system. The new clarifier will provide redundancy for wet weather primary treatment. Consistent with the alternative analysis and decision process, this new facility will ensure that the CBWTP site provides 450 MGD of primary treatment capacity when the East Side CSO flows begin arriving by December 2011 in full compliance with the NPDES permit and the CSO Policy.
- **Wet Weather Headworks and Fine Screening Facility**. Portland is in the process of rehabilitating the old CBWTP screenhouse to create a 150 MGD Wet Weather Headworks. This new facility will provide fine screening (1/4-inch openings) for 150 MGD of captured CSO flows and will be operated intermittently when flows are sent to the wet weather primaries.
- **Chemically Enhanced Primary Treatment**. Performance of the wet weather treatment system has been measured and analyzed since December 2006 to better estimate the system's performance in 2011, when wet weather flows to the plant will increase by 120 MGD. Analyses indicate that the wet weather primaries may not be able to achieve 70% TSS annual removal, as required in the NPDES permit, under the current configuration. To improve the settling of wet weather solids and meet the 70% TSS annual removal requirement, Portland initiated a pilot test for Chemically Enhanced Primary Treatment (CEPT). Based on the successful results of those tests, the City has begun design and implementation of a CEPT system. This system, to be retrofitted into existing CBWWTF structures, will inject ferric-chloride and polymer into the wet weather stream before it enters the wet weather primaries. Based on the pilot tests, this enhancement will ensure that the CBWWTF will achieve 70% TSS annual removal.
- **Solids Digester Expansion**. The CBWTP uses anaerobic digestion to stabilize organic solids that enter the plant. The organic solids, known as primary sludge, are pumped out of the primary clarifiers and distributed to four primary anaerobic digesters. In addition, organic solids wasted from the activated sludge process receive preliminary thickening in the sludge processing area and are then pumped to the primary digesters.

  After receiving treatment in the primary digesters, solids are transferred either to the solids holding lagoon or to the four secondary digesters. After adequate detention time in the anaerobic digesters, sludge is processed via belt press dewatering and lagoon digestion, storage, and dredging. Processed biosolids eventually are dewatered and shipped to Eastern Oregon for land application.

  Due to the connections from the West Side CSO System, solids loading to the CBWTP site have increased during wet weather. Captured CSO solids and flows during extreme storms can stress the capacity of the existing primary digesters by reducing detention time to the minimum 15 days. To ensure that there is adequate capacity for the increased CSO solids expected after December of 2011, the City has completed design and is now constructing two additional anaerobic digesters.

- **Tunnel Storage Optimization**. One of the final improvements for treating CSO flows at the CBWTP site will be the utilization of CSO tunnel storage to provide flow equalization for small storms, and extended detention for large storms to allow more CSO to be treated through secondary capacity after the storm has ended.

  The 2006 System Operations Plan is being updated to reflect lessons learned since 2006 and new strategies for the 2011 system that will provide operating features and options to support both dry and wet weather treatment at the CBWTP site.

- **Sellwood/Lents CSO Storage & Pumping System**: This system utilizes the large, 4,000-foot-long Lents Trunk outfall (OF#27) as an in-line storage system that is dewatered by the new Sellwood CSO pump station. Combined sewage flows from the Lents basin are diverted into the Southeast Relieving Interceptor until it surcharges (to maximize the flow to the treatment plant, NMC #4) before overflowing to the Lents Trunk outfall. This system effectively controls CSO from the Lents and the Sellwood overflow locations.

## 3.7 Successful Completion of ASFO Requirements

Every step of the way, the City has met the SFO and ASFO milestones and CSO reduction requirements. The final ASFO-related projects are on schedule to be completed in 2011. As specified by the ASFO, CSOs to the Columbia Slough are eliminated for all storms up to the 5-year winter and the 10-year summer storms, and CSOs to the Willamette River will be eliminated for all storms up to the 4-per-winter and 3-year summer storms.

The completed Columbia Slough CSO control system is shown in Figure 3-4. This figure also provides a comprehensive view of the Cornerstone Projects and the scale of their implementation accomplished from 1995 through 2009. The completed Willamette CSO control facilities and those scheduled for completion in 2011 are shown in Figure 3-5. The CSO outfalls shown in these figures are color coded to indicate their status.

Monitoring data indicate that the expected CSO control performance standards are being achieved by the completed systems. For a comparison of the expected CSO control performance standards with actual performance data for each outfall refer to Section 4.11. Performance projections for the City-wide CSO control system facilities scheduled to be finished in 2011 are presented in Section 5.2. The 2011 projections indicate that with implementation of the final phase of the LTCP the ASFO CSO control requirements will be met.

When the CSO LTCP began in the early 1990s, the annual CSO volume was estimated to be approximately 6 billion gallons. Since then with the implementation of LTCP projects, the annual CSO volume has been reduced to approximately 2.0 billion gallons as of 2009. With completion of the East Side CSO projects in 2011, the volume is projected to be reduced to approximately 200 million gallons. The CSO reductions achieved by Portland's LTCP are shown graphically in Figure 3-6 along with the CSO reductions expected to be achieved in 2011 when the final projects are implemented. These dramatic and steady CSO reductions illustrate Portland's commitment to meeting the ASFO and NPDES permit requirements and the benefits of Portland's successful partnership with City rate payers.

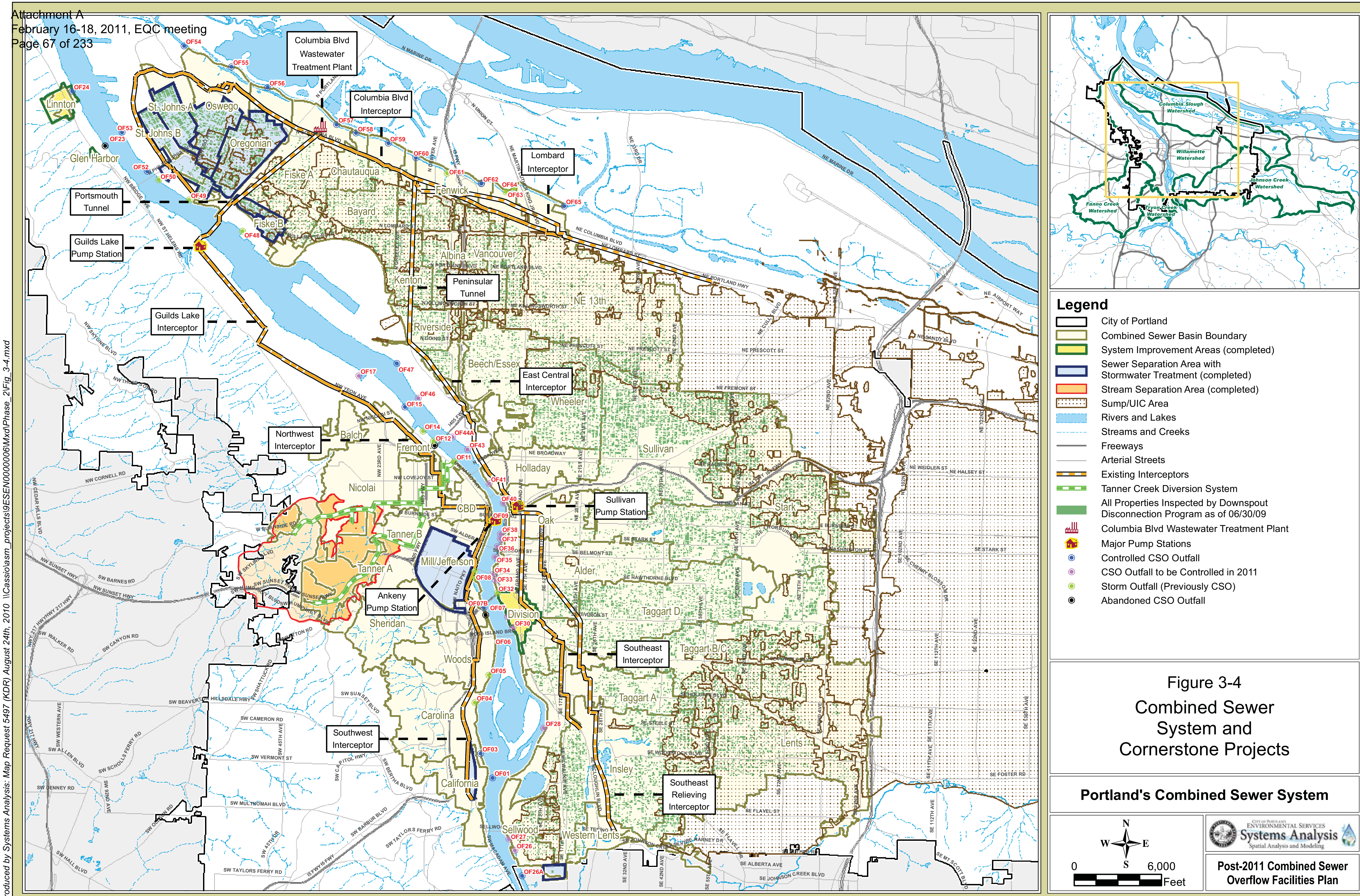


Figure 3-4
Combined Sewer System and Cornerstone Projects

**Portland's Combined Sewer System**

**Post-2011 Combined Sewer Overflow Facilities Plan**

Produced by Systems Analysis: Map Request 5497 (KDR) August 24th, 2010 \\Cassio\asm_projects\9ESEN0000006\Mxd\Phase_2\Fig_3-4.mxd

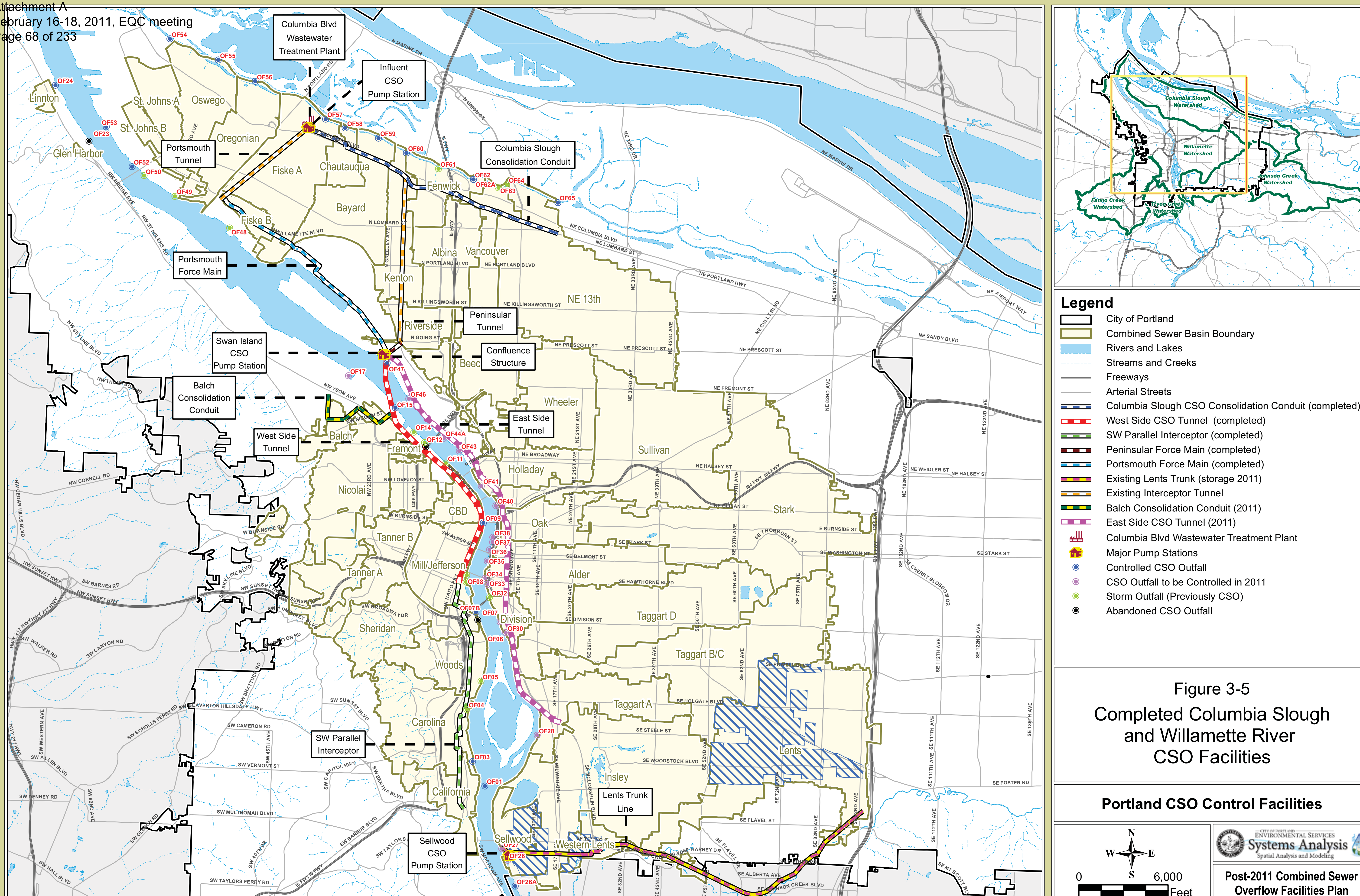


Figure 3-5
Completed Columbia Slough and Willamette River CSO Facilities

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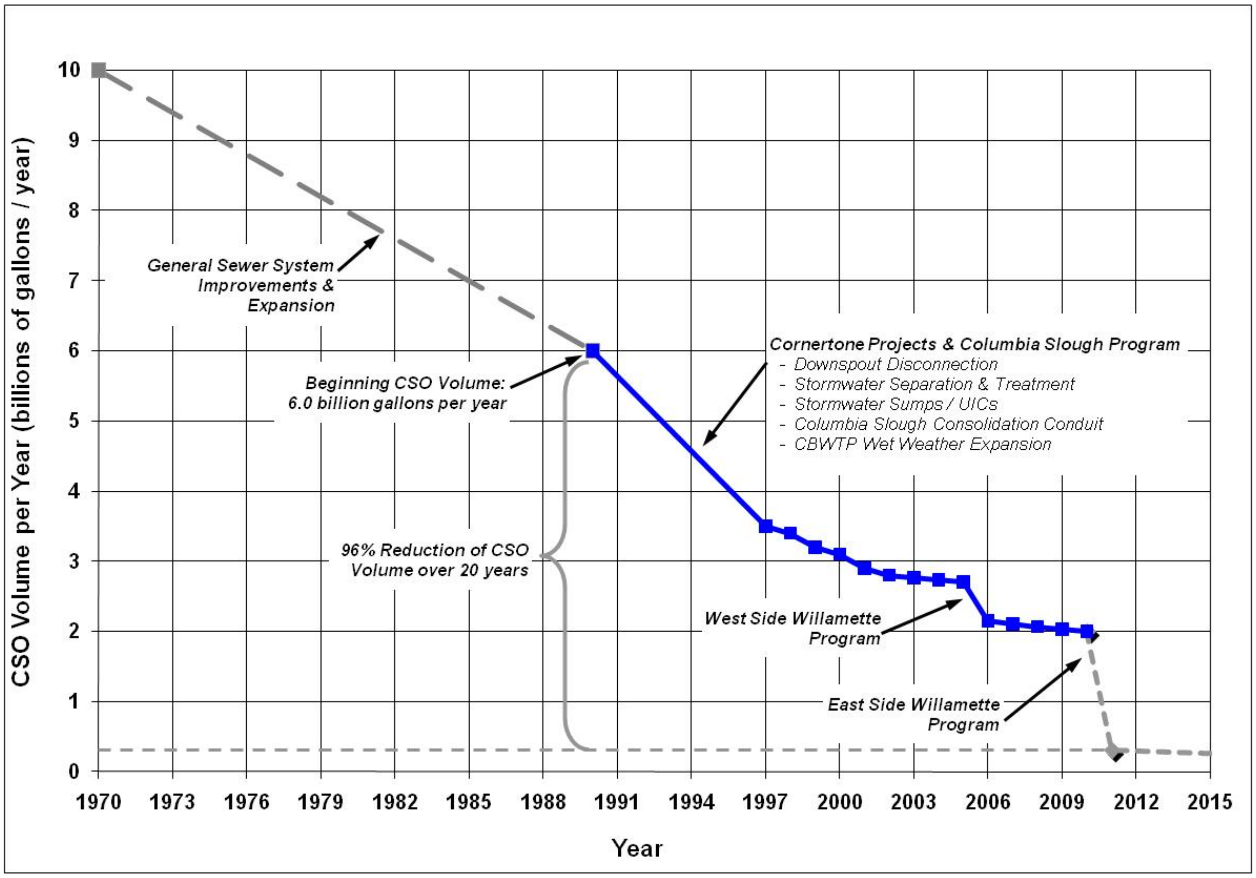



**Figure 3-6**. Overview of Portland's CSO Reductions Since 1970
*CSO LTCP begins in 1991 and concludes in 2011*

# Section 4: Outfall-Specific Levels of Control Achieved by 2011

## 4.1 Introduction

This section describes how BES addressed the following key facets of the LTCP, which are outlined in Section 2.3 of this report:

- Characterization
- Sensitive Uses
- Treatment
- Solids and Floatables Control
- Operations Plans
- Attainment of Water Quality Standards
- Phasing Implementation for Affordability
- Post-Construction Monitoring

In conclusion, this section documents an outfall-by-outfall comparison of expected and actual levels of CSO control based on monitoring data since December 2006.

## 4.2 Characterization

BES addressed the requirements of the CSO Policy with the development of the 1992 *CSO Characterization Report*, 1993 Draft and 1994 *Final CSO Facilities Plan*, 2001 *Willamette River CSO Predesign Report*, 2001 *Updated CSO Facilities Plan*, and the 2005 *CSO Sizing and Flow Management Predesign Report*. These plans included characterization of the system, overflow frequency, volume, and impacts. Characterization was improved with each submission based on better and more information and data.

## 4.3 Sensitive Uses

The Columbia Slough was identified as a sensitive use water body that was severely impacted by CSOs. Consequently the level of control is higher there than in the Willamette River and the deadline for achievement of the controls was sooner—December 2000.

## 4.4 Treatment of Captured Combined Sewage

### 4.4.1 NPDES Permit Effluent Requirements

The draft NPDES permit contains, in Schedule A, effluent requirements for both the CBWTP and the CBWWTF, which specifically requires maximizing the flow up to 130 MGD[3] to secondary treatment and sets effluent limits for the remainder of the wet weather flow:

- BOD annual average removal efficiency of 50%
- TSS annual average removal efficiency of 70%

Although a CSO is a point source that requires a permit, neither a CSO nor a combined sewage collection system are publicly owned treatment works under the regulations of the Clean Water Act. Consequently, CSO flows are not subject to secondary treatment requirements. The CSO Policy has established the equivalent of primary clarification, control of solids and floatables, and disinfection where necessary, as the national treatment technology standard.

The effluent requirements for the CBWWTF are greater than what are established in the CSO Policy. The State has the authority to impose more stringent requirements in order to achieve water quality levels to protect receiving water beneficial uses. With the completion of the CBWTP upgrades, including the Chemically Enhanced Primary Treatment (CEPT) facilities, these effluent limits will be met.

### 4.4.2 CSO Policy and Blending

The CSO Policy specifically requires maximizing the flow to the treatment plant to reduce CSOs and to provide at least primary treatment before discharge. Even though the case law and the CSO Policy confirm that CSOs are not subject to secondary treatment regulations, the framers of the CSO Policy wanted to encourage CSO communities to direct as much combined sewage as practicable to the existing POTW. In 40 CFR 122.41 (m) (4) (A) the intentional bypass of any portion of the treatment plant is prohibited unless there is no feasible alternative. To respond to this requirement, the CSO Policy calls for permitted bypass based on the alternatives analyzed and the cost-effectiveness justification provided in the LTCP. The concept was that the LTCP would propose and review alternatives for CSO control, including treatment options and thereby cover the requirements of the

[3] During workshops at BES on April 15 and 16, 2010, discussion about maximum flow through the secondaries at CBWTP focused on 120 MGD, even with completion of the upgrades to the plant. The draft NPDES permit in Schedule A specifically defines "*130 MGD when wet weather flow is maximized through the secondary treatment train due to captured combined sewage.*" The maximum of 130 MGD defines the mass loading discharges for specific regulated pollutants. The justification for bypass at the CBWTP states that 100 MGD is the minimum rate to secondaries before bypass can occur, and that the average rate of 110 MGD can be safely sent through the secondaries once the new SVI-selector and step-feed improvements have been implemented.

regulation. The justification would meet the test of allowing a bypass to prevent "severe property damage."

Recently, EPA Regional Offices around the country have been unwilling to rely on the analyses developed in the LTCPs for CSO Control and are requiring the separate submission of a no feasible alternatives analysis (NFAA). BES prepared just such an analysis for the NPDES permit renewal. The NFAA concludes that there is no feasible alternative to the CSO-related bypass:

- All secondary treatment facilities are utilized and there are no auxiliary secondary treatment facilities.
- The maximum capacity for treating wet weather flow through the secondary system is 100 MGD on a sustained basis. Forcing more flow through the secondary system can cause the biomass blanket to be washed out of the clarifiers and cause severe damage to the biological treatment system (severe property damage).
- In combination, the CBWTP and CBWWTF have significantly more primary treatment capacity (450 MGD) than secondary capacity (100 MGD). All 450 MGD of inflow receives a minimum of screening for solids and floatables removal, primary clarification, and disinfection.
  - There are no additional storage facilities onsite to retain the excess flow and the CBWWTF storage is filled.
  - Site constraints make it technically infeasible to add additional secondary clarifiers at the existing site.
- With the addition of the CEPT facilities, the wet weather effluent limits and applicable water quality standards will be attained.

The City's CSO-related bypass to the CBWWTF meets all the requirements of 40 CFR Section 122.41(m)(4) and the National CSO Control Policy. The bypass is unavoidable, there are no feasible alternatives, and water quality standards are met.

## 4.5 Solids and Floatables Control

In addition to the control of solids and floatables at the CBWWTF, BES has developed a plan for debris control for the Willamette River outfalls that will discharge CSO during storms more frequent than a 5-year winter or a 10-year summer storm. For outfalls controlled by the deep tunnels, no additional control is necessary because the tunnel walls and the drop shafts together act as baffles to keep floatable debris in the tunnel for eventual pump out to the treatment plant. In contrast, the SW Parallel Interceptor is designed to overflow at the top of the pipe at the Sheridan Outfall 07; therefore a large paneled bar screen system downstream of the overflow structure captures the solids and floatable materials. Also, when CSOs are controlled by a modified diversion structure (North Willamette basins), floatables are controlled with a siphon-baffle or bar screens constructed into the diversion structure. Permanent floatable control devices are intended to be self-cleaning or efficiently and easily cleaned by maintenance crews. Cleaning and inspection of these permanent devices will be done within 7 days after a CSO event has ended as determined by the monitoring system.

## 4.6 Operation Plans

The permit requires additional treatment conditions that are consistent with the CSO Policy to maximize the removal of pollutants during and after each wet weather event using all available facilities within the collection and treatment system. The BES Operations Plan uses a hierarchy of objectives to: protect the treatment plant, public health and the environment, comply with NPDES permits limits, and comply with the CSO Policy including the NMCs. The prioritized objectives for the System Operation Plan are:

1. Protect and maintain CBWTP's biological system and meet effluent discharge limits:
   - Maintain 100+ MGD through secondaries in wet weather
   - Secondary effluent: achieve maximum monthly average:
     - < TSS 30 mg/l
     - < BOD 30 mg/l
2. Capture and convey all dry weather flow:
   - Treat all through primary and secondary system
3. Prevent releases to street/basement:
   - Keep sewage away from human contact
4. Capture and convey maximum amount of wet weather flow:
   - Treat all CSO via primary and disinfection as a minimum
5. Treat as much CSO through secondary as possible:
   - Store CSO in wet weather primaries and tunnels until secondary system is available (but not > 48 hours)
6. Protect Columbia Slough (Sensitive Area):
   - Higher level of CSO control required for Columbia Slough compared to Willamette River (10x's difference)

7. Minimize energy usage and pumping costs:
   - Keep flows to tunnel at a minimum if possible
   - Pump during low-cost periods of the day
8. Minimize sedimentation/settling in tunnels and other maintenance headaches:
   - Keep flows at high rate through interceptors and tunnels to prevent sedimentation and hardening
   - Employ self-cleaning cycles at CSO pump stations

BES has implemented real time control systems as new large facilities have come on line. To fully comply with all the requirements of the ASFO, the NPDES Permit, and the Operations Objectives listed above, the components of the system have to operate at the design level. At present, the CBWTP operators are successfully operating the West Side collection system relying on the real time automated communication and control system. An example of the excellent management of the CSO system is provided by the performance data, which show that between December 1, 2006, and June 2010 there have been no overflows to the Columbia Slough and a total of eight CSO events on the West Side, as follows:

- Six winter events, which equal an average of two events per winter
- Two summer events that exceeded the 3-year summer storm criteria
- Approximately 94% of the combined sewage flow was treated through the secondary system at the CBWTP

## 4.7 Attainment of Water Quality Standards

The levels of CSO control for both the Willamette and the Columbia Slough were established in order to attain water quality standards. After these overflow limits were set, the Willamette River Bacteria TMDL was developed taking into account the bacteria loading reductions that would be achieved with the CSO controls. The TMDL incorporated these loading reductions to develop the waste load allocation for Portland's CSO system. As a result, the 4-per-winter and 3-year summer design storm criteria for CSO control demonstrate full compliance with the bacteria TMDL and water quality standards in the Willamette River.

## 4.8 Phasing Implementation for Affordability

The ASFO and the EPA CSO Policy recommend that strategies and technologies for control of CSO should be cost-effective. The CSO Policy recommends an analysis to determine

City of Portland Post-2011 CSO Facilities Plan

where the increment of pollution reduction achieved in the receiving water diminishes compared to the increased costs; this approach is known as the "knee of the curve."

The SFO was issued in 1991, but it was unclear at the time how much it would cost and how long it would take to meet the requirements. The SFO included a reopener clause which BES exercised. The 1993 Draft CSO Facility Plan (consistent with the requirements of the LTCP) considered alternatives, costs, and water quality benefits, and proposed a cost-effective program. Cost-effectiveness was determined from the "knee-of-the-curve approach, indicating the cost-effective level for CSO control as shown in Figure 4-1 (based on information provided in Table 3-1). This chart was helpful in establishing a new cost-effective and affordable level of control for the Willamette River CSO program.

Affordability is greatly impacted by the schedule for implementation and cash flow; however, the schedule for the Portland CSO Program remained fixed for completion in 2011. BES's approach was to first focus on cost-effective stormwater management programs in the Cornerstone Projects to ensure that clean stormwater does not reach the combined sewer system. This reduced the size and cost of the grey infrastructure needed to control the remaining CSO. The proposed program was reviewed by a committee in the collaborative process and approved in the 1994 AFSO.

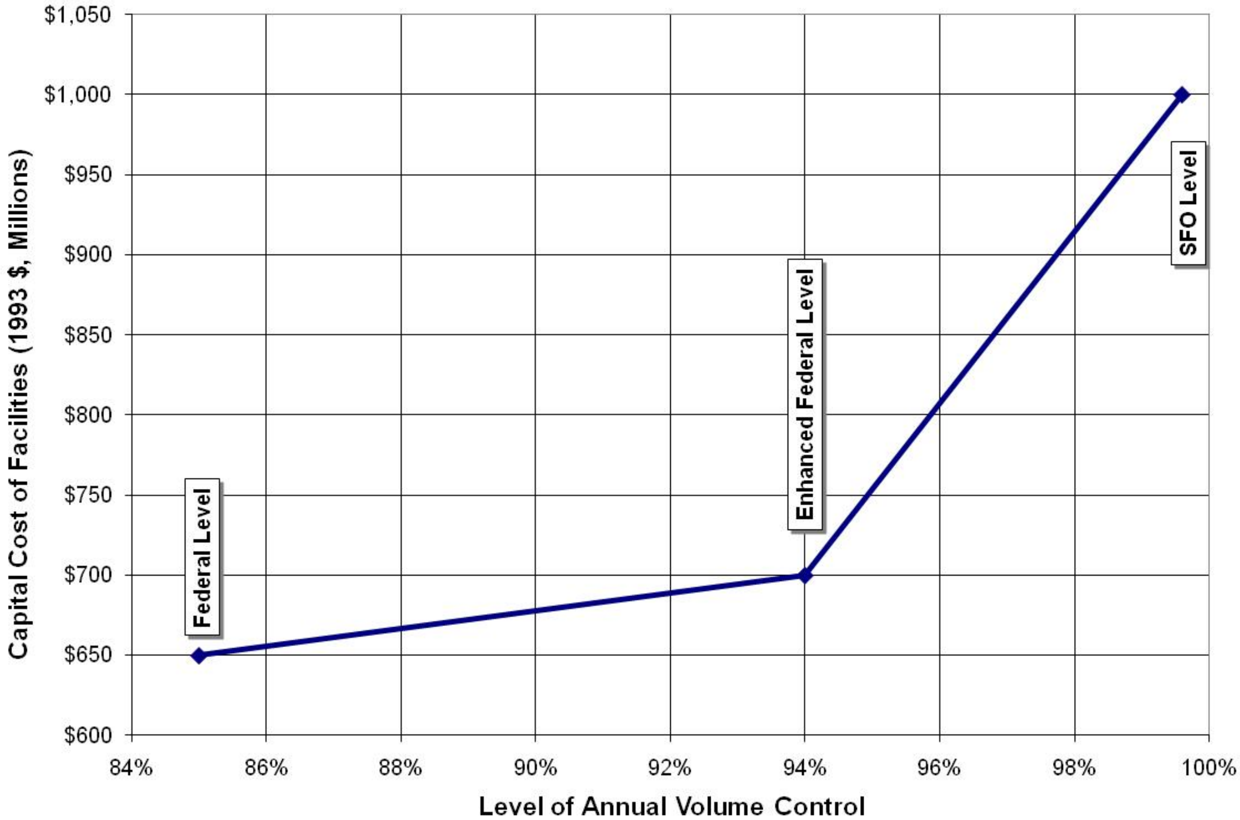



**Figure 4-1**. 1993 Draft CSO Facilities Plan Knee-of-the-Curve Chart

In 1998, as part of the Willamette River CSO Predesign Project, the cost-effective "knee-of-the-curve" for annual and summer CSO volume and frequency with cost information was updated and compared to the 1993 data that were used to select the 4-per-winter and 1-in-3 summer levels of control. Figure 4-2 shows the volume-based knee-of-the-curve chart, which indicated in 1998 that the 94% level of control was still the most cost-effective point. The updated information showed a clear "knee-of-the-curve" at the same 1-in-3 summer levels and 4-per-winter levels of control. Therefore, the level of CSO control was confirmed and the implementation schedule continued to be guided by a phased approach.

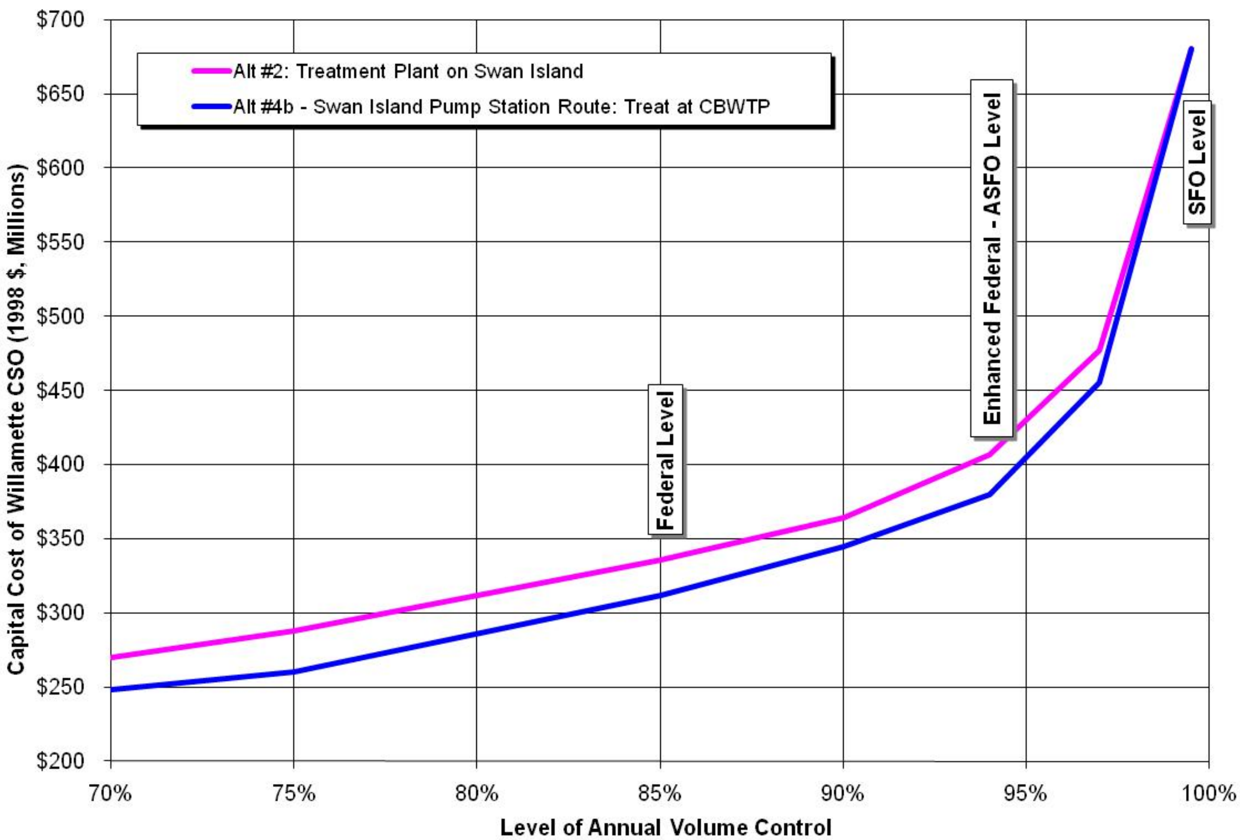



**Figure 4-2**. 1998 Alternatives Review Knee-of-the-Curve Chart

## 4.9 Post Construction Monitoring

Refer to Section 8.2—Long-Term CSO System Inflow and Overflow Tracking.

## 4.10 Expected and Actual Levels of Control

The expected and actual levels of CSO control are summarized in Table 4-1. The table is organized by the LTCP project phases: (1) December 2000 control of all Columbia Slough CSO outfalls, (2) December 2001 closing of 7 Willamette River CSO outfalls, (3) December 2006 control of 16 Willamette River CSO outfalls, and (4) December 2011 control of the 19 remaining Willamette River CSO outfalls.

As shown in Table 4-1, since 2006 no CSOs have occurred at the Columbia Slough outfalls since the CSO control improvements were completed but eight CSOs have occurred at the completed Willamette River CSO outfalls. The corresponding storm characteristics shown in Table 4-2 indicate that all the CSO events occurred due to stormwater larger than the 4-per-winter and 3-year summer storm criteria. These tables indicate that the CSO system is operating as required.

**Table 4-1**. Expected and Actual CSO Control Performance of LTCP Improvements

| Basin | CSO Outfall Number | Method of CSO Control | Expected Storm Performance Standard for CSO Control | Actual Number of CSO Events December 2006 to July 2010 |
|---|---|---|---|---|
| **December 2000: Controlled 13 Columbia Slough Outfalls** | | | | |
| St. Johns A | 54 | Expanded Separation and Downspout Disconnection | 10-Year Summer | Zero |
| Oswego | 55 | Sumps, Expanded Separation, and Downspout Disconnection | 10-Year Summer | Zero |
| Oregonian | 56 | Sumps, Expanded Separation, and Downspout Disconnection | 10-Year Summer | Zero |
| Fiske A | 57 | Cornerstone Projects & Columbia Slough CSO Facilities | 10-Year Summer | Zero |
| Chautauqua | 58 | Cornerstone Projects & Columbia Slough CSO Facilities | 10-Year Summer | Zero |
| Bayard | 59 | Cornerstone Projects & Columbia Slough CSO Facilities | 10-Year Summer | Zero |
| Kenton | 60 | Cornerstone Projects & Columbia Slough CSO Facilities | 10-Year Summer | Zero |
| Fenwick | 61 | Cornerstone Projects & Columbia Slough CSO Facilities | None - Sealed - Stormwater Only | Closed to CSOs |
| Albina | 62/62A | Cornerstone Projects & Columbia Slough CSO Facilities | 10-Year Summer | Zero |
| Vancouver | 63 | Cornerstone Projects & Columbia Slough CSO Facilities | None - Sealed - Stormwater Only | Closed to CSOs |
| NE 13th | 64 | Cornerstone Projects & Columbia Slough CSO Facilities | None - Sealed - Stormwater Only | Closed to CSOs |
| NE 13th | 65 | Cornerstone Projects & Columbia Slough CSO Facilities | 10-Year Summer | Zero |
| **December 2001: Controlled 7 Willamette River Outfalls** | | | | |
| Mill | 8 | Separation - Treat WQ Storm via CSO Facilities | None - Sealed - Stormwater Only | Closed to CSOs |
| Jefferson | 8A | Separation - Treat WQ Storm via CSO Facilities | None - Sealed - Stormwater Only | Closed to CSOs |
| Glen Harbor | 23 | Outfall Sealed | Sealed - No Discharges | Closed to all discharges |
| Fiske B | 48 | Expanded Separation and Downspout Disconnection | None - Sealed - Stormwater Only | Closed to CSOs |
| St. Johns B | 49 | Expanded Separation and Downspout Disconnection | None - Sealed - Stormwater Only | Closed to CSOs |

City of Portland Post-2011 CSO Facilities Plan

**Table 4-1**. Expected and Actual CSO Control Performance of LTCP Improvements

| Basin | CSO Outfall Number | Method of CSO Control | Expected Storm Performance Standard for CSO Control | Actual Number of CSO Events December 2006 to July 2010 |
|---|---|---|---|---|
| Division | 29, 32 | System Improvements & Outfall Sealed | None - Sealed - Stormwater Only | Closed to CSOs |
| **December 2006: Controlled 16 Willamette River Outfalls** | | | | |
| NW 110th | 24 | Partial Separation & Pump Station Improvements | 3-Year Summer | Zero |
| Sellwood | 26A | Partial Separation, System Improvements | 10-Year Summer | Zero |
| California [a] | 1B | System Improvements & Outfall Sealed | None - Sealed - Stormwater Only | Closed to CSOs |
| Carolina | 3 | Southwest Parallel Interceptor (SWPI) | 10-Year Summer | 1 summer, 2 winter |
| Carolina | 4 | Southwest Parallel Interceptor (SWPI) | None - Sealed - Stormwater Only | Closed to CSOs |
| Lowell | 5 | Southwest Parallel Interceptor (SWPI) | None - Sealed - Stormwater Only | Closed to CSOs |
| Woods | 6 | Southwest Parallel Interceptor (SWPI) | None - Sealed - Stormwater Only | Closed to CSOs |
| Sheridan | 7 (7B) | West Side CSO Facilities | 3-Year Summer | 2 summer, 4 winter |
| CBD/Ankeny | 9 | West Side CSO Facilities | 3-Year Summer | 2 summer, 6 winter |
| Tanner | 11 | West Side CSO Facilities, Stream Separation | None - Sealed - Stormwater Only | Closed to CSOs |
| Fremont | 12A, 13 | West Side CSO Facilities | None - Sealed - Stormwater Only | Closed to CSOs |
| Nicolai | 15 | West Side CSO Facilities | 3-Year Summer | 2 summer, 4 winter |
| Riverside | 47 | West Side CSO Facilities | 3-Year Summer | 2 summer, 4 winter |
| St. Johns B [a] | 50 | Expanded Separation and Downspout Disconnection | None - Sealed - Stormwater Only | Closed to CSOs |
| St. Johns B [a] | 53 | Expanded Separation and Downspout Disconnection | 3-Year Summer | Zero |
| **December 2011: 19 Remaining Willamette River Outfalls to be Controlled** | | | | |
| California | 1 | Sewer Separation, Downspout Disconnection; SWPI | 10-Year Summer | Zero |
| St. Johns B | 52 | Expanded Separation and Downspout Disconnection | 3-Year Summer | Zero |
| Balch | 17 | West Side CSO Facilities, Balch Consolidation Conduit | 10-Year Summer | Not applicable [b] |

**Table 4-1**. Expected and Actual CSO Control Performance of LTCP Improvements

| Basin | CSO Outfall Number | Method of CSO Control | Expected Storm Performance Standard for CSO Control | Actual Number of CSO Events December 2006 to July 2010 |
|---|---|---|---|---|
| Sellwood | 26 | Partial Separation, System Improvements | None - Sealed - Stormwater Only | Not applicable [b] |
| Sellwood/ Lents | 27 | Partial Separation, System Improvements, Inline Storage & Pumping | 10-Year Summer | Not applicable [b] |
| Insley | 28 | Cornerstone & East Side CSO Facilities | None - Sealed - Stormwater Only | Not applicable [b] |
| Division | 31 | East Side CSO Facilities | None - Sealed - Stormwater Only | Not applicable [b] |
| Taggart | 30 | Cornerstone & East Side CSO Facilities | 3-Year Summer | Not applicable [b] |
| Alder | 33, 34, 35 | Cornerstone & East Side CSO Facilities | None - Sealed - Stormwater Only | Not applicable [b] |
| Alder | 36 | Cornerstone & East Side CSO Facilities | 3-Year Summer | Not applicable [b] |
| Stark | 37 | Cornerstone & East Side CSO Facilities | None - Sealed - Stormwater Only | Not applicable [b] |
| Oak | 38 | Cornerstone & East Side CSO Facilities | None - Sealed - Stormwater Only | Not applicable [b] |
| Sullivan | 40 | Cornerstone & East Side CSO Facilities | None - Sealed - Stormwater Only | Not applicable [b] |
| Holladay | 41 | Cornerstone & East Side CSO Facilities | None - Sealed - Stormwater Only | Not applicable [b] |
| Wheeler | 43 | Cornerstone & East Side CSO Facilities | 3-Year Summer | Not applicable [b] |
| Beech-Essex | 44A | Cornerstone & East Side CSO Facilities | None - Sealed - Stormwater Only | Not applicable [b] |
| Beech-Essex | 46 | Cornerstone & East Side CSO Facilities | 3-Year Summer | Not applicable [b] |

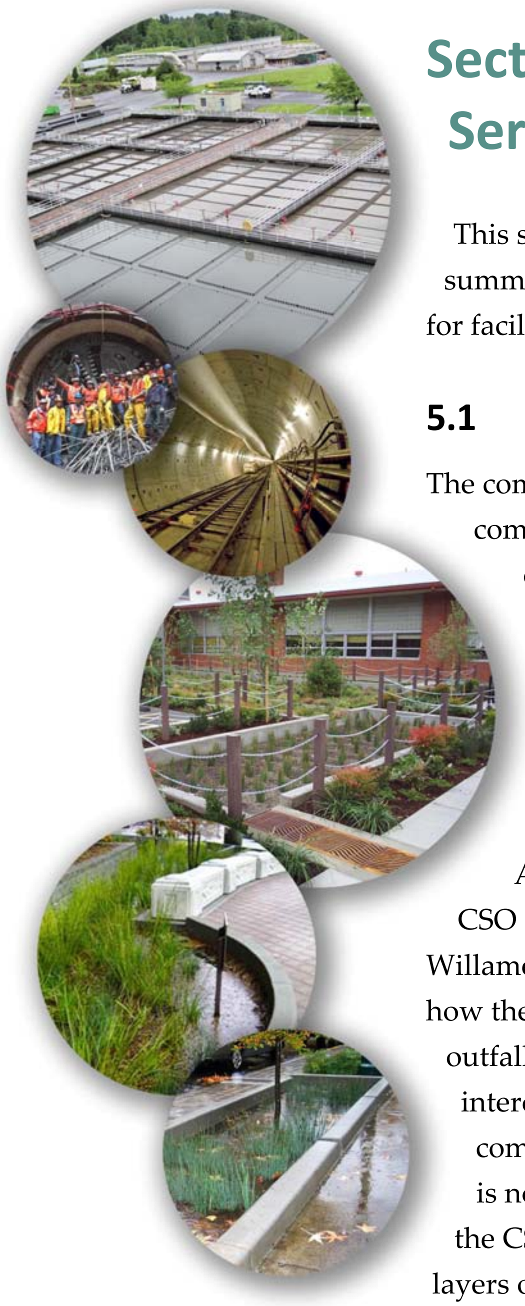
[a] These outfalls were controlled before 2011, but are included in the 2011 list to accommodate ASFO outfall number requirements.

[b] The LTCP improvements (CSO controls) for this outfall are under development and scheduled for completion in 2011. Therefore, this performance evaluation is not yet applicable.

**Table 4-2**. Willamette CSO System Event Record from December 2006 to July 2010

| | | Storm Characteristics | | | System Totals | | Ankeny Pump Station Outfall 9 | | | Nicolai Shaft Outfall 15 | | | Sheridan Outfall 7B | | | Riverside Outfall 47 | | | Carolina Outfall 3 | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Storm Count | Dates of Storm/ Overflow Events | Description | Duration (hr) | Depth (inches) | Overflow (MG) | Duration (hr) | Overflow (MG) | Duration (hr) | Peak Rate (MGD) | Overflow (MG) | Duration (hr) | Peak Rate (MGD) | Overflow (MG) | Duration (hr) | Peak Rate (MGD) | Overflow (MG) | Duration (hr) | Peak Rate (MGD) | Overflow (MG) | Duration (hr) | Peak Rate (MGD) |
| 1 | Dec 14-15, 2006 | 25% larger than ASFO | 48 | 1.97 | 66.9 | 24 | 34.6 | 24 | 132 | 15.9 | 24 | 72 | 7.6 | 24 | 43 | 8.7 | 24 | 40 | | | |
| 2 | Jan 3, 2007 | 25% larger than ASFO | 24 | 1.57 | 5.2 | 4 | 5.2 | 4 | 127 | | | | | | | | | | | | |
| 3 | Dec 2-3, 2007 | 10-year winter storm | 48 | 4.61 | 154.5 | 27 | 99.1 | 27 | 145 | 23.5 | 21 | 93 | 20.5 | 21 | 83 | 11.2 | 21 | 48 | 0.1 | 5 | 1 |
| 4 | Nov 12, 2008 | 23% larger than ASFO | 24 | 1.42 | 8.1 | 4 | 8.1 | 4 | 121 | | | | | | | | | | | | |
| 5 | Jan 1-2, 2009 | Nearly 5-year winter | 24 | 2.73 | 122.6 | 22 | 73.2 | 22 | 110 | 17.6 | 16 | 92 | 21.6 | 18 | 139 | 9.9 | 16 | 68 | 0.4 | 4 | 7 |
| 6 | May 4, 2009 | 1-in-3 year summer | 6 | 0.94 | 5.3 | 1 | 3.5 | 1 | 119 | 0.7 | 1 | 60 | 0.6 | 1 | 102 | 0.4 | 1 | 33 | | | |
| 7 | Nov 7, 2009 | 30% larger than ASFO | 24 | 1.51 | 9.6 | 3 | 8.8 | 3 | 110 | 0.4 | 1 | 29 | 0.1 | 1 | 13 | 0.2 | 1 | 16 | | | |
| 8 | Jun 6, 2010 | 26% larger than 1-in-3 year summer | 6 | 1.07 | 26.0 | 3 | 20.5 | 3 | 258 | 2.6 | 2 | 65 | 1.3 | 2 | 47 | 1.5 | 2 | 36 | 0.1 | 0 | 19 |
| Average Overflow Statistics per Event | | | | | 50 | 11 | 32 | 11 | 140 | 10 | 11 | 69 | 9 | 11 | 71 | 5 | 11 | 40 | 0 | 3 | 9 |

Note: (1) No overflows from Columbia Slough Outfalls 54 through 65 occurred during this time and (2) no overflows from other Willamette River outfalls controlled as of 2006 occurred during this time.



# Section 5: CSO Volumes, Events, and Service Area Characteristics

This section presents an overview of the combined sewer system and summarizes the combined sewer system performance projections used for facilities planning.

## 5.1 Combined Sewer System Overview

The combined sewer service area covers approximately 35,430 acres. The combined system is divided into 42 separate basins. The boundaries of the basins are dictated by the property sewer connections that are associated with the basin outfalls. The extent of the combined sewer service area is shown in Figure 5-1. The CSO outfalls shown in this figure are those initially addressed by the ASFO; the status of these outfalls as a result of implementation of the LTCP is also indicated on the map.

As shown in Figure 5-1, the basins can be grouped into four major CSO service areas: West Side Willamette, East Side Willamette, North Willamette, and the Columbia Slough. The service areas are defined by how the individual basins connect to the interceptor system and how the outfalls connect to the CSO control system. Each basin connects to an interceptor at diversion structures that are designed to send the combined sewage from the basin into the interceptors. When capacity is not available in the interceptor, the diversion structures overflow to the CSO control facilities, as illustrated in Figure 5-2. These cascading layers of basins, interceptors, and CSO facilities define the comprehensive system by which sanitary and combined sewage flows are controlled, captured, and conveyed to CBWTP for treatment. During large, infrequent storms when the tunnels are filled, the excess CSO spills over the control dams in the shafts and discharges to the river or slough. Therefore, the inter-connected combined sewer and CSO systems operate together to minimize the CSO discharge volume, locations, and event characteristics. The features of the CSO service areas are summarized separately below and are illustrated in Figure 5-1.

City of Portland, Post-2011 CSO Facilities Plan

### 5.1.1 West Side Willamette Service Area

The West Side Willamette service area is divided into two parts: the northwest basins that can connect to the Northwest Interceptor, and the southwest basins that connect to either the Southwest Interceptor or the new Southwest Parallel Interceptor. The southwest system receives separated sanitary flows from the Fanno Basin at a manhole near SW Taylors Ferry Road, which divides the flow between the Southwest Interceptor (flows to Ankeny), and the Southwest Parallel Interceptor (flows to the Clay Street Shaft on the West Side Tunnel). CSO from the southwest system is captured in the Southwest Parallel Interceptor and is conveyed to the West Side Tunnel. The Northwest Interceptor technically begins at the Yeon Pump Station, which can pump into the Northwest Interceptor, which flows to Ankeny, or it can pump into the Guilds Lake Interceptor, which flows to the Guilds Lake Pump Station. The Balch Consolidation Conduit captures CSO from Yeon Pump Station and from the upper reaches of Balch Basin and conveys it to the Nicolai Shaft. CSO from the Northwest basins is conveyed to the Nicolai Shaft or to the Upshur Shaft in the Pearl District area. The center of the West Side system is the Ankeny Pump Station, which receives flow from the Northwest and Southwest interceptors. Ankeny pumps dry and wet weather flows to the East-Central Interceptor via force mains under the river. When wet weather flows exceed Ankeny's pump rates, the excess flow spills over a dam into the Ankeny Shaft and the West Side Tunnel.

### 5.1.2 East Side Willamette Service Area

The East Side Willamette service area is divided into three parts according to the three different interceptors: the Southeast Interceptor, the Southeast Relieving Interceptor, and the East-Central Interceptor in the north part of the service area. The Southeast Relieving Interceptor (SERI) receives combined and separated sanitary flows from the Johnson Creek and Lents Trunk service areas and conveys that flow north toward the Sullivan Pump Station. When the SERI exceeds capacity, it will overflow to the Lents Trunk, which conveys flow west toward the Sellwood CSO Storage & Pumping Facility. This new CSO control system receives overflows from the Sellwood and Lents Trunk systems, and pumps the captured flow north to the upper end of the Southeast Interceptor in the Insley basin. At Insley Street, the Southeast Interceptor flows north to Sullivan Pump Station collecting flows from the Insley, Taggart, Division, Alder and Oak basins. Large diversion structures help relieve the Southeast Interceptor and overflow to the East Side Tunnel at Insley (McLoughlin Shaft), Taggart Shaft, and Alder Shaft.

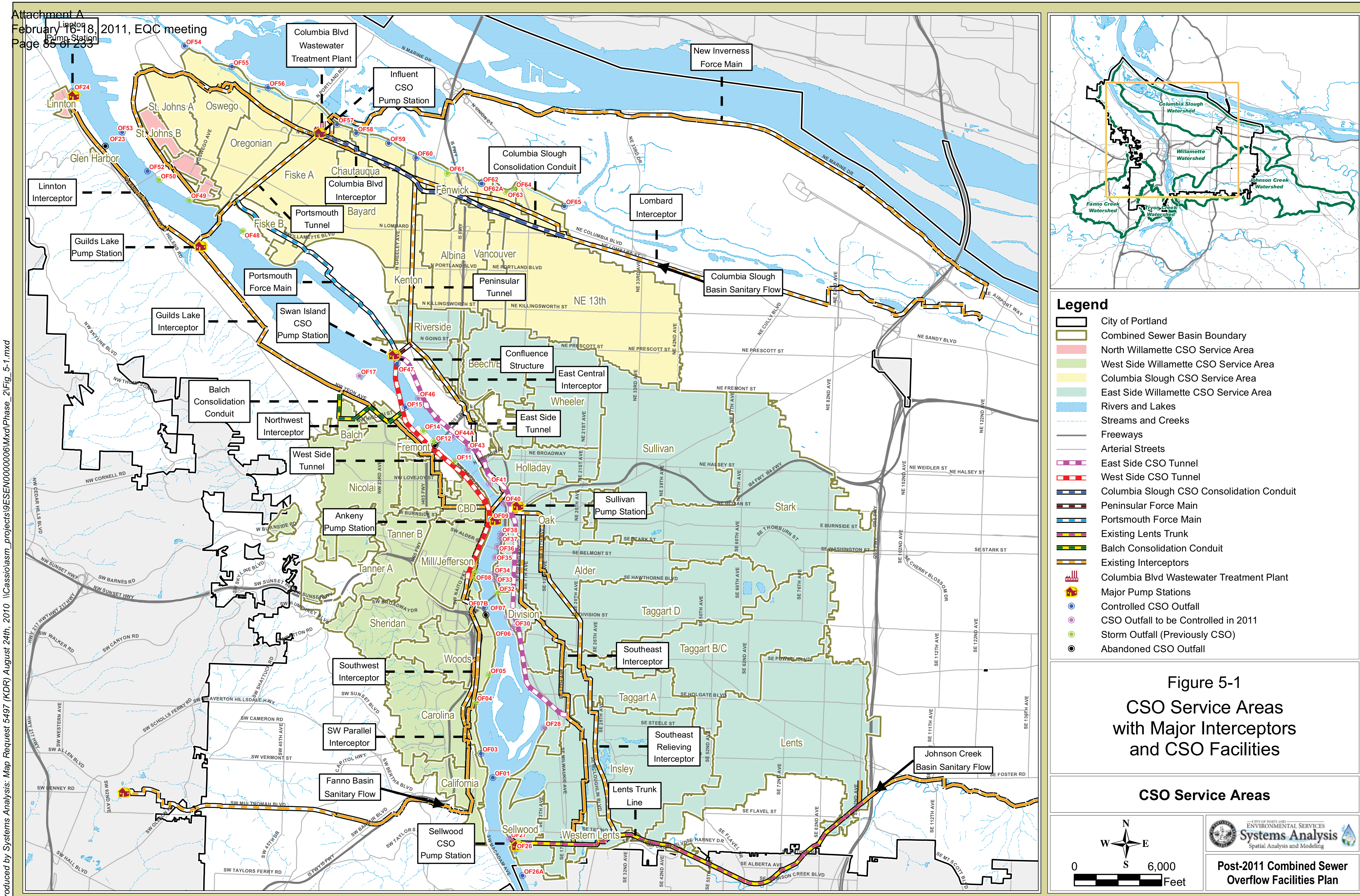



Figure 5-1
CSO Service Areas with Major Interceptors and CSO Facilities

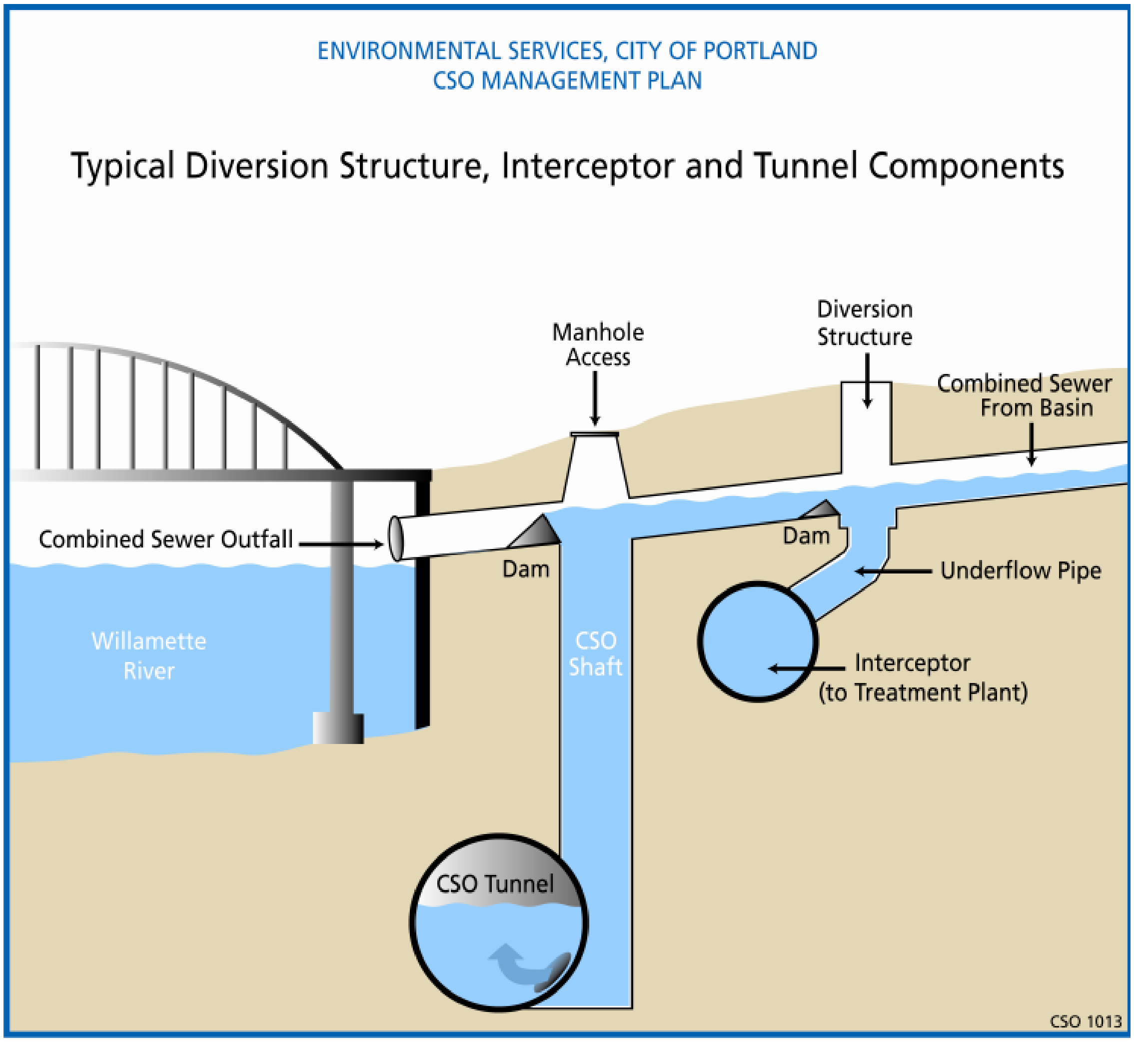



**Figure 5-2.** Typical Diversion Structure, Interceptor, and Tunnel Components

The two interceptors join at the Sullivan Pump Station, which pumps dry and wet weather flows north to the East-Central Interceptor. Overflows from the Sullivan Pump Station, the Sullivan Basin, and excess flows from the East-Central Interceptor all enter Outfall 40 and are dropped into the tunnel at the Steel Bridge Shaft. The Steel Bridge Shaft, which also collects flows from the Holladay basin, is sealed and will not overflow to the river when the tunnel is filled.

The East-Central Interceptor, which serves the third part of the East Side Willamette area, receives flows from Ankeny and Sullivan Pump Station, as well as the Sullivan, Holladay, Wheeler, Beech-Essex, and Riverside Basins, and conveys that flow north into the Peninsular Tunnel. Overflows from these basins are sent to the East Side Tunnel through the Steel Bridge, River Street, and Port-Center Shafts. The captured CSOs from both the East and West Side tunnels are pumped out by the Swan Island Pump Station, which can send flows west to the Portsmouth Tunnel and/or east to the Peninsular Tunnel at the Greeley Shaft.

City of Portland, Post-2011 CSO Facilities Plan

The Peninsular Tunnel conveys the flows from Swan Island and from the East Central Interceptor north to the Columbia Interceptor and into the CBWTP.

During large extreme storms, the East-Side CSO Tunnel, receiving flows from the East Side basins, will fill and overflow out four outfalls: Taggart (OF30), Alder (OF36), River Street (OF43), and Beech (OF46). The four relief points will be activated at the same water surface elevation as the West Side Tunnel overflow points: Sheridan (OF07B), Ankeny (OF09), Nicolai (OF15), and Riverside (OF47) on Swan Island. Because the two tunnels are connected at the Confluent Shaft, they fill and overflow and drain as one large storage system.

### 5.1.3 North Willamette Service Area

The North Willamette basins are unique in that they do not connect into any CSO tunnels and were controlled early in the CSO Program by stormwater inflow controls and structural improvements that prevent CSO discharges from occurring for storms smaller than the ASFO design storms. The Linnton and Glen Harbor basins connect to the Linnton Interceptor, which conveys flow to the Guilds Lake Pump Station. Guilds Lake pumps the northwest Portland flow to the Portsmouth Tunnel and to CBWTP. The St. Johns B basin discharges into the upper end of the St. Johns Interceptor, which conveys flow to the CBWTP and collects dry and wet weather flow from three Columbia Slough basins. The Fiske B basin conveys all flow into the Fiske A basin, which connects to the Columbia Interceptor just upstream of the CBWTP.

### 5.1.4 Columbia Slough Service Area

The Columbia Slough CSO service area is divided into two parts: east and west, with the treatment plant representing the dividing point. The three western basins, St. Johns B, Oswego, and Oregonian, are served by the St. Johns Interceptor and the Rivergate Interceptor. CSOs in this section have been controlled by extensive stormwater inflow controls and system improvements. The eastern part of the Columbia Slough system has also received extensive stormwater inflow controls, and is served by the Columbia Interceptor and the upstream (further east) Lombard Interceptor. In addition, the Columbia Slough Consolidation Conduit was implemented to capture CSOs from the NE 13th, Vancouver, Albina, Kenton, Bayard, Chautauqua, and Fiske A basins. The consolidation conduit is drained by the Influent Pump Station. This multi-level capacity pump station is operated directly by the CBWTP staff to manage flows into the CBWTP while also preventing overflow to the Columbia Slough. This CSO system also receives captured CSO from the Willamette System through the Argyle Structure that conveys peak flows from the Peninsular Tunnel and drops them into the Columbia Slough Consolidation Conduit. This allows the operators to use the maximum available storage in the system before exceeding CBWTP treatment capacity and before discharging CSO to the Willamette River.

### 5.1.5 Other Elements

The majority of pipes within the combined sewer service area convey combined sewage. However, there are a number of locations within the service area where sanitary sewers convey the sanitary flows from upstream basins and individual properties which discharge into the combined system. In addition, storm sewers, combined sewers, or underground injection control structures manage the stormwater runoff from the properties and the public right-of-way.

## 5.2 1994 CSO Long-Term Control Plan Projections

In the early 1990s, BES prepared hydrologic and hydraulic models to examine the behavior of the combined sewer system over the long term and during the SFO design storms. These projections were used in the development and evaluation of CSO management alternatives and subsequent development of ASFO requirements. As documented in the 1994 Portland CSO facilities plan (CH2M HILL, et al.), the performance of the 1990 combined sewer system configuration was simulated for the average year rainfall, long-term performance (with future land use and population) to determine the magnitude and frequency of CSO discharges at each of the 55 outfalls. The results are summarized in Table 5-1.

**Table 5-1**. Estimated Annual CSO Statistics for 1990 System Configuration (from 1994 Portland CSO Facilities Plan)

| Basin | Outfall Number | Annual Number of Events | Annual Overflow Volume (MG) | Overflow Volume per Event (MG) | Overflow Duration per Event (hr) | Maximum Peak Hour Flow Rate 1st Event (cfs) | Average Days of Overflow per Event |
|---|---|---|---|---|---|---|---|
| **West Side Willamette** | | | | | | | |
| California | 1, 1B | 49 | 15 | 0.3 | 26.8 | 27 | 2 |
| Carolina | 3 | 49 | 160 | 3.3 | 24 | 145 | 1.9 |
| Carolina | 4 | 41 | 1 | 0 | 11.1 | 1 | 1.4 |
| Woods | 6 | 48 | 44 | 0.9 | 15.9 | 50 | 1.6 |
| Lowell | 5 | 50 | 3 | 0 | 19.1 | 2 | 1.7 |
| Sheridan | 7 | 49 | 152 | 3.1 | 23.3 | 98 | 1.9 |
| Mill/Jefferson | 8A | 2 | 0 | 0 | 2.8 | 0 | 1 |
| Central Business District/Ankeny Pump Station | 9 | 32 | 114 | 3.5 | 8 | 180 | 1.3 |

City of Portland, Post-2011 CSO Facilities Plan

**Table 5-1**. Estimated Annual CSO Statistics for 1990 System Configuration (from 1994 Portland CSO Facilities Plan)

| Basin | Outfall Number | Annual Number of Events | Annual Overflow Volume (MG) | Overflow Volume per Event (MG) | Overflow Duration per Event (hr) | Maximum Peak Hour Flow Rate 1st Event (cfs) | Average Days of Overflow per Event |
|---|---|---|---|---|---|---|---|
| Tanner | 11 | 50 | 294 | 5.9 | 21.4 | 306 | 1.8 |
| Fremont | 11 | 50 | 294 | 5.9 | 21.4 | 306 | 1.8 |
| Fremont | 12A | 47 | 5 | 0.1 | 16.7 | 8 | 1.6 |
| Nicolai | 13 | 45 | 3 | 0.1 | 14.3 | 5 | 1.4 |
| Balch | 15 | 49 | 260 | 5.3 | 18.7 | 164 | 1.7 |
| *West Side Willamette* | | *Max: 50* | *Total: 1,345* | *Total: 28.4* | *Max: 26.8* | *Total: 1,292* | *Max: 2* |
| **East Side Willamette** | | | | | | | |
| Sellwood | 26A, 26 | 51 | 26 | 0.5 | 20.6 | 20 | 1.8 |
| Lents | 27 | 25 | 8 | 0.3 | 5.7 | 54 | 1.2 |
| Insley | 28 | 29 | 132 | 4.6 | 7.4 | 254 | 1.2 |
| Division | 29, 31, 32 | 51 | 24 | 0.5 | 21.1 | 14 | 1.8 |
| Taggart | 30 | 54 | 1386 | 25.7 | 28 | 855 | 2 |
| Alder | 33, 34, 35 | 46 | 18 | 0.4 | 14.8 | 14 | 1.5 |
| Alder | 36 | 41 | 129 | 3.2 | 14.2 | 137 | 1.5 |
| Stark | 37 | 47 | 484 | 10.3 | 32.1 | 358 | 2.2 |
| Oak | 38 | 57 | 110 | 1.9 | 22.7 | 69 | 1.9 |
| Sullivan/ Sullivan PS | 40 | 49 | 862 | 17.6 | 23.3 | 474 | 1.9 |
| Holladay | 41 | 51 | 93 | 1.8 | 17.0 | 68 | 1.6 |
| Wheeler | 43 | 44 | 77 | 1.7 | 14.4 | 71 | 1.5 |
| Essex | 44A | 49 | 85 | 1.8 | 29.2 | 40 | 2.1 |
| Beech | 46 | 48 | 116 | 2.4 | 19.3 | 96 | 1.7 |
| Riverside | 47 | 54 | 58 | 1.1 | 27.2 | 33 | 2.1 |
| *East Side Willamette* | | *Max: 57* | *Total: 3,608* | *Total: 74* | *Max: 32.1* | *Total: 2,557* | *Max: 2.2* |
| **North Willamette** | | | | | | | |
| Fiske B | 48 | 49 | 12 | 0.2 | 14.6 | 10 | 1.5 |
| St. Johns B | 49, 50, 52, 53 | 52 | 22 | 0.4 | 19.6 | 17 | 1.7 |
| Linnton | 24 | Not simulated in 1990 model | | | | | |

**Table 5-1**. Estimated Annual CSO Statistics for 1990 System Configuration (from 1994 Portland CSO Facilities Plan)

| Basin | Outfall Number | Annual Number of Events | Annual Overflow Volume (MG) | Overflow Volume per Event (MG) | Overflow Duration per Event (hr) | Maximum Peak Hour Flow Rate 1st Event (cfs) | Average Days of Overflow per Event |
|---|---|---|---|---|---|---|---|
| Glen Harbor | 23 | Controlled before 1994 | | | | | |
| *North Willamette* | | *Max: 52* | *Total: 34* | *Total: 0.6* | *Max: 19.6* | *Total: 27* | *Max: 1.7* |
| **Columbia Slough** | | | | | | | |
| St. Johns A | 54 | 44 | 35 | 0.8 | 13.3 | 31 | 1.4 |
| Oswego | 55 | 49 | 55 | 1.1 | 17.4 | 39 | 1.6 |
| Oregonian | 56 | 49 | 112 | 2.3 | 23.7 | 60 | 1.9 |
| Fiske A | 57 | 51 | 195 | 3.8 | 20.9 | 99 | 1.8 |
| Chautauqua | 58 | 50 | 32 | 0.6 | 19.8 | 19 | 1.7 |
| Bayard | 59 | 50 | 110 | 2.2 | 21.7 | 67 | 1.8 |
| Kenton | 60 | 49 | 92 | 1.9 | 23.7 | 52 | 1.9 |
| Fenwick | 61 | 52 | 48 | 0.9 | 19.5 | 24 | 1.7 |
| Albina | 62, 62A | 47 | 49 | 1 | 16.4 | 35 | 1.6 |
| Vancouver | 63 | 48 | 49 | 1 | 24.7 | 32 | 1.9 |
| NE 13th | 64 | 23 | 1 | 0 | 4.1 | 2 | 1.1 |
| NE 13th | 65 | 52 | 470 | 9 | 42.3 | 262 | 3 |
| *Columbia Slough* | | *Max: 52* | *Total: 1,248* | *Total: 24.6* | *Max: 42.3* | *Total: 722* | *Max: 3* |
| **COMBINED SEWER SYSTEM** | | **Max: 57** | **Total: 6,235** | **Total: 127.6** | **Max: 42.3** | **Total:** | **Max: 3** |

## 5.3 Current Projections for 2011 System Performance

By 2005, BES had developed performance projections for the combined sewer system using a highly detailed modeling technique called explicit modeling. With this technique, all of the pipes, manholes, diversion structures, sumps, and pump stations in the basins are simulated as individual objects and impervious surfaces are modeled at the tax lot level.

Modeling at this level of detail makes it possible to calibrate to flow monitoring data with more certainty than with BES's previous traditional models and provides for evaluation of the effects of sustainable stormwater controls. Flows developed using explicit modeling were routed through the interceptor and CSO system for hydraulic analysis of the overflow controls.

The estimated CSO control statistics for summer and winter CSO events for the combined sewer system configuration as it will be completed in 2011 are shown in Tables 5-2 and 5-3. After 2011, all CSO outfalls will be controlled in compliance with the ASFO. These modeling results assume completion of the West Side and East Side CSO Tunnels, Sellwood CSO Pump Station, and the Swan Island Pump Station with pumping capacity of 220 MGD. The modeling results in Tables 5-2 and 5-3 are for existing (2009) Portland population, effective impervious area, and land use conditions.

There are fewer outfalls listed in these tables than Table 5-1 because many of the outfalls previously listed were closed to CSOs as a consequence of the LTCP (see Table 4-1 for information about CSO outfall closures). The model used for these projections was calibrated to the 2007–2009 system configuration, dry weather conditions, and large storms that occurred in 2007–2009.

**Table 5-2.** Estimated Summer CSO Statistics for 2011 System Configuration

| Basin | Outfall Number | Annual Number of Events | Annual Overflow Volume (MG) | Overflow Volume per Event (MG) | Overflow Duration per Event (Hours) | Maximum Peak Hour Flow Rate 1st Event (cfs) | Average Days of Overflow per Event |
|---|---|---|---|---|---|---|---|
| **West Side Willamette** | | | | | | | |
| Carolina | 3 | 0 | 0 | 0 | 0 | 0 | 0.0 |
| Sheridan | 7B | 0.3 | 2 | 6.6 | 3.4 | 175 | 1.0 |
| Ankeny | 9 | 0.3 | 1 | 2.6 | 2.6 | 88 | 1.0 |
| Nicolai | 15 | 0.3 | 4 | 10.8 | 3.2 | 332 | 1.0 |
| Balch | 17 | 0 | 0 | 0 | 0 | 0 | 0.0 |
| *West Side Willamette Basin* | | *Max: 0.3* | *Total: 7* | *Total: 20* | *Max: 3.4* | *Total: 595* | *Max: 1.0* |
| **East Side Willamette** | | | | | | | |
| Sellwood-Lents | 27 | 0 | 0 | 0 | 0 | 0 | 0.0 |
| Taggart | 30 | 0.3 | 6 | 17.3 | 3.3 | 502 | 1.0 |
| Alder | 36 | 0.3 | 3 | 9.8 | 3.3 | 274 | 1.0 |
| Wheeler | 43 | 0.3 | 3 | 8.3 | 3.3 | 223 | 1.0 |
| Beech-Essex | 46 | 0.3 | 2 | 5.1 | 3.3 | 129 | 1.0 |
| Riverside | 47 | 0.3 | 1 | 3.3 | 3.2 | 90 | 1.0 |
| *East Side Willamette* | | *Max: 0.3* | *Total: 15* | *Total: 43.8* | *Max: 3.3* | *Total: 1,218* | *Max: 1.0* |
| *Willamette Tunnels* | | *Max: 0.3* | *Total: 22* | *Total: 63.8* | *Max: 3.4* | *Total: 1,813* | *Max: 1.0* |
| **North Willamette** | | | | | | | |
| St. Johns B | 52 | 0.2 | 0 | 0 | 1.5 | 1 | 1.0 |
| St. Johns B | 53 | 0.3 | 0 | 0.1 | 1.5 | 4 | 1.0 |
| *North Willamette* | | *Max: 0.3* | *Total: 0* | *Total: 0.1* | *Max: 1.5* | *Total: 5* | *Max: 1.0* |
| **Columbia Slough** | | | | | | | |
| St. Johns A | 54 | 0 | 0 | 0 | 0 | 0 | 0.0 |
| Oswego | 55 | 0 | 0 | 0 | 0 | 0 | 0.0 |
| Oregonian | 56 | 0 | 0 | 0 | 0 | 0 | 0.0 |
| Fiske | 57 | 0 | 0 | 0 | 0 | 0 | 0.0 |
| Chautauqua | 58 | 0 | 0 | 0 | 0 | 0 | 0.0 |
| Kenton | 60 | 0 | 0 | 0 | 0 | 0 | 0.0 |
| Albina | 62A/B | 0 | 0 | 0 | 0 | 0 | 0.0 |
| NE 13th | 65 | 0 | 0 | 0 | 0 | 0 | 0.0 |
| *Columbia Slough* | | *Max: 0* | *Total: 0* | *Total: 0* | *Max: 0* | *Total: 0* | *Max: 0.0* |
| **COMBINED SEWER SYSTEM** | | **Max: 0.3** | **Total: 22** | **Total: 63.9** | **Max: 3.4** | **Total: 1,818** | **Max: 1.0** |

**Table 5-3.** Estimated Winter CSO Statistics for 2011 System Configuration

| Basin | Outfall Number | Annual Number of Events | Annual Overflow Volume (MG) | Overflow Volume per Event (MG) | Overflow Duration per Event (Hours) | Maximum Peak Hour Flow Rate 1st Event (cfs) | Average Days of Overflow per Event |
|---|---|---|---|---|---|---|---|
| **West Side Willamette** | | | | | | | |
| Carolina | 3 | 0 | 0 | 0 | 0 | 0 | 0.0 |
| Sheridan | 7B | 1.7 | 22 | 13.4 | 12.1 | 175 | 1.7 |
| Ankeny | 9 | 1.5 | 12 | 6.9 | 11.6 | 100 | 1.7 |
| Nicolai | 15 | 1.7 | 32 | 19.2 | 11.7 | 279 | 1.7 |
| Balch | 17 | 0 | 0 | 0 | 0 | 0 | 0.0 |
| *West Side Willamette* | | *Max: 1.7* | *Total: 66* | *Total: 39.5* | *Max: 12.1* | *Total: 554* | *Max: 1.7* |
| **East Side Willamette** | | | | | | | |
| Sellwood-Lents | 27 | 0 | 0 | 0 | 0 | 0 | 0.0 |
| Taggart | 30 | 1.7 | 60 | 36.1 | 11.8 | 613 | 1.7 |
| Alder | 36 | 1.7 | 35 | 20.7 | 11.8 | 313 | 1.7 |
| Wheeler | 43 | 1.7 | 28 | 16.8 | 11.7 | 213 | 1.7 |
| Beech-Essex | 46 | 1.7 | 17 | 10.3 | 11.8 | 133 | 1.7 |
| Riverside | 47 | 1.7 | 11 | 6.6 | 11.7 | 82 | 1.7 |
| *East Side Willamette* | | *Max: 1.7* | *Total: 151* | *Total: 90.5* | *Max: 11.8* | *Total: 1,354* | *Max: 1.7* |
| *Willamette Tunnels* | | *Max: 1.7* | *Total: 217* | *Total: 130* | *Max: 12.1* | *Total: 1,908* | *Max: 1.7* |
| **North Willamette** | | | | | | | |
| St. Johns B | 52 | 0.2 | 0 | 0 | 4.6 | 0 | 1.0 |
| St. Johns B | 53 | 0.5 | 0 | 0 | 12.4 | 1 | 1.7 |
| *North Willamette* | | *Max: 0.5* | *Total: 0* | *Total: 0* | *Max: 12.4* | *Total: 1* | *Max: 1.7* |
| **Columbia Slough** | | | | | | | |
| St. Johns A | 54 | 0 | 0 | 0 | 0 | 0 | 0.0 |
| Oswego | 55 | 0 | 0 | 0 | 0 | 0 | 0.0 |
| Oregonian | 56 | 0 | 0 | 0 | 0 | 0 | 0.0 |
| Fiske | 57 | 0 | 0 | 0 | 0 | 0 | 0.0 |
| Chautauqua | 58 | 0 | 0 | 0 | 0 | 0 | 0.0 |
| Kenton | 60 | 0 | 0 | 0 | 0 | 0 | 0.0 |
| Albina | 62A/B | 0 | 0 | 0 | 0 | 0 | 0.0 |
| NE 13th | 65 | 0 | 0 | 0 | 0 | 0 | 0.0 |
| *Columbia Slough* | | *0* | *0* | *0* | *0* | *0* | *0.0* |
| **COMBINED SEWER SYSTEM** | | **Max: 1.7** | **Total: 217** | **Total: 130** | **Max: 12.4** | **Total: 1,909** | **Max: 1.7** |

Since completion of the West Side CSO controls in 2006, the average winter CSO performance has been equal to two events per year for the West Side system. This historical performance is characterized in Table 4-2 and shown graphically in Figure 5-3.

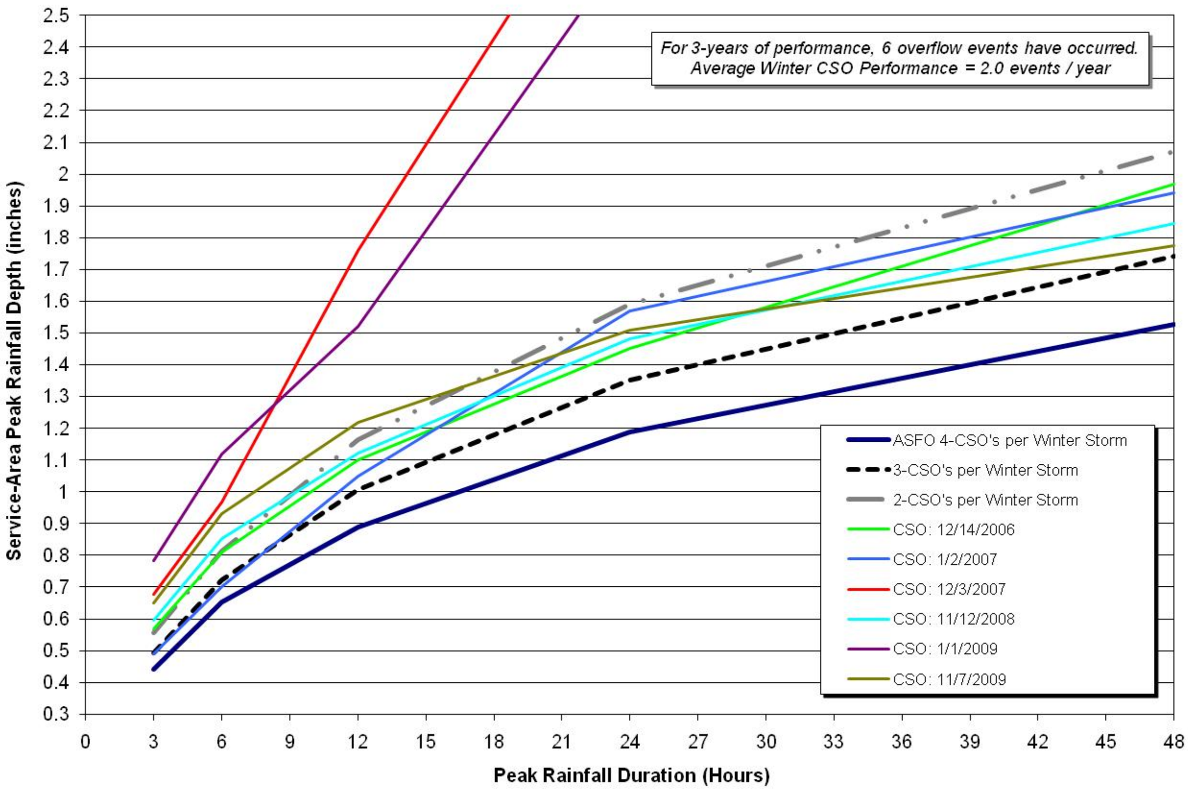



**Figure 5-3.** West Side CSO Tunnel Historical (2006–2009) CSO Events versus Storm Frequency
*Conclusion: All CSO events from the West Side Tunnel System have been caused by storms that exceeded the ASFO 4-per-winter criteria. For statistics on these CSO events see Table 4-2.*

As shown in Figure 5-3, all the winter storms that have caused the West Side Tunnel to fill and overflow since December 2006 have been larger storms (and therefore less frequent) than the ASFO-specified 4-per-winter design storm. When plotted as rainfall depth-duration curves against 4-per-winter, 3-per-winter, and 2-per-winter curves, Figure 5-3 shows that all CSO-causing storms were larger than the 4-per-winter and 3-per-winter design storms. (Note: The larger the storm, the less frequently it occurs, so 3-per-winter storms are larger than 4-per-winter storms.) This result demonstrates that the West Side Tunnel is achieving further reductions in winter overflow frequency compared to the ASFO criteria of 4-per-winter frequency storms. Based on the statistics in Table 4-2, we know that the West Side Tunnel has averaged 2 events per winter. Figure 5-3 gives more information in that it shows the approximate return-frequency of each storm that exceeded the CSO tunnel capacity. Based on Figure 5-3, it can be seen that the tunnel system from 2006 to 2010 has reliably controlled all storms except those that exceeded the 3-per-winter return frequency.

City of Portland Post-2011 CSO Facilities Plan

Therefore, it can be expected that this 2006 tunnel system will overflow fewer than three times per winter on average, which has been the case.

Using similar methods, BES applied the computer model to simulate the future configurations in 2011 and in 2050 to confirm that CSO events will only occur due to storms that exceed the 4-per-winter return frequency as specified in the ASFO. The 2011 Willamette tunnel configuration, with the East Side CSO controls completed, is represented in the storm-frequency results shown in Figure 5-4. In this figure, all storms that cause the tunnel system to overflow are shown as purple lines, and the storms that are captured in the tunnel without overflowing are shown as green lines.

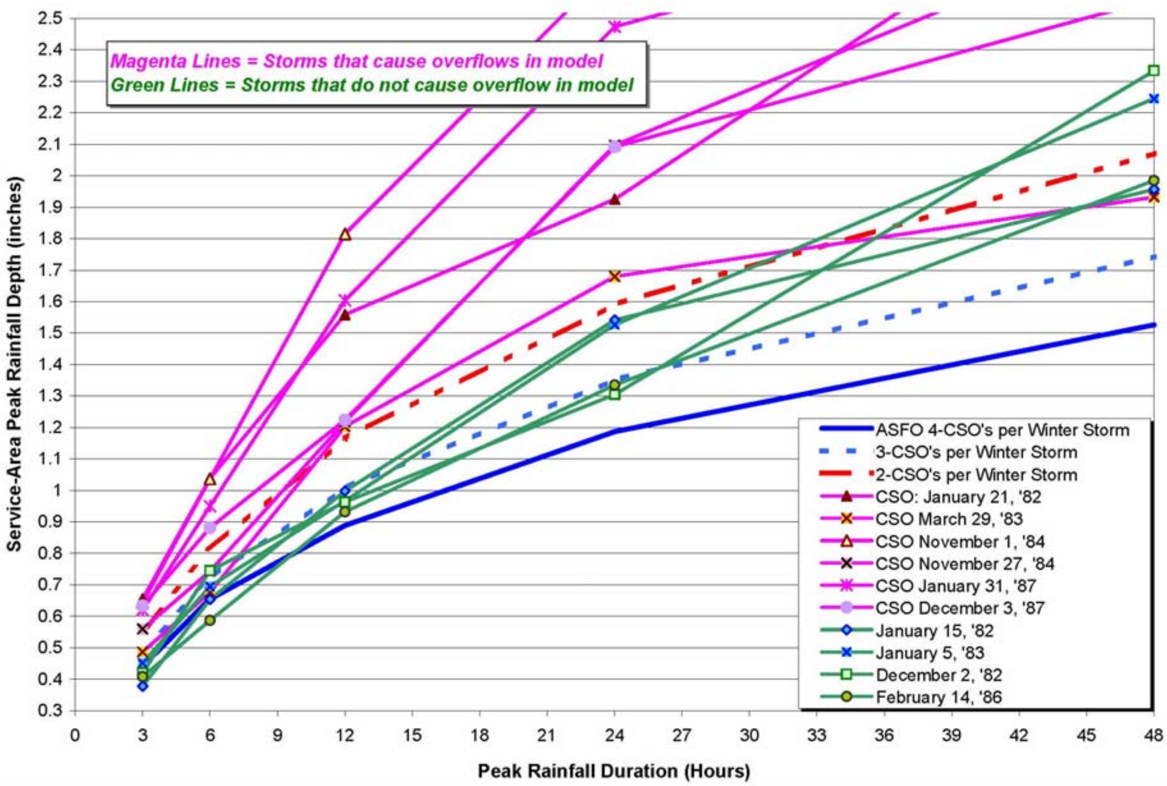



**Figure 5-4**. Simulated Winter CSO Events versus Storm Frequency for 2011 Willamette Tunnel System Configuration

*Conclusion: Tunnel system is not expected to overflow until storms reach a rainfall depth and duration of about two events per winter. For estimated statistics about these simulated CSO events see Table 5-3.*

As can be seen in Figure 5-4, the completed system in 2011 is expected in the models to overflow only when storms equal or exceed the 2-per-winter frequency. This means that the model shows the tunnel overflowing two times per winter or less frequently on average over time. This represents the clearest measure for achieving in 2011 the further reductions in CSO events beyond the 4-per-winter frequency required in the ASFO.

## 5.4 Future (2050) Performance Projections

For long-term planning, BES estimated future condition characteristics based on the City's comprehensive planning data and used the combined sewer system explicit model to simulate how the CSO system will handle future flows under design storm conditions in accordance with the CSO control compliance methodologies approved by DEQ (BES, 2007a and 2007b).

### 5.4.1 Development of Future Condition Characteristics

To characterize future (2050) conditions, BES developed and mapped estimates for changes in effective impervious area in the combined sewer service area. For future conditions, it was assumed that the impervious areas of the following 2006 Comprehensive Plan build-out areas identified by the City of Portland Bureau of Planning will increase:

- Complete 2006 Comprehensive Plan build-out for the Metro 2025 Refill areas. These areas reflect high potential re-development and infill areas that are expected to be 60% developed by 2025 and approximately 100% by 2040.
- Complete 2006 Comprehensive Plan build-out for the Main Street Polygon areas (main corridor town-centers).
- Complete 2006 Comprehensive Plan build-out for the Vacant Lands coverage.
- Complete 2006 Comprehensive Plan build-out for the Interstate Urban Development area.

In addition, the future effective impervious area is estimated by modifying the current effective impervious area through a series of assumptions related to downspout disconnections and implementation of the *Stormwater Management Manual*. These future assumptions were decided upon by the BES Standards & Practices Committee in January 2004. The projected future increases in effective impervious area are illustrated in Figure 5-5. From these assumptions, BES determined via system-wide modeling that approximately 600 acres of new impervious surface would be added to the system and thereby require additional stormwater controls to mitigate runoff into the combined system. Under the future (2050) condition, approximately 22.4 million gallons (MG) of CSO will be generated during the 3-year summer design storm and must be controlled and removed to sustain the further reductions in CSO accomplished in 2011.

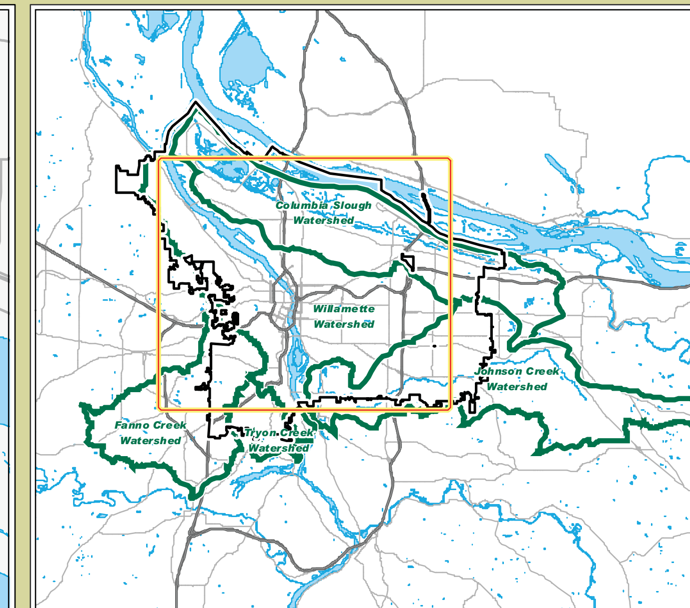
### 5.4.2 Performance Projections for Combined Sewer System with Service Improvements

BES estimated the statistics for summer and winter CSO events under future (2050) conditions assuming that currently planned combined sewer service improvement programs and projects will be implemented. The results are summarized in Tables 5-4 and

5-5 and shown graphically in Figure 5-6. The modeling results shown in Figure 5-6 indicate that the future Willamette CSO Tunnel system, which includes increased impervious surfaces from development and proposed green infrastructure for stormwater reduction, will not overflow except during storms more intense than a 2-per-winter frequency.

The combined sewer system facilities assumed in the 2050 performance projections are those that would be designed and constructed if all of the projects identified in the current BES Combined Sewer System Plan were implemented. These projects were developed to reduce localized street flooding and reduce basement sewer backup risk, but those that incorporate stormwater controls also serve to reduce flows into the combined sewer system and consequently help to reduce CSOs. Implementation of these projects was modeled to demonstrate that stormwater controls can be effective in reducing CSOs in the long-term.

As shown in Figure 5-6, a stormwater control (green infrastructure) approach can effectively keep pace with community growth and sustain further reductions in CSOs. It is unlikely, however, that all of the projects identified in the combined sewer plan for street flooding and BSBR reduction will be implemented because approximately 40% do not meet cost-benefit criteria. The cost-benefit calculations were primarily associated with BSBR reduction but also considered the benefit of CSO reduction. Integration of these projects into a cost-effective CSO reduction plan is discussed in the analysis of post-2011 alternatives presented in Section 6 and the recommended plan for further CSO reductions presented in Section 7.


**Legend**

- City of Portland
- Combined Sewer Basin Boundary
- Rivers and Lakes
- Streams and Creeks
- Freeways
- Arterial Streets

Assumed Change in Effective Impervious Area

- > 60%
- > 40 to 60%
- > 20 to 40%
- ≤ 20%
- No Increase

Portland Comprehensive Plan Year = 2006

Figure 5-5
Increase in Effective Impervious Area From Existing 2006 to Future Zoning

**Combined Sewer System Impervious Areas**

N W E S
0 6,000 Feet

City of Portland Environmental Services Systems Analysis Spatial Analysis and Modeling

**Post-2011 Combined Sewer Overflow Facilities Plan**

Produced by Systems Analysis: Map Request 5464 (KDR) July 23rd, 2010 \\Cassiolasm_projects\ESEN0000006\Mxd\Phase_1\Fig_5-4.mxd

**Table 5-4.** Estimated Summer CSO Statistics for 2050 System Configuration

| Basin | Outfall Number | Annual Number of Events | Annual Overflow Volume (MG) | Overflow Volume per Event (MG) | Overflow Duration per Event (Hours) | Maximum Peak Hour Flow Rate 1st Event (cfs) | Average Days of Overflow per Event |
|---|---|---|---|---|---|---|---|
| **West Side Willamette** | | | | | | | |
| Carolina | 3 | 0 | 0 | 0 | 0 | 0 | 0 |
| Sheridan | 7B | 0.3 | 3 | 7.5 | 7.7 | 181 | 1.5 |
| Ankeny | 9 | 0.3 | 1 | 3.6 | 7.2 | 95 | 1.5 |
| Nicolai | 15 | 0.3 | 4 | 11.8 | 7.5 | 332 | 1.5 |
| Balch | 17 | 0 | 0 | 0 | 0 | 0 | 0 |
| *West Side Willamette* | | *Max: 0.3* | *Total: 8* | *Total: 22.9* | *Max: 7.7* | *Total: 608* | *Max: 1.5* |
| **East Side Willamette** | | | | | | | |
| Sellwood-Lents | 27 | 0 | 0 | 0 | 0 | 0 | 0 |
| Taggart | 30 | 0.3 | 6 | 19.2 | 7.7 | 514 | 1.5 |
| Alder | 36 | 0.3 | 4 | 10.9 | 7.7 | 280 | 1.5 |
| Wheeler | 43 | 0.3 | 3 | 9.2 | 7.6 | 226 | 1.5 |
| Beech-Essex | 46 | 0.3 | 2 | 5.8 | 7.6 | 133 | 1.5 |
| Riverside | 47 | 0.3 | 1 | 3.7 | 7.5 | 91 | 1.5 |
| *East Side Willamette* | | *Max: 0.3* | *Total: 16* | *Total: 48.8* | *Max: 7.6* | *Total: 1,244* | *Max: 1.5* |
| *Willamette Tunnels* | | *Max: 0.3* | *Total: 24* | *Total: 71.7* | *Max: 7.7* | *Total: 1,852* | *Max: 1.5* |
| **North Willamette** | | | | | | | |
| St. Johns B | 52 | 0.3 | 0 | 0 | 1.3 | 2 | 1 |
| St. Johns B | 53 | 0.3 | 0 | 0.1 | 1.5 | 5 | 1.3 |
| *North Willamette* | | *Max: 0.3* | *Total: 0* | *Total: 0.1* | *Max: 1.5* | *Total: 7* | *Max: 1.3* |
| **Columbia Slough** | | | | | | | |
| St. Johns A | 54 | 0 | 0 | 0 | 0 | 0 | 0 |
| Oswego | 55 | 0 | 0 | 0 | 0 | 0 | 0 |
| Oregonian | 56 | 0 | 0 | 0 | 0 | 0 | 0 |
| Fiske | 57 | 0 | 0 | 0 | 0 | 0 | 0 |
| Chautauqua | 58 | 0 | 0 | 0 | 0 | 0 | 0 |
| Kenton | 60 | 0 | 0 | 0 | 0 | 0 | 0 |
| Albina | 62A/B | 0 | 0 | 0 | 0 | 0 | 0 |
| NE 13th | 65 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Columbia Slough* | | *Max: 0* | *Total: 0* | *Total: 0* | *Max: 0* | *Total: 0* | *Max: 0* |
| **COMBINED SEWER SYSTEM** | | **Max: 0.3** | **Total: 24** | **Total: 71.8** | **Max: 7.7** | **Total: 1,859** | **Max: 1.5** |

**Table 5-5.** Estimated Winter CSO Statistics for 2050 System Configuration

| Basin | Outfall Number | Annual Number of Events | Annual Overflow Volume (MG) | Overflow Volume per Event (MG) | Overflow Duration per Event (Hours) | Maximum Peak Hour Flow Rate 1st Event (cfs) | Average Days of Overflow per Event |
|---|---|---|---|---|---|---|---|
| **West Side Willamette** | | | | | | | |
| Carolina | 3 | 0 | 0 | 0 | 0 | 0 | 0 |
| Sheridan | 7B | 1.8 | 26 | 14.1 | 12.7 | 185 | 1.6 |
| Ankeny | 9 | 2 | 13 | 6.4 | 8.9 | 105 | 1.4 |
| Nicolai | 15 | 1.8 | 33 | 18 | 12.4 | 294 | 1.6 |
| Balch | 17 | 0 | 0 | 0 | 0 | 0 | 0 |
| *West Side Willamette* | | *Max: 2* | *Total: 72* | *Total: 38.5* | *Max: 12.7* | *Total: 584* | *Max: 1.6* |
| **East Side Willamette** | | | | | | | |
| Sellwood-Lents | 27 | 0 | 0 | 0 | 0 | 0 | 0 |
| Taggart | 30 | 1.8 | 65 | 35.4 | 12.4 | 559 | 1.6 |
| Alder | 36 | 1.8 | 38 | 20.5 | 12.4 | 292 | 1.6 |
| Wheeler | 43 | 2 | 31 | 15.3 | 9.1 | 210 | 1.4 |
| Beech-Essex | 46 | 2 | 19 | 9.3 | 9.2 | 126 | 1.4 |
| Riverside | 47 | 2 | 12 | 5.9 | 9 | 79 | 1.4 |
| *East Side Willamette* | | *Max: 2* | *Total: 165* | *Total: 86.4* | *Max: 12.4* | *Total: 1,266* | *Max: 1.6* |
| *Willamette Tunnels* | | *Max: 2* | *Total: 237* | *Total: 124.9* | *Max: 12.7* | *Total: 1,850* | *Max: 1.6* |
| **North Willamette** | | | | | | | |
| St. Johns B | 52 | 0.5 | 0 | 0 | 15.1 | 1 | 1.7 |
| St. Johns B | 53 | 0.8 | 0 | 0.1 | 11.3 | 2 | 1.4 |
| *North Willamette* | | *Max: 0.8* | *Total: 0* | *Total: 0.1* | *Max: 15.1* | *Total: 3* | *Max: 1.7* |
| **Columbia Slough** | | | | | | | |
| St. Johns A | 54 | 0 | 0 | 0 | 0 | 0 | 0 |
| Oswego | 55 | 0 | 0 | 0 | 0 | 0 | 0 |
| Oregonian | 56 | 0 | 0 | 0 | 0 | 0 | 0 |
| Fiske | 57 | 0 | 0 | 0 | 0 | 0 | 0 |
| Chautauqua | 58 | 0 | 0 | 0 | 0 | 0 | 0 |
| Kenton | 60 | 0 | 0 | 0 | 0 | 0 | 0 |
| Albina | 62A/B | 0 | 0 | 0 | 0 | 0 | 0 |
| NE 13th | 65 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Columbia Slough* | | *Max: 0* | *Total: 0* | *Total: 0* | *Max: 0* | *Total: 0* | *Max: 0.0* |
| **COMBINED SEWER SYSTEM** | | **Max: 2** | **Total: 237** | **Total: 124.9** | **13.2** | **Total: 1,853** | **Max: 1.7** |

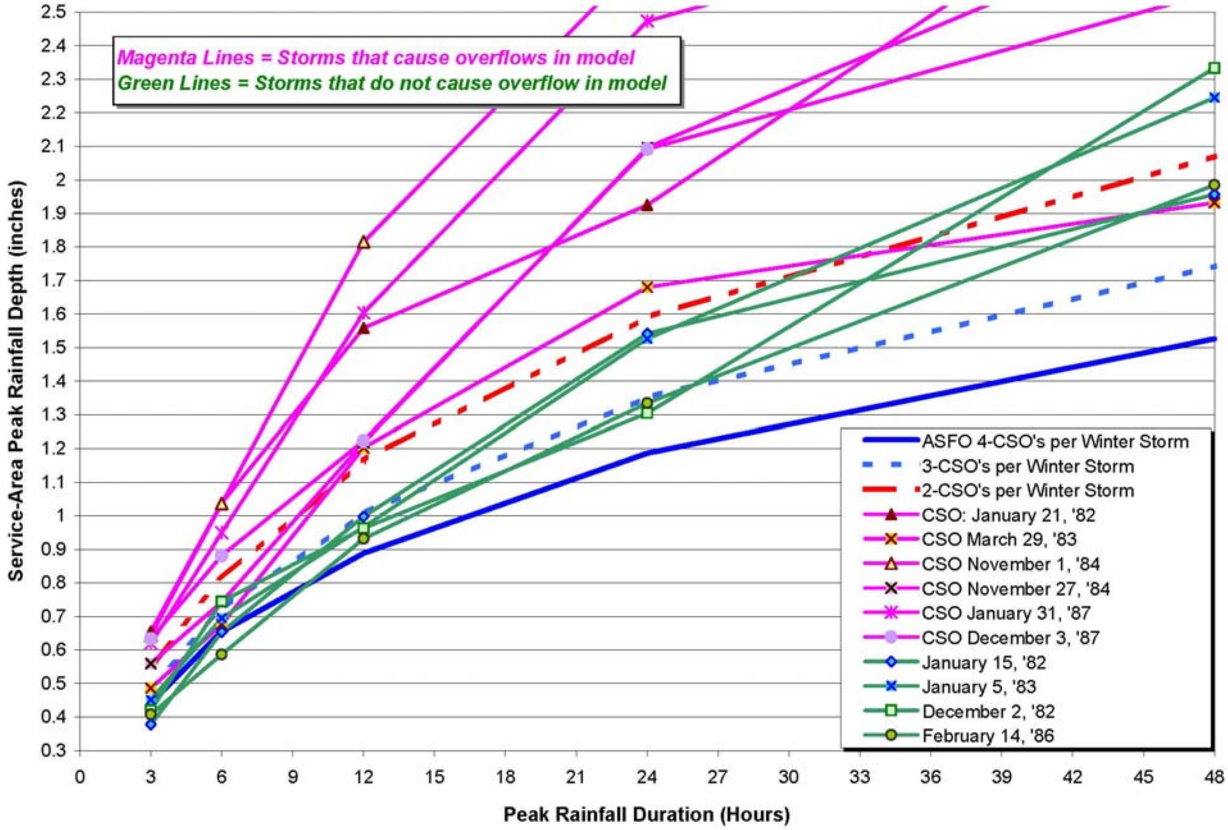



**Figure 5-6.** Simulated Winter CSO Events versus Storm Frequency for 2050 Willamette System Configuration

*Conclusion: Under improved 2050 conditions with the implementation of stormwater inflow control projects, the Willamette Tunnel system is not expected to overflow until storms reach a rainfall depth and duration of about two events per winter. For estimated statistics about these simulated CSO events, see Table 5-5.*

# Section 6: Development and Evaluation of Post-2011 Alternatives

## 6.1 Introduction

### 6.1.1 Purpose

Section 4 demonstrated that the completed CSO system will meet and exceed the ASFO performance criteria by December 2011, and that further reductions beyond the ASFO's 4-per-winter event criteria will be achieved by the December 2011 system. Section 5 established that the Combined System Plan improvements, if fully implemented, could reasonably ensure that the 2050 CSO system performance will also meet and exceed the ASFO criteria and will achieve further reductions of the winter CSO events in a similar manner. Additional analysis for the post-2011 system configuration is warranted, however, for two reasons:

- The ASFO requires consideration of several specific technologies as part of the post-2011 plan.
- Not all Combined Sewer System Plan projects meet cost-benefit criteria, and are therefore not preferred for implementation.

This section evaluates and prioritizes alternatives for ensuring that the "further reductions" to CSO discharges achieved in 2011 are cost-effectively maintained under post-2011 conditions.

### 6.1.2 Organization

The section begins with a discussion of what the post-2011 facilities plan elements must accomplish. The post-2011 goals of further reduction of CSO discharges are first described in terms of CSO volume, then converted to equivalent managed impervious area, in keeping with an integrated watershed-based approach that considers a variety of methods for reducing CSO discharges.

City of Portland, Post-2011 CSO Facilities Plan

Next, the selection criteria for cost-effective candidate methods to achieve further reductions are described and the potential alternative methods with the following ASFO-specified technologies are considered:

- Sewer Separation
- Upsizing of Trunk and Interceptor Lines for Storage
- Operational Enhancements
- Wet Weather Treatment Improvements
- Enhanced Inflow and Pollutant Source Control
- Comprehensive and Multi-Objective Water Quality Improvement Strategies

After screening for viable alternative methods, a multi-criteria comparison and ranking of alternatives is presented.

## 6.2 Goals for Post-2011 Alternatives

BES's policy for controlling CSO and achieving further reductions is to manage stormwater runoff from the future increase in impervious surfaces using green stormwater infrastructure as part of an integrated watershed management approach. Through modeling of the assumed future development growth within the combined sewer service area that contributes flow to the Willamette tunnel system, BES has predicted that stormwater runoff volume for the 3-year summer storm will increase by 22.4 MG in 2050. The modeling determined that this additional volume could be mitigated by directing the runoff to infiltrating and vegetated stormwater control facilities or to separated stormwater conveyance systems. Through additional analysis and review of green street facility monitoring data it was determined that controlling stormwater runoff from 600 acres of impervious area would accomplish the desired decrease of flow into the tunnel system by approximately 22.4 MG during the 3-year summer storm. Therefore, the practical goal for the post-2011 alternatives is to control stormwater runoff from 600 acres of impervious area. This goal may be achieved through the following methods:

- Additional new impervious areas mitigated by refinements to the Stormwater Management Manual (SWMM) and to the assumed effectiveness of specific technologies required by the SWMM
- Existing impervious acres mitigated by new stormwater retrofit projects (public and private)
- Other system changes that remove volumes that are not directly associated with impervious area (e.g., decreased inflow from private separated sanitary sewer laterals)

New or redevelopment must follow the current approved SWMM. Impervious acres managed under current SWMM requirements have already been accounted for in developing the estimated 600 acres of additional mitigated impervious area.

## 6.3 Selection Criteria

This facilities plan must provide BES with prioritized methods to adaptively manage ASFO compliance through 2050. The basic philosophy is to consider cost effectiveness first when selecting proposed methods. If a method is found to be cost effective, given current available information, then further screening is performed to rank alternatives for implementation. A more detailed description is provided below.

The approach to selecting alternative methods for further CSO reduction involves three basic components:

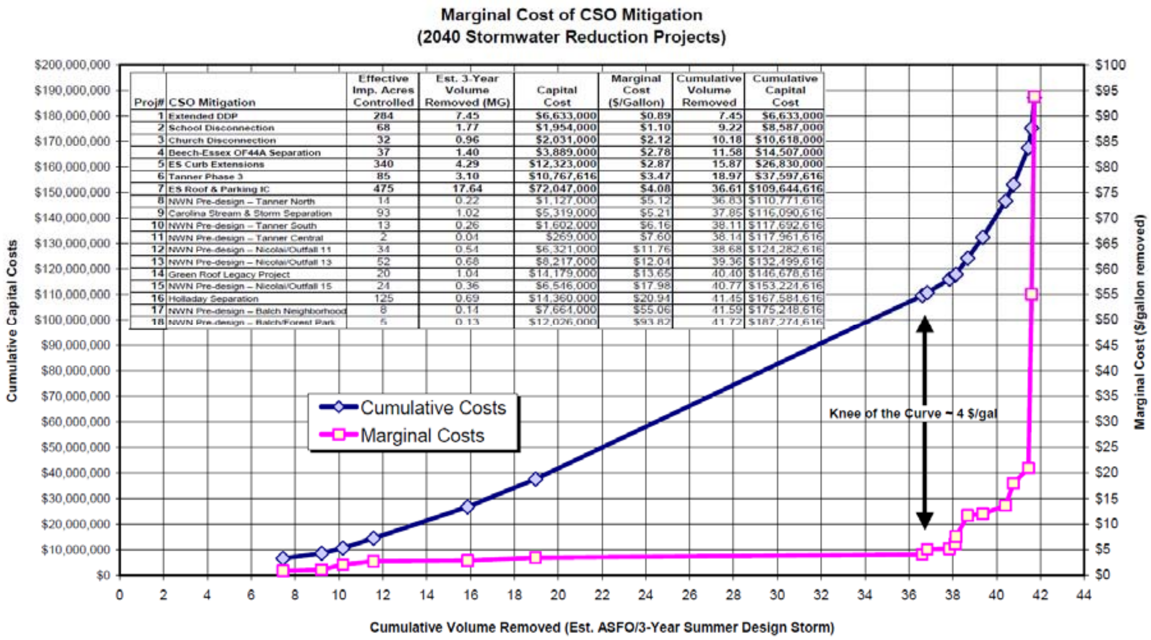
- Estimation of the potential benefits of implementation
- Use of available cost data and knowledge of similar programs or previous analysis to establish whether the method is likely to be cost effective relative to expected benefits
- Prioritization of likely cost effective methods using risk criteria

Potential benefits of implementation have been described for each method in terms of managed impervious area. In most cases, this was analyzed based on GIS-level investigation of land use and impervious surfaces. In some cases the total projected impervious area that might be impacted by a method has been discounted to reflect previous success rates or other factors. The GIS-based analysis of potential benefits should be considered conservative. In most cases, the potential for managed impervious area is likely greater than reported.

In this context, cost effectiveness is defined largely by BES's past efforts to achieve the levels of CSO control required in the ASFO. The *CSO Sizing and Flow Management Final Predesign Report* (BES, 2005) developed a basis for comparison of cost effectiveness for CSO volume removal across various project types using impervious area managed as a surrogate.

Consistent with EPA guidance for long-term control plans, the 2005 *CSO Sizing and Flow Management Final Predesign Report* Project staff agreed that the cost-effectiveness point for projects would be the inflection point, or knee-of-the-curve, on a graph comparing cost to stormwater volume removed from the CSO system.

Figure 6-1 is a graph from that report depicting the relationship between volume removed and cost. As shown in the table embedded in the graph, the projects are sorted by a unit cost of dollars per volume removed for the 3-year summer storm. The inflection point along the cumulative cost curve corresponds to approximately $4 per gallon removed from the CSO system.




| Proj# | CSO Mitigation | Effective Imp. Acres Controlled | Est. 3-Year Volume Removed (MG) | Capital Cost | Marginal Cost ($/Gallon) | Cumulative Volume Removed | Cumulative Capital Cost |
|---|---|---|---|---|---|---|---|
| 1 | Extended DDP | 284 | 7.45 | $6,633,000 | $0.89 | 7.45 | $6,633,000 |
| 2 | School Disconnection | 68 | 1.77 | $1,954,000 | $1.10 | 9.22 | $8,587,000 |
| 3 | Church Disconnection | 32 | 0.96 | $2,031,000 | $2.12 | 10.18 | $10,618,000 |
| 4 | Beech-Essex OF44A Separation | 37 | 1.40 | $3,889,000 | $2.78 | 11.58 | $14,507,000 |
| 5 | ES Curb Extensions | 340 | 4.29 | $12,323,000 | $2.87 | 15.87 | $26,830,000 |
| 6 | Tanner Phase 3 | 85 | 3.10 | $10,767,616 | $3.47 | 18.97 | $37,597,616 |
| 7 | ES Roof & Parking IC | 475 | 17.64 | $72,047,000 | $4.08 | 36.61 | $109,644,616 |
| 8 | NWN Pre-design – Tanner North | 14 | 0.22 | $1,127,000 | $5.12 | 36.83 | $110,771,616 |
| 9 | Carolina Stream & Storm Separation | 93 | 1.02 | $5,319,000 | $5.21 | 37.85 | $116,090,616 |
| 10 | NWN Pre-design – Tanner South | 13 | 0.26 | $1,602,000 | $6.16 | 38.11 | $117,692,616 |
| 11 | NWN Pre-design – Tanner Central | 2 | 0.04 | $269,000 | $7.60 | 38.14 | $117,961,616 |
| 12 | NWN Pre-design – Nicolai/Outfall 11 | 34 | 0.54 | $6,321,000 | $11.76 | 38.68 | $124,282,616 |
| 13 | NWN Pre-design – Nicolai/Outfall 13 | 52 | 0.68 | $8,217,000 | $12.04 | 39.36 | $132,499,616 |
| 14 | Green Roof Legacy Project | 20 | 1.04 | $14,179,000 | $13.65 | 40.40 | $146,678,616 |
| 15 | NWN Pre-design – Nicolai/Outfall 15 | 24 | 0.36 | $6,546,000 | $17.98 | 40.77 | $153,224,616 |
| 16 | Holladay Separation | 125 | 0.69 | $14,360,000 | $20.94 | 41.45 | $167,584,616 |
| 17 | NWN Pre-design – Balch Neighborhood | 8 | 0.14 | $7,664,000 | $55.06 | 41.59 | $175,248,616 |
| 18 | NWN Pre-design – Balch/Forest Park | 5 | 0.13 | $12,026,000 | $93.82 | 41.72 | $187,274,616 |

**Figure 6-1.** Marginal Cost of CSO Mitigation (2005 *CSO Sizing and Flow Management Final Predesign Report*)

Thus, all projects below this "knee-of-the-curve," or costing less than $4 per gallon removed, are considered cost-effective for long-term control of the CSO system.

For those cases where a method is considered for this facilities plan but cannot be plotted on a similar graph, past BES and industry experience with similar project types has been used as a basis for establishing whether the method is likely to be cost effective.

For those methods found likely to be cost effective, three risk criteria related to implementation are used to prioritize recommendations:

- Difficulty of policy changes
- Difficulty of public or project partner acceptance
- Level of implementation risk

In this case, implementation risk is considered to be the uncertainty regarding how much CSO volume could be reduced if the method were actually implemented.

The three risk criteria were evaluated as low, medium, or high, with an associated value of 1 to 3 for each item, respectively. Lowest total summed score across all three criteria for a strategy is 3, meaning a generally positive outlook for implementation. Highest total summed score possible is 9, meaning a negative outlook for implementation.

Total potential managed impervious area was not used explicitly to prioritize recommended alternatives, but was considered in comparison to the overall need to meet or exceed the demands of development in the CSO basin.

## 6.4 Screening of Methods by ASFO Technology

Over the 20-year program history, a large number of methods for CSO reduction have been considered, incorporated into previous projects, or rejected for sufficient cause. City staff pulled from this previous experience to produce a set of most likely methods that may be cost effective and implementable. In some cases, previous studies are referenced to support a conclusion about one of the ASFO-listed technologies. A summary of this screening process is provided below.

## 6.5 Sewer Separation

Analysis performed for the 2005 *CSO Sizing and Flow Management Final Predesign Report* evaluated the cost for several stormwater volume removal projects including sewer and stream separation projects. Based on this approach the Tanner Creek Separation Project – Phase 3 and the Beech-Essex (OF44A) Sewer Separation projects were recommended for further design and implementation.

Further analysis of the Beech-Essex separation project determined that it was no longer cost-effective due to expensive constructability challenges. The project has been referred back to the planning stage to develop a new cost-effective solution using sustainable stormwater technologies. In 2006, the City completed construction of a pipeline that diverts clean water from Tanner Creek and smaller west hills streams from the combined sewer system. The completed Tanner Creek project removes about 165 million gallons of cold, clean stream water annually from the combined sewer system and delivers it directly to the Willamette River.

Partial stormwater separation projects with water quality treatment are recommended in the Combined Sewer System Plan for the Tanner basin and the Lloyd District areas to reduce basement sewer backup risk (BSBR) and CSO volume.

## 6.6 Upsizing of Trunk and Interceptor Lines for Storage

One potential method of CSO reduction is to make use of local storage facilities in the combined system in addition to the storage that is provided by the West Side and East Side

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CSO Tunnels. If localized storage were to be utilized, the storage facilities would need to store water for the entire period that the tunnel system would be overflowing, which is about 12 hours for a summer storm and 24 hours for a winter storm. These local storage systems would also need to be able to bypass high flows so that the storage facilities did not cause localized BSBR upstream of the facility location. Therefore, any localized storage would most likely need to occur in areas where the combined sewer system is fairly deep so that the storage volume of the facility could be maximized and there would be additional elevation to bypass high flows that could otherwise cause basement sewer backups.

Localized storage is not a cost effective method to further reduce combined sewer overflows. A sample of the cost for these projects is the Insley Parallel Trunk project (BES project 6528). This is a passive storage project with no automated controls. It was built to control 25-year storm backups and to also help with compliance of the ASFO. It provides about 280,000 gallons of storage capacity and the cost of the project was $3,760,000. Therefore it costs about $13.50 per gallon of storage to store the ASFO 3-year summer storm for the 12 hours or so when the CSO tunnel is full and overflowing. This is much more expensive than the $4 per gallon removed that is considered the cutoff for cost effective projects that are presented in the *CSO Sizing and Flow Management Final Predesign Report* (BES, 2005). The costs to build and maintain this project with automated controls would be even higher.

Similar to the sewer separation projects, basement sewer backup control projects that could provide storage and reduce overflows were evaluated in the *CSO Sizing and Flow Management Final Predesign Report*. That evaluation recommended improvements described in Section 3. All of these projects either have been implemented or are in the process of being implemented. System conditions have not changed such that additional storage projects would be cost effective in achieving the further reductions in frequency and volume of CSOs.

## 6.7 Operational Enhancements

The *CSO System Operating Plan* (BES, July 2005 with an update in process for 2010) is an on-going effort by City staff to optimize the performance of the overall collection and treatment system to address dry weather and especially wet weather issues. Two of the Nine Minimum Controls addressing operational enhancements (NMC#2 Maximize use of In-System Storage, and NMC#4 Maximize Flow to POTW) are key priorities for the System Operating Plan.

Operational enhancements to the 2006 configuration have already been incorporated into the modeling for the 2011 and 2050 systems, which has reduced expected CSO discharge volumes by approximately 10%. This was accomplished by changing the 2005 System Operating Plan schemes at the Ankeny and Sullivan Pump Stations to use their wet weather capacity earlier in the storm and send more wet weather flow from Swan Island Pump Station through the Portsmouth Tunnel earlier in the storm. Controls at Ankeny Pump Station will be revised to pump more flow into the East Central Interceptor to reduce CSO discharges at the pump station and maximize the volume of water stored throughout the Willamette Tunnel system. Maximizing flow to the plant earlier in the storm will result in higher flows reaching CBWTP sooner, but the rapid rise in flow must be managed to prevent negative consequences within the plant. Future enhancements being considered include the use of rainfall gauges and simplified models to provide real-time flow projections to the operators. These concepts and possible enhancements will be further developed after completing the December 2011 system startup; therefore, no estimate of further CSO reductions is available at this time for this alternative.

As a requirement of the 1991 SFO, the City submitted an *Interim Control Measures Study* (CH2M HILL, 1993) that examined sewer flushing for reducing CSO volume (which was *not* recommended) and expanded street sweeping (which *was* recommended) for reducing suspended solids in CSO discharges but did not help to meet the bacteria water quality standard.

The Nine Minimum Controls implemented by BES include three specific strategies to reduce the quantity of pollutants in CSO discharges:

- Proper Operations and Maintenance: NMC#1 (sewer inspection and cleaning, diversion inspection, street sweeping, catch basin cleaning and sump-sedimentation manhole cleaning, pump station maintenance and inspection)
- Pretreatment Program: NMC#3 (batch discharge and pretreatment programs)
- Pollution Prevention Programs: NMC#7 (Pollution Prevention—P2 program, stenciling and signage, outreach through coalitions, green initiatives, public involvement, information disbursement and education)

The Nine Minimum Controls implementation report was last updated in 2003 and is due to be updated fall 2010 as a supplement to this facilities plan. These controls will continue to be implemented in the future.

Once the full CSO control system is in place, however, the effectiveness and applicability of operational enhancements will change because the CSO tunnel systems will capture first-flush flows from streets and pavement and will capture floatables. Overflows (95% reduced from the 1990 value) will occur only during large storms that have highly dilute runoff; therefore, the water quality effectiveness of additional street sweeping in the CSO area will

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be negligible. Diversion of street-sweeping resources to non-combined sewer service areas may be a more effective approach to overall watershed health.

System optimization for maximizing flow to the plant (the goal of pipe cleaning) has been demonstrated to be accomplished early in the program. Additional pipe capacity due to removing the 6 inches or so of sediment found in the bottom of a few of the interceptors (4 to 8 feet in diameter) does not represent a significant volume. For maintenance purposes (pipe inspection and repair), these interceptors will be drained and cleaned once the Willamette tunnel system is online and performing as required and can be used for flow-bypass around the interceptors. There is no expectation that cleaning the small amount of sediment in a few of the interceptors will have a measurable effect on the performance of the system for controlling CSO. For these reasons, no further operational enhancements have been considered for this plan, although wet weather protocols may be changed in the future.

## 6.8 Wet Weather Treatment Improvements

All captured CSO is conveyed to the CBWTP/CBWWTF site where it receives a minimum of screening for solids and floatables removal, primary clarification, and disinfection before discharge to the Columbia River. Under current conditions, CSO treatment is meeting water quality standards and permit effluent limitations. After the CSO control system is completed in December 2011, wet weather flows and loads to the CBWTP/CBWWTF are not expected to increase because the City's post-2011 CSO reduction strategy shifts to a reliance on green infrastructure, i.e., sustainable stormwater management, to reduce stormwater inflows to the combined sewer system.

### 6.8.1 Post-2011 Performance Projections

BES analyzed the performance of the CBWTP and CBWWTF systems under post-2011 flows and loads and found the following:

- **Effluent from both the CBWTP and the CBWWTF outfalls will clearly meet water quality standards**. This is based on effluent monitoring from the two systems and a detailed analysis of the two outfalls discharging into the Columbia River.
- **Effluent from CBWTP and CBWWTF will meet permit limits.** Averaged annual effluent quality to the Columbia River is expected to be 23 mg/l TSS and BOD; and a maximum month (wet-weather) quality of 30 mg/l TSS and 24 mg/l BOD. This compares well to the maximum month effluent limit of 30 mg/l TSS and BOD specified in the permit for secondary treated effluent alone.
- **The CBWTP will continue to meet the permit requirements** by providing a sustained secondary treatment capacity of 100 MGD minimum and 110 MGD average during wet weather events. Effluent limits will also be met as indicated by

an average effluent water quality for both BOD and TSS of 17 mg/l for secondary effluent.

- **The operational enhancements currently in design for CBWTP**, including Sludge Volume Index (SVI) control and Modified Step-feed, will result in an average secondary treatment rate of 110 MGD, with captured CSO being diverted to CBWWTF for treatment on an average frequency of about 31 events per year and a volume of 2,500 MG.
- **The CBWWTF will continue to meet permit requirements** requiring a minimum annual pollutant reduction of 50% for BOD and 70% for TSS. Effluent water quality with CEPT is expected to be 42 mg/l BOD and 42 mg/l TSS averaged for the 2,500 MG/year sent to the CBWWTF.

### 6.8.2 Improved and Expanded Secondary Treatment of Captured CSOs

As described above, under post-2011 conditions, treatment of captured CSO at the CBWTP/ CBWWTF is projected to meet water quality standards and permit effluent limits. However, because captured CSO is routed through the Main Headworks and must bypass the secondary system, Portland was recently required by DEQ to examine alternatives for increasing the amount of captured CSO that is given secondary treatment. For additional information refer to the *Final Draft Columbia Boulevard Wastewater Treatment Plant Justification for CSO-Related Bypass with a No Feasible Alternative Analysis* (NFAA)(BES, 2009). Seven alternatives were evaluated by comparing their costs, treatment performance, benefits, and affordability impacts.

The alternatives analysis resulted in the recommendation to implement three of the seven alternatives:

- **SVI Control Improvements:** Improves the selector process in the aeration system that will result in reliably growing good-settling microorganisms and reduce the growth of filamentous microorganisms. Faster settling microorganisms will reduce the sludge volume index (SVI) and allow the secondary clarifiers to operate more efficiently at a higher sustained rate. Estimated capital cost is $12 million.
- **Step-Feed Implementation**: Install piping, controls, and monitoring equipment necessary to implement a step-feed system that will allow an increased sludge retention time during wet weather, improve the growth of the fast settling microorganisms, and distribute solids in the aeration system in a manner that helps protect the biomass from washing out. Estimated capital cost is $8 million.
- **Chemically Enhanced Primary Treatment (CEPT):** This alternative provides for the addition of ferric chloride and a polymer to significantly improve the primary settling in the Wet Weather Treatment Facility and provides “near secondary” treatment. This improvement is expected to be needed for the higher post-2011 flows

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that will occur when the East Side CSO Tunnel is brought online. The estimated cost of the CEPT system is $5.8 million.

These recommended projects will ensure that the CBWTP and CBWWTF continue to meet permit requirements, effluent limits, water quality standards, and continue to improve effluent quality. BES has placed these projects into the CIP and they are currently in design phases.

BES also examined expanding the capacity of the secondary system by constructing new secondary clarifiers. Due to the current site constraints, building new secondary clarifiers would require developing the Western Site across the N. Portland Road and Burlington Northern Railroad. Large tunnels, piping, pumping, gates, and flow controls systems would have to be constructed first in order to move sewage, activated sludge, and effluent between the current site and the Western Site. This major step to provide room for expanding the secondary clarifier system is estimated to cost $40 million. (This is in addition to the $20 million that must be spent first on SVI control and step-feed system to ensure that the added clarifiers will be able to provide the expected capacity.) Once completed, new clarifiers would have to be constructed on the Western Site to provide up to 160 MGD capacity at a total cost of $134 million (including SVI and step-feed enhancements and site development).

The projects to build additional secondary clarifiers are not recommended. The recommended post-2011 system (SVI control, step-feed and CEPT) is expected to produce an average annual effluent concentration of 23 mg/l for BOD and TSS. As an alternative, the expanded secondary clarifiers would only reduce that concentration to 21 mg/l (for 160 MGD capacity). The potential reductions on a maximum month basis indicate the 30 mg/l TSS and 24 mg/l BOD at 110 MGD could be reduced to 28 mg/l TSS and 19 mg/l BOD at 160 MGD. To pay for these small reductions in effluent concentrations, the projected sewer rates in 2016 would need to be raised by $3 per month. Because Portland's monthly sewer rates are already expected to be $84/month, which is 1.78% of mean household income, this added community burden would be difficult to justify, especially in light of the fact that the permit effluent limits and water quality standards are already being met without these projects.

The projects to build additional secondary clarifiers are economically infeasible because the added financial burden they place on the community does not result in appreciable improvements in the effluent quality from the CBWTP site nor does it result in improved water quality in the Columbia River.

BES also examined two projects that would eliminate the bypass in question by building the infrastructure needed to separate the CBWTP headworks from the CBWWTF headworks. The cost to split the existing headworks was estimated to be $12 million. The cost to build a new wet weather headworks structure was estimated to be $18 million. However, because these alternatives provide no environmental benefit, they were not recommended.

The maximum wet weather flow under post-2011 conditions to the CBWTP site is within the 450 MGD capacity of the dry and wet primary treatment facilities. All of the 450 MGD wet weather flow will receive a minimum of primary clarification, solids and floatables removal via screening, and disinfection. At a minimum, 100 MGD of the 450 MGD will also receive secondary treatment.

### 6.8.3 Diversion and/or Reuse of Sewage to Reduce Base Flow

Diversion of base flow has been incorporated into system operations and models for 2011 and 2050. Flow is diverted away from the tunnel and to the treatment plant via the NW Yeon, Ankeny, and Sullivan Pump Stations.

Additionally, as a part of this post-2011 facilities plan, onsite treatment at large commercial buildings was evaluated for reuse or diversion of sewage to reduce base flow. Screening of this method was accomplished with the following steps:

- Using aerial photos and Google Maps Earth view, 120 high rise commercial buildings within the downtown core area and the Lloyd Center area were selected for analysis. These were generally 8 stories or more and could be candidates for decentralized wastewater treatment systems.
- The sanitary base flow from these properties over the 48 hours duration of the 3-year summer storm is 2.2 MG. The standard conditional criterion was utilized for picking the base flow to use on each tax lot (existing base flow or half of the design manual base flow, whichever is greater).
- Through analysis it was determined that this volume has an equivalent impervious area of approximately 60 acres.

It is expected that building individual wastewater treatment systems at 120 locations in these densely developed areas would be extremely expensive and outside of direct BES control. Therefore, it does not seem likely that this alternative would be a cost-effective method under our current water supply and pricing programs and reclamation treatment technologies.

## 6.9 Enhanced Inflow and Pollutant Source Control

Several candidate methods are reviewed below.

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#### 6.9.1.1 Re-evaluate the Current Effectiveness of the SWMM for Managing Volume Reduction from New or Re-Developed Impervious Areas

For hydrologic modeling purposes, BES currently predicts that approximately 25% of new impervious area in the combined system will be effectively managed for stormwater volume control through the implementation of the City of Portland Stormwater Management Manual standards. Recent investigation indicates that under current practices and design guidelines, it is appropriate for hydrologic modeling purposes to assume that approximately 40% of the new impervious area will be effectively managed for stormwater volume control. (For more information, refer to the investigation memorandum by Greenworks provided in Appendix B.) BES has standards and practices review procedures in place that would allow for a careful re-evaluation of this modeling assumption. Implementation of the SWMM as currently approved is already a requirement for development. The cost of a standards and practices review and re-study of SWMM stormwater volume control effectiveness is assumed to be a cost-effective marginal cost increase to the existing program.

#### 6.9.1.2 Improve Stormwater Facility Design

A variety of stormwater facilities may be used to manage stormwater runoff from new impervious surfaces. Table 6-1 describes the estimated volume removal percentage for a CSO event of four typical facility types that may be implemented in the CSO basin. The SWMM allows a number of additional facility types that were not evaluated as part of this screening. One alternative would be to improve the effectiveness of the flow-through planter for volume control. The effect of improving the flow-through facility from 25% to 40% flow removal would be to mitigate for approximately 10% of the predicted increase in impervious area (approximately 60 acres). Modifications to design details would be expected to produce increased volume reduction with only marginal increase in construction cost for this technology, which has generally been shown cost effective.

**Table 6-1.** Estimated Volume Control Effectiveness for Select Stormwater Facility Types

| Type | % Effectiveness for Volume Control |
|---|---|
| Flow-through Facility | 25% |
| Ecoroof | 60% |
| East Side Soakage Trench | 70% |
| Infiltration Facility | 80% |

### 6.9.1.3 *Refine Requirements of SWMM for New and Redevelopment*

As development continues post-2011, there is opportunity to refine the requirements of the Stormwater Management Manual. The current required hierarchy for design of facilities, shown in Figure 6-2 below, demonstrates a comprehensive commitment to volume reduction as part of an overall stormwater management approach. The highest technically feasible category must be used for design of site facilities.

The following bullets describe a number of ideas for refining these requirements to continue to encourage all development to utilize onsite stormwater management methods. Each would need to demonstrate cost effectiveness independently, but the suggested modifications are likely to add only marginal cost to the existing program.

- Increase use of ecoroofs through incentives and grants for ecoroofs throughout the City. Ecoroofs directly reduce effective impervious surfaces and provide a reduction in stormwater runoff volume
- Consider application and design of flow-through planters
- Continue and enhance existing incentive programs
- Integrate and enhance urban forestry requirements with the SWMM and target implementation in CSO areas
- Pursue effective public and private maintenance of installed facilities

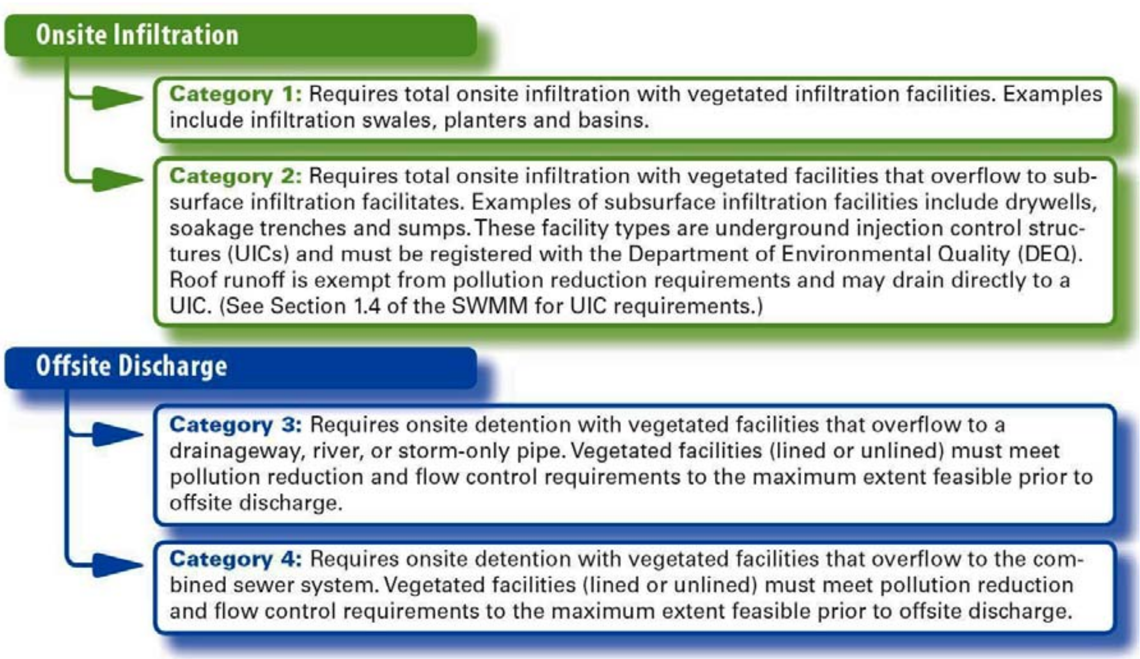


**Figure 6-2**. SWMM Stormwater Infiltration and Discharge Hierarchy

#### 6.9.1.4 Implement Projects at Large Institutions (Educational, Religious, Other Large Institutions)

The CSO Sizing and Flow Management Predesign Project (7341) predicted that approximately 80 acres of impervious area could be managed from educational and religious institutions in the East Willamette basins. Stormwater runoff from about 15 acres of this impervious area is either already directed to infiltrating stormwater facilities or is proposed to be as part of the Combined Sewer System Plan. Since these projects may be on private property, funding strategies and coordination with owners are important considerations. Based on the Predesign Project, 65 additional acres of impervious area could be directed to infiltrating stormwater facilities. The *CSO Sizing and Flow Management Final Predesign Report* estimated the cost per gallon removed for these projects to range from $2 to $4 per gallon. However, recent experience has found the cost to construct these facilities is greater than these costs that were estimated for the predesign.

#### 6.9.1.5 Implement Projects at Commercial Facilities (Retrofit Existing Facilities)

A query of large, multi-block commercial buildings including big box stores, hospitals, and other commercial facilities was completed in the East Willamette basins. The query specified properties that had combined parking and roof areas that were greater than 3 acres and had a commercial (COM) land use designation. Most of these large properties were found to be along 82nd Avenue and in areas that are relatively close to the river. Most properties along 82nd Avenue route stormwater runoff to dry wells and many of the properties close to the river route stormwater runoff directly to the river and do not discharge to the combined sewer system.

A manual investigation using these criteria found that there is about 60 acres of impervious area where stormwater runoff could possibly be routed to infiltrating stormwater facilities or to new stormwater systems that discharge directly to the Willamette River. However, it is assumed that only 50% of that area would be available for re-direction. Therefore, it is assumed that approximately 30 acres of impervious area from large parcels could be re-directed. This estimate may be conservative given that onsite management may also be cost effective at tax lots with a smaller parcel size and in areas without commercial land use designation.

The CSO Sizing and Flow Management Predesign Project estimated a cost of $4.08 per gallon to implement this type of project. Routing stormwater runoff from these 30 acres to infiltrating facilities would remove slightly over 1 million gallons from the combined sewer system. Implementation of this strategy is estimated to cost about $4 million.

#### *6.9.1.6 Evaluate Point of Sale Requirements for Onsite Stormwater Retrofits*

Queries were performed on the Downspout Disconnection Program database to develop an understanding of the level of onsite stormwater management that has already been completed in the East Willamette basins through downspout disconnection or other onsite stormwater facilities. There are approximately 52,000 properties in these basins that were potential Downspout Disconnection Program participants and about 80% of these properties have some level of onsite management, either through program participation or preexisting conditions. This translates to approximately 293 acres of roofs that currently have no onsite management. The mean roof area management rate for the properties that do have some level of management is 67%. This refers to the percentage of the roof area where stormwater runoff is routed to the ground or managed with dry wells, soakage trenches, etc. The level of onsite management for residential owner-occupied properties that have participated in the program is approximately 60%; the level of onsite management for rental, multifamily, and commercial properties that participated in the program is approximately 50%.

The Downspout Disconnection Program primarily sought owner-occupied residential properties for disconnection before targeting residential non-owner occupied and non-residential properties (multifamily and commercial). Therefore, a significant portion of the remaining properties are residential rentals, managed multifamily and commercial properties. Rentals, multifamily, and commercial properties account for 221 acres of the roofs that have no onsite management and the remaining 144 acres of roofs are on owner-occupied homes. An evaluation of property sales in this area found that about 30% of the properties were sold in the last 10 years. This is a turnover rate of 30% for every 10 years. These were primarily owner-occupied homes. Therefore, it is assumed that 100% of owner-occupied properties will turnover in the 40-year period between 2011 and 2050. However, rental, multifamily, and commercial properties tend to turnover at a much slower rate. The turnover rate over the same 40 year period for rental, multifamily, and commercial properties is assumed to be 20%. The turnover rate for non-owner occupied residential properties was estimated through conversations with the Manager of the Portland Downspout Disconnection Program about her experience with rental property owners that have been contacted through the Downspout Disconnection Program.

The BES standard modeling assumption for downspout disconnection is that stormwater runoff from 70% of the managed area is infiltrated and the remaining 30% runs off into the street. Also, it is assumed that 65% of the property owners would be granted exceptions because of lot size, slope, etc. Applying all of the above assumptions to the 293 acres of single family residence (SFR) roofs that currently have no onsite stormwater management results in about 25 acres of additional downspout management from point of sale requirements for owner-occupied properties and rental properties. In order to implement this mandatory program there would have to be significant political capital invested and increased staffing to monitor and enforce these requirements.

A Point of Sale program would have some similarities to the existing program in terms of types of installed facilities, but costs would be expected to be substantially higher due to increased tracking, enforcement, and installation requirements. A point of sale program is not expected to be cost effective, based on these factors.

#### *6.9.1.7 Oregon Department of Transportation (ODOT) Corridor Stormwater Projects*

A query of ODOT maintained streets within the Eastside and Westside Willamette River basins resulted in about 130 acres of impervious area that ODOT maintains. The drainage areas of these 130 acres were reviewed to estimate which areas could feasibly be separated from the combined sewer system and routed to an existing stormwater system that discharged to the Willamette River or a tributary stream. Some street corridors are not feasible for separation because of the distance to a receiving stream. Examples of these streets are SE 82nd Avenue and SE Powell Boulevard. These two street systems discharge stormwater runoff to the combined sewer system from over 60 impervious acres. However, the existing discharge is directly to the combined sewer system and there are no receiving streams within a reasonable distance from the river.

Several criteria were used to help estimate how many ODOT impervious acres could feasibly be directed away from the combined sewer system. The first criterion is that the existing ODOT stormwater runoff must be collected in an ODOT stormwater system before it is discharged to the combined sewer system. The second criterion requires that the discharge point of the ODOT stormwater system be within 2,500 feet of the Willamette River, assuming that as the practical limit for conveying additional flow in existing or new separate stormwater facilities. Using these criteria, it is estimated that about 20 acres of ODOT maintained impervious surfaces could feasibly be directed away from the combined sewer system. These street systems include SW Barbur Boulevard, McLoughlin Boulevard, and Interstate 5, just north of the Terwilliger curves. However, policy and organizational changes would be required for implementation. In some cases, runoff from these high traffic areas may be candidates for diversion to the treatment plant due to the potential for pollutants. In addition, the high-volume corridors would be expected to have severe right-of-way constraints, high construction costs, and other factors that make it unlikely that this alternative would be cost effective for BES unless some or all of the costs were paid by ODOT.

#### 6.9.1.8 Private Lateral Inspection in Separated Areas

For this analysis, rainfall-derived infiltration and inflow (RDII) reduction in the Fanno/Burlingame system was considered. Baseline conditions for the Fanno/Burlingame Trunk model were set using existing conditions for both base flow and RDII. The regression equation used to develop the RDII hydrograph was based on late spring antecedent conditions.

Hydrology was calculated for future conditions by multiplying the existing hydrographs by a series of factors. The factors accounted for increases in base flow, increases in RDII from system degradation, and (as necessary) an RDII reduction based on theoretical and/or recommended plan projects. These factors were based on assumptions made during the development of the Sanitary System Plan.

It is assumed that the theoretical maximum reduction in RDII (60% reduction to all areas over 8,000 gallons per acre per day) could be obtained, which would result in a net decrease of 2.52 MG during the 3-year summer storm. This volume has an equivalent area of about 65 acres. The estimated cost to obtain this reduction in RDII is approximately $69 million, or $27/gallon.

Therefore, it is not cost-effective for CSO control because the cost is much higher than $4 per gallon.

#### 6.9.1.9 Existing Program Activities

A potentially cost effective method of CSO control is to make use of existing programs that may have CSO volume reduction as a benefit but not necessarily a primary purpose. Many of these projects from various programs have been described in the Combined Sewer System Plan (BES, forthcoming in 2010).

For example, the CIP projects in the Taggart D basin are components of a new, large program called “Tabor to the River,” which integrates hundreds of sewer, green stormwater management, tree planting and other watershed projects to improve sewer system reliability, stop sewer backups in basements and streets, reduce CSOs to the Willamette River, and restore watershed health.

Many of the projects that are currently listed in the Capital Improvement Program – Fiscal Year 2011 thru 2015 Budget and Estimated Fiscal Year 2016-2020 Projections have stormwater runoff reduction components. These project components are predicted to direct stormwater runoff from at least 185 impervious acres to infiltrating stormwater control facilities and/or to stormwater systems that discharge directly to the Willamette River or a tributary stream.

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There are additional projects that have not yet been submitted to the CIP. These planned projects are predicted to reduce stormwater runoff from at least an additional 190 impervious acres.

Projects that are selected for implementation from existing programs use cost-benefit criteria that may consider CSO volume reduction as one element to prioritize funding and construction. See Appendix C for details of one such cost-benefit analysis.

Any projects proposed on private property would not be included in CIP funding. If projects are on private property (or non-capitalizable public property), then alternate funding must be identified.

Another existing program activity pertinent to CSO reductions is implemented by the Portland Bureau of Transportation (PBOT). Under SWMM guidelines, PBOT is responsible for stormwater runoff management (pollution reduction and flow control) for roadway improvement projects that involve more than re-paving an existing roadway. It is assumed for this facilities planning effort that under this program PBOT will implement stormwater management to an average of 1 additional acre of impervious surface per year over the 40 year analysis period.

For this plan, the existing program activities outlined above are expected to mitigate stormwater runoff from a total of 415 impervious acres within the combined sewer area.

## 6.10 Comprehensive and Multi-Objective Water Quality Improvement Strategies

#### *6.10.1.1 Assess Stormwater Water Quality Problem Areas (Such As Mill and Jefferson Basins)*

The tunnel system provides an opportunity to route stormwater from densely developed and highly trafficked areas to the treatment plant. The Mill and Jefferson outfalls are the only two stormwater outfalls where it is feasible and beneficial to direct flow to the tunnel system. Stormwater from Mill and Jefferson could be routed into the tunnel until the water surface elevation reached -75 feet. At that time, real time controls would close the gate and all remaining stormwater would discharge to the Willamette River via the existing stormwater outfalls.

It is predicted that approximately 3.1 MG of stormwater would be routed to the tunnel system. When the gates are closed at water surface elevation -75 feet, the tunnel system would be about 20% full. It is assumed that 20% of the 3.1 MG would be stored in the tunnel and 80% would be conveyed through the system. Therefore, 0.62 MG of the stormwater runoff would use tunnel storage capacity. This volume has an equivalent impervious area of about 20 acres added to the post-2011 increase. This alternative is beneficial for the Willamette River water quality, but it does slightly increase the amount of runoff to the CSO system that must be reduced elsewhere.

#### *6.10.1.2 Pursue Integrated Water Resource Management through Water Conservation, Stormwater Harvesting, and Other Emerging Technologies*

Small, distributed actions including conservation behavior and capture & reuse facilities are technologies that are expected to continue to develop and mature during the planning period, through 2050. Although generally not cost effective for CSO volume reduction at this time, opportunities to nurture and support promising technologies for implementation may occur in the future.

## 6.11 Analysis of Screened Methods

Selected methods described above were evaluated based on cost-effectiveness and risk criteria. Table 6-2 below indicates the results of that evaluation.

Based on this analysis, the ranked methods for consideration as feasible actions under this plan are shown in Table 6-3.

Implementation strategies, specific project elements (where currently identified), and techniques for managing risk associated with implementation of these methods are described in Section 7.

Given the need to demonstrate capacity to adapt to expected development in the CSO basins, including the estimated 22.4 MG of runoff volume (600 acres of equivalent impervious area) to be managed to achieve further reductions, Table 6-3 indicates that the selected cost-effective methods are adequate to meet the demand and provide sufficient flexibility in implementation to mitigate expected risks.

**Table 6-2.** Analysis of Screened Alternatives

| Technology Category | Method | Financial | | | Risk | | | |
|---|---|---|---|---|---|---|---|---|
| | | Potential Benefit (impervious acres) | Marginal Cost ($/gal)[b] | Cost Effective for CSO Control? (Presumed finding if in parentheses) | Difficulty of Policy Change Required? | Difficulty of Public or Project Partner Support Required? | Implementation Risk Level? | Total Risk Score |
| Sewer Separation | Evaluated in the Combined Sewer System Plan[a] | Not Applicable | | | | | | |
| Upsizing for Storage | Evaluated in the Combined Sewer System Plan[a] | Not Applicable | | | | | | |
| Operational Enhancements | Optimize operations | | $14 | N | Low | Low | Medium | 4 |
| Wet Weather Treatment Improvements | Divert and/or reuse sewage to reduce flow | 60 | | (N) | Medium | High | High | 8 |
| Enhanced Inflow and Pollutant Source Control | Re-evaluate SWMM effectiveness for CSO volume control | 110 | | (Y) | Low | Low | Low | 3 |
| | Improve stormwater facility design | 60 | | (Y) | Low | Low | Medium | 4 |
| | Refine Requirements of SWMM for new and redevelopment | 60 | | (Y) | Low | Medium | Medium | 5 |
| | Implement projects at large institutions | 65 | $2+ | Y | Low | Medium | Medium | 5 |
| | Implement projects at large commercial facilities | 30 | $4 | Y | Low | Medium | Medium | 5 |
| | Evaluate point of sale requirements | 25 | | (N) | High | High | Medium | 8 |
| | ODOT corridor stormwater projects | 20 | | (N) | High | Medium | Low | 6 |
| | Private lateral inspections in separated areas | 65 | $27 | N | High | High | Medium | 8 |
| | Existing program activities | 415 | $3 | (Y) | Low | Low | Low | 3 |

**Table 6-2.** Analysis of Screened Alternatives

| Technology Category | Method | Financial | | | Risk | | | |
|---|---|---|---|---|---|---|---|---|
| | | Potential Benefit (impervious acres) | Marginal Cost ($/gal)[b] | Cost Effective for CSO Control? (Presumed finding if in parentheses) | Difficulty of Policy Change Required? | Difficulty of Public or Project Partner Support Required? | Implementation Risk Level? | Total Risk Score |
| Comprehensive WQ Improvement Strategies | Assess SW WQ problem areas | -20 | | (Y) | Low | Low | Medium | 4 |
| | Conservation, rainwater harvest, reuse technologies | | | (N) | Medium | Medium | Medium | 6 |

[a] Further sewer separation and upsizing for storage were not found to be cost effective for CSO control, but will be implemented where cost-beneficial for basement sewer backup relief.

[b] Cost per gallon is gathered from several sources. Underlying assumptions may vary, including the size of the project area (which may not be equal to the potential area shown in the table). Costs shown are the assumed marginal cost of CSO control when a project may include multiple benefits. Costs are reported without consideration of the funding source, which may be BES, another public agency, or a private entity.

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**Table 6-3**. Ranked Methods for Further CSO Reductions

| Method | Potential Benefit (impervious acres) | Cost Effective for CSO control? (Presumed finding if in parentheses) | Total Risk Score |
|---|---|---|---|
| Existing program activities | 415 | (Y) | 3 |
| Re-evaluate SWMM effectiveness | 110 | (Y) | 3 |
| Improve stormwater facility design | 60 | (Y) | 4 |
| Assess stormwater water quality problem areas | -20 | (Y) | 4 |
| Implement projects at large institutions | 65 | Y | 5 |
| Refine SWMM requirements for new and redevelopment | 60 | (Y) | 5 |
| Implement projects at large commercial facilities | 30 | Y | 5 |
| **Total Managed Impervious Area** | **720** | | |

# Section 7: Recommended Plan for Further CSO Reductions

## 7.1 Introduction

BES developed this recommended plan to sustain CSO reductions achieved by implementation of the City's LTCP and to establish an approach for pursuing further CSO reductions as they become cost-effective. This plan meets the ASFO requirements to:

- Evaluate technologies identified in the ASFO plus others to achieve further reductions in frequency and volume of CSOs
- Outline the methods for achieving those further reductions based on the evaluation of technologies

The plan incorporates the results of the alternatives analyses presented in Section 6—specifically addressing potential further CSO reductions—and the results of a risk analysis to identify future concerns. Taking into account these results and applying the planning criteria and policies described in Section 2, the plan is developed using a risk-based asset management approach. This is followed by a financing plan and implementation plan. Future performance monitoring and tracking of service area changes are discussed in Section 8.

## 7.2 Recommended Plan

### 7.2.1 Overview

As system performance data are collected and analyzed, the extent to which the LTCP improvements have achieved the ASFO goals will become apparent. Preliminary projections based on explicit hydrologic and hydraulic modeling of the City's combined sewer system with the East Side CSO projects completed indicate that ASFO-specified reductions in the frequency and volume of CSOs will be met and exceeded. Long-term modeling indicates that further reductions in CSO event frequency can be achieved during the winter period, and may result in an average of approximately 50% fewer events than the ASFO winter criteria.

Recognizing that performance data for the CSO control improvements are extrapolated from the 2006–2009 system performance, BES plans to monitor system performance and revisit CSO reduction alternatives as specific reduction needs are identified.

Over the next 40 years, Portland will experience growth and development, increases in impervious surfaces, and other changes that have the potential to erode the level of CSO reduction currently achieved. Consequently, risk analysis will be essential to understanding how to achieve CSO reduction levels greater than ASFO requirements.

To establish a comprehensive framework for future decisions about CSO reduction, BES has developed a suite of methods for implementation as circumstances dictate. This adaptive management approach provides BES the flexibility to cost-effectively address evolving regulatory requirements, community values, and economic constraints.

As described below, BES has already budgeted for implementation of a set of projects that will significantly reduce CSOs in the short-term and identified another set of projects for potential implementation in the near-term. These are supported by a suite of cost-effective CSO reduction methods for development as needed in the long-term.

### 7.2.2 Recommended Plan Methods

Recommended and candidate methods are summarized in Table 7-1 in order of priority. As discussed in Section 6, BES has estimated that approximately 22.4 MG of stormwater runoff (equivalent to 600 acres of impervious area) will need to be managed to limit inflow to the CSO tunnels by 2050 to reduce the number of overflows per winter. This estimate takes into account the future CSO reduction benefits of SWMM.

As shown in Table 7-1 the impervious area acres of the recommended and candidate methods exceed the overall goal of 600 acres. This finding is a favorable indication that the recommended suite of methods affords the City the flexibility it needs to address future changes. The recommended methods in Table 7-1 are derived from existing program activities as defined in the Combined Sewer System Plan and existing PBOT stormwater runoff management program. The candidate methods can be applied in multiple combinations and areas as future conditions dictate. The existing program activities are discussed in Section 7.2.3.

**Table 7-1**. Recommended Plan

| Method | Description | Impervious Area Managed (acres) |
|---|---|---|
| **Recommended** | | |
| Existing Program Activities | CIP-Budgeted Cost-Beneficial Combined Sewer System Plan Projects: Implement Maintenance and Reliability projects to address local street flooding and basement sewer backup risk. Associated green infrastructure stormwater controls will provide significant CSO reduction benefits. | 185 |
| | Additional Cost-Beneficial Combined Sewer System Plan Projects: Reassess cost-benefit of additional Combined Sewer System Plan projects to address local street flooding and basement sewer backups and submit for CIP and Operating funds as needed for implementation. Associated stormwater controls will provide significant CSO reduction benefits. | 190 |
| | PBOT Stormwater runoff management (pollution reduction and flow control) for roadway improvement projects that involve more than just re-paving an existing roadway. Assumed to mitigate for an average of 1 impervious acre per year over the 40 year analysis period. | 40 |
| *Recommended Methods Sub-total* | | *415* |
| **Candidate** | | |
| Re-evaluate SWMM Volume Control Effectiveness | Re-evaluate assumption that SWMM stormwater facility designs required by the City at new developments and redevelopments effectively manage 26% of new impervious area for volume control. Recent investigation indicates that the managed impervious area may be greater than 40% effective for volume control. Monitor to verify and adjust planning demands. | 110 |
| Improve Stormwater Facility Design | Improve design to increase effectiveness of flow volume removal. The flow-through planter is an excellent candidate for improved design because it is currently estimated to remove 25% of the stormwater flow it receives and it is frequently implemented to meet SWMM. If the flow-through planter volume removal efficiency could be increased to 40%, this would produce 60 acres of impervious area removal. | 60 |
| Assess Stormwater Water Quality Problem Areas | The tunnel system provides an opportunity to route a portion of the stormwater from densely populated areas to the CBWTP using gates and real time controls. This method achieves water quality benefits while minimizing increased flow to the CSO control system. | -20 |
| Implement Stormwater Projects at Large Institutions | Manage impervious areas from educational and religious institutions in the East Willamette basins by directing stormwater runoff to vegetated infiltration facilities. | 65 |

City of Portland Post-2011 CSO Facilities Plan

**Table 7-1**. Recommended Plan

| Method | Description | Impervious Area Managed (acres) |
|---|---|---|
| Refine Requirements of SWMM for New Development and Redevelopment | ▪ Increase use of ecoroofs through incentives and grants for ecoroofs throughout the City<br>▪ Review the application criteria for flow-through planters<br>▪ Continue and enhance existing stormwater incentive programs<br>▪ Integrate and enhance urban forestry requirements with the SWMM and target implementation in CSO areas<br>▪ Pursue effective public and private maintenance of installed facilities | 60 |
| Implement Stormwater Projects at Large Commercial Facilities | Manage impervious areas from existing commercial facilities in the East Willamette basins by directing stormwater runoff to vegetated infiltration facilities. | 30 |
| *Candidate Methods Sub-total* | | *305* |
| **Grand Total** | | **720** |

## 7.2.3 Existing Program Activities

### *7.2.3.1 CIP-Budgeted Cost-Beneficial Combined Sewer System Plan Projects*

**Overview**. BES has budgeted for implementation more than 50 cost-beneficial Maintenance and Reliability projects. These projects were developed as part of the Combined Sewer System Plan process to address local street flooding and basement sewer backup risk. In keeping with BES's integrated watershed and sustainable stormwater management approaches, stormwater control alternatives were developed and evaluated for these purposes. Consequently, many of these projects also provide significant CSO reduction benefits. These projects are predicted to direct stormwater runoff from 185 impervious acres to either infiltrating stormwater control facilities and/or to stormwater systems that discharge directly to the Willamette River or a tributary stream.

These projects are listed in the Capital Improvement Program—Fiscal Year 2011 through 2020 shown in Table 7-2. The project locations are shown on Figure 7-1. Projects that include green infrastructure stormwater controls are identified with green thumbtack icons. These projects will help to reduce CSOs beyond the ASFO-specified level that is to be achieved when the final East Side CSO projects are completed in 2011.

**Table 7-2**. Combined Sewer System Relief Projects in the Capital Improvement Program - Fiscal Year 2011 through 2020[a]

| Project Number | Project Name | Basin | Impervious Area Reduction (acres) | Cost[b] |
|---|---|---|---|---|
| E07388 | 15th Ave Storage HO1 | Holladay | 0 | $4,012,000 |
| E07389 | E Burnside & 30th Ave ST3 | Stark | 0 | $4,950,000 |
| E07390 | NE Couch and 52nd Ave ST9 | Stark | 0 | $1,079,000 |
| E07391 | HAN/SCH/GR to 16 | Holladay | 0 | $2,696,000 |
| E07392 | SE Pine and 28th Ave ST4 | Stark | 0 | $1,826,000 |
| E07818 | Sandy Storage (SU6)[c] | Sullivan | 0 | $13,678,000 |
| E08300 | Oak Basin CP-B | Oak | 0 | $2,000,000 |
| E08301 | Oak Basin CP-C/1 | Oak | 0 | $3,000 |
| E08385 | Beech Essex CP-G | Beech-Essex | 15.3 | $8,027,000 |
| E08386 | Beech Essex CP-K | Beech-Essex | 0 | $827,000 |
| E08387 | Oak A Basin Phase 1 | Oak | 0 | $2,950,000 |
| E08388 | Oak Basin CP-C | Oak | 0 | $1,805,000 |
| E08389 | Oak Basin CP-D | Oak | 0 | $1,824,000 |
| E08390 | Oak Basin CP-E | Oak | 0 | $1,023,000 |
| E08391 | Oak Basin CP-F | Oak | 0 | $81,000 |
| E08655 | Beech Essex CP-C | Beech-Essex | 17.9 | $9,041,000 |
| E08656 | Beech Essex CP-J | Beech-Essex | 0 | $5,541,000 |
| E09095 | SE Oak St Sewer Repair & Stormwater Control | Oak | 15.3 | $690,000 |
| E10074 | Oak Basin Phase 2 | Oak | 0.0 | $9,228,000 |
| E08383 | Nicolai Green Streets and Pipe Replacements | Nicolai | 2.3 | $3,587,000 |
| E08401 | Far North Nicolai | Nicolai | 0 | $3,770,000 |
| E08402 | North Tanner | Tanner | 0 | $5,139,000 |
| E08403 | Fremont | Fremont | 0 | $6,283,000 |
| E08657 | Central Balch B | Balch | 0 | $1,387,000 |
| E08658 | East Nicolai | Nicolai | 9.4 | $5,782,000 |
| E09017 | BCC Support Project | Balch | 0 | $5,632,000 |
| E09018 | Central Nicolai A | Nicolai | 0 | $3,816,000 |
| E09019 | Southeast Tanner | Tanner | 0 | $3,278,000 |
| E10028 | Southwest Tanner | Tanner | 19.1 | $6,225,000 |

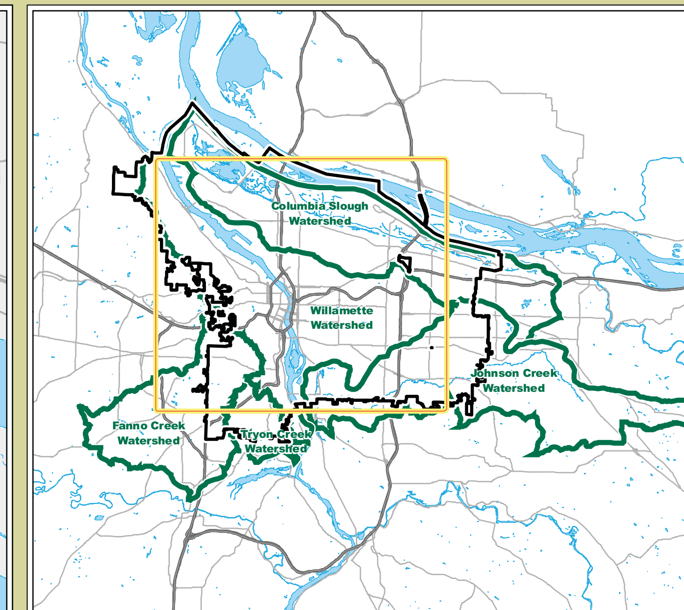
**Table 7-2**. Combined Sewer System Relief Projects in the Capital Improvement Program - Fiscal Year 2011 through 2020[a]

| Project Number | Project Name | Basin | Impervious Area Reduction (acres) | Cost[b] |
|---|---|---|---|---|
| E08659 | SE Powell Reconstruction & Green Streets (1) | Taggart D (Tabor to the River) | 4.1 | $7,026,000 |
| E08660 | SE 9th Green Street (TGD-02) | | 1.5 | $487,000 |
| E08661 | SE 12th and Gideon Reconstruction (TGD-04) | | 0.5 | $4,441,000 |
| E08662 | SE Division Green Streets (TGD-09) | | 3.4 | $537,000 |
| E08663 | SE 26th and Tibbets Green Streets (TGD-12) | | 0 | $678,000 |
| E08664 | SE 28th & Harrison Green Streets | | 0 | $1,181,000 |
| E08665 | SE Division Reconstruction (TGD 15) | | 3.5 | $7,793,000 |
| E08666 | SE 34th and Grant Reconstruction (18) | | 0.5 | $11,213,000 |
| E08667 | SE 41st Reconstruction & Green Streets (22) | | 3.2 | $945,000 |
| E08668 | SE Hawthorne Reconstruction & Green Streets (23) | | 1.3 | $2,216,000 |
| E08669 | SE Clay-Taylor Green Streets | | 0 | $484,000 |
| E08670 | SE 41st and Ivon Green Streets (25) | | 1.6 | $158,000 |
| E08671 | SE Salmon Reconstruction & Green Streets (26) | | 2.3 | $1,593,000 |
| E08673 | SE Madison Green Streets (34) | | 1.0 | $341,000 |
| E08790 | Taggart D Phase 2 | | 35.4 | $20,000,000 |
| E06900 | Taggart B&C R&R | Taggart B&C | 0 | $33,402,000 |
| E08468 | Lents 1&2 Relief and Reconstruction | Lents | 9.6 | $21,627,000 |
| E10003 | Stark Stormwater Controls | Stark | 6.2 | $1,636,000 |
| E09061 | Woods Outfall Disconnection and Mitigation Project | Woods | 0 | $400,000 |
| E10044 | Wheeler F3 | Wheeler | 12.1 | $2,751,000 |
| E10045 | SIW F4 | Insley | 0.2 | $1,240,000 |
| E10041 | Alder F1 | Alder | 9.1 | $4,300,000 |
| E10042 | Alder F2 | Alder | 5.9 | $7,905,000 |
| E10043 | Alder F3 | Alder | 4.6 | $4,602,000 |
| | | **Total Impervious Area Reduction** | **185 acres** | |
| | | **Total Cost** | **$253,136,000** | |

[a] Fiscal Year 2011 projects are approved; other projects are budgeted. Budgeted projects may be altered before approval to reflect additional information as it becomes available.

[b] Some of the stormwater control components of these projects are planned for installation on private property. The project costs shown in this table include the costs for installation on private property, which cannot be funded through the CIP. These projects require recorded maintenance agreements or easements to ensure continued benefit to the City system.

[c] These projects are no longer planned to be storage solutions.


**Legend**

- City of Portland
- Combined Sewer Basin Boundary
- Rivers and Lakes
- Streams and Creeks
- Freeways
- Arterial Streets

**Projects In CIP**

- Basement Sewer Backup Risk reduction projects
- Basement Sewer Backup Risk reduction projects that Include "green" infrastructure

Figure 7-1
CIP Projects (2011-2020)
Maintenance and Reliability
Program

**Basement Sewer Relief Projects**

N W E S
0 6,000 Feet

CITY OF PORTLAND ENVIRONMENTAL SERVICES
Systems Analysis
Spatial Analysis and Modeling

**Post-2011 Combined Sewer Overflow Facilities Plan**

Produced by Systems Analysis: Map Request 5464 (KDR) July 23rd, 2010 \\Cassiolasm_projects\9ESEN00000006\Mxd\Phase_1\Fig_5-4.mxd

**Tabor to the River**. The Taggart D basin projects listed in Table 7-2 are components of a new, large program called "Tabor to the River." This program combines innovative stormwater management techniques with sewer repairs and improvements to solve a variety of urban challenges. It integrates hundreds of sewer, green stormwater management, tree planting and other watershed projects to improve sewer system reliability, stop sewer backups in basements and street flooding, reduce CSOs to the Willamette River, and restore watershed health. This program is an example of the triple-bottom-line approach that BES plans to follow in the development and implementation of combined sewer system improvements listed in Table 7-2 and candidate CSO reduction methods in the future.

The Tabor to the River project area (shown in Figure 7-2) extends from the Willamette River to Mt. Tabor between SE Hawthorne and SE Powell boulevards, and covers about 2.3 square miles.

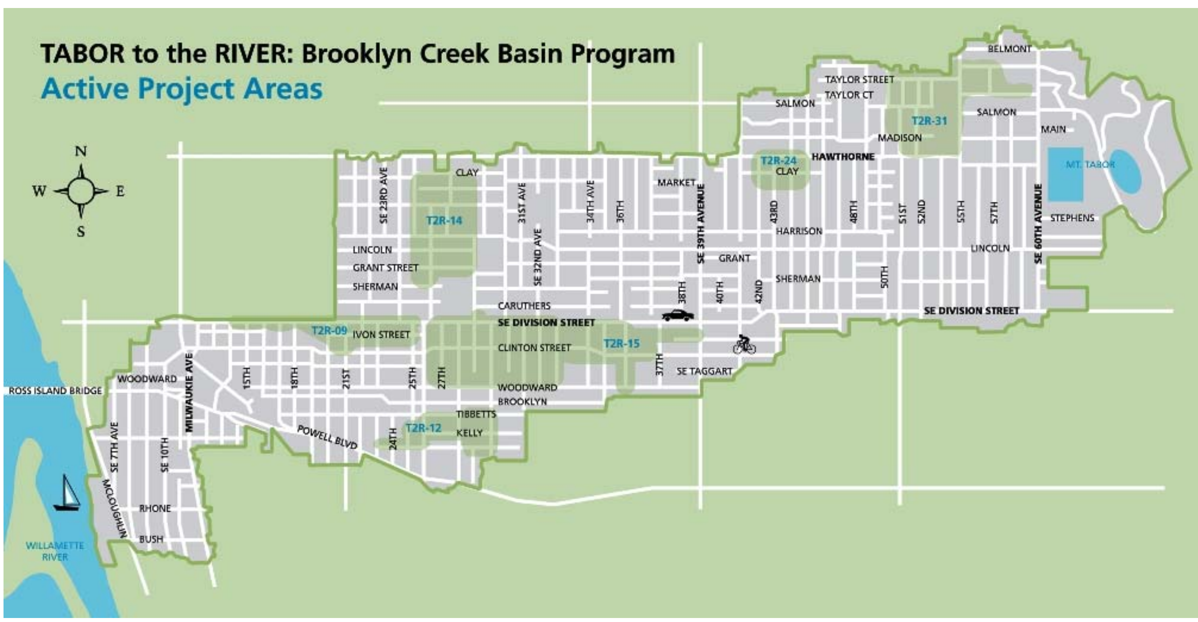



**Figure 7-2**. Tabor to the River Project Areas

Tabor to the River is a partnership between the City and the community to create sustainable solutions to urban sewer and watershed problems by:

- Adding more than 500 green street facilities, vegetated curb extensions and streetside planters that will collect street stormwater runoff and let it soak into the ground as soil and vegetation filters pollutants
- Repairing or replacing 81,000 feet of sewer pipe, adding new pipe and installing new manholes as necessary
- Planting nearly 4,000 street trees to absorb rain and reduce and slow stormwater runoff

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- Restoring natural areas in the basin by removing invasive vegetation and introducing native plants
- Working with private property owners to construct facilities that will collect and manage roof and parking lot runoff

Resolving these problems with pipe-only solutions was estimated to cost $144 million. Adding sustainable, green stormwater management systems reduced the estimated cost to $86 million while enhancing water quality and watershed health.

The City is designing sewer and green street projects in the first two of 35 project areas. Construction on the Richmond-Clay and Mt. Tabor-Taylor projects began in spring 2009. The entire Tabor to the River Program will take more than 10 years to complete.

#### *7.2.3.2 Additional Cost-Beneficial Combined Sewer System Plan Service Improvement Projects*

The Combined Sewer System Plan (BES, forthcoming 2010) identified additional service improvement projects that are currently thought to be cost-beneficial for reduction of local street flooding and basement sewer backups, but have not yet been submitted to the CIP. These projects are predicted to direct stormwater runoff from about 190 impervious acres to infiltrating stormwater control facilities and/or to stormwater systems that discharge directly to the Willamette River or a tributary stream. The estimated cost of implementing these projects is approximately $214 million. The cost-benefit of these projects for the reduction of CSOs is assumed for planning purposes but will need to be evaluated as they are considered for CIP budgeting.

#### *7.2.3.3 PBOT Stormwater Runoff Management Projects*

Under SWMM guidelines, PBOT is responsible for stormwater runoff management (pollution reduction and flow control) for roadway improvement projects that involve more than re-paving an existing roadway. Examples of these types of projects within the combined system are the Burnside-Couch couplet project and the Eastside Streetcar project. It is assumed that projects such as these will continue to be constructed and PBOT will have to mitigate for an average of 1 impervious acre per year over the 40 year analysis period.

### 7.2.4 Other City Programs

Other policies and programs that support sustainable stormwater management and have potential CSO reduction benefits include:

- Clean River Rewards, the stormwater discount program, offers up to 100% discount for onsite stormwater charges to ratepayers who register onsite Green Infrastructure practices.

- Green Streets policy to promote and incorporate Green Infrastructure to manage stormwater in City funded development, redevelopment, or enhancement projects.
- Grey to Green Initiative to make stormwater management more sustainable, restore watershed health, and enhance Portland's livability. The 5-year goals are to add 43 acres of ecoroofs, plant 33,000 yard trees and 50,000 street trees, restore native vegetation, construct 920 Green Street facilities, control the spread of invasive plants, replace 8 culverts that block fish passage, and purchase and protect 419 acres of high priority natural areas.
- Climate Change Action Plan of 2009 with a local government objective to develop green buildings.

## 7.3 Risk Assessment of Recommended Plan

A risk assessment of the recommended plan is summarized in Table 7-3. Monitoring for increased risk in the areas outlined in Table 7-3 is recommended as an implementation plan activity. If the associated risks increase, then the mitigation measures will be developed as appropriate to support successful implementation of the CSO reduction methods.

Two other risks over which BES has no control but which could affect the recommended plan are climate change and the state of the economy. An overview of climate data for the Pacific Northwest shows the following:

- Projected sea level rise on the west coast in the range of 7 to over 9 inches from 1990 to 2050[4]
- An average temperature increase of 1.5°F has been observed for the Pacific Northwest between 1920 and 2000[5]
- Data show increases in "very heavy" (defined as the top 1% of the daily precipitation at selected stations) daily precipitation of 16% from 1958 to 2007[6]
- Mean annual precipitation changes projected from the 1950-1979 period to 2030-2059 are between 2 and 4% in the Portland/SW Washington area[7]

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[4]CH2M HILL, October 2009, Report for the National Association of Clean Water Agencies NACWA.

[5] University of Washington, Climate Impacts Group, Past and Future Trends in Pacific Northwest Climate, http://cses.washington.edu/cig/pnwc/pnwc.shtml

[6] Global Climate Change Impacts in the United States, Thomas R. Karl, Jerry M. Melillo, and Thomas C. Peterson, (eds.). Cambridge University Press, 2009.

[7] U.S. Department of Interior, Bureau of Reclamation, 2009, *Literature Synthesis on Climate Change Implications for Reclamation's Water Resources*, Technical Memorandum 86-68210-091, Technical Service Center Water Resources Planning and Operations Support Group, Water and Environmental Resources Division (Mark Spears, Levi Brekke, Alan Harrison, and Joe Lyons [peer reviewer])

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These are some of the currently available data for precipitation that are limited to annual average data, which should be revisited in the future after event-based local data have been developed and analyzed. It is anticipated that BES's focus on development of green infrastructure for stormwater volume management, continued implementation of SWMM, and revegetation and restoration of natural systems via the City's Green Streets Program, Portland Watershed Management Plan, and Grey to Green Initiative will help improve the adaptive capacity of the City's watersheds to handle climate change.

The impact of the economy on the pace of development and redevelopment will be monitored to identify necessary adjustments to the recommended plan as circumstances unfold.

**Table 7-3**. Risk Assessment and Mitigation Measures

| Plan Element | Risk of Implementation | Mitigation Measures |
|---|---|---|
| **Recommended Methods** | | |
| Existing Program Activities | Volume reduction estimates are overstated through model assumptions or their actual reduction performance | Monitor performance from existing facilities; apply additional stormwater reduction strategies identified in plan |
| | Maintenance of green infrastructure stormwater controls not performed over long term to maintain performance | Apply cost-benefit risk analysis in a business case to justify adequate maintenance budget<br>Commit to investigation of optimal maintenance cycles, work planning, and procedures with monitoring of how maintenance affects facility functionality<br>Consider alternative maintenance delivery methods |
| | Unauthorized public and private stormwater facility modifications diminish performance | Perform periodic inspections to ensure facilities (including disconnections) are intact and functioning properly |
| | Funding not approved for stormwater control facilities on private property | Seek alternative funding and implementation approaches or revise public works projects to incorporate needed control |
| | Participation by private property owners is not sufficient to meet onsite stormwater control targets | Develop outreach, technical assistance, and financial incentive programs<br>Revise public works projects to incorporate needed control |

**Table 7-3**. Risk Assessment and Mitigation Measures

| Plan Element | Risk of Implementation | Mitigation Measures |
|---|---|---|
| | Green streets not feasible | Increase options for onsite stormwater controls through partnering with private properties |
| **Candidate Methods** | | |
| Re-evaluate SWMM Volume Control Effectiveness | Volume reduction estimates are overstated vs. actual reduction performance | Monitor performance from existing facilities<br>Apply additional stormwater reduction strategies identified in plan |
| Improve Stormwater Facility Design | Long-term improvements not realized | Monitor performance from existing facilities, apply results to modified design to achieve greater volume removal |
| | Design improvements are more costly and less attractive to developers | Develop design improvements that are cost conscious |
| Assess Stormwater Water Quality Problem Areas | Real time control requirements increase costs beyond cost effective levels | Include water quality improvements in benefit assessment |
| | Permitting issues regarding Waterfront Park | Apply additional green infrastructure solutions to the areas rather than sending to the tunnel system |
| Implement SWMM Projects at Large Institutions | Resistance from property owners because of lack of design capabilities or concern about facility maintenance commitments | Develop outreach, technical assistance, and financial incentive programs<br>Develop alternative maintenance delivery systems |
| Refine Requirements of SWMM for New Development and Redevelopment | Resistance from property owners, developers, and stormwater facility installers | Develop outreach, technical assistance, and financial incentive programs |
| | Conflict with City developmental policies fostering maximum density and use of property | Increase requirements for ecoroofs and other facilities that provide flow control<br>Evaluate sharing facilities in the public right-of-ways |
| Implement Stormwater Projects at Large Commercial Facilities | Resistance from property owners | Develop outreach, technical assistance, and financial incentive programs |

City of Portland, Post-2011 CSO Facilities Plan

# 7.4 Financing Plan

## 7.4.1 Sources of Funding

The two primary sources of revenue are sewer service rates and system development charges. These can be used to cover service reimbursements, wholesale sewer agreement revenues, development review fees, and the like. Also, interest earnings are available as a financial resource.

All operations, maintenance, and capital projects are financed with revenues, revenue bond debt, or with ending fund balances. Key financial policies for each source of funding are described below.

### *7.4.1.1 Revenues*

One of BES's financial planning objectives is to provide smooth sewer rate changes over time in order to maintain financial stability and predictability for BES as well as its customers. This objective increases customer satisfaction by providing consistent price changes from year to year. The Rate Stabilization Fund (RSF) is a key tool for meeting this planning goal. The RSF balance reached a peak of $76.5 million in Fiscal Year 2007-2008, and will be drawn down to the policy-derived minimum in Fiscal Year 2012-2013 to help offset the effects of increasing debt service as the remaining CSO facilities are completed.

### *7.4.1.2 Revenue Bonds*

The bulk of BES's CIP programs are financed by revenue bonds, and for this reason, principal and interest payments on outstanding debt are a substantial part of BES's current and forecast revenue requirements. Covenants on BES's outstanding first-lien and second-lien bonds contain coverage requirements that have a direct effect on revenue requirements.

BES's planning standard is to set rates adequate to provide net income, including transfers to or from the RSF, equal to or greater than 1.5 times the annual debt service requirement for first-lien bonds, and 1.3 times the annual debt service requirement for first-lien and second-lien bonds on a combined basis. This exceeds the coverage required by existing bond covenants, and serves three purposes:

- The absolute dollar difference between the planning standard and BES's actual debt service coverage requirement provides a margin of safety for meeting coverage requirements.
- The 1.5 and 1.3 standards play a significant role in demonstrating BES's commitment to sound fiscal management of the sewer system. They also support BES's efforts to maintain the highest possible bond rating which helps to hold down borrowing costs.

- The 1.5 and 1.3 standards further strengthen BES's financial position by providing ongoing equity contributions to the capital program.

#### *7.4.1.3 Ending Fund Balances*

The combined ending fund balances within the Operating Fund and the RSF must be equal to or greater than 10% of each year's operating expenses, as defined by BES's financial policies. The combined 10% is consistent with industry standards and is a reasonable amount to meet cash flow requirements and fund minor budget adjustments. It also reflects the City's commitment to strong fiscal management of its sewer utility. BES also maintains a debt service reserve of $200,000 for the nearly $27 million of outstanding low-interest loans from the DEQ State Revolving Fund.

The Construction Fund minimum ending fund balance is targeted at 35% of the following year's estimated capital improvement expenditures for planning purposes. The actual ending fund balance will differ depending on the rate of expenditures within BES's capital program and the timing of CIP borrowings.

#### *7.4.1.4 System Development Charges (SDCs)*

Sanitary and stormwater SDCs ensure that new customers pay their equitable portion of the costs (net of grant revenues) of major sanitary and stormwater system facilities that serve the entire community. Major facilities are generally considered to be facilities other than local collection systems sewers, and include treatment plants, pump stations, trunk and interceptor sewers, UICs, and water quality facilities.

State law (ORS 223.307) allows the use of SDC revenues for capital construction or debt service payments. It is BES policy to use cash SDC revenues to pay debt service, while SDC revenues received in the form of special assessment bond proceeds are used in funding the CIP. State law does not permit SDC revenues to be used to pay operating expenditures. However, SDC revenues do still help reduce the revenue requirement.

### 7.4.2 Financial Planning Process

The financial planning process has three key elements: (1) Development of the CIP; (2) Development of the Operating Plan; and (3) Development of Revenue Requirements and the Funding Plan.

#### *7.4.2.1 CIP Planning Process*

The CIP is developed annually using a multi-step process to identify, develop, review, score, and rank projects for funding and scheduling priority. A BES-wide stakeholder review team investigates, scores, and ranks all BES proposed CIP projects in accordance with identified CIP criteria which is based on a triple bottom line approach. CIP weighting criteria, scoring instructions, scheduling guidelines, estimating procedures, and project request forms ensure each proposed project is defined, reviewed, and scored based on detailed and consistent information regardless of where the project originated.

The CIP management team evaluates all of the information from the process, meets with selected BES project and program managers to further reduce costs where appropriate, and submits final recommendations to the BES Director. The BES Director reviews the findings, makes further refinements as needed, and approves the CIP plan that is then presented to the City Council for their consideration and adoption.

#### 7.4.2.2 The Operating Planning Process

BES's operating planning process addresses two areas. The first includes the routine functions of the City's sanitary and stormwater utility, including day-to-day operations and the maintenance of collection, transportation, treatment, and disposal systems. The second includes costs for activities and services that respond to the regulatory requirements or that specifically promote water quality and watershed health. The two areas are closely interrelated: regulatory actions impose requirements on routine system operations, and a large share of day-to-day operations focus beyond the basic municipal infrastructure toward watershed protection and environmental improvement.

#### 7.4.2.3 Development of Revenue Requirements and Funding Plan

Developing revenue requirements and a funding plan requires developing a mix of funding sources. The primary sources to date have been monthly service charges and revenue bonds (with system development charges comprising a much smaller percentage). Revenue requirements over the forecast interval will depend on the mix of funding sources. Since the inception of the CSO control program in 1992, BES has relied primarily on revenue bonds to finance capital construction, with rate revenues being used primarily for operating expenditures and to pay debt service on the bonds (with some cash financing of construction activity).

### 7.4.3 Short-Term

The 5-year forecasted CIP expenditures for fiscal years ending June 30, 2011 through 2015 are summarized in Table 7-4.

**Table 7-4**. BES Forecast of Capital Improvement Expenditures by Program for Fiscal Years 2010-2011 through 2014-2015 *(in thousands of dollars)*

| Category/Program | 2010-2011 | 2011-2012 | 2012-2013 | 2013-2014 | 2014-2015 | 5-Year Total |
|---|---|---|---|---|---|---|
| Combined Sewer Overflow | $109,126 | $20,037 | $0 | $0 | $0 | $129,163 |
| Maintenance and Reliability | $48,398 | $26,934 | $46,350 | $68,286 | $71,078 | $261,046 |
| Systems Development | $10,039 | $1,830 | $1,824 | $3,799 | $5,229 | $22,721 |
| Sewage Treatment | $28,419 | $25,020 | $21,909 | $10,212 | $12,604 | $98,164 |
| Surface Water Management | $25,475 | $17,669 | $16,055 | $16,416 | $12,829 | $88,444 |
| **Total** | **$221,457** | **$91,490** | **$86,138** | **$98, 713** | **$101,740** | **$599,538** |

Note: Fiscal years are from July 1 through June 30.

The 5-year capital improvement expenditures shown in Table 7-4 are discussed by category below:

- CSO-required expenditures account for $129 million, or 21% of total capital expenditures during the forecast interval. Major projects include completion of the East Side CSO Tunnel system, CSO-related improvements at the CBWTP, Balch Consolidation Conduit, Sellwood CSO Pump Station, and the Portsmouth force main.
- Maintenance and reliability expenditures are forecast at $261 million, or 44% of total capital expenditures over the 5 year planning interval. This program rehabilitates or replaces failing pipe discovered during system inspections. Projects will include nearly all areas of the city. Major work will include the Fanno Basin and Oak B Basin projects and major pipe rehabilitation projects. Several of these projects, particularly in the Oak and Taggart D basins, include green infrastructure stormwater controls that will reduce flows into the combined sewer system.
- Systems development program expenditures comprise 4% of total capital expenditures over the five year planning interval. Systems Development is the program that extends sewers to areas that are currently not served, such as the South Airport Basin and the Lents Sewer Extension projects, and for the elimination of shared "party sewers." This program also supports construction of BES infrastructure required to support development efforts by others, including sewer relocation related to the Portland-Milwaukie Light Rail line.
- Forecast expenditures for the sewage treatment systems of $98 million are 16% of total capital expenditures over the five year planning interval. The projects include CBWTP secondary treatment expansion, CBWTP digester expansion, CBWTP selector performance enhancement, Ankeny Pump Station upgrade, CBWTP lagoon

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reconstruction, and projects within the Pump Station Improvement and the Treatment Facilities Rehabilitation & Modification programs.

- Forecast expenditures for surface water management of $88 million are 15% of the 5-year CIP. This program includes projects that are exclusively related to drainage and water quality while providing other watershed benefits such as flood management, fish and wildlife habitat and recreational opportunities. Johnson Creek restoration projects are primary examples of these types of projects. Projects in the Grey to Green Initiative for land acquisition, Green Streets, and culvert replacement make up the largest of the planned expenditures.

As a result of the capital expenditures indicated in Table 7-4, BES will be required to issue additional bonds totaling $750 million between now and the end of the 5-year interval. This will require an additional $60 million in annual debt service by fiscal year 2014–2015, which is an increase of 50% over the fiscal year 2009–2010 debt service levels.

### 7.4.4 Long-Term

Beyond the 5-year forecast interval, BES long-term financial forecasts rely on knowledge of longer-term project costs[8] and estimates of the impacts of potential regulatory requirements over a longer horizon. BES assumes that it will continue to rely on revenue bond financing for CIP expenditures (decreasingly over the next 15 years). On the operating side, expenditures are driven primarily by normal operation and maintenance expenditures for the infrastructure in place, unless BES models a specific regulatory or operational scenario.

### 7.4.5 Affordability and Financial Capability

#### *7.4.5.1 Introduction*

From 1991 through 2011, BES will have invested approximately $1.4 billion in its CSO LTCP to address the requirements of the ASFO. Over the last 20 years, the citizens of Portland have also made significant investments in upgrades to the CBWTP and improvements to the separated sanitary sewer system. The sewer service charge for the average single family household is nearing $50/month. The pace of investment is hardly slowing down in the next 10 to 20 years. In addition to the considerable debt for the CSO control program, continued investments include a projected $1 billion for the capacity, management, operation, and maintenance (CMOM) program over the next 20 to 40 years, annual operations and maintenance for the new CSO control system, and new efforts for stormwater and watershed management. BES will need to ensure that the Portland community is financially capable of paying for these continued water quality investments.

[8] CSO Program costs over the last 18 years, and the capital Maintenance and Reliability Program for the next 20 years as examples.

The National Association of Clean Water Agencies (NACWA) has published two White Papers[9] on financial capability and affordability for wet weather programs as tools for consent decree negotiations. Even though BES is not negotiating a consent decree, and will focus on cost-effectiveness and triple bottom line cost-benefit before proceeding to implement programs and grey or green infrastructure projects, the principles of financial capability and affordability still apply. It is important to note here that all the previous discussions about cost-effective and cost benefits are related to the pricing of a project, not whether money can be raised to pay for the project. The NACWA White Paper definitions are:

- ***Affordability*** *relates to whether individual utility ratepayers or customers can pay their utility bills without undue hardship or unreasonable sacrifice in their lifestyle or in their essential spending patterns*.[10]
- ***Financial capability*** *is the relationship between a community's economic condition and the investments needed to make water quality-related improvements. A community's ability to pay for these needed improvements is determined by its existing and potential future economic situation. Based on an assessment of a community's economic situation, the scope of any improvements and the timeframe for making the improvements is determined*.

Affordability accounts for all the demands on individual's income and specifically examines the range of income across the households to understand what is affordable across this spectrum. This is often referred to as "ability-to-pay."

The purpose of undertaking a financial capability assessment is to deliberately balance the dual responsibilities of compliance with various environmental laws and regulations, with effective stewardship of public funds. The balance should account for BES programs against other needed public investments to ensure that reasonable limits of annual expenditure are established. Often bond agencies will assess a City's bonding capacity, as a test of financial capability.

To support this approach to both affordability and financial capability, NACWA developed some guidelines; these are:

A. The first consideration in a financial capability assessment must be the community's economic situation:

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[9] NACWA, *Financial Capability and Affordability in Wet Weather Negotiations*; Prepared for NACWA by CH2M HILL, October 2005; and *Principles for Assessment and Negotiation of Financial Capability: A Compilation of Resources*, Prepared for NACWA by CH2M HILL and the Galardi Rothstein Group, November 2007.

[10] NACWA, *Principles for Assessment and Negotiation of Financial Capability: A Compilation of Resources, Document 1 Annotated Guiding Principles for Financial Capability Assessment of Clean Water Programs*; Prepared for NACWA by CH2M HILL and Galardi Rothstein Group, November 2007, Page 1-1.

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- This speaks to local conditions including water rates, energy rates, low income population as a percentage of total population, shelter costs, construction market, etc.

B. Economic capability for clean water programs must be assessed in light of other investment demands and potential environmental benefit:

- With cost-effectiveness measurement and a triple bottom line approach to implementing projects beyond what is required by NPDES permits and state orders, this principle will be well served.

C. Environmental improvements should be structured so as to mitigate the potential adverse impact of their cost on distressed populations:

- Even if a project/program is cost-effective and provides triple-bottom line benefits, it may still be difficult for some segments of the community to afford rate increases to support such programs.

The City's financial capability and affordability analyses, presented below, follow these guidelines.

#### *7.4.5.2 Portland Sewer Rates Since 1990*

A simple measurement of the financial burden on the Portland community due to environmental programs is illustrated by the history of Portland's sewer rates since 1990. As shown in Figure 7-3, monthly sewer bills for residential customers, which were $10 per month in 1990, have increased nearly 400%. This increase is more than five times the rate of inflation and more than four times the growth in Portland median household income.

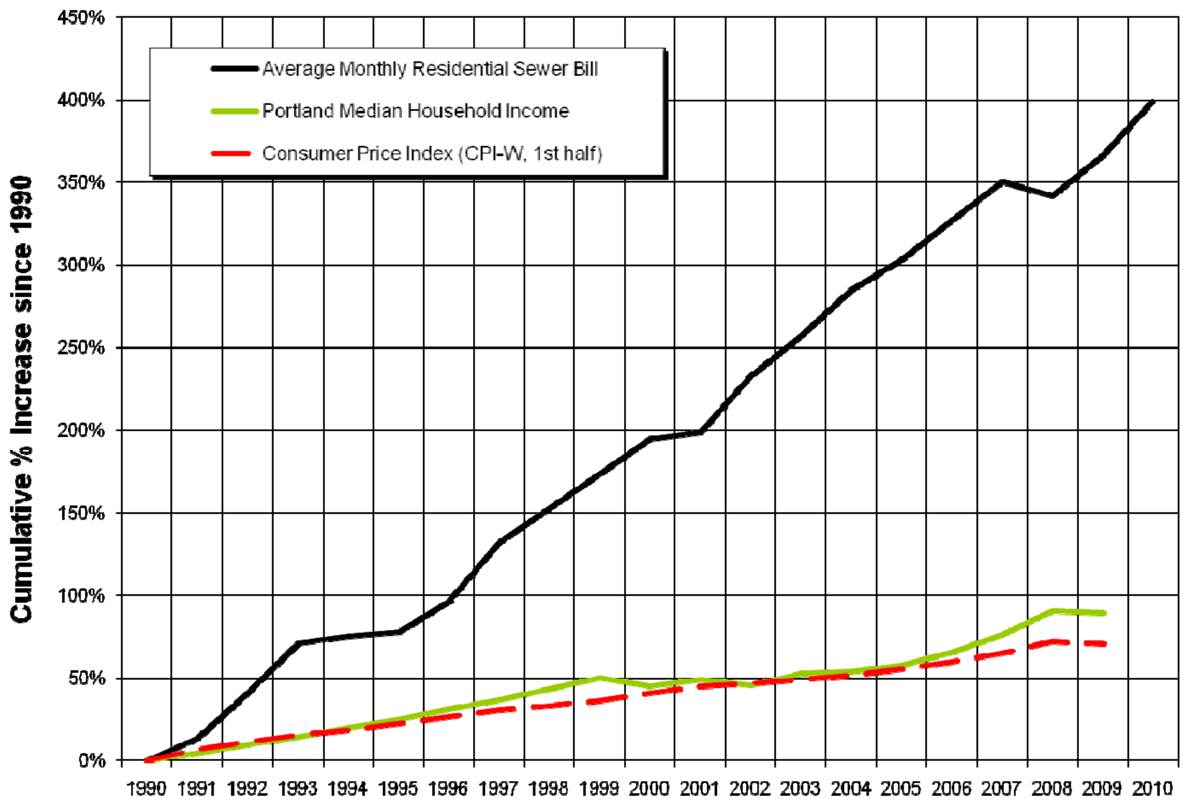


**Figure 7-3.** Portland's Average Monthly Residential Sewer Rates Since 1990

### *7.4.5.3 Affordability of Short-Term Plan*

In 2006, the City worked with a consultant for EPA to evaluate the financial feasibility of expanding CBWTP's secondary capacity to treat more captured CSO. The results of that affordability analysis demonstrated that additional expenditures would result in further exceedance of EPA's affordability guidelines. The evaluation also found that the most pressing and justifiable need, rather than constructing additional secondary clarifiers, is to invest in pipe rehabilitation in the combined and sanitary sewer area. Consequently, in 2007, the City began a 5-year program to increase Maintenance and Reliability capital investments, including a comprehensive pipe rehabilitation program. In 2009, Portland increased the level of investment for pipe rehabilitation as a result of the needs identified in the asset management-based Phase II Pipe Rehabilitation Plan.

Using 2009 CIP information, Portland updated the Affordability Analysis from 2006 to show the impacts to affordability ratios based on actual 2008 sewer rates, and the expected sewer rates in 2016.

The Affordability Index, a ratio of residential sewer rates to Median Household Income (MHI), was calculated on an annual basis for the 150 Census Tracts in the Portland area for the CIP baseline scenario out to year 2016, the year after which the selected scenario will be

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completed. The results for the 2011 baseline condition and the CIP scenario in 2016 are shown in Figure 7-4. This map shows the spatial pattern of census tracts where households are most impacted by the increased sewer rates. A detailed calculation table for the CIP scenario is provided in Appendix D. This table shows that Portland's sewer rates, already among the highest in the nation for municipalities of its size, will continue to increase to cover the current 5-year CIP driven by the completion of the CSO Program, Maintenance and Rehabilitation, and regulatory-driven Surface Water work. By 2016:

- Average monthly residential sewer bill = $84/month – a significant increase to current rates
- Citywide average affordability index = 1.78%
- 73% of households will exceed the 1.5% affordability index for sewer rates
- 30% of households will exceed the 2.0% affordability index for sewer rates

The Baseline Conditions in 2016 reflect the completion of the CSO Program, the CIP elements shown in Table 7-2, and the costs to implement the SVI Improvements and CEPT projects. However, the values do not include the additional $106 million of priority CIP requests because the new expanded CIP was not approved at the time. Even so, the current CSO and CIP commitments have resulted in an economic burden on the community that will continue to be felt by more and more households as the programs are completed and bond payments come due. As shown in the attached Affordability tables, the 2016 sewer rates are expected to be near $84/month, which will result in 30% of households (72,000) in Portland exceeding the 2% Affordability Index.

This affordability analysis uses available economic data from the U.S. Census Bureau's American Community Survey, the Congressional Budget Office (CBO), the Office of Management and Budget (OMB), and Bureau of Labor Statistics. It includes OMB and CBO projections of the national average consumer price index (CPI) for 2009 which were used to estimate Portland's median household income. However, the downturn in the local economy appears to be more severe than the nation as a whole, based on mid-year actual CPI and unemployment figures—and more severe than the national estimates projected. Therefore, the real financial burden of sewer rates on the Portland community is likely higher than the current affordability analysis, using the same EPA methodology and data sources, is able to show.

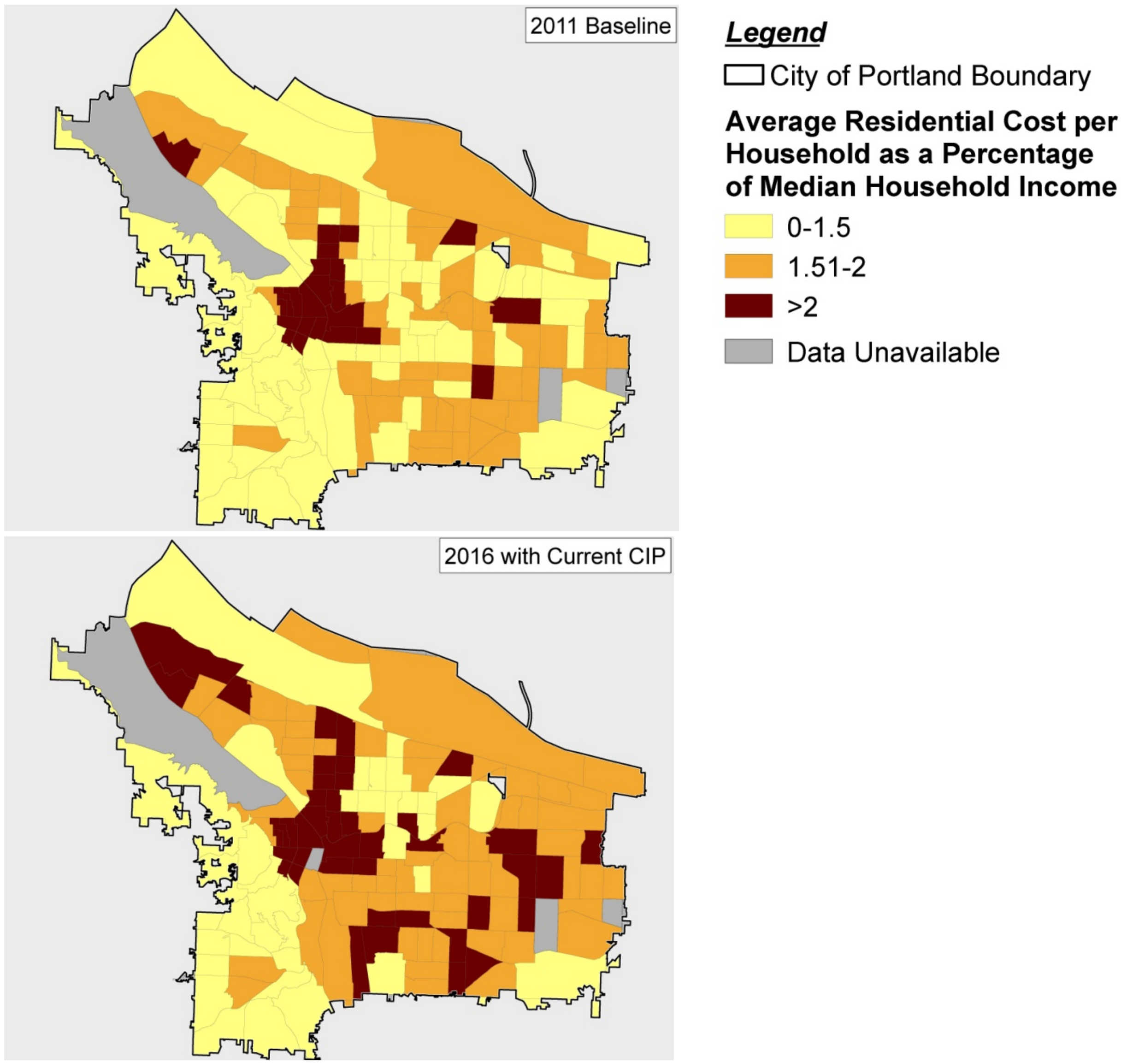


**Figure 7-4.** Census Tracts Exceeding EPA Affordability Index Due to Increased Sewer Costs

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#### *7.4.5.4 Portland Financial Capability Analysis for 2016 Conditions*

EPA's Guidance for Financial Capability Assessments (FCA) indicates that the analysis has two goals:

1. To evaluate a permittee's financial resources to implement CSO controls
2. To develop CSO control implementation schedules

Portland is in the 19th year of implementing its 20-year CSO Control Program. Since 1991, the City has met every ASFO milestone on schedule. Because Portland is close to completing its CSO program, the FCA, which is designed to measure financial capability at the outset of a CSO abatement effort, is not applicable. It is more appropriate to use the financial capability analysis to evaluate the financial burden on the community from Portland's capital improvement program, which includes the CSO program as well as other infrastructure projects.

As required by EPA, Portland completed the Financial Capability Analysis for 2016 conditions. The purpose of this final part of the analysis is to characterize the degree of financial burden on the community for the CSO program and other programs funded by sewer rates. Table 7-5 shows that Portland's Financial Capability Indicator is 2.2, which reflects a mid-range evaluation of the City's financial strength.

**Table 7-5**. Financial Capability Index for Baseline 2016 Condition
*Summary of Permittee Financial Capability Indicators*

| Worksheet 9 Line No. | Financial Capability Indicator | Value | Score/Source/ Notes |
|---|---|---|---|
| 901 | Bond Rating | Strong | 3 |
| 902 | Overall Net Debt as Percent of Full Market Property Value | Strong | 3 |
| 903 | Unemployment Rate | Weak | 1 |
| 904 | Median Household Income | Mid-range | 2 |
| 905 | Property Tax Revenues as a Percent of Full Market Property Value | Strong | 3 |
| 906 | Property Tax Revenue Collection Rate | Weak | 1 |
| 907 | Permittee Indicators Score: *Weak (<1.5); Mid-range (1.5-2.5); Strong (>2.5)* | Mid-range | 2.2 |

The Financial Capability Indicator and the average citywide Affordability Index are used in the Financial Capability Matrix shown in Table 7-6 to determine the degree of burden faced by Portland's ratepayers. The Citywide Affordability Index for the 2016 CIP scenario falls within the "Mid-Range" category: Citywide average affordability index = 1.78%.

Applying the results to the matrix in Table 7-6 indicates that the currently planned projects through 2016 reflect the upper range a "Medium Burden" financially for the City. This information typically is used to establish an implementation schedule for CSO control. As noted at the beginning of this section, in light of the fact that Portland's CSO Program is over 90% complete, this index is not applicable to the CSO Program.

**Table 7-6**. Financial Capability Matrix for Baseline 2016 Condition
*(CSO Guidance for Financial Capability Assessment and Schedule Development, p. 41)*

| Permittee Financial Capability Indicators Score (Socioeconomic, Debt, and Financial Indicators) | Residential Indicator (Cost per Household as a % of MHI) | | |
|---|---|---|---|
| | Low (Below 1.0%) | Mid-Range (Between 1.0 and 2.0%) | High (Above 2.0%) |
| Weak (below 1.5) | Medium burden | High burden | High burden |
| Mid-range (between 1.5 and 2.5) | Low burden | Medium burden | High burden |
| Strong (above 2.5) | Low burden | Low burden | Medium burden |

#### *7.4.5.5 Economic Feasibility Analysis Conclusions*

Portland has consistently raised sewer rates to pay for CSO control projects and other CIP investments since the start of the CSO program in 1990. The current financial model requires the city to continue to raise rates to retire the substantial debt incurred to finance the CSO control program. Portland ratepayers have shouldered this financial burden since 1990 and the burden on the ratepayers will continue to grow past 2016 when it is projected 30% of households will exceed the 2.0% affordability index for sewer rates.

Based on EPA's FCA, this financial burden would be considered in the upper range of a "Medium Burden" on the community. With the anticipated additional costs of pursuing further CSO reductions, the City-wide average affordability index will grow even higher from the currently projected 1.78% toward the 2% threshold for "High Burden."

## 7.5 Implementation Plan

The Implementation Plan includes the following categories:

- ASFO and Permit documentation and procedural requirements
- Methods identified in the Recommended Plan
- Implementation guidance

### 7.5.1 ASFO and NPDES Permit Documentation and Procedural Requirements

The following items are referenced in the ASFO and NPDES permit, and several require post 2011 actions.

City of Portland Post-2011 CSO Facilities Plan

#### 7.5.1.1 Demonstrate Compliance with CSO Elimination per Design Storm

The ASFO requires that within 12 months of the compliance deadline of December 1, 2011, BES demonstrate that the design storm requirements for controlling the remaining Willamette River CSO outfalls have been achieved. This report must be submitted to DEQ by December 1, 2012. The method for demonstrating compliance also must be approved by DEQ, as was done in 2001 for the Columbia Slough system and 2007 for the West Side CSO system.

#### 7.5.1.2 ASFO Termination No later than January 30, 2013

Section 18 of the ASFO states that the order shall terminate 60 days after the respondent demonstrates full compliance with the requirements for CSO overflows on the Columbia Slough and the Willamette River as set forth in Section 12a of the ASFO.

#### 7.5.1.3 NPDES Permit Compliance

The CSO outfalls and treatment are regulated under the CBWTP NPDES permit issued by the State of Oregon under a federal delegation from EPA. EPA engages both informally and formally in the development and approval of the permit. The permit contains enforceable and specific mass load limits, overflow limits, wet weather effluent limits, special conditions, and monitoring/reporting requirements.

#### 7.5.1.4 The Permit Requires Maintaining Operations, Maintenance, and the NMCs

Section 3b of the NPDES permit (draft) requires ongoing operations and maintenance for the combined sewers system. It also requires the submittal of an updated Nine Minimum Controls report during the 5 years of the permit cycle to document the on-going implementation of the NMCs. The NPDES Permit (draft) states once the CSO discharge points have been controlled consistent with the discharge frequency and schedule established (in both the permit and the ASFO) **and** floatables and solids controls are in place **and** BES continues to perform and implement the NMCs, CSO discharges will be deemed in conformance with statewide narrative criteria.

#### 7.5.1.5 Permit Overflow Limits

Future NPDES permits will continue to require compliance with the ASFO overflow limits; the ASFO levels of CSO control are consistent with the Willamette River Bacteria TMDL, the Clean Water Act, and other requirements within the permit.

### 7.5.2 Methods Identified in the Recommended Plan

Adaptive management will be essential to secure cost-effective further reductions. Over the next 40 years Portland will experience growth and development, increases in impervious surfaces, and other changes that must be monitored to achieve further reductions. Consequently, risk analysis to identify potential risk and mitigation and adaptive management will be essential.

#### *7.5.2.1 Recommended Methods*

Initial implementation will consist of Combined Sewer System Plan projects with stormwater removal characteristics that are already programmed into the CIP. In addition PBOT projects are ongoing and are assumed to be implemented such that they remove 1 acre per year of impervious surfaces. Following the CIP-programmed Combined Sewer System Plan projects, the remaining cost-beneficial combined sewer system projects will be implemented and will provide additional stormwater removal. This implementation approach is shown in Figure 7-5. The figure shows the demand for stormwater removal from 2011 to 2050 when growth creates a 22.4 MG demand as previously described. The project categories to achieve the desired removal are shown relative to the increasing demand for removal over time. The stormwater removal demand has been converted to impervious acres as described in Section 6.

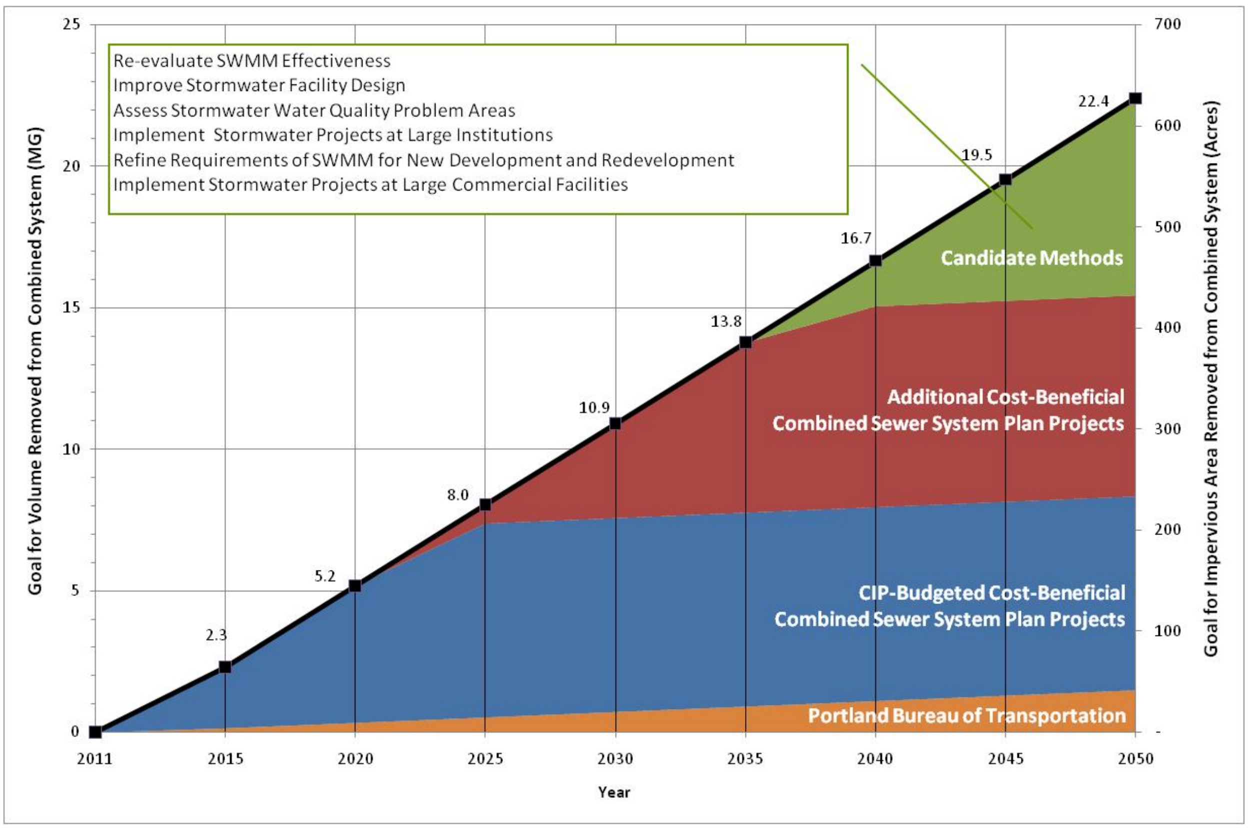



**Figure 7-5**. Post-2011 CSO Implementation Plan for Further CSO Reductions

Figure 7-5 results in the following general conclusions regarding implementation characteristics and timing:

- PBOT stormwater runoff management projects remove a constant 0.04 MG per year for a total of 1.5 MG or 40 acres of impervious area removal by 2050.
- Combined Sewer System Plan projects in the CIP need to start in 2011 and would need to be implemented at a rate of approximately 0.5 MG or 14 acres of impervious area removal per year through 2025.
- Cost-beneficial Combined Sewer System Plan projects not in the CIP need to be initiated by 2020 and by 2025 need to remove impervious area at a rate of approximately 0.5 MG/14 acres per year through 2040.

#### *7.5.2.2 Candidate Methods*

The "Candidate Methods" shown in Figure 7-5 and described in the recommended plan are more flexible in their timing relative to the project groups described above. For purposes of this facilities plan, the specific candidate methods are not identified individually but are shown as a group and implemented following the recommended projects starting in 2035 through the end of the planning period in 2050. Their estimated rate of removal is similar to the projects at 0.5 MG/14 acres per year.

Given that some of these methods (e.g., effectiveness and modifications to the application of the SWMM) provide benefit with minimal cost, it is likely, but not certain, that they will be integrated with earlier stages of the implementation period.

### 7.5.3 Implementation Considerations

It is recognized that during the term of plan implementation, changes may occur in the areas of technology, public support, regulatory and other policies, and control strategy benefit that may result in additional cost-effective control measures not currently considered. Also, a number of implementation monitoring items were identified during the development of the plan. As this adaptive management plan is implemented, the following should be taken into account:

- Coordination with other City programs. Continue existing regulatory and incentive programs for residential and commercial use of green infrastructure. These other policies and programs include: Stormwater Management Manual, Green Streets Policy, Clean Rivers Rewards, etc.
- Effective maintenance program for the existing sustainable stormwater management program.
- Maintenance for attractive appearance of stormwater facilities (e.g., removal of weeds and cleaning of drainageways) so that they are visually pleasing and are well

maintained to function properly. These facilities are visible reminders of stormwater practices and policies located in communities that are usually directly affected by construction and sewer backups.

- Continued odor control at facilities to maintain trust and public acceptance for all its programs including stormwater management. Odor is often regarded by the public as an indicator of competency. If the public detects odor or if odor is a significant nuisance, the conclusion is that BES is not doing its job, and it is not protecting the public or environment. Consequently, odor control is critical to building and maintaining trust with the public. BES learned this with the odor control program at CBWTP where reducing odors was a major factor in gaining neighborhood support for plant expansion.
- Corrosion control and other management, operation, and maintenance programs, both within the combined sewer system and sanitary sewer system to protect the sewers, extend life, and retain function and capacity. Corrosion control will be implemented as part of an asset management program in which risk reduction and mitigation is the goal of an extensive sewer maintenance and rehabilitation program.
- Investigation and support of development of rainwater harvesting, reuse, and conservation technologies that may become cost-effective for CSO control in the future.
- Continued adaptation and improvement based on scientific information, monitoring, and modeling. Consistent with the policies that will focus the CSO control program, reliance on integrated watershed management and stormwater management programs will be important to target new pollutants that may be carried in stormwater. Reliance on pollution prevention/source control, green chemistry, and product stewardship will also be part of the BES tool box.

### 7.5.4 Implementation Summary

By December 2011, Portland will complete the 20-year CSO program in full compliance with the ASFO; this includes "outlining methods for further reductions of the frequency and volume of CSO." System modeling indicates that the most frequent winter overflows may be reduced to as few as two per winter on average compared to the ASFO requirement of four per winter in December 2011 once these facilities are on-line.

Post-2011, the recommended and candidate methods for further reductions provide on-going opportunities for mitigating increased impervious areas due to development. The post-2011 controls are integrated into the implementation plan described above and rely on policies that will guide the program. The recommended plan is supported by a risk analysis and associated mitigation measures to adaptively manage the plan throughout the implementation period.

# Section 8: Plan Performance Monitoring and Reporting

## 8.1 Method for Demonstrating Compliance with Permit Requirements

The method to demonstrate compliance with permit requirements for the winter and summer season is based on the characteristics of the storm frequency specified in the ASFO. For storms that occur during the winter-season (November 1 through April 30), the ASFO storm frequency for Willamette River CSO is a 4-per-winter storm. The summer-season (May 1 through October 31) storm frequency is specified by the ASFO for Willamette River CSO to be 1-in-3 summers. In addition to the different seasonal requirements, there are also differences in the manner by which outfalls are controlled. The method of compliance therefore focuses on the type of rainfall that is most likely to make the CSO control mechanism overflow. DEQ approved the method for demonstrating compliance in 2001 for the Columbia Slough system and in 2007 for the West Side CSO system (BES, 2007a and 2007b).

For outfalls controlled by the large West Side CSO Tunnel, the storm characteristics that may cause an overflow are those storms with large volumes of rain. Therefore, the compliance method focuses on storms with peak rainfall durations of 1 hour through 2 weeks. The amount of rainfall falling on the West Side CSO Tunnel service area is measured by 12 rainfall gages located in and around the area. For the outfalls controlled by diversion structures (not served by the tunnel system), the method of compliance focuses on the short-duration, highly intense rainfall patterns that BES has observed may cause a locally controlled diversion structure to overflow. The rainfall-depth-duration data for these outfalls start at 5-minute durations and go out to 24 hours only.

After the East Side CSO control projects are completed in December 2011, BES will submit a similar method for demonstrating that the design storm requirements for the Columbia Slough and the Willamette River have been achieved and submit it to DEQ for approval.

## 8.2 Long-Term CSO System Inflow and Overflow Tracking

### 8.2.1 Tracking CSO Event Frequencies versus Permit Requirements

At present, each time a CSO event occurs, BES submits a CSO event report to DEQ, which includes an analysis of the CSO event (timing, duration, volume), the rainfall that caused the event, and the system operations during the storm. The purpose of the report is to determine if the storm was larger than the ASFO criteria of a 4-per-winter or a 3-year summer storm. The report includes a plot of the storm characteristics against the ASFO frequency criteria similar to Figure 5-3. If the depth-duration values of the storm plot above the 4-per-winter storm curve shown in Figure 5-3, then the storm is larger than the ASFO criteria, which means the CSO is allowable and permit requirements are being met. The long-term plan is to continue using this tracking method. The 4-per-winter storm curve that will be used for comparison is shown in Figure 8-1.

### 8.2.2 Tracking Further Reductions in CSO Event Frequency

Similarly, further reductions in CSO event frequency will be tracked when winter CSO events occur by plotting them on the 4-per-winter frequency curve, but also comparing them with the other curves shown in Figure 8-1:

- 3-per-winter storm
- 2-per-winter storm
- 1-per-winter storm
- 5-per-winter storm

Over time, this will allow the City and DEQ to track the *degree* to which "further reductions of CSO" have been achieved and continue to be achieved year by year.

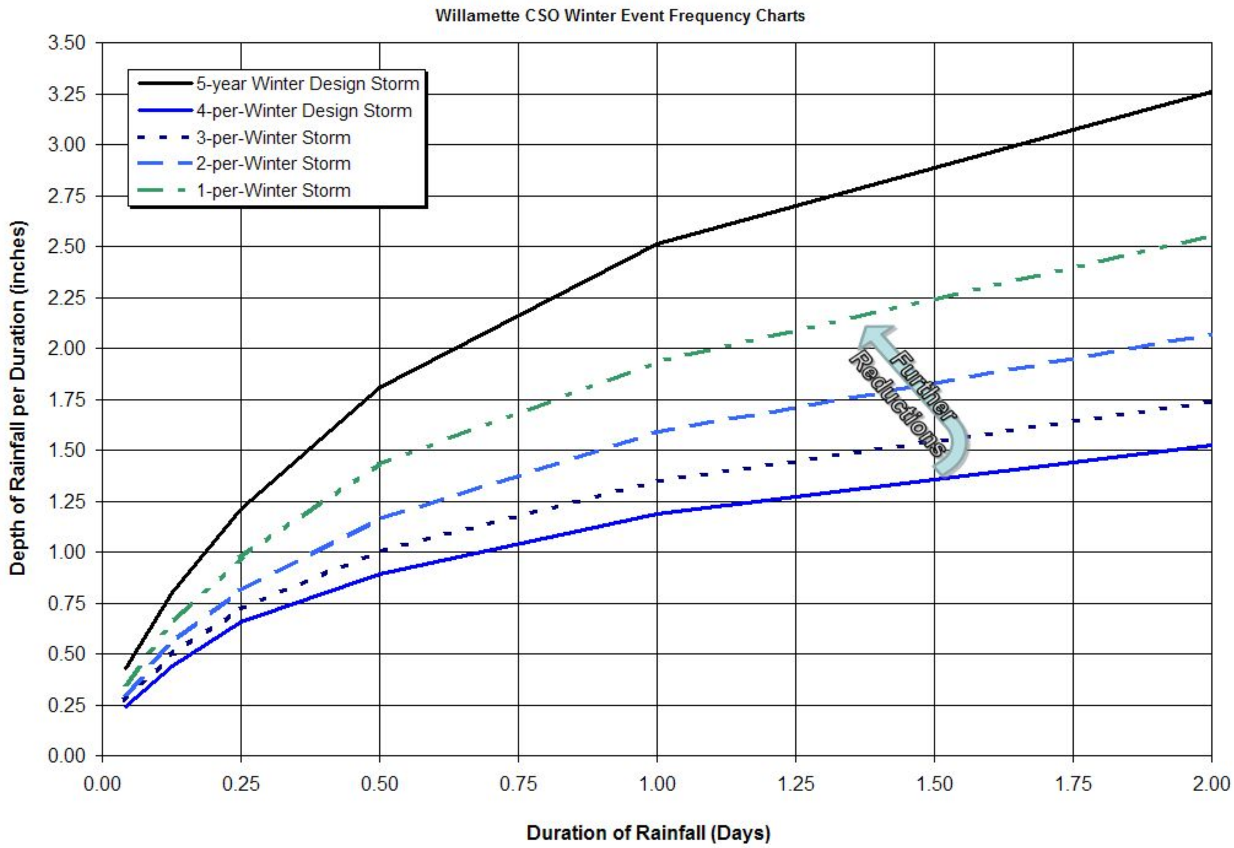



**Figure 8-1**. Depth Duration Frequency Chart for Winter Storms

### 8.2.3 Post-Construction Monitoring for Tracking Inflow and Outflow Impacts

BES developed and submitted a draft Post-Construction Monitoring Program (PCMP) to DEQ and EPA Region X in July 2008 (copy provided in Appendix E). The PCMP documents the CSO monitoring and sampling activities the City of Portland will implement to ensure the CSO Program complies with the NPDES permit and water quality standards as required by the EPA CSO Policy and the Clean Water Act.

The PCMP represents the final stage of the long-term CSO monitoring program the City has carried out since 1990 when it began development and implementation of the CSO program. Initially, the monitoring program focused on characterizing the CSO discharges and their impacts to the receiving water bodies. The monitoring information was coupled with hydrologic, hydraulic, and water quality models to evaluate the efficacy of proposed CSO solutions. Once implementation of the CSO Program was underway, the monitoring program shifted to trending in-stream river water quality improvements and measuring the performance of the completed CSO facilities. This information confirmed the CSO facilities will perform as required by the NPDES permit and will provide the expected water quality improvements for bacteria, which is the primary pollutant of concern.

This program consists of event-based performance compliance monitoring including:

- Rainfall measurements across the service area for comparison against the design storm event frequency criteria for compliance
- CSO discharge measurements with alarms to determine occurrence, duration, total volume, and peak rates
- CSO facilities operations monitoring to confirm performance compared to design expectations
- Water quality sampling of CSO discharges at overflow structures to confirm that water quality will be achieved outside of the mixing zones

The PCMP is critical to the adaptive management approach of supporting "further reductions in the frequency and volume." In order to have information for adaptive management purposes, the PCMP includes long-term performance monitoring with the intent to:

- Improve operations performance
- Calibrate the City's explicit combined sewer system hydrologic and hydraulic model and other various models
- Detect long-term water quality trends

## 8.3 Service Area Change Tracking and Reporting

### 8.3.1 Ongoing System Information Tracking

BES keeps track of service area changes via its explicit modeling dataset, which was created with blending database tools with a geographical information system (GIS). The City developed the explicit model generation and analysis tool set (EMGAATS) to help build hydrological and hydraulic models in PDX-SWMM and XP-SWMM with explicit sewer system detail.

The primary sources of data for the explicit models are outlined in Table 8-1.

**Table 8-1.** Explicit Model Data Sources

| Dataset | Description |
|---|---|
| As-built drawings | Sewer data. |
| Building, parking, and street impervious surface database | Existing imperviousness. |
| Diversion structure database | This database and supporting program is used as one source for information about diversion manhole characteristics. |
| Diversion surveys | Photographs and surveyed dimensions of interior diversion features (for example, weirs, chamber heights and widths, and pipe diameters) serve as an additional source of information about diversion manhole characteristics. |
| Downspout Disconnection Program survey data | The Downspout Disconnection Program is targeted primarily at residential properties on the east side of the Willamette River. This program includes records for over 80,000 parcels. The data provide an estimate of roof area disconnected or removed from combined sewers for individual parcels. |
| Facilities maps | Originally a computer-aided drafting (CAD) system, BES facilities maps were recently converted to GIS and are tied to Hansen data. The GIS data provide spatial representation of surface water conveyance facilities including sewers, manholes, ditches, and streams. The Systems Analysis Group maintains a separate "parallel" master database of sewers and manholes. This master database and the Hansen database are reconciled approximately once every 6 months. |
| Hansen facilities database | Sewer connectivity and maintenance data; "Hansen" is the company that created the database BES uses to track TV inspection and maintenance of its sewer facilities. |
| HYDRA rainfall data | Rain gage information from the BES network of over 40 rain gages scattered throughout the BES service area. HYDRA is the acronym for BES' permanent rainfall and monitoring network (Hydrologic Data Retrieval and Alarm). |
| HYDRA sewer level data | Level, velocity, and flow data in sewers, usually found near diversion structures at the lower part of basins and near hydraulically important locations. |
| JANUS temporary flow monitoring data | Flow monitors that collect level and velocity data (which are used to estimate flow rates) are placed in sewers during predesign and design of projects. JANUS is BES' name for the program used to retrieve the monitoring data. |
| Laterals map | Limited service laterals coverage extending from buildings to sewer lines. |
| Maintenance Inspection Program | The Maintenance Inspection Program (MIP) is the private property stormwater facilities database created and maintained by BES. |
| Metroscan data | Tax assessor data containing basement information; useful in generating basement sewer backup risk maps. Metroscan is the name of the program used to view these data. |
| Pump Station Data | Series of five separate databases that contain information on pump stations, wet wells, pump data, pump schedules, and force mains. The databases are linked through common field names. |
| Separation area map | Storm-separated areas. |
| Sump coverage map | Inflow areas formerly connected to combined sewers, which are now effectively separated via large dry wells positioned generally at non-arterial street intersections. |

**Table 8-1.** Explicit Model Data Sources

| Dataset | Description |
|---|---|
| Tax lot maps | Existing zoning and future base flow assumptions. |
| Topography map and spot elevations map | Slope of land, creation of digital terrain models. |
| Tree canopy over paved area map | Parts of tree canopy hanging over paved areas (streets and parking lots). |
| Water usage data | Existing base flows. |
| Zoning map | Future zoning assumptions for future imperviousness assumptions. |

The system data can be updated and adjusted to represent changing conditions in the City and provides the flexibility to evaluate many different kinds of alternatives for improving system performance and meet BES targeted levels of service. This includes changes to the master sewer system database that occur as a regular part of the standard BES business processes and improvements to the infrastructure data developed from as-built drawings, plumbing records, and onsite investigations.

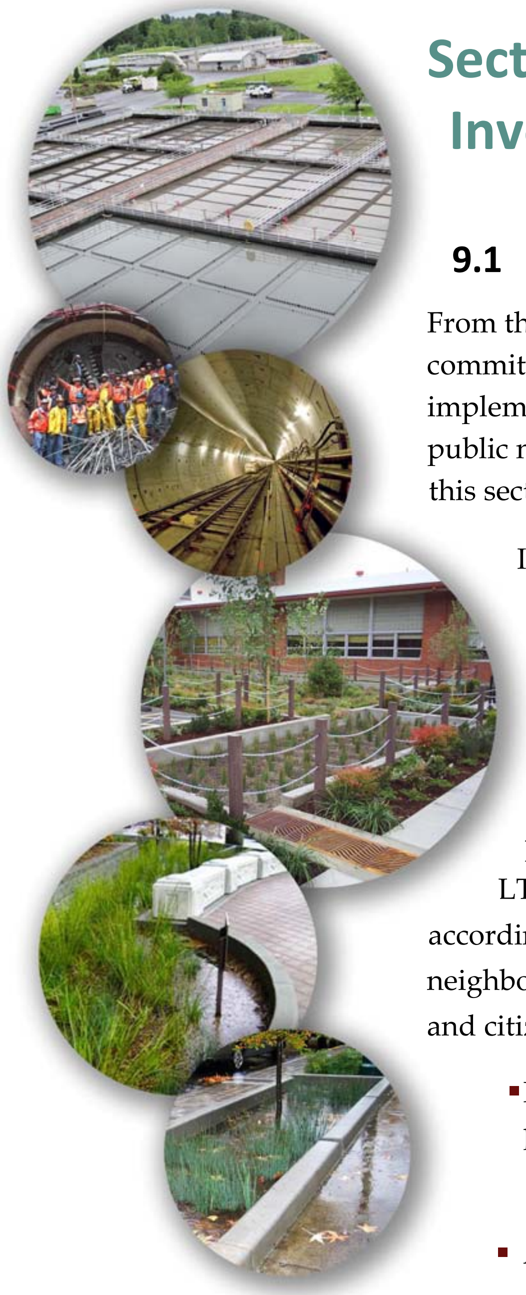
### 8.3.2 Triggers

Further reductions in CSO will be achieved by the 20-year CSO Program, and then sustained by the recommended projects presented in Section 7. As these projects are being implemented, additional performance monitoring data will be collected and evaluated to identify potential capacity shortfalls. Also, based on a review of the SWMM program, it is expected that greater CSO reductions will be realized than previously forecasted. As these activities transpire, the City will monitor the following primary triggers for potential activation of the appropriate long-term strategies described in the recommended plan:

- System performance indicates that winter CSO events occur due to storms more frequent than two per winter on average. This more stringent frequency will be used as a trigger for planning activities rather than the regulatory requirement in order to allow time to implement projects to sustain further CSO reductions, which can be measured as the reduced number of overflows per winter.
- Community development is expected to increase impervious area at a greater rate than anticipated. For this plan, growth is assumed to occur at an average rate of 14 impervious acres a year.
- Stormwater runoff volume from new impervious area managed onsite as per SWMM requirements is found to exceed expected reduced volumes.

## 8.4 Nine Minimum Controls

The nine minimum controls are low-cost, technology-based actions or measures designed to reduce CSOs and their effects on receiving water quality. They include monitoring activities to characterize CSO impacts and the efficacy of CSO controls. These are described in the *Implementation of the Nine Minimum Controls Report* (BES, 2003), which will be updated in fall 2010 to reflect the post-2011 system configuration.



# Section 9: Public Notification, Involvement, and Education

## 9.1 Introduction

From the beginning, the Bureau of Environmental Services has been committed to meaningful public involvement as essential to successful implementation of the CSO LTCP. The components of Portland's CSO public notification, involvement, and education programs are described in this section.

Initially, these programs raised awareness about CSO issues and supported public participation in the formulation of ASFO goals and requirements and fostered public involvement in the development, evaluation, and selection of preferred alternatives for the City's 20-year CSO LTCP.

For the past several years, however, the public involvement programs have been integral to the effective implementation of LTCP project phases and have been broadened and revised accordingly. Public involvement staff continues working with neighborhood and business associations, agencies, environmental groups, and citizens to ensure that:

- Public issues and concerns are identified and addressed early in the process.
- Conflict is managed and issues are resolved.
- Activities are consistent and coordinated.
- Two-way communication with the community is enhanced.
- Public understanding and support for Environmental Services projects and programs are increased.
- Projects and programs are and will be completed on time and within budget.
- Project and program outcomes are achieved.
- Citizen knowledge and stewardship of Portland watersheds is improved.

City of Portland Post-2011 CSO Facilities Plan

As projects have advanced from design to construction, the goals of the public involvement activities have continued to be:

- Informing and involving residents and businesses within proposed alignment areas and the broader public about key issues such as alignment, construction schedules, and traffic plans.
- Developing and maintaining good working relationships between the public and project team members.
- Meeting construction timelines and minimize community impacts.
- Responding to individual citizen or business concerns within 24 hours.
- Assisting project teams in completing projects on time and within budget.

After the term of the ASFO concludes, the character and scope of the City's CSO public involvement program will be redirected to focus on sustaining hard-earned CSO reductions via green infrastructure solutions as the community continues to grow and change and promoting ways to further reduce CSOs cost-effectively.

Key components of the current public involvement program are described below followed by an outline of future program plans at the end of this section.

## 9.2 Current Public Involvement Program

### 9.2.1 River Alert Program

The River Alert program began in summer 1991. The purpose of the program is to inform the public about the presence of CSO outfalls and issue warnings about CSO events. This has been done by installing and updating warning signs at affected locations, posting alerts on the Environmental Services website, and sending notifications to the media.

As of May 2005, the Environmental Services Spill Prevention/Citizen Response Section has been on call to respond to any CSO discharge to the Columbia Slough by posting portable Extreme Rain Event signs. Staff will post the warning signs at potentially impacted recreational access points along the Columbia Slough between NE 13th Avenue and Kelley Point Park. The Columbia Slough extreme rain event warning signs display the phone number of the Spill Prevention/Citizen Response Section. Staff monitors the line 24 hours a day. There have been no combined sewer overflows to the Columbia Slough since Environmental Services developed this warning system.

The River Alert system also includes ten permanent, folding signs installed at public access points to the Willamette River. A contractor travels the river by boat and locks the warning signs in the open position each time there is a CSO between May 15 and October 15. Forty eight hours after each CSO event ends, the contractor locks the signs in the closed position. The contractor is required to supply Environmental Services with written reports that verify that the signs were opened or closed and when the work was completed. In the rainy season between October 15 and May 15, the signs remain open with the warning message in view for boaters and other river users. The Willamette River warning signs display the phone number of the River Alert Hotline, a 24-hour recorded message the public can call to learn if a CSO advisory is in effect and to hear a message about the CSO program.

The River Alert program notifies the media by fax and email every time there is an overflow to the Willamette River between May 15 and October 15. The Oregonian newspaper publishes an overflow warning at the top of the weather page when overflows occur. In addition, Internet users can go to www.portlandoregon.gov/bes/overflow to learn if a CSO advisory is in effect. Internet users can also subscribe to automatic email notification each time Environmental Services issues a CSO advisory.

### 9.2.2 Clean River Works Construction Signage

The City requires contractors to post signage at any sewer system-related construction site to inform the public that the construction is a sewer project designed to keep rivers and streams clean. In addition, the City posts banners at some project construction sites.

### 9.2.3 Media Relations

The City uses media advisories, news releases, and media events to gain media coverage of CSO projects. Individual briefings are also held with reporters. The City provides timely, accurate responses to all media requests and keeps files of all newsprint and broadcast media coverage.

In conjunction with implementation of the CSO LTCP, the City releases media notifications regarding combined sewer overflows during the summer, CSO tunnel (Big Pipe) construction, the work of the Willamette River Stakeholders Task Force, and traffic advisories related to CSO construction.

Recent media events held to draw attention to significant milestones in the CSO Program, include:

- February 2010 public demonstration of the cutter soil mixing equipment used for the Balch Consolidation Conduit Project, the first use of the technology in Oregon
- Removal of the 530-ton tunnel boring machine from the East Side CSO Tunnel on Swan Island in December 2009
- Barging of the East Side CSO tunnel boring machine from Swan Island to OMSI in December 2009

City of Portland, Post-2011 CSO Facilities Plan

- September 2009 dedication of the Big Pipe Portal public sculpture at the Swan Island CSO Pump Station
- July 2009 dedication of the new home of the Golden Harvesters, a non-profit group relocated due to construction of the Portsmouth Force Main project
- Tours of the East Side Big Project for stakeholders, reporters, and invited guests in January 2008, May 2008, November 2008 and December 2009
- North American record of 3,055 feet for the longest continuous microtunneling drive in April 2008

In addition to media events and media coverage, Environmental Services also makes annual public presentations to the Portland City Council to update the Council on the CSO abatement 16 program. The briefings are covered by Portland media and broadcast on the community and government access channel of Portland Cable Access.

### 9.2.4 Riverviews Newsletters

Environmental Services distributed the Riverviews newsletter citywide in 2003, 2004, 2007 and spring 2010. The Riverviews mailings update Portland residents on bureau projects and programs, including CSO Program milestones and progress.

### 9.2.5 Internet

Environmental Services provides current information about the city's CSO programs at www.cleanriverworks.com. The site is dedicated entirely to CSO construction projects, schedules, and impacts. The bureau's main website is www.portlandoregon.gov/bes.

### 9.2.6 Public Involvement

Public involvement activities include maintaining stakeholder databases; distributing newsletters and fact sheets; presentations to community and business groups; and site visits to businesses and residents.

### 9.2.7 Community Benefit Opportunity Program

The Portland City Council created this program to add amenities to neighborhoods affected by CSO construction. East Side CSO construction affects 11 neighborhoods between SE 17th and McLoughlin and the CBWTP. Community groups and citizens in those areas nominated projects in 2007. A citizen advisory committee reviewed the proposals and worked with Environmental Services to recommend 19 projects for funding, for a total of $1.77 million. The funded projects include bank restoration along the Willamette River, street tree planting, sustainable stormwater management facilities, trail access, and community gardens.

### 9.2.8 Environmental Education

Environmental Services provides free water quality education programs to Portland schools and community groups, including a Combined Sewer Overflow presentation for students in grades 6 to 12. Students learn about the history of the CSO problem, and discuss solutions and how to pay for improvements. The program uses a plastic model that physically shows (with the use of water) how overflows occur.

An interactive computer kiosk installed at the Oregon Museum of Science and Industry (OMSI) allows users to get information about the CSO control program.

### 9.2.9 OMSI Display

OMSI exhibit staff developed the concept for a 5-year exhibit housed in the museum's main science section (just outside the Watershed Lab). The exhibit highlights CSO program components. OMSI worked with Environmental Services to identify partners to sponsor construction of the exhibit.

## 9.3 Public Involvement After 2011

In the future, the City's CSO-related public involvement activities will be developed on a project-by-project basis as CSO controls are integrated with sustainable stormwater management projects. An example is the current Tabor to the River project, which is a partnership for sewer, green stormwater, and watershed improvements.

Environmental Services is committed to meaningful public involvement as an essential element of all Environmental Services programs and projects. Public involvement provides opportunities for Portland's citizens to participate in decision-making, take part in stewardship activities, and help build sustainable community partnerships.

To provide consistent, comprehensive public involvement services and management, Environmental Services staff incorporates the following principles into their activities as appropriate:

- Public involvement is an early and integral part of the concept, design, and implementation of programs and projects.
- The decision-making process requires a wide range of opportunities for citizen participation.
- Information about programs and projects, including their potential impacts on the community, will be accurate, timely, and complete.
- Partnerships with community organizations encourage and facilitate public involvement.

- Other city staff and public agencies should be part of the public involvement partnership.
- Opportunities to foster stewardship of the Willamette River and our urban watersheds are important.
- Citizens and community groups may need training in the skills needed for effective public involvement.
- Classes, workshops, and site visits provide opportunities for learning about watershed health.
- The public involvement process requires monitoring and evaluation, and can be modified to adapt to new or changing circumstances.

Public involvement activities are tailored to the particular circumstances and needs of each program or project. Environmental Services public involvement staff works with project managers to identify stakeholders, issues, and public involvement goals, designing plans that specify what, how, and when activities will be conducted. Commonly used approaches and techniques include:

- Developing and distributing printed and electronic materials about the program or project
- Presentations to stakeholder groups including business and neighborhood associations
- Public meetings including open houses and design charrette meetings
- Site visits to maintain ongoing, face-to-face contact with businesses and residents affected by projects
- Forming advisory committees to help make decisions about policy issues for Environmental Services programs, such as the CSO and stormwater programs
- Offering free, public educational opportunities to help broaden the knowledge base of the community about watershed health and stewardship opportunities, the CSO control program, wastewater collection and treatment, and other program and projects
- Evaluating effectiveness of public involvement activities using surveys, focus groups, and feedback forms.

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# APPENDIX A
# ASFO

BEFORE THE ENVIRONMENTAL QUALITY COMMISSION
OF THE STATE OF OREGON

| | | |
|---|---|---|
| DEPARTMENT OF ENVIRONMENTAL QUALITY, OF THE STATE OF OREGON, Department, v. CITY OF PORTLAND, Respondent. | ) | AMENDED STIPULATION AND FINAL ORDER No. WQ-NWR-91-75 MULTNOMAH COUNTY |

WHEREAS:

1. On August 5, 1991, the Department of Environmental Quality (Department or DEQ) issued National Pollutant Discharge Elimination System (NPDES) Waste Discharge Permit Number 100807 (Permit) to the City of Portland (Respondent), pursuant to Oregon Revised Statutes (ORS) 468B.050 and the Federal Water Pollution Control Act Amendments of 1972, P.L. 92-500, as amended. The Permit authorizes the Respondent to construct, install, modify or operate waste water treatment control and disposal facilities (facilities) and discharge adequately treated waste waters into the Columbia River, Columbia Slough and Willamette River, waters of the state, in conformance with the requirements, limitations and conditions set forth in the Permit. The Permit expires on March 31, 1996.

2. Respondent's sewage collection system is comprised in part of combined sewers designed to collect both sanitary sewage and storm runoff water. The combined sewer system is designed and intended to collect and transport all sanitary sewage to

Respondent's sewage treatment plant during periods of dry weather; however, during some periods of wet weather, the combined sanitary sewage and storm runoff entering the system exceeds the system's capacity to collect and transport sewage to the sewage treatment plant. At such times, the excess combined sanitary sewage and storm runoff are discharged through bypass pipes, commonly referred to as Combined Sewer Overflows or CSO's, directly to the Willamette River and Columbia Slough, waters of the state, without treatment. Respondent's system includes 54 Combined Sewer Overflows. In addition, Respondent owns and operates sewage pump stations, one of which, the Ankeny Pump Station, may not be capable of pumping all incoming combined sanitary sewage and storm runoff during periods of wet weather. At such times, combined sanitary sewage and storm runoff are discharged from the Ankeny Pump Station directly to the Willamette River without treatment. The discharges of combined sanitary sewage and storm runoff from the Combined Sewer Overflows and the Ankeny Pump Station (Discharges) may cause violations of Oregon's water quality standards for Fecal Coliform bacteria and Possibly other parameters in the Columbia Slough and the Willamette River.

3. Respondent's prior NPDES permit, issued on September 18, 1984, did not expressly identify the combined sewer overflow discharge points that are part of the sewer system. Prior to the development of the Department's final draft 'Oregon Strategy for Regulating Combined Sewer Overflows (CSOs)' on February 28,

1991, as a matter of policy the Department did not always list CSO discharge points in an NPDES permit but, in many instances, issued permits for an entire sewer system. EPA's Region 10 office approved the issuance of such permits. Respondent's 1984 NPDES permit is a permit for the sewer system, which includes CSO outfalls, but did not contain specific effluent limitations for CSOs.

4. Since the adoption of water quality standards for the Willamette Basin (included in Oregon Administrative Rules 340-41-445) by the Environmental Quality Commission in 1976, Respondent has discharged combined sanitary sewage and storm runoff and may have caused violations of water quality standards. These water quality standards include narrative limitations on visible solids and floatable material and numeric limitations for bacteria and other parameters.

5. DEQ and the Respondent recognize that until new or modified facilities are constructed and put into full operation, Respondent may cause violations of the water quality standards at times.

6. On August 5, 1991, Stipulation and Final Order No. WQ-NWR-91-75 (Order) came into effect. Under terms of the Order, Respondent is required to carry out necessary studies and corrective actions to eliminate the discharge of untreated overflows from Respondent's combined sewer system, up to acne in ten year summer storm event and up to a one in five year winter storm event (allowable overflow frequency).

7. The August 5, 1991, Stipulation end Final Order, No. WQ-NWR-91-75, called for the following activities to be implemented by Respondent, each of which was accomplished in a timely manner:

a. By no later than September 1, 1991, the Respondent shall submit to the Department a draft scope of study for the facilities plan. The scope of study shall include an outline of the final facilities plan content, and sufficient detail on how the necessary information is to be obtained to complete the facilities plan. The facilities plan shall, at a minimum, include a characterization of the Discharges including volume, times of discharge, and bacterial and chemical content; alternatives for eliminating water quality Violations attributable to CSO's; the environmental and other impacts of the alternatives evaluated; the estimated cost of the alternatives; an evaluation of the impact of the CSO control alternatives on the Columbia Blvd. wastewater treatment plant; if the CSO alternatives will cause permit violations at the treatment plant, an evaluation of alternatives to expand or upgrade the treatment plant so as to maintain compliance with existing discharge standards; recommended control alternatives including any required plant upgrades that will result in compliance with water quality standards for the CSO discharges and compliance with the existing treatment plant discharge standards; a detailed implementation schedule for completing the recommended actions; a detailed demonstration that the recommended actions are the least cost/environmentally sound alternatives that will achieve the discharge limitations specified in this order; and a mechanism for financing the recommended improvements. The facilities plan shall include detailed implementation plans and financing plans for attaining compliance with applicable water quality standards at all CSO's alternatively: (1) for attaining compliance at all CSO's by December 1, 2006; and (2) for attaining compliance at a11 CSO’s by December 1, 2011;

b. By no later than October 1,. 1991, the Respondent shall submit to the Department a draft scope of study for an interim control measures study. The interim control measures study shall include a brief narrative description of each control measure; which CSO's would be affected by each control measure; the estimated impact of each control measure on quantity, quality, and timing of discharge; the estimated impact of each control measure on beneficial uses; the estimated capital cost and annual operation and maintenance cost for each control measure; and the estimated time needed to install or initiate each control measure. The interim control measures to be evaluated and included in the interim control measures study shall include but are not limited to the following: screens and other technologies for removing large solids and floatables; maximization of in-line storage including passive and automatic regulators; removal of new and/or existing roof drain connections from the sewer system; increased line flushing including an evaluation of timing and location of flushing activities; increased street sweeping; the review and modification of pretreatment program; and increased cleaning of catch basins;

c. Within thirty (30) days of receiving written comments from the Department, the Respondent shall submit to the Department final approvable scopes of study for interim control measures study and the facilities plan;

d. By no later than December 31, 1992, the Respondent shall submit the portion of the facilities plan that characterizes Combined Sewer Overflows;

e. By no later than December 31, 1992, the Respondent shall submit the draft interim control measures study to be used by the Department and the Commission to determine appropriate and reasonably practicable interim control measures to reduce water quality impacts until such time as final compliance is attained.

f. Within thirty (30) days of receiving written comments from the Department, the Respondent shall submit to the Department and the Commission the final interim control measures study that is approvable by the Department as to content and completeness;

g. Upon submission of the final interim control measures study, the Commission, upon recommendation of the Department, shall establish the required interim control measures and the schedule for their implementation.

h. By no later than July 1, 1993, the Respondent shall submit a draft facilities plan to the Department;

i. Requiring Respondent to implement the interim control measures as specified in Attachment 1 to this Order;

8. On July 1, 1993, as required by paragraph 7. h. above, Respondent submitted a facilities plan that included information on how Respondent intended to meet the terms of the Order. Included in the facilities plan was an evaluation of other possible allowable overflow frequencies, including environmental impacts, control technologies, costs, and other impacts of the control measures required to meet the alternative allowable overflow frequencies.

9. At the time the parties agreed to the terms of the SFO, it was understood that the Respondent did not have sufficient information necessary to adequately characterize the City's combined sewer system. Several of the activities in the schedule set out in the SFO were designed to develop that data so that an appropriate facilities plan could be implemented. Paragraph 13 of the SFO provided for amendment of the requirements of the Order, in recognition that information

acquired during the facilities planning process could lead to beneficial strategies that differed from the terms of the SFO.

a. In the course of gathering data and conducting the activities set out in the SFO, the Respondent has developed a substantial body of information about the combined sewer system: the number and duration of overflows, the character [composition] of overflows, the impact of overflows on water quality, technology for CSO control, project costs and potential economic impacts. Also during this time the federal government developed a draft policy providing guidance to the States about CSO control.

b. In light of relevant information developed during the facilities planning process, the Department, the Commission and the Respondent agreed to conduct a collaborative process to evaluate the requirements of the SFO in an effort to achieve an appropriate level of CSO control, pursuant to paragraph 13 of the SFO. In the fall of 1993 a Collaborative Committee (Committee) was formed, consisting of two Environmental Quality Commission Commissioners, two City of Portland Commissioners, the Director of DEQ and the intergovernmental affairs coordinator for the City's Bureau of Environmental Services.

c. The Committee held four public informational meetings between October 18, 1993, and December 14; 1993, in which they heard presentations and public testimony about the history of the Willamette River; the value of the environment and the importance of the river to the City of Portland, the State and its residents; water quality and pollution; health risks related to CSOs; economic issue and. alternative strategies for CSO control. The committee held two additional public meetings in January 1994 to discuss issues and recommendations. The committee members held open discussions of the issues during each meeting during which there was also an opportunity for public testimony.

d. As a result of information offered during the presentations, public comment and Committee discussions in the course of the collaborative process, the following issues were identified as fundamental to achieving consensus regarding CSO control:

- The people of the Portland Region place a high value on the Willamette River and good water quality. The River's importance to the people of Portland and the value of Water quality both continue to increase over time.
- Recreational use of the river is an important use which demands high quality water.
- It is prudent public policy to establish the goal of eliminating untreated sewage discharges to public waters.

- Discharge of untreated sewage to public waters in Oregon constitutes a potential threat to public health and safety -- even when bacteria standards are met. Bacteria standards are an imperfect measure of public health protection.
- Untreated sewage discharges will occasionally occur, whether due to unavoidable equipment breakdowns, natural disasters, or other causes. Even under the most stringent regulatory approach imaginable, complete elimination is not realistically achievable.
- It is therefore good public policy to require that, whenever decisions are made regarding sewerage facilities, cost effective options to reduce the frequency and quantity of untreated sewage discharges be evaluated and implemented.
- CSOs are a significant contributor of untreated sewage discharges to the Willamette River in the Portland area and to the Columbia Slough. Prudent public policy dictates the need to reduce combined sewer overflows significantly.
- Responsible public policy calls for a cost effective approach to CSO reduction.
- Based on analysis of alternatives presented in the facility plan, CSO control beyond the level achieved with the Enhanced Draft Federal Policy

alternative (96% reduction of overflow volume) appears to be very costly for a relatively small increment of water quality improvement.

- New technology may emerge that will provide more cost effective methods of reducing CSOs than are available today.
- The Cornerstone Projects, outlined in the draft facilities plan, and a phased implementation for CSO control provide an opportunity to periodically review progress and provide cost effective results.

e. The Respondent is committed to an overall policy of water quality improvement and is implementing a comprehensive clean river strategy. Elements of this program include:

- In-process projects to increase secondary treatment capacity to serve the growing sewered population of Portland:
  - Modifications to the Columbia Boulevard secondary treatment plant to increase the effective hydraulic capacity of the secondary portion of the plant from the initial design capacity of 100 mgd to 160 mgd.
  - Construct a second force main from the Inverness Site to the Columbia Boulevard

Secondary Treatment Plant to serve the expanding sewered population in Mid-Multnomah County. Design is scheduled for completion in June 1996. Construction completion and startup is scheduled for July 1998.

- Other in-process enhancement programs:
  - Clean Rivers Program -- This program is a comprehensive approach to surface water quality management within the city and includes stormwater management (development controls, industrial controls, erosion and sediment controls, etc.); flood control and drainage; and watershed management projects including but not limited to those in Columbia Slough, Johnson Creek, Balch Creek, and Fanno Creek in the Tualatin Basin.
  - Collection System Structural Assessment and Enhancements -- These projects are intended to identify and correct problems in the existing system to increase the storage and transport capacity and eliminate any untreated overflows during times when no rain is falling (i.e. dry weather).
- Cornerstone Projects: cost effective projects to reduce the magnitude of the problem by getting

storm water out of the combined sewer system: (estimated capital cost = $240 million in 1993 dollars)

- Roof Drain Disconnects;
- Storm Water Sumps;
- Stream Diversions;
- Selective Localized Sewer Separation.

- Columbia Slough: Implementation of a high level of control of combined sewer overflows to the Columbia Slough. Columbia Slough is considered a sensitive water body because of low natural stream flow and the very limited ability to assimilate wastes and cleanse itself. Because the Slough is a sensitive water body, Portland agrees that it requires a high level of control equivalent to the level specified in the 1991 SFO. The estimated capital cost to achieve that level of control is $150 million in 1993 dollars for facilities for capture, storage, and treatment of combined sewer overflows, and discharge of the treated effluent to the Columbia River.

f. Willamette River CSO Control Options: The Portland Facility Plan evaluated 4 alternatives for Willamette River Control. The Cornerstone Program Projects and Columbia Slough Cleanup mentioned above are included within the capital cost estimates for each of these options. Attention was given to developing alternatives so that other community benefits would result, including relocating any remaining overflows to minimize impact on high priority beneficial use areas. The "Enhanced Draft Federal Policy Level″ alternative reflects a policy decision which seeks to responsibly balance competing demands and priorities, costs and benefits. This option consists of the following basic components:

- 96% reduction of overflow volume
- An estimated $700 million capital investment (in 1993 dollars, including Cornerstone Projects and Columbia Slough Cleanup).
- Winter design storm equivalent: 3-4 overflows per year. 250 mg overflow in typical year;
- Summer design storm equivalent: storm that would have a 1 in three year occurrence frequency. Based on last 15 years of data, rainfall would have produced 2 overflow events of 2 days duration each in the last 15 years.
- Overflows would cause bacteria standards to be exceeded 65 hrs in winter.
- 5 mile tunnel, primary treatment and disinfection, discharge to Willamette. (Larger facilities than in the Draft Federal Policy Level alternative.)

- Average monthly sewer rate projected to be $38-41 by 2010 (in 1993 dollars).

g. The Respondent is committed to a public outreach and notification program to encourage community action and involvement and increase public awareness about CSO control and water quality issues.

h. The Respondent is committed to incorporating CSO reduction activities into its ongoing sewer system planning and water quality management efforts beyond the termination of the requirements of this Order.

i. The Department, with the assistance of an advisory committee, is presently reviewing several water quality standards, including the bacteria standard, as part of the federally required triennial review process. Following receipt of the committee report, the Department expects to propose revisions to the bacteria standard to make it a more meaningful indicator of beneficial use protection.

j. The Department, within the limits of budgetary authority and federal constraints, is attempting to increase the effectiveness of controls on nonpoint sources of water pollution in all areas of the state. In these efforts, the Department's fundamental commitment is to approach all sources of pollution on a comprehensive, watershed management basis.

10. The Department and Respondent recognized that the Environmental Quality Commission (commission) had the power to impose a civil penalty and to issue an abatement order for violations of water quality standards. Therefore, pursuant to ORS 183.415(5), the Department and Respondent have settled those possible past violations referred to in Paragraph 4 and wish to limit and resolve the future violations referred to in Paragraph 5 in advance by this Amended Stipulation and Final Order. In light of the recent development of EPA and Departmental strategies and policies governing permitting and evaluation of CSO impacts on water quality, imposition of a civil penalty at this time is not deemed appropriate by the Department.

11. This Amended Stipulation and Final Order is not intended to limit, in any way, the Department's right to proceed} against Respondent in any forum for any past or future violations not expressly settled herein.

NOW THEREFORE, it is stipulated and agreed that:

12. The Commission hereby issues a final order:

a. Requiring the Respondent to eliminate all untreated CSO discharges to the Columbia Slough from November 1 through April 30 except during storms greater than or equal to a storm with a five year return frequency and to eliminate all untreated CSO discharges from May 1 through October 31 except during storms greater than or equal to a storm with a ten year return frequency; and requiring Respondent to eliminate all untreated CSO discharges to the Willamette River from November 1 through April 30 except during storms greater than or equal to a storm with a four in one year return frequency and to eliminate all untreated CSO discharges from May 1 to October 31 except during storms greater than or equal to a storm with a three year return frequency, as soon as reasonably practicable, but no later than the following schedule:

(1) Within six months of receiving written comments from the Department on the draft facilities plan submitted to the Department on July 1, 1993, the Respondent shall submit to the Department a final facilities plan that is approvable by the Department as to content and completeness. The Department will review the facilities plan and prepare recommendations to the Commission for CSO control strategies and schedules for implementing them. Final approval of the control strategies and schedules to eliminate untreated CSO discharges will be by the Commission;

(2} By no later than December 1, 1997, the Respondent shall submit final engineering plans and specifications for construction work required to comply with Section 12.a.(4);

(3) By no later than May 1, 1998, the Respondent shall begin construction required to comply with Section 12.a.(4);

(4) By no later than December 1, 2001, the Respondent shall eliminate untreated CSO discharges, subject to the storm return frequencies specified in Paragraph 12.a. of this Amended Order, at 20 of the CSO discharge points, including discharges to Columbia Slough, consistent with the facilities plan approved by the Commission; however, the Respondent shall eliminate all untreated CSO discharges to the Columbia Slough, subject to the storm return frequencies specified in Paragraph 12.a. of this Amended Order, by no later than December 1, 2000;

(5) By no later than December 1, 2001, the Respondent shall submit final engineering plans and specifications for construction work required to comply with section 12.a.(7);

(6) By no later than May 1, 2003, the Respondent shall begin construction required to comply with Section 12.a.(7);

(7) By no later than December 1, 2006, the respondent shall eliminate untreated CSO discharges, subject to the storm return frequencies specified An Paragraph 12.a. of this Amended Order, at 16 of the remaining CSO discharge points, consistent with the facilities plan approved by the Commission;

(8) By no later than December 1, 2006, the Respondent shall submit engineering plans and specifications for construction work required to comply with Section 12.a.(10);

(9) By no later than May 1, 2008, the Respondent shall begin construction required to comply with Section 12.a.(10);

(10) By no later than December 1, 2011, the Respondent shall eliminate untreated CSO discharges, subject to the storm return frequencies specified in Paragraph 12.a. of this Amended Order, at all remaining CSO discharge points, consistent with the facilities plan approved by the Commission;

(11) By no later than September 1 of each year that this Amended Order is in effect, the Respondent shall submit to the Department and to the Commission for review an annual progress report on efforts to eliminate untreated CSO

discharges, subject to the storm return frequencies specified in Paragraph 12.a. of this Amended Order. These annual reports shall include at a minimum work completed in the previous fiscal year and work scheduled to be completed in the current fiscal year.

b. Requiring Respondent to implement the following interim control measures:

(1) Respondent shall inspect all diversion structures on a weekly basis and clean the structures as necessary to maintain hydraulic performance. Respondent shall report all blockages at diversion structures that result in dry weather discharges on Respondent's Daily Monitoring Report submitted to the Department on a monthly basis. Respondent shall record whether or not a discharge is occurring from each diversion structure to an outfall, as observed at each diversion structure during the weekly inspections, and shall make this report available to the Department upon request by the Department.

(2) Respondent shall prohibit all dischargers who request Respondent's approval prior to a non-permit, periodic, or one-time batch discharge from discharging during rain events. Exceptions shall be made only if

extenuating circumstances can be demonstrated to show that it is unreasonable to apply this restriction.

c. Requiring Respondent to comply with all the terms, schedules and conditions of the Permit, except those modified by Paragraph 12.a. above, or of any other NPDES waste discharge permit or modified permit issued to Respondent while this Amended Order is in effect.

d. Requiring Respondent to demonstrate that each untreated CSO discharge has been eliminated, subject to the storm return frequencies specified in Paragraph 12.a. of this Amended Order, by a means approved by the Department, within twelve months of the scheduled date when compliance is required in this Amended Order. (Nothing in this paragraph shall prevent the Department from enforcing this Amended Order during the twelve month demonstration period.)

e. Requiring Respondent to identify each discharge that is converted to a storm sewer discharge only.

f. Requiring Respondent, in the event that Respondent chooses to retain a Discharge with any connected sanitary wastes, to apply for a modification of Respondent's permit requesting a waste load increase and appropriately sized mixing zone. (Nothing in this paragraph shall affect the Department’s or the Commission’s discretion over granting such a request.)

g. Requiring Respondent, upon receipt of a written notice from the Department for any violations of the Amended Order, to pay the following civil penalties:

(i) $1,000 for each day of each violation of each provision of the compliance schedules set forth in Paragraph 12.a.

(ii) $2,500 per outfall per day for each CSO outfall for which Respondent fails to demonstrate elimination of untreated CSO discharges as specified in Paragraph 12.d. Discharges that are listed and regulated in Respondent's Permit as may be allowed in Paragraph 12.f. shall not be subject to stipulated civil penalties under the terms of this Order.

13. Respondent agrees that the requirements and dates specified in Paragraph 12 above are firm commitments to undertake and complete those tasks within the time required for the completion of each task subject only to extraordinary events beyond Respondent's reasonable control which causes or may cause a delay or deviation in performance of the requirements of this Amended Order. In the event of such an extraordinary event, Respondent shall immediately notify the Department verbally of the cause of delay or deviation and its anticipated duration, the measures that have been or will be taken to prevent or minimize the delay or deviation, and the timetable by which

Respondent proposes to carry out such measures. Respondent shall confirm in writing this information within five (5) working days of the onset of the event. It is Respondent’s responsibility in the written notification to demonstrate to the Department’s satisfaction that the delay or deviation has been or will be caused by circumstances beyond the control and despite due diligence of Respondent. If Respondent so demonstrates, the Department shall extend times of performance of related activities under the Stipulation and Final Order as appropriate. Circumstances or events beyond Respondent’s control include, but are not limited to, acts of nature, unforeseen strikes, work stoppages, fires, explosion, riot, sabotage, or war. Increased cost of performance or consultant's failure to provide timely reports shall not be considered circumstances beyond Respondent’s control.

14. Regarding the violations set forth in Paragraphs 4 and 5 above, which are expressly settled herein without penalty, Respondent and the Department hereby waive any and all of their rights to any and all notices, hearing, Judicial review, and to service of a copy of the final order herein. The Department reserves the right to enforce this order through appropriate administrative and judicial proceedings.

15. Regarding the schedule set forth in Paragraph 12.a. above, Respondent acknowledges that Respondent is responsible for complying with that schedule regardless of the availability of any federal or state grant monies.

16. The terms of this Amended Stipulation and Final Order may be amended by the mutual agreement of the Commission and Respondent, after notice and opportunity for public comment; or with respect to the compliance schedules or limitations herein, by the Commission if it finds, after review and evaluation of the facilities plan including alternative discharge limitations and the alternative schedules required under Paragraph 7.a., that modification of this Amended Order is reasonable. It is understood that the draft facility plan submitted on July 1, 1993, has provided substantial additional information that was not available when the original order was entered. Therefore, it is intended that any modification of this order under this paragraph be justified by a showing of substantial and new circumstances or substantial and new technologies;

17. Respondent acknowledges that it has actual notice of the contents and requirements of the Amended Order and that failure to fulfill any of the requirements hereof would constitute a violation of this Amended Order and subject Respondent to payment of civil penalties pursuant to Paragraph 12.g. above.

18. This Amended Order shall terminate 60 days after Respondent demonstrates full compliance with the requirements of the schedule set forth in Paragraph 12.a. above.

19. If it becomes necessary to allocate wasteloads as a result of either the Willamette River or the Columbia River being designated as Water Quality Limited, the parties agree

that Respondent's reductions in discharges pursuant to this agreement will be considered as contributing to Respondent's share of the obligation to achieve water quality standards. Nothing in this paragraph shall affect the Commission's authority to revise water quality standards pursuant to applicable law.

20. The Respondent shall continue to implement the Cornerstone Projects, as outlined in the draft facilities plan which was submitted to DEQ on July 1, 1993, on a schedule that is approved in the final facilities plan.

21. The Respondent may submit to the Department no later than December 1, 2001, and December 1, 2006, or at other appropriate times during the implementation of the facilities plan, an updated facilities plan report evaluating the effectiveness of CSO control technologies, including, if appropriate, recommendations for reevaluation of activities necessary to accomplish the requirements of this Order if new information or technology has become available. DEQ shall approve or disapprove the recommendations within six months of receipt of the updated facilities plan.

22. The Respondent shall implement CSO control measures as outlined in the facilities plan in a phased approach, with the highest priority for control of CSO discharges in high contact recreation areas.

23. Respondent, the Commission, and the Department agree that further reductions in untreated discharges beyond the level

to be achieved through the Enhanced Draft Federal Level alternative, particularly in the period of May 1 through October 31, are desirable if the reductions can be done in a cost effective manner. Further, it is recognized that during the term of the Order advances in technology may result in additional cost-effective control measures not currently known or available.

a. During the period of this order, whenever sewerage planning, capital improvement projects, operation and maintenance planning, and other water quality management activities are undertaken that are not included with the approved facility plan, an evaluation shall be made of opportunities to achieve further reductions in the frequency and volume of CSOs. Such evaluation shall take into account generally accepted technologies, potential innovative technologies, cost effectiveness, and environmental benefit achieved. Potential innovative technologies will include measures used elsewhere that may have application in Portland as well as those pioneered by Portland. Technologies evaluated should include, but not be limited to, the following:

- Separation of sewers in selected basins where determined to be beneficial.
- Continual replacement of deteriorated trunk and interceptor lines with larger diameter pipes to

provide additional inline storage to convey more wastewater for treatment.

- Implementation of operational enhancements to reduce the quantity of pollutants discharged when overflows do occur: e.g., sewer flushing, street cleaning by vacuuming/washing, etc.
- Addition of further treatment technology to the wet weather treatment facility to further reduce the pollutants being discharged.
- Enhanced inflow and pollutant source control: e.g., organic composting stormwater filters and permeable pavements.
- Comprehensive and multi objective water quality improvement strategies in all tributaries to the Willamette River within Portland. Such strategies should include preservation and enhancement of riparian environments and wetland systems, storm water management, Water conservation, implementation of BMPs, source control of roadway runoff including pretreatment facilities, implementation of land use policies and requirements that benefit water quality, development of private property stewardship programs, and other strategies designed to prevent pollutants from reaching the Willamette River.

The respondent shall implement all measures which are cost effective.

b. The Respondent shall report on the evaluations undertaken and the projects implemented as part of the annual report required by Section 12.a. (11).

c. For the purposes of this Order, cost effective shall be as defined in the final facilities plan required by Paragraph 12.a.(1); subject to review and approval by the Commission.

d. Respondent shall submit to DEQ no later than September 1, 2010, an approvable facilities plan report outlining the methods for achieving further reductions in the frequency and volumes of CSOs after the term of this Amended Order. Methods evaluated should include, but not be limited to, those listed in Section a. of this paragraph. This facilities plan shall be subject to approval by the Environmental Quality Commission.

24. The Respondent shall report to the Commission in a public forum its progress for CSO reductions as outlined in paragraph 23, above, at a time established by the Commission and the Respondent in the years 2001 and 2010.

RESPONDENT

August 1, 1994
Date

(Name) Mike Lindberg
(Title) Commissioner of Public Utilities

DEPARTMENT OF ENVIRONMENTAL QUALITY

August 11, 1994
Date

Fred Hansen, Director

FINAL ORDER

IT IS SO ORDERED:

ENVIRONMENTAL QUALITY COMMISSION

August 11, 1994
Date

William W. Wessinger, Chairman
Environmental Quality Commission

## APPENDIX B
# Re-Evaluation of SWMM

**MEMORANDUM**

**DATE:** June 18, 2010

**TO:** Mark Johnson / CH2M HILL

**FROM:** Dave Elkin / Mike Faha – GreenWorks PC

**PROJECT:** **BES CSO – Post 2011 Controls Facilities Plan**

**RE:** Improve Implementation of SWMM for New and Redevelopment

Modeling assumptions for the Post-2011 CSO Controls are in the process of being updated to calculate the future demand for CSO compliance. As of 2010, there are an estimated 10,421 acres of impervious surface in the Eastside and Westside Willamette CSO Basin. It has been estimated that by 2050, that area will grow to 11,124 acres as development continues. This is an increase of 702 acres of impervious surface in the Willamette CSO Basin.

It has been assumed that the SWMM will mitigate approximately 182 acres (26%) of the increase in impervious surface within the Willamette CSO Basins. This leaves a net increase of 521 acres of impervious surface. It is the purpose of this memo to determine if the SWMM mitigation of 26% is adequate based on our experience implementing stormwater management facilities on public and private projects. Additionally, we have been asked to identify any additional improvements to the implementation of the SWMM and determine if these may impact the predicted net increase of impervious surface.

## Background

The Willamette CSO Basins collect drainage from both the east side and west side of Portland. The Westside basins account for approximately 273 acres (39%) of the total predicted increase in impervious surfaces. The East side basins will account for the remaining 429 acres (61%) acres of predicted net increase in impervious surface. The following table shows the estimated distribution for the predicted net increase in impervious surface by land use and its division between Westside and Eastside basins.

LAND USE DISTRIBUTION

| Land Use | % of Total | Total Acres | West Side (39%) | East Side (61%) |
|---|---|---|---|---|
| COM | 57% | 400 | 156 | 244 |
| IND | 9% | 63 | 24 | 39 |
| MFR | 11% | 77 | 30 | 47 |
| SFR | 23% | 162 | 63 | 99 |
| Total | 100% | 702 | 273 | 429 |

## Stormwater Management Manual Requirements

All new development is required to comply with the current Stormwater Management Manual which states that property owners must provide runoff controls for any newly developed or redeveloped impervious area in excess of 500 ft².

## Facility Effectiveness

A variety of stormwater facilities may be used to manage stormwater runoff from the new impervious surfaces. To keep the evaluation brief, the variety of stormwater facilities have been categorized. The following table describes the estimated volume removal percentage for a CSO event of each facility type[1,2].

| Type | % Flow Volume Removed |
|---|---|
| Flow-through Facility | 25% |
| Ecoroof | 60% |
| East Side Soakage Trench | 70% |
| Infiltration Facility | 80% |

**The use of each facility type will vary depending upon general land use type and overall density of the development.**

Single-Family Residential (SFR)
The Land Use Distribution table above identifies 162 acres (23% of Total) of the net impervious increase will likely be single family residential development. Westside development will account for 62 ac of impervious surface, and east side development will account for 100 acres of development.

The flow-through planter is the facility of choice for Westside SFR development due to poor infiltration of soils and slope stability issues. The main stormwater facility type for single family residential constructed in the east side of Portland is the eastside soakage trench facility which may remove up to 100% of the CSO storm event[2]. The eastside soakage trench is assumed to be 100% effective, but in order to follow the assumptions on downspout disconnections for modeling purposes, we have assumed that they are 70% effective and the remaining 30% of impervious area eventually drains to the system.

| | Location and Facility Type | Total IA | | Impervious Acres Removed* |
|---|---|---|---|---|
| | | % | ac | ac |
| SFR | West Side<br>Flow-through Facility<br>(25% Effective) | 38% | 62 | 16 |
| SFR | East Side<br>Soakage Trench<br>(70% Effective) | 62% | 100 | 70 |
| | Totals | 100% | 162 | 86 (53%) |

* Impervious Acres Removed = (Facility Effectiveness % x Acres Managed)

The remaining 540 acres (77%) of new impervious surface falls under three different land use types: Commercial, Industrial, and Multi-family Residential.

Commercial Development (COM)
Commercial development is estimated to account for 57% (400 ac) of the new impervious surface. Roof area in COM areas can account for 85% to 100% of the 400 acres. Westside development will account for 152 ac (38%) of impervious surface, and east side development will account for 248 acres (62%) of development.

Ecoroofs and flow-through planters are the two main choices for treatment of stormwater from rooftops in commercial developments. Infiltration planters have not been used more because commercial developments are typically constrained for space, and areas used for stormwater treatment are adjacent to the building foundation which does not make infiltration facilities feasible. Infiltration planters are not used on the westside due to poor infiltration of soils and slope stability issues. The following tables show the estimated use of the three facility types between Westside development and Eastside development, and their respective impervious acres removed.

| | Facility Type | Acres Managed | | Impervious Acres Removed* |
|---|---|---|---|---|
| | | % | ac | ac |
| West Side COM (152 ac) | Ecoroofs (50% Effective) | 20% | 30 | 15 |
| | Flow-through Facilities (25% Effective) | 80% | 122 | 31 |
| | Totals | 100% | 152 | 46 (30%) |

* Impervious Acres Removed = (Facility Effectiveness % x Acres Managed)

| | Facility Type | Acres Managed | | Impervious Acres Removed* |
|---|---|---|---|---|
| | | % | ac | ac |
| East Side COM (248 ac) | Ecoroofs (50% Effective) | 20% | 50 | 25 |
| | Flow-through Facilities (25% Effective) | 70% | 174 | 44 |
| | Infiltration Facilities (80% Effective) | 10% | 24 | 19 |
| | Totals | 100% | 248 | 88 (35%) |

* Impervious Acres Removed = (Facility Effectiveness % x Acres Managed)

Based on the tables above, it is estimated that approximately **33%** (132 ac) of new impervious surface from the COM area development will be removed from the Willamette CSO Basins.

### Industrial Development (IND) and Multi-family Residential (MFR)

Industrial development is estimated to account for 9% (63 ac) of the new impervious surface, and Multi-family Residential development is estimated to account for 11% (77 ac) of the new impervious surface. The two development types combined account for approximately 140 acres of new impervious surface. Westside development will account for 53 ac (38%) of the new impervious surface, and east side development will account for 87 acres (62%) of the new impervious surface.

It is likely that use of the various stormwater management facilities will be similar between IND and MFR developments due to reduced property constraints. Infiltration facilities will be used more often to manage stormwater because of opportunities to manage stormwater away from building foundations and property setbacks. Infiltration planters are not used on the westside due to poor infiltration of soils and slope stability issues. The following tables show the estimated use of the three facility types between Westside development and Eastside development, and their respective impervious acres removed.

| | Facility Type | Acres Managed | | Impervious Acres Removed* |
|---|---|---|---|---|
| | | % | ac | ac |
| West Side IND & MFR (53 ac) | Ecoroofs (50% Effective) | 20% | 11 | 6 |
| | Flow-through Facilities (25% Effective) | 80% | 42 | 11 |
| | Totals | 100% | 53 | 17 (30%) |

* Impervious Acres Removed = (Facility Effectiveness % x Acres Managed)

| | Facility Type | Acres Managed | | Impervious Acres Removed* |
|---|---|---|---|---|
| | | % | ac | ac |
| East Side IND & MFR (87 ac) | Ecoroofs (50% Effective) | 20% | 17 | 9 |
| | Flow-through Facilities (25% Effective) | 20% | 17 | 4 |
| | Infiltration Facilities (80% Effective) | 60% | 53 | 42 |
| | Totals | 100% | 87 | 55 (63%) |

* Impervious Acres Removed = (Facility Effectiveness % x Acres Managed)

Based on the table above, it is estimated that approximately **51%** (72 ac) of new impervious surface from the IND and MFR area development will be removed from the Willamette CSO Basin.

## Summary

As the City continues to develop, impervious area will increase across a range of land use types. The important distinction is each land use type will manage stormwater differently depending upon the density of the sites. The table below summarizes the findings of total acres managed per land use type.

| | Total Increased IA | West Side Acres Managed | | East Side Acres Managed | |
|---|---|---|---|---|---|
| Land Use | ac | % | ac | % | ac |
| COM | 400 | 6.6% | 46 | 12.5% | 88 |
| IND & MFR | 140 | 2.4% | 17 | 7.8% | 55 |
| SFR | 162 | 2.3% | 16 | 10% | 70 |
| Subtotals | 702 | 11.3% | 79 | 30.3% | 213 |

It is estimated that 292 (79+213)acres of the net increase of 702 acres will be removed from the Willamette CSO Basin. **A reduction of 292 acres would reduce the net impervious area by 42%.** This reduction is an increase of 110 acres (16%) above the original estimate of 182 acres.

## Improvements in Implementation of SWMM

As development continues post-2011, there is opportunity to refine the implementation of the Stormwater Management Manual. The following bullets are some of those ideas.

- Increase use of ecoroofs through incentives and grants for ecoroofs throughout the City. Ecoroofs provide a significant (50%) reduction in impervious surface for the modeling of the Willamette CSO Basins
- Promote use of infiltration facilities throughout the eastside of Portland, especially on commercial properties.
- Improve overall effectiveness of flow-through planters.
- Consider restrictions on flow-through planters on west side and approve use only where necessary.
- Focus efforts on managing stormwater on large institutional properties due to their often high percentages of impervious area.

The largest impact to the implementation of the SWMM will be on the eastside COM developments. The use of the flow-through planter will continue to limit the overall effectiveness of the stormwater management system. The table below shows how the reduction in use of the flow-through planter (and subsequent increase in infiltration facilities) would raise the impervious acres removed from 88 acres (in COM table above) to 177 acres, which is an increase of 89 acres (13%). That would increase the net impervious reduction to 381 acres, or **55%**.

| | Facility Type | Acres Managed | | Impervious Acres Removed* |
|---|---|---|---|---|
| | | % | ac | ac |
| East Side COM (248 ac) | Ecoroofs (50% Effective) | 20% | 50 | 25 |
| | Flow-through Facilities (25% Effective) | 20% | 50 | 25 |
| | Infiltration Facilities (80% Effective) | 60% | 148 | 147 |
| | Totals | 100% | 248 | 177 (71%) |

* Impervious Acres Removed = (Facility Effectiveness % x Acres Managed)

An alternative would be to improve the effectiveness of the flow-through planter. The table below shows the result of improving the effectiveness from 25% to 40%. The result would increase impervious area effectiveness to **50%**, and bring the total acres managed to 354.

| | Total IA | West Side Acres Managed | East Side Acres Managed | Total Acres Managed |
|---|---|---|---|---|
| Land Use | ac | ac | ac | |
| COM | 400 | 64 | 114 | 178 |
| IND & MFR | 140 | 23 | 58 | 81 |
| SFR | 162 | 25 | 70 | 95 |
| Subtotals | 702 | 112 | 242 | 354 (50%) |

### Ecoroof Assumptions

The Grey to Green Ecoroof Incentive Program currently run by BES' Sustainable Stormwater Division has a goal of 43 acres over 5-years (an average of 8.6 acres / year). The program provides a $5 per square foot grant to property owners who install ecoroofs on their buildings. The Ecoroof Incentive Program has averaged approximately 3.2 acres per year over the first two years of its 5-year program. Because of these programs, it is expected that the use of ecoroofs will increase and installation costs continue to decline.

The information above estimates that approximately 108 ac of impervious surface will be covered with ecoroofs over the next 40 years. This is an average of approximately 2.7 acres of ecoroofs per year. This estimate is lower than the current rate of 3.2 acres per year, and therefore is a conservative estimate of the application of ecoroof over the next 40 years of development in the Willamette CSO Basins.

### References

1. *2008 Stormwater Management Facility Monitoring Report – December 2008*
2. E*ffectiveness Evaluation of Best Management Practices in Portland, Oregon, Appendix K 1&2 – September 2006*

APPENDIX C

# Draft Technical Memorandum: Approach for Evaluation of Alternatives and Ranking of Projects

City of Portland - Environmental Services
Systems Planning Program

System Plan Update

# *DRAFT TECHNICAL MEMORANDUM*

| | |
|---|---|
| To: | File |
| From: | David Whitaker |
| Reviewed By: | To be reviewed |
| Date: | June 17, 2010 |
| Task: | System Plan Update Task 4 |
| Subject: | Approach for Evaluation of Alternatives and Ranking of Projects |

**Contents**



# Approach for Evaluation of Alternatives and Ranking of Projects

BES evaluated CSO projects using a risk-based asset management approach that incorporates triple-bottom-line principles in two phases of analysis:

- Cost-Benefit Evaluation of Alternatives
- Cost-Benefit Ranking of Recommended Projects

The methods for these phases are described separately below.

# Cost-Benefit Evaluation of Alternatives

## Introduction

The City of Portland Bureau of Environmental Services (BES) developed and evaluated improvement alternatives to address basement sewer backup risk (BSBR), street-flooding risk, or pipeline capacity deficiencies in the combined sewer system service area. This was done as part of the *Combined Sewer System Plan*, which is part of the larger *BES System Plan Update*.

The combined sewer system plan is a "Living Systems Plan" developed using database, geographical information system (GIS), and hydraulic modeling tools. As such, it is easily updated and adjusted to represent changing conditions in the City and provides the flexibility to evaluate many different kinds of alternatives for improving system performance and meet BES targeted levels of service.

Taking advantage of the living systems plan approach, BES updated sewer hydraulic characterization to reflect the latest available information and developed multiple alternatives to identify reliable, timely, and cost-effective improvements suitable to address system capacity deficiencies.

BES evaluated the costs and environmental and community values of the alternatives.

## Sewer Hydraulic Characterization

The hydraulic characterization of the combined sewer system was performed using a highly detailed modeling technique called explicit modeling. With this technique, all of the pipes, manholes, diversion structures, sumps, and pump stations in the basins were simulated as individual objects. Flows developed using the explicit modeling technique were routed through XP-SWMM software for the hydraulic analysis, which simulated flow through the pipe network for the following conditions:

- Existing conditions (2006) during the 2-year design storm: identifies the highest priority areas.
- Existing conditions (2006) during the 5-year design storm: identifies high priority areas.
- Existing conditions (2006) during the 25-year design storm: identifies areas that potentially are not currently meeting the BES combined sewer system service levels.
- Future conditions (2040) during the 25-year design storm: identifies areas that potentially will not meet the BES combined sewer system service levels and therefore require planning to accommodate future growth.

The sewer hydraulic characterization BES developed for the combined sewer system study areas is documented in the *Combined Sewer Basin Hydraulic Characterization Technical Memoranda* (BES, October 2006). These technical memoranda identify predicted locations for street flooding, basement sewer backup risk, and pipe segments with deficient hydraulic capacity. The risks and deficiencies of the study area sewer system are summarized in the *Combined Sewer System Plan Characterization Summary* (BES, October 2006).

## Combined System Capacity Analysis Criteria

The combined sewer system capacity analysis concentrated on basement sewer backup, street flooding, and pipeline surcharge risks as indicators of system capacity deficiencies. These were analyzed for the 25-year design storm under future conditions, which represents the BES targeted level of service for planning and sizing of facilities. Future conditions account for projected changes in land use, basin imperviousness, sewer infrastructure, underground injection controls, and roof disconnections.

The 25-year design storm is defined as a 6-hour, 25-year event with a peak rainfall intensity of 3.32 inches per hour and a total rainfall depth of 1.89 inches. The rainfall distribution for this design storm was derived using the BES 1991 *Sewer Design Manual* intensity-duration-frequency curves based on the Portland Airport rain gauge data. Placement of the 5-minute peak intensity at the beginning of the design storm reflects historical rainfall patterns for similar storms occurring in the fall and spring seasons.

The criteria used to identify capacity deficiency risks during the alternatives analysis and evaluate the effectiveness of proposed alternative solutions were as follows:

1. **Basement sewer backups.** Individual tax lots were determined to be at a high risk for basement sewer backups when the maximum water surface elevation, referred to as hydraulic grade line (HGL), in the sewer pipe during future the 25-year design storm was within 8 feet of the estimated finish floor elevation of the property. This criterion was used in the 2006 sewer basin hydraulic characterization.

   The estimated finish floor elevation was assumed to be 3 feet above the ground elevation. The accuracy of basement sewer backup risk is limited by the estimated finish floor and ground elevations, which are determined with a digital terrain model. The ground elevation was assumed to be the average parcel elevation for the portion of the parcel that has the outline of the building structure. Actual first floor elevations have been surveyed during the design phase of recent projects that include stormwater controls. These surveyed elevations are typically within 1 foot of the estimated elevation, but have been as much as 4 feet higher or lower than the estimated elevation.

2. **Street flooding.** Street flooding was assumed to occur when the HGL was within 2 feet of the street surface elevation at a manhole. This criterion was used in the 2006 characterization, but *street flooding* was also referred to as *manhole freeboard.*

   The 2-foot range helps to ensure that potential instances of street flooding are identified by providing an allowance for erratic flow behaviors related to storm severity, uncertainties about the modeling calibration, variability in the modeling results because of imprecise data, and potential unrecorded changes in the ground elevations.

3. **Surcharging in a pipe constructed of brick.** Any degree of surcharging (within reason) in a pipe made of brick is not allowed. This criterion was used in the 2006 characterization.

   Since many of the large trunk sewers are made of brick and can be very expensive to upsize, the basin modeler used good engineering judgment to assess how the depth and duration of surcharge might affect the structural integrity of the pipe. Records were also checked to see whether segments of the pipe have been lined as part of a rehabilitation project.

4. **Pipe surcharge for a duration of greater than 30 minutes.** Any pipe segment that surcharges for 30 consecutive minutes is considered excessive surcharge.

   Since this condition may often be caused by backwater that is created by a downstream pipe segment with inadequate capacity, this criterion was assessed at the end of the modeling process after solutions were developed for the first three criteria.

## Development of Alternatives

To facilitate the development of discrete improvement alternatives, the combined sewer system study areas were subdivided into smaller focus areas that correspond to hydraulically-related concentrations of sewer system risks or deficiencies. The BES approach was to develop two primary types of alternatives for evaluation and comparison:

- **Conveyance Alternative**: Upsizing of sanitary and combined sewer pipeline segments to increase system capacity to meet the BES targeted level of service.

- **Stormwater Control Alternative**: Roof, parking, or street controls to detain or retain stormwater, thus delaying flows or eliminating flows to the combined sewer system. This alternative is supplemented with conveyance components as necessary to meet the BES targeted level of service.

The alternatives were developed to be effective during the 25-year design storm under future conditions.

Other types of alternatives such as storage, flow diversion, and stormwater separation were considered and evaluated as opportunities were identified in the basins.

## Cost Estimates

Order-of-magnitude cost estimates were developed to evaluate and compare the alternatives developed for individual focus areas. An order-of-magnitude estimate is made without detailed engineering data. Some examples include estimates developed from cost-capacity curves, scale-up and scale-down factors, and approximate ratios. Typically, an order-of-magnitude estimate is prepared at the end of the schematic design phase of the design delivery process. Based on historical averages, BES anticipates that an estimate of this type would be accurate within +30 percent to -25 percent.

Cost estimates included capital cost to construct the project, the benefit the alternative provides by removing volume from the tunnel system[1], the annual costs that the bureau would incur for operation and maintenance of the alternative, the present worth cost of the alternative, and the cost per basement sewer backup risk (BSBR) resolved, which is calculated as the present worth cost divided by the number of BSBRs resolved. The costs and credits included in the present worth calculation were total capital cost, present worth operations and maintenance cost, present worth of salvage value, present worth replacement, present worth of annual stormwater credit, and the one-time stormwater volume credit. Present worth cost is calculated for 100-year analysis period at a discount rate of 2.5%.

[1] The 4th storm of the summer six is used to evaluate volume of runoff that can be applied for credit for removing volume from the tunnel system.

## Environmental and Community Values

To represent City of Portland environmental and community values (ECV), BES staff developed level-of-service goals for evaluation. The following are applicable to the combined sewer system alternatives analysis:

**Watershed Benefits**

- Infiltrate on public and private property to the level consistent with the 2007 Green City Strategy. Success in meeting this goal is indicated by the number of impervious drainage area acres directed to planters, swales, rain gardens, or any other infiltration facility.

- Reduce the level of water quality pollutants in non-Municipal-Separate-Storm-Sewer-System (MS4) areas from 2007 levels. Success in meeting this goal is indicated by how many impervious drainage area acres are directed to planters, swales, rain gardens, or any other facility that reduces pollutant loads.

- Protect and improve terrestrial habitat conditions from 2007 levels. Success in meeting this goal is indicated by how many acres of existing habitat are protected or improved and how many acres of new habitat are created through the construction of planters, swales, rain gardens, ecoroofs or any other facility that develops new habitat.

- Protect and improve aquatic habitat conditions from 2007 levels. Success in meeting this goal is indicated by how many linear feet of channels and/or floodplains are given an improved score (over 2007 levels if no baseline scores available).

**Implementation Risks**

- Minimize construction risk. This is done through the use of standard construction techniques. Success in meeting this goal is determined by the BES staff after an evaluation of the conveyance and any stormwater control components of the alternative to see if non-standard construction techniques are required.

- Minimize work on private property. The purpose of this goal is to minimize the risk that a partner that is a private property owner backs out of the project either during design or construction of the project. This goal is met if there are no stormwater controls proposed on private property and if there are no pipe upsizing or pipe additions planned across private property.

**Neighborhood Impacts**

- Limit duration of street closure and other short-term impacts. The purpose of this goal is to minimize the number of street closures and length of time that street closures occur. Success in meeting this goal is determined by BES staff after an evaluation of the alternative components, particularly the amount of deep pipe work and work on high traffic, arterial streets.

- Limit loss of street parking and other long-term impacts. The purpose of this goal is to minimize the long-term impacts that a project may have on a neighborhood. Success in meeting this goal is determined by BES staff after an evaluation of the alternative components, particularly the number of curb extensions proposed or other potential long-term impacts such as odors that may emanate from an underground storage facility.

- Provide a consistently reliable solution for a broad range of conditions. The purpose of this goal is to develop a solution that is reliable in a broad range of conditions. Success in meeting this goal is determined by BES staff after an evaluation of the alternative components, particularly the number of street stormwater controls, the density of street trees, and the steepness of street slopes. This goal is focused on the potential for a stormwater control inlet to be plugged by leaves and other debris and not function properly.

- Provide other community benefits. The purpose of this goal is to integrate project components that provide beneficial uses other than the reduction of basement sewer backup risk and street flooding. Success in meeting this goal is determined by BES staff after an evaluation of the alternative components, particularly the number of street stormwater controls proposed. These facilities may help to reduce the street crossing length for pedestrians and may be include the installation of new sidewalk access ramps at street corners near the facilities.

The watershed benefit goals are evaluated in two steps for stormwater control alternatives: (1) by quantifying the number of acres or linear feet affected by the alternatives and (2) by converting these data to ECV level-of-service indicator scores for comparison with the other level-of-service goals. Conveyance alternative watershed benefits are not expressed in terms of acres affected but are assigned commensurate ECV scores to represent watershed benefits

Because implementation risks and neighborhood impacts are not easily measured, they are determined by BES staff after a thorough evaluation of the components of the alternative.

## Summary of Evaluation Factors

The alternatives were evaluated based on the total ECV indicator score, present worth cost, and an indicator to cost ratio (ICR). The ICR provides a way to evaluate the level of ECV per dollar expended for the project. The ratio is multiplied by 100,000 to produce a value that is easily used for comparison of alternatives, as follows:

$$\frac{ECV\ Indicator\ Score}{Present\ Worth\ Cost} \times 100{,}000 = Indicator\ to\ Cost\ Ratio$$

The highest ICR for each focus area represents the alternative that has the greatest level of environmental and community value per dollar invested.

## Selection of Preferred Alternatives and Development of Recommended Plan

The alternatives were evaluated and compared based on the effectiveness of addressing the hydraulic deficiencies, costs, watershed benefits, implementation risks, and neighborhood impacts. The advantages and disadvantages of each were considered in the selection of the preferred improvement alternatives. The preferred alternatives were then analyzed and evaluated as integrated recommended project plans for the basins and refined to optimize benefits and reduce costs.

## Cost-Benefit-to-Risk Ranking of Recommended Projects

After the recommended projects were selected and defined, they were evaluated in terms of CSO reduction benefits and pipe mortality and basement sewer backup (pipe capacity) risks before being recommended for the City's capital improvement plan (CIP). This was done by calculating a cost-benefit ratio (CBR) for comparison.

The cost portion of the CBR consists of estimated cost to construct and maintain the project plus a credit of $3 per gallon for all stormwater runoff that was diverted away from the combined sewer system. The benefit portion of the CBR is the benefit of solving the risk within the project area. The risk is calculated as the sum of the associated pipeline mortality risk and the basement sewer backup risk. The CBR is calculated using the following formula:

$$CBR = ((MortalityRisk + CapacityRisk) - \Pr oject \Pr esentWorthCost)) / \Pr ojectCapitalCost$$

Both the credit for stormwater runoff that is diverted away from the combined sewer system and the cost to maintain and replace infiltrating stormwater facilities are included in the Project Present Worth Cost. Those projects that have a CBR that is greater than zero are considered to be cost effective projects.

Pipeline mortality risk is the cost of having to replace a pipe segment. This risk was calculated taking into account age and condition of the pipe segment. Capacity risk is the cost to the city of a basement sewer backup, including cleanup costs and compensation to the property owner. These costs were developed based on the level of risk defined for properties affected by the proposed projects during the combined sewer system basin characterization. The costs were accumulated for a 100-year planning period consistent with the present worth cost estimates. For example, a property with a risk of basement sewer backup for a 2-year return interval rainfall event, would be projected to be at risk of a sewer backup 50 times over the hundred year planning period. The cost estimate of the capacity risk for that property reflects that potential repetition of basement sewer backup.

By comparing the CBR of proposed projects, BES ranks the projects for inclusion in the CIP. This way, those projects that provide the most benefit for the cost will be constructed first for optimal use of public funds in the management of the City assets.

## APPENDIX D
# Affordability Calculations

**1999 Household Income**
**Median Household Income**
**by Census Tract**

**Baseline Condition**
**Affordability Indices by Census Tract**

| | 1999 | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | Average | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Actual MHI** (1999 Census & American Community Survey): | $40,146 | $50,979 | | | | | | | | | 2.69% | |
| **Projected City-wide MHI** (based on CBO & OMB average CPI projections): | | | $50,719 | $51,500 | $52,242 | $52,994 | $53,784 | $54,784 | $55,803 | $56,841 | | 12.7% |
| **Projected Annual MHI Growth Rates:** | | | -0.51% | 1.54% | 1.44% | 1.44% | 1.49% | 1.86% | 1.86% | 1.86% | 1.37% | |
| annual growth + 1 (for sumproduct calc) : | | | 99.49% | 101.54% | 101.44% | 101.44% | 101.49% | 101.86% | 101.86% | 101.86% | | 11.5% |
| **Average Residential Cost per Household -- Monthly** (from "EPA Financial Capability Assessment, DCP, 11-9-09.xls"): | | $52.94 | $58.34 | $61.09 | $65.45 | $70.07 | $75.02 | $78.38 | $81.88 | $84.30 | | -2.8% |
| **Average Residential Cost per Household -- Annual** (from "EPA Financial Capability Assessment, DCP, 11-9-09.xls"): | | $635 | $700 | $733 | $785 | $841 | $900 | $941 | $983 | $1,012 | | |
| **Citywide Average Affordability Ratio: Sewer Rate as % of MHI** | | 1.25% | 1.38% | 1.42% | 1.50% | 1.59% | 1.67% | 1.72% | 1.76% | 1.78% | | |

**Baseline Condition**

| State | County | City | Census Tract | 1999 Census MHI | Number of Households in 1999 Census | Projected 2008 MHI (based on 1999-2008 avg. MHI growth) | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | Projected 2016 MHI | increase vs. 7/09 analysis | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Oregon | Multnomah County | Portland | 1 | $44,326 | 2,467 | $56,287 | 1.13% | 1.25% | 1.29% | 1.36% | 1.44% | 1.52% | 1.55% | 1.59% | 1.61% | $62,759 | 10.9% | 0.00% |
| Oregon | Multnomah County | Portland | 2 | $33,681 | 2,855 | $42,769 | 1.49% | 1.65% | 1.70% | 1.79% | 1.89% | 2.00% | 2.05% | 2.10% | 2.12% | $47,687 | 10.9% | 0.00% |
| Oregon | Multnomah County | Portland | 3.01 | $35,586 | 2,086 | $45,189 | 1.41% | 1.56% | 1.61% | 1.70% | 1.79% | 1.89% | 1.94% | 1.99% | 2.01% | $50,385 | 10.9% | 0.00% |
| Oregon | Multnomah County | Portland | 3.02 | $61,915 | 2,542 | $78,622 | 0.81% | 0.89% | 0.92% | 0.97% | 1.03% | 1.09% | 1.11% | 1.14% | 1.15% | $87,663 | 10.9% | 0.00% |
| Oregon | Multnomah County | Portland | 4.01 | $42,578 | 1,423 | $54,067 | 1.17% | 1.30% | 1.34% | 1.42% | 1.50% | 1.58% | 1.62% | 1.66% | 1.68% | $60,284 | 10.9% | 0.00% |
| Oregon | Multnomah County | Portland | 4.02 | $39,600 | 1,409 | $50,286 | 1.26% | 1.40% | 1.44% | 1.52% | 1.61% | 1.70% | 1.74% | 1.78% | 1.80% | $56,068 | 10.9% | 0.00% |
| Oregon | Multnomah County | Portland | 5.01 | $39,058 | 1,432 | $49,597 | 1.28% | 1.42% | 1.46% | 1.55% | 1.63% | 1.72% | 1.76% | 1.81% | 1.83% | $55,300 | 10.9% | 0.00% |
| Oregon | Multnomah County | Portland | 5.02 | $33,264 | 1,735 | $42,240 | 1.50% | 1.67% | 1.72% | 1.81% | 1.91% | 2.02% | 2.07% | 2.12% | 2.15% | $47,097 | 10.9% | 0.00% |
| Oregon | Multnomah County | Portland | 6.01 | $36,838 | 1,722 | $46,778 | 1.36% | 1.50% | 1.55% | 1.64% | 1.73% | 1.82% | 1.87% | 1.92% | 1.94% | $52,157 | 10.9% | 0.00% |
| Oregon | Multnomah County | Portland | 6.02 | $35,721 | 1,648 | $45,360 | 1.40% | 1.55% | 1.60% | 1.69% | 1.78% | 1.88% | 1.93% | 1.98% | 2.00% | $50,576 | 10.9% | 0.00% |
| Oregon | Multnomah County | Portland | 7.01 | $40,083 | 1,820 | $50,899 | 1.25% | 1.38% | 1.43% | 1.51% | 1.59% | 1.68% | 1.72% | 1.76% | 1.78% | $56,752 | 10.9% | 0.00% |
| Oregon | Multnomah County | Portland | 7.02 | $42,670 | 1,812 | $54,184 | 1.17% | 1.30% | 1.34% | 1.41% | 1.49% | 1.57% | 1.62% | 1.66% | 1.67% | $60,414 | 10.9% | 0.00% |
| Oregon | Multnomah County | Portland | 8.01 | $39,984 | 1,928 | $50,773 | 1.25% | 1.39% | 1.43% | 1.51% | 1.59% | 1.68% | 1.72% | 1.77% | 1.79% | $56,611 | 10.9% | 0.00% |
| Oregon | Multnomah County | Portland | 8.02 | $34,030 | 1,959 | $43,213 | 1.47% | 1.63% | 1.68% | 1.77% | 1.87% | 1.97% | 2.03% | 2.08% | 2.10% | $48,182 | 10.9% | 0.00% |
| Oregon | Multnomah County | Portland | 9.01 | $41,044 | 1,699 | $52,119 | 1.22% | 1.35% | 1.39% | 1.47% | 1.55% | 1.64% | 1.68% | 1.72% | 1.74% | $58,112 | 10.9% | 0.00% |
| Oregon | Multnomah County | Portland | 9.02 | $32,337 | 1,877 | $41,063 | 1.55% | 1.71% | 1.77% | 1.87% | 1.97% | 2.08% | 2.13% | 2.19% | 2.21% | $45,784 | 10.9% | 0.00% |
| Oregon | Multnomah County | Portland | 10 | $38,393 | 2,406 | $48,753 | 1.30% | 1.44% | 1.49% | 1.57% | 1.66% | 1.75% | 1.80% | 1.84% | 1.86% | $54,359 | 10.9% | 0.00% |
| Oregon | Multnomah County | Portland | 11.01 | $23,800 | 1,125 | $30,222 | 2.10% | 2.33% | 2.40% | 2.54% | 2.68% | 2.82% | 2.90% | 2.97% | 3.00% | $33,697 | 10.9% | 0.00% |
| Oregon | Multnomah County | Portland | 11.02 | $40,648 | 676 | $51,616 | 1.23% | 1.36% | 1.41% | 1.48% | 1.57% | 1.65% | 1.70% | 1.74% | 1.76% | $57,552 | 10.9% | 0.00% |
| Oregon | Multnomah County | Portland | 12.01 | $28,960 | 2,485 | $36,775 | 1.73% | 1.91% | 1.97% | 2.08% | 2.20% | 2.32% | 2.38% | 2.44% | 2.47% | $41,003 | 10.9% | 0.00% |
| Oregon | Multnomah County | Portland | 12.02 | $45,542 | 1,432 | $57,831 | 1.10% | 1.22% | 1.25% | 1.33% | 1.40% | 1.48% | 1.51% | 1.55% | 1.57% | $64,481 | 10.9% | 0.00% |
| Oregon | Multnomah County | Portland | 13.01 | $37,181 | 1,743 | $47,214 | 1.35% | 1.49% | 1.54% | 1.62% | 1.71% | 1.81% | 1.85% | 1.90% | 1.92% | $52,643 | 10.9% | 0.00% |
| Oregon | Multnomah County | Portland | 13.02 | $45,947 | 1,229 | $58,345 | 1.09% | 1.21% | 1.24% | 1.31% | 1.39% | 1.46% | 1.50% | 1.54% | 1.56% | $65,054 | 10.9% | 0.00% |
| Oregon | Multnomah County | Portland | 14 | $44,802 | 2,090 | $56,891 | 1.12% | 1.24% | 1.28% | 1.35% | 1.42% | 1.50% | 1.54% | 1.58% | 1.59% | $63,433 | 10.9% | 0.00% |
| Oregon | Multnomah County | Portland | 15 | $56,662 | 1,362 | $71,952 | 0.88% | 0.98% | 1.01% | 1.07% | 1.12% | 1.19% | 1.22% | 1.25% | 1.26% | $80,225 | 10.9% | 0.00% |
| Oregon | Multnomah County | Portland | 16.01 | $45,229 | 2,436 | $57,434 | 1.11% | 1.23% | 1.26% | 1.33% | 1.41% | 1.49% | 1.52% | 1.56% | 1.58% | $64,038 | 10.9% | 0.00% |
| Oregon | Multnomah County | Portland | 16.02 | $39,559 | 1,525 | $50,234 | 1.26% | 1.40% | 1.44% | 1.53% | 1.61% | 1.70% | 1.74% | 1.79% | 1.81% | $56,010 | 10.9% | 0.00% |
| Oregon | Multnomah County | Portland | 17.01 | $37,095 | 2,639 | $47,105 | 1.35% | 1.49% | 1.54% | 1.63% | 1.72% | 1.81% | 1.86% | 1.91% | 1.93% | $52,521 | 10.9% | 0.00% |
| Oregon | Multnomah County | Portland | 17.02 | $38,792 | 1,382 | $49,260 | 1.29% | 1.43% | 1.47% | 1.56% | 1.64% | 1.73% | 1.78% | 1.82% | 1.84% | $54,924 | 10.9% | 0.00% |
| Oregon | Multnomah County | Portland | 18.01 | $35,347 | 1,631 | $44,885 | 1.42% | 1.57% | 1.62% | 1.71% | 1.80% | 1.90% | 1.95% | 2.00% | 2.02% | $50,046 | 10.9% | 0.00% |
| Oregon | Multnomah County | Portland | 18.02 | $45,000 | 1,493 | $57,143 | 1.11% | 1.23% | 1.27% | 1.34% | 1.42% | 1.49% | 1.53% | 1.57% | 1.59% | $63,713 | 10.9% | 0.00% |
| Oregon | Multnomah County | Portland | 19 | $71,321 | 1,885 | $90,566 | 0.70% | 0.78% | 0.80% | 0.85% | 0.89% | 0.94% | 0.97% | 0.99% | 1.00% | $100,980 | 10.9% | 0.00% |
| Oregon | Multnomah County | Portland | 20 | $32,683 | 2,946 | $41,502 | 1.53% | 1.70% | 1.75% | 1.85% | 1.95% | 2.06% | 2.11% | 2.16% | 2.19% | $46,274 | 10.9% | 0.00% |
| Oregon | Multnomah County | Portland | 21 | $21,654 | 1,251 | $27,497 | 2.31% | 2.56% | 2.64% | 2.79% | 2.94% | 3.10% | 3.18% | 3.26% | 3.30% | $30,659 | 10.9% | 0.00% |
| Oregon | Multnomah County | Portland | 22.01 | $14,091 | 157 | $17,893 | 3.55% | 3.93% | 4.06% | 4.28% | 4.52% | 4.77% | 4.89% | 5.02% | 5.07% | $19,951 | 10.9% | 0.00% |
| Oregon | Multnomah County | Portland | 22.02 | $19,792 | 118 | $25,133 | 2.53% | 2.80% | 2.89% | 3.05% | 3.22% | 3.40% | 3.48% | 3.57% | 3.61% | $28,023 | 10.9% | 0.00% |
| Oregon | Multnomah County | Portland | 23.01 | $28,342 | 1,142 | $35,990 | 1.77% | 1.96% | 2.02% | 2.13% | 2.25% | 2.37% | 2.43% | 2.49% | 2.52% | $40,128 | 10.9% | 0.00% |
| Oregon | Multnomah County | Portland | 23.02 | $27,589 | 697 | $35,034 | 1.81% | 2.01% | 2.07% | 2.19% | 2.31% | 2.44% | 2.50% | 2.56% | 2.59% | $39,062 | 10.9% | 0.00% |
| Oregon | Multnomah County | Portland | 24.01 | $63,512 | 1,108 | $80,650 | 0.79% | 0.87% | 0.90% | 0.95% | 1.00% | 1.06% | 1.09% | 1.11% | 1.12% | $89,924 | 10.9% | 0.00% |
| Oregon | Multnomah County | Portland | 24.02 | $34,826 | 1,956 | $44,223 | 1.44% | 1.59% | 1.64% | 1.73% | 1.83% | 1.93% | 1.98% | 2.03% | 2.05% | $49,309 | 10.9% | 0.00% |
| Oregon | Multnomah County | Portland | 25.01 | $78,915 | 1,704 | $100,209 | 0.63% | 0.70% | 0.72% | 0.76% | 0.81% | 0.85% | 0.87% | 0.90% | 0.91% | $111,732 | 10.9% | 0.00% |
| Oregon | Multnomah County | Portland | 25.02 | $41,071 | 2,006 | $52,154 | 1.22% | 1.35% | 1.39% | 1.47% | 1.55% | 1.64% | 1.68% | 1.72% | 1.74% | $58,151 | 10.9% | 0.00% |
| Oregon | Multnomah County | Portland | 26 | $70,806 | 1,061 | $89,912 | 0.71% | 0.78% | 0.81% | 0.85% | 0.90% | 0.95% | 0.97% | 1.00% | 1.01% | $100,251 | 10.9% | 0.00% |
| Oregon | Multnomah County | Portland | 27.01 | $67,324 | 1,181 | $85,491 | 0.74% | 0.82% | 0.85% | 0.90% | 0.95% | 1.00% | 1.02% | 1.05% | 1.06% | $95,321 | 10.9% | 0.00% |
| Oregon | Multnomah County | Portland | 27.02 | $33,202 | 1,330 | $42,161 | 1.51% | 1.67% | 1.72% | 1.82% | 1.92% | 2.02% | 2.08% | 2.13% | 2.15% | $47,009 | 10.9% | 0.00% |
| Oregon | Multnomah County | Portland | 28.01 | $56,774 | 1,236 | $72,094 | 0.88% | 0.98% | 1.01% | 1.06% | 1.12% | 1.18% | 1.21% | 1.25% | 1.26% | $80,384 | 10.9% | 0.00% |
| Oregon | Multnomah County | Portland | 28.02 | $48,469 | 1,260 | $61,548 | 1.03% | 1.14% | 1.18% | 1.25% | 1.31% | 1.39% | 1.42% | 1.46% | 1.47% | $68,625 | 10.9% | 0.00% |
| Oregon | Multnomah County | Portland | 29.01 | $47,867 | 1,923 | $60,783 | 1.05% | 1.16% | 1.19% | 1.26% | 1.33% | 1.40% | 1.44% | 1.48% | 1.49% | $67,773 | 10.9% | 0.00% |
| Oregon | Multnomah County | Portland | 29.02 | $38,659 | 2,437 | $49,091 | 1.29% | 1.43% | 1.48% | 1.56% | 1.65% | 1.74% | 1.78% | 1.83% | 1.85% | $54,735 | 10.9% | 0.00% |
| Oregon | Multnomah County | Portland | 29.03 | $50,596 | 1,631 | $64,249 | 0.99% | 1.10% | 1.13% | 1.19% | 1.26% | 1.33% | 1.36% | 1.40% | 1.41% | $71,637 | 10.9% | 0.00% |
| Oregon | Multnomah County | Portland | 30 | $54,052 | 1,881 | $68,637 | 0.93% | 1.03% | 1.06% | 1.12% | 1.18% | 1.24% | 1.28% | 1.31% | 1.32% | $76,530 | 10.9% | 0.00% |
| Oregon | Multnomah County | Portland | 31 | $48,264 | 1,818 | $61,288 | 1.04% | 1.15% | 1.18% | 1.25% | 1.32% | 1.39% | 1.43% | 1.46% | 1.48% | $68,335 | 10.9% | 0.00% |
| Oregon | Multnomah County | Portland | 32 | $48,315 | 1,594 | $61,352 | 1.04% | 1.15% | 1.18% | 1.25% | 1.32% | 1.39% | 1.43% | 1.46% | 1.48% | $68,407 | 10.9% | 0.00% |
| Oregon | Multnomah County | Portland | 33.01 | $26,186 | 1,134 | $33,252 | 1.91% | 2.12% | 2.18% | 2.30% | 2.43% | 2.57% | 2.63% | 2.70% | 2.73% | $37,076 | 10.9% | 0.00% |
| Oregon | Multnomah County | Portland | 33.02 | $33,721 | 994 | $42,820 | 1.48% | 1.64% | 1.69% | 1.79% | 1.89% | 1.99% | 2.04% | 2.10% | 2.12% | $47,744 | 10.9% | 0.00% |
| Oregon | Multnomah County | Portland | 34.01 | $27,122 | 1,228 | $34,441 | 1.84% | 2.04% | 2.11% | 2.23% | 2.35% | 2.48% | 2.54% | 2.61% | 2.63% | $38,401 | 10.9% | 0.00% |
| Oregon | Multnomah County | Portland | 34.02 | $25,318 | 1,029 | $32,150 | 1.98% | 2.19% | 2.26% | 2.38% | 2.52% | 2.65% | 2.72% | 2.79% | 2.82% | $35,847 | 10.9% | 0.00% |
| Oregon | Multnomah County | Portland | 35.01 | $39,306 | 1,335 | $49,912 | 1.27% | 1.41% | 1.45% | 1.54% | 1.62% | 1.71% | 1.75% | 1.80% | 1.82% | $55,652 | 10.9% | 0.00% |
| Oregon | Multnomah County | Portland | 35.02 | $44,261 | 810 | $56,204 | 1.13% | 1.25% | 1.29% | 1.36% | 1.44% | 1.52% | 1.56% | 1.60% | 1.61% | $62,667 | 10.9% | 0.00% |
| Oregon | Multnomah County | Portland | 36.01 | $33,869 | 1,669 | $43,008 | 1.48% | 1.64% | 1.69% | 1.78% | 1.88% | 1.98% | 2.03% | 2.09% | 2.11% | $47,954 | 10.9% | 0.00% |
| Oregon | Multnomah County | Portland | 36.02 | $43,788 | 2,277 | $55,604 | 1.14% | 1.27% | 1.31% | 1.38% | 1.45% | 1.53% | 1.57% | 1.61% | 1.63% | $61,997 | 10.9% | 0.00% |
| Oregon | Multnomah County | Portland | 36.03 | $51,447 | 637 | $65,329 | 0.97% | 1.08% | 1.11% | 1.17% | 1.24% | 1.31% | 1.34% | 1.37% | 1.39% | $72,841 | 10.9% | 0.00% |
| Oregon | Multnomah County | Portland | 37.01 | $35,182 | 1,509 | $44,676 | 1.42% | 1.58% | 1.62% | 1.72% | 1.81% | 1.91% | 1.96% | 2.01% | 2.03% | $49,813 | 10.9% | 0.00% |
| Oregon | Multnomah County | Portland | 37.02 | $40,375 | 908 | $51,270 | 1.24% | 1.37% | 1.42% | 1.49% | 1.58% | 1.66% | 1.71% | 1.75% | 1.77% | $57,165 | 10.9% | 0.00% |
| Oregon | Multnomah County | Portland | 38.01 | $36,683 | 1,157 | $46,582 | 1.36% | 1.51% | 1.56% | 1.65% | 1.74% | 1.83% | 1.88% | 1.93% | 1.95% | $51,938 | 10.9% | 0.00% |
| Oregon | Multnomah County | Portland | 38.02 | $37,575 | 1,217 | $47,714 | 1.33% | 1.47% | 1.52% | 1.61% | 1.70% | 1.79% | 1.83% | 1.88% | 1.90% | $53,201 | 10.9% | 0.00% |
| Oregon | Multnomah County | Portland | 38.03 | $38,716 | 1,621 | $49,163 | 1.29% | 1.43% | 1.48% | 1.56% | 1.65% | 1.74% | 1.78% | 1.83% | 1.85% | $54,816 | 10.9% | 0.00% |
| Oregon | Multnomah County | Portland | 39.01 | $38,434 | 2,474 | $48,805 | 1.30% | 1.44% | 1.49% | 1.57% | 1.66% | 1.75% | 1.79% | 1.84% | 1.86% | $54,417 | 10.9% | 0.00% |
| Oregon | Multnomah County | Portland | 39.02 | $46,767 | 1,248 | $59,387 | 1.07% | 1.18% | 1.22% | 1.29% | 1.36% | 1.44% | 1.47% | 1.51% | 1.53% | $66,215 | 10.9% | 0.00% |
| Oregon | Multnomah County | Portland | 40.01 | $30,868 | 2,123 | $39,197 | 1.62% | 1.80% | 1.85% | 1.96% | 2.06% | 2.18% | 2.23% | 2.29% | 2.31% | $43,705 | 10.9% | 0.00% |
| Oregon | Multnomah County | Portland | 40.02 | $42,143 | 1,591 | $53,515 | 1.19% | 1.31% | 1.36% | 1.43% | 1.51% | 1.59% | 1.64% | 1.68% | 1.70% | $59,668 | 10.9% | 0.00% |
| Oregon | Multnomah County | Portland | 41.01 | $35,459 | 2,296 | $45,027 | 1.41% | 1.56% | 1.61% | 1.70% | 1.80% | 1.90% | 1.94% | 1.99% | 2.02% | $50,205 | 10.9% | 0.00% |
| Oregon | Multnomah County | Portland | 41.02 | $37,990 | 1,868 | $48,241 | 1.32% | 1.46% | 1.50% | 1.59% | 1.68% | 1.77% | 1.81% | 1.86% | 1.88% | $53,788 | 10.9% | 0.00% |
| Oregon | Multnomah County | Portland | 42 | $25,732 | 1,315 | $32,676 | 1.94% | 2.15% | 2.22% | 2.35% | 2.48% | 2.61% | 2.68% | 2.75% | 2.78% | $36,433 | 10.9% | 0.00% |
| Oregon | Multnomah County | Portland | 44 | $58,750 | 37 | $74,603 | 0.85% | 0.94% | 0.97% | 1.03% | 1.08% | 1.14% | 1.17% | 1.20% | 1.22% | $83,181 | 10.9% | 0.00% |
| Oregon | Multnomah County | Portland | 45 | $42,202 | 901 | $53,590 | 1.19% | 1.31% | 1.35% | 1.43% | 1.51% | 1.59% | 1.63% | 1.67% | 1.69% | $59,752 | 10.9% | 0.00% |
| Oregon | Multnomah County | Portland | 46.01 | $81,158 | 1,497 | $103,058 | 0.62% | 0.68% | 0.70% | 0.74% | 0.78% | 0.83% | 0.85% | 0.87% | 0.88% | $114,908 | 10.9% | 0.00% |
| Oregon | Multnomah County | Portland | 46.02 | $91,684 | 821 | $116,424 | 0.55% | 0.60% | 0.62% | 0.66% | 0.69% | 0.73% | 0.75% | 0.77% | 0.78% | $129,811 | 10.9% | 0.00% |
| Oregon | Multnomah County | Portland | 47 | $39,950 | 2,323 | $50,730 | 1.25% | 1.39% | 1.43% | 1.51% | 1.59% | 1.68% | 1.73% | 1.77% | 1.79% | $56,563 | 10.9% | 0.00% |
| Oregon | Multnomah County | Portland | 48 | $26,519 | 2,014 | $33,675 | 1.89% | 2.09% | 2.15% | 2.28% | 2.40% | 2.53% | 2.60% | 2.67% | 2.69% | $37,547 | 10.9% | 0.00% |
| Oregon | Multnomah County | Portland | 49 | $22,457 | 2,156 | $28,517 | 2.23% | 2.47% | 2.54% | 2.69% | 2.84% | 2.99% | 3.07% | 3.15% | 3.18% | $31,796 | 10.9% | 0.00% |
| Oregon | Multnomah County | Portland | 50 | $28,558 | 495 | $36,264 | 1.75% | 1.94% | 2.00% | 2.11% | 2.23% | 2.35% | 2.41% | 2.48% | 2.50% | $40,434 | 10.9% | 0.00% |
| Oregon | Multnomah County | Portland | 51 | $20,642 | 1,893 | $26,212 | 2.42% | 2.68% | 2.77% | 2.92% | 3.09% | 3.26% | 3.34% | 3.42% | 3.46% | $29,226 | 10.9% | 0.00% |
| Oregon | Multnomah County | Portland | 52 | $21,897 | 2,855 | $27,806 | 2.28% | 2.53% | 2.61% | 2.76% | 2.91% | 3.07% | 3.15% | 3.23% | 3.26% | $31,003 | 10.9% | 0.00% |
| Oregon | Multnomah County | Portland | 53 | $10,241 | 1,406 | $13,004 | 4.89% | 5.41% | 5.58% | 5.89% | 6.22% | 6.56% | 6.73% | 6.90% | 6.98% | $14,500 | 10.9% | 0.00% |
| Oregon | Multnomah County | Portland | 54 | $8,179 | 241 | $10,386 | 6.12% | 6.77% | 6.99% | 7.38% | 7.79% | 8.22% | 8.43% | 8.64% | 8.74% | $11,580 | 10.9% | 0.00% |
| Oregon | Multnomah County | Portland | 55 | $16,847 | 1,380 | $21,393 | 2.97% | 3.29% | 3.39% | 3.58% | 3.78% | 3.99% | 4.09% | 4.20% | 4.24% | $23,853 | 10.9% | 0.00% |
| Oregon | Multnomah County | Portland | 56 | $17,574 | 2,426 | $22,316 | 2.85% | 3.15% | 3.25% | 3.43% | 3.62% | 3.82% | 3.92% | 4.02% | 4.07% | $24,882 | 10.9% | 0.00% |
| Oregon | Multnomah County | Portland | 57 | $45,779 | 1,684 | $58,132 | 1.09% | 1.21% | 1.25% | 1.32% | 1.39% | 1.47% | 1.51% | 1.54% | 1.56% | $64,816 | 10.9% | 0.00% |
| Oregon | Multnomah County | Portland | 58 | $60,076 | 2,304 | $76,287 | 0.83% | 0.92% | 0.95% | 1.00% | 1.06% | 1.12% | 1.15% | 1.18% | 1.19% | $85,059 | 10.9% | 0.00% |
| Oregon | Multnomah County | Portland | 59 | $46,946 | 2,254 | $59,614 | 1.07% | 1.18% | 1.22% | 1.29% | 1.36% | 1.43% | 1.47% | 1.51% | 1.52% | $66,469 | 10.9% | 0.00% |
| Oregon | Multnomah County | Portland | 60.01 | $65,184 | 700 | $82,773 | 0.77% | 0.85% | 0.88% | 0.93% | 0.98% | 1.03% | 1.06% | 1.08% | 1.10% | $92,291 | 10.9% | 0.00% |
| Oregon | Multnomah County | Portland | 60.02 | $53,047 | 897 | $67,361 | 0.94% | 1.04% | 1.08% | 1.14% | 1.20% | 1.27% | 1.30% | 1.33% | 1.35% | $75,107 | 10.9% | 0.00% |
| Oregon | Multnomah County | Portland | 61 | $67,717 | 991 | $85,990 | 0.74% | 0.82% | 0.84% | 0.89% | 0.94% | 0.99% | 1.02% | 1.04% | 1.06% | $95,877 | 10.9% | 0.00% |
| Oregon | Multnomah County | Portland | 62 | $68,188 | 1,209 | $86,588 | 0.73% | 0.81% | 0.84% | 0.89% | 0.93% | 0.99% | 1.01% | 1.04% | 1.05% | $96,544 | 10.9% | 0.00% |
| Oregon | Multnomah County | Portland | 63 | $77,574 | 1,541 | $98,507 | 0.64% | 0.71% | 0.74% | 0.78% | 0.82% | 0.87% | 0.89% | 0.91% | 0.92% | $109,833 | 10.9% | 0.00% |

**Baseline Condition**

| State | County | City | Census Tract | 1999 Census MHI | Number of Households in 1999 Census | Projected 2008 MHI (based on 1999-2008 avg. MHI growth) | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | Projected 2016 MHI | increase vs. 7/09 analysis | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Oregon | Multnomah County | Portland | 64.01 | $54,948 | 3,177 | $69,775 | 0.91% | 1.01% | 1.04% | 1.10% | 1.16% | 1.22% | 1.25% | 1.29% | 1.30% | $77,798 | 10.9% | 0.00% |
| Oregon | Multnomah County | Portland | 64.02 | $83,905 | 2,097 | $106,546 | 0.60% | 0.66% | 0.68% | 0.72% | 0.76% | 0.80% | 0.82% | 0.84% | 0.85% | $118,797 | 10.9% | 0.00% |
| Oregon | Multnomah County | Portland | 65.01 | $67,554 | 2,267 | $85,783 | 0.74% | 0.82% | 0.85% | 0.89% | 0.94% | 0.99% | 1.02% | 1.05% | 1.06% | $95,647 | 10.9% | 0.00% |
| Oregon | Multnomah County | Portland | 65.02 | $44,116 | 1,735 | $56,020 | 1.13% | 1.26% | 1.30% | 1.37% | 1.44% | 1.52% | 1.56% | 1.60% | 1.62% | $62,462 | 10.9% | 0.00% |
| Oregon | Multnomah County | Portland | 66.01 | $56,989 | 1,021 | $72,367 | 0.88% | 0.97% | 1.00% | 1.06% | 1.12% | 1.18% | 1.21% | 1.24% | 1.25% | $80,688 | 10.9% | 0.00% |
| Oregon | Multnomah County | Portland | 66.02 | $39,286 | 2,229 | $49,887 | 1.27% | 1.41% | 1.45% | 1.54% | 1.62% | 1.71% | 1.75% | 1.80% | 1.82% | $55,623 | 10.9% | 0.00% |
| Oregon | Multnomah County | Portland | 67.01 | $51,571 | 1,273 | $65,487 | 0.97% | 1.07% | 1.11% | 1.17% | 1.24% | 1.30% | 1.34% | 1.37% | 1.39% | $73,017 | 10.9% | 0.00% |
| Oregon | Multnomah County | Portland | 67.02 | $50,348 | 1,351 | $63,934 | 0.99% | 1.10% | 1.14% | 1.20% | 1.27% | 1.33% | 1.37% | 1.40% | 1.42% | $71,285 | 10.9% | 0.00% |
| Oregon | Multnomah County | Portland | 68.01 | $51,000 | 988 | $64,762 | 0.98% | 1.09% | 1.12% | 1.18% | 1.25% | 1.32% | 1.35% | 1.39% | 1.40% | $72,209 | 10.9% | 0.00% |
| Oregon | Multnomah County | Portland | 68.02 | $62,813 | 1,412 | $79,762 | 0.80% | 0.88% | 0.91% | 0.96% | 1.01% | 1.07% | 1.10% | 1.13% | 1.14% | $88,934 | 10.9% | 0.00% |
| Oregon | Multnomah County | Portland | 69 | $111,064 | 1,015 | $141,034 | 0.45% | 0.50% | 0.51% | 0.54% | 0.57% | 0.61% | 0.62% | 0.64% | 0.64% | $157,250 | 10.9% | 0.00% |
| Oregon | Multnomah County | Portland | 70 | $108,931 | 1,903 | $138,325 | 0.46% | 0.51% | 0.52% | 0.55% | 0.58% | 0.62% | 0.63% | 0.65% | 0.66% | $154,230 | 10.9% | 0.00% |
| Oregon | Multnomah County | Portland | 71 | $61,480 | 1,213 | $78,070 | 0.81% | 0.90% | 0.93% | 0.98% | 1.04% | 1.09% | 1.12% | 1.15% | 1.16% | $87,047 | 10.9% | 0.00% |
| Oregon | Multnomah County | Portland | 72.01 | $40,705 | 1,224 | $51,689 | 1.23% | 1.36% | 1.40% | 1.48% | 1.56% | 1.65% | 1.69% | 1.74% | 1.76% | $57,632 | 10.9% | 0.00% |
| Oregon | Multnomah County | Portland | 72.02 | $49,256 | 860 | $62,547 | 1.02% | 1.12% | 1.16% | 1.23% | 1.29% | 1.36% | 1.40% | 1.44% | 1.45% | $69,739 | 10.9% | 0.00% |
| Oregon | Multnomah County | Portland | 73 | $38,309 | 240 | $48,646 | 1.31% | 1.45% | 1.49% | 1.58% | 1.66% | 1.75% | 1.80% | 1.85% | 1.87% | $54,240 | 10.9% | 0.00% |
| Oregon | Multnomah County | Portland | 74 | $37,617 | 1,165 | $47,768 | 1.33% | 1.47% | 1.52% | 1.60% | 1.69% | 1.79% | 1.83% | 1.88% | 1.90% | $53,260 | 10.9% | 0.00% |
| Oregon | Multnomah County | Portland | 75 | $39,099 | 1,784 | $49,649 | 1.28% | 1.42% | 1.46% | 1.54% | 1.63% | 1.72% | 1.76% | 1.81% | 1.83% | $55,358 | 10.9% | 0.00% |
| Oregon | Multnomah County | Portland | 76 | $27,865 | 1,311 | $35,384 | 1.80% | 1.99% | 2.05% | 2.17% | 2.29% | 2.41% | 2.47% | 2.54% | 2.56% | $39,453 | 10.9% | 0.00% |
| Oregon | Multnomah County | Portland | 77 | $37,632 | 800 | $47,787 | 1.33% | 1.47% | 1.52% | 1.60% | 1.69% | 1.79% | 1.83% | 1.88% | 1.90% | $53,281 | 10.9% | 0.00% |
| Oregon | Multnomah County | Portland | 78 | $45,385 | 688 | $57,632 | 1.10% | 1.22% | 1.26% | 1.33% | 1.40% | 1.48% | 1.52% | 1.56% | 1.57% | $64,259 | 10.9% | 0.00% |
| Oregon | Multnomah County | Portland | 79 | $37,521 | 1,665 | $47,646 | 1.33% | 1.48% | 1.52% | 1.61% | 1.70% | 1.79% | 1.84% | 1.88% | 1.90% | $53,124 | 10.9% | 0.00% |
| Oregon | Multnomah County | Portland | 80.01 | $40,269 | 1,333 | $51,135 | 1.24% | 1.38% | 1.42% | 1.50% | 1.58% | 1.67% | 1.71% | 1.76% | 1.77% | $57,015 | 10.9% | 0.00% |
| Oregon | Multnomah County | Portland | 80.02 | $40,344 | 1,109 | $51,230 | 1.24% | 1.37% | 1.42% | 1.50% | 1.58% | 1.67% | 1.71% | 1.75% | 1.77% | $57,121 | 10.9% | 0.00% |
| Oregon | Multnomah County | Portland | 81 | $29,730 | 2,672 | $37,752 | 1.68% | 1.86% | 1.92% | 2.03% | 2.14% | 2.26% | 2.32% | 2.38% | 2.40% | $42,093 | 10.9% | 0.00% |
| Oregon | Multnomah County | Portland | 82.01 | $43,110 | 970 | $54,743 | 1.16% | 1.29% | 1.33% | 1.40% | 1.48% | 1.56% | 1.60% | 1.64% | 1.66% | $61,037 | 10.9% | 0.00% |
| Oregon | Multnomah County | Portland | 82.02 | $34,438 | 2,190 | $43,731 | 1.45% | 1.61% | 1.66% | 1.75% | 1.85% | 1.95% | 2.00% | 2.05% | 2.07% | $48,759 | 10.9% | 0.00% |
| Oregon | Multnomah County | Portland | 83.01 | $24,719 | 1,153 | $31,389 | 2.02% | 2.24% | 2.31% | 2.44% | 2.58% | 2.72% | 2.79% | 2.86% | 2.89% | $34,998 | 10.9% | 0.00% |
| Oregon | Multnomah County | Portland | 83.02 | $40,000 | 1,303 | $50,794 | 1.25% | 1.39% | 1.43% | 1.51% | 1.59% | 1.68% | 1.72% | 1.77% | 1.79% | $56,634 | 10.9% | 0.00% |
| Oregon | Multnomah County | Portland | 84 | $35,244 | 1,251 | $44,754 | 1.42% | 1.57% | 1.62% | 1.71% | 1.81% | 1.91% | 1.96% | 2.01% | 2.03% | $49,900 | 10.9% | 0.00% |
| Oregon | Multnomah County | Portland | 85 | $38,396 | 1,194 | $48,757 | 1.30% | 1.44% | 1.49% | 1.57% | 1.66% | 1.75% | 1.80% | 1.84% | 1.86% | $54,363 | 10.9% | 0.00% |
| Oregon | Multnomah County | Portland | 86 | $31,179 | 1,287 | $39,592 | 1.60% | 1.78% | 1.83% | 1.94% | 2.04% | 2.16% | 2.21% | 2.27% | 2.29% | $44,145 | 10.9% | 0.00% |
| Oregon | Multnomah County | Portland | 87 | $38,923 | 1,616 | $49,426 | 1.29% | 1.42% | 1.47% | 1.55% | 1.64% | 1.73% | 1.77% | 1.82% | 1.84% | $55,109 | 10.9% | 0.00% |
| Oregon | Multnomah County | Portland | 88 | $37,015 | 1,387 | $47,003 | 1.35% | 1.50% | 1.54% | 1.63% | 1.72% | 1.82% | 1.86% | 1.91% | 1.93% | $52,408 | 10.9% | 0.00% |
| Oregon | Multnomah County | Portland | 89.01 | $57,389 | 1,975 | $72,875 | 0.87% | 0.97% | 1.00% | 1.05% | 1.11% | 1.17% | 1.20% | 1.23% | 1.25% | $81,254 | 10.9% | 0.00% |
| Oregon | Multnomah County | Portland | 89.02 | $35,933 | 1,355 | $45,629 | 1.39% | 1.54% | 1.59% | 1.68% | 1.77% | 1.87% | 1.92% | 1.97% | 1.99% | $50,876 | 10.9% | 0.00% |
| Oregon | Multnomah County | Portland | 91.01 | $36,231 | 1,849 | $46,008 | 1.38% | 1.53% | 1.58% | 1.67% | 1.76% | 1.85% | 1.90% | 1.95% | 1.97% | $51,298 | 10.9% | 0.00% |
| Oregon | Multnomah County | Portland | 91.02 | $43,339 | 1,767 | $55,034 | 1.15% | 1.28% | 1.32% | 1.39% | 1.47% | 1.55% | 1.59% | 1.63% | 1.65% | $61,362 | 10.9% | 0.00% |
| Oregon | Multnomah County | Portland | 92.01 | $33,028 | 2,581 | $41,940 | 1.51% | 1.68% | 1.73% | 1.83% | 1.93% | 2.03% | 2.09% | 2.14% | 2.16% | $46,763 | 10.9% | 0.00% |
| Oregon | Multnomah County | Portland | 92.02 | $45,972 | 1,429 | $58,377 | 1.09% | 1.21% | 1.24% | 1.31% | 1.39% | 1.46% | 1.50% | 1.54% | 1.55% | $65,090 | 10.9% | 0.00% |
| Oregon | Multnomah County | Portland | 93.01 | $32,627 | 1,853 | $41,431 | 1.53% | 1.70% | 1.75% | 1.85% | 1.95% | 2.06% | 2.11% | 2.17% | 2.19% | $46,195 | 10.9% | 0.00% |
| Oregon | Multnomah County | Portland | 93.02 | $43,571 | 1,321 | $55,328 | 1.15% | 1.27% | 1.31% | 1.39% | 1.46% | 1.54% | 1.58% | 1.62% | 1.64% | $61,690 | 10.9% | 0.00% |
| Oregon | Multnomah County | Portland | 94 | $45,242 | 2,891 | $57,450 | 1.11% | 1.22% | 1.26% | 1.33% | 1.41% | 1.49% | 1.52% | 1.56% | 1.58% | $64,056 | 10.9% | 0.00% |
| Oregon | Multnomah County | Portland | 95.01 | $40,015 | 1,743 | $50,813 | 1.25% | 1.38% | 1.43% | 1.51% | 1.59% | 1.68% | 1.72% | 1.77% | 1.79% | $56,655 | 10.9% | 0.00% |
| Oregon | Multnomah County | Portland | 95.02 | $42,635 | 1,663 | $54,140 | 1.17% | 1.30% | 1.34% | 1.42% | 1.49% | 1.58% | 1.62% | 1.66% | 1.68% | $60,365 | 10.9% | 0.00% |
| Oregon | Multnomah County | Portland | 97.01 | $37,083 | 1,865 | $47,089 | 1.35% | 1.49% | 1.54% | 1.63% | 1.72% | 1.81% | 1.86% | 1.91% | 1.93% | $52,504 | 10.9% | 0.00% |
| Oregon | Multnomah County | Portland | 97.02 | $36,293 | 2,462 | $46,086 | 1.38% | 1.53% | 1.57% | 1.66% | 1.76% | 1.85% | 1.90% | 1.95% | 1.97% | $51,386 | 10.9% | 0.00% |
| Oregon | Multnomah County | Portland | 99.03 | $76,799 | 1,664 | $97,522 | 0.65% | 0.72% | 0.74% | 0.79% | 0.83% | 0.87% | 0.90% | 0.92% | 0.93% | $108,736 | 10.9% | 0.00% |
| Oregon | Multnomah County | Portland | 102 | $42,667 | 2,055 | $54,180 | 1.17% | 1.30% | 1.34% | 1.41% | 1.49% | 1.57% | 1.62% | 1.66% | 1.67% | $60,410 | 10.9% | 0.00% |
| Oregon | Clackamas County | Portland | 208 | $37,500 | 1,933 | $47,619 | 1.33% | 1.48% | 1.52% | 1.61% | 1.70% | 1.79% | 1.84% | 1.88% | 1.91% | $53,095 | 10.9% | 0.00% |
| Oregon | Clackamas County | Portland | 222.01 | $30,892 | 2,159 | $39,228 | 1.62% | 1.79% | 1.85% | 1.95% | 2.06% | 2.18% | 2.23% | 2.29% | 2.31% | $43,739 | 10.9% | 0.00% |
| Oregon | Clackamas County | Portland | 222.03 | $78,821 | 1,960 | $100,090 | 0.63% | 0.70% | 0.73% | 0.77% | 0.81% | 0.85% | 0.87% | 0.90% | 0.91% | $111,599 | 10.9% | 0.00% |
| Oregon | Clackamas County | Portland | 222.04 | $72,321 | 2,214 | $91,836 | 0.69% | 0.77% | 0.79% | 0.83% | 0.88% | 0.93% | 0.95% | 0.98% | 0.99% | $102,396 | 10.9% | 0.00% |
| Oregon | Clackamas County | Portland | 301 | $57,111 | 4,187 | $72,522 | 0.88% | 0.97% | 1.00% | 1.06% | 1.12% | 1.18% | 1.21% | 1.24% | 1.25% | $80,861 | 10.9% | 0.00% |
| Oregon | Clackamas County | Portland | 306 | $50,952 | 2,164 | $64,701 | 0.98% | 1.09% | 1.12% | 1.18% | 1.25% | 1.32% | 1.35% | 1.39% | 1.40% | $72,141 | 10.9% | 0.00% |
| 151 | | | | Total | 242,828 | | | | | | | | | | | | | |

| | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 |
|---|---|---|---|---|---|---|---|---|---|
| # Census Tracts >= 1.5% | 25 | 37 | 41 | 53 | **59** | 64 | 70 | 72 | **72** |
| % of Total # Census Tracts | 16.6% | 24.5% | 27.2% | 35.1% | **39.1%** | 42.4% | 46.4% | 47.7% | **47.7%** |
| Households | 49,574 | 80,163 | 96,445 | 128,646 | **140,093** | 158,393 | 172,336 | 177,267 | **177,267** |
| % of Total # Households | 20.4% | 33.0% | 39.7% | 53.0% | **57.7%** | 65.2% | 71.0% | 73.0% | **73.0%** |
| # Census Tracts >= 2.0% | 11 | 17 | 19 | 20 | **21** | 25 | 29 | 31 | **35** |
| % of Total # Census Tracts | 7.3% | 11.3% | 12.6% | 13.2% | **13.9%** | 16.6% | 19.2% | 20.5% | **23.2%** |
| Households | 16,161 | 23,578 | 26,526 | 31,683 | **37,252** | 49,574 | 59,241 | 63,957 | **71,618** |
| % of Total # Households | 6.7% | 9.7% | 10.9% | 13.0% | **15.3%** | 20.4% | 24.4% | 26.3% | **29.5%** |

| | 1999 Census MHI | Projected 2008 MHI | Projected 2016 MHI |
|---|---|---|---|
| Total Household Income (millions) | $10,609 | $13,472 | $15,021 |
| Simple Average MHI | $43,597 | $55,361 | $61,726 |
| Weighted Average MHI | $43,689 | $55,479 | $61,858 |
| Median MHI | $40,000 | $50,783 | $56,634 |

## APPENDIX E

# Draft Post-Construction Monitoring Program

# DRAFT - POST-CONSTRUCTION MONITORING PLAN

## *Purpose*

The post-construction monitoring plan documents the CSO monitoring and sampling activities the City of Portland will implement to ensure the CSO Program complies with the NPDES permit and water quality standards as required by the EPA CSO Policy and the Clean Water Act.

### Overview

There are two main categories of monitoring in the Post-Construction Monitoring Program to ensure the CSO system meets event-based requirements and long-term performance criteria:

1. **Event-based Performance Compliance Monitoring:**
    - Rainfall measurements over service area for comparison against the storm event frequency criteria for compliance
    - CSO discharge measurements to determine overflow occurrence (with alarms), start/stop time, peak discharge rates and total volume released.
    - CSO Facilities operations monitoring to confirm the integrated system operated according to design expectations.
    - Water quality sampling of CSO discharges at overflow structures to confirm water quality standards will be achieved outside of intermittent mixing zones.
2. **Long-term Performance Monitoring:**
    - Collection system monitoring for operations & analysis to provide calibration and future detection of increased loads to CSO system
    - Instream river sampling for long-term trends in water quality

### Background

The Post-Construction Monitoring Program (PCMP) represents the final stage of the long-term CSO monitoring program the City has carried out since 1990 when it began development and implementation of the CSO Program. Initially, the monitoring program was focused on characterizing the CSO discharges and their impacts to the receiving water bodies. The monitoring information was coupled with hydrologic, hydraulic and water quality models to evaluate the efficacy of proposed CSO solutions. Once implementation of the CSO Program was underway, the monitoring program shifted to trending in-stream river water quality improvements and measuring the performance of the completed CSO facilities. This information confirmed the CSO facilities will perform as required by the NPDES permit and will provide the expected water quality improvements for bacteria, which is the primary pollutant of concern.

## *Event-based Performance Compliance Monitoring*

As required by the ASFO, the CBWTP NPDES Permit, and the Willamette River TMDL for Bacteria, Portland is required to control CSO discharges to meet the following event-based performance criteria:

i) All untreated CSO discharges to the Columbia Slough are eliminated except for storms that exceed a five (5) year winter return frequency (November 1 through April 30) and a ten (10) year summer return frequency (May 1 through October 31)

ii) All CSO discharges to the Willamette River are eliminated except for storms that exceed a four (4) per winter return frequency (November 1 through April 30) and a three (3) year summer return frequency (May 1 through October 31)

CSO discharges that occur due to storms events that exceed these requirements are allowed under the permit. Bacteria loads from the approved discharges are allocated under the Willamette TMDL and meet Portland's Bacteria Control Management Plan specified in the Oregon bacteria water quality standards.

For these reasons, compliance with the permit, the bacteria TMDL, and the water quality standards requires event-based monitoring data that can verify:

- CSO discharges are the result of storms exceeding the performance criteria
- CSO facilities have been fully utilized prior to and during discharge periods

Demonstrating that the CSO system meets these performance criteria is the one of the critical functions fulfilled by the post-construction monitoring program. In this manner, the monitoring program directly fulfills EPA's Guidance for post-construction monitoring to ascertain the effectiveness of the CSO controls in meeting water quality standards.

In order to verify compliance with the CSO performance criteria and the water quality standards, the post-construction monitoring program includes the collection of the following data:

- Rainfall measurements over service area for comparison against the storm event frequency criteria for compliance
- CSO discharge measurements to determine overflow occurrence (with alarms), start/stop time, peak discharge rates and total volume released.
- CSO Facilities operations monitoring to confirm the integrated system operated according to design expectations.
- Water quality sampling of CSO discharges at overflow structure to confirm water quality standards will be achieved outside of intermittent mixing zones.

## Portland's Monitoring & Data Collection Systems

For CSO program monitoring, Portland has two fundamental systems that provide rainfall, sewer level, pump station, overflow, and treatment performance data. The HYDRA system has been in use by the City since 1976 and provides rainfall measurements, sewer level monitoring, and pump station alarms and cycle data. The second system is the CSO Communications & Controls System that was created as part of the 2006 Willamette CSO Facilities. This is essentially a large

SCADA (Supervisory Control and Data Acquisition) system with a graphical interface called iFIX. This communications and controls system provides real-time data to the operators for tracking and controlling flows and levels across the CSO system.

### *HYDRA Monitoring System*

Since 1976, Portland has owned, operated and maintained a large monitoring system for collecting rainfall, water level & flow, and pump station data. The system is called HYDRA, which stands for Hydrologic Data Retrieval and Alarms system. The data collected by HYDRA is stored on a separate server and shared with users via the NEPTUNE data management system. The HYDRA system uses a radio telemetry system to collect data from over 40 rainfall gages, 100 sewer level monitors and 90 pump station alarm/monitors. Data from the monitoring system are stored at the 1-minute time-step. The maps in Figure 1 and Figure 2 show the locations where these HYDRA monitors are installed.

### *CSO Communications & Control System*

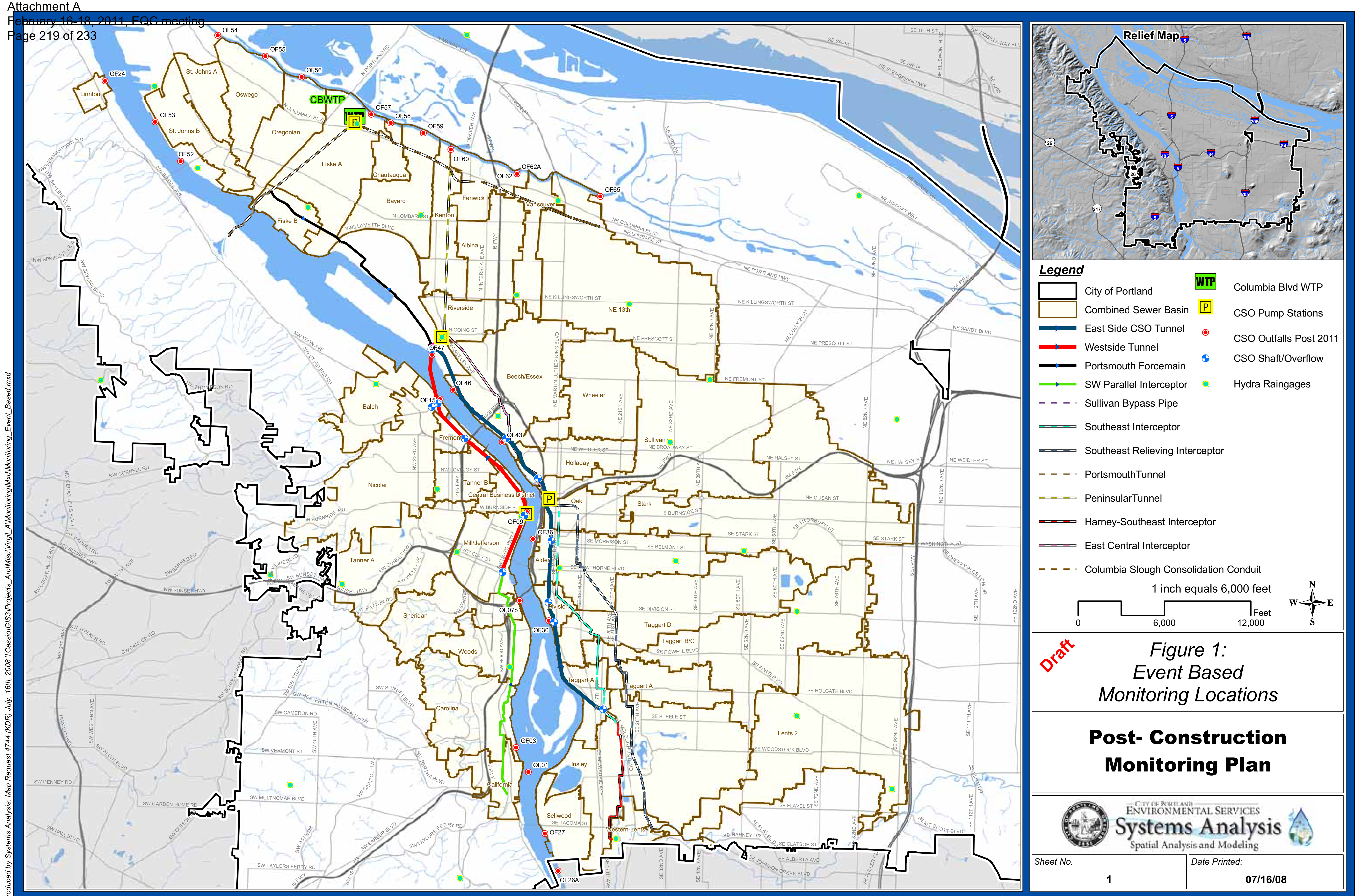
For facilities and locations that are valuable for controlling and operating the CSO collection system, Portland uses the CSO Communications & Control System implemented under the West Side CSO Program. The CBWTP Operators use this communications & control system via the SCADA program called iFIX to receive alarms, view and record performance data, and operate the CSO facilities, collection system and the treatment plant as an integrated system. Data from the monitoring devices are relayed by each facility's PLC to the iFIX servers using a fiber-optic loop that connects the CSO facilities to the CBWTP Operations Center. The iFIX data is stored on servers on the 5-second time-step and is available for historical trend analysis and data extraction. Operators can also access HYDRA data via the iFIX system.

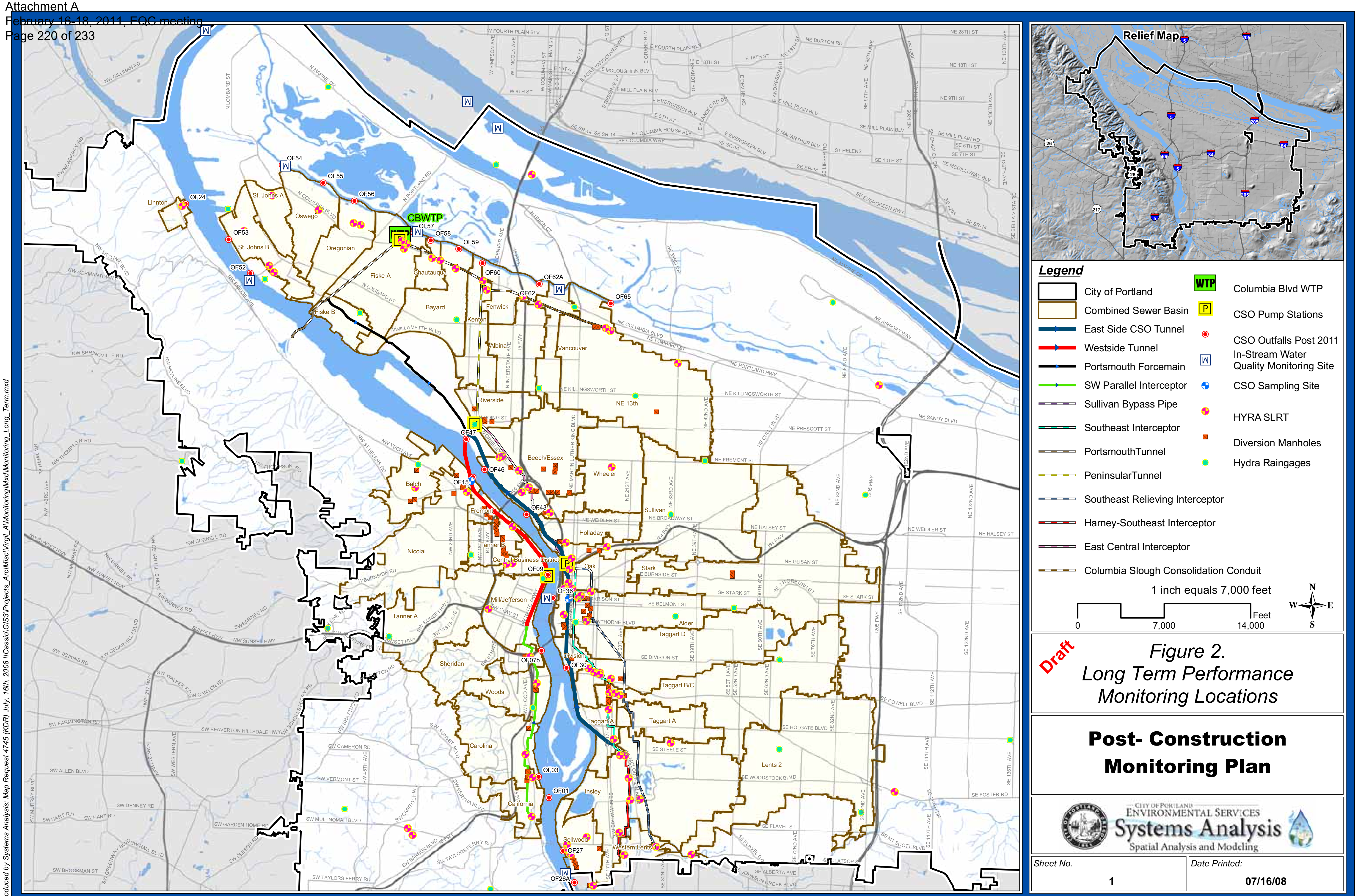
## Rainfall Measurement

The HYDRA system includes approximately 40 tipping-bucket raingages that are active and located throughout the City to provide area-specific measurements of rainfall. These raingages record a time-stamp of every time the tipping bucket fills with 0.01-inch of rainfall. The time-stamp data is stored on the server and converted to 1-minute or longer rainfall durations for use in spreadsheets and graphing tools.

For the purpose of evaluating CSO system performance, the rainfall data is analyzed using the processes described in the City's report to ODEQ titled "Method for Demonstrating Compliance for the Willamette CSO System" (December 1, 2007). This report, similar to the 2001 report for the Columbia Slough system, documents the procedures for:

- Calculating areal rainfall patterns using the point-measurements at the nearby raingages
- Calculating the areal-weighted average storm statistics in the form of a rainfall depth-duration-frequency curve.
- Comparing a specific storm against the ASFO Design Storms using the depth-duration-frequency curves (DDF).


Relief Map
Legend
City of Portland
Combined Sewer Basin
East Side CSO Tunnel
Westside Tunnel
Portsmouth Forcemain
SW Parallel Interceptor
Sullivan Bypass Pipe
Southeast Interceptor
Southeast Relieving Interceptor
PortsmouthTunnel
PeninsularTunnel
Harney-Southeast Interceptor
East Central Interceptor
Columbia Slough Consolidation Conduit
Columbia Blvd WTP
CSO Pump Stations
CSO Outfalls Post 2011
CSO Shaft/Overflow
Hydra Raingages
1 inch equals 6,000 feet
0 6,000 12,000 Feet
Draft
Figure 1:
Event Based
Monitoring Locations
Post- Construction
Monitoring Plan
City of Portland
Environmental Services
Systems Analysis
Spatial Analysis and Modeling
Sheet No.
1
Date Printed:
07/16/08
CBWTP
Produced by Systems Analysis: Map Request 4744 (KDR) July, 16th, 2008 \\Cassio\GIS3\Projects_Arc\Misc\Virgil_A\Monitoring\Mxd\Monitoring_Event_Based.mxd




Produced by Systems Analysis: Map Request 4745 (KDR) July, 16th, 2008 \\Cassio\GIS3\Projects_Arc\Misc\Virgil_A\Monitoring\Mxd\Monitoring_Long_Term.mxd

- If a storm DDF exceeds the applicable ASFO Design Storm DDF, then that storm exceeds the ASFO criteria and overflows resulting from that storm (assuming no operational problems) comply with the CSO performance standards.

## CSO Discharge Measurement

All potential CSO discharge locations are monitored to provide the following event-based information:

- Overflow Imminent Alarm
- Start and Stop Times & Dates (used to calculate duration of overflow)
- Depth of water over dam (used to calculate flowrate and volume of discharge)

Table 1 on the following page lists all 24 of the locations where, by design, CSO could potentially be discharged to either the Willamette River or the Columbia Slough after December 2011. In almost all cases, overflow weirs are used to release excess CSO from the system. Level monitors are installed on the overflow weirs to directly measure the depth of water in the overflow structure – from the base of the weir all the way up to the ceiling of the overflow structure.

When an overflow occurs, the discharge flowrate is calculated from the depth of water over the weir using the weir equation:

$$Q(t) = C\,L\,H(t)^{3/2}$$

where:
- $Q(t)$ = Flow over weir for time (t) in units of cfs
- $C$ = Discharge coefficient for diversion weirs = 2.5
- $L$ = Effective length of weir (feet)
- $H(t)$ = Depth of flow over weir (feet) for time (t)
- $(t)$ = Time increment (5 minutes)

Once the flow rate is determined, the total volume of CSO discharged over the weir is calculated as follows:

$$V = \sum_{t=0}^{T} Q(t) * \Delta t$$

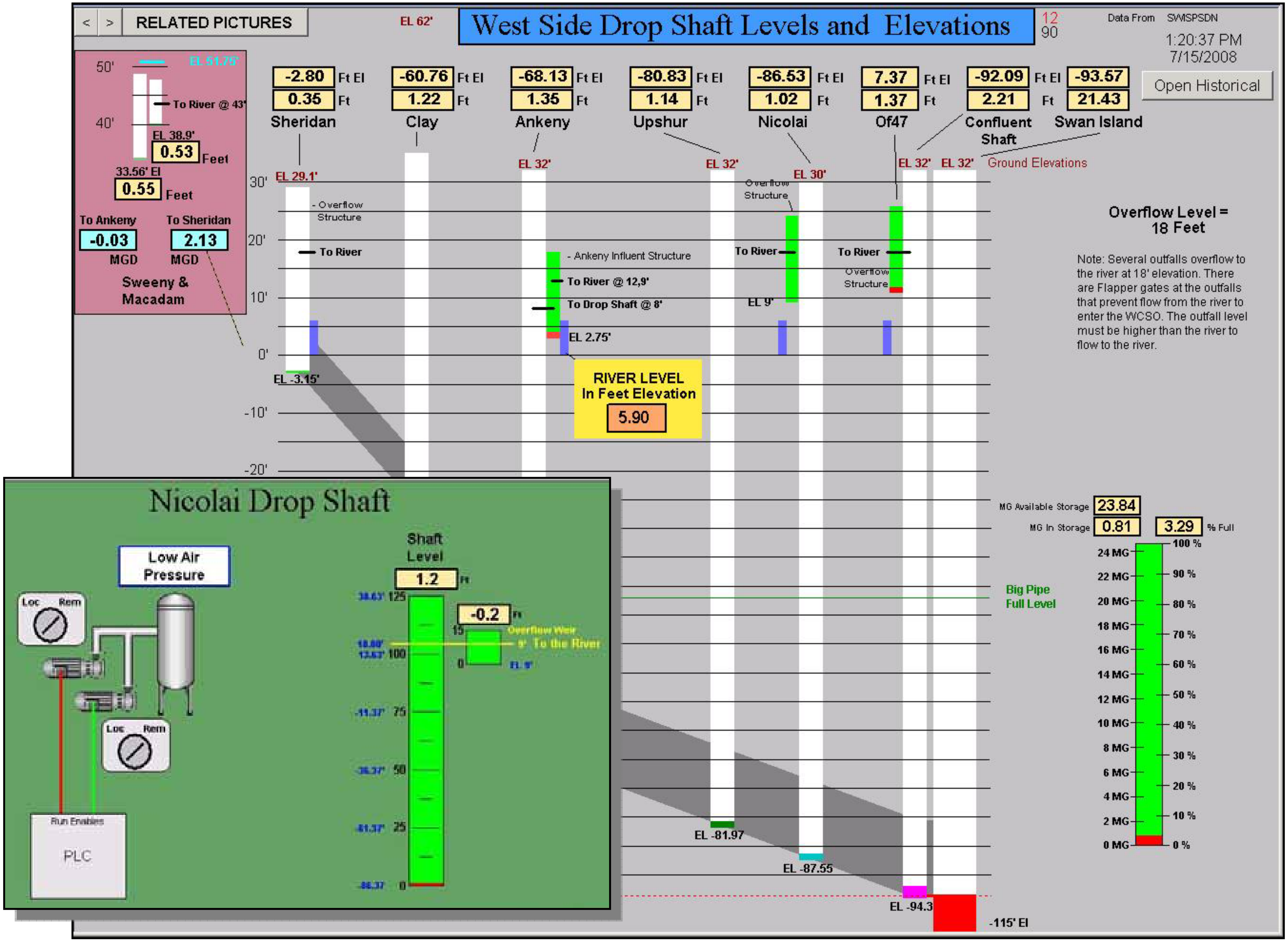
where:
- $V$ = Total volume of flow over weir ($ft^3$)
- $T$ = Total time duration of overflow event
- $\Delta t$ = Time step for calculations (5 minutes)

Overflow structures that are below Elevation 30' also have a tidegate / flap valve to prevent the river from entering the CSO system. When the river level is higher than the overflow weir, the calculations for the discharge rate (Q) must use the difference in head between the CSO depth above the weir (H) minus the river depth above the weir. The river data is available for both the HYDRA and the CSO Communications & Control Systems. The calculations for CSO flowrate are performed by programmable logic controllers (PLCs) in the communications & control system using the above information. Figure 3 shows an iFIX screen of the West Side CSO Tunnel that displays the depth of water in the tunnel, river level, and a detail of the Nicolai overflow structure monitoring for the depth of water in the shaft and at the overflow weir.

# Table 1: CSO Discharge Monitoring at Overflow Locations Active Post-2011

| Basin | CSO Outfall Number | Storm Frequency for CSO Control Performance Standard | Monitoring Devices | Monitoring Data Collected |
|---|---|---|---|---|
| **Outfalls Controlled by CSO Tunnels: Columbia Slough** | | | | |
| Fiske A | 57 | 10-Year Summer | Level monitor in CSCC invert and on Overflow Weir at N. Woosly & Columbia Blvd. | Level in CSCC; Level on weir; Overflow alarms, Overflow rates from weir equation |
| Chautauqua | 58 | 10-Year Summer | Level monitor in CSCC invert and on Overflow Weir at N. Chautauqua & Columbia Blvd. | Level in CSCC; Level on weir; Overflow alarms, Overflow rates from weir equation |
| Bayard | 59 | 10-Year Summer | Level monitor in CSCC invert and on Overflow Weir at N. Bayard & Columbia Blvd. | Level in CSCC; Level on weir; Overflow alarms, Overflow rates from weir equation |
| Kenton | 60 | 10-Year Summer | Level monitor in CSCC invert and on Overflow Weir at Argyle Vent in Columbia Blvd. | Level in CSCC; Level on weir; Overflow alarms, Overflow rates from weir equation |
| Albina | 62 / 62A | 10-Year Summer | Level monitor in CSCC invert and on Overflow Weir at N. Albina & Columbia Blvd. | Level in CSCC; Level on weir; Overflow alarms, Overflow rates from weir equation |
| NE 13th | 65 | 10-Year Summer | Level monitor in CSCC invert and on Overflow Weir at NE 11th & Lombard. | Level in CSCC; Level on weir; Overflow alarms, Overflow rates from weir equation |
| **Outfalls Controlled by Local Diversion Structures: Columbia Slough** | | | | |
| St. Johns A | 54 | 10-Year Summer | Level monitor on dam and inflow channel for diversion NW29 | Level of inflow; Level on dam; Overflow alarms; Flow over dam from weir equation |
| Oswego | 55 | 10-Year Summer | Level monitor on dam and inflow channel for diversion NW20 | Level of inflow; Level on dam; Overflow alarms; Flow over dam from weir equation |
| Oregonian | 56 | 10-Year Summer | Level monitor on dam and inflow channel for diversion NW9 | Level of inflow; Level on dam; Overflow alarms; Flow over dam from weir equation |
| **Outfalls Controlled by CSO Tunnels: Willamette River** | | | | |
| Sheridan | 7 (7B) | 3-Year Summer | Level monitor in SW Parallel Interceptor invert and on Overflow Weir at Sheridan & Moody | Level in SWPI; Level on weir; Overflow alarms; Overflow rates from weir equation |
| CBD / Ankeny | 9 | 3-Year Summer | Level monitors in inverts of SW Interceptor, WS Tunnel and Ankeny Wet Well; Level monitors on dam to WS Tunnel and Overflow Weir to River; Storm Pump cycle monitors. | Levels in SW Interceptor, WS Tunnel, & Ankeny Wet Well; Levels on dam to tunnel and weir to river; Overflow alarms; Overflow rates from weir equation; Storm Pumping To River On/Off cycles, Pumping rates determined from pump cycle time. |
| Nicolai | 15 | 3-Year Summer | Level monitor in West Side Tunnel invert and on Overflow Weir at Nicolai & NW Front | Level in WS Tunnel; Level on weir; Overflow alarms; Overflow rates from weir equation |
| Taggart | 30 | 3-Year Summer | Level monitor in East Side Tunnel invert and on Overflow Weir at SE Taggart & Grand Ave | Level in ES Tunnel; Level on weir; Overflow alarms; Overflow rates from weir equation |
| Alder | 36 | 3-Year Summer | Level monitor in East Side Tunnel invert and on Overflow Weir at SE Alder & 3rd Ave | Level in ES Tunnel; Level on weir; Overflow alarms; Overflow rates from weir equation |
| Wheeler | 43 | 3-Year Summer | Level monitor in East Side Tunnel invert and on Overflow Weir at N. River Street | Level in ES Tunnel; Level on weir; Overflow alarms; Overflow rates from weir equation |
| Beech-Essex | 46 | 3-Year Summer | Level monitor in East Side Tunnel invert and on Overflow Weir near Albina Railyard | Level in ES Tunnel; Level on weir; Overflow alarms; Overflow rates from weir equation |
| Riverside | 47 | 3-Year Summer | Level monitor on Weir in Riverside Overflow Structure | Level on weir; Overflow alarms; Overflow rates from weir equation |
| **Outfalls Controlled by Local Diversion Structures: Willamette River** | | | | |
| California | 1 | 10-Year Summer | Level monitor in California PS wet well | Level in pump station; Level on overflow weir; Overflow alarms; Flow over weir from equation |
| Carolina | 3 | 10-Year Summer | Level monitor on dam for diversion SW48 | Level on dam; Overflow alarms; Flow over dam from weir equation |
| NW 110th | 24 | 3-Year Summer | Level monitor in Flow Control Manhole | Level in Manhole / on Siphon; Overflow alarms; Overflow rates from siphon equation |
| Sellwood | 26A | 10-Year Summer | Level monitor on dam for diversion SE195 | Level on dam; Overflow alarms; Flow over dam from weir equation |
| Sellwood / Lents | 27 | 10-Year Summer | Level monitor in Inline Storage / Flow Control Structure | Level in storage; Level on overflow weir; Overflow alarms; Flow over weir from equation |
| St. Johns B | 52 | 3-Year Summer | Level monitor on dams for diversions SJ22 and SJ17 | Level on dam; Overflow alarms; Flow over dam from weir equation |
| St. Johns B | 53 | 3-Year Summer | Level monitor on dam for diversion SJ9 | Level on dam; Overflow alarms; Flow over dam from weir equation |

**Figure 3: Example Display of CSO Shaft & Overflow Structure Monitoring** *(Note "To River" symbol indicates overflow weir location)*



One item to note is that CSO discharge monitoring at Ankeny Pump Station is a unique because it includes flow over the weir and pumped CSO via two 45-MGD storm pumps. These devices pump CSO to the river when the wet well approaches the flood-warning level. Pumped CSO discharge is determined from the pump cycle monitoring on the two storm pumps.

## CSO Facilities Operations Monitoring

The CBWTP NPDES Permit and EPA's CSO Policy (Nine Minimum Controls) requires that the collection system and CSO facilities be operated in a manner that:

- Minimize CSO discharge volumes
- Maximize the volume of CSO captured in storage facilities
- Maximizes the volume of CSO delivered to the treatment plant for primary (and as possible secondary) treatment

Measuring system performance to ensure that these objectives are achieved is done through CSO Facilities operations monitoring. Major CSO facilities that are controlled by operational decisions are monitored for levels, flows and device (gate, pump) settings. The measured performance data can then be compared against the original design parameters or the tactical settings established by the System Operating Plan (update in October 2008).

Operations monitoring is performed for each of the major CSO facility type:

- CSO Storage Tunnels
- CSO Pump Stations
- CSO Flow Control Structures
- CSO Treatment Facilities

The Operations monitoring is provided by the CSO Communications & Control System that connects all of the major CSO facility types to the CBWTP Operations Center via the fiber optic loop. The relevant CSO performance data collected for each structure is described below.

### *CSO Tunnels*

Portland's CSO tunnels are designed to be dewatered by a CSO pump station, and fill up when CSO inflows exceed the available pumping capacity. The tunnel storage volume is fully utilized before water levels rise high enough to overtop the weirs in the overflow structures.

For the Columbia Slough Consolidation Conduit (CSCC), the level of water in storage (measured from the invert) and level at the overflow weir are measured at the shafts/overflow structures:

- Fiske OF57
- Chautauqua OF58
- Bayard OF59
- Kenton OF60
- Albina OF62/62A

- NE 13$^{th}$ OF 65

The Willamette West Side & East Side Tunnels share a common water level or hydraulic grade due to their connection at the Confluent Structure and the Swan Island Pump Station. The levels in the tunnels and at the overflow weirs are measured in the following shafts/overflow structures:

- Sheridan OF07
- Clay Street Shaft (no overflow)
- Ankeny OF09
- Upshur Shaft (no overflow)
- Nicolai OF15
- Insley/McLoughlin Shaft (no overflow)
- Taggart OF30
- Alder OF36
- Steele Bridge Shaft / Sullivan (no overflow)
- River Street (Wheeler) OF43
- Port Center Shaft / Beech-Essex OF46
- Confluent Structure / Riverside OF47

***CSO Pump Stations***

The CSO pump stations are the primary facilities that control the levels and flows across the CSO system. Due to the complexity of each station, there is a significant amount of monitoring data collected continuously at these stations. The data that is most relevant for CSO System operations is described below for each pump station:

- Swan Island Pump Station:
  - Wet Well Level
  - Cycle times for all pumps
  - Pumping Rate to Peninsular Tunnel Interceptor (total peak design of 100 MGD)
    - Flow rate through Dry Weather Forcemain
    - Flow rate through Wet Weather Forcemain
  - Pumping Rate to Portsmouth Tunnel Interceptor (design peak of 120 MGD)
    - Flow rate through Portsmouth Forcemain
- Sellwood/Lents Pump Station
  - Wet Well Level

  - Cycle times for all pumps
  - Pumping rate to Harney-Insley Interceptor (system in design)
- Ankeny Pump Station
  - Wet Well Level
  - Cycle times for all Sanitary Pumps
  - Pumping Rate to East-Central Interceptor (total peak design of 54 MGD)
    - Flow rate through 30-inch forcemain
    - Flow rate through 42-inch forcemain
  - Pumping Rate to Willamette River via Storm Pumps
    - Cycle time of each 45-MGD Storm Pumps (total peak of 90 MGD)
- Sullivan Pump Station
  - Wet Well Level
  - Cycle times for all pumps
  - Pumping Rate to East-Central Interceptor (total peak design of 110 MGD)
    - Flow rate through East Forcemain
    - Flow rate through West Forcemain
- Columbia Boulevard Influent Pump Station (IPS)
  - Wet Well Level
  - Cycle times for all low and high pumps
  - Total flow from pump station (total design peak of 135 MGD)
  - Pumping Rate from Low Pump Set
  - Pumping Rate from High Pump Set
  - Pumping Rate from High-High Pump Set

### *CSO Flow Control (Gate) Structures*

Portland's CSO flow control structures (FCS) are used to split flow between the combined sewer interceptor system and the CSO system. The operational data relevant to CSO system performance consists of gate settings, level in the FCS, and the downstream flow rates. There are four main flow control structures operated as part of the CSO system:

- Argyle Flow Control Structure:
  - Directs flows from Peninsular Tunnel to CSCC
  - Data includes depth of water in structure, gate setting (height open), and flowrate under gate to the CSCC

- NE Lombard & $13^{th}$ :
  - Splits flows between Lombard Interceptor and CSCC
  - Manually set gate, not remotely controlled
  - Data includes flow rate to CSCC
- SW Sweeney & Macadam:
  - Splits flows between SW Interceptor and the SW Parallel Interceptor (and West Side Tunnel)
  - Data includes depth of water in structure, gate setting (height open), and flowrate under gate to the SW Interceptor and to SWPI (West Side Tunnel)
- SE Insley & McLoughlin:
  - Splits flows between SE Interceptor and the East Side Tunnel
  - Data includes depth of water in structure, gate setting (height open), and flowrate under gate to the SE Interceptor and to East Side Tunnel

### *CSO Treatment Facilities*

To demonstrate compliance with the Nine Minimum Controls and the specific CSO requirements incorporated into the NPDES permit, it is necessary to provide operational data regarding the flows delivered to the CBWTP dry weather system and the Columbia Boulevard Wet Weather Treatment Facility (CBWWTF). The relevant operational data includes:

- Pumped flowrates through the CBWTP Headworks
- Measured flowrates to the Wet Weather Headworks
- Measured flowrates to the Dry Weather Primary & Secondary Systems
- Measured flowrates to the Wet Weather Primary Treatment System
- Measured flowrates returned from Wet Weather Primary System to Dry Weather Primary & Secondary System after a storm event

## Water Quality Sampling of CSO Discharges

The analyses performed for CSO Pollutants of Concern (DEQ 1997 and LTI 2003) consistently agree that bacteria (E. coli) and total metals (copper and lead) are the primary concern. As presented earlier, meeting the CSO-based water quality standard for bacteria is accomplished through achieving the required level of CSO frequency control. In contrast, demonstrating that water quality standards for total metals are met can be done by performing representative grab samples of CSO discharges and analyzing them for total copper and lead. The concentration of total copper and total lead in CSO discharges must be below the acute criteria outside the 10:1 dilution mixing zones defined in the NPDES permit.

Due to the infrequent CSO discharges, the intermittent duration of discharges, and the likely complete mixing conditions in the CSO tunnels, effluent water quality sampling will consist of:

- Grab samples taken from one CSO discharge event per year (if there is a CSO event lasting more than 4 hours)
- Average of one sample per year (5 within 5-year permit cycle) from West Side CSO effluent (Nicolai Overflow Structure)
- Average of one sample per year (5 within 5-year permit cycle) from East Side CSO effluent (Alder Overflow Structure)
- Samples will be analyzed for:
    - Total Copper
    - Total Lead
    - E. coli bacteria
    - TSS (for modeling loads to CBWTP)
    - BOD (for modeling loads to CBWTP)

To provide further information regarding the CSO discharges meeting bacteria water quality standards, the protocol for CSO effluent sampling for bacteria will be similar to the protocol required for CBWTP effluent:

- Samples are analyzed for E. coli bacteria
- If a single bacteria sample exceeds 406 organisms per 100 ml given a 10:1 dilution mixing zone, then five consecutive re-samples shall be taken at four hour intervals beginning as soon as practicable (preferably within 28 hours) after the original sample was taken. If the log mean (geometric average) of the five re-samples is less than or equal to 126 organisms per 100 ml given the 10:1 dilution mixing zone, then the CSO discharge is within standard.

## *Long-term Performance Monitoring*

The CBWTP NPDES Permit requires the City to conduct two categories of long-term performance monitoring:

- Collection System Monitoring for Modeling & Analysis
- In-stream Water Quality Monitoring for Water Quality Improvements from CSO Control

Portland's approach for performing long-term monitoring and meeting these requirements for both the collection system and in-stream monitoring is described below.

## Collection System Monitoring for Modeling & Analysis

The NPDES specifically requires the City to monitor the levels and flows in the collection system to support modeling and analysis for:

- Design of future control facilities
- Determinations on optimum operations of the sewer system
- Estimating system discharge reductions as a result of the provision of inflow control measures and structural changes implemented for CSO control

Much of the necessary data is provided through the event-based monitoring described in the first section of this document. The monitoring and data collection for rainfall, CSO discharges, and CSO facility operations and performance is carried out as an on-going, continuous process.

In addition to rainfall, CSO discharges, and CSO facilities monitoring, the collection system monitoring also includes important sewer level monitoring at HYDRA sites:

- Diversion Structures with previous CSO level monitors act as flow measurement devices
- Permanent sewer level remote telemetry system monitors (SLRTS) in the interceptors and major trunklines

**Overflow Monitors on Diversion Structures**

In the earlier phase of the CSO program, the City installed HYDRA sewer level monitors on more than 30 diversion structures to broadcast an alarm signaling an imminent dry weather overflow (DWO) and to measure the amount of CSO or DWO discharged from the structure. These diversion structures represented those locations that generated the largest amount of overflow or the most frequent overflow. The map in Figure 2 displays the location of these diversion structures with HYDRA level monitors.

When the overflow from the diversion structures was permanently directed to a CSO facility, the alarm function for the monitor was cancelled. However, the flow measurement function is still very valuable. When equipped with a sewer level monitor, a diversion structure is an excellent flow measurement device and provides good information on the amount of flow sent to the CSO tunnels from the various locations. Therefore, these previous DWO alarm monitors are now excellent upstream combined sewage monitors that can be used to calibrate the collection system models and confirm the sources of CSO to the tunnel systems.

**Permanent SLRTS in Interceptors and Trunklines**

One of the major components of the original HYDRA system installed back in 1976 was the sewer levels monitors placed in the interceptors and large trunklines in the combined sewer system. The location of these SLRTS are shown in Figure 2. The SLRTS directly measure depth (including surcharge level). Where appropriate, the HYDRA system calculates an estimated flow rate based on depth-adjusted Manning's "n" values that have shown to be sufficiently accurate. The depth and (where applicable) flow rate data are stored on the HYDRA system in 1-minute increments.

All of the monitoring data presented in this report – rainfall, overflow measurements, CSO facilities operations data, SLRT data from diversion structures and interceptors and trunklines – all are frequently used by the City for:

- Hydrologic and Hydraulic Model calibration for small areas, large basins, major interceptor systems, and the total flow delivered to the CSO faculties, the treatment plant site, and the receiving streams.
- Long-term trend analysis of flows to the collection system to confirm the amount of flow delivered to the CSO control system. This long-term trend analysis will eventually display the amount of contingency or safety factor provided in the CSO system for additional development or significant climate change impacts.
- Trend analysis of flows and loads to CBWTP (coupled with state-required Daily Monitoring Reports) to ensure treatment capacity for wet weather flows (both liquid and solids handling systems) have adequate capacity to meet demand.

## In-stream Water Quality Monitoring for Water Quality Improvements

In continuation of the original water quality monitoring program for the Willamette River, the City will continue to perform fixed-day monthly sampling program to track impacts of CSO and improvements to the water quality after the CSO facility implementation is completed in December 2011. The City will also continue to perform fixed-day monthly sampling of the Columbia River upstream and downstream of the two outfalls (OF 001 and OF003). A brief summary of both instream monitoring programs is provided below. As identified in the NPDES permit, these two programs will no longer be required after a 5-year compliance period has been completed with no CSO-related water quality violations.

### *Willamette River Monitoring Program*

On the Willamette River, Portland currently collects instream water quality samples in the Willamette River on a monthly basis. Samples are collected at the west and east banks as well as the middle of the river at four main sampling locations:

1. River Mile 17.9: Near Waverley Country Club

2. River Mile 12.7: Morrison Bridge
3. River Mile 6.8: St. Johns Railroad Bridge
4. River Mile 1.1: Kelley Point

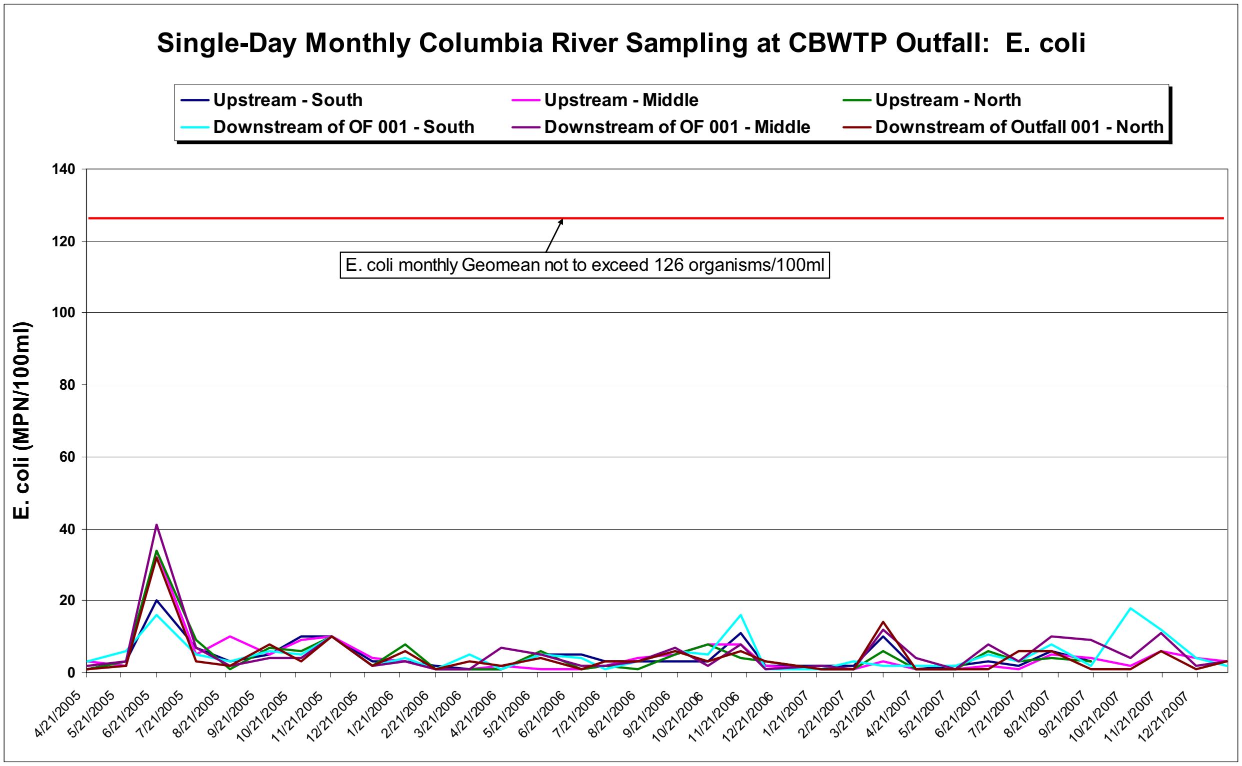
Portland collects grab and composite samples at these locations and analyzes them for multiple constituents including:

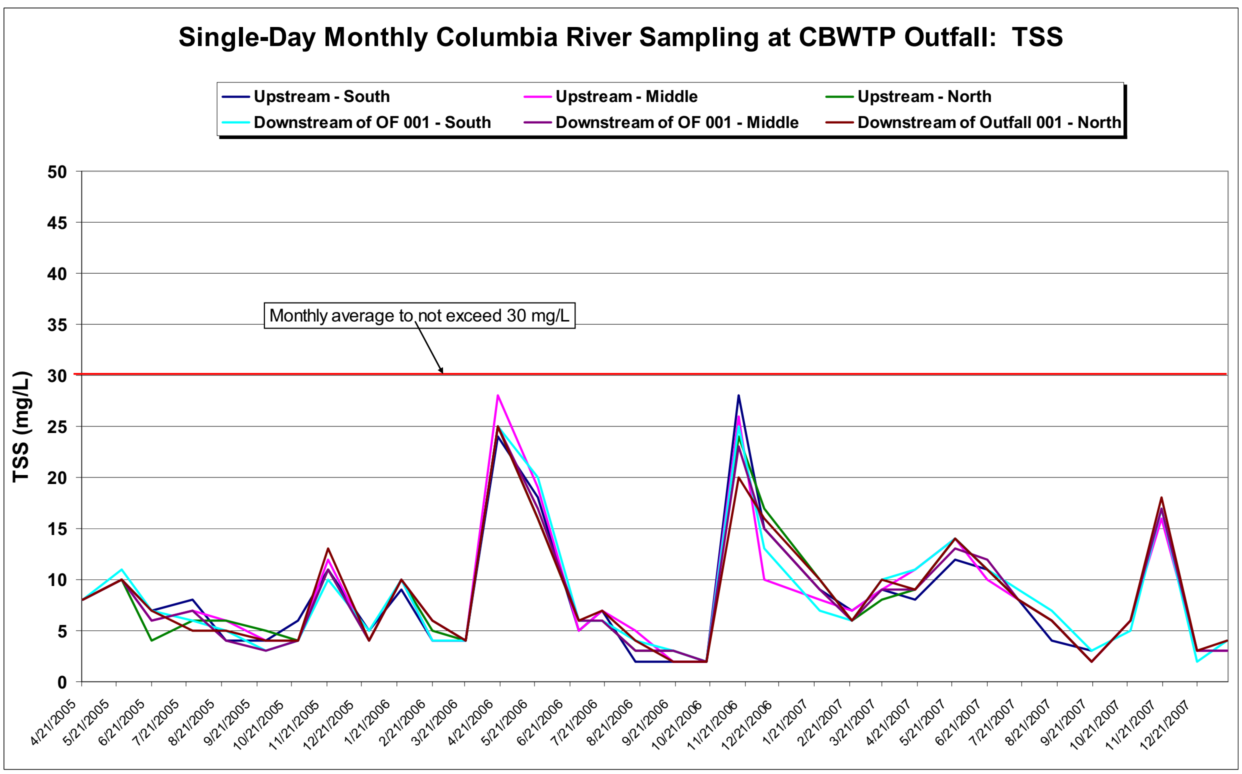
- Dissolved oxygen
- Escherichia coli (E. coli) and fecal coliform bacteria
- Copper (total and dissolved)
- Lead (total and dissolved)
- Zinc (total and dissolved)
- Hardness
- pH
- Temperature
- Total dissolved solids (TDS)
- Total solids (TS)
- Total suspended solids (TSS)

### *Columbia River Outfall Monitoring Program*

In 2005, the City began a similar fixed-day monitoring program on the Columbia River to identify any significant impacts of discharges from the CBWTP and the CBWWTF during wet weather conditions. The same parameters identified for the Willamette River system are also collected on the Columbia River. Two transects are used – one upstream of Outfalls 001 and 003 and one downstream of the outfalls. Figure 4 on the attached page displays some of the results for the 2005-2007 period for a few different parameters.

**Figure 4: Example Results from Columbia River Outfall Fixed-Day Sampling Program**



## *Conclusions*

The Post-Construction Monitoring Plan for the CSO Program is a reasonable extension of the comprehensive monitoring program that the City of Portland has been implementing in various forms since the beginning of the CSO Program. The PCMP clearly:

- Meets objectives of EPA's Guidance for Monitoring Program
- Meets requirements to show compliance with the Clean Water Act as specified in the CBWTP NPDES Permit and the Oregon Water Quality Standards
- Provides comprehensive information for demonstrating compliance with the CSO Control Standards identified by the ASFO, NPDES Permit, and the Willamette River Bacteria TMDL.
- Provides a full spectrum of rainfall, overflow discharge, and collection system / CSO system performance monitoring for CSO-event and long-term performance reviews.

Attachment B
D
P

# Fact Sheet

# Portland Combined Sewer Overflow (CSO) Management

### Background

For many years, a large part of the City of Portland, about 30,000 acres, has been served by a combined sewer system in which sanitary sewage from homes and businesses, and stormwater from streets, roofs and driveways flow into a single set of sewer pipes. During periods of dry weather, all of the sanitary sewage is delivered by the sewer system to the Columbia Boulevard Wastewater Treatment Plant (CBWTP) for proper treatment and discharge to the Columbia River.

However, almost any time it rains, the inflow of stormwater into the combined sewers causes the capacity of the large interceptor sewers that run along the Willamette River to be exceeded, and a combination of stormwater and untreated sanitary sewage is discharged to the river. (In the past, there were similar frequent CSO discharges to Columbia Slough but these have been virtually eliminated as of December 2000.)

While CSO discharges raise several environmental concerns, the most important is the risk of contracting disease from pathogenic organisms that may be found in raw sanitary sewage. Such risk impairs the beneficial use of waters subject to CSOs for safe contact recreation.

In regulatory terms, the CSO discharges result in violation of the Water Quality Standards established by the Environmental Quality Commission (EQC) for bacteria, floatables and solids, and other pollutants. The Wastewater Discharge Permit issued to Portland by DEQ for the CBWTP expressly prohibits violation of Water Quality Standards by the CSO discharges.

To address these violations, the EQC and Portland entered into a mutually agreed upon enforcement order called a Stipulation and Final Order (SFO) in August of 1991. The SFO was amended in August 1994.

The Amended Stipulation and Final Order (ASFO) requires that the frequency of CSOs to the Willamette River be drastically reduced by the year 2011. A detailed compliance schedule of implementation milestones is set forth, with stipulated penalties identified for failure to meet the schedule or to attain the level of CSO control required.

### Portland complies with CSO Order

The City of Portland has thus far met all CSO compliance schedule milestones set forth in the original and amended versions of the Order.

The City has made substantial progress constructing the stormwater inflow reduction facilities that are intended to reduce combined sewage volume. These "Cornerstone Projects" include stormwater infiltration sumps, down spout disconnections, sewer separations and stream diversions.

Construction of the major CSO control facilities for the Columbia Slough sewer basins--the "Columbia Slough Big Pipe" and appurtenances-- was completed at the end of 2000. Overflows to the Slough will now occur only with the largest storms, averaging about three overflow events per decade.

Construction of the massive CSO control facilities for the west side Willamette River sewer basins--the "West Side Big Pipe"-- was completed in December 2006. Swan Island Pump Station, Phase 1, necessary to convey the west side combined flows, is completed in 2006.

Construction of the even larger CSO control facilities for the east side Willamette River sewer basins began in May 2006. Swan Island Pump Station Phase 2, which will convey the combined flows of the east and west side "Big Pipes" is currently under

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Department of Environmental Quality

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Michael Pinney
(503) 229-55310
pinney.mike@deq.state.or.us

See also City's Bureau of Environmental Services CSO Website at: www.cleanriverworks.com

Last Updated 09-05-10
By: Michael Pinney
NWR-025

construction and on track for completion in 2011.

### EQC--Portland CSO chronology

August 1991
The EQC and the City execute original SFO to address permit violations caused by CSOs. SFO requires that CSO discharges to Columbia Slough and Willamette River be controlled except when 10 year return summer storm/5 year return winter storm or larger occur. Development of CSO Management Plan is required.

June 1993
Draft Management Plan is completed. It analyzes facilities and costs needed to meet level of CSO control specified in SFO, and other more and less stringent levels of control for the Willamette River discharges.

November 1993-March 1994
The non-decision making "Collaborative Process" Committee ( 2 EQC members, 2 City Council members, DEQ Director, a Portland Bureau of Environmental Services senior manager) hold a series of well-attended public meetings to evaluate options identified in the Draft Management Plan. Committee recommends to EQC and City Council that a less stringent level of CSO control than specified in the SFO be adopted for Willamette discharges, but that Columbia Slough control requirement remain as in SFO.

June-August 1994
EQC and Council concur in Collaborative Process Committee recommendation and execute ASFO. CSO control requirement for Willamette is set at 3 year return summer storm and 4-in-year winter storm because it is the most "cost effective" level of control. This reduces estimated overall CSO control program cost from about $1billion to about $700million (in 1993 dollars).

December 1994
City completes Final CSO Management Plan, which elaborates on facilities needed to meet ASFO. EQC approves "Schedule and Control Strategy" set forth in Final Plan in April 1995.

January 1996
EQC adopts new "Bacteria Rule" Water Quality Standard which establishes 10 year summer/5 year winter storm prohibition of raw sewage discharges as regulatory standard, but allows EQC to approve less stringent standard for individual CSO systems. DEQ considers prior EQC concurrence in ASFO and Final Management Plan to constitute such approval for Portland's CSOs to Willamette.

1995-2007
Ongoing "Cornerstone Projects" (sewer separations, storm water sumps, down spout disconnections, stream diversions, sewer system inline storage optimization) make significant progress to remove storm water from combined sewer system and reduce volume of CSO discharges.

March 1998
NWEA and City settle 1991 citizen lawsuit on CSOs. Terms of settlement include commitment by City to implement ASFO and plaintiffs standing to seek relief from court for City's failure to comply with ASFO schedule.

2000-2001
Columbia Slough CSO control facilities completed December 2000. Seven CSO discharge points on the Willamette eliminated by December 2001

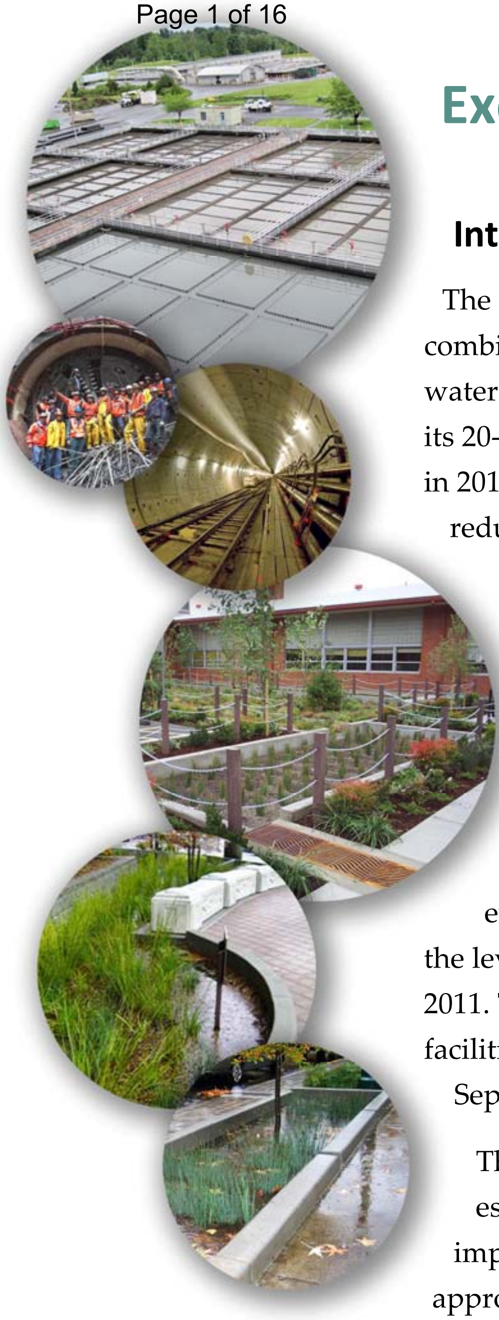
December 2001
City prepares CSO Management Plan Update pertaining to configuration of Willamette sewer basins control facilities.

2001-2010
Construction of major west side Willamette control facilities begun in 2001 with completion in 2006. Construction of major east side control facilities begun with completion by 2011.

### Alternative Formats

*Alternative formats of this document can be made available. Contact DEQ Public Affairs for more information (503) 229-5696.*

DEQ-DC1



# Executive Summary

## Introduction

The City of Portland is committed to cost-effectively controlling combined sewer overflows (CSOs) to protect the water quality in its watersheds. This commitment is demonstrated by the implementation of its 20-year long-term control plan (LTCP), which is due to be completed in 2011. At that time, CSO annual discharge volume will have been reduced by 96% and the number of events reduced from 50 per year to less than 4.

As agreed in the Amended Stipulation and Final Order (ASFO) between the Oregon Environmental Quality Commission (EQC) and the City of Portland, the Bureau of Environmental Services (BES) has prepared this facilities plan report to outline "methods for achieving further reductions in the frequency and volumes of CSOs after the term of the amended order." The plan evaluates cost-effective approaches to further reduce CSO beyond the level of control specified in the ASFO that Portland will achieve in 2011. The City is required by the ASFO to submit this post-2011 CSO facilities plan to the Department of Environmental Quality (DEQ) by September 1, 2010. The plan is subject to approval by the EQC.

This facilities plan expands on the ASFO requirements by establishing a framework for future system refinements, improvements, and enhancements. A risk-based asset management approach is applied to focus available resources on high-priority, cost-beneficial projects that rely on green infrastructure to provide CSO reduction, watershed benefits, and relieve capacity problems in the combined sewer system.

City of Portland Post-2011 CSO Facilities Plan

## Further CSO Reductions—Statement of Understanding

The following questions and answers explain how the concept of "further CSO reductions" is interpreted in the development of this facilities plan.

### How does the ASFO characterize further reductions?

As further reductions of *frequency* and *volume* of CSOs.

### What is the starting point for *further*? Further than *what?*

The starting point for measuring further reductions is the level of CSO reduction required by the ASFO for the Willamette River, which is to be fully achieved by December 2011. The ASFO requires all 42 CSO outfalls on the Willamette River to be controlled to eliminate all CSO events for storms up to a 4-per-winter return frequency and a 3-year summer return frequency.

In contrast, the Columbia Slough system was controlled to the original Stipulation and Final Order (SFO) criteria consisting of 5-year winter and 10-year summer storm frequency. The SFO was amended in 1994 to recognize that the Willamette CSO should be controlled to a lower, more cost-effective level that was equally protective of the Willamette water quality. Because the difference between the two levels was driven by cost-effective CSO control benefits, the ASFO added a requirement that the City outline methods by which further reduction of Willamette CSO discharges beyond the 4-per-winter and 3-year summer frequencies could be cost-effectively achieved.

### To what extent will further reductions be achieved in December 2011 when the East Side CSO Controls become operational, thus completing implementation of the LTCP?

System modeling indicates that the winter overflows may be reduced to as few as two per winter on average compared to the ASFO requirement of four per winter once these facilities are on-line.

### When must the further reductions be achieved?

There is no ASFO requirement for timing of the further reductions. It is expected that further reductions of CSO discharges will be achieved at varying levels throughout the 2011–2050 planning period subject to timing and patterns of infill development and recommended plan implementation rates.

## Are further reductions required by regulations or permits?

No. The ASFO-specified reductions for CSOs meet regulatory requirements, including the draft National Pollutant Discharge Elimination System (NPDES) permit and the Willamette River Bacteria Total Maximum Daily Load (TMDL). The TMDL allocation specifically matches the ASFO level of control. The further reductions being considered by this facilities plan are not required by the EPA CSO Policy, the City's NPDES permit, or the Clean Water Act.

## If further reductions are not required, why are they being evaluated?

Section 23d of the ASFO, adopted in 1994, requires that the City "submit to DEQ no later than September 1, 2010, an approvable facilities plan report outlining the methods for achieving further reductions in the frequency and volumes of CSOs after the term of this Amended Order." Developing the plan and evaluating the methods is required by the ASFO, which was adopted in 1994. At that time, the process of identifying new cost-effective opportunities to reduce CSOs was incorporated into the ASFO because, as stated in Section 9d, "New technology may emerge that will provide more cost effective methods of reducing CSOs than are available today." Moreover, as also stated in the ASFO, "The people of the Portland Region place a high value on the Willamette River and good water quality. The River's importance to the people of Portland and the value of water quality both continue to increase over time." It is in the City's interest to pursue cost-effective further reductions over time.

## Ultimately, how will further reductions be measured?

Further reductions will be most easily measured by the reduced number of overflows per winter into the Willamette River. The number of overflows is a more reliable metric than volume because the volume of each overflow will vary according to the severity of the storm. In addition, winter overflows are expected to occur more frequently than summer overflows. Reduction of CSO in terms of winter overflow events provides a metric that can be evaluated more frequently than allowed by the infrequent summer overflow events.

## Do further reductions need to be cost effective?

Yes. Section 23 of the ASFO states that the City, "the commission, and the Department agree that further reductions in untreated discharges beyond the level to be achieved through the Enhanced Draft Federal Level [four per winter, three-year summer storms]…are desirable **if the reductions can be done in a cost effective manner**." [Emphasis added.] Thus, if CSO reduction measures are not cost effective they are not desirable. Moreover, the City's approximately $1.4 billion investment in CSO controls to address the requirements of the ASFO has significantly affected Portland's monthly sewer rates, which have increased

City of Portland Post-2011 CSO Facilities Plan

nearly 400% since 1990. It is not tenable to implement reduction measures that are not cost effective and have a program that Portlanders can afford.

### Can further CSO reductions be achieved via green infrastructure?

Yes. Green infrastructure could be developed with sufficient capacity to meet future stormwater removal demand and sustain reduction of winter CSO events achieved in 2011. Preliminary hydrologic and hydraulic modeling of the combined sewer system was performed to confirm this for future (2050) conditions and recommended projects contained in the Combined Sewer System Plan (BES, forthcoming 2010). These projects rely on green infrastructure (also called sustainable stormwater) projects and pipe improvements that address local street flooding and basement sewer backup risk, while also helping to reduce inflow to the CSO tunnel system.

## Implementation of CSO Long-Term Control Plan

### LTCP Implementation History

The City has planned, designed, and implemented a successful 20-year CSO control program. With the adoption of the SFO in 1991, the CSO program officially began. The Cornerstone Projects, designed to divert stormwater runoff away from the combined sewer system through efforts such as the Downspout Disconnection Program, were initiated in 1993. In 1994 the City entered into an Amended SFO (ASFO) which incorporated the LTCP and facilities planning information developed between 1990 and 1993. Portland completed the Columbia Slough CSO projects in 2000 and the West Side Willamette CSO projects in 2006. The East Side CSO projects are on schedule to be completed in 2011.

When the CSO LTCP process began in 1990, the annual CSO volume discharged to the Willamette River and the Columbia Slough was estimated to be approximately 6 billion gallons per year total. With the implementation of LTCP projects, the annual CSO volume has been reduced to approximately 2.1 billion gallons as of 2006. With completion of the East Side CSO projects in 2011, the volume is projected to be reduced to approximately 200 to 300 million gallons per year, which represents a 96% reduction from the 1990 total. The timing of CSO reductions achieved now and in 2011 by Portland's LTCP is shown graphically in Figure ES-1. The dramatic decline illustrates Portland's commitment to CSO reduction. As required by the CSO Policy, the completed LTCP program complies with the water quality standards established by the State of Oregon and the City's NPDES permit requirements.

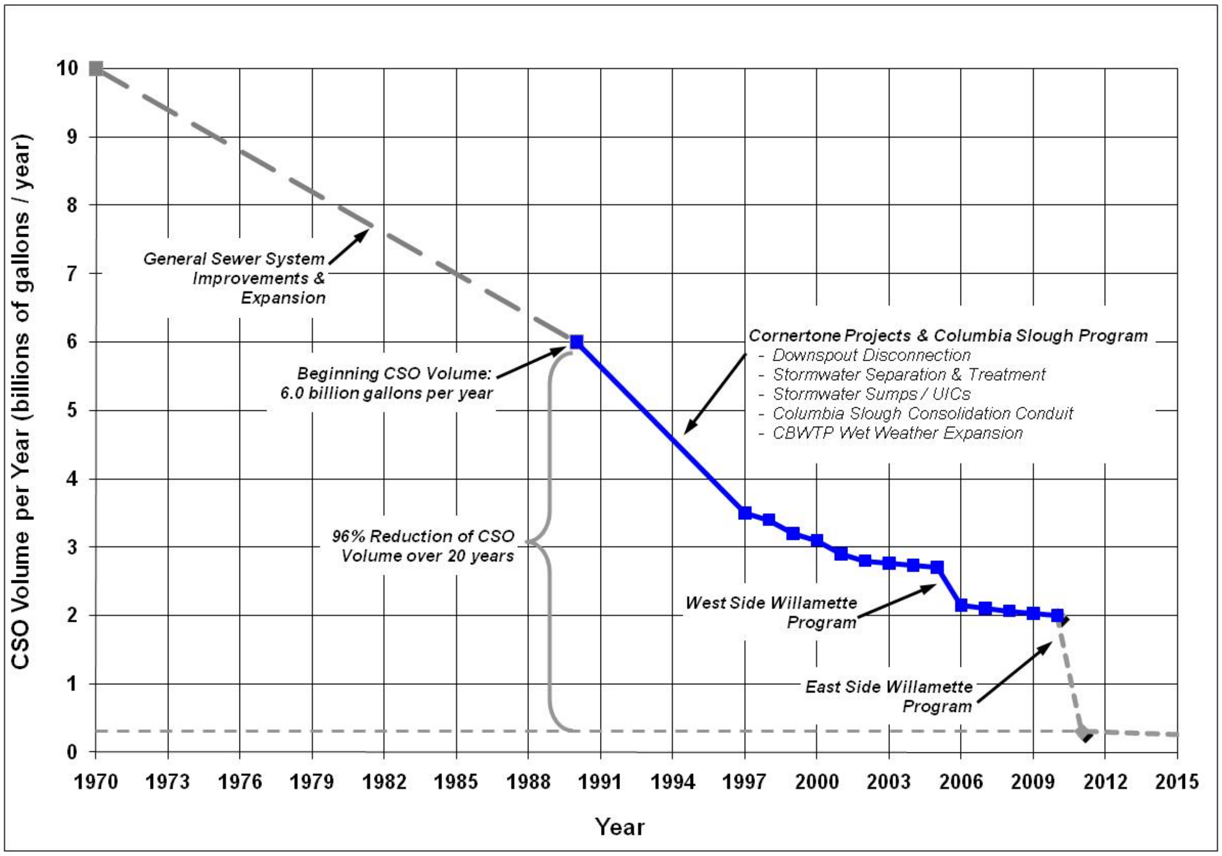



**Figure ES-1**. Overview of Portland's CSO Reductions Since 1970
*CSO LTCP begins in 1991 and concludes in 2011*

## Successful Completion of ASFO Requirements

Throughout the 20-year CSO program, the City has met the SFO and ASFO milestones and CSO control requirements. The final ASFO projects are on schedule to be completed in 2011. As described in the ASFO, annual CSO discharge volumes to the Columbia Slough are reduced 99.5%, and CSO volumes to the Willamette River will be reduced 94%, providing an average system-wide annual reduction of 96%.

The completed Columbia Slough CSO control system is shown in Figure ES-2. This figure also provides a comprehensive view of the implemented Cornerstone Projects. The completed Willamette CSO control facilities and those scheduled for completion in 2011 are shown in Figure ES-3. The CSO outfalls shown in these figures are color coded to indicate their control status.

Monitoring data for the completed CSO control system confirm that the ASFO-required CSO control performance standards are being achieved for the Columbia Slough and the Willamette River outfalls. Modeling projections indicate that with implementation of the final phase of the LTCP the ASFO CSO control requirements will be met at the remaining CSO outfalls. In summary:

- At all 13 Columbia Slough outfalls, the CSOs are eliminated for storms smaller than 5-year winter and 10-year summer design storms.
- At 23 Willamette River outfalls, the CSOs are eliminated for storms smaller than the 4-per-winter and 3-year summer design storms.
- At the remaining 19 Willamette River outfalls, the CSOs will be eliminated as of December 2011 for storms smaller than the 4-per-winter and 3-year summer design storms.

## CSO Volumes, Events, and Service Area Characteristics

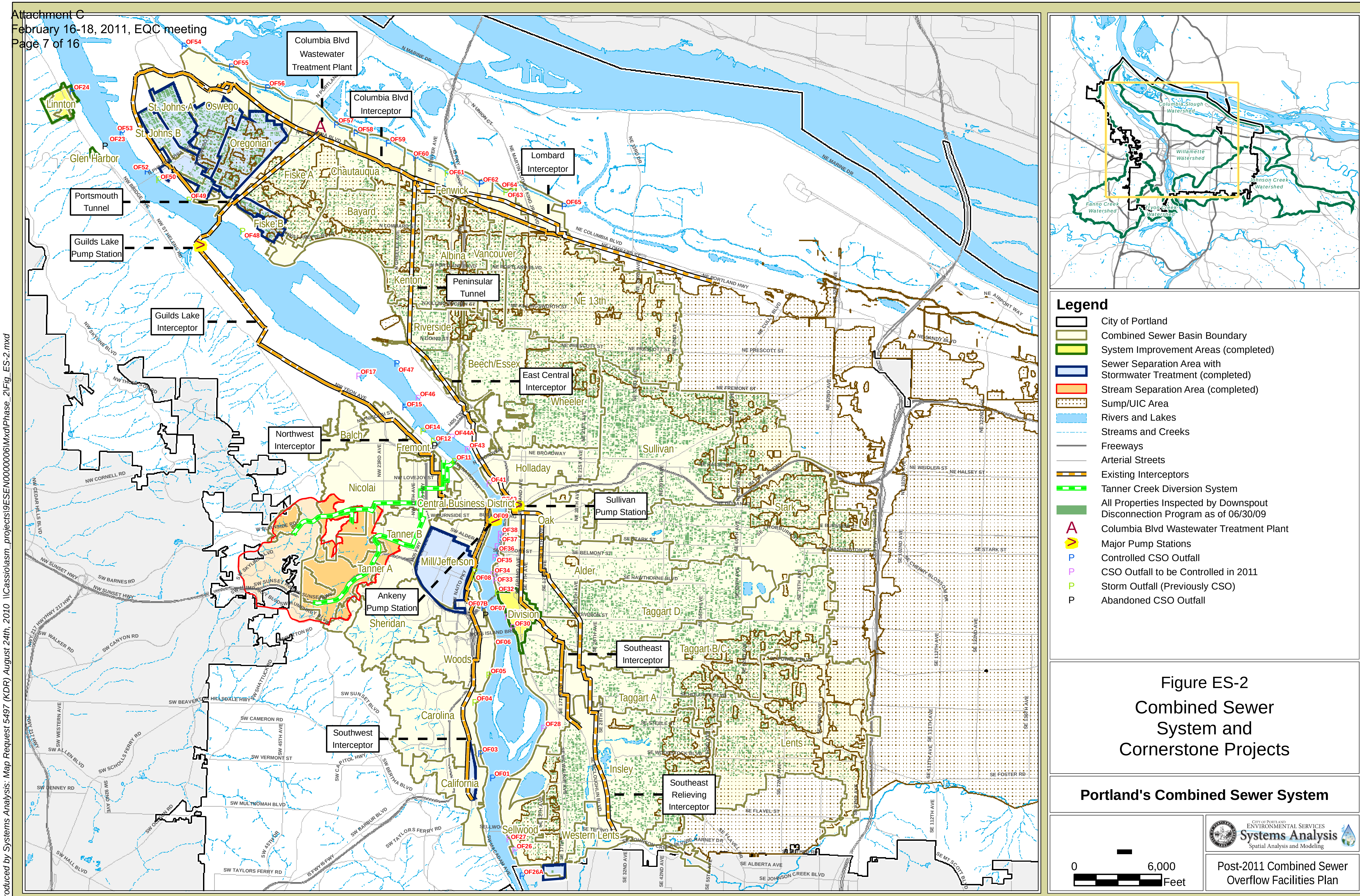
For long-term planning, BES estimated future condition characteristics based on the City's comprehensive planning data. The combined sewer system explicit model was used to simulate how the system will handle future flows under design storm conditions in accordance with the CSO control compliance methodologies approved by DEQ.

### Development of Future Condition Characteristics

To control CSOs, the City must also control the amount of stormwater entering the combined system. To characterize future (2050) conditions, BES simulated new effective impervious areas that could increase the stormwater volume entering the combined system. BES determined via system-wide hydrologic and hydraulic modeling that under 2050 conditions, new efforts will be needed to control an additional 22.4 million gallons (MG) of stormwater during the 3-year summer storm to sustain the further reductions of CSO achieved in 2011.

### Performance Projections for Future Service Improvements

The 2010 Combined Sewer System Plan, which was developed to address localized street flooding and basement sewer backup risk, integrates green infrastructure stormwater controls to reduce flows into the combined system and consequently help to reduce CSOs. Implementation of these integrated improvements was modeled to demonstrate that the stormwater controls embedded in the proposed projects to relieve local pipe capacity problems can also be effective in reducing CSOs in the long-term. The results showed that the steady implementation of green infrastructure stormwater controls can effectively keep pace with community growth and sustain further CSO reductions. However, not all of the recommended Combined Sewer System Plan projects are cost-beneficial and therefore not all of the embedded stormwater controls will be implemented.


Columbia Blvd Wastewater Treatment Plant
Columbia Blvd Interceptor
Lombard Interceptor
Portsmouth Tunnel
Guilds Lake Pump Station
Guilds Lake Interceptor
Peninsular Tunnel
East Central Interceptor
Northwest Interceptor
Sullivan Pump Station
Ankeny Pump Station
Southeast Interceptor
Southwest Interceptor
Southeast Relieving Interceptor
Linnton
Glen Harbor
St. Johns A
St. Johns B
Oswego
Oregonian
Fiske A
Fiske B
Chautauqua
Fenwick
Bayard
Albina
Vancouver
Kenton
NE 13th
Riverside
Beech/Essex
Wheeler
Balch
Fremont
Holladay
Sullivan
Nicolai
Central Business District
Tanner B
Tanner A
Mill/Jefferson
Oak
Stark
Alder
Sheridan
Division
Taggart D
Taggart B/C
Woods
Taggart A
Carolina
Lents
Insley
California
Sellwood
Western Lents
Legend
City of Portland
Combined Sewer Basin Boundary
System Improvement Areas (completed)
Sewer Separation Area with Stormwater Treatment (completed)
Stream Separation Area (completed)
Sump/UIC Area
Rivers and Lakes
Streams and Creeks
Freeways
Arterial Streets
Existing Interceptors
Tanner Creek Diversion System
All Properties Inspected by Downspout Disconnection Program as of 06/30/09
Columbia Blvd Wastewater Treatment Plant
Major Pump Stations
Controlled CSO Outfall
CSO Outfall to be Controlled in 2011
Storm Outfall (Previously CSO)
Abandoned CSO Outfall
Figure ES-2
Combined Sewer System and Cornerstone Projects
Portland's Combined Sewer System
0 6,000 Feet
City of Portland Environmental Services
Systems Analysis
Spatial Analysis and Modeling
Post-2011 Combined Sewer Overflow Facilities Plan
Produced by Systems Analysis: Map Request 5497 (KDR) August 24th, 2010 \\Cassiolasm_projects\9ESEN00000006\Mxd\Phase_2\Fig_ES-2.mxd

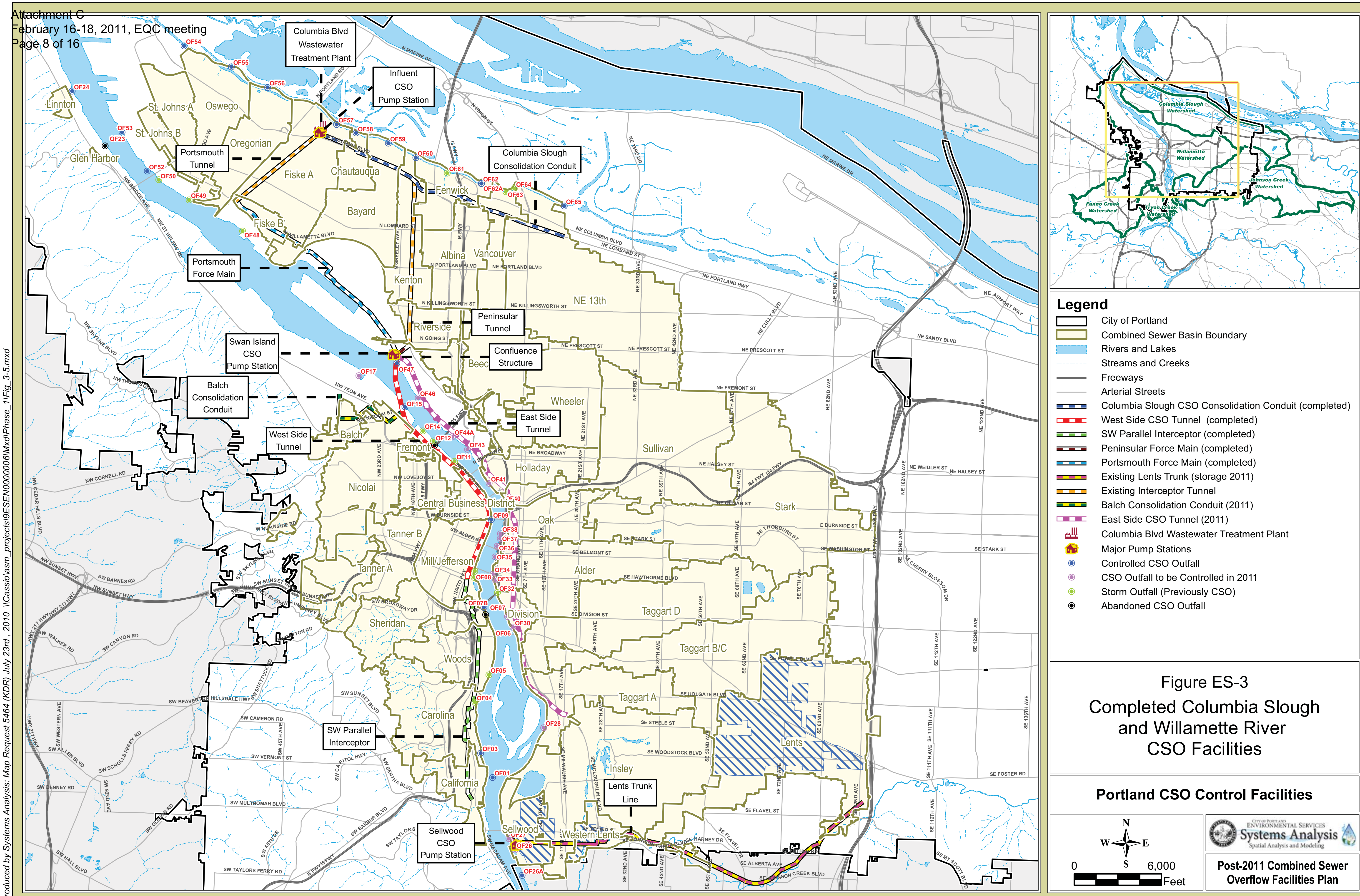


Figure ES-3
Completed Columbia Slough and Willamette River CSO Facilities
Portland CSO Control Facilities
Post-2011 Combined Sewer Overflow Facilities Plan
Legend
City of Portland
Combined Sewer Basin Boundary
Rivers and Lakes
Streams and Creeks
Freeways
Arterial Streets
Columbia Slough CSO Consolidation Conduit (completed)
West Side CSO Tunnel (completed)
SW Parallel Interceptor (completed)
Peninsular Force Main (completed)
Portsmouth Force Main (completed)
Existing Lents Trunk (storage 2011)
Existing Interceptor Tunnel
Balch Consolidation Conduit (2011)
East Side CSO Tunnel (2011)
Columbia Blvd Wastewater Treatment Plant
Major Pump Stations
Controlled CSO Outfall
CSO Outfall to be Controlled in 2011
Storm Outfall (Previously CSO)
Abandoned CSO Outfall
0 6,000 Feet
N S E W
Systems Analysis
Spatial Analysis and Modeling
Columbia Slough Watershed
Willamette Watershed
Johnson Creek Watershed
Fanno Creek Watershed
Tryon Creek Watershed
Columbia Blvd Wastewater Treatment Plant
Influent CSO Pump Station
Portsmouth Tunnel
Columbia Slough Consolidation Conduit
Portsmouth Force Main
Peninsular Tunnel
Swan Island CSO Pump Station
Confluence Structure
Balch Consolidation Conduit
East Side Tunnel
West Side Tunnel
SW Parallel Interceptor
Lents Trunk Line
Sellwood CSO Pump Station
Linnton
Glen Harbor
St. Johns A
St. Johns B
Oswego
Oregonian
Fiske A
Fiske B
Chautauqua
Bayard
Fenwick
Albina
Vancouver
Kenton
Riverside
NE 13th
Beech
Wheeler
Balch
Fremont
Sullivan
Holladay
Nicolai
Central Business District
Oak
Stark
Tanner A
Tanner B
Mill/Jefferson
Alder
Sheridan
Division
Taggart D
Taggart B/C
Woods
Taggart A
Carolina
Lents
Insley
California
Sellwood
Western Lents

## Development and Evaluation of Post-2011 Methods

BES developed and evaluated methods to mitigate the projected increase in stormwater runoff that could not be addressed by existing BES program activities. The following technologies were considered for this facilities plan as specified by the ASFO: sewer separation, upsizing of trunk and interceptor lines for storage, operational enhancements, wet weather treatment improvements, enhanced inflow and pollutant source control, and comprehensive and multi-objective water quality improvement strategies.

As previously discussed, the increased 3-year summer storm volume of stormwater that will need to be controlled by 2050 is estimated to be 22.4 MG or the equivalent of 600 acres of impervious surface in the Willamette River combined sewer service area.

After initial screening, BES evaluated the viable methods for expected cost-effectiveness and risk factors. The evaluation showed that the total number of impervious acres that could be managed by candidate methods exceed the target of 600 acres. Because of this, the methods with the greatest risk could be eliminated from further consideration.

## Recommended Plan for Further Reductions

### Overview

To establish a comprehensive framework for future CSO reductions, BES has developed a combination of policies and methods for implementation in an adaptive management approach.

### Policies

The following policies define the acceptable characteristics for CSO reduction methods:

- Reduce the amount of clean stormwater entering the combined sewer system by maximizing infiltration where practicable.
- Integrate watershed health goals, including restoration of the hydrologic cycle by using stormwater as a resource and not a waste.
- Apply green approaches alongside traditional approaches to stormwater management in the combined sewer system.
- Increase the adaptive capacity of the City's built and natural stormwater systems by developing and maintaining an urban stormwater system that can respond to a range of possible future conditions.
- Implement reduction methods only if they are cost-effective and meet the requirements of a risk-based asset management approach to efficiently achieve

environmental, social, and economic benefits—Triple Bottom Line benefits. Consider a wide array of environmental and social benefits (and external costs) to the community when performing a Triple Bottom Line assessment.

In short, the post-2011 BES approach to CSO reductions emphasizes development of green infrastructure, cost effectiveness, risk-based asset management, and the synthesis of multiple benefits.

## Methods

The recommended methods and candidate methods of the plan are listed in Table ES-1 in order of priority with the corresponding acres of managed impervious area. If, in addition to the recommended methods, all of the candidate methods are implemented, then the grand total of managed effective impervious area is estimated to be greater than 700 acres, which compares favorably with the 2050 goal to manage 600 acres of effective impervious area

**Table ES-1**. Recommended Plan

| Method | Description | Impervious Area Managed (acres) |
|---|---|---|
| **Recommended** | | |
| Existing Program Activities | CIP-Budgeted Cost-Beneficial Combined Sewer System Plan Projects: Implement Maintenance and Reliability projects to address local street flooding and basement sewer backup risk. Associated green infrastructure stormwater controls will provide significant CSO reduction benefits. | 185 |
| | Additional Cost-Beneficial Combined Sewer System Plan Projects: Reassess cost-benefit of additional Combined Sewer System Plan projects to address local street flooding and basement sewer backups and submit for CIP and Operating funds as needed for implementation. Associated stormwater controls will provide significant CSO reduction benefits. | 190 |
| | Portland Bureau of Transportation Stormwater runoff management (pollution reduction and flow control) for roadway improvement projects that involve more than re-paving existing roadways. Assumed to mitigate for an average of 1 impervious acre per year over the 40 year planning period. | 40 |
| Recommended Methods Sub-total | | 415 |
| **Candidate** | | |
| Re-evaluate Stormwater Management Manual (SWMM) Volume Control Effectiveness | Re-evaluate assumption that SWMM stormwater facility designs required by the City at new developments and redevelopments effectively manage 26% of new impervious area for volume control. Recent investigation indicates that the managed impervious area may achieve greater than 40% effective for volume control. Monitor to verify and adjust planning demands. | 110 |

**Table ES-1**. Recommended Plan

| Method | Description | Impervious Area Managed (acres) |
|---|---|---|
| Improve Stormwater Facility Design for Volume Control | Improve design to increase effectiveness of flow volume removal. The flow-through planter is an excellent candidate for improved design because it is currently estimated to remove 25% of the stormwater flow volume it receives and it is frequently implemented to meet SWMM. If the flow-through planter volume removal efficiency could be increased to 40%, this would produce 60 acres of impervious area removal. | 60 |
| Assess Stormwater Water Quality Problem Areas | The tunnel system provides an opportunity to route a portion of the stormwater from densely populated areas to the CBWTP using gates and real time controls. This method achieves water quality benefits while minimizing the increased flow to the CSO control system. | -20 |
| Implement Stormwater Projects at Large Institutions | Manage impervious areas from educational and religious institutions in the East Willamette basins by directing stormwater runoff to vegetated infiltration facilities. | 65 |
| Refine Requirements of SWMM for New Development and Redevelopment | ■ Increase use of ecoroofs through incentives and grants for ecoroofs throughout the City<br>■ Review the application criteria for flow-through planters<br>■ Continue and enhance existing stormwater incentive programs<br>■ Integrate and enhance urban forestry requirements with the SWMM and target implementation in CSO areas<br>■ Pursue effective public and private maintenance of installed facilities | 60 |
| Implement Storm-water Projects at Large Commercial Facilities | Manage impervious areas from existing commercial facilities in the East Willamette basins by directing stormwater runoff to vegetated infiltration facilities. | 30 |
| Candidate Methods Sub-total | | 305 |
| **Grand Total** | | **720** |

## Risk Assessment of Recommended Plan

A risk assessment of the recommended plan is summarized in Table ES-2. Monitoring for increased risk in the areas outlined in Table ES-2 is recommended as an adaptive implementation plan activity.

City of Portland Post-2011 CSO Facilities Plan

**Table ES-2**. Risk Assessment and Mitigation Measures

| Plan Element | Risk of Implementation | Mitigation Measures |
|---|---|---|
| **Recommended Methods** | | |
| Existing Program Activities | Volume reduction estimates are overstated through model assumptions or their actual reduction performance | Monitor performance from existing facilities; apply additional stormwater reduction strategies identified in plan |
| | Maintenance of green infrastructure stormwater controls not performed over long term to maintain performance | Apply cost-benefit risk analysis in a business case to justify adequate maintenance budget<br>Commit to investigation of optimal maintenance cycles, work planning, and procedures with monitoring of how maintenance affects facility functionality<br>Consider alternative maintenance delivery methods |
| | Unauthorized public and private stormwater facility modifications diminish performance | Perform periodic inspections to ensure facilities (including disconnections) are intact and functioning properly |
| | Funding not approved for stormwater control facilities on private property | Seek alternative funding and implementation approaches or revise public works projects to incorporate needed control |
| | Participation by private property owners is not sufficient to meet onsite stormwater control targets | Develop outreach, technical assistance, and financial incentive programs<br>Revise public works projects to incorporate needed control |
| | Green streets not feasible | Increase options for onsite stormwater controls through partnering with private properties |
| **Candidate Methods** | | |
| Re-evaluate SWMM Volume Control Effectiveness | Volume reduction estimates are overstated vs. actual reduction performance | Monitor performance from existing facilities<br>Apply additional stormwater reduction strategies identified in plan |
| Improve Stormwater Facility Design | Long-term improvements not realized | Monitor performance from existing facilities, apply results to modified design to achieve greater volume removal |
| | Design improvements are more costly and less attractive to developers | Develop design improvements that are cost conscious |

**Table ES-2.** Risk Assessment and Mitigation Measures

| Plan Element | Risk of Implementation | Mitigation Measures |
|---|---|---|
| Assess Stormwater Water Quality Problem Areas | Real time control requirements increase costs beyond cost effective levels | Include water quality improvements in benefit assessment |
| | Permitting issues regarding Waterfront Park | Apply additional green infrastructure solutions to the areas rather than sending separated stormwater to the tunnel system |
| Implement SWMM Projects at Large Institutions | Resistance from property owners because of lack of design capabilities or concern about facility maintenance commitments | Develop outreach, technical assistance, and financial incentive programs<br>Develop alternative maintenance delivery systems |
| Refine Requirements of SWMM for New Development and Redevelopment | Resistance from property owners, developers, and stormwater facility installers | Develop outreach, technical assistance, and financial incentive programs |
| | Conflict with City developmental policies fostering maximum density and use of property | Increase requirements for ecoroofs and other facilities that provide flow control<br>Evaluate sharing facilities in the public right-of-ways |
| Implement Stormwater Projects at Large Commercial Facilities | Resistance from property owners | Develop outreach, technical assistance, and financial incentive programs |

## Financial Planning

### Funding and Financial Planning Process

BES operations, maintenance, and capital projects are financed with revenues from sewer rates and system development charges, revenue bond debt, or with ending fund balances. Beyond the short-term (5-year) forecast interval, BES financial plans rely on knowledge of longer-term sewer and water quality program costs and estimates of the impacts of potential regulatory requirements over a longer horizon. BES assumes that it will continue to rely on revenue bond financing for capital expenditures (decreasingly over the next 15 years).

### Financial Capability and Affordability

Portland is well positioned to financially manage the future sewer and water quality programs. However, Portland has consistently raised sewer rates to pay for CSO control projects and other capital improvement program (CIP) investments since 1990. The current financial model requires the City to continue to raise rates to retire the substantial debt incurred to finance the CSO control program. Portland ratepayers have shouldered this financial burden and it will continue to grow past 2016 when it is projected that 30% of households will exceed the 2.0% EPA affordability guideline for sewer rates.

Based on EPA's Financial Capability Assessments, Portland's financial burden would be considered in the upper range of a "Medium Burden" on the community. With the anticipated additional costs of pursuing further CSO reductions, the City-wide average affordability index will grow even higher from the currently projected 1.78% toward the 2% threshold for "High Burden."

# Implementation Plan

## Recommended Methods

Initial implementation of the Existing Program Activities will consist of recommended 2010 Combined Sewer System Plan Service Improvements with stormwater removal activities that are already programmed into the CIP. The remaining cost-beneficial Combined Sewer System Plan projects (those not yet in the CIP) are recommended to provide additional stormwater removal. The implementation approach is shown in Figure ES-4. The figure shows the demand for stormwater removal from 2011 to 2050 when growth creates a 22.4 MG demand during the 3-year summer design storm as previously described. The methods to achieve the desired stormwater removal are shown relative to the increasing demand for removal over time.

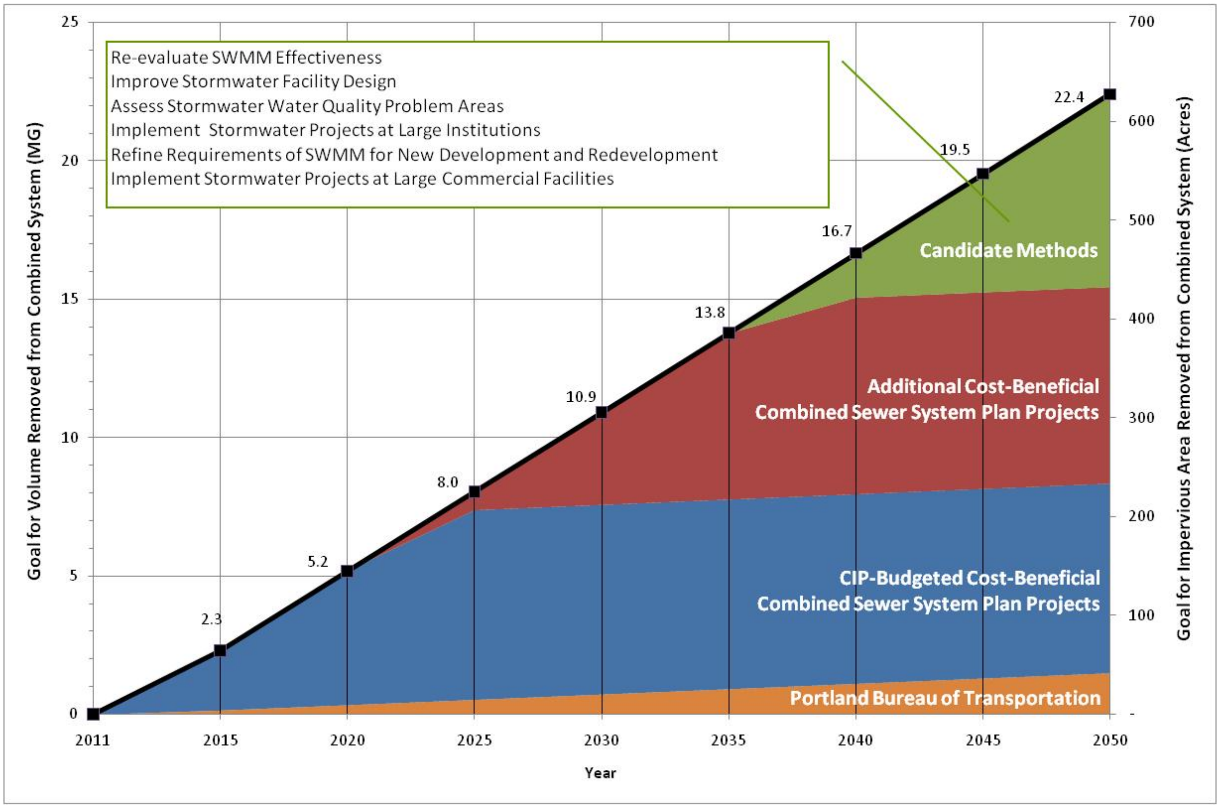



**Figure ES-4**. Post-2011 CSO Implementation Plan for Further CSO Reductions

Figure ES-4 results in the following general conclusions regarding implementation characteristics and timing:

- Portland Bureau of Transportation projects are assumed to remove a 3-year summer storm equivalent of 0.04 MG per year for a total of 1.5 MG by 2050.
- Combined Sewer System Plan projects in the CIP start in 2011 and would need to be implemented at a rate of approximately 0.5 MG or 14 acres of impervious area removal per year through 2025.
- Cost beneficial Combined Sewer System Plan projects not yet in the CIP need to be initiated by 2020 and by 2025 need to remove impervious area at a rate of 0.5 MG/14 acres per year through 2040.

## Candidate Methods

The candidate methods shown in Figure ES-4 and described in the recommended plan are more flexible in their timing relative to the project groups described above. For purposes of this facilities plan, the specific candidate methods are not identified individually but are shown as a group and are to be implemented following the recommended projects starting in 2035 through the end of the planning period in 2050. Their maximum rate of removal is similar to the recommended projects at 0.5 MG/14 acres per year.

Given that some of these methods (e.g., effectiveness and modifications to the application of the SWMM) provide benefit with minimal cost, it is likely, but not certain, that they will be integrated with earlier activities in the implementation period.

## Plan Performance Monitoring and Reporting

### Method for Demonstrating Compliance with Permit Requirements

DEQ approved the design storm method for demonstrating CSO compliance in 2001 for the Columbia Slough system and in 2007 for the West Side CSO system. After the East Side CSO control projects are completed in December 2011, BES will submit to DEQ for approval the method for demonstrating that the ASFO's design storm requirements for eliminating CSOs from the remaining Willamette River outfalls have been achieved.

### Long-Term CSO System Inflow and Overflow Tracking

BES developed and submitted a draft *Post-Construction Monitoring Program* to DEQ and EPA Region X in July 2008. That report documents the CSO monitoring and sampling activities that BES will implement to ensure that the CSO Program complies with the City's NPDES permit and water quality standards as required by the permit, CSO Policy, and the Clean Water Act.

Through post-construction monitoring and the CSO event reports that are required by the City's permit, Portland will be able to track the influence of the increased or decreased stormwater inflow on the performance of the CSO system.

## Public Notification, Involvement, and Education

From the beginning, BES has been committed to meaningful public involvement as essential to successful implementation of the CSO LTCP. Initially, programs were developed to raise awareness about CSO issues and support public participation in the formulation of ASFO goals and requirements. They fostered public involvement in the development, evaluation, and selection of preferred alternatives for the City's 20-year CSO LTCP. The public involvement programs were integral to the effective implementation of LTCP project phases and were expanded and adjusted accordingly.

In the future, the City's CSO-related public involvement activities will be developed on a project by project basis as combined sewer service improvements are integrated with sustainable stormwater management projects. Public involvement provides opportunities for Portland's citizens to participate in decision-making, take part in stewardship activities, and help build sustainable community partnerships.

# Summary of BES Presentation to EQC on:

# Progress for Controlling Portland Combined Sewer Overflows

## EQC Meeting Date: December 9-10, 2010

### *Presenters*

- Dean Marriott, BES Director
- Paul Gribbon, Chief Engineer for Willamette River CSO Program
- Virgil Adderley, CSO Program Manager

### *Purpose of Presentation*

The Amended Stipulated Final Order (ASFO) requires the City of Portland to "report to the Commission in a public forum its progress for CSO reductions" that meet the specified levels of combined sewer overflow (CSO) control as well as working to achieve higher levels of control through other activities. This presentation will cover the work completed as of December 2010 in meeting and exceeding the ASFO requirements for the Columbia Slough and the Willamette River. We will also present the work underway to complete the control facilities for the East Side Willamette CSO discharges by 2011. Finally, we will present the post-2011 CSO Facilities Plan for activities to further reduce CSO discharges beyond the level required in the ASFO.

### *Status of Portland's CSO Program*

We are within one year of completing the 20-Year CSO control program begun in 1991. By December 2011, we will control CSO discharges by more than 96% from the original 6 billion gallons/year in 1990

- **Columbia Slough CSO - 13 Outfalls Controlled:** ASFO requires CSO discharges to be eliminated for all storms smaller than a ten-year summer storm and a five-year winter storm by December 2000. This resulted in a 99% annual CSO volume reduction in the Columbia Slough.
  - *13 CSO outfalls controlled as of December 2000*
- **Willamette River CSO - 42 Outfalls Controlled:** ASFO requires CSO discharges to be eliminated for all storms smaller than a three-year summer storm and a four-per-winter storm by December 2011. This will results in a 94% annual CSO volume reduction in the Willamette River.
  - *7 CSO outfalls controlled as of December 2001*
  - *16 CSO outfalls controlled as of December 2006*
  - *19 remaining CSO outfalls in process to be controlled by December 2011*

*The CSO Program has achieved 99% CSO reduction in the Columbia Slough, while today the Willamette River CSO has been reduced by 58% for a current citywide reduction of 66%.*

When completed, Portland will have invested about $1.4 billion over the span of the 20-year Program.

## *Cornerstone Projects – Initial Green Infrastructure*

The Cornerstone Projects were a set of cost-effective actions that reduced CSO by treating stormwater as a resource to be returned to the watershed via infiltration and kept out of the combined sewer system. Removing stormwater from the combined system also reduced the amount of combined sewage and allowed construction of smaller, less expensive pipes and treatment facilities that helped hold down total program costs. To date, the Cornerstone Projects have removed about 2.2 billion gallons of stormwater annually from the combined sewer system at a cost of approximately $145 million.

There are four categories of Cornerstone Projects designed to address stormwater at the source – Sewer Separation, Stormwater Sumps, Roof Downspout Disconnection, and Stream Diversion. These projects helped with two major challenges in Portland's combined sewer system – they reduced CSO and significantly reduced basement backups.

**1. Sewer Separation**

In specific Portland neighborhoods, Environmental Services installed new pipes to separate stormwater from sewage and remove stormwater runoff from the combined sewer system. Sewer separation projects are complete in the designated areas of west, north and southeast Portland.

**2. Stormwater Sump Installation**

Environmental Services has installed sedimentation manholes with infiltration sumps in North/Northeast Portland to collect, treat, and infiltrate stormwater runoff into the ground. More than 2,800 sumps have been installed in areas served by combined sewers. Sump installation projects were substantially completed by the end of 2001.

**3. Downspout Disconnection**

The Downspout Disconnection Program works with residents of Portland's combined area neighborhoods to disconnect their downspouts from the sewer system and allow their roof water to drain to their gardens and lawns. Over 55,000 residential downspouts have been disconnected through the Program, removing more than 1.2 billion gallons of stormwater per year from the combined sewer system.

**4. Stream Diversion**

Environmental Services has built new pipelines to divert the large Tanner Creek stream system from the combined sewer. This creek was piped into the sewer system decades ago. Today, this relatively clean source of water has been removed from the combined sewer system and released to the Willamette River.

## *Completed Columbia Slough Projects*

Environmental Services completed a series of projects in north Portland to reduce combined sewer overflows to the Columbia Slough by more than 99 percent as of December 2000. The projects included the Cornerstone Projects described earlier and the Columbia Slough CSO Facilities. The Cornerstone Projects completed in the Columbia Slough consisted of sumps, downspout disconnection and sewer separation in the St Johns, Oswego and Oregonian basins. The stormwater separated from the combined system is treated at the Ramsey Lake wetland that was constructed specifically to treat runoff from these Columbia Slough basins.

The second phase of the Columbia Slough projects created large scale CSO facilities including the 6 to 12-foot diameter Columbia Slough Consolidation Conduit (CSCC) and the Columbia Boulevard Treatment Plant (CBWTP) Additions. These projects included a 105 MGD Influent Pump Station, new and refurbished primary clarifiers, and a new 72-inch outfall line and dechlorination facility. All these facilities were constructed and placed in service by December 2000. The total cost of the Columbia Slough CSO Facilities was $160 million.

## *Willamette River Projects*

Environmental Services is completing the last of the projects in the Willamette basin designed to control the remaining CSO outfalls by December 1, 2011 as required by the ASFO. The large Willamette River CSO Projects controlled the CSO outfalls on the Willamette by the Year 2011 in two phases. The first phase controlled 16 outfalls (mostly on the west side of the Willamette) by December 2006. The second phase, nearly complete, will control the remaining CSO outfalls on the east side by December 1, 2011.

To meet the December 2006 ASFO milestone, Portland constructed the first phase of the large Willamette CSO facilities, consisting of a 3.5-mile long, 14-foot diameter tunnel, a large 100 MGD pump station on Swan Island, and additional Columbia Boulevard treatment facilities to capture, transport and treat the west side Willamette CSO flows. These facilities were all constructed and operational by December 1, 2006. That same year, construction began on the larger east side Willamette CSO facilities. The east side facilities include a 6-mile long, deep 22-foot diameter tunnel, an expansion to the Swan Island CSO Pump Station from 100 to 220 MGD, a new 3-mile long 66-inch diameter forcemain, a Sellwood CSO storage & pump station, and additional treatment facilities at Columbia Boulevard. Control of the Balch CSO outfall on the west side of the river will be completed by a large consolidation conduit connecting to the West Side tunnel by the December 2011 deadline. All CSO construction is on schedule for completion by 2011. Once these facilities are operational, the CSO volume discharged to the Willamette River will have been reduced by 94% and overflow events will occur less than once in three years during the summer and four times per year during the winter.

### West Side CSO Facilities (all operational by December 1, 2006)

#### Southwest Parallel Interceptor

The Southwest Parallel Interceptor (SWPI) is a 15,000 foot pipeline three to six feet in diameter that runs parallel to the river and collects wastewater and CSO flows from the southwest area of the combined system. The original interceptor pipe, built in the 1950's, was too small to handle both wastewater and storm flows. The new interceptor added capacity to handle existing and future combined flows from the west side of the Willamette and transports them to the Columbia Boulevard Wastewater Treatment Plant. The total cost of the Southwest Parallel Interceptor was about $45 million.

#### West Side CSO Tunnel

The City constructed a large, deep tunnel pipeline from SW Clay Street, along Waterfront Park, through the northwest industrial area and under the Willamette River to carry combined sewer flows from the west side of the river to the new Swan Island CSO Pump Station. The tunnel is 18,000 feet in length, 14-feet in diameter, and approximately 120 feet underground.

#### Swan Island CSO Pump Station

This facility on Swan Island pumps combined sewage from the West Side CSO Tunnel through a new forcemain to an existing sewer in north Portland. This station was completed in September 2006 and currently pumps up to 100 million gallons per day (MGD) from the west side tunnel into the new Peninsular Forcemain into an existing interceptor to deliver the flows to the Columbia Boulevard Wastewater Treatment Plant. This station is currently being expanded to pump 220 MGD to drain the combined sewer flows from both the west side and the east side tunnels.

#### Peninsular Forcemain

This 30 and 48-inch diameter dual forcemain conveys up to 100 MGD of sewage pumped from Swan Island east to a portal that connects into the existing Peninsular Interceptor.

The cost of the West Side Tunnel, the Swan Island CSO Pump Station, and the Peninsular Forcemain was approximately $350 million.

**East Side CSO Facilities**

**East Side CSO Tunnel**
This 120-foot deep, 22-foot internal diameter tunnel will collect combined sewage from southeast to northeast Portland and deliver the flows to the Swan Island CSO Pump Station. The tunnel is approximately 30,000 feet in length and, including seven shafts and associated pipelines and structures, is estimated to cost approximately $450 million at project completion. The mining of the tunnel itself was completed in October 2010 and the connections of the outfalls, which will put the tunnel into operation, are scheduled for summer 2011.

**Swan Island CSO Pump Station Expansion**
Three additional wet weather pumps and associated piping and control equipment are currently being added to the existing pump station to increase pumping capacity from 100 MGD to 220 MGD in anticipation of the East Side CSO Tunnel coming on-line in September 2011. With the addition of the Portsmouth Forcemain, this will provide for full operation of the east side CSO system by December 2011. The cost of this additional capacity is $14 million.

**Portsmouth Forcemain**
This 16,000 foot long, 66-inch diameter forcemain is being installed from the Swan Island CSO Pump Station north across Swan Island, under Waud Bluff, and then under N. Willamette Blvd to a portal which connects it to the existing Portsmouth Interceptor. Combined with the Peninsular Forcemain completed in 2006, the total CSO transport capacity from Swan Island CSO Pump Station to the Columbia Boulevard Wastewater Treatment Plant will increase to 220 MGD. The forcemain is being installed under two separate construction contracts, one predominantly an open-cut installation and the second a micro-tunnel. The total cost of both segments is approximately $70 million.

**Sellwood CSO Storage and Pump Station System**
Construction work is underway on these projects which will eliminate CSOs at Outfall 27. The facilities consist of upgrades of existing sewers to provide CSO conveyance, inline-storage, and an 8 MGD pump station and pressure line to control CSO during the ASFO design storms. Cost of these facilities will be approximately $25 million.

**Balch Consolidation Conduit**
This project will control an additional west side outfall and consists of approximately 7000 feet of 84-inch diameter pipeline to convey CSOs from the Balch drainage basin on the west side of the Willamette to the West Side CSO Tunnel through the existing Nicolai Shaft. The cost of this facility when complete will be approximately $75 million.

## *Post-2011 CSO Facilities Plan to Achieve Further CSO Reductions*

BES is committed to protecting human health while improving water quality and watershed functions in the Portland area. That commitment is reflected in the implementation of the CSO Program as well as the integration of traditional engineered facilities along with sustainable stormwater projects to control CSO and protect water quality.

When completed in December 2011, Portland's CSO control system will meet applicable water quality standards as well as meet allocation limits established in the Willamette River TMDL for bacteria. The EQC, when it signed the ASFO, established a requirement for the City to examine the potential for additional cost-effective methods for achieving "further CSO reductions" in the Willamette River system beyond the level required by the ASFO. As required, the City submitted the Post-2011 CSO Facilities Plan to the Oregon Department of Environmental Quality (DEQ) on September 1, 2010. The facilities plan outlines future sewer system improvements and expansion of the city's green stormwater management infrastructure. Managing stormwater at its source keeps runoff out of the combined sewer system to reduce CSOs, relieves sewer capacity problems, replenishes groundwater, protects water quality and enhances watershed health. This facilities plan, required by the ASFO, is subject to EQC approval.

The ASFO describes "further CSO Reductions" in terms of additional volume and frequency reductions where cost-effectively possible. Cost-effectiveness is a key criterion due to the fact the level of CSO control established in the ASFO was determined from a "knee-of-the-curve" cost-effectiveness analysis.

Sewer system modeling indicates that after December 2011, Portland's CSO system will immediately achieve "further reductions" of CSO frequency beyond the level required by the ASFO. It is anticipated that the Willamette River CSO system will control winter season overflows to approximately two per winter compared to the four per winter established in the ASFO. Over the next 40 years, development pressures could cause the stormwater runoff reaching the combined system to increase and thereby reduce the "further reductions" achieved earlier. Therefore, BES developed the Post-2011 CSO Facilities Plan to implement green stormwater infrastructure improvements that can be adopted to maintain the "further CSO reductions" achieved for the Willamette River to an average of two per winter.

### Recommended Projects

To establish a comprehensive framework for future CSO reductions, Environmental Services has developed a suite of methods to control stormwater inflow from impervious surfaces as circumstances dictate. Following an adaptive management approach will provide Environmental Services the flexibility to cost-effectively address evolving regulatory requirements, community values, and economic constraints. Methods include specific recommended projects and activities:

- Combined Sewer System Plan Projects that incorporate maintenance and rehabilitation activities along with green infrastructure stormwater controls to address structural and capacity problems that cause local street flooding and basement sewer backup risk. (The Tabor to the River program is an example collection of these types of projects.)
- Projects that manage impervious areas from commercial, educational and religious institutional properties in the East Willamette basins by directing runoff to vegetated infiltration facilities.
- Evaluation and possibly modification of designs and implementation of the Stormwater Management Manual (SWMM) for increased volume control effectiveness

**Adaptive Management Strategy**

Further reductions in CSO will be achieved by the 20-year CSO Program, and then sustained by the recommended projects presented above. As these projects are being implemented, additional performance monitoring data will be collected and evaluated to identify potential capacity shortfalls. Also, based on a review of the SWMM program provided in the report, greater CSO reductions may be realized than previously forecasted. As development occurs and recommended projects are implemented, the City will monitor for the following primary triggers to potential activate the appropriate long-term strategies as part of an adaptive management strategy:

- Possible Trigger 1: System performance indicates that winter CSO events are occurring due to storms more frequently than two per winter on average.
- Possible Trigger 2: Community development increases impervious area at a greater rate than anticipated. For this plan, growth is assumed to occur at an average rate of 14 impervious acres a year.
- Possible Trigger 3: Stormwater runoff volume from new impervious area managed onsite as per SWMM requirements is found to exceed expected volumes.

If potential triggers such as these occur, BES will be able to respond by implementing the next set of cost-effective recommended projects identified in the Post-2011 CSO Facilities Plan.