Reclaimed Water Strategy Effects on Lakes, Streams and Rivers

WORKING DRAFT

March 2012

King County

Department of
Natural Resources and Parks
Wastewater Treatment Division

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Table of Contents

Tables

Figures

EXECUTIVE SUMMARY

King County is considering using reclaimed water to enhance and create wetlands and, thereby, to indirectly augment streamflows. This document presents an evaluation of the potential effects on the quality and quantity of water in lakes, streams, and rivers from using reclaimed water for these environmental enhancement wetland projects.

This report was prepared to support development of a Reclaimed Water Comprehensive Plan for King County's Wastewater Treatment Division (WTD). The purpose of the Reclaimed Water Comprehensive Plan is to determine if, how, when, where, and by what funding mechanisms King County's existing reclaimed water program should expand over the next 30 years, through 2040 and beyond.

This report is part of a series of reports that document efforts to further define and evaluate three reclaimed water strategies developed and approved earlier in the reclaimed water planning process. The following sections describe the three reclaimed water strategies under consideration; the areas considered for wetland environmental enhancement; the objectives, methods, and findings of this evaluation; and recommendations for further study if King County were to implement any of the environmental enhancement wetland projects.

Reclaimed Water Strategies

Each reclaimed water strategy represents a concept for producing and supplying reclaimed water to serve potential uses identified during the reclaimed water planning process. The uses include both non-potable consumptive uses (irrigation, commercial, industrial) and environmental enhancement uses (wetland enhancement or creation and associated indirect groundwater recharge and/or streamflow augmentation). The following are brief descriptions of the strategies:

- **Redmond/Bear Creek Basin Brightwater Centralized Strategy.** Reclaimed water would be produced through the membrane bioreactor (MBR) process at the Brightwater Treatment Plant for distribution to two areas—one in the immediate vicinity of the plant and one farther south above Lake Sammamish—via new pipelines connected to the South Segment of the Brightwater reclaimed water pipeline.
- **Renton/Tukwila South Plant Centralized Strategy.** Reclaimed water would be produced through expansion of the South Treatment Plant's tertiary sand filtration system for distribution to an area just south of Lake Washington via extension of an existing pipeline that delivers reclaimed water to the City of Tukwila.
- **Reclaimed Water Skimming or Polishing Decentralized Strategy.** This strategy represents opportunities for smaller-scale reclaimed water implementation. Infrastructure was constrained to a single treatment plant of up to 0.5 million gallons per day (mgd) capacity and up to 1 mile of reclaimed water pipeline. Three potential areas and configurations—two in Seattle and one in the Green River Valley—have been identified to help define the decentralized strategy.

Wetland Enhancement Areas in the Strategies

Four potential Areas of Interest (AOIs) are being considered for wetland enhancement through introduction of Class A reclaimed water, which is the highest standard of reclaimed water in the State of Washington. Three of the AOIs are part of the Redmond/Bear Creek Basin Brightwater Centralized Strategy, and one is part of the Renton/Tukwila South Plant Centralized Strategy. No wetland enhancement uses were identified for the Reclaimed Water Skimming or Polishing Decentralized Strategy.

Four potential areas considered for wetland enhancement were identified by King County and were analyzed for this report. They include the following Areas of Interest (AOIs):

- Crystal Lake, an approximately 130-acre wetland adjacent to the north shore of Crystal Lake in Snohomish County.
- Cottage Lake, an approximately 129-acre wetland in the Cold Creek Natural Area, west of Cottage Lake in King County.
- Sammamish River/Lake Sammamish, an approximately 154-acre site in Marymoor Park with two potential subareas: Area A, 54 acres of wetlands west of the Sammamish River, and Area B, 100 acres of wetlands at the north end of Lake Sammamish.
- Cedar River, an approximately 30-acre area located on a terrace along the south side of the Cedar River in Renton approximately 1.9 miles from the Cedar River discharge to Lake Washington. This area is being considered as a potential location for creation of a 16-acre wetland using reclaimed water.

Two potential reclaimed water enhancement scenarios, a 7-month and a 12-month duration scenario, are considered for the Crystal Lake, Cottage Lake, and Sammamish River/Lake Sammamish sites. Only a 12-month scenario is considered for the Cedar River site.

Objectives and Methods

This report provides a preliminary evaluation of the feasibility of applying reclaimed water to the areas proposed for wetland enhancement. The analysis is based on existing information and is presented and compiled to help address the following questions regarding the reclaimed water strategies:

- How will the strategy alter freshwater quality and quantity in lakes, streams, and rivers?
- How will the strategy alter groundwater quality and quantity?
- What are the potential benefits or impacts to lake and stream biota including threatened and endangered species and their habitat?

Summary of Findings

This report addresses how flow and water quality of lakes, streams, and rivers could be altered within each strategy area and identifies potential effects of any alteration on aquatic biota. In general, each reclaimed water strategy would increase river and stream flow through the introduction of reclaimed water to wetland enhancement and constructed wetland projects. The quality of reclaimed water introduced to these wetlands would be altered as it passed through the wetland system. In the case of wetlands with a direct discharge to the stream or river system, the water temperature would be similar to the temperature of water exiting the existing wetlands since no major change in the depth or areal extent of the wetlands is proposed (King County 2012b). Other water quality characteristics of the wetland discharge would depend on a number of factors, including the quality of the reclaimed water introduced and the dilution and residence time of the reclaimed water in the wetland.

There is also a potential for seepage of a mixture of native wetland water and reclaimed water to shallow aquifers. The areas proposed for wetland enhancement generally occur on soils with low permeability. Therefore, it is expected that negligible amounts of diluted reclaimed water will infiltrate to shallow aquifers. There is also a potential for diluted reclaimed water to infiltrate from stream channels, particularly in summer, and enter shallow aquifers. However, regional streams are generally gaining rather than losing water to the shallow aquifer system and it is expected that negligible amounts of reclaimed water will infiltrate to shallow aquifers.

Redmond/Bear Creek Brightwater Centralized Strategy

Potential effects on lakes, streams, and rivers from the Redmond/Bear Creek Brightwater Centralized Strategy are as follows. This assessment suggests that wetland enhancement with reclaimed water has the potential to improve summer flow and aquatic habitat in Daniels, Cottage Lake and Bear creeks. The additional water provided to the stream has the potential to reduce daily maximum temperatures under critical summer conditions on the order of 0.5 to almost 1.8 °C. An increase in typical summer flows in the Sammamish River below the confluence with Bear Creek would also be expected. A reduction in maximum summer river temperatures would be expected as well, primarily as a result of reduced maximum temperatures in Bear Creek. However, the assessment of the potential effects of the input of additional nutrients suggests that uses of lakes, streams, and rivers by aquatic life may be affected by a decrease in dissolved oxygen. Lakes may be particularly sensitive to additional inputs of phosphorus since phytoplankton growth in local lakes is typically limited by this nutrient.

Year-round wetland enhancement use of reclaimed water is not likely to significantly increase flooding in designated flood hazard zones, although a more detailed hydraulic analysis could be performed to confirm this. In the upper watershed, particularly at NE 165th Street where the contributions from the Cottage Lake and Crystal Lake wetland enhancement projects would be combined, flooding that has been reported to result in road closures could be exacerbated. However, this type of flooding generally poses no significant economic risk or risk to public safety as alternative routes are available when the road is closed due to flooding.

Renton/Tukwila South Plant Centralized Strategy

Potential effects from the Renton/Tukwila South Plant Centralized Strategy are as follows. This assessment suggests that the effect on water quality of the Cedar River and Lake Washington from the creation of a wetland using reclaimed water will depend primarily on the removal of nutrients, primarily phosphorus and ammonia nitrogen, prior to release of water to the river. Ideally, the water released from the wetland would be allowed to infiltrate prior to release to the river to minimize potential adverse effects on river temperature and minimize the input of phosphorus to Lake Washington. Effects on summer and winter river flow and lake levels are not expected to be significant. If water released from the wetland is allowed to infiltrate into the ground, a detailed hydrogeologic study would be required to evaluate the potential effect of the project on groundwater quality, groundwater levels, and the stability of the floodplain terrace on which the wetland would be located.

Recommendations for Further Study

This assessment of the potential effects of the reclaimed water strategies on lake, stream, and river water quality and quantity is based on existing data, reports, and readily available water quality models. A more detailed assessment of the potential effects of these strategies on lake, stream, and river water quality and quantity could be conducted that would include:

- Hydraulic modeling of lakes and streams to better quantify the effect of additional water on lake levels and stream flood profiles
- Water quality modeling of lakes to quantify the potential effect of additional phosphorus input on algae growth and bottom water dissolved oxygen levels
- Water quality modeling of the Sammamish River to quantify the potential effect of the Redmond/Bear Creek Brightwater Centralized Strategy on river temperature

In addition to further evaluation specific to the proposed reclaimed water strategies, some broader issues may warrant further study. Efforts designed to support evaluation of environmental enhancement uses of reclaimed water in general include but are not limited to:

- Developing a framework to evaluate the fate and transport of trace contaminants in reclaimed water, including a human health and/or ecological risk assessment
- Developing a water quantity regulatory framework for streamflow augmentation (via direct discharge, wetland enhancement/creation, or indirect groundwater recharge)
- Developing a method to quantify the effect of improvements in stream flow (and temperature) into improvements in fish production and/or survival

Results of these broader efforts could, in turn, be used in more detailed investigation of one or more of the proposed reclaimed water strategies.

1.0. INTRODUCTION

King County is considering using reclaimed water to enhance and create wetlands and, thereby, to indirectly augment streamflows. This document presents an evaluation of the potential effects on the quality and quantity of water in lakes, streams, and rivers from using reclaimed water for these environmental enhancement projects. The evaluation was done as part of a comprehensive planning effort to better understand the potential for expanding the County's reclaimed water program through implementation of three reclaimed water strategies.

King County is considering wetland enhancement as a potential use for two of these strategies, the Redmond/Bear Creek Basin Brightwater Centralized Strategy and the Renton/Tukwila South Plant Centralized Strategy. The objective of the wetland enhancement component for both strategies is to improve the extent and quality of selected wetlands and the habitat they provide, within the limits imposed by the amount of available land, the quality and extent of existing wetlands, and the amount and timing of available reclaimed water. A separate document reports on an evaluation of the potential for using reclaimed water to enhance or create wetlands in these areas (King County 2012b). This document presents an evaluation of the wetland enhancement use with respect to effects on water quality and water quantity in lakes, streams, and rivers.

This chapter provides background information on the comprehensive planning process and reasons for analyzing the strategies. It then briefly describes the reclaimed water strategies, outlines the objectives of this evaluation, and describes the organization of this report.

1.1 Background

This report was prepared to support the development of a Reclaimed Water Comprehensive Plan for King County's Wastewater Treatment Division (WTD). The purpose of the Reclaimed Water Comprehensive Plan is to determine if, how, when, where, and by what funding mechanisms the County's existing reclaimed water program should expand over the next 30 years, through 2040 and beyond.

The work documented in this report was conducted as part of Step 4 of the reclaimed water planning process as amended and approved by the King County Council in May 2011. It is one of a series of reports that document efforts to define and analyze three reclaimed water strategies developed and approved earlier, during Step 3.[1] The results of these analyses will provide information on the following topics:

- Potential for use of reclaimed water to reduce reliance on Puget Sound for discharge of treated effluent.
- How reclaimed water strategies could fit into regional wastewater system planning and operations, including their effect on planned improvements and future operation of the regional wastewater system.

[1] More information on the reclaimed water comprehensive planning process is available at http://www.kingcounty.gov/environment/wastewater/RWCompPlan.aspx. More information on prior reclaimed water strategy development and identification is available at http://your.kingcounty.gov/dnrp/library/wastewater/rw/CompPlan/1012_RWCPStrategyReport.pdf.

- The ability to use small prepackaged or preassembled reclaimed water facilities to produce and distribute reclaimed water.
- The potential effects of reclaimed water strategies on the environment, including the following:
    - — Potential for reclaimed water to enhance watershed basin flows
    - — Effects of reclaimed water use on groundwater and surface water quality
    - — Effects of reclaimed water use on the built environment, including energy demands and greenhouse gas emissions
- Changes in existing laws and policies that may be needed in order to allow expanded use of reclaimed water.
- The full range of benefits and costs associated with providing additional reclaimed water to serve both nonpotable consumptive and environmental enhancement uses.

Throughout the development, definition, and analysis of the strategies, WTD applied County Council−approved evaluation criteria to assess how each strategy addresses the three drivers for the Reclaimed Water Comprehensive Plan—regional wastewater system planning, creating resources from wastewater, and protecting Puget Sound water quality.

The strategies were developed for planning and evaluation purposes only; they are not intended to necessarily represent any future reclaimed water improvement projects or any implied preference or commitment on the part of any interested parties or potential end users.

1.2 Description and Location of Strategies

Each reclaimed water strategy represents a concept for producing and supplying reclaimed water to serve potential uses identified during the reclaimed water planning process. The uses include both nonpotable consumptive uses (irrigation, commercial, industrial) and environmental enhancement uses (wetland enhancement and associated indirect groundwater recharge and/or streamflow augmentation). The following are brief descriptions of the strategies:

- **Redmond/Bear Creek Basin Brightwater Centralized Strategy.** Reclaimed water would be produced through the membrane bioreactor (MBR) process at the Brightwater Treatment Plant for distribution to two areas—one in the immediate vicinity of the plant and one farther south above Lake Sammamish—via new pipelines connected to the South Segment of the Brightwater reclaimed water pipeline.
- **Renton/Tukwila South Plant Centralized Strategy**. Reclaimed water would be produced through expansion of the South Treatment Plant's tertiary sand filtration system for distribution to an area just south of Lake Washington via extension of an existing pipeline that delivers reclaimed water to the City of Tukwila.
- **Reclaimed Water Skimming or Polishing Decentralized Strategy.**[2] This strategy represents opportunities for smaller scale reclaimed water implementation. Infrastructure

[2] A skimming plant removes some of the raw wastewater from pipelines that carry the wastewater to regional plants for treatment and then treats the wastewater to reclaimed water quality standards for local distribution. A polishing

was constrained to a single treatment plant of up to 0.5 mgd capacity and up to 1 mile of reclaimed water pipeline. Three potential areas and configurations were identified to help define the decentralized strategy:

- — An MBR skimming plant located in the Interbay area of Seattle would produce reclaimed water from untreated wastewater in adjacent conveyance pipelines for distribution near the plant via a new pipeline.
- — A sand filtration polishing plant located in Seattle on the west side of the Duwamish River would produce reclaimed water from flows in the Effluent Transfer System (ETS) pipeline that carries South plant secondary effluent for discharge at Alki Point in West Seattle. The reclaimed water would be distributed to nearby uses via a new pipeline.
- — An MBR skimming plant located in the lower Green River Valley in south King County would produce reclaimed water from untreated wastewater in adjacent conveyance pipelines for distribution near the plant via a new pipeline.

The locations of the strategies are shown in Figure 1-1.

1.3 Wetland Enhancement Locations

This analysis is being done to evaluate, on a site-specific basis, the potential for reclaimed water to be used in wetland enhancement and as a method to introduce water to watersheds that have been identified as in need of additional water to support instream flows. The following sections describe the wetland enhancements considered for the two reclaimed water strategies.

1.3.1 Redmond/Bear Creek Brightwater Centralized Strategy

Three potential wetland enhancement opportunities have been identified for the Redmond/Bear Creek Brightwater Centralized Strategy. The source of reclaimed water for this strategy is treated effluent from the Brightwater Treatment Plant that has undergone additional phosphorus removal. As described in the document Engineering Analysis and Definition of Reclaimed Water Strategies (King County 2012a), application of Class A reclaimed water from Brightwater would require further nutrient removal before it could be used for potential environmental enhancement reclaimed water uses, including wetland enhancement. If application of reclaimed water for wetland enhancement is implemented, the additional treatment necessary to satisfy these water quality standards would be applied to all reclaimed water generated.

The wetlands being considered for wetland enhancement include the Areas of Interest (AOIs) listed below and illustrated in Figure 1-2. These AOIs are being evaluated as conceptual locations for wetland enhancement using reclaimed water in order to analyze both the potential for using reclaimed water in wetland enhancement, as well as the potential to add water to support instream flows.

- Crystal Lake, an approximately 130-acre wetland adjacent to the north shore of Crystal Lake in Snohomish County.

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plant removes some secondary-treated effluent from pipelines delivering wastewater to exiting regional treatment plants and treats the effluent to reclaimed water quality standards.

- Cottage Lake, an approximately 129-acre wetland in the Cold Creek Natural Area, west of Cottage Lake in King County.
- Sammamish River/Lake Sammamish, an approximately 154-acre site in Marymoor Park with two potential subareas: Area A, 54 acres of wetlands west of the Sammamish River, and Area B, 100 acres of wetlands at the north end of Lake Sammamish.

Wetland enhancement flows under consideration for each wetland are described in Table 1-1. Both a 7-month (April through October, 214-day) application duration scenario and a 12-month (January through December, 365-day) application duration scenario were considered in this analysis.

This strategy has the potential to influence the hydrology (water quantity) and water quality in the Bear-Evans Creek basin, the Sammamish River, and Lake Sammamish. Specifically in the Bear-Evans Creek basin, the Crystal Lake and Cottage Lake wetland enhancement uses have the potential to affect the quality and water levels of Crystal and Cottage lakes, Daniels Creek that connects Crystal Lake to Cottage Lake, Cottage Lake Creek from the outlet of Cottage Lake to the confluence with Bear Creek and Bear Creek from this point to where it discharges to the Sammamish River. The lower portion of Cold Creek also has the potential to be affected by the Cottage Lake wetland enhancement uses before it empties into Cottage Lake Creek below Cottage Lake. With a wetland enhancement use at the headwaters of the Sammamish River, this use potentially affects Lake Sammamish and the Sammamish River.

1.3.2 Renton/Tukwila South Plant Centralized Strategy

One potential environmental enhancement opportunity has been identified for the Renton/Tukwila South Plant Centralized Strategy. The source of reclaimed water for this strategy is treated effluent from the South Treatment Plant. As described in the document Engineering Analysis and Definition of Reclaimed Water Strategies (King County 2012a), the South Treatment Plant effluent meets Class A reclaimed water standard.

The area being considered for reclaimed water application is an approximately 30-acre area located on a terrace along the south side of the Cedar River in Renton, approximately 1.9 miles from the Cedar River discharge to Lake Washington. The site does not appear to be a wetland. As such it is being considered as a conceptual location for wetland creation using reclaimed water. Additional treatments to reduce nutrient concentrations are not being reviewed, given that the conceptual wetland enhancement is a created wetland using a small quantity of reclaimed water. Table 1-1 summarizes proposed reclaimed water flows to the Cedar River AOI.

This strategy has the potential to influence the hydrology and water quality in the lowest reach of the Cedar River in Renton and Lake Washington.

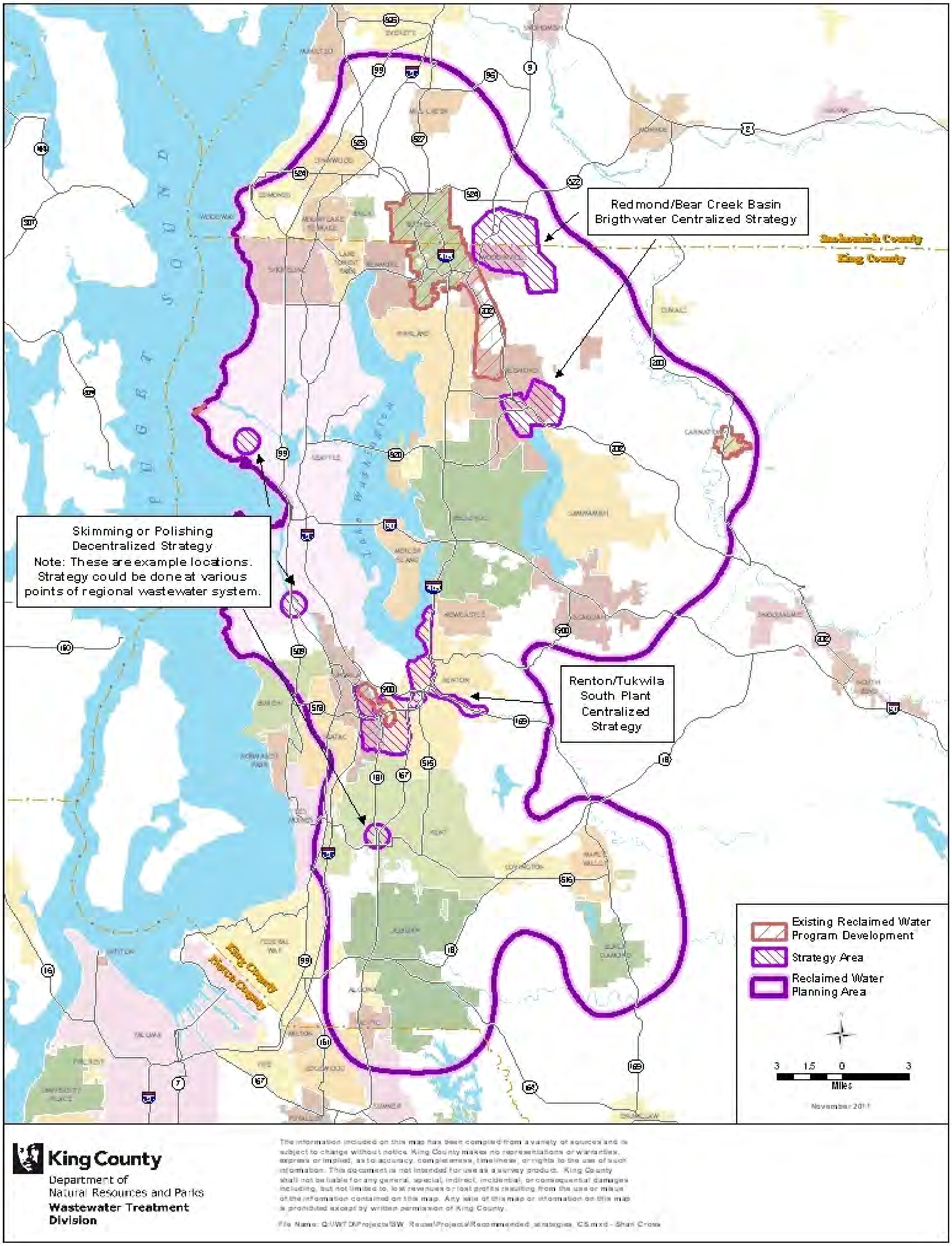

Figure 1-1. Reclaimed Water Strategies Recommended for Analysis

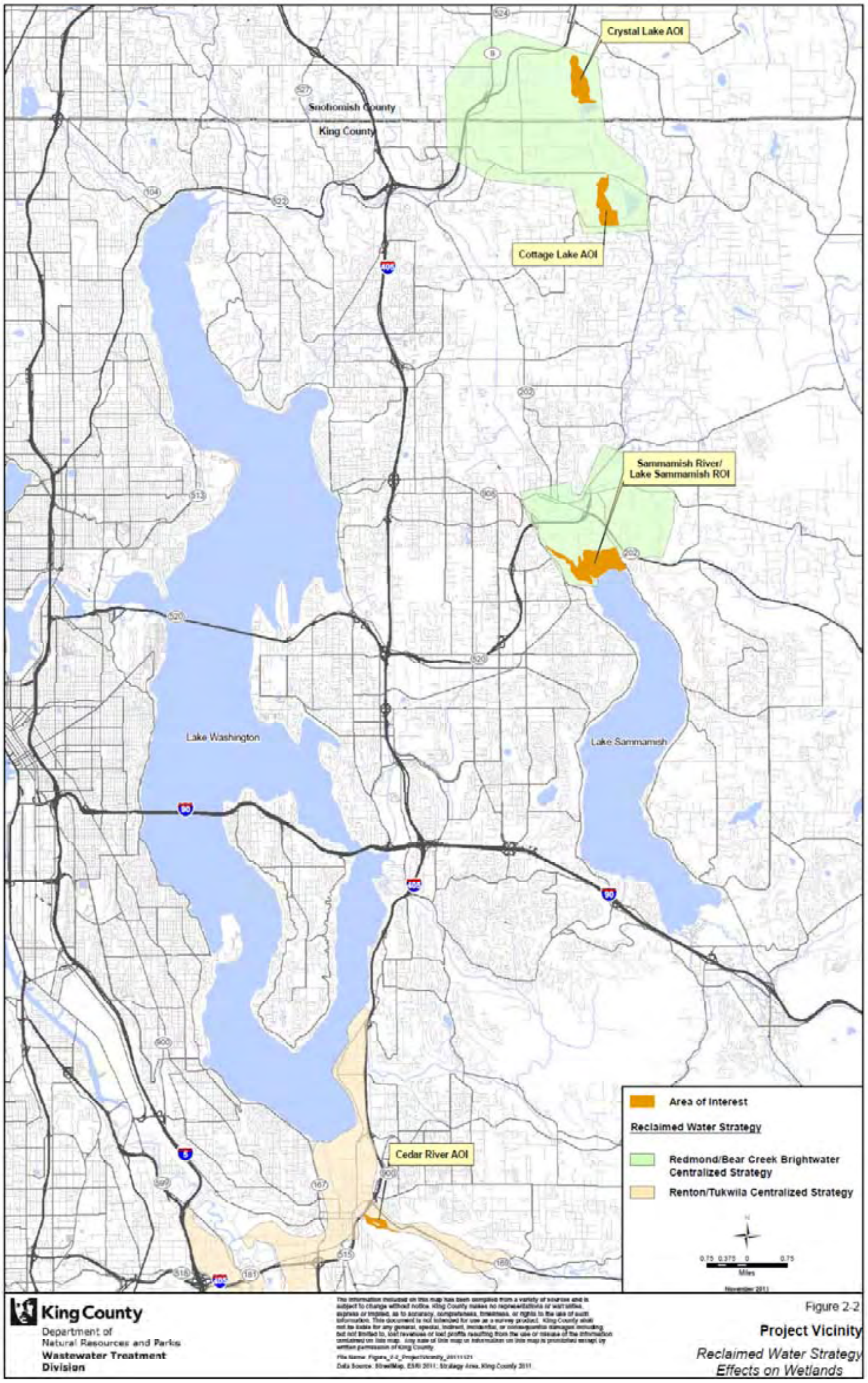

Figure 1-2. Reclaimed Water Strategies Areas of Interest

Table 1-1. Wetland Enhancement Flows under Consideration

	Cottage Lake	Crystal Lake	Sammamish River/Lake Sammamish	Cedar River[1]
Annual Volume[2]	1,350 MG (5.7 cfs)	730 MG (3.1 cfs)	730 MG (3.1 cfs)	182.5 MG (0.8 cfs)
Application Rate	2 cm/day	2 cm/day	2 cm/day	2 cm/day
Total Phosphorus	1 mg/L	1 mg/L	1 mg/L	2 mg/L
Total Kjeldahl Nitrogen (TKN)[3]	3 mg/L	3 mg/L	3 mg/L	25-30 mg/L (>90% ammonia)
Total Inorganic Nitrogen (TIN)[4]	8 mg/L	8 mg/L	8 mg/L	25-30 mg/L
Temperature	50°F (leaving treatment facility; cooler farther away from the facility)			
Scenario 1 (12-months)				
Duration (days/year)	365 days	365 days	365 days	365 days
Average Daily Demand	3.7 mgd	2.0 mgd	2.0 mgd	0.5 mgd
Scenario 2 (7-months April–October)				
Duration (days/year)	214 days	214 days	214 days	N/A
Average Daily Demand	3.7 mgd	2.0 mgd	2.0 mgd	N/A

[1] Renton/Tukwila South Plant Centralized Strategy
2 Annual volume assumes 12 months of application.
[2] TKN includes ammonium (NH4-N) and Org-N.
[3] TIN includes ammonia, nitrate and nitrite-nitrogen.
MG = million gallons; cfs = cubic feet per second, °F = degrees Fahrenheit; n/a = not applicable.

1.4 Objectives of this Evaluation

This report provides a preliminary evaluation of the feasibility of applying reclaimed water to the two wetland enhancement strategy areas. The analysis is based on existing information and is presented and compiled to help address the following questions regarding the reclaimed water strategies:

- How will the strategy alter freshwater quality and quantity in lakes, streams, and rivers?
- How will the strategy alter groundwater quality and quantity?
- What are the potential benefits or impacts to lake and stream biota including threatened and endangered species and their habitat?

1.5 Content and Organization of this Report

The next two chapters describe the locations that would potentially be affected by the strategies for wetland enhancement as well as the methods used in this evaluation. These chapters are followed by chapters that assess the effects on water quality and water quantity for each strategy as well as a chapter providing a general assessment of the strategies on trace contaminants. The report ends with recommendations for additional studies in the event of more detailed assessment.

2.0. ENVIRONMENTAL CONDITIONS

This chapter provides background on locations that would potentially be affected by the reclaimed water strategies in order to establish relevant environmental conditions in the Crystal Lake, Cottage Lake, Sammamish River/Lake Sammamish, and Cedar River AOIs

2.1 Redmond/Bear Creek Brightwater Centralized Strategy

This section describes the relevant environmental conditions in the Bear-Evans Creek basin, Crystal Lake, Cottage Lake/Cold Creek, the Sammamish River basin, and Lake Sammamish.

2.1.1 Bear-Evans Creek Basin

The Bear-Evans Creek basin encompasses approximately 32,100 acres. The basin can be further divided into three subbasins: Bear Creek at 14,300 acres, Cottage Lake Creek at 8,000 acres (which includes the Cold Creek subbasin), and Evans Creek at 9,800 acres. The Bear-Evans Creek basin contains nine lakes and over 2,000 acres of wetlands. Local jurisdictions within the basin include unincorporated portions of King and Snohomish counties and the cities of Redmond, Sammamish, and Woodinville. The headwaters of Bear and Cottage Lake creeks originate in Snohomish County.

Land use in the Bear-Evans Creek basin has changed markedly in the past 150 years, resulting in a transition from forests and wetlands to a mixture of land cover that includes agricultural, residential, and commercial development (Vanderhoof et al. 2011). Areas along the creek exhibit high aquatic habitat and salmon diversity, including chinook, sockeye, coho, kokanee, and steelhead, as well as cutthroat trout. In addition to salmon and other coldwater fish species, a unique population of freshwater mussels is found.

Although the basin still continues to support salmon, freshwater mussels, and other aquatic life, development in the basin has adversely affected water quantity and quality. Ecology has identified portions of Bear-Evans Creek as having impaired beneficial use for aquatic life due to elevated summer water temperatures and low dissolved oxygen. A Total Maximum Daily Load (TMDL) study was conducted that concluded that riparian shade restoration and maintenance and improvement in stream base flow were needed to improve stream temperature and dissolved oxygen conditions (Ecology 2008a). A number of other studies have indicated that development of effective impervious cover[3] (resulting in a net reduction in groundwater recharge) and water management activities (e.g., net export of potable water through inter-basin transfers and regional wastewater conveyance exports) in the Bear-Evans Creek basin have likely resulted in lower summer base flows (summarized in King County 2011).

Ecology has also identified elevated indicator bacteria levels in basin creeks and lakes suggesting impairment of human recreational use of these waters. Ecology conducted a TMDL study that

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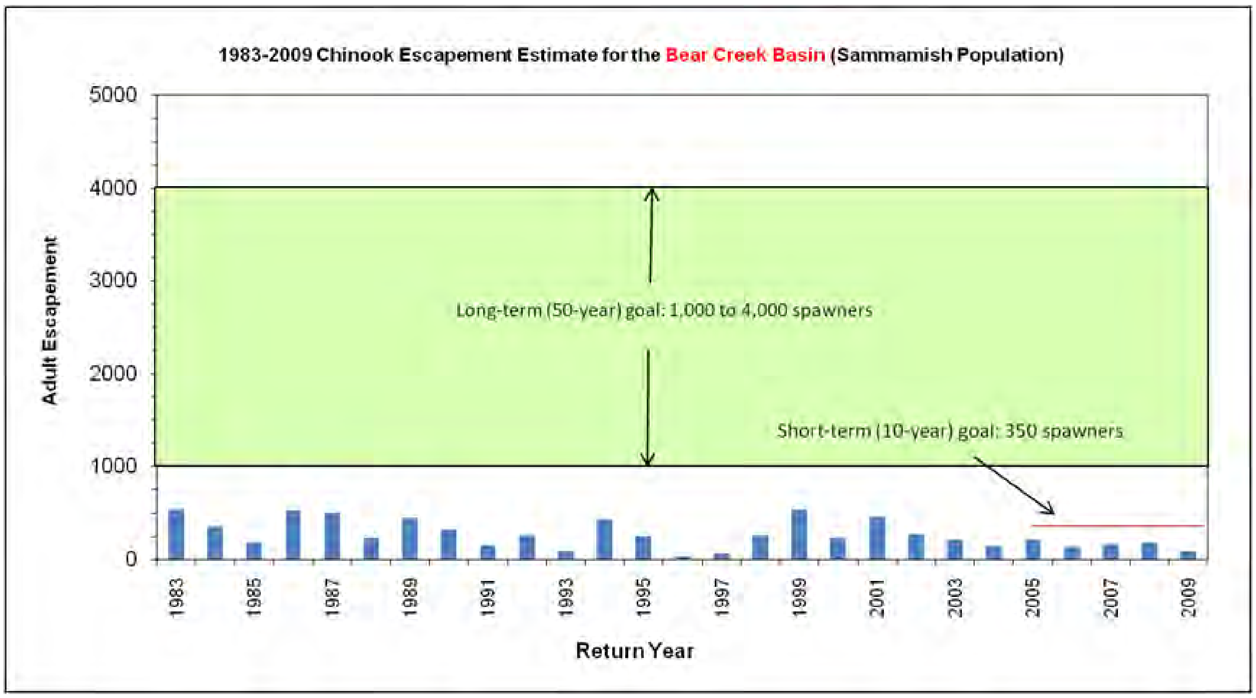
[3] Effective impervious area is the portion of total impervious area that conveys runoff directly into receiving waters. This concept recognizes that some forms of impervious land cover direct runoff to adjacent forested or grassed areas that would permit some infiltration and attenuation of direct runoff to receiving waters.

identified a number of potential sources of bacteria, including livestock, pet and wildlife waste as well as domestic wastewater and sewage introduced through leaky municipal sanitary sewer lines, failing on-site septic systems, and illicit cross-connections to the stormwater drainage system (Ecology 2008b).

The Bear Creek basin is included in a regional salmon recovery plan that was created in response to Puget Sound summer/fall chinook salmon being listed as threatened under the Endangered Species Act in 1999. Planning efforts to protect and restore chinook habitat, an effort led by 27 local governments in the Lake Washington/Cedar/Sammamish Watershed (Water Resource Inventory Area or WRIA 8), began in 2000. This planning effort led to the development of a salmon recovery plan that is overseen by the WRIA 8 Salmon Recovery Council. The plan includes a number of recommended actions, including the protection and restoration of instream flows. Since the plan's adoption in 2005, the numbers of adult salmon that have survived to spawn in the Bear Creek basin have been below the short-term (10-year) goal of 350 spawners per year and well below the long-term goal of 1,000 to 4,000 spawners per year needed to have a sustainable population of chinook salmon (Figure 2-1).



Source: http://www.govlink.org/watersheds/8/planning/chinook-conservation-plan.aspx

Note: Escapement refers to the number of fish that escaped various causes of mortality to reach the spawning grounds. The numbers include both natural-origin and hatchery origin stock.

Figure 2-1. Number of adult chinook salmon on the spawning grounds in Bear/Cottage basin

2.1.2 Crystal Lake

Crystal Lake is a private lake just north of the Snohomish-King County line. The lake has a surface area of about 50 acres and a maximum depth of about 30 feet. There are extensive wetlands to the north of the lake. Lake outflow is controlled by a low earthen dam constructed in

1931. The lake drains south to Daniels Creek, which flows into Cottage Lake. A water right certificate allows for the storage of 2,500 acre-feet of water to increase habitat for fishing and hunting—the size of the original lake has expanded due to the impoundment of additional water. There are apparently no provisions for maintaining flow in Daniels Creek during summer months through the release of water from Crystal Lake. According to Ecology (2004), it is not unusual that only minimal discharge from the dam structure occurs, resulting in only minor inflow to Cottage Lake during summer months. Coho is the only salmon species known to occur above Cottage Lake. Cutthroat trout are also known to occur above Cottage Lake.

The lake stratifies thermally and low oxygen concentrations develop in bottom waters during the summer. Available data indicates that Crystal Lake has low water clarity, moderate phosphorus levels, and moderate to high chlorophyll-a levels (a surrogate for algal biomass). The lake would likely be classified as eutrophic (Snohomish County 2009).

2.1.3 Cottage Lake/Cold Creek

Cottage Lake and its associated wetland complex is located approximately four miles east of the city of Woodinville. Its drainage area is situated within the upper Bear Creek basin.

Cottage Lake has a drainage area of approximately 4,200 acres and receives surface water inflow from Daniels and Cottage Lake creeks. The Daniels Creek drainage area comprises 78 percent (3,300 acres) of Cottage Lake's drainage area while Cottage Lake Creek represents approximately 18 percent of the total area. The remainder of the area drains directly to the lake. The surface area of Cottage Lake is approximately 63 acres and the lake has a maximum depth of about 25 feet. The lake stratifies thermally during summer and the bottom waters become anaerobic. A phosphorus TMDL has been established for Cottage Lake (Ecology 2007).

The Cold Creek basin includes the 250 acre Cold Creek Natural Area and includes one of the highest quality, salmonid-bearing tributaries in the Bear-Evan Creek basin (King County 2001). The creek is fed by springs that provide a significant coldwater refuge in the basin (King County 2007a). The creek discharges downstream of the outlet of Cottage Lake and upstream of the confluence of Cottage Lake Creek with Bear Creek.

2.1.4 Sammamish River Basin

The Sammamish River basin drains a watershed of approximately 153,700 acres that includes 62,080 acres in the Lake Sammamish basin, 32,100 acres in the Bear-Evans Creek basin, and 42,880 acres that are the combined Little Bear, Swamp, and North creek basins. The remaining 16,640 acres comprise the remaining drainage to the Sammamish River.

The Sammamish River of the early 1800s has been extensively modified as a result of various human efforts to use the channel for navigation, to utilize the floodplain for agriculture, and to reduce flooding in the Sammamish River valley and Lake Sammamish. Prior to major hydrologic modifications that began in the early 1900s, the river was wider and deeper and generally flowed more slowly due to a relatively small difference in elevation between Lake Sammamish and Lake Washington (Chrzastowski 1983).

Although early drainage and navigation improvement efforts likely affected the form and function of the river, the most significant modifications occurred as a result of two largely federally funded navigation and flood control projects. The first major change occurred as a result of the reduction in the mean level and seasonal elevation range of Lake Washington in 1916 as part of the development of the Lake Washington Ship Canal and Lock system. The second major change resulted from a King County/U.S. Army Corps of Engineers (ACOE) channel dredging, straightening project completed in November 1964 that included construction of a weir at the Lake Sammamish outlet. This project practically eliminated flooding in the Sammamish River valley and reduced maximum flood elevations and seasonal water surface elevations in Lake Sammamish.

Chinook, coho, sockeye, kokanee, steelhead, and cutthroat are known salmonid species to currently inhabit the Sammamish River system. In 2002, the Sammamish River Corridor Action Plan was completed with the primary focus on the Sammamish River as a migratory pathway for anadromous salmon (King County 2002). Recommended protection and restoration strategies most relevant to this report were ensuring that cool water continued to be delivered to the river via Bear-Evans Creek and to exploring engineered solutions to reduce summer river temperatures in the river between the confluence of Bear-Evans Creek and Lake Sammamish. These evaluations were based in part on the application of a water quality model of the Sammamish River to assess a number of efforts targeting improvements in river temperatures (see Appendix B of King County 2002).

Ecology, as part of Clean Water Act Section 303(d) evaluation of available data, has determined that river beneficial uses (aquatic life and contact recreational use) are impaired and require establishment of TMDLs to remedy low dissolved oxygen, high summer temperatures, and elevated fecal coliform concentrations (Ecology 2008c).

The most recent comprehensive evaluation of river water quality, conducted in the fall of 2001 and 2002, included an evaluation of trace metal and organic contaminant levels in water and sediment to establish baseline water quality conditions for future King County projects, such as use of reclaimed water within the basin (King County 2005). The evaluation concluded that no contaminants were measured at concentrations that would suggest significant adverse effects to aquatic life or human health. This study also noted that benthic fauna diversity was relatively low and dominated by a relatively low number of tolerant organisms: oligochaetes and chironomids.

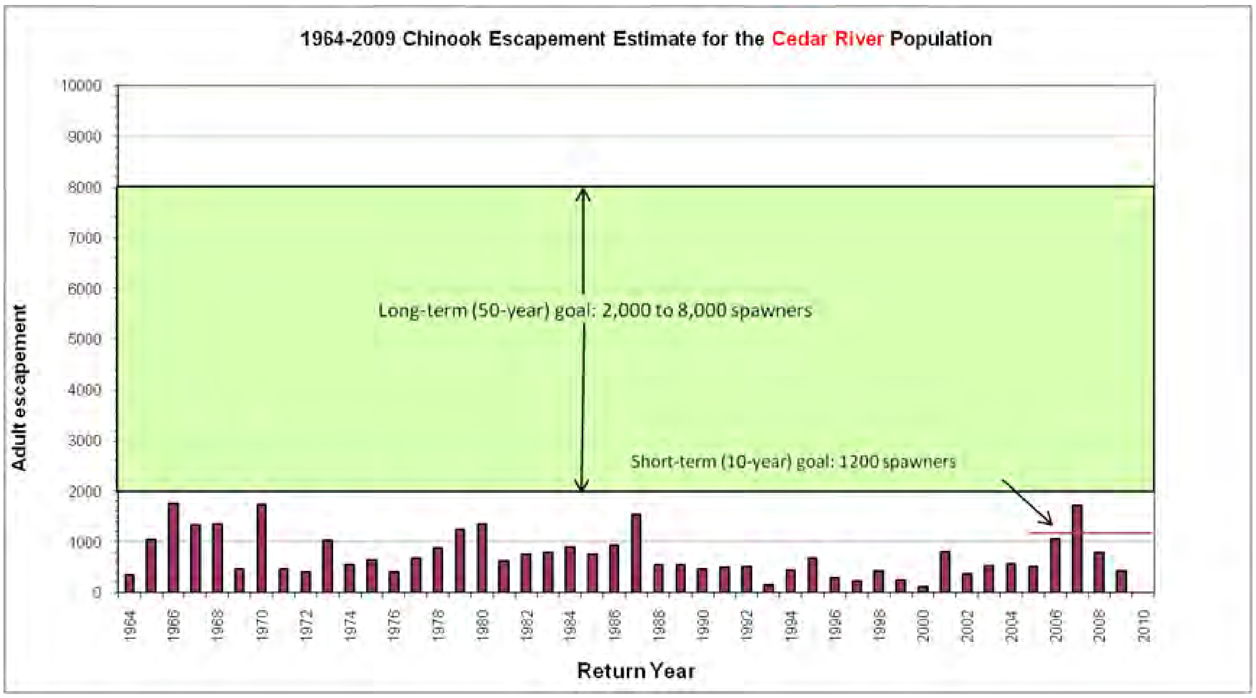
2.1.5 Lake Sammamish

Lake Sammamish has a surface area of approximately 63,000 acres and a mean residence time of 1.8 years. The lake has a maximum depth of about 105 feet and a mean depth of 58 feet. The lake typically stratifies thermally beginning in May and de-stratifies in November. As the lake stratifies, the hypolimnion becomes progressively depleted of oxygen resulting in anaerobic bottom waters in late summer.

Wastewater from the Issaquah Wastewater Treatment Plant and a milk processing plant were completely diverted from the lake by 1968. Lake Sammamish did not recover as quickly as expected based on flushing alone. The delayed recovery of Lake Sammamish is well documented and has been attributed to sediment-nutrient interactions and the relatively smaller proportion of the total phosphorus load that was diverted (Welch et al. 1986). Even before wastewater was completely diverted from the lake, concern was raised that rapid development of the basin would offset water quality benefits obtained from wastewater diversion.

2.2 Renton/Tukwila South Plant Centralized Strategy

The Cedar River basin covers about 188 square miles extending from the crest of the Cascades to the southern shore of Lake Washington in the City of Renton. The upper basin provides for over half of the Seattle Public Utilities potable water supply through a diversion at Landsburg over 20 miles upstream of the river mouth. The Cedar River is also included in the WRIA 8 salmon recovery plan described above. Though the numbers of chinook surviving to spawn in the Cedar River basin has been highly variable, escapement was above the short-term plan target of 1,200 spawners per year in 2007 (Figure 2-2).



Source: http://www.govlink.org/watersheds/8/planning/chinook-conservation-plan.aspx

Note: Escapement refers to the number of fish that escaped various causes of mortality to reach the spawning grounds. The numbers include both natural-origin and hatchery origin stock.

Figure 2-2. Number of adult chinook salmon on the spawning grounds in the Cedar River basin

Historically, from the 1940s until the late 1960s Lake Washington received treated wastewater discharge from a number of treatment plants along the shoreline of the lake until signs of eutrophication appeared and a regional wastewater utility was created to convey the region's wastewater to treatment plants with discharges to Puget Sound. The lake rapidly improved (Edmondson and Lehman 1981), but protection of lake quality has remained a priority for the region.

3.0. METHODS

Assessment of the potential effects of the reclaimed water strategies on lakes, streams, and rivers is based on existing data, reports, and readily available water quality models. Existing water quantity and quality data were used to put the amount and quality of reclaimed water proposed for environmental enhancement use in the context of the local ambient environment. To the extent that the available data allowed, the effects of the reclaimed water strategies on human and aquatic life beneficial uses were qualitatively assessed.

While the focus of this assessment is on flow, water temperature, nutrients, and dissolved oxygen, the potential effects of contaminants that are not completely removed by the reclaimed water treatment process were also assessed. These contaminants include trace metals and organic contaminants, including pharmaceuticals, hormones, and other organic compounds and, for this study, the focus was primarily on Endocrine Disrupting Compounds (EDCs). This assessment was general, consisting primarily of a qualitative review of existing information on the occurrence and fate of wastewater derived trace contaminants (see Chapter 6).

The potential water quality effects addressed in this assessment focus on the requirements outlined in the Washington State Water Reclamation and Reuse Standards (Washington State Department of Health and Washington State Department of Ecology 1997). While that document provides detailed reclaimed water standards for wetlands and direct groundwater recharge, only general requirements are outlined for streamflow augmentation and groundwater recharge by surface percolation.

In addition to the state requirements for the use of reclaimed water, use of reclaimed water must not result in the impairment of designated or beneficial uses of surface or ground waters of the state or degrade existing quality of outstanding water. These standards are considered in this evaluation to the extent possible given available information and assessment tools. The relevant surface and groundwater quality standards are briefly summarized in two separate sections below.

Because Class A reclaimed water is completely disinfected, this assessment does not address the potential for these strategies to result in impairment of primary contact recreational use of receiving waters for any strategy.

3.1 Water Quality Standards for Surface Waters

Washington Administrative Code (WAC) 173-201A establishes water quality standards for surface waters of the state to protect public health and water-based enjoyment as well as the propagation and protection of fish, shellfish, and wildlife. These standards include numeric and narrative criteria to protect specific existing and designated uses and an antidegradation policy to restore and maintain the highest possible quality of state surface waters.

The Washington State Department of Ecology (Ecology) ultimately considers if a particular reclaimed water project is in the overriding public interest and that all known, available, and reasonable methods of prevention, control, and treatment are provided. Ecology also determines the point of compliance and monitoring requirements as needed to protect existing and future beneficial uses.

Designated aquatic life use for all of the receiving waters considered in this assessment is core summer salmonid habitat (Table 3-1). The key identifying characteristics of this use are summer salmonid spawning, salmonid emergence, or adult holding; important summer rearing habitat by one or more salmonids; and foraging by adult and sub-adult native char. Cottage Lake Creek and Bear Creek also have a designated aquatic life use for salmonid spawning, rearing, and migration to protect salmon or trout spawning or emergence that occurs outside of the summer season, as well as rearing and migration by salmonids.

3.1.1 Temperature

The relevant temperature standard for use in this assessment is a seven-day average of the daily maximum (7-DADMax) temperature of 16 °C. This standard only applies to the assessment of stream and river quality. A supplemental spawning/incubation criterion of 13 °C from September 15 through May 15 also applies to Cottage Lake Creek and Bear Creek (Ecology 2011a).

Other standards relevant to this assessment are that:

- When a waterbody's temperature is warmer than the relevant criterion (or within 0.3°C of the criterion) and that condition is due to natural conditions, then human actions considered cumulatively may not cause the 7-DADMax temperature of that water body to increase more than 0.3°C.
- When the background condition of the water is cooler than the relevant criterion, the allowable rate of warming up to, but not exceeding, the numeric criteria from human actions is restricted as follows:
    - Incremental temperature increases resulting from individual point source activities must not, at any time, exceed 28/(T+7) as measured at the edge of a mixing zone boundary (where "T" represents the background temperature as measured at a point or points unaffected by the discharge and representative of the highest ambient water temperature in the vicinity of the discharge); and
    - Incremental temperature increases resulting from the combined effect of all nonpoint source activities in the water body must not, at any time, exceed 2.8°C.

There are no specific numeric temperature standards established for lakes, with the exception that human actions considered cumulatively may not increase the 7-DADMax temperature more than 0.3 °C. The surface waters of lakes, particularly those addressed in this assessment, are naturally warmer than the stream standard in summer due to direct exposure of the lake surface to the sun. These lakes are also often thermally stratified so that cool water fish habitat is available at depth. However, the bottom waters in these thermally stratified lakes have the potential to become depleted in oxygen as the result of nutrient inputs, phytoplankton production, and subsequent decomposition by bacterial respiration. This situation can reduce the available coldwater habitat for fish (Welch et al. 2011).

Table 3-1. Use Designations for Waterbodies Addressed in this Assessment

Waterbody	Aquatic Life Uses						Recreation Uses			Water Supply Uses				Miscellaneous Uses				
	Char Spawning and Rearing	Core Summer Habitat	Spawning/Rearing	Rearing/migration Only	Redband Trout	Warm Water Species	Extraordinary Primary Contact	Primary Contact	Secondary Contact	Domestic Water	Industrial Water	Agricultural Water	Stock Water	Wildlife Habitat	Harvesting	Commerce/Navigation	Boating	Aesthetics
Redmond/Bear Creek Brightwater Centralized Strategy																		
Bear-Evans Creek		x					x			x	x	x	x	x	x	x	x	x
Sammamish River		x					x			x	x	x	x	x	x	x	x	x
Lake Sammamish		x					x			x	x	x	x	x	x	x	x	x
Renton/Tukwila South Plant Centralized Strategy																		
Cedar River from Lake Washington to the Maplewood Bridge (river mile 4.1)		x						x		x	x	x	x	x	x	x	x	x
Lake Washington		x					x			x	x	x	x	x	x	x	x	x

3.1.2 Nutrients and Dissolved Oxygen

There are no water quality standards established for nutrient levels in streams and rivers, primarily because dissolved oxygen is a more direct measure of the effect of nutrients (and other factors, such as temperature) on designated uses for aquatic life. The dissolved oxygen standard for core summer salmonid habitat is a lowest 1-day minimum of 9.5 mg/L. When stream dissolved oxygen is lower than the criterion (or within 0.2 mg/L) due to natural conditions, then human actions considered cumulatively may not cause the dissolved oxygen of that water body to decrease more than 0.2 mg/L. For lakes, human actions considered cumulatively may not decrease the dissolved oxygen concentration more than 0.2 mg/L below natural conditions.

It is possible to establish nutrient criteria for lakes following the guidance provided in WAC 173-201A-230. The guidance recommends total phosphorus action values by ecoregion; the action value for the lakes in the assessment area is 20 µg/L (average of surface water samples collected during summer), which if exceeded can lead to a lake specific study to establish a lake-specific total phosphorus standard.

3.1.3 Water Cleanup Plans

In conjunction with standards for the protection of surface and ground water quality, the state also maintains a program to restore lakes, streams, and rivers that have been identified as having impairment of designated uses. This regulatory framework is commonly referred to as a Total Maximum Daily Load (TMDL) or Water Cleanup Plan[4], which was established by Section 303(d) of the federal Clean Water Act. These projects are triggered by information that suggests that one or more designated uses in a particular lake, stream or river is impaired and typically result in allocations or limits on the amount (i.e., load) of a particular constituent or contaminant that can be assimilated without impairing the designated use. These allocations can include loads from permitted point sources and non-point sources and can provide for a margin of error and/or future growth.

3.2 Water Quality Standards for Groundwater

Washington Administrative Code (WAC) 173-200 establishes water quality standards to protect and preserve groundwater quality. These standards include numeric and narrative criteria to protect specific beneficial uses and an antidegradation policy to restore and maintain the highest possible quality groundwater.

Ecology ultimately considers if a particular reclaimed water project is in the overriding public interest and that all known, available, and reasonable methods of prevention, control, and treatment are provided. Ecology also determines the point of compliance and monitoring requirements as needed to protect existing and future beneficial uses. Ecology (2005) provides guidance for the implementation of the state ground water quality standards.

In general, the groundwater quality standards become relevant only if there is a potential to contaminate groundwater. If an activity has the potential to contaminate groundwater, then a hydrogeologic study and monitoring plan are required. If an activity has a limited potential to

[4] Ecology also refers to these projects as Water Quality Improvement Projects.

contaminate groundwater, then the required hydrogeologic study is waived, but monitoring may still be required.

Use of reclaimed water for groundwater recharge by surface percolation or direct aquifer recharge more clearly has the potential to contaminate groundwater and would likely require a hydrogeologic study. Determination of the need for a hydrogeologic study for a reclaimed water application to a wetland depends on the potential for groundwater recharge and contamination. The potential for groundwater recharge in the vicinity of the wetland enhancement areas is addressed in a companion report (King County 2012b).

In general, the available guidance for reclaimed water use or groundwater quality protection does not address the evaluation of the potential for groundwater infiltration in a lake or stream channel downstream of the wetland application areas. The potential for groundwater recharge and the effects on groundwater quality and quantity are addressed qualitatively in this assessment.

3.3 Water Quality Assessment

Water quality wass assessed for lakes, streams, and rivers potentially affected by the reclaimed water strategies.

3.3.1 Lakes

Nutrients and dissolved oxygen as well as temperature were assessed for lakes.

Nutrients and Dissolved Oxygen

It is assumed that there is a potential for these strategies to exacerbate lake eutrophication. Lake eutrophication is the enrichment of lakes with nutrients that results in enhanced algal growth, sometimes of algal species that form scums on the lake surface and cause objectionable odors, impairing the aesthetic enjoyment of the lake. The enhanced algal growth can also result in additional declines in oxygen levels in deeper portions of thermally stratified lakes during the summer, which can impair the use of the lake by aquatic organisms that rely on oxygenated waters for survival.

Small lakes in King County along the urban-rural fringe are known to be threatened by eutrophication caused by non-point source pollution (Moore et al. 2005). Phosphorus is typically the nutrient limiting algae growth in these lakes. A phosphorus TMDL has been established for Cottage Lake (Ecology 2007), which allowed for a comparison between potential phosphorus loading from the wetland enhancement at Crystal Lake to the load allocation established in the TMDL. This comparison was then generalized to the potential for eutrophication of Crystal Lake.

Lake Sammamish and Lake Washington are potentially affected by these strategies through the additional input of phosphorus. Both lakes experienced a period of enhanced eutrophic conditions due to the input of treated wastewater and subsequent recovery following the creation of the regional wastewater utility and diversion of wastewater to treatment plants discharging to Puget Sound (Edmondson and Lehman 1981, Welch et al. 1986). Published post-diversion total phosphorus loading estimates were compared to the potential phosphorus loading from wetland enhancement strategies to qualitatively determine the potential for these strategies to contribute to the eutrophication of Lake Sammamish and Lake Washington. The potential effect was bracketed by assuming either no reduction in total phosphorus concentration by the wetland system or reduction to ambient background concentration.

Temperature

This assessment assumes that there is little potential for these strategies to affect the temperature of lakes because the heat budget of these lakes is driven primarily by heat exchange across the lake surface (e.g., incoming solar and longwave radiation and evaporative heat loss). Although beyond the scope of this assessment, a lake temperature model could be used to confirm this assumption.

3.3.2 Streams

Nutrients and dissolved oxygen as well as temperature were assessed for lakes.

Note that the potential effect of the wetland enhancement strategy on Cold Creek to the west of Cottage Lake is addressed in a companion report (King County 2012b).

Nutrients and Dissolved Oxygen

The same water quality model was used to evaluate the potential effect of additional nutrient input on stream dissolved oxygen concentrations. As with the application of the temperature component of the model described above, the nutrient concentrations specified at the upstream boundary of the model were not modified, so the assessment assumes that the reclaimed water nutrient loading rate to the wetland enhancement areas would not exceed regulatory limits designed to provide sufficient nutrient attenuation within the wetland such that a downstream increase in nutrient concentrations would not result. Although nutrient concentrations are assumed to remain unchanged, the load of nutrients to the upstream boundary of the model will increase due to the additional flow provided by the proposed wetland enhancements.

Temperature

There is potential for these strategies to lower summer maximum stream temperatures, which would be most important in streams where loss of riparian shade through clearing and development for other uses have, along with summer flow declines, contributed to increases in maximum summer temperatures. Improvement in summer stream temperature is important because native fish species and other aquatic life are generally adapted to live in cooler waters or rely on cold water refuges for maintenance and survival (Poole and Berman 2001).

A Water Cleanup Plan has been developed for the Bear-Evans Creek basin for temperature and dissolved oxygen (Ecology 2008a), which is used in this evaluation along with the steady-state stream water quality model developed for that plan to assess the potential effects of the Crystal Lake and Cottage Lake wetland enhancement projects on the summer temperature of Cottage Lake Creek and Bear Creek. Because the upstream model boundary occurs just downstream of Cottage Lake, it is assumed that the boundary temperature is not affected by the proposed wetland enhancement at Crystal or Cottage lakes. This is a reasonable assumption if the area of the wetland exposed to direct solar radiation in the summer remains relatively unchanged. Therefore, the model only provides an assessment of the effect of the increase in flow on summer stream temperatures.

3.3.3 Rivers

Nutrients and dissolved oxygen as well as temperature were assessed for rivers.

Nutrients and Dissolved Oxygen

The potential effect of these strategies on the oxygen concentrations in the Sammamish River are discussed qualitatively, considering the potential effect of additional nutrient loading to the river. The potential effects of the proposed wetland enhancement projects in the vicinity of Marymoor Park are also evaluated qualitatively and consider the relative effect of releasing water directly to the outlet of Lake Sammamish or providing a means of infiltrating the wetland discharge prior to release to the river.

Temperature

The potential effect of these strategies on the summer temperatures of the Sammamish River are discussed qualitatively, considering the potential effect of changes in the temperature of Bear-Evans Creek as it enters the Sammamish River in response to the proposed Crystal Lake and Cottage Lake wetland enhancements. The potential effects of the proposed wetland enhancement projects in the vicinity of the Sammamish Slough are also evaluated qualitatively and consider the relative effect of releasing water directly to the outlet of Lake Sammamish or providing a means of infiltrating the wetland discharge prior to release to the river. If necessary, a dynamic temperature model of the river could be used to more quantitatively evaluate the effects of this strategy on the temperature of the river (King County 2009).

3.4 Water Quantity Assessment

In addition to evaluation with respect to Ecology’s regulatory framework for the protection of water quality, an assessment of the potential effects of additional streamflow provided via wetland enhancement was also conducted. Environmental enhancement use of reclaimed water has the potential to improve summer stream flows in basins that have experienced declines in streamflow due to diversion of water from the basin for out of stream uses. Improvement in summer stream flow is important because it determines the amount and quality of habitat available to fish and other aquatic organisms. Summer streamflow is considered a potentially key variable affecting growth of trout and other fish species including coho, cutthroat trout, and steelhead (e.g., Beecher 1979, Mathews and Olson 1980, Harvey et al. 2006).

This assessment was limited to quantifying the potential increase in stream cross-sectional area and wetted perimeter at representative locations along Cottage Lake Creek and Bear Creek under critical low flow conditions using the QUAL2Kw model developed as part of the Bear-Evans Creek basin temperature and dissolved oxygen TMDL (Ecology 2008a). The potential effects on flow in the Sammamish and Cedar rivers is somewhat more qualitative using a comparison of the amount of reclaimed water provided to typical summer flow levels at a representative flow gage on each river. Translating these improvements in flow into quantitative benefits to fish or other aquatic life was beyond the scope of this assessment.

Although enhancement of summer streamflow has the potential to increase aquatic habitat, it also has the potential to increase high flows, particularly winter flood flows if the strategy includes year-round use of reclaimed water. While natural floodplain inundation is generally considered beneficial to native vegetation and wildlife (Bunn and Arthington 2002), regulations have been promulgated to minimize risk of economic losses and loss of human life as development has encroached into areas that are seasonally flooded. An assessment was conducted to evaluate the potential effect of year-round wetland application of reclaimed water on flood flows and seasonal flooding. This assessment relied on published flood peak flow return frequencies at representative locations on the assessed streams and rivers.

Although beyond the scope of this assessment, a more complete evaluation of the effect of the additional flow on the “zero-rise” flood hazard mitigation standard could be conducted using available county flood models. It should be noted that the county drainage regulations do not explicitly consider the evaluation of direct or indirect stream flow enhancement projects on flooding. These regulations are generally directed to the management of stormwater runoff from construction and development activities and the effect of encroachment of development or construction within designated floodplains (i.e., the area subject to inundation by the 100-year flood flow). For example, a Zero-Rise Study is sometimes needed to determine whether a proposed development meets flood standards (i.e., does not cause more than a 0.01 foot rise in the modeled 100-yr flood water surface elevation).

4.0. REDMOND/BEAR CREEK BRIGHTWATER CENTRALIZED STRATEGY

This chapter presents results of the assessment of the potential effects of the Redmond/Bear Creek Brightwater Centralized strategy on water quality, water quantity, and groundwater. The sections below address the effects on lakes, streams, and rivers, with the final section of the chapter providing a summary.

4.1 Cottage, Crystal and Sammamish Lakes

This section presents effects on water quality in the lakes first, followed by effects on water quantity.

4.1.1 Water Quality

Results are presented for nutrients and dissolved oxygen as well as for temperature.

Nutrients and Dissolved Oxygen

Cottage Lake, Crystal Lake, and Lake Sammamish would all potentially be negatively affected by additional nutrient input from the reclaimed water strategy.

Ecology has determined that beneficial uses of Cottage Lake are impaired due to excessive phosphorus input and increased algal growth (Ecology 2004, Ecology 2007). Ecology has established a TMDL for point and non-point sources of phosphorus to the lake, including a load allocation for Daniels Creek of 16 kg of phosphorus between June and August (Ecology 2007).

Assuming that a reclaimed water wetland enhancement project were implemented at Crystal Lake and that the reclaimed water phosphorus concentration was 1 mg/L and passed through the wetland enhancement with little or no dilution or removal by vegetation or by Crystal Lake, then the total additional load of phosphorus to Daniels Creek—at the Daniels Creek inlet to Cottage Lake—would be on the order of 700 kg between June and August. Assuming that dilution and attenuation of phosphorus resulted in phosphorus concentrations typical of concentrations measured in Daniels Creek between June and August (0.060 mg/L; King County, unpublished data), then the additional load associated with reclaimed water would be about 42 kg from June and August, still much greater than the TMDL allocation of 16 kg (June-August) for Daniels Creek.

Although a phosphorus TMDL for Crystal Lake has not been established, it is reasonable to assume that this lake would also be sensitive to additional phosphorus inputs. The potential additional phosphorus load, assuming the reclaimed water phosphorus concentration were 1 mg/L and passed through the wetland enhancement with little or no dilution or removal by vegetation, would be the same as those given for Daniels Creek above (700 kg between June and August). Using the same assumptions for potential dilution and attenuation as for the Cottage Lake loading evaluation above, the load associated with the additional reclaimed water would be about 42 kg from June and August. Since these lakes are similar in size and the background contribution of flow and nutrients is smaller in the headwater Crystal Lake basin, the additional phosphorus loading to Crystal Lake has a high potential to exacerbate the already eutrophic condition of the lake, further promoting algal blooms, and potentially contributing to low oxygen concentrations in the bottom of the lake during summer.

There is a potential for Lake Sammamish to receive nutrient inputs, particularly phosphorus, via the Sammamish River/Lake Sammamish wetland enhancement AOI, particularly from the lake-fringe wetland area in Marymoor Park. Assuming no attenuation of phosphorus in the wetland, the potential phosphorus loading from reclaimed water under 12-month operation would be approximately 2,700 kg per year. This can be compared to the total estimated fluvial load of total phosphorus to Lake Sammamish of 16,600 kg (King County 1995, Table 4-2 below). Therefore, worst-case would be that the strategy increases total phosphorus loading to the lake by about 16 percent. The 7-month operation scenario would contribute less—about 1,600 kg, or a 10 percent increase in total phosphorus loading. However, if the wetland enhancement is designed to achieve a background total phosphorus level either via adjustment of the nutrient loading rate and/or infiltration of some or all of the discharge, then the potential total phosphorus loading rate would be much lower. Using a typical background stream or river total phosphorus concentration of 0.06 mg/L, the potential year-round total phosphorus loading to Lake Sammamish would be on the order of 170 kg and for 7-month operation would be about 100 kg or 1 percent or less of the total estimate load to the lake.

Temperature

This strategy is not expected to affect lake temperatures. In general, the temperatures of lakes of this size that thermally stratify in summer are controlled primarily by the exchange of heat across the lake surface.

4.1.2 Water Quantity

The effect of this strategy on summer lake levels is expected to be minimal due to the relatively large surface area of these lakes and relatively small amounts of water that will be introduced, particularly with respect to Lake Sammamish. A more detailed assessment of the potential effect on the levels of Crystal Lake and Cottage Lake would require the development of relatively simple reservoir storage models of these lakes.

4.2 Streams

This section presents effects on water quality in streams first, followed by effects on water quantity.

4.2.1 Water Quality

Results are presented for nutrients and dissolved oxygen as well as for temperature.

Nutrients and Dissolved Oxygen

Although there are potential benefits to streams that would result from the environmental enhancement use of reclaimed water, there are also some potential negative effects that could result from the introduction of additional nutrients, primarily nitrogen and phosphorus. Additional nutrients have the potential to promote nuisance growth of algae attached to the stream bottom (periphyton) and to cause associated changes in daily dissolved oxygen fluctuations in the stream. Dense periphyton growth can cause oxygen levels to increase during the day as the algae take up nutrients and use sunlight and carbon dioxide in photosynthesis (also resulting in an increase in pH), but as the attached algae respire at night oxygen levels (and pH) can go down to levels that can harm aquatic life that depend on oxygen for survival. Nitrogen introduced to streams in the form of ammonia can also affect stream dissolved oxygen levels through the bacterial conversion of ammonia to nitrate, which results in the consumption of oxygen in the process.

To evaluate the effect of the wetland enhancement uses on Cottage Lake and Bear Creek on nutrients and dissolved oxygen, the QUAL2Kw model developed to support the Bear-Evans Creek temperature and dissolved oxygen TMDL was used. The QUAL2Kw model is used by Ecology to simulate summer maximum temperatures and minimum oxygen levels in impaired streams to establish riparian restoration and nutrient load targets.

The TMDL model representing current riparian conditions and summer critical flow and weather conditions (nominally a worst-case seven-day average period with a one-in-ten chance of occurring in any year—i.e., 7Q10 conditions) was used. The model representing Cottage Lake Creek represents the portion of the creek from just below Cottage Lake and the confluence of Cottage Lake Creek and Cold Creek to the point where Cottage Lake Creek joins Bear Creek. The upstream flow boundary of the model was increased to represent the additional flow (8.8 cfs) that would enter the creek from the two wetland enhancement uses upstream of this point (i.e., Crystal and Cottage lakes wetlands).

To evaluate the potential effect of additional nutrient inputs to Cottage Lake Creek and Bear Creek, it was assumed that the additional nutrients introduced as part of the wetland enhancement would be completely attenuated to existing background conditions used in the model upstream boundary. Therefore, the effect of the reclaimed water enhancement use would be limited to the additional nutrient load associated with the additional volume of water. The comparison of the base case TMDL model run for current critical summer conditions to the effect of adding an additional 8.8 cfs of water at the upstream boundary of the Cottage Lake Creek model (with no change in the boundary nutrient concentrations) indicates that daily minimum dissolved oxygen levels could decline by as much as 0.6 mg/L in Cottage Lake Creek and could increase or decrease in Bear Creek depending on the distance below the Cottage Lake Creek confluence (Figure 4-1 and Figure 4-2). The decrease of 0.6 mg/L would exceed the allowable 0.2 mg/L decrease due to human influence identified in the state water quality standards. Any additional nutrient contribution above background at the point below Cottage Lake would be expected to result in additional declines in stream summer minimum dissolved oxygen levels.

Temperature

To evaluate the effect of the wetland enhancement uses on Cottage Lake and Bear Creek summer temperature, the QUAL2Kw model developed to support the Bear-Evans Creek temperature and dissolved oxygen TMDL was used.

It was assumed that the temperature of the upstream boundary would remain unchanged by the upstream introduction of reclaimed water at this point—seven-day moving average of the daily maximum (7-DMADMax) of 21.2 °C. This is a reasonable assumption since much of the reclaimed water would become diluted as it passed through open wetland and lake areas, which would also be exposed directly to heating by the sun. The output from the Cottage Lake Creek model was then used as input to the Bear Creek model representing Bear Creek from its headwaters to the confluence with the Sammamish River.

The modeled effect of the additional flow on water temperature suggests a reduction in daily maximum temperatures under critical summer conditions on the order of 0.5 to almost 1.8 °C, depending on the downstream assessment point (Figure 4-3 and Figure 4-4). However, daily minimum temperature is predicted to generally increase, resulting in an overall increase in average stream temperature under critical summer conditions of up to about 0.3 °C depending on the assessment point, with the exception of the mile below the upstream boundary of Cottage Lake Creek, where average stream temperature is predicted to be 0.2 to 0.3 °C lower.

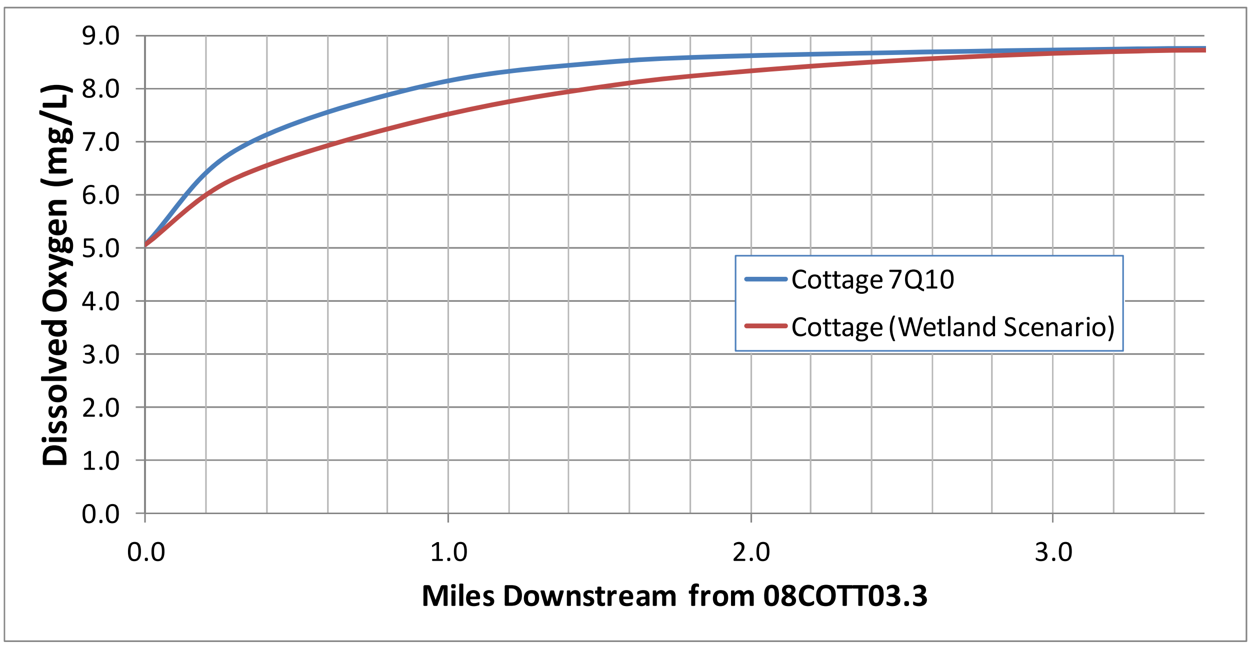


Figure 4-1. Comparison of the effect of an increase of 8.8 cfs at the upstream boundary (below Cottage Lake) of the Ecology Current Critical Conditions (7Q10) QUAL2Kw model of Cottage Lake Creek on summer minimum dissolved oxygen concentrations

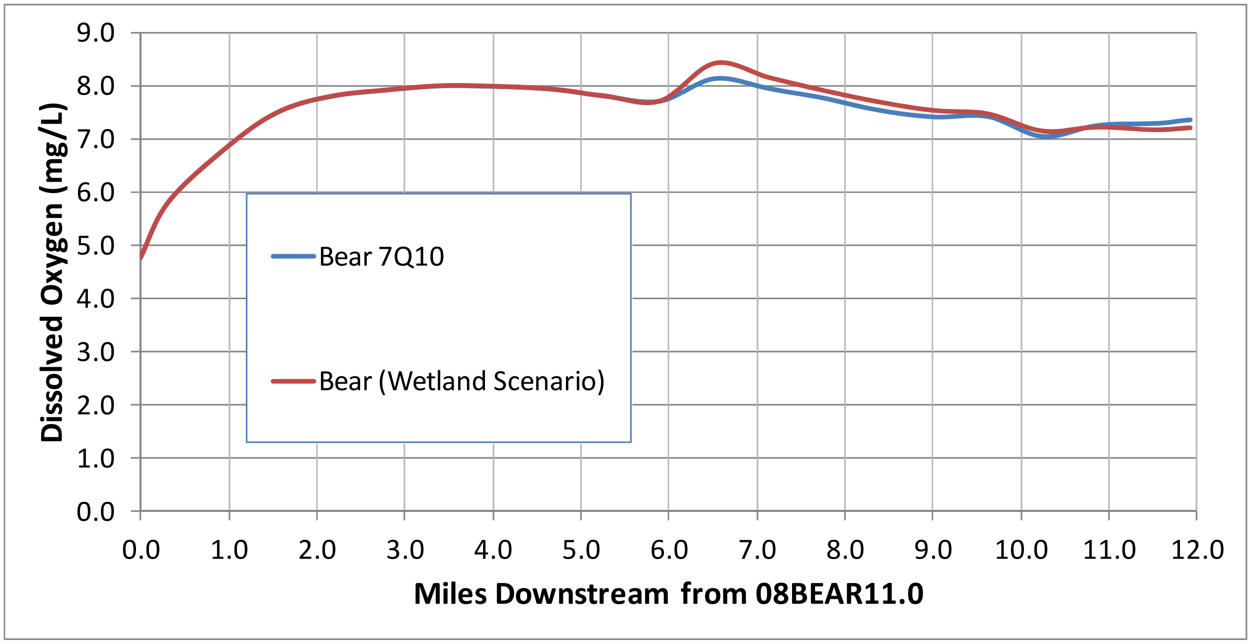


Figure 4-2. Comparison of the effect of an increase of 8.8 cfs at the upstream boundary (below Cottage Lake) of the Ecology Current Critical Conditions (7Q10) QUAL2Kw model of Bear Creek on summer minimum dissolved oxygen concentrations

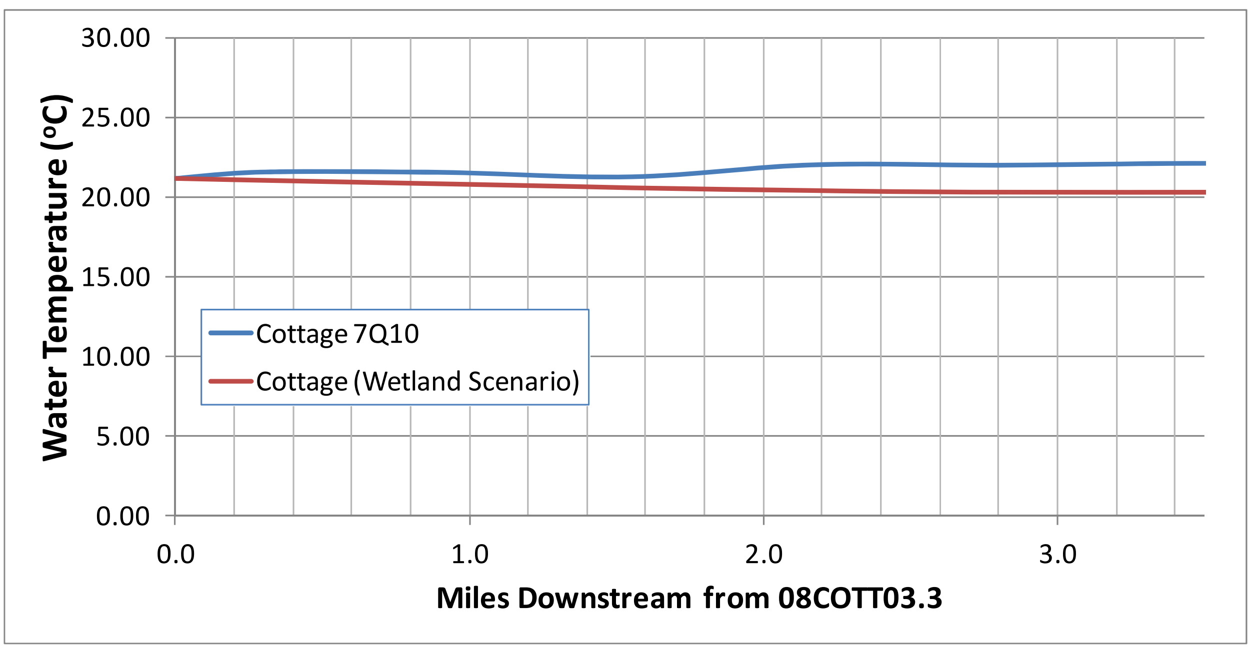


Figure 4-3. Comparison of the effect of an increase of 8.8 cfs at the upstream boundary (below Cottage Lake) of the Ecology Current Critical Conditions (7Q10) QUAL2Kw model of Cottage Lake Creek on summer maximum stream temperature

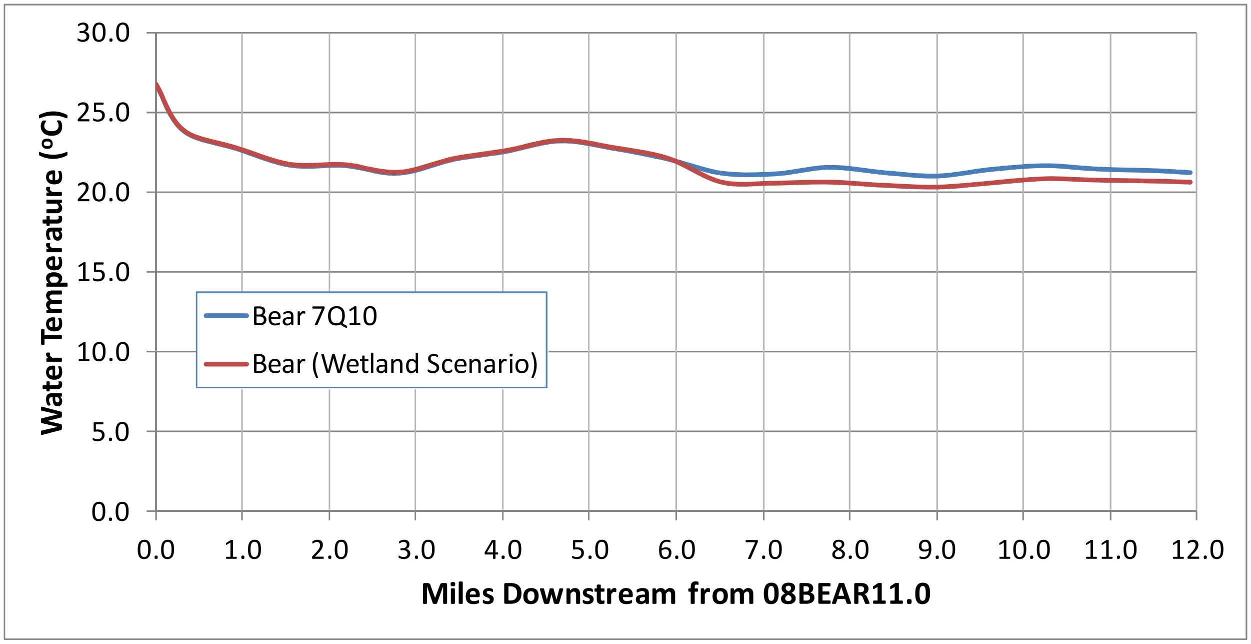


Figure 4-4. Comparison of the effect of an increase of 8.8 cfs at the upstream boundary (below Cottage Lake) of the Ecology Current Critical Conditions (7Q10) QUAL2Kw model of Bear Creek on summer maximum stream temperature

4.2.2 Water Quantity

Water quantity in streams is discussed with respect to summer low flow and winter high flow.

Summer Low Flow

To evaluate the effect of the wetland enhancement uses on Cottage Lake and Bear Creek on summer low flow, the QUAL2Kw model developed to support the Bear-Evans Creek temperature and dissolved oxygen TMDL was used.

Model results for the effect of additional flow on stream habitat as measured by wetted cross-sectional area indicate a potential doubling of wetted cross-sectional area in Cottage Lake Creek and an average of about a 50 percent increase in Bear Creek below the confluence with Cottage Lake Creek (Figure 4-5 and Figure 4-6). Model results for the effect of additional flow on stream habitat as measured by wetted perimeter indicates a potential increase of about 10 percent in Cottage Lake Creek and an average of about a 15 percent increase in Bear Creek below the confluence with Cottage Lake Creek (Figure 4-7 and Figure 4-8).

Winter High Flow

With respect to the year-round application of reclaimed water for wetland environmental enhancement, one concern is for the potential to increase stream flooding. Although a detailed hydraulic analysis of the effect of the additional water release to Daniels and Cottage Lake creeks is beyond the scope of this assessment, available flood return frequency statistics are published in the Federal Emergency Management Agency (FEMA) Flood Insurance Study.[5] Flood Insurance Studies (FIS) and Flood Insurance Rate Maps (FIRMs) cover Cottage Lake Creek up to a point just south of where Cottage Lake Creek crosses NE 155th Street and south of Cottage Lake and the confluence of Cold Creek and Cottage Lake Creek. Therefore, comparison to flood return frequency flows cannot be made for the stream reaches immediately downstream of the wetland enhancement uses (i.e., along Daniels Creek and Cold Creek).

To evaluate the potential effect of an additional year-round addition of 8.8 cfs to the headwaters of Cottage Lake Creek below Cottage Lake on Cottage Lake Creek and Bear Creek flooding, the percent increase in the peak flow associated with the 5-yr to the 500-yr return frequency instantaneous peak flow published in the FIS for King County was calculated (Table 4-1). It appears that 8.8 cfs would contribute at most an additional 3.1 percent to the 5-yr return flow at the mouth of Cottage Lake Creek and less than 1percent for flows with a expected 5-yr through 500-yr expected return frequency to reaches of Bear Creek below the confluence with Cottage Lake Creek.

A more detailed zero-rise hydraulic assessment could provide an indication of the effect of this additional flow on water surface levels along the strategy stream reaches, but considering that the error associated with measuring flow in these small streams is unlikely to be better than ±5 percent, it is unlikely that the additional flow would result in an observable increase in flooding below Cottage Lake.

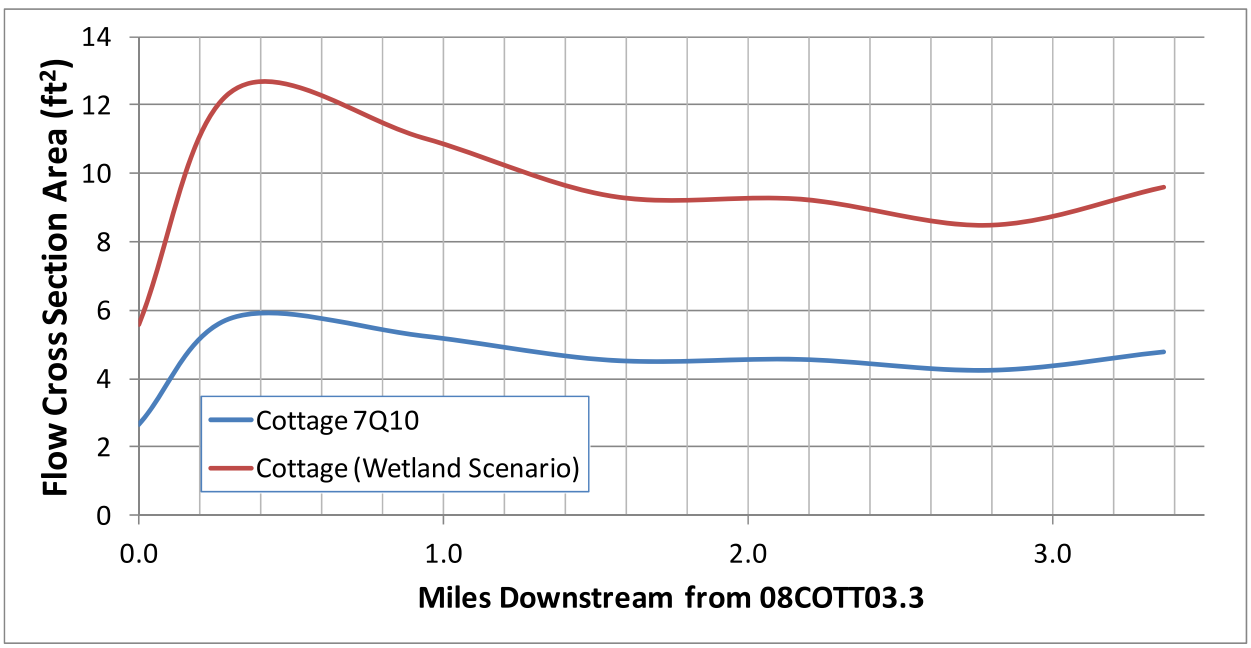


Figure 4-5. Comparison of the effect of an increase of 8.8 cfs at the upstream boundary (below Cottage Lake) of the Ecology Current Critical Conditions (7Q10) QUAL2Kw model of Cottage Lake Creek on wetted stream cross-sectional area

[5] Available online: http://your.kingcounty.gov/dnrp/wlr/flood/dfirm/pdf/53033CV001B_Volume1.pdf

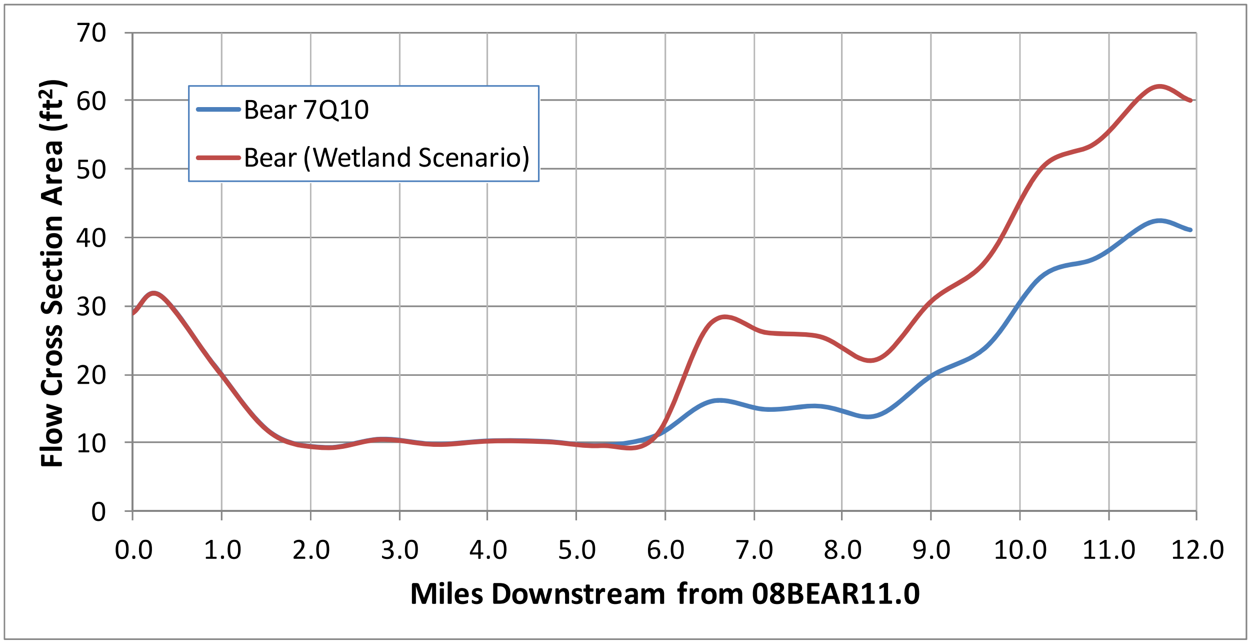


Figure 4-6. Comparison of the effect of an increase of 8.8 cfs at the upstream boundary (below Cottage Lake) of the Ecology Current Critical Conditions (7Q10) QUAL2Kw model of Bear Creek on wetted stream cross-sectional area

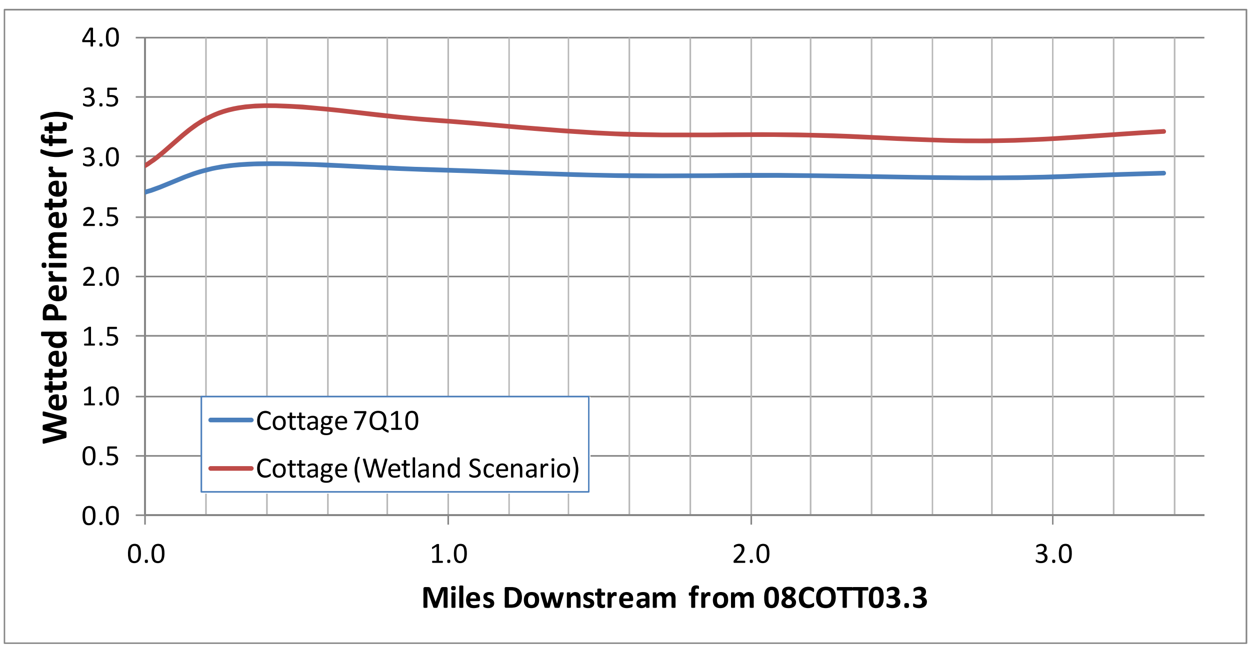


Figure 4-7. Comparison of the effect of an increase of 8.8 cfs at the upstream boundary (below Cottage Lake) of the Ecology Current Critical Conditions (7Q10) QUAL2Kw model of Cottage Lake Creek on wetted stream perimeter

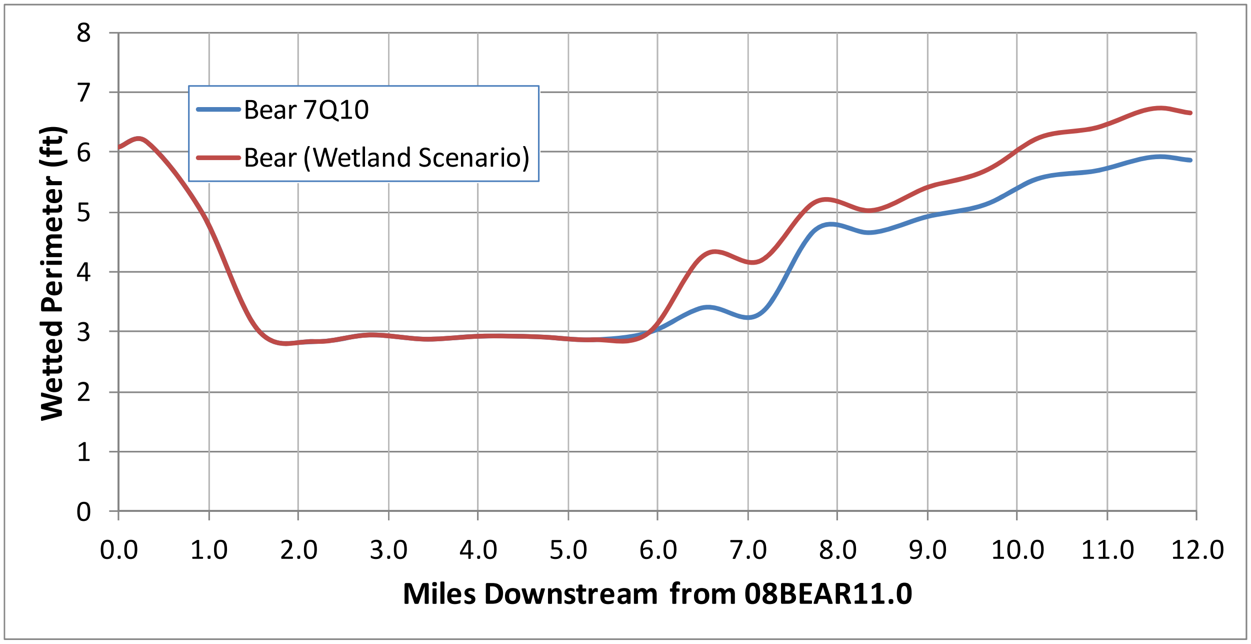


Figure 4-8. Comparison of the effect of an increase of 8.8 cfs at the upstream boundary (below Cottage Lake) of the Ecology Current Critical Conditions (7Q10) QUAL2Kw model of Bear Creek on wetted stream perimeter

Table 4-1. Published King County Flood Insurance Study peak discharge return frequency flows and calculated percent increase in Cottage Lake Creek and Bear Creek assuming an additional 8.8 cfs of flow contributed below Cottage Lake

Peak discharge return frequencies		Cottage Lake Creek at Mouth		Bear Creek at River Mile 3.5		Bear Creek at SR 202	
		cfs	%	cfs	%	cfs	%
5-yr	10-percent chance	288	3.1%	689	1.3%	1,060	0.8%
50-yr	2-percent chance	386	2.3%	887	1.0%	1,365	0.6%
100-yr	1-percent chance	428	2.1%	998	0.9%	1,535	0.6%
500-yr	0.2-percent chance	527	1.7%	1,300	0.7%	2,000	0.4%

The potential effect of additional water inputs on flooding in the upper reaches of Cottage Lake Creek or Daniels Creek cannot be quantitatively assessed. According to anecdotal information, the area where Cold Creek and Cottage Lake Creek merge routinely floods NE 165th Street. While additional water would contribute to the flooding, a more detailed assessment would be needed to determine if such a contribution were significant enough to warrant some type of mitigation. In general, this type of flooding does not pose a significant economic risk or risk to public safety since alternative routes are available when the road is closed due to flooding.

The potential amount of water added to Daniels Creek as part of the Crystal Lake wetland strategy is 3.1 cfs, which is less than half the total environmental enhancement strategy flow to the basin. Although this amount would be delivered to the headwaters of the basin and the stream channel capacity is likely to be less than that in Cottage Lake Creek below Cottage Lake, a more detailed hydraulic assessment would be needed to determine potential effects on flooding of this creek. As noted above, it might be possible to mitigate any effects on flooding that are determined to be significant.

4.3 Sammamish River

This section presents effects on water quality in the Sammamish River first, followed by effects on water quantity.

4.3.1 Water Quality

Results are presented for nutrients and dissolved oxygen as well as for temperature.

Nutrients and Dissolved Oxygen

The effect of potential nutrient inputs to the Sammamish River resulting from the wetland enhancement uses will also depend on the quality of the water released from the Sammamish River/Lake Sammamish wetland AOI. As noted above in the evaluation of additional nutrient releases to lakes and streams, any additional nutrient input is likely to result in an overall decrease in oxygen levels in the river. Infiltration of water released from the wetlands would provide the potential for further reduction in nutrient levels as a result of dilution and removal, providing more protection of the oxygen resources of the Sammamish River.

Temperature

The effect of these wetland enhancement uses on summer maximum temperatures in the Sammamish River will depend primarily on the temperature of water released from the Sammamish River/Lake Sammamish wetland enhancement uses. If water exits the wetland via surface discharge to the outlet of Lake Sammamish above the weir that controls the level of the lake, then it is likely that additional warm water from the lake would be contributed to the upstream boundary of the river, which might be offset by the reduction in daily maximum temperature of about 0.3 ^{o}C, as well as the additional flow, expected from Bear-Evans Creek. If the wetland release is allowed to infiltrate to the shallow groundwater before reaching the river, then some reduction in Sammamish River temperatures might be expected depending on the final temperature and amount of water released to the river via subsurface flow. Although currently beyond the scope of this assessment, it may be possible to evaluate the effect of various temperature scenarios using the temperature model of the Sammamish River used in the Sammamish River Corridor Action Plan (King County 2002).

4.3.2 Water Quantity

Water quantity in the Sammamish River is discussed with respect to summer low flow and winter high flow.

Summer Low Flow

The effect of additional flow provided by the strategy wetland enhancement projects in Bear Creek and at the headwaters of the Sammamish River at Marymoor Park would likely provide only a marginal benefit to flow and wetted habitat in the Sammamish River. Based on long-term gage records for the Sammamish River, there does not appear to be a statistically significant decline in summer seven-day low flow in the Sammamish River, although a statistically significant decline in mean annual flow has been noted (King County 2011). Any decline in summer flow has likely been masked by storage and release of water in Lake Sammamish (King County 2011). The total flow contribution from the wetland strategies would potentially contribute an additional 11.9 cfs to the Sammamish River. This would increase typical summer low flows from 52 to almost 64 cfs, or about 23 percent.

Winter High Flow

The effect of the additional water on Sammamish River flooding is expected to be minimal. The increase in flood return frequency flows is expected to be less than 1 percent for flows from the 5-yr to the 500-yr return frequency (Table 4-2).

Table 4-2. Published King County Flood Insurance Study peak discharge return frequency flows and calculated percent increase in Sammamish River assuming an additional 11.9 cfs of flow contributed from the combined Crystal Lake, Cottage Lake and Sammamish River/Lake Sammamish AOIs

Peak discharge return frequencies		Sammamish River at Redmond below Bear Creek	
		cfs	%
5-yr	10-percent chance	1,740	0.7%
50-yr	2-percent chance	2,480	0.5%
100-yr	1-percent chance	2,830	0.4%
500-yr	0.2-percent chance	3,820	0.3%

4.4 Groundwater Quality and Quantity

Some potential exists for seepage of a mixture of native wetland water and reclaimed water to local shallow aquifers. The areas proposed for wetland enhancement generally occur on soils with low permeability. Therefore, negligible amounts of diluted reclaimed water would be expected to infiltrate to shallow aquifers as a result of the reclaimed water strategy.

Some potential exists for recharge of groundwater via loss through the creek system. In the QUAL2Kw model, there is a net diffuse inflow to Cottage Lake Creek, indicating little potential for groundwater recharge. However, in the Bear Creek model, there are diffuse losses to groundwater specified for the reach just below the confluence with Cottage Lake Creek (1.7 cfs) and another losing reach just below the confluence of Bear and Evans creeks (0.53 cfs). At these points along the creek, the reclaimed water released to the headwater wetlands would be considerably diluted.

The potential effect of the reclaimed water strategy on groundwater recharge through the Sammamish River channel is likely to be very limited. A study by Ecology (2003) indicates that during summer, the Sammamish River primarily gains water through groundwater inflow rather than losing water to the shallow aquifer in the river valley.

4.5 Summary

Potential effects on lakes, streams, and rivers from the Redmond/Bear Creek Brightwater Centralized Strategy are as follows. This assessment suggests that wetland enhancement with reclaimed water has the potential to improve summer flow and aquatic habitat in Daniels, Cottage Lake, and Bear creeks. The additional water provided to the stream also has the potential to reduce daily maximum temperatures under critical summer conditions on the order of 0.5 to almost 1.8 °C. An increase of about 20 percent in typical summer flows in the Sammamish River below the confluence with Bear Creek would also be expected. A reduction in maximum summer river temperatures would also be expected, primarily as a result of reduced maximum temperatures in Bear Creek. However, the assessment of the potential effects of the input of additional nutrients suggests that uses of lakes, streams, and rivers by aquatic life may be affected by a decrease in dissolved oxygen. Small lakes may be particularly sensitive to additional inputs of phosphorus; even if the wetland system resulted in background concentrations of phosphorus, the additional input of phosphorus associated with the additional input of reclaimed water has the potential to exacerbate the eutrophic condition of these lakes, including increases in the duration and magnitude of nuisance algal blooms and anaerobic conditions in lake bottom waters.

Year-round wetland enhancement use of reclaimed water is not likely to significantly increase flooding in designated flood hazard zones, although a more detailed hydraulic analysis could be performed to confirm this. In the upper watershed, particularly at NE 165th Street where the contributions from the Cottage Lake and Crystal Lake wetland enhancement projects would be combined, nuisance flooding that has been reported to result in road closures could be exacerbated. However, this type of nuisance flooding generally does not pose a significant economic risk or risk to public safety as alternative routes are available when the road is closed due to flooding.

In general, the existing regulatory framework for preventing or mitigating drainage problems and minimizing flooding-associated economic risk and risk to public safety are designed to manage drainage impacts of development and encroachment of development in floodplains. The existing regulatory framework does not explicitly address these issues with respect to the intentional addition of water, reclaimed or otherwise, for environmental enhancement purposes.

5.0. RENTON/TUKWILA SOUTH PLANT CENTRALIZED STRATEGY

This chapter presents results of the assessment of the potential effects of the Renton/Tukwila South Plant Centralized strategy on water quality, water quantity, and groundwater. The sections below address the effects on Lake Washington and the Cedar River, with the final section of the chapter providing a summary.

5.1 Lake Washington

This section presents effects on water quality in Lake Washington first, followed by effects on water quantity.

5.1.1 Water Quality

Results are presented for nutrients and dissolved oxygen as well as for temperature.

Nutrients and Dissolved Oxygen

The potential effect of the wetland enhancement use on nutrient delivery to the Cedar River and ultimately to Lake Washington would also depend on the method used to deliver the water from the wetland to the river. A worst-case scenario assuming little or no attenuation of phosphorus by the wetland and a direct discharge to the river of 0.8 cfs would result in approximately 1,420 kg of phosphorus delivered to the river on an annual basis. This can be compared to the total annual fluvial load to Lake Washington (post-diversion of secondary treated wastewater discharges) of approximately 53,000 kg (Edmondson and Lehman 1981). Thus a year-round direct discharge from the wetland strategy assuming little removal of phosphorus beyond the expected reclaimed water discharge concentration of 2.0 mg/L would increase the annual phosphorus load by about 3 percent. This amount is approximately equivalent to the estimation error reported in Edmondson and Lehman (1981) of about 3 percent. However, the relative availability of the form of phosphorus released may be at least as important as the total amount (Edmondson and Lehman 1981). Assuming that some combination of wetland attenuation and/or infiltration before release to the river resulted in a concentration closer to that of the river at that point—assuming a concentration of 0.06 mg/L—then the phosphorus load would be reduced to about 40 kg for a year-round application. This additional load of phosphorus would likely make an insignificant contribution to eutrophication of the lake, being less than 1 percent of the estimated annual fluvial load.

Temperature

This strategy is not expected to affect the temperature of Lake Washington. In general, the temperatures of lakes of this size that thermally stratify in summer are controlled primarily by the exchange of heat across the lake surface.

5.1.2 Water Quantity

The relatively small amount of water associated with this strategy is not expected to significantly affect the level of Lake Washington, although it would be expected to make a small contribution to the maintenance of summer lake levels that would assist the Army Corps of Engineers in maintaining water levels in both Lake Washington and Lake Union and in allowing sufficient water for the operation of the fish ladder and smolt slide (Ecology 2011b).

5.2 Cedar River

This section presents effects on water quality in the river first, followed by effects on water quantity.

5.2.1 Water Quality

Results are presented for nutrients and dissolved oxygen as well as for temperature.

Nutrients and Dissolved Oxygen

A quantitative assessment of the potential effect of this strategy on dissolved oxygen levels in the Cedar River as a result of the nutrient inputs is beyond the scope of this assessment. If the nutrient levels in the reclaimed water can be attenuated in the wetland and/or via infiltration to near background levels, particularly the relatively high expected ammonia concentrations, then the effects on the oxygen levels in the river are likely to be minimal.

Temperature

Temperature effects on the river are also likely to be relatively insignificant, although the magnitude of effect is likely to be less if the wetland discharge is allowed to infiltrate into the ground before it reaches the river.

5.2.2 Water Quantity

Water quantity in the Cedar River is discussed with respect to summer low flow and winter high flow.

Summer Low Flow

The effect of additional flow provided by the strategy wetland enhancement project on the Cedar River would likely provide only a marginal benefit to flow and wetted habitat in the river. Summer low flow in the river is on the order of 120 cfs, so the addition of 0.8 cfs has the potential to increase the flow by less than 1 percent.

Winter High Flow

The effect of the additional water on Cedar River flooding is expected to be minimal. The increase in flood return frequency flows is expected to be 0.01 percent or less for flows from the 5-yr to the 500-yr return frequency (Table 5-1). It is very unlikely that the increase in flow would result in a 0.01 foot rise in the 100-year flood flow elevation in the Cedar River.

Table 5-1. Published King County Flood Insurance Study peak discharge return frequency flows and calculated percent increase in the Cedar River assuming an additional 0.8 cfs of flow contributed from the wetland enhancement use in Renton

Peak discharge return frequencies		Cedar River at USGS gage in Renton	
		cfs	%
5-yr	10-percent chance	5,940	0.01%
50-yr	2-percent chance	9,860	0.01%
100-yr	1-percent chance	12,000	0.01%
500-yr	0.2-percent chance	18,400	0.00%

5.3 Groundwater Quality and Quantity

The effect of this strategy on groundwater recharge is expected to be relatively small given the volume of water (0.8 cfs), although the relative magnitude of the effect would depend strongly on whether the wetland would discharge directly to the Cedar River or be allowed to infiltrate the ground first. If infiltration is considered, then a hydrogeologic study would be required to evaluate the potential effect on groundwater, including groundwater quality and groundwater levels. Because the proposed wetland location is on a floodplain terrace above the river, the stability of the terrace would also need to be evaluated.

5.4 Summary

Potential effects on Lake Washington and the Cedar River from the Renton/Tukwila South Plant Centralized Strategy are as follows. This assessment suggests that the effect on water quality of the river and the lake from the creation of a wetland using reclaimed water will depend primarily on the removal of nutrients, primarily phosphorus and ammonia nitrogen, prior to release of water to the river. Ideally, the water released from the wetland would be allowed to infiltrate prior to release to the river to minimize potential adverse effects on river temperature and minimize the input of phosphorus to Lake Washington. Effects on summer and winter river flow and lake levels are not expected to be significant. If water released from the wetland is allowed to infiltrate into the ground, a detailed hydrogeologic study would be required to evaluate the potential effect of the project on groundwater quality, groundwater levels, and the stability of the floodplain terrace on which the wetland would be located.

6.0. TRACE CONTAMINANTS

Trace contaminants in reclaimed water may be harmful to aquatic organisms inhabiting lakes, streams, and rivers and to humans who use surface waters for recreational purposes and groundwater for potable water supply. The fate of trace contaminants in reclaimed water used for wetland enhancement is complex and depends on the chemical, physical, and biological properties that facilitate the sorption and/or degradation of constituents within the wetland (ICF Jones and Stokes 2008). In general, trace contaminants for which water quality standards exist are more easily evaluated, but there are many trace contaminants in water treated to Class A reclaimed water standards for which no established water quality standards or guidelines exist. These include a number of household chemicals, pharmaceuticals, and other chemical products and biogenic hormones (natural and synthetic) that are not completely removed during the wastewater treatment process, whether the treatment process is a centralized wastewater treatment facility or an on-site septic system (Kolpin et al. 2002). Furthermore, the effect of these contaminants on humans and aquatic organisms is poorly understood (Kolpin et al. 2002).

A class of these contaminants that has received recent attention are endocrine disrupting compounds (EDCs). EDCs are natural and synthetic hormonally active agents that can affect the endocrine system in humans and animals, including fish. Wastewater treatment typically removes over 90 percent of many of the most common EDCs entering a treatment plant. To date, no studies have effectively linked low concentrations of EDCs in wastewater to adverse health effects in humans as a result of using lakes, streams, and rivers. However, Kolpin et al. (2002) suggest that although acute effects on aquatic biota appear to be limited, chronic effects from low-level exposure to organic contaminants, including EDCs, in wastewater may be of greater concern.

Exposure of aquatic organisms to EDCs during sexual maturation has the potential to disrupt development and cause subsequent adverse effects. Three EDCs account for most of the hormonal activity of treated wastewater: estrone (E1), 17β-estradiol (E2), and 17α-ethinylestradiol (EE2). The first two are naturally occurring steroids and the third is a synthetic steroid found in contraceptives. Sampling of lakes, streams, and rivers throughout King County indicates that many EDCs already occur in the ambient environment in the absence of direct wastewater or reclaimed water discharges (King County 2007b). Some of these constituents appear to be primarily associated with stormwater runoff (e.g., 4-nonylphenol, King County 2005), while others appear to be associated with releases from sanitary sewer exfiltration or on-site septic systems (e.g., the synthetic estrogen hormone EE2, King County 2007b). EE2 has the highest specific estrogenic activity of these compounds.

Although a detailed evaluation of the potential fate and transport of EDCs associated with these strategies is beyond the scope of this assessment, recently an environmental feasibility study was conducted of a proposed reclaimed water wetland enhancement project in Kingston, Washington. As part of this study, an ecological risk assessment indicated limited risk for adverse effects on fish downstream of the wetland system (Golder 2010).

7.0. RECOMMENDATIONS FOR FURTHER STUDY

The assessment of the potential effects of the reclaimed water strategies on lake, stream, and river water quality and quantity presented in this document was based on existing data, reports, and readily available water quality models. A more detailed assessment of the potential effects of these strategies on lake, stream, and river water quality and quantity could be conducted that would include:

- Hydraulic modeling of lakes and streams to better quantify the effect of additional water on lake levels and stream flood profiles
- Water quality modeling of lakes to quantify the potential effect of additional phosphorus input on algae growth and bottom water dissolved oxygen levels
- Water quality modeling of the Sammamish River to quantify the potential effect of the Redmond/Bear Creek Brightwater Centralized Strategy on river temperature

In addition to further evaluation specific to the proposed reclaimed water strategies, some broader issues may warrant further study. Efforts designed to support evaluation of environmental enhancement uses of reclaimed water in general include but are not limited to:

- Developing a framework to evaluate the fate and transport of trace contaminants in reclaimed water, including a human health and/or ecological risk assessment
- Developing a water quantity regulatory framework for streamflow augmentation (via direct discharge, wetland enhancement/creation, or indirect groundwater recharge)
- Developing a method to quantify the effect of improvements in stream flow (and temperature) into improvements in fish production and/or survival

Results of these broader efforts could, in turn, be used in more detailed investigation of one or more of the proposed reclaimed water strategies.

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