Irrigating sports fields

Irrigating golf courses

Water for nursery plants

Enhancing wetlands

Industrial processes

Reclaimed Water Feasibility Study

March 2008

King County

Department of
Natural Resources and Parks
Wastewater Treatment Division

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Executive Summary

Water Reuse Policy 2 (WRP-2) in King County's Regional Wastewater Services Plan (RWSP) calls for preparation of a reclaimed water feasibility study by December 2007.[1] The full text of the policy is as follows:

> **WRP-2**: By December 31, 2007, the King County executive shall prepare for review by council a reclaimed water feasibility study as part of a regional water supply plan which will include a comprehensive financial business plan including tasks and schedule for the development of a water reuse program and a process to coordinate with affected tribal and local governments, the state and area citizens. The reclaimed water feasibility study shall be reviewed by the RWQC.[2] At a minimum the feasibility study shall comply with chapter 90.46 RCW and include:
>
> 1. Review of new technologies for feasibility and cost effectiveness, that may be applicable for future wastewater planning;
> 2. Review of revenue sources other than the wastewater rate for distribution of reused water;
> 3. Detailed review and an update of a regional market analysis for reused water;
> 4. Review of possible environmental benefits of reused water; and
> 5. Review of regional benefits of reused water.

In addition to meeting specific provisions of WRP-2, this feasibility study provides a compendium of local, state, and national information that will be useful in developing King County's reclaimed water program. The county has long recognized that the reclaimed water produced at its wastewater treatment plants is a valuable resource with potential offsite uses. The study affirms the county's goal of finding appropriate uses for reclaimed water in places where it can provide environmental, social, or financial benefits.

The regional water supply plan, which was expected to be completed by the end of 2007 and which was to incorporate this feasibility study, has not yet been done. The regional water supply planning process is generating a set of reports from technical committees on different topics, including reclaimed water. The last such report is due in September 2008.[3] Information developed during the regional water supply planning process and during this reclaimed water feasibility study, along with comments from council members and stakeholders, will inform the development of the reclaimed water comprehensive plan. The Wastewater Treatment Division will work with its stakeholders to develop the comprehensive plan. The process, to be completed by 2010, will include participation by water purveyors, local sewer agencies, tribal governments,

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[1] The RWSP was adopted in 1999; Water Reuse Policy 2 was amended in September 2006 by King County Ordinance 15602.

[2] RWQC = Regional Water Quality Committee.

[3] See http://www.govlink.org/regional-water-planning/index.htm for more information and for completed reports from the regional water supply planning process.

cities, environmental groups, and the public. This feasibility study includes a schedule and basic outline for the process.

Developing a comprehensive strategy for reclaimed water use is particularly important as King County embarks on two critical regional efforts—restoring Puget Sound by 2020 and developing a comprehensive strategy for adaptation to the impacts of climate change. By increasing the use of reclaimed water, the county reduces wastewater discharges to the Sound and provides a drought-resistant source of water that can generate a range of benefits for use in a broad water resource management strategy.

This study also introduces the potential uses of a new benefit-cost analysis tool developed by the WateReuse Foundation.[4] This tool provides an integrated approach that weaves together information on technologies, benefits, costs, revenues, and market demand to determine the types of projects that could provide the greatest benefits. The tool was presented to the reclaimed water technical committee that was formed as part of the regional water supply planning effort and was applied to two possible examples that committee members nominated. Use of benefit-cost analysis can help inform decisions about potential future investments in reclaimed water or other elements of a water resource management program.

As discussed in the study, the West Point and South Treatment Plants have been producing and using reclaimed water onsite since 1997. South plant also provides reclaimed water for offsite uses. The future Brightwater and Carnation Treatment Plants are being equipped with state-of-the-art membrane bioreactor technology that will treat the wastewater at these plants to Class A reclaimed water standards, offering significant quantities of reclaimed water for appropriate and authorized uses. Reclaimed water from the South Segment of the Brightwater backbone pipeline will be available beginning in 2011. This water can be used for irrigation in place of water that is drawn from salmon-bearing rivers and streams or from sometimes over-tapped groundwater aquifers. Reclaimed water produced at the Carnation Treatment Plant will be used to enhance a degraded wetland at the Chinook Bend Natural Area. This beneficial use will restore fish and wildlife habitat and will reduce direct discharge of effluent to the Snoqualmie River.

The following summary begins with major findings from the study and then provides information on how we arrived at these findings. It concludes with a description of how the reclaimed water comprehensive plan will extend the discussion of the issues identified in WRP-2, will address other relevant issues, and will produce a comprehensive strategy by 2010 for a long-term, progressive reclaimed water program for King County and the region.

What Have We Learned From This Study?

This feasibility study represents one part of a continuum in developing the county's reclaimed water program—a continuum that includes the start of reclaimed water production at county treatment plants in 1997 and continuing through the planned preparation of a reclaimed water

[4] Raucher, R., K. Darr, J. Henderson, R. Linsky, J. Rice, B. Sheikh, and C. Wagner. 2006. *An Economic Framework for Evaluating the Benefits and Costs of Water Reuse*. Alexandria, VA: WateReuse Foundation.

comprehensive plan that will build on the feasibility study. Major findings of the study are described below.

Reclaimed water is a feasible and potentially cost-effective wastewater management tool.

Reclaimed water in Washington State is being used for an increasing number of purposes, including irrigation, industrial processes, and environmental enhancement.

Puget Sound recovery efforts highlight the need for King County to be poised for more stringent discharge requirements. Treatment technology that produces reclaimed water is becoming a standard wastewater treatment pathway, with unit treatment costs declining. By incorporating use of reclaimed water into wastewater planning that already includes such treatment technologies, investments can be leveraged into production of a product that has value and can be sold.

Wastewater plants discharging into Puget Sound are being encouraged, and aided financially, to move to upland discharge via use of reclaimed water. Modest reclaimed water investments made now will enable King County to meet today’s permit requirements while positioning the agency to cost-effectively meet more stringent future discharge requirements. For example, two King County treatments plants under construction—Brightwater and Carnation—will use membrane bioreactor treatment technology, which will generate reclaimed-quality water that can be used as a product for irrigation, industrial processes, environmental enhancement, or other uses authorized under Washington State standards.

Treatment technologies at existing and planned county facilities are appropriate for most identified reclaimed water uses in this region.

The feasibility study confirmed that membrane bioreactor technology, which is planned for the future Carnation and Brightwater Treatment Plants, and sand filters, which are being used at the South and West Point Treatment Plants, are appropriate treatment technologies for the majority of reclaimed water uses identified in this region. These technologies are capable of producing the highest class of reclaimed water under existing and anticipated state standards. Promising technologies, such as reverse osmosis, are being developed and tested but are for the moment more expensive and provide little if any additional benefit for either wastewater treatment or reclaimed water purposes.

Sources of revenue for reclaimed water distribution lines are varied and may be increasing.

A key element of cost recovery for reclaimed water facilities is determining the appropriate allocation of costs to the wastewater utility (borne by the wastewater rate) and to others (preferably borne by the reclaimed water customers and other project beneficiaries). A review of funding strategies nationally for recovering reclaimed water costs shows a variety of strategies, including broad-based rates and dedicated fees, that have been successfully employed. At the federal level, legislation directed at potential impacts of climate change on water supplies is beginning to incorporate funding of reclaimed water projects to provide more efficient use of existing resources. The Washington State Department of Ecology (Ecology) recently announced its priority list for $5.5 million worth of reclaimed water projects that will contribute to restoration of Puget Sound, including two potential projects in King County. The Washington State Legislature has directed Ecology to convene committees to address barriers to further use of reclaimed water, including the lack of a dedicated funding source. That committee has recommended an initial approach, with a dedicated funding source, that would provide $50 million annually within the state.

A benefit-cost analysis can identify environmental, social, and financial benefits of reclaimed water projects.

Identifying environmental, social, and financial benefits directly allocable to reclaimed water provides complete information for decision-makers in assessing the full value of a project to the community and region, and is essential in assessing the merits of a reclaimed water project. This is the approach developed by the WateReuse Foundation in its economic framework for evaluating reclaimed water projects. The framework is based on a “triple bottom line” analysis that has become more common in utility planning.

There is a market for reclaimed water projects in King County.

The potential cost is likely the major barrier to developing reclaimed water projects in the county. Critical to addressing this issue is the appropriate allocation of costs between the wastewater program (as wastewater treatment or regulatory compliance) and the reclaimed water program (as a water resource). Projects that reduce the costs allocated to the reclaimed water program or that have some prospect of shared or dedicated funding would be the most likely to proceed. These projects would include conditions such as the ones described below:

- Providing reclaimed water is either a requirement or secondary benefit of new or upgraded wastewater facilities and all or a significant portion of the cost is properly attributed to the development of the wastewater system.
- The reclaimed water demand is located sufficiently close to the supply so that the distribution costs are minimized.
- The reclaimed water is needed to mitigate or benefit another environmental objective, such as wetland enhancement, farmland preservation, or groundwater recharge, for which other entities besides the wastewater utility will contribute to the cost of the reclaimed water.

Other projects that are likely to be pursued are those where demand outstrips available or future supply, where the reliability of the existing supply (due to environmental, legal, or other issues) may be in question, or where the potential user views the use of reclaimed water as good public policy. In these cases, cost may be a less important determinant. In addition, regional needs—such as providing additional water to ensure the success of watershed-based salmon recovery plans or of regional strategies to address the impacts of climate change—may foster regional approaches to development of reclaimed water. Regional analyses of streamflow needs and of impacts from climate change have yet to be done.

The level of interest in and need for reclaimed water vary across potential wholesale customers, and are continuing to be explored.

Some water and wastewater agencies want reclaimed water now to enhance their water resources and the environment. Others see uses for reclaimed water in their service areas in the next 10 years. Several agencies, such as those served by the City of Everett or Seattle Public Utilities, state that they have a secure water supply for years to come. They view investing now in additional reclaimed water facilities strictly as a source of supply as premature. Seattle Public Utilities is about to embark on its own evaluation of the potential for future reclaimed water projects near the area that could be served by the West Segment of the Brightwater backbone pipeline.

Public education, outreach, and research and development are essential to maintain public support and a market for reclaimed water.

Information on reclaimed water programs in Washington and other states reviewed for this study underscores the importance of outreach and research efforts in building successful programs. Potential wholesale customers and retail users in King County substantiated the importance of this need. Local research that answers specific questions regarding reclaimed water safety and quality will provide a strong foundation for projects and will further King County’s efforts to protect public health and the environment.

Issues, such as liability for reclaimed water use, may not be a barrier to use in King County.

The past 10 to 20 years use of reclaimed water use throughout the country has demonstrated its safety. A review by insurance underwriters for King County concluded that there had been no liability claims filed anywhere in the country against a reclaimed water project owner because of alleged health problems with the water. Based on that history, King County has taken the position that it will hold harmless any wholesale customers of its reclaimed water, provided that the water is used consistent with permit terms and applicable state requirements.

A comprehensive reclaimed water plan is needed that identifies and prioritizes water resource management needs for a full range of beneficial uses.

A more detailed analysis than could be completed in this timeframe needs to be done to determine which reclaimed water projects are most feasible. The comprehensive planning process needs to involve internal and external stakeholders and to include an environmental review. The resulting plan will consist of policies for pricing, cost recovery, and allocation. The policies and overall plan will provide guidance for designing a reclaimed water system that can meet immediate demands and adapt to new demands over time, while ensuring compatibility with the operation of the regional wastewater treatment system. The plan will also identify specific projects and schedules.

What Is King County's Current Reclaimed Water Program?

King County's Wastewater Treatment Division (WTD) has developed a reclaimed water program in conformance with RWSP policies. Reclaimed water was an important issue during development of the RWSP. As a result, 15 water reuse policies were adopted. These policies provide direction to pursue the use of reclaimed water at all county treatment plants, coordinate with regional water supply planning efforts, work with local water purveyors, and evaluate and implement nonpotable water projects on a case-by-case basis.

WTD has been producing reclaimed water at its South and West Point Treatment Plants since 1997. Both plants use reclaimed water for onsite landscape irrigation and internal plant processes. South Plant also provides reclaimed water for offsite uses, including sports field irrigation in the City of Tukwila and habitat restoration.

Reclaimed water continues to serve as an important aspect of WTD's efforts to efficiently manage its water resources. The county's two newest treatment plants, both under construction, will treat their wastewater to reclaimed water standards. Reclaimed water from the Carnation Treatment Plant will be used to enhance nearby wetlands. Reclaimed water from the Brightwater Treatment Plant will be available through a backbone distribution line that runs south into the Sammamish Valley.

A review of reclaimed water treatment technologies illustrates the importance of matching technology to local standards, uses, needs, and conditions. WTD facilities produce high-quality reclaimed water through advanced treatment and disinfection technologies (sand filters, membrane bioreactors, and sodium hypochlorite or ultraviolet light disinfection) that meets the highest state standard for reclaimed water (Class A).[5] Class A reclaimed water is required for most of the county's current and planned nonpotable applications. The review found that the technologies currently in use are appropriate for serving potential uses in the foreseeable future. The county will continue to assess other available technologies for their applicability and cost-effectiveness.

What Needs to be Considered in Evaluating Reclaimed Water Projects?

This feasibility study describes the differences between financial and economic analyses and then emphasizes the importance of performing a full economic analysis when evaluating reclaimed water projects.

A *financial analysis* indicates how anticipated revenues from sales of reclaimed water compare to incurred expenses. While financial analysis is important, it does not reveal the true worth or

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[5] State guidelines and standards include the Reclaimed Water Use Act of 1992 (Chapter 90.46 RCW) and the 1997 *Washington State Water Reclamation and Reuse Standards*.

value of reclaimed water to the community and region as a whole. An *economic analysis* (a benefit-cost approach) starts with the financial analysis but then examines the benefits of the reclaimed water project, including environmental and social benefits, and compares these to the costs.

Reclaimed water has the potential to generate a range of benefits for the region. When broad regional benefits are identified, such as increased streamflows, increased reliability, and offset of costs for upgrading the wastewater system, the net benefits of the project may be positive.

Agencies that produce reclaimed water to manage effluent discharge often set low prices or make long-term volume commitments as ways to provide incentives for using the water. When the value and demand for reclaimed water increases, the price can be raised to meet the demand.

Reclaimed water costs must be appropriately allocated between the wastewater utility, reclaimed water users, and other beneficiaries. Once that is done, an assessment of the revenue need for the reclaimed water costs is possible. For example, the LOTT Alliance in Thurston County sells its water to member agencies for $1.00 per year; the costs of the major infrastructure (collection, treatment, transmission) are viewed as wastewater costs for the regional system. If there is a large potential market for end users that are not wastewater members, the unit price for reclaimed water may be very competitive. If there is a small market and few customers, some innovative cost-sharing or other cost-spreading mechanisms can be tapped. For example, in some areas in the country, broad taxes or fees are levied based on the perceived broad benefit.

Potential Benefits of Reclaimed Water…

Environmental – Benefits could include reducing wastewater discharge to water bodies and enhancing instream flows.

Social – When a climate-independent source such as reclaimed water is added to a region's water portfolio, it can add reliability and value to a community's economic base. It can also be a hedge against increasing demands from anticipated growth in region-wide population and the impacts of climate change.

Financial – Potential local financial benefits include avoided costs of building conveyance or storage, revenue from the sale of reclaimed water, and use of reclaimed water for potable offsets or groundwater recharge.

Applying a benefit-cost analysis to identify all beneficiaries can point to potential sources of revenue. Such an analysis may reveal benefits to both water and wastewater utilities or broader environmental and social benefits that accrue to an entire community or region. Costs for reclaimed water projects nationwide are often borne by both wastewater and water revenues to reflect the benefits of reclaimed water to a broad base of individuals.

As the county's reclaimed water program moves forward to consider specific projects and facilities, it will be important to assess potential project drivers and beneficiaries, both current and future, in determining pricing structures and cost allocations that are transparent and equitable.

Where Are Potential Uses for Reclaimed Water?

The updated reclaimed water market analysis built on studies conducted by the county and other agencies between 1995 and 2006. The analysis identified potential irrigation areas, groundwater recharge areas, and flow-limited streams near reclaimed water sources. Interviews with water and wastewater agencies helped to clarify this information and to identify interest in using reclaimed water in the near and far term.

The Pacific Northwest, like most regions of the world, is projected to experience changes in temperature, precipitation, and snowpack as a result of climate change. Changes in climate have, and are expected to continue to have, an increasing impact on water resources. As the seasonal patterns in surface water flow regimes change, water resource managers in the region may need to re-evaluate historical water use, resource management, flood control, instream flow regimes, and general development in the region. This analysis has already begun through the work of the Climate Change Technical Committee of the regional water supply planning process. More utilities and other entities will likely begin to incorporate such issues in their short-term and long-term planning.

Use of non-traditional resources, such as reclaimed water, can serve as a water resource management tool for adapting to changing conditions. In addition to reducing the amount of effluent discharged to Puget Sound, reclaimed water can help restore and protect instream flows, enhance wetlands, and recharge groundwater, thereby helping to preserve critical habitats in the region. The Freshwater Preparation and Adaptation Workgroup—part of the Governor’s Climate Initiative—identified in its December 2007 report the expanded use of alternative sources of water as one option to be pursued in an adaptation strategy to changed water resource circumstances in the future.

What Are the Next Steps?

The business plan prepared for this study presents activities for the next three or four years that will support existing reclaimed water production at the West Point and South plants and the development of programs at the Carnation and Brightwater plants. Activities include negotiating agreements with purveyors, providing support to customers, working with university researchers to answer technical questions, and developing public outreach programs.

In early 2008, WTD will begin a formal comprehensive planning process for reclaimed water. This process will give WTD the opportunity to work with local, state, federal, tribal, and business stakeholder groups to identify and prioritize water resource needs and the range of beneficial uses that can be met through reclaimed water. The process will address policy, economic, environmental, and technical issues. Alternatives will be developed and evaluated. The resulting reclaimed water comprehensive plan will define a comprehensive financial business plan beyond 2010.

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Acronyms and Abbreviations

AAF	average annual flow
ADWF	average dry weather flow
AF	acre-foot
AOP	advanced oxidation process
AWWA	American Water Works Association
BCA	benefit-cost analysis
BOD	biochemical oxygen demand
BWRW	Brightwater Reclaimed Water system
CBOD	carbonaceous biological oxygen demand
CWWTF	Carnation Wastewater Treatment Facility
ccf	100 cubic feet
C-E	cost-effectiveness
cf	cubic feet
cfs	cubic feet per second
CSO	combined sewer overflow
CTED	Washington State Department of Trade and Economic Development
DO	dissolved oxygen
DOH	Department of Health, Washington State
E2SHB	Engrossed Second Substitute House Bill
EDC	endocrine disrupting compound
EPA	U.S. Environmental Protection Agency
ESA	Endangered Species Act
ESHB	Engrossed Substitute House Bill
ETS	Effluent Transfer System
GFC	general facility charges
GHG	greenhouse gases
GW	groundwater
gpd	gallons per day
HB	House Bill
HUD	U.S. Department of Housing and Urban Development
I/I	infiltration and inflow
IPS	Influent Pump Station
IRP	Integrated Resource Planning
ITS	Influent Transfer System
KCDNRP	King County Department of Natural Resources and Parks

LF	linear feet
LID	Local Improvement District
LOTT	Lacey, Olympia, Tumwater and Thurston County Alliance
MBR	membrane bioreactor
MF	micro-filtration
MG	million gallons
mgd	million gallons per day
mg/L	milligrams per liter
MIT	Muckleshoot Indian Tribe
MWPAAC	Metropolitan Water Pollution Abatement Advisory Committee
NF	nano-filtration
NOAA	National Oceanic and Atmospheric Administration
NPDES	National Pollutant Discharge Elimination System
NTU	nephelometric turbidity unit
O_2	oxygen
O_3	ozone
O&M	operation and maintenance
PAA	paracetic acid
PhACs	pharmaceutically active compounds
psi	pounds per square inch
PVC	polyvinyl chloride
PWS	potable water suppliers
PWTF	Public Works Trust Fund
RCW	Revised Code of Washington
RO	reverse osmosis
RW	reclaimed water
RWQC	Regional Water Quality Committee
RWSP	Regional Wastewater Services Plan
SBR	sequencing batch reactors
sf	square feet
SPU	Seattle Public Utilities
SRF	State Revolving Fund
T/E	threatened and endangered
TM	technical memo
TMDL	total maximum daily load
TP	treatment plant
TPP	treatment plant policy
TSS	total suspended solids

UF	ultra-filtration
ULID	(Utility) Local Improvement District
USDA	U.S. Department of Agriculture
UV	ultraviolet
UW	University of Washington
WAC	Washington Administrative Code
WDNR	Washington State Department of Natural Resources
WEF	Water Environment Federation
WRF	WateReuse Foundation
WRIA	Watershed Resource Inventory Area
WRP	water reuse policy
WQ	water quality
WTD	Wastewater Treatment Division
WWTP	wastewater treatment plant

Chapter 1

Introduction

King County Ordinance 15602, adopted in September 2006, amends policies in King County's Regional Wastewater Service Plan, including Water Reuse Policy 2 (WRP-2). The amended WRP-2 calls for completion of a reclaimed water feasibility study, as follows:

> **WRP-2**: By December 31, 2007, the King County executive shall prepare for review by council a reclaimed water feasibility study as part of a regional water supply plan which will include a comprehensive financial business plan including tasks and schedule for the development of a water reuse program and a process to coordinate with affected tribal and local governments, the state and area citizens. The reclaimed water feasibility study shall be reviewed by the RWQC.[1] At a minimum the feasibility study shall comply with chapter 90.46 RCW and include:
>
> 1. Review of new technologies for feasibility and cost effectiveness, that may be applicable for future wastewater planning;
> 2. Review of revenue sources other than the wastewater rate for distribution of reused water;
> 3. Detailed review and an update of a regional market analysis for reused water;
> 4. Review of possible environmental benefits of reused water; and
> 5. Review of regional benefits of reused water.

This feasibility study addresses the requirements in WRP-2 and constitutes the next step in the continuum of developing a reclaimed water program in King County.[2] The county has been producing reclaimed water for a decade. Several factors are prompting a new look at how this program will change in the future—factors such as policy requirements, construction of new treatment plants that create reclaimed-quality water, climate change, threatened salmon species, and the need to clean up Puget Sound. The feasibility study begins this new look.

The study includes information beyond that requested in WRP-2, including information on the county's current reclaimed water facilities and program, an economic framework developed by the WateReuse Foundation, and the approach and timelines for the reclaimed water comprehensive plan to be completed by 2010. Information in the study will be used as the basis

[1] RWQC = Regional Water Quality Committee.

[2] Reclaimed water is wastewater that is treated to such a high level that it can be used safely and effectively for a variety of non-drinking purposes. The 1997 Washington State *Water Reclamation and Reuse Standards* defines reclaimed water as "effluent derived in any part from sewage from a wastewater treatment system that has been adequately and reliably treated, so that as a result of that treatment, it is suitable for a beneficial use or a controlled use that would not otherwise occur and is no longer considered wastewater."

for the reclaimed water comprehensive plan. The planning process will have a broad stakeholder process that will include participants and interests identified in WRP-2.

This chapter presents the scope, approach, and organization of this feasibility study.

1.1 Feasibility Study Scope

WRP-2 guides the scope of this reclaimed water feasibility study. Subsequent chapters provide specific analyses and products called for in WRP-2 (see the following section for study approach and organization).

This policy directs that the study be prepared as part of a regional water supply plan. In February 2005, King County and Cascade Water Alliance signed a memorandum of understanding on water resource and water supply planning. In response to this agreement, the county convened a multi-party scoping process for regional water supply planning. The scoping led to initiation of a water supply planning process in October 2005. The goal of this phase of the process was not to develop a regional water supply plan but to develop the best available data, information, and pragmatic tools that participants could use, at their discretion, to assist in planning for and managing their respective water systems and resources. Voluntary technical committees have developed, or are developing, substantive information in seven areas: regional water demand forecast, water supply assessment, climate change impacts, reclaimed water, tributary streamflows, source exchange strategies, and small water systems.[3]

One of these committees was the Reclaimed Water Technical Committee, whose self-selected membership was composed of local jurisdictions, water and sewer districts, regional water associations, and the Washington State Departments of Health and Ecology. The committee met 10 times in 2006 and focused on developing a knowledge base, identifying some regional benefits and barriers to reclaimed water use, accumulating data on potential users, and reviewing a framework published by the national WateReuse Foundation for evaluating the environmental, social, and economic benefits and costs of potential reclaimed water projects.[4]

Although a regional water supply plan has not yet been developed during the water supply planning process, King County chose to proceed with this feasibility study in order to meet the intent of the policy. The scope of the study and the amount of time during which it had to be completed did not enable WTD to develop a comprehensive long-term financial business plan, also called for in WRP-2. Much more work needs to be done to achieve this objective.

This feasibility study provides useful methods for analyzing reclaimed water projects more systematically and enables King County's program to focus more on the areas where there is the greatest potential to implement feasible projects. It helps to define the county's approach to developing a reclaimed water program. King County has long recognized that reclaimed water

[3] More information on the Regional Water Supply Planning Process is available at http://www.govlink.org/regional-water-planning/index.htm

[4] The WateReuse Foundation is an educational, nonprofit, public-benefit corporation that serves as a centralized organization for the water and wastewater community to advance the science of water reuse, recycling, reclamation, and desalination.

produced at its treatment plants is a valuable resource with potential offsite uses. The study affirms the county's goal of finding appropriate uses for reclaimed water in places where it can provide environmental, social, or financial benefits.

The study builds on the work of the Reclaimed Water Technical Committee and other technical committees and on information from previous studies, including the 1995 reclaimed water feasibility study, the 2000 water reuse work plan, and the draft white paper on the Brightwater reclaimed water system.[5,6,7] Subsequent efforts, including a reclaimed water comprehensive plan to be developed over the next couple of years, will build on the work of this feasibility study and supply information not included in its scope. The reclaimed water comprehensive plan will consist of policies for pricing, cost recovery, and allocation. The policies and overall plan will provide guidance for designing a reclaimed water system that can meet immediate demands and adapt to new demands over time, while ensuring compatibility with the operation of the regional wastewater treatment system. The plan will also identify specific projects and schedules.

1.2 Feasibility Study Approach and Organization

The feasibility study approach focuses on addressing each of the provisions of WRP-2. It also uses the WateReuse Foundation (WRF) economic framework—reviewed earlier by the Reclaimed Water Technical Committee—to illustrate how both the costs and benefits of reclaimed water can be evaluated to determine feasibility. The analyses relied on information developed during the reviews of treatment technologies, revenue sources, and environmental and regional benefits, called for in WRP-2.

The reviews of reclaimed water treatment technologies and revenue sources relied in part on case studies conducted for this feasibility study. The case studies provide information on the types of treatment technologies used by reclaimed water producers in Washington and other states, including construction and operations costs for these technologies, and information on how these producers are funding and recovering costs for reclaimed water systems.

The content of the chapters follows the provisions of WRP-2, except in cases where content was added to provide context and background information—such as descriptions of the King County wastewater system and of the WRF's economic framework (Chapters 2 and 4)—or where content was moved or combined to help readers better understand succeeding information (see Table 1-1).

The chapters, including their approach and relationship to WRP-2, are as follows:

- **Chapter 2, Description of King County Reclaimed Water Facilities and Program,** provides context for development of a reclaimed water system in King County and an overview of the county's existing and planned reclaimed water facilities.

[5] King County Department of Natural Resources, *Water Reuse Work Plan*, December 2000.
[6] ECONorthwest, *Water Reclamation and Reuse: A Feasibility Study for the King County Metropolitan Area*, 1995.
[7] King County, *Draft White Paper, Reclaimed Water Backbone Project*, version 3, March 2006.

- **Chapter 3, Review of Current and Developing Reclaimed Water Technologies,** addresses Provision 1 of policy WRP-2, "review of new technologies for feasibility and cost effectiveness, that may be applicable for future wastewater planning." The chapter summarizes Washington State reclaimed water treatment standards and describes both time-tested and new technologies for producing reclaimed water to meet these standards. The study uses information from case studies to show how technologies can be combined into treatment trains, to estimate construction costs for such trains, and to link the trains to allowed uses under Washington State reclaimed water standards.[8]
- **Chapter 4, Economic Framework for Assessing Reclaimed Water Projects,** explores how reclaimed water projects can be evaluated from both a financial and an economic perspective, leading to the broader discussion of the economics (benefits and costs) of water reclamation and the economic framework that can be applied to reclaimed water projects.
- **Chapter 5, Review of Revenue Sources for Reclaimed Water Distribution Facilities,** addresses Provision 2 of WRP-2, "review of revenue sources other than the wastewater rate for distribution of reused water." Case studies highlight various methods for pricing reclaimed water and for recovering and allocating costs associated with providing the water.
- **Chapter 6, Review of Environmental and Regional Benefits of Reclaimed Water,** addresses Provisions 4 and 5 of WRP-2, "review of possible environmental benefits of reused water and review of regional benefits of reused water." The benefits are presented in terms of wastewater and water resource management challenges in the region, including reducing wastewater discharges to Puget Sound, protecting threatened and endangered fish species, and preparing for uncertainties associated with climate change, population growth, and other unknowns.
- **Chapter 7, Review and Update of Regional Market Analysis for Reclaimed Water,** addresses Provision 3 of WRP-2, "detailed review and an update of a regional market analysis for reused water." The updated market analysis assumes that King County will produce reclaimed water and will wholesale the water to local utilities ("customers") in its wastewater service area and that the utilities will then provide the water to "users" in their service areas. Potential users—who could use the water primarily for irrigation or industrial processes—were identified based on review of available data, on proximity to reclaimed water sources, and on interviews and focus groups conducted for the feasibility study.
- **Chapter 8, Business Plan for King County's Existing and Near-Term Reclaimed Water Program,** presents the mission, goals, objectives, tasks, and schedule for the existing reclaimed water program. It includes a process to coordinate with affected tribal and local governments, the state, and area citizens. The reclaimed water comprehensive plan will develop a financial business plan and review.
- **Chapter 9, Next Step: Reclaimed Water Comprehensive Plan,** describes the process, including tasks and timelines, for completing the reclaimed water comprehensive plan.

[8] Treatment trains consist of a treatment technologies used in series to produce reclaimed water. For example, primary treatment, membrane bioreactors, and chlorine disinfection would be considered a treatment train.

Table 1-1. Location of WRP-2 and Other Topics in Feasibility Study

Topics Required by WRP-2	Feasibility Study Chapter
Business plan	Chapter 8
Review of new technologies	Chapter 3
Review of revenue sources	Chapter 5
Review and update of market analysis	Chapter 7
Review of environmental benefits	Chapter 6
Review of regional benefits	Chapter 6
Additional Topics	
Description of King County reclaimed water facilities and program	Chapter 2
Economic framework for assessing reclaimed water projects	Chapter 4
Process to develop a reclaimed water comprehensive plan	Chapter 9

Chapter 2

Description of King County Reclaimed Water Facilities and Program

The King County reclaimed water program is based on authority in state law (Chapter 90.46 RCW) and was developed in response to a set of policies in the Regional Wastewater Services Plan that promotes the use of reclaimed water in King County. These policies emphasize the goals of using reclaimed water to protect the environment by reducing discharges to receiving waters and developing the resource for multiple beneficial purposes.

The state Legislature has in recent sessions (2006 and 2007) enacted bills that strengthen the original 1992 directive promoting reclaimed water use, noting its linkage to restoring Puget Sound and responding to climate change impacts. The bills direct state agencies to form committees and task forces to address barriers to expanded use, including regulatory, financial, and legal barriers.

Reclaimed water is a principal feature of the county's comprehensive response to climate change.

As the largest discharger into Puget Sound, the county's wastewater facilities and planning efforts must contribute to cleaning up the Sound. The existing reclaimed water program, which was initiated in response to drought conditions in 1992, produces reclaimed water at both treatment plants in Renton and Seattle. The Brightwater regional treatment plant and the Carnation treatment plant, approved by the County Council and currently under construction, include membrane bioreactor wastewater treatment technology, which will produce Class A reclaimed water as a product and will provide that water for nonpotable water supply and environmental enhancement purposes.

This chapter describes King County's reclaimed water system. The information in the chapter provides background for later chapters that address the provisions of Water Reuse Policy 2 (WRP-2). The chapter begins with a review of the policy, regulatory, and environmental context and directives for providing reclaimed water. This review is followed by an overview of King County's regional wastewater service area and system, a brief history of development of its reclaimed water system as a part of the wastewater system, and descriptions of existing and planned reclaimed water facilities and uses.

2.1 Context and Directives for Developing a Reclaimed Water System

King County's Wastewater Treatment Division (WTD) is charged with protecting public health and the environment by conveying, treating, and recycling wastewater and its byproducts. Local agencies collect and convey wastewater to the county's regional treatment plants that treat the flows to meet National Pollutant Discharge Elimination System (NPDES) limits before discharging to Puget Sound. The division's vision—"Creating Resources from Wastewater"—describes WTD's approach to its mission.

King County, as the wastewater provider by statute (Chapter 35.58 RCW), must include its reclaimed water program in a regional water supply plan and it must participate in such a process if reclaimed water will substitute for potable supplies (RCW 90.46.120). The county must also include opportunities for reclaimed water in its wastewater planning (RCW 90.48.112). In addition to this statutory authority, King County policy provides direction to participate in regional water supply planning and to produce and use reclaimed water. This direction includes a set of regionally approved countywide policies that were translated into specific action-oriented policies in the King County Comprehensive Plan and the Regional Wastewater Services Plan (RWSP), both of which call for expanding the production and use of reclaimed water.

The following paragraphs describe RWSP water reuse policies other than WRP-2. In addition, the paragraphs summarize developments on the state and regional level that are prompting a closer look at how increased production of reclaimed water could aid WTD in fulfilling its mission while meeting emerging opportunities and challenges. These developments include new state reclaimed water legislation, increasing concern for the health of Puget Sound, and impacts of climate change.

2.1.1 Policy Framework

The King County Council adopted the RWSP in December 1999. The RWSP—the 30-year comprehensive plan for King County's wastewater system—is guided by a number of policies, including wastewater treatment and conveyance, water quality protection, and water reuse policies. RWSP policies were developed with extensive input from various stakeholders. Guidance from these stakeholders during the process consistently stressed the need to examine reclaimed water as a potential resource. This interest was carried forward in the planning for the new Brightwater System in that potential for reclaimed water uses was included as one of the criteria for siting the system.[1]

WRP-2 is one of fifteen RWSP water reuse policies. The policies serve as the foundation for King County's reclaimed water program. The policies provide direction to pursue the use of reclaimed water, coordinate with regional water supply planning efforts, prepare a reclaimed

[1] The Brightwater System includes a new treatment plant that when online in 2010, will produce reclaimed water. A reclaimed water distribution system is being constructed as part of the project. See the description of the project later in this chapter.

water feasibility study, and evaluate and implement nonpotable water projects on a case-by-case basis.[2] WTD's vision of creating resources from wastewater closely aligns with these policies.

The general direction of RWSP water reuse policies can be seen in these four policies:[3]

- **WRP-1**: King County shall actively pursue the use of reclaimed water while protecting the public health and safety and the environment. The county shall facilitate the development of a water reuse program to help meet the goals of the county to preserve water supplies within the region and to ensure that any reclaimed water reintroduced into the environment will protect the water quality of the receiving water body and the aquatic environment.
- **WRP-3**: Recycling and reusing reclaimed water shall be investigated as a possible future significant new source of water to enhance or maintain fish runs, supply additional water for the region's nonpotable uses, preserve environmental and aesthetic values and defer the need to develop new potable water supply projects.
- **WRP-5**: King County shall implement nonpotable projects on a case-by-case basis. To evaluate nonpotable projects, King County shall develop criteria which will include, but are not limited to, capital, operation and maintenance costs; cost recovery; potential and proposed uses; rate and capacity charge impacts; environmental benefits; fisheries habitat maintenance and enhancement potential; community and social benefits and impacts; public education opportunities; risk and liability; demonstration of new technologies; and enhancing economic development. A detailed financial analysis of the overall costs and benefits of a water reuse project shall include cost estimates for the capital and operations associated with a project; the anticipated or existing contracts for purchases of reused water, including agricultural and other potential uses; anticipated costs for potable water when the project becomes operational; and estimates regarding recovery of capital costs from new reused water customers versus costs to be assumed by existing ratepayers and new customers paying the capacity charge. Water reuse projects that require major capital funding shall be reviewed by RWQC and approved by the council.
- **WRP-12**: King County shall retain the flexibility to produce and distribute reclaimed water at all treatment plants including retaining options to add additional levels of treatment.

The other eleven water reuse policies guide particular aspects of the program. In addition to policies, such as WRP-2, that call for specific actions, there are policies to investigate reclaimed water as a means to maintain or enhance the environment, to work with local water purveyors and regulatory agencies, to develop a public education and involvement program, and to evaluate potential funding for projects from the wastewater utility rate base.

The RWSP contains other polices related to reclaimed water. For example, Treatment Plant Policy 8 (TPP-8) states "King County shall continue water reuse and explore opportunities for

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[2] In 2006, the RWSP water reuse policies were amended to take into account changed conditions and completion of some actions mandated in the 1999 policies.
[3] All policies can be found in *Regional Wastewater Services Plan, 2006 Comprehensive Review and Annual Report.* 2007. King County Department of Natural Resources and Parks, Wastewater Treatment Division. http://dnr.metrokc.gov/WTD/rwsp/documents/06CompReviewAR/index.htm

expanded use at existing plants, and shall explore water reuse opportunities at all new treatment facilities."

To meet this policy direction, WTD has been producing reclaimed water at its two regional plants, primarily for onsite uses, and has been exploring and acting on other opportunities for production and use of reclaimed water, including designing new treatment plants that can treat effluent to reclaimed water quality standards (see Chapter 3).

2.1.2 State Reclaimed Water Legislation

In 1992, the Washington State Legislature passed the Reclaimed Water Use Act (Chapter 90.46 RCW), which encourages the use of reclaimed water while assuring the health and safety of all Washington citizens and the protection of its environment.

Legislation passed in 2006 and 2007 (ESHB 2884 and E2SSB 6117), amending the act, recognizes that the use of reclaimed water can contribute to restoring and protecting instream flows that are needed to preserve the state's salmonid resources, restoring Puget Sound by reducing wastewater discharge, and responding to climate change—and directs the Departments of Health and Ecology to develop standards in rule for reusing treated wastewater from treatment plants and to encourage development of water reclamation infrastructure.[4]

2.1.3 Protecting Puget Sound and Threatened/Endangered Species

King County is the largest discharger of treated wastewater effluent to Puget Sound. Every five years, the county renews the NPDES permits for its treatment plants. Regulators have historically imposed more stringent requirements with each renewal. Future renewals may require more vigorous treatment standards and specific limitations on the volume of discharge.

[4] Also in 2007, the legislature budgeted $5.5 million to support grants for reclaimed water projects in the Puget Sound watershed.

In addition, the Washington State Department of Natural Resources (WDNR) has stated that its goal is to "reduce the reliance on the receiving waters of the state for the disposal of waste effluent, stormwater, and other discharges, and to promote water reuse" (King County, 2006). To that end, the Plan of Operations attached to the Brightwater Outfall Use Authorization granted by WDNR requires that King County provide updates at each renewal of the Brightwater NPDES permit that document the progress made toward reducing reliance on receiving waters for the disposal of waste effluent and toward promoting water reuse.

Washington State Actions on Reclaimed Water

1992—Reclaimed Water Use Act (Chapter 90.46 RCW) directs Departments of Ecology and Health to develop standards.

1997—Ecology and Health issue final reclaimed water standards (guidance).

1997–2003—Provisions are included in various acts and house bills for consideration of reclaimed water in water and sewer plans.

2005—Ecology publishes case studies in reclaimed water use (Cupps and Morris, 2005).

2006—Amendments to the Reclaimed Water Use Act (ESHB 2884) direct Ecology to form an advisory committee and develop rules for all reclaimed water uses by December 2010.

2007—Further amendments (E2SSB 6117) facilitate use of reclaimed water; tie it to climate change, salmon recovery strategy, and Puget Sound Initiative; and require use at state agencies if feasible.

2007—The legislature budgets $5.5 million for reclaimed water projects in Puget Sound watershed.

In passing Washington State Engrossed Senate Bill 5372 in July 2007, the state Legislature recognized that Puget Sound is in serious decline—as evidenced by loss of critical habitat, numerous toxic-contaminated sites, and urbanization and attendant stormwater drainage. The bill creates the Puget Sound Partnership, which is tasked to create a "2020 Action Agenda" in 2008 that will outline actions to restore the health of Puget Sound by 2020.[5]

The 2020 Action Agenda will most likely contain elements that promote reclaimed water as a means to curtail discharges to the Sound and provide needed habitat for species listed as endangered or threatened under the Endangered Species Act.[6] Because reclaimed water is a reliable, year-round water resource, it could be used during seasonal and longer-term droughts instead of withdrawals from the region's lakes, rivers, and streams to maintain instream flows and water temperatures that these species require for survival.

2.1.4 Responding to Climate Change

The challenges described above, along with a growing population and uncertainties regarding climate change, could stress regional water resources and, hence, increase the need for reclaimed water as part of a portfolio of resources. On April 1, 2006, the King County Executive issued an Executive Order titled *Environmental Management Strategies for Global Warming Preparedness*. Through this order, King County departments are directed to maximize the creation of resources from waste products such as wastewater in ways that "adapt to natural

[5] In 2007, the Washington State Legislature established the Puget Sound Partnership to lead efforts to protect and restore Puget Sound. For more information, see http://www.psp.wa.gov/

[6] The governor recommends the provision of financial assistance for water reuse projects to reduce demand on potable water supply, to help control toxic, nutrient, and pathogen discharges, and to help keep water in rivers and streams, as part of her five immediate actions for the Puget Sound Partnership (Puget Sound Partnership, 2006).

resource conditions impacted by global warming and mitigate contribution to global warming by reducing greenhouse gas emissions."

The *King County 2007 Climate Plan* itemizes actions that WTD is taking in response to this Executive Order.[7,8] The goals are to maximize development and use of reclaimed water produced from the wastewater system and to support operational resilience of wastewater treatment to climate change impacts through actions such as working with state, regional, and local governments to expand the use of reclaimed water to help achieve recovery of Puget Sound.

2.2 Wastewater Service Area and System

King County is located on Puget Sound and covers more than 2,200 square miles. With more than 1.9 million people, King County is the 14th most populous county in the nation. The county protects water quality and public health in the Central Puget Sound region by collecting and treating wastewater from 17 cities, 16 local sewer utilities, and 1 Indian tribe. The county's regional wastewater system serves about 1.4 million people, including most urban areas of King County and parts of south Snohomish County and northeast Pierce County (Figure 2-1).

The county's existing wastewater system includes two large regional treatment plants (West Point in the City of Seattle and South plant in the City of Renton), one small treatment plant and one community septic system on Vashon Island, four combined sewer overflow (CSO) treatment facilities in the city of Seattle, over 335 miles of pipes, 19 regulator stations, 42 pump stations, and 38 CSO outfalls. Construction on two new treatment plants began in 2006: the Brightwater Treatment Plant, the system's third regional plant, scheduled for completion in 2010, and a smaller local treatment plant in the city of Carnation, scheduled for completion in mid 2008.

[7] The executive orders to reduce global warming (PUT 7-5 to 7-8 [AEO]) are available at http://www.metrokc.gov/recelec/archives/sysindex.htm
[8] The *King County 2007 Climate Plan* is available at http://www.metrokc.gov/exec/news/2007/pdf/ClimatePlan.pdf

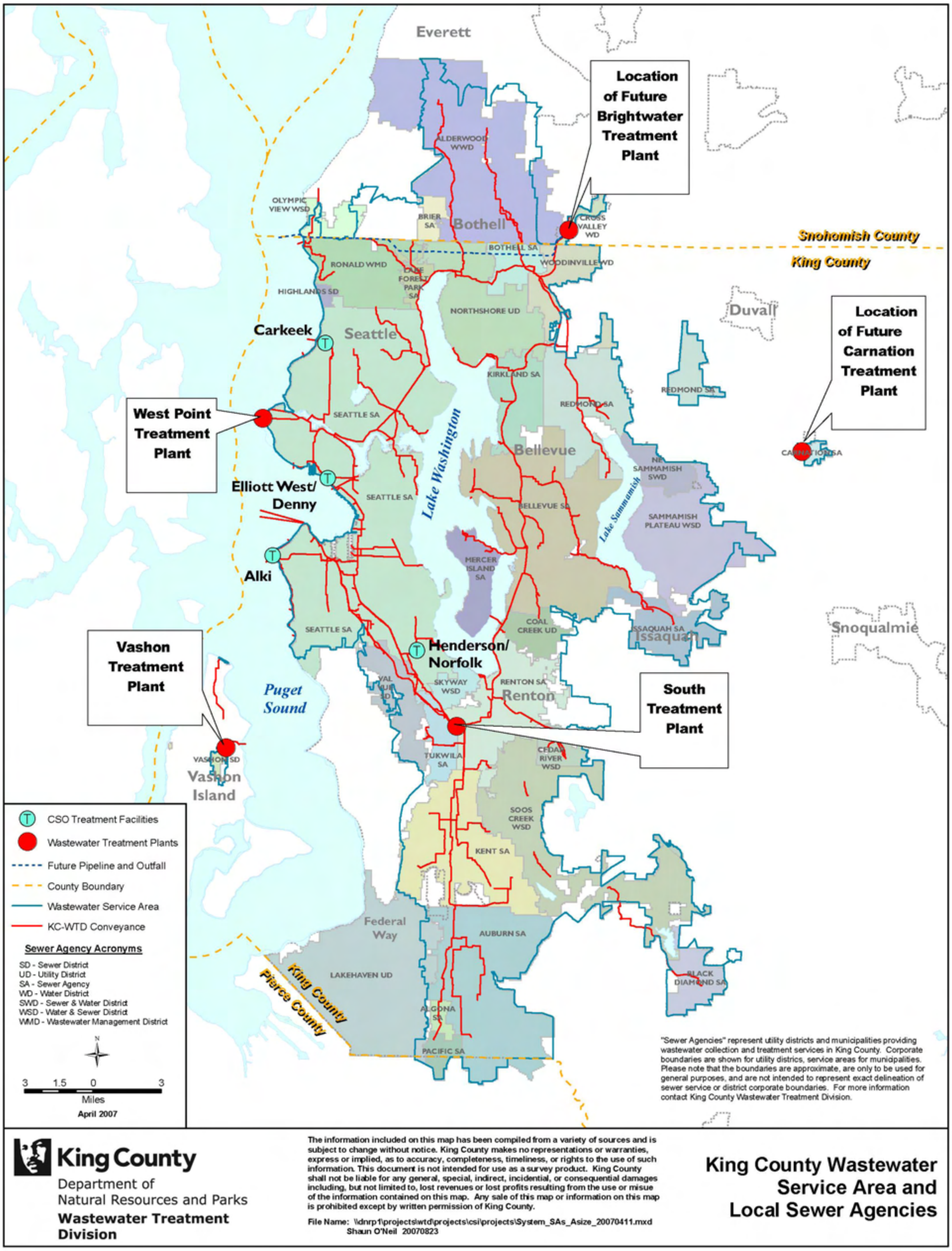

Figure 2-1. King County Wastewater Service Area and Facilities

2.3 History of the Reclaimed Water System

King County's active support for reclaiming water began in 1991 with proposals that resulted in Washington State's 1992 Reclaimed Water Use Act. In 1995, the county completed a water reclamation and reuse feasibility study, which identified the county's treatment plants as large users of potable water for nonpotable uses (ECONorthwest, 1995). This study led to the production of reclaimed water in 1997 at the county's two regional treatment plants, the West Point and South plants.

A Water Reuse Policy Development Task Force was formed in 1997 to help develop water reuse policies in the RWSP.[9] A multi-stakeholder Reclaimed Water Task Force built on the work of the Water Reuse Policy Development Task Force to carry out the policies set forth in the RWSP.[10] Task force recommendations and the RWSP policies were used to guide the development of a reuse work plan submitted to the King County Council in 2000 (King County, 2000).

The water reuse work plan called for evaluation of the potential for both satellite and centralized reclaimed water facilities. In response to the plan, the county evaluated the merits of building a small satellite facility in the Sammamish Valley. This proposed facility would have provided water for a local golf course, athletic fields, nurseries, and crops. A small pilot-scale facility at one of the county's pump stations was built. Reclaimed water produced at the facility was used to irrigate test garden plots that represented the range of water users in the valley.

A History of Reclaimed Water in King County

1992—In response to a drought, Metro and Seattle develop a 650,000 gpd facility to produce reclaimed water for controlling dust, washing streets, and flushing sewers.

1995—King County completes a water reclamation and reuse feasibility study (ECONorthwest, 1995).

1997—West Point and South Treatment Plants start producing reclaimed water.

1999—Reclaimed water policies are adopted by King County Council as part of the Regional Wastewater Services Plan (RWSP).

2000—A water reuse work plan is submitted to the Council, per RWSP policy; Sammamish Valley is slated as a priority area.

2001—A technology demonstration project begins at West Point to test technologies for producing reclaimed water; a reclaimed water demonstration garden operates in the Sammamish Valley; opportunities for reclaimed water use were included as a criterion for siting Brightwater.

2002—Planning and design continue on a reclaimed water facility in Sammamish Valley; membrane bioreactor technology is selected to produce Class A reclaimed water at Brightwater; agreement is signed with Ecology to provide reclaimed water to properties south of Brightwater.

2004—The Sammamish Valley project is canceled because of rising costs.

2005—The Council approves appropriations for the Brightwater backbone to distribute reclaimed water west and south of the plant; the county initiates a regional water supply planning process; design begins on wetlands discharge for Carnation Treatment Plant.

2006—Ordinance 15602, amending RWSP policies, calls for completion of a reclaimed water feasibility study by the end of 2007.

2007—The county co-sponsors the Washington State Reclaimed Water Conference; a greenhouse opens at South plant to showcase reclaimed water.

[9] The Water Reuse Policy Development Task Force included representatives from Washington Association of Sewer and Water Districts, Cascade Water Alliance, City of Everett, City of Seattle, King County, State of Washington (Health and Ecology), and Suburban Cities Association.

[10] Reclaimed Water Task Force members included representatives from Seattle Public Utilities, City of Tukwila, Muckleshoot Tribe, state Departments of Ecology and Health, Cedar River Water and Sewer District, Shoreline Water District, Center for Environmental Law and Policy, City of Bellevue, Woodinville Water District, King County, Cascade Water Alliance, and UW Department of Civil Engineering.

Instead of constructing a satellite facility, King County will be producing reclaimed water at the new Brightwater plant and distributing the water through a “backbone” system. The Sammamish Valley project was cancelled in the 2004 King County budget process because of rising costs and the realization that providing reclaimed water to Sammamish Valley from Brightwater was more cost-effective.

WTD issued a draft white paper on the Brightwater backbone in fall 2005 and updated it in spring 2006 (King County, 2006). The paper provides information on reclaimed water quality and on the opportunity to build the backbone in conjunction with construction of Brightwater conveyance. It also presents the results of a preliminary analysis of reclaimed water rates, revenues, and impacts to monthly sewer rates. In 2005, The Washington State Department of Ecology approved and reiterated its support of the backbone as part of the state and region’s water resource management strategy (King County, 2006) and the King County Council approved appropriations for the first phase of the backbone.

Reclaimed water from the Brightwater plant will be available to customers via pipeline to the Sammamish Valley south of the plant. Reclaimed water production capacity can be expanded south and west along the effluent conveyance line as customer demand grows. The new Carnation Treatment Plant will also produce reclaimed water. The water will be used to enhance a wetland near the plant. King County’s reclaimed water program continues to identify potential reclaimed water users near its regional wastewater plants and conveyance systems.

2.4 Reclaimed Water Facilities and Uses

WTD has been producing and using reclaimed water at the South and West Point plants since 1997. These plants produce about 255 million gallons (MG) of reclaimed water annually for onsite landscape irrigation, plant processes, and other nonpotable purposes. Combined, these facilities save about 700,000 gallons of drinking water each day—enough to serve about 9,400 households. Reclaimed water for offsite uses meets Class A standards set by the Washington State Departments of Health and Ecology.[11]

The West Point Treatment Plant has the capacity to produce up to 0.5 million gallons per day (mgd) of reclaimed water. It uses about 172 MG annually for onsite processes and irrigation. West Point also serves as an applied research center for evaluating alternative technologies for producing reclaimed water. Data from these studies have proven helpful both to King County and to other utilities investigating options for advanced wastewater treatment.

The South Treatment Plant has the capacity to produce up to 1.3 mgd of reclaimed water. It uses about 84 MG annually for onsite processes and irrigation and for irrigation of sports fields at the City of Tukwila’s Fort Dent Park. In addition, a reclaimed water hydrant provides water for county and other jurisdictions to transport via truck for street sweeping, dust control, and other

[11] Class A reclaimed water is reclaimed water that, at a minimum, is at all times an oxidized, coagulated, filtered, and disinfected wastewater. Allowed end uses of Class A reclaimed water are irrigation of food and non-food crops and irrigation of open access areas, such as parks. The water could also be used for industrial cooling and process water and other non-drinking-water (nonpotable) uses.

nonpotable uses. King County's Water and Land Resources Division uses the water to irrigate newly planted vegetation for stream restoration and flood control projects.

Installation of a greenhouse began in early 2007 at South plant as part of the county's resource recovery program. The greenhouse will showcase the safe use of reclaimed water and biosolids compost in growing ornamental and horticultural plants. Researchers from the University of Washington will be able to use the greenhouse for onsite studies involving reclaimed water and biosolids to seek answers to questions from current and future customers of both reclaimed water and biosolids. The research will also help fine-tune operational practices.

2.5 Planned Facilities and Uses

The treatment plant policies in the RWSP direct the county to explore reclaimed water opportunities at all new treatment plants. The Brightwater and Carnation Treatment Plants will use membrane bioreactor (MBR) technology, which provides better and more consistent overall treatment than conventional activated sludge secondary treatment. MBR produces treated wastewater that is seven to ten times cleaner than typical secondary treated wastewater. In addition, MBR systems can produce Class A reclaimed water. As a result, King County has looked for opportunities to incorporate reclaimed water considerations into the design and construction of the conveyance systems associated with the Brightwater and Carnation projects.

2.5.1 Carnation Treatment Plant Wetland Enhancement

All water treated at the new Carnation Wastewater Treatment Plant (under construction) will meet Class A reclaimed water standards. The initial capacity will be about 0.4 mgd. Reclaimed water from the plant will be used to enhance a wetland in the Chinook Bend Natural Area. The wetlands enhancement is a beneficial use of reclaimed water, avoids discharge to the Snoqualmie River, and has broad stakeholder support. King County is partnering with Ducks Unlimited, a nonprofit organization dedicated to wetland conservation, to design the wetland discharge project. In summer 2005, the county and Ducks Unlimited worked with the Snoqualmie Tribe and other interested parties to develop a design. The design will increase the size of the wetland to nearly four acres, benefiting wildlife and enhancing opportunities for passive recreation (Figure 2-2).

Working with King County staff, Ducks Unlimited obtained $166,000 to fund the design, permitting, construction, and wetlands restoration for this project. King County obtained an additional $395,350 in grant funds from the Interagency for Outdoor Recreation Aquatic Lands Enhancement Account. These funds will be used to fund public access and environmental education improvements to the site.

Construction of the wetland began in 2007. The treatment plant is expected to come online in 2008. During startup, treated wastewater will be discharged via an outfall to the Snoqualmie River. After startup, the wetland will become the primary discharge site for reclaimed water.

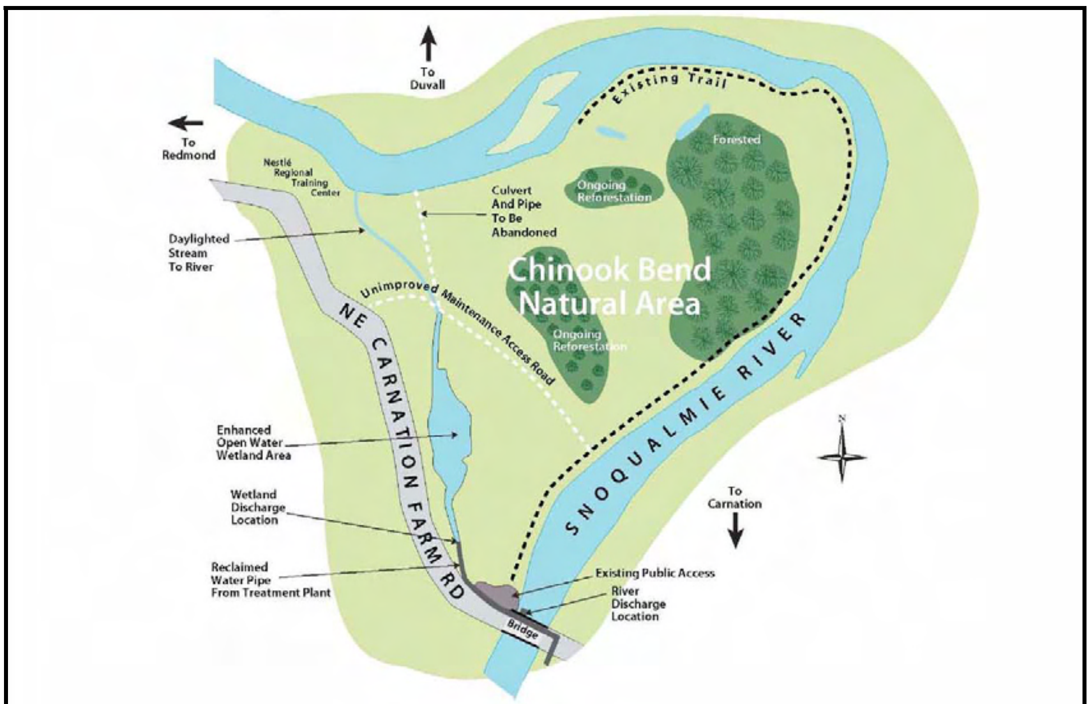

Figure 2-2. Conceptual Enhancement of the Chinook Bend Natural Area

2.5.2 Brightwater Reclaimed Water System

Reclaimed water will be available from Brightwater by 2011. The backbone into the Sammamish Valley will carry 7 million gallons per day (mgd) using gravity alone. As more reclaimed water is needed, pumps can be added to the system to convey up to 21 mgd.

To keep costs down, the Brightwater backbone takes advantage of existing infrastructure and planned construction. The backbone consists of two segments: West Segment and South Segment. The South Segment consists of new pipe from the Brightwater Influent Pump Station in Bothell to the North Creek Pump Station, an upgraded North Creek force main to the York Pump Station, and approximately 10,000 feet of purple pipe from the York Pump Station to points in the Sammamish Valley (Figure 2-3). It will have the capacity to provide up to 7 mgd of reclaimed water to customers beginning in 2011. Potential reclaimed water opportunities from this segment include uses for parks and businesses in Bothell, Woodinville, Redmond, and other cities in the area, as well as farms, parks, and businesses in the Sammamish Valley. The county has one agreement in place to supply the Willows Run Golf Course with reclaimed water and is working to identify more potential customers, including existing and planned soccer fields at the 60 Acres site near Willows Run, as the availability gets closer.

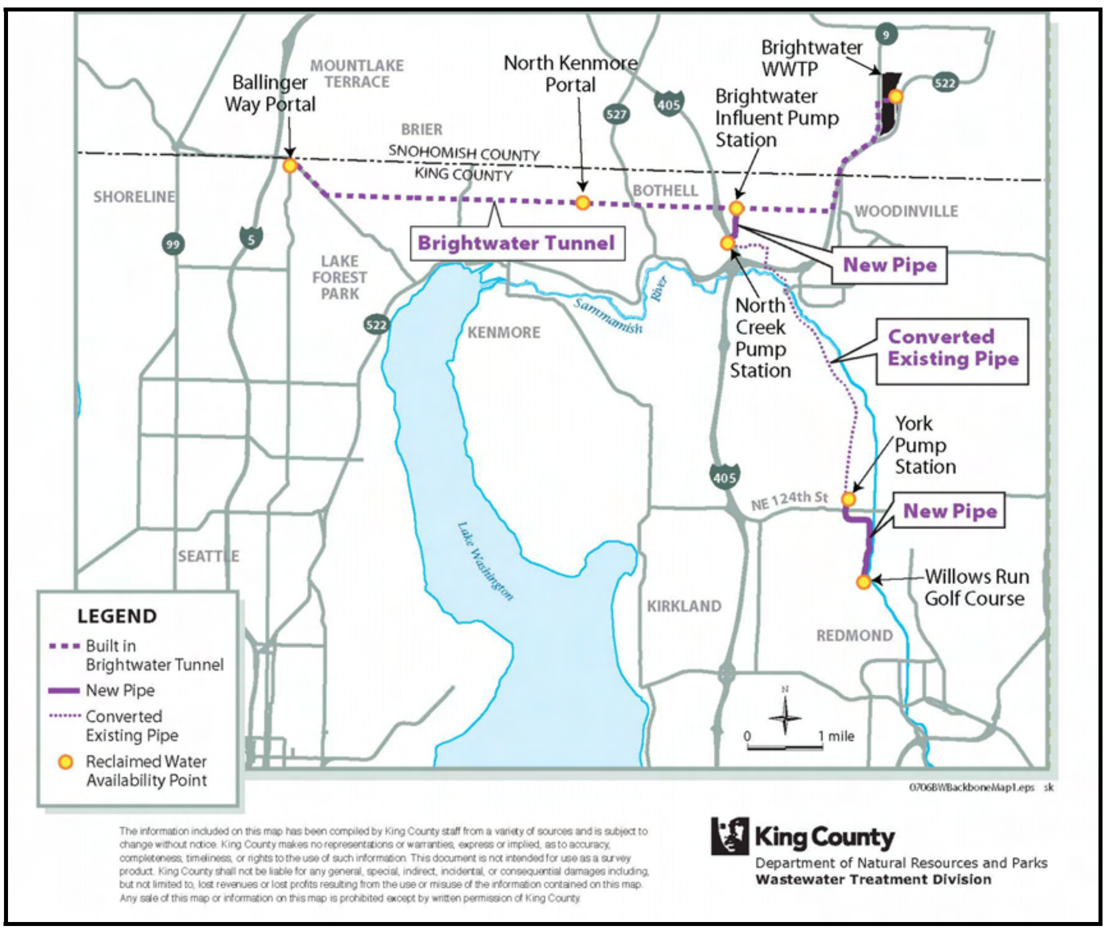

Figure 2-3. Brightwater Reclaimed Water System

The West Segment consists of dedicated concrete-encased 27-inch-diameter reclaimed water pipes in the effluent tunnel that runs from the Influent Pump Station in Bothell to the Ballinger Way Portal in Shoreline. Additional infrastructure will be needed to provide access to reclaimed water from the West Segment; this infrastructure will be built when demand is demonstrated. When the entire reclaimed water pipeline and associated pumps and infrastructure are constructed and operational, 21 mgd of reclaimed water will be available.

King County is working with cities, districts, and businesses to identify potential Brightwater reclaimed water users. In addition, the county will continue to work with local agencies to address concerns raised during the development of the backbone; these concerns focused on issues of who pays for and who benefits from reclaimed water. Some of the agencies also expressed concern about their potential loss of water customers and stranded costs. The county's preference is to act as a wholesale supplier of reclaimed water to the cities or districts; the cities or districts would then retail the water to the users in their service areas.

The Washington State Public Works Board awarded a $1 million low-interest loan in spring 2006 to help with the preconstruction costs of building Brightwater's reclaimed water system. The county is working to identify additional funding sources for the project.[12]

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[12] For more information on the Brightwater Reclaimed Water System, see http://dnr.metrokc.gov/wtd/reuse/brightwater/index.htm

Chapter 3

Review of Current and Developing Reclaimed Water Technologies

As directed by Water Reuse Policy 2 (WRP-2) of the Regional Wastewater Services Plan, this feasibility study is to conduct a "review of new technologies for feasibility and cost effectiveness that may be applicable for future wastewater planning."

This chapter reviews current and developing treatment technologies for producing reclaimed water that meets standards for allowed uses in Washington State. The chapter presents state reclaimed water standards and compares them with those in other states, describes the relative merits and costs of proven and emerging technologies, and provides examples of how technologies and the resulting reclaimed water are being used in Washington and in other states.

The results of this review indicate that in the foreseeable future, technologies used at existing and planned facilities in King County's system are appropriate for creating high quality reclaimed water that meets the standards required for identified and potential end uses. Both the West Point and South Treatment Plants use sand filters and additional disinfection with sodium hypochlorite to produce reclaimed water from some of the secondary effluent produced a the plants. The Brightwater and Carnation Treatment Plants, both under construction, will use membrane bioreactor technology plus disinfection with sodium hypochlorite (Brightwater) or ultraviolet light (Carnation) to treat their incoming flows to reclaimed water quality standards.

There are no federal standards for reclaimed water use, although the Environmental Protection Agency in 2005 issued national guidelines for state programs. Washington has a set of standards that have been in place for approximately 10 years. These standards authorize reclaimed water for virtually all uses other than direct potable use, including industrial processes, irrigation of food and non-food products, wetland and streamflow augmentation, and groundwater recharge. The state standards take a multiple-barrier approach that ensures a high level of protection for both public health and the environment. They are comparable to and, in some areas, more stringent than state standards in other states with large amounts of reclaimed water use, such as California, Florida, Arizona, and Texas.

Washington state standards are currently being reviewed and will be revised and adopted by the Washington State Department of Ecology into formal rules by December 31, 2010. King County staff are participating in workgroups and committees developing the new standards and do not anticipate any issues regarding the ability of King County facilities to comply with the standards.

3.1 Reclaimed Water Standards

In 2005, the U.S. Environmental Protection Agency (EPA) published the *2004 Guidelines for Water Reuse,* which examines opportunities and requirements for water reclamation and reuse throughout the world, with emphasis on the United States. This publication reports that as of 2004, 41 states had reclaimed water regulations or standards in place (25 of these states had adopted reuse regulations and 16 had published reuse standards or guidelines); the remaining 9 states allowed reuse on a case-by-case basis. The various regulations and standards typically divide water reuse into types of uses. General categories of use and the number of states allowing each use are as follows (EPA, 2005):

- Unrestricted urban use, primarily irrigation where public access is not restricted; also includes uses such as dual plumbing, fire protection, and ornamental uses (28)
- Restricted urban use in controlled areas such as golf courses (34)
- Agricultural use (21–40, depending on whether for food or non-food crops)
- Unrestricted and restricted recreational uses, such as impoundments with both contact and non-contact activities (7–9)
- Wetland and streamflow augmentation (3)
- Industrial use, primarily for cooling and process water (9)
- Groundwater recharge (5)
- Indirect potable use—reclaimed water is discharged into surface water or groundwater that is ultimately used as a source of potable water (5)

Washington State is one of the 16 states with published reuse standards. Washington is the only state, however, that allows all of the uses listed above (with different requirements for levels of treatment depending on use). State standards are described below, followed by a comparison with standards in other states.

3.1.1 Washington State Reclaimed Water Standards

Each type of reuse application allowed by Washington state standards requires specific treatment requirements and water quality standards. In 1992, the Washington State Legislature passed the Reclaimed Water Use Act (Chapter 90.46 RCW). In 1997, the Washington State Departments of Ecology (Ecology) and Health (DOH) published the Washington State Water Reclamation and Reuse Standards, which lists the required level of treatment for the most common uses of reclaimed water. These standards were developed under the authorization and specific requirements delineated in Chapter 90.46 RCW.

In 2006, the Washington State Legislature enacted Engrossed Substitute House Bill (ESHB) 2884. This bill amended the Reclaimed Water Use Act, directing development and promulgation of rules on all aspects of reclaimed water use by no later than December 31, 2010. The 1997 standards will be superseded by any standards adopted by Ecology and DOH under ESHB 2884. Rule-making is under way.[1]

The 1997 standards are divided into three sections according to categories of use: (1) uses under "general requirements," (2) wetlands, and (3) direct groundwater recharge.

General Requirements

Uses under the general requirements include landscape, public park, golf course, and crop irrigation. They also include industrial cooling water, toilet flushing, dust control, construction activities, groundwater recharge through surface percolation, impoundments, and streamflow augmentation. Reclaimed water used to recharge aquifers or augment streamflows or that has the greatest potential for human contact must have the highest level of treatment. The requirements may be less stringent for non-potable uses where human contact is less likely to occur.

Production of reclaimed water suitable for reuse generally requires treatment and disinfection systems over and above conventional wastewater treatment facilities. State standards list four basic classes of reclaimed water: A, B, C, and D. Class D, the lowest class of reclaimed water, requires a minimum of secondary treatment plus additional disinfection. Class D reclaimed water may be used only in restricted areas on non-food crops. Increasingly stringent levels of disinfection differentiates Class D from the higher levels of Class C and B. Class A is the highest quality reclaimed water and thus has the broadest range of uses. Class A reclaimed water requires additional treatment beyond secondary treatment to remove contaminants prior to disinfection.

Ecology and DOH use a multi-barrier approach to assure adequate and reliable treatment for reclaimed water use. A multi-barrier approach is a required sequence of prevention, control, and treatment steps to keep water from leaving the reclamation facility until it meets the required quality:

- The first step, source control, prevents contaminants from entering the wastewater through best management practices and pretreatment.
- Next, the wastewater is treated through a series of processes including biological oxidation to meet the federal secondary treatment standards.
- For Class A reclaimed water, the secondary effluent receives additional chemical coagulation and filtration.
- More treatment steps are added for some uses such as aquifer recharge or streamflow augmentation.

All reclaimed water receives a high level of disinfection. Table 3-1 shows the treatment requirements for each reclaimed water class, and Table 3-2 shows acceptable uses for these classes. In addition to secondary treatment removal standards for biochemical oxygen demand (BOD) and total suspended solids (TSS) of 30 milligrams per liter (mg/L), Class A reclaimed water must meet turbidity standards. Turbidity standards are generally applied as a surrogate to

[1] Information on the rule development process is available at http://www.ecy.wa.gov/programs/wq/reclaim/rule_develpmnt.html

measure treatment efficiency of suspended solids removal (and therefore pathogen reduction) in addition to the secondary treatment standards. There are generally no organic removal standards for carbon, nitrogen, or phosphorus, except in the case of wetlands and direct groundwater recharge (see below). Disinfection practices for Class A, B, C, and D reclaimed water are measured in total coliform, rather than fecal coliform traditionally used to measure wastewater disinfection effectiveness. Classes A and B require less than 2.2 total coliforms per 100 milliliters (mL) based on a 7-day median. Sampling is to be performed daily.

Table 3-1. Reuse Class and Water Quality Requirements

Class	**Oxidized** BOD and TSS (mg/L)[a]	Coagulated	**Filtered** Turbidity (NTU)	**Disinfection** (Total Coliform/100 mL)	
				7-Day Median	Single Sample
A	30	Yes	2	2.2	23
B	30	No	No	2.2	23
C	30	No	No	23	240
D	30	No	No	240	No standard

BOD = biochemical oxygen demand; TSS = total suspended solids; NTU = nephelometric turbidity unit.
[a] Oxidation is part of the secondary process.

Table 3-2. Required Reclaimed Water Class for Nonpotable Uses

Reclaimed Water Use	Reclaimed Water Class			
	A	B	C	D
Irrigation of nonfood crops				
Trees and fodder, fiber, and seed crops	X	X	X	X
Sod, ornamental plants for commercial use, and pasture to which milking cows or goats have access	X	X	X	
Irrigation of food crops				
Spray irrigation – all food crops	X			
Spray irrigation – food crops which undergo physical or chemical processing sufficient to destroy all pathogenic agents	X	X	X	X
Surface irrigation – food crops where there is no reclaimed water contact with edible portion of crop	X	X		
Surface irrigation – root crops	X			
Surface irrigation – orchards and vineyards	X	X	X	X
Surface irrigation – food crops which undergo physical or chemical processing sufficient to destroy all pathogenic agents	X	X	X	X
Landscape irrigation				
Restricted access areas (e.g., cemeteries and freeway landscapes)	X	X	X	
Open access areas (e.g., golf courses, parks, playgrounds, schoolyards, and residential landscapes)	X			

Reclaimed Water Use	Reclaimed Water Class			
	A	B	C	D
Impoundments				
Landscape impoundments	X	X	X	
Restricted recreational impoundments	X	X		
Nonrestricted recreational impoundments	X			
Fish hatchery basins	X	X		
Decorative fountains	X			
Commercial				
Flushing of sanitary sewers	X	X	X	X
Street sweeping, brush dampening	X	X	X	
Street washing, spray	X			
Washing of corporation yards, lots, and sidewalks	X	X		
Dust control (dampening unpaved roads and other surfaces)	X	X	X	
Soil dampening for compaction (construction sites, landfills, etc.)	X	X	X	
Water jetting for consolidation of backfill around pipelines	X	X	X	
Fire fighting and protection – dumping from aircraft	X	X	X	
Fire hydrants or sprinkler systems in buildings	X			
Toilet and urinal flushing	X			
Ship ballast	X	X	X	
Washing aggregate and making concrete	X	X	X	
Industrial				
Boiler feed	X	X	X	
Cooling – no creation of aerosols or other mist	X	X	X	
Cooling aerosols or other mist created (e.g., use in cooling towers, forced air evaporation, or spraying)	X			
Process water – without exposure of workers	X	X	X	
Process water – with exposure of workers	X			

Source: Washington State Department of Ecology, *Frequently Asked Questions about Reclaimed Water Use* (05-10-0d2), January 2005.

Requirements for Wetlands, Groundwater Recharge, and Streamflow Augmentation

Reclaimed water used for wetlands, groundwater recharge, and streamflow augmentation must undergo treatment in addition to that indicated in Table 3-1. Many of these requirements are summarized below and in Appendix A.

For discharge to wetlands, treatment requirements differ based on the type of wetlands receiving the reclaimed water. The BOD and TSS concentrations allowed are usually lower and additional requirements are included for nitrogen, phosphorus, ammonia, and various metals.

Groundwater recharge requires additional treatment beyond Class A. The reclaimed water must meet drinking water standards once it reaches the aquifer. The degree of treatment depends on whether the reclaimed water is released at the surface to percolate through the soil or is injected directly into the aquifer. For surface percolation, the reclaimed water treatment process must include nitrogen removal and may have additional requirements depending on site-specific conditions such as type of soils and depth to the aquifer. For direct injection, reclaimed water must receive an additional treatment step—reverse osmosis (RO)—before injection. RO is a membrane system that removes dissolved salts and minerals from solution based on reversing osmotic pressure differentials. It also removes pathogens, although additional disinfection is required as part of the multi-barrier approach.

The quality of reclaimed water used to augment surface water tends to be site specific. The reclaimed water must meet not only the state reclaimed water standards but also the state surface water quality standards and the federal requirements for discharge to surface water under the Clean Water Act. Additional requirements may be necessary to protect aquatic life under the Endangered Species Act.

Permits and Other Requirements

Anyone who generates reclaimed water must obtain a state reclaimed water permit before putting the water to use. State law requires the permits to be issued only to public entities or to entities permitted under the state Water Pollution Control Act (Chapter 90.48 RCW). Although DOH has permitting authority for commercial and industrial uses of reclaimed water, in most cases DOH requirements are included in a single permit issued by Ecology. Ecology issues the permit to the generator of the reclaimed water and usually combines the reclaimed water permit with requirements for NPDES or state wastewater discharges from the same facility.

The reclaimed water permit includes requirements for treatment, water quality, monitoring, distribution, and use of reclaimed water. State law also gives the treatment facility owner the exclusive right to the water and provides exemptions from the appropriative water right permitting requirements. However, the owner may not be able to divert reclaimed water from an existing effluent discharge location if this diversion would impair existing downstream water rights. Whenever the water is transferred to another party for distribution or use, the permit holder must do so under a legal contract to assure proper and safe water use.

State standards require maintaining residual chlorine in reclaimed water distribution lines. All reclaimed water pipes are color coded purple to distinguish them from drinking water supply lines. The permit also includes requirements for cross-connection controls and pipe separation between drinking water, reclaimed water, and sanitary sewer lines.

3.1.2 Washington State Standards Compared with Those in Other States

Reclaimed water standards in four other western states (Oregon, Colorado, California, and Arizona) and in Florida and Texas were reviewed to see how Washington State standards compare and to facilitate the description of technologies that follows. The comparison is shown in a table in Appendix B and summarized in the text below.[2]

Washington State standards are based on, and therefore are most similar to, California standards in regard to classification, effluent quality, and use. In general, Washington standards are equal to or more stringent than other states in the areas of disinfection and turbidity requirements, most similar to Florida in regard to reliability and storage requirements, and most similar to Oregon in performance monitoring requirements.

Washington standards showed the following similarities and differences to other reuse states:

- **Disinfection standards.** Oregon, California, and Colorado have reclaimed water treatment classes with disinfection standards based on total coliform, similar to Washington State; Arizona, Florida, and Texas base disinfection standards on fecal coliform; Colorado bases disinfection standards on *E.coli* and/or total coliform, depending on the end use.
- **Filtration standards.** Filtration turbidity requirements in Oregon, Colorado, California, and Arizona are similar to those in Washington. Florida's filtration requirements are based on carbonaceous biological oxygen demand (CBOD) and TSS, not turbidity like Washington. Texas allows a slightly higher turbidity than Washington.
- **Classes and uses.** End uses separated by reclaimed water class in Oregon, California, Colorado, Arizona, and Texas are similar to those in Washington. End uses in Florida are separated based on whether the reclaimed water is filtered.

3.2 Reclaimed Water Treatment Technologies

This section describes proven and emerging advanced treatment technologies for producing reclaimed water that meets Washington and other state standards.[3] Advanced technologies are usually combined with preliminary, primary, and secondary treatment technologies in "treatment trains" to produce reclaimed water. Advanced treatment technologies can remove suspended solids, organics, pathogens, nutrients (nitrogen and phosphorus), and metals remaining in the secondary effluent. Secondary treatment can remove a portion of trace contaminants such as endocrine disrupting and pharmaceutically active compounds; however, additional treatment is needed to reach the non-detectable level. Not all advanced technologies are capable of reaching this level of treatment. Later in this chapter, existing and emerging advanced technologies capable of this additional treatment are identified.

[2] The *2004 Guidelines for Water Reuse* (EPA, 2005) provide a detailed inventory of treatment standards for Arizona, California, Florida, Hawaii, Nevada, and Texas; the guidelines also include a comprehensive table that compares standards in all states that have them.

[3] Advanced treatment is also referred to as tertiary treatment.

Washington's reclaimed water standards are based on reliable technologies that were available at the time the standards were published. Standards for "oxidized, coagulated, filtered, and disinfected" wastewater are based on using chemical addition to sand filters as the "minimum standard." Ecology and DOH recognize, however, that advanced treatment technology is continually changing. Proven technologies are being improved and new technologies are being introduced, often in response to issues of concern before standards are in place to address the concerns. To accommodate these changes, Ecology and DOH approve application of new technologies on a case-by-case basis after review of others' experience with these technologies.

This is true, for example, in the case of membrane filtration. Membranes are becoming increasingly popular, both as advanced treatment to produce reclaimed water and as a new process to provide secondary treatment. Because current Washington State standards do not include the use of membranes for Class A reclaimed water production, Ecology and DOH are using the California standards as an interim standard for membrane treatment to test equivalency to filtration steps for Class A reclaimed water (Figure 3-1). They recently approved membrane processes for two projects in Washington State, based on nationwide experience and on regulatory review of pilot plant results and design documents prepared by the applicant.

Choice of technology for production of reclaimed water depends primarily on treatment standards and anticipated uses. Reclaimed water standards are based on protecting public health. Technologies must therefore be able to reliably and consistently meet public health standards. Selection of technology will most likely rely on a broad-based review of alternatives that considers the following criteria:

- Quantity and quality of the source water (untreated or treated wastewater), including proximity of source to use, peak/average flow ratio to take into account the portion of the flow that will be lost to solids residuals, and available average dry-weather flow
- Reuse applications and required treatment level
- Maturity of the technology, whether it can be applied to the required scale and whether there is tolerance for risks associated with new technologies
- Environmental policies and agency/public values and goals that can affect process, plant footprint, carbon footprint, and other decisions
- Public input on plant location, footprint, aesthetics, and odor; emerging contaminants of concern; use area and use type; interest in addressing perceived health issues that may not be addressed in regulations and standards
- Capital, operation and maintenance, and financing costs
- Operations and maintenance considerations such as reliability, ability to coordinate with other water supplies and to use small- or large-scale applications, efficiency, and operational complexity

Table 3-3 lists commonly used and emerging reclaimed water treatment technologies. Most of these technologies, with the exception of carbon adsorption and advanced oxidation processes, are being used in Washington State. Table 3-4 compares reclaimed water technologies on the basis of factors such as limitations, design criteria, reliability, performance, and cost. The

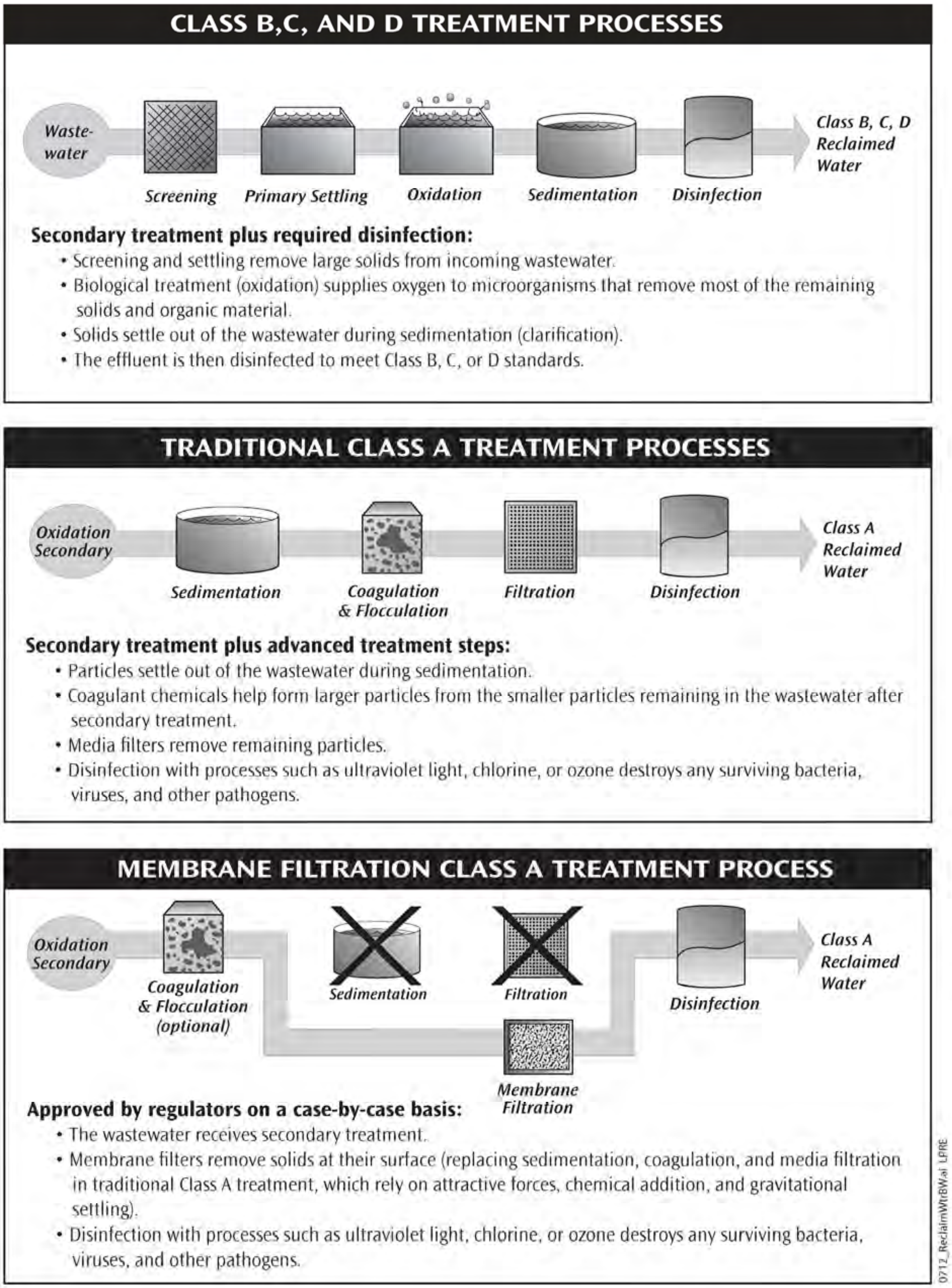

Figure 3-1. Treatment Processes for Reclaimed Water Classes

sections that follow the tables describe filtration and disinfection technologies, many of which are currently used or are planned to be used at King County treatment plants or that hold promise for future use in the county's system.[4]

Table 3-3. Advanced Treatment Technologies

Process	Technology	Treatment Use & Notes
Coagulation, Flocculation, and Sedimentation	Chemical addition, mixing, sedimentation, including ballasted sedimentation	Used after secondary treatment for enhanced particulate removal. Results in enhanced pathogen, trace contaminant, and phosphorus removal.
Filtration	Media (cloth, screens, sand, other granular material)	Used to meet reclaimed water standards for TSS and turbidity. Generally deep bed filtration is more robust than surface filtration.
	Membrane (micro-, ultra-, nano-filtration, and reverse osmosis)	Used to meet reclaimed water standards for TSS and turbidity. When combined with disinfection, provides a reliable multi-barrier for most pollutants including pathogens, viruses, and salts.
Combination and additional treatment	**Membrane bioreactors (MBRs)** (combination of biological treatment and filtration)	Used with preliminary treatment and primary treatment, MBR processes combine secondary treatment and filtration. Useful where a small footprint is required. Used to meet reclaimed water standards for TSS and turbidity. When combined with disinfection, provides a multi-barrier for pathogen and nitrogen removal.
	Biological filtration (denitrification filters)	Used to remove particulates and nitrogen.
	Natural systems (overland flow, wetlands)	Used to remove metals, nitrogen, phosphorus, and some organics. Typically, a polishing step.
	Carbon adsorption (additional treatment train for certain applications)	Used to remove trace hydrophobic contaminants after filtration. Uncommon in use because of rapid fouling of carbon from wastewater organics. Cost-effective only when preceded by membranes.
Disinfection	**Advanced oxidation processes (AOP), including ozone**	Used to remove pathogens and trace contaminants, such as endocrine disrupting compounds, from media or membrane filtration effluent.
	Chemical, ultraviolet light, ozone	Used for pathogen destruction. Most effective following filtration. Ozone can serve as an AOP or disinfectant depending on the dose and target contaminant.

[4] The term "trace pollutants" used in this and subsequent sections of this chapter can include endocrine disrupting compounds, pharmaceutically active compounds, chlorinated compounds, and organics.

Table 3-4. Comparison of Reclaimed Water Technologies

Technology	Limitations	Production Quantity	Design Criteria[a]	Byproducts	Equipment Reliability	Compliance Reliability	Flexibility in Treating Various Influent Qualities	Cost Efficiency	Environmental Benefits/ Adverse Impacts
Filtration Technologies									
Sand Filtration	Widely used and readily designed by most engineering firms.	Has been used for a wide range of flows and water qualities.	Requires reliability features and filter loading rate of 3–6 gpm/ft^2 for rapid sand, 0.1 gpm/ft^2 for slow sand filters, 3 gpm/ft^2 for automatic backwash filters. Loading rate for continuous backwash filters depends on demonstrated or manufacturer-justified values.	Filter backwash waste, settled sludge, and solids.	Continuous backwash filters have experienced problems with degradation of the airlift tube. High chemical doses can bind the filters.	A well-proven means for reducing turbidity and TSS. All filtration technologies, with the exception of deep bed filtration, may not perform well if the influent quality is poor.	Various technologies are in use. Continuous backwash, disc filtration, traveling bridge, and pulsed bed systems are not robust filters and do not typically handle high chemical doses that may be part of future efforts to improve filtrate water quality. Deep bed filtration shows more potential for successfully modifying operational tactics to improve filtrate quality.	Typically the lowest capital cost filtration alternative for advanced treatment.	Unlike membranes, media filtration does not provide a pathogen barrier.
Micro- and ultra-membrane filtration (MF and UF)	Require specialty design experience if used post-clarification.	Design flows range from less than 2.5 mgd to greater than 80 mgd.	Optimal flux (rate of flow across a membrane surface) should be determined through piloting pressure or immersed membranes.	Membrane backwash waste, settled sludge, and solids.	System should be sized to handle maximum-month flow conditions at the design flux rate with one train out of service. This requirement may be relaxed if there is sufficient storage or a potable supply for backup. There must be sufficient capacity to handle flow requirements when membranes need to be taken out of service for cleaning once every 2 to 3 months.	Research indicates reliable performance in maintaining low levels of TSS and turbidity in effluent and in providing an effective barrier to bacteria and protozoa. Typical effluent is free of detectable coliform, thus substantially lightening the burden for downstream disinfection.	If used post-clarification, addition of chemicals or carbon ahead of the membranes can improve removal of metals, trace organics such as EDCs, and other items of concern.	Construction and operational costs (mainly energy) are substantially higher than media filtration costs. Typical warranty for submerged membranes is 5 years so expected replacement is around that timeframe. Pressure membranes may need replacement more frequently.	Multi-barrier for pathogen reduction when coupled with UV.
Ultra-filtration/reverse osmosis (RO)	Requires specialized engineering and manufacturing knowledge. Sufficient small and large designs are in place to demonstrate performance.	Design flows range from 2.5 to 80 mgd.	Design criteria for minimum flux (rate of flow across a membrane surface) and minimum recovery are project specific.	RO brine, settled sludge and solids. Backwash waste when coupled with UF.	RO usually requires more equipment (pumps, valves, and instruments) than other treatment processes. May need to monitor for biological, organic, and inorganic fouling and for inorganic/silica scaling. Some plants carry a low level of chloriamines through the RO membranes to control fouling. However, free chlorine will degrade the performance of membranes (irreversibly).	Proven to remove all pollutants and pathogens to below detection.	Best available technology; will meet all known standards.	Highest cost of filtration technologies by a wide margin. Typical warranty for submerged membranes is 5 years so expected replacement is around that timeframe. RO will require more frequent replacement.	Effluent water quality exceeds potable sources. RO brine disposal an issue.
Membrane bioreactor (MBR)	Widely employed and readily designed by many engineering firms.	Used over a wide range of flows and water qualities, although most MBR designs are for smaller flows.	Typical MBR membrane flux (rate of flow across a membrane surface) ranges between 12 and 17 gallon per square foot per day (gfd).	Membrane backwash waste, settled sludge, and solids.	System should be sized to handle maximum-month flow conditions at the design flux rate with one train out of service. This requirement may be relaxed if there is sufficient storage or a potable supply for backup. There must be sufficient capacity to handle flow requirements when membranes need to be taken out of service for a clean in place once every 2 to 3 months.	Typically runs at reduced fluxes.	Supplemental chemical addition is used if trying to enhance removal of a specific contaminant (phosphorous or metals) or to reduce fouling of the membrane. Removal of phosphorus for reuse is generally not required. May use alum or ferric to tie up soluble chemical oxygen demand and minimize membrane fouling.	Construction and operational costs (mainly energy) are substantially higher than media filtration costs; these costs are somewhat offset by the lack of secondary clarifiers. Typical warranty for membranes is 5 years so expected replacement is around that timeframe. Pressure membranes may need replacement more frequently.	Multi-barrier for pathogen reduction when coupled with UV.

Technology	Limitations	Production Quantity	Design Criteria[a]	Byproducts	Equipment Reliability	Compliance Reliability	Flexibility in Treating Various Influent Qualities	Cost Efficiency	Environmental Benefits/ Adverse Impacts
Disinfection Technologies									
Chlorination	Bench-top analysis is needed to ensure predictable pathogen disinfection.	Has been used for a wide range of flows and water qualities.	Requires reliability features and contact time of 450 minutes (a total chlorine residual of 5 mg/L times a modal contact time of at least 90 minutes).	Disinfection byproducts (DBPs) and toxicity.	Chlorine gas systems require diligent maintenance to prevent chlorine gas leaks. Sodium hypochlorite systems often have liquid chlorine leaks and scale.	Once tailored to a specific wastewater, will reliably meet coliform requirements in most cases.	May be problematic due to toxicity, safety, and DBPs. Many facilities are converting to an alternative disinfection to meet upcoming regulations for sensitive applications.	Typically, the low capital cost disinfection alternative, depending on chlorine design. Operations and maintenance costs, when compared to UV disinfection, are usually lower for chlorine gas and about the same for sodium hypochlorite, depending on the chlorine dose.	DBPs, toxicity, safety, and poor pathogen disinfection (i.e., protozoa).
UV	Widely used and readily designed by most engineering firms. Proper equipment selection coupled with a proactive maintenance program and a scientific-based approach to UV design help to prevent UV system failures.	Being used over a wide range of flows and water qualities	For reclaimed water, design UV transmittances and UV doses are 65%/80 mJ/cm^2 following micro-filtration and ultra-filtration and 55%/100 mJ/cm^2 following media filtration.[b] Higher design values can be used if collected data dictate such use.	Lamp disposal, although most manufacturers now recycle lamps at no cost to the utility.	Reliability depends on the UV technology. Some lamp types last 3,000 to 5,000 hours (medium pressure); some lamp types last >10,000 hours (low pressure and low pressure high-output), and new microwave-generated UV systems may last 3 to 5 years. Ballast issues have been reduced from those encountered over the last 10 years. Other reliability issues are related to lamp-sleeve cleaning.	If properly designed and maintained, will routinely meet compliance criteria.	At reclaimed water doses, UV has been proven to destroy protozoa, viruses, and bacteria to below detection limits, without producing DBPs and creating toxicity in the effluent. UV can be supplemented with various oxidants, including peracetic acid, ozone, and hydrogen peroxide to combine pathogen/pollutant destruction technology.	For high design values (>65%), UV can be cost competitive with sodium hypochlorite (but not chlorine gas) for new construction. For high operating values, UV operating costs can be equal or less than sodium hypochlorite.	Pathogen-free water with no DBPs or toxic elements.
UV/hydrogen peroxide (H_2O_2)	Requires specialized engineering and manufacturing knowledge. If properly done, results in the generation of the hydroxyl radical, a superior oxidant. UV reactor hydraulics dramatically affect the efficient generation of these radicals.	Used at only three wastewater facilities—all post RO. Ongoing research as part of WRF 02-009[c] shows effective destruction of pathogens and EDCs at low UV doses with 5 to 10 mg/L of hydrogen peroxide. There is no reason that this application cannot be engineered for a wide range of flows and wastewater UV transmittance.	Design criteria are site specific. WRF 02-009[c] pilot data suggest that reclaimed water UV doses of 100 mJ/cm^2 at 65% UVT coupled with 10 mg/L of hydrogen peroxide will destroy 90% of a range of EDCs and trace pollutants. Alternatively, other data suggest that UV doses of 300 to 500 mJ/cm^2 coupled with 5 mg/L of hydrogen peroxide result in greater than 99.99% removal/destruction of pathogens and pollutants.	Lamp disposal, although most manufacturers now recycle lamps at no cost to the utility. No byproducts expected from hydrogen peroxide	Similar to UV reliability documented above.	No track record of compliance at this time, though data suggests a similar compliance to UV systems without peroxide.	The combination of MBRs, MF, or UF with UV/hydrogen peroxide provides a level of treatment well beyond conventional reclaimed water treatment, providing a pathogen-free and substantially reduced pollutant load to receiving water bodies or use locations.	Not a substantial construction cost increase when compared to UV. Hydrogen peroxide costs substantially increase operations costs.	Multi-barrier for pathogen and EDC reduction. Hydrogen peroxide may need to be quenched prior to discharge, depending on application. Quenching can be done with chlorine, ozone, thiosulfate, sulfite, or granular activated carbon. Typical chemical handling precautions necessary. Hydrogen peroxide not considered an EPA hazardous chemical.
Ozone	Requires specialized engineering, but not manufacturing knowledge. Ozone performance is highly variable.	Used at only one reclaimed water facility in the country and at fewer than 10 wastewater facilities designed to meet less stringent coliform standards. There is no reason that the large-scale ozone designs in drinking water cannot be used for large-scale reclaimed water designs.	Design criteria are site specific. Data suggest that ozone doses ranging from 3 to 15 mg/L meet non-detect coliform standards in media-filtered effluent and that doses of 3 to 5 mg/L reliably destroy 90% of a range of EDCs in MBR, UF, or MF effluent.	Bromate, which can be mitigated by hydrogen peroxide addition.	Ozone systems should have redundant generators and vaporizers for reliability. Redundant contactors may be needed for large flows with "conventional contactors".	No track record of compliance in a media filtered effluent.	The combination of MBRs, MF, or UF with ozone provides a level of treatment well beyond conventional reclaimed water treatment, providing a pathogen-free and substantially reduced pollutant load to receiving water bodies or use locations.	Higher cost for construction when compared to UV. If hydrogen peroxide is not used to reduce bromate formation, then operational cost is equivalent to UV.	Multi-barrier for pathogen and EDC reduction. Ozone residual is typically gone after a few minutes and does not require quenching.

[a] Criteria are based on the "Orange Book" (*Criteria for Sewage Works Design,* 2006, Washington State Department of Ecology).
[b] National Water Research Institute, *Ultraviolet Disinfection Guidelines for Drinking Water and Water Reuse*, 2003, Second Edition.
[c] WateReuse Research Foundation, *Innovative Treatment Technologies for Reclaimed Water,* ongoing study that began in 2005.

3.2.1 Filtration Technologies

Filtration removes residual suspended solids and organic matter to ensure more effective disinfection. There are two major types of filters: media filters (cloth, sand, other granular material) and membrane filters. Media filtration relies on chemical addition and captured flocculation particles to achieve solids removal. Membrane filtration removes solids by physical separation.[5]

The following sections describe sand filtration (and sand filtration combined with other media) and membrane filtration.

Sand filtration

Sand filters are essentially media beds that strain and settle solids. Chemical adsorption to media surfaces and chemical flocculants remove dissolved pollutants such as phosphorus. Sand filtration requires lower capital outlay than membrane filtration. It is well proven for reducing TSS and turbidity but does not reduce pathogens.

Conventional sand filters are usually lined, excavated structures filled with uniform media over an underdrain system. The wastewater is applied on top of the media and percolates through to the underdrain system. Two design variations include depth filtration and continuous backwashing counter-current upflow filters.

Depth filtration uses a granular media, typically sand or a diatomaceous earth. Usually, there are four layers of filter media. The particle size decreases through the filter layers. The coarse top layer removes larger particles, with finer material removed in the lower layers. This filtration system offers improved filter efficiency and can handle poorer quality influent when compared to a conventional sand filter.

In continuous backwashing counter-current upflow filters, secondary effluent enters the bottom of the filter instead of the top as in conventional sand filters. The water slowly rises through the sand bed to the top of the filter and overflows. During filter operation, water is always flowing upward while the sand is slowly moving downward. An airlift pump, located at the center of the filter bed, lifts the dirty sand from the bottom of the filter. While it moves through the bed, the sand is washed with filtered water and cleaned through natural abrasion. The cleaned sand overflows back into the sand bed at the top of the filter while the dirty cleaning water overflows to a waste drain. Continuous backwashing counter-current upflow filters are currently used at King County's South and West Point plants to treat a portion of their secondary effluent.

Design must take into consideration the type and size of filter media, filter bed depth, hydraulic loading rate, organic loading rate, and dosing frequency and duration. Backwashing is required to prevent buildup of oil and grease on the filter media; agglomeration of biological floc, dirt, and filter media into mudballs; and loss of filter media. Different designs for sand filters are

[5] Flocculation is the process by which fine particles in wastewater are made to clump together into larger masses. Often done prior to clarification and/or filtration in the wastewater treatment process.

based on the type of media, whether the operation needs to be taken offline to be backwashed, and whether the flow is up or down through the sand filter.

Membranes

Semi-permeable membranes filter pollutants from clarified wastewater. (See section that follows for a discussion of MBRs.) There are four classes of membrane filtration with increasingly smaller pore size: micro-filtration (MF), ultra-filtration (UF), nano-filtration (NF), and reverse osmosis (RO). As wastewater passes through a membrane, the membrane selectively traps larger pollutants, splitting the feed-stream into a purified stream and a waste stream.

Membrane filtration processes can remove particles, bacteria, other microorganisms, particulate matter, natural organic matter, and salt (desalination). Removal is determined by membrane pore size. However, as pore size decreases, operating pressure and energy increase. Pretreatment, including coagulation, may be required to remove larger particles and natural organic impurities to improve effectiveness.

Pollutant buildup on the membrane surface can foul the membrane. A backwash system integrated into the plant’s operation manages fouling. Periodic chemical cleaning is required to rejuvenate the membranes. Membranes have a finite life and are typically replaced every two to five years. Higher operating pressure increases permeate flow, thereby increasing efficiency but increasing the fouling rate. Higher flow velocity across the membrane reduces the fouling. Waste disposal must be considered during design. Membrane processes produce a waste stream of about 15 percent of total feed volume, and up to 50 percent in some RO operations.

Micro-filtration and ultra-filtration provide an effective barrier to bacteria and protozoa but not viruses. The effluent is generally free of detectable coliform, thus decreasing the burden on downstream disinfection. RO, the membrane technology with the smallest pore size, removes most pollutants including pathogens, viruses, and salts. RO membranes are generally made from cellulose acetate and polyamide polymers. The cellulose acetate can tolerate chlorine levels used for microbial control, but chlorine will destroy polyamide polymers.

RO membranes are well suited for removing dissolved solids but are adversely affected by suspended solids, colloidal matter, organics, and bacteria. Membrane fouling from these constituents is a major reason for RO system failure. Membrane replacement comprises approximately 25 percent of an RO system’s annual operating cost. For this reason, appropriate pretreatment is critical to the RO system’s long-term, stable performance. Microfiltration is typically required prior to RO membranes for proper operation of the RO system.

Membrane technology has several advantages over other filtration technologies:

- Improved physical barriers for removal of pathogens
- Increased process control and reliability
- Smaller footprint, with reductions in site costs

Continued innovation and the modular design of membrane filtration processes for small-scale applications are improving the operational and economic feasibility of these systems, but membrane construction and operational costs, particularly energy costs, are higher than for media filtration.

3.2.2 Membrane Bioreactors

Membrane bioreactors (MBRs) are a proven, reliable treatment technology in other countries such as Japan, where they are used extensively for reclaimed water systems (Melbourne, 2004), and are becoming increasingly popular in the United States. Advancements in membrane filtration have fostered a new generation of compact MBR systems. King County's new Brightwater and Carnation Treatment Plants will use MBRs to treat their flows.

An MBR system uses a combination of aerobic biological process and integrated, immersed membrane filtration. The system captures suspended solids, bacteria, and some viruses as water passes through the membranes. The treatment process has a small footprint and generates high quality effluent with low TSS, BOD, and turbidity. When combined with ultraviolet or chlorine disinfection, MBR provides a multi-barrier to pathogens.

The biological process and membrane operating systems are typically located in separate tanks to optimize performance of the overall process and to simplify operation and maintenance. This form of filtration eliminates the need for secondary clarifiers and other peripheral equipment, and for process control and maintenance normally associated with a conventional clarification process. The overall footprint therefore can be reduced by more than 50 percent compared with a conventional biological process. Replacing clarifiers with membranes allows the biological process to be designed and operated as a high-rate wastewater treatment process. The system can provide advanced nitrogen and phosphorus removal to meet the most stringent effluent requirements.

Membrane replacement can be costly. Operating experience has shown that membranes need to be replaced every five to seven years, depending on operating conditions. If fouling is not controlled, membranes will wear more quickly, energy costs will increase, and filtration rates will decrease. In some cases, regular chemical cleaning of the membrane elements is necessary to restore filtration flow rates. Backflushing with dilute chemicals and/or clean-in-place (CIP) methods may be required, depending on the membrane manufacturer. Sodium hypochlorite and mild citric acid solutions are commonly used for CIP. MBRs also have higher capital cost and energy costs than other treatment systems; however, advances in technology are reducing energy demands.

3.2.3 Disinfection

Disinfection is the primary mechanism for the inactivation/destruction of pathogenic organisms to prevent the spread of waterborne diseases to downstream users and the environment. It is important that wastewater be adequately treated prior to disinfection in order for any disinfectant to be effective.

Chlorine is the most widely used disinfectant for municipal wastewater because it destroys target organisms by oxidizing cellular material. Some alternative disinfectants include ultraviolet (UV) lights and ozone. Choosing a suitable disinfectant for a treatment facility depends on the following criteria:

- Ability to penetrate and destroy infectious agents under normal operating conditions
- Safe and easy handling, storage, and shipping
- Absence of toxic residuals and mutagenic or carcinogenic compounds after disinfection
- Affordable capital and operation and maintenance costs

This section describes chlorine, UV, and ozone disinfection technologies.

Chlorine

Chlorine can be supplied in many forms, including chlorine gas, hypochlorite solutions, and other chlorine compounds in solid or liquid form. King County's West Point and South plants use sodium hypochlorite for disinfection, as will the new Brightwater plant. Chlorine carries some health and safety limitations, but at the same time, it is a well-established technology with a long history of effective disinfection.

Chlorine disinfection is reliable and effective against a wide spectrum of pathogenic organisms. It is effective in oxidizing certain organic and inorganic compounds. However, the oxidation of some organics may create hazardous compounds, such as trihalomethanes. Chlorine can also eliminate certain noxious odors during disinfection. Chlorination has flexible dosing control. Storage, shipping, and handling pose a risk, requiring increased safety regulations.

The chlorine residual that remains in the wastewater effluent can prolong disinfection even after initial treatment and can be measured to evaluate its effectiveness. Chlorine residual is unstable in the presence of high concentrations of chlorine-demanding materials, thus requiring higher doses to achieve adequate disinfection. The chlorine residual is toxic to aquatic life and may require dechlorination. The long-term effect of discharging dechlorinated compounds into the environment is not known; however, dechlorination is an established practice. Chlorination also increases the level of total dissolved solids and the chloride content in the treated effluent.

Historically, chlorine has been more cost-effective than either UV or ozone disinfection. Chlorine gas continues to be the least costly disinfection technology. Costs for UV disinfection are now becoming competitive with sodium hypochlorite, especially when dechlorination is used. For this reason and because of the potential disinfection byproducts and toxicity associated with chlorine, reclaimed water producers are increasingly selecting UV for disinfection.

Ultraviolet Light

King County's new Carnation Treatment Plant will use UV disinfection.

UV radiation, generated by an electrical discharge through mercury vapor, penetrates the genetic material of microorganisms and retards their ability to reproduce. The main components of a UV disinfection system are mercury arc lamps, a reactor, and ballasts. The source of UV radiation is either the low-pressure or medium-pressure mercury arc lamp with low or high intensities. UV disinfection is widely used. Its effluent will meet reclaimed water standards as long as the appropriate equipment is selected and the system is properly designed and maintained.

The effectiveness of a UV disinfection system depends on the characteristics of the wastewater, the intensity of UV radiation, the amount of time the microorganisms are exposed to the radiation, and the reactor configuration. UV disinfection has a shorter contact time (approximately 20 to 30 seconds with low-pressure lamps) and requires less space than other disinfectants. At high enough dosages, UV disinfection is effective at inactivating most viruses, spores, and cysts with no harmful residual effect. However, organisms can sometimes repair and reverse the destructive effects of UV through a “repair mechanism” known as photoreactivation. Turbidity and TSS in the wastewater can also render UV disinfection ineffective.

Because UV disinfection is a physical process rather than a chemical disinfectant, it eliminates the need to generate, handle, transport, or store toxic/hazardous or corrosive chemicals. The system is relatively easy to operate and maintain. Preventive maintenance is necessary to control fouling of tubes. Lamps are now available with longer lives, and most manufacturers will recycle the lamps.

Depending on the system, construction and operation costs for UV are generally more than for chlorine gas and about the same as for sodium hypochlorite.

Ozone

Ozone, an advanced oxidation process, is the least-used disinfection method in the United States, although this technology has been widely accepted in Europe for decades (EPA, 1999b). There is only one ozone system in this country that produces reclaimed water. Ozone treatment has the ability to achieve higher levels of disinfection than either chlorine or UV; however, capital and maintenance costs are generally not competitive with available alternatives.

Ozone is produced when oxygen (O_2) molecules are dissociated by an energy source into oxygen atoms that collide with an oxygen molecule to form an unstable gas, ozone (O_3). Most wastewater treatment plants generate ozone onsite because it is unstable and decomposes to elemental oxygen shortly after generation.

Ozone is a very strong oxidant and virucide. When ozone decomposes in water, the free radicals hydrogen peroxy (HO_2) and hydroxyl (OH) that are formed have great oxidizing capacity and play an active role in the disinfection process. Ozone is also used for odor control. Ozone disinfection is generally used at medium- to large-size plants after at least secondary treatment. Ozonation is not economical for wastewater with high levels of suspended solids, BOD, chemical oxygen demand, or total organic carbon.

The ozonation process uses a short contact time (approximately 10 to 30 minutes). There are no harmful residuals that need to be removed after ozonation and no regrowth of microorganisms, except for those protected by the particulates in the wastewater stream. Ozonation elevates the dissolved oxygen (DO) concentration of the effluent, which can eliminate the need for reaeration and can raise the level of DO in the receiving stream.

Ozonation is a more complex technology than is chlorine or UV disinfection. It requires complicated equipment, efficient contacting systems, and corrosion-resistant material such as stainless steel because ozone is very reactive and corrosive. The effectiveness of disinfection depends on the susceptibility of the target organisms, the contact time, and the concentration of the ozone. It is critical that all ozone disinfection systems be pilot tested and calibrated prior to installation to ensure they meet discharge permit requirements for their particular sites.

The components of an ozone disinfection system include feed-gas preparation, ozone generation, ozone contacting, and ozone destruction. Air or pure oxygen is used as the feed-gas source and is passed to the ozone generator at a set flow rate. The energy source for production is generated by electrical discharge in a gas that contains oxygen. Because ozone is extremely irritating and possibly toxic, the off-gases from the contact chamber must be treated to destroy any remaining ozone before release into the atmosphere. Therefore, it is essential to maintain an optimal ozone dosage for better efficiency. When pure oxygen is used as the feed-gas, the off-gases from the contact chamber can be recycled to generate ozone or reused in the aeration tank.

Because of its complexity, ozone carries a higher construction cost than UV. Operation costs may be comparable, depending on procedures and materials.

3.2.4 Developing Technologies

Most recent and current research in reclaimed water treatment technologies focuses on developing advanced oxidation and disinfection processes that can remove pathogens and micro-constituents, such as endocrine disrupting compounds (EDCs), pharmaceutically active compounds (PhACs), and trace recalcitrant volatile organics contaminants; that generate few or no disinfection byproducts; and that cost substantially less than RO. Some of the technologies currently being tested by the WateReuse Foundation (WRF) have been used for potable water treatment, and their efficacy in reclaimed water is the subject of much of the recent testing. These advanced processes are not required in Washington State; however, growing awareness of micro-constituents may provide impetus to explore and use them in the future.

The following treatment technologies are either under construction (ozone) or receiving serious consideration for use:

- Advanced oxidation processes for the oxidation of pathogens and other micro-constituents:
  - Ozone
  - Ozone/hydrogen peroxide
  - UV/hydrogen peroxide
  - UV/peracetic acid (PAA)
  - Titanium dioxide (TiO_2)/UV
- Pasteurization for temperature/time disinfection of pathogens

Recent pilot-scale and benchtop-scale studies funded by WRF showed that ozone in conjunction with hydrogen peroxide effectively destroyed greater than 90 percent of various EDCs and PhACs. The synergistic effect of combining UV with PAA has been investigated in Europe (WateReuse Foundation, 2005).

In addition, recent work in the United States has shown that a 10 mg/L dose of PAA upstream of UV at a dose of 50 mJ/cm2 results in non-detect coliform levels (WateReuse Foundation, 2005).[6,7]

Advanced oxidation technologies have also been combined with UV to improve operations. For example, it was found that a combination of ozone and UV following membrane processes increased the effectiveness of the UV process and reduced operating costs as compared to ozone alone (Appendix C).[8]

Appendix D contains further information, including costs, for these developing technologies.

3.3 Conceptual Treatment Trains

Conceptual treatment trains were developed for this feasibility study to illustrate combinations of treatment processes and the construction costs for such combinations. Some of the treatment trains include advanced oxidation processes (AOPs) to illustrate the cost impacts of adding these processes to treatment systems. The influent waste stream for each treatment train is raw wastewater; reclaimed water is the primary discharge method. All trains include preliminary treatment consisting of coarse screening and grit removal. Primary treatment is assumed to include primary sedimentation; secondary treatment is assumed to include aeration and secondary sedimentation, without nitrogen or phosphorus removal.

The conceptual treatment trains are as follows:

- Train A – Preliminary, primary, and secondary treatment, sand filtration, chlorination (sodium hypochlorite)
  - Train A1 – Add ballasted flocculation for treatment of secondary effluent to base Train A.[9]
  - Train A2 – Remove the filtration step from base Train A.
- Train B – Preliminary, primary, and secondary treatment, sand filtration, UV
- Train C – Preliminary, primary, and secondary treatment, ultra-filtration, UV
- Train D – Preliminary treatment, fine screening, primary treatment, MBR, UV
  - Train D1 – Remove primary treatment from Train D
  - Train D2 – Remove fine screening and UV from Train D and add chlorination (sodium hypochlorite)

[6] mJ/cm^2 = millijoules per centimeter squared.
[7] Membranes also can produce effluent with non-detect coliform levels.
[8] City of Davis, California, 2006.
[9] Ballasted flocculation consists of sand filtration plus coagulants.

- Train E – Preliminary treatment, fine screening, primary treatment, MBR, UV/hydrogen peroxide
- Train F – Preliminary, primary, and secondary treatment, ultra-filtration, ozone
- Train G – Preliminary treatment, fine screening, primary treatment, MBR, ozone
- Train H – Preliminary, primary, and secondary treatment, ultra-filtration, reverse osmosis, UV/hydrogen peroxide (AOP)

Treatment Trains A through D have been widely applied to reclaimed water production; Trains E through H include processes that are still in development, particularly with regard to disinfection technologies. All of the treatment trains, with the exception of Trains A, A1, A2, and D2, include UV disinfection. Chlorine would need to be added after UV disinfection to meet Washington State standards for chlorine residual in the distribution system, unless a waiver based on end use is obtained from the Ecology and DOH.

Table 3-5 shows categories of reclaimed water applications allowed in Washington State and which treatment trains could be used to meet or exceed the required reclaimed water quality for each category. The sections that follow the table present capital cost estimates for each treatment train and discuss general operations and maintenance considerations for reclaimed water systems.

Table 3-5. Treatment Trains to Meet or Exceed Allowed Reclaimed Water Uses in Washington State

Reuse Application	Treatment Standards	Treatment Trains: To Meet Standards	Treatment Trains: For Higher Pathogen and Trace Pollutant Barrier	Notes
Direct Aquifer Recharge Injection				
Nonpotable aquifers	Class A plus BOD and TSS 5 mg/L	A, A1, A2	B, C, D, D1, D2, E, F, G	Membranes and processes such as UV/peroxide and ozone provide a multi-barrier to pathogens and trace pollutants.
Potable aquifers	Class A plus reverse osmosis	H		Best available technology
Surface Percolation for Groundwater Recharge	Class A plus nitrogen removal Meet groundwater standards Meet drinking water standards	B	C, D, D1, D2, E, F, G	UV does not produce disinfection byproducts like chlorine does. Soil aquifer treatment (percolation) is well proven to provide a pathogen and pollutant barrier.
Streamflow Augmentation	Class A plus project-specific requirements Meet Federal Water Pollution Control Act Meet Surface Water Standards Meet EPA Clean Water Act	B	C, D, D1, D2, E, F, G	Membranes and processes such as UV/peroxide and ozone provide a multi-barrier to pathogens and trace pollutants that have been shown to impact aquatic organisms.
Wetlands	Class A-D plus project-specific requirements BOD and TSS 20 mg/L, nitrogen 3 mg/L Total phosphorus 1 mg/L Meet toxicity standards for NH_3-N Meet Surface Water Standards Meet EPA Clean Water Act	Class A: Trains A, A1, A2, if toxicity standard can be met. Class B–D: secondary + disinfection	B, C, D, D1, D2, E, F, G	Membranes and processes such as UV/peroxide and ozone provide a multi-barrier to pathogens and trace pollutants that have been shown to impact aquatic organisms.
Irrigation of Nonfood Crops	Use-specific, Class C or D	Secondary + disinfection	B	
Irrigation of Food Crops				
Spray or surface irrigation of root crops	Class A or better	A, A1, A2	B	UV provides higher pathogen destruction than chlorine.
Surface irrigation no contact to edible portion	Class B or better	Secondary + disinfection		Chlorination is sufficient unless there are substantial concerns such as carbon footprint or safety. In which case, UV would be a better choice.
Surface irrigation of orchards & vineyards	Class D or better	Secondary + disinfection		
Landscape Irrigation				
Open access areas	Class A or better	A, A1, A2	B	Same notes as above for Irrigation of Food Crops.
Restricted areas	Class C or better	Secondary + disinfection		
Impoundments				
Non-restricted recreational impoundments	Class A or better	A, A1, A2	B	Same notes as above for Irrigation of Food Crops.
Restricted recreational impoundments	Class B or better	Secondary + disinfection		
Landscape Impoundments	Class C or better	Secondary + disinfection		
Commercial and Industrial Uses				
Uses with potential human exposure	Class A or better	A, A1, A2	B	Same notes as above for Irrigation of Food Crops.
Fish hatchery basins	Class B or better	Secondary + disinfection	C, D, D1, D2, E, F, G	Concerns over trace pollutants that may harm aquatic organisms may drive technology selection.
Dust control and making concrete	Class C or better	Secondary + disinfection		
Flushing of sanitary sewers	Class D or better	Secondary + disinfection		

BOD = biochemical oxygen demand; TSS = total suspended solids; UV = ultraviolet; UF = ultra-filtration; MBR = membrane reactor; RO = reverse osmosis; AOP = advanced oxidation process.

Treatment Train Key:

A	Preliminary, primary, and secondary treatment, sand filtration, chlorination
A1	Same as Train A, with ballasted flocculation added
A2	Same as Train A, without filtration
B	Preliminary, primary, and secondary treatment, sand filtration, UV
C	Preliminary, primary, and secondary treatment, UF, UV
D	Preliminary and primary treatment, MBR, UV
D1	Same as Train D, without primary treatment
D2	Same as Train D, without fine screening and with chlorination instead of UV
E	Preliminary and primary treatment, MBR, UV/peroxide
F	Preliminary, primary, and secondary treatment, UF, ozone
G	Preliminary and primary treatment, MBR, Ozone
H	Preliminary, primary, and secondary treatment, UF, RO, UV/peroxide (advanced oxidation process)

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3.3.1 Capital Costs

The following sources were used to generate the cost curves for each treatment technology train:

- Case studies and interviews with agencies (see Appendix C and Appendix E)
- Construction costs for specific treatment train components extrapolated from data from completed projects (see Appendix F)
- UV cost model developed for the WateReuse Foundation in 2006 (see Appendix G)
- Generic reclaimed water treatment plant cost model developed for King County in 2005 for use in evaluating potential satellite treatment plants

Figure 3-2 shows capital cost curves for flows up to 5 mgd. The curves are intended to generally compare costs for various combinations of technologies. Costs for potential projects will vary depending on project-specific conditions. The figure shows cost curves for two variations of Treatment Train A to reflect differences between site-specific reclaimed water goals and applications. Train A1, with ballasted flocculation costs added, would be useful in treating a secondary effluent with high organic loads. Train A2 illustrates costs for reuse applications that do not require filtration. The sodium hypochlorite costs for all three trains assume a typical 90-minute modal contact time and 5-mg/L free chlorine residual.

The curves reflect costs in the *Engineering News–Record* construction cost index, normalized to Seattle 2007 dollars. Solids handling costs were not included in the cost curves because discharge of residual solids to the sewer was assumed. The cost curves represent the production cost per million gallons (MG) as a function of the total quantity produced (million gallons per day—mgd). Each curve is steep at lower production flows and then begins to level out as production flow increases. The higher cost at lower flows is due to basic construction costs associated with all facilities regardless of size. For smaller treatment plants, the construction cost for a 1-mgd facility is not as cost competitive as the cost for producing 1 mgd in a larger 30-mgd facility.

As expected, the relationships between the treatment train curves in Figure 3-2 illustrate that the higher the level of treatment, the higher the cost per MG. This is clearly seen in the relationship between Train H (ultra-filtration, reverse osmosis, and advanced oxidation process) as compared to Train A (sand filters and sodium hypochlorite). The relationships between curves and the costs per MG for each treatment train can be used in conjunction with the desired reclaimed water applications and class (A–D) for conceptual planning purposes, such as project screening, project location studies, and gauging the level of public interest.

3.3.2 Operations and Maintenance Cost Considerations

O&M costs typically include costs for labor, chemicals, energy, and materials replacement. In General, these costs will follow capital cost curves shown in Figure 3-2 in that O&M costs will be higher for more complex or newer technologies. The following are some considerations regarding O&M costs:

- **Treatment train complexity and maturity.** More mature and less complex systems such as sand filters typically have the lowest operational costs. However, costs associated with UV disinfection, which is less mature than chlorination, have been shown to be competitive with chlorine processes in many cases. Moreover, a recent analysis for King County's Carnation Treatment Plant indicated that O&M costs were essentially equal for sequencing batch reactor (SBR),[10] oxidation ditch, and MBR processes (all with UV disinfection).[11]
- **System treatment requirements.** O&M costs for reclaimed systems may also include costs for operating and maintaining primary and secondary treatment systems and for downstream solids residuals handling and treatment.
- **Reclaimed water distribution system operation.** Reclaimed water distribution systems require monitoring, training, and other operations that are a cross between wastewater and potable water systems. Additional operations staff will be required to meet these requirements.
- **Local staffing and training costs.** Local labor conditions and the need for specialized training are factors in overall long-term implementation costs.
- **Energy and chemical costs.** Energy and chemical costs will vary by local energy rates and level of treatment required.
- **Replacement parts and equipment.** Costs to replace parts and equipment vary by treatment technology. UV systems require replacement lamps; micro-filtration, ultra-filtration, and MBR systems may require membrane replacement.

[10] A sequencing batch reactor is an activated sludge process where all the main treatment steps occur in the same reactor.
[11] Susanna Leung, Carollo Engineers, personal communication.

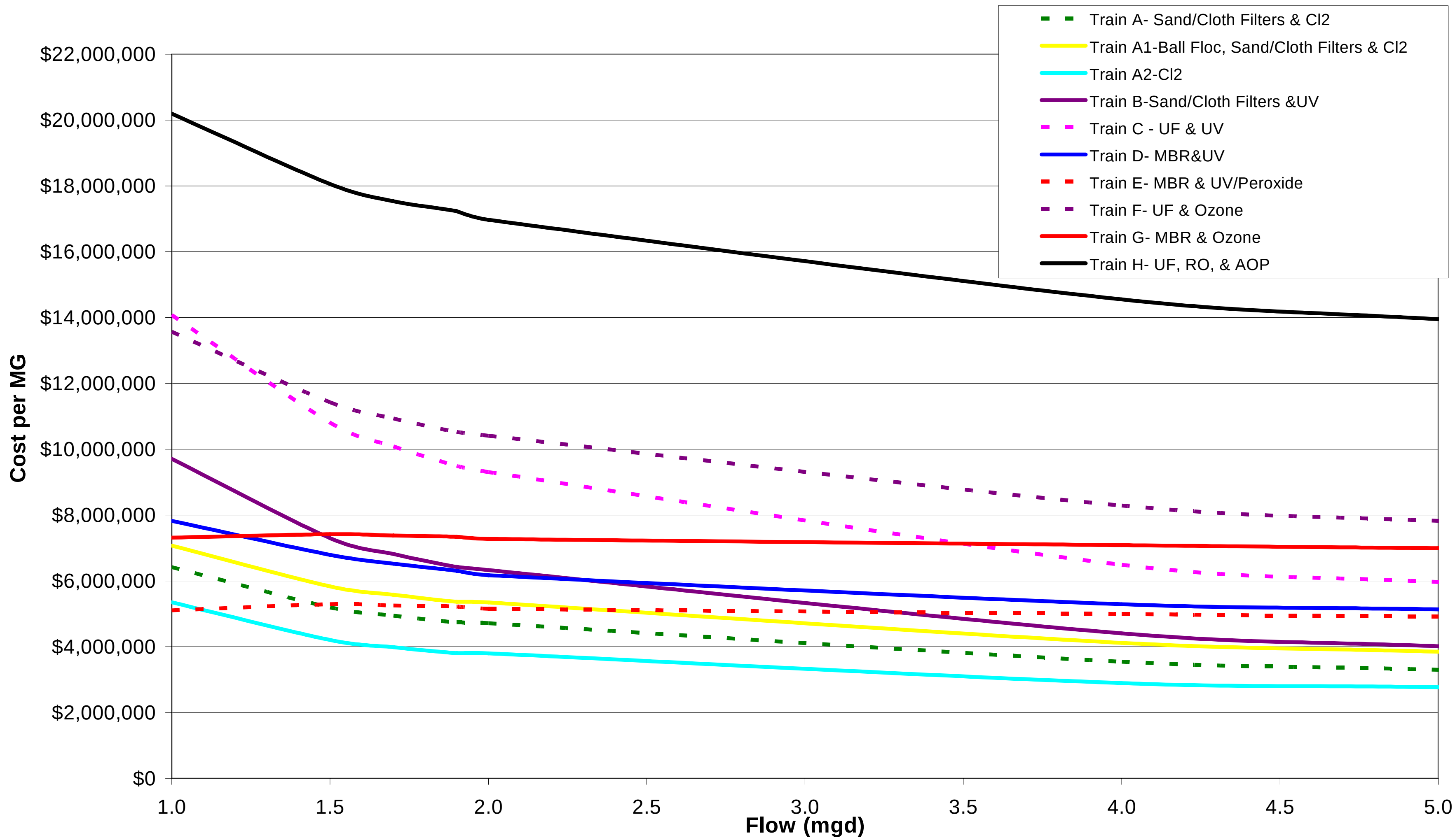

Figure 3-2. Construction Cost Curves for Treatment Trains

3.4 Technologies and Uses in Washington

There are 19 water reclamation facilities either operating or in construction in Washington State. For each of these facilities, Table 3-6 describes the treatment train, volume and class of reclaimed water produced, type of reclaimed water application (turf irrigation, for example), date of construction, capital cost, annual O&M cost, and any notes of particular interest.

Information on 15 projects outside of King County was extracted from *Case Studies in Reclaimed Water Use*, published by Ecology (Cupps and Morris, 2005). These projects were implemented between 1992 and 2005. The implementing agencies were interviewed as a part of this feasibility study to gain information on operating experience and to update projects that were under development in 2005. A contact summary and detailed surveys are provided as Appendix E.

A majority of the utilities use reclaimed water for either irrigation, groundwater recharge, or to augment streamflow, lakes, or wetlands. The first four reclaimed water facilities listed in Table 3-6 were constructed as part of a water reclamation and reuse demonstration project in the Cities of Ephrata, Royal City, Sequim, and Yelm, and began producing Class A effluent between 1998 and 2000. These plants have since moved past the demonstration phase into long-term operation.

Most of the reclaimed water facilities constructed in the 1990s added filtration and disinfection units to secondary treatment units, such as oxidation ditches or sequencing batch reactors (SBRs) to meet reclaimed water standards. The advanced treatment technologies used at these facilities consist of chemical coagulation and then filtration with upflow sand filters, cloth disk filters, or anthracite filters, followed by disinfection with either UV or chlorine. More recent facilities that have been constructed since 2003 or are currently being designed use or plan to use MBR technology and UV disinfection for advanced treatment. Several of the reclaimed water facilities were included in plant upgrades as a cost-effective alternative for meeting effluent discharge limitations. Others were developed to offset potable water uses, improve groundwater quality, or recharge aquifers.

Two King County treatment plants—West Point and South Treatment Plants—are designed to produce Class A or equivalent reclaimed water. West Point produces 0.5 mgd of reclaimed water for use as process water; South plant produces approximately 0.23 mgd of reclaimed water for onsite process uses, irrigation, and offsite unrestricted reclaimed water uses.

King County’s Brightwater and Carnation facilities, both under construction, will use MBR technology. Brightwater (initial membrane capacity of 24 mgd with phased additions up to 54 mgd) is scheduled to go online in 2010 and will produce Class A reclaimed water. Initially, the reclaimed water will be used for in-plant processes and onsite irrigation. Possible near-term additional uses include industrial cooling, agricultural irrigation, and landscape irrigation (see Chapter 7 of this study).

Table 3-6. Reclaimed Water Washington Technologies and Applications in Washington State

Case Study	Reclaimed Water Capacity/ Production	Process Description	Reclaimed Water Class Produced	Typical Offsite Uses[a]								Onsite Process Water[b]	Current Status	Unit Capital Cost	Annual O&M Cost[c]	Notes	Reference[d]
				Irrigation	Municipal Non-Potable Uses	Construction Water	Constructed Wetlands/ Wetland Maintenance	Streamflow/ Lake Augmentation	Aquifer Recharge	Equipment Washdown	Toilet Flushing						
City of Sequim, Clallam County	0.67 mgd/0.5 mgd average	Oxidation ditch, coagulation/ flocculation, anthracite filter, UV (low-pressure, low-intensity)	Class A	X	X		X	X		X		X	Operational	$5.3 M - plant upgrades to Class A (1998); $3.4 M - Carrie Blake reclaimed water demonstration park; $2.5 M - administrative, debt repayment, supplies, & equipment in 2004		Demonstration project	A
Sunland Sewer District, Clallam County	0.162 mgd/ 0.09–0.12 mgd average	SBRs, chemical addition, cloth-disk filter, chlorine, polishing ponds for 2 to 3 days before spraying on a restricted access pasture	Class D[d]	X									Operational	Tertiary upgrades: $76,000 - design (1997); $910,000 - construction (1999); $25,000 - engineering (1999)			A
North Bay/Case Inlet, Mason County	0.37 mgd maximum; 0.15 mgd average	SBRs, coagulation and mixing, cloth-disk filter, UV	Class A	X					X				Operational	Began operation in 2000: $22 M - planning, design, & construction of new facility (~ $6.2–6.5 M for WWTP only)	$447,939, not including debt service; costs divided among 3 plants.		A, B
The LOTT Alliance, Thurston County																	
Budd Inlet Facility	1 mgd (up to 1.5 mgd peak)	Budd Inlet WWTP: advanced secondary treatment (nitrogen removal, UV). Reclaimed Water facility: coagulation, continuously self-cleaning sand filter, chlorine,	Class A	X	X					X	X		Operational	$2.8 M – construction of sand filters (2004)	$127,000 (2005)	Upgraded a portion of Budd Inlet WWTP	A, C
Hawks Prairie Satellite	2 mgd (expandable to 5 mgd)	MBR, UV	Class A	X			X		X				Operational	Began operation in 2006: $21.1 M - reclaimed water plant; $7.2 M - constructed wetlands and groundwater recharge basins; $4.4 M - conveyance lines		Solids are returned to the sewer for treatment at the Budd Inlet WWTP	A, C
City of Yelm, Thurston County	1 mgd design capacity	SBRs, flow equalization, chemical coagulation, upflow sand filters, chlorine (also a small RO pilot unit on site)	Class A	X	X				X			X	Operational	Began operation in 1999: $9.6 M – total cost; $7.4 M - Class A treatment plant; $473,429 -recycled water distribution line; $771,928 - wetlands, infiltration galleries, pond; $759,694 - design engineering; $211,522 - administrative and legal.	$1.2 M (2007)	Demonstration project; modified WWTP	A, D
King County																	
South WWTP	1.3 mgd design capacity/0.23 mgd average production	Activated sludge, chemical coagulation, upflow sand filters, sodium hypochlorite	Class A	X	X							X	Operational	$2.24 M upgrade for advanced treatment (1995)	$95,700 (2005)		A
West Point WWTP	0.5 mgd design capacity/0.5 mgd average production	Activated sludge, chemical coagulation, upflow sand filters, sodium hypochlorite	Class A equivalent									X	Operational	$300,000 upgrade for advanced treatment	$102,200 (2005)		A
Brightwater	24 mgd initial design capacity (expandable to 54 mgd)/18 mgd initial production (average dry weather flow)	Perforated plate screens, aerated grit, primary clarifiers with MBRs, sodium hypochlorite	Class A	X (future)								X (future)	Plant online in 2010; distribution by about 2011.	Estimated $280 M (2004), not including solids handling.			E
Carnation	0.37 mgd design capacity/0.16 mgd estimated initial production	Activated sludge BNR, MBR, UV	Class A	X (future)			X (future wetland enhancement)						Estimated 2008	Estimated $19.65 M for tertiary facility, river outfall, wetlands discharge upgrades, and dual-discharge and public access improvements	Estimated $625,000, not including debt service or large equipment replacement.; estimated $10,000 for wetlands O&M	Discharge to wetlands; backup discharge to surface water. The surface water discharge has not been approved as a reclaimed water application.	F

Case Study	Reclaimed Water Capacity/ Production	Process Description	Reclaimed Water Class Produced	Typical Offsite Uses[a]								Onsite Process Water[b]	Current Status	Unit Capital Cost	Annual O&M Cost[c]	Notes	Reference[d]
				Irrigation	Municipal Non-Potable Uses	Construction Water	Constructed Wetlands/ Wetland Maintenance	Streamflow/ Lake Augmentation	Aquifer Recharge	Equipment Washdown	Toilet Flushing						
City of Snoqualmie, King County	3.9 mgd design capacity/0.8 mgd average summer production	Screening, oxidation ditch, chemical coagulation, dual-media traveling bridge filter (sand and anthracite), UV	Class A	X									Operational	Phase I began operation in 1998, and Phase II in 2002: $18 M - Class A (includes Phase II expansion of primary and secondary treatment); $4 M - distribution	$165,000 (2007)	Operates seasonally: May 15–September 30	A, G
Holmes Harbor Sewer District, Island County	0.1 mgd design capacity/0.04 mgd average daily flow	SBRs, equalization, chemical coagulation and flocculation, traveling bridge sand filter, chlorine disinfection	Class A	X									Operational	$1.7 M - treatment facility (1995); $666,666 - collection system	$295,000 (2007)	Septic tank effluent pumping	A, H
City of Ephrata, Grant County	1.22 mgd design capacity/0.55 mgd average	Grit channel, self-cleaning fine screen, oxidation ditch (extended aeration) for secondary biological treatment and nitrogen removal, clarifier, chemical coagulation, upflow sand filters, UV (low pressure, low intensity)	Class A	X		X			X	X		X	Operational	$6.1 M - upgrading the original plant	$780,000	Demonstration facility; upgraded original plant, but is essentially a new plant (only a clarifier and pump house remain)	A, I
City of Royal City, Grant County	0.25 mgd design capacity, 0.15 mgd average	Extended aeration biological treatment with nitrogen removal, chemical coagulation, cloth disk filter, UV (low-pressure, low-intensity)	Class A	X		X			X	X			Operational	Began operation in 2000: $3.66 M – design & construction	$300,000 (2007)	Demonstration facility	A, J
City of Quincy, Grant County	1.25 mgd design capacity/0.7 mgd average	Activate sludge lagoons with SBRs for nitrogen removal, equalization basin, chemical coagulation, continuous backwash upflow sand filters, UV	Class A						X				Operational	Began operation in 2002; $5.9 M (no distribution)	$98,000 (2007)		A, K
City of Walla Walla, Walla Walla County	20 mgd peak and 9.6 mgd average design capacity	Trickling filters and carousel oxidation ditch, traveling bridge sand filter, UV	Class A by 2008	X									Operational	$20 M - secondary treatment improvements (added basins and clarifiers) (2000); $6.1 M - added coagulation, sand filters, and UV (2004); $7 M total - construction of storage basins and sand filter rehabilitation (late 2008), sand filter replaced in kind with added depth - $1.1 million	$1.3 million (2005)		A, L
City of College Place, Walla Walla County	1.65 mgd design capacity/0.9 mgd summer average	SBRs, chemical coagulation, cloth-disk filter, UV, reaeration basin	Class C	X				X					Operational	Began operation in 2001: $16.4 M - new WWTP; ~ $20 M including land & wetlands construction	$430,000 (2005)		A, M
City of Medical Lake, Spokane County	1.0 mgd design capacity; 1.85 mgd maximum capacity	Oxidation ditch, chemical coagulation, dual-media (anthracite and sand) traveling bridge filter, UV	Class A	X				X					Operational	Began operation in 2000: $14 M-total; $8 M - estimated cost for tertiary treatment	$700,000 (2007)	Discharge to West Medical Lake; discharge to Deep Creek when Class A standards are not met	A, N
City of Cheney, Spokane County	1.5 mgd average annual flow; 2.7 mgd maximum month flow	Fine screens, grit removal, oxidation ditch, chlorine, constructed wetlands	Class D	X			X			X			Operational	$15.7 M (1994); estimated $6 M to upgrade to Class A	$793,400 (2005)		A

BNR = biological nutrient removal; MBR = membrane biological reactor; SBR = sequencing batch reactor; UV = ultraviolet (disinfection); WWTP = wastewater treatment plant.

[a] Onsite uses for process water are equivalent to Class A in quality but not regulated as such.

[b] Off the primary treatment plant site.

[c] If the reclaimed water facility is part of a larger facility, O&M costs are for the entire facility.

[d] References: A - Cupps, K., and Morris, E, 2005, *Case Studies in Reclaimed Water Use, Creating New Water Supplies Across Washington State.* Washington State Department of Ecology, Publication Number 05-10-013; B - Tom Moore, 2007, Personal Communication; C - Karla Fowler, 2007, Personal Communication; D - Jon Yanasak, 2007, Personal Communication; E - Karl Hadler, 2007, Personal Communication; F – Susanna Leung, Carollo Engineers, Personal Communication, 2005 and 2007; G - Kirk Holmes, 2007, Personal Communication; H - Ken Eckelberger, 2007, Personal Communication; I - Wes Crago, 2007, Personal Communication; J - Todd Perry, 2007, Personal Communication; K - Tim Sneed, 2007, Personal Communication; L - Frank Nicholson, 2007, Personal Communication; M - Paul Hartwig, 2007, Personal Communication; N - Doug Ross, 2007, Personal Communication.

[d] Plans to produce Class A by 2007.

Carnation (0.37 mgd average annual design capacity and 0.16 mgd estimated initial capacity), scheduled to begin operating in 2008, will use MBR and UV disinfection to produce Class A reclaimed water for wetland enhancement as its primary use, with river discharge as a backup. (The Lacey Olympia Tumwater Thurston County (LOTT) Hawks Prairie plant (2 mgd, 2004) uses similar treatment processes for similar reclaimed water end uses.)

The moderate investment made at the Brightwater and Carnation plants to produce reclaimed-quality effluent enables King County to meet permit requirements now while positioning WTD to meet more stringent requirements more cost-effectively in the future.

The treatment trains used at King County's existing and planned treatment plants are as follows:

- **West Point Treatment Plant.** Preliminary treatment (coarse screening and grit removal), primary treatment, activated sludge process, secondary sedimentation, chlorination, and dechlorination for discharge to Puget Sound; chemical coagulation, continuous upflow sand filters, and chlorination produce reclaimed water for onsite nonpotable process use.
- **South Treatment Plant.** Preliminary (coarse screening and grit removal), primary, and secondary treatment similar to West Point for discharge to Puget Sound; chemical coagulation, continuous upflow sand filters, and chlorination produce reclaimed water for non-potable onsite use and unrestricted offsite urban reuse.
- **Brightwater Treatment Plant** (online in 2010). Preliminary treatment (coarse screening, aerated grit removal, fine screening), primary treatment, membrane bioreactors (MBRs) for treatment and reclaimed water production; chemically enhanced primary clarification for peak wet-weather flows (and then blended with MBR-treated flows); chlorination, using sodium hypochlorite for all flows; dechlorination prior to the Puget Sound discharge; rechlorination anticipated to meet regulations for chlorine residual in reclaimed water distribution pipes.
- **Carnation Treatment Plant** (online in 2008). Preliminary treatment (fine screens only), MBRs, and UV disinfection for all flows; discharge to wetlands.
- **Vashon Treatment Plant.** Preliminary treatment (screens), oxidation ditch, clarifiers, and UV disinfection for discharge to Puget Sound; no reclaimed water produced.[12]

3.5 Technologies and Uses in Other States

In 2004, EPA, estimated that at least 27 states had reuse facilities in operation. A survey of 17 reclaimed water producers, including approximately 26 separate facilities, in California, Nevada, Arizona, Florida, and Colorado, was completed as part of this study. The sample of reclaimed water producers reflects the range of technologies and applications used nationally.

[12] An oxidation ditch is used for a long-term aeration, usually in relatively small wastewater treatment plants. It consists of a long channel equipped with a rotor for generating a wastewater flow and stirring the water to supply oxygen. Although it requires a relatively large area, an oxidation ditch has a simple structure, can be easily operated, and can easily remove nitrogen.

Treatment technologies and reuse applications for the surveyed facilities are summarized in Table 3-7. Appendix E provides complete case studies, including comprehensive information on why unit processes were selected. The survey results show that there are some differences in technologies when compared to those used in Washington State, which reinforces the importance of selecting technology to meet end use and environmental quality factors. The survey found the following technology and end uses:

- Twelve of the twenty-six facilities use membrane technologies for multi-barrier pathogen control, most often for uses that involve substantial public contact.
- Eight of the twenty-six facilities use reverse osmosis in addition to membrane technologies, for uses including industrial process water, seawater intrusion barriers, streamflow augmentation, indirect potable recharge, and turf irrigation.
- Thirteen facilities use UV for disinfection.
- Two of the producers use sand filters and UV to provide irrigation-quality reclaimed water.
- One facility uses ballasted flocculation for post-secondary sedimentation, followed by cloth filters and UV disinfection, for irrigation.
- One facility uses UV followed by ozone to enhance UV for a sensitive lake discharge, where EDCs and pharmaceuticals were of concern.
- One facility uses micro-filtration (membranes) followed by RO and hydrogen peroxide to address micro-contaminants for groundwater discharge.

Table 3-7. Examples of Technologies and Applications in Other States

Utility	Technology	Reclaimed Water Capacity (mgd)	Reclaimed Water Use
Carmel Area Water District, CA	MF, RO, sodium hypochlorite	1.9	Irrigation – unrestricted use, low TDS for sensitive golf course greens
Centennial Water and Sanitation District, CO	Satellite reclamation systems (physical processes and UV)	0.05	Irrigation – restricted/unrestricted uses
Clark County WRF, NV	UF, ozone	20.0	Lake discharge, irrigation – unrestricted use
City of Davis, CA	UF, UV	7.5	Irrigation
City of Petaluma, CA	Continuous backwash sand filters, UV, polishing wetlands	4.0	River discharge, irrigation - unrestricted use
City of Phoenix, AZ	Filtration, chlorination, UV	3.0	Tributary discharge, aquifer storage/recovery
City of Roseville, CA	Filtration, chlorination, UV	45.0	Plant process water and irrigation

Utility	Technology	Reclaimed Water Capacity (mgd)	Reclaimed Water Use
City of Turlock, CA	High-rate flocculation and sedimentation, cloth filters, chlorine	20.0	River discharge, irrigation – unrestricted use
City of Watsonville, CA	High-rate flocculation and sedimentation, cloth filters, UV	7.7	Bay discharge, irrigation – unrestricted use
Daly City, CA	Continuous backwash upflow sand filters, chlorination	2.8	Irrigation – unrestricted use
Dublin San Ramon Services District	One train: MF-RO-UV (RO not currently in use)	2.5	Irrigation and planned indirect potable reuse
	Continuous backwash sand filters, UV	10.5	Irrigation - unrestricted use
Fountain Hills Sanitary District, AZ	Cloth disk filters, MF, UV	2.92	Aquifer storage/recovery for unrestricted use
LA County Sanitation District	(10 Facilities Below)		
Lancaster	MBR, chlorination (in the process of adding UV)	2.0	Irrigation, lake discharge
Whittier Narrows	Conventional deep bed (coal, sand, gravel) filtration, chlorination (in the process of adding UV)	24.2	Groundwater recharge by percolation and irrigation - unrestricted use
La Canada	Secondary, chlorination	0.12	Irrigation
Long Beach	Conventional deep bed (coal, sand, gravel) filtration, chlorination	18.5	Irrigation
Los Coyotes	Conventional deep bed (coal, sand, gravel) filtration, chlorination	32.9	Irrigation and industrial uses
Pomona	Conventional deep bed (coal, sand, gravel) filtration, chlorination	10.5	Irrigation and industrial uses
San Jose Creek	Conventional deep bed (coal, sand, gravel) filtration, chlorination	81.2	Groundwater recharge and irrigation
Valencia	Conventional deep bed (coal, sand, gravel) filtration, chlorination	16.0	Irrigation
Saugus	Conventional deep bed (coal, sand, gravel) filtration, chlorination	4.1	River discharge
Palmdale	Secondary, chlorination	9.9	Irrigation of airport property
	Carbon adsorption, RO, well water blend	9	Seawater intrusion barrier, indirect potable reuse
	MF, RO, UV/peroxide	70	Groundwater recharge, seawater intrusion barrier
SW Florida Water Management District	MF, RO, UV/peroxide	6.5	Streamflow augmentation

Utility	Technology	Reclaimed Water Capacity (mgd)	Reclaimed Water Use
Sarasota County, FL	Tertiary treatment, UV	5.5	Groundwater injection and irrigation
West Basin Municipal Water District	MF, RO, UV/peroxide	Entire plant is 15 mgd; each use is a portion of 15 mgd	Groundwater recharge for indirect potable reuse
	MF, RO, chlorination	Entire plant is 15 mgd; each use is a portion of 15 mgd	Low-pressure boiler feed water
	MF, RO, second-pass RO, chlorination	Entire plant is 15 mgd; each use is a portion of 15 mgd	High-pressure boiler feed water

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Chapter 4

Economic Framework for Assessing Reclaimed Water Projects

A key element for deciding whether to move forward with an investment in reclaimed water projects is the completion of an economic evaluation of the project. Most, if not all, reclaimed water projects are inextricably linked with wastewater facilities. Evolving technology, reduced costs, increasingly stringent regulatory requirements, and a desire for better environmental management are driving wastewater system managers more and more toward production of reclaimed water as part of their wastewater planning and capital investment strategy. Reclaimed water production and distribution add additional elements to the benefit-cost analysis when evaluating the feasibility of a given reclaimed water investment. This is particularly true for a regional wastewater system, where regional costs and benefits need to be an integral part of the evaluation.

An important distinction for evaluating reclaimed water is the difference between financial analysis and economic analysis. This chapter covers both. A financial analysis has meaning only in the context of identification and analysis of the benefits and costs of any alternative. The bulk of the discussion, therefore, focuses on economic analyses, emphasizing benefit-cost comparisons as the appropriate form of economic analysis. First, the chapter explains the distinctions between financial and economic analyses and then describes an economic framework developed by the WateReuse Foundation specifically for evaluating the benefits and costs of reclaimed water projects.

Some reclaimed water projects will be clearly supportable from a fairly narrow financial analysis, particularly where a wastewater system objective is met or where costs are low and the need for water is significant. Other projects, particularly those with an environmental benefit, will require more analyses to sufficiently describe both quantitative and qualitative benefits and will need to establish an equitable approach to paying for their costs.

Although not called for in Water Reuse Policy 2 (WRP-2), the information in this chapter provides the foundation for the reviews and analyses in the chapters that follow, particularly the review of regional and environmental benefits in Chapter 6 and the market analysis update in Chapter 7.

4.1 Distinctions Between Financial and Economic Analyses

When evaluating reclaimed water programs and projects, it is important to consider both the benefits and costs of producing and using reclaimed water, rather than looking only at the financial costs. This perspective can be viewed in relation to the difference between two types of analyses: financial analyses and economic analyses. The following paragraphs offer more detail on the distinctions between these two types of analyses and how they can be used to evaluate reclaimed water programs and projects.

4.1.1 Cash Flows Versus Benefit-Cost Analysis

A *financial* analysis of reclaimed water focuses solely on the *cash flows* of revenues brought into and expenses paid out by the utilities and districts involved. In other words, a financial analysis focuses on the internal monetary bottom line and disregards any impacts or values that do not register within the utilities as cash transactions. This means that a financial analysis will reveal how much money is brought in to pay for the costs of a project and how much money the utility spends to produce and distribute reclaimed water (in operating expenses, debt service and other payments for applicable capital equipment, construction, and other one-time investments). This comparison of cash outlays (expenses) to cash inflows (revenues) produces the project's *financial bottom line.* This bottom line reflects the degree to which cash expenses may exceed inflowing revenues (or vice versa).

Another form of analysis—a cost-effectiveness analysis—simply explores how much one alternative costs relative to another alternative and assumes that each alternative provides exactly the same output; the only metric examined is relative cost.

It is important to note that the assumptions driving the discussion of "cost" of a given reclaimed water source of supply are critical to the rest of the analysis. Where, for instance, the reclaimed water is produced because of a wastewater decision to treat to that level, the treatment costs can be fully allocated to the wastewater system and do not need to be borne by the reclaimed water project. Similarly, if the reclaimed water project is being developed in response to a wastewater system driver—for example, a desire to reduce discharges to Puget Sound or to comply with a regulatory requirement—then other components of the reclaimed water project (pumps and pipes for delivery to customers) can and should have at least a portion of their costs allocated to the wastewater system. Being able to undertake this cost allocation exercise is one of the most important parts of the analysis.

A traditional analysis of reclaimed water projects starts from the assumption that the costs of all the components of the reclaimed water facilities—from additional wastewater treatment through delivery to an end user—should be attributed to the reclaimed water project as part of the project's costs. Certain elements of a reclaimed water project may have extraordinarily high costs—for instance, constructing a new delivery infrastructure ("purple pipe") through an already built environment. The combination of both broad scope of costs and high costs of certain elements has traditionally led to the conclusion that the "cost" of the reclaimed water is higher than an alternative source, such as potable supply. This leads to the further conclusion that the project needs additional funding beyond revenue from its customers in order for the reclaimed water to be affordably priced and attractive to potential customers from a financial perspective. Without the additional sources of revenue, the reclaimed water alternative does not appear to make as much sense to the utility as the existing potable water or direct withdrawal alternative (although for the user, the reclaimed water may be cheaper because of the rate structure applied).

In contrast to a financial analysis, an *economic* analysis starts with the financial analysis and then includes analyses of the *benefits* that a project or process will generate. Economic analyses provide a broader perspective about the value of a project or process in relation to its costs. Economic analyses can focus only on market-related benefits or can include non-market benefits such as environmental and social benefits (as in a Triple Bottom Line [TBL] approach described in Chapter 6).[1]

An economic analysis provides a suitable benefit-cost perspective for considering if a reclaimed water option is an investment that is worth the expense, giving due consideration to all the values provided to (as well as costs imposed on) the broader region as a whole. The comparison of all the benefits generated (regardless of who accrues them) to all the costs (including any costs borne outside the utility) indicates whether there are positive net benefits (benefits that outweigh costs) for the region.

> In a financial analysis, *revenues* are compared to costs and in the economic analysis, *benefits* are compared to costs. All the key benefits of a reclaimed water project (and other alternatives) must be recognized in some fashion in an economic analysis.
>
> Such an analysis may often require a compilation of several different types of benefits to recognize whether the overall benefits outweigh costs; if some of the benefit categories are overlooked, then the project may not appear to be economically justified.

Thus, a financial analysis helps determine how much a reclaimed water project or program will cost and whether the entities involved will earn sufficient revenues from "paying customers" to cover their costs or will need to find additional sources of revenue to help render the project feasible from a financial perspective. An economic analysis, in contrast, reveals whether the investment in a reclaimed water project is worthwhile from a broader environmental and social net-benefit perspective.

4.1.2 Adding Other Bottom Line Values to the Equation

While financial analyses are important, they typically provide too limited a context for evaluating the environmental and social worth of most reclaimed water programs. This is because a financial analysis focuses strictly on revenue and cost streams internal to the wastewater agency and these cash flows are not the same as the true worth or *value* of most reclaimed water projects to the region.

The financial analysis alone does not account for all the values of the goods and services that reclaimed water might provide. For example, a financial analysis focused on the wastewater utility would not typically reflect benefits to the region, such as the environmental and social costs avoided when a reclaimed water project enhances water levels in flow-limited streams and rivers or enables a community to forego or postpone an upgrade to its wastewater treatment plant.

[1] The TBL approach is a common economic analytical method used to identify and quantify the full costs and benefits of reclaimed water projects and operations.

The key is to conduct a *full social cost accounting* of the benefits and costs of reclaimed water projects. Both benefits and costs can be grouped into three main categories: environmental, social, and financial (consistent with the TBL perspective):

- **Environmental benefits** can be provided when use of reclaimed water reduces effluent discharges to water bodies, offsets demands on potable supplies that directly or indirectly draw down flows of inland rivers and streams, recharges aquifers, or develops or enhances wetlands.
- **Social benefits** may include providing for a more reliable water resource and the related value that this can bring to the region's economic base and lifestyles. Related to the reliability concept is the longer-term insurance value that reclaimed water may provide as a hedge against the potential future adverse impacts of climate change (or other possible adverse events) or future regulatory changes.
- **Financial benefits** typically include any avoided costs and cost offsets in other wastewater and water resource management programs. For example, in many parts of the country, increasingly stringent National Pollutant Discharge Elimination System (NPDES) permits and other factors (for example, land costs, chemical costs, and the cost of monitoring) are driving up the compliance costs of municipal wastewater treatment and discharge. By converting some of the effluent stream into reclaimed water, agencies (and their customers) are able to avoid or postpone additional investments in wastewater treatment and discharge expenses, while at the same time creating more value by developing a new water resource for their region. The costs to develop reclaimed water may be offset, at least in part, by the avoided costs for wastewater treatment and discharge.

Chapter 6 provides a more in-depth discussion of regional and environmental benefits of reclaimed water. The specific types of benefits generated by reclaimed water and the size of their potential value will depend on case-specific circumstances.

4.2 The WateReuse Foundation's Economic Framework

This section describes the WateReuse Foundation's (WRF) *An Economic Framework for Evaluating the Benefits and Costs of Water Reuse* (Raucher et al., 2006). The WRF framework is an economic analysis tool developed specifically for evaluating the benefits and costs of reclaimed water projects to help inform decisions about potential future investments in reclaimed water or other elements of a water resource management program.

By identifying and quantifying the range of benefits that may accrue from a project and the groups that would receive the benefits, this framework can help answer questions about who should pay, how much, and why. This information can be used to expand the customer base for recovering costs. For example, use of the framework may quantify at $100 million the total benefit of a reclaimed water project that recharges an aquifer and mitigates a city's draw on groundwater for its water supply. The analysis may attribute $75 million to reduced impact on Puget Sound (from reduced discharges to the Sound) and the remaining $25 million to mitigating impacts to groundwater. This information can form the basis for proposing that costs for the project can be split 75/25 percent between the two customer classes.

The following paragraphs describe the general principles and methods employed in the WRF economic framework.

4.2.1 Initial Benefit-Cost Screening to Guide Reclaimed Water Program Development

At this early stage of exploring the potential to develop a regional reclaimed water opportunity, the economic framework, and the closely related Triple Bottom Line approach, can be used as a way to evaluate and guide the general direction that King County's reclaimed water program might take as it progresses toward a more defined set of potential projects. By looking at where and how benefits might be generated by reclaimed water applications and where costs might be best contained, the county can begin to focus on the types of reclaimed water projects that may have the greatest potential to generate positive net environmental and social benefits.

Figure 4-1 depicts the concept of using initial benefit-cost screening to help guide the future reclaimed water program toward relatively productive and cost-effective project ideas. This diagram starts by looking only at the financial aspects, focusing on the most promising reclaimed water project alternatives by identifying where there is a good overlap between the supply-side and the market demand aspects of reclaimed water.

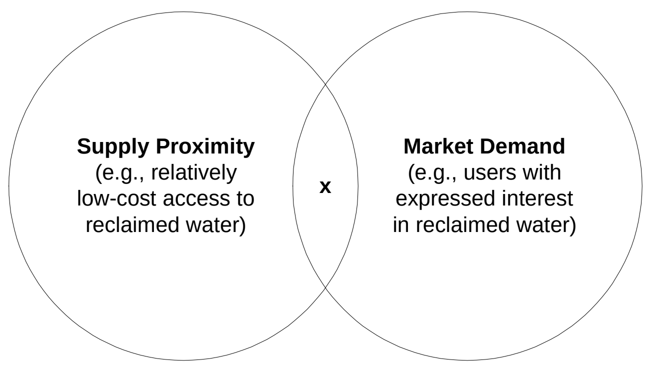

Figure 4-1. Market-Oriented Reclaimed Water Program Development – Focusing on Internal Financial Factors Only

The supply-side aspects (left circle in the diagram) reflect opportunities to provide relatively low-cost reclaimed water, which is typically driven by proximity to available sources and distribution facilities (high cost options are outside the circle). The demand-side aspects (right circle in the diagram) reflect where there are identified or interested users that can likely pay for the reclaimed water. Where the two circles overlap in Figure 4-1 (Area x), there is a good convergence of identified demand with reasonably efficient delivery of a reclaimed water supply. This convergence of supply and market demand should be a logical guide to reclaimed water program development from the financial perspective, because it focuses on potential projects in which costs can be relatively reasonable and there is a likely valued use.

The WRF economic framework adds another dimension to the process, depicted by the third circle in Figure 4-2 as "environmental and social benefits" (nonmarket demand). This nonmarket demand includes the types of value-generating potential uses of reclaimed water that are not typically reflected by market demand, such as environmental applications of reclaimed water to enhance instream flows or wetlands. There is not likely to be a "paying customer" for these potential reclaimed water uses, but there is nonetheless value generated for the environment and society as a whole (for example, helping to protect and restore endangered salmon species and subpopulations).

Economists have developed several methods for valuing nonmarket goods and services, including a range of "stated preference" and "revealed preference" methods (including the contingent valuation and travel cost methods, respectively). These valuation techniques have been refined and applied over many years, and there is a large body of conceptual and empirical information in the peer reviewed literature that can be used to obtain a sense of how valuable many types of nonmarket values tend to be. Using nonmarket values derived from existing studies and applying these values to a new policy or project is known as "benefits transfer." This approach can be a useful way to develop a general estimate of nonmarket values.

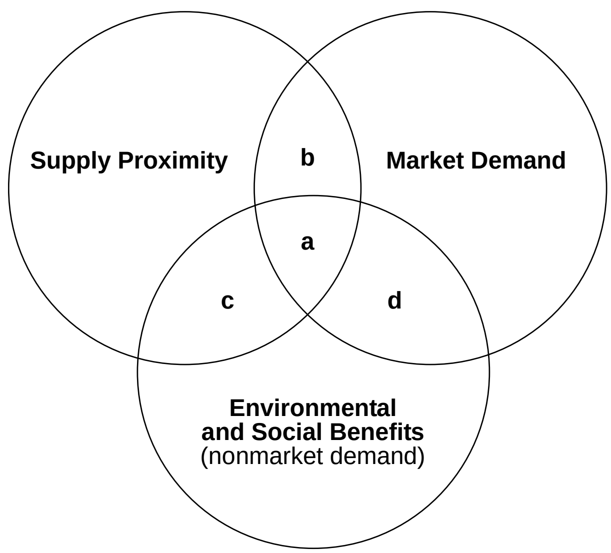

Figure 4-2. Value-Oriented Reclaimed Water Program Development – Both External and Internal Economic Factors Considered

Figure 4-2 shows both the original market-driven suite of potentially advantageous future reclaimed water projects (Areas a and b, corresponding to Area x in Figure 4-1) and other potentially valuable and cost-effective reclaimed water projects. For example, Area c indicates an opportunity to use a relatively low-cost reclaimed water supply in a way that will simultaneously generate important environmental and/or social nonmarket values. Projects in Area c are good candidates for future consideration as potential reclaimed water projects because they provide a relatively cost-effective opportunity to provide environmental and social benefits (even though there may not be much or any revenue-generating opportunity). Area d represents locations or uses in which there are both market and nonmarket values to be obtained from reclaimed water use. While Area d may be more expensive to serve because it is outside the sphere of relatively low-cost supply opportunities, there may be enough combined market and nonmarket value to justify a reclaimed water supply project.

Figure 4-3 shows how this type of analysis can be used along with a Triple Bottom Line (TBL) analysis to evaluate specific reclaimed water projects. For example, a large red downward-facing triangle in the financial corner of the TBL triangle represents a case where the costs to provide reclaimed water appear to outweigh the revenues (if any are anticipated) and a large green upward facing triangle in the environmental corner indicates the potential to generate significant environmental benefits. A blank corner indicates a neutral outcome, such as where no anticipated net benefits or net costs have been identified for the environmental, social, and. financial factors. TBL triangles are useful in indicating the potential tradeoffs and opportunities associated with reclaimed water.

The objective of using these diagrams is to portray a logic that can be applied to help guide a future reclaimed water program toward potential projects that are most likely to make the most economic sense (environmentally, socially, and financially). Ideally, there will be a suite of projects that correspond to Area a, but projects in Areas b, c, and d also may warrant consideration. Ultimately, the potential reclaimed water projects should be evaluated in a more complete and formal manner and then compared to reasonable alternatives, such as recommended through the WRF economic framework. However, the general principles in the economic framework can also be used constructively in the early formative stages of program development to help guide the process of identifying potential reclaimed water projects.

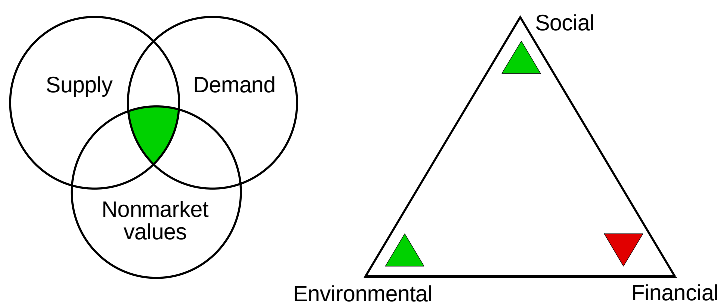

Figure 4-3. Example of Economic and Triple Bottom Line Analyses Combined

4.2.2 Equity: Who Realizes the Benefits and Who Bears the Costs?

Another aspect of the WRF economic framework is to evaluate who pays the costs and who enjoys the benefits.[2] Generally, it is desirable environmentally, socially, and financially that the same parties that pay for reclaimed water are also the ones who receive its benefits. Given the broad environmental and societal nature of many of the potential benefits of reclaimed water, its benefits could be dispersed over a large number of individuals and organizations spread over a large geographic area. It is, thus, important to tap cost-sharing or other mechanisms to ensure that the costs are not confined to a fairly limited number of entities and their members/customers.

As mentioned earlier in this chapter, the proper allocation of costs is a critical step in the economic analysis. If a substantial portion of the costs of a reclaimed water project is appropriately allocated to the wastewater system, then determining how to pay the costs and who should do so becomes a less challenging exercise. In regard to who bears the cost, the answer depends on three features of a specific reclaimed water project: (1) whether or not costs exceed benefits, (2) what water (or whose water), if any, is replaced with reclaimed water, and (3) how the retail agency decides to price reclaimed water to end users.

If reclaimed water revenues match or exceed the cost to provide the water, then there is no need to find another source of funds (such as the wastewater or potable water customer rate base) to cover the difference. The reclaimed water users bear the cost and receive the associated direct use benefits. (Other parties may benefit as well, such as when environmental or social benefits are generated.)

If production and use of reclaimed water are an integral part of a wastewater utility's water resource management activities, such as meeting permit requirements, then it may be appropriate to recover or allocate all or part of the reclaimed water costs to the wastewater ratepayers.

If an existing potable supply is offset, then the supplier may initially lose sales revenue. However, the potable water may then be sold to another customer instead or used to postpone an investment in expanding the supply, in which case there may not ultimately be a loss borne by the potable supplier. If the potable supplier agrees to serve as the retailer of the reclaimed water, it will then gain revenues from its sales of the reclaimed water to end users. Assuming the retail agency sells reclaimed water at some markup over the wholesale rate, then the retail agency can earn a positive net financial return.

The end user of reclaimed water is also likely to realize a net gain, although the size of such a potential gain depends on how much the retail agency marks up the wholesale reclaimed water rate. The net value to the end user may also depend on whether onsite investments are required (and how much they would cost) to enable the user to make use of the reclaimed water.

If reclaimed water replaces a private supply (such as an irrigator's extraction of river or groundwater), then the analysis needs to account for how the reduced extraction may benefit the extractor and others. If providing the reclaimed water resolves a legal issue such as water rights

[2] See Chapter 5 for a more detailed discussion of cost recovery issues and methods.

for the extractor, there will clearly be a direct benefit to the extractor. If providing reclaimed water means that the original irrigation water remains instream, then there may be benefits to the stream, such as improved habitat for fish. Or there may now be sufficient instream water such that holders of junior water rights in the watershed may be better able to exercise their rights and extract a larger volume of water than otherwise. Thus, the beneficiaries will depend on what happens with the instream water offset by the reclaimed supply.

To the extent that reclaimed water helps maintain and restore fish populations, then the beneficiaries will be all the people and entities that value the protection and recovery of these species. For King County, these will include many households throughout the county as well as people residing considerable distances away (reflecting nationwide interest and support for protecting threatened or endangered species). Commercial salmon fishermen may also be beneficiaries.

Given such widely dispersed benefits, it often is difficult (if not impossible) to collect funds from most of the beneficiaries, even though the collective value of the benefits across all the individuals may be very high (for example, the combined willingness to pay across all benefiting households may well outweigh the costs of the reclaimed water program). Such situations indicate that revenues from state or federal agencies (for example, through geographically broader taxes or fees) may be warranted to capture the value provided by reclaimed water such that the monies obtained can be used to relieve some of the costs borne by a small set of local entities and households paying the wastewater bills.

4.3 Conclusions

Reclaimed water projects need to be evaluated from both a financial and an economic perspective in order to fully evaluate the costs of projects in relation to their benefits. A financial analysis indicates how anticipated revenues from sales of reclaimed water compare to incurred expenses. Because of several factors, including the typical use of relatively low pricing of reclaimed water, it is likely that many water reclamation projects will not be able to recover all of their fully allocated costs through user fees and charges only. This may change if increasingly stringent regulatory requirements drive wastewater facilities to use treatment that produces reclaimed-quality water, thereby reducing the incremental cost of distributing reclaimed water. Revenue needs are often covered through wastewater or water supply rates and/or through grants or other cost-sharing mechanisms.

An economic assessment examines all the benefits of the reclaimed water project, including revenues plus environmental and social benefits, and compares these total benefits to the costs. A reclaimed water project may provide positive net benefits (benefits outweighing costs), even if the revenues generated from reclaimed water do not fully cover the costs.

An economic framework has been developed by the WateReuse Foundation (Raucher et al., 2006) to help guide benefit-cost assessments of reclaimed water projects (or other water resource options). As the King County reclaimed water program moves forward, this framework can be used as a guide in identifying potential projects where the prospects are greatest for attaining relatively important benefits.

4.4 References

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Chapter 5

Review of Revenue Sources for Reclaimed Water Distribution Facilities

As directed by Water Reuse Policy 2 (WRP-2) of the Regional Wastewater Services Plan, this feasibility study is to identify "revenue sources other than wastewater rates for distribution of reused water." This chapter expands on this scope to also describe a range of options used by other agencies to address the complex issues related to funding reclaimed water programs in addition to distribution costs.

In order to determine the financial feasibility of expanding a reclaimed water program, costs and revenue needs must first be defined and appropriately allocated to the reclaimed water program. Projected costs might include operation and maintenance of treatment and distribution facilities, annual debt service, reserve objectives, and capital replacements and improvements. WRP-2 requested that the feasibility study identify revenue sources for facilities for distributing reclaimed water. Distribution is an important component for reclaimed water projects, like the Brightwater backbone, where the costs for treatment and for pipes to convey the water both south and west of the treatment plant have been included in the wastewater project itself. Once these costs are known, revenue sources must be identified. Revenue sources may include, among others, grants, loans, and user fees and charges.

One means to recover remaining costs is to allocate these costs to system beneficiaries. The beneficiaries of the environmental, social, and financial benefits from using reclaimed water, identified through a benefit-cost analysis, can be factored into the allocation (see Chapter 4). Beneficiaries might include reclaimed water users, wastewater users, potable water users, and environmental, economic, and other interests. Pricing and cost recovery targets derive from policy decisions that must balance a number of possibly conflicting goals, such as equity, affordability, ease of administration, and economic incentive.

Concurrent with preparation of this feasibility study, the Washington State Department of Ecology (Ecology) evaluated possible sources of funds for a new state financial assistance program for water reclamation facilities. The 2007 Washington Legislature directed Ecology to establish a task force to define and recommend a comprehensive funding, loan, and grant program. The task force's draft report identifies options and funding sources similar to those identified in this feasibility study (http://www.ecy.wa.gov/programs/wq/reclaim/long_term_funding.html).

The number of reclaimed water projects in Washington is steadily increasing. Local governments and wastewater utilities across the state are increasingly able to address cost and revenue issues for reclaimed water in a manner that has local support. One example is the LOTT Alliance in Thurston County, where the regional wastewater agency has invested in major reclaimed water infrastructure as a method of addressing water quality limitations on further discharges to Puget Sound. Because the reclaimed water facilities are addressing a wastewater issue, the regional entity has funded the basic elements of its reclaimed water system through wastewater rates and then charges its member agencies $1.00 per year for the reclaimed water. Each member agency is responsible for funding the distribution system, which has been possible through a variety of charges and fees built largely on the need for irrigation water to accommodate residential and commercial growth.

In adopting the 2007–2008 biennial budget, the state Legislature included $5.5 million for reclaimed water projects that will benefit and contribute to the effort to restore Puget Sound. Congress is considering legislation that includes funding for reclaimed water projects as part of the country's efforts to adapt to impacts of climate change on water resources. The governor's Freshwater Preparation and Adaptation Workgroup, part of her broader climate change initiative, identified expanded use of alternative supplies like reclaimed water as a likely part of this state's strategy for response to climate change. While each of these developments is not a major new investment commitment for reclaimed water, together they indicate what is likely to be a willingness to commit public funds to reclaimed water projects as the recognition grows of the role that reclaimed water can play in meeting water resource management challenges. In addition, what may have been other significant costs for reclaimed water projects in the past—such as insurance to cover potential liability for reclaimed water use—are not likely to be a cost issue in King County because the county has agreed to "hold harmless" any utility purchasing reclaimed water from the county and using it according to prescribed conditions of use.

This chapter covers the above topics. It presents an overview of typical reclaimed water system costs and various options for recovering costs. It then provides more detail on these recovery methods, followed by a discussion of options for financing and funding capital costs. It discusses the full range of potential revenue sources, which is large and growing, for all components of a reclaimed water system, including distribution lines. The chapter ends with examples of costs and cost recovery methods in use by King County and other entities.

5.1 Overview of Costs to Develop and Operate a Reclaimed Water System

The full cost for reclaimed water service will include costs typical to a water/wastewater utility, such as capital costs associated with treatment and distribution facilities; operation, maintenance, and replacement costs; and administrative costs, such as customer billing. The total cost of a program could vary greatly, depending on the services provided and the system infrastructure. Typical reclaimed water capital, operation, and other expenses are described below.

5.1.1 Capital Costs

Capital costs are by far the largest portion of costs for a reclaimed water program. Evaluation of reclaimed water costs requires proper allocation of costs to the reclaimed water service that are over and above the costs of constructing, operating, and maintaining the wastewater system.

These costs can include investment in treatment plant upgrades or satellite plants, secondary and tertiary pump stations, reclaimed water storage, main transmission lines, and distribution system infrastructure. Costs for permitting activities should also be factored into the capital budget. Activities include an engineering report that must be approved by the Washington State Departments of Ecology and Health and completion of a permit by the reclaimed water distributor to verify items such as system as-builts, agreements with users, and operation and maintenance (O&M) procedures.

Capital costs are often financed with bonds or, when available, low-interest loans. In some cases, repayment of principal, interest, and reserve requirements constitute a large part of the ongoing annual operating budget.

5.1.2 Operation and Maintenance Costs

Annual operation and maintenance costs include expenses to deliver reclaimed water, including maintenance of distribution and storage facilities, and can also include treatment-related costs above those required for wastewater discharge. Other costs include the annual cost of regulatory compliance beyond NPDES permit compliance and costs for meter testing and system inspection.

5.1.3 Other Costs

Marketing, customer training, and retrofit connection costs are typical reclaimed water program costs that are not usually found in water and wastewater programs. Marketing costs can include working with new customers to develop user and inter-local construction agreements, providing training on the use of reclaimed water, and offering technical and permitting assistance for extending the distribution system and/or converting potable water users to reclaimed water. If reclaimed water will replace potable water use, planning should also consider the potential drop in potable water revenues that will accrue to water purveyors as a result of reduced potable water use.

Reclaimed water systems may also incur costs associated with the following:

- Conversions of customer facilities to accommodate reclaimed water use
- Pre-retrofit site assessments
- Retrofit incentives to encourage customers to use reclaimed water
- Post-retrofit site inspections, use and water quality monitoring, and user agreement monitoring
- Potable water supplemental price differential to meet reliability requirements[1]
- Enhanced cross-connection prevention programs

[1] Some reclaimed water programs must supplement reclaimed water with potable water to meet peak demands. Potable water rates are generally higher than reclaimed water rates, so the reclaimed water utility pays a higher rate for the potable water than is charged to the reclaimed water customer.

- Liability insurance

Pre-retrofit site assessments, cross-connection prevention, and liability issues are discussed in the following subsections.

Pre-Retrofit Site Assessments

Pre-retrofit site assessments can help to document site foliage as a baseline for future comparison after irrigating with reclaimed water. For example, East Bay Municipal Utility District in California uses a horticulturist to perform pre-retrofit site assessments, which incorporate photographs of site foliage. In response to customer claims that the salts in reclaimed water led to the deaths of redwood trees, the South Bay Water Recycling program, also in California, is funding a study to examine the issue and has hired a horticulturist to perform site assessments of existing foliage prior to retrofits for reclaimed water use.

Preventing Cross-Connections

Preventing cross-connections is a major concern in design, construction, and operation of reclaimed water distribution systems. A cross-connection is a physical connection between a potable water system and any source containing non-potable water through which potable water could be contaminated. Enhanced cross-connection prevention measures as outlined in the U.S. Environmental Protection Agency (EPA) Guidelines for Water Reuse (EPA, 2004) include the following:

- Procedures and regulations to prevent cross-connections
- Uniform scheme to mark all non-potable components of the system
- Proactive public information program
- Routine monitoring and surveillance of non-potable system
- Specially trained team responsible for operations, maintenance, inspection, and approval of reuse connections
- Design and construction standards
- Physical separation of potable water, reclaimed water, sewer lines, and appurtenances

Liability

Some potential reclaimed water customers in King County have expressed concern about liability for the long-term use of reclaimed water. They are concerned about who would be liable for cleanup if, many years from now, a constituent in the reclaimed water is found to be harmful to the environment. With the exception of the salt content of reclaimed water in some areas of California and its effect on redwood trees, review of various long-standing reclaimed water programs throughout the country found no indication of environmental or public health effects of using reclaimed water for irrigation or industrial purposes. As a rule, purveyors guarantee the quality, quantity, and timing of delivery of reclaimed water, but do not assume liability for the long-term impacts of its use. King County, however, will assume long-term liability for the use of reclaimed water produced by the county, subject to conditions of a user agreement and compliance by the user with all state, local, and federal requirements.

Some of the agencies interviewed for this study include standard “hold harmless” language in their customer or “right-of-entry” agreements, which effectively holds the agency harmless for impacts of reclaimed water use. Agencies that include such language in their use agreements include South Bay Water Recycling and Redwood City, both in California, and St. Petersburg, Florida. South Bay Water Recycling incorporates liability waivers into its right-of-entry agreements; the agreements tell customers that using reclaimed water is a state requirement and that the city passes on the liability of use to the users. Redwood City agreements disclaim all liability for impacts on vegetation that is irrigated with reclaimed water. Most agencies in Florida require signing a hold harmless agreement as part of customer agreements, and the Southwest Florida Water Management District’s *Reclaimed Water Guide* (1999) includes copies of such agreements (Anthony Andrade, project manager and senior water conservation analyst, Southwest Florida Water Management District, personal communication, 2007).

Discussions with several reclaimed water professionals and one insurance broker indicated that only one reclaimed water program carries liability insurance specifically covering the reclaimed water program. Monterey County, California, obtained insurance when starting its program 10 years ago because it was the first to provide reclaimed water for use on raw food crops (such as lettuce and strawberries). The current policy provides $40 million of pollution contamination coverage and $33 million excess general liability coverage at a cost of approximately $230,000 per year. The insurance also covers claims brought as a result of decisions made by public officials regarding the reclaimed water program. For instance, it would cover a claim where crop damage was determined to be a result of deciding to reduce the amount of water made available. Monterey has not had any claims filed in the 10-year history of its reclaimed water program. Insurance providers that write pollution contamination policies are the type of insurer that would cover reclaimed water programs.[2]

5.2 Overview of Cost Recovery Options

WRP-2 calls for review of revenue sources other than the wastewater rate for distribution of reclaimed water. As discussed in the previous section of this chapter, distribution costs are an element of total costs for reclaimed water projects and are key to ensuring delivery to end users.

Some reclaimed water users may not receive additional benefit from using reclaimed water in place of potable water. Users who replace potable water use with reclaimed water generally will not pay more for the same or lesser benefit, which results in placing a cap on the price of reclaimed water and further impeding the possibility of operating a financially self-sufficient system. The appropriate cost recovery amount, therefore, is generally a policy decision, as is the period over which costs are recovered (AWWA/WEF, unpublished). Cost recovery strategies normally aim to recover costs over a period of time rather than in a given year.

[2] Keith Grand, Marsh Risk and Insurance Services, personal communication, June 1, 2007.

Incentives, in the form of loans, grants, and other funding strategies, discussed later in this chapter, help to reduce and defray capital costs for reclaimed water providers. Tax breaks can also serve as an incentive to build a reclaimed water system. For example, from 2001–2003, the reclaimed water purveyors in the State of Washington were exempted from paying 75 percent of the Public Utility Tax (Chapter 82.16 RCW) on revenues received for reclaimed water services for commercial and industrial users. The Public Utility Tax is levied on gross income of public and privately owned utilities. (The incentive program, created in ESHB 1832, Chapter 237, Laws of 2001, expired in June 2003.)

Even with these incentives, the cost of treatment and distribution makes it difficult to recover 100 percent of reclaimed water costs solely from reclaimed water users. Moreover, most incentives are provided to encourage customers to shift from potable water to reclaimed water and often serve to reduce the amount that can be recovered from reclaimed water users. Examples of user incentives include subsidized reclaimed water costs, discounted price for interruptible service, fund conversions from potable water to reclaimed water, utility-funded distribution system extensions, reduced connection charges, and reductions in watering use restrictions (R.W. Beck, 2002). Other incentives are higher fees for wastewater disposal than for reclaimed water use and surcharges placed on water withdrawals from critical groundwater or surface water sources (Ecology, 2000).

In certain circumstances, costs can be recovered through wastewater rates or through formation of a reclaimed water utility. In most circumstances, reclaimed water is funded through a combination of reclaimed water user rates (fees and charges) and other sources. A 2002 economic analysis for the LOTT Wastewater Alliance confirmed that most reclaimed water systems in the United States must find financial support beyond reclaimed water user charges and fees (R.W. Beck, 2002). LOTT wastewater customers pay for the reclaimed water system through wastewater user rates, in recognition of the benefit of avoiding the costs of building an outfall.

A survey of approximately 100 reclaimed water systems found that 19 percent funded their systems solely through reclaimed water revenues. This contrasts with 34 percent of the survey respondents who had a goal to recover 100 percent of reclaimed water costs through reclaimed water revenues (27 percent had no cost recovery goals, and the remaining 39 percent had partial cost recovery goals). Only 19 percent recovered 100 percent of costs, with 46 percent reporting recovery of less than 25 percent of system costs (R.W. Beck, 2002).

In California, the Monterey County Water Recycling Projects recovers 100 percent of its costs through property tax assessments and reclaimed water user charges. Also in California, the West Basin Municipal Water District recovers 100 percent of reclaimed water costs through reclaimed water sales and a regional funding program. Almost 38 percent of West Basin’s 2006 reclaimed water revenues were from Metropolitan Water District Local Resource Program payments.

A recent study of 2005 and 2006 reclaimed water costs and rates by the Southwest Florida Water Management District concluded that reclaimed water cost recovery on a strictly financial basis is very difficult and that reclaimed water rates would, in many cases, have to exceed potable water rates in order to fully recover the costs of reclaimed water (Reclaimed Water Task Force, 2007).

A summary of the 2006 reclaimed water costs and charges for utilities in the Southwest Florida Water Management District is shown in Table 5-1.

Table 5-1. Reclaimed Water Supply Costs and Charges (2006)
Southwest Florida Management District

Customer Type	Supply Cost/ccf			Average Charge/ccf[b]	Percent Cost Recovery
	Capital[a]	Utility O&M	Total		
Residential/Commercial	$0.70	$0.22	$0.92	$0.44	48%
Large Industrial/Commercial	$0.43	$0.22	$0.65	$0.19	28%
Agricultural/Recreation/ Aesthetics	$0.19	$0.22	$0.41	$0.14	34%

Source: Reclaimed Water Task Force, 2007.
[a] The Southwest Florida Water Management District provides funding for many projects. This table includes the utilities' costs only.
[b] Reported in $/1,000 gallons; converted to $/ccf to be consistent within report.

Potable water or wastewater users usually make up the difference; many utilities split the reclaimed water deficits between both water and wastewater users. Two utilities interviewed reported they have recently changed from charging 100 percent of the deficit to wastewater users to charging a portion to potable water users. Alternatively, one interviewee noted that they have funded their reclaimed water program to date through a water enterprise fund and are currently studying what percentage of costs to allocate to wastewater.

The State of Florida includes the following language supporting recovery from water and wastewater users (367.0817, Florida Statutes):

> All prudent costs of a reuse project shall be recovered in rates. The Legislature finds that reuse benefits water, wastewater, and reuse customers. The commission shall allow a utility to recover the costs of a reuse project from the utility's water, wastewater, or reuse customers or any combination thereof as deemed appropriate by the commission.

The State of Florida's rationale for allocating reclaimed water costs to all users is that high quality aquifer water can be conserved by using reclaimed water for irrigation and other nonpotable applications and that all customers benefit from preserving the aquifer.

5.3 Recovering Costs Through Wastewater Rates

Some wastewater drivers and circumstances may indicate that wastewater rates are the appropriate method to recover all or part of the cost of a reclaimed water project. Examples are as follows:

- Reducing volume of effluent discharged or using advanced treatment to help meet discharge limitations
- Avoiding or delaying upgrades to wastewater treatment and disposal facilities (for example, delaying or avoiding outfall expansion or avoiding the necessity of purchasing more land on which to dispose of effluent)
- Using reclaimed water for treatment plant processes and onsite irrigation

Although most wastewater agencies in Washington State do not generate revenue for delivering reclaimed water, several do garner cost savings by using reclaimed water instead of potable water for municipal and in-facility irrigation, process, and washdown water. In 2004, King County estimated annual savings at the West Point plant at over 300,000 gallons and $161,000 (Cupps and Morris, 2005).

All the effluent at the county's new Carnation Treatment Plant will be treated to Class A reclaimed water standards and will be discharged to enhance a nearby wetland. This beneficial use avoids a direct discharge to the Snoqualmie River, opposed by tribes and others, and thus is considered a necessary cost of doing business. Wastewater ratepayers will carry costs not covered by grants.

Another example of effluent disposal as the primary driver for new reclaimed water systems is the LOTT Wastewater Alliance. LOTT is composed of four members: Lacey, Olympia, Tumwater, and Thurston County, Washington. It currently produces 3 mgd of Class A reclaimed water at two reclamation plants. The program was developed because wastewater treatment facilities were required to upgrade to produce Class A reclaimed water in response to total maximum daily load (TMDL) issues in Budd Inlet. Distributing reclaimed water was considered as a viable alternative to finding and funding other effluent discharge locations. LOTT wastewater users pay for the system through wastewater rates. LOTT supplies reclaimed water to water purveyors (its members) at a cost of $1 per year, in recognition of the costs incurred by the purveyors to build local distribution facilities and to market and deliver the water to end users.

Where effluent disposal or permit limitations are at issue, end-user reclaimed water service charges and fees are often set at a flat monthly rate that is lower than the potable water rate in order to encourage high usage. Some agencies provide reclaimed water for free or pay users to take delivery of the water. Such pricing strategies encourage customers to use more water. A survey of utilities in Pinellas County, Florida, found that residential customers who were charged a flat rate used an average of 1,112 gallons of reclaimed water per day, while residential customers who were charged per 1,000 gallons used an average of only 579 gallons per day (EPA, 2004).

As noted earlier, Florida specifically authorizes allocating costs to both water and wastewater users (see the section later in this chapter on allocation to water ratepayers). Ecology advocates that benefit-cost analyses be applied to water reuse decision-making. Such analyses compare the total costs for services with or without the reclaimed water project. While the intent is to ensure benefit-cost analyses are prepared during feasibility studies for reclaimed water projects, this line of thinking can be applied to cost sharing as well:

> It is essential to include the avoided costs of developing new potable water sources as well as the expansion costs of wastewater treatment plants that would otherwise occur. Analyses should also factor in the difficult to quantify avoided costs associated with the prevention of environmental degradation, protection of in-stream flows for fish, and the value of watershed enhancement. They should also project cost recovery from selling reclaimed water (Ecology, 2000).

Ecology summarized the challenges of funding reclaimed water systems in its 2000 report on reclaimed water demonstration projects:

> Financial incentives are still needed to reduce the capital and operational costs sufficiently for reclaimed water to be affordable and successfully compete with other existing water supplies.
>
> Current water and wastewater utility rates are not reflective of the true cost of water and wastewater collection, treatment, distribution or disposal. Federal agencies such as the Corps of Engineers and Bureau of Reclamation played a major role in the funding and construction of water supply reservoirs. Most existing municipal water supply and wastewater treatment facilities have also been subsidized at the state or federal levels through low interest loans or grants (Ecology, 2000).

5.4 Recovering Costs Through Reclaimed Water User Charges and Fees

Pricing is a key issue when implementing a startup reclaimed water program. The unit cost of reclaimed water is often highest initially when costs are high and demand is low. At the same time, utilities usually need to build demand over time by setting prices that will attract customers. As the demand for reclaimed water increases and the available capacity is used, the per-unit cost decreases. Pricing is most often associated with potable water pricing. Potable water pricing policies, which are often outside the control of the reclaimed water supplier, can greatly impact revenues generated from reclaimed water sales.

Reclaimed water customers may not perceive that reclaimed water provides greater benefit than does potable water, and may not be willing to pay more for reclaimed water even though it usually costs more to provide. Reclaimed water, therefore, is often priced lower than potable water in order to promote customer acceptance and use. However, many utilities that started with pricing strategies designed to promote high usage are now shifting to volume-based rates as augmenting water supply grows in importance (EPA, 2004).

This section describes typical potable water pricing policies and possible reclaimed water pricing strategies. It concludes with a discussion of the advantages and disadvantages of forming a reclaimed water utility to recover all costs through user charges and fees.

5.4.1 Typical Potable Water Pricing Policies

Most water utilities use a rate structure that includes two components: (1) a fixed monthly base or service charge, often based on meter size, and (2) a per-unit usage charge based on the amount of water used. The billing unit is typically equal to one hundred cubic feet (ccf) of water, which is 748 gallons. Three basic rate structures are commonly used for the usage charge (also known as a commodity or volume charge):

- **Flat or "uniform" rates** charge the same amount per unit for all quantities of water delivered. Seasonal rates are uniform rates that change during the year. For instance, Phoenix, Arizona, charges a higher per unit rate during summer than it does during winter, spring, and fall.
- **Inclined block rates** encourage conservation by charging a higher per-unit rate for higher usage. For instance, Tucson, Arizona, charges residential users a service charge of $5.42 per month plus a usage charge based on four tiers of usage:[3]
    - $1.17 per ccf for consumption of 1–15 ccf
    - $4.09 per ccf for consumption of 16–30 ccf
    - $5.78 per ccf for consumption of 31–45 ccf
    - $8.03 per ccf for consumption of over 45 ccf
- **Declining block rates** charge a lower rate per unit for additional units of consumption.

A convenient source of information on potable water rates in King County is the annual survey of wholesale customers published by Seattle Public Utilities (SPU). The following information is from the 2005 survey (SPU, 2006). SPU sells water directly to end users and to 25 wholesale water agencies. SPU and its wholesale customers charge a fixed monthly charge (usually based on meter size) plus a volume charge based on the amount of water used. Three of the 25 wholesale customers use a uniform rate structure that charges the same rate per ccf for all volumes of water use. Four customers use seasonal rates per ccf, which are uniform rates that increase for a specified number of months (usually four) in the summer. Fourteen customers have inclined block rates that charge a higher rate per ccf for higher volumes used. SPU and four wholesale customers use a hybrid of seasonal rates and inclined block rates. Tables 1.1 and 1.2 from the SPU survey are included in Appendix H; they show a comparison of 2005 residential and commercial rates for the 26 purveyors included in the report.

King County obtained rate information for some agencies not included in the SPU survey, including Alderwood Water and Wastewater District and Cross Valley Water District. Both districts obtain their water from the City of Everett. Alderwood's potable water rate structure includes a monthly meter charge plus a seasonally adjusted usage charge per ccf. The 2007 single-family residential usage charge increases from $1.38 to $1.54 per ccf for June through September. The 2007 monthly meter charge is $10.23 for a three-quarter-inch meter[4]. Rates for Cross Valley Water District consist of a monthly base rate that includes 700 cubic feet (cf) of

[3] http://www.ci.tucson.az.us/water/newrates.htm, accessed 6/28/07.
[4] http://www.alderwoodwater.com/billings/WaterRates.pdf, accessed 6/29/07.

water usage plus a water consumption rate for usage over 700 cf. The current base rate is $19.47 for a three-quarter-inch meter.[5] Consumption rates are as follows:

- $1.47 per ccf for consumption of 701–2,000 cf
- $1.73 per ccf for consumption of 2,001–6,000 cf
- $2.16 per ccf for consumption of over 6,000 cf

5.4.2 Reclaimed Water Pricing Strategies

A survey of reclaimed water fees and charges recommends that the following criteria be considered when developing rates (AWWA and WEF, unpublished):

- Easy to understand, from the customer perspective
- Not difficult to administer
- Customers' ability to pay
- Policy considerations (such as encouraging conservation and economic development)
- Revenue stability, from month to month and from year to year
- Promotes efficient use of resource
- Continuity, over time, of the rate-making philosophy
- Equitable and non-discriminating (cost-based)

Other considerations specific to reclaimed water systems are as follows:

- Pricing structures and user agreements that include measures to protect utilities against stranded costs
- An attractive price compared to potable water or groundwater
- Local regulations that mandate reclaimed water use (making demand less sensitive to pricing)
- Metering and volume-based charges instead of flat rates to discourage wasteful use

Another issue that affects efficient pricing in both positive and negative ways is reliability. In a positive way, reclaimed water is often called "drought-resistant" because summertime curtailments of potable water can be offset by the year-round availability of treated wastewater. Reliability allows a utility to price the reclaimed water efficiently. Without adequate storage, utilities may have to periodically augment the recycled water supply with potable water (at higher cost) to provide reliability or underprice the reclaimed water to account for any

[5] http://www.crossvalleywater.net/calculating.htm, accessed 6/29/07.

unreliability.[6] Where reclaimed water supply is greater than demand, reclaimed water storage may be less expensive to build and operate than augmenting with potable water.

Recent surveys of reclaimed water rates found that a variety of methods are used to set reclaimed water rates. The American Water Works Association (AWWA)/Water Environment Federation (WEF) conducted a survey in 1999–2000, which was updated in 2007 and is currently being reviewed prior to publication. A total of 109 reuse facilities responded to the 1999–2000 survey. In 2007, 89 of the 109 utilities were contacted again to update the survey and about 30 responded. Results from the surveys are shown in Table 5-2 and discussed below.

Table 5-2. Reclaimed Water Pricing Strategies

Rate Strategy	Percent of Respondents[a] (2000)	Percent of Respondents[b] (2007)
Reclaimed water system cost of service	14%	11%
Percentage of potable water rate	19%	16%
Promote use	24%	42%
Market analysis	9%	5%
Other	34%	26%

Source: (AWWA/WEF, unpublished).
[a] 109 respondents.
[b] Around 30 respondents.

Cost of Service

Cost of service rates, designed to recover the full cost of providing service from the utility's users, are typically used by water and wastewater utilities. The ability to recover all the costs for reclaimed water greatly depends on local conditions and whether the reclaimed water is cost competitive with local potable supplies. For example, the projected cost for reclaimed water supplied from Phase I of the Brightwater backbone is $1.35 per ccf compared to SPU's potable wholesale water rate of $1.48 to $1.53 per ccf to utilities in the serving areas near the backbone. On the other hand, the cost to supply reclaimed water for industrial processes to Nucor Steel in the City of Seattle is $3.34 per ccf (annual average cost) compared to SPU's rate of $2.29 to $3.35 per ccf for its commercial customers.[7]

[6] Jay Yingling, Southwest Florida Water Management District, personal communication, May 8, 2007.
[7] King County, Department of Natural Resources and Parks. 2006. *Reclaimed Water Backbone Project.* (Draft white paper, version 3.0). Seattle, WA.

Percentage of Potable Water Rate to Promote Use

Reclaimed water is often priced below cost in order to promote use. The “percentage of potable water rate” category in Table 5-2 is a subset of this pricing strategy, and although exact figures are not delineated in the AWWA/WEF report, it does note that in 2000 “promote use” respondents reported that they set rates at a percentage of potable water rates. Other pricing incentives also fall into this category.

The City of Phoenix, Arizona, and the Santa Rosa Subregional Water Reclamation System in California established reclaimed water prices for urban irrigation users at a percentage of potable water rates (see the discussion later in this chapter). LOTT sells reclaimed water on a wholesale basis to its members for $1 per year to encourage use and to recognize the investment in distribution facilities that the water purveyors will incur. State of California statutes mandate reclaimed water rates be equal to or less than potable water rates. Table 5-3 shows the range of discounts for reclaimed water, per a 1998 study of reclaimed water utilities in California (Lindow and Newby, 1998).

Table 5-3. California Reclaimed Water Rates as a Percentage of Potable Rates

Jurisdiction	Percentage of Potable Water Rates
City of Long Beach	53%
Marin Municipal Water District	56%
City of Milpitas	80%
Orange County Water District	80%
San Jose Water Company	85%
Irvine Ranch Water District	90%
Carlsbad Municipal Water District	100%
East Bay Municipal Utility District	100%
Otay Water District	100%

Source: (Lindow and Newby, 1998).

Market Analysis

Market analyses that determine how much customers are willing to pay may be used to develop reclaimed water rates. St. Petersburg, Florida, initially implemented a flat user rate for reclaimed water based on what other utilities in the area charged for reclaimed water.

Other

The “other” category in Table 5-2 includes a variety of methods for setting rates. In 2000, 49 percent of the utilities that answered “other” did not charge for reclaimed water at all;

22 percent reported that rates are negotiated with users; and 11 percent established rates as a percentage of raw water rates. The 2007 "other" respondents included some who are not charging for reclaimed water and some with rates set at cost of service minus a percentage to keep them below the potable water rate. Others adjust rates based on who paid for the original connection (for example, a developer or the utility).

The Florida Department of Environmental Protection publishes an inventory of water reclamation facilities in Florida each year. Table 5-4 shows various reclaimed water pricing strategies in terms of residential and non-residential users culled from the 1999 inventory of 176 reclaimed water systems. Table 5-5 shows average user rates for 128 respondents of Florida reclaimed water systems surveyed in 2005.

Table 5-4. Reclaimed Water Pricing Strategies in Florida (1999)

Rate Strategy	Non-Residential Percent of Reclaimed Water Systems	Residential Percent of Reclaimed Water Systems
Free of charge	45%	8%
Per-gallon charge	33%	12%
Flat rate	10%	22%
Base facility charge plus per-gallon charge	12%	10%

Note: 48 percent of the systems 176 surveyed did not provide residential service.
Source: (EPA and U.S. Agency for International Development, 2004).

Table 5-5. Summary of Reclaimed Water Rates in Florida (2005)

	Residential		Non-Residential	
	Average	Range	Average	Range
Flat rate ($/month)	$8.77	$0.00–$26.68	$368.82	$0.00–$3,263.75
Charge based on usage ($/ccf)[a]	$0.39	$0.00–$1.34	$0.26	$0.00–$1.92

Source: (Florida Department of Environmental Protection, 2006).
Note: 37 percent of the 128 systems that provided rate information did not provide residential service.
[a] Reported in $/1,000 gallons; converted to $/ccf to be consistent within report.

5.4.3 Forming a Reclaimed Water Utility

Establishing a separate reclaimed water utility and recovering 100 percent of reclaimed water costs through reclaimed water user charges and fees over time is theoretically possible but would be difficult given the infrastructure-intensive nature of reclaimed water systems and the perceived lower quality of the water, which exerts downward pressure on pricing. No one interviewed for this study is aware of any reclaimed water–only utilities.

The primary benefit of forming a separate utility district is to segregate reclaimed water costs and recover them from direct beneficiaries of the facilities. Segregating the costs can be accomplished through a separate utility or through cost accounting methods applied within the wastewater utility. A major disadvantage is that bonding capacity and bond ratings of a separate utility would likely be much less than that of King County. Other disadvantages include an increase in administrative costs and potential complexities in allocating unrecovered costs to water or wastewater users.

5.5 Recovering Costs Through Water Rates

As noted earlier in this chapter, the rate-making process for reclaimed water starts with cost allocation. The allocation of reclaimed water costs need not necessarily be limited to wastewater and reclaimed water users. As existing potable water customers convert from potable water supplies to reclaimed water, wastewater reclamation facilities effectively create a water resource and thus water capacity. Water supply agencies may also be interested in using reclaimed water as a form of water resource mitigation to retain or gain water rights. Costs to treat poor quality sources may be avoided or postponed, and reductions in average day or peak day water demand can result in substantial savings when sizing potable water infrastructure. Potable water customers may benefit from the following:

- Increased capacity in the potable water supply system to serve future development
- Savings resulting from deferring augmentation of potable water supply infrastructure
- Avoided cost of peaking capacity caused by seasonal irrigation and cooling needs
- Avoided O&M costs for transmission, treatment, and distribution of potable water
- Avoided cost for supplying higher quality water than the use requires
- Avoided increased groundwater pumping costs from declining groundwater levels
- Local control over water resources (for example, not relying on imported water)

Local conditions may create other benefits for potable water users. In 1999, Tucson Water charged its potable water customers $1.74 per ccf (Cuthbert and Hajnosz, 1999). Meeting demands in 1999 without reclaimed water sales would have required additional groundwater wells and other potable facilities. Further, Tucson Water would have faced exposure to fines and civil penalties for exceeding the limit on groundwater pumping set by the Arizona Department of Water Resources, which would have increased the water rate by about another $0.01. The overall impact on rates of meeting what would have been reclaimed water sales with potable water would have been about $0.05 per ccf (or 3 percent) to $1.79 per ccf.

The cost of producing and distributing reclaimed water was $1.37 per ccf in 1999. Tucson Water was, however, selling reclaimed water at $1.06 per ccf, or 90 percent of the lowest commercial potable water rate. A separate analysis of the data indicates that were the full cost of reclaimed water ($1.37 per ccf) added to the full cost of potable water ($1.74 per ccf) and spread over all water ratepayers, the effective rate would have been reduced from a potential high of $1.79 per ccf without reclaimed water to $1.71 per ccf, a benefit for all ratepayers (Cuthbert and Hajnosz, 1999). If reclaimed water continued to be sold at $1.06 per ccf, water rates would still be only $1.76 per ccf, a small increase of $0.02 per ccf (1.1 percent). The results indicate not only that there is no subsidy of reclaimed water by the water ratepayers but also that all potable water users could benefit from reclaimed water sales.

As illustrated by the left graph in Figure 5-1, capacity of the potable water system must be increased in time to meet projected future demands. Conversely, the graph on the right in Figure 5-1 shows how the implementation of a reclaimed water program could eliminate or delay the expansion of a potable water system as the projected demand for potable water shifts downward as some water demands are met using reclaimed water. Water use efficiency measures can similarly delay or eliminate the need to increase system capacity.

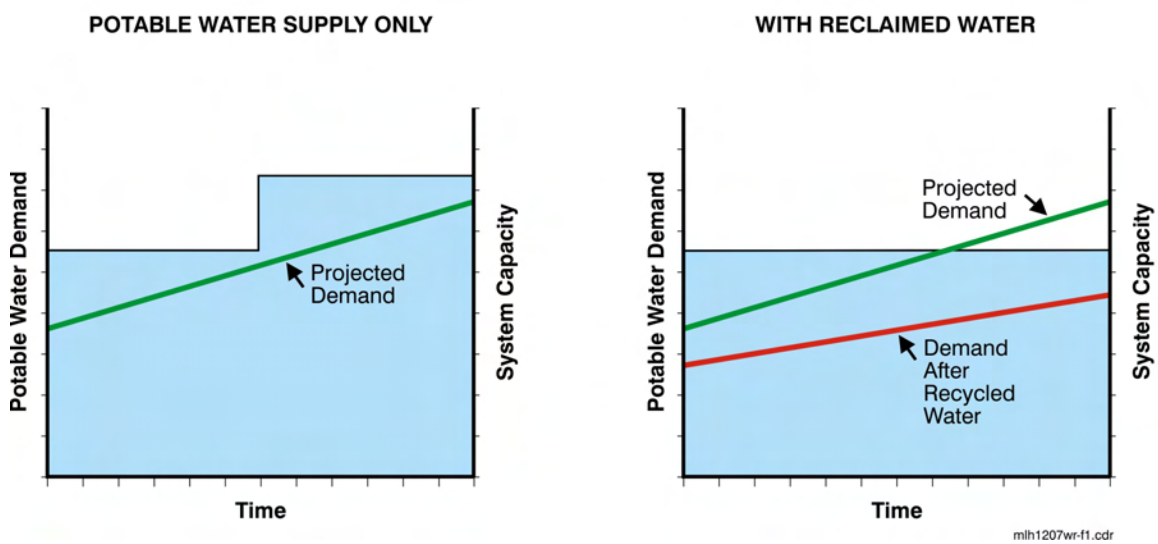

Figure 5-1. Example of Decrease in Potable Demand with Increase of Reclaimed Water Use

As regulations for water withdrawals and wastewater discharges become more stringent, reclaimed water may play a more important and cost-effective role in mitigating impacts.

System capacity can represent not only the physical limitations of the constructed infrastructure but also of the water supply or a community's water rights. For example, the use of reclaimed water could be used for indirect streamflow augmentation to offset groundwater pumping as water demands increase. Under this example, reclaimed water costs could be directly attributable to future potable water users if stream augmentation is necessary in order to supply the next increment of water.

5.6 Options for Financing and Funding Capital Costs

Funding capital costs is a primary constraint in implementing new reclaimed water projects. In a recent survey conducted by Ecology of utilities in Washington State, the majority of respondents (25 of 34) reported "generally positive" feelings toward reclaimed water. However, only 18 respondents reported current or planned participation in reclaimed water projects, and 29 out of 34 respondents cited treatment and distribution costs as the top barriers to producing reclaimed water, closely followed by lack of funding availability (Radcliff, 2007).

This section describes potential financing and funding sources and outlines current grant and loan opportunities in the State of Washington. Financing sources include low-interest loans, bond financing, and capital reserves generated through reclaimed water, water, or wastewater revenues. Funding can come from a variety of sources, including the following:

- Grants
- Voter approved taxes
- Capacity charges (also known as general facilities charges or connection fees)
- Developer contributions and latecomer agreements
- Separate reclaimed water utility
- Environmental credits
- Check box on bill allowing wastewater users to voluntarily contribute to the reclaimed water program
- "Special refunding districts" where assessments are proportional to reclaimed water use instead of being proportional to the special benefit to the property, as they are for local improvement districts[8]

5.6.1 Historical Funding of Reclaimed Water Projects in Washington

According to Ecology's case studies in reclaimed water, $30.5 million in grants and $91.9 million in low-interest loans helped fund $229.5 million in construction of wastewater treatment and reclaimed water systems in Washington (Cupps and Morris, 2005). Table 5-6 shows the grant and loan programs used to fund the 15 projects profiled in the report.

[8] As noted in the LOTT economic analysis (Beck, 2002).

Table 5-6. Historical Grant and Loan Funding for Wastewater Treatment and Reclaimed Water Projects in Washington (through 2004)

Source	Funding Amount (millions)
Washington Centennial Clean Water Program	$12.9
EPA Innovative & Alternative Treatment Grants	$6.0
USDA Rural Development Grant Program	$5.9
Ecology Grants	$5.0
Community Development Block Grants	$0.75
State Water Pollution Control Revolving Fund Loans	$58.1
Washington Public Works Trust Fund Loans	$18.7
USDA Rural Development Loan Program	$15.1

Source: Compiled from case studies (Cupps and Morris, 2005) and personal communications (see Appendix E).
USDA = U.S. Department of Agriculture.

5.6.2 Current Funding Sources

Capital costs for implementing a reclaimed water program are often financed through long-term debt, such as water and wastewater revenue bonds and low-interest loans. Long-term debt is usually paid back over 20–30 years, so this method of financing helps to equate expenditures with the useful life of the facilities.[9] In general, debt financing allows an agency to undertake a larger share of its capital improvements program in the near term and/or mitigate immediate impacts on rates. Creative debt structure can be explored where payment schedules are tied to forecasted usage demands, thereby increasing annual payments in proportion to projected increases in reclaimed water demand. This approach provides rate equity between front-end system users and future users.

Current grants and loans and the total available funding that could be used for reclaimed water projects in Washington are listed in Table 5-7.

[9] King County is currently issuing 40-year bond terms for wastewater projects.

Table 5-7. Grant and Loan Funding Available for Washington Reclaimed Water Projects

Source	Funding Amount for FY 2008–2009 (millions)
Ecology Reclaimed Water Grants Program	$5.5
Washington Centennial Clean Water Program—Grants and Loans (competitive only)[a]	$13.8
USDA Rural Development Grant Program	N/A
Community Development Block Grant[b]	$12
State Water Pollution Control Revolving Fund Loan Program[c]	$85.4
Washington Public Works Trust Fund Loan Program	N/A
USDA Rural Development Loan Program	N/A
EPA State and Tribal Assistance Grant Program	N/A
EPA Five Start Restoration Program	N/A

Source: Amounts are per Mary Ann Ness, King County WTD, unless otherwise noted below.
N/A indicates that information was not located.
[a] Hardship facilities only; an additional $6.92 million allocated for nonpoint activities.
[b] 2008 only (CTEC, 2007).
[c] Facility loans only

Ecology's Water Quality Program has implemented a combined funding cycle for the Centennial, Federal Clean Water Act Section 319 Nonpoint Source, and State Revolving Fund programs. All programs may be applied for on one application and all eligible projects for funding under any one of the programs must appear on a statewide Final Offer and Applicant List. Applications are evaluated and prioritized on a draft offer list, which is sent to the Legislature prior to budget development. There is a 30-day public comment period, after which the Legislature passes a budget and the Final Offer List is issued with funding letters.

It should be noted that several years ago, Ecology amended the selection process of financial assistance programs to award additional points to applications that include reclaimed water as an element in their project proposals, thus increasing their competitiveness with respect to other applications (Ecology, 2000).

Low-Interest Loans

State Water Pollution Control Revolving Fund Loan Program

The State Revolving Fund financial assistance program is managed by the states under EPA guidance. It is funded 80 percent by the federal government and 20 percent by state funds. Loans can be up to 100 percent of project expenditures.

Washington's State Water Pollution Control Revolving Fund is administered by Ecology. The program provides loans for planning, design, and/or construction of water pollution control facilities and other high-priority water quality projects that are consistent with the Clean Water Act. Loan rates are 60 percent of average market rates for up to 20 years, and may be reduced for facilities serving low-income areas. Current interest rates are 1.5 percent for terms up to 5 years and 3.1 percent for terms from 5–20 years.

Funding is available to public agencies for projects included on the statewide Final Offer and Applicant List. In fiscal years 2008 and 2009, $45.2 and $40.2 million are anticipated to be available, respectively, for facility loans.[10] Further information can be found at http://www.ecy.wa.gov/programs/wq/funding/2009/.

Centennial Clean Water Program

The Centennial Clean Water Program, administered by Ecology, provides grants and low-interest loans to communities that qualify for "hardship" assistance for high-priority water quality projects through appropriations from the state Legislature. Funds may be used for planning, design, and/or construction of water pollution control facilities and nonpoint source pollution control management programs. Loan rates are 60 percent of average market rates for up to 20 years and may be reduced for facilities serving low-income areas. Current interest rates are 1.5 percent for terms up to 5 years and 3.1 percent for terms from 5-20 years.

Funding is available to public agencies for projects included on the statewide Final Offer and Applicant List. In each of the fiscal years 2008 and 2009, $6.9 million is anticipated to be available for hardship facilities loans and grants.[11] Further information can be obtained at http://www.ecy.wa.gov/programs/wq/funding/2009/.

Public Works Trust Fund Loan Program

Washington State's Public Works Board provides low-interest loans to finance public works projects. Reclaimed water projects are eligible for Public Works Trust Fund (PWTF) financing. Pre-construction and construction loans are available with terms up to 20 years with interest rates between 0.5 percent and 2 percent based on the local match. Planning loans with 6-year terms and 0 percent interest are also available, as are emergency loans at 3 percent interest for 20 years. Further information can be found at http://www.pwb.wa.gov/FORMS.HTM.

King County's Wastewater Treatment Division (WTD) has secured $1 million in PWTF loans to finance a portion of the pre-construction costs for the Brightwater reclaimed water pipeline and has submitted an application for an additional $6.4 million for construction.

USDA Rural Development Loan Program

The U.S. Department of Agriculture (USDA) Rural Development Loan Program offers funding to public bodies, non-profit organizations, and recognized Indian tribes that serve rural areas and

[10] Per Mary Ann Ness, King County WTD.
[11] Per Mary Ann Ness, King County WTD.

towns with populations of 10,000 or less for water, wastewater, or solid waste projects. Further information can be obtained at http://www.usda.gov/rus/water/index.htm.

Bond Financing

The types of bonds usually used for financing public works projects are local government tax-exempt bonds. RCW 36.94.200 authorizes counties to issue general obligation bonds, revenue bonds, and local improvement district bonds.

General Obligation Bonds

General obligation bonds are backed by the general taxing authority of local government and are often repaid using utility revenues when issued in support of an enterprise fund. RCW 39.46.110 governs government obligation bonds.

Revenue Bonds

Revenue bonds, covered by RCW 36.67.500, are issued to finance specific projects, or groups of projects, and assets from which revenues can be derived (such as water systems). They are secured by the revenue of an enterprise fund and have no claim to other funds. Revenues, such as user rates and capacity charges, are used to make payments on the bonds. Tax revenues of the county would not be used to secure or guarantee payment on revenue bonds. Revenue bonds are typically perceived to carry higher risk than government obligation bonds, and therefore often carry a slightly higher interest rate. The perceived risk is derived from the possibility that the projects financed will not bring in enough revenue to pay bondholders.

Utility Local Improvement District

The information in this section does not apply to WTD and is included only for the benefit of other agencies in Washington State.[12] WTD was created and operates under RCW 35.58.200, which does not authorize utility local improvement districts.

Local improvement districts (LIDs) are special assessment districts developed to provide local improvements to property owners in the district and must be approved by the local government and the benefiting property owners. LIDs provide a means of financing capital improvement projects. Utility local improvement districts (ULIDs), a variation of LIDs, require that the debt for the improvement project be repaid by the benefiting property owners and by utility revenues. ULID bonds are tax-exempt, but are not always guaranteed by the municipality; developers, therefore, must often guarantee the bonds.

Generally, water and sewer projects are governed by RCW 36.94.220, which authorizes the establishment of ULIDs to levy special assessments on properties benefited by the local

[12] The source for information in this section is the *Washington State Local Improvement District Manual*, 5th edition, Municipal Research and Services Center of Washington and American Public Works Association, Washington State Chapter, October 2003.

improvements. The assessments may not exceed the combined cost of the direct improvements plus the general wastewater/water facilities costs allocable to the district. Similarly, the assessment per parcel may not exceed the benefit of the improvement to that parcel. This benefit is defined as the difference between the fair market value of the property before and after implementation of the local improvement project.

Several options exist by which the cost of the utility improvement is distributed among the participating property owners. Assessment methods include mathematical cost distribution formulas such as front foot (the parcel length adjacent to the street), lot area, or zone termini (in which the costs are distributed based on a grid system of north-south and east-west streets). Mathematical cost distribution methods are typically easier to justify to property owners; however, they do not always provide equitable distribution of the improvement benefits. In such a case, a special benefit analysis method may be warranted. A qualified appraiser can prepare this analysis. It is recommended that a special benefit analysis be conducted for projects encompassing mixed land use zones or involving significant topographic changes within the ULID.

Capital Reserves

Reclaimed water capital programs can be cash funded with capital reserves, as available. Cash funding can be cost-effective by reducing borrowing costs. This approach is possible under long-term cost-of-service rate setting principles. Building capital reserves by increasing rates in anticipation of projected capital improvements can help the county to meet pay-as-you-go objectives. Cash funding must be balanced within the practical limitations of rates. It is unlikely that sufficient cash reserves would be available to fund near-term reclaimed water projects in King County.

5.6.3 Funding Sources

Grants

Funding capital costs through grants reduces the debt service component of the annual revenue requirement that is recovered through reclaimed water rates. Although grant funding is limited, the state has demonstrated a growing interest in fostering increased use of reclaimed water. This growing interest is evidenced by Engrossed Second Substitute Senate Bill 6117 (E2SSB 6117), which passed the House and Senate in April 2007 and was approved by the governor on May 11, 2007:

- Section 2 of E2SSB 6117 directs the state to “expand both direct financial support and financial incentives for capital investments in water reuse and reclaimed water…”
- Section 3 requires consideration of reclaimed water use as a source in water supply planning.
- Section 8 reiterates state financial assistance and requires state agencies “… to review and reduce regulatory barriers and streamline permitting for the use of reclaimed water where appropriate.”

- Section 9 requires state agencies to use reclaimed water where feasible.
- Section 10 establishes a task force to develop "… a recommendation for a long-term dedicated funding program to construct reclaimed water facilities."

King County has demonstrated the ability to secure grants, such as on the Carnation wetlands enhancement project, and will continue to work toward securing the maximum amount of grants available to help reduce overall project costs.

Reclaimed Water Grants Program

The Reclaimed Water Grants Program, administered by Ecology, provides grants to local governments in the Puget Sound region for completion of reclaimed water projects. For the 2007–2009 biennial budget years, $5.5 million is available. Although there is no maximum ceiling for capital projects, the target is to fund three to six high priority capital projects with varying match amounts required. Priority will be given to projects in water-short areas and areas where reclaimed water will restore important ecosystem functions in Puget Sound. Feasibility studies are eligible for 100 percent funding up to a maximum of $250,000. Applications were due September 28, 2007.

King County worked with jurisdictions to apply for state grants that could facilitate early connection to the Brightwater reclaimed water system.

Further information can be obtained at http://www.ecy.wa.gov/programs/wq/funding/ReclaimedWaterGuidelines.pdf.

Centennial Clean Water Program

The Centennial Clean Water Program, administered by Ecology, provides grants and low-interest loans to public bodies for high-priority water quality projects through appropriations from the state Legislature. Funds may be used for planning, design, and/or construction of water pollution control facilities and nonpoint source pollution control management programs.

Funding is available to public agencies for projects included on the statewide Final Offer and Applicant List. It is anticipated that $6.9 million will be available for hardship facilities loans and grants in each of the fiscal years 2008 and 2009.[13] Further information can be obtained at http://www.ecy.wa.gov/programs/wq/funding/2009/.

USDA Rural Development Grant Program

The USDA Rural Development Grant Program offers funding to public bodies, non-profit organizations, and recognized Indian tribes that serve rural areas and towns with populations of 10,000 or less for water, wastewater or solid waste projects. Further information can be obtained at http://www.usda.gov/rus/water/index.htm.

[13] Per Mary Ann Ness, King County WTD.

Community Development Block Grant Program

The Washington State Department of Trade and Economic Development offers grants to cities and towns with less than 50,000 in population or counties with less than 200,000 in population for water, wastewater, and solid waste projects. Projects must principally benefit low- and moderate-income persons (80 percent of county median income). Applicants must be non-entitlement jurisdictions or must not be participating in a U.S. Department of Housing and Urban Development (HUD) Urban County Entitlement Consortium.

Further information can be obtained at http://www.cted.wa.gov/site/314/default.aspx.

State and Tribal Assistance Grant Program (STAG)

EPA's State and Tribal Assistance Grant Program (STAG) grants are available to states, tribes, and universities to carry out compliance assurance activities and to build their capacity to enforce environmental laws and regulations. Eligible activities include training, studies, and surveys. Awards typically range from $50,000 to $200,000. Further information can be obtained at http://www.epa.gov/compliance/state/grants/stag/index.html.

Five Star Restoration Program

EPA's Five Star Restoration Program offers grants to local public agencies, non-profit organizations, and educational institutions to provide environmental education and training through projects that restore wetlands and streams. The amount awarded to a project ranges from $5,000 to $20,000. Further information can be obtained at http://www.epa.gov/owow/wetlands/restore/5star/.

Voter Approved Taxes

Funding infrastructure through property taxes offers some advantages over using utility rates and fees. Costs are shared by a larger group, which subsequently lowers per-unit prices. While using taxes to fund reclaimed water facilities provides an alternative revenue source to using rates and fees, this option would require significant public support.

The Funding Work Group of the Puget Sound Partnership identified the Maryland "Flush Tax" as a promising model to raise revenue to protect Puget Sound.[14] The Maryland Legislature enacted the Flush Tax in 2004. It is a $30 flat tax imposed on all residential parcels, collected as a $2.50 surcharge on monthly wastewater bills or a $30 dollar annual fee for owners of septic systems. It is earmarked for the cleanup of Chesapeake Bay and surrounding bodies of water by reducing nitrogen and phosphorus discharge into waterways. The Funding Working Group calculated that a similar Puget Sound Flush Tax would generate approximately $54 million per year, $26.4 million from King County and $28.1 million from the rest of Puget Sound (Funding Working Group, 2006).

[14] In 2007, the Washington State Legislature established the Puget Sound Partnership to lead efforts to protect and restore Puget Sound. For more information, see http://www.psp.wa.gov/

Florida's regional water management districts have taxing authority. They allocate a portion of tax revenues to grant programs to develop alternative water supply sources, with a high priority placed on reclaimed water projects. California voters have passed several bond measures (Propositions 13, 50, and 84) that include grant funding for reclaimed water projects.

Developer Contributions and Latecomer Agreements

Funding capital costs through developer contributions reduces the debt service component of the annual revenue requirement that is recovered through reclaimed water rates. Special agreements can be reached with developers or industrial users that require the contribution of either assets or money to offset the costs of a particular project. When reclaimed water is to be used for a specific purpose, such as cooling water, it may be possible to obtain the capital financing for new transmission facilities directly from one or more major users that benefit from the available reclaimed water supply. Onsite storage is another fairly common contribution by large users to reclaimed water systems.

Utilities may require developers to install local collection and distribution facilities as a condition of development. A utility may also require a developer to extend transmission and trunk lines (as well as pump stations) to provide capacity for the development. Further, the utility may require the developer to oversize facilities to accommodate future additional development. The developer may be reimbursed for the cost of oversized facilities directly by the utility or through a latecomer agreement. Under the terms of a latecomer agreement, future developments using the excess capacity will pay the initial developer directly for the cost of the capacity. Latecomer agreements provide a reimbursement to developers for a period of not more than 15 years by any owner of real estate who did not contribute to the original cost of facilities and who subsequently taps into or uses them.

Capacity Charges

Municipalities and other governmental units have the authority to impose capacity charges, or general facilities charges, on new development for the right to connect to the water and wastewater system. Capacity charges can be imposed on new development as a means of recovering the cost of developing available capacity necessary to serve growth.

Municipalities and local agencies can collect capacity charges for capital costs they incur. A capacity charge could be imposed on reclaimed water users to recover the cost of providing reclaimed water, particularly as these customers become new reclaimed water users. A reclaimed water capacity charge could recover treatment, transmission, and local distribution system costs. King County could work with local agencies to impose a capacity charge for treatment and transmission costs incurred by the county. Capacity charge revenues could be collected at the local level and then remitted to the county, similar to a pass-through charge.

One option is to waive a reclaimed water capacity charge for potable water customers that convert to reclaimed water because these customers have already paid a cost for capacity in the water system. Existing potable customers have presumably paid for their share of capacity in the water system by paying a capacity charge and/or water usage rates over time. They should not, therefore, be charged a reclaimed water capacity charge unless they increase their water meter size to meet increased usage demands. In such a case, an incremental charge might be appropriate. Alternatively, a municipality could impose a reclaimed water capacity charge on converted customers and then give them a credit for “selling back” capacity in the potable water system. Such a credit would be commensurate with the potable water capacity charge. New potable water users would then fund this purchased-back capacity through the potable water capacity charge.

Local jurisdictions may recover some reclaimed water treatment and distribution costs through wastewater and potable water capacity charges. Because treatment facilities, including advanced treatment, benefit wastewater users, expansion related costs could be recovered through a wastewater capacity charge. Reclaimed water may also provide direct and indirect benefits to potable water users, who may pay a potable water capacity charge to recover reclaimed water capital investments based on an appropriate cost allocation. These recovered capital costs may include tertiary wastewater treatment costs, pumping and transmission costs, and local costs, such as metering and retrofits, to convert existing potable water users to the reclaimed water system.

King County WTD rates and capacity charges are governed by state statute, and WTD does not currently have the authority to impose a reclaimed water capacity charge. The county could seek to amend the statute to include the ability to recover reclaimed water costs through a reclaimed water capacity charge.

Property Owner Credit Offsets

One of the ways that Largo, Florida, uses to finance extension to the reclaimed water distribution system is through credit offsets. Property owners construct and pay for extending the reclaimed water system to their property. The city may then provide a credit for water used against the cost of the installation. Once the credit is issued, the city takes ownership of the distribution line. When the credits equal the cost of the installation, the customer begins paying for the water at the prevailing rate. The city is not responsible for reimbursing the property owner except through issuing credits for water used. This method was “instrumental” in installing the distribution infrastructure at little to no cost to the city (Southwest Florida Water Management District, 1999).

Environmental Credits

WTD could explore environmental credits as a potential additional source of revenue. Carbon credits and renewable energy credits are examples of environmental credits.

Chehalis, Washington, is using reclaimed water to grow a poplar plantation for lumber quality wood. The city anticipates earning revenue by selling the lumber. Hybrid poplars sequester carbon, so there may also be mitigation benefits for greenhouse gas emissions to be harvested with this project (Kathy Cupps, Washington Department of Ecology, personal communication, May 9, 2007).

Stratus Consulting, an environmental sciences and economics firm, recently incorporated the idea of creating a "wetlands bank" as a potential additional source of revenue for reclaimed water project options considered in a master plan in California. California allows creation of these banks to provide habitat for endangered/threatened species. The credits purchased by developers allow them to mitigate development projects elsewhere (Jim Henderson, Stratus Consulting, personal communication, June 5, 2007). Stratus also reported that there are water supply credits associated with recharge projects in Arizona and loss of Colorado River return-flow credits associated with water reuse in Las Vegas.

Voluntary Customer Contributions

Voluntary customer contributions could be collected through water or wastewater bills, similar to contributions collected for low-income customers. Seattle City Light operates the Green Power Program that funds local renewable energy demonstration projects through voluntary customer contributions collected with electric bill payments. These programs often include a check box on monthly bills allowing users to pay the optional monthly program contributions. Such a voluntary program could be a good public relations strategy that shows public support for investment in reclaimed water use.

5.7 Examples of Costs and Cost Recovery Methods

This section summarizes eight case studies that describe costs, financing, and revenue strategies of various reclaimed water programs:

- Carnation Wastewater Treatment Facility, King County, Washington
- LOTT Wastewater Alliance, Thurston County, Washington
- City of Phoenix, Arizona
- Monterey County Water Recycling Projects, California
- Santa Rosa Subregional Reclamation System, California
- South Bay Water Recycling, California
- West Basin Municipal Water District, California
- St. Petersburg, Florida

Appendix I includes full write-ups of six out-of-state reclaimed water programs researched and interviewed for this study; Appendix J summarizes Washington State case studies; and Appendix E includes write-ups of Washington State case studies.

All of the reclaimed water systems highlighted in this section are owned and operated by public agencies: three wastewater-only agencies, one potable water-only agency, two cities that provide both water and wastewater services, and two joint ventures between water and wastewater agencies. Avoiding or reducing wastewater effluent discharge was the original driver for six agencies; providing additional water supply was the driver for three agencies. (Phoenix is included in both categories because of different drivers for different facilities.) One project (Monterey County) was initiated by agricultural customers who needed the water. Three agencies that originally developed their systems to address effluent disposal concerns have now determined that reclaimed water is also an important part of the water supply portfolio.

All case study agencies deliver reclaimed water for at least one typical use, including agricultural and large area landscape irrigation, groundwater recharge, and wetland enhancement. One agency (St. Petersburg) delivers to 10,000 residential irrigation customers as well. These uses are often seasonally dependent. Demand is high during dry months (usually summer) and low during rainy months. Reclaimed water supply is year-round. Some agencies have opportunities to supply customers with year-round demand. One agency (Phoenix) obtains potable water or groundwater credits in exchange for reclaimed water. Four agencies (Phoenix, Santa Rosa, South Bay, and West Basin) deliver reclaimed water to power plants, refineries, and other industrial/commercial customers for process and cooling water needs.

All agencies financed capital costs through a combination of low-interest loans, grants, and bonds. Two of the agencies (West Basin and South Bay) have goals to recover 100 percent of system costs through reclaimed water rates.[15] In 2005–2006, West Basin recovered all its costs, while South Bay had about $2.8 million of unrecovered costs that were passed on to wastewater customers. Monterey County's goal, which it consistently meets, is to recover 100 percent of system costs through property taxes and reclaimed water delivery charges.

Of the six agencies that do not recover 100 percent of reclaimed water costs through the reclaimed water revenue schemes described above, five cover the remaining costs through wastewater rates and charges, one through water rates, and one through a 50-50 split between water and wastewater charges. Phoenix is included under both water and wastewater, because of different methods for different facilities. Phoenix's Cave Creek facility allocates all remaining costs to water customers; the city is currently studying how to allocate some of the costs to wastewater customers. Santa Rosa has funded shortfalls through charges to wastewater customers but is planning to charge 40 percent of the shortfalls from its new urban water program to water customers and 60 percent to wastewater customers. St. Petersburg originally funded all shortfalls through charges to wastewater users but now splits the charges 50-50 to water and wastewater customers.

The agencies use a variety of methods to build distribution systems to user sites. Many agencies have developers or large customers fund at least a portion of the costs. Carnation obtained grants to build the wetlands discharge system; the U.S. Bureau of Reclamation (USBR) and the U.S. Army Corps of Engineers have built much of West Basin's lateral delivery system.

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[15] The goal for West Basin is to recover all costs through reclaimed water revenues plus Metropolitan Water District Local Resource Program payments. South Bay also receives local water development funds from the Santa Clara Valley Water District when the district has to import a quantity of water over a specified threshold; however, the goal is to recover all reclaimed water costs through reclaimed water rates and not rely on District funds. In 2005–2006, West Basin and South Bay both obtained about 40 percent of their revenue from these water agency local development funds.

Several agencies have offered incentives for new customers to sign up. LOTT, a reclaimed water wholesaler, charges only $1 per year for water delivered, recognizing that the retail water purveyors will have to build delivery systems. The City of Phoenix waives water meter and connection fees for reclaimed water users. Under old contracts, Santa Rosa delivers reclaimed water for free to some agricultural users and pays other users to take the water. It offers new customers of the urban system one year of free water. In the early years of its program, South Bay paid for connection and construction costs to retrofit new users.

5.7.1 Carnation Wastewater Treatment Facility, King County, Washington

King County WTD is currently constructing a wastewater treatment plant to serve the City of Carnation, Washington. The design capacity of the plant is 0.37 mgd. Treated water will meet Washington State Class A reclaimed water standards. The estimated initial flow from the plant will be 0.2 mgd. The reclaimed water will be used in a wetland enhancement project at the Chinook Bend Natural Area north of the City of Carnation. In the future, other reclaimed water uses may occur as other interested end users are identified.

The project was initiated through an agreement between King County and the city. The agreement stipulates that King County's responsibility is to construct and operate a wastewater treatment plant to serve the city and that the city's responsibility is to construct and operate a collection system to deliver wastewater to the plant.

During the siting process for the plant, three discharge alternatives were considered: upland infiltration disposal, river discharge, and reclaimed water wetland enhancement discharge. The outcome of the selection process was the river outfall because it was a proven design and the lowest cost alternative.

Because the stretch of the Snoqualmie River where discharge would occur provides important habitat for fish species listed under the Endangered Species Act, because the local community expressed concerns, and because water quality is already compromised in the river, King County committed to treat the wastewater at the Carnation plant to reclaimed-water quality. The reclaimed water wetland enhancement project is a beneficial use of the reclaimed water produced by the facility and has broad stakeholder support. In order to achieve beneficial use of the reclaimed water and satisfy permit conditions, WTD continued to seek a reclaimed water wetland discharge.

WTD developed a partnership with a sister agency, King County Water and Land Resources Division, and a non-profit wetland conservation organization, Ducks Unlimited, to develop a reclaimed water wetland enhancement project at the Chinook Bend Natural Area immediately adjacent to river discharge.

Costs and Financing

Total costs for the Carnation treatment plant and outfall are estimated to be $19.65 million. State Revolving Fund loans are financing $1.2 million for design and $14 million for construction and construction management services.

Class A reclaimed water and wetlands discharge upgrades plus dual-discharge improvements cost an additional $3.046 million.

Working with King County staff, Ducks Unlimited obtained $166,000 to fund the design, permitting, construction, and wetlands restoration for this project:

King Conservation District	$ 14,000
King County Water Works Grant	$ 30,000
North American Wetland Conservation Act Grant	$122,000

King County obtained an additional $395,350 in grant funds from the Interagency for Outdoor Recreation Aquatic Lands Enhancement Account. These funds will be used to fund public access and environmental education improvements to the site.

O&M costs for treatment and distribution/outfall are estimated to be $625,000 per year. This does not include debt service or replacements of large equipment. O&M and monitoring of the wetlands is estimated to cost $10,000 per year.

Cost Recovery

Revenues to fund construction and operation of the treatment plant will be generated from sewer rates and connection and capacity fees. The city and county will each charge new sewer users a connection fee of several thousand dollars and a capacity charge to pay for the system. These charges and sewer rates and a sewer surcharge are expected to cover all costs of the system. The initial City of Carnation sewer rate is estimated at approximately $88 per month per customer.

Partnering with other agencies and a non-profit contributed to making this project a reality. Working with Ducks Unlimited as a non-profit partner has helped WTD to be more successful in obtaining grants. King County's Water and Land Resources Division is another partner that over the long-term will monitor and maintain the Chinook Bend wetland in accordance with the requirements set forth in an end-user agreement. The work includes periodic monitoring of plants and animals in and around the wetland and maintenance of native wetland and riparian plant species.

5.7.2 LOTT Wastewater Alliance, Thurston County, Washington

The LOTT Wastewater Alliance, composed of four members, Lacey, Olympia, Tumwater, and Thurston County, Washington, produces 3 mgd of Class A reclaimed water at two reclamation plants. Uses include irrigation, in-plant processes, equipment and boat washing, dust suppression, constructed wetlands discharge, and groundwater infiltration.

The program was developed as the core of LOTT's long-range wastewater plan, in response to total maximum daily load (TMDL) issues in Budd Inlet and public values articulated during the planning process.

Costs and Financing

The 1-mgd average daily flow Budd Inlet treatment plant was upgraded by adding sand filters at a capital cost of $2.8 million. The Hawks Prairie 2-mgd project cost $32.7 million: the treatment plant cost $21.1 million, the constructed wetland recharge ponds cost $7.2 million, and the reclaimed water pipeline cost $4.4 million.

Financing for the Budd Inlet upgrade was included in an approximately $15 million bond issuance that covered many different projects. The Hawks Prairie facilities were financed primarily through an SRF loan from Ecology, at 1.5 percent interest.

O&M costs were not obtained during the case study interviews; however, $127,000 for Budd Inlet was included in the Ecology reclaimed water case studies report (Cupps and Morris, 2005).

Cost Recovery

LOTT wastewater customers pay for the reclaimed water system through wastewater user rates, in recognition of the benefit of avoiding the costs of building an outfall. LOTT supplies reclaimed water to water purveyors (its members) at a cost of $1 per year. The purveyors will fund and build local distribution facilities and will market and deliver the water to end users.

5.7.3 City of Phoenix, Arizona

The City of Phoenix operates two older wastewater treatment plants and a water recycling facility, as shown in Table 5-8. Reclaimed water programs were set up to dispose of effluent from the regional 91st Avenue and 23rd Avenue Wastewater Treatment Plants. The Cave Creek Water Recycling Facility was developed as an alternative source of water to offset potable use for landscape irrigation and to reduce wastewater flows to the 91st Avenue and 23rd Avenue plants.

While not considered reclaimed water by the Arizona Department of Environmental Quality, all secondary effluent from the 91st Avenue Wastewater Treatment Plant is piped either to the Buckeye Irrigation District or, before disinfection, to a nuclear power plant for cooling water use. A three-way partnership allows the City of Phoenix to send tertiary effluent from the 23rd Avenue Wastewater Treatment Plant to the Roosevelt Irrigation District in exchange for either potable water from the Salt River Project or groundwater credits.

Table 5-8. City of Phoenix Wastewater and Reclamation Facilities

Description	Year Online	Design Capacity (mgd)	Average Daily Flow (mgd)	Uses
91st Avenue Wastewater Treatment Plant (secondary)	1959, 1960s	180	130–140	Nuclear power plant cooling water; Buckeye Irrigation District
23rd Avenue Wastewater Treatment Plant (tertiary)	1930	63	50	Exchange with Roosevelt Irrigation District for either potable water or groundwater credits
Cave Creek Water Recycling Facility (tertiary)	2001	8	3.3	Landscape irrigation; aquifer recharge

Sources: Paul Kinchella, personal communication, May 23, 2007; Andy Terrey, personal communication, May 24, 2007.

Costs and Financing

Costs were not obtained during the case study interviews for the 91st Avenue and 23rd Avenue facilities; only O&M costs were obtained for the Cave Creek facility. Annual 2005–2008 O&M cost for the Cave Creek facility are as follows:

- 2005–2006 actual – $3,124,726
- 2006–2007 actual – $3,035,613
- 2007–2008 budget – $3,330,031

The City of Phoenix usually finances projects through revenue bonds, paying 0.5 percent more than it would for general obligation bonds. Loans from the Water Infrastructure Finance Authority paid for 23rd Avenue upgrades in the 1990s.

The 91st Avenue plant is owned regionally. The city sells bonds to pay its share (50–70 percent of any project). The city then bills other cities monthly for funds to capitalize plant improvements. The billing amount is adjusted every six months.

Cost Recovery

Wastewater customers fund capital and O&M costs for the 91st Avenue and 23rd Avenue plants. Reclaimed water sales from these plants to the nuclear power plant and irrigation districts are governed by contracts that are over 25 years old, and revenues do not recover operating costs.

The Cave Creek facility is fully funded by potable water customers through the water enterprise fund, although there is a study under way to determine the percentage of costs that can be allocated to wastewater customers. New customers pay a buy-in fee (in lieu of the water development fee) for their percentage of use of the system capacity. The fees vary widely, depending on the distance from the Cave Creek facility. To simplify the system and accommodate customers that are farthest away, the city is considering changing to an approach whereby all customers in a particular pressure zone pay the same amount (similar to a local improvement district). The city does not expect to recover all capital costs through fees because there are too few customers. They believe a holistic approach is required that views reclaimed water as part of the regional wastewater and water resources plan, recognizes that the system will not pay for itself, and that costs should be shared by wastewater and water customers.

Water meter and hookup fees are waived for users of reclaimed water from the Cave Creek facility. Developers pay the cost of local distribution to their site. The city will pay for over-sizing and recover costs through the buy-in fees charged to new customers.

The reclaimed water rate is 80 percent of the potable water rate, which varies with season of the year. Reclaimed water revenues have recovered an average of 50 percent of O&M costs over the past three years. Annual Cave Creek revenues for 2005–2008 are as follows:

- 2005–2006 actual – $1,431,041 (46 percent)
- 2006–2007 actual (estimated) –- $1,622,996 (51 percent)
- 2007–2008 budget – $1,727,420 (52 percent)

The current business model goal is to provide reclaimed water from the Cave Creek facility to customers with turf area greater than 5 acres. This goal is supported by an ordinance that requires use of reclaimed water for turf areas 5 acres or larger in designated areas. Because this is a limited customer base that is geographically spread out, the city is investigating a transition to implement more groundwater recharge. It could treat the water to a higher level and send it directly to the water impoundment for a nearby water treatment plant, but this option currently is politically infeasible.

5.7.4 Monterey County Water Recycling Projects, California

Monterey County Water Recycling Projects was formed in 1992 through an inter-agency partnership between the Monterey Regional Water Pollution Control Agency and the Monterey County Water Resources Agency. The treatment facilities are owned by Monterey Regional Water Pollution Control Agency; the distribution system is owned by the Monterey County Water Resources Agency. The pollution control agency serves as a contractor to operate the tertiary treatment and distribution systems.

The driver for this system is to reduce agricultural groundwater pumping and resultant seawater intrusion. Reclaimed water meets about 67 percent of the agricultural customer demand; groundwater pumping meets the remaining demand. The goal is to reduce groundwater pumping to zero. To meet this goal, another project is being developed to build a dam and use river water instead of groundwater to meet agricultural demand.

The system currently delivers an average flow of 21–22 mgd, which is limited by supply. Demand is at least twice the supply during peak summer months and is supplemented by groundwater. The reclaimed water is used for agricultural irrigation of food crops, including lettuce, celery, broccoli, cauliflower, strawberries, artichokes, and spinach.

Monterey County Water Recycling Projects has been delivering reclaimed water to farmers that are growing edible food crops for almost 10 years without any public health incident. While there are no contracts or "hold harmless" agreements between the county and the growers, there are general guidelines for using reclaimed water and the county does hold a separate insurance policy covering its reclaimed water program.

Several additional reclaimed water projects are under way. A system to deliver reclaimed water for urban uses, including golf course and other landscape uses, including residential, has been designed. An indirect potable groundwater recharge project (winter only) is in the conceptual planning stage. And discussions are taking place regarding collecting agricultural drainage water and returning it to the treatment plant.

Costs and Financing

Capital cost of the system was $78 million. The capital cost was funded through USBR low-interest loans, State Revolving Fund loans, and local bonds.

Annual O&M costs for the tertiary treatment and distribution systems are a little over $5 million. Annual debt service payments to the USBR and the state are about $4–5 million. Included in the O&M costs is the liability insurance policy that the county purchased, which provides coverage beyond the regular countywide policy. The county is reimbursed for the policy by the pollution control agency. Current annual cost is about $230,000 for approximately $40 million coverage for pollution contamination and $33 million for excess general liability.

Cost Recovery

Rates are designed to recover all costs and are reviewed/adjusted annually to cover the operations (including debt service) budget. Annual revenue is $9–10 million.

Monterey uses a dual-revenue mechanism, whereby property taxes levied on all beneficiaries of the system cover most of the costs of the system, with water delivery charges contributing a small portion. About half the revenue comes from all property owners in the zone of benefit through a property tax assessment; the other half comes from growers through the property tax assessment and water delivery charges:

- The annual property tax assessment is designed to recover the annual debt service (capital costs) and O&M costs from beneficiaries of the project. Beneficiaries are those that live over the saltwater-intruded aquifers, especially growers who are receiving the water. A study was done to analyze the benefits to different classes of property owners. All entities in the zones of benefit pay the assessment whether or not they take reclaimed water. The growers pay Zone 2B, 2Y, and 2Z assessments. In 2006–2007, these assessments were $252.57 per acre. Non-growers pay the Zone 2Y and 2Z charges only; in 2006–2007, these assessments ranged from $1.18 for dry farmers to $98.07 for commercial and industrial accounts. Homeowners pay $11.25 per year.

- The water delivery charge is designed to recover a small amount of annual O&M costs. This charge is $17.63 per acre-foot.[16]

5.7.5 Santa Rosa Subregional Reclamation System, California

The Subregional Reclamation System, which treats an average flow of 16.5 mgd, is a regional system operated by the City of Santa Rosa, California. Reclaimed water usage constituted 88, 89, and 82 percent of the treated flows for 2004, 2005, and 2006, respectively. The lower percentage in 2006 was due to higher rainfall, not lower usage. The system delivers roughly 11 mgd (12,580 acre-feet) year-round to Calpine, a power company, to recharge its Geysers power generation steamfield. Irrigation usage is seasonal and accounts for roughly 7,980 acre-feet per year, with discharge between 3,070 and 4,605 acre-feet per year.

The system is made up of two subsystems: (1) the original agricultural irrigation system, consisting of a low-pressure backbone and 17 reservoirs, and a newer urban irrigation system, and (2) the Geysers steamfield recharge system, a high-pressure pipeline and related facilities.

The city began delivering reclaimed water to agricultural users in the 1960s and to urban irrigation users in the early 1990s. The conveyance system to the Geysers steamfield became operational in 2003. Currently, the city is conducting environmental impact review to expand the reclaimed water system to provide additional urban irrigation and storage and deliver additional reclaimed water to the Geysers steamfield.

The reclaimed water program was originally established to meet more stringent effluent disposal requirements. Water supply shortage issues are driving the planned expansion of urban reuse.

Costs and Financing

Annual O&M costs (excluding debt service) for the system is about $25 million. Calpine provides 80 percent of the power required to pump reclaimed water to its steamfield. Capital costs and sources to fund these costs are shown in Table 5-9.

[16] Reclaimed and potable water are often sold in acre-feet. One acre-foot is equal to 325,850 gallons.

Table 5-9. Santa Rosa Subregional Reclamation System Capital Costs and Financing Sources

Description	Year	Capital Cost (millions)	Source of Funds
Agricultural and Urban Irrigation System			
Agricultural system backbone and storage (secondary)	1975–1985	$30	Clean Water Act grants
Upgrade treatment to Title 22 tertiary	1989	No data	No data
Add first urban irrigation customer (golf course on backbone)	1990	$2	City of Santa Rosa
Rohnert Park urban irrigation system	1994–1995	$6	Revenue bonds
Gallo Wineries storage, conveyance and pumping system	1997	$3	50-50 split between City of Santa Rosa and Gallo Wineries
Steamfield Recharge System			
High-pressure pipeline, pump stations, steamfield piping, and injection wells	2000–2004	$275	Calpine (customer) paid $75 million; 5% in small grants; State Revolving Fund loans

Source: D. Carlson, personal communication, May 8, 2007.

Cost Recovery

Agricultural and Urban Irrigation System

From inception of the reclaimed water system, the city has paid agricultural customers to use reclaimed water (capital costs were funded through grants). Agricultural users irrigating more than 100 acres receive payment to use reclaimed water, while those irrigating less than 100 acres receive reclaimed water for free.

The city is recovering some of the cost for the newer urban distribution system (funded through revenue bonds) through reclaimed water rates set at 75 percent of the user's equivalent potable water cost (groundwater pumping or water rates). One year of free water was given to encourage users to sign up. Cost bases are evaluated every three years. To date, costs not recovered through reclaimed water revenues have been recovered through wastewater rates.

When the current pricing structures were established, the primary driver for the reclaimed water system was effluent disposal. Although effluent disposal is still a strong driver, potable water offset is now a driver as well. The system is constrained in its bargaining power with agricultural users, which are large (and, therefore, desirable) customers. Urban irrigation users pay more for the reclaimed water, but they are generally more expensive to service.

Because water supply limitations are driving the planned expansion of the urban reuse system, capital and O&M costs for the expansion are proposed to be funded 40 percent by water and 60 percent by wastewater customers. This will be the first time that potable water users will help fund the Subregional Reclamation System.

Steamfield Recharge System

Calpine funded $75 million of the $275 million in capital costs to build a high-pressure reclaimed water pipeline to the steamfield; it also pays 80 percent of the pumping costs. The remaining capital costs were funded through grants and State Revolving Fund loans.

5.7.6 South Bay Water Recycling, California

South Bay Water Recycling delivered 10,000 acre-feet of reclaimed water in fiscal year 2006–2007. Two cities, San Jose and Santa Clara, own a wastewater treatment plant that sells wastewater treatment capacity to nine agencies. San Jose is the administrator for the treatment plant and South Bay Water Recycling under a joint powers agreement. South Bay distributes manufactured water from the treatment plant. Total plant design capacity is 167 mgd, with an average flow of 110 mgd. Reclaimed water design capacity is 50 mgd, with an average flow of 10 mgd.

The largest use is landscape irrigation, but the system also serves power plants, commercial and industrial cooling towers, manufacturing, and several dual-plumbed buildings. When the power plants came online in 2001–2005, South Bay transitioned from a summer-only to a year-round operation.

The reclaimed water program was established in 1989 to meet more stringent effluent disposal requirements. South Bay is currently reviewing how recycled water can help meet future water supply needs.

Costs and Financing

Capital cost for the tertiary treatment plant was approximately $250 million. In addition, a 108-inch-diameter pipe from the filter building to the transmission pump station, the transmission pump station, 60 miles of distribution pipe, and a 4-MG reservoir cost $140 million. A recent 7-mile extension of distribution pipeline to a power plant cost $22 million.

Of the $140 million for conveyance and storage, $35 million was funded through U.S. Bureau of Reclamation Title XVI. Only $28 million has been received to date. Congress approved the project under Title XVI without providing additional budget. USBR has to fund out of the ongoing annual budget and has been reimbursing South Bay for over 10 years for work that has long since been completed. The remainder of the cost was funded through state funding and wastewater service and use charges.

Developers pay for distribution system extensions. They have funded 108 miles of pipe to extend the system to new development. Capital costs for the 7-mile pipe extension to the power plant were shared between San Jose, the Santa Clara Valley Water District, and Calpine (customer).

The power plant is charged the industrial rate for 1–2 mgd with a maximum capacity of 5 mgd. South Bay provided a low cost loan to Calpine to extend a pipeline to one of its facilities.

The 2005–2006 O&M cost was $5.3 million. South Bay has O&M agreements with partner cities to maintain pipe installed in their service areas. The cities submit bills for pipe replacement, and are reimbursed from the South Bay Joint Powers Fund.

Cost Recovery

The goal is to fund 100 percent of the reclaimed water costs through reclaimed water revenues. Currently, South Bay relies on reimbursement from Santa Clara for a payment of $115 per acre-foot of reclaimed water sold every year. This reimbursement begins when Santa Clara cannot meet their customers' potable water demand through local sources (groundwater) and has to import a stated minimum amount from the Hetch Hetchy Reservoir. Fiscal year 2005–2006 reclaimed water revenues were $2.5 million, including a $986,000 reimbursement ($115 times 8,600 acre-feet) from Santa Clara, resulting in a revenue shortfall of just under $1 million.

The current wholesale reclaimed water rate of $475 per acre-foot is the price of untreated water from Santa Clara. Discounts given to irrigation, industrial, and agricultural customers are reflected in the rates. The irrigation rate is $310 per acre-foot ($165 per acre-foot discount). The industrial and agriculture rate is $110 per acre-foot ($365 per acre-foot discount).

The rate structure was designed to include appropriate changes in rates without requiring additional council action. The reclaimed water wholesale rate is indexed to the Santa Clara groundwater pumping charge. Increases in the Santa Clara groundwater pumping charge automatically increase wholesale rates. Adjusting the discount on potable rates appropriately sets the price of reclaimed water. Per-usage retail rates vary by water purveyor; they range from 20 to 92 percent below potable water rates.

To get the program started in 1987, construction cost retrofit incentives were offered to achieve a desired delivery volume. There is no longer a need for incentives. South Bay is involved with the Bay Area Section of the WateReuse Foundation, which recently sponsored a workshop for Bay Area industries to inform them about reclaimed water use, with a goal to develop new markets for reclaimed water.

5.7.7 West Basin Municipal Water District, California

West Basin Municipal Water District, a public agency water wholesaler in California, started delivering reclaimed water in 1995. The water reclamation program was developed to meet the following goals: (1) reduce dependence on imported water by 50 percent; (2) improve water supply reliability by providing a local water source; (3) reduce wastewater effluent discharge to Santa Monica Bay by 25 percent; and (4) prevent continued saltwater intrusion of the groundwater basin.

West Basin treatment facilities include West Basin Water Recycling Plant and a satellite micro-filtration/reverse osmosis plant that provide tertiary treatment of secondary effluent purchased from the City of Los Angeles Hyperion Wastewater Treatment Plant. These facilities have a combined capacity of 52 mgd. In 2006, 23,653 acre-feet (7.7 billion gallons) were delivered. Five different qualities of reclaimed water, or "designer waters," are produced to meet specific user needs. Reverse osmosis reject water is discharged into the Los Angeles wastewater treatment plant outfall.

Uses include landscape irrigation; industrial cooling and boiler feed water (customers include two oil refineries); commercial applications; and groundwater recharge.

Costs and Financing

Total capital costs, including land, through 2003 were $365 million. West Basin revenue bonds, USBR grants, and low-interest state loans funded $200 million. USBR built 25 percent of the pipelines in the early phases. The U.S. Army Corps of Engineers has been building the pipeline lateral projects over the past 3–4 years; West Basin pays back 25 percent of the cost.

Reclaimed water O&M costs in 2006 were $14.9 million.

Cost Recovery

In 2006, reclaimed water revenues were $15.68 million, including $5.9 million (about 38 percent) of Metropolitan Water District Local Resource Program payments. West Basin signed an agreement with the district to secure local project rebates of up to $250 per acre-foot for 25 years. The district determined that it would be cost-effective for member agencies to produce water on a local basis, so it invests in developing local water supplies and pays $250 per acre-foot for reclaimed water produced.

West Basin sells imported water for $510 per acre-foot. The 2002 reclaimed water rates varied depending on level of treatment. The 2002 prices relative to the price of imported water are shown in Table 5-10.

Table 5-10. West Basin Recycled Water Production and Prices Relative to Potable Water Prices (2002)

Use	Type of Treatment	Quantity (mgd)	Percentage of Total	Price (compared to imported water)
Irrigation	Disinfected tertiary	2.5	10%	25–40 percent less
Industrial cooling makeup water	Nitrified and disinfected tertiary	7.4	30%	20 percent less
Groundwater recharge	Lime treatment, RO, disinfected tertiary	6.5	26%	10 percent less
Low pressure boiler feed water	Microfiltration, RO, disinfection	5.8	24%	Equal or slightly higher
High pressure boiler feed water	Microfiltration, RO, disinfection, second pass RO	2.4	10%	Equal or slightly higher

Source: (Crook, 2004).
RO = reverse osmosis.

A recently recognized additional benefit of the reclaimed water program is the lower carbon footprint. Recycled water use in this situation uses significantly less energy per acre-foot to produce than does delivery from either Northern California or the Colorado River (J. Walters, personal communication, May 10, 2007).

5.7.8 St. Petersburg, Florida

St. Petersburg, Florida operates one of the oldest dual-distribution systems for reclaimed water in the United States. The system serves more than 10,500 customers, including 10,000 residential accounts for landscape irrigation and several public and commercial irrigation accounts. Reclaimed water is also used for backup fire protection and cooling water. In 2006, the total average flow from St. Petersburg's water reclamation facilities was 34 mgd, of which 20 mgd was reclaimed for beneficial reuse.

St. Petersburg operates four reclamation plants. The transmission mains from all four plants are interconnected to maintain pressure in the system when a plant is taken offline. Reclaimed water not sold is injected into deep wells.

The initial driver for building the water reclamation system was to avoid the cost of upgrading treatment to reduce nutrient levels in effluent discharged to receiving waters. Currently, reclaimed water is an important component in meeting water supply needs as well.

Costs and Financing

The following cost, financing, and cost recovery information is from *Innovative Application in Water Reuse: Ten Case Studies* (Crook, 2004). Even though the information is a few years old, it is reported as "current" for ease of reading.

Capital cost to date is $135 million to upgrade treatment plants and build the distribution system. Annual operating cost is $5.2 million. EPA provided $100 million in grants; the city contributed $20 million; and $15 million is recoverable through the Voluntary Assessment Program through which $11 million has been recovered to date. The Voluntary Assessment Program is a charge that residents pay to extend the distribution system to serve them. The charge is typically between $500 and $1,200 per customer, depending on costs of construction.

Cost Recovery

Revenues were $1.6 million, compared with the $5.2 million O&M cost. The city's water and wastewater customers pay for the $3.6 million of unrecovered cost, each paying half. Initially, the split was more heavily weighted to wastewater customers; however, the benefit to water users of potable water offsets is now recognized and reflected in the 50–50 split. The city has been able to postpone a water treatment plant expansion because of the significant role reclaimed water has played in reducing potable water demand.

St. Petersburg initially implemented a flat user rate for reclaimed water based on a market comparison to what other utilities in the area charged for reclaimed water. Rate increases have been implemented in recent years, but reclaimed water revenues still do not recover the full cost of the program.

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Chapter 6

Review of Environmental and Regional Benefits of Reclaimed Water

This chapter addresses Provisions 4 and 5 of Water Reuse Policy-2 (WRP-2): review of possible environmental benefits of reused water and review of regional benefits of reused water. It explores the potential benefits that may accrue to the King County regional wastewater service area from the use of reclaimed water for wastewater and other water resource management applications.

The content in this chapter was developed by following the guidelines in the economic framework for evaluating reclaimed water programs created by the WateReuse Foundation (Raucher et al., 2006) and described in Chapter 4. Specifically, the chapter provides the following:

- A brief overview of the types of environmental, social, financial, and other benefits that could arise from adding more reclaimed water as a part of the region's water resource management portfolio.
- The context for considering the benefits of King County's reclaimed water program by defining the baseline and motivation for the program and then looking ahead to plausible future issues that could affect the baseline.
- A discussion of specific types of benefits that could arise from a reclaimed water program, given the broadly defined water resource challenges faced by the region under alternative futures.

This general discussion of benefits establishes principles that could be used to guide the development of a reclaimed water comprehensive plan and establishes a foundation on which future program development can be guided toward projects that are most likely to provide the greatest benefits to the region. As King County's reclaimed water program evolves and has specific projects under consideration, such projects can be reviewed in a benefit-cost context such as the WateReuse Foundation's economic framework (Raucher et al., 2006). As much as possible, the environmental and social benefits should be quantified as part of the analysis.

6.1 Overview of the Types of Benefits from Using Reclaimed Water

Reclaimed water has the potential to generate a range of benefits to the region. Ultimately, the specific types of benefits and the magnitude and distribution of those benefits will depend on specific projects under consideration. This section is organized to facilitate a benefit-cost approach to analyzing reclaimed water projects. It presents potential benefits in three categories: environmental, social, and financial.[1]

6.1.1 Environmental Benefits

Reclaimed water can generate environmental benefits in several ways. Use of reclaimed water can reduce the volume of wastewater discharged to surface waters, including Puget Sound. It can enable enhanced streamflows when reclaimed water use offsets demands on potable supplies that directly or indirectly draw down flows of inland rivers and streams. Reclaimed water can likewise be used to recharge aquifers or develop or enhance wetlands that are hydrologically connected to flow-sensitive surface waters. Environmental benefits can also arise by postponing the need to build or expand water supply reservoirs, other potable water storage facilities, and possibly large conveyance pipelines.

Environmental benefits can include many of the ecological services and values, such as improved fisheries and riparian ecosystems, associated with enhanced streamflows, improved instream water quality, and lower summertime water temperatures. Where the impacted watersheds provide critical habitat to threatened and endangered (T/E) or other special status species, the benefits are especially likely to be significant. In the Pacific Northwest, the potential benefits associated with maintaining or enhancing wetlands and salmon-bearing rivers and streams may be of particular importance.

Achieving a net environmental benefit is case specific and depends on whether any other alternatives are readily available.

6.1.2 Social and Reliability Benefits

Reclaimed water can provide a range of social and related reliability benefits for a region. Social benefits may take numerous forms, including adherence to (and reflecting) a widely shared environmental ethic for recycling and the use of green approaches to local resource management challenges. The social values may also embody a desire in the region to adhere to regional and state policies, such as the expectations of the Washington State Departments of Ecology, Health, and Natural Resources that King County expand its reclaimed water program. Also, the Legislature's recent additions to the Washington State Reclaimed Water Use Act (Chapter 90.46 RCW) recognize reclaimed water as a resource that can help address issues related to climate change, Puget Sound restoration, salmon recovery, water quality, and watershed plans.

Because it is a climate-independent water resource, reclaimed water offers some added economic reliability values to the region compared to sources that depend on snow pack, precipitation, and storage. Empirical investigations, while limited to date, indicate that there can be considerable economic value to a region from having a more reliable, climate-independent water resource option in its portfolio.[2] These reliability values accrue to households; commercial, industrial, and institutional organizations; and the regional economy as a whole. Reliability values pertain to reclaimed water's ability to help avoid the potential of water shortages and water use restrictions

[1] These categories—environmental, social, and financial—are used in Triple Bottom Line (TBL) analyses.
[2] For a recent review of the literature on the value of reliability, see Raucher et al., 2005, pp. 68–79.

that would otherwise have adverse impacts on residents and businesses (existing and potential new enterprises) in the region. For example, periodic water shortages can have a negative impact on landscape businesses and nurseries.

Related to the reliability concept is the longer-term insurance value that reclaimed water provides as a hedge against the potential future adverse impacts of climate change, regulatory changes, or natural disasters, such as long-term droughts or seismic events, on the region's current set of water resource options. Climate and/or other changes may impact the region in ways or at levels not currently anticipated.

For example, the need to capture larger volumes of earlier snowmelt and other runoff in existing reservoirs may elevate flood risks and necessitate more reservoir releases earlier in the season than now anticipated. Or potentially hotter and drier summers may require more late summer and fall reservoir releases to maintain instream flows and stream temperatures below dams. Moreover, more severe climate change impacts in other areas of the state or nation may lead to higher-than-predicted population influx and growth in the region, leading to higher-than-anticipated increases in water use demands. Having reclaimed water as part of the region's future portfolio provides an additional hedge against these possible scenarios and offers the region a greater suite of options in the event that these or other potential future impacts arise.

Finally, there can be benefits and costs associated with developing reclaimed water in the nearer term. In general, cost savings can accrue from postponing large-scale capital investments, such as those associated with reclaimed water, until the need is more immediate. On the other hand, investing earlier—to coordinate pipeline construction projects and minimize associated public nuisance and traffic disruptions—can provide considerable benefits. The timing of some reclaimed water investments, therefore, needs to account for the tradeoffs between more cost-effective and coordinated project development, as compared to later higher costs when more access and right-of-way issues are likely to be confronted.

6.1.3 Financial Benefits

Reclaimed water can provide some financial benefits in terms of avoided costs and cost offsets to other wastewater management and water resource management options. For example, in many parts of the country, increasingly stringent National Pollutant Discharge Elimination System (NPDES) permits and other factors (for example, costs for land, chemicals, and monitoring) are driving up the compliance costs of municipal wastewater treatment and discharge. By converting some of the effluent stream into reclaimed water, many agencies (and their customers) are able to avoid or postpone additional investments in wastewater treatment and discharge expenses while, at the same time, creating more value by developing a new water resource for their region. Costs for producing reclaimed water may be offset, at least in part, by the avoided costs for wastewater treatment and discharge.

Avoided costs can also arise where reclaimed water offsets demands for potable waters that are limited in supply and/or expensive to produce and deliver. In many parts of the country, potable supplies are stretched thin (especially in periods of peak demand, such as summers, or during droughts). Adding new potable supplies can be expensive because of the need to transport water a long distance and/or treat low quality source waters to potable standards. By avoiding or postponing the need to expand potable supplies, the use of reclaimed water can offer some communities considerable cost savings.

In addition, in some states including Washington, reclaimed water can be produced without a water right (RCW 90.46.120). The generator has an exclusive right to use the water. Value from reclaimed water can arise from a potable supply offset, a groundwater recharge program, or other reclaimed water applications that offset an existing extraction and/or supplement the potential yield of a source water. There may be opportunities in the King County wastewater service area to use reclaimed water to generate water rights of considerable value (for example, for rapidly growing communities in the southern part of the county where expanded use of local groundwater supplies may be limited by the state without some form of water exchange or offset).

Reclaimed water can also offer financial returns in the form of revenues from sales. The value of revenues depends on the rate structure used. Who receives the revenues depends on the wholesale-retail relationship established among the relevant parties. Nonetheless, if revenues are generated from reclaimed water sales, then what had been a waste (discharged effluent) becomes instead a resource that generates some revenue to one or more entities in the region.

6.2 The Baseline: The Context for Considering Reclaimed Water Benefits

The template for the WRF economic framework calls for placing the reclaimed water program within the context of the region's broader suite of water resource management challenges before identifying and assessing the types of benefits that may arise from the program. This context helps define the baseline (status quo) against which the program can be considered. The baseline needs to not just account for current conditions but also reflect changes that are likely to occur over the relevant useful lifetime of the investment (which may be 20 to 30 years, or longer). This section looks at the current suite of regional water resource management challenges and then looks forward to how these challenges may change over time.

6.2.1 Defining the Baseline: Articulating the Region's Current Water Resource Challenges

While the greater Seattle/King County region receives considerable amounts of annual precipitation and is home to beautiful water bodies, it also faces several water resource management challenges. This suite of water resource management challenges provides the baseline for a programmatic assessment of reclaimed water benefits and costs, because these challenges reflect the problems that reclaimed water may help address in the region.[3]

3. For a specific reclaimed water *project* (or other water supply or wastewater management project), a narrowly defined baseline may be suitably defined. However, for a programmatic assessment, a more general baseline is appropriate, because different elements of the program (for example, different projects within the program) may address different specific challenges or offer different specific opportunities.

Some of the significant water resource management challenges in the region include present and future concerns in the following areas:

- **Protecting and enhancing surface water quality through improved wastewater management**, including concerns over preserving and restoring the overall quality of Puget Sound. This challenge is evident in several ways, including the Governor's Puget Sound Initiative, described later in this chapter. Among other things, this initiative points to a need to reconsider the quality and amount of wastewater effluent discharged to Puget Sound. Increased production of reclaimed water provides one avenue through which these concerns and challenges may be addressed through measures such as reducing the volume and/or improving the quality of wastewaters reaching the Sound.
- **Protecting and enhancing threatened and endangered (T/E) species and the integrity of the region's aquatic and riparian ecosystems**, especially with respect to critical habitat for salmon and other special status species listed under the Endangered Species Act (ESA). This issue reflects a need to consider not only the water quality in the region's lakes, rivers, and streams but also the level of instream flows and water temperatures. Additional discussion of this issue is provided later in this chapter. Reclaimed water can play a role in addressing this challenge by increasing flows in targeted streams through offsetting potable supply extractions from surface water or groundwater resources that are hydraulically connected to an ecosystem of concern.
- **Ensuring the adequacy and reliability of the region's water resources**, given the anticipated growth in region-wide population and economic activity and the impacts of climate change. There are concerns about periodic shortages in some parts of the region during droughts or other possible supply-disrupting events, especially if more stringent instream flow and temperature requirements are imposed (for example, for salmon or other T/E species protection). Reclaimed water could assist in meeting these potential challenges.

Thus, when evaluating the role that reclaimed water may play in the region, the program needs to be evaluated within the broad context of the water resource challenges facing the region. This requires an integrated perspective across the challenges faced in the areas of managing wastewater, protecting T/E species, and ensuring the adequacy and reliability of water resources. A reclaimed water program offers the region a resource and an opportunity to address some of these challenges now and into the future.

6.2.2 How the Baseline May be Influenced by Alternative Futures

One of the keys to defining the baseline against which benefits can be assessed is that one needs to look forward many years and try to account for changes that are reasonably likely to occur to resources, supplies, and demands. Looking into the future is an uncertain enterprise. Evaluating a potential future program based on past and current conditions may not be relevant or accurate. While it is necessary to be forward-looking in defining the baseline, it is important to recognize the inherent limits of our predictive abilities.

This section presents a suite of reasonably plausible alternatives for the future as a means of conceiving of sensitivity analyses for this study and for future analyses of reclaimed water in the region. The plausible futures pertaining to the water resource challenges described above are summarized in Table 6-1. The table shows four alternative baselines for characterizing the region's future:

- **Status Quo**, in which the future of the region looks essentially much like today, apart from basic socio-demographic trends such as anticipated population growth.
- **Climate Change**, in which the plausible anticipated impacts of global warming and associated precipitation pattern changes are factored into water resource challenges, in addition to the status quo issues (for example, impacts on the quality and/or quantity of potable supplies from potential changes in the level of water demands, available supplies and storage, saltwater intrusion, elevated wildfire or other watershed risks, seasonal flooding, combined sewer or sanitary sewer overflow impacts).
- **Ecological Stresses** on ecosystems, in which there are elevated stresses on salmon and other species of concern and their associated critical habitats from a variety of possible causes (for example, pollution, conversion and loss of habitat to development, climate change impacts, flow-impacting water extractions or impoundments).
- **Puget Sound and other water quality/wastewater management initiatives** that would impact the regulatory regime governing allowable concentrations or masses of pollutants in effluent to Puget Sound or other regional surface waters.

Naturally, several of these future scenarios may overlap and compound one another. Climate change, for example, will add to the other stresses placed on salmon and other species and on habitats of concern (for example, by increasing stream temperatures, reducing summer and autumn instream flows, elevating salinity levels in transition waters, reducing prey and other food sources, heightening vulnerability to disease, and scouring eggs during sudden storm events). This would make it more difficult to maintain current species levels, much less to enhance and restore habitat and species numbers to more desirable levels.

To complicate the picture, events from outside the area might impact the region. For example, climate change impacts in areas well beyond King County could lead to severe water shortages or other critical challenges in other parts of the Western United States. These distant impacts, in turn, could put added pressure on King County resources. For example, unanticipated levels of in-migration from other areas may lead to population growth and elevated water demands at levels greater than currently considered. In addition, climate change and/or other threats to salmon that originate in other Pacific Northwest watersheds could lead to the perception that it is all the more important to protect these and other T/E species in the greater King County area, where their best opportunities for continued survival may reside.

Clearly, the types and levels of benefits that will arise from a reclaimed water program will depend on how the future unfolds and on how those changes impact the baseline against which reclaimed water options are evaluated. The discussion provided in Table 6-1 provides a general indication of how these plausible alternative futures for the region may affect the benefits and costs of reclaimed water projects.

Likewise, the information in Table 6-1 touches on how the distribution of who pays and who benefits—referred to as the "equity"—depends on the future.[4] For example, if the future includes higher costs for wastewater treatment because of actions such as the Puget Sound Initiative, then the cost of producing reclaimed water will likely be offset to some degree by accounting for the fact that some reclaimed water costs would otherwise have been incurred for upgrading treatment facilities for wastewater (instead of paying to further treat wastewater that would have been discharged to regional surface waters, one pays instead for converting that effluent to reclaimed water). This means that some of the benefits of reclaimed water in this context would be realized by the entities paying for wastewater management.[5]

The following sections provide additional information related to how the baseline may be affected by alternative futures related to climate change, salmon issues, and wastewater management, respectively.

[4] See Chapter 4 for a discussion of equity in relation to reclaimed water costs and cost allocation.
[5.] The development of satellite plants to produce reclaimed water may help the region avoid or postpone costly upgrades and expansions of its wastewater treatment facilities.

Table 6-1. How the Baseline for Reclaimed Water May Be Influenced by Alternative Futures

	Alternative Futures for Baseline			
	Status Quo	**Climate Change**[a]	**ESA/Ecosystem (Salmon) Stress**	**Puget Sound/ Wastewater Management**
Description	The future looks much like today (but with population growth, etc.).	Climate change alters seasonal balance in regional water demand and supply.	Heightened stress on salmon and other critical species requires more instream interventions.	Regulatory initiatives to protect and enhance Puget Sound; more stringent NPDES permits.
Plausible characterization	Current conditions serve as basis for assessing regional water resource management challenges and options.	Changes in seasonal precipitation patterns (e.g., longer, drier summers) lead to elevated irrigation demands.[b]	Continued decline in critical species leads to more water allocated to enhance instream flows and regulate water temperatures.	Ecology creates more stringent NPDES requirements (to help protect and restore water quality in Puget Sound).[c] WDNR continues to require reduced reliance on outfalls as a condition of easements.
Reclaimed water (RW) benefits implications	Location- and case-specific. For some RW projects, the benefits may be large and diverse.	RW provides increased reliability of regional water supply in summers (or in extended drought periods); avoids water use restrictions and/or other impacts from demands exceeding potable supply.[d]	Where RW enables less use of potable supplies, and where those potable offsets enable higher instream flows (via less groundwater extraction or more surface water reservoir releases), better conditions aid T/E species survival rate.	Benefits may include improved WQ in Puget Sound.[e] Potentially large benefits in terms of offsetting RW costs with the incremental cost of WWTP upgrades to meet more stringent NPDES permits.
RW cost implications	RW as relatively expensive. Possible stranded assets for potable water suppliers (PWS).	RW still costly, but more benefits likely to be realized that balance out costs. Stranded assets no longer likely issue for PWS.	Some possible added costs to extend RW to locations and uses that are targeted because they provide the most potential for ESA/instream flow benefits.	None anticipated beyond status quo baseline. Biggest impact is the possible offset in costs (the benefit) of developing RW rather than paying for WWTP upgrades.

	Alternative Futures for Baseline			
	Status Quo	Climate Change[a]	ESA/Ecosystem (Salmon) Stress	Puget Sound/ Wastewater Management
Equity (Who bears what costs vs. who benefits?)	Wastewater agencies and PWS (and hence their ratepayers) bear variety of costs (including stranded assets), but benefits are much more dispersed and less apparent.	Benefits to broader community (households, businesses, regional economy) from having a more reliable summer (or drought period) supply and avoided shortfalls (or avoided cost of new potable supplies or storage). PWS could be beneficiaries.	Beneficiaries are all other persons who value enhanced survival potential for salmon and other T/E species. "Can we make the fish pay?" type equity questions arise.	Wastewater agencies and ratepayers are both the cost-bearers and also the beneficiaries, given the cost offset at WWTPs. Beneficiaries include individuals who value improved Puget Sound; benefits spread over many households could lead to big total social benefit value (but little revenue-recovery potential).
Other issues and comments	Useful to examine alternative cost-allocation and revenue sharing approaches to relieve some of the equity issues.	Climate change issues depend on many factors, such as changes to summer rainfall levels and patterns. Climate impacts also important for instream flow and related ESA issues.	Difficult to predict changes in instream flows, temperatures, and other factors. Even tougher to translate this into potential enhancement of salmon habitat/fishery. Valuation is also a challenge.	Issue of predicting what Ecology is really likely to do (and when) regarding NPDES limits for WWTP discharges to Puget Sound. Reliance of continued outfall discharge uncertain with WDNR.

Ecology = Washington State Department of Ecology; ESA = Endangered Species Act; NPDES = National Pollutant Discharge Elimination System; PWS = potable water suppliers; RW = reclaimed water; T/E = threatened/endangered; WDNR = Washington State Department of Natural Resources; WQ = water quality.

[a] Climate change could also be related to the other alternative future impacts on the baseline, such as by heightening stresses on salmon or by adversely impacting water quality and salt balance in Puget Sound.
[b] Could also lead to increased demand for ecologic uses of water to enhance summertime instream flows (to counter ecological impacts of elevated water temperatures and lower instream flows in summer).
[c] Could conceivably include bans on some discharges, or appreciably more stringent permit requirements.
[d] Benefits could include avoided cost of obtaining additional potable supplies or added storage.
[e] May be more relevant for South and West Point plant discharges than for Brightwater MBR-treated discharge. These benefits may also apply generally to other future alternatives where reclaimed water reduces discharges to Puget Sound.

6.3 Climate Change and its Implications for Regional Water Resources Management

The Pacific Northwest, like most regions of the world, is projected to experience changes in temperature, precipitation, and snowpack as a result of climate change. While some changes have already been observed and documented, still others are projected to occur during the course of the twenty-first century. Changes in climate have, and are expected to continue to have, an increasing impact on water resources. As the seasonal patterns in surface water flow regimes change, affecting water supplies and ecosystems, water resource managers in the region may need to re-evaluate historical water use, supply management, flood control, instream flow regimes, and general development in the region.

6.3.1 Observed Changes in Regional Climate

Changes in the current climate of the Pacific Northwest are relatively well understood in the region's academic and local government circles. The University of Washington's Climate Impacts Group (CIG), for example, supports research, publishes articles, and provides newsletters, workshops, and seminars aimed to help regional planners, decision-makers, and natural resource managers understand the ways in which regional resources are vulnerable to changes in climate. Furthermore, Washington State's Reclaimed Water Use Act (Chapter 90.46 RCW) explicitly lists observed consequences of global warming and articulates how climate change may impact water resources in the region. Regional public sector entities have also developed a consensus statement of 13 building blocks related to climate change and its importance to the region, outlined in Table 6-2 (Palmer et al., 2006).

The Pacific Northwest experienced an increase in average temperatures in the twentieth century; this warming increased at a faster rate than the global average (Mote, 2003b; Palmer et al., 2006). As a result of this warming, there has been a loss of snowpack and glaciers in the region (Mote, 2003a; Hamlet et al., 2005). The volume of glaciers in the North Cascade Mountains has dropped during the past few decades by between 18 and 32 percent from 1983 levels (Chapter 90.46 RCW). Peak streamflows have shifted to earlier in the year and mountain snowpack has declined throughout the Pacific Northwest since 1948, leading to an 18 percent decrease in streamflow during summer months as of 2003 (Chapter 90.46 RCW).

Figures 6-1 through 6-3 reveal some of the observed and projected changes in the region's climate. Figure 6-1 indicates the relatively high percentage decline in April 1 snow water equivalent since 1950, which is an important indicator for forecasting summer water supplies. Figure 6-2 shows increases in water temperatures in Lakes Washington, Sammamish, and Union, over past decades. Figure 6-3 provides projections for 2020 and 2040 of changes in monthly temperature and precipitation, including anticipated reductions in precipitation during the summer months.

Table 6-2. Climate Change Building Blocks

Dr. Richard Palmer, a team of colleagues from the department of Civil and Environmental Engineering at the University of Washington, and members of the multi-stakeholder Climate Change Technical Committee[1] prepared a document entitled "Climate Change Building Blocks" that presents 13 key issues related to climate change and its impact on the region. These building blocks come from peer-reviewed literature and address the impacts of climate change on temperature, precipitation, snowpack and glaciers, streamflows, and sea level rise, as well as the impacts on salmonid habitats and populations.

(1) The global average temperature has increased during the 20th century, and is forecasted to increase in the 21st century.

(2) Warming in the Puget Sound Region has increased at a faster rate during the 20th century than the global average, and increases in temperature are forecasted to continue.

(3) Increased surface temperatures in the Pacific Northwest will increase the rates of evaporation and transpiration (evapotranspiration).

(4) Global precipitation is projected to increase in the future, although there is less certainty in predicting changes in precipitation than in temperature.

(5) The occurrence of heavy precipitation events has increased over the U.S. during the 20th century. This trend is projected to continue during the 21st century.

(6) The loss of snowpack and glaciers in the Pacific Northwest mountains has been due to increased temperatures in the 20th century.

(7) Forecasted increases in temperatures associated with climate change will further reduce snowpack and glaciers in the Pacific Northwest mountains.

(8) Climate change is projected to increase winter flows and decrease summer flows in snowmelt influenced river systems of the Pacific Northwest, particularly transient watersheds.

(9) Climate change is projected to increase the frequency of flood events in most western Washington river basins.

(10) Climate change is projected to increase the frequency of drought events in the Pacific Northwest.

(11) Climate change is forecasted to raise global mean sea level in the 21st century.

(12) Climate change is forecasted to increase temperatures of rivers, streams, lakes, and river mouth estuaries in the Puget Sound region.

(13) Climate change, as described in Building Blocks 1-12, is forecasted to contribute toward streamflow and temperature conditions that have been shown to negatively impact freshwater and estuarine habitat of most species of salmonids in the Puget Sound watersheds.

[1] Members of the committee include individuals from the following organizations and municipalities: City of Auburn, City of Everett, City of Kent, City of Kirkland, Woodinville Water District, U.S. Army Corps of Engineers, Muckleshoot Indian Tribe, City of Seattle, Seattle Public Utilities, Washington Environmental Council, University of Washington, Washington State Department of Ecology, Steward and Associates, National Oceanic and Atmospheric Administration, and King County Department of Natural Resources and Parks. The committee was formed as a part of the regional water supply planning process.

Source: Climate Change Building Blocks (Palmer et al., 2006).

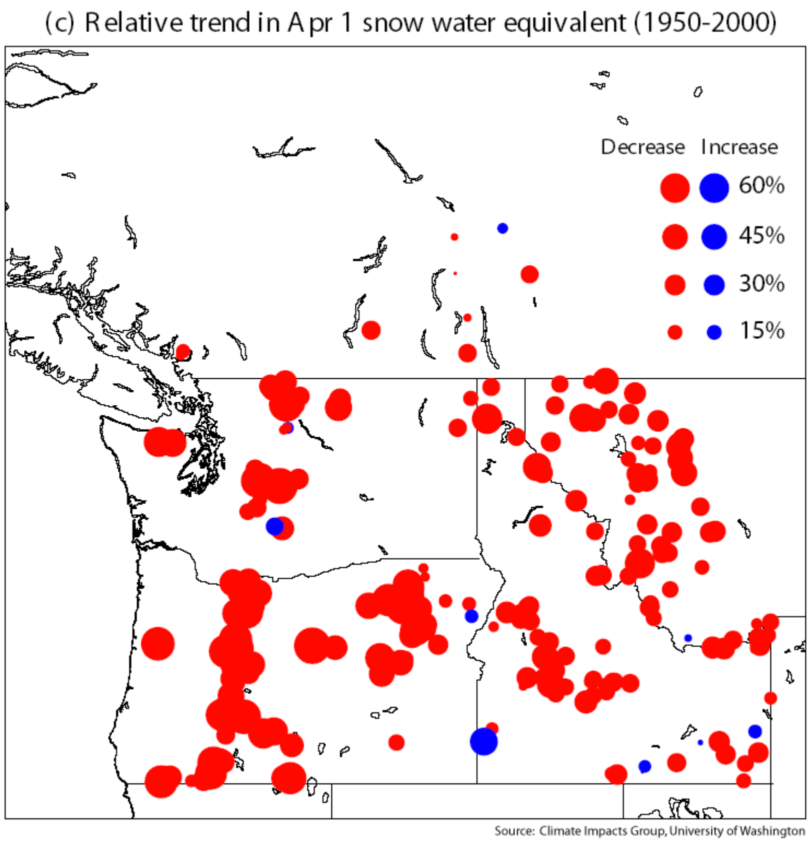

Figure 6-1. April 1 Snow Water Equivalent (1950–2000)
Source: Mote, 2003a.

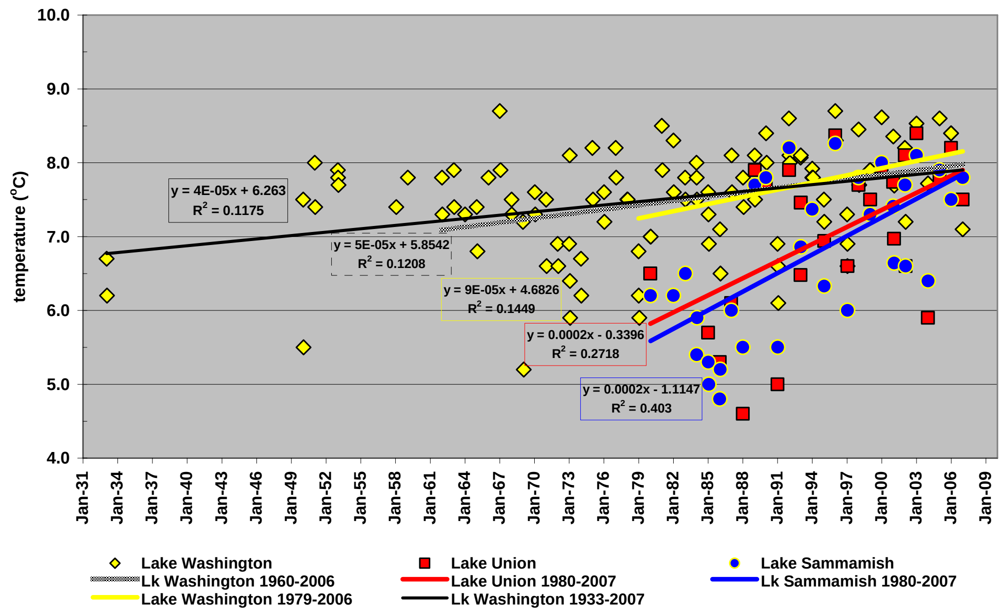

Figure 6-2. January Water Temperatures in Lakes Washington, Sammamish, and Union (1933–2007)
Source: King County, 2007.

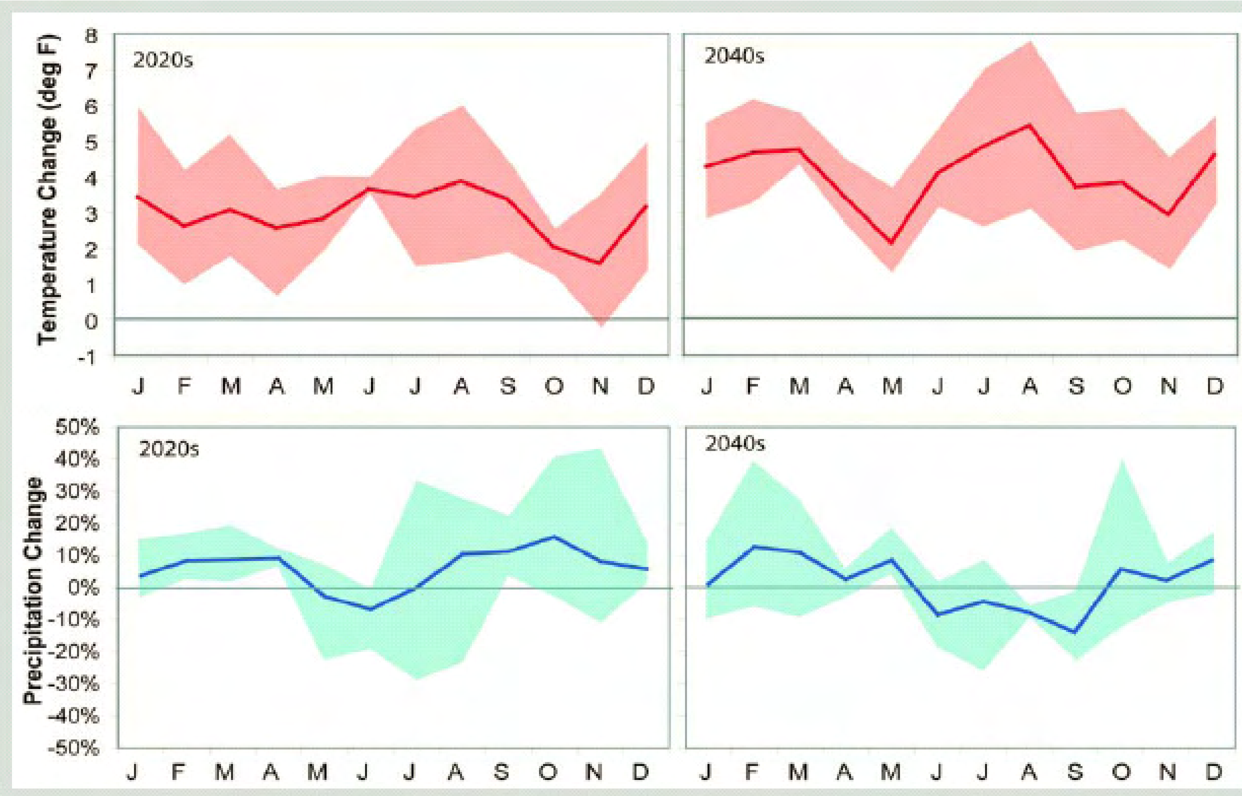

Figure 6-3. Projected Changes in Monthly Temperature and Precipitation in the Pacific Northwest for the 2020s and 2040s (in degrees F and percent)
Source: Casola et al., 2005.

6.3.2 Projected Changes in Regional Climate

Increases in temperatures in the region are forecasted to continue in the twenty-first century (Snover et al., 2005; Palmer et al., 2006). Warmer temperatures are projected to cause more winter precipitation to fall as rain rather than snow, decrease the snow-covered area in mountain regions, and lead to earlier snowmelt (Hamlet and Lettenmaier, 1999; Mote et al., 1999; Miles et al., 2000; Mote et al., 2003; Snover et al., 2003). As a result of warmer temperatures, the rates of evaporation and transpiration are also expected to increase (IPCC, 2001a).

There is generally less certainty about changes in the amount of precipitation, but even for regions where total annual average precipitation may not change, variability is expected to increase and the number of extreme events (for example, heavy precipitation events) is expected to increase (Trenberth et al., 2007). Also, while mean annual precipitation may increase in the Pacific Northwest, most of the increase is expected during winter months and "most climate models tend to show slight decreases in precipitation in summer months" (Mote et al., 2005).[6]

[6] For the latest studies on expected changes in temperature and precipitation and the resulting impact on streamflows into the region's drinking water storage reservoirs, see the final report form the Climate Change Technical Committee (Palmer, 2007) at www. tag.washington.edu/projects/regionalplanning.html

6.3.3 Climate Change Impacts on Regional Water Resources

Changes in temperature, snowpack, and precipitation patterns will have notable impacts on a broad range of water resource issues, including streamflow regimes, the occurrence of extreme events, ecosystems, and water supply and demand:

- **Streamflow regimes** will likely change. Peak streamflows will occur earlier in the season, winter flows will increase (as more precipitation falls as rain rather than snow), and summer flows will decrease (Cayan et al., 2001; IPCC, 2001b; Regonda et al., 2005; Stewart et al., 2005; Palmer et al., 2006). In 2007, the Climate Change Technical Committee of the regional water supply planning process estimated average seasonal changes in streamflow from simulated historical levels (1928–2004) for local rivers. Average summer flows for the Cedar River, for example, are predicted to decrease by 37 percent by 2075, while average winter flows are predicted to increase by 48 percent.[7]
- **Extreme events**, such as floods and droughts, are expected to increase. In most Western Washington river basins, the frequency of *flood* events is expected to increase (IPCC, 2001b; Snover et al., 2005; Palmer et al., 2006). Furthermore, *drought* frequency is also expected to increase in the Pacific Northwest (Hamlet and Lettenmaier, 1999; Mote et al., 2003).
- **Freshwater and estuarine habitats** are expected to be affected by climate change. Changes in lake temperatures have already been documented for Lakes Washington, Sammamish, and Union (King County, 2007). Temperatures of rivers and streams are expected to increase in the Puget Sound region (Sinokrot and Stefan, 1993; Mohseni and Stefan, 1999; Snover et al., 2005). Changes in streamflow conditions (both flow regimes and temperatures) will have negative impacts on freshwater habitats (Hyatt et al., 2003; Mote et al., 2003; Snover et al., 2005).
- **Water consumers and suppliers** may be adversely impacted by climate change. Changes in streamflow patterns will affect hydropower production capabilities and changes in precipitation patterns and evapotranspiration will affect irrigation demands. Changes in snowpack will alter seasonal water storage patterns and may lead to reduced supplies. Reduced supplies and increased demand are expected to lead to an increase in the length of average summer reservoir drawdown (Palmer et al., 2004; Palmer and Hahn, 2002). Reservoir storage may also be impacted if additional dam releases are needed for instream flow or flood control purposes.

6.3.4 The Role of Reclaimed Water

The use of reclaimed water as an alternative to traditional surface water and groundwater sources may serve as means to alleviate some of the stress that climate change may have on the region's water resource systems. As a climate-independent source, reclaimed water is not vulnerable to

[7] The committee's full report can be found at http://www.govlink.org/regional-water-planning/tech-committees/climate-change/UWreports/FinalReport(12-13-07).pdf

variability in streamflow regimes (for example, changes in the timing of peak flows that may result from earlier snowmelt) or extreme events, such as droughts. Indeed, reclaimed water is often referred to as a “drought-resistant” water supply.

Furthermore, the use of reclaimed water can offset some of the dependence on traditional water supply sources (surface water or groundwater that is hydrologically connected to key surface waters), thereby making it possible to reduce withdrawals and possibly maintain current water levels in flow-limited or temperature-sensitive streams in future decades. By helping to minimize (or eliminate) reductions in streamflow, the use of reclaimed water may help preserve critical habitats (where, for example, there may be a minimum flow required to support certain species) and hydropower production capabilities.

As a changing climate alters traditional water resource management, non-traditional sources of supply, such as reclaimed water, may be necessary to maintain traditional uses of water resources. In particular, self-supplied users of water from either wells or surface water may find themselves in short supply, requiring development of alternative sources of water for non-potable uses. Development of satellite reclaimed water facilities or connection with a regional reclaimed water facility may become increasingly important to maintain quality of life as the population grows in conjunction with increased water scarcity.

Finally, the population of the Puget Sound region is anticipated to grow. It has been suggested that rising temperatures and water shortages in other parts of the country may create an even greater influx of residents than previously projected. This would result in even greater pressure on water supplies than previously considered.

6.4 Ecologic Stress, Salmon, and Related Endangered Species and Habitat Issues

Several species of salmonids and trout rely on the rivers and streams throughout King County for part or all of their lifecycle, including Chinook, sockeye, coho, chum, winter steelhead, coastal steelhead, bull trout, and others. Puget Sound Chinook (*Oncorhynchus tshawtscha*), bull trout (*Slavelinus confluentus*), and steelhead trout (*Oncorhynchus mykiss*) are all listed as threatened species under the ESA as the result of hydropower operations, commercial and recreational fishing, poor hatchery practices, and habitat degradation from land development and other causes.

6.4.1 Impact of Low Flows

Human activities have disrupted historical flow patterns throughout the region by diverting waterways, building dams, increasing impervious surfaces, developing homes and businesses along the rivers, and withdrawing water. Low summer flows in area streams and rivers degrade the waters with elevated temperatures and low dissolved oxygen, which diminish the ability to support aquatic organisms that may be important to continued survival of threatened species.

Chinook, bull trout, and steelhead trout rely on varying levels of streamflows throughout their lifecycle. Low flows that persist for long periods can reduce spatial habitat for rearing; decrease water depth in riffles, glides, and pools; and may constrain upstream adult Chinook migration. Low flows also can reduce water velocity, potentially constraining downstream juvenile movement, and can decrease the wetted width of rivers available for spawning (WRIA 9, 2005).[8]

6.4.2 Impact of Climate Change on Flows

The climate in the region has been changing, which has made survival even more difficult for Chinook, steelhead trout, and bull trout. Spring peak flows are lower than average in snowmelt-dominated basins. These flows may impact spring out-migration of juvenile salmonids in larger rivers and tributaries, may create lower average flows for spawning of steelhead trout in tributaries, and may reduce spawning capacity in some streams (King County, 2007).

With climate change, there is also the potential for lower late-summer and fall flows. As a result, water temperatures are likely to exceed standards in larger rivers more often. If annual minimum flows occur earlier, the low flows may affect the timing of upstream adult migration and may create warmer, more stressful instream conditions (WRIA 9, 2005). The state may also have a more difficult time meeting instream flow requirements and out-of-stream demand (for example, irrigation, municipal, industrial uses).

6.4.3 The Role of Reclaimed Water

The use of reclaimed water may provide benefits to salmon during low flow periods by reducing the pressure on groundwater or surface water withdrawals that affect rivers where salmon are most impacted by low flows. Reclaimed water also has the potential to reduce the pressure of meeting instream flow agreements, particularly during times of low flow. Increasing streamflows and improving habitat, particularly for salmonids and their prey, can benefit the overall environment.

Reclaimed water may also help mitigate saltwater intrusion problems. The transition zone where juveniles adapt from freshwater to saltwater is a critical habitat in the life history of salmonids, especially for Chinook. In the Duwamish Estuary, for example, freshwater input has been reduced by 70 percent as the result of the diversion of the White and Cedar/Black Rivers. Saltwater intrusion has pushed the transition zone upstream from its historical location. Withdrawing less groundwater and surface water through the use of reclaimed water might help prevent the transition zone from moving farther upstream.

The state Reclaimed Water Use Act (Chapter 90.46 RCW) mentions that reclaimed water should be used to “contribute to the restoration and protection of instream flows that are crucial to preservation of the state’s salmonid fisheries resources.” Direct streamflow augmentation is specifically authorized under state law.

[8] The Salmon Habitat Plan for Green/Duwamish and Central Puget Sound watershed Water Resource Inventory Area can be found at http://dnr.metrokc.gov/wrias/9/HabitatPlan.htm#download

Table 6-3 provides a list of candidate streams that have been prioritized for streamflow augmentation by the Tributary Streamflow Technical Committee.[9] The committee used 12 criteria to prioritize several candidate streams in WRIAs 8 and 9 for future flow restoration through source exchanges.[10] The criteria were divided into three main categories: relative biological importance, hydrologic need, and probability of measurable benefit.

The technical committee limited its assessment to examining the effect of adding 2 cubic feet per second (cfs) because2 cfs is a common flow rate for some municipal wells (about 900 gallons per minute). This relatively small addition to instream flows means that the approach was constrained to identifying smaller streams in the region; larger rivers and streams typically would not benefit as appreciably from flow enhancements at the 2-cfs scale. Larger water bodies in the region that are flow-impacted also could potentially benefit from exchanges facilitated by reclaimed water at volumes greater than 2 cfs.

Adding 2 cfs to some streams could improve the abundance and distribution of salmon and steelhead populations. The committee (2006) recognized that restoring groundwater contributions to streams has the potential to enhance the quality and quantity of instream habitat and to mitigate the trend toward warmer water temperatures.

Table 6-3. Salmon Bearing Streams Identified as Flow Limited

Cedar River-Sammamish/Lake Washington Basin (WRIA 8)	Green/Duwamish River Basin (WRIA 9)
Lake Washington Ship Canal	Big Soos Creek
Sammamish River	Covington Creek
Bear Creek	Jenkins Creek
Cottage Lake Creek	Newaukum Creek
Evans Creek	Lower Green River (below Howard Hanson Dam)
Little Bear Creek	Upper Green River (above Howard Hanson Dam)
North Creek	North Fork Green River
Issaquah Creek	
East Fork Issaquah Creek	
North Fork Issaquah Creek	
Lower Cedar River (below Landsburg Dam)	
Rock Creek (below Landsburg Dam)	
Taylor Creek (below Landsburg Dam)	

Note: These streams were listed as being flow impaired in the *Central Puget Sound Low Flow Survey* report (Somers and Lombard, 2004).

Source: Tributary Streamflow Technical Committee (2006).

[9] Several agencies, utilities, organizations, and the Muckleshoot Indian Tribe comprised the Tributary Streamflow Technical Committee, which was a part of a regional water supply planning process.
[10] These streams were identified in Somers and Lombard's (2004) *Central Puget Sound Low Flow Survey* report.

6.4.4 Reclaimed Water Potential for the Sammamish River

A reclaimed water project has the potential to alleviate some of the stresses on the Sammamish River Chinook populations by reducing pressures on valuable groundwater resources that support the Sammamish River basin. Low flows and extremely high temperatures in the river threaten the survival of juvenile-rearing and pre-spawning migrant Chinook, which use the river primarily as a migration corridor with some rearing in its tributaries.

The Lake Washington/Cedar/Sammamish Watershed *Chinook Salmon Conservation Plan* recommends investigating and addressing the impacts of surface water and groundwater withdrawals on flow conditions for salmon life stages; raising the overall water level in the river channel by inducing more groundwater flow; and protecting and restoring cool, clean water sources and inflows to the Sammamish River. The plan also recommends further research on the potential for reclaimed water facilities to shift municipal water supply sources in order to maximize summer instream flows (WRIA 8, 2005).

6.5 Puget Sound Water Quality Issues and Implications

King County is the single largest point source discharger of effluent into Puget Sound through its outfalls into the Central Basin. Although the Central Basin has not experienced the same degree of water quality degradation as have the Hood Canal and South Sound areas. King County will likely come under increasing pressure to reduce reliance on outfalls and to manage loadings in ways other than a marine discharge that is permitted based on dilution.

It is reasonable to expect regulations to become more stringent in the future regarding the parameters governing effluent discharges to Puget Sound. Accordingly, it is prudent to anticipate the need to either produce Class A effluent or develop more appropriate and beneficial ways of using reclaimed water on land.

For example, treating Brightwater effluent to the Class A reclaimed water standard will reduce loadings to the Sound and create the opportunity to use a high quality water for the portion of the discharge diverted to land application where it can be beneficially used in applications such as irrigation of agricultural lands and golf courses.

6.6 Conclusions

It is important to consider the benefits of reclaimed water when evaluating projects, rather than focusing only on costs. As the region considers the development of reclaimed water, the discussion of benefits provided here offers a general perspective on what types of benefits may arise, and why. At this stage, a net benefits perspective will help guide the county’s reclaimed water program as it moves forward toward a comprehensive plan and specific project ideas.

In order to properly conceive of the benefits and costs of reclaimed water (and other options), it is critical to establish a suitable forward-looking baseline. There are several water resource management challenges facing the region that are essential to defining this baseline. In addition, there are several factors and related plausible scenarios that are important to consider in establishing the baseline. These scenarios have been laid out in this chapter as alternative futures for the region's water resource management challenges.

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Chapter 7

Review and Update of Regional Market Analysis for Reclaimed Water

This chapter addresses Provision 3 of Water Reuse Policy 2 (WRP-2), which calls for "detailed review and an update of a regional market analysis for reused water." The regional market analysis update in this chapter identifies potential uses of reclaimed water in the King County's wastewater service area. It builds on work previously completed by the county and other agencies.

There is a potential market for use of reclaimed water in this region. A number of environmental, social, and financial drivers are leading to increased interest in using reclaimed water. Although the region's water supplies in the aggregate appear to be substantial, there are areas where existing supplies are limited in some ways and reclaimed water may help meet an existing or growing demand. Subregional analyses such as Seattle's review of the West Segment of the Brightwater backbone, Covington Water District's review for irrigation and wetland enhancement, and the Southeast King County review of satellite wastewater facilities will help to define feasible future projects.

The chapter presents the following information:

- Summary of previous market analyses and proposals for reclaimed water projects.
- Description of the approach used to update these market analyses.
- Identification of potential reclaimed water sources and users.

7.1 Previous Market Analyses

Reclaimed water market, financial, and technical studies completed between 1995 and 2006 were reviewed to identify and evaluate the potential for reclaimed water demand. These studies provide a historical basis for current policies and a useful foundation for analyses conducted as part of this feasibility study. The following studies are summarized in this section:

- *Water Reclamation and Reuse: A Feasibility Study for the King County Metropolitan Area*, ECONorthwest, 1995.[1]
- *Identification of Potential Satellite Projects for Direct Non-Potable Uses*, King County Department of Natural Resources, 2000.

[1] Co-authors: Brown and Caldwell, Camp Dresser McKee, Herrera Environmental Consultants, and Pacific Rim Resources.) Prepared for the King County Department of Natural Resources, Water Pollution Control Division; the Seattle Water Department; and the City of Renton.

- *Wastewater Reclamation and Rainwater Harvesting Study,* Seattle Public Utilities (SPU), 2003.

In addition, King County conducted studies to identify water reuse potential as a part of the siting process for the Brightwater System and as a part of the analysis for the Brightwater backbone.[2]

Significant findings from the studies are as follows:

- Optimum projects will be large-volume users close to existing sources of treated effluent (1995 study).
- Reclaimed water interest is centered in the Sammamish Valley and in the southeastern part of the service area around the Cities of Newcastle and Covington (2000 study).
- Projected costs to supply reclaimed water exceeds the costs of existing potable water supplies in the majority of cases investigated.

7.1.1 Water Reclamation and Reuse Study (1995)

The 1995 *Water Reclamation and Reuse: A Feasibility Study for the King County Metropolitan Area* (ECONorthwest) considered the general feasibility of providing reclaimed water as a supplemental source of water to accommodate population growth in the King County wastewater service area. Features of the study included an inventory of potential reclaimed water demand based on water meter records provided by purveyors, surveys of potential demand and user attitudes, and a general assessment of current (1995) cost and economic feasibility for providing reclaimed water service.

The study focused on large-volume users with a high level of nonpotable use—for irrigation, heating and cooling, or industrial processes. These users were considered to be the most likely candidates for reclaimed water. Such users would be more economical to serve with reclaimed water than small users, because of economy of scale. The study indicated that 18 potable water suppliers were most likely to serve the largest-volume water users. Most of these suppliers provided the names of organizations with meters that recorded more than 5,000 ccf of water use in the most recent year for which they had tabulated records.[3] The Seattle Water Department and the City of Bellevue provided the names of organizations with meters that recorded more than 10,000 ccf. A total of 535 meters were identified. The two largest nonpotable water users were the University of Washington and the Boeing Auburn facility. Companies using less than 10,000 ccf along King County's Effluent Transfer System in the Duwamish industrial area were added to the sample because of their proximity to a source of secondary effluent.[4]

A questionnaire was sent to 410 people identified as contacts for the companies with the identified meters. A total of 262 responded (64 percent). Results indicated that 57 percent of large-volume water use is for irrigation, industrial processes other than food and beverage

[2] *Brightwater Siting Project, Phase 2—Water Reuse Potential form Future Brightwater Sites*, technical memorandum, 2001, and *Reclaimed Water Backbone Project,* (Draft white paper, version 3.0), 2006.
[3] ccf = hundred cubic feet, or 748 gallons.
[4] The Effluent Transfer System conveys secondary treated effluent from the South plant in Renton to Puget Sound.

processing, heating and cooling, and other uses appropriate for reclaimed water. This constitutes a potential reuse market of up to an average of 8.8 million gallons per day (mgd)—comprising approximately 5 percent of the region's annual water use at the time.

Results indicated that 57 percent of respondents expressed an interest in reclaimed water. The 50 largest water users expressed somewhat more interest in reclaimed water than the other respondents: 20 percent of them were "very interested" in reclaimed water and 46 percent were "somewhat interested."

Finally, the study analyzed the costs of reclaimed water based on planning level estimates of hypothetical reclaimed water facilities and on case studies of actual and planned reclaimed water projects. Unit costs were projected to vary depending on capacity of a single treatment facility using treated effluent, ranging from $0.57 per ccf for 0.1 mgd to $3.69 per ccf for 10 mgd. Costs for using untreated wastewater as a source for seasonal treatment without solids handling ranged from $2.12 per ccf for 0.1 mgd to $8.23 per ccf for 10 mgd. In addition to treatment costs, distribution costs were predicted to add up to $8 per ccf for distances up to 2 miles from the treatment source.

Costs of reclaimed water were compared with the costs of new sources of potable water and with the costs of water conservation measures, such as commercial incentive programs. A general conclusion was that reclaimed water costs would likely be higher than marginal costs for developing new water supplies. The analysis indicated that a successful project would have to serve a large demand, approaching 1 mgd, and be located near a source of secondary treated effluent.

The study concluded that there was no single large volume user (over 1 mgd) and there were not enough large-volume users (0.1 to 1 mgd) to serve as the basis for a large-scale water reclamation program. Large volume irrigation usage was too widely dispersed, requiring several production centers to serve this collective demand. However, the study concluded that site-specific projects could be economically feasible in the near term. The best candidates for such projects were expansion of reclaimed water production at the Renton (South plant) and West Point wastewater treatment plants, which at the time of the study, used over 0.20 mgd of potable water. The Duwamish industrial area in Seattle also showed potential, because of its concentration of industrial users and proximity to the Effluent Transfer System that carries secondary effluent from South plant to Puget Sound. Several of the large irrigators appeared to be located close to potential reclaimed water sources.

7.1.2 Study to Identify Potential Satellite Projects (2000)

In 1999, the Regional Wastewater Services Plan (RWSP) policy called for continued funding of pilot-scale and other reclaimed water projects. A reuse work plan was submitted to the King County Council in 2000 (King County, 2000), also to comply with RWSP policy. The water reuse work plan called for evaluation of the potential for both satellite and centralized reclaimed water facilities. To respond to these recommendations, the King County Department of Natural Resources published the *Identification of Potential Satellite Projects for Direct Non-Potable Uses* in 2000.

The county established a task force to identify pilot projects for satellite reclaimed water treatment plants. A multi-faceted program was undertaken that included implementing a strategic public outreach program, preparing an updated GIS-based water user database, exploring water reclamation funding mechanisms, outlining the steps necessary to implement satellite plants, and soliciting and evaluating nominations for pilot projects.

In 2002, the county initiated a feasibility study for the Sammamish Valley Reclamation Plant as the demonstration satellite plant selected from the nomination process. The feasibility study, which included predesign, evaluated six alternative sites in the valley that were near nine anticipated user areas. The selected site was near the county's Sammamish Valley Interceptor, which has adequate flow to serve as a source of untreated wastewater and to convey solids away from the plant. Average seasonal day capacity of the membrane bioreactor (MBR) plant was to be 3.4 mgd. Environmental review and public involvement activities were completed, a site was chosen, and a design process was initiated. The Sammamish Valley project was cancelled in the 2004 King County budget process because of rising costs and the realization that providing reclaimed water to Sammamish Valley from Brightwater would be more cost-effective.

The following sections describe the nomination and evaluation processes—documented in the *Identification of Potential Satellite Projects for Direct Non-Potable Uses*—that led to selection of the Sammamish Valley Reclamation Plant.

Nominations for Pilot Projects

Eleven nominations for satellite treatment plants were received from the following organizations:

- Willows Run Golf Course (golf course)
- Molbaks Greenhouse (greenhouse)
- Woodinville Water District (sod farm and park)
- Shoreline Water District (a variety of agricultural uses)
- Northshore Utility District (car washes, schools, and golf courses)
- The Golf Club at Newcastle (golf course)
- Covington Water District (schools, parks, and golf courses)
- Tam O'Shanter Golf Course (golf course)
- Sammamish Plateau Water and Sewer District (streamflow augmentation)
- University of Washington (recreational)
- City of Tukwila (industrial and recreational)

The nominated projects included a variety of reclaimed water uses. For the most part, the uses focused on seasonal turf irrigation, including golf courses, cemeteries, and recreational fields. One agency, Sammamish Plateau Water and Sewer District, proposed to discharge reclaimed water into a creek to augment flow and supplement groundwater resources. At the time, the district indicated a need for additional water supplies of up to 5.6 mgd by 2015.

The county grouped the proposals into five projects: the Sammamish River Valley project (from Redmond to Woodinville), the north Sammamish River project around Kenmore, two golf course projects in Newcastle and Bellevue, and a proposed project in Covington. The total projected reclaimed water capacity for the five projects was 7.3 mgd.

The five areas were evaluated based on the availability of source water, locations for satellite plants, capital costs, and operation and maintenance (O&M) costs. The technology assumed in cost estimates included primary, biological secondary treatment, sand filtration, chemical addition, and chlorination. Plant capacities in terms of peak-day demand ranged from 0.44 to 4.3 mgd. Costs were developed from methods and curves reported in the ECONorthwest study (1995). Capital costs for treatment and distribution ranged from $10 to $43 million (year 2000 dollars); annualized costs ranged from $4.01 to $10.35 per ccf.

Evaluation and Ranking of Projects

King County evaluated and ranked the five nominated projects (eleven nominated projects that were grouped into five projects). The size of one of the projects, the Sammamish River Valley project, was reduced to save on distribution cost. This “Modified Sammamish River Reuse” project was ranked first among the nominations. It was then recommended that the three top ranked projects be evaluated against two new criteria: minimizing long-term impacts and demonstration of new technologies.

The Modified Sammamish River Reuse project was then compared with the two projects that the county had added. Use of reclaimed water from the proposed new regional plant ranked first. However, delivery of reclaimed water from the regional plant was projected for 2010 and the need for reclaimed water would occur sooner. The Modified Sammamish River Reuse project was therefore selected to proceed to evaluation in a feasibility study that would include an analysis of new technologies. The project was renamed the “Sammamish Valley Reclamation Plant” for the subsequent feasibility study.

7.1.3 Wastewater Reclamation and Rainwater Harvesting Study (2003)

Seattle Public Utilities (SPU) undertook the *Wastewater Reclamation and Rainwater Harvesting Study* in 2003 to examine how the use of reclaimed wastewater and harvested rainwater could be substituted for potable water where practical.

An initial list of over 90 possible projects throughout Seattle and the SPU water purveyor area was compiled and eventually reduced to 11 candidate projects, of which 8 included reclaimed water at least in some part. Identified reclaimed water projects were mainly for seasonal turf irrigation at city golf courses. Other projects included industrial uses at Birmingham Steel (now Nucor) and the city’s South Transfer Station and one project for toilet flushing at Green Lake Park.

Evaluations of the reclaimed water projects assumed that Class A reclaimed water would be provided for all uses. It was assumed that membrane bioreactor (MBR) treatment with ultraviolet

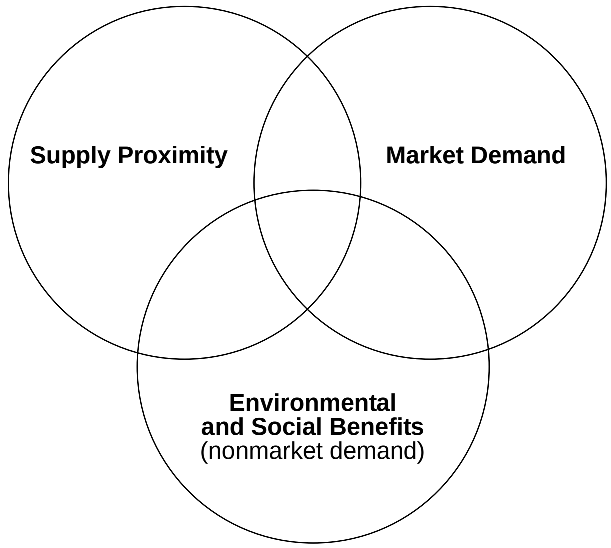
(UV) disinfection would be used when untreated wastewater was the source water and that sand filters with continuous backwash and UV disinfection would be used when treated secondary effluent was the source water (for example, South plant effluent conveyed by the Effluent Transfer System pipeline).

Capital cost estimates for the eight projects ranged from $0.25 to $4.8 million, with unit costs ranging from $1.88 to $64.33 per ccf. The project with the lowest unit cost ($1.88 per ccf) comprised seasonal turf irrigation at the West Seattle Golf Course combined with year-round industrial use for cooling at Birmingham Steel. The capacity of the treatment system for this project was listed as 0.56 mgd; capital, design, and construction management costs were estimated at $2.4 million; and annual O&M costs were approximately $0.1 million. The study concluded that this project was worthy of consideration for implementation. No further action was taken on this recommendation.

7.2 Approach Used in this Market Analysis Update

As discussed in Chapter 4 and shown in the figure below, likely reclaimed water projects (weighing both benefits and costs) in our region are projects that have one or more of the following characteristics:

- Providing reclaimed water is either a requirement or secondary benefit of new or upgraded wastewater facilities such that all or a significant portion of the cost is attributed to the development of the wastewater system.
- The reclaimed water user (market demand) is located sufficiently close to the supply (supply proximity) so that the distribution costs are minimized.
- The reclaimed water is needed to mitigate or benefit another environmental objective, such as wetland enhancement, farmland preservation, or groundwater recharge, for which other entities besides the wastewater utility will contribute to the cost of the reclaimed water.



The market update analysis considers these factors in its approach to identifying and refining the potential reclaimed water market:

- Location of source water, such as treated or untreated wastewater in the county system, that could be reclaimed
- GIS-based identification by land use of potential areas where reclaimed water could be used for irrigation (parcels that are one acre or larger)
- Identification of parcels near the county's wastewater collection system and estimated potential demand based on land use
- Identification of flow-limited streams and critical groundwater recharge areas that may present potential for environmental enhancement through use of reclaimed water
- Refinement of the GIS-based information and identification of interest in and perceptions of reclaimed water through interviews and focus groups with water and wastewater agencies and other interested groups
- Identification of focused potential use areas and conceptual projects in King County's wastewater service area

After potential sources of water and potential use areas were identified, focus groups were held with potential user groups (recreational, agricultural, and business) and interviews were conducted with purveyors (water and wastewater agencies). The agency interviews were held to confirm or disconfirm the identified land-use-based parcels and to determine the level of interest in exploring reclaimed water projects. The interviews provided specific information to refine real market potential, especially in regard to interest in using reclaimed water, as opposed to previous generalized methods of predicting demand.

It is anticipated that a broader application of this approach, to include potential reclaimed water users, and ongoing outreach efforts will expand the knowledge of potential demand for reclaimed water.

7.3 Potential Sources of Reclaimed Water

Previous studies concluded that the most cost-effective projects were likely to be those nearest sources of treated wastewater. Existing and planned King County facilities related to reclaimed water production, described below, were used in the analysis.

7.3.1 Existing Reclaimed Water Capacity, Production, and Uses

King County's wastewater treatment and conveyance system provides opportunities for increased production of reclaimed water using either untreated or treated wastewater (Figure 7-1 and Table 7-1).

King County currently produces reclaimed water at its West Point and South Treatment Plants. Reclaimed water production capacity is 0.5 mgd at West Point and 1.3 mgd at South plant. Existing system-wide use is estimated to be 0.73 mgd.

South plant produces and distributes approximately 0.23 mgd of Class A reclaimed water for both onsite and offsite uses. Onsite uses for process water account for about 0.2 mgd. About 0.03 mgd is distributed to the City of Tukwila through a 1.3-mile 16-inch-diameter pipeline that extends to the county's Interurban Pump Station for seasonal turf irrigation at Fort Dent Park. The treatment system consists of three continuous backwash sand filters, alum and polymer coagulants, and sodium hypochlorite disinfection. Modifications are planned for 2008 to improve the coagulant mixing system.

West Point produces approximately 0.5 mgd of reclaimed water for onsite process uses. The reclaimed water is equivalent to Class A in treatment quality; however, the plant does not have a reclaimed water permit because reclaimed water is used only onsite. The treatment system consists of sand filters and sodium hypochlorite disinfection. There are no plans for plant modifications or to provide reclaimed water to offsite locations.

Table 7-1. King County Wastewater System Sources for Production of Reclaimed Water

Element	Existing Infrastructure and Treatment Plant Flow	Comments
Influent pipelines	About 86 miles	Pipelines with an average dry-weather flow greater than 2 mgd.[a] Source of untreated wastewater for potential satellite treatment plants.
Treatment plants	West Point, 110 mgd, average dry-weather flow (ADWF)	Secondary treatment using primary sedimentation, aeration, and sodium hypochlorite disinfection. Existing onsite Class A reclaimed water production using sand filters and sodium hypochlorite disinfection, with 0.5-mgd capacity; about 0.5 mgd is used onsite.
	South Plant, 96 mgd ADWF	Secondary treatment using primary sedimentation, conventional aeration, sodium hypochlorite disinfection. Existing onsite Class A reclaimed water production using sand filters and sodium hypochlorite disinfection, with 1.3-mgd capacity; current production: 0.23 mgd (about 0.2 mgd is used onsite and 0.03 mgd is distributed to offsite irrigation uses in City of Tukwila).
	Brightwater, estimated 18 mgd ADWF at startup in 2010	Secondary treatment using primary sedimentation, membrane bioreactor, sodium hypochlorite disinfection of average wet-weather flow. Class A reclaimed water production capacity will be 24 mgd initially. An estimated demand of 1 mgd at startup for WTD operations.
	Carnation, 0.16 mgd, average annual flow (AAF) at startup in 2008	Secondary treatment using membrane bioreactor and ultraviolet disinfection. Ultimate Class A reclaimed water production capacity is 0.37 mgd, average annual flow. Planned distribution of all reclaimed water for wetland enhancement.
	Vashon, 0.25 mgd AAF	Secondary treatment using oxidation ditch, clarifiers, ultraviolet disinfection. No plans for reclaimed water production.
Effluent pipeline/outfall	South plant Effluent Transfer System, 12 miles, 132 mgd	Pumped and gravity flow system that conveys South plant effluent to Puget Sound. Access points provided for future connection for water reuse.

[a] 2 mgd is used as a minimum flow threshold value, based on current flow and on an assumption that wastewater treatment residuals from satellite plants will be returned to the pipeline for treatment at either West Point or South plant.

Figure 7-1 highlights conveyance pipelines with an average dry-weather flow (ADWF) of 2 mgd or greater. ADWF represents the least flow that a particular pipeline is likely to convey during the summer irrigation season. An ADWF of at least 2 mgd will allow for withdrawal of untreated wastewater while maintaining adequate velocity to carry away residual solids from satellite treatment plants. The Carnation Treatment Plant is an exception to this criterion. The Carnation collection system is a vacuum system and is therefore not subject to variations of infiltration and inflow (I/I) that cause changes in flows over the seasons.[5] Therefore, average annual flow (AAF) represents the average flow to the Carnation plant that would be available as source water.

The wastewater treatment system includes a total of about 86 miles of pipelines that carry over 2 mgd ADWF of untreated wastewater to the West Point and South plants. In addition, the 12-mile-long Effluent Transfer System (ETS), which carries South plant’s treated effluent to Puget Sound, includes nine taps where effluent could be extracted and treated for reuse.

7.3.2 Reclaimed Water Capacity, Production, and Uses in Design or Construction

Additional sources of reclaimed water will be available at the Brightwater Treatment Plant in 2011 and the Carnation Treatment Plant in 2008. Both plants will treat incoming wastewater to Class A reclaimed water standards through membrane bioreactor technology and disinfection (sodium hypochlorite at Brightwater and UV at Carnation). The capacity of the Carnation plant will be 0.37 mgd; the initial reclaimed water production capacity at the Brightwater plant will be 24 mgd.

Reclaimed water produced at the Carnation plant will be used for wetland augmentation. Planned uses to date for reclaimed water produced at Brightwater are approximately 0.1 mgd for onsite uses, 0.8 mgd (annual periodic uses estimated to be 76 million gallons) at four offsite pump stations for cleaning, pump testing, and regular force main maintenance flushing operations; and 0.5 mgd for irrigation at Willows Run Golf Course south of the plant.

Conveyance systems carrying reclaimed water from the Carnation and Brightwater plants will have a combined capacity of 22 mgd. Carnation reclaimed water conveyance will consist of 1.7 miles of 12-inch-diameter pipe. The Brightwater reclaimed water conveyance system will consist of the following elements:

- 12 miles of 27- and 30-inch-diameter pipe in Brightwater tunnels
- 0.5 mile of 30-inch-diameter pipe in the City of Bothell
- 5 miles of 30-inch-diameter pipe in the Cities of Bothell, Woodinville, and unincorporated King County
- 2.5 miles of 20- and 18-inch-diameter pipe in unincorporated King County and the City of Redmond

[5] Infiltration and inflow are clean groundwater and stormwater that enter sanitary sewers.

7.4 GIS-Based Identification of Potential Irrigation Areas

A GIS-based analysis was performed to identify potential demand for nonpotable irrigation water in King County's wastewater service area. The objective of this analysis, similar to objectives of the 1995 ECONorthwest study and 2000 King County satellite plant study, was to identify demand on a regionwide scale. The analysis consisted of an initial screening to identify parcels by size and land use, followed by further screenings to identify parcels near reclaimed water sources

7.4.1 Initial Screening by Land Use Type

For the initial screening, a GIS database was used to identify parcels inside the boundaries of the county's wastewater service area over 1 acre by land use type. Parcels were identified by land uses that typically use large volumes of water for turf irrigation, such as parks, school athletic facilities, playgrounds, cemeteries, and golf courses.

Parcels identified through this initial broad-based screening are shown in Figure 7-2 and listed by category and acreage in Table 7-2.

Table 7-2. Potential Irrigation Demand Areas in King County's Wastewater Service Area

Land Use	Number of Parcels	Total Acreage
Agriculture	39	1,639
Cemetery	40	916
Commercial	15	545
Golf	33	4,463
Industrial	148	2,664
Landscape irrigation	59	464
Large-scale residential irrigation	6	461
Nursery/greenhouse	12	96
Public park	333	10,282
School	275	4,383
Sports facility	6	87
TOTAL	966	26,002

7.4.2 Screening for Proximity to Water Sources

Costs of reclaimed water delivery may depend in part on the distance of a potential use location from the wastewater conveyance system, particularly if satellite plants are used to produce reclaimed water, and proximity to regional treatment plants where reclaimed water may be produced. Another screening was therefore done to estimate the parcels and total acreage that lie within 3,000 feet of county interceptors with ADWF rates of 2 mgd or greater or within 3,000 feet of existing or planned regional plants or reclaimed water conveyance systems.[6] This screening reduced the number of parcels by two-thirds and the acreage by half. Locations of these parcels are shown Figure 7-3; Table 7-3 lists the parcels by category and acreage.

Table 7-3. Potential Irrigation Demand Areas Within 3,000 feet of Interceptors or Treatment Plants in King County's Wastewater Service Area

Land Use	Number of Parcels	Total Acreage
Agriculture	32	1,779
Cemetery	14	344
Commercial	4	309
Golf	11	1,505
Industrial	62	1,442
Landscape irrigation	56	426
Nursery/greenhouse	4	70
Public park	101	5,211
School	80	1,818
Sports facility	3	126
TOTAL	**367**	**13,032**

7.4.3 Screening for Water Usage in Identified Parcels

Because it is unlikely that the total identified acreage will be irrigated, the next screening applied assumptions regarding percentage of the land that would be irrigated and the rates of irrigation. Assumptions used in a recent study for the Green River Valley (Brown and Caldwell, 2007) were applied to the parcels identified in the initial and proximity screenings, as follows:

- The percentage of the parcels in a land use category that will use reclaimed water will depend on several factors, including whether water is available, public perception, and the price of reclaimed water. For this screening, it was assumed that this percentage would range from 50 to 90 percent depending on type of land use.
- The percentage of impervious and pervious areas in each parcel for each land use category was estimated based on aerial photos of sample land use types.
- The percentage of pervious area in each parcel that would likely be irrigated was estimated from knowledge of the land use types.

[6] Costs to distribute reclaimed water at long distances may be prohibitive. A distance of 3,000 feet was selected as reasonable for the purpose of this analysis.

- The percentage of a parcel that would be irrigated and the acreage irrigated were calculated on the basis of the percentage of parcels using reclaimed water, of pervious area, and of pervious area irrigated.
- Annual use was based on an estimate of annual water use for agricultural irrigation in King County—an average 1.7 acre-feet per year per acre (about 1 inch of water per acre, or 3,700 gallons per acre per day).[7] Golf courses tend to irrigate at slightly higher rates, but for this level of analysis, the agricultural irrigation rate is used.
- Average day use was calculated from annual use and an assumed 150-day irrigation season.[8]

Table 7-4 and Table 7-5 show the results of these calculations. Estimated potential reclaimed demand ranges from 13 mgd (average day use) for parcels in proximity to source water to 23 mgd for all parcels over 1 acre.

[7] Personal communication Jay Mirro, Farm Planner, King Conservation District, September 2007.

[8] Average seasonal day refers to the flow rate for reclaimed water demand based on agronomic rates of irrigation as established by Washington State University (WSU), King Conservation District, and others. The irrigation season is assumed to be 150 calendar days from May through September, annually. Average seasonal day flow is used to calculate annual usage for the purpose of determining the cost to deliver water on an annual basis.

Table 7-4. Potential Irrigation Uses for Reclaimed Water in the Service Area

Land Use	Number of Parcels	Total Acreage	% Parcel using RW	Impervious Area (%)	Pervious Area (%)	Pervious Area Irrigated (%)	Irrigation Area (%)	Irrigation Area (acre)	Annual Use (MG)	Average Day Use (mgd)
Agriculture	39	1,639	90%	15%	85%	100%	85%	1254	683	4.6
Cemetery	40	916	90%	25%	75%	100%	75%	618	337	2.2
Commercial	15	545	50%	70%	30%	100%	30%	82	45	0.3
Golf	33	4,463	90%	25%	90%	30%	27%	1,085	590	3.9
Industrial	148	2,664	50%	80%	20%	50%	10%	133	73	0.5
Landscape irrigation	59	464	90%	10%	90%	100%	90%	376	205	1.4
Large-scale residential irrigation	6	461	90%	70%	30%	50%	15%	62	34	0.2
Nursery/greenhouse	12	96	50%	30%	70%	50%	35%	17	9	0.1
Public park	333	10,282	50%	50%	50%	50%	25%	1285	700	4.7
School	275	4,383	50%	25%	75%	80%	60%	1315	716	4.8
Sports facility	6	87	50%	25%	75%	80%	60%	59	32	0.2
TOTAL	966	26,002						6,286		22.8

Table 7-5. Potential Irrigation Uses for Reclaimed Water Within 3,000 Feet of Interceptors or Regional Plants

Land Use	Number of Parcels	Total Acreage	% Parcel using RW	Impervious Area (%)	Pervious Area (%)	Pervious Area Irrigated (%)	Irrigation Area (%)	Irrigation Area (acre)	Annual Use (MG)	Average Day Use (mgd)
Agriculture	32	1779	90%	15%	85%	100%	85%	1361	741	4.9
Cemetery	14	344	90%	25%	75%	100%	75%	232	126	0.8
Commercial	4	309	50%	70%	30%	100%	30%	46	25	0.2
Golf	11	1505	90%	25%	90%	30%	27%	366	199	1.3
Industrial	62	1442	50%	80%	20%	50%	10%	72	39	0.3
Landscape irrigation	56	426	90%	10%	90%	100%	90%	345	188	1.3
Large-scale residential irrigation	4	70	90%	70%	30%	50%	15%	9	5	0.0
Nursery/greenhouse	101	5211	50%	30%	70%	50%	35%	912	496	3.3
Public park	80	1818	50%	50%	50%	50%	25%	227	124	0.8
School	3	126	50%	25%	75%	80%	60%	38	21	0.1
TOTAL	**367**	**13032**						3609		13.1

7.5 Areas Where Reclaimed Water Could Enhance Water Resources

In addition to areas where reclaimed water could be used for irrigation, areas in King County identified as critical aquifer recharge and flow-limited stream areas may benefit from reclaimed water. The existing conveyance system, as a source of untreated wastewater for reclaimed water, is reasonably close to some of these areas. This juxtaposition of needs and resources provides opportunities to benefit the environmental by increasing instream flows through source exchanges and other strategies.

Figure 7-4 depicts flow-limited streams, where an increase in base flow would enhance the quality of salmon habitat, and also critical groundwater recharge areas that contribute base flows to the streams. Two areas are of particular interest (circled in the figure), one in the Green River Valley and the other in the Sammamish Valley. Both of these areas share some common features that may make them amenable to reclaimed water use:

- Large areas of agricultural use overlay critical groundwater recharge areas.
- Portions of the county conveyance system with sufficient dry-weather flows are within a few hundred feet of these areas.
- Major wastewater treatment plants are within 5 miles of both areas.

The Green River Valley area is near a major wastewater interceptor. The Sammamish Valley area is near a major wastewater interceptor, the Brightwater Treatment Plant (online in 2010), and the Brightwater Reclaimed Water System backbone (online in 2011). The agriculture parcels in the Sammamish Valley, identified in the GIS analysis described above, are known to draw irrigation water from the Sammamish River, which has been identified as a critical stream for salmon habitat. Other than potential agricultural irrigation uses for reclaimed water, which would reduce groundwater and surface water withdrawals, the potential demand for reclaimed water to recharge groundwater aquifers is largely unknown.

7.6 Identification of Perceptions and User Interest

To supplement the GIS-based land use data on potential irrigation uses, the county invited stakeholders and the public to provide input to help determine potential demand for reclaimed water. A number of activities were conducted to learn more about opportunities, interests, and concerns.

A survey of 400 county residents gave insight into the perceptions of the general public and suggested that there could be a significant market for reclaimed water. More detailed focus group discussions with parks users and with agriculture and business interests provided information about what potential reclaimed water users think about the product. In addition, the county learned more about potential reclaimed water opportunities and specific concerns through interviews with 19 water and wastewater agencies in its service area. Some of the agencies might become reclaimed water purveyors in the future, and they were able to confirm and clarify the data generated for this analysis.

7.6.1 Public Surveys and Focus Groups

King County's annual Water Quality Survey includes questions on reclaimed water. The survey is a statistically valid survey that gathers input from 400 randomly selected county residents. Results from the 2006 survey show that 82 percent of respondents think that the county should use as much reclaimed water as possible for a variety of purposes and that 70 percent have no concerns about applying reclaimed water for a variety of uses (Appendix K). These findings suggest a significant market for reclaimed water.

This broad outreach was supplemented with four focus group meetings in late April and early May 2007 to determine public perception, acceptance, and possible use of reclaimed water. A complete report of the process and information gathered at the focus group sessions is included in Appendix K. The sessions were held in Redmond, Burien, and Woodinville (areas near the Brightwater reclaimed water backbone and the South Treatment Plant) and were conducted by a professional facilitator.

A total of 28 people participated in the four focus groups—two sessions for members of the public who use parks in these areas, one session for members of the agriculture community, and one for business interests. Focus groups are not intended to provide statistically valid samples. Rather, they are used as follow-up to surveys and other instruments in order to gather more in-depth and nuanced information to supplement the information gathered from larger samples.

Participants for two of the focus group sessions were recruited randomly from members of the public who identified themselves as parks users and who resided in areas near the Brightwater backbone and South plant. Efforts were made to include participants of both genders and varying ages. A total of 21 people participated. The participants ranged in age from under 30 to over 50 years. Participants for the agriculture session were recruited from a list compiled by the county that included granges, farm alliances, and farms in the Sammamish Valley. Five participants attended this session. Finally, participants for the business session were recruited from professional landscape associations, developers, and local chambers of commerce. Two participants attended this session.

Participants were encouraged to share questions that they would want answered if they were told a neighborhood park was to be irrigated with reclaimed water. A number of participants at both public focus groups were already well informed about reclaimed water in general, including knowledge of costs, environmental benefits, and potential uses. Participants in the agriculture and business sessions were asked about their familiarity with the county's plans for reclaimed water and then asked to articulate concerns and questions. All focus group participants provided input to help identify effective mechanisms for educating and raising awareness about reclaimed water.

Overall, most participants responded positively to the concept of reclaimed water and appreciated the county's efforts to take advantage of this potential source of water. Participants felt that information on reclaimed water would be more credible to the public if provided by an unbiased third party (U.S. Environmental Protection Agency, University of Washington, and environmental groups were mentioned). It was suggested that information about reclaimed water use be provided prior to implementation so that the public can adjust to the idea and become educated about the benefits of reclaimed water. Participants felt that reclaimed water could play a larger role in new development in the region. They suggested that acceptability would increase with a history of use by large water users such as golf courses, parks, and landscapes. A few participants noted that unless reclaimed water costs much less than the water they currently use, there would not be much incentive to switch. Other participants felt that reclaimed water is not yet "on people's radar," or if it is, there may be concerns about the safety of the water.

Farmers were well aware of their dependence on water and saw a role for reclaimed water in the region. Farmers who have other sources of water (wells, water rights to withdraw from rivers, and sometimes potable water) may be cautious about being the first to use reclaimed water because of concerns that the public may not be ready to accept reclaimed water. They acknowledged that farmers who do not have another source of water may be very interested.

Four key findings emerged from the focus groups:

- The public wants facts about the safety of reclaimed water.
- Once they understand that it is being safely used, people are supportive of using reclaimed water.
- More information about the pricing and financing of reclaimed water infrastructure is desired.
- More communication and education are needed to support reclaimed water use.

7.6.2 Agency Interviews

To help determine potential demand for reclaimed water, the county conducted interviews with water and wastewater agencies in its service area. Agencies were identified by proximity to a current or future reclaimed water source, previous Brightwater mitigation agreements, or previously expressed opinions on reclaimed water. Nineteen agencies participated. Details of the agency interviews are included in Appendix K.

The interviews provided an opportunity to confirm or disconfirm GIS-identified parcels and assess interest in using reclaimed water The agencies shared their thoughts about the benefits and drawbacks of reclaimed water, drivers for building a regional reclaimed water program, decision-making factors that would determine the extent of participation in such a program, and current reclaimed water opportunities and challenges.

Benefits identified included water conservation, increased water supply, decreased levels of discharge into streams, offsetting peak consumer demands, and general environmental benefits. Some of the drawbacks mentioned included costs, quality of the reclaimed water, endocrine-disrupting compounds, communicating the benefits to the public, and the potential for new concerns that could occur in the future.

Agencies indicated that costs, including issues about how to distribute costs, and public perception are the greatest challenges facing implementation of a reclaimed water program. Among a variety of decision-making factors discussed, 13 of the 19 agencies named cost as the number one factor. The remaining 6 agencies stated that cost would be a considerable factor but that other benefits, such as environmental enhancement, could offset costs. All agencies interviewed expressed the need to demonstrate that reclaimed water is safe to use and that the environmental benefits justify costs. Many recommended that the county provide credible unbiased information about reclaimed water safety.

Six key findings emerged from the agency interviews:

- Interest in near-term reclaimed water use was indicated in three specific locations—the Cities of Bothell, Newcastle, and Tukwila.
- Agency representatives expressed strong opinions, both positive and negative, about a reclaimed water program.
- Cost is the number one decision-making concern (regardless of degree of support).
- Wastewater rates should not be the only source of funding for reclaimed water infrastructure.
- Agencies want unbiased reassurance about the safety of using reclaimed water.
- A comprehensive program of public education and awareness is imperative.

7.7 Summary and Conclusions

General conclusions from this analysis are as follows:

- Potential for regional reclaimed water use for irrigation may range from 13 to 23 mgd average seasonal day.
- The potential for industrial demand is largely unknown. More information is needed about potential industrial reclaimed water uses along the Duwamish corridor near the South Treatment Plant’s Effluent Transfer System.
- Agency interviews and other contacts during this study identified an average seasonal day demand of 3 to 8 mgd for identified uses.
- Identified potential uses were primarily for turf irrigation (golf courses, recreational grounds, cemeteries).
- Interest in and support for reclaimed water have not significantly changed and have remained generally positive since 1995, as indicated by the support, perceived benefits, opinions, and concerns expressed by the public and agencies regarding the use of reclaimed water.

- Identifying interest in reclaimed water improves the level of detail available for cost analyses and refines the market. Face-to-face contact appears to initiate discussion of market potential with increased levels of specificity of demand and use, including the elimination of parcels that would not be candidates for reclaimed water use.
- Cost of reclaimed water remains the largest concern for utilities; safety is the next concern.
- Endocrine-disrupting compounds and related micro-constituents are emerging concerns.

7.8 References

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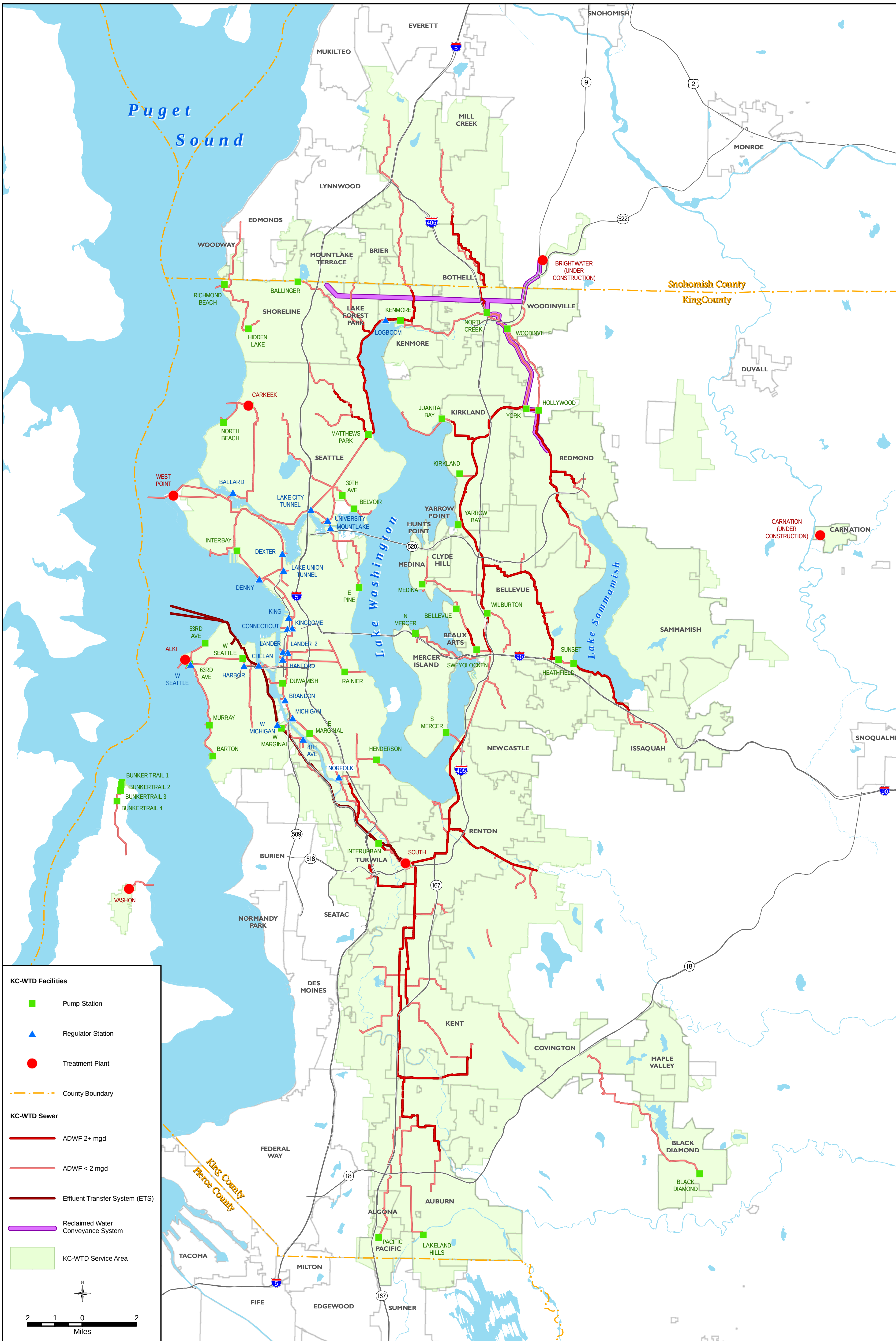

King County
Department of
Natural Resources and Parks
Wastewater Treatment Division

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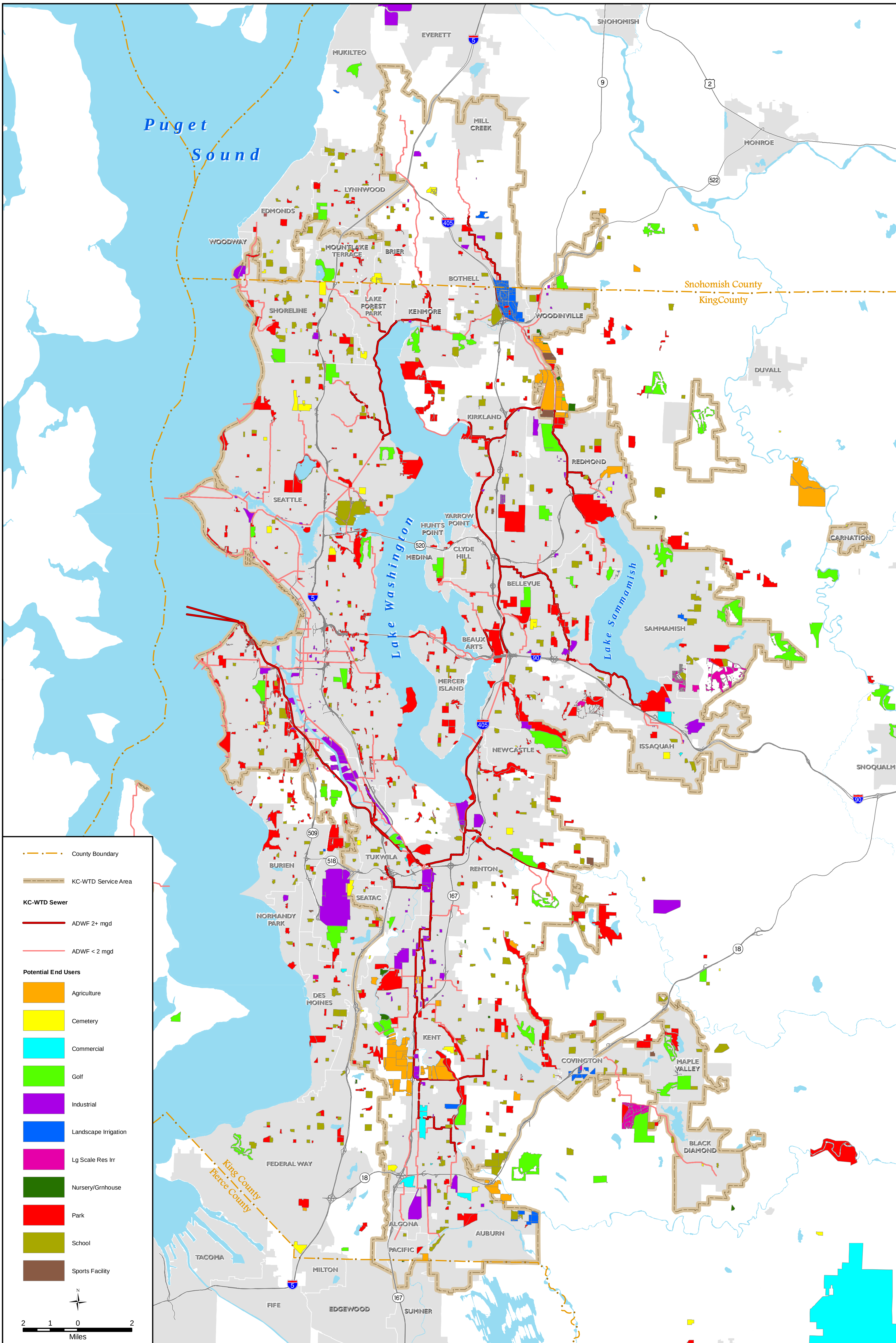
Figure 7 - 1

King County Wastewater Service Area and Facilities

RECLAIMED WATER FEASIBILITY STUDY



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Department of
Natural Resources and Parks
Wastewater Treatment Division

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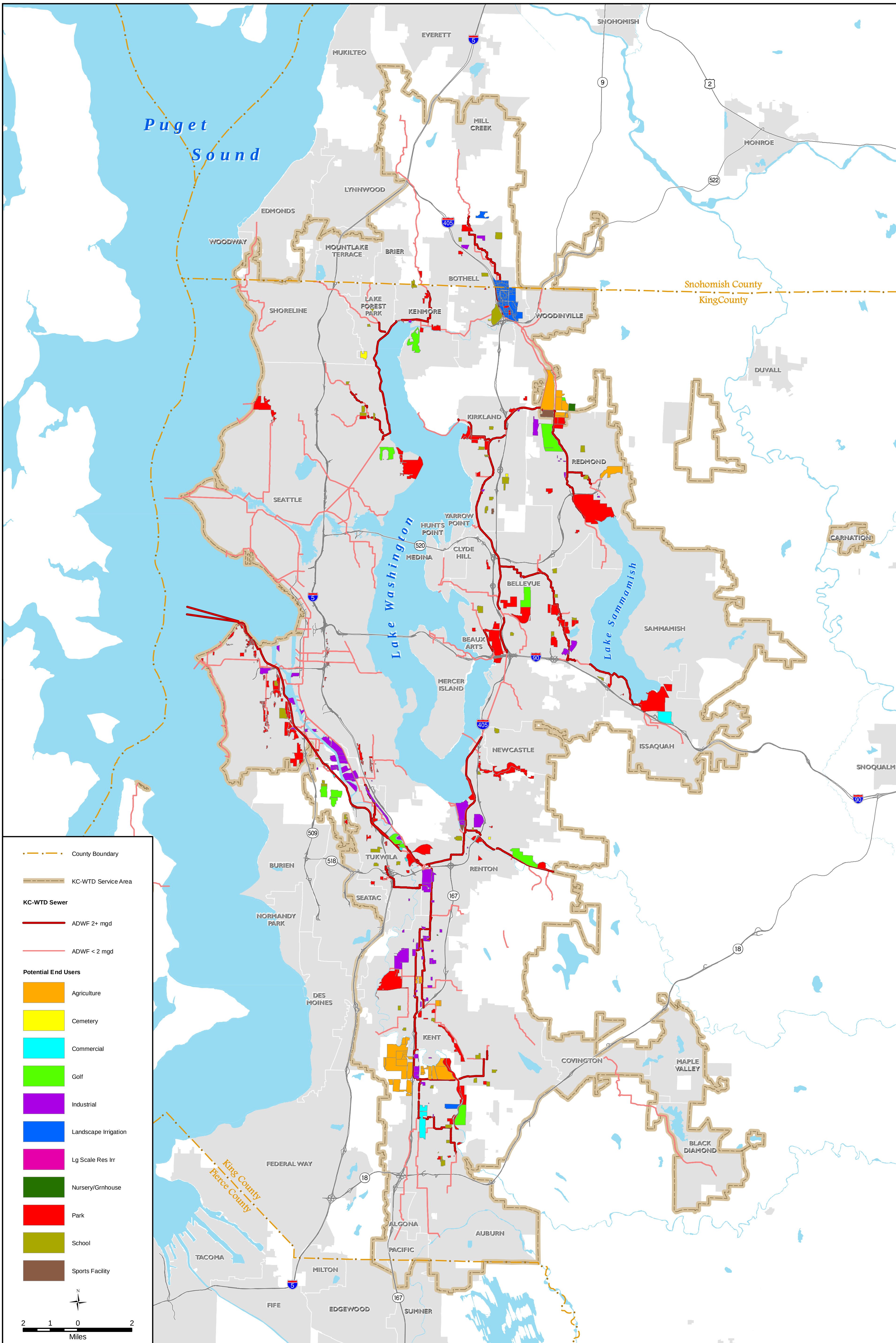
Data Source: King County

Figure 7 - 2

Potential Reclaimed Water Users In and Near King County's Service Area

RECLAIMED WATER FEASIBILITY STUDY



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Data Source: King County

Figure 7 - 3

Potential Reclaimed Water Users Within 3000 Feet of Reclaimed Water Sources

RECLAIMED WATER FEASIBILITY STUDY

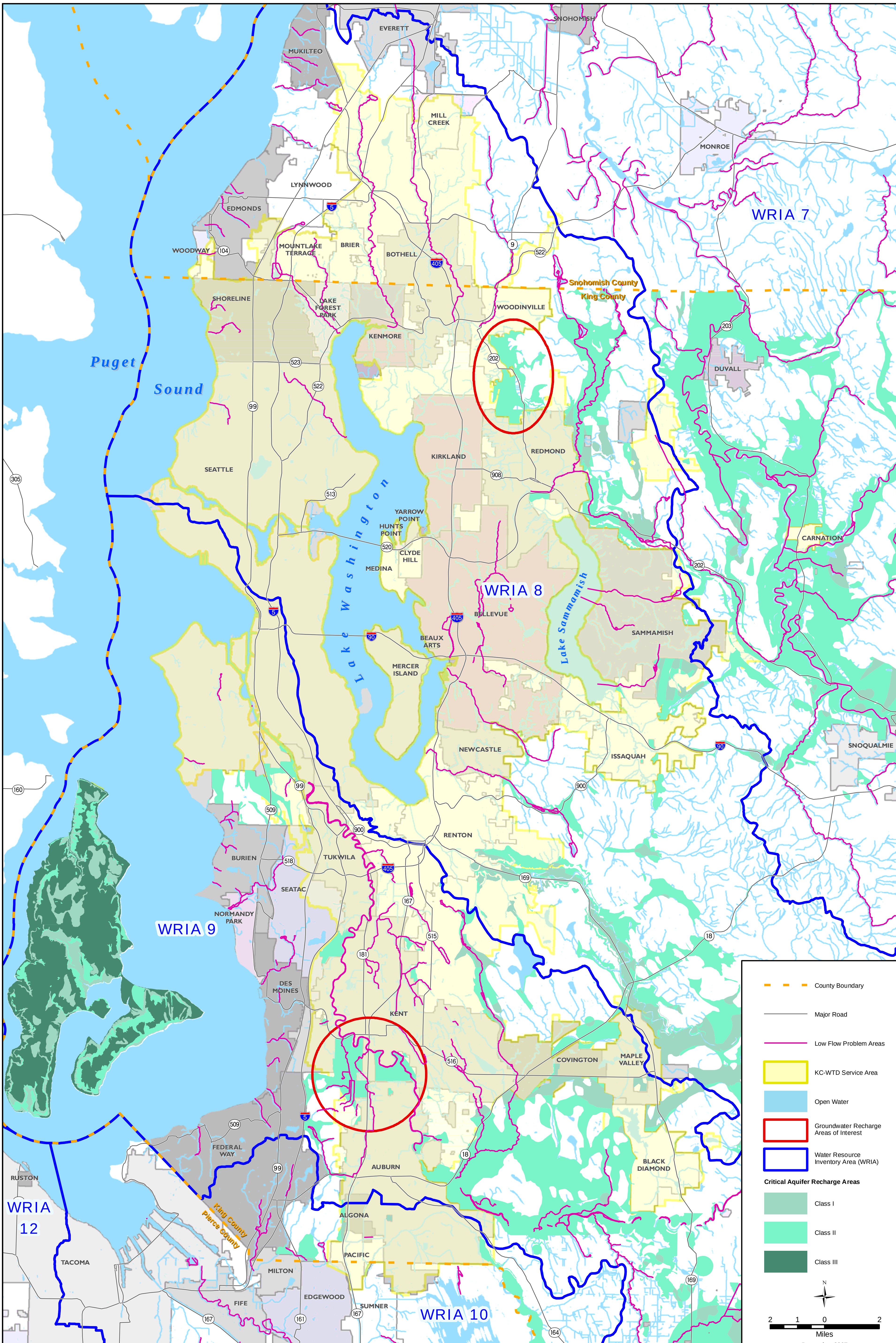

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Figure 7 - 4

Potential Reclaimed Water Use Areas Based on Critical Groundwater Recharge Areas and Flow-Limited Streams

RECLAIMED WATER FEASIBILITY STUDY

Chapter 8

Business Plan for King County’s Existing and Near-Term Reclaimed Water Program

This chapter responds to the direction in Water Reuse Policy 2 (WRP-2) that calls for a comprehensive financial business plan, including tasks and schedule for the development of a water reuse program and a process to coordinate with affected tribal and local governments, the state, and area citizens.

After describing the Wastewater Treatment Division’s (WTD) reclaimed water program and its goals, the business plan in this chapter presents activities for the next three to four years that will support existing reclaimed water production at the West Point and South Treatment Plants and the development of programs at the Brightwater and Carnation Treatment Plants. The plan concludes with an outline of interim financial strategies.

This feasibility study has provided useful methods for analyzing reclaimed water projects more systematically and has enabled the program to focus more on the areas where there is the greatest potential to implement feasible projects. But the scope of the study and the amount of time during which it had to be completed did not enable WTD to develop a comprehensive financial business plan. Much more work needs to be done to achieve this objective.

In January 2008, WTD will initiate a formal comprehensive planning process for reclaimed water. The process will identify and evaluate policy, economic, environmental, and technical issues. The resulting reclaimed water comprehensive plan will define the business plan beyond 2010.

8.1 Existing Reclaimed Water Program

King County’s South Treatment Plant in Renton has a reclaimed water production facility with a capacity of 1.3 mgd. Reclaimed water produced at the plant is used onsite for treatment processes and offsite by the City of Tukwila. A reclaimed water permit issued by the Washington State Department of Ecology (Ecology) governs offsite uses of the water. The reclamation plant (sand filters) was installed as a pilot project in 1997 and was subsequently converted into a permanent facility. While some operational improvements are under way, an assessment of the facility to determine its remaining functional life and capacity will be completed in 2008.

The West Point Treatment Plant in Seattle also produces reclaimed water. Because the current permit for West Point does not include offsite transportation of reclaimed water, use is limited to onsite uses at the plant..

The Brightwater Treatment Plant, under construction near Woodinville, will use membrane bioreactor (MBR) technology to treat wastewater to a high standard. The effluent resulting from MBR treatment will meet Washington State standards for Class A reclaimed water. Starting in 2011, approximately 7 mgd (millions gallons per day) of reclaimed water will be available from Brightwater as a resource for irrigation and industrial uses. The first identified customer for the water is Willows Run Golf Course south of the plant. King County has an existing agreement with Willows Run for use of reclaimed water from the Brightwater plant.

The wastewater treatment plant under construction in the City of Carnation will be operational in 2008. Also using MBR technology, the highly treated water will meet Class A reclaimed water standards and will be beneficially used for enhancement of an existing wetland near the Snoqualmie River. The enhanced wetland is currently the only reclaimed water project associated with this facility. Potential future projects include irrigation of a tree farm adjacent to the plant, but no facilities or plans are in place at this time to accommodate this use.

8.2 Reclaimed Water Program Goals

The current reclaimed water program is guided by the policies in the Regional Wastewater Services Plan (RWSP), by direction in executive orders to reduce global warming, and by guidance provided in Chapter 90.46 RCW. WTD's mission and vision are consistent with this guidance and direction:

Mission: Protect public health and the environment by treating and reclaiming water, recycling solids, and generating energy.

Vision: Creating resources from wastewater.

From the mission and vision, the following goals and objectives have been developed for the reclaimed water program:

Reduce discharges from wastewater treatment plants and beneficially use treated wastewater as a resource.

Maximize the production of reclaimed water at King County's wastewater plants.

- Successfully complete projects already in implementation.
- Identify the beneficial uses of reclaimed water that can address the most important water resource needs within the regional wastewater service area.
- Continue to establish reclaimed water projects under current RWSP planning policies until a reclaimed water comprehensive plan is completed.

Ensure production of sustainable and safe supply for customers.

- Maintain regulatory compliance in production.
- Provide training for all users in safe and effective use of reclaimed water.

Earn trust and confidence from regulators and customers.

- Ensure regulatory compliance in field applications.
- Provide public information and technical support.
- Partner with state universities to answer specific questions and to provide targeted research and demonstration in support of customers and projects.

Promote a cooperative regional approach.

- Obtain the input and support of component agencies, water purveyors, tribes, the state Departments of Ecology and Health, environmental stakeholder groups, and the public for a regional reclaimed water program.
- Pursue interlocal construction agreements where desirable and feasible.
- Determine the most efficient means of producing and delivering reclaimed water to identified customers.

8.3 Reclaimed Water Work Plan

The reclaimed water work plan outlined in Table 8-1 supports the goals described in the previous section. Some projects included in Table 8-1 must be evaluated prior to implementation. RWSP WRP- 5 will guide the evaluation and approval process of new reclaimed water projects that require major capital funding. The policy reads as follows:

> **WRP-5**: King County shall implement nonpotable projects on a case-by-case basis. To evaluate nonpotable projects, King County shall develop criteria which will include, but are not limited to: capital, operation and maintenance costs; cost recovery; potential and proposed uses; rate and capacity charge impacts; environmental benefits; fisheries habitat maintenance and enhancement potential; community and social benefits and impacts; public education opportunities; risk and liability; demonstration of new technologies; and enhancing economic development. A detailed financial analysis of the overall costs and benefits of a water reuse project shall include cost estimates for the capital and operations associated with a project, the anticipated or existing contracts for purchases of reused water, including agricultural and other potential uses, anticipated costs for potable water when the project becomes operational; and estimates regarding recovery of capital costs from new reused water customers versus costs to be assumed by existing ratepayers and new customers paying the capacity charge. Water reuse projects that require major capital funding shall be reviewed by RWQC and approved by the council.

Table 8-1. Reclaimed Water Work Plan

Project	General Description	Tasks	Schedule
Reclaimed Water Comprehensive Plan	Work with local, state, federal, tribal, and business stakeholder groups to identify and prioritize water resource needs and the range of beneficial uses that can be met through the production, delivery, and use of reclaimed water within the regional wastewater service area. Such uses will include those identified by stakeholders to supplement or mitigate increasing demands for water, and uses to improve degraded environmental conditions in the region. The process will also take into account the projects that are determined to be the most feasible.	• Develop and initiate a public involvement/input plan • Form external stakeholder's advisory committee • Identify reclaimed water plan alternatives for analyses • Conduct policy, technical, operational, financial, and environmental analyses of alternatives • Develop a draft comprehensive reclaimed water plan based on analytical results • Circulate draft plan to stakeholders, decision-makers, and public for review and comment • Finalize plan based on review and comment • Submit plan to King County Council for review and approval	2008–2010
Brightwater			
Brightwater/ Sammamish Valley	Continue to identify and work with potential reclaimed water customers that would be served by the south leg of the Brightwater reclaimed water backbone. Address concerns and needs.	• Identify customers and execute use agreements	2008–2011
City of Bothell reclaimed water project	Work with the City of Bothell on supplying reclaimed water to business park areas and other locations	• Assist with state grant applications for feasibility analysis • Assist with feasibility analysis for reclaimed water distribution lines in Bothell • Provide construction specifications for reclaimed water agreements • Negotiate agreements for the use of abandoned pipelines for reclaimed water pipelines • Assist with customer outreach and education	2008–2011

Project	General Description	Tasks	Schedule
Willows Run Golf Course	(1) Ensure compliance with the Ecology water rights change for use of Sammamish River (2) Coordinate with Willows Run to ensure a smooth startup and operating program for reclaimed water	• Maintain Sammamish River monitoring Web site, including monitoring and calibration of flow meter for the Sammamish River • Provide construction standards guidance for onsite system • Coordinate with Willows Run on pipe construction, startup, operational planning, and customer related issues • Modify water rights as necessary • Provide public outreach support and information	2008–2011
60 acres North and South	Evaluate feasibility of providing reclaimed water to parcels	• Prepare engineering report • Conduct financial and policy analysis	2008–2011
Sammamish Valley agriculture	Work with farmers regarding the provision of reclaimed water in place of river withdrawals	• Prepare engineering report • Conduct financial and policy analysis	2008-2011
Carnation			
Carnation plant	Provide technical assistance for permitting and monitoring to ensure smooth startup and transition to wetland discharge	• Obtain water reuse permit from Departments of Ecology and Health for wetland discharge • Coordinate with startup and operations teams • Conduct post-construction monitoring of Class A reclaimed water at the plant and wetland • Provide public outreach support and information	2008-2012
South Plant			
South plant	Coordinate with reclaimed water operations staff	• Assess sand filter plant • Coordinate a demonstration program for reclaimed water using the small greenhouse at South plant	2008
City of Tukwila	(1) Continue providing reclaimed water, technical support, and training. (2) Extend contract and add new user (Foster Golf Links)	• Complete interlocal agreement • Provide public information and communication materials for Foster Golf Links • Coordinate construction of Foster Golf Links reclaimed water line • Coordinate turf grass research and provide information to city	2008

Project	General Description	Tasks	Schedule
South County Agencies	Coordinate with Kent, Auburn, and other south county cities to explore reclaimed water possibilities	• Jointly review studies • Provide reports and technical information as requested	2008
Covington Water District	Work with district to explore reclaimed water options during evaluation of wastewater service delivery options	• Implement provisions of the memorandum of understanding with the District • Initiate feasibility study in partnership with District	2008–2010
City of Black Diamond	Work with city to explore reclaimed water options	• Meet with city and others to explore options for reclaimed water • Provide technical information • Coordinate with storage tank design team to explore options	2008–2010
Green Valley Demonstration project	Work with the agriculture community and King Conservation District	• Install a demonstration garden in the Green River Valley with selected farmers who want reclaimed water trucked from the plant	2008–2009
City of Renton and Boeing	Continue to work with the City of Renton and Boeing for reclaimed water use at Boeing Administration Building	• Develop demonstration irrigation project at the Boeing administrative offices • Track and review project status	2008
General Program Activities			
Research and demonstration	Address customer questions about safety and health	• Work with University of Washington, Washington State University, and other organizations to develop and implement research studies • Apply for grants and solicit partners to leverage funds • Develop demonstration program at South plant greenhouse	2008–2011
Legislative and regulatory initiatives	Represent King County in development of state rules and standards for reclaimed water	• Participate in Rule Advisory Committee and task forces • Attend water planning activities	2008–2010
Peer and professional information sharing	Participate in professional organizations and technical conferences	• Participate in developing local and regional workshops on reclaimed water • Attend technical conferences	2008–2010
Public outreach and education	Develop educational and outreach materials for reclaimed water	• Develop a public outreach and education plan • Plan outreach activities such as the Flower and Garden Show and other events	ongoing

Project	General Description	Tasks	Schedule
Water conservation	Work with the Saving Water Partnership on water conservation in King County Facilities	• Assess water use data • Meet and work with Facilities Management on methods of conservation including fixture retrofit	2008–2009
Stakeholder coordination	Develop a process to coordinate with affected tribal and local governments, the state, and area citizens	• Hold meetings, write correspondence. and use other methods to build relationships, exchange information, and coordinate activities	2008

8.4 Financial Aspects of Existing Program

This section discusses current staffing for King County's existing reclaimed water program. It also presents current and projected revenues from sales of reclaimed water from South Plant. Projections of revenues for the Brightwater Reclaimed Water System can be found in the draft white paper for the Brightwater backbone (King County, 2006).

8.4.1 Staffing

The reclaimed water program will focus primarily on customer support and development for South plant and Brightwater reclamation facilities. Over the next few years, staff will work to identify potential users along the Brightwater distribution system. Staff will also be involved in the process to develop the reclaimed water comprehensive plan.

A small core team of employees is assigned to the reclaimed water program. Portions of other FTEs are matrixed to the program as needed for specific tasks such as community involvement. Additional resources will be allocated on an as-needed basis.

8.4.2 Reclaimed Water Revenues from South Plant

The current reclaimed water program at South plant includes sales of reclaimed water to the City of Tukwila. The city irrigates Fort Dent Park, an active and popular sports complex. An interlocal agreement between the county and city sets the reclaimed water rate at 80 percent of the current wholesale water rate that the city pays to Seattle Public Utilities. Table 8-2 shows the revenue generated for 2005 and 2006. All charges are levied using the typical unit of measure: one hundred cubic feet (ccf).

Table 8-2. Annual Revenue from South Plant Reclaimed Water Used at Fort Dent Park, City of Tukwila (2005–2006)

Year	ccf	Average Rate	Total Sales
2005	4,585	$1.0419	$4,777
2006	5,145	$1.1425	$5,878

In 2008, the county and the city will partner to install a reclaimed water line to Foster Golf Links. Currently, the city irrigates Foster Golf Links with water from the Green River, using a valid water right. Table 8-3 shows the potential revenue that would be generated from serving Foster Golf Links based on charging 80 percent of the wholesale water rate as described above. A new interlocal agreement and construction agreement will be completed in early 2008.

Table 8-3. Annual Potential Revenue from South Plant Reclaimed Water Used at Foster Golf Links (2008–2011)

Year	Projected Revenue [a]	Estimated Annualized Cost	Projected Net Revenue
2008	$75,600	$64,400	$11,200
2009	$75,600	$64,400	$11,200
2010	$75,600	$64,400	$11,200
2011	$75,600	$64,400	$11,200

[a] Revenue projection is based on assumed sale of reclaimed water at 80 percent of applicable potable rate. The revenue forecast does not include possible increases in revenue that may arise from potential increases in the rate charged for potable (and/or reclaimed) water.

8.5 References

King County, Department of Natural Resources and Parks. 2006. *Reclaimed Water Backbone Project.* (Draft white paper, version 3.0). Seattle, WA.

Chapter 9

Next Step: Reclaimed Water Comprehensive Plan

The next step in the process of determining how, when, and where reclaimed water produced from the regional wastewater system should be used in our region is to develop a comprehensive reclaimed water plan. The focus of the plan will be to identify all potential uses for reclaimed water in the region, including methods for enhancing the natural environment through the production, distribution, and beneficial use of reclaimed water. Beneficial uses will likely include groundwater recharge, wetlands enhancement, streamflow augmentation, and nonpotable water supply. Preparation of the plan will allow for review and possible revision of existing Regional Wastewater Services Plan policies that guide the development of reclaimed water for the region. Depending on the results of stakeholder input and of policy, operational, financial, and environmental analyses, the plan will also include a specific set of projects to be explored and a comprehensive financial and business plan that will guide the reclaimed water program in the future.

In order for the plan to be supported and implemented regionally, it will be important to engage all interested stakeholders during the entire planning process. A reclaimed water advisory committee will be formed at the outset of the process. The committee will consist of representatives of diverse interest groups including state regulatory agencies, individuals with experience in regional governance, tribal governments, environmental organizations, city governments, water utilities, wastewater utilities, agriculture, and business and industry. The function and role of the advisory committee will be to provide input and to review major components of the plan. At a minimum, members will identify key issues from various stakeholder groups, provide input on uses for reclaimed water in the region, identify project goals to guide the planning process, provide input for the development of criteria for evaluating reclaimed water project alternatives, provide input on methods of financing projects, and review and provide input on plans for informing and involving the public throughout the planning process.

The general scope of the reclaimed water comprehensive plan is expected to be as follows:

- Identification and prioritization of water resource needs and the range of authorized beneficial uses that can be met through the production, delivery, and use of reclaimed water in the region. Such uses will likely include uses to improve degraded environmental conditions in the region as well as those identified by stakeholders to supplement or mitigate increasing demands for water. It will also include identification of ways that reclaimed water may be integrated into larger regional initiatives and priorities, such as restoring Puget Sound and adapting to climate change.
- Identification and analysis of alternative approaches to producing and delivering reclaimed water to meet identified beneficial uses. The principal alternatives will include

centralized treatment and distribution, decentralized treatment and distribution (satellite/skimming plants), and decentralized polishing treatment (for example, along the Effluent Transfer System that transports treated water from South plant to Puget Sound).

- Analysis of issues related to all identified production and delivery alternatives. Major issues to be analyzed will include environmental, regulatory/legal, social, financial, technical, and managerial. The financial analysis will include ways of financing the production and distribution of reclaimed water.
- Conducting an environmental assessment of all alternatives.
- Identification of likely feasible projects to be pursued.
- Completion of a long-term financial and business plan.

Currently, development of a draft reclaimed water comprehensive plan that reflects the input of all stakeholders is expected to take the remainder of 2008 and all of 2009 to complete. In 2010, the draft plan will be reviewed by stakeholders, then finalized to address all comments and input received. It is expected that a final plan will be transmitted to the King County Council for its consideration in the second half of 2010.

Glossary

acre-foot	The volume of water needed to cover one acre with water one foot deep. Equals 325,851 gallons of water. An acre-foot serves the approximate annual water needs for four typical urban households.
activated sludge	Wastewater solids that have been aerated and subjected to decomposition by bacteria and other microorganisms.
aquifer	A geologic formation of saturated permeable material underlain by impermeable material that is capable of storing significant quantities of water.
average dry-weather flow (ADWF)	The average non-storm related wastewater flow between May and October, expressed on a per day basis. Composed of the average base flow and the average infiltration/inflow (I/I).
average wet-weather flow (AWWF)	The average flow between November and April on days when no rainfall has occurred on the previous day. Composed of the average base flow and the average infiltration/inflow (I/I).
backbone	the primary or main lines of a water or reclaimed water distribution system. See Brightwater Reclaimed Water System.
base flow	Wastewater flow (not including inflow and infiltration) originating from residential, commercial and industrial sources. Also refers to the component of streamflow that that comes from groundwater (as opposed to surface runoff).
beneficial use	The use of reclaimed water, which has been transported from the point of production to the point of use without an intervening discharge to waters of the State, for a beneficial purpose.
benefit-cost analysis	A systematic process of quantifying and evaluating the economic advantages (benefits) and disadvantages (costs) of a proposed project and a set of alternatives.
biosolids	A nutrient-rich organic material that results from the biological treatment of wastewater and is suitable for recycling as a soil amendment and fertilizer. Under Washington Administrative Code, biosolids refers to sewage sludge that has been treated to meet standards so that it can be applied to the land.
biochemical oxygen demand (BOD)	The amount of oxygen required by microorganisms to decompose organic wastes. BOD is often used to indicate the impact of a discharge such as effluent on receiving waters.

blending	A technique of managing excess wet weather flows by diverting them from secondary treatment and recombining them with treated wastewater before discharging. The goal is a blended effluent that meets all relevant water standards.
Brightwater Reclaimed Water System (BWRW)	The system of purple pipes that delivers reclaimed water from Brightwater Treatment Plant closer to users. Because additional local distribution pipes will be needed to deliver reclaimed water directly to users, the original west and south legs of the system were referred to as the "Brightwater Backbone". The west leg of the BWRW system is located in the Brightwater effluent conveyance tunnel; the south leg is a converted wastewater pipeline that can convey reclaimed water to the Sammamish Valley.
Class A reclaimed water	Reclaimed water that meets the highest quality standards under a tiered (Class A, B, C, D) Washington State classification system. Class A reclaimed water has no restrictions for non-potable application, and can be used for recreational and agricultural irrigation, wetland restoration and enhancement, and ground-water recharge.
coliform bacteria (fecal coliform)	Bacteria found in the intestinal tracts of mammals. The presence of high numbers of fecal coliform bacteria in a water body can indicate the recent release of untreated wastewater and/or the presence of animal feces. These organisms may also indicate the presence of pathogens that can be harmful to humans.
conveyance	The systematic and intentional flow or transfer of water from one point to another. In wastewater applications, conveyance includes the system of pipes, pumps and other facilities that move wastewater.
cubic feet per second (cfs)	A rate of flow equal to a volume of water one foot high and one foot wide flowing a distance of one foot in one second. One cfs is equal to 7.48 gallons of water flowing each second.
denitrification	Bacterial reduction of nitrate/nitrite to gaseous nitrogen under anaerobic conditions. Results in removal of nitrate and nitrate products from water to achieve water quality standards.
direct potable reuse	Use of reclaimed water as a drinking water supply; not authorized under Washington State reclaimed water standards.
discharge	The release of treated or untreated wastewater into the environment.
disinfection	Destruction of pathogens. Wastewater treatment plants often use ultraviolet light or chemicals to disinfect effluent.
effluent	Water that flows from a sewage treatment plant after treatment.

endocrine disrupting chemicals (EDCs)	Any natural or synthetic chemical that interferes with or mimics the hormones that are responsible for the maintenance, reproduction, development and/or behavior of an organism.
flocculation	The process by which fine particles in water or wastewater are made to clump together into larger masses. Often conducted prior to clarification and/or filtration in the wastewater treatment process.
framework	See WateReuse Economic Framework
groundwater	All water that exists beneath the land surface or beneath the bed of any stream, lake or reservoir, or other body of surface, whatever may be the geological formation or structure in which such water stands or flows, percolates or otherwise moves (RCW 90.44).
groundwater injection	Introduction of water directly into a groundwater aquifer.
groundwater recharge	The process of adding water back into an aquifer in order to replace water withdrawn or otherwise gone from the aquifer; can occur naturally (via precipitation or flow from other nearby water sources) or artificially (by spreading and percolation, or by injection).
hydrologic cycle	The natural recycling process that causes water to fall to the earth as rain or snow, travel as surface or ground water, and eventually evaporate to the atmosphere where it subsequently condenses and returns to earth as precipitation.
industrial water use	Water used for industrial purposes such as fabrication, processing, washing, cooling or mixing.
infiltration	The water that enters a wastewater conveyance system from the ground through means such as corroded or broken pipes, pipe joints, pipe connections from storm sewers or combined sewers, catch basins, and surface runoff.
infiltration/inflow (I/I)	The total quantity of water from both infiltration and inflow without distinguishing the source.
infiltration rate	The rate at which water will descend into and through soil.
inflow	The water discharged into a wastewater system from sources such as roof leaders, yard and area drains, foundation drains, cooling water discharges, drains from springs and swampy areas, manhole covers, cross connections from storm sewers and combined sewers, catch basins, surface runoff, and street wash waters.
influent	Water or wastewater entering a treatment plant.

instream flow	A numeric standard or volume of water that is adopted in rule that specifies the amount of water needed at a particular place in a river or stream and is seasonally adjusted. It reflects the amount of flow needed to sustain instream values (e.g., fish and wildlife habitat, recreation, and aesthetics).
integrated resource planning (IRP)	A planning approach that considers simultaneous consideration of all processes that affect a resource or resources.
irrigation	The controlled application of water through manmade systems to supply the water requirements of crops or vegetation that are not satisfied by rainfall or naturally occurring subsurface supplies.
membrane bioreactor (MBR)	A wastewater treatment system that combines ultra-filtration technology with biological treatment to produce treated water that meets the state's Class A standards for reclaimed water.
National Pollutant Discharge Elimination System (NPDES)	Defined in Section 402 of the federal Clean Water Act. It prohibits the discharge of pollutants into navigable waters of the United States unless a special permit is issued by the U.S. Environmental Protection Agency, a state, or a tribal government. These permits are referred to as NPDES permits and, in Washington State, are administered by the Washington State Department of Ecology.
nearshore marine environment	A habitat for fish, shellfish, and other marine life that extends from the riparian zone through the intertidal (area within the tidal exchange) and subtidal (area below low tide) habitats.
nitrification	The process where ammonia in wastewater is oxidized to nitrate by microorganisms.
non-potable water	Any water, including reclaimed, not meeting federal, state and local drinking water standards.
nephelometric turbidity unit (NTU)	Unit of measure for the cloudiness of water, or turbidity, based on the amount of light reflected off particles in the water.
osmosis	Diffusion of fluid through a semi-permeable membrane until concentration of solutes is equal on both sides of the membrane.
outfall	The outlet or structure through which treated effluent is discharged to a receiving water body.
peak demand	Maximum amount of water use during an identified period of time; typically refers to the amount of water delivered during peak water use times, such as hot summer days when domestic customers are using water to irrigate lawns.
peak flow	The highest base flow and infiltration/inflow expected to enter a wastewater system during wet weather at a given frequency that the treatment plant is designed to accommodate.

potable water	Water suitable for human consumption.
purple pipe	The nationally-recognized color used for reclaimed water distribution lines and conveyance systems to distinguish from potable water lines.
Raucher economic framework	See WateReuse Framework
recharge	Replenishment of groundwater by the addition of water, such as rainfall that soaks into the ground, or through artificial sources and means (e.g., groundwater injection). The surface where water soaks into the ground is called the recharge area.
reclaimed water	Effluent derived in any part from sewage from a wastewater treatment system that has been adequately and reliably treated, so that as a result of that treatment, it is suitable for a beneficial use or a controlled use that would not otherwise occur and is no longer considered wastewater (RCW 90.46.010).
reverse osmosis	A treatment process that separates water from impurities by using pressure to force water through a semipermeable membrane that retains impurities on one side while allowing pure water to pass to the other side.
riparian, riparian zone	A transition area between aquatic and terrestrial environments. The microclimate, soil and vegetation are typically influenced by both surface water and groundwater.
runoff	Water that travels over the surface of the earth and generally discharges to a body of water.
sand-filtered	A method of moving water through sand to remove suspended solids from the water.
satellite reclamation facility	Small reclaimed water plants located close to the point of use of reclaimed water, using relatively small amounts of water from wastewater collection pipelines, thereby avoiding the costs to convey reclaimed water from regional wastewater treatment plants.
seawater intrusion	The movement of salt water into a body of fresh water; it can occur in either surface water or groundwater basins.
self-supplier	A water user who withdraws water from a surface or ground source rather than obtaining it from a water utility.
snowpack	The natural winter accumulation of snow in mountain areas that usually melts during warmer months. Some water utilities use captured snowmelt as a potable water source.

source exchange	Utilization of an alternate source of water supply to reduce, discontinue, or temporarily rest an existing source of supply, allowing the previously withdrawn water to flow to the natural system for instream flow benefit.
stranded costs	In general, costs incurred that cannot be recouped. Costs (often debt service) faced by a utility because of past investments in infrastructure made to serve anticipated ratepayer needs, but for which the capital investments become unused (or used at less than anticipated levels) due to an unanticipated reduction in demand.
streamflow	The main mechanism by which water moves naturally from uplands to the oceans, transporting sediment, nutrients and other materials downstream.
streamflow augmentation	The discharge of reclaimed water to rivers and streams of the state or other surface water bodies (not wetlands) for environmental enhancement.
sustainable development	Development that ensures that the management and use of resources today does not restrict their use by future generations.
tertiary treatment	Any advanced treatment of wastewater that goes beyond the secondary or biological treatment stage and includes the removal of nutrients such as phosphorus and nitrogen and a high percentage of suspended solids.
treatment plant	A facility designed to receive wastewater from residential, business and industrial sources and treat it by removing biochemical oxygen demand, suspended solids, pathogens and inorganic solids.
total maximum daily load (TMDL)	A calculation of the maximum amount of a single pollutant, summed from point and non-point sources, that a water body can receive without violating water quality standards.
total suspended solids (TSS)	A measure of the concentration of particles suspended in water. Suspended solids reduce the amount of light that penetrates the water and can clog the gills of fish and aquatic invertebrates. The wastewater treatment process uses a number of techniques to settle out and remove suspended solids before discharge.
turbidity	Cloudiness or opacity in a liquid caused by solid particles and other matter in suspension.
ultraviolet disinfection	A means to disinfect treated wastewater prior to discharge or reuse. Ultraviolet light penetrates the cells of microorganisms and destroys their ability to reproduce.
water impoundment	A body of water confined by a dam, dike, floodgate or other barrier used to collect and store water for future use.

WateReuse Economic Framework	A process, developed by Dr. Robert Raucher for the WateReuse Foundation, through which to identify, assess, and compare the full range of benefits and costs of a water reuse project. The type of benefit-cost analysis (BCA) embodied in this economic framework embodies both qualitative and quantitative benefits and costs, including externalities.
water right	A legal authorization to use a certain amount of public water for specific beneficial use or uses.
watershed	The total land area from which water drains or flows to a body of water.
wetlands	Land with saturated soils that are at least periodically inundated and that under normal conditions support vegetation suited to such environments. Wetlands include swamps, marshes, and bogs.
wetland enhancement	Actions taken to intentionally improve wetland functions, processes and values.
withdrawal	Water removed from the ground or diverted from a surface-water source for use.

Appendices (available on CD in back of report)

A. Washington Reuse Class Standards
B. Comparison of Reclaimed Water Regulations and Standards for Selected Sites
C. Examples of Developing Technologies in Use (CA, NV, AZ, FL, CO)
D. Developing Reuse Technologies
E. Washington Case Studies
F. Construction Costs for Treatment Technologies
G. Summary of UV Sizing and Cost Tool
H. 2005 Annual Survey of Wholesale Customers: Summary of Results, Seattle Public Utilities
I. Out of State Case Studies
J. Summary of Case Studies
K. Stakeholder Program Summary

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