

411 108TH AVENUE NE, SUITE 1800  
BELLEVUE, WA 98004-5571  
T. 425.458.6200 F. 425.458.6363  
www.parametrix.com

## TECHNICAL MEMORANDUM

**Date:** November 5, 2008  
**To:** Erika Conkling and Renton Staff  
**From:** David Sherrard, Parametrix  
**Subject:** Opportunities and Constraints for Maintaining and Enhancing Ecological Productivity  
**cc:** Project File  
**Project Number:** 553-1779-031  
**Project Name:** Renton Shoreline Master Program

---

### INTRODUCTION

This technical memorandum addresses issues relating to opportunities and constraints for maintaining and enhancing ecological functions.

This is one of four technical memoranda that address the framework of decisions needed to be made to implement the 2003 Shoreline Guidelines in Washington Administrative Code (WAC) 173-26. Other technical memoranda prepared to address other issues include:

- Regulatory Options
- Public Access
- Market Opportunities for Water Dependent Uses

This memorandum discusses the issues relating to the maintenance and enhancement of ecological functions with the intent of providing suggested options to incorporate into the City of Renton's Shoreline Master Program (SMP). The options discussed in this memorandum may influence the content of the following elements of the SMP:

- Policies and Regulations for Shoreline Environments (or zoning classifications)
- Specific regulations, including performance standards for specific uses
- Specific regulations, including performance standards for specific shoreline reaches
- Specific regulations, including performance standards to address cumulative impacts
- Designation of preferred mitigation strategies for project impacts
- The Restoration Element of the SMP

Although specific projects and performance standards are listed in this memorandum, the intent is to provide an overview of opportunities and constraints for implementation, rather than provide the specifics of regulations and performance standards that may be developed.

This memorandum addresses:

- Existing relevant policies and regulation in the Renton SMP
- Shoreline Management Guidelines in WAC 193-26
- A discussion of options for maintaining and enhancing ecological productivity on a shoreline reach basis that includes:
  - An overview of ecological functions provided within each watershed
  - An overview of other programs, such as U.S. Army Corps of Engineers (Corps) guidelines for docks on Lake Washington that focus on species designated threatened and endangered under the Endangered Species Act (ESA)
  - An overview of opportunities for specific practices that could be implemented to maintain or enhance the ecological functions as well as constraints on implementation
  - Identification of projects in other plans, such as Salmon Recovery Plans

### Existing Code

Policies and regulations that relate to ecological functions in the Renton SMP that relate to ecological functions are found in Section 4.02, the Conservation Element, or in the 2005 Ordinance No. 5136, which introduced Critical Areas into the SMP.

#### 4.02 Conservation Element

##### 4.02.01 Goal:

The resources and amenities of all shorelines situated in the City of Renton are to be protected and preserved for use and enjoyment by present and future generations.

##### 4.02.02 Policies:

- A. Existing natural resources should be conserved.
  1. Water quality and water flow should be maintained at a level to permit recreational use, to provide a suitable habitat for desirable forms of aquatic life, and to satisfy other required human needs.
  2. Aquatic habitats and spawning grounds should be protected, improved and, if feasible, increased.
  3. Wildlife habitats should be protected, improved and, if feasible, increased.
  4. Unique natural areas should be designated and maintained as open space for passive forms of recreation. Access and use should be restricted, if necessary, for the conservation of these areas.
- B. Existing and future activities on all shorelines of the State regulated by the City of Renton should be designed to minimize adverse effects on the environment.
- C. The City of Renton should take aggressive action with responsible governmental agencies to assure that discharges from all drainage basins are considered an integral part of shoreline planning.
  1. Soil erosion and sedimentation which adversely affect any shoreline within the City of Renton will be prevented or controlled.
  2. The contamination of existing water courses will be prevented or controlled.

- D. Shoreline areas having historical, cultural, educational or scientific value should be identified and protected.
  - 1. Public and private cooperation should be encouraged in site preservation and protection.
  - 2. Suspected or newly discovered sites should be kept free from intrusions for a reasonable time until their value is determined.
- E. Festivals and temporary uses involving public interest and not substantially or permanently impairing water quality, water flow, or unique and fragile areas may be permitted per Chapter 5-21 of the Renton Municipal Code (RMC).
- F. All further development of the shorelines of May Creek east of I-405 right-of-way, and that portion of Springbrook Creek beginning from approximately SW 27th Street on the north to SW 31st Street on the south, abutting City-owned wetlands in this area, and for that portion of the west side of the Creek in the vicinity of SW 38th Street abutting the City's recently acquired Wetlands Mitigation Bank should be compatible with the existing natural state of the shoreline.
  - 1. Low density development should be encouraged to the extent that such development would permit and provide for the continuation of the existing natural character of the shoreline.
  - 2. The existing waterway of May Creek east of I-405 right-of-way, and that portion of Springbrook Creek beginning from approximately SW 27th Street on the north to SW 31st Street on the south, abutting City-owned wetlands in this area, and for that portion of the west side of the Creek in the vicinity of SW 38th Street abutting the City's recently acquired Wetlands Mitigation Bank should be left in an undeveloped natural state as much as possible.
- 5.02.01 Designation of the Natural Environment: A. Objective: The objective in designating a natural environment is to protect and preserve unique and fragile shoreline or wetland environments in their natural state. The natural environment is intended to provide areas of wildlife sanctuary and habitat preservation.
- 6.02.01 Pollution and Ecological Disruption: The potential effects on water quality, water and land vegetation, water life and other wildlife (including, for example, spawning areas, migration and circulation habits, natural habitats, and feeding), soil quality and all other environmental aspects must be considered in the design plans for any activity or facility which may have detrimental effects on the environment.
- 6.02.02 Burden on Applicant: Applicants for permits must explain the methods that will be used to abate, avoid or otherwise control the harmful effects.
- 6.02.03 Erosion: Erosion is to be controlled through the use of vegetation rather than structural means where feasible.
- 6.02.04 Geology: Important geological factors, such as possible slide areas, on a site must be considered. Whatever activity is planned under the application for the development permit must be safe and appropriate in view of the geological factors prevailing.
- 6.06 Landscaping 6.06.01 General: The natural and proposed landscaping should be representative of the indigenous character of the specific types of waterway (stream, lake edge, marshland) and shall be compatible with the Northwest image. The scenic, aesthetic, and ecological qualities of natural and developed shorelines should be recognized and preserved as valuable resources.
- 7.15.01. B. Sensitive Design: Roadways and Railroads located in shoreland areas shall be limited and allowed only if the following conditions are met:

1. The proposed route is determined to have the least impact on the environment, while meeting City Comprehensive Plan Transportation Element requirements and standards in RMC 4-6-060; and
- 7.17.02 Permitted Uses Trail uses shall be permitted within the shoreline, when the following standards are met:
- G. They are designed with a surface material which will carry the actual user loads and will have a minimum impact on the environment.
- 6.08.03. Shoreline Buffers:(d) Environmental Criteria: Proposals meeting Subsection (a) or (b) or (c) above shall also meet the following environmental criteria:
- (i) Buffer Enhancement:
    - The project includes a buffer enhancement plan using native vegetation and provides documentation that the enhanced buffer area will maintain or improve the functional attributes of the buffer; or
    - In the case of existing developed sites where a natural buffer is not possible, the proposal includes on- or off-site riparian/lakeshore or aquatic enhancement proportionate to its project specific or cumulative impact on shoreline ecological functions; or
  - (ii) The proposal will result in, at minimum, no-net loss of stream/lake/riparian ecological function;
- 6.08.03. Shoreline Buffers (e): Averaging of Buffer Width:
- ii. Criteria for Approval: Buffer width averaging may be allowed only where the applicant demonstrates all of the following:
    - (a) The water body and associated riparian area contains variations in ecological sensitivity or there are existing physical improvements in or near the water body and associated riparian area;
- 6.08.04. Stream/Lake Buffer Standards: Any proposal subject to RMC 4-3-090 shall comply with the following standards within required buffer areas:
- b. Sites with Developed Shorelines: Where the shoreline is largely in an unnatural state and the buffer predominantly contains impervious surfaces due to existing, legally permitted activities, the following standards shall apply:
    - iii. Where impervious surfaces exist in buffer areas, such impervious surfaces shall not be increased or expanded within the buffer area. The extent of impervious surfaces within the buffer area may only be re-arranged if the reconfiguration of impervious surfaces and restoration of prior surfaced areas is part of an enhancement proposal that improves ecological function of the area protected by the buffer.
    - iv. Existing native vegetation shall be preserved or enhanced to the extent possible, preferably in consolidated areas.
    - v. The proposal will result in, at minimum, no net loss of stream/lake/riparian ecological function;
- 6.08.05. Permit Evaluation Criteria for Shoreline Developments:
- a. No-Net-Loss of Functions: Shoreline uses or activities shall not adversely impact unique or fragile areas or stream/lake/riparian ecology function unless adequate mitigation measures are provided to ensure that there is no-net-loss of ecological functions as a result of the shoreline uses or activities.

***SMA Guidelines***

The statute and the 2003 Shoreline Guidelines have multiple provisions that address environmental concerns and ecological functions. Only the most significant are reproduced below.

**RCW 90.58.020:**

"The legislature finds that the shorelines of the state are among the most valuable and fragile of its natural resources and that there is great concern throughout the state relating to their utilization protection, restoration, and preservation."

"This policy contemplates protecting against adverse effects to the public health, the land and its vegetation and wildlife, and the waters of the state and their aquatic life. .."

"To this end uses shall be preferred which are consistent with the control of pollution and prevention of damage to the natural environment."

"Permitted uses in the shorelines of the state shall be designed and conducted in a manner to minimize, insofar as practical, any resultant damage to the ecology and environment of the shoreline area."

**WAC 173-26-181** Special policy goals of the act and guidelines for shorelines of statewide significance.

- (4) Protect the resources and ecology of the shoreline;

**WAC 173-26-186** Governing principles of the guidelines.

(8) Through numerous references to and emphasis on the maintenance, protection, restoration, and preservation of "fragile" shoreline "natural resources," "public health," "the land and its vegetation and wildlife," "the waters and their aquatic life," "ecology," and "environment," the act makes protection of the shoreline environment an essential statewide policy goal consistent with the other policy goals of the act. It is recognized that shoreline ecological functions may be impaired not only by shoreline development subject to the substantial development permit requirement of the act but also by past actions, unregulated activities, and development that is exempt from the act's permit requirements. The principle regarding protecting shoreline ecological systems is accomplished by these guidelines in several ways, and in the context of related principles...

- (a) Local government is guided in its review and amendment of local master programs so that it uses a process that identifies, inventories, and ensures meaningful understanding of current and potential ecological functions provided by affected shorelines.
- (b) Local master programs shall include policies and regulations designed to achieve no net loss of those ecological functions.
- (i) Local master programs shall include regulations and mitigation standards ensuring that each permitted development will not cause a net loss of ecological functions of the shoreline; local government shall design and implement such regulations and mitigation standards in a manner consistent with all relevant constitutional and other legal limitations on the regulation of private property.
- (ii) Local master programs shall include regulations ensuring that exempt development in the aggregate will not cause a net loss of ecological functions of the shoreline.
- (c) For counties and cities containing any shorelines with impaired ecological functions, master programs shall include goals and policies that provide for restoration of such impaired ecological functions. These master program provisions shall identify existing policies and programs that contribute to planned restoration goals and identify any additional policies and programs that local government will implement to achieve its goals. These master program

elements regarding restoration should make real and meaningful use of established or funded nonregulatory policies and programs that contribute to restoration of ecological functions, and should appropriately consider the direct or indirect effects of other regulatory or nonregulatory programs under other local, state, and federal laws, as well as any restoration effects that may flow indirectly from shoreline development regulations and mitigation standards.

- (d) Local master programs shall evaluate and consider cumulative impacts of reasonably foreseeable future development on shoreline ecological functions and other shoreline functions fostered by the policy goals of the act. To ensure no net loss of ecological functions and protection of other shoreline functions and/or uses, master programs shall contain policies, programs, and regulations that address adverse cumulative impacts and fairly allocate the burden of addressing cumulative impacts among development opportunities...
- (e) The guidelines are not intended to limit the use of regulatory incentives, voluntary modification of development proposals, and voluntary mitigation measures that are designed to restore as well as protect shoreline ecological functions.

**WAC 173-26-201** Comprehensive process to prepare or amend shoreline master programs.

- (2) Basic concepts.
- (c) Protection of ecological functions of the shorelines. This chapter implements the act's policy on protection of shoreline natural resources through protection and restoration of ecological functions necessary to sustain these natural resources. The concept of ecological functions recognizes that any ecological system is composed of a wide variety of interacting physical, chemical and biological components, that are interdependent in varying degrees and scales, and that produce the landscape and habitats as they exist at any time. Ecological functions are the work performed or role played individually or collectively within ecosystems by these components.

As established in WAC 173-26-186(8), these guidelines are designed to assure, at minimum, no net loss of ecological functions necessary to sustain shoreline natural resources and to plan for restoration of ecological functions where they have been impaired. Managing shorelines for protection of their natural resources depends on sustaining the functions provided by: [following text not reproduced]

**WAC 173-26-201** Comprehensive process to prepare or amend shoreline master programs.

- (2) Basic concepts.
- (e) Environmental impact mitigation.(i) To assure no net loss of shoreline ecological functions, master programs shall include provisions that require proposed individual uses and developments to analyze environmental impacts of the proposal and include measures to mitigate environmental impacts not otherwise avoided or mitigated by compliance with the master program and other applicable regulations. To the extent Washington's State Environmental Policy Act of 1971 (SEPA), chapter 43.21C RCW, is applicable, the analysis of such environmental impacts shall be conducted consistent with the rules implementing SEPA, which also address environmental impact mitigation in WAC 197-11-660 and define mitigation in WAC 197-11-768. Master programs shall indicate that, where required, mitigation measures shall be applied in the following sequence of steps listed in order of priority, with (e)(i)(A) of this subsection being top priority. [following text not reproduced]

## ***Options***

This section provides:

- An overview of ecological functions provided within various shoreline reaches
- An overview of opportunities for specific practices that could be implemented to maintain or enhance the ecological functions
- A discussion of other programs that relate to the opportunities or practices
- A discussion of the constraints that may be present in existing land uses, public facilities, or policies and regulations

Although specific projects and performance standards are listed in this memorandum, the intent is to provide an overview of opportunities and constraints for implementation, rather than provide the specifics of regulations and performance standards that may be developed.

The information on existing ecological functions within the Renton shoreline is based on the *City of Renton, Draft Shoreline Inventory and Analysis*, October 2008. This document is referenced throughout and should be consulted for additional detailed information.

## **Shoreline Jurisdiction**

The term ‘shorelines’ in this memorandum refers to areas that meet the criteria for ‘shorelines of the state’ as defined by the SMA (see *City of Renton, Draft Shoreline Inventory and Analysis* Section 1.3 – Shoreline Jurisdiction and Definitions for additional information). In Renton, these shorelines are:

- Lake Washington
- May Creek
- Cedar River
- Green River
- Black River/Springbrook Creek
- Lake Desire, located in the City’s potential annexation area.

Ecological structure and function in shorelines are driven by physical and biological processes across the entire ecosystem. These processes operate within a physical structure defined by geology and climate. Processes affect shoreline structure and function through the input, transport, storage and/or loss of materials, including water, sediment, chemicals, and organic matter. Although many of the processes that affect ecological function in the City of Renton’s shorelines occur outside the city and are outside the City’s control, an understanding of their impact is important when considering the potential for management actions that may be undertaken by the City. For this reason, SMA guidelines require local jurisdictions to look beyond shorelines and “assess the ecosystem-wide processes to determine their relationship to ecological functions present within the jurisdiction” (see *City of Renton, Draft Shoreline Inventory and Analysis* Section 3– *Ecosystem-wide Characterization*, for additional information).

## **Watershed Context**

The shorelines in Renton are contained in two watersheds:

- The Lake Washington watershed (Water Resource Inventory Area [WRIA] 08) encompasses 692 square miles (Kerwin 2001) and has two major subbasins, the Sammamish River and the Cedar River, both of which flow into Lake Washington. Lake Washington flows to Puget Sound

via the ship canal and Lake Union. Of primary interest in the City of Renton are the Lake Washington shoreline and the Cedar River. The upper Cedar River drainage extends through the foothills into the Cascade Mountains. WRIA 8 has a population of 1.5 million people, the most of any WRIA in the state.

- The Green River and its tributaries, including the Duwamish waterway/estuary, and nearby tributaries (WRIA 9) drain directly to Puget Sound at Elliott Bay. The Green River watershed is 566 square miles, and the river itself stretches 93 miles from its source in the Cascade Mountains through the Cascade foothills and Puget Lowlands before emptying into Puget Sound at Elliott Bay. Of primary interest to the City of Renton are the Black River/Springbrook Creek watershed. The human population of WRIA 9 is approximately 565,000.

## Lake Washington

Most species of anadromous salmon and trout native to the west coast of North America, including Chinook (*Oncorhynchus tshawytscha*), coho (*O. kisutch*), sockeye (*O. nerka*), chum (*O. keta*), and pink salmon (*O. gorbuscha*); and steelhead (*O. mykiss*), coastal cutthroat (*O. clarki clarki*), and bull trout (*Salvelinus confluentus*) (native char), can be found in Lake Washington, although the rainbow trout appear to be descendants of non-native hatchery stock (Kerwin 2001).

Because of its listing as threatened under the ESA, Chinook salmon is the best understood aquatic resource in the lake. Much of the discussion below focuses on Chinook, although some of the habitat issues are similar for other aquatic species. Young fall Chinook produced in the Cedar River migrate into Lake Washington from late winter through late spring (February through March). The early migrants are small fry that remain in very shallow water along the lake's shorelines. These fry prefer gently sloping sand to gravel shorelines with some overhanging or submerged vegetation or fine woody debris that provides cover from avian or fish predators. The early juvenile Chinook are highly dependent on shallow shoreline habitat during their early rearing in Lake Washington. The larger juvenile Chinook migrating to the lake in late spring are less dependent on shorelines and move rapidly through the lake to the Ship Canal and Puget Sound (Tabor et al. 2006). Surveys of juvenile Chinook presence in Lake Washington indicate that the density of fish fall off with distance from the mouth of the Cedar River. This may indicate that the first several miles of shallow habitat along Lake Washington in Renton are of disproportionate importance for this critical lifecycle stage (Tabor 2008).

Habitat restoration opportunities along Lake Washington shorelines are limited by intensive development, but opportunities for habitat improvement are possible at most of these previously altered shorelines.

Restoration opportunities for Lake Washington shorelines are guided by the premise that reconstruction of those physical attributes that have been identified to support habitat functions important to the survival of young Chinook salmon will also provide habitat functions for other aquatic and avian species.

### ***Lake Shoreline physical attributes related to Chinook:***

- Restore shallow habitat, including:
  - Shallow shoreline depths (0 to 4 feet ordinary high water mark [OHWM]) with a gradual substrate slope (1:V to 4:H or shallower) to provide sand-gravel substrate where young salmon prefer this substrate during their early residence in Lake Washington (Tabor et al. 2006).
  - Shallow substrate composed of a mix of silt, sand, and gravel, and possible cobble size material at high wave energy locations. Young Chinook prefer sand and gravel substrates during their rearing in shallow water in Lake Washington.
  - Alteration or replacement of bulkheads. Alternative: sloped bulkheads not extending to depths exceeding 1-foot water depth at OHWM (21.8 feet code datum), preferably natural

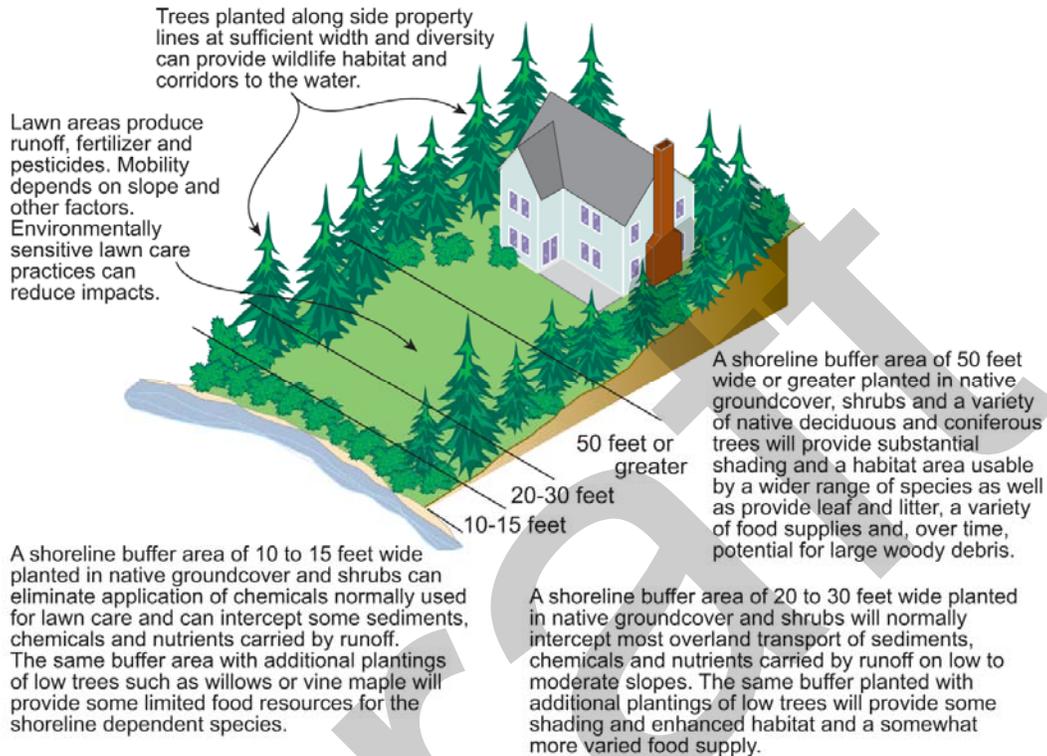
logs or riprap. No concrete, riprap, or sheet pile bulkheads exposed below OHWM. Hard vertical bulkheads eliminate the shallow water (1 to 2 feet deep) shoreline habitat preferred by juvenile Chinook.

- Native shoreline vegetation overhanging shoreline edge:
  - This shoreline vegetation provides shading and refuge habitat within the water for young salmon.
  - Riparian buffer vegetation to provide fish prey (insects), shade, and fine woody debris.
  - Localized shading may reduce the increase in water temperature from solar radiation in shallow nearshore waters.
  - Native vegetation limits the use of fertilizers and pesticides that degrade water quality along the shoreline and promote noxious aquatic plant growth as compared to lawns.
- Limits on docks, including:
  - Limited number of docks.
  - Limited facilities in shallow water (0 to 3 feet).
  - Limitations to shading through grated decks or other means to facilitate shoreline migration of young salmon and reduce potential predation.
  - Minimize number and size of piles supporting over-water structures.
- Woody debris:
  - Small woody debris at the shoreline, similar overhanging vegetation, provides refuge habitat for young salmon.
  - Large woody debris in shallow water must be highly embedded, otherwise it provides structure likely to attract smallmouth bass (*Micropterus dolomieu*) that prey on young salmon in late spring.

The WRIA 8 Salmon Recovery Plan Project C282 provides for working with private landowners to restore shorelines.

## Vegetation

Shoreline vegetation can provide a variety of ecological functions, as indicated in the graphic below.



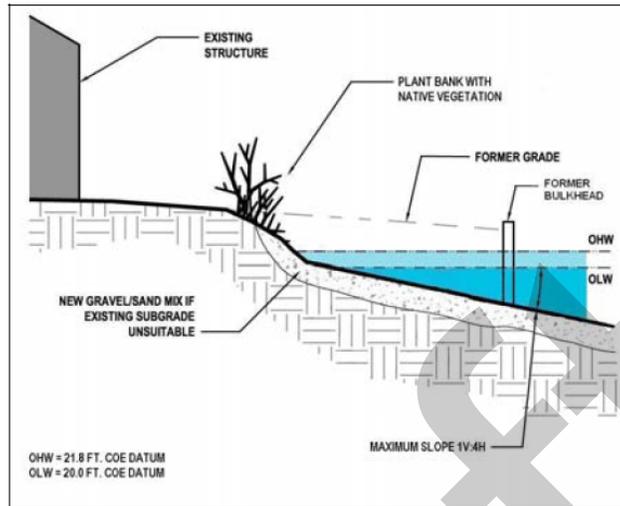
## Existing Program by Other Agencies

In order to protect threatened species in the Lake Washington freshwater system, the Corps, the National Marine Fisheries Service (NMFS), and the U.S. Fish and Wildlife Service have developed ESA guidance for applicants proposing new and replacement piers, bulkheads, and other activities.

- A. The Corps issued Regional General Permit No. 3 in 2005 that addresses docks in Lake Washington and generally requires:
1. Removal of additional in-water structures in addition to the permitted dock.
  2. Provides the following specifications:
    - Only piers and ramps can be within the first 30 feet from shore. All floats and ells must be at least 30 feet waterward of OHWM.
    - Surface coverage is limited to 480 square feet for a single-family dock, 700 square feet for two property owners, and 1,000 square feet for three or more.
    - Widths is limited to a width of 4 feet and must be fully grated.
    - Ramps are limited to a width of 3 feet and must be fully grated.
    - Ells must be in water with depths of 9 feet or greater and have limited dimensions and grating requirements.

- Floats must be in water with depths of 10 feet and have dimension and grating requirements.
  - 3. Pilings must be of be steel, or have limits on preservatives and must be spaced at least 18 feet apart.
  - 4. Paint, stain or preservative must be leach resistant, completely dried or cured prior to installation. Pentachlorophenol, creosote, chromated copper arsenate, or comparably toxic compounds are not allowed.
  - 5. Existing habitat features (e.g., large and small woody debris, substrate material, etc.) shall not be removed from the riparian or aquatic environment.
  - 6. No more than two mooring piles are allowed for single-family docks. Joint-use structures can have up to four mooring piles.
  - 7. Impact reduction measures for cumulative impacts include planting emergent vegetation waterward of OHWM (if site appropriate) and a zone of riparian vegetation a minimum of 10 feet wide along the entire length of the shoreline immediately landward of OHWM. A path 6 feet wide or less is allowed through the zone of riparian vegetation for access to the pier. Chemical fertilizers, herbicides and pesticides are prohibited in the riparian zone (USACE 2005).
- B. NMFS issued a Programmatic Biological Evaluation of Shoreline Protection Alternatives in Lake Washington in December 2007. NMFS proposes three alternative standard approaches. Other approaches require individual permits. A summary of the three alternatives are (NMFS 2007):
1. *Replace with vegetation and beach*
- This option involves:
- Removing existing riprap or concrete bulkhead and cut into the existing bank to attain a shallow shoreline grade and further reduce the effects of scouring wave action.
  - Plant native riparian vegetation 10 feet deep across at least 50 percent of the width of the shoreline. Plant emergents in areas where wave action is suitable for growth.
  - Place gravel beach fill grading slope to range of 1 Vertical (V):4 Horizontal (H) or less steep. The design target for the slope is 1V:7H. Add emergent plants in areas where wave action is suitable for growth.
  - For higher energy areas shoreline logs may be partially buried within the new substrate at the water's edge. The area behind the logs will be planted with willows and/or emergent vegetation.

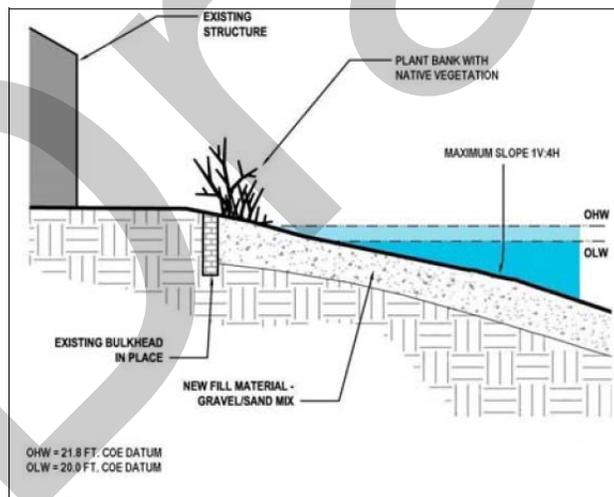
A typical cross section is shown below:



2. *Beach creation leaving the existing bulkhead in place*

This option is allowed where site conditions do not allow Option 1. This includes the same specifications as above, but the existing bulkhead can remain and is in effect buried by the new beach.

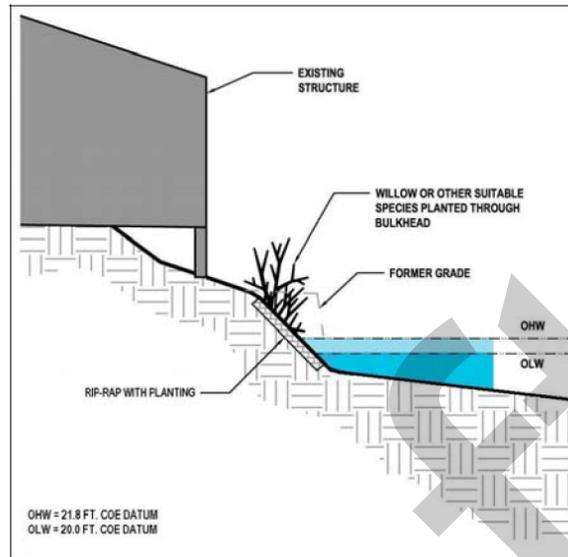
A typical cross section is shown below:



3. *Re-vegetated armored banks are allowed where existing riprap cannot be removed because it is very close to an existing residential or commercial structure*

- Vegetation can be added to restore some functions. Willow stakes must be planted into replacement riprap (or other material) with soil amendment or provide design with similar functional vegetation benefit in front of the bulkhead.
- Gravel beach fill may be added in front of the bulkhead to provide some shallow water.
- Overhanging riparian plantings must be added along the entire length of the riprap bulkhead.

A typical cross section is shown below:



### ***Lake Washington Opportunities and Constraints by Reach***

**Lake Washington Reach A** is entirely single-family residential use and lies between the Bellevue city limits and Renton city limits. Bulkheads and docks predominate. Natural riparian vegetation has been removed, and only a few residences have trees or shrubs that support natural habitat functions. However, many of the bulkheads do not extend far into the lake, leaving a small amount of shallow water habitat used by Chinook and other shallow water fishes. Most of the docks in these reaches are narrow at the shorelines; therefore, most are not likely to impede shoreline migration of young Chinook.

*Opportunities* for maintaining and enhancing ecological productivity include all of the items listed above in *Lake Shoreline physical attributes related to Chinook*. Many of these may be required by the Corps at the time of construction or replacement of docks and bulkheads.

*Constraints* relate largely to the existing developed character of the shoreline and the lack of necessity for bulkhead or dock replacement in most cases. Bulkheads made of durable materials in this area are unlikely to fail and require replacement. Docks tend to have a practical lifespan of about 20 years. Given this situation, it is unlikely that a substantial portion of the shoreline would be upgraded over a 15- to 20-year period.

A regulatory approach that tied replacement of docks and bulkheads to major remodeling or replacement of residences would provide additional opportunities to require upgrading docks, bulkheads, and riparian vegetation. Under this approach, bulkheads, docks, and vegetative cover not meeting current standards would be considered non-conforming. Thresholds of percent of floor area or value added to a residence would trigger compliance with new standards for the shoreline.

Regulations can also encourage this type of installation by:

- Allowing fill below the OHWM for shoreline protection and habitat enhancement
- Allowing regrading of existing shorelines without penalizing landowners if the OHWM is moved back by allowing setbacks to be measured from the previous bulkhead line

This is an area and a type of use where education programs for property owners and voluntary programs are likely to be an important element, in addition to regulation. Such programs are most likely to lead to

changes in management of riparian vegetation. It is unlikely that voluntary programs will lead to a result in changes in bulkheads and docks, unless they are failing or need replacement for other reasons.

**Lake Washington Reach B** extends from the city limits to the Seahawks training facility and includes mostly single-family use with one large shoreline multi-family development. The character is similar to Reach A and involves similar opportunities, constraints, and regulatory options.

**Lake Washington Reach C** includes the recently constructed Seattle Seahawks headquarters and training facility at the northernmost portion of the reach. The Quendall Terminals south of the Seahawks headquarters has been designated a Superfund site by the U.S. Environmental Protection Agency (EPA). The site is being studied by the EPA to determine the extent of the pollution caused by coal tar and creosote application and the best course of action to clean it up. A residential development is currently being built on the southernmost portion of reach on the former Barbee Mill site.

The shoreline adjacent to the Seattle Seahawks facilities have undergone recent regrading and replanting in some areas, with retention of existing deteriorating wooden bulkheads in others. Some overhanging vegetation and deciduous tree cover does exist, but existing riparian areas generally have sparse vegetation.

The shoreline of the Quendall Terminals site retains substantial native vegetation in the riparian zone mixed with a variety of deteriorating bulkheads and other structures along the shoreline and in the water. At this time, it is unknown whether potential cleanup of the Superfund site will extend to the shoreline areas.

The former Barbee Mill site has had extensive shoreline restoration along the western half of the site where bulkheads were removed and the shoreline regraded to depend on the beach grade and shoreline logs to provide shoreline protection. The area is required to be revegetated, but full installation has not occurred to date. Planting plans include largely shrubs with vine maple being the only tree. This will provide some benefits of native riparian vegetation but will not provide the shading benefits of larger native trees for temperature attenuation of the nearshore. The eastern portion of the shoreline is largely sheet pile bulkheads retained from the former sawmill operation and riprap.

Opportunities for maintaining and enhancing ecological productivity relate to extensive shallow habitat that is very productive for a variety of species. Existing and potential actions include:

- Enhancement of shorelines through bulkhead removal and riparian plantings that have been partially realized by restoration activities of adjacent uplands at the Seahawks training facility and Barbee Mill subdivision. All of the items listed above in *Lake Shoreline physical attributes related to Chinook* have been, or may be applied to this reach.
- The delta of May Creek has the potential to provide extensive enhanced shallow habitat if the natural process of deposition is allowed to continue. The delta was formerly dredged periodically to accommodate log storage for the previous use as a sawmill. A high priority for a productive nearshore should be allowing the natural processes of delta formation to occur. The delta likely will extend to the south and west over a substantial area during the next 20 to 40 years. This will result in shallow habitat in areas dredged in the past, including adjacent to bulkheaded areas of the Barbee Mill subdivision, as well as adjacent to residences to the south. This natural deposition process will likely result in very productive shallow habitat areas.
- The productivity of the May Creek delta can be enhanced by speeding the natural process of creating upland areas within the wetland with riparian vegetation. This could be accommodated by placing fill in the area once the natural delta processes have produced shallow enough conditions to allow this to be practical and planting with upland riparian vegetation.

The WRIA 8 Salmon Recovery Plan Project C280 calls for the restoration of the mouth of May Creek.

*Constraints* relate to:

- Existing moorage in the area that will be rendered less useful with shallower water due to delta formation. There is one former boathouse previously used by the sawmill and a joint use dock in the area. Limits due to shallow water could be addressed by extending docks into deeper water, relocating further from the delta, or transitioning to use of mooring buoys in deeper waters with docks used for small boats providing access to mooring buoys. Access to the former sawmill boathouse will be problematic with increased delta deposition. This facility may be considered non-conforming as to its original purpose related to the sawmill and may be considered ineligible for maintenance dredging for access with the cessation of sawmill use.
- In the long term, delta formation will result in deposition within public aquatic lands that eventually will provide upland areas having a variety of riparian vegetation. This vegetation may obstruct open water views from upland residences.

**Lake Washington Reach D** extends from May Creek to Mountain View Avenue. This is a single-family area on lots that are of limited depth, often less than 100 feet. Access to most lots is from a private road on the Burlington Northern Santa Fe (BNSF) (now Port of Seattle) railroad right-of-way. Many of the lots are within a 1904 subdivision of Lake Washington bottomlands. These lots are very constrained and have limited setbacks from the shoreline. The shoreline consists almost entirely of bulkheads of large riprap or concrete. Most residences have docks that are very close together. There is shallow nearshore habitat in the area, but the density of docks may impede shoreline migration of young Chinook or force them to deeper water away from food sources. The City's Kennydale Park is in this area and includes concrete bulkheads and playground and lawn areas. The park is devoid of native vegetation.

*Opportunities* for maintaining and enhancing ecological productivity include all of the items listed above in *Lake Shoreline physical attributes related to Chinook* designed to provide a more productive nearshore environment. Many of these may be required by the Corps at the time of construction or replacement of docks and bulkheads. South of N 34th Street there is a small area of the shoreline that is part of the railroad right-of-way, now owned by the Port of Seattle, that is relatively natural. The parcels to the south are also larger. As discussed under Reach A, SMP regulations can lead to a gradual upgrade of bulkheads, docks, and adjacent vegetation to reduce impacts on aquatic habitat by: (a) designating bulkheads and docks not meeting current standards as non-conforming, (b) allowing fill below the OHWM for shoreline protection and habitat enhancement, and (c) allowing regrading of existing shorelines without penalizing landowners if the OHWM is moved back by measuring setbacks from the previous bulkhead line. This is an area where education programs for property owners and voluntary programs are likely to be an important element, in addition to regulation.

*Constraints* relate largely to the existing high intensity of development on this reach. The placement of residences close together and close to the water provides limited opportunities to reduce dock coverage or provide an area of native vegetation adjacent to the shoreline. In addition, the infrequent need to replace bulkheads and docks are not likely to lead to much upgrading. The Kennydale Park theoretically could provide opportunities for more productive shoreline conditions, but at the expense of active recreation and public access, which is also a Shoreline Management Act goal.

**Lake Washington Reach E** extends from Mountain View Avenue to Gene Coulon Park. It is entirely single-family residential but has lots of greater depth and width than most shoreline residences in Renton, with greater setbacks of buildings from the shoreline. There is also more vegetation along the shoreline, although most is ornamental. The shallow nearshore habitat is used by Chinook and other shallow water fishes. The greater separation between docks and the generally small size of docks in the area are not likely to impede shoreline migration of young Chinook.

*Opportunities* for maintaining and enhancing ecological productivity include all of the items listed above for Reach A in *Lake Shoreline physical attributes related to Chinook*. Many of these may be required by the Corps at the time of construction or replacement of docks and bulkheads.

*Constraints* relate largely to the existing developed character of the shoreline. The infrequent need to replace bulkheads and docks is not likely to lead to a significant number of replacements in the short term.

This is an area where a regulatory approach that tied replacement of docks and bulkheads to major remodeling or replacement of residences would provide additional opportunities to require upgrading docks and bulkheads as outlined under Reach A. Many of the residences in this area, however, have been replaced or extensively remodeled in the past decade. Regulations can lead to a gradual upgrade of bulkheads, docks and adjacent vegetation to reduce impacts on aquatic habitat by: (a) designating bulkheads and docks not meeting current standards as non-conforming, (b) allowing fill below the OHWM for shoreline protection and habitat enhancement, and (c) allowing regrading of existing shorelines without penalizing landowners if the OHWM is moved back by measuring setbacks from the previous bulkhead line. This is a case where education programs for property owners and voluntary programs are likely to be an important element, in addition to regulation.

**Lake Washington Reaches F and G** encompass the city of Renton Gene Coulon Park.

**Reach F** is the less developed northerly portion of the park and provides generally favorable physical shoreline characteristics with productive shallow nearshore habitat. However, native vegetation in the riparian zone is variable. From the north park boundary to near Kennydale Creek, vegetation consists of lawn with a narrow fringe of grasses, forbs, and bushes near the shoreline that consists of a deteriorating wooden bulkhead. In the vicinity of John's Creek there is an area with native evergreen and deciduous vegetation, as well as several other small areas of largely cottonwood trees. The shoreline from John's Creek to the aquatics center at the north extent of the parking area is cobble beach. There is a riprap section of shoreline near the aquatics center, but most of the shoreline to the south is gravel beach.

**Reach G** is the more developed southerly portion of the park that includes activity areas, restaurant uses, a large launch ramp and parking area, and the intensively used beach area. The shoreline in this area is largely gravel beach, except where armoring has been added to protect walkways and other features and the concrete bulkhead between the restaurants and the launch area. Vegetation is primarily lawn. John's Creek enters the park between the launch ramp and the swimming beach and provides shallow habitat and replenishment of the beach.

Juvenile Chinook use throughout the park is very high. The gently sloping sand-gravel beaches, including the swimming beach, provides shallow water habitat used extensively by juvenile Chinook soon after they enter Lake Washington from the Cedar River. Surveys of juvenile salmon use in the area have extended over several years. The peninsula, at the south end of Gene Coulon Park provides natural riparian vegetation overhanging the natural shoreline (Tabor 2003; Tabor et al. 2006).

*Opportunities* for maintaining and enhancing ecological productivity relate largely to the addition of more riparian vegetation with overhanging brush that would improve shoreline refuge habitat for young salmon. Additional riparian buffer vegetation would enhance prey resources (insects) for young salmon and other fish, as well as isolate grass areas from the shoreline. Limiting public access (dogs, kids, and adults) to specific areas would limit the disruption of young salmon rearing in shallow water, and avoid impacts to the riparian vegetation.

The WRIA 8 Salmon Recovery Plan Project C268 calls for enhancement of the mouth and lower portion of John's Creek. The project would enhance the mouth, remove silt, facilitate recruitment of sand and gravel, and protect shallow water habitat. Project C267 calls for enhancement of the mouth and Lower John's Creek channel to reduce predator habitat, restore riparian vegetation, and protect water quality and quantity from stormwater flows. The project would enhance the mouth, remove silt, and facilitate recruitment of sand and gravel.

*Constraints* relate largely to the design goals of the park in providing areas for picnicking and other active uses, as well as visual access to the shoreline. Additional native trees could be provided in areas of the shoreline that would continue to allow substantial lawn areas and allow framed views of the water from upland portions of the park.

**Lake Washington Reach H** is the location of Southport mixed-use development. Long-term plans for the site include 338 apartments, 40,000 square feet of commercial/retail/restaurant use, 789,000 square feet of office use, and a luxury waterfront hotel (SECO 2008). About one-third of the 600-foot frontage is currently developed as a multi-family use; the remaining area is vacant. The entire shoreline consists of a concrete walkway adjacent to the shoreline, which incorporates portions of a previous wood bulkhead and pier built originally for the Shuffleton Steam Plant. A sheet-pile channel for steam plant cooling water extends into the lake.

*Opportunities* for maintaining and enhancing ecological productivity relate largely to preserving the movement of salmon fry and other aquatic species across the shoreline and mitigating impacts of development, including water quality and disturbance from high levels of human use. Potential options include maintaining and restoring shallow habitat and the potential addition of riparian vegetation with overhanging brush. Non-water-oriented uses, such as the retail/restaurant uses contemplated, require provision of public access and/or ecological restoration to comply with WAC 173-26-26-241(3)(d). This has been accomplished in areas with extensive public walkways, as indicated in the photo below.



Thea Foss bulkhead  
City of Tacoma

*Constraints* relate largely to the design goals of the mixed-use development proposed for the site. Incorporating a more ecologically productive waterfront for nearshore habitat may limit some development options, but can be incorporated with appropriate design. Opportunities also may be limited by the terms of current permits (which have expiration period).

**Lake Washington Reach I** is the shoreline frontage of the Renton Boeing Plant immediately east of the mouth of Cedar River. About half of the frontage is public aquatic lands. The public land frontage of 1,200 feet is about half isolated from the water by the power plant outfall and has about 600 feet of gravel and sand beach. Vegetation cover is largely shrubs and small willows. The beach section of the waterfront has productive shallow nearshore habitat. The section adjacent to the power plant outfall is deeper and has

little habitat value at present. The Boeing Company has an easement for wing overhang over the public lands. The City of Renton has proposed the Sam Chastain Waterfront Trail, which would connect the public access at the Southport development to the Cedar River Trail. The Renton pier is located at the western edge of this reach. The Boeing Plant shoreline west of the aquatic lands consists of concrete bulkhead or riprap and is largely devoid of vegetation, although bounded by shallow nearshore habitat.

A portion of this reach consists of the Cedar River delta that provides a large amount of natural shallow water habitat at the mouth of the river. In the past the Cedar River delta was periodically dredged. Renton has no plans to dredge the delta in the future for flood control. The delta has not yet developed any areas of sufficient elevation to support riparian vegetation, but does provide a large amount of shallow water habitat where young Chinook first enter the lake. Habitat at the river's mouth is particularly important because it is the first low velocity rearing habitat encountered by salmon fry after they pass through the rapid velocity migratory corridor of the lower Cedar River. As demonstrated by Tabor et al. (2006), the use of shallow shoreline habitat by young Chinook is greatest with proximity to the Cedar River mouth.

*Opportunities* for maintaining and enhancing ecological productivity include:

- Maintaining and enhancing the productivity of the delta of the Cedar River. This can be done by allowing the natural process of deposition to continue, which will lead to continuing shallow habitat and eventual formation of uplands that will support riparian vegetation.
- Hastening the natural process of formation of delta islands by adding material to the delta to raise the surface to elevations that will support native riparian vegetation. This will allow opportunities for habitat improvement. Most of these opportunities are in public aquatic lands. Large woody debris (LWD) may be installed in this area if deeply embedded to stabilize shorelines. LWD can provide habitat for prickly sculpins, which are substantial predators of young salmon (Tabor et al. 1998).
- Enhancing shorelines through riparian plantings on the aquatic shorelines that are natural beach areas, which would enhance the nearshore aquatic habitat.
- Removing the existing sheet pile outfall, or placing fill outside of the sheet pile wall with the potential to extend the area of shallow nearshore habitat.
- Redeveloping or replacing the Boeing Plant shoreline in the future would provide opportunities to provide a full range of restoration along this 1,100-foot-long shoreline.

The WRIA 8 Salmon Recovery Plan Project C269 calls for restoration of public aquatic lands as part of the Sam Chisham Trail, including removing a portion of flume to create shallow water habitat, protecting the existing cove, and planting overhanging riparian vegetation along the shore.

*Constraints* relate largely to funding opportunities for enhancement. The Boeing Plant is not likely to substantially change while airplane manufacturing continues. Any enhancement activities are likely to be related to public projects like the Sam Chastain Waterfront Trail, which is proposed along this reach, or through public funding for salmon enhancement. The public aquatic lands that are about half the shoreline frontage provide an opportunity for management of aquatic habitat that would connect the public access at the Southport development to the Cedar River Trail. If the Boeing plant should be redeveloped in the future, tradeoffs between a variety of potential uses, public access, and ecological enhancement must be weighed.

**Lake Washington Reach J** is the shoreline frontage of the Renton Municipal Airport. Use as a seaplane base and runway end requirements have led to management of riparian vegetation. Low-growing forms have been used or no vegetation permitted to prevent birds from becoming a hazard to aviation. There is some woody debris in the water near the end of the runway that enhances shoreline habitat. The airport currently has concrete and rock riprap from the Cedar River to the seaplane ramp and a vertical sheet pile bulkhead west of the seaplane ramp.

Relocation of the seaplane dock to deeper water with associated dredging is proposed to maintain seaplane access to that facility. A section of the shoreline dock is proposed for relocation to an offshore position eliminating cover over a shallow water portion of the shoreline.

*Opportunities* for maintaining and enhancing ecological productivity include many of the same measures as for Reach H to the east including:

- Maintaining and enhancing the productivity of the delta of the Cedar River.
- Providing habitat improvement opportunities by hastening the natural process of formation of delta islands that will support native riparian vegetation. Aviation safety will limit opportunities in the immediate vicinity of the runway.
- Enhancing shorelines through placement of fill adjacent to the bulkheads, which would provide for riparian plantings that will enhance the nearshore aquatic habitat.
- Acknowledging that future redevelopment or replacement of the Boeing Plant may affect the viability of the airport. Redevelopment would provide opportunities for a full range of restoration along this 850-foot-long Lake Washington shoreline, as well as about a mile of Cedar River shoreline.
- Placing substrate against the sheet pile to provide a narrow bench for low-growing riparian vegetation.

*Constraints* relate largely to potential conflicts with the operation of the municipal airport and funding opportunities for enhancement. The establishment of riparian vegetation in the area has the potential of attracting increased populations of birds that are a potential hazard to aviation. In addition, the airport is not likely to substantially change while the Boeing Plant on the east side of the Cedar River is in operation. Some mitigation to aquatic habitat is currently being developed as mitigation for alterations to the existing seaplane dock on the shoreline. Other enhancement activities are likely to be publicly funded for salmon enhancement. If the airport should be redeveloped in the future, in conjunction with redevelopment of the Boeing Plant, tradeoffs between a variety of potential uses, public access, and ecological enhancement must be weighed.

**Lake Washington Reach K** extends from the Renton Municipal Airport to the Seattle city limits and is largely a Potential Annexation Area of the City of Renton. This area is similar in character to Reaches A and D and consists of relatively small lots with limited depth with shoreline frontage largely bulkheaded. Lawn and ornamental vegetation predominates. Much of the water surface is covered by docks and moored vessels. Many bulkheads in this reach extend to water depths of several feet at the low lake elevation and there is limited shallow shoreline habitat. There are two privately owned undeveloped parcels in this reach with a total of about 250 linear feet of unarmored shoreline. Existing development that has caused these conditions continue to degrade conditions through ongoing landscaping practices and shoreline modification, including installation of bank features and new overwater structures.

*Opportunities* for maintaining and enhancing ecological productivity include all of the items listed above for Reach A that has a similar character of development. Many of these may be required by the Corps at the time of construction or replacement of the docks and bulkheads. SMP regulations can lead to a gradual upgrade of bulkheads, docks, and adjacent vegetation to reduce impacts on aquatic habitat. These regulations can designate bulkheads and docks not meeting current standards as non-conforming, allow fill below the OHWM for shoreline protection and habitat enhancement, and allow regrading of existing shorelines without penalizing landowners if the OHWM is moved back by measuring setbacks from the previous bulkhead line.

*Constraints* relate largely to the existing high intensity of development on this reach. The placement of residences close together and close to the water provides limited opportunities to reduce dock coverage or provide an area of native vegetation adjacent to the shoreline. In addition, the infrequent need to replace

bulkheads and docks is likely to lead to a slow pace of upgrading. This is a case where education programs for property owners and voluntary programs are likely to be an important element, in addition to regulation.

## **May Creek**

The May Creek watershed is about 8,960 acres in Renton, Newcastle, and unincorporated King County and includes 26 miles of mapped streams, two small lakes, and over 400 acres of wetlands. The portion of May Creek in Renton includes 2.3 stream miles of shoreline planning area partitioned into four reaches. May Creek is an important salmonid stream and contains a substantial proportion of protected shoreline.

The watershed can be divided roughly into two halves:

- The upper, eastern portion of the basin is characterized by less dense residential and agricultural development, and includes a significant portion of the undeveloped parkland on Cougar Mountain.
- The lower, western portion of the basin is inside the Urban Growth Boundary (primarily within the jurisdiction of Renton and Newcastle) and is fairly dense urban residential development.

About 50 percent of the basin is forested but the percent of urban development is increasing. (Kerwin 2001). The May Creek Basin Action plan was adopted in 2001 by King County and the cities of Renton and Newcastle.

### ***May Creek Opportunities and Constraints by Reach***

**May Creek Reach A** extends from the mouth of the creek to the Lake Washington Boulevard bridge. The stream was re-routed in the 1920s to accommodate industrial development and moved from its central location across the alluvial fan/delta to the east edge. The stream is completely straightened with little naturalized riparian, suggesting a high degree of modification to prevent channel migration and flooding. The recent Barbee Mill subdivision has included extensive vegetation planting in a narrow riparian corridor extending about 35 feet on each side of the channel. There has been armoring associated with the BNSF railroad crossing; however, the abutments are set back from the OHWM. The replanting of the riparian buffer with native vegetation will result in mature vegetation over time that will provide overhanging vegetation that will improve shoreline refuge habitat for young salmon and other aquatic species, provide a source of food (insects) for young salmon and other fish, as well as contribute to temperature control.

*Opportunities* for maintaining and enhancing ecological productivity in this reach are limited to the narrow buffer area outside the adjacent residential lots. Because this area has been revegetated, the major actions that can best provide the buffer functions within the narrow corridor are to ensure survival of the plantings and control of invasive species. If informal public use leads to trampling of vegetation and a network of informal trails, fencing of the existing trails should be considered.

*Constraints* largely relate to the narrow width of the buffer, which is not likely to change given the adjacent residential development.

**May Creek Reach B** extends between Lake Washington Boulevard and I-405 within a 5.5-acre undeveloped parcel zoned for residential use. Armoring is associated with the Lake Washington Boulevard and I-405 grades where they cross the stream at each end of Reach B. The stream section between the roads is relatively unaltered.

*Opportunities* for maintaining and enhancing ecological productivity in this reach relate largely to ensuring that future private development preserve an intact buffer area of native vegetation that will provide a variety of functions for aquatic and terrestrial habitat. Future development also should consider water quality and increased flow.

*Constraints* largely relate to the placement of the stream in relation to topography and future site layout for roads, lots, and public facilities such as stormwater control.

**May Creek Reach C** extends from I-405 to the alignment of NE 36th Street and is bounded by I-405 on the west and Jones Road on the east. The stream flows through the I-405 right-of-way of publicly owned land in the majority of the reach. The stream flows through a large undeveloped privately owned parcel just east of the I-405 crossing and adjacent to three residential lots just north of NE 36th Street. A portion of streambank in upper Reach C appears to be armored where it flows parallel to Jones Avenue (200 feet) and a portion of the right streambank appears to be modified to protect a private residence (500 feet).

*Opportunities* for maintaining and enhancing ecological productivity in this reach relate to maintenance of existing natural vegetation, with the potential for enhancement where clearing has taken place or where invasive species have become established. Future development of the large privately owned parcel should preserve an intact buffer area of native vegetation. Existing residential lots are of moderate size and generally with a depth of 150 to 200 feet, which requires flexibility for location of homes while providing riparian vegetation buffers.

*Constraints* relate largely to the existing residential lots that currently provide a narrow buffer and may contribute stormwater runoff that may include herbicides and pesticides from lawns and ornamental vegetation. The opportunity to apply regulations to provide enhanced buffers and remove bank armoring would occur only as major remodeling or replacement of residences occurs. This likely would result in a slow pace of enhancement. Education programs for property owners and voluntary programs are likely to be an important element in leading to changes in management of riparian vegetation by private property owners.

**May Creek Reach D** extends to the city limits. It is largely bounded by the King County May Creek Park or open space tracts set aside in residential subdivisions. Near the end of the reach, four single-family residences on lots of 1 to 5 acres in size have cleared an area relatively close to the stream. There are several road crossings to serve these residences. Except for this area, buffers generally are in the range of 200 to 600 feet.

*Opportunities* for maintaining and enhancing ecological productivity in this reach relate to maintenance of existing natural vegetation, with the potential for enhancement where clearing has taken place or where invasive species have become established. Future development of the privately owned parcel may provide the opportunity to relocate development away from the stream with preservation and replanting of a buffer area and elimination of road crossings. The existing residential lots are of a size that would likely cause future subdivision.

*Constraints* relate largely to the existing residential lots that currently provide a narrow buffer that reduces wildlife habitat functions and may contribute stormwater runoff that may include herbicides and pesticides from lawns and ornamental vegetation. The opportunity to apply regulations to provide enhanced buffers and remove bank armoring is likely to take place when these large parcels are subdivided. Education programs for property owners and voluntary programs are also likely to be an important element in leading to changes in management of riparian vegetation by private property owners.

## **Cedar River**

The Cedar River watershed is about 607 square miles in area and about 47 miles long. The upper portion of the river is almost entirely contained in the City of Seattle watershed. The lower 22 miles of the river is about 62 percent forested, about 90 percent low to medium density development, and less than 1 percent high density development. The City of Renton comprises 7.8 percent of the lower Cedar River.

The river has experienced a wide variety of human alterations since the 1800s including water supply dams and diversions, timber harvest, coal mining, railroad construction, and urban development. Water

withdrawal and flow regulation have reduced the average mainstem channel width from 250 feet in 1865 to 170 feet by 1936. The lower 1.2 miles of the river were channelized and diverted from the Green River to Lake Washington in the early 1900s.

The river supports a variety of aquatic species, including:

- A Chinook stock that is listed as threatened under the ESA. Fall Chinook produced in the Cedar River have a broad range of life histories. Rearing can be stream-type or a combination of stream- and lake-type. Young Chinook commonly rear for some time in the very shallow portions of the river with low current velocities. These areas tend to be relatively free of the sculpins that are prevalent predators in deeper water and along riprap shorelines. Chinook juveniles then migrate into Lake Washington from late winter through late spring (February through March), where they continue to rear or move directly to saltwater (Kerwin 2001).
- Coho salmon are produced in the Cedar River and generally spend their first year of life rearing in freshwater prior to migrating to the ocean as smolts in their second year of life. Juvenile coho commonly rear along streambanks and in off-channel habitat. Coho smolts migrate through the lower Cedar River in late April through May on their way to the ocean (Kerwin 2001).
- Sockeye salmon spawn in the Cedar River. Young sockeye may rear in the river for some time prior to migrating to Lake Washington for additional rearing. In the river the young sockeye may seek off-channel ponds for winter rearing (Hall 2002).
- Steelhead reproduce in the Cedar River. Commonly, the young steelhead rear within the river and its tributaries for 2 or more years before beginning their migration to the ocean through Lake Washington. During their riverine rearing, the young steelhead are substantial predators of migrating sockeye salmon. At an age of 2 years or more, the juvenile steelhead migrants tend to be substantially larger than other salmon migrants (Beauchamp 1990).
- Cutthroat trout also occur in Cedar River. Cutthroat trout prefer steep riffle habitat, but use the entire river for rearing and migration. Preferable spawning habitat is not common within the shoreline located in Renton (Kerwin 2001).
- Bull trout spawn in the upper Cedar River and rear in Chester Morse Lake. Small numbers of sub-adult and adult bull trout have been observed in Lake Washington over a number of years. These bull trout appear to be migrants into Lake Washington from other river basins or fish that have passed downstream from Chester Morse Dam and become isolated from their population (Kerwin 2001).
- Other native fish species found in Cedar River may include western brook lamprey (*Lampetra richardsoni*), river lamprey (*Lampetra ayresii*), peamouth chub (*Mylocheilus caurinus*), largescale sucker (*Catostomus snyderi*), pygmy whitefish (*Prosopium coulteri*), northern pikeminnow (*Ptychocheilus oregonensis*), speckled dace (*Rhinichthys osculus*), and five species of sculpin (*Cottus* sp). Numerous species of non-native fish also occur in the watershed including yellow perch (*Perca flavescens*), brown bullhead (*Ameiurus nebulosus*), black crappie (*Pomoxis nigromaculatus*), pumpkinseed sunfish (*Lepomis gibbosus*), largemouth bass (*Micropterus salmoides*), and smallmouth bass, which can be significant predators of juvenile salmonids (Kerwin 2001; Parametrix 2000). Many of these species are found in the Green River. Although many may occur in shallow shoreline areas, none are known to require specific shoreline habitat characteristics.

Ecological productivity of the Cedar River and smaller streams are based on the premise that physical characteristics and other provisions that support or restore natural riverine processes will best support habitat functions desirable for the survival of anadromous salmonids and resident fish species. The analysis of opportunities and constraints for maintaining and enhancing ecological productivity are guided

by the River Continuum Concept (Vannote et al. 1980), which describes streams as longitudinally linked ecological systems in which processes in downstream reaches are linked to those in upstream reaches. Thus, it is desirable to view each habitat restoration opportunity in the context of what it can provide to the river as a whole, as well as the habitat functions of the specific reach.

### ***Cedar River Opportunities and Constraints by Reach***

**Cedar River Reach A** extends from the Cedar River mouth upstream to the Logan Avenue bridge. The river is constrained to a straight channel by the dikes and fill that provide the land on which the Renton Airport and Boeing Plant are constructed. Reach A is a very low-gradient, depositional area with substrate that has high levels of fine sediment. Reaches A and B were channelized by watershed realignment following the decrease in Lake Washington elevation in 1916. These reaches were routinely dredged in the past for flood control with portions most recently dredged in 1998. The levees along the river are certified by the Corps and are subject to restrictions on vegetation composition and size to maintain the integrity of the structures.

The river is primarily run-type habitat with little habitat complexity and is used by salmonids primarily as a migratory corridor for returning adults and downstream migrating juveniles. Longfin smelt (*Spirinchus thaleichthys*) also migrate and spawn in this area. Resident fish such as prickly sculpin (*Cottus asper*) are also common in these reaches. The sculpins are substantial predators of juvenile salmon (Tabor et al. 1998).

Land use on the eastern shore of the river is the City of Renton Cedar River Trail Park. The certified flood control levee is in the eastern portion of this linear park, which has allowed plantings of trees and shrubs adjacent to the shoreline. The western shore of the river is bounded by the municipal airport. This reach has flood control walls and levees that are subject to restrictions on vegetation.

*Opportunities* for maintaining and enhancing ecological productivity range from minor enhancements to riparian vegetation within the scope of the existing flood control facilities; to removal of hardened shorelines, which would require substantial changes to flood control facilities; to substantial reconfiguration of the river to provide more natural stream character, which likely would take place only with substantial redevelopment of adjacent uses.

Vegetation enhancement to encourage additional and more complex vegetation communities with overhanging vegetation would provide increased refuge habitat for young salmon and some food resources. This could be accomplished within the scope of the existing flood control facilities along the shoreline of the park on the eastern bank, but only within the area between the waters edge and the prism of the formal levee. Vegetation enhancement adjacent to the municipal airport on the west bank would require a plant community limited to shrubs and small trees and would probably require periodic trimming.

Removal of hardened shorelines to decrease habitat favorable to introduced prickly sculpins, which are a predator of native salmon, would require substantial changes to flood control facilities.

More extensive natural channel conditions, that might include construction of low-velocity embayments or side channels, could provide habitat that would allow juveniles to interrupt their rapid migration through the lower reaches of the Cedar River. This would allow this reach to function as a rearing area, rather than primarily as a migration corridor. Sufficient space to accomplish this level of modification would require substantial reconfiguration of the municipal airport, which probably would occur only with redevelopment.

*Constraints* to maintaining a denser and more complex vegetation community on the park shoreline relate largely to the design goals of the park in providing areas for picnicking and other active uses, as well as visual access to the shoreline from the trail. Additional plantings would tend to block views to the water. This could be accommodated by side trails leading to viewing areas on the shoreline, but would involve

additional capital and maintenance expense. Under current rules for levee maintenance, the lawn areas on the levee could not be replaced by native trees.

Constraints to providing additional vegetation on the municipal airport frontage relate both to maintenance standards for flood control facilities and the potential aviation hazard in attracting increased populations of birds.

Changes to the existing flood control levees could not occur without substantial changes in surrounding uses, or modification of the North Boeing bridge, which is a partial impediment to peak flood flows. Some changes to riprap materials to provide habitat less suited to prickly sculpins habitat may be possible.

Existing development is the primary constraint to larger-scale enhancements associated with a more natural channel including off-channel habitat. If the airport should be redeveloped in the future, in conjunction with redevelopment of the Boeing Plant, tradeoffs between a variety of potential uses, public access, and ecological enhancement must be weighed.

**Cedar River Reach B** extends from the Logan Avenue bridge to the I-405 bridges. This portion of the river is constrained to a straightened channel and has a low gradient with substrate that has high levels of fine sediment. This reach is primarily run-type habitat with little habitat complexity and is used by salmonids primarily as a migratory corridor for returning adults and downstream migrating juveniles. Some salmon spawning does occur in this area.

The majority of Reach B is characterized by a narrow corridor of public ownership managed by the City as successor to Commercial Waterway District No. 2. The Renton Senior Center is located on the north side of the river east of Logan Avenue with a park maintenance facility adjacent to it that extends to Williams Avenue. The north side of the river is generally bounded by public streets to Bronson Way. There is a paved public pedestrian trail on the north side of the river a few feet above the OHWM between Logan Avenue and Bronson Way with a narrow fringe of grasses and shrubs between the trail and the river. The private land to the north of the public street is single-family residential. Liberty Park is located on the north side of the river between Bronson Way and Houser Way. The park is primarily active recreation fields. The banks of the river are heavily vegetated and there are pedestrian trails beyond the top of the bank.

The south side of the river is largely bounded by single-family, multi-family, and commercial uses outside of the narrow strip of public ownership. There is a continuous public trail along the upper bank and a public street between Williams Avenue and Wells Avenue. There is a small public playground east of Wells Avenue. The Renton Library spans the river between Bronson Way and Houser Way. The majority of the riverbank on the south side consists of deciduous trees and ornamental shrubs from the top of the bank to the OHWM.

*Opportunities* for maintaining and enhancing ecological productivity in this reach are largely limited to public lands along the river. Vegetation enhancement to encourage additional and more complex vegetation communities with overhanging vegetation would provide increased refuge habitat for young salmon and some food resources. The location where this would be most effective would be where the existing paved pedestrian trail is located next to the water. Elsewhere, the vegetation community could be enhanced in density and complexity and extended farther from the water's edge in areas such as Liberty Park.

*Constraints* are present in the existing private development along both sides of the river outside public ownership, as well as the public roadways. Extending vegetation into the road rights-of-way would require alternative access for adjacent private parcels where the roads are the exclusive access. Displacing the existing public trail involves tradeoffs between the Shoreline Management Act goals of public access and ecological restoration. Public access along the top of the bank would provide less immediate access to the water's edge.

**Reach C** extends from the I-405 bridge to the SR 169 bridge. The south side of the river is largely public open space. The Cedar River Trail on the old Milwaukee Road Railroad right-of-way is set back from the river except near I-405 and at the bridge crossing.

On the north side, the first 700 feet of river frontage are part of the City of Renton Cedar River Park. The next upstream area of about 1,400 feet is a highly altered hardened band from a former concrete batch plant with virtually no vegetation cover. The next 2,500 feet is similarly altered multi-family and commercial sites. SR 169 fronts closely on the shoreline for an additional 1,200 feet with little area for riparian vegetation. East of the former railroad bridge carrying the Cedar River Trail, the north shoreline is single-family residential for about 6,000 linear feet (1.13 miles) and immediately to SR 160 for another 1,000 feet. This portion of the reach is hardened to varying extents with minimal native vegetation in most areas. Most of the residential lots have lawn or ornamental vegetation extending to the water's edge.

*Opportunities* for maintaining and enhancing ecological productivity on the south side of the river would include maintenance of existing natural vegetation, with the potential for enhancement where clearing has taken place in the past near I-405. Opportunities on the north side include additional building setbacks, removal of hardened banks and provision of a buffer area of native vegetation. There is a likely short-term opportunity to accomplish this at the former concrete batch plant with consideration of tradeoffs between public access and ecological enhancement required for location of non-water-oriented mixed uses, including retail/restaurant, office, or multi-family uses. The residential lots are of moderate size and generally with a depth of 150 to 250 feet, which requires flexibility for location of homes while providing riparian vegetation buffers.

*Constraints* relate largely to the existing high intensity of development on this reach or the location of a state highway adjacent to the stream. The residential lots provide opportunities for native vegetation adjacent to the shoreline; however, the opportunity to apply regulations would occur only as major remodeling or replacement of residences occurs. This likely would result in a slow pace of enhancement. As for Lake Washington Reach A, considering existing land cover as nonconforming would allow enhancement when a threshold of percent of floor area or value added to a residence would trigger compliance with new standards. Education programs for property owners and voluntary programs are likely to be an important element in leading to changes in management of riparian vegetation. However, they are not likely to result in substantial changes to overall coverage of mature riparian vegetation. The large parcels with high intensity zoning allowing mixed-use development can be expected to redevelop as market opportunities dictate over the next decade or so.

**Reach D** retains the most intact channel characteristics in the city, although the river channel is constrained by flood control levees. The City owns all of the south side of the river to the city limits as Maplewood Park or Ron Regis Park. The north side of the river is either owned by the City, is open space dedicated as part of subdivisions, or is large undeveloped parcels. This reach is the least constrained reach within the city allowing a small degree of meandering, channel migration, and development of gravel bars. It has a significant amount of LWD due to the landslide caused by the Nisqually earthquake in 2001, including log-jams adjacent to Ron Regis Park. Riparian vegetation width generally ranges from about 100 to over 500 feet, although one fairway north of the river comes within about 80 feet of the river. Three off-channel salmon spawning channels have been constructed on the south side of the river adjacent to the golf course.

*Opportunities* for maintaining and enhancing ecological productivity throughout the reach includes maintenance of existing natural vegetation, with the potential for enhancement in a few cases to add density and complexity. Opportunities to allow additional meandering and channel migration through relocating or eliminating flood control facilities must be balanced with maintaining existing off-channel spawning channels. Future development of the remaining privately owned parcels should accommodate substantial riparian buffers.

*Constraints* relate largely to the existing high intensity of development on this reach or the location of a state highway adjacent to the stream. The residential lots provide opportunities for native vegetation adjacent to the shoreline; however, the opportunity to apply regulations would occur only as major remodeling or replacement of residences occurs. This likely would result in a slow pace of enhancement. As for Lake Washington Reach A, considering existing land cover as nonconforming would allow enhancement when a threshold of percent of floor area or value added to a residence would trigger compliance with new standards. Education programs for property owners and voluntary programs are likely to be an important element in leading to changes in management of riparian vegetation. However, they are not likely to result in substantial changes to overall coverage of mature riparian vegetation. The large parcels with high intensity zoning allowing mixed-use development can be expected to redevelop as market opportunities dictate over the next decade or so.

### **Green River and Springbrook Creek**

Only a small portion of the Green River watershed of 566 square miles is within Renton. For the purposes of this analysis, the portion of the Black River downstream of the pump station is considered part of the Green River, because most of its hydrologic functions are related to the adjacent Green River. Except for the Black River, all of the Green River channel is separated from Renton by the BNSF railway mainline that parallels the river. The areas that are within the Shoreline Management Act jurisdiction are slivers of land adjacent to the railway where the river meanders to the east.

Springbrook Creek is the largest subbasin in the lower Green River Basin with a watershed area of about 15,763 acres (24.6 square miles). The basin is composed of two distinct physical settings. In the eastern half of the subbasin, rolling hills rise to elevations of about 525 feet above the valley floor. The western half of the basin is virtually flat.

The creek is about 12 miles long with about 3.5 miles in the city of Renton. Mill and Garrison Creeks enter from the south from Kent. Panther Creek and Rolling Hills Creek originate on plateaus to the east with headwaters at Panther Lake and flow into Springbrook Creek near SW 30th Street. Only the mainstem of Springbrook Creek is within Shoreline Management Act jurisdiction, together with associated wetlands.

All of Springbrook Creek in Renton was extensively modified and straightened for agricultural drainage in the 1920s by King County Drainage District #1, which owns the Springbrook Creek right-of-way. The channel area from the Black River Pump Station, including the forebay area up to the Oakesdale bridge crossing just upstream of SW 16th Street, was improved in the 1980s and 1990s for flood control by the City of Renton in cooperation with the Natural Resource Conservation Service (formerly the Soil Conservation Service).

The pump station prevents high flows in the Green River from backing water up into Springbrook Creek, reducing the risk of flooding. The pump station is a barrier to salmonids upstream and downstream during certain seasons (Kerwin and Nelson 2000).

Coho salmon, cutthroat trout, and winter steelhead spawning is largely limited to tributaries. Roughly 17.2 miles of potential fish habitat are accessible to anadromous salmonids (Kerwin and Nelson 2000).

Water quality conditions in Springbrook Creek have historically been characterized as poor (King County 2008) with low dissolved oxygen concentrations, high temperatures, high fecal coliform bacteria, high turbidity, high total phosphorus and ammonia, and high conductivity (King County 2008).

### ***Green River/Springbrook Creek Opportunities and Constraints by Reach***

**Green River Reach A** consists of the Black River below the pump station. It is the only portion of the Green River Basin within the shoreline planning area that has a hydraulic connection to the river. Although most of the historical floodplain was likely wetland, the channel has been channelized and

realigned and no wetlands are known to occur within the shoreline planning area. The riparian corridor west of 68th Avenue South Bridge is typically 80 to 150 feet wide on the south side and 50 to 100 feet wide on the north side. The riparian buffer widens between the bridge and the pump station to about 150 feet. Vegetation within the buffer is primarily small to medium-sized deciduous trees and emergent vegetation. East of 68th Avenue, the riparian area is the City of Renton Black River riparian forest and wetland discussed in more detail under Black River/Springbrook Creek Reach A.

*Opportunities* for maintaining and enhancing ecological productivity in this reach relate to maintenance of existing buffer vegetation, with the potential for enhancement to provide greater density and complexity or removal of invasive species.

*Constraints* relate largely to the existing industrial development with buildings and parking lots adjacent to the buffer. The opportunity to apply regulations to provide enhanced buffers and remove bank armoring would occur only as major remodeling or replacement of buildings occurred and is not considered likely in the near future. Education programs for property owners and voluntary programs or public funding may lead to enhanced management of riparian vegetation.

**Black River/Springbrook Creek Reach A** extends from the pump station to SW 16th Street. Immediately upstream from the pump station the reach is contained in a large pond. The riparian corridor in this reach is primarily forested, and more than 250 feet wide on either bank. However, invasive reed canarygrass (*Phalaris arundinacea*) is also dominant in areas, particularly in the shoreline on the left bank where there is public access and a trail system. This area also hosts a heron rookery with approximately 90 nests.

The stream then flows through a 100- to 150-foot-wide vegetated corridor bounded on the east by Oakesdale Avenue and on the west by the Metro Sewage Treatment Plant. A combination of deciduous forest and open canopy emergent areas extend 30 feet on river left and 80 to 100 feet on river right. The stream then flows under two local streets and I-405, with highly altered riparian conditions.

*Opportunities* for maintaining and enhancing ecological productivity in this reach relate to maintenance of existing buffer vegetation, with the potential for enhancement to provide greater density and complexity and removal of invasive species. Local community groups have sponsored a series of work parties to restore native vegetation, in cooperation with the Renton Parks Department (Heron Forever 2008).

*Constraints* relate largely to the surrounding development, roads that allow little opportunity to expand buffers, and the crossings under city streets and I-405 that include bank armoring and little opportunity for riparian vegetation due to shading and lack of water.

**Black River/Springbrook Creek Reach C** extends from SW 16th Street to SW 19th Street. It has undergone restoration and has a natural corridor open space in Boeing Longacres Industrial Park. Riparian width varies between 60 and 80 feet on the north side. The south side of the stream is bounded by a 5-acre wetland restoration site.

*Opportunities* for maintaining and enhancing ecological productivity in this reach relate to maintenance of existing buffer vegetation, with the potential for enhancement to provide greater density and complexity and removal of invasive species.

*Constraints* relate largely to the surrounding development and roads that allow little opportunity to expand buffers.

**Black River/Springbrook Creek Reach D** extends from SW 19th Street to the city limits. This portion of the stream channel is owned and maintained by King County Drainage District #1. Maintenance includes removal of most native vegetation from the streambanks, except where the stream flows through wetland mitigation sites between SW 23rd Street and SW 30th Street. A small stretch of the stream from SW 41st Street to SW 43rd Street has a moderate cover of small deciduous trees. Where vegetation is

removed by the drainage district, cover is dominated by reed canarygrass and provides little buffer function.

*Opportunities* for maintaining and enhancing ecological productivity relate to maintenance of existing buffer vegetation where it is present with the potential for enhancement to provide greater density and complexity and removal of invasive species. Where the drainage district removes native vegetation from the streambanks, a vegetation management plan that provides for native vegetation while allowing the drainage and conveyance functions of the channel would greatly enhance a range of buffer functions, including refuge habitat for young salmon, food sources, and shading to control temperature. The drainage district should examine their vegetation maintenance programs in light of the mandate in Revised Code of Washington (RCW) 90.58.340 for all state agencies, counties, and public and municipal corporations to review administrative and management policies, regulations, plans, and ordinances relative to lands under their respective jurisdictions adjacent to the shorelines of the state so as to achieve a use policy on said land consistent with the policy of this chapter, the guidelines, and the master programs for the shorelines of the state.

*Constraints* relate largely to the location of surrounding development, which often includes buildings and impervious surfaces up to the drainage district right-of-way. This adjacent land, however, can be expected to redevelop over the long term and provide opportunities for additional vegetated buffer area.

## REFERENCES

- Beauchamp, D. A. 1990. Seasonal and diet food habits of rainbow trout stocked as juveniles in Lake Washington. Transactions of the American Fisheries Society 119:475-482.
- Hall, J.L. 2002. Habitat selection by sockeye salmon (*Oncorhynchus nerka*) in off-channel ponds of the Cedar River and the implications for restoration. Thesis, University of Washington, Seattle, WA.
- Hérons Forever. 2008. Accessed at: <http://www.héronsforever.org/>.
- Kerwin, J. 2001. Salmon and Steelhead Habitat Limiting Factors Report for the Cedar-Sammamish Basin (WRIA 8). Washington Conservation Commission. Olympia, WA.
- Kerwin, J. and Nelson, T. S. (Eds). 2000. Habitat Limiting Factors and Reconnaissance Assessment Report. Green/Duwamish and Central Puget Sound Watersheds (WRIA 9 and Vashon Island). Washington Conservation Commission and the King County Department of Natural Resources.
- King County. 2008. May Creek Water Quality. Accessed at: <http://dnr.metrokc.gov/wlr/Waterres/streamsdata/May.htm>. May 5, 2008.
- National Marine Fisheries Service (NMFS). 2007. Programmatic Biological Evaluation for Shoreline Protection Alternatives in Lake Washington, National Marine Fisheries Service, Northwest Fisheries Science Center, 2725 Montlake Boulevard East, Seattle, Washington 98112. December 13, 2007.
- SECO. 2008. Southport Website available at <http://www.secodev.com/southport.asp>.
- Straka, Ron. 2008. City of Renton Surface Water Utility Engineering Supervisor, Personal communication, September 2008.
- Tabor, R., J. Chan, and S. Hager. 1998. Predation of sockeye fry by cottids and other predatory fishes in the Cedar River and southern Lake Washington, 1997. Unpublished report, U.S. Fish and Wildlife Service, Lacey, Washington. 61 pp.
- Tabor, R.A., H.A. Gearn, C.M. McCoy III, and S. Camacho. 2003. Nearshore habitat use by juvenile Chinook salmon in lentic systems. 2001 Report. U.S. Fish and Wildlife Service, Lacey, WA. 94 pp.
- Tabor, R. A., H. A Gearn, C. M. McCoy III, and S. Camacho. 2006. Nearshore habitat use by juvenile Chinook salmon in lentic systems, 2003 and 2004 Report. U.S. Fish and Wildlife Service, Lacey, Washington. 94 pp.

- Tabor, R.A. and M. Celedonia. 2008. Habitat use of juvenile Chinook salmon in Lake Washington presentation, U.S. Fish and Wildlife Service, Lacey, Washington. Washington State Department of Ecology, Shorelines Section, Regular SMP Coordination and Assistance Meetings, Summer 2008. Available at: [http://www.ecy.wa.gov/programs/sea/sma/st\\_guide/SMP/download/habitat\\_use\\_of\\_chinook.pdf](http://www.ecy.wa.gov/programs/sea/sma/st_guide/SMP/download/habitat_use_of_chinook.pdf).
- U.S. Army Corps of Engineers (USACE). 2005. Regional General Permit No. 3. Construction of New or Modification of Existing Residential Overwater Structures and Installation of Moorage Piling in Lake Washington, Lake Sammamish, the Sammamish River and Lake Union, including the Lake Washington Ship Canal. Available at: [http://www.nws.usace.army.mil/publicmenu/DOCUMENTS/REG/RGP%203%20Final%20Text%20\\_6-13-05\\_.pdf](http://www.nws.usace.army.mil/publicmenu/DOCUMENTS/REG/RGP%203%20Final%20Text%20_6-13-05_.pdf).
- Vannote, R. L., G. W. Minshall, K. W. Cummins, K. W. Sedell, and C. E. Cushing. 1980. The river continuum concept. *Canadian Journal of Fisheries and Aquatic Sciences* 37:130-137.
- Weitkamp, D. E., G.T. Ruggerone, L. Sacha, J. Howell, and B. Bachen. 2000. Factors Affecting Chinook Populations, Background Report. Report Prepared by Parametrix, Inc., Natural Resources Consultants, Inc. and Cedar River Associates. 224 pp.