King County Auditor's Office
Cheryle A. Broom, King County Auditor

King County

Performance Audit of Combined Sewer Overflow Program

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October 1, 2012
Report No. 2012-04

Executive Summary

The King County Wastewater Treatment Division (WTD) is experienced with planning and implementing large infrastructure projects. Such projects are the traditional approach to addressing the problem of overflows. However, large infrastructure projects are expensive, and historically the cost of combined sewer overflow (CSO) control projects has increased through the planning and execution phases.

This audit finds that WTD is less experienced than some other jurisdictions in pursuing alternative approaches to controlling combined sewer overflows. Such alternatives include smaller "green infrastructure" projects to control stormwater at its source, as well as providing financial incentives for customers to control stormwater runoff from their properties. Such approaches can be less costly than traditional "gray infrastructure" approaches. The audit also finds that WTD is not prioritizing projects based on a measure of their cost-effectiveness in reducing pollution, and includes a recommendation for WTD to begin developing quantitative measures of the impacts on water quality from CSO control projects.

King County

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MEMORANDUM

DATE: October 1, 2012

TO: Metropolitan King County Councilmembers

FROM: Cheryle A. Broom, County Auditor

SUBJECT: Performance Audit of Combined Sewer Overflow Program

Attached for your review is the Combined Sewer Overflow audit report. The primary objective of the audit was to evaluate the County Executive's $711 million plan for controlling combined sewer overflows by 2030.

The general audit conclusion was that the Wastewater Treatment Division's planning process for the combined sewer overflow program is professional and thorough, but opportunities exist for improving the cost-effectiveness of the program. These opportunities include:

- Improving how life cycle cost analysis is used to select projects;
- Using rate incentives to reduce the volume of stormwater entering the sewer system;
- Enhancing planning for green stormwater infrastructure, and
- Considering project cost-effectiveness when sequencing projects.

Implementing these recommendations could potentially lower the cost and improve the effectiveness of the Combined Sewer Overflow Program.

The County Executive's response to the audit concurred with the audit recommendations and is contained in the appendices of the report. Auditor's comments to the County Executive's response are also provided in the report appendices.

The Auditor's Office sincerely appreciates the cooperation received from the Wastewater Treatment Division's management and staff.

CB:LB:lo

Performance Audit of Combined Sewer Overflow Program

Report Highlights

October 1, 2012

Report No. 2012-04

Purpose

The federal Clean Water Act, as administered by the state Department of Ecology (Ecology), requires municipalities to control overflows from combined sewer systems. Ecology requires that King County achieve compliance with its control standards by 2030. In June 2012, the County Executive submitted an updated plan for achieving control of overflows at an estimated cost of $711 million (2010 dollars). The County Council requested this audit to evaluate the cost effectiveness of the Combined Sewer Overflow (CSO) Control Plan.

Key Audit Findings

The Wastewater Treatment Division's (WTD) planning process for the CSO Control Program is professional, thorough, and transparent. Nevertheless, we found several areas for improvement.

Project Costs: The $711 million estimate to achieve CSO control is a planning-level estimate with a wide range of uncertainty. Based on performance of past projects, the actual cost is likely to exceed the $711 million estimate. We have identified areas which could reduce the ultimate cost of the CSO Control Program, including a more thorough analysis of using green stormwater infrastructure as an alternative to gray infrastructure, improvements in life cycle cost analysis, and using rate incentives to reduce the volume of stormwater entering the system.

Project Effectiveness: The sequencing of projects in the proposed CSO Control Plan does not take into account the effectiveness of the various projects in reducing pollution. We found that some of the projects necessary to control CSOs achieve control at a far lower cost per gallon of discharge than others. This report provides an illustration of how re-sequencing control projects could remove an additional 3.5 billion gallons of CSO discharge, with about the same impact on rates as the sequence in the currently proposed plan. This kind of information can be of value to county policy-makers and can be used as a way to quantify the opportunity costs of choosing one sequence of control projects over another.

What We Recommend

Our recommendations are intended to increase the cost-effectiveness of the CSO Control Program by:

- Improving the planning and implementation of green infrastructure projects.
- Improving how life cycle cost analysis is used to select projects among alternatives, and revisiting alternatives if there is a significant change in the cost of the selected alternative.
- Providing rate incentives for customers to reduce their use of the system.
- Considering the effectiveness of the projects in removing pollution when sequencing projects.

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CSO Regulatory Environment

Section Summary

The federal and state governments regulate the discharge from local sewer systems, including overflows from combined sewer systems. The regulatory regime focuses on combined sewer overflows (CSOs) based on overflow events, rather than overflow volume or pollutant load. However, given the complexity of the regulatory regime, the audit focuses on maximizing the impact of CSO control within the current "one event" standard.

Federal and State CSO Regulation Authorities Overlap

The Clean Water Act (CWA) is the basic federal law regulating water pollution. The CWA empowers the Environmental Protection Agency (EPA) to set and enforce water pollution standards and controls. It also prohibits discharge of pollutants from "point sources" (pipes, culverts, etc.) without a National Pollution Discharge Elimination System (NPDES) permit. Under the CWA, states administer NPDES permit programs (and issue NPDES permits) complying with the requirements defined in the CWA. The EPA and the Washington Department of Ecology (Ecology), as the Washington State NPDES authority, have overlapping regulatory authorities for water pollution control in Washington.

CWA NPDES regulation includes discharges from combined sewers, called combined sewer overflows (CSOs). Common in older cities throughout the United States, combined sewers are systems that integrate sanitary sewer and stormwater infrastructure. During heavy rains, the volume and flow of stormwater from impervious surfaces (hardscape land features such as roofs, streets, and parking lots) can overwhelm the capacity of the combined sewer. A CSO is a release of the overage into a nearby water body as a relief mechanism, preventing backflow of sewage-laden stormwater into basements and streets. As point sources, CSO outfalls are regulated under the CWA as components of the system provider's NPDES permit.

Ecology's NPDES regulations in the Washington Administrative Code (WAC) set the performance standards that treatment system operators must meet relative to CSOs in Washington. In comparison to most states, Washington's standards are unique, in that they blend the technology and water-quality based requirements of the CWA. Washington regulations define the threshold for CSO control as one event per year, i.e., one unlimited release of untreated combined sewage and stormwater annually at any given CSO outfall; excluding other technical requirements, a combined sewer system in Washington is in regulatory compliance if each of its CSO outfalls are controlled to one CSO a year (or less). King County's NPDES permit interprets compliance with the one event standard for each outfall as over a rolling 20-year average.

CSO Standard Not Based on Measurable Pollution

Although Ecology's regulations prioritize CSO control projects in areas of human and environmental exposure, a latent weakness of the "one event" regulatory standard is that it does not account for actual pollutant loading or for the volume of overflow. "Control" of a CSO outfall with relatively clean overflows of a thousand gallons is the same as control of one with very dirty overflows of a million gallons, so long as each limits the overflow to the "one event" standard.

In addition, outfalls of separated storm sewer systems, conveying stormwater laden with pollutants from streets and the like, are regulated under a completely different NPDES standard. As such, some regional officials question the CSO regulatory standard, or the wisdom of pursuing CSO control projects relative to efforts related to separated sewers and stormwater pollution generally, in the Puget Sound region. CSO control program costs are a comparably small fraction of the total estimated costs of stormwater control and environmental restoration overall. For example, WTD's estimate for the CSO Control Program is $711 million, compared to the Puget Sound Partnership's roughly $8 billion estimate – with annual maintenance costs of $300 million – for stormwater retrofitting areas of over 50 percent impervious surface in Puget Sound watersheds.

Conclusion

We found that, while concerns with the regulatory environment may have some validity, the regulatory requirements related to the CSO Control Plan are unlikely to change. The existing regulatory regime is roughly thirty years old, and fundamental changes would necessitate complex negotiation and likely require legislation at both the federal and state level. As such, this audit focuses on WTD's CSO Control Program's compliance with the existing regulatory regime, including Ecology's WAC requirements regarding cost-effective implementation of CSO control programs.

Evaluating CSO Control Program Cost Estimates

Section Summary

Although WTD has a strong planning process for the gray[1] infrastructure projects that comprise its control program, there is still a very wide range and considerable risk in what the projects in that plan will eventually cost. This risk is compounded by the fact that once projects are selected, alternatives to them are not reconsidered even when new estimates for the selected project shows the selected alternatives to be much more expensive than originally thought. There are also technical problems with how WTD compares the costs of project alternatives, and with how information about cost comparisons is presented to decision-makers.

Fourteen Outfalls Combined into Nine Projects

In 1999, the County Council passed the Regional Wastewater Services Plan (RWSP). Included in the plan was a proposed set of projects for completing the CSO controls to meet the regulatory standard by 2030. In 2006, WTD published an update to the RWSP relating to the CSO Control Program, and in 2011, WTD published the 2011 *CSO Control Program Review*. Following review and amendment by the County Executive, the Executive transmitted the 2012 CSO Control Plan to the County Council. The 2012 CSO Control Plan includes nine projects for controlling the remaining 14 uncontrolled CSO outfalls by 2030. The locations of the 14 outfalls and project areas are shown in the map below.

[1] Traditional wastewater infrastructure (e.g., sewer conveyances, treatment plants, and the like) is correspondingly referred to as "gray" stormwater infrastructure.

Exhibit A: Location of CSO Outfalls in the Control Plan

Source: WTD.

$711 Million CSO Program Cost Estimate Subject to a Wide Range of Uncertainty

WTD estimates that the cost of the remaining control projects will be $711 million in 2010 dollars.[2] The cost estimates for the individual projects are generally based on WTD's previous experience with projects of similar types, or the costs of similar projects elsewhere.

It is important to note that WTD's estimated cost to complete the CSO control program is based on what are referred to as planning-level, Class 5 estimates, which have a wide range of uncertainty expressed as -50 percent

[2] WTD's Technical Memo 620.

to +100 percent.[3] Applying this range to the $711 million estimated cost of the CSO Control Program, the actual cost could range from $355 million to $1.4 billion (in 2010 dollars). Reasons for the uncertainty are many, and include the fact that the project sizes and locations are not yet firmly established.

Our analysis suggests that the actual range of uncertainty may be even broader, which is something that WTD staff have also indicated. If that is the case, the upper end of the range might potentially be even greater than the $1.4 billion ceiling currently implied.

Planning Level Cost Estimates Have Been Too Low

In 1999, when the County Council passed the RWSP, the estimated cost of completing the CSO program was $360 million, in 1998 dollars. Within that plan were the four Beach Projects (Magnolia, North Beach, Barton, and Murray) that are currently in design. They are not, however, part of the 2011 *Program Review's* $711 million estimate for completing the CSO program.[4]

The following table compares the cost estimates for the nine projects included in the 2011 *CSO Control Program Review* to the estimates for the comparable (i.e., those addressing the same CSO outfalls) projects in the 1999 RWSP. This excluded the Beach Projects.

Exhibit B: Control Project Cost Estimate Growth

1999 RWSP Cost Estimate (1998$)	1999 RWSP Cost Estimate (2010$)	2011 CSO Plan Review Cost Estimate (2010$)	Percent Change in Cost (2010$)
$255 million	$364 million	$711 million	95%

Source: King County Auditor's Office analysis of WTD data.

WTD has published an explanation of the several factors explaining the increases in the estimated cost of the CSO Control Program. They include a new cost estimating methodology, higher land costs, higher sales tax, and higher project contingencies.

WTD has also attempted to control costs by various means including combining projects, collaborating with City of Seattle CSO projects, and using green stormwater infrastructure, but despite these efforts, the estimated cost of completing the program has nearly doubled since 1999.

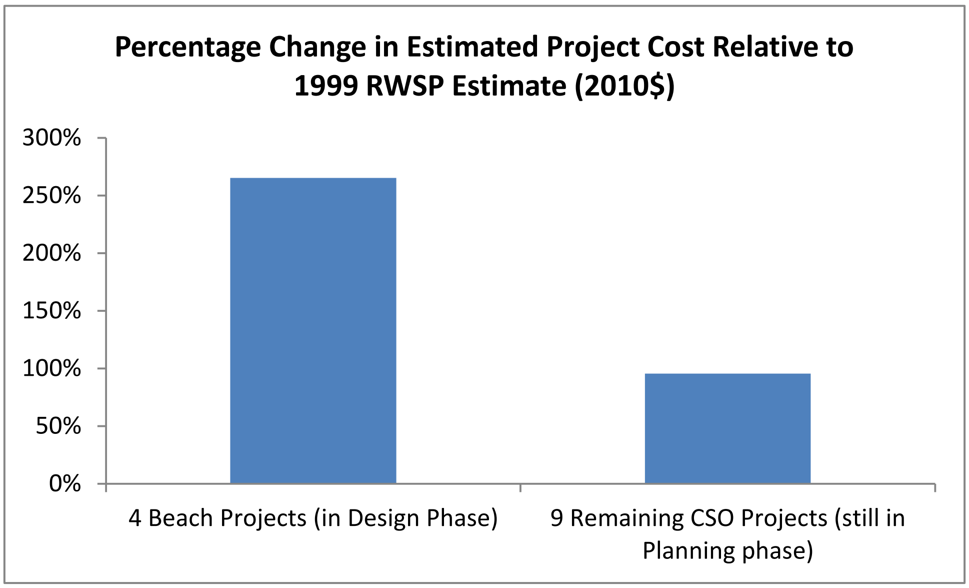
[3] Estimate ranges developed by the Association for the Advancement of Cost Estimating (AACE).
[4] Other projects included in the 1999 RWSP have been dropped from the plan or consolidated (i.e., one project in the 2011 *CSO Control Program Review* replaces several projects in the 1999 RWSP).

Evaluating CSO Control Program Cost Estimates

Costs for Projects in Design Increased More than Projects in Planning

It may be that the changes in WTD's cost estimating process will increase the likelihood that the 2011 estimates for the cost of the CSO Control Program are more accurate than the 1999 estimates. Nevertheless, our analysis suggests that there is still risk of further upward revisions in the estimated cost of the CSO Control Program.[5] The Beach Projects provide an example. Because they are currently in the design phase, more is known about these projects than the planning level information available for the nine projects included in the $711 million cost estimate. As the chart below illustrates, the current estimated cost of the Beach Projects has increased by a substantially greater percentage than the planning level estimates for the remaining nine projects.

Exhibit C: Comparison of Cost Growth of Projects in Design Phase versus Projects in Planning Phase



Source: King County Auditor's Office analysis of WTD data.

At least in the case of the four Beach Projects, as they have entered the design phase and more information has become available, the estimated cost of the projects has gone up. Beach Project costs have increased by a substantially greater percentage than the nine projects that are still in the planning phase. This suggests that the risk range for the current planning level cost estimates could still understate what the eventual project costs will be.

Finally, we note that despite significantly increased costs, the four Beach Projects are relatively early in the design phase and are behind schedule for baselining. A project is baselined at 30 percent of design, and the baselining process establishes a project scope, schedule, and budget from

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[5] This considers projects included in the 1999 RWSP but not in the 2011 *CSO Control Program Review* because they are currently in the execution phase (the four Beach Projects).

which overruns are measured. According to WTD staff, one reason they are behind schedule is the cost estimates have increased again, and WTD is trying to use value engineering to reduce the estimated cost.

Apart from Uncertainties about Cost Ranges, Efforts Should Be Made to Ensure that Cost Comparisons Are Valid

As part of our evaluation of the process and methodology for identifying, selecting, and prioritizing CSO projects, we conducted technical reviews of the life cycle cost analyses that WTD has performed on alternatives for the Beach Projects and the finalist alternatives for the nine CSO control projects that are the main focus of this audit.

Overall we found that the life cycle cost model developed by WTD is robust and technically sound, and is a valuable tool for examining the comparative life cycle costs of project alternatives. Particular advantages of the model are that:

- The period of analysis can be varied to reflect different assumptions about the useful lives of the alternatives being compared;
- The net present values can be converted into annual equivalents for making comparisons of alternatives with different useful lives;
- The cash flows related to financing can be included; and
- On-going operations and maintenance costs are included.

These are all model features that were recommended in the guidelines for economic analysis published by the Auditor's Office in 2006. However, as with any model the outputs are only as good as the inputs and the care with which the model is used.

Some Technical Issues with Comparisons of the Cost of Alternatives in Planning Phase

In our review, we found several instances of the model being used with questionable assumptions (e.g., period of analysis used by consultants was too short for the Beach Projects) or with incomplete data (e.g., major systems periodic repair and replacement costs not included, the finance cash flow function of the model not being used). There were also some instances of the wrong kind of data entered due to unfamiliarity with the model (e.g., using inflated O&M costs in a version of the model that does not include inflation).

It is important to point out that the problems we found in some cases were offsetting or were not significant enough to change the results of the individual life cycle cost comparisons. Nevertheless, in future analyses project selection decisions could be negatively impacted, resulting in less cost-effective projects achieving an undue higher ranking. Also, because some costs were left out and the financing function was not used, the net present value costs of the project alternatives did not represent the full life cycle costs based on taking all cash flows into account.

To its credit, WTD has committed to improve its approach to such analyses in the future and recognizes the need for completeness, accuracy, and consistency in its process of analysis.

Issues with Selecting a Project Alternative to Proceed to Design

In addition to evaluating the cost comparisons of alternatives that were done at the planning phase for the nine projects recommended by the 2011 *CSO Control Program Review*, we also evaluated the cost comparisons of alternatives that were conducted at the project development phase for the four Beach Projects. As a project progresses from the planning phase to project development, additional work is done to:

- quantify the problem,
- refine the scope for alternative approaches to addressing the problem,
- refine the life cycle cost estimates of the various alternatives,
- identify project siting, and
- solicit public input.

The purpose of this analysis is to identify and select a preferred alternative and the selected alternative then enters the predesign phase. As we discussed relating to the planning level life cycle cost analysis of alternatives, we found the same kinds of technical problems with the life cycle cost analysis of alternatives conducted at the project development phase.

However, in addition to the technical problems related to WTD's life cycle cost analysis of alternatives at the project development phase, we also have some observations about how the life cycle cost analysis is used by WTD in project selection.

Inconsistent Information Presented to Decision-Makers

During the project development phase, a short list of alternatives is selected to forward to WTD management, who select the preferred alternative to move forward into predesign. We observed inconsistencies in the type of cost information that was presented to the decision-makers who selected a preferred alternative. For example, in some cases, life cycle cost comparisons of two or three alternatives were presented to the decision-makers, and in one case, only construction cost information was presented. In the cases where life cycle cost comparisons were presented, the information was presented in different formats. For example, in some cases, the life cycle cost of alternatives were presented as a net present value while in other cases, it was presented as an annual equivalent. While the information can accurately be presented in either format, we believe that consistency in how information is presented to decision-makers will assist in their understanding of the information that is presented. WTD has a template for providing information about project selection to decision-makers, but it is not always being followed.

Lowest Cost Project Not Always Selected

We also observed that for three of the four Beach Projects, the alternative that was selected to move forward to design was not the alternative with the lowest life cycle cost. According to WTD staff, cost is only one of several factors that are considered when selecting an alternative to proceed to design. Other factors include construction risk, input from the community, and etc.

Alternatives Not Reconsidered If the Cost of the Selected Alternative Increases

The four Beach Projects are currently in the predesign phase and have not yet had a baseline scope, schedule, or budget developed. However, the current estimated cost of the Beach Projects has increased significantly for all four projects. For example, when the preferred alternative for the Barton project was selected to move forward to predesign, its estimated construction cost was $13 to $16 million compared to the $9 million to $9.5 million cost estimates for non-selected alternatives. The current estimated cost of the Barton project is $21 million.

WTD staff indicated that once a project is selected, there is no further attempt to compare the life cycle cost of the selected alternative with alternatives not selected. WTD staff indicated that after an alternative is selected, it would be very costly to generate comparable information about options that were not selected. However, we note that this practice is inconsistent with WTD's own economic guidelines.[6] These guidelines require updated life cycle cost estimates at various points of a project's development cycle, including when there are significant changes in the project scope or budget.

With some exceptions, WTD's CSO control program planning for the variety of gray infrastructure projects is competent, extensive, and transparent. Despite these strengths, we found evidence that the uncertainty range of minus 50 percent to plus 100 percent used by WTD for the $711 million estimate to complete the control plan may be understated. We also found several problems once a project alternative is selected, including:

- cost information presented to decision-makers is inconsistent, and
- there is no further analysis of alternatives, even if there are significant increases in the estimated cost.

Finally, we noted several technical problems with WTD's life cycle cost comparisons of alternatives. To its credit, WTD has committed to improve future analyses.

Recommendation 1

WTD should develop and follow a quality assurance procedure to ensure the consistent and valid use of its life cycle cost model.

Recommendation 2

WTD should revise its *Guidelines for Life Cycle Cost Analysis and Doing Economic Analysis of WTD Capital Improvement Projects* to identify thresholds for revisiting alternatives if project costs increase to that threshold and describe how the analysis should be conducted.

Recommendation 3

WTD should ensure that its template for presenting information on project alternatives to decision-makers is followed, and that information is presented in a consistent format.

Recommendation 4

If the project alternative selected to move forward to design is not the lowest cost alternative, WTD should clarify in its documentation why other considerations that resulted in a more costly alternative being selected are worth the additional cost.

[6] Guidelines for Life Cycle Cost Analysis and Doing Economic Analysis of WTD Capital Improvement Projects.

Evaluating WTD's Rate Model and Rate Structure

Section Summary

We found that although WTD's rate model is a robust and useful tool for financial planning purposes, that could be better utilized. We also found that the rate structure provides no incentive for the local sewer agencies to reduce their usage of the county sewer system.

WTD's Rate Model Is a Useful Tool, But Could Be Better Utilized

WTD's rate model projects monthly sewer rates into the future based on assumptions about operating costs, capital expenditures, and debt service costs. It also takes into account financial policy and bond covenant requirements for reserves and debt coverage ratios. The model attempts to determine the lowest rate necessary in order to cover operating costs, debt service requirements, and required reserves and coverage ratios.

We found that WTD's rate model is a robust and useful tool for financial planning purposes. However, we noted that when the rate impacts of completing the CSO Control Program were projected in the 2011 *CSO Control Program Review*, the estimated impact on monthly sewer rates was projected to be $7.61. This projection was based on the $711 million estimated cost of completing the CSO Control Program. As we noted previously, this projection is a planning level estimate with a wide range of uncertainty. WTD has noted that the range of uncertainty for this estimate is -50 percent to +100 percent. This range of uncertainty in the cost of the program applied to the monthly sewer rates could mean the rate impact could range from $3.80 per month to $15.22 per month.

Conclusion

Because of the wide range of uncertainty in the estimated cost of the CSO Control Program, there is a correspondingly wide range of uncertainty in the impact of the program on customer rates.

Recommendation 5

WTD projections of the rate impacts of the CSO Control Program should reflect the wide range of uncertainty in the cost of the program.

WTD Rate Structure Does Not Provide Incentives to Reduce Use of the Wastewater System

King County charges local sewer providers a flat amount of $36.10 for each single-family residence connected to the system, and $36.10 for each 750 cubic feet of water used by each multi-family and commercial customer. Therefore, there is no incentive for residential customers to reduce their use of the wastewater treatment system, and no incentive for commercial and multi-family customers to reduce usage below 750 cubic feet.

The lack of sufficient incentives to reduce discharges into the system is important in the context of combined sewer overflows in that the cause of sewer overflows is stormwater entering the system. Many of the homes and businesses within the combined sewer system have roof downspouts that are connected to the combined sewer system, and the volume of water from roofs connected to the system can be a significant contributor to combined sewer overflows. Additionally, stormwater runoff from driveways and parking lots can also enter the combined system through culverts in the street.

The City of Portland has a variety of incentive programs to encourage property owners to divert stormwater out of the sewer system. For example, Portland provides incentives for residential customers to disconnect downspouts from the sewer system, and for owners of commercial property to manage stormwater runoff from impervious surfaces on site.

Disconnecting downspouts from the combined sewer system can be a particularly cost-effective way to reduce volume entering the system. For example, the City of Portland's downspout disconnection program is credited with disconnecting 56,000 downspouts, reducing 1.2 billion gallons of stormwater from the combined sewer system each year. Given the relatively modest cost of the program ($12.8 million) relative to the amount of volume reduction it achieved (1.2 billion gallons per year); it is an extremely cost-effective way of addressing the cause of combined sewer overflows.

As a wholesale provider of wastewater services, King County does not have the one-to-one customer relationship with individual customers in order to provide direct incentives to customers to reduce their use of the wastewater system. Instead, King County would need to work with their local sewer agency customers to encourage them to work with their customers to reduce stormwater inflow into the system. This creates an additional level of complexity in trying to address the behavior of individual customers. However, given the cost-effectiveness of the downspout disconnect program in Portland, the additional level of complexity should not deter consideration of cost-effective ways of reducing the amount of stormwater entering the system.

King County is working with the City of Seattle on various programs of mutual benefit to reduce sewer overflows. However, these efforts do not include the provision of rate incentives to encourage customers to reduce their use of the combined sewer system. While the City of

Seattle's RainWise downspout disconnection program covers a portion of the cost for customers to participate in the program, it does not cover all of the cost, and therefore provides little financial incentive.

Conclusion

Rate incentives could be a cost-effective way of reducing the cost of the CSO Control Program.

Recommendation 6

King County should enhance its efforts to work with the City of Seattle to provide incentives for individual customers to reduce their use of the wastewater treatment system.

Evaluating Green Stormwater Infrastructure Planning

Section Summary

This section of the report discusses green stormwater infrastructure (GSI): what it is, why the experience of GSI implementation is critical to WTD's CSO Control Plan, and how the methodology WTD uses to incorporate GSI into the plan could be improved. Due to its unique role as a regional services provider, WTD faces barriers in implementing GSI alternatives, and its project development methodology accordingly did not consider some applications of GSI approaches for CSO control. We recommend that WTD reconsider aspects of its approach to CSO control planning, in both individual control projects and within the overall CSO Control Plan, to allow for the application of GSI in CSO control to the maximum extent feasible.

Background on Green Stormwater Infrastructure: Reduced Costs and Green Benefits

Across the nation, CSO control project options and alternatives are increasingly including GSI. GSI consists of infrastructure engineered to mimic natural systems, reducing runoff from developed areas through infiltration and evapotranspiration, or through stormwater reuse. GSI often features trees, shrubs, and other "green" elements. By preventing stormwater from entering the combined sewer system, GSI reduces the system demand that causes CSOs. Stormwater control programs that integrate green and gray infrastructure components can maximize control effectiveness for lower cost, compared to "all-gray" approaches without GSI. For these reasons, the United States Environmental Protection Agency (EPA) encourages application of GSI approaches "to the maximum extent possible" in stormwater and CSO control; similarly, the Washington Department of Ecology requires utilization of GSI to the "extent feasible" for projects within minimum stormwater control thresholds.

GSI provides WTD's rate payers an opportunity to mitigate the significant cost risk of the plan's $711 million in gray infrastructure projects. Ensuring consideration of the full array of GSI alternatives available and applying them to their maximum extent across the CSO Control Plan could reduce costs. Nationwide, GSI projects have proven to be of equivalent or lower cost in comparison with traditional gray alternatives – an experience confirmed by regional municipalities including Portland and Bremerton. According to the EPA, in addition to reducing costs, GSI has the added benefit of conserving treatment capacity within the combined sewer system, and providing additional green space, increasing property values, and reducing urban heat island effects.

Evaluating Green Stormwater Infrastructure Planning

WTD's Concerns and Challenges With Using GSI in CSO Control

GSI is supported by regional officials with experience in its application,[7] and WTD staff expressed general support for GSI approaches in CSO control. However, in discussions regarding project planning methodology, some WTD staff opined that GSI has more uncertainty than comparable gray alternatives in ensuring that CSO control projects meet the one event regulatory standard, and, therefore, could not easily be compared directly with gray infrastructure in terms of system modeling and cost-effectiveness. WTD staff explained that GSI carries performance risks in its application in CSO control and management, in that most of the "industry" experience with GSI – including WTD's – is in the context of low-impact development and localized stormwater control, not in attenuating CSO overflows.

While WTD's perspective is understandable, this concern should be balanced with the significant cost risks presented in constructing gray infrastructure and with the recognition that gray projects also present performance risks of their own. WTD also faces external challenges. Unlike Bremerton, Portland, Seattle, and other jurisdictions that have successfully carried out GSI approaches, WTD does not have a direct billing and stormwater regulation relationship with the consumers that contribute stormwater to the combined system. Instead, WTD has a contractual relationship with City of Seattle and Seattle Public Utilities (SPU). SPU bills its customers and WTD is paid a set per-customer sewerage consumption rate, regardless of the consumer's actual contribution to the system. WTD also lacks direct regulatory authority to compel particular actions by those customers relative to stormwater control. Although a high level of collaboration was reported by both WTD and SPU staff, this relationship impacts WTD's ability to directly implement potentially cost-effective GSI approaches.

WTD's Approach Defaults to Gray Infrastructure Solutions in CSO Control Projects

We found WTD's CSO control project development methodology limited the consideration and inclusion of GSI approaches in the recommended CSO Control Plan. The CSO Control Plan features gray infrastructure approaches for each of the nine CSO control projects, but appends a GSI component on four of the nine project areas. The development of the GSI alternatives in the CSO Control Plan was conducted independently of the gray alternatives, and considered GSI as a potential overlay on the CSO project areas.

[7] Some regional officials have noted concerns with widespread regional implementation of GSI in the context of the Department of Ecology's stormwater management/development regulations; these concerns are limited as they relate to CSO control since all King County CSO outfalls are located within the City of Seattle.

Evaluating Green Stormwater Infrastructure Planning

WTD's Triple-Bottom-Line project selection methodology, intended to include social and environmental factors along with costs, consisted of the gray project options and did not clearly show that GSI was considered as a criterion among all project alternatives. Although WTD performed an evaluation of GSI in the 14 CSO basins, it did not directly compare the cost-effectiveness of GSI in each basin with their gray infrastructure counterparts in recommending control projects. The program's $711 million estimated cost consists entirely of gray infrastructure.

WTD staff explained that the $711 million estimate utilized gray alternatives as a conservative measure for costing purposes early in the planning process. Although WTD supports the social and environmental benefits of GSI, the uncertainty and variability in GSI applications limits it to CSO basins where engineering studies show its potential to be effective. However, as detailed below, we found that the methodology and criteria for evaluation of GSI alternatives and selection of potential application areas for application was, in some aspects, unclear.

An explanatory factor in WTD's approach to GSI planning may be its lack of direct experience in GSI projects and approaches. Other regional municipalities, including Portland, Bremerton, and others, have effectively utilized GSI approaches at both the programmatic level and within individual control projects. The Barton CSO control project, currently in design, is WTD's first GSI project, and represents WTD's commitment to incorporate GSI principles into CSO control efforts.

Despite this commitment, we found that implementation of GSI to its full potential in the CSO Control Plan may be limited by two central problems:

1. WTD's planning methodology documentation did not show it considered the full range of known GSI alternatives available, or opportunities for GSI innovation. Some approaches used by other municipalities were not included or documented in the GSI analysis.

2. WTD limited the extent to which some of the GSI approaches it did consider could be applied, based on qualitative thresholds rather than cost-effectiveness or other criteria.

Related to both of these issues are WTD's unique external challenges, in that it that does not have the full range of incentive tools utilized by other jurisdictions that have a direct relationship with its customer base to maximize utilization of GSI.

WTD Unnecessarily Limits Inclusion of GSI in the CSO Control Plan

WTD's analysis of potential GSI alternatives for the CSO Control Plan is documented in Technical Memorandum 810, *Green Stormwater Infrastructure Alternatives* (TM 810). We found a significant disconnect between the TM 810 analysis and the resulting CSO Control Plan.

If GSI is to be applied to the "maximum extent feasible" per regulatory standard, the CSO project planning methodology should apply GSI to the extent it is cost-effective to do so. Doing so requires estimating the cost-effectiveness of GSI versus gray infrastructure components, and then implementing GSI in those locations where it is of comparable or lower cost than its equivalent gray infrastructure alternatives.

Although TM 810 includes an estimate of costs among GSI approaches, the CSO Control Plan does not include a cost-benefit analysis comparing GSI with gray alternatives, either in project- or plan-specific cost estimates. GSI costs are not included, "as they are expected to replace and reduce [gray] project costs" in the basins selected for GSI. Instead, WTD's TM 810 methodology considered GSI based on its potential feasibility within each CSO basin, determining that potential feasibility based on subjective factors. WTD's TM 810 methodology included a number of threshold analysis steps, including:

- Four of the 14 CSO basins were eliminated from geographic information systems (GIS) and stormwater modeling of GSI opportunities based on a "high-level assessment;"
- GIS modeling determined the areas suitable for GSI in each basin, eliminating steep slopes, slide-prone areas, and the like;
- From these suitability figures, application of GSI alternatives assumed high and low technical feasibility and participation range thresholds; and
- GSI cost analysis estimated costs for application of GSI in each basin up to these thresholds.

TM 810 did not recommend CSO basins for consideration of GSI alternatives. The areas (CSO basins) found most promising for the application of GSI (shown in the "Rank" column in Exhibit D, below) do not fully align with the project basins actually selected for GSI in the CSO Control Plan (as shown in the “Selected" column of Exhibit D):

Exhibit D: Comparison of TM 810 Potential GSI Effectiveness with Plan GSI Project Areas

CSO GSI Basin	Estimated Runoff Volume Reduction (MG)[8]		Estimated Runoff Volume Reduction (% of total)		Rank (% High)	Selected as GSI Project in Plan
	Low	High	Low	High		
Brandon St	0.2	1.7	2%	15%	1	
11th Ave NW	0.7	5.2	2%	14%	2	X
University	2.9	16.6	2%	10%	3 (Tie)	X
S Michigan St	0.8	5.0	2%	10%	3 (Tie)	
3rd Ave W	0.2	1.7	1%	8%	5	
Montlake	0.7	3.3	1%	6%	6	X
Hanford	0.6	3.8	1%	4%	7	
Chelan Ave	0.2	1.5	0%	3%	8 (Tie)	
W Michigan St	0.0	0.1	0%	3%	8 (Tie)	X

Source: TM 810; CSO Control Plan.

Chapter 5.7 of the June 2012 *CSO Control Program Review* summarizes the reasons why the above basins were not recommended for GSI.

[8] MG: million gallons.

Exhibit E: Summary of CSO Basins Not Recommended for GSI [Table 5-11, 2012 CSO Control Program Review]

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

Source: 2012 CSO Control Program Review Report, Table 5-11 pg. 5-37.

In discussing the GSI evaluation methodology, WTD staff remarked that GSI opportunities were evaluated for all basins, and elucidated the challenging context of CSO control as requiring highly technical modeling of stormwater flow and volume to guide sizing and location of potential project alternatives and components. WTD explained that the additional time and cost involved in performing modeling made doing so cost-prohibitive, where GSI opportunities are limited, and are therefore “not feasible.” However, WTD was unable to provide documentation of quantitative criteria or analysis used to reach these conclusions.

Other aspects of the GSI evaluation process in the CSO Control Plan may limit GSI’s potential application. The modeling within TM 810 was limited to stormwater volumes and not flow rates. Cisterns were therefore not given any credit; in terms of potential CSO control benefit, because they are “not capable of reducing flow volumes.” And the project selection process – including the Triple-Bottom-Line scoring methodology – did not include comparisons of GSI alternatives among the project component alternatives. As a result, the analysis regarding the potential application of GSI was not fully incorporated in the project selection process for the CSO Control Plan.

WTD's GSI Approach Creates Risks

Although GSI's potential can help minimize cost risks for both individual CSO control projects and for the entire CSO Control Plan, WTD's analysis limitations are exacerbated by jurisdictional challenges. For example, WTD staff identified the Barton CSO control project as a model of the project development process to be used in the remaining CSO control projects. But the Barton analysis did not consider downspout disconnection infiltration as a potential option in the project area despite other jurisdictions, such as Bremerton and Portland, are effectively using such approaches for well over a decade. WTD explained that some GSI approaches were not only considered at Barton due to the very early stage of the project, but also due to the lack of a direct customer relationship. WTD staff noted that SPU's RainWise program had not been fully implemented and was not available for the Barton analysis, and that recent reevaluation by the Barton project team revealed that RainWise type alternatives are feasible.

These issues carry through into WTD's analysis in the CSO Control Plan. For instance, TM 810 assumes a target participation rate in SPU's residential infiltration program, RainWise, ranging from 10 to 35 percent; WTD staff reported that SPU RainWise pilot projects found a 22.5 percent program participation rate. However, other jurisdictions have captured participation rates in excess of 60 percent in residential infiltration programs. Thus, if held to these assumptions, WTD's present CSO control project selection and development processes may limit application of GSI options where higher costs can be avoided and overall public benefit may be realized. WTD staff have informed us that, during the project development phase for the selected GSI basins, technical and participation targets may be set higher if the project stormwater modeling and cost analysis support doing so.

WTD should continue to increase its institutional expertise and capacity with GSI, strengthening its program methodology to address the planning and jurisdictional challenges noted above. Phasing implementation of the individual control projects within the CSO Control Plan could allow time for improved planning and wider application of GSI, potentially resulting in lower costs.

Recommendation 7

WTD should increase its institutional knowledge and expertise with GSI and strengthen its program methodology to address its planning and jurisdictional challenges by:

a) Examining and investigating innovative and cost-effective GSI approaches successfully utilized by other jurisdictions, such as Portland's downspout disconnection program;
b) Continuing detailed GSI-effect modeling (based on EPA's (Storm Water Management Model also known as SWMM model) for CSO basins feasible for GSI, not just basins pre-selected as having a GSI project component;
c) Performing an analysis of cost-effectiveness and cost comparison of GSI with gray infrastructure alternatives for each CSO project basin, applying GSI in the project design phase to the maximum extent cost-effectively possible and setting project targets based on these maximums;
d) Allowing for a wider range of GSI alternatives consideration in the project development phase for each CSO control project basin; and
e) Revising the planning model for future iterations of the CSO Control Plan to integrate GSI planning and engineering into each project recommendation (while keeping the gray component for early phase cost estimating).

Recommendation 8

WTD should phase implementation of the individual control projects within the CSO Control Plan, ensuring inclusion of greater system modeling to assess wider application of GSI in each CSO basin, developing integrated project approaches, and providing a more concerted GSI strategy overall.

Evaluating the Cost-Effectiveness of CSO Projects

Section Summary

WTD is thorough in its evaluation of individual gray infrastructure alternatives. However, WTD should work to better understand water quality impacts from CSOs and the cost-effectiveness of reducing the volume of pollution when considering the priority or sequencing of projects. In 1996, WTD reached agreement with the Washington Department of Ecology to revise the schedule of CSO projects which had been focused on removing 75 percent of CSO volume by 2006. Among the reasons for this change, three are particularly relevant to this performance audit:

1. The most cost-effective projects in terms of volume reduction also happened to be the most expensive;
2. There was a concern that focusing on volume reduction would drive early implementation of projects perceived to have less public health and environmental benefit than others; and
3. WTD had a desire to obtain a better understanding of the environmental effects of CSOs and the appropriate priorities for their correction.

Since that time, in setting project priorities, WTD has considered factors such as human health exposure, receiving water characteristics, and coordination with other projects for increased environmental benefits.

What has not changed since that time is that there is still a lack of conclusive scientific knowledge about environmental impacts for choosing one sequence of CSO control projects over another. Also, some of the most cost-effective projects, in terms of volume reduction, still remain the most expensive.

In this section of the report we offer a method of evaluating the cost-effectiveness of pollution reduction that is different. Because a scientific weighting of pollution effects is not available, this method still focuses on the volume of discharge reduced, but does so while recognizing that volume reduction has a time value – that gallons of sewer overflow reduced now have greater value than gallons reduced in the future. This same methodology could be employed if a more sophisticated approach using weighted pollution effects were available.

Evaluating the Cost-Effectiveness of CSO Projects

To illustrate how the new method can be used, this section of the report includes the example of a project sequence that could remove an additional 3.5 billion gallons of CSO discharge, with about the same impact on rates as the sequence in the currently proposed plan. This kind of information can be used as a way to quantify the opportunity costs of choosing one sequence of control projects over another.

We include recommendations for WTD to begin developing quantitative measures of the impacts on water quality from CSO control projects, and to consider the time value of CSO control project volume reduction as part of the evaluation of control projects and sequences.

WTD's Approach

WTD's recommended CSO Control Plan (October 2011), which formed the basis for the County Executive's recommended plan (June 2012), was developed through a multi-phase, thorough process that considered the costs of control project alternatives at several junctures during the planning process. Of the nine control projects in the proposed plan, four were identified as having opportunities for green stormwater infrastructure (GSI) to be part of the control solution. The analysis of costs was limited to the full gray infrastructure versions of the alternatives until such a time that WTD further progressed in the design phase for the four projects. Once in the design phase, WTD intends to examine the costs and effectiveness of GSI alternatives.

As part of its approach, WTD first evaluated control alternatives as to their feasibility, and then considered costs in determining which preliminary alternatives would go forward as final alternatives. These final alternatives were then evaluated using a Triple-Bottom-Line analysis, which seeks to balance financial, social, and environmental concerns. Value scores quantified social and environmental criteria as measures of effectiveness. Risk was applied as an indication of uncertainty in both cost and effectiveness.

Overall, WTD's approach was to address cost-effectiveness on a project-by-project basis, identifying the most cost-effective gray infrastructure alternative for reducing overflows for particular outfalls. The approach did not, however, evaluate the individual projects or project sequencing based on the cost-effectiveness of reducing volume or pollution.

Evaluating the Cost-Effectiveness of CSO Projects

For the purposes of this audit, WTD provided a succinct explanation and documentation of how its process for recommending project sequences has evolved since the early 1980s. This explanation reflects our understanding of events as well, and we are providing it in its entirety below.

Exhibit F: How WTD's Approach to Control Project Sequencing Has Changed

> Prioritization of projects is a complex process that seeks to balance the types of pollutants of concern and their hazards, the sensitivity of the water bodies and their uses, the quantity and duration of exposure to pollutants in those water bodies, and the potential liabilities resulting from the overflows. At this time such a sophisticated metric is not available. EPA and Ecology have described qualitative approaches, including screening and ranking models that identify factors to be considered however no truly quantitative prioritization methods currently exist.
>
> Beginning in the early 1980s, WTD initially assessed volume reduction for prioritization and negotiated a control target of 75% volume reduction with Ecology. However, as knowledge improved via regional and WTD studies such as the 1998 CSO Water Quality Assessment of the Duwamish and Elliott Bay, it became clear to WTD that focusing on volume reduction drove early implementation of projects providing less public health and environmental benefit than others. In 1996, Ecology agreed to release WTD from the 75% volume reduction target and concurred with an approach to prioritize CSO projects based on public health, endangered species and environmental protection. It was agreed that the 1999 RWSP WTD would propose a different prioritization approach and a control program end date. In approving the RWSP Ecology defined the "greatest reasonable reduction of CSOs at the earliest possible date" for WTD as achieving 1 event per year on average at each CSO by 2030. As directed by Council in Ordinance 15602 and RWSP Policy CSOCP-2, WTD used public health, endangered species and environmental protection qualitatively in prioritizing and sequencing projects. WTD continued that approach in the current planning process, expanding the factors to include new definitions of public health around fish consumption and evaluation of Superfund liability risks and opportunities.

Source: WTD.

One point we would add to this description is that when WTD moved away from the focus on volume, the metric used at that time was dollars per gallon controlled. The method we describe later in this section is different in that it also takes into account the time value of the gallons controlled.

Evaluating the Cost-Effectiveness of CSO Projects

Guidance from Regulatory Agencies

The EPA does not give guidance on particular methodologies or criteria for prioritizing CSO control projects in a way to achieve the most cost-effective reduction of pollution.

The state of Washington does have criteria for cost-effectiveness, as are reflected in the Washington Administrative Code:

> *This can include a determination of the monetary cost per annual mass of pollution, per annual volume reduction, and/or per annual frequency reduction achieved by each project.*[9]

WTD currently does not employ a quantifiable measure of cost-effectiveness in how it prioritizes projects, but does focus on the costs of projects in terms of their effectiveness in reducing events to meet the state standard.

Information to Weigh Pollution Effects Is Lacking

Ideally, a determination of the cost-effectiveness of control projects would be based on data that would allow one to know how the pollutant loading from a particular outfall poses health risks and degrades the quality of the receiving body of water. Unfortunately, such data and a pollutant weighting methodology are not available at this time. In our interviews with WTD, Ecology, the EPA, and other stakeholders, one of the standard questions we asked was whether the agency had enough information that could be used to conduct a cost-effectiveness analysis based on the weighted effects of pollutants. Uniformly, the answer was no. Moreover, WTD's *Technical Memorandum 540 Environmental and Habitat Priorities* concluded that on a scientific basis it was difficult to prioritize CSO control in one body of water over another. And subsequently, when WTD considered prioritization of CSO control efforts based on an analysis of sensitive areas, which is an EPA requirement, its qualitative review gave similar rankings to the areas that would be affected by the remaining control projects. This qualitative review underscored the conclusion of *Technical Memorandum 540*. In the current proposed plan, given the lack of conclusive scientific evidence, WTD and the County Executive have given priority to the Duwamish River projects, taking into account environmental concerns and recognizing the County's role in the regional cleanup effort concerning this waterway.

[9] WAC 173-245-040 (2) (d) (ii).

Evaluating the Cost-Effectiveness of CSO Projects

Executive Has Proposed a New Study

In order to advance knowledge and to better understand the scientific research that may be available, the County Executive has recommended, and the County Council has approved, completion of a Water Quality Assessment and Monitoring Study. This study is designed to take a comprehensive view of the effects on water quality in the sub-watersheds where CSO discharges occur. The study is estimated to cost approximately $5 million and would be scheduled to have findings and recommendations in 2016. It would look at a range of actions to improve water quality, potentially integrating CSO control planning with stormwater controls. According to the County Executive and underscored by the County Council, the results of the assessment may identify benefits to changing the sequencing or prioritization of the CSO projects but would not alter the County's legal obligations to complete the remaining nine CSO projects.

Since an aim of the study is to identify the kinds of investments that will bring the best value in terms of improving water quality, a potential outcome and benefit would be to shed more light on relative polluting effects of the combined sewer overflows that the County has committed to control by 2030. It is difficult to predict at this time, however, how or by what degree decision-making about project prioritization would be improved.

In the meantime, there are estimates from WTD about CSO discharge volumes that can be used as a proxy for pollution in the absence of better information. Although it is an imperfect measure, consideration of volume reduction can enrich the discussion of project prioritization and sequencing.

Volume Matters

The importance of the volume of sewer overflow has long been recognized on the federal, state, and county level.

- The federal Clean Water Act of 1972 created a standard of performance for "the control of the discharge of pollutants which reflects the greatest degree of effluent reduction."[10] In setting CSO control policy, the EPA allowed compliance with a volume reduction standard as one of the ways presumed to meet the water quality-based requirements of the CWA.
- In Washington State, RCW 90.48 is the law that governs CSOs and the actions that jurisdictions must take to control overflows. This law states that the CSO compliance schedule "shall be designed to achieve the greatest reasonable reduction of combined sewer

[10] Federal Water Pollution Control Act (Clean Water Act), 33 USC 1251, Sec 306 (a) (1).

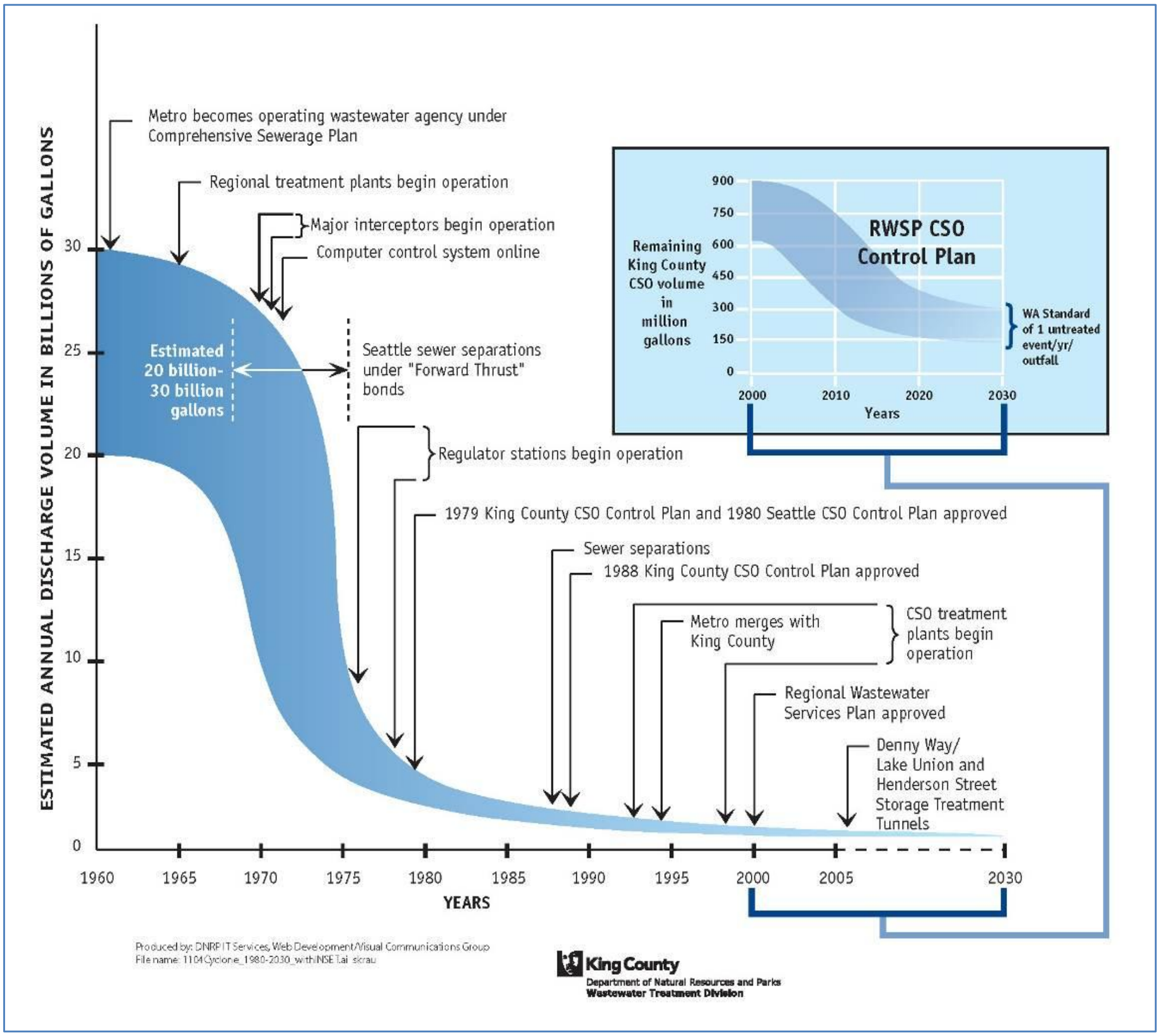
overflows at the earliest possible date."[11]

- When administrative rules were developed to implement state law, volume reduction was included as a cost-effective criterion.
- For King County, recognition of the importance of volume reduction, and the per-gallon cost of volume reduction, has been emphasized numerous times over the years. At the time that the state of Washington was beginning to codify its CSO control requirements in 1987, the head of the Water Pollution Control Department for Metro (the predecessor agency of WTD), argued for a cost-effectiveness criterion based on the cost per gallon of treated CSO discharge. Then, in 1988 Metro revised its CSO Control Plan and established a goal of achieving a 75 percent CSO volume reduction by the end of 2005. Since then in the 1999 RWSP, WTD included cost per gallon as one of the metrics in its planning process; and a key measure of agency performance over time has been the reduction of wastewater released into the waterways, as illustrated in the following exhibit.

[11] RCW 90.40.480.

Evaluating the Cost-Effectiveness of CSO Projects

Exhibit G: WTD's Annual Discharge Volume Graphic



Source: Wastewater Treatment Division.

To put the matter of volume into perspective, it is helpful to contrast volume reduction with overflow event reduction. Two recent years, 2008 and 2010, can serve as examples. Both were exceptional years in that 2008 was a low volume discharge year, whereas 2010 was an exceptionally high volume year.

For these two years, the ratios of the largest discharge events to the smallest events were as follows:

- In 2008 the ratio of the largest event to the smallest event was 243 thousand to 1.
- In 2010 the ratio of the largest event to the smallest event was 1.5 million to 1.

In 2008 the smallest event was only 69 gallons compared to 175 million gallons for the largest event in 2010. Yet each of these events counted the same in terms of whether the county is meeting the state standard.

Most importantly, volume matters because the stormwater that comprises the vast majority of the gallons of sewer overflow is a major source of pollution itself. According to the Puget Sound Partnership,[12] surface runoff is the primary pathway for toxic chemicals getting into Puget Sound. These pollutants include oil and grease, PCBs, phthalates (a plasticizer), PBDES (a flame retardant), as well as toxic heavy metals such as copper, lead, and zinc, all of which have harmful environmental effects. In its recent effort to quantify the costs of stormwater retrofit for Puget Sound, the partnership used a measure of pollution that was ultimately based on volume.

Finally, volume reduction may be the most relevant of the cost-effectiveness criteria currently available. The WAC requirements for the CSO Control Program say that priority rankings of control projects shall consider mass pollutant reduction, volume reduction and/or [event] frequency reduction. WTD collects information about the mass of pollution discharged from outfalls, but has found that the variability between discharges at a single outfall was greater than that between outfalls. Therefore, averages have very wide standard deviations, making them not very useful. WTD's conclusion was that the quality of the discharge was similar at all outfalls. And, as illustrated above, an event can be a discharge within an enormous range, making the use of event frequency of questionable value as part of a cost-effectiveness criterion.

[12] Puget Sound Partnership was created by the Washington State Legislature in 2007 to coordinate and lead the effort to restore Puget Sound by 2020.

Evaluating the Cost-Effectiveness of CSO Projects

There Is Value in Reducing Pollution Sooner

Untreated stormwater and wastewater creates polluted sediments and ambient water, can pose health hazards, endanger species, and reduce beneficial uses of water bodies. The longer the pollution persists from any source, the worse the situation can become. For this reason, pollution reduction has a time value, meaning that reducing pollution now has a greater value than reducing it sometime in the future. If there were no time value of pollution there would be no urgency for controlling combined sewer overflows by any particular date.

The life cycle cost analyses performed by WTD in evaluating the cost-effectiveness of project alternatives have taken into account the time value of money. In looking at alternatives for each CSO project, WTD was consistent in how it portrayed costs by showing all net present values in terms of 2010 dollars. For simplicity's sake, and as a practical matter, WTD also estimated the life cycle costs of all project alternatives as though they had the same 2010 starting date. For comparing individual project alternatives, the approach WTD took was appropriate. However, treating all projects as though they start at the same time does not address the issue of how project sequencing can impact pollution over time. Another way to think about the issue is to consider the entire plan to control combined sewer overflows as a single project that achieves overflow reduction in increments, with a deadline for meeting the event standard by year 2030.

To illustrate how taking the time value of pollution into account could provide valuable information to policy-makers, we have looked at the potential impacts of re-sequencing some of the preferred CSO control projects. We started by comparing the recommended control projects in terms of cost per gallon of discharge avoided. The example of re-sequencing we provide below focuses on doing the most cost-effective volume reduction projects first and giving the maximum time possible for identifying cost-effective GSI approaches for the basins where GSI according to WTD is most promising.

Evaluating the Cost-Effectiveness of CSO Projects

The purpose of this analysis is not to recommend a particular project sequence, but rather to illustrate how the time value of volume reduction can be quantified for purposes of cost-effectiveness analysis. In this case, we are using volume, which can be quantified, as a proxy for pollution. Of course, if a more sophisticated approach using weighted pollution effects were available, the same analysis could be done with that information.

We see the approach of taking into account the time value of pollution, or volume reduction as a proxy, as something that can and should be considered along with other factors such as probable and potential impact on human health. A particular value of the approach is that it can be used as a way to quantify the opportunity costs of choosing one sequence of control projects over another.

Cost Effectiveness of Volume Reduction Can Be Estimated

The information presented below on the cost-effectiveness of the preferred alternatives is based on our own update of the life cycle cost analyses performed by WTD, combined with information about the average volume of overflow expected to be avoided by the control projects.

One of the key observations from the analysis is that the most expensive project in terms of net present value (NPV) (the Hanford, Lander, King Dome, King Street project - HLKK) is also by far the most cost-effective project when effectiveness is defined as volume of discharge avoided. This single project accounts for 39 percent of the total NPV for all projects, but is estimated to achieve on an annual basis 73percent of all the discharge reduction.

The table below shows how the individual projects compare. NPV refers to the net present value of the full life cycle costs of each project over its expected useful life.[13] The NPVs are then expressed as annual equivalents. As can be seen, there is a wide range in annualized cost per gallon of overflow avoided. The most expensive per gallon, West Duwamish (WDUW),[14] is about 50 times more than HLKK (on a per gallon basis).

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[13] For these calculations we used a real discount rate of 5% and an inflation rate of 3%. Technical Appendix 1 describes the results of a sensitivity analysis of these and other assumptions.

[14] This project combines control of the West Michigan and Terminal 115 outfalls.

Exhibit H: Cost-Effectiveness of Annual Gallons of Discharge Avoided

	NPV (millions)	Percent NPV	Annualized (millions)	Ann. Gal Avoided (millions)	Ann. Cost per Gal. Avoided	Percent Gal. Avoided
HLKK	$199.1	39%	$11.23	497.2	$0.023	73%
Brandon	$104.2	20%	$5.88	118.4	$0.050	17%
11th Ave.	$15.2	3%	$0.86	10.3	$0.083	2%
Hanford@ Rainier	$12.9	3%	$0.73	6.0	$0.121	1%
3rd Ave.	$34.3	7%	$1.94	13.1	$0.147	2%
Chelan	$36.7	7%	$2.07	13.1	$0.158	2%
Montlake	$66.5	13%	$3.75	17.9	$0.209	3%
University	$32.2	6%	$1.82	3.7	$0.489	1%
WDUW	$10.4	2%	$0.59	0.5	$1.178	0%
Total	$511.6	100%	$28.87	680.3	$0.042	100%

Source: KCAO analysis of WTD data.

Re-Sequencing Example

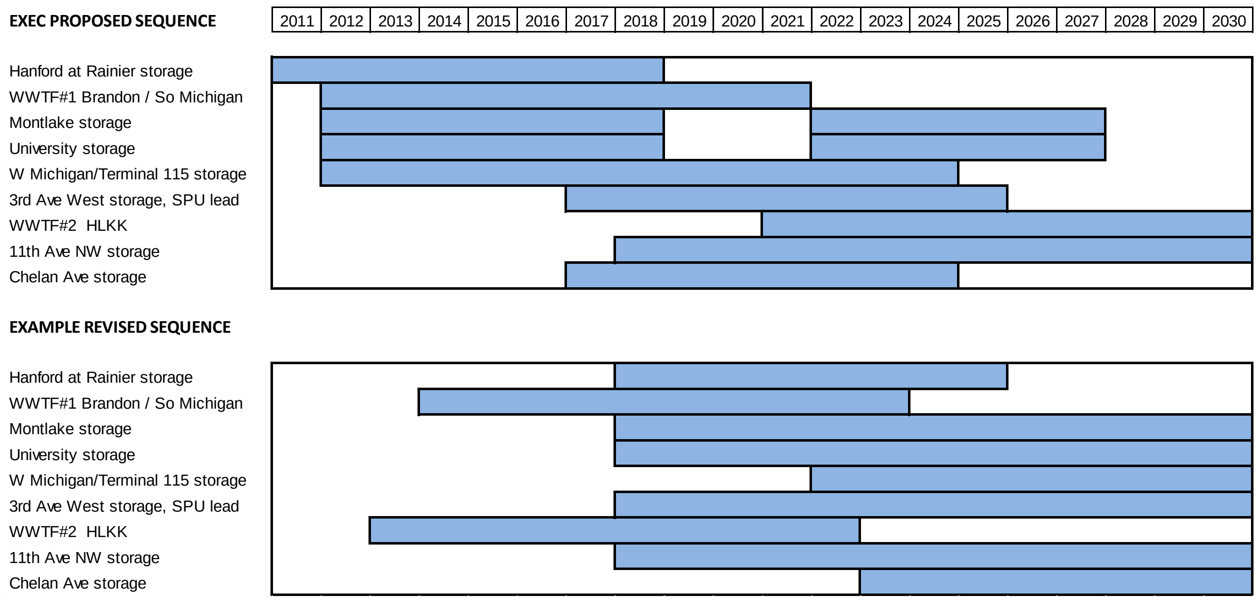
Under the current plan, HLKK would not be completed until 2030, the deadline King County has per its commitments to EPA and Ecology. Under the example scenario we have created, this project would begin sooner and be completed eight years earlier. In general, the emphasis with this example is a focus on:

- doing the most cost-effective projects first (in terms of overflow volume reduction);
- delaying GSI-potential projects in order to further explore GSI applications and take advantage of the best and most successful strategies to employ; and
- staggering projects in a way to mitigate and smooth rate impacts.

A comparison of the County Executive's proposed project sequence to the example scenario is shown in the exhibit below.

Evaluating the Cost-Effectiveness of CSO Projects

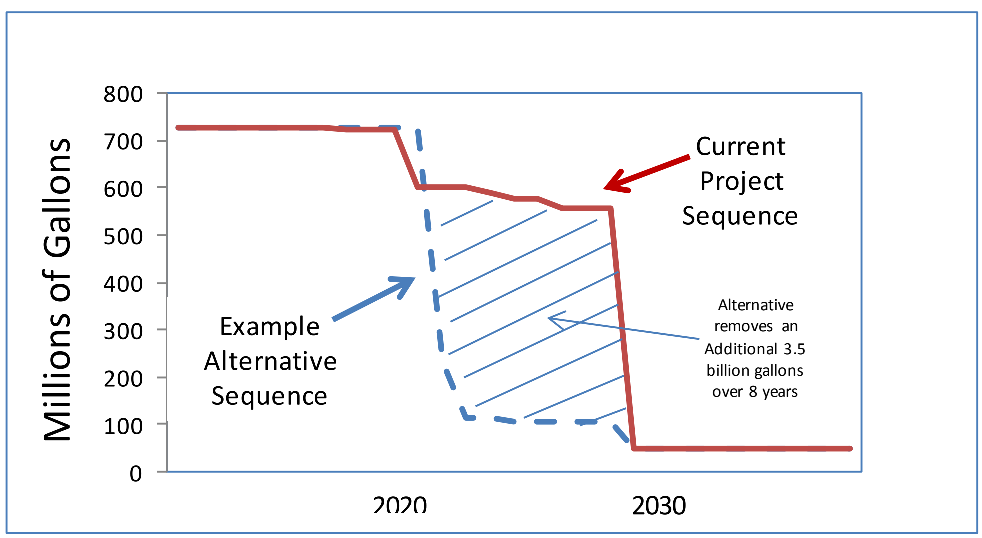
Exhibit I: Comparison of Project Sequences



Source: Information provided by WTD with re-sequencing conducted by KCAO.

The next chart provides a representation of how the example of re-sequencing could remove an additional 3.5 billion gallons of discharge between now and 2030 compared to the current recommended plan. Both the current plan and the example eventually reach the same target of annual discharge avoidance and meeting the one-event standard. The example scenario simply achieves most of the result earlier.

Exhibit J: Gallons of CSO Discharge



Source: KCAO analysis of WTD data.

Evaluating the Cost-Effectiveness of CSO Projects

The Time Value of Pollution Can Be Taken into Account

In order to make policy choices about project sequencing, both the time value of money and the time value of volume reduction, or ideally pollution reduction, should be taken into account. In order to do so, it is necessary to recognize the timing of the cash flows for the project sequence scenarios as well as the resulting estimated volumes of discharge avoided. Once this is done, the present value of the volume reduction can be discounted just like any economic benefit.

Again using the example sequence scenario in comparison to the project sequence in the recommended plan, the results of calculating a net present value of cost per gallon of discharge avoided are shown in the following table. A description of the methodology, together with a sensitivity analysis, is included in Appendix 1.

Exhibit K: Cost-Effectiveness Based on Discounting both Dollars and Discharge Volume

	Analysis to 2080 (50 yrs from last project end)		
Discharge Avoided/Cost-Effectiveness	NPV $	NPV Gallons	NPV $/Gal.
WTD Preferred Alternatives and Sequencing	$418,093,659	2,448,397,532	$0.1708
Alternative Example	$435,181,084	3,562,240,809	$0.1222

Source: KCAO analysis of WTD data.

By this comparison, the NPV cost per gallon of discharge avoided is 28 percent lower than the cost under the current recommended project sequence. What is interesting to note is that even when we assumed no time value of pollution (i.e., using a discount rate of zero), the NPV cost per gallon of the alternative was still lower, by about 5 percent, than the cost of the current sequence. What this means is that giving any consideration to the time value of volume reduction lowers the cost per gallon of the alternative sequence. The more value that is given to that time (that is, the higher the discount rate), the lower the cost becomes in comparison to currently proposed sequence.

We chose this particular re-sequencing example because it could meet the federal criterion of greatest degree of effluent reduction, and because it could meet the Washington state criterion of the greatest reasonable reduction of combined sewer overflows at the earliest possible date. Other sequences are of course possible, and we recognize that factors other than cost-effectiveness in terms of volume can and should be taken into account.

- For example, in the 1999 CSO Control Plan Amendment, projects were prioritized not on the volume controlled, but on criteria that included protection of public health. For that reason, projects at CSO sites that discharge near beaches on Puget Sound were scheduled for completion first, because of the exposure people would have if they come in contact with sewer overflow during recreational activities such as swimming.

- In the current County Executive's proposed plan, the Lower Duwamish projects[15] are placed first in sequence based on factors such as perceived human health exposure, receiving water characteristics, and coordination with other projects for increased environmental benefits.

Although consideration of the time value of volume reduction is not same or as valuable as a measure that would fully capture pollution reduction and environmental benefits, we still see it as a useful, interim measure. In the current situation where the Lower Duwamish is recommended to be the first in sequence, decision-makers can ask about how much environmental risk there is related to overflows in the Lower Duwamish area, and how doing the Lower Duwamish project first will mitigate those risks. This information can then be considered in light of alternative sequences that might remove a far greater amount of discharge in other areas of CSO discharge that pose different environmental risks. Additionally, in any instance in which project sequences have the same perceived environmental benefit, or where the environmental benefits are simply unknown, the time value of volume reduction could be one of the deciding factors in choosing a project sequence. Lastly, without such a measure we are left with mainly subjective criteria.

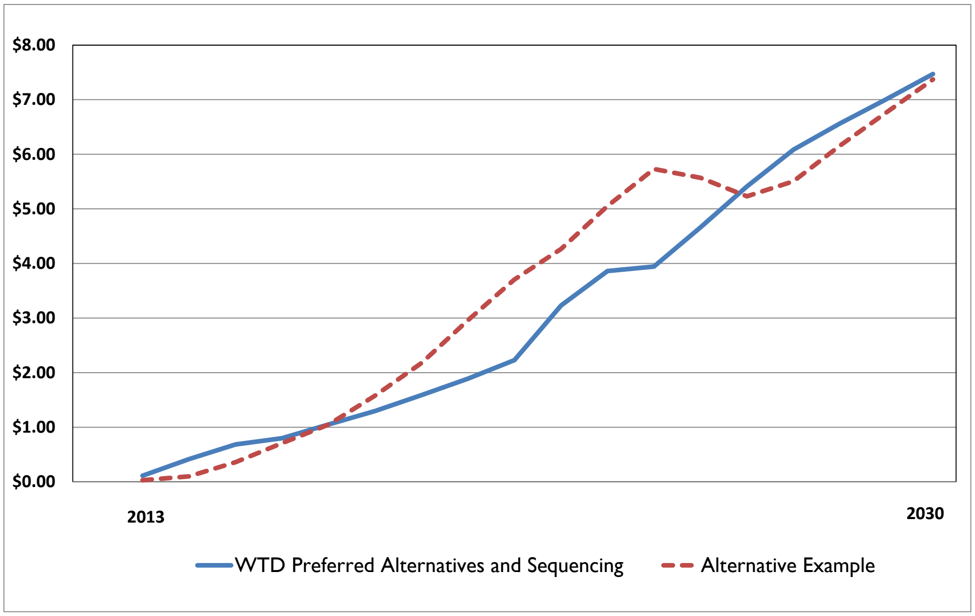
Changing Project Sequence Affects Rates

Any change in the sequencing of projects will have an effect on rates. Based on the current recommended plan, the average net impact on rates of the CSO control project, as expressed in 2013 dollars, would be $2.27 per month, whereas under the alternative scenario we have illustrated, the impact would be $2.53, a difference of 26 cents. The growth in the net increase from the CSO Control Program under the two scenarios is shown in the chart below.

[15] Hanford at Rainier, Brandon, and the combined West Michigan and Terminal 115 projects.

Evaluating the Cost-Effectiveness of CSO Projects

Exhibit L: Net Impact on Rates of CSO Alternatives



Source: KCAO analysis of WTD data.

For the first four years the alternative would have a lower rate impact, then cross over and start to become higher at year five. By the year 2030 the two rate impacts are almost the same. Here is the detail for the first five years:

Exhibit M: 5-Year Net Rate Impacts

	2013	2014	2015	2016	2017
WTD Preferred Alternatives and Sequencing	$0.11	$0.42	$0.68	$0.80	$1.05
Alternative Example	$0.03	$0.10	$0.36	$0.71	$1.05

Source: KCAO analysis of WTD data.

Alternative Financing Can Mitigate Impact on Rates

Under the traditional way of financing capital projects, the kind of bond that is issued has level payments, similar to a fixed mortgage. What this means is that, relative to inflation, debt service is higher in the early years, with a corresponding higher impact on rates in the early years.

Recognizing that under any project sequencing scenario the county's policy-makers may wish to consider ways to mitigate the short and intermediate term impacts on rate payers, we investigated some alternatives for financing. The objective was to see if reducing rate increases could be accomplished without paying a high premium in terms of interest.

We identified two approaches that would likely have a low (identified here as less than 20 basis points) interest premium. They are:

1. Bonds with graduated payments. With these bonds the annual payments start lower than with traditional bonds with level payments,

but then later are higher. The payments on these bonds would start lower than with level payments and increase at 2 percent per year. The interest premium on these bonds would be approximately .2 percent higher (20 basis points) on a 40-year bond.

2. Bonds with an interest only period. With these bonds, payments are for interest only for a prescribed period, and then the principal is refinanced at a predetermined rate for the remainder of the bonding period. The interest premium on these bonds is an additional .05 percent to .1 percent (5 to 10 basis points).

The approximate impact on rates from 2013-2030 is shown below.

Exhibit N: Effects of Alternative Financing

	2013-2030 Avg. Rate Impact in 2013 Dollars	With Graduated Bond Payments	With Interest Only First 10 Years
WTD Preferred Alternatives and Sequencing	$2.27	$1.98	$2.13
Alternative Example	$2.53	$2.22	$2.37

Source: KCAO analysis of WTD data

Under either sequencing scenario, the alternative financing approaches could reduce the average net impact on rates while having only a small effect on the NPV cost per gallon of discharge avoided.

Conclusion

WTD is thorough in its evaluation of individual gray infrastructure alternatives, but has not included an evaluation of cost-effectiveness in a manner that enables consideration of the time-value of pollution reduction specific to water-quality improvement. This could, however, be considered in the future and be addressed in the County Executive's proposed Water Quality Assessment and Monitoring Study, should that study be funded. In the meantime, there are estimates from WTD about CSO discharge volumes that can be used as a proxy for pollution in the absence of better information. Although it is an imperfect measure, consideration of volume reduction can enrich the discussion of project prioritization and sequencing and can be considered along with other factors such as probable and potential impact on water quality improvement and on human health. A particular value of the approach is that it can be used as a way to quantify the opportunity costs of choosing one sequence of control projects over another.

Evaluating the Cost-Effectiveness of CSO Projects

Recommendation 9

To the extent that reliable scientific knowledge is available, WTD should develop quantitative measures of the impacts on water quality from CSO outfalls, and the expected water quality improvements to be provided by each control alternative. The development of such measures should be included in the Water Quality Assessment and Monitoring Study.

a) These measures should then be applied in an analysis of project cost-effectiveness and the time-value of program sequencing alternatives.
b) This analysis should be used to propose updated prioritization and sequencing in the next *CSO Control Program Review*, to be completed in 2018.

Recommendation 10

Until such time that reliable scientific knowledge becomes available, in evaluating the cost-effectiveness of overflow projects and project sequences, WTD should document:

a) consideration of CSO discharge volumes to be reduced, and
b) the time value of volume reduction in evaluating the cost-effectiveness of overflow projects and project sequences.

Appendix I

Sensitivity Analysis of Project Life Cycle Costs and Project Sequences

Life Cycle Cost Analysis (LCCA) Update

For our update of the life cycle cost analysis of finalist CSO control project alternatives, we inflated expenditures to reflect 2012 dollars and utilized the financing capabilities of the WTD model to capture the cash flows related to selling bonds to finance the projects. We also included information provided by WTD regarding the average annual estimated gallons of discharge avoided that can be attributed to each of the control projects.

For assumptions about the real discount rate, inflation, bond interest, bond term and period of analysis, we used the following default values for portraying the results of the analysis in the performance audit report.

Exhibit O: LCCA Variables

		Defaults
Real Discount Rate	0.050	0.05
Inflation	0.03	0.03
Nominal Discount Rate	0.0815	
Debt Issuance Cost	0.02	0.02
Borrowing Rate	0.0463	0.0463
Period of Financing	40	
First Year Original O&M Costs	2019	2019
Useful Life	50	
Original O&M Denomination Yr	2010	
Current Year	2012	2012

Source: KCAO Analysis.

In the exhibit above, the yellow-shaded cells to the left of the defaults are where the defaults can be changed to see how the results of the analysis change.

For purposes of conducting sensitivity analysis, we varied the key assumptions to see whether singly or in combination the results of the life cycle cost analyses would be different (in terms of relative differences between finalist alternatives) from the results portrayed by WTD.

For example, the sensitivity range we set for the Real Discount Rate was 2% to 8%, and for inflation we used 0 percent to 5 percent. Likewise we varied the other key assumptions.

Appendix 1 (continued)

The results of the sensitivity analysis showed that under reasonable ranges for the assumptions, the relative differences among finalist alternative pairs remained approximately the same. This result gives confidence to the choice of the preferred alternatives. For the one project where the preferred alternative (both WTD's analysis and our update) did not have a lower net present value (NPV), the relative differences between the NPVs in the sensitivity analysis remained approximately the same. In this one example, the project alternative that was selected to be preferred, although it had a higher NPV, also had a higher value score.

The Time Value of Pollution

In calculating the NPV of the cost per gallon of discharge avoided by the CSO control projects, we discounted both the cash flow and the gallons of discharge for a period of 50 years beyond 2030 – the deadline for meeting the one-event standard and the end date for the construction of the capital projects.

Discounting cash flow to calculate an NPV is a familiar and standard practice. However, while discounting pollution is not uncommon, it may be less familiar.

We tested the effect of discounting volume reduction, as a proxy for pollution reduction, using the sequence of projects recommended by the County Executive and comparing the result to the example sequence with described in the audit report.

What we found is that without discounting volume reduction, the comparison of NPV $/gallons avoided yielded similar results for both scenarios:

Exhibit P: Cost-Effectiveness without Including Time Value of Discharge Volume Reduction

	Analysis to 2080 (50 yrs from last project end)		
	NPV $	NPV Gallons	NPV $/Gal
WTD Preferred Alternatives and Sequencing	$418,093,659	35,364,756,875	$0.0118
Alternative Example	$435,181,084	38,851,424,375	$0.0112

Source: KCAO Analysis based on WTD Data.

Although the alternative example has a relatively higher NPV cost, it also has higher NPV gallons of overflow avoided, effects which in combination mainly cancel one another. For the calculation results shown in the table above, we set the nominal discount rate (real discount rate factored by inflation) to zero.

Once gallons are discounted to recognize their time value, the difference between the alternatives begins to widen. The table below shows the results of using the same real discount range we used for LCCA sensitivity, and assuming an inflation rate of three percent.

Exhibit Q: Sensitivity Analysis of Discount Rate

	$ / Gallon Avoided	
	WTD Preferred	Alternative
Real DR		
2%	$0.143	$0.112
3%	$0.152	$0.115
4%	$0.161	$0.119
5%	$0.171	$0.122
6%	$0.181	$0.126
7%	$0.192	$0.129
8%	$0.203	$0.133

Source: KCAO Analysis based on WTD Data.

This test demonstrates that the higher the value one places on removing discharge volume earlier than later, those projects that remove the most gallons will have a more favorable NPV $/Gallon as long as they are not relatively too expensive. In the example sequence given in the report, the main reason the alternative is attractive is because the most expensive project – Hanford, Lander, Kingdome, King Street – starts first. This project accounts for 39 percent of total NPV costs, but removes 73 percent of the discharge gallons among the nine projects.

Impact on Rates

In the report we present a table showing the impact on rates of the CSO control project sequences with additional information on the effects of using alternative financing. The table from the report is shown below.

Exhibit R: Effects of Alternative Financing

	2013-2030 Avg. Rate Impact in 2013 Dollars	With Graduated Bond Payments	With Interest Only First 10 Years
WTD Preferred Alternatives and Sequencing	$2.27	$1.98	$2.13
Alternative Example	$2.53	$2.22	$2.37

Source: KCAO Analysis based on WTD Data.

WTD has also published information on the average rate impact for the period 2013-2030. Our approach was different from WTD's in that the average we portray is simply the average of the inflation-adjusted CSO control rate impacts. WTD discounted the rate impacts instead of adjusting for inflation only. We believe that the approach we took would be more easily understood by rate payers.

Executive Response

King County

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September 6, 2012

Cheryle A. Broom
King County Auditor
Room 1033
C O U R T H O U S E

Dear Ms. Broom:

Thank you for the opportunity to review and comment on the proposed final report on the Department of Natural Resources and Parks, Wastewater Treatment Division (WTD) Combined Sewer Overflow Program (CSO) Performance Audit. We appreciated the opportunity to work with your office to provide information and discuss issues related to this extremely complex and technically-challenging program. WTD has a strong culture of continuous improvement, and we were pleased that the audit report determined that "WTD's CSO control program planning is professional, thorough and transparent."

The audit also highlighted specific successes, including the following:

- The lifecycle cost model developed by WTD is robust, technically sound, and a valuable tool for examining the comparative life cycle costs of project alternatives.
- WTD is thorough in its evaluation of individual gray infrastructure alternatives and the planning effort for gray infrastructure included in its CSO control program.

WTD also appreciates that the observations and recommendations in the audit acknowledged the technical complexities of the CSO control program and the challenges associated with the regulatory requirements. Many of the recommendations build on proposals or procedures that WTD is already undertaking, and the recommendations will assist WTD in fine-tuning the program. For example, I appreciate the audit's support for my proposed Water Quality Assessment and Monitoring Study. I anticipate that the King County Council will act on an update to the CSO Plan in September which includes the Water Quality Assessment and Monitoring Study. The purpose of the assessment is to provide a thorough analysis of the factors that impact water quality where our CSOs discharge. This will help us build on our work to determine the most cost-effective and beneficial sequencing of CSO projects.

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Cheryle A. Broom
September 6, 2012
Page 2

WTD generally concurs with the recommendations, and as indicated in the Attachment, many of them are already being implemented. The recommendations for specific improvements to the WTD cost model are underway, and we are confident these will make an excellent analytical tool even more effective. The cost model is used to weigh and evaluate alternative projects not only based on cost, but also based on the greatest potential benefits to public health and the environment.

As noted in the comments, WTD believes it has followed its guidelines for life cycle cost analysis when there is a significant change in scope for a selected CSO project alternative. It is important to note that any determination regarding revisiting alternatives must be balanced against the benefits and potential costs and delays associated with further analysis.

I also strongly support the use of Green Stormwater Infrastructure (GSI) where it is feasible and cost-effective. WTD has expertise using GSI for CSO volume control. The examples from other jurisdictions cited in the audit do not involve using GSI to reduce CSO volumes.

In addition, the audit recommendation to work on a program that provides incentives for rate-payers to limit stormwater into the wastewater system is consistent with the efforts and progress we have made in recent months with Seattle Public Utilities in implementing a joint RainWise program for items such as downspout disconnection. However, as the audit recognizes, WTD is not able to provide rate incentives directly to customers for downspout connection because WTD provides wholesale sewage treatment and conveyance services and does not bill customers directly.

WTD also supports the recommendation to use scientific knowledge in evaluating the cost-effectiveness of overflow projects and project sequencing. Since the 1980s, the process for prioritizing and sequencing projects has evolved from using volume to measure the effectiveness of CSO control to prioritizing projects based on other factors such as impacts to public health, endangered species, water quality and the environment. Multiple factors, in addition to cost-effectiveness, currently provide the basis for prioritizing projects. The use of scientific knowledge strengthens the evaluation process.

Today, given the complexities of CSO control, WTD uses a comprehensive approach to prioritize projects that is consistent with best practices and in compliance with applicable legal requirements. This approach prioritizes CSO projects based on many factors such as impacts to public health, the environment and fish and shellfish, and reductions in pollutant loading and volume. This comprehensive approach ensures that project prioritization best serves the public interest. The Water Quality Assessment and Monitoring Study will provide important information to further enhance WTD's ability to assess the cost-effectiveness of projects in reducing pollution to assist in prioritizing future CSO control projects.

Cheryle A. Broom
September 6, 2012
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We will carefully consider the recommendations of the audit as WTD implements the updated CSO Plan. Thank you for your review of WTD's CSO program.

If you have any questions regarding our audit responses, please contact Pam Elardo, Wastewater Treatment Division Director, at 206-684-1236 or pam.elardo@kingcounty.gov.

Sincerely,

Rhonda A. Berry
for Dow Constantine
King County Executive

Enclosure

cc: Fred Jarrett, Deputy County Executive, King County Executive Office (KCEO)
Rhonda Berry, Assistant Deputy County Executive, KCEO
Christie True, Director, Department of Natural Resources and Parks (DNRP)
Pam Elardo, P.E., Director, Wastewater Treatment Division, DNRP

Executive Response (continued)

Attachment

Executive Response-Combined Sewer Overflow Program Performance Audit

No	Recommendation	Agency Position	Schedule for Implementation	Comments
1	WTD should develop and follow a quality assurance procedure to ensure the consistent and valid use of its life cycle cost model.	Concur	Review and revise current tools, design new tools, as needed, and develop staff training. Estimated completion: Q2 2013.	This process is underway.
2	WTD should revise its *Guidelines for Life Cycle Cost Analysis and Doing Economic Analysis of WTD Capital Improvement Projects* to identify thresholds for revisiting alternatives if project costs increase to that threshold and describe how the analysis should be conducted.	Concur	Analyze potential for workable thresholds. Estimated completion: Q3 2013.	WTD believes its review of life cycle costs when there is a significant change in scope for the selected alternative is consistent with the guidelines referred to in the audit. Any determination regarding revisiting alternatives must balance potential benefits against potentially significant additional costs.
3	WTD should ensure that its template for presenting information on project alternatives to decision-makers is followed and that information is presented in a consistent format.	Concur	Implemented.	There are required templates in place for presentations to decision makers. WTD will ensure future submittals adhere to the templates to ensure consistency. The example cited by the auditors, North Beach Combined Sewer Overflow (CSO) Project, was an anomaly.
4	If the project alternative selected to move forward to design is not the lowest cost alternative, WTD should clarify in its documentation why other considerations that resulted in a more costly alternative being selected are worth the additional cost.	Concur	This process is underway.	Documentation on why an alternative is or is not selected is an existing WTD requirement. During design the rationale for an alternative selection is included in the Facilities Plan as required by Ecology. Numerous factors play a role in determining the option that will best serve the public interest (such as public safety, community input, etc.) However, in future Facility Plans, WTD will work to

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Executive Response (continued)

Attachment

Executive Response-Combined Sewer Overflow Program Performance Audit

No	Recommendation	Agency Position	Schedule for Implementation	Comments
				document more explicitly the rationale for selecting an alternative other than the lowest cost approach.
5	WTD projections of the rate impacts of the CSO control program should reflect the wide range of uncertainty in the cost of the program.	Concur	Implemented.	This process is in already in place and is current WTD practice.
6	King County should enhance its efforts to work with the City of Seattle to provide incentives for individual customers to reduce their use of the wastewater treatment system.	Concur	Implement with adoption of Executive's Recommended CSO Plan. (The Executive has proposed an update to the County's CSO Plan in compliance with permit requirements and it includes a Water Quality Assessment and Monitoring Study. Council will consider the Executive's CSO Plan for approval in September 2012.	The audit indicated that WTD's rate structure does not provide incentives to individuals to reduce the use of the wastewater system. It is important to note that WTD provides wholesale sewage treatment and conveyance services and, therefore, does not bill customers directly. Incentives for disconnecting downspouts as part of the RainWise program are included in the Executive's Recommended CSO Plan and in Technical Memorandum 810, Section 3.2. Downspout disconnection has been included as an alternative for CSO control since 1994 (*Task 4 Technical Memorandum*). It's also important to note that a reduction in stormwater flow into the combined system does not necessarily reduce CSOs and engineering analyses are also necessary to ensure that disconnections do not have unintended consequences, such as basement backups.

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Attachment

Executive Response-Combined Sewer Overflow Program Performance Audit

No	Recommendation	Agency Position	Schedule for Implementation	Comments
7.a	WTD should increase its institutional knowledge and expertise with Green Stormwater Infrastructure (GSI) and strengthen its program methodology to address its planning and jurisdictional challenges by: Examining and investigating innovative and cost-effective GSI approaches successfully utilized by other jurisdictions, such as Portland's downspout disconnection program.	Concur	This process is underway.	Portland provides a good model for balancing cost-effective green and gray alternatives. WTD has benefited from its experience and applied this knowledge to the Executive's Recommended CSO Plan. Portland and Bremerton needed to provide secondary treatment capacity as a component of their CSO control efforts. Saving secondary treatment plant costs by reducing flow during all storm events was the main purpose of some of their stormwater diversion efforts. This is different from targeting peak flows that are the cause of CSOs as is the case in the King County system. A reduction in stormwater flow into the combined system does not necessarily reduce CSOs.
7.b	Continuing detailed GSI-effect modeling (based on EPA's SWMM model) for CSO basins feasible for GSI, not just basins pre-selected as having a GSI project component.	Concur	This process is underway.	WTD has already initiated detailed flow monitoring and will analyze the potential for GSI in those basins where GSI is feasible. GSI has unique requirements, and a feasibility analysis is necessary to evaluate permeability and type of soils, available acreage, steep slopes/streets, contaminated soils, ground water levels, connectivity to sewer and stormwater systems, etc. In areas in which the analysis shows that GSI is feasible, models are then developed and run to determine the estimated effectiveness of

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Attachment

Executive Response-Combined Sewer Overflow Program Performance Audit

No	Recommendation	Agency Position	Schedule for Implementation	Comments
				GSI for a given project (and its impact on reducing gray alternative sizes and costs). (Monitoring and modeling is not appropriate in areas in which GSI is not feasible.) Currently 10 sub-basins within the four identified project areas have been identified for detailed modeling and models are currently in development. Flow monitoring is underway for calibration, and site data is being gathered.
7.c	Performing an analysis of cost-effectiveness and cost comparison of GSI with gray infrastructure alternatives for each CSO project basin, applying GSI in the project design phase to the maximum extent cost-effectively possible and setting project targets based on these maximums.	Concur	This process is underway.	This detailed analysis will occur during the next phase of project development. With funding from EPA, WTD and SPU are beginning a project to better analyze cost benefit and cost effectiveness for GSI as part of their respective CSO control programs.
7. d	Allowing for a wider range of GSI alternatives consideration in the project development phase for each CSO control project basin.	Concur	This process is underway.	WTD reviewed other municipalities' programs and approaches and incorporated them into the Executive's Recommended CSO Plan. Regional technical experts and officials were consulted on WTD's approach and engineering methods for GSI and their input was included. WTD will further analyze GSI opportunities and alternatives as part of future feasibility assessments, project specific engineering evaluations and project design.

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Attachment

Executive Response-Combined Sewer Overflow Program Performance Audit

No	Recommendation	Agency Position	Schedule for Implementation	Comments
7.e	Revising the planning model for future iterations of the CSO Control Plan to integrate GSI planning and engineering into each project recommendation (while keeping the gray component for early phase cost estimating).	Concur	This process is underway.	The 2012 CSO Program Review developed the first-generation of modeling for GSI. Modeling done on individual projects during problem definition and project design will provide further model refinements and understanding. Subsequent 5-year plan updates will re-evaluate GSI opportunities and feasibility and include any new approaches for GSI. Also, future recommendations will be based on performance of GSI projects constructed as part of the Executive's Recommended CSO Plan.
8	WTD should phase implementation of the individual control projects within the CSO Control Plan, ensuring inclusion of greater system modeling to assess wider application of GSI in each CSO basin, developing integrated project approaches, and providing a more concerted GSI strategy overall.	Concur	Implemented.	The recommended schedule is phased and implements GSI first to allow time to construct and monitor GSI performance before constructing the gray infrastructure component. A two-year problem definition phase as included in the Executive's Recommended CSO Plan allows for detailed monitoring, modeling, a feasibility study, and public outreach for GSI projects. The current schedule allows adequate time to model and consider GSI approaches while at the same time moving ahead with our 2030 deadline for completing the CSO program. Technical Memorandum 1100 contains more information regarding various scheduling

Executive Response (continued)

Executive Response-Combined Sewer Overflow Program Performance Audit

No	Recommendation	Agency Position	Schedule for Implementation	Comments
				scenarios that were considered and the rationale for the scenario in the Executive's Recommended CSO Plan.
9	To the extent that reliable scientific knowledge is available, WTD should develop quantitative measures of the impacts on water quality from CSO outfalls, and the expected water quality improvements to be provided by each control alternative. The development of such measures should be included in the County Executive's proposed Water Quality Assessment and Monitoring Study, if that study is funded. • These measures should then be applied in an analysis of project cost-effectiveness, including the time-value of program sequencing alternatives. • This analysis should be used to propose updated prioritization and sequencing in the next CSO Control Program Review, to be completed in 2018.	Concur	Implement with adoption of the Executive's Recommended CSO Plan. Results of the Water Quality Assessment and Monitoring Study are expected to be available in late 2016.	WTD agrees with the Auditor's recognition that having incomplete science-based measures presents a challenge. The Executive's Recommended CSO Plan that is pending approval by the King County Council recommends a Water Quality Assessment and Monitoring Study to determine the water quality impacts to waterbodies where CSOs discharge. The assessment is expected to provide more robust information regarding balancing the types and risks of pollution, water body uses and needs, and coordination opportunities in those areas. Project-cost effectiveness is only one of several important factors considered when evaluating a CSO control project.
10	Until such time that reliable scientific knowledge becomes available, in evaluating the cost-effectiveness of overflow projects and project sequences, WTD should document: • Consideration of CSO discharge volumes to be reduced.	Concur	Partially implemented with the balance to be completed based on the results of the Water Quality Assessment and Monitoring Study that is part of the Executive's Recommended CSO Plan Update.	WTD will work to more explicitly document volume reduction and the other factors used for prioritization. Currently, WTD uses a comprehensive approach to prioritize projects that is in compliance with applicable legal requirements and includes prioritizing based on many factors such as impacts to public

Executive Response-Combined Sewer Overflow Program Performance Audit

No	Recommendation	Agency Position	Schedule for Implementation	Comments
	• The time value of volume reduction in evaluating the cost-effectiveness of overflow projects and project sequences.			health, fish and shellfish, pollutant loading and volume. Stakeholder input is also an important part of the process. The Water Quality Assessment and Monitoring Study proposed in the Executive's Recommended CSO Plan will provide important information regarding the benefits of CSO projects and their prioritization. It is important to note that prioritizing projects solely based on volume could result in giving priority to projects that have fewer human health and environmental benefits. For this reason, WTD will continue to evaluate a variety of factors, including volume reduction, when prioritizing and sequencing projects for the next CSO plan update in 2018.

Auditor's Comments

Recommendation 6

We recommend that WTD enhance its efforts to work with the City of Seattle to provide rate incentives for individual customers to reduce their use of the combined sewer system.

The County Executive concurs with the recommendation but notes that as a wholesale provider, WTD does not bill individual customers.

Auditor's comment: This is why the report recommends that WTD work with the City of Seattle to provide rate incentives.

The Executive also notes that there are currently incentives for customers to participate in the City of Seattle's RainWise downspout disconnection program.

Auditor's comment: Our report notes that the existing incentives for customers to participate in the City of Seattle's RainWise program are limited to small geographic areas of the city, and are insufficient to cover the customer's cost of participating in the program.

Finally, the County Executive states that volume reductions due to downspout disconnection programs don't necessarily reduce combined sewer overflows.

Auditor's comment: We emphasize that the City of Portland's downspout disconnection program provided incentives that covered the full cost for customers to disconnect downspouts from the combined sewer system, and was very successful in that over 54,000 downspouts were disconnected. These downspout disconnections resulted in an estimated reduction of 1.5 billion gallons per year of stormwater from entering the combined sewer system. The total cost of Portland's downspout disconnection program was $12.75 million. The cost of this program relative to the large amount of volume of stormwater it removed from the combined sewer system results in an extremely low cost per gallon of stormwater removed from the system, far less than any of the projects in King County's plan. Due to the low cost per gallon removed from the system of a downspout disconnection program, we think a broadly-applied downspout disconnection program facilitated by rate incentives could prove to be cost-effective, even if not all of the volume removed directly reduces combined sewer overflows.

Recommendations 7 and 8:

We recommend that WTD increase its institutional knowledge and expertise with GSI and strengthen its program methodology to address its planning and jurisdictional challenges by:

a. Examining and investigating innovative and cost-effective GSI approaches successfully utilized by other jurisdictions, such as Portland's downspout disconnection program;
b. Continuing detailed GSI-effect modeling (based on EPA's SWMM model) for CSO basins feasible for GSI, not just basins pre-selected as having a GSI project component;

c. Performing an analysis of cost-effectiveness and cost comparison of GSI with gray infrastructure alternatives for each CSO project basin, applying GSI in the project design phase to the maximum extent cost-effectively possible and setting project targets based on these maximums;
d. Allowing for a wider range of GSI alternatives consideration in the project development phase for each CSO control project basin; and
e. Revising the planning model for future iterations of the CSO Control Plan to integrate GSI planning and engineering into each project recommendation (while keeping the gray component for early phase cost estimating).

We also recommend WTD phase implementation of the individual control projects within the CSO Control Plan, ensuring inclusion of greater system modeling to assess wider application of GSI in each CSO basin, developing integrated project approaches, and providing a more concerted GSI strategy overall.

The County Executive concurs with these recommendations, indicating that WTD will continue to analyze the potential for GSI in those basins where GSI is feasible, continuing development of detailed flow modeling in GSI project areas and analysis of GSI cost-effectiveness and cost benefit for the next phase of project development, and subsequent 5-year plan updates will re-evaluate GSI opportunities and feasibility, including any new approaches for GSI. The Executive also indicates that the recommended CSO project schedule is phased and implements GSI first to allow time to construct and monitor GSI performance before constructing gray infrastructure components.

We want to emphasize that these recommendations are interrelated in that the potential application of GSI in the future should not be limited due to current evaluations of its feasibility. As additional modeling, cost-effectiveness, and technical performance data enhance the knowledge base regarding GSI specific to King County CSO control projects, additional opportunities for cost-effective utilization of GSI approaches may similarly emerge. Project prioritization and sequencing in the CSO Control Plan, as well as the project definition and implementation of individual CSO control projects, should consider and minimize the risk that such future opportunities for GSI are eliminated solely as a result of insufficient time for additional evaluation of GSI potential and/or implementation.

Recommendation 10:

We recommend that until reliable scientific knowledge becomes available, in evaluating the cost-effectiveness of overflow projects and project sequences, WTD should document:
a. Consideration of CSO discharge volumes to be reduced.
b. The time value of volume reduction in evaluating the cost-effectiveness of overflow projects and project sequences.

The County Executive concurs with the recommendation and indicates that WTD will continue to evaluate a variety of factors, including volume reduction, when prioritizing and sequencing projects for the next CSO Control Plan update in 2018.

We want to emphasize that consideration of the volume of discharge to be reduced and its time value can enrich not only future planning but also the current discussion of project prioritization and sequencing. In the County Council's striking amendment to the to the county's long-term combined sewer overflow control plan ordinance, a new Section 3 requested the County Executive to consider modifications to the CSO Control Plan when new information is obtained from studies, audits, or other analyses. Our CSO performance audit presents new information that can be taken into account in prioritizing projects from now and going forward.

Statement of Compliance

Statement of Compliance with Government Auditing Standards

We conducted this performance audit in accordance with generally accepted government auditing standards. Those standards require that we plan and perform the audit to obtain sufficient, appropriate evidence to provide a reasonable basis for our findings and conclusions based on our audit objectives. We believe that the evidence obtained provides a reasonable basis for our findings and conclusions based on our audit objectives.

Scope of Work on Internal Controls

We assessed internal controls relevant to the audit objectives. These objectives were satisfied by testing the accuracy of the Wastewater Treatment Division (WTD) Rate Model outputs, reviewing and reconstructing the life cycle cost analyses performed by WTD in comparing costs of control project alternatives, and evaluating the completeness and reliability of the information about the control planning process published by WTD.

Scope, Objective & Methodology

Scope:

This audit reviewed the performance of the Wastewater Treatment Division's (WTD) Combined Sewer Overflow (CSO) Program since the adoption of the Regional Wastewater Service Plan in 1999, and assessed forward-looking plans to comply with state and federal requirements for control of combined sewer overflows by 2030.

Objectives:

- Compile information about CSO expenditures and projects completed since 1999 and their effectiveness at controlling overflows.
- Evaluate the process and methodology for identifying, selecting, and prioritizing CSO projects.
- Evaluate the methodology for estimating the costs of the remaining CSO control projects identified by WTD to bring the County into compliance with state and federal regulations by 2030, and assess the reasons why the estimated cost of compliance has increased since 1999.
- Assess the regulatory environment influencing CSO control, including whether WTD is achieving compliance in the most cost-effective manner.
- Assess the cost-effectiveness of the CSO Control Program in achieving the goals of the Clean Water Act.
- Evaluate WTD's financial plan and rate model to determine whether it accurately reflects the impacts of the CSO Control Program on future sewer rates, and whether the costs of regulatory compliance are distributed fairly among different types of ratepayers.

Methodology:

To achieve the objectives noted above, the King County Auditor's Office interviewed WTD leadership, management and staff, key stakeholders, experts in the area of Green Stormwater Infrastructure, and management of other municipalities who are engaged in controlling combined sewer overflows. We also conducted an extensive literature review about CSO control and an analysis of the regulatory environment. We carried out detailed evaluations of WTD's life cycle cost analyses and replicated the analyses in order to test their reliability and to conduct sensitivity analysis. Leveraging data provided by WTD and using the agencies' life cycle cost model, we created a consolidated model that allowed us to illustrate the impact on discharge volume reduction, and show the economic impact, of alternative sequences of control projects. We reviewed numerous documents from WTD including the CSO Control Plan and all technical memorandums, and facility master plans and supporting documentation for CSO projects that are currently underway. We evaluated WTD's financial model including testing formulas and compared the results of the model with a simpler model we created in-house.

List of Recommendations & Implementation Schedule

Recommendation 1: WTD should develop and follow a quality assurance procedure to ensure the consistent and valid use of its life cycle cost model.

> **Implementation Date:** 2nd Quarter 2013
> **Estimate of Impact:** Greater certainty that actual costs are considered in project selection decisions.

Recommendation 2: WTD should revise its Guidelines for Life Cycle Cost Analysis and Doing Economic Analysis of WTD Capital Improvement Projects to identify thresholds for revisiting alternatives if project costs increase to that threshold and describe how the analysis should be conducted.

> **Implementation Date:** 3rd Quarter 2013
> **Estimate of Impact:** Reconsideration of project alternatives if estimated costs increase for the selected alternative could result in the identification of a lower-cost alternative.

Recommendation 3: WTD should ensure that its template for presenting information on project alternatives to decision-makers is followed and that information is presented in a consistent format.

> **Implementation Date:** 3rd Quarter 2012
> **Estimate of Impact:** Providing information to decision-makers in a consistent format should increase understanding of the information presented.

Recommendation 4: If the project alternative selected to move forward to design is not the lowest cost alternative, WTD should clarify in its documentation why other considerations that resulted in a more costly alternative being selected are worth the additional cost.

> **Implementation Date:** 3rd Quarter 2012
> **Estimate of Impact:** Decision-makers will have more information with which to consider when choosing among alternatives.

Recommendation 5: WTD projections of the rate impacts of the CSO control program should reflect the wide range of uncertainty in the cost of the program.

> **Implementation Date:** 3rd Quarter 2012
> **Estimate of Impact:** Decision-makers will have more information to consider when choosing alternatives and funding priorities.

List of Recommendations & Implementation Schedule (continued)

Recommendation 6: King County should enhance its efforts to work with the City of Seattle to provide incentives for individual customers to reduce their use of the wastewater treatment system.

> **Implementation Date:** 4th Quarter 2013
> **Estimate of Impact:** Rate incentives could be a cost-effective way to reduce the volume of stormwater in the sewer system and thus lower the need for CSO control projects.

Recommendation 7: WTD should increase its institutional knowledge and expertise with GSI and strengthen its program methodology to address its planning and jurisdictional challenges by:

a. Examining and investigating innovative and cost-effective GSI approaches successfully utilized by other jurisdictions, such as Portland's downspout disconnection program;
b. Continuing detailed GSI-effect modeling (based on EPA's SWMM model) for CSO basins feasible for GSI, not just basins pre-selected as having a GSI project component;
c. Performing an analysis of cost-effectiveness and cost comparison of GSI with gray infrastructure alternatives for each CSO project basin, applying GSI in the project design phase to the maximum extent cost-effectively possible and setting project targets based on these maximums;
d. Allowing for a wider range of GSI alternatives consideration in the project development phase for each CSO control project basin; and
e. Revising the planning model for future iterations of the CSO Control Plan to integrate GSI planning and engineering into each project recommendation (while keeping the gray component for early phase cost estimating).

> **Implementation Date:** September 2013, and ongoing within project development for each CSO control project and in future CSO Control Plan iterations.
> **Estimate of Impact:** Consistent, thorough consideration and analysis of GSI approaches for each CSO control project area, applying GSI to the maximum extent cost-effective, could result in lower individual project and overall CSO Control Plan costs.

Recommendation 8: WTD should phase implementation of the individual control projects within the CSO Control Plan, ensuring inclusion of greater system modeling to assess wider application of GSI in each CSO basin, developing integrated project approaches, and providing a more concerted GSI strategy overall.

> **Implementation Date:** December 2012, and ongoing in future CSO Control Plan iterations.
> **Estimate of Impact:** Sequencing projects to allow for the detailed monitoring, modeling, and public outreach necessary for GSI approaches in each CSO basin – including project areas not currently designated for GSI in the CSO Control Plan – ensures that opportunities for cost-effective GSI are not eliminated.

List of Recommendations & Implementation Schedule (continued)

Recommendation 9: To the extent that reliable scientific knowledge is available, WTD should develop quantitative measures of the impacts on water quality from CSO outfalls, and the expected water quality improvements to be provided by each control alternative. The development of such measures should be included in the County Executive's proposed Water Quality Assessment and Monitoring Study, if that study is funded.

a. These measures should then be applied in an analysis of project cost-effectiveness and the time-value of program sequencing alternatives.
b. This analysis should be used to propose updated prioritization and sequencing in the next CSO Control Program Review, to be completed in 2018.

Implementation Date: As information becomes available and upon completion of the Water Quality Assessment and Monitoring Study that the Executive estimates will be completed in 2016.
Estimate of Impact: Re-sequencing projects has the potential to reduce the net present cost per gallon of discharge avoided, and could have a similar benefit in terms of reducing the greatest amount of polluting effects sooner at the lowest cost.

Recommendation 10: Until such time that reliable scientific knowledge becomes available, in evaluating the cost-effectiveness of overflow projects and project sequences, WTD should document:

a. consideration of CSO discharge volumes to be reduced, and
b. the time value of volume reduction in evaluating the cost-effectiveness of overflow projects and project sequences.

Implementation Date: December 2012, and ongoing in future CSO Control Plan iterations.
Estimate of Impact: Re-sequencing projects has the potential to reduce the net present cost per gallon of discharge avoided, and could have a similar benefit in terms of reducing the greatest amount of polluting effects sooner at the lowest cost.