City of Pacific
Shoreline Master Program

Shoreline Inventory and Analysis

Prepared for
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<tr>
<td>BAS</td>
<td>best available science</td>
</tr>
<tr>
<td>BMP</td>
<td>best management practice</td>
</tr>
<tr>
<td>BNSF</td>
<td>Burlington Northern Santa Fe</td>
</tr>
<tr>
<td>cfs</td>
<td>cubic feet per second</td>
</tr>
<tr>
<td>City</td>
<td>City of Pacific</td>
</tr>
<tr>
<td>CMZ</td>
<td>channel migration zone</td>
</tr>
<tr>
<td>DAHP</td>
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</tr>
<tr>
<td>DDES</td>
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</tr>
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</tr>
<tr>
<td>DO</td>
<td>dissolved oxygen</td>
</tr>
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<td>Washington State Department of Ecology</td>
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<tr>
<td>EPA</td>
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</tr>
<tr>
<td>ESA</td>
<td>Endangered Species Act</td>
</tr>
<tr>
<td>ESU</td>
<td>evolutionarily significant unit</td>
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<tr>
<td>FEMA</td>
<td>Federal Emergency Management Agency</td>
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<tr>
<td>GIS</td>
<td>Geographic Information System</td>
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<tr>
<td>GMA</td>
<td>Growth Management Act</td>
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<tr>
<td>HCP</td>
<td>Habitat Conservation Plan</td>
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<tr>
<td>KCFCZD</td>
<td>King County Flood Control Zone District</td>
</tr>
<tr>
<td>LWD</td>
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<tr>
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## ACRONYMS AND ABBREVIATIONS (CONTINUED)

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</tr>
<tr>
<td>PSE</td>
<td>Puget Sound Energy</td>
</tr>
<tr>
<td>RCW</td>
<td>Revised Code of Washington</td>
</tr>
<tr>
<td>RM</td>
<td>river mile</td>
</tr>
<tr>
<td>PMC</td>
<td>Pacific Municipal Code</td>
</tr>
<tr>
<td>ROW</td>
<td>right-of-way</td>
</tr>
<tr>
<td>SMA</td>
<td>Shoreline Management Act</td>
</tr>
<tr>
<td>SMP</td>
<td>Shoreline Master Program</td>
</tr>
<tr>
<td>SR</td>
<td>State Route</td>
</tr>
<tr>
<td>TMDL</td>
<td>total maximum daily load</td>
</tr>
<tr>
<td>UGA</td>
<td>Urban Growth Area</td>
</tr>
<tr>
<td>USACE</td>
<td>U.S. Army Corps of Engineers</td>
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<td>U.S. Fish and Wildlife Service</td>
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<td>USGS</td>
<td>U.S. Geological Survey</td>
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<tr>
<td>WAC</td>
<td>Washington Administrative Code</td>
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<tr>
<td>WDFW</td>
<td>Washington Department of Fish and Wildlife</td>
</tr>
<tr>
<td>WHR</td>
<td>Washington Historic Register</td>
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<td>WRIA</td>
<td>Water Resource Inventory Area</td>
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1. INTRODUCTION

1.1 PURPOSE

The City of Pacific (City) is conducting a comprehensive Shoreline Master Program (SMP) update with the assistance of a grant administered by the Washington State Department of Ecology (Ecology) (Shoreline Management Act [SMA] Grant No. G0800310). Cities and counties are required to update their SMPs to be consistent with the state SMA, Revised Code of Washington (RCW) 90.58 and its implementing guidelines, the Shoreline Management Guidelines, and Washington Administrative Code (WAC) 173-26.

The City of Pacific is located on the King County/Pierce County line on the White River as indicated in Figure 1-1 and Portfolio Map 2.

Early steps in the comprehensive SMP update process include the inventory and characterization of shoreline conditions. The inventory and characterization provide a basis for updating the City’s goals, policies, and regulations for shoreline management. The term _shorelines_' in this report refers to areas that meet the criteria for _shorelines of the state_ as defined by the SMA (see Section 1.3 – Shoreline Jurisdiction and Definitions). As shown in Map 1, the shorelines in the City include only the White River. The White River south of R Street in Auburn was historically called the Stuck River.

This report describes the initial results of the shoreline inventory and characterization in accordance with Task 2 of the City’s grant agreement with Ecology. It includes a general discussion of the ecosystem-wide processes that influence the City’s shorelines and provides a detailed account of the ecological functions and land use patterns along each shoreline segment or reach. A Map Portfolio is included as an appendix to this report.

This draft report was revised and finalized based on comments from Ecology and other reviewers. This report will be used to guide other elements of the City's SMP update process, including the development of shoreline policies, regulations, environment designations, and restoration strategies.

1.2 REGULATORY OVERVIEW

Washington’s Shoreline Management Act (SMA) was passed by the State Legislature in 1971 and adopted by the public in a referendum. It is codified as Chapter 90.58 of the Revised Code of Washington (RCW). The SMA was created in response to growing concerns about the effects of unplanned and unregulated development on the state’s shoreline resources. As a result, the central goal of the SMA is “to prevent the inherent harm in an uncoordinated and piecemeal development of the state’s shorelines” (RCW 90.58.020).

The SMA is a joint state/local program. Local governments responsible for administration are charged with developing SMPs in accordance with state guidelines developed by Ecology. The guidelines give local governments discretion to adopt SMPs that reflect local circumstances and to develop other local regulatory and non-regulatory programs that relate to the goals of shoreline management.

The City adopted its first SMP in February 1974. The SMP is maintained as a separate document. In addition, the SMP Purpose, Definitions and Permits provisions are contained in Title 21 of the Pacific Municipal Code (PMC).
Figure 1-1. City of Pacific Vicinity
1.3 SHORELINE JURISDICTION AND DEFINITIONS

1.3.1 Criteria

According to the Shoreline Management Act (SMA), the City’s Shoreline Master Program (SMP) policies and regulations apply to all _shorelines of statewide significance_, _‘_shorelines,’_ and their adjacent _shorelands’_ (RCW 90.58.030). The general criteria for shoreline jurisdiction are depicted in Figure 1-2.

- _Shorelines of statewide significance_ include portions of Puget Sound and other marine water bodies, rivers west of the Cascade Range that have a mean annual flow of 1,000 cubic feet per second (cfs) or greater, rivers east of the Cascade Range that have a mean annual flow of 200 cfs or greater, and freshwater lakes with a surface area of 1,000 acres or more.
- _Shorelines_ are defined as streams or rivers having a mean annual flow of 20 cfs or greater and lakes with a surface area of 20 acres or greater.
- _Shorelands_ are defined as the upland area within 200 feet of the ordinary high water mark (OHWM) of any shoreline or shoreline of statewide significance, floodways and contiguous floodplain areas landward 200 feet from such floodways, and all associated wetlands and river deltas.
- _Associated wetlands_ means those wetlands that are in proximity to and either influence or are influenced by waters subject to the SMA (WAC 173-22-030(1)). These are typically wetlands that physically extend into the shoreline jurisdiction, or wetlands that are functionally related to the shoreline jurisdiction through surface water connection and/or other factors.

![Figure 1-2. Graphic Depiction of Criteria for SMA Shoreline Jurisdiction](image-url)
In any given area, the landward extent of shoreline jurisdiction is identified based on site-specific factors, such as the location of the OHWM and the presence of wetlands. The area in shoreline jurisdiction in the City of Pacific is generally indicated in Figure 1-3 as 200 feet from the OHWM. This boundary does not include associated wetlands which may extend jurisdiction considerably. All existing mapped wetlands in the city are shown in Map 4 of the Map Portfolio.

### 1.3.2 Shoreline Jurisdiction

The White River has a mean annual flow of 821 cubic feet per second (cfs) based on 20 years of gauge data (USGS 2007). This places it well over the 20 cfs threshold for shoreline jurisdiction.

### 1.3.3 Shoreline of Statewide Significance

The threshold for a stream being defined as a Shoreline of Statewide Significance (SSWS) is 1,000 csf. Therefore, shorelines of the White River do not qualify under this criterion.

### 1.3.4 Shorelands

Shorelands to which the SMP applies generally are within 200 feet of the ordinary high water mark (OHWM). The criteria for including floodways and contiguous floodplain areas landward 200 feet from such floodways includes essentially the same lands since the existing flood control facilities limit the floodway to within a few feet of the OHWM. In the future, the levee setbacks proposed by flood control agencies will change the floodway and include more of the floodplain within shoreline jurisdiction. This inventory considers all such lands as well as adjacent lands.

### 1.3.5 Associated Wetlands

Major associated wetlands based on available information in Figure 1-3 and Portfolio Map 4 include:

- A wetland complex of roughly 3.5 acres is located on the left bank within 100 feet of the White River located near the King/Pierce County line.
- A wetland complex on the right bank at the confluence of and south of the Government Ditch is in shoreline jurisdiction but is not within the current city limits. Because it is within the Urban Growth Area (UGA) designated by Pierce County for future annexation to the City of Pacific, the SMP will include planning, designs, and regulations for these wetlands.
- Field reconnaissance has identified a large wetland complex on the left bank south of the BNSF railroad that is currently separated from the river by flood control levees. This wetland complex is likely to expand with future flood control levee setback projects.

### 1.3.6 Urban Growth Area

The City of Pacific has an Urban Growth Area (UGA) designated by Pierce County for future annexation by the city that includes the area on both sides of the White River in Pierce County extending from the existing city limits at the King/Pierce County line to Stewart Road and from Butte Avenue SE on the west to the Sumner City limits on the east. The UGA is shown on Portfolio Maps 1-3 and other figures.

The portions of the White River that are located in Pacific's UGA are included in this report. The Shoreline Management Guidelines allow a city to pre-designate shoreline regulations within adopted UGAs. Thus, adopted SMP regulations will be applicable to these areas upon annexation without requiring future amendment of the SMP (WAC 173-26-150).
1.4 RELATIONSHIP TO OTHER PLANS

The City’s SMP works in concert with the City’s Comprehensive Plan and a variety of other regulatory plans and programs to manage shoreline resources and regulate development near the shoreline. The Comprehensive Plan and associated Sub-Area Plans establish the general land-use pattern providing an overall vision for growth and development for areas inside and outside shoreline jurisdiction. Various sections of the Pacific Municipal Code (PMC) pertaining to Land Use and Environmental Procedures (Title 16), Zoning (Title 20), Stormwater Management (Title 24), Critical Areas (Title 23), and Subdivision (Title 19) also play a major role in how the City’s shorelines are managed.

The SMA requires local governments to review any plans, regulations, and ordinances that apply to areas adjacent to shoreline jurisdiction. Those plans, regulations, and ordinances need to ‘achieve a consistent use policy’ in conformance with the SMA and the SMP (RCW 90.58.340). This means that the Comprehensive Plan and the development regulations of the City’s municipal code must be consistent with the SMP.

One of the most important areas for consistency is between the SMP and ‘environmentally critical areas’ (Title 23 PMC) development standards and use regulations. Environmentally critical areas, including streams, wetlands, aquifer recharge areas, frequently flooded areas, fish and wildlife conservation, and geologic hazard areas, are found throughout the City’s shoreline jurisdiction. Although critical areas are to be identified and designated under the Growth Management Act (GMA), they must also be protected under SMA when located within the shoreline jurisdiction. The Washington State Legislature and the Growth Management Hearings Board have determined that local governments must adopt SMPs that protect critical areas within the shoreline to assure ‘no net loss of shoreline ecological functions necessary to sustain shoreline natural resources as defined by department of ecology guidelines adopted pursuant to RCW 90.58.060.’

The GMA also calls for coordination and consistency of comprehensive plans among local jurisdictions. Because SMP goals and policies are an element of the local comprehensive plan, the requirement for internal and intergovernmental plan consistency may be satisfied by watershed-wide or regional planning. Consistent with this provision, the City of Pacific is coordinating during the SMP update process with King and Pierce Counties; the neighboring cities of Auburn and Sumner; and the Muckleshoot and Puyallup Indian Tribes.

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1 RCW 36.70A.48(5) (Engrossed House Bill 1653, 2010)
Figure 1-3. Generalized SMA Shoreline Jurisdiction in the City of Pacific
2. METHODS

2.1 DATA SOURCES

A number of local, regional, state, and federal agency data sources, maps, and technical reports were reviewed to compile this inventory and characterization report. This includes information pertaining to watershed conditions and ecosystem-wide processes as well as data on the land-use patterns and ecological conditions of the City’s shorelines. Assessing conditions at these two distinct geographic scales, the watershed scale and the shoreline reach scale is a key requirement of the SMP update process. A series of maps depicting shoreline and watershed attributes accompanies this report (as summarized in Table 2-1). Data sources from the King and Pierce Counties’ Geographic Information Systems (GIS) database were used. A complete list of data sources used to compile the report is included in the references.

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2.2 DETERMINING SHORELINE PLANNING AREA BOUNDARIES

The approximate extent of shoreline jurisdiction within the municipal limits of the City and its designated Urban Growth Area (UGA) is shown in Figure 1-1 and Portfolio Map 1, referred to as the shoreline planning area. In general this extent represents:

- Lands within 200 feet of the mapped edges of the White River within the City's municipal limits

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2 WAC 173-26-201
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- Lands within 200 feet of the mapped edges of Mainstem White River within the UGA designated for annexation to the City;
- All floodways associated with the areas above; and
- Those portions of the 100-year floodplain currently mapped by the Federal Emergency Management Agency (FEMA) that are within 200 feet of the mapped floodway.

(Note: Lands within the floodplain of the White River within 200 feet of the floodway are only marginally different than lands within 200 feet of the OHWM in channelized portions of the river within the City.)

This area of shoreline jurisdiction covers a total of approximately 4,570 linear feet or 0.85 miles within the City limits, and 3,000 linear feet or 0.57 miles within the designated UGA.

Planning area boundaries were derived using existing information from the King and Pierce Counties’ GIS database. The location of the 20 cfs flow point on streams was confirmed using best available information (U.S. Geological Survey [USGS] 1998). For purposes of this report, the mapped edges of the lake and creek shorelines are assumed to correspond to the approximate location of the OHWM. Field inspection is required to identify the actual OHWM location on a specific property to determine jurisdiction limits, regulatory setbacks, and/or buffers. Likewise, shoreline jurisdiction may include ‘associated’ wetlands. Generally, a wetland’s relationship to the shoreline must be determined in the field by on-site inspection. All currently mapped wetlands shown on Map 4 may be considered as potentially associated wetlands if they are in the floodplain or hydraulically connected to the river. It is likely the map includes some wetlands that do not meet the criteria of ‘associated’ wetlands and some wetlands are not shown that do meet the criteria.

The shoreline planning area is intended for planning purposes only. As a result, the actual regulated boundaries of shoreline jurisdiction may differ from the area shown on Figure 1-3 and Portfolio Maps, depending on information gathered on the ground at any specific location.

For purposes of the shoreline inventory and characterization, the shoreline planning area was divided into segments, called reaches. Reach designations were determined based on existing and potential land-use (e.g., residential, commercial, industrial land-use, parks, and open space). The White River is divided into seven reaches as shown on Figure 1-3.

The extent and general description of individual shoreline reaches that comprise the City’s shoreline planning area are summarized in Table 2-2.

---

3 USGS data regarding upstream boundaries for SMA streams and rivers (USGS, Water-Resources Investigations Report 96-4208) to confirm SMP jurisdictional boundaries.

4 Additional associated wetlands may be present that are not depicted on the available maps.
<table>
<thead>
<tr>
<th>Shoreline</th>
<th>Reach No.</th>
<th>General Description</th>
<th>Linear Distance (feet)</th>
<th>Approximate Size (acres)</th>
<th>Approximate Percentage of City’s Shoreline</th>
</tr>
</thead>
<tbody>
<tr>
<td>White River</td>
<td>A</td>
<td>Extends from the east City Limits to the south side of the BNSF right-of-way (ROW) on the right bank (west) of the river</td>
<td>420</td>
<td>1.93</td>
<td>2.9%</td>
</tr>
<tr>
<td>White River</td>
<td>B</td>
<td>Extends from the BNSF ROW to the north side of City Park on the right bank (west) of the river</td>
<td>1,050</td>
<td>4.82</td>
<td>7.2%</td>
</tr>
<tr>
<td>White River</td>
<td>C</td>
<td>Includes the City Park on the right bank (west) of the river</td>
<td>1,600</td>
<td>7.35</td>
<td>11.0%</td>
</tr>
<tr>
<td>White River</td>
<td>D</td>
<td>Extends from the south side of City Park to the King/Pierce County Line on the right bank (west) of the river</td>
<td>1,500</td>
<td>6.89</td>
<td>10.3%</td>
</tr>
<tr>
<td>White River</td>
<td>E</td>
<td>Extends from the King/Pierce County Line to southwest to Stewart Rd SW on the right bank (west) of the river</td>
<td>3,000</td>
<td>13.77</td>
<td>20.6%</td>
</tr>
<tr>
<td>White River</td>
<td>F</td>
<td>Extends from the BNSF ROW to the King/Pierce County Line on the left bank (east) of the river</td>
<td>4,000</td>
<td>18.37</td>
<td>27.5%</td>
</tr>
<tr>
<td>White River</td>
<td>G</td>
<td>Extends from the King/Pierce County Line to Stewart Rd SW on the left bank (east) of the river</td>
<td>3,000</td>
<td>13.77</td>
<td>20.6%</td>
</tr>
</tbody>
</table>

* Does not include open water areas; however, does include floodways, and floodplains within 200 feet of floodways based on existing mapping sources (see Map 1).

### 2.3 APPROACH TO CHARACTERIZING ECOSYSTEM-WIDE PROCESSES AND SHORELINE FUNCTIONS

SMA guidelines require local jurisdictions to evaluate ecosystem-wide processes and their relationship to shoreline ecological functions (WAC 173-26-201 (2)(c)). Ecosystem processes generally refer to the dynamic physical and chemical interactions that form and maintain aquatic resources at the watershed scale. These processes include the movement of water, sediment, nutrients, pathogens, toxins, and wood as they enter into, pass through, and eventually leave the watershed.

For this report, ecosystem processes were characterized using an approach similar to that described in *Protecting Aquatic Ecosystems: A Guide for Puget Sound Planners to Understand Watershed Processes* (Stanley et al. 2005). The approach predicts water movement through a watershed based on topography, soils, geology, climate, and other hydrogeologic factors. Across a watershed, these factors govern the patterns of surface water and groundwater flow between upland and aquatic areas. The approach focuses on water flow patterns because water movement underlies most of the other physical and chemical interactions that occur in a watershed.

The purposes of the ecosystem-scale analysis are to highlight the relationship between key processes and aquatic resource functions, and to describe the effects of land-use on those key processes. The goals are to:
- Identify and map areas in the watershed that are most important to processes that sustain shoreline resources;
- Determine the extent to which those important areas and their processes have been altered; and
- Identify management strategies and potential opportunities for protecting or restoring these areas.

The results of the analysis are provided in Sections 3.

2.4 APPROACH TO INVENTORY AND CHARACTERIZATION OF REGULATED SHORELINES

The inventory and characterization at the reach-scale of the White River is intended to characterize conditions adjacent to the SMA-regulated water bodies as well as in-water conditions.

The analysis of shoreline modifications included interpretation of 2005 and 2007 King and Pierce Counties aerial photography (King and Pierce Counties 2005; King and Pierce Counties 2010).

In addition, the 2007 King County, 2009 Pierce County, 2007 Auburn, and 2002 Sumner Shoreline Inventory and Characterization reports were used as resources to characterize ecosystem processes, land-use, and archaeological and historic properties, as well as to identify potential restoration opportunities.

This report includes information on land-use, zoning, public access, impervious surface, water quality, priority habitats and species, and lake shore modifications.
3. ECOSYSTEM-WIDE CHARACTERIZATION

Ecological structure and function in shorelines are driven by physical and biological processes occurring at varying spatial scales 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’s shorelines occur outside the City and are thus 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.\(^5\)

The following ecosystem characterization defines the area contributing to shoreline functions in the City, identifies the hydrogeologic controls and physical processes that occur, and characterizes changes to processes resulting from land-use. In addition, important areas where processes can be managed with the highest return on investment are identified, with emphasis given to areas within the City.

3.1 STUDY AREA

Jurisdictional shorelines in the City of Pacific lie within the Puyallup/White River (Water Resource Inventory Area (WRIA) 10 watershed (Figure 3-1). Information presented below is either taken directly or modified from literature produced as part of WRIA planning and is supplemented by published information from a variety of sources, including ecosystem characterizations recently conducted as part of SMP updates prepared by King and Pierce Counties and incorporated cities, including Auburn and Sumner.

The main stem of the White River flows 57 miles from its source at Emmons Glacier on Mount Rainier to its confluence with the Puyallup River. The portion subject to the City of Pacific SMP is approximately 1.4 miles, approximately 4,570 linear feet or 0.85 miles within the City limits, and 3,000 linear feet or 0.57 miles within the designated UGA. This is about 2.5 percent of the length of the main stem of the river. The White River basin, including tributaries, occupies approximately 496 square miles. The total area of the City of Pacific is 2.6 square miles, and the area under SMA jurisdiction is about 67 acres or about a tenth of a square mile. The entire area of the City is about one half of one percent of the area of the basin. Because the Pacific SMP is a small part of the overall White River basin, an understanding of the larger ecological context is essential to understanding processes and functions provided within the City as well as the range of appropriate management strategies.

\(^5\) WAC 173-26-201(3)(d)(i)
Figure 3-1. White River Watershed
3.2 ECOSYSTEM-WIDE PROCESSES

Watershed physical processes deliver, transport, store, and remove materials from the ecosystem, thereby affecting the structure and biological functions of river and lake shorelines. The movement of water, sediment, chemicals, and organic material occur throughout the landscape, but these processes occur at varying intensities, depending on local geologic and climate conditions. This section summarizes conditions broadly across the entire watershed and covers the hydrologic setting, land cover, human alteration and other factors that affect such processes. It also identifies the areas most important for supporting those processes and functions

3.2.1 Water

The cycling of water through the ecosystem is dependent on geologic and climate controls such as slope, elevation, precipitation type and amount, soil permeability, storage potential on the surface (landform), and underground (soil porosity) (Figure 3-2).

The general hydrologic cycle within the shoreline is shown in the figure below, emphasizing water exchange and other functions between the uplands and the water body.

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Figure 3-2. Hydrologic Cycle in the Shoreline

Source: WA Dept. Ecology
3.2.2 Hydrogeologic Setting

The White River basin occupies approximately 496 square miles of Pierce and King Counties. As shown in Figure 3-1, the majority of the basin area (75 percent) is located in Pierce County whereas the smaller northern portion of the basin (25 percent) is located in King County. About 427 square miles (or 86 percent) lies upstream of the Mud Mountain Dam (MMD) with about 70 square miles (14 percent) below the dam. Of the area above the dam, approximately 175 square miles or 40 percent is owned and managed by the Mount Baker-Snoqualmie National Forest. Another 90 square miles (21 percent) of is part of Mount Rainier National Park (MRNP). About 130 square miles (30 percent) of the land above the dam is commercial forest land owned largely by Hancock Resources (PCWPD 2007).

The White River in the vicinity of Pacific exhibits geology, climate, and topography generally typical of most Puget Lowland drainages. The major rivers in the area were shaped by the underlying geologic features found throughout the region and include uplift and mountain building, volcanic activity, glaciation, marine deposition, and post-glacial alluvial deposition. Climate is driven by maritime patterns that foment mild, wet fall to spring months and cool, dry summer months.

Mean annual precipitation in the City is 42 inches, most of which accumulates between October and May. Precipitation in the Puget Lowlands typically occurs as low-intensity, long-duration storms. Snowfall is uncommon and short-lived, but snowpack can range from around 50 inches at elevations above 2,000 feet to several hundred inches at elevations greater than 5,000 feet in the Cascade Mountains, where total water equivalent precipitation averages between 60 and 100 inches per year (NCDC 2008).

Upper Watershed

For the purposes of this analysis, the upper watershed is considered to be the area above the Mud Mountain Dam (MMD). The White River headwaters are at Emmons Glacier on the northwest flank of Mount Rainier in Mount Rainier National Park (MRNP). The West Fork has its headwaters at Winthrop Glacier. Water is input to the watershed system via either rain or snow. In upper elevations, snowfall typically remains until late spring and early summer, when it melts and discharges to rivers and streams. Glacial meltwater functions similar to snowpack melt, but does not completely melt during the summer and therefore provides a continuous base flow that varies according to summer temperature at the base of the glacier. Snowfall and glacial formation on Mount Rainier has been in a pattern of glacier retreat since the late 1800s (Burbank 1981). In the near term, increases in glacial meltwater can be expected to increase river flows. The long-term effects of global warming also can be expected to reduce the significance of glacier meltwater in river flows. This is likely to reduce low summer flows in the long-term future and increase temperatures. (Mote 2008)

The peak flows in the upper watershed occur during winter months. During these months, storm events related to generally warmer marine weather systems result in rainfall above an altitude of 1,500 feet. This rain falls on existing snowpack, melting the snow and causing flood events. At elevations below 1,500 feet, precipitation occurs mostly in the form of low-intensity rainfall that infiltrates the soil to recharge groundwater or is delivered to surface water bodies via shallow subsurface flow.

The flow regime within the upper White River basin was modified with the construction of the MMD in 1948 by the U.S. Army Corps of Engineers (USACE) at River Mile (RM) 29. MMD is a "run of the river" dam, passing lower flows unchecked, and retaining higher flows to reduce downstream flooding. The primary objective of MMD flood regulation is to reduce flows from the White River into the Puyallup River, thus maintaining discharge into the Puyallup below the confluence to less than 45,000 cfs for as long as is feasible A secondary
objective is to hold MMD releases below 12,000 cfs to reduce flood damages on the White River. A 1999 USACE study determined that holding MMD releases below 12,000 cfs for up to a 250-year flood would not reduce flood protection on the Puyallup River. Recent experience also indicates that reduction in channel capacity has led to flooding along the White River at discharges below 12,000 cfs (USACE 2009).

**Lower Watershed**

Downstream from Mud Mountain Dam, the river channel is confined for 3 miles in a narrow, steep-sided canyon before the valley widens just downstream of the R Street Bridge in Auburn, where it opens out onto the White River Fan. In the canyon reach, the river has been incising in the last few thousand years, which has created a series of terraces between 15 and 100 feet above the floodplain, mostly in the upper part of the canyon.

Prior to the 20th Century, when the White River flowed into the alluvial fan it split into a number of channels as shown in Figure 3-3. The majority of flow was to the north and joined the Green River north of Auburn. The flow to the south toward the Puyallup River was known as the Stuck River and was a much smaller channel that flowed southward generally in the area of the modern White River. In the last decade of the 19th century, farmers on both sides of the river would periodically dynamite logjams and bluffs to direct the White River away from their land. In 1898, farmers dynamited a bluff and diverted much of the White River into the Stuck River. A November 14, 1906, flood built a large logjam and completely diverted the White River into the former Stuck River channel.

![Historic Map: Tacoma Quadrangle U.S. Geological Survey 1894-95](image)

**Figure 3-3. White/Stuck/Green Rivers in 1894**

*Source: US Geological Survey*
King and Pierce Counties agreed in 1914 to establish the Inter-County River Improvement District, which resulted in construction of the Auburn Dam (at the site of the Auburn Game Farm Park) which permanently closed off the White River’s historical northward-flowing path and enlarged and straightened the channel for flood conveyance. Levees and bank protection were first built on the lower part of the relocated and channelized White River downstream of the East Valley Highway. In the mid-20th century, levees were built on the upper part of this fan segment, and were progressively narrowed with time. Levees were also built on the lower part of the canyon in the mid-20th century. Between 1955 and 1959, dikes were built upstream to about SE 376th Street. The river breached the dikes between transects SE 366th Street and SE 376th Street in the late 1970s (Collins 2004a).

Approximately 5 miles downstream from MMD, Puget Sound Power & Light Company (now Puget Sound Energy [PSE]) constructed a diversion in 1912 with the construction of the White River Hydroelectric Project at approximately RM 24.3 near Buckley. At this location, a portion of the flow was diverted via canals and flumes to what would become Lake Tapps. Lake Tapps was created by raising the level of four small, preexisting lakes by construction of embankments. The water diverted for hydroelectric power generation previously passed through a generating facility at Dieringer, west of Lake Tapps. Water from the diversion returns to the White River, at RM 3.5, near 24th Street East in Sumner and reduces in-stream flows in the intervening reaches. Puget Sound Energy (PSE) has abandoned the power facility and has sold its rights to Lake Tapps to the Cascade Water Alliance (CWA 2008). This agency plans to divert water for domestic use, as opposed to the previous pass through use of the water for power generation, which will result in future reduction of flows, particularly during summer low flow months.

The White River is listed as impaired for inadequate in-stream flows in the bypass reach (RM 3.5 to 24.25) as a result of the dam and diversion. This is a Category 4c impairment under Sections 303(d) and 305(b) of the Clean Water Act as a non-pollutant that cannot be addressed through a Total Maximum Daily Load (TMDL). These problems require complex solutions to help restore streams to more natural conditions (Ecology 2010).

Changes in channel morphology have included straightening, channelizing, installation of levees and revetments, and construction of bridges and other river crossings. Flood control levees were typically installed more than 50 years ago, and these levees would not meet current engineering standards (King County 2006).

The gauge on the White River at the Burlington Northern Santa Fe (BNSF) bridge (approximately RM 6.3) at the north end of the City (USGS No. 12100496) provides measurements of flow from a drainage area of 464 square miles. Daily maximum flows from 1988 to 2010 measured at the gauge are shown on Figure 3-4. Dry season monthly average flows in this period range from approximately 150 cfs to 850 cfs. Wet season monthly average flows for this period range from 550 cfs to 4,500 cfs. Yearly instantaneous peak flows from 1988 to 2010 range from 2,610 cfs to 14,500 cfs. The gauge on the White River at approximately RM 23.9 near Buckley (USGS No. 12099200) shown in Figure 3-5 indicates flow immediately downstream of the MMD for a drainage area of 411 square miles (which is 89 percent of the drainage area of the Auburn/Pacific gauge) and indicates that most peak flows originate from the upper portion of the watershed, rather than from rainfall events in the lower watershed.
**Shoreline Master Program**

**Shoreline Inventory and Analysis**

**City of Pacific**

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**Figure 3-4. White River Mean Daily Flow at Auburn/Pacific**

Source: USGS 2010

**Figure 3-5. White River Mean Daily Flow at Buckley**

Source: USGS 2010
3.2.3 Land Cover

Land cover is the key factor that influences both the hydrologic cycle and wildlife and aquatic habitat. Generalized land cover in the shoreline planning area is shown in Map 13 in the Map Portfolio.

The hydrologic cycle under natural conditions is the continuous circulation of water from the atmosphere to and under the land surface and back to the atmosphere by various processes. In the native environment of the Puget Sound lowland, precipitation generally follows three pathways:

- It is intercepted by leaves and needles on vegetation and evaporates before reaching the ground.
- It reaches the ground and percolates into the soil. This process is called infiltration. After reaching the soil, additional processes the water can go through include interflow which is shallow subsurface flow from precipitation that travels by means of gravity toward a stream channel. Interflow is often a substantial component of base flows of streams in low-precipitation periods and is a substantial source of water for many wetlands. Aquifer recharge refers to percolation to deeper subsurface water systems in either unconsolidated sediment or pervious or fractured bedrock. Aquifers can be a source of surface water recharge.
- It becomes incorporated in surface water runoff, which includes water that travels over the land surface and through channels to reach a stream, wetland or other surface water.

These general processes are illustrated in Figure 3-6.

Vegetation affects the rate at which water reaches the surface by providing a physical barrier that reduces the force of raindrops hitting the surface and also by intercepting, storing, and releasing water at a reduced rate. Intercepted precipitation may be stored on leaves, branches, or stems. A certain proportion may evaporate back into the atmosphere, largely depending on seasonal temperatures. The amount of precipitation that is intercepted depends on the water storage capacity of the vegetation, which depends on leaf size and shape, and the surface area of the canopy, which varies with tree age and density of stems. A component of the water that passes through the tree canopy drips from the canopy and reaches the ground at a reduced rate, (throughfall), which facilitates infiltration into the soil. An additional component runs down stems. This stemflow is influenced by a number of factors including canopy shape that is related to the species mix. Stemflow tends to deposit water deeper into the soil than throughfall.

Soil is the primary water storage reservoir that influences the rate of infiltration. Local soils are shown on Portfolio Map 7. The infiltration depends on the soil structure and is influenced by:

- Parent material and age and depth of the soils influence the capacity of pores between soil particles. The water holding capacity of soils is determined by the total pore volume, which is a function of the capacity of the pores in the soil and the soil depth. Soils in the area are generally of fluvial origin with course substrate and substantial pore volume.
- The forest litter layer provides partially decomposed vegetative matter that has a high capacity to absorb water and limits evaporation of water from forest soils by blocking hydraulic continuity.
- Coarse woody debris, such as downed logs and soil wood in the forest floor, also holds water; the more decomposed organic matter and rotting wood, the more water a soil can hold.

Numerous studies of Puget Sound lowland streams indicate that stream ecosystems are impacted by development. In general, conversion of forest to pasture or impervious (paved) surface changes the hydrology of a watershed. As shown in Figure 3-6, forest vegetation and native soils can store up to 85 percent of precipitation. This water is either returned to the atmosphere through evapotranspiration, infiltrated to deep groundwater, or slowly released to streams (Coleman 1996). Replacing forest vegetation and native soils with impervious surfaces and lawns dramatically increases the amount of surface water. As a result, the magnitude and frequency of flows in streams increases. This results in increased scour, erosion, and flooding which directly impact stream habitat.

Past studies that characterized forest cover for watersheds within the White River Basin are summarized below in Table 3-1.

**Table 3-1. White River Basin Forest Cover**

<table>
<thead>
<tr>
<th>Sub-Basin</th>
<th>Non-Forrested (percent)</th>
<th>Forested (percent)</th>
<th>Seral Stage (percent)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Early Seral</td>
</tr>
<tr>
<td><strong>Upper Watershed</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Upper White</td>
<td>5</td>
<td>95</td>
<td>.4</td>
</tr>
<tr>
<td>White West Fork</td>
<td>2.5</td>
<td>97.3</td>
<td>.4</td>
</tr>
<tr>
<td>Greenwater</td>
<td>1</td>
<td>98.7</td>
<td>.3</td>
</tr>
<tr>
<td>Huckleberry</td>
<td>6.7</td>
<td>93.2</td>
<td>.3</td>
</tr>
<tr>
<td>Clearwater</td>
<td>1.2</td>
<td>98.8</td>
<td>0.2</td>
</tr>
<tr>
<td>Middle White</td>
<td>0.2</td>
<td>99.9</td>
<td>1.3</td>
</tr>
<tr>
<td>Mud Mt</td>
<td>13.0</td>
<td>86.9</td>
<td>3.7</td>
</tr>
<tr>
<td><strong>Lower Watershed</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lower White</td>
<td>50.4</td>
<td>43.3</td>
<td>6.3</td>
</tr>
</tbody>
</table>

Later Seral: conifer cover 70% > 10% 21 in dbh. Mid-seral: conifer cover 70%; <10% 21 in dbh; Early seral: conifer cover 10 to <70%. Other: cleared forest; shrubs. Water: lakes and large rivers. Non-forested: urban, agricultural, glaciers Source data 1988-1999

Source: Cosentino et al 1997 cited in Kerwin 1999

Multiple studies have measured physical and biological changes across a range of watershed land use conditions. In general, both physical and biological attributes of streams correlate with changes in land use and generally decline as watershed development increases. Biologic measures may be more sensitive indicators of degradation and indicate some impact even at very low levels of development (Morley 2000).

Three key finding from the studies are as follows:

1. Stream ecosystems are sensitive to very low levels of development, with noticeable effects occurring at 5 percent to 10 percent impervious surface coverage (Booth 1997; May 1997).

2. The effects of intense urban development on the hydrologic cycle can never fully be mitigated (Booth et al 2002).
(2) Stormwater management facilities such as detention do not fully mitigate development impacts on the hydrologic cycle (Maxted and Shaver 1999).

**Figure 3-6. Hydrologic Cycle**

Source: CTED
**Upper Watershed**

The upper watershed above Mud Mountain Dam (MMD) including the Upper White, West Fork, Greenwater, Middle White and Mud Mountain sub-basins is largely forested. However, the amount of cleared land, which ranges from about 30 to about 40 percent in various sub-watersheds has a substantial effect on the amount and patterns of runoff. Generally speaking, runoff increases with initial clear cutting then decreases substantially with reestablishment of vegetation. Slight decreases in runoff rates occur as forests move from early to late seral stages (Grant 2008). The conditions in the upper watershed, which is more than 80 percent of the watershed area, have the greatest effect on flows within the White River.

**Lower Watershed**

The lower watershed below MMD is estimated to be about 25 percent open space, including forest, about 35 percent agriculture and about 40 percent urban, including residential, commercial, industrial, and civic uses (PCPWU 2007). Although this portion of the watershed is about 20 percent of the total area, it contributes a disproportionately greater peak runoff because of the amount of impervious surface associated with urban development as well as a variety of pollutants related to both agricultural and urban uses.

**3.2.4 Sediment**

The cycling of sediment through an ecosystem is dependent on geologic features such as slope, land cover, soil cohesion, and storage potential determined by landform, as well as climate features such as precipitation duration and intensity. Also important are interactions (including impairments) with the hydrologic process, which is a vehicle for sediment delivery and transport. Therefore, many of the alterations to the hydrologic process also directly and indirectly affect the sediment process.

Sediment has largely beneficial effects on natural processes such as aquatic habitat formation. Sediment is important for geomorphic processes of stream formation and clean gravels are essential for spawning areas for salmon and other species. Too much fine sediment in the water, however, can suffocate egg nests of fish, including threatened and endangered salmon and irritate fish gills, making it difficult for fish to breathe. Sediment also may have adverse impacts on flooding, especially in an area with housing and industrial development, such as Pacific.

Sediment delivery in the White River basin is highly influenced by Mount Rainier (Kerwin 1999). Glaciers on the northwestern slopes of the mountain contribute coarse and fine sediments to the White River. Further, the relatively high gradient of the White River in the canyon area after it leaves the Cascades results in water velocities sufficient to transport significant quantities of sediment. The majority of the sediment in the river, however, comes from erosion of the Holocene and Pleistocene glacial deposits and Osceola mudflow deposits downstream of the Mud Mountain Dam (MMD). (KCRFM 2010)

In addition to glacial influence, mudflows (lahars) from Mount Rainier provide an important structural control on the geomorphology of the White River Valley. Approximately 5,700 years ago the Osceola Mudflow flowed down from Mount Rainier and moved the White River to its northerly course, with mudflow sediments likely reaching Puget Sound (Crandell 1971). Other lahars have followed the current course of the White River, adding deposits that are eroded by the river and tributaries contributing significant fine and coarse materials to the river system and impacting local and regional longitudinal channel slope (Hoblitt et al.1998).
The MMD has changed sediment delivery pathways; however, the dam is designed to pass at least a portion of the river's bedload. The dam is more than 24 river miles upstream of the City of Pacific, and sediment can be generated in the intervening distance via in-channel erosion and large scale earth movement through landslides and other mass wasting. Timber harvesting in the upper watershed also increases the potential for sediment delivery to the channel via related road construction and increased potential for mass wasting (King County 2006). The bedload yield above Mud Mountain Dam, however, is only a fraction of the total yield downstream. (Herrera 2010)

The White River in the ‘canyon’ section between MMD and about RM 7.6 at about the Auburn Game Park has sufficient gradient to transport sediment through the reach and also erodes sediment from this reach. The Holocene and Pleistocene glacial deposits and Oseola mudflow deposits in this area are the dominant sources of coarse alluvium to downstream reaches. (Herrera 2010) Downstream of the canyon, the river widens into the Alluvial Fan from about RM 7.6 to RM 4.9, which is the natural deposition zone for the river (Collins 2004b). Deposition in the alluvial fan section has continued the natural process, which is concentrated in the available channel by flood control levees. The lack of connectivity to the adjacent floodplain and the loss of the ability to migrate laterally restricts sediment accumulation to the confined channel. (Herrera 2010)

In 1948, when MMD was completed, the White River channel capacity was estimated to be 20,000 cfs in the Pacific/Sumner reach, approximately RM 0-9. By the mid-1970s, flood damages were being reported along the White River when MMD discharges reached 12,700 cfs indicating a reduction in channel capacity related both to deposition and to narrowing of the channel by flood control structures. A King County channel capacity study in 1969 calculated the channel capacity between RMs 5-11 to be 14,000 cfs. A USACE study in 1975 found the Pierce County portion of the reach at RMs 0-5 had a channel capacity of 10,000 cfs, while in King County the capacity varied from 13,000 cfs for RMs 5-7.5 to 16,000 cfs for RMs 7.5-11. The increase in channel capacity between 1969 and 1975 for RMs 7.5-11 was attributed to maintenance dredging. (USACE 2009).

In 1988, the USGS found the channel capacities to be 10,800 cfs between RMs 0-5 and 15-19,000 cfs from RMs 5-10 (Prych 1988). A 2009 study by USACE computed the channel capacity at RM 6.013 at Pacific City Park to be no more than 9,000 cfs. The channel capacity at RMs 5.6-5.7 at the White River Estates subdivision is calculated to be 5,000 cfs. At RMs 5.3 above the Stewart Road Bridge, the bank-full channel capacity is calculated to be 5,000 cfs, but the levees on both sides are set back and provide an undeveloped overbank area that extends almost to Butte Road on the right bank (west) and to higher elevation areas on the left bank (east) with a capacity of about 12,000 cfs (USACE 2009).

Flooding issues may be addressed in the long term by levee setback proposals discussed in Section 3.7 and under individual reaches. The USACE (in partnership with Pierce County (and the City of Pacific) and is conducting a lower White River flood reduction alternative analysis to begin in 2010 and conclude in 2015 that will yield additional information and options for sediment transport within the Pacific reach. (Bennett 2010)

### 3.2.5 Temperature

Proper temperatures are vital to threatened and endangered salmon that need cold, clean water to survive. Colder temperatures allow for greater levels of dissolved oxygen (DO). If the water is too warm, the salmon are less able to successfully spawn, and may also suffer health effects during rearing. (Weitkamp 2000).
The Upper White River (above the confluence of Greenwater River) exceeds TMDL standards for temperature and sediment. The river provides spawning area for Chinook salmon and other salmonids.

Restoration of stream temperatures and sediment regimes as provided in the Upper White Watershed Sediment and Temperature Detailed Implementation Plan rests heavily on implementation of the Northwest Forest Plan (NWFP) standards and guidelines, specifically the Aquatic Conservation Strategy. Measures expected to be implemented by the Forest Service as part of the Forest Plan include decommissioning of roads. However, such efforts have been too ‘opportunistic,’ where funding was available and continuation of progress is uncertain. Other watershed restoration efforts, such as hillslope stabilization, road cutslope and streambank stabilization, road relocation, culvert replacement, and in-stream structures have had inconsistent funding. The placement of 89 percent of the Upper White River in Wilderness or Late-Successional Reserve will improve water quality as vegetation transitions to late-seral forest conditions will result in more mature vegetation, which is expected to reduce effects on rain-on-snow peak flows and also provide additional shade that will contribute to reduction in temperature (Ecology 2006).

The lower reaches of the White River from the King County line to the R Street Bridge in Auburn is listed as a _water of concern_ for temperature due to limited data and pending further monitoring. The stretch of the river from Salmon Creek to the confluence with the Puyallup River in Sumner is listed as a Category 2 impairment. Category 2 refers to _waters of concern_ where there is some evidence of a water quality problem but not enough to require production of a TMDL or Water Quality Improvement Project at this time (Ecology 2010a).

### 3.2.6 Water Quality

The delivery of elements and compounds to water bodies is highly dependent on water and sediment processes that provide a vehicle for dissolved and adsorbed materials transportation. Vegetation and the atmosphere also play a role in the delivery of certain compounds/elements. These mechanisms for delivery do not result in background levels that degrade ecological structure and function in the study area, although aluminum may naturally occur at relatively elevated levels (Kerwin and Nelson 2001). Furthermore, they do not typically occur in important, localized areas on the landscape (Stanley et al. 2005). While important areas for input of these materials are not identified, the discussion of alterations to delivery of contaminants in a subsequent section (Section 4) will include a description of important areas. Water quality functions of sediment are reduced in much of the river due to constriction of the available channel by flood control levees. The lack of connectivity to the adjacent floodplain and the loss of the ability to migrate laterally restricts sediment accumulation to the confined channel (Herrera 2010). This restricts the surface area in which such sediment processes would take place under natural conditions.

Storage of materials that affect water quality is similar to those for sediment, where adsorbed compounds, including phosphorus, nitrogen, and toxins, can be deposited and potentially removed via biotic uptake. Wetlands with mineral soils are important areas where dissolved phosphorus can undergo adsorption and storage. Toxin storage, however, is better facilitated by wetlands with clay or organic soils where adsorption and biotic uptake is better catalyzed (Stanley et al. 2005). Nitrogen cycling and storage is fomented by small streams, where alders have a great capacity for nitrogen uptake in hyporheic zones. Nitrogen cycling is also augmented by wetlands with non-organic soils (denitrification) and pH-neutral or alkaline soils (nitrification; Stanley et al. 2005).
Areas in upland plateaus that have a high frequency of peaty and clay wetlands underlying surficial geology are important for toxin storage, denitrification, and adsorption and deposition of dissolved contaminants. Lowland wetlands are more likely to be either fine grained, where floodplain deposition has occurred, or mineral, where coarse-grained alluvium is present. These depositional areas also support deposition of adsorbed contaminants.

Fecal coliform standards have occasionally been exceeded in the vicinity of Buckley, but it is not currently listed as an exceedance (Ecology 2010a). The Lower White River from Hemlock Street SE in Auburn to the confluence with the Puyallup River has high pH values that exceed state water quality standards for much of the river. pH is a measure of the acidity or alkalinity of the water. Fish and other aquatic species thrive in water with pH values between 6.5 and 8.5 (7 is considered neutral). A high pH means the water is alkaline. If the pH is too high, fish are stressed and may die. The river exceeds water quality standards for ammonium as nitrogen for a stretch about a mile upstream of the R Street Bridge in Auburn (Ecology 2010a).

To address these concerns, the White River Memorandum of Agreement (MOA) between the Muckleshoot Tribe, Ecology, and U.S. Environmental Protection Agency (EPA) is under development. The MOA will contain the technical report, water quality improvement report, and the implementation recommendations (Ecology 2010b).

### 3.2.7 Organic Matter

Organic materials include living organisms and the carbon-based material they leave behind after dying, including coarse woody debris, finer woody debris, and detritus. These elements are important for the cycles of energy and nutrients in aquatic ecosystems, including storage, transport, and chemical transformation (Naiman 2001). Downed trees play a significant role in the aquatic ecosystems of the Pacific Northwest. Large woody debris (LWD) significantly influences the geomorphic form and ecological functioning of riverine ecosystems (Maser et al. 1988; Nakamura and Swanson 1993; Abbe and Montgomery 1996; Collins and Montgomery 2002; Collins et al. 2002; Montgomery et al. 2003a; Montgomery et al. 2003b). In a natural system, LWD provides organic material to aquatic ecosystems and is considered a principal factor in forming stream structure and associated habitat characteristics (e.g., pools and riffles). Riparian vegetation is the key source of LWD. LWD is primarily delivered to rivers, streams, or wetlands by mass wasting (landslide events that carry trees and vegetation along with sediment), windthrow (trees, branches, or vegetation blown into a stream or river), and bank erosion (Stanley et al. 2005). Thus, riparian areas, steep forested slopes adjacent to streams, and channel migration zones are important areas for LWD recruitment.

### 3.2.8 Floodplain

Floodplains are relatively flat areas adjacent to larger streams and rivers that are periodically inundated during high flows. Floodplains are often distinguished from stream channels by the frequency in which flow occurs. Floodplains are shown on Portfolio Map 8. Stream channels are the areas in which water normally flows throughout one or two typical annual cycles of high and low flows and typically has a defined geometry created by the flow of water. They usually are characterized by a change in plant communities at the boundaries of the channel. Floodplains typically are formed by water flows at frequencies of 2 years or less and at velocities that may not affect the character of vegetation (Gordon 2004). Floodplains may have defined landforms, or they may be defined statistically by the probable level of flow in a given year.
In the United States, the most commonly used definition of a floodplain is the area inundated by a flood having a one percent chance of being equaled or exceeded in magnitude in any given year. Although commonly called a 100-year floodplain, it is defined by a statistical probability rather than whether records indicate that such a flood has happened or will happen within a 100-year period. The one percent standard was chosen by the Federal Flood Insurance program as a reasonable compromise between the need for building restrictions to minimize potential loss of life and property and the economic benefits to be derived from floodplain development. A structure located within a 100-year floodplain has a 26 percent or greater chance of suffering flood damage during the term of a 30-year mortgage (FEMA 2010).

In a natural state, floodplains allow for the lateral movement of the main channel and provide storage for floodwaters and sediment. Functional floodplains moderate high flows by increasing the area available for water storage (Ziemer and Lisle 2001). This tends to decrease the velocity in the stream channel during flood events. Flood events also tend to create a variety of channel features within floodplains, including subsidiary channels, sloughs and ponds that provide important spawning habitat, rearing habitat, and refuge during high flows (Benda et al. 2001; Montgomery 2003). The concentration of flows in a single main channel tends to increase water velocities, limiting flow conditions suitable for spawning and making it difficult for juveniles to maintain their position or defend territories (Shared Strategy 2005). In addition, water seeps into the groundwater table during floods, recharging wetlands, off-channel areas, shallow aquifers, and the hyporheic zone. Wetlands, aquifers, and the hyporheic zone in turn release water to the stream during the summer months through a process called hydraulic continuity that contributes to stream flows during the summer months (Water Facts Group 1997).

Human modification has diminished the amount of available floodplain, and has changed the character of remaining intact floodplains by altering the hydrologic characteristics. Typical flood plan modification includes physical alteration through fill, disconnection from the main channels, and reduction of channel lateral movement from dikes, levees, revetments, and roads.

It is likely that the entire White River Fan was a floodplain inundated periodically by peak flows during floods prior to the 1914 construction of the Auburn Dam (and the permanent diversion of the White River into the Stuck River channel, and hence to the Puyallup River). Floodwaters diverged and flowed down the White River Fan, in a number of shifting and ephemeral flood channels. Floodwaters flowed to both the Green River to the north and to the south to the Stuck River. Major Hiram Chittenden in a 1906 study characterized the lower Stuck valley as a "low, swampy basin, with a surface soil of peat" thick enough to suggest a lower-energy depositional environment for a considerable period of time (Collins 2004a).

The flooding character of the river changed substantially with the diversion to the south; however, this likely changed the character of the channel more than the floodplain. The channel increased substantially compared to the previous ephemeral nature of the Stuck River channel to carry increased base flows. Several large floods between 1918 and 1934 correspond in time with the channel widening in the period up to the construction of the Mud Mountain Dam (MMD) in 1948. After construction of the dam, average channel widths have decreased substantially. Most of the White River floodplain between the Auburn Dam and the confluence with the Puyallup River has been narrowed by flood control levees and revetments installed by King and Pierce Counties (Collins 2004a).

Flood control structures installed in the vicinity of the City of Pacific have generally been designed to provide flood protection for flows up to the range of 12,000 to 13,000 cfs. (Prych 1988). Areas where flood hazards have been identified, below the flows of 12,000 cfs
identified by the US Army Corps of Engineers (USACE) as their secondary objective, include:

- The Pacific City Park area, which flooded in November 2006 and January 2009.
- The White River Estates subdivision area that also flooded in January 2009 is adjacent to a portion of the river with an estimated channel capacity of 5,000 cfs.
- At RM 5.3 above the Stewart Road Bridge the bank-full channel capacity is calculated at 5,000 cfs but the levees are set back and provide a high flow capacity of about 12,000 cfs (USACE 2009).

Both Pierce and King Counties (through the King County Flood Control Zone District (KCFCZD) have a variety of strategies for managing flood risk, including:

- Updating, collecting, and managing of flood hazard information that is used to direct flood mitigation actions.
- Managing land uses to prevent the creation of new flood risks and the promotion of flood tolerant land uses in flood hazard areas.
- Maintaining river channels.
- Managing of flood protection facilities, including levees, revetments, pump stations, and appurtenances.
- Providing flood hazard education, promoting flood preparedness, and improving flood warning and emergency response.

King County has identified a number of specific projects on the White River in the 2006 Flood Hazard Management Plan: (KCFCZD 2006).

- The TransCanada Flood Conveyance Improvement upstream of Auburn.
- The 41st Street Setback Levee Feasibility Analysis and Design in Auburn.
- The City of Pacific Right Bank/City Park/3rd Place project includes a temporary flood protection barrier. Construction of the permanent project is not envisioned to start before 2014. (Vanderpool 2010)
- The County Line to A Street Flood Conveyance Improvement which is expected to start construction in 2012 or later. (Vanderpool 2010). The County Line to A Street Project is anticipated to be implemented in conjunction with Pierce County and would set the levee on the left (east) side of the river back a distance of up to 1,000 feet as indicated in Figure 3-7. This increase in the floodplain is likely to increase flood conveyance substantially as well as allow channel migration that will facilitate reestablishment of subsidiary channels, sloughs, and ponds and enhance wetland connectivity to the river.

Additionally, as a result of the January 2009 flooding, the KCFCD has identified the need to begin acquisition of properties along the right bank that would provide for the installation of a future levy set back project, beginning at Pacific City Park and ending in the White River Estates area shown in Figure 3-8 (Bennett 2010).

Pierce County has identified a number of levee setback projects as a result of a 2008 study, including the following finalists:

- Countyline levee setback, left bank RM 5.1 to 5.5 (in conjunction with King County as illustrated in Figure 3-7).
- 8th Street East levee setback, left bank, RM 3.9 to 4.4.
- 24th Street East levee setback, left bank, RM 3.2 to 3.5.
- Interurban levee setback, right bank, RM 2.6 to 2.8 (PCPWU 2008).
Figure 3-7. Countyline Flood Conveyance Improvement
Source: King County Flood Control Zone District (KCFCZD) 2009

Figure 3-8. Countyline Flood Conveyance Improvement
Source: King County Flood Control Zone District (KCFCZD) 2009
The channel migration zone (CMZ) is often addressed in conjunction with floodplains because the area affected often is similar and many of the processes that affect channel migration occur during high flow events. A CMZ is an area along a stream within which the channel can be reasonably predicted to migrate over time as a result of natural and normally occurring hydrologic processes (WAC 173-26-020(6)). Channel migration can occur gradually, as a river erodes one bank and deposits sediment along the other. The natural meander patterns of stream channels are the result of the dissipation of energy of flowing water and the transportation of sediment. Channel migration also can occur abruptly, as the river channel shifts (or _avulses_) to a new location. Avulsions are usually unpredictable events that occur during high flood flows when the existing channel cannot transport all of the water and sediment supplied to it.

For the purposes of the Shoreline Management Act (SMA), the extent of likely migration along a stream reach can be identified using evidence of active stream channel movement over the past 100 years. Evidence of active movement can be provided from historic and current aerial photos and maps and may require field analysis of specific channel and valley bottom characteristics in some cases. A time frame of 100 years was chosen because aerial photos, maps, and field evidence can be used to evaluate movement in this time frame. It should also be recognized that past action is not a perfect predictor of the future and that human and natural changes may alter migration patterns. Consideration should be given to such changes that may have occurred and their effect on future migration patterns.

The Shoreline Guidelines in WAC 173-26-221(3)(b) direct local governments to take into account the river’s characteristics and its surroundings, noting that in some cases river channels are prevented from normal or historic migration by human-made structures or other shoreline modifications. Legally-existing artificial channel constraints limit channel movement are not to be considered within the CMZ. There are a number of existing levees on the White River owned and maintained by King and Pierce Counties. These levees effectively contain the CMZ to within close proximity of the existing channel. The King County 2006 Flood Hazard Management Plan provides a policy direction to selectively set-back flood protection facilities to reconnect the river with its floodplain and allow habitat restoration work to take place while managing flood hazards to protect private property and infrastructure (King County 2006).

The proposed County Line to A Street levee setback project (Figure 3-7) is anticipated to allow channel migration processes to occur in the area that will allow reestablishment of subsidiary channels, sloughs, and ponds as well as enhance wetland connectivity to the river.

### 3.2.9 Other Processes

Other secondary processes have less widespread but important influences on overall ecological function in shorelines, including heat/light inputs, biotic interactions, and habitat connectivity. Climate change may already be acting to increase water temperatures as the region experiences a warming trend (Kerwin 2000), and riparian vegetation, channel morphology, and water input source also contribute to overall temperature regimes in water bodies. The introduction of invasive plants and animals can have a significant influence on community productivity through competition, food web dynamics, and predator-prey interactions, among others. Habitat connectivity, which may be limited by natural barriers such as waterfalls, can also limit community or population productivity by limiting availability to valuable habitat.

Riparian areas are the zones where aquatic and terrestrial ecosystems interact. Riparian areas are often referred to as buffers, but the functions are more closely interrelated than the standard dictionary definition as an area that separates incompatible areas or functions and
reduces the adverse effects of one on another. In fact, riparian areas are an integral part of a web of physical and biological functions that extend from a water body inland. Functions provided include large watershed functions such as providing water from both surface water and groundwater and also include a wide range of habitat functions, including:

- Providing shade necessary to maintain the cool temperatures required by salmonids, spawning forage fish, and other aquatic biota.
- Providing organic inputs critical for aquatic life.
- Providing food in the form of various insects and other benthic macroinvertebrates.
- Stabilizing banks, minimizing erosion, and reducing the occurrence of landslides. The roots of trees and other riparian vegetation provide the bulk of this function.
- Reducing fine sediment input into the aquatic environment through stormwater retention and vegetative filtering.
- Filtering and vegetative uptake of nutrients and pollutants from groundwater and surface runoff.
- Providing a source of large woody debris (LWD) into the aquatic system. LWD is the primary structural element that functions in streams to provide hydraulic roughness element to moderate flows. LWD also serves a pool-forming function in streams, providing critical salmonid rearing and refuge habitat. Abundant LWD increases aquatic diversity and stabilization.
- Regulating of microclimate in the stream-riparian corridors.
- Providing critical wildlife habitat, including migration corridors and feeding, watering, rearing, and refuge areas
- LWD provides cover from birds, fish, and other juvenile salmonid predators.

Sustaining different individual functions requires different widths, densities, and compositions of vegetation. The importance of the different functions varies with the character of shoreline setting. Figure 3-9 illustrates some of the functions provided by riparian vegetation at various widths and character in an urban setting.
Figure 3-9. Riparian Vegetation Function in an Urban Setting

3.3 PROCESS IMPAIRMENTS

Both regional water resource management and land-use have altered watershed processes in the White River basin. Water resource management creates important social benefits but also disrupts natural watershed processes that historically occurred in the basin. In addition, historic, regional planning actions to manage flooding and accommodate a variety of land uses, including infrastructure such as transportation, have directly altered processes and degraded shoreline ecological function. The potential for the City of Pacific to restore processes and ecological function via this management framework is limited, as most management actions occur at a regional level or on reaches outside of city jurisdiction. Therefore, the effect of water resource management on watershed processes is discussed briefly, but the analysis is not extended to the identification of management opportunities.

The City has the potential to improve ecosystem function through land-use management, including conservation and restoration actions both inside and outside of City limits. Forest practices, agriculture, and rural and urban development all impact processes by changing land cover and limiting process connectivity. Watershed analyses presented below discuss the effect of these activities on watershed processes and identify priority management areas for protecting and restoring processes.
3.3.1 Dams

Dams typically disrupt a number of natural stream processes including material transport processes (e.g., water, sediment, wood, chemicals, heat) and split the river into two distinct functional areas. Upstream watershed processes are generally intact, but the influence of those intact processes on downstream ecological structure and function has been muted. Functions that are affected include:

- Fish passage/migration
- Timing and amount of water delivery and storage
- Sediment and organic matter storage and transport

Two dams on the White River interrupt a variety of processes. The Puget Sound Energy (now Cascade Water Alliance) Lake Tapps diversion dam at RM 24.3 and the U.S. Army Corps of Engineers flood control Mud Mountain Dam (MMD) at RM 29.6. Water from the Lake Tapps Diversion Dam is returned to the White River at RM 3.5 near 24th Street in Sumner. Both dams are impassable to fish. Returning adult salmon are trapped at the diversion dam and trucked upstream of the MMD impoundment where they are released back into the White River. The operation of these dams essentially eliminates 9.6 miles of mainstem spawning and rearing habitat. Tributaries accessible to anadromous fish are very limited in this reach of the White River and past summer flows have been relatively low. The fish trap and transportation program partially mitigates the adverse fish passage impacts of both dams. The trap and transport system causes delays in upstream migration, along with additional stress of fish through handling, hauling, and release. Theses stresses can adversely affect the reproductive success of individual fish and thereby potentially reduce the productivity of the run. Both dams also affect the timing and mortality of juvenile anadromous fish moving downstream to saltwater (Kerwin 1999). Recent modifications by USACE of the MMD penstocks and control valves from the intake works and installation of the new radial gates has improved survival (USACE 2010).

The dams also disrupts the natural delivery of sediments by impounding fine sediments during high flow and/or high load periods and discharging those same sediments during lower river flows which increases localized deposition. The dams also prevent the movement of woody debris from the upper reaches above the dams. This has implications for stream morphology and other functions important for aquatic habitat. The result is that the remaining sources of sediment and wood recruitment downstream of the dams become relatively more important to creating and sustaining fish habitat. The combination of this circumstance together with substantial areas in the lower watershed that do not have buffers that allow native trees to maturity increases the challenge of providing stream conditions that provide productive aquatic habitat (Kerwin 1999).

The diversion of water to Lake Tapps reduces flows in the intervening reaches between the diversion and the return at RM 3.5, especially affecting aquatic species during the summer when the lowest flows are experienced. These flows have not occurred to the same extent in recent years as in the past due to the abandonment of the hydroelectric project, but are expected to resume with use of the water for domestic supply. Altered flow conditions have a number of structural and functional consequences. Reduction in flood events limits the capacity of rivers to renew themselves, including forming habitat features and transporting sediment downstream and storing it in the floodplain. Biotic communities adapted to natural flow regimes are affected as well. Juvenile salmonids use spring freshets to indicate migration and smoltification. Plants, such as cottonwoods, are also dependent on flooding for germination. Reduced summer low flows may alter the migration timing of escaped adult
salmon returning to spawn and affect water temperature and dissolved oxygen (DO) levels (Kerwin 1999).

### 3.3.2 Land Conversion, Development, and Management

The upper watershed of the White River is in U.S. Forest Service and National Park Service control as part of the Mt. Baker Snoqualmie National Forest and Mount Rainier National Park. The national park management plan is based on preserving the natural environment of the park and enhancing the visitor experience. Little additional alteration of the natural environment is allowed and long-term plans call for maintaining visitor impacts at or below current levels (MRNP 2001). The national forest management plan includes balancing of multiple-use goals including maintaining water resources, forest harvest, and recreation. About 4,000 acres in the White River watershed are licensed for winter sports as part of the Crystal Mountain Ski Area. Within the White River watershed, a number of projects are being implemented under funding provided by H.R.2643 providing Legacy funds to improve water quality in rivers that support threatened species and community water systems. This is completed through decommissioning of unused roads, road and trail maintenance, watershed restoration, culvert replacement, and aquatic habitat improvement (MBSNF 2010).

In the Puget Sound lowland, settlement by non-indigenous peoples began in the 1850s. After the Treaty of Elliott Point in 1855, tribes were relegated to reservations, and rapid development and resource consumption ensued. In the White River Valley timber harvest of old growth was largely complete by the 1870s. From the 1870s through the 1940s agriculture was the largest land use in the area. From the 1940s to the present, substantial urban development occurred.

Timber harvesting, agriculture, and urban land uses have a substantial effect on the amount and timing of runoff in response to rainfall and snowmelt events. In general, the reduction of mature forest has resulted in greater runoff volumes with a faster time to peak flow. This pattern is often most pronounced in urban areas where rainfall on impervious surfaces is conveyed directly to receiving waters via a pipe or ditch system (Dunne and Leopold 1979).

Several studies have also documented that streams can be degraded by low-density (1du/5ac) rural development, primarily due to conversion of forest cover to lawn or pasture (King County 1990a, 1990b). Studies indicate that readily observable aquatic-system degradation is noticeable at development levels of around 10 percent effective impervious surface, with impacts noticeable at even lower levels of development (Booth 1997). Several studies have documented that streams can be degraded by low-density (1du/5ac) rural development, primarily due to conversion of forest cover to lawn or pasture. Low-density development with low levels of impervious surface can clear up to 60 percent of native vegetation to create large lawns, pastures, or hobby farms. This level of clearing has been correlated with significant effects on watershed flow regime (Booth 2002). An investigation of 22 Puget Sound lowland streams indicates a sharp decline in the biological integrity and habitat conditions of the streams as the total impervious area increased above 5 percent (May 1997).

Although degradation to stream ecosystems occurs at low levels of watershed development and has a variety of responses as development increases, it is generally shown that there are two thresholds for impacts (Schueler 1994; Henshaw and Booth 2000; Booth et al. 2002):

- When the sub-basin has approximately 10 percent effective impervious cover; and
- When the peak runoff rate from a 10-year forested condition equals the 2-year developed peak flow rate (this is estimated to occur at 65 percent forest cover).
Both physical and biological measures of healthy stream habitat have been used to assess impacts related to development within a watershed. Hammer (1972) and Booth (1989, 1990), as well as numerous other studies, document physical changes in stream morphology related to increased watershed development. Examples of such changes include channel incision (downcutting), bank erosion, and stream widening. In general, impacts increase across a gradient as the level of development in a watershed increases. Changes in morphology indicate reduced channel stability and degraded physical habitat. Higher flows generally lead to changes in channel character, higher stream erosion rates, increases in scour and erosion, sedimentation, and disconnections from the floodplain with resulting loss of flood storage. In general, these changes compound each other in an urban environment. In addition, stream channelization, culverts, bank protection and other alterations can reduce channel complexity and eliminate off-channel refuge habitats.

The transition from a forest to a cleared environment substantially reduces LWD in streams. The amount of large wood in streams has been correlated to salmon abundance and distribution. This relationship is attributed to the role of LWD as cover. LWD helps ensure that cover and suitable habitat can be found over a wide range of flow and climatic conditions. Functionally, LWD has a major impact on channel form in both small streams and large rivers (Bisson et al. 1987).

Urban development can degrade water quality. Degradation of water quality can occur during construction activities, in which the water quality impacts (primarily sedimentation) may be of short duration. Water quality degrades as a result of runoff and stormwater discharges that wash nutrients, contaminants, and toxic materials from impervious surfaces into waterways (Schueler 1997). In addition, there can be large shifts in nutrient loadings to streams and estuaries due to alterations in riparian communities.

Culvert and bridge installations often create passage problems for upstream migrating salmon, either by creating velocity barriers or falls.

The overall changes in watershed function and quality as a result of urbanization can also impact the base of the food web on which aquatic organisms depend. Several studies have documented changes in the type and abundance of stream biota such as fish and aquatic invertebrates, as development increases in a watershed (Whiting and Clifford 1983; Pederson and Perkins 1986; Fore et al. 1996). In general, these studies indicate an overall decrease in diversity, shifts in aquatic invertebrate structure, and composition with a loss of sensitive species, as development increases in a watershed. Because aquatic invertebrates comprise a large percentage of the diet of juvenile salmon, impacts on the benthic communities can lead to reductions in populations (May 1997).

Tributaries in the lower watershed have also experienced altered stormflows as a result of human development. Many of these streams flow through relatively steep and confined valleys or ravines, and altered hydrology has caused incision and increased sediment inputs, channelization, riparian disconnection, and habitat simplification Kerwin (1999).

### 3.4 AQUATIC AND RIPARIAN HABITAT

Habitat provides the resources necessary for individuals of a species to survive and reproduce. Habitat functions are often described as the ability to provide:

- Food (foraging habitat),
- Protection from the weather and predators (cover), and
- Successful reproduction (breeding habitat) (O’Neil et al. 2001).
An additional function of habitat is to allow the movement of animals over the landscape through dispersal, which allows genetic mixing between populations, and migration, which allows a species to maximize available resources (Lemkuhl et al. 2001; McComb 2001).

The suitability of habitat for a given wildlife species is determined by the habitat occurring within the species’ range, the size of the habitat patch, whether the habitat is accessible (connectivity), the presence of requisite structural elements, and the amount of habitat alteration and disturbance (Morrison et al. 1998; McComb 2001).

The White River contains anadromous runs of steelhead and coastal cutthroat trout; fall- and spring-run Chinook, coho, chum, pink salmon, and a small run of riverine sockeye salmon. Resident coastal cutthroat trout and bull trout also are present and sea-run bull trout may occur in the system. Fall-run Chinook, chum, and pink salmon spawning occurs primarily below the diversion dam; steelhead trout and spring-run Chinook salmon primarily spawn above Mud Mountain Dam (MMD). Coho salmon and coastal cutthroat trout spawn and rear primarily in tributary streams throughout the basin. Bull trout spawning occurs only in snowmelt-fed tributaries in the upper White River Basin above MMD.

The analysis below characterizes the aquatic and riparian habitat of each reach in the Lower Watershed of the White River Basin. Reach observations are summarized from the Pierce County White River Basin Plan Characterization Report (WRBPCR) (PCPWU 2007)

An important element of aquatic habitat referred to in the characterization is riffle and pool sequences. Riffle and pool sequences are generally formed in streams with gravel substrate and describe the alternation from areas of relatively shallow to deeper water. Riffles are formed in shallow areas by coarser materials such as gravel deposits over which water flows. Pools are deeper and calmer areas with bed loads made up of finer material. Pools provide cover, shelter, and resting areas for fish. Riffles aerate the water, harbor most of the insect life, and are used by fish as primary feeding and spawning sites (Keller 1978; Taylor 2000).

Lower Watershed

White River WRBPCR Reach 01. This reach is located between the confluence with the Puyallup River and the outlet of the Dieringer Canal. The reach is confined, with very little channel migration. Banks are steep, with little shallow water habitat present. The stream is mostly run habitat (deep, with no pools). The substrate is mostly silt and sand, with some cobble and gravel present. This reach is used primarily as a migration corridor but also provides rearing habitat for cutthroat (all cutthroat trout present in the surveyed portion of the White River are coastal cutthroat trout subspecies) and summer/fall Chinook salmon. Some rearing of juvenile steelhead trout and coho salmon is likely to occur in the reach. The riparian corridor is narrow and varies between being dominated by shrubs and trees. Most of the land use is agricultural or industrial parks.

White River WRBPCR Reach 02. This reach is located between the outlet of the Dieringer Canal and the Stewart Road Bridge. The channel is largely confined as in Reach 01, with similar riparian habitat and land use. However, a few riffles and pools are present as are limited spawning gravels for summer/fall Chinook, chum, and pink salmon (it is unknown whether they are utilized). A golfing range is on the left bank in the upper part of the reach. Fish use is similar to that of Reach 01, but some spawning may occur in this reach.

White River WRBPCR Reach 03. This reach is located between Stewart Road and the Auburn Game Farm. All of the shoreline in the City of Pacific is in this reach. There are numerous levees and substantial residential development is along this reach. Riparian canopy is present through much of the reach’s length but is rather narrow in most areas. The channel has a moderate amount of pool and riffle habitat, and much more spawning gravel is present.
than was observed in Reach 02. Fish use is similar to that of Reach 02, but more spawning by chum, pink, and summer/fall Chinook salmon likely occurs, and yearling steelhead trout are more likely to use this habitat. Fish use within the Pacific Shoreline planning area is indicated on Maps 10 and 11 in the Map Portfolio.

**White River WRBPCR Reach 04.** This reach is located between the Auburn game farm and a major pipeline crossing on the Muckleshoot reservation. The reach has fair spawning habitat for steelhead trout, chum, pink, and summer/fall Chinook salmon and rearing habitat for all of the above species, plus cutthroat trout. Most of the floodplain corridor is forested, with the exception of the Auburn game farm park and a small amount of residential land downstream from the diversion levee (1906 diversion dam that stopped the White River from flowing into the Green River). A few side channels are present, and there is a smaller amount of LWD than upstream in Reach 05.

**White River WRBPCR Reach 05.** This reach is located between a pipeline that crosses the river and Muckleshoot tribal land. This reach has the best spawning and rearing habitat for salmonids available in the White River below the Buckley diversion dam. There are numerous side channels and the river has a relatively normal braided channel typical of a glacial river. Most of the floodplain and the surrounding valley walls are forested with second growth forest, and there is more LWD present than elsewhere below the Buckley diversion dam. Numerous pools occur at the junctures of channels and at bends in the river, as well as near a moderate number of logjams that are present at bends in the river. There are also several areas where ponds and small connecting side channels are present in forested side terraces between the valley walls and the river. Some ripples in this reach of the river may be too shallow for adult salmon (Chinook) spawner passage during periods of low water.

**White River WRBPCR Reach 06.** This reach is located from RM 14.7 to RM 19.0. This reach has fair spawning gravel and some deep pools where braids in the river join or where the river bends and comes into contact with the valley walls. A few residences are present on the floodplain, but access roads are few and most of the roads are private. Most of the floodplain is forested, but some parts have been clearcut recently (away from the river channel). Several small tributaries on the King County side provide spawning and rearing habitat for coho and chum salmon. Fish use is similar to that of Reaches 05 and 07, but there is substantially less side channel habitat present than in Reach 05. Some ripples in this reach of the river may be too shallow for adult salmon spawner passage during periods of low water.

**White River WRBPCR Reach 07.** This reach is located from RM 19.0 to Buckley diversion dam. This reach is similar to Reach 06 but has slightly more gradient and very little side channel habitat. Most of the stream channel consists of runs, with little LWD or pools present. The stream channel does not appear to have any riffle areas wide and shallow enough to create a problem for the passage of Chinook salmon spawners.

Tributaries in the lower White River generally have fair to poor aquatic habitat and riparian vegetation. Strawberry Creek (0035) and its tributaries have generally poor to fair aquatic habitat and riparian vegetation except for Salmon Creek or Salmon Springs Creek (0036), a very short stream with generally good aquatic habitat and riparian vegetation. Jovita Creek (0033), and its tributaries have generally poor to fair aquatic habitat and riparian vegetation. Tributaries west of Lake Tapps are highly variable in habitat and riparian vegetation, depending largely on the intensity of development (PCPWU 2007).

**Upper Watershed**

Portions of the watershed above MMD generally have fair to good aquatic habitat and riparian vegetation. The Upper White River and Clearwater River generally have fair to good
aquatic habitat and riparian vegetation. The Greenwater River aquatic habitat and riparian vegetation ranges widely but is largely high quality. The West Fork White River and tributaries generally have good riparian vegetation but relatively poor quality aquatic habitat resulting largely from past forest practices (PCPWU 2007).

3.5 PRESERVATION/RESTORATION POTENTIAL

An important element of the analysis includes identifying priority areas for process-based protection and restoration. In general, emphasis for protection and restoration depends on land-use and the degree to which the area supports ecosystem-wide processes (Figure 3-10). The two criteria for rating functions result in three general categories:

- Areas with the highest priority for protection and preservation are the areas with a moderate to high importance for processes and moderate to low levels of alteration which have the highest priority to allow the processes to continue with minimal change in existing conditions.

- Areas with for restoration may have a range of importance for processes and a range of alteration. Figure 3-10 indicates that priority is generally based on the importance of the process, rather than the extent of alteration. Some areas of high alteration may have high potential for restoration if the affected processes are important.

- Areas with low importance for processes and high levels of alteration generally are those areas with the greatest suitability for development for human use, which generally entails loss of ecological processes.

Reach analyses also provides a perspective of the City’s location in the watershed and the relative capacity for protecting and restoring processes within the City limits and UGA.

![Figure 3-10. Rating of Priority Areas for Process-based Protection and Restoration.](image-url)
4. CITY OF PACIFIC SHORELINE INVENTORY AND ANALYSIS

4.1 NATURAL PROCESSES AND FUNCTIONS

This section discusses conditions in the City of Pacific in addition to a slight distance upstream and downstream to provide context.

4.1.1 Hydrological and Biological Resources

The White River in Pacific is constrained by flood control revetments and levees throughout the City. Riparian canopy is variable as described below. The channel substrate consists largely of gravels. The relatively straight constrained channel and high velocities allows for limited formation of riffles and pools. Riffle and pool sequences are generally formed in streams with gravel substrate and describe the alternation from areas of relatively shallow to deeper water. In most of the City of Pacific, the constraints on channel width from levees, together with gravel bars result in a channel configuration dominated by riffles with little pool habitat. This portion of the river is likely used largely for migration with some spawning by chum, pink, and summer/fall Chinook salmon, though yearling steelhead trout are more likely to use this habitat.

Reach A: This reach includes the right bank (north side) if the river and extends from the upstream Pacific City Limits to the downstream BNSF right-of-way boundary, including A Street. The total length is about 420 linear feet. About 210 linear feet are along a private parcel upstream of the bridges occupied by a mobile home park visible in Figure 4-1. The remaining 210 feet is occupied by the A Street right-of-way and the BNSF railroad right-of-way. The upstream is constrained by revetments on both sides and is 400 to 600 feet wide, allowing formation of gravel bars and subsidiary channels. In this reach the channel is constrained by the road and railroad bridges. The A Street bridge has two spans with a central support in the river and is about 350 feet between abutments. The narrower railroad bridge is about 175 feet between abutments and creates a channel constriction that results in relatively fast moving water which moves gravels through this reach for deposition downstream. There is a narrow vegetated riparian corridor of less than 50 feet on the privately-owned site upstream of the bridges. This reach provides primarily for fish migration only, because of the relatively high velocity of the stream.

Reach B: This reach includes the right bank (west) downstream of the BNSF bridge and extends about 1,050 feet to the City of Pacific Park. It is characterized by residential use as part of the White River Park subdivision with 16 single-family lots averaging 50 feet wide along the river. The river bank is characterized by a sloping concrete revetment owned and maintained by King County Flood Control Zone District (KCFCZD) as shown in Figure 4-2. A 1935 aerial photos show the revetment in place from the BNSF bridge through this property to about halfway down the current park site. There is essentially no riparian vegetation. The few trees in this area are either at the top of the revetment or in small clumps where silt has accumulated at the toe of the revetment. As a result of the constriction of the river by the upstream railroad bridge there is a relatively narrow channel with fast moving water on the right bank. There is substantial deposition of gravel on the opposite side of the river, left bank (east) described below as Reach F which tends to further divert the river adjacent to the levee on this side.
Figure 4-1. Reach A Existing Features Photo

Figure 4-2. Reach B Existing Features Photo
Reach C: This reach includes the right bank (west) downstream of the White River Park residential development and is occupied by the City of Pacific Park on land partially owned by the KCFCZD and extending about 1,600 linear feet. The river bank is characterized by a sloping concrete revetment owned and maintained by KCFCZD as shown in Figure 4-3. An additional area of gravel was deposited on top of the slope for approximately 500 linear feet to provide additional flood protection after the 2009 flood (Bennett 2010). About half of the reach frontage has riparian vegetation in a corridor ranging up to about 60 feet wide on a gravel and silt bar at the toe of the revetment. There is a small subsidiary channel between the gravel bar and revetment that may provide some aquatic habitat value. The channel width between revetments is about 250 feet and may provide gravels suitable for spawning, although success is likely limited by flow velocity. King County has designated this area as well as Reach D for a levee setback project indicated in Figure 3-8.

Figure 4-3. Reach C Pacific City Park Existing Features Photo

Reach D: This reach extends on the right bank (west) downstream of the City Park and is about 1,500 feet long. About 900 linear feet of the northern portion of the reach was recently purchased by King County for the levee setback project illustrated in Figure 3-8. About 600 linear feet is adjacent to the White River Estates subdivision which includes an 80-foot-wide buffer and storm detention area dedicated to the City shown in Figure 4-12. The river bank through the reach is characterized by a rip-rap revetment owned and maintained by KCFCZD. The channel width between revetments on both sides is about 225 feet. There is a gravel bar on the opposite side of the river. The riparian vegetation consists of a narrow band along the outside of the revetment between the channel and the maintenance road as shown in Figures 4-4 and 4-5. There is a
complex of upland and wetland vegetation between the revetment and the lots in White River Estates. The stormwater detention facility that was located in the area was partially filled by silt during the 2009 flood (Parametrix 2009). KCFCZD installed a temporary flood control wall along the back of the lots and is in the process of negotiating for acquisition of lots in the White River Estates and a portion of the private property upstream of the subdivision to allow levee setbacks to up to about 400 feet from the existing OHWM (KCFCZD 2009). The riparian vegetation in the area (behind the revetment) varies from about 80 feet to up to 400 feet. There is a small subsidiary channel between the gravel bar and revetment that may provide some aquatic habitat value. The channel width and relatively high velocities likely limits the suitability of this area for spawning and rearing, despite the gravel substrate.

**Reach E:** This reach on the right bank (west) extends downstream of the White River Estates subdivision (which is also the King/Pierce County line) to Stewart Road. This reach is about 3,000 feet long. The river frontage is owned by Pierce County. The county-owned parcel is from 200 to 500 feet wide and includes about 1,900 feet of frontage along Butte Avenue. The Government Ditch flows into the river about 600 feet south of the county line and has a flashboard dam which directs part of the flow to a large wetland complex that connects to the river about 900 feet further to the south. The right bank does not have a formal revetment but is characterized by a break in topography. The county has installed a temporary sandbag barrier south of Boeing/Government Ditch which provides drainage for the federal GSA complex and Boeing warehouse complex in Auburn. The river includes subsidiary channels on the right bank due to the wider channel migration zone in the area that varies between about 200 feet at the county line to about 500 feet at mid-reach and about 290 feet near Stewart Road. The Stewart Road Bridge has a span of about 220 feet between abutments and narrows the river in the vicinity. This is the most complex portion of the White River in the City of Pacific. It contains off-channel areas, substantial riparian vegetation on the right bank and has gravel substrate and pool and riffle sequences that likely provide spawning areas as well as cover, shelter, and resting areas for fish. In addition a variety of food from insect life is provided by the vegetated riparian area and in-stream riffles. The area likely is used for spawning by chum, pink, and summer/fall Chinook salmon. Yearling steelhead trout are also likely to use this habitat.

**Reach F:** The left bank (east) downstream of the BNSF bridge to the King/Pierce County Line extends about 4,000 linear feet and is largely owned by KCFCZD. The river frontage is bounded by a rip-rap revetment. Behind the revetment is a complex of isolated channels and wetlands extending from 650 to 900 feet from the revetment. King County has designated this area for a levee setback project indicated in Figure 3-7.

**Reach G:** This reach on the left bank (east) downstream of the King/Pierce County Line extends to Stewart Road is about 3,000 feet long. Pierce County owns a parcel that extends about 1,700 feet in the northerly portion of the reach which is about 400 feet wide and contains part of the river channel and the revetments on the left bank. This parcel generally extends up to 200 feet inland from the river channel. Behind the county parcel are privately owned lands. There is a large wetland complex in the northerly portion of the reach that extends about 650 feet from the existing revetment. A portion of the levee setback project shown in Figure 3-7 is located behind this wetland complex. The lower 1,300 linear feet of the reach includes a vegetated area behind the revetment of 60 to 100 feet with a privately-owned truck and contractor storage area upland. As indicated in the discussion of Reach E, this is the most complex portion of
Figure 4-6. Reach E Existing Features Photo

Figure 4-7. Reach F Existing Features Photo
Figure 4-8. Reach G Existing Features Photo

Figure 4-9. Reach G Existing Rip-Rap Revetment
the White River in the City of Pacific. The left bank, however, does not have the off-channel areas or substantial riparian vegetation that characterizes the right bank. The channel in Reach G has a gravel substrate and pool and riffle sequences that likely provide spawning areas as well as cover, shelter, and resting areas for fish in addition to a variety of food from insect life produced by the riparian area and ins-stream riffles. The area likely is used for spawning by chum, pink, and summer/fall Chinook salmon, with use by yearling steelhead trout.

4.1.2 Tributaries and Associated Wetlands

There is one tributary stream that flows into the White River in the City. This is the Boeing/Government Ditch that enters the river in Reach E via a channel about 600 feet south of the King/Pierce County Line and through a wetland complex about 1,600 feet south of the county line. The Government Ditch flows from the General Services Administration (GSA) warehouse complex in Auburn south along the east side of the Union Pacific Railroad (formerly Milwaukee Road railroad) right-of-way to about 6th Avenue SW where it turns southeast, crosses Butte Avenue, and flows into the river. The ditch provides stormwater drainage to the Boeing/GSA/Safeway Distribution Center sites in Auburn, portions of the City of Algona and much of the City of Pacific east of Milwaukee Blvd.

There is a wetland in Reach D, a large wetland recharged by the Government Ditch in Reach E, a large wetland complex on King County owned land in Reach F and a large complex on privately owned lands in Reach G. These are shown on Portfolio Map 4.

4.1.3 Fish and Wildlife Presence

The White River basin contains anadromous runs of steelhead and coastal cutthroat trout; fall- and spring-run Chinook, coho, chum, pink salmon, and a small run of riverine sockeye salmon. Resident coastal cutthroat trout and bull trout also are present and sea-run bull trout may occur in the system. Fall-run Chinook, chum, and pink salmon spawning occurs primarily below the diversion dam; steelhead trout and spring-run Chinook salmon primarily spawn above Mud Mountain Dam (MMD). Coho salmon and coastal cutthroat trout spawn and rear primarily in tributary streams throughout the basin. Bull trout spawning occurs only in snowmelt-fed tributaries in the upper White River Basin above MMD.

The White River within the City of Pacific hosts Spring and Fall Chinook salmon, coho salmon, chum salmon, pink salmon, and winter and summer steelhead.

The river provides primarily rearing and migration functions for Spring and Fall Chinook salmon (Williams et al. 1975; Anchor 2004). Spawning and rearing habitat are provided for coho salmon, chum salmon, and winter steelhead. The river is a migration corridor for pink salmon and summer steelhead. General habitat is provided for cutthroat trout and sockeye salmon (Kerwin 1999; WDFW 2005). Although this habitat is moderately suitable for spawning and rearing, that utilization is minimal below RM 11, including the reaches within the City’s shoreline planning area (Puyallup Tribal Fisheries 2005).

The White River, from the confluence with the Puyallup River to Boise Creek, has been designated by NOAA Fisheries as critical habitat for Puget Sound Chinook salmon (Federal Register, Vol. 70, No. 170). The U.S. Fish and Wildlife Service (USFWS) designated the White River, both upstream and downstream of the City, as critical habitat for bull trout (Federal Register, Vol. 70, No. 185). Primary bull trout habitat use is for foraging, migration, and over-wintering (WDFW 2005). The most productive reaches in the City are from the King/Pierce County Line to Stewart Road because of the more complex channel and riparian environment.
Upland habitat provides the resources necessary for individuals of a species to survive and reproduce. Habitat functions are often described as the ability to provide:

- Food (foraging habitat),
- Protection from the weather and predators (cover), and
- Successful reproduction (breeding habitat) (O’Neil et al. 2001).

An additional function of habitat is to allow the movement of animals over the landscape through dispersal, which allows genetic mixing between populations, and migration, which allows a species to maximize available resources (Lemkuhl et al. 2001; McComb 2001).

Wildlife species vary in their habitat requirements and use of a particular habitat type will vary by season and over the life of the individual. Habitat generalists, such as deer or red-tailed hawks thrive in a variety of habitat types, while habitat specialists, such as the harlequin duck require very specific habitat types and features. For most species, the habitat type selected for foraging will differ from habitat selected for thermal or security cover. Most species require specialized habitat features for reproduction (e.g., tree cavities for cavity-nesting birds) and for many species the availability of these breeding habitat features is used to determine the suitability of habitat (Anderson and Gutzwiller 1994; McComb 2001; Sheldon et al. 2003).

The suitability of habitat for a given wildlife species is determined by the habitat occurring within the species’ range, the size of the habitat patch, whether the habitat is accessible (connectivity), the presence of requisite structural elements, and the amount of habitat alteration and disturbance (Morrison et al. 1998; McComb 2001). Some habitats may only be used for a short period of time but are critical in sustaining a species. During migration, shorebirds are dependent on intertidal mud bays for foraging and may stop for a few days at a particular site.

Providing travel corridors for wildlife that maintain connectivity between habitat blocks is an important role of habitat. This connectivity reduces the likelihood of populations becoming isolated and prone to extinction due to random events or inbreeding (Morrison et al. 1998). If wide enough and suitable vegetation/structure is present, corridors may serve as habitat in their own right (O’Connell et al. 2000). The potential value of corridors to wildlife is not entirely positive as corridors may contribute to the spread of fire, invasive species, and disease and may dampen speciation by contributing to genetic mixing.

Local habitat is indicated in Maps 12 and 12a. The latter map indicates the presence of various species based on intensive short-term inventories. The large amounts of open space in the area meet many of the needs for a variety of habitat. The river itself provides a corridor for movement of wildlife and contributes to the productivity for a variety of functions.

The Washington Department of Fish and Wildlife (WDFW) publishes the Priority Habitats and Species (PHS) list for Washington State, which includes a catalog of habitats and species considered to be priorities for both conservation and management. Priority species include those species that, due to their population status, require specific protective measures to perpetuate their existence. This includes State Endangered, Threatened, Sensitive, and Candidate species; species congregations considered vulnerable; and those species of recreational, commercial, or tribal importance that are vulnerable. Priority habitats are those habitat types or elements with unique or significant value to a diverse assemblage of species, which may consist of unique vegetation types or dominant plant species, a described successional stage, or a specific structural element (WDFW 2010).
Priority species documented in the City include Chinook salmon, coho salmon, chum salmon, pink salmon, steelhead, bull trout, bald eagle, and concentrations of waterfowl. According to WDFW PHS maps, the City’s shoreline planning area contains the following priority habitats: riparian areas, urban natural open spaces, wetlands, cliffs and caves. Priority species are indicated in Map 12.

### 4.1.4 Floodplain and Channel Migration

Flood management on the White River in general is discussed in Section 3.2.8 above.

The entire White River channel in the City of Pacific has been constrained by flood control revetments and levees. Flood control structures installed in the vicinity of the City of Pacific have generally been designed to provide flood protection for flows up to the range of 12,000 to 13,000 cfs (Prych 1988). These measures have not been effective, at least to some extent because of reduction of channel capacity due to sedimentation. The extent of the floodplain as defined by the Federal Emergency Management Agency is indicated in Map 8 in the Map Portfolio. This floodplain map reflects the current limitations of the flood control facilities in the area.

Areas where flood hazards have been identified, below the flows of 12,000 cfs identified by the US Army Corps of Engineers (USCE) as their secondary objective include:

- The Pacific City Park area, which flooded in 2006 and 2009.
- The White River Estates subdivision area that also flooded in 2009. The river channel adjacent to the subdivision has an estimated channel capacity of 5,000 cfs.
- At RM 5.3 above the Stewart Road Bridge where the bank-full channel capacity is calculated at 5,000 cfs but the levees are set back and provide a high flow capacity of about 12,000 cfs (USACE 2009).

Both Pierce and King Counties have identified flood management activities in the City, including:

- The 3rd Place SE and Pacific City Park Revetment Retrofit in Reach B (King County).
- The Pacific City Park Revetment Repair in Reach C (King County).
- The Right Bank Temporary Levee Setback extending from the City park to the City limits (King County).
- The County Line to A Street Flood Conveyance Improvement (KCFCZD 2006) in Reaches F and G (King and Pierce Counties; see Figure 3-7).

The County Line to A Street Project is anticipated to be implemented in conjunction with Pierce County and would set the levee back on the left side (east) of the river at varying distances of up to 1,000 feet as indicated in Figure 3-7. This increase in the floodplain is likely to increase flood conveyance substantially as well as allowing channel migration that will facilitate reestablishment of subsidiary channels, sloughs, and ponds, as well as enhancing wetland connectivity to the river.

King County also has implemented temporary flood control measures on the right bank and is acquiring land south of the City of Pacific Park for long term flood control.

In addition, King and Pierce Counties are coordinating with the Puyallup River Executive Task Force, Pierce County, the USACE, the FEMA, local cities, and other stakeholders to develop a long term strategy for managing flooding on the White River.
The channel migration zone (CMZ) is often addressed in conjunction with floodplains because the area affected often is similar and many of the processes that affect channel migration occur during high flow events. A CMZ is the area along a stream within which the channel can be reasonably predicted to migrate over time as a result of natural and normally occurring hydrologic processes (WAC 173-26-020(6)). The natural meander patterns of stream channels are the result of the dissipation of energy of flowing water and the transportation of sediment. Channel migration also can occur abruptly, as the river channel shifts (or “avulses”) to a new location. Avulsions are usually unpredictable events that occur during high flood flows when the existing channel cannot transport all of the water and sediment supplied to it.

The Shoreline Guidelines in WAC 173-26-221(3)(b) direct local governments to take into account the river’s characteristics and its surroundings, noting that in some cases, river channels are prevented from normal or historic migration by human-made structures or other shoreline modifications. Legally-existing artificial channel constraints limit channel movement and therefore are not to be considered within the CMZ. There are a number of existing levees on the White River owned and maintained by King and Pierce Counties. These levees effectively contain the CMZ to within close proximity of the existing channel. The King County 2006 Flood Hazard Management Plan provides a policy direction to selectively set-back flood protection facilities to reconnect the river with its floodplain and allow habitat restoration work to take place while managing flood hazards to protect private property and infrastructure (King County 2006).

The proposed County Line to A Street levee setback project is anticipated to allow channel migration processes to occur in the area that will allow reestablishment of subsidiary channels, sloughs, and ponds, as well as enhancing wetland connectivity to the river.

4.1.4.1 Critical Areas and Other Natural Features

The area within shoreline jurisdiction in the City of Pacific does not contain steep slopes or landslide hazards because of the generally flat topography as indicated in Map 3. There is a steep slope area east of the City limits and erosion hazard areas relating to moderately steep slopes at the edge of the channel migration area as shown in Map 6.

The entire White River valley floor is a liquefaction hazard area during seismic events due to alluvial deposits. Liquefaction occurs when loose, saturated sand or silt is shaken violently enough to increase pore water pressure between individual grains, effectively reducing shear strength of the soil mass. Shallow liquefaction zones can cause severe damage to structures when foundation supports suddenly become fluid. Liquefaction susceptibility is mapped as moderate to high over the alluvial valley bottom, which incorporates all of the White River shoreline planning area (Palmer et al. 2004). The City addresses liquefaction through International Building Code provisions.

The lahar hazard zone is focused along the White River Valley and covers all of the area of shoreline jurisdiction as well as much of the lowland area of the City. Lahars, also called mudflows are a dense mixture of water-saturated debris that move quickly down valleys, behaving much like flowing concrete. Lahars are associated with volcanic eruptions on glacier-covered mountains, such as Mount Rainier, where melting snow or glacier provides a source of water to the debris flows. Lahars originating from Mount Rainier have been a fairly common occurrence. They vary in size and magnitude and are fairly unpredictable. The largest lahar originating at Mount Rainier in the last 10,000 years is known as the Osceola Mudflow. This cohesive lahar, which occurred about 5,600 years ago, was at least 10 times larger than any other known lahar from Mount Rainier. The Osceola deposits cover an
area of about 212 square miles in the Puget Sound lowland including much of the City of Pacific. (Hoblitt et al. 1988) Lahar hazards are generally addressed by evacuation.

Much of the lowland area of the City, including all of the areas in shoreline jurisdiction, is an aquifer recharge area based on the alluvial deposits in the area as indicated in Map 9. It is probable that interflow occurs from the White River during high flows and to the river during low flows (Woodward 1995). The City designates a critical aquifer recharge area within the 10-year time-of-travel wellhead protection zone for City wells 2 and 3, from which the City draws nearly all its drinking water, located near the northeast corner of Ellingson Road and Pacific Avenue as indicated in Map 9 in the Map Portfolio.

4.2 BUILT ENVIRONMENT

4.2.1 Existing and Planned Land-Use

Existing Land-Use

Land-use patterns along the shoreline of the White River are a mix of residential, parks, recreation and open space, government/institutional, and undeveloped lands. Information relevant to this description is contained in the Map Portfolio and includes Land Cover in Map 13, Impervious Surfaces in Map 14, Parks and Open Space in Map 16, Zoning in Map 17, and Existing Shoreline Designations in Map 18. In addition, current aerial photos and reconnaissance level fieldwork contributed to the description of land uses.

Table 4-1 provides an overview of existing development in shoreline jurisdiction. Especially significant is the proportion under public ownership.

<table>
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<th>Reach</th>
<th># of Lots</th>
<th>% Undeveloped Lots</th>
<th>% Undeveloped Area</th>
<th>Public Ownership</th>
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<td>2</td>
<td>1</td>
<td>80%</td>
<td>65%</td>
</tr>
</tbody>
</table>

Source: King and Pierce Counties 2010

Reach A, on the right bank (north), extends on the upstream side from the Pacific City Limits to the BNSF right-of-way at the downstream boundary. It is about half residential and half transportation right-of-way. Of the total of about 420 linear feet, about 210 linear feet is a 1.75-acre private parcel occupied by a mobile home park with 12 existing units. Reach A includes the area indicated as Tract C in Figure 4-10. The parcel is zoned Highway Commercial, which allows a variety of retail, office, restaurant, and limited light industrial uses. The mobile home park is a non-conforming use and may be displaced by higher value uses in the future. The parcel is abutted by a City of Auburn sewer pump station and the White River Estates Mobile Home Park on about a 30-acre parcel that extends upriver about a half mile. Across the river within the City of Auburn is a small office park with about 600 feet of river frontage and the City
of Auburn Roegner Park that extends about a mile upstream (see Map 16). The downstream portion of this reach is occupied by the A Street Bridge and the BNSF Railway bridge.

**Reach B** on the right bank (west) downstream of the BNSF bridge is occupied by the White River Park subdivision with 16 single-family lots fronting about 1,050 linear feet of the river. The lots are generally about 50 feet wide as indicated in Figure 4-11 and are occupied largely by mobile homes. The White River Park subdivision is a replat of Tract –D” in Figure 4-10. The river bank is characterized by a sloping concrete revetment owned and maintained by KCFCZD. A 1935 aerial photos show the revetment in place from the BNSF bridge through this property to about halfway down the current park site. The subdivision plat, as indicated in Figure 4-11 provides for lot boundaries at the edge of the revetment and provides a 20 foot easement adjacent to the revetment. There is essentially no riparian vegetation in Reach B. The few trees along this area are either at the top of the revetment or in small clumps where silt has accumulated at the toe of the revetment. This area is zoned Single Family Residential RS-6.

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**Figure 4-10. Hillman’s Division 2 Plat 1906**
**Reach C** on the right bank (west) downstream of the White River Park residential development consists of the City of Pacific Park on land owned by the KCFCZD and extending about 1,600 linear feet of the river. Most of the park is grassed open space with a covered bandstand area, restrooms and a parking lot. The river bank is characterized by a sloping concrete revetment owned and maintained by KCFCZD. The park is zoned Open Space. To the south of the park is a multi-family area that does not extend to the river and is out of shoreline jurisdiction. King County has designated this area for the levee setback project shown in Figure 3-8 which extends through Reach D.

**Reach D:** The right bank (west) downstream of the City Park consists of about 1,500 total linear feet. Almost all of the shoreline frontage has recently been purchased by the KCFCZD. The area within 250 to 450 feet of the OHWM is zoned Open Space. The area to the west is zoned single family residential with a 6,000 square foot minimum lot size. About 20 to 30 lots could be accommodated on this parcel, depending on configuration. About 600 linear feet of the southerly portion of the reach is adjacent to the White River Estates subdivision shown in Figure 4-12, which includes an 80-foot-wide buffer and storm detention area dedicated to the City. There are ten residential lots adjacent to the buffer tract. KCFCZD is in the process of purchasing these lots on a willing-seller basis. The subdivision is zoned Single Family Residential RS-6, and the buffer tract is zoned Public Lands. The river bank through the reach is characterized by a rip-rap revetment owned and maintained by KCFCZD. The stormwater detention facility that was located in the area was partially filled by silt during the recent flood (Parametrix 2009). KCFCZD has installed a temporary flood control wall along the back of the lots.
**Reach E:** The river frontage on the right bank (west) downstream of the White River Estates subdivision (the King/Pierce County Line) extending to Stewart Road is owned by Pierce County and managed for flood control. This parcel has about 3,000 linear feet of river frontage. The northerly 750 feet are separated from Butte Avenue by intervening private parcels and is about 400 feet wide, as measured to the existing OHWM. The southerly 2,250 feet abuts Butte Avenue on the west and ranges from about 450 to 160 feet wide. The Government Ditch flows into the river about 600 feet south of the county line and also flows to a large wetland complex that connects to the river about 900 feet to the south. Stewart Road is within the City of Sumner. The area between the Summer City Limits on the east and the Pacific City limits along Butte Avenue is currently in unincorporated Pierce County and designated a UGA for annexation to Pacific. The current county zoning of this area is Employment Centers, which allows a wide variety of industrial uses with some limited commercial uses. The Pierce County shoreline designation is currently Rural.

**Reach F:** The left bank (east) downstream of the BNSF bridge to the King/Pierce County Line is owned by KCFCZD with minor private inholdings for which the county is currently negotiating acquisition for flood control improvements. It extends about 4,000 linear feet. The river frontage is bounded by a rip-rap revetment with a maintenance road accessed from Stewart Street to the south. There is no access to the site from A Street or the BNSF right-of-way. Behind the revetment is a complex of isolated channels and wetlands extending from 650 to 900 feet from the revetment. King County has designated this area for a levee setback project indicated in Figure 3-7. There one privately owned parcel Mosby along the shoreline.

**Reach G:** The left bank (east) downstream of the King/Pierce County Line and extending to Stewart Road is about 3,000 feet long. Pierce County owns a parcel about 400 feet wide that contains part of the river channel and the revetments on the left bank. The width of the upland portion of the county owned parcel, as measured from the
Shoreline Inventory and Analysis
Shoreline Master Program
City of Pacific

OHWM, varies from around 250 feet to less than 50 feet. Behind the county parcel are privately-owned lands that are within the City of Sumner and zoned Light Industrial, M-1. The Shoreline within Sumner is designated Urban Conservancy. Shoreline jurisdiction extends into 100 to 150 feet of the developed area of the privately-owned truck and contractor storage area north of Stewart Road in Sumner. The parcels further north in Sumner are partially within SMA jurisdiction with associated wetlands extending several hundred feet east of OHWM.

Planned and Likely Future Land-Use

The City’s Comprehensive Plan land-use designations and zoning are essentially the same within the White River shoreline planning area.

Reaches A through D on the right (west) bank are designated Medium Density Residential and zoned Single Family Residential RS-6 except for the City Park and a corridor along the river downstream of the park which are zoned Open Space as indicated in Map 17.

All of the upland along the river frontage is developed except for the 900 linear feet downstream of City Par.. In this area the river frontage has been acquired by KCFCZD for flood control purposes. (Bennett 2010). The current Shoreline designations are generally Urban, except for the City Park which is designated Rural as well as an area to the south, where parallel designations are provided with a Rural designation closer to the river.

There is little redevelopment potential for existing residential use on the right (west) bank.

The parcel with the most development potential is the commercially zoned mobile home park in Reach A upstream of A Street.. The commercial zoning of this site renders the mobile home park non-conforming. At some time in the future, retail, office, or other commercial use can be expected on the site. The redevelopment potential of the site is constrained somewhat by the configuration of A Street and the right-in-right-out driveway restriction which may limit the potential for retail uses because of less convenient access patterns. Future setbacks from the river can be expected to be governed by this SMP, floodplain regulations, and possibly acquisition of a portion of the river frontage by KCFCZD, although the County has no current plans for acquisition. This is not a site designated by the KCFCZD for willing seller acquisition.

Reach E on the right (west) bank is owned by Pierce County, although wetland buffers for the wetland complex south of Government Ditch may extend into adjacent private parcels. This land is not within the city and does not have a city zoning designation. The Pierce County zoning is Employment Centers EC, which allows a wide variety of industrial uses with some limited commercial uses. This area is designated Industrial as part of the x Manufacturing/Industrial Center. (M/IC) jointly adopted by the Cities of Pacific and Sumner in 2009. The current Pierce County Shoreline designation is rural. There is no probability of development of the publicly-owned parcel along the river, except for flood control purposes. The several acres of privately-owned land along Butte Avenue currently in residential use can be expected to develop into industrial uses in the future.

Reach F on the left (east) bank is owned by King County, although wetland buffers may extend into adjacent private parcels. This land is zoned Open Space. It is likely that all land within shoreline jurisdiction, including associated wetlands is in public ownership, except for wetland buffers. CHECK The private parcel along A Street is currently in residential and agricultural use and is designated Open Space, providing limited redevelopment potential.

Reach G on the left (east) bank downstream of the King/Pierce County Line and extending to Stewart Road is partially contained in a Pierce County-owned parcel that extends 50 to 250 feet from the OHWM. Several private parcels within the City of Sumner are within shoreline
jurisdiction as well as affected by wetland buffers. This adjacent land is entirely zoned Light Industrial, M-1 and is part of the Sumner-Pacific Manufacturing and Industrial Center (MIC). The northerly 1,700 linear feet of shoreline frontage are partly in Pierce County ownership with the adjacent private parcel currently in agricultural use to the east of the existing wetland complex. The private parcel can be expected to be converted to industrial use in the future. Setbacks from the shoreline will be determined largely by required wetland buffers in the Sumner land use code. For the two private parcels near Stewart Road, shoreline jurisdiction extends 100 to 150 feet into the developed area, which is currently truck storage and a contractor’s storage yard. When these parcels are redeveloped in the future, buffer requirements can be expected to be implemented.

4.2.2 Impervious Areas

Impervious areas were analyzed based on recent aerial photos and from USGS interpretation of Landsat satellite information presented in Portfolio Map 14 in the Map Portfolio. Table 4-2 below shows the total amount of impervious area for each reach within the White River shoreline planning area based on review of current aerial photos. The impervious area includes public ROWs, buildings, and other impervious area such as driveways or storage. Overall, impervious area within shoreline jurisdiction is relatively limited, reflecting the large areas under public ownership used for park and open space purposes.

<table>
<thead>
<tr>
<th>Reach</th>
<th>Total Acres</th>
<th>Impervious Area (Acres)</th>
<th>Percent Impervious</th>
<th>Roadway Acres</th>
<th>Building Acres</th>
<th>Other Impervious Acres</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>1.93</td>
<td>1.74</td>
<td>90.0%</td>
<td>0.00</td>
<td>1.16</td>
<td>0.58</td>
</tr>
<tr>
<td>B</td>
<td>4.82</td>
<td>3.37</td>
<td>70.0%</td>
<td>0.72</td>
<td>1.69</td>
<td>0.96</td>
</tr>
<tr>
<td>C</td>
<td>7.35</td>
<td>0.00</td>
<td>0.0%</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
</tr>
<tr>
<td>D</td>
<td>6.89</td>
<td>1.38</td>
<td>20.0%</td>
<td>0.34</td>
<td>0.69</td>
<td>0.34</td>
</tr>
<tr>
<td>E</td>
<td>20.66</td>
<td>0.00</td>
<td>0.0%</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
</tr>
<tr>
<td>F</td>
<td>27.55</td>
<td>0.00</td>
<td>0.0%</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
</tr>
<tr>
<td>G</td>
<td>20.66</td>
<td>3.10</td>
<td>15.0%</td>
<td>0.00</td>
<td>1.03</td>
<td>2.07</td>
</tr>
</tbody>
</table>

Source: City of Pacific 2005

According to the data in the table, the vast majority of impervious surface adjacent to the River is related to residential use in Reach B and industrial use in Reach G.

4.2.3 Public Access

The White River provides significant opportunities for formal and informal shoreline access.

4.2.3.1 Existing Public Access

Existing park and public land is indicated on Map 16 in the Map Portfolio.

Reach A upstream of the A Avenue bridge does not provide public access in the existing mobile home park. Upstream on the same side of the river there is public access along the entire White River Estates Mobile Home Park on a soft-surface trail. There is a chain link fence at the property line. Across the river, there is public access along the
City of Auburn Roeqner Park to R Street/Kearney Way. On the downstream side of the BNSF bridge, on the Skinner Road right-of-way there is informal public access west of the bridge abutments.

**Reach B** provides no formal public access along the concrete revetment adjacent to the White River Park subdivision. There is, however, an informal path at the top of the revetment adjacent to the private fences installed by property owners. This informal path proves access at low river flows but can be considered dangerous at high flows.

**Reach C** provides public access along the entire 1,600 linear feet of river frontage at the City Park at the top of the revetment on a gravel surface trail/maintenance road as shown in Figure 4-13. This public access is heavily used.

![Figure 4-13. Reach C City Park Public Access](image)

**Reach D** provides informal access along the KCFCZD maintenance road along the entire 1,500 linear feet of the reach and extending into the Pierce County-owned Reach E. This is not formally designated a non-motorized trail but it receives extensive use from the public and is generally accessed from the City Park. There is no formal access further to the south, but many property owners in White River Estates subdivision with lots fronting on the open space area have gates in their fences allowing access to the public land along the river.

**Reach E** provides informal access on a portion of this Pierce County-owned parcel from the north on the existing maintenance road on the flood control levee. The maintenance road connects to the maintenance road on the King County side and extends over the Government Ditch and extends about 900 feet further south to the channel that connects the existing wetland complex to the river. There is informal
access to the parcel from Stewart Road to the south and from Butte Avenue. The portion of the parcel fronting on Butte Avenue is posted ‘no trespassing’ but receives extensive public use as evidenced by the network of informal trails in the area.

Reaches F and G on the left bank (east) provides informal public access from Stewart Road to the south to the BNSF right of way at the north City limits on the maintenance road along the flood control levee shown in Figure 4-14. There is no access to the north across the BNSF railroad right-of-way. There is informal access at low river flows under the BNSF railroad bridge and the A Street Bridge that provides an informal connection to the City of Auburn Roegner Park. This provides a connection to the White River trail that extends 2.25 miles along the White River to the Game Farm Wilderness Park.

![Image](image_url)

Figure 4-14. Reach F Maintenance Roadway – Informal Public Access

4.2.3.2 Public Access Opportunities

Opportunities for enhanced public access by reach are detailed below.

Reach A has the opportunity to provide public access at such time as the existing mobile home park redevelops. Such access would be most effective if connected with the sidewalk on A Street and also connected to the north with the existing soft surface trail along the White River Estates Mobile Home Park. It would be desirable to set the access back behind the vegetated buffer. The existing informal public access downstream of the BNSF bridge could be formalized and rendered safe by providing a formal viewing platform above high water. It is unlikely that safe access to the water’s edge is feasible on the sloping concrete revetment. If the revetment is modified in the future, safe public access may be feasible and should be considered in evaluating design options.
Reach B likely cannot provide safe formal public access along the concrete revetment adjacent to the White River Park subdivision with the configuration of the sloping concrete slabs. If the revetment is modified in the future, safe public access may be feasible and should be considered in evaluating design options.

Reach C provides public access at the City of Pacific Park at the top of the revetment, which will likely to be maintained indefinitely. The city may wish to evaluate whether a hard surface trail is desirable to provide more flexible access for bicycles and the mobility impaired.

Reach D provides informal access along the KCFCZD maintenance road that could be formalized by an agreement with the City. This agreement would specify maintenance responsibilities and oversight and would require little or no change in the existing configuration. In the future, if the revetment is modified, formal public access can be incorporated. The Shoreline Guidelines in WAC 173-26-186(3)(c)(iv) requires that new structural public flood hazard reduction measures, such as dikes and levees, dedicate and improve public access pathways unless public access improvements would cause unavoidable health or safety hazards to the public, inherent and unavoidable security problems, unacceptable and unmitigable significant ecological impacts, unavoidable conflict with the proposed use, or a cost that is disproportionate and unreasonable to the total long-term cost of the development. It is likely that issues such as safety can be successfully mitigated. Public access from King County-owned parcels in White River Estates and in future subdivision to the north would enhance the ability of the general public to access this corridor.

Reach E provides the opportunity for formalizing the existing informal access in the Pierce County-owned parcel along the existing maintenance road in the north portion of the property. This access could be extended to Stewart Road by a bridge over the channel that connects the wetland to the river. Provision of public parking along Stewart Road would greatly enhance opportunities for the public to enjoy access to this publicly owned resource.

Reaches F and G on the left bank (east) provide an immediate opportunity to formalize the existing informal access along the maintenance road through an agreement with the City that would provide access along the entire corridor to Stewart Road. In the future, with the levee setback project illustrated in Figure 3-7, formal public access can be incorporated, together with interpretive access to the wetland complex in the area. As indicated above under Reach D, the Shoreline Guidelines in WAC 173-26-186(3)(c)(iv) requires that new structural public flood hazard reduction measures dedicate and improve public access. Access to the north would be desirable and may be feasible under the A Street and BNSF bridges, or may be feasible from existing railroad crossings that currently provide access to private parcels. In the long-term, a public bridge from the Pacific City Park may be desirable to provide enhanced access from that existing public facility where parking and other infrastructure is available. Such a connection would integrate public access facilities on both sides of the river.

There also is a proposal by a citizen group, the Friends of the Lower White River to develop the King County property into a Big Nature Park /Wetlands Mitigation Bank/Outdoor Recreation Area. The group envisions a 200 to 300+ acre “wicking” Park which encompasses the Sumner Meadows golf course and land to the north and south for floodplain restoration, storm water planning, habitat restoration, and tourist and residential recreation. (FLWR 2010)
Public access in ecologically sensitive areas involves tradeoffs between protecting those areas and providing for public access. In many cases in an urban context, open space areas cannot be effectively closed to informal public access. In many cases, the provision of formal public access trails, will direct the public to the least sensitive portions of the site and can reduce the impacts of a network of informal trails created randomly. In sensitive areas, signage and fencing can encourage use of trails and reduce off-trail use. Public access also can reduce informal adverse practices such as dumping and vegetation removal by providing public observation that discourages such use or provides information for enforcement and remediation (Sherrard 1996).

4.2.4 Infrastructure

The following three bridges span the White River within Pacific shoreline planning area:

- The A Street bridge in Reach A is a two-lane concrete bridge with a total span of about 350 feet between abutments with a middle support in the stream channel. Abutments are set back from the OHWM.
- The BNSF bridge in Reach A is a 175-foot-long steel bridge carrying two sets of rails with abutments located immediately adjacent to the OHWM.
- The Stewart Road bridge in the City of Sumner is a two-lane two-span concrete bridge that is slated for replacement as provided for in both Pacific and Sumner long-range transportation plans. An implementation date and funding source is uncertain.

There are also several roads that travel parallel to the river within the shoreline planning area, including:

- On the right (west) bank 3rd Avenue SE is within 100 feet of the shoreline east of City Park in Reach B and at the BNSF bridge in Reach A, but is generally 500 feet or further from the shoreline.
- On the right (west) bank in Reach B 3rd Place SE, a private road within the White River Park subdivision is within 100 feet of the shoreline for about 400 feet.
- On the right (west) bank in Reach D, White River Drive in the White River Estates subdivision is about 300 feet from the OHWM.
- On the right (west) bank in Reach E, Butte Ave. SE is about 300 feet from the OHWM at the closest.
- On the left (east) bank in Reach G, 142nd Ave E. in Sumner is about 400 to 500 feet from the OHWM.

Overall, street improvements are not a substantial component of shoreline alteration, except in Reach B.

4.2.5 Historic and Cultural Resources

4.2.5.1 Native-American History

The White River Valley served as an economic and cultural resource for a variety of Native American groups that harvested fish, game, and plant species in the area for generations. Puget Salish-speaking group resided in winter villages along the shores of various fresh and marine waters. Groups tended to share large cedar plank houses along the shorelines during the winter months. For the rest of the year, smaller clan-based groups would leave their winter houses to harvest salmon, dig clams, hunt wildlife, and gather plants.
In 1854 and 1855, the Treaty of Medicine Creek and the Treaty of Point Elliott with the United States provided for the relocation of Native Americans to various reservations while retaining the right to fish at all usual and accustomed grounds and stations and to hunt on all open and unclaimed lands. Several tribes are federally recognized as the present-day political successor to tribes and bands that utilized the White River Valley (Forsman 2001).

The City of Pacific Shoreline Master Program study area falls within the recognized usual and accustomed fishing grounds and stations of the Puyallup and Muckleshoot Tribes.

4.2.5.2 Euro-American History

Euro-American settlement of the Pacific area began in 1853. Settlement in the vicinity of the City was driven initially by timber harvest and subsequently by agriculture and urbanization. From the mid-1800s to World War II, agricultural and timber harvesting were the main uses in the Lower White River Valley. An 1897 USGS land classification map displays the major land uses near the present City as primarily timber rotations. Aerial photos from the 1930s indicate primarily agricultural uses. Flood control, including levees and the Mud Mountain Dam (MMD), encouraged urban development from the 1930s to the present.

The adjacent City of Auburn was established in 1891 and initially named Slaughter. It initially was a marketing center for the surrounding agricultural area. The Northern Pacific Railroad established a major repair yard and classification yard in 1914 which became a major employer until the 1970s. During World War II, the Federal Government developed a major warehouse facility in Auburn which set the precedent for extensive warehouse and industrial development in the Green and White River Valleys after completion of flood control measures in the late 1940s (Stein 2010).

The City of Pacific was developed by the real estate developer CD Hillman and incorporated in 1909. It has been a primarily residential area with a substantial industrial component of land use developed since the 1990s (McAbee 2003).

4.2.5.3 Registered and Inventoried Sites

The Washington State Department of Archaeology and Historic Preservation (DAHP) maintains a database system which catalogs sites that are registered with the Washington’s Historic Register (WHR) and the National Register of Historic Places (NRHP). The database also has sites inventoried by state archaeologists and cultural survey reports prepared during project-specific planning efforts. A search of the database indicated the following:

- There are no sites on the NRHP within the shoreline planning area.
- There are no sites designated by the state, King or Pierce Counties, or the Cities of Pacific or Sumner within the Pacific shoreline planning area.
- There are no inventoried archaeological sites.

4.2.5.4 Potential for Encountering Archaeological Resources

Several cultural resources investigations have been conducted for recent projects in the City. These reports note that areas along the White River have a high probability of encountering archaeological resources. There is also high probability along edges of contemporary river channels, old river channels, and streams within the Green River floodplain. Laura Murphy with the Muckleshoot Indian Tribe has indicated that the Tribe considers most of the City of Pacific to have a high probability for archaeological resources (Murphy 2010).
5. ECOLOGIC MANAGEMENT AND PROTECTION TOOLS

5.1 OVERVIEW
A wide range of options are available for management and protection of ecological functions in shorelines. The discussion below covers several topics, including:

- Designation, rating and classification systems
- Functional assessment options
- Classification based buffers
- No harm regulations

5.2 NO NET LOSS OF ECOLOGICAL FUNCTIONS
The Shoreline Management Act (SMA) provides a broad policy framework for protecting the natural resources and ecology of the shoreline environment. The statute addresses this in several places.

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... (RCW 90.58.020)

SMP Guidelines in WAC 173-26 establish the standard of —no net loss” of shoreline ecological functions as the means of implementing that framework through shoreline master programs. WAC 173-26-186(8) directs that master programs include policies and regulations designed to achieve no net loss of those ecological functions.” Simply stated, the no net loss standard is designed to halt the introduction of new impacts to shoreline ecological functions resulting from new development. Both protection and restoration are needed to achieve no net loss. Restoration activities also may result in improvements to shoreline ecological functions over time.

No net loss incorporates the following concepts:

- The existing condition of shoreline ecological functions should not deteriorate due to permitted development. The existing condition or baseline is documented in the shoreline inventory and characterization. (See Chapter 7.) Shoreline functions may improve through shoreline restoration.

- New adverse impacts to the shoreline environment that result from planned development should be avoided. When this is not possible, impacts should be minimized through mitigation sequencing.

- Mitigation for development projects alone cannot prevent all cumulative adverse impacts to the shoreline environment, so restoration is also needed.

An important element of the SMA is the protection and restoration of ecological functions necessary to sustain these natural resources. The Shoreline Guidelines contain specific direction to consider programs to enhance or restore impaired ecological functions.
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. (173-26-186(8)(c)).

5.3 DESIGNATION, RATING, AND CLASSIFICATION

There is no universally accepted method for classifying rivers, streams, and lakes or related habitat areas for regulatory purposes. In the State of Washington, there are a variety of classification systems used by different agencies based on specific regulatory needs. For example, Ecology classifies water types for the purposes of meeting water quality standards and employs a system that emphasizes the use of the water and the requirements of the Federal Clean Water Act, while the Department of Natural Resources (DNR) employs a system based on forest practices needs.

5.3.1 Washington DNR Stream Typing System

The DNR classification system was developed for forest practices and generally is based on the presence or absence of fish. The designation of shorelines of the state as a separate classification is based primarily on the statutory limitations on forest practices within shorelines of statewide significance in RCW 90.58.150, which allows only selective timber cutting. In general, the designation of streams over 20 cfs as a separate category may be relevant because of the wider range of processes provided in streams with higher flows, but the DNR designation is not based on the presence or absence of particular geomorphic processes or ecological functions.

5.3.2 Fish Species and Lifestage Stream Classification System

The specific biological and ecological functions provided by individual streams differ substantially. Therefore, one potential classification system classifies stream reaches according to the fish species and lifestages present within the reach. The presence of salmonids in various lifestages within a stream or river reach can indicate or infer information on the habitat quality and quantity of that specific reach. For example, if a headwater stream reach supports bull trout, it may indicate that riparian buffer conditions within that reach are relatively intact, and the buffers are of adequate size to provide for adequate moderation of water temperature and sediment filtration capability, because spawning bull trout require cool water and clean gravel. Likewise, a reach known to be occupied by spawning chum salmon can be assumed to be accessible to all other salmon species, because chum salmon are the least powerful swimmer of the salmon species.

This approach would use the WDFW PHS database to assign fish presence or lifestage information. The database covers streams in the Pacific UGA that have been identified as having anadromous species and classifies stream reaches as spawning, rearing, or migration habitat for each individual salmonid species. Other reaches of stream, where
site-specific information is lacking, could be classified based on current knowledge as presumed or historical habitat for a species with the option that more detailed analysis could be done at the project review stage to confirm or change the presumption.

The primary advantages of this system are in its biological and ecological relevance, coupled with a relatively complete, easily accessible database. However, there are several potential drawbacks to such a classification system. First, the link between fish presence and the quality or type of aquatic habitat is not complete. Dams, for example, can completely block anadromous fish access to high-quality, productive, instream habitat, which may not be occupied for these reasons. Second, the quality of fish presence/lifestage information is currently incomplete, and may be biased toward easily-accessed valley-bottom reaches as compared to more isolated headwater tributary reaches.

In Pacific, this option is not particularly valuable because most streams and lakes provide habitat for a variety of fish species; however, specific reaches vary greatly in the character of the stream and adjacent uplands and the ecological functions provided.

### 5.3.3 Aquatic Habitat Quality Based Classification System

A third type of classification system is based on ecological functions using known differences in habitat quality and limiting factors to classify streams. The relative quality and quantity of individual geophysical or habitat parameters have direct correlation to the ecological functions that a particular stream reach or subbasin provides. The presence of particular species in various life stages within a stream or river reach can indicate or imply information on the habitat quality and quantity of that specific reach. For example, if a headwater stream reach supports bull trout, it may indicate that riparian buffer conditions within that reach are relatively intact, and the buffers are of adequate size to provide for adequate moderation of water temperature and sediment filtration capability, because spawning bull trout require cool water and clean gravel. Likewise, a reach known to be occupied by spawning chum salmon can be assumed to be accessible to all other salmon species, because chum salmon are the least powerful swimmer of the salmon species.

This approach would rely on review of available reports on habitat conditions and limiting factors (e.g., LCFRB 2002) to assign a classification system based on the relative ecological condition of a stream reach or subbasin. The primary advantage of such a classification system is that ecological relevance is built into the system. However, several major disadvantages are also present. For example, detailed, high-quality information on habitat quality is not available for many stream and lake reaches within the Pacific UGA, and because different sources of information have used different methods for habitat evaluation. Available information, therefore, is not directly comparable. Furthermore, in many cases, this approach would require reliance on best professional judgment to combine information on multiple ecological functions in order to classify a particular stream or subbasin. Most likely, the approach would be most practical to apply at a larger spatial scale, such as the subbasin or subwatershed level, which could potentially negate the benefits by blending ecological function.

### 5.3.4 Functional Assessment Options

The current practice in assessing ecological functions provided by streams and other aquatic systems is to use a classification and rating system. Such systems focus on
identifiable features and use rating systems to characterize factors such as sensitivity, significance, rarity, functions, and opportunities for replacement.

While the use of the current WDFW/DNR stream rating system is understood as common practice, it presents limitations that an ecosystem perspective can remedy. The current rating system focuses on discrete identifiable features of streams that are roughly related to functions important to aquatic species.

An alternative approach is to focus on the variety of functions provided by the landscape. The rationale for focusing on functions rather than the stream classification is to shift emphasis from a discrete element of the ecosystem, such as a stream, to a system of indicators that are integrated with other aquatic resource and habitat evaluations. Further, the current methodology relies on discrete stream evaluations. The alternative functional analysis would utilize structural components rather than particular features, such as streams, as the basis for units within sites. This also allows for a broader view of stream values that provides opportunities for including other functions, such as flood management functions, and evaluating water supply functions such as seeps and springs that have an integral part in aquatic ecological functions.

This functional approach allows for a detailed understanding of the ecosystem services provided by a natural or impacted site. Quantitative values can be developed for existing conditions in a natural or altered state, and alternatives can be compared in both restoration and impact scenarios. These values, or scores, allow for a clearer understanding of tradeoffs under site selection, design, or mitigation analysis.

The analysis of specific stream reaches in this report provides a qualitative assessment of these factors. It is not converted into a rating or other system because that intermediate step is not necessary in an area as small as the city. The approach used in the Draft SMP Policies and Regulations is to use all the relevant information about each reach in developing regulations that specify the application of the SMA’s competing priorities for water dependent use, public access and preserving or enhancing ecological functions.

5.4 BUFFER OPTIONS

For protection of ecological functions in streams and lakes, wetlands and habitat areas, a relatively narrow range of options have been used in Washington State. Most of the regulations developed in Washington State have been related to GMA requirements to protect Critical Areas.

The predominant means of regulating uplands adjacent to water bodies and areas adjacent to wetlands and critical wildlife habitat has been through buffers. The SMA makes reference to buffers in RCW 90.58(2)(f)(ii) which allows inclusion of buffers for critical areas in SMP jurisdiction.

References to buffers in the Shoreline Master Program Guidelines (WAC 173-36) are numerous and include the following:

WAC 173-26-186(2)(c)(f)(i)(D) Buffers. Master programs shall contain requirements for buffer zones around wetlands. Buffer requirements shall be adequate to ensure that wetland functions are protected and maintained in the long term. Requirements for buffer zone widths and management shall take into account the ecological functions of the wetland, the characteristics and setting of the buffer, the potential impacts associated with the adjacent land use, and other relevant factors.
WAC 173-26-186(2)(b) Local governments may implement these objectives through a variety of measures, where consistent with Shoreline Management Act policy, including clearing and grading regulations, setback and buffer standards, critical area regulations, conditional use requirements for specific uses or areas, mitigation requirements, incentives and nonregulatory programs.

WAC 173-26-211(4)(f)(ii)(A) Standards for density or minimum frontage width, setbacks, lot coverage limitations, buffers, shoreline stabilization, vegetation conservation, critical area protection, and water quality shall be set to assure no net loss of shoreline ecological functions, taking into account the environmental limitations and sensitivity of the shoreline area, the level of infrastructure and services available, and other comprehensive planning considerations.

WAC 173-241(3)(j) Standards for density or minimum frontage width, setbacks, lot coverage limitations, buffers, shoreline stabilization, vegetation conservation, critical area protection, and water quality shall be set to assure no net loss of shoreline ecological functions, taking into account the environmental limitations and sensitivity of the shoreline area, the level of infrastructure and services available, and other comprehensive planning considerations.

A wide range of buffer widths have been analyzed for a variety of functions. Variation in recommendations or buffer effectiveness is frequently due to variation in site conditions such as side-slope angle, stream type, geology, climate, etc. Design of riparian buffers must consider the ecological, cultural, and economic values of the resource, land-use characteristics, and existing riparian quality throughout watersheds in order to address the cumulative impacts on stream functions and the resources being protected (Johnson and Ryba 1992; Castelle et al. 1994; Wenger 1999).

Appropriate buffer sizes will depend on the area necessary to maintain the desired riparian or stream functions for the given suite of land-use activities. A wider buffer may be desired to protect streams from impacts resulting from high-intensity land use while narrower buffers may suffice in areas of low-intensity land use (May 2000). It should be noted though that opportunities for protection or improvement of buffer conditions in areas of high-intensity land use are often effectively foreclosed by existing development, or the existing habitat conditions are already highly altered. Under such conditions, establishing buffers wide enough to provide an effective full-range of riparian functions is likely unattainable; other actions may be required to improve habitat conditions beyond what riparian buffers are able to provide. In addition, buffer vegetation type, diversity, condition, and maturity are equally as important as buffer width, and the best approach to providing high-quality buffers is to strive for establishing and maintaining mature native vegetation communities (May 2000).

Potential riparian, lake, wetland, and habitat buffer frameworks include the following types, which are discussed in greater detail below:

1. **Standard Single-Zone Buffers** – Fixed-distance stream buffers based on the maintenance of individual aquatic functions. The buffer widths may be further divided by land use (e.g., urban versus rural) or by other variables.

2. **Dual-Zone Buffers** – This approach employs two smaller adjacent buffer zones, which, when combined, make up the overall riparian buffer. An inner ‘core’ zone, directly adjacent to the aquatic feature, consisting of an area where uses are prohibited or severely restricted, and an outer riparian zone, adjacent to the core zone, where uses are still restricted, but to a lesser degree.
3. **Reach Based Buffers** – This approach is most relevant to streams and lakes that have been altered by human use. The approach focuses on "no net loss" of existing functions as they currently exist.

All of the above approaches could potentially incorporate buffer averaging techniques, in cases where the overall buffer area will be equal to un-averaged conditions, and it can be clearly demonstrated that averaging will result in no net loss of aquatic functions.

### 5.4.1 Standard Single-Zone Stream Buffers

Single-zone buffers are the most common type of riparian buffer, with a designated minimum buffer for each class or type of stream/habitat as defined by the applicable stream classification scheme.

The advantages of single-zone stream buffers are that they:

- Are the most common buffer type and have had extensive best available science (BAS) and legal review;
- Are relatively simple to understand from a public standpoint and lend themselves to straightforward and efficient administrative processing; and
- Allow for buffer averaging.

One disadvantage of such a system is that riparian buffers are not uniform in the functions they provide relative to the width of the buffer, as discussed further below.

Table 5-1 was developed by Parametrix scientists and summarizes this information in relation to the specific aquatic functions that are of greatest importance in maintaining conditions suitable to support fish and other aquatic life (e.g., LWD recruitment, stream temperature, sediment filtration). For each buffer width, the suitability of the buffer is rated by its ability to maintain these aquatic functions. Although this evaluation is qualitative, it is firmly based on BAS regarding ecological functions (see Section 1.5 for more detail).

These results are generally valid for relatively level or gently sloping sites. On steeply sloping sites, greater dimensions are appropriate for sediment and nutrient removal.

An example of a buffer recommendation based on a choice of a critical factor is the recommendation by Pollack and Kennard (1998) of a minimum buffer width of 250 feet on all perennial streams based on LWD recruitment and the height at maturity of trees in Pacific Northwest forests. These buffer widths would reasonably provide for a full range of riparian functions, and therefore, not contribute significantly to the loss of salmonid habitat. May (2000) and other extensive reviews provide detailed summaries of buffer width sizes necessary to achieve stream and riparian functions (FEMAT 1993; Knutson and Naef 1997).
Table 5-1. Comparison of Functions of Stream Buffer Widths

<table>
<thead>
<tr>
<th>Stream Function</th>
<th>15 Feet</th>
<th>50 Feet</th>
<th>150 Feet</th>
<th>300 Feet</th>
<th>600 Feet</th>
</tr>
</thead>
<tbody>
<tr>
<td>Microclimate</td>
<td>X</td>
<td>X</td>
<td>N</td>
<td>P</td>
<td>F</td>
</tr>
<tr>
<td>Wildlife Habitat</td>
<td>X</td>
<td>N</td>
<td>P</td>
<td>P</td>
<td>F</td>
</tr>
<tr>
<td>LWD Recruitment</td>
<td>X</td>
<td>N</td>
<td>P</td>
<td>F</td>
<td>F</td>
</tr>
<tr>
<td>Pollutant Removal</td>
<td>N</td>
<td>N</td>
<td>P</td>
<td>P</td>
<td>F</td>
</tr>
<tr>
<td>Sediment Filtration</td>
<td>X</td>
<td>N</td>
<td>P</td>
<td>F</td>
<td>F</td>
</tr>
<tr>
<td>Water Temperature</td>
<td>X</td>
<td>P</td>
<td>F</td>
<td>F</td>
<td>F</td>
</tr>
<tr>
<td>Organic Litter</td>
<td>X</td>
<td>F</td>
<td>F</td>
<td>F</td>
<td>F</td>
</tr>
<tr>
<td>Bank Stability</td>
<td>X</td>
<td>F</td>
<td>F</td>
<td>F</td>
<td>F</td>
</tr>
</tbody>
</table>

KEY
- F = Buffer width fully supports/maintains stream function.
- P = Buffer width partially supports/maintains stream function.
- N = Buffer width nominally supports/maintains stream function.
- X = Buffer does not adequately support/maintain stream function.

As mentioned above, the disadvantage of uniform buffers is that a single buffer is designed to provide multiple functions. Depending on the stream and the adjacent use, some functions may continue to be provided on adjacent land outside of the buffer with appropriate management practices. For example, the riparian functions of bank stability and litter fall are primarily provided for within a relatively short distance of a waterbody (10 to 50 feet). Also, along highly managed streams such as in agricultural, residential, or commercial areas, some functions normally provided (at least in part) by riparian buffers, such as flow attenuation or filtration of pollutants, can be provided by application of appropriate best management practices in combination with smaller buffers. In addition, uniform buffers do not take into consideration the extent to which different vegetation communities in different parts of the buffer contribute to specific riparian functions. For example, impacts to the outer 25 feet of a 100-foot-wide buffer would likely have much less impact to bank stability and litter fall functions than would identically scaled impacts directly adjacent to the stream.

In an urban setting, the range of activities adjacent to a resource may affect the size or character of a buffer. Degradation of wildlife by domestic animals is difficult to address by buffer size, no matter how extensive. Buffers also may become habitat for feral domestic animals. In such a case, controls on domestic animals, such as fencing, may be needed in addition to buffers.

Buffer enhancement, particularly at the margins, protection from invasive species and other vegetation management is critical for effective buffers in areas dominated by human influence.

5.4.2 Dual-Zone Stream Buffers

This approach, commonly used in forestry applications, is similar to the single-zone stream buffer (see above). However, the overall stream buffer is composed of two smaller adjacent buffer zones, which when combined make up the overall riparian buffer. The two zones are:

- An inner 'core' buffer zone, located directly adjacent to the aquatic feature. In this area land uses are prohibited or severely restricted.
- An outer riparian zone, landward and adjacent to the core zone, where land uses are still restricted, but to a lesser degree than within the core area.

Dual-zone buffers are not as common as single-zone buffers and are more complex from a public understanding and City administrative standpoint, although buffer averaging could still occur within the outer riparian zone.

The primary advantage of this type of buffer system is that the dual-zone system recognizes that riparian buffers are not uniform in the functions they provide relative to the width of the buffer. For example, for a relatively small stream that supports salmonid rearing and has a mixed forest riparian buffer, a continuous buffer width of 75 to 100 feet may be adequate to support the aquatic functions of LWD recruitment, temperature regulation, and the provision of detritus and nutrients to the stream. The segment of the buffer from 100 to 150 feet still supports important ecological functions such as pollutant filtration and microclimate regulation, but in this outer area a solid homogeneous buffer may not be required to support these functions to a high degree. In summary, as compared to a single-zone buffer, a dual-zone buffer may allow for different impact types within different parts of the buffer.

Examples of specific ecologically relevant provisions that could be applied to the outer buffer zone include:

- A limit to the amount of clearing allowed within the outer buffer zone.
- A minimum amount of forest required to be retained within the outer buffer zone.
- A limit to the amount of impervious surface allowed within the outer buffer zone.
- A limit to the development density allowed within the outer buffer zone.

In this system, the overall buffer width for the combined dual-zone buffers would be wider than for the single-zone buffer, because more uses are allowed within the outer portion of the dual-zone buffer. This approach has the advantage that it is adaptable to a wide range of land use activities, and gives the applicant choice on which approach is best suited to their particular situation, while still maintaining equal levels of aquatic habitat functions for the overall system. A disadvantage of the system is that it may be more difficult to administer, as compared to a single-zone buffer approach.

Dual zone systems are implicitly recognized in the 211(4)(c)(ii) in reference to ‘parallel environments’ that divide shorelands into different sections generally running parallel to the shoreline or along a physical feature such as a bluff or railroad right of way. Such environments may be useful, for example, to accommodate resource protection near the shoreline and existing development further from the shoreline.

### 5.4.3 Reach Based Stream Buffers

An additional approach to stream buffers that combines some of the advantages of both the classification-based buffer system and a ‘no harm’ approach is applying specific buffers for specific reaches based on assessment of the functions currently being provided by those reaches. This approach is particularly applicable to streams in areas of existing high-intensity land use where parcels are small and few remain undeveloped, and there is little practical opportunity to achieve buffers that will provide the full range of desired riparian functions.
In this case, the objective of the management approach is to preserve the existing functions and to improve, if possible, a limited range of functions such as improving temperature and water quality. Improving temperature through providing effective overhead shade can be achieved to varying degrees with intensive management of smaller buffers. Water quality improvements can be achieved by stormwater management and control of fertilizer and other chemical applications near streams.

5.5 ‘NO HARM’ REGULATORY SYSTEM

This type of regulatory system is best known in Washington State in its application to agricultural use in Skagit County. The approach was endorsed in challenges heard by the Growth Management Hearings Board for Western Washington and the Washington State Supreme Court (Swinomish v Skagit 2006). The ‘no harm’ approach may be regarded as an ‘adaptive management’ approach to protecting critical areas.

The most succinct overview of a no-harm system is provided in a Growth Management Hearings Board decision. Although not directly related to SMPs developed under RCW 90.58, the rationale can be considered applicable.

After careful consideration of all the arguments, and the entire record, we are no longer convinced that the Act requires the County to mandate that regulation of critical areas provide for all the functions in every watercourse that contains or contributes to watercourses that contain anadromous fish in ongoing commercially significant agricultural lands where some of those functions have been missing for many years and where these functions are not required for a particular life stage of anadromous fish. By reaching the above conclusion, we are not saying that farmers do not need to alter their practices if they are continuing activities which will further degrade the streams. Those activities must stop and practices must be implemented which ensure no additional harm or further loss of function (Swinomish Indian Tribal Community et al. v. Skagit County; 02-2-0012c).

Essential elements for such a program are adequate monitoring, benchmarks, and the ability to require changes to the program if benchmarks are not achieved. In assessing the difference between a prescriptive approach such as buffers and a ‘no harm’ approach, both the hearings board and the court have held that local governments must either be certain that their critical areas regulations will prevent harm, or be prepared to recognize and respond effectively to any unforeseen harm that arises.

Implementation of a ‘no harm’ approach in Pacific is not likely to be effective in regulating future development. Application to urban development is substantially different than application to agriculture where changes in farming practices may be developed. It would be difficult to meet a ‘no harm’ standard if monitoring of a specific buffer area determined that a functional criterion was not being met. If, for example, a particular buffer dimension was not effective, the presence of physical improvements such as roads or buildings would generally preclude its expansion. In addition, developing performance standards, implementing a monitoring system, and taking action to correct deficiencies would be very resource demanding both for property owners and the city. To be practical, additional areas would likely need to be reserved from development or land alteration to provide the opportunity for future change as well as requiring substantial security deposits for monitoring and reporting and corrective measures.
A _no harm_ system also is likely to be much more difficult and expensive to implement, especially the monitoring component, and provides little certainty to applicants of the standards likely to be imposed on their development. It also introduces an element of uncertainty to land owners in the continued use of facilities initially allowed, but subject to adaptive management requirements.
6. FUNCTIONAL ANALYSIS AND OPPORTUNITY AREAS

6.1 OPPORTUNITY STRATEGY

Watershed-scale processes that have been altered by land-use degrade ecological function in shorelines. This section summarizes the conditions within each shoreline and assesses the potential for restoring ecosystem processes and improving shoreline ecological function (see Table 5-1).

An important element of the SMA is the protection and restoration of ecological functions necessary to sustain these natural resources. The Shoreline Guidelines contain specific direction to consider programs to enhance or restore impaired ecological functions.

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. (173-26-186(8)(c)).

The City lies very low in the White River watershed and is well downstream of the tributaries that provide most of the flows. Extensive development generally limits the potential for the City to implement projects in areas currently developed.

Options to enhance ecological function within the shoreline within the City include the following opportunities:

- Pursue restoration opportunities as part of flood control projects, largely on the left (east) bank of the river
- Pursue levee setbacks and smaller scale restoration opportunities on the right (west) bank south of City Park.
- Partner with others in WRJA 10 to implement salmon recovery actions that are outside the city if future development should produce impacts not readily mitigateable on site or in the city.
- Make minor improvements to riparian areas at the very few properties likely to redevelop.

Generally, restoration actions should be prioritized where multiple processes can be enhanced. Floodplain areas in large river systems are a high priority because they are important areas for all processes, including water movement, materials storage, and shoreline-scale processes such as LWD recruitment and temperature regulation. Restoring wetlands in floodplains augments the potential effect of restoration.

Riparian and floodplain areas in tributaries are also priority areas, particularly where geologic deposits augment process function. Failing restoration and protection of these
areas, enhancement of single processes that may be limiting ecological function becomes the priority.

Table 6-1 provides a summary of the ecological processes and physical functions that provide the basis for identifying opportunities for ecological restoration. Table 6-2 provides a summary of these opportunities as they apply at the watershed and at the reach-level within the City of Pacific.

6.2 GEOGRAPHIC OPPORTUNITIES

The following sections describe specific conditions and opportunities within each shoreline reach. These are further categorized in Table 6-2 as they apply to specific ecological functions at both the watershed and at the reach-level within the City of Pacific.

**Reach A:** This short right (west) bank reach upriver from the A Street and BNSF bridges has little potential for substantial increase in ecological functions, unless in conjunction with upstream revisions to the revetment adjacent to the upstream mobile home park. The location where the river is narrowed by the BNSF bridge also limits the potential for affecting aquatic habitat. Provision of buffers and restoration of native vegetation in the buffer area is likely the most realistic potential for enhancing riparian functions.

**Reach B:** This right (west) bank reach downriver from BNSF bridges has limited potential for substantial increase in ecological functions due to the existing sloping concrete revetment owned and maintained by KCFCZD. It is not practical to add vegetation plantings to such a structure. The likely most ecologically productive and cost effective means of encouraging formation of natural riparian vegetation communities is through encouraging natural deposition on the water side of the revetment. This would become practical with the levee setback on the opposite side of the river in Reach F as indicated in Figure 3-7. With the levee setback, the river may naturally meander in that direction, allowing for formation of gravel bars and gradually reestablishing a margin of vegetation below the flood control revetment. It also may be beneficial to construct a point diversion structure on the right bank to encourage meandering of the river to the opposite bank. Such structural options and the potential for enhancing riparian functions on the right bank should accompany the levee setback proposal on the left bank.

**Reach C:** This right (west) bank reach along the Pacific City Park has similar limitations because of the concrete abutment along about half of its frontage. The natural processes of accretion has produced a small gravel bar and native vegetation below the revetment in the southerly portion of the reach. Measures to encourage aggradation on this bank should be pursued in conjunction with Reach B.

**Reach D:** The major ecological enhancement for this reach would be set-back of the current levee at the OHWM to allow more natural stream conditions to form natural channel features such as subsidiary channels, sloughs, and ponds that provide important spawning habitat, rearing habitat, and refuge during high flows and also provide more effective connections between wetlands and the river. The potential for levee setback is more practical in the undeveloped area of about 900 linear feet in the upstream portion of the reach. The area adjacent to the White River Estates subdivision of about 600 linear feet provides less potential due to the existing adjacent residential use. It is also likely that the levee setback on the
opposite side of the river in Reach F would allow formation of gravel bars and gradually reestablishing a wider margin of vegetation along the river. In this reach it also may be beneficial to construct point diversion structures to encourage meandering of the river to the opposite bank.

**Reach E:** The right (west) bank downstream of the White River Estates subdivision owned by Pierce County is relatively unconstrained with human structures. Maintaining the natural character of the land and natural functions will likely maintain existing functions. Enhancement of vegetation to provide a greater proportion of native conifers may be valuable in providing complexity to wildlife communities. Any flood control structures that may be constructed should be located in the far westerly portions of the parcel to minimize interference with natural riverine functions.

**Reach F:** The left (east) bank downstream of the BNSF bridge and extending about 4,000 feet to the King/Pierce County Line is programmed for a levee setback project indicated in Figure 3-7. In addition to meeting flood control goals, the levee setback and removal of the existing levee would to allow reconnection of natural channel features currently isolated by the existing levee including subsidiary channels and sloughs and would reconnnect existing wetlands to the river. This project would enhance spawning habitat, rearing habitat, and refuge during high flows and provide for greater interflow from wetlands and other features to augment low flows.

**Reach G:** The left (east) bank downstream of the King/Pierce County Line and extending about 3,000 feet to Stewart Road is part of the joint King/Pierce County levee setback project which would affect the upstream portion of this reach with the same benefits outlined for Reach F above. The existing industrial parcels in the lower portion of the reach have the potential to enhance the narrow riparian corridor in this portion of the reach through providing buffer areas to augment the buffers on public land.

As described above, the key opportunities for enhancing ecological conditions on the White River in the City of Pacific involve removal of existing restrictions from levees and revetments, where established land uses allow. This will provide opportunities for restoration of natural channel dynamics in those areas. The widened corridor also provides opportunities for natural deposition processes to improve riparian conditions where existing development and flood control structures limit opportunities.

The WRIA 10 Chinook Recovery Plan identified the following projects in the White River basin in the 2009 Work Program.

**Floodplain reconnection, levee setback, and riparian habitat improvements**

- White River land acquisition – protection (Tier 1 parcels from —Ecological Preservation Priorities in White River Sub-Basin”)
- TransCanada setback levee (White River – RM 8.4-8.8)
- White River Corridor projects in Pacific (Phase 1 – Abernethy, and Phase 2-setback berm)
- 24th Street pointbar setback levee (White River – RM 3.2-3.6)
- White River Restoration Assessment
Sediment load, LWD and riparian condition in Upper Whit River tributaries
- Upper White – Greenwater/Huckleberry Creek – road decommission
- White River Watershed Stewardship Program

Programmatic habitat restoration and protection Activities

Shoreline Program updates
- Greenwater LWD study
- Update regional Culvert Study
- Develop nearshore projects
<table>
<thead>
<tr>
<th>Process</th>
<th>Major Alterations</th>
<th>Physical Functions</th>
<th>Biological Functions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hydrology: Surface Runoff</td>
<td>Forest cover loss; impervious surfaces, channelization and hydromodification</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hydrology: Storage</td>
<td>Wetland and floodplain loss</td>
<td>•</td>
<td></td>
</tr>
<tr>
<td>Hydrology: Recharge</td>
<td>Forest cover loss; impervious surfaces</td>
<td>•</td>
<td></td>
</tr>
<tr>
<td>Hydrology: Groundwater Movement</td>
<td>Wetland and floodplain loss, artificial drainage features, roads/embankments, withdrawals</td>
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<td>•</td>
</tr>
<tr>
<td>Sediment Input and Storage</td>
<td>Disturbed areas, channel instability (peak flows), wetland and floodplain loss, channelization, hydromodification</td>
<td>•</td>
<td>•</td>
</tr>
<tr>
<td>Water Quality Input and Storage</td>
<td></td>
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<td></td>
</tr>
</tbody>
</table>

Table 6-1. Influence of Watershed-scale Processes on Shoreline Ecological Function
<table>
<thead>
<tr>
<th>Process</th>
<th>Major Alterations</th>
<th>Physical Functions</th>
<th>Biological Functions</th>
</tr>
</thead>
<tbody>
<tr>
<td>WQ: Inputs and Storage</td>
<td>All land-use types; wetland and floodplain loss, riparian disturbance</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Temperature</td>
<td>Baseflow alteration, riparian disturbance</td>
<td></td>
<td></td>
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<tr>
<td>Riparian/Organic Matter</td>
<td>Riparian disturbance, channel dredging and hydromodification</td>
<td></td>
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<tr>
<td>Biotic Interactions</td>
<td>Invasive species introduction; physical habitat alteration</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Key Landscape Process</td>
<td>Physical or Biological Function</td>
<td>Sources of Human Disturbance</td>
<td>Current Status</td>
</tr>
<tr>
<td>----------------------</td>
<td>---------------------------------</td>
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</tr>
<tr>
<td>Hydrology</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Surface runoff and peak flow</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Groundwater flow</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Shallow aquifers</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Watershed Level:</td>
<td>Base Flow: The greatest component of flow is from the portion of the river upstream of Mud Mountain Dam.</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Peak Flow: The watershed size affects the structure and pattern of tributary discharge to the system. Larger systems with a greater geographical coverage tend to have tributaries that are affected differentially by precipitation patterns. The effect of single storm events on the system depends on the geographic extent of weather patterns. The greatest component of peak flow is from the portion of the river upstream of Mud Mountain Dam and results from snowmelt, particularly rain-on-snow events.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Groundwater/Interflow</td>
<td>Streamflow also consists of interflow, which is shallow subsurface flow from precipitation that infiltrates into the soil surface and travels by means of gravity toward a stream channel. Interflow is often a substantial component of base flows in low-precipitation periods.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Reach Level:</td>
<td>The portion of the White River in Pacific has relatively little hydrologic input compared to the watershed as a whole. Most flows are from drainage from urban development outside SMP jurisdiction. Small stream headwaters remaining within Pacific are protected by vegetated buffers in CAO to the extent that they were not previously displaced or headwaters placed in piped stormwater systems.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Watershed Level:</td>
<td>Peak Flow: The White river hydrology is modified by diversion of a substantial portion of its flow for domestic water supply. Land use in the upper watershed is highly altered with forestry, agricultural and rural use. Urban development is not present along the main-stem of the river but has altered most of the lower watershed and affects tributaries that provide substantial flows and has altered peak flow levels and duration for tributaries.</td>
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<td>Groundwater/Interflow Development leads to increased impervious surfaces, which increases surface runoff and decreases infiltration and interflow. Decreased interflow may reduce the natural base flow of smaller stream systems. Resourced and rural areas outside the UGA have the greatest influence on these factors.</td>
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<td>Reach Level:</td>
<td>Interflow is an important component of low summer flows and especially important for maintaining temperature suitable for aquatic habitat.</td>
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<td>Watershed Level:</td>
<td>Remaining vegetation adjacent to streams is protected by King County and other upstream jurisdiction CAOs that require maintaining existing buffering vegetation based on stream classification. The loss of native vegetation from the area outside buffers generally will result in a substantial change in runoff character.</td>
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<td>Reach Level:</td>
<td>The portion of the White River in Pacific has relatively little hydrologic input compared to the watershed as a whole. Most flows are from drainage from urban development outside SMP jurisdiction. Small stream headwaters remaining within Pacific are protected by vegetated buffers in CAO to the extent that they were not previously displaced or headwaters placed in piped stormwater systems.</td>
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<td>Opportunities are relatively small for actions related to the Pacific SMP since upstream influences in the watershed as a whole are of much greater importance.</td>
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<tr>
<td>Key Landscape Process</td>
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<td><strong>Water Quality</strong></td>
<td>High water quality is required for most biological functions. Water and sediment processes provide a vehicle for dissolved and adsorbed materials. These mechanisms for delivery do not result in background levels that degrade ecological structure and function in the study area, although aluminum may naturally occur at relatively elevated levels. Adsorbed compounds, including phosphorus, nitrogen, and toxins, can be deposited and potentially removed via biotic uptake in areas of deposition. Wetlands with mineral soils are important areas where dissolved phosphorus can undergo adsorption and storage. Tewin storage and biotic uptake is facilitated by wetlands with clay or organic soils. Nitrogen cycling and storage is fomented by small streams, where alders have a great capacity for nitrogen uptake in hydric zones. Nitrogen cycling is also augmented by wetlands with non-organic soils (denitrification) and pH-neutral or alkaline soils.</td>
<td>Pervious surfaces such as lawns and pastures can be an unnatural source of nutrients and other pollutants that can degrade water quality in streams and wetlands. Impervious surfaces related to roadways, driveways and parking areas tend to produce pollution loading of chemicals, heavy metals, and particulates from sources related to vehicular use. Roadways and driveways generally increase with single family density. Multifamily driveways and parking area is determined more by development type, especially provision of garages rather than surface parking. Nutrients result from a variety of sources, including fertilizers, herbicides, and pesticides used in agriculture or landscaping; and discharge from on-site sewage treatment or leakage from sewer lines. Chemical contaminants result from a variety of sources, including fertilizers, herbicides, and pesticides used in agriculture or landscaping; and discharge from on-site sewage treatment or leakage from sewer lines.</td>
<td>Watershed Level: Throughout the watersheds land alteration is pervasive, most of which are associated with a variety of applications of substances on the land. Roadways and driveways generally increase with single family density. Multifamily driveways and parking area is determined more by development type, especially provision of garages rather than surface parking.</td>
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<tr>
<td><strong>Stream Geomorphology</strong></td>
<td>Stream width and depth is a function of flow magnitude, size and type of transported sediment, and the bed and bank materials. Channel width tends to increase downstream. The width/depth ratio varies with channel slope, bank erodability, degree of entrenchment, and velocity (Rogerson 1996).</td>
<td>Width and depth ratios can be changed through channelization, loss of riparian vegetation, flood control structures and other alteration and may result in increases in flood frequency and magnitude.</td>
<td>Watershed Level: In the overall watershed, widespread changes in stream structure have resulted in stream channel alteration. Stormwater management standards for new development affect less altered streams in less developed areas but have limited effect on previously developed areas.</td>
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<tr>
<td><strong>Aquatic Habitat</strong></td>
<td>The stream bottom substratum is critical habitat for salmonid egg incubation and embryo development, as well as being habitat for benthic macroinvertebrates. Streambed quality can be degraded by deposition of fine sediment, by streambed instability due to high flows, or both. Although the redistribution of streambed particles is a natural process in gravel-bed streams, excessive scour and degradation often result from excessive flows. Salmon rear primarily in pools with high habitat complexity, with abundant cover, and where large woody debris (LWD) is the main structural component (Bisson et al. 1988). Some species of salmon rely heavily on small lowland streams and associated off-channel wetland areas during their rearing phase (Bisson et al. 1988).</td>
<td>Stream channel morphology can be affected by shifts in the hydraulic regime due to increases in impervious surfaces, which changes the amount and patterns of runoff and streamflows. Higher flows generally lead to changes in channel character, higher stream erosion rates, increases in sedimentation, and disconnections from the floodplain with resulting loss of flood storage. In general, these changes compound each other in an urban environment. Increased scour and erosion are particularly relevant to substrate.</td>
<td>Watershed Level: In the overall watershed, widespread changes in stream structure have resulted in stream substrate alteration. Reach Level: White River reaches throughout the city are substantially altered by existing flood control facilities. Spawning and rearing habitat is limited by geomorphic conditions created by narrowing the channel by flood control facilities. The river serves primarily as a migration route.</td>
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Aquatic Habitat: In-stream LWD
LWD performs several critical functions in forested
lowland streams, including dissipation of flow energy,
protection of streambanks, stabilization of
streambeds, storage of sediment, and providing in-
stream cover and habitat diversity (Bisson et al. 1987;
Salmon rear primarily in pools with high habitat
complexity, with abundant cover, and where large
woody debris (LWD) is the main structural component
(Bisson et al. 1988). Some species of salmon rely
heavily on small lowland streams and associated off-
channel wetland areas during their rearing phase
(Bisson et al. 1998). Cutthroat and salmon are
sympatric in many small streams in the Pacific
Northwest, and as such, are potential competitors
(adult cutthroat also prey on juvenile coho). In
general, habitat, rather than food, is the limiting
resource for most salmonids in the Pacific
Northwest region (Groot and Margolis 1991).

Aquatic Habitat: Off-channel habitat
Salmon rely heavily on small lowland streams and
associated off-channel wetland areas during their
rearing phase (Bisson et al. 1988). Off-channel
habitats (such as sloughs, beaver ponds, wetlands,
and other permanently or seasonally flooded lands)
are important rearing areas for juvenile salmonids.

Aquatic Habitat: Adjacent Upland Vegetation
Tree cover helps maintain cool water temperatures
through provision of shade and creation of a cool and
humid microclimate over the stream.
Organic matter is important to the ecosystem in the
form of leaves, branches, and terrestrial insects and is
an important element of the food chain in streams and
nearshore habitat in lakes.

Physical or Biological Function
Clearing for pasture, crops, or lawn removes woody
vegetation recruitment.
Immature forest lacks the potential for mature trees to
fall and provide woody vegetation recruitment.
Channel clearing and channelization removes LWD
Human development with resulting changes in the
hydrologic regime can lead to stream channelization,
dredging, and degradation of the riparian zone,
resulting in loss of pool frequency and quality.
Reduction of riparian cover can lead to a loss of LWD
recruitment, resulting in a degradation of pool habitat.

Sources of Human Disturbance

Current Status
Watershed: The area and maturity of trees adjacent to the water
above Mud Mountain Dam is controlled primarily by forest practices
on National Forest and industrial forest lands. South of the dam, the
large areas of riparian buffer have been cleared for pasture or urban
use. Flood control facilities also have isolated the river from LWD
recruitment and affected stream morphology.
Reach Level: At White River Reaches are substantially isolated from
the river by flood control facilities.

Opportunities to Protect or Restore Processes and Function
Watershed Level: Pacific SMP has little influence because of
location within the watershed and small area affected.
Reach Level Opportunities: on aquatic habitat related to LWD
recruitment are provided by KCFCDI levee setback projects in
reaches D, E and F would to allow reconnection of subsidiary
channels and sloughs and would allow LWD recruitment and likely
would improve opportunities for spawning and rearing.

Watershed Level: Pacific SMP has limited influence on
off-channel habitat effect on the system as a whole because of location within the
watershed and small area affected.
Reach Level Opportunities: on aquatic habitat are provided by
KCFCDI levee setback projects in Reach F that would allow
reconnection of subsidiary channels and sloughs and likely would
improve opportunities for spawning and rearing.

Watershed Level: Pacific SMP has limited influence on upland
vegetation effect on habitat on the system as a whole because of
location within the watershed and small area affected.
Reach Level Opportunities: on aquatic habitat related to riparian
vegetation are provided by KCFCDI levee setback projects in
reaches D, E and F would to allow substantial areas of vegetation to
provide functions in relation to the river.
<table>
<thead>
<tr>
<th>Key Landscape Process</th>
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<tr>
<td><strong>Terrestrial Habitat</strong></td>
<td>Area, width and longitudinal continuity are all important to wildlife productivity. Continuity along corridors links a variety of upland areas, links different types of riparian vegetation communities, and provides for movement to respond to local disruptions in productivity due to flooding, fire, local predation pressure, and human disturbance. A nearly continuous riparian zone is the typical natural condition in the Pacific Northwest (Naiman 1992).</td>
<td>The riparian corridor in urban watersheds can become fragmented from a variety of human influences; the most common and potentially damaging is the enclosing of streams in paved conveyance systems that remove most ecological functions from the areas enclosed. Ditching and canalization are nearly as damaging. Road crossings can be similarly disruptive, depending on the character and frequency of crossings.</td>
<td>Watershed: the loss of riparian buffers adjacent to the water is as the result of human alteration occurs throughout the watershed. The main stem of the White River provides variable opportunities for continuous animal movement along areas that have continuous native vegetation. This is especially the case for areas in public ownership. Most private land does not provide continuous buffers that would facilitate animal movement. The stream miles in tributaries outside of SMA jurisdiction provides the vast majority of potential habitat. Remaining vegetation adjacent to streams is protected by King and Pierce Counties and other upstream jurisdiction CAOs that require maintaining existing buffering vegetation based on stream classification. The loss of native vegetation from the area outside buffers generally result in a substantial loss of habitat.</td>
<td>Watershed Level: Pacific SMP has limited influence on terrestrial habitat within the system as a whole because of location within the watershed and small area affected. Reach Level: Vegetation providing habitat is addressed by SMP 4-3-090. E.4. Environmental Effects No Net Loss of Ecological Functions that establishes a review process for new development, 4-3-090.G. Vegetation Conservation includes the major provisions addressing riparian buffers. Reach Level Opportunities on terrestrial habitat related to riparian vegetation are provided by KCFCDZ levee setback projects in reaches D, E and F would to retain substantial areas of vegetation as well as provide additional functions in relation to the river. The relative change in habitat function would change little.</td>
</tr>
<tr>
<td><strong>Wetlands Water quality</strong></td>
<td>Pollutants that are in the form of particulates (e.g., sediment, or phosphorus that is bound to sediment) will be retained in a wetland with greater detention time. Wetlands with no outlet are the most effective in this, followed by wetlands with an outlet that flows only seasonally, followed by wetlands with year-round outlet but with longer times that water is retained and sediment can settle (Adanson et al. 1991). Plants enhance sedimentation by acting like a filter and causing sediment particles to drop to the wetland surface (Adanson et al. 1991). The uptake of dissolved phosphorus and toxic compounds through adsorption to soil particles is highest when soils are high in clay or organic content (Mitsch and Gosselink 1993). Removal of nitrogen from the aquatic system (denitrification) is done by bacteria that live only in the absence of oxygen (Mitsch and Gosselink 1993). The highest levels of nitrogen transformation occur in areas of the wetland that undergo a cyclic change between oxic (oxygen present) and anoxic (oxygen absent) conditions. (Mitsch and Gosselink 1993).</td>
<td>Wetland function can be reduced through direct displacement and through off-site factors that reduce function. Urban development and agriculture can increase the amount of sediments entering the wetland and adjacent stream systems and affect the soil substrates and affect the type of vegetation by changing the conditions under which different plants compete with one another. Loss of function can occur through displacements and through change in runoffs patterns or the type and amount of pollutants that enter a system. Degradation can occur due to changes in the hydrologic conditions maintaining soil type or to a pollutant load that is greater than the capacity of the system to process nutrients. Development and increases in impervious surfaces may lead to changes in hydrologic regime that change the patterns of seasonal ponding to either year-round ponding, deeper ponding, or ponding of a different duration. This can change the balance of functions provided.</td>
<td>Watershed Level: In the overall watershed, widespread changes in stream structure have resulted in loss of wetland function. Reach Level: White River Reaches A, B and C are substantially altered and provided no associated wetlands. Reaches D, E, F and G provide wetlands that provide limited localized functions because they are largely isolated from the river. The exception is created wetlands in Reach E that are connected to the river.</td>
<td>Watershed Level: Pacific SMP has limited influence on wetland water quality function habitat because of the relatively small portion of the potential for wetland presence within SMA jurisdiction. Reach Level Opportunities for improved wetlands function will be provided by KCFCDZ levee setback projects that would to allow reconnection of existing wetlands to the river in reaches D and F. These features would provide local water quality benefits.</td>
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<tr>
<td>Key Landscape Process</td>
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<td>Wetlands</td>
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<td>Watershed: The widespread conversion to urban use has produced proximity impacts, even in those cases where buffers are provided resulting in a general transition to human tolerant species. The widespread conversion to urban use has resulted in additional pressure from domestic animals and tends to further depress population of native species. Reach Level: White River Reaches A, B and C are substantially altered and provided no associated wetlands. Reaches D and E provide wetlands that provide limited localized habitat functions largely due to limited buffers. Reach F provides a large wetland complex that is isolated from the river by levees.</td>
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<td>Buffers</td>
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<td>Watershed Level: Pacific SMP has little influence on wetland habitat in the system as a whole because of the small area affected. Reach Level Opportunities for improved wetlands function will be provided by KCFC2D levee setback projects that would to allow reconnection of existing wetlands to the river in reaches D and F. These features would provide a wider range of wetland habitat functions.</td>
</tr>
<tr>
<td>Habitat – Proximity Impacts</td>
<td>Species that are sensitive to proximity impacts such as noise or light may not occupy otherwise suitable habitat that is subject to those features. Habitat provides for a complex balance between prey and predators. A variety of factors may affect this balance. Under natural conditions, predators cannot exceed the food supply provided by prey. Domestic animals such as cats may increase the total predator population far beyond the normal balance because they receive their food from humans and therefore the predator population is not affected by the prey population.</td>
<td>Noise, light, and other proximity impacts result in direct disturbance to species using the habitat. Natural predators tend to be more mobile than prey species and move more readily between habitat areas. The isolation of prey species in small areas with limited ability for refuge may increase predatory efficiency such that a balance between predation and replacement may not be maintained. Domestic animals such as dogs and cats may increase the total population of predators in an area beyond natural levels such that a balance between predation and replacement of prey species may not be maintained. Habitat conditions may be adequate to maintain a population of a specific species, but they will not persist due to predation.</td>
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<td>Habitat – Predation – Habitat Diversity</td>
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