CITY OF TUKWILA

Shoreline Master Program Update

Shoreline Inventory and Characterization Report

Prepared for:

City of Tukwila

Ecology Grant #G0600234

May 2007

ESA Adolfson

Table of Contents

List of Tables

List of Figures/Photos

Appendices

1.0 INTRODUCTION

1.1 Background and Purpose

The purpose of this study is to conduct a baseline inventory and characterization of conditions relevant to the shoreline resources of the City of Tukwila (City), Washington. According to Substitute Senate Bill (SSB) 6012, passed by the 2003 Washington State Legislature, cities and counties are required to amend their local shoreline master programs (SMPs) consistent with the Shoreline Management Act (SMA), Revised Code of Washington (RCW) 90.58 and its implementing guidelines, Washington Administrative Code (WAC) 173-26. The City is conducting a comprehensive SMP update with the assistance of a grant administered by the Washington State Department of Ecology (SMA Grant No. G0600234).

A first step in the comprehensive update process is development of a shoreline inventory and characterization. The inventory and characterization documents current shoreline conditions and provides a basis for updating the City's SMP goals, policies, and regulations. This characterization will help the City identify existing conditions, evaluate existing functions and values of its shoreline resources, and explore opportunities for conservation and restoration of ecological functions.

This study characterizes ecosystem-wide processes and how these processes relate to shoreline functions. Processes and functions are evaluated at two different scales: (1) a watershed or landscape scale, and (2) a shoreline reach scale. The purpose of the watershed or landscape scale characterization is to identify ecosystem processes that shape shoreline conditions and to determine which processes have been altered or impaired. The intent of the shoreline reach scale inventory and characterization is to: (1) identify how existing conditions in or near the shoreline have responded to process alterations; and (2) determine the effects of the alteration on shoreline ecological functions. These findings will help provide a framework for updates to the City's shoreline management policies and regulations. Other steps in the SMP update process will include:

1. Determining shoreline environment designations;
2. Reviewing and revising development standards and use regulations for shoreline development;
3. Assessing cumulative impacts of shoreline development; and
4. Preparing a restoration plan.

1.2 Report Organization

The information in this report is divided into eight main sections. The introduction discusses the purpose of this report and describes the regulatory context for shoreline planning. The second section describes the methods, approach, and primary data sources used for this inventory and characterization. The third section provides a profile of the ecosystems surrounding the City. The ecosystem profile discusses regional overview, process controls in the watershed (e.g., climate, geology), and key ecosystem-wide processes. The fourth section is the shoreline inventory for the Green River. The inventory provides information regarding land use patterns

and the physical and biological characterization of conditions in the vicinity of the shoreline regulatory zone (referred to as the shoreline planning area). Data gaps and limitations on available information are also identified in Section 4. The fifth section summarizes conditions for the portions of the Green River in the City's planning area, provides an assessment of shoreline functions, and identifies and discusses potential opportunity areas for protection, enhancement, and restoration. The sixth section describes existing plans and policies affecting the shoreline planning area. This section identifies potential opportunities and conflicts between planned land and shoreline uses in the City and opportunities for shoreline protection, enhancement, or restoration. Section 7 provides conclusions and recommendations. References are contained in Section 8.

Appendix A of this report is a map folio that identifies the City's shoreline planning area and documents various biological, land use, and physical elements at a variety of scales.

1.3 Regulatory Overview

1.3.1 Shoreline Management Act and Shoreline Guidelines

Washington's Shoreline Management Act (SMA) was passed by the State Legislature in 1971 and adopted by the public in a referendum. The SMA was created in response to a growing concern among residents of the state that serious and permanent damage was being done to shorelines by unplanned and uncoordinated development. The legislative findings and policy intent of the SMA states: in:

> *There is, therefore, a clear and urgent demand for a planned, rational, and concerted effort, jointly performed by federal, state, and local governments, to prevent the inherent harm in an uncoordinated and piecemeal development of the state's shorelines* (RCW 90.58.020).

While protecting shoreline resources by regulating development, the SMA is also intended to provide balance by encouraging water-dependent or water-oriented uses while also conserving or enhancing shoreline ecological functions and values.

The primary responsibility for administering the SMA is assigned to local governments through the mechanism of local shoreline master programs, adopted under guidelines established by Ecology. The guidelines (WAC 173-26) establish goals and policies that provide a framework for development standards and use regulations in the shoreline. The SMP is based on state guidelines but tailored to the specific conditions and needs of individual communities. The SMP is also meant to be a comprehensive vision of how the shoreline area will be managed over time.

1.3.2 Shoreline Jurisdiction

Under the SMA, the shoreline jurisdiction includes areas that are 200 feet landward of the ordinary high water mark (OHWM) of waters that have been designated as "shorelines of statewide significance" or "shorelines of the state." These designations were established in 1972 and are described in WAC 173-18. Generally, "shorelines of statewide significance" include portions of Puget Sound and other marine waterbodies, 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 (RCW 90.58.030). "Shorelines of the state" are generally described as all marine shorelines and shorelines of all other streams or rivers having a mean annual flow of 20 cfs or greater and lakes with a surface area 20 acres or greater (RCW 90.58.030).

Under the SMA, the shoreline area to be regulated under the City's SMP must include all shorelines of statewide significance, shorelines of the state, and their adjacent shorelands, defined as the upland area within 200 feet of the OHWM, as well as any associated wetlands (RCW 90.58.030). "Associated wetlands" means those wetlands that are in proximity to and either influence or are influenced by tidal waters or a lake or stream subject to the SMA (WAC 173-22-030 (1)). These are typically identified as 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. The specific language from the RCW describes the limits of shoreline jurisdiction as follows:

> *Those lands extending landward for two hundred feet in all directions as measured on a horizontal plane from the ordinary high water mark; floodways and contiguous floodplain areas landward two hundred feet from such floodways; and all associated wetlands and river deltas* (RCW 90.58.030(2)(f)).

Local jurisdictions can choose to regulate development under their SMPs for all areas within the 100-year floodplain or a smaller area as defined above (RCW 90.58.030(2)(f)(i)).

In Tukwila, the Green/Duwamish River is the only waterbody regulated under the SMA and the City's SMP. There are no lakes and no other rivers or streams in the City that meet criteria established in the Shoreline Management Act for designating "shorelines of the state." The Green/Duwamish River is designated as "shorelines of statewide significance."

1.3.3 City of Tukwila Shoreline Master Program

The City of Tukwila first adopted its SMP in 1974 by Ordinance No. 898. The original SMP provides policies, regulations, and permitting procedures to govern development and other activities in the City's shorelines. Since that time, SMP goals and policies have been integrated as a chapter of the City's Comprehensive Plan. Development standards, use regulations, and permitting procedures have been codified in Chapter 18.44, Shoreline Overlay District, of the City's municipal zoning code. The City regulates portions of the City annexed since 1974 along the Green River by applying King County Shoreline Master Program provisions.

Local SMPs establish a system to classify shoreline areas into specific "environment designations." The purpose of shoreline environment designations is to provide a uniform basis for applying policies and use regulations within distinctly different shoreline areas. In a regulatory context, shoreline environment designations function similarly to zoning overlay districts. That is, they provide an additional layer of policy and regulations that apply to land within the SMP jurisdiction. Generally, environment designations should be based on biological and physical capabilities and limitations of the shoreline, existing and planned development patterns, and a community's vision or objectives for its future development.

The City's current SMP designates all shorelines as "Urban" and employs a tiered system of regulations within the shoreline jurisdiction based on the distance from the Green River mean high water mark (MHWM). These tiered management zones within the Urban Environment are generally described below and illustrated on Figure 1-1:

- River Environment/Zone: a 40-foot wide zone extending landward from MHWM and having the most environmentally protective regulations;
- Low-Impact Environment/Zone: the area between the River Environment and 100 feet from the MHWM; and
- High-Impact Environment/Zone: the area between 100 and 200 feet from the MHWM.

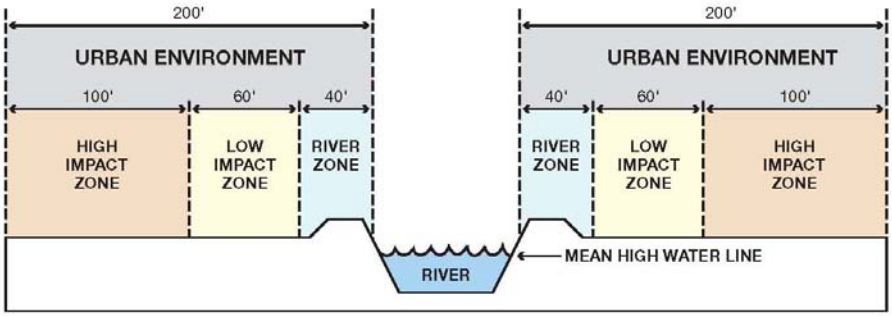


Figure 1-1. Tukwila SMP Shoreline Management Zones (1974 SMP; TMC 18.44)

During 1999-2001 the City began a comprehensive update of its SMP. Work elements included a baseline inventory, revised and expanded goals and policies, updated environment designations, a draft Shoreline Design Manual, and a public outreach strategy. In working with a Citizen Advisory Committee, this effort culminated with a recommended SMP for Planning Commission review and consideration. However, state guidelines for SMP updates were in flux and eventually invalidated during this period. The City's SMP update was put on hold in late 2001 without formal action by the Planning Commission or City Council.

A variety of other regulatory programs, plans, and policies work in concert with the City's SMP to manage shoreline resources and regulate development near the shoreline. The City's Comprehensive Plan and associated Sub-Area Plans establish the general land use pattern and vision of growth and development the City has adopted for areas both inside and outside the shoreline jurisdiction. Various sections of the Tukwila Municipal Code (TMC) are relevant to shoreline management, such as zoning (Title 18), environmental regulations (Title 21), stormwater management (TMC 14.30), and floodplain management (TMC 16.52). The City's development standards and use regulations for environmentally sensitive areas (TMC 18.45) are particularly relevant to the City's SMP. Designated environmentally sensitive areas in the Sensitive Areas Ordinance (SAO) are found in places throughout the City's shoreline jurisdiction, including streams, wetlands, fish and wildlife habitat conservation areas, and areas of potential geologic instability. While the City has not mapped fish and wildlife habitat areas mapped under SAO their location is closely associated with regulated watercourses and wetlands. The SAO recognizes the Green/Duwamish River as the most significant fish and wildlife habitat corridor in the City.

2.0 METHODS

2.1 Data Sources

The collection of information to support the development of this shoreline inventory was well supported by past work to both: (1) reconstruct the pre-European Contact environment of the Puget Sound Lowlands, and (2) describe existing conditions within WRIA 9. At the watershed scale, the following reports were the primary sources of information:

- Habitat Limiting Factors and Reconnaissance Assessment Report Green/Duwamish and Central Puget Sound Watersheds (WRIA 9 and Vashon Island) (Kerwin and Nelson, 2000);
- Near-Term Action Agenda: Green/Duwamish and Central Puget Sound Watersheds – Water Resource Inventory Area 9 (WRIA 9 Steering Committee, 2002)
- Salmon Habitat Plan – Making Our Watershed Fit for a King. (WRIA 9 Steering Committee, 2005).
- Review Draft King County Flood Hazard Management Plan (King County, 2006);
- Historical Aquatic Habitats in the Green and Duwamish River Valleys and the Elliott Bay Nearshore, King County, Washington (Collins and Sheikh, 2005); and
- Occurrence and Quality of Ground Water in Southwestern King County, Washington, (Woodward et al., 1995)

In addition, sources of data specific to shorelines within the City of Tukwila were used to describe reach-scale characteristics, including significant previous inventory efforts:

- Draft Inventory of Shoreline Habitat and Riparian Conditions of the Green/Duwamish River Within the City of Tukwila (Pentec Environmental, 2003);
- Lower Green River Baseline Habitat Survey Report (Anchor, 2004);
- Lower Green River Corridor Assessment (King County, 2003); and
- Green River Baseline Habitat Survey Report (R2, 2002).

To analyze spatial patterns and visually display data, numerous cartographic resources were consulted and used in ArcGIS (ArcView 9.1), including:

- City of Tukwila GIS data for topography (2-foot contours), existing land use, parcels, zoning, parks and trails, storm drainage basins, impervious surface, environmentally sensitive areas, historic/cultural sites, and orthophotos (April, 2005);
- King County GIS data for 2002 aerial photography, topography, wetlands, surface water drainage basins, surficial geology, parks and trails, and roadways;
- Natural Resource Conservation Service (NRCS) Soil Survey Geographic Database (SSURGO) (digital data for the King County soil survey);
- Washington Department of Natural Resources (WDNR) data for topography (30m DEM for King County);
- King County Assessor data for existing land uses within the shoreline planning area;

- Available FEMA floodplain mapping for the City of Tukwila and King County (Green River FEMA 1990, King County 1994);
- Washington Department of Fish and Wildlife (WDFW) data for Priority Habitat and Species distribution; and
- University of Washington Puget Sound River History Project for georeferenced historic mapping (1860s GLO survey maps) and air photos (1940 aerial photography).
- Historic and cultural uses from Vision Tukwila.

No new field-based data collection efforts were performed to develop the summaries and characterization included in this document, although City staff conducted field checks of the previous shoreline inventory data sheets prepared by Pentec Environmental in 2003 to identify any significant changes in shoreline characteristics. Consultant staff also conducted limited "spot checks" of shoreline characteristics. Access was limited to public trails and right-of-way.

2.2 Determining Shoreline Jurisdiction and Planning Area Boundary

This characterization is focused on those shorelines of the state within the city limits of the City of Tukwila and its potential annexation areas (PAA). The approximate extent of shoreline jurisdiction within the City of Tukwila and in its PAA is shown on Map 2, and referred to throughout this report as the "shoreline planning area." In general, it follows a 200-foot extension from the mapped edge of the approximate mean or ordinary high water mark (MHWM or OHWM) of the Green River and any bordering, neighboring, or contiguous wetlands, inside the city limits or in its PAA. The City's current SMP regulates the area between the Mean High Water Mark and 200 feet landward; the OHWM is used for areas annexed since the 1974 adoption of the City's SMP and areas in its PAA. The annexed areas continue to be regulated by the King County SMP, which is administered by the city until its SMP update is adopted and approved by the Department of Ecology. The updated SMP will use the OHWM.

This approximate extent of shoreline jurisdiction should be considered useful for planning purposes only since its resolution is based on relatively coarse mapping. Site-specific delineation of MHWM or OHWM, wetlands, and /or floodplains could result in modifications to the extent of regulated shoreline areas. Applicants for a shoreline substantial development permit are required to provide a survey of the exact location of the MHWM or OHWM. The shoreline planning area as shown on Map 2 is approximately 855 acres (approximately 1.34 square miles) and represents approximately 13 percent of the City's total land area (including municipal boundaries and PAA).

Approximately 13.6 river miles of the Green/Duwamish River are included within the City of Tukwila and its PAAs, from about USGS River Mile (RM) 17.3 and RM 3.7 (Map 2). Potential annexation areas are included to be consistent with comprehensive planning efforts in the City. The City has two PAAs on the Green/Duwamish River. The North PAA is located on the west (left) bank of the river, extending approximately 0.6 miles downstream from the city limits. The adjacent east (right) bank of the river is in the city limits. The South PAA is located on the west (left) bank of the river, extending approximately 1.3 miles upstream from the city limits. The adjacent east (right) bank of the river is in the City of Kent.

The portion of the Green River that flows through the City of Tukwila and its PAAs is addressed in this report as four reaches, G1 (Lower Green), G1-PAA (Lower Green PAA), G2 (Duwamish), and G2-PAA (Duwamish PAA), as described in more detail in Section 4 (Maps 6b, 6c, 6d, and 6e; Table 2-1). Reaches are described moving from upstream to downstream throughout this report.

Table 2-1. Green / Duwamish River Reaches

Reach	Length/River Miles	Shoreline Planning Area (acres)	General Location
G1-PAA	~1.3 miles (RM 16.0 to 17.3)	~36 acres	Tukwila South Potential Annexation Area (left bank only; right bank is in City of Kent)
G1	~5 miles (RM 16.0 to 11.0)	~282 acres	From upstream City boundary downstream to Black River / Green River confluence within the city limits (S. 204th Street to the north boundary of Ft. Dent Park).
G2	~7.3 miles (RM 11.0 to 3.7)	~503 Acres	From the Black River / Green River confluence downstream to the northern city limits near the 16th Avenue S. bridge.
G2-PAA	~0.6 miles (RM X to X)	~33 acres	Tukwila North Potential Annexation Area (left bank only).

2.3 Approach to Inventory and Characterization of Regulated Shorelines

The inventory of the Green River at the shoreline reach scale is intended to characterize conditions in and adjacent to the regulated waterbody. The shoreline planning area roughly approximates the regulatory limits of the City's SMP as described above. GIS data were used to quantify certain conditions in this area (e.g., spatial extent of zoning or land uses). Aerial photography, review of existing reports, and brief field reconnaissance were used to qualitatively describe conditions in the shoreline.

The Green River shoreline was divided into four reaches or planning segments for purposes of this inventory. These divisions were developed to provide an organizational element to the inventory, and provide consistency with past work. The divisions were determined to provide general breaks in shoreline function based on existing conditions in the Green/Duwamish River system. The main reach break in the Green/Duwamish River occurs at the confluence of the Green and Black Rivers at RM 11.1. This location has been identified as the approximate extent of salt water influence in the system (Kerwin and Nelson, 2000). WRIA 9 uses the confluence as the boundary between the Lower Green River and the Green/Duwamish Estuary. Anchor (2004) uses the confluence as the boundary between their Reach 4 and Reach 5. The other two reach breaks are located between current Tukwila municipal boundaries and Tukwila's designated potential annexation areas (PAA). These divisions are intended to provide information to support future decision-making regarding annexation.

2.4 Approach to Characterizing Ecosystem-Wide Processes and Shoreline Functions

SMA guidelines require local jurisdictions to evaluate ecosystem-wide processes during SMP updates. Ecosystem-wide processes that create, maintain, or affect the City's shoreline resources were characterized using an adapted version of the five-step approach to understanding and analyzing watershed processes described in *Protecting Aquatic Ecosystems: A Guide for Puget Sound Planners to Understand Watershed Processes* (Stanley et al., 2005). This approach defines watershed processes as the delivery, movement, and loss of water, sediment, nutrients, toxins, pathogens, and large woody debris. The processes are qualitatively described using available reports and spatial information related to topography, geology, soils, land cover, and other themes. This approach is most appropriate at the watershed scale. However, examining conditions and processes at both the watershed and City-wide or reach scales informs local shoreline planning by providing a broader understanding of how ecosystem-wide processes form and influence conditions in the shoreline planning area. Natural processes, and alterations to those processes, are described at a variety of geographic scales based on existing reports and readily available mapping information.

2.5 Naming Conventions

In consideration of existing studies and City planning documents, the following naming conventions are used in this report:

- Lower Green Valley is used to describe the valley in which the City of Tukwila is located;
- The Green/Duwamish River is used to refer to the regulated shoreline of statewide significance in the City generally;
- The Lower Green River is used to refer to the portion of the river in the City limits and PAA upstream of the confluence with the Black River/Spring Brook Creek; and
- The Duwamish River is used to refer to the portion of the river in the City limits and PAA downstream of the confluence with the Black River/Spring Brook Creek.

Additionally, the use of the terms "left bank" and "right bank" throughout this report refer to the convention of referring to the bank of the river looking downstream.

3.0 ECOSYSTEM PROFILE

In accordance with WAC 173-26-210(3)(d), this chapter describes how the shorelines of the City of Tukwila function within the context of watershed-scale processes. Information is presented at a watershed-scale and provides a basis for understanding shoreline management in relation to the broader landscape context. This watershed-scale overview is intended to provide context for the reach-scale discussion provided in Chapter 4 and the assessment of shoreline functions in Chapter 5. This chapter is organized to provide:

- An overview of the region, including physical description, land use changes, and existing habitats;
- A discussion of the process controls that influence the form and ecological functioning of the Green / Duwamish Valley; and
- A discussion of ecosystem processes that affect shoreline function.

The key distinction between process controls and ecosystem processes is that process controls act independently of each other and land uses in the watershed, while ecosystem processes are the end result of the interaction of process controls and artificial modifications to the landscape. For example, the climate and geology of a region will combine to influence the surface hydrology of a watershed. Ecosystem processes, such as hydrology and sediment generation and transport, result in the physical form of the landscape and the types of habitats that occur throughout the region (Brinson, 1995). Ecosystem processes function at multiple scales, from the watershed scale to site-specific habitat scale (Figure 3-1).

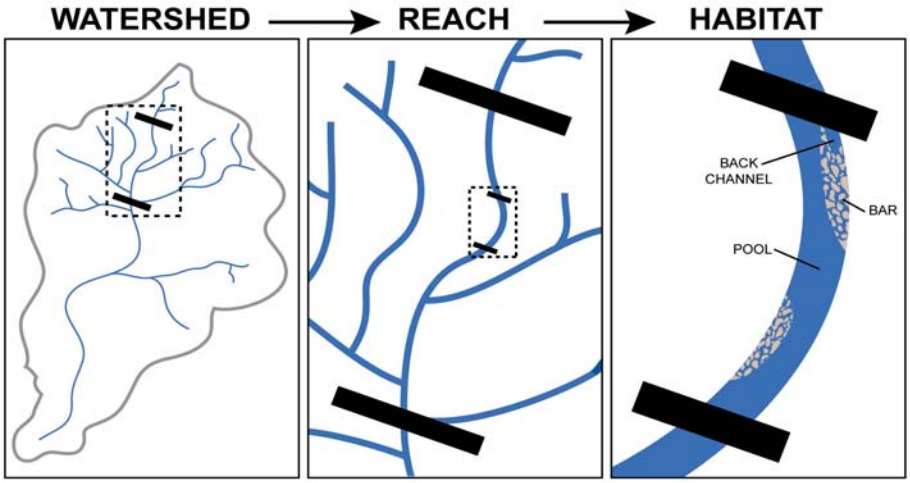


Figure 3-1. Relationship of Scales

3.1 Regional Overview

The City of Tukwila is situated in the Puget Sound Lowlands, at the transition from the freshwater alluvial Green / Duwamish valley to the tidally influenced Duwamish Estuary. The region now covered by the City of Tukwila has long been an important junction between fresh

and saltwater habitats. All shorelines of the state within the City of Tukwila occur within the Green / Duwamish River basin (WRIA 9) (Map 1). The Black River and the Green River converge to form the Duwamish River at approximately USGS River Mile (RM) 11 just north of Fort Dent Park at the eastern limit of the City of Tukwila (Photo 3-1).

Photo 3-1 View of the Black and Green River confluence, facing downstream (Black River is on right). (November 2, 2006).

The Green River drains 492 square miles extending from the western Cascade Mountains to Elliott Bay. The City of Tukwila lies at the lower ¼ of the overall watershed. As the Green River flows into the southern boundary of the City of Tukwila, it has drained approximately 440 square miles, or about 78 percent of its total drainage basin. Approximately 12.3 river miles of the Green / Duwamish River are included within the City of Tukwila, from about RM 16 to RM 3.7.

The Green/Duwamish River channel has been highly modified during the last 150 years. Modifications range from the installation of levees and revetments to straightening and dredging for navigation purposes. In general, the level of physical modification to the system increases with distance downstream, culminating at the artificial Harbor Island that supports industrial activities at the Port of Seattle. Several turning basins are maintained by periodic dredging throughout the straightened reach. The highly modified portion of the Green/Duwamish has also been the location of significant discharge of pollutants, resulting in portions of the river being designated as Federal Superfund sites. Remediation, source control, and disposal activities are ongoing throughout the area.

3.1.1 Historic Watershed Conditions

Significant previous work has been performed by University of Washington researchers to support King County in the reconstruction of past riverine conditions in the Green River Valley (Collins and Sheikh, 2005). Prior to European settlement of the Lower Green River Valley, the floodplain likely consisted of a highly interspersed pattern of active and temporarily abandoned meandering channels, secondary channels, logjams, riparian forest, and scrub-shrub wetlands

(Collins and Sheikh, 2005). The proportion of open channel to forest in the floodplain appears to have varied depending on the severity and timing of floods. High flows resulted in wider channels, and the creation of new channels across the floodplain. Accounts of the channel systems indicate that major floods resulted in channel avulsion (abrupt change in the course of a river) and rerouting around logjams, and the formation of new logjams (Collins and Sheikh, 2005). Therefore, the area presently occupied by the City of Tukwila appeared to historically contain oxbow channels, secondary and backwater channels, and extensive floodplain wetlands.

As part of regional flood control and river management efforts, significant watershed-scale changes occurred to the major river drainages south of Elliott Bay. River management resulted in significant changes to the alignments and discharge points of the Cedar, Black, Green, and White Rivers. In general, these changes have reduced the amount of water flowing through the Green/Duwamish River to about a third of historic conditions (Kerwin and Nelson, 2000).

Land use changes between European settlement and the current day have occurred in two general phases. From the mid 1800s to World War II, agriculture and timber harvesting dominated the Lower Green River Valley. Population densities in the Lower Green River Valley remained low until the Howard A. Hanson Dam project was completed in 1962, providing flood protection for the valley (Collins and Sheikh, 2005). Levees have also been constructed along the banks of the Green/Duwamish River, ranging from federally-certified levees to unengineered agricultural berms (King County, 2006). Since the dam and levee systems have significantly decreased the extent of flooding within the Lower Green River Valley, land development and urbanization have occurred. Figure 3-2 illustrates these changes over time.

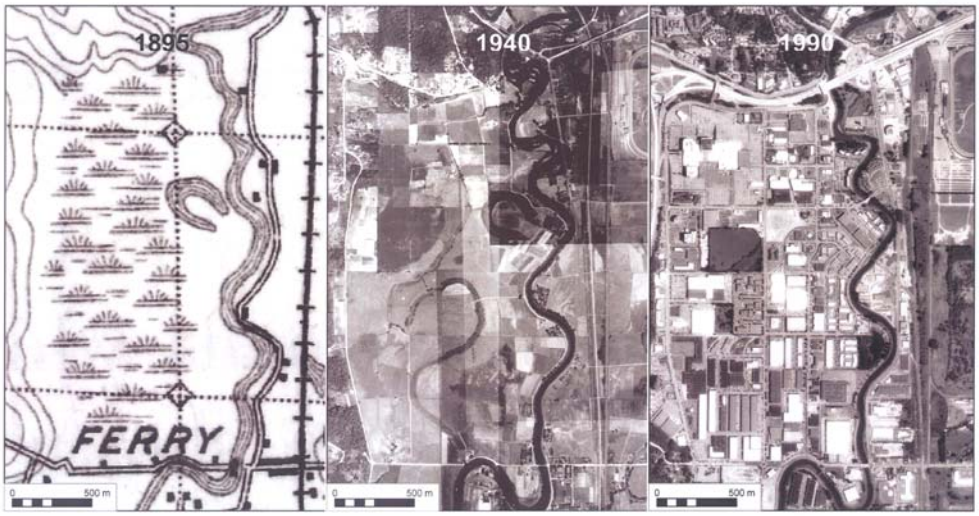


Figure 3-2. Land use / land cover change in Tukwila Reach G-1
(source: Collins and Sheikh, 2005)

3.1.2 Current Land Use

The majority of the upper Green River watershed is in managed forestland, parkland, or designated wilderness area in the Cascade foothills. Agricultural land covers much of the higher river terraces along the middle Green River from RM 32 to 40. The lower Green River Valley is a transitional area between the forest and agricultural activities upstream to the highly developed

residential, industrial and commercial development. The lower Green River Valley includes the cities of Kent, Renton, and Tukwila.

Industrial, commercial, and residential land uses dominate the former Green River floodplain in the vicinity of Tukwila. South of the city, commercial and warehouse/industrial land uses dominate on the right bank in the City of Kent, with agricultural fields on the left bank within the Tukwila South annexation area. Commercial development is dominant between the southern city boundary and I-405. Residential development dominates between I-405 and the I-5 bridge. North of the I-5 bridge to the turning basin, residential uses give way to commercial uses. The upper turning basin is the southern boundary of the predominantly industrial area that extends to the northern city limit.

3.1.3 Habitat and Species Usage

Estuaries (the tidally-influenced area where fresh water from a river or stream mixes with salt water), estuarine emergent wetlands, and nearshore areas provide essential habitat for salmonid species. Salmonids have developed physiological adaptations to help with the transition from freshwater to saltwater, depending on refuge and foraging opportunities in estuarine environments (Shreffler et al., 1992; Kerwin and Nelson, 2000; Fresh et al., 2003). Some salmon species are more heavily dependent on estuaries, particularly Chinook, chum, and to a lesser extent pink salmon (Kerwin and Nelson, 2000).

The transition zone between fresh and salt water has effectively been pushed upstream from its historic location due to: (1) a significant reduction (70%) of fresh water flowing into the Duwamish estuary (owing to the diversion of the White and Cedar/Black Rivers), (2) channel dredging, and (3) reduction of flows as a result of the Howard A. Hanson dam. The establishment of heavy industrial uses in the transition zone has replaced wetlands with impervious surfaces, and the stream banks have been replaced by levees and other armoring, eliminating slow-moving flows through edge habitat and creating unrestrained downstream flows. Spatial structure, residence time, and the habitat available for refugia and rearing functions in the Duwamish estuary have therefore been reduced and constrained. High densities of fish have been observed utilizing what is left of this specific habitat. At the watershed scale, overall increases in salmonid survival rates are dependent on the availability of sufficient transition zone habitat to accommodate fish while they adjust from fresh to salt water (WRIA 9 Steering Committee, 2005).

3.2 Watershed Process Controls

3.2.1 Climate

Tukwila's climate is dominated by maritime patterns that define the overall climate of the Puget Sound Lowlands. These patterns include mild, wet fall to spring months, and cool dry summer months. Annual precipitation in the Puget Sound Lowlands typically ranges from 32 to 37 inches, the vast majority of which is distributed between October and May. January temperatures typically range from lows around 30º F to highs around 43º F. July temperatures typically range from lows around 50º F to highs around 75º F (National Climatic Data Center Summary [NCDC] for Washington State).

Precipitation typically occurs as low-intensity, long-duration storms. Precipitation as snow is relatively rare and short-lived in the Puget Lowlands. However, hydrologic systems in the Pacific Northwest are especially sensitive to warm rain-on-snow events, when significant volumes of water can be released into the system at one time.

The Green River responds to precipitation events in the western Cascade Mountain range. Precipitation levels in the Cascades can be significantly higher than in the lowlands. Annual precipitation in the western Cascades averages between 60 and 100 inches per year (NCDC). Higher elevations and lower temperatures result in snowpack development in the contributing area. Therefore, snowmelt dominates the high flow periods of the spring and early summer. Snowpack depths can range from around 50 inches at lower elevations to several hundred inches above 5,000 feet in elevation.

3.2.2 Geology

Geology of the Green / Duwamish River watershed is the end product of mountain building, volcanic activity, glaciation, marine deposition, and post-glacial alluvial deposits. The region has been exposed to numerous geologic processes including:

- Multiple advances of a lobe of a continental ice sheet;
- Estuarine and lacustrine deposition in a marine embayment that occupied the Green / Duwamish Valleys;
- Incision of upland plateaus to form the Green River gorge;
- Deposition by lahars from Mount Rainier; and
- Accumulation of alluvium (Map 3).

Six or more glacial advances over the past 2 million years helped shape the Puget Lowland, and deposited sediments that now underlie much of Tukwila. The trough that defines the Green / Duwamish Valley was constructed as glacial ice covered the Straight of Juan de Fuca, resulting in pro-glacial lakes. The glacial silt that was deposited within these lakes is typically dense enough to limit water transmission, thereby acting as an aquitard. The Green / Duwamish marine and alluvial sediments typically overlie the glacial silt or bedrock to depths of between 20 and 100 feet (Fabritz et al., 1998).

In the vicinity of Tukwila subsurface geology is a combination of bedrock, glacial, and interglacial sediments. Tertiary bedrock known as the Tukwila Formation is exposed along the valley walls as the Green / Duwamish Valley narrows north of the I-5 and I-405 intersection (Map 3). In these locations, the bedrock units appear to limit the contribution of groundwater from the upland drift plain to the valley bottom.

The topography and near-surface geology in the area (Maps 2 and 3) are largely the product of the last glaciation (known as the Vashon Stade of the Fraser glaciation), which receded from the area about 15,000 years ago. The ice sheet deposited glacial drift (e.g. sediment deposited directly or indirectly by a glacier or associated meltwaters) on the expansive upland plains. Drift in the Tukwila area consists principally of till (Qvt) and advance outwash sand and gravel (e.g. sediment deposited by water flowing off the advancing glacier) (Qva), and recessional outwash

sands and gravels (e.g., sediment deposited by water flowing off the receding glacier). The primary distinction between the advance and recessional outwash units is that the advance outwash materials have been overconsolidated under the weight of the ice sheet.

Following retreat of the Vashon ice sheet, marine water inundated the Green / Duwamish Valley trough to form an arm of Puget Sound. A layer of silt and clay tens of feet thick accumulated in the estuary, which now lies at depths of up to approximately 10 to 100 feet below ground surface near Tukwila (Fabritz et al., 1998). Deltas, consisting of sand and gravel, grew into the embayment at the mouths of the Green, Cedar, and White Rivers (see Figure 3-3).

Filling of the marine embayment in the Lower Green River and Green / Duwamish estuary is largely attributable to lahars from Mount Rainier and to marine and fluvial deposition by the ancestral White and current Green Rivers (Dragovich et al., 1994; Zehfuss, 2005). A significant fill event occurred about 5,600 years ago as a lahar. The Osceola Mudflow from Mount Rainier flowed down the White River, over a broad area of the upland plateau of the Green River Valley, and into the embayment (Mullineaux, 1970; Dragovich et al., 1994; Vallance and Scott, 1996). These deposits are generally poorly sorted and consist of gravel, sand, silt, and clay (Dragovich et al., 1994). Sediment excavated by the White River as it readjusted after the mudflow was deposited in the marine embayment and on top of the Osceola Mudflow. The Green and White Rivers have since reworked lahar and other sediments, depositing sand and gravel alluvium along the river gorges, aggrading the Middle and Lower Green River valley floor, and building a delta front northward towards Seattle (mapped as Qyal on Map 3) (Dragovich et al., 1994; Zehfuss, 2005).

The alluvial sediments along the valley bottom have been classified into two general groups, referred to as younger and older alluvium (Fabritz et al., 1998). The younger alluvium is typically 15 to 20 feet deep at the ground surface. This unit consists of organics in a silt and sand matrix and is typically finer grained than the underlying older alluvium. The young alluvium layer is often capped by fill as a result of urbanization. The younger alluvial overlies the older, and therefore all the alluvial deposits are mapped as young (Qyal) on Map 3. Near Tukwila, the older alluvium can reach 90 feet thick, extending to ~100 feet below Mean Sea Level (MSL). The older alluvium is generally coarser and has less organic content than the younger alluvium (Fabritz et al., 1998). The depths and stratigraphic patterns of the alluvium become more variable within the deltaic portion of the Duwamish valley.

3.2.3 Topography

Topography in the eastern part of the Green / Duwamish Valley consists of a broad alluvial valley surrounded by a relatively flat-lying upland plateaus (Galster and Laprade, 1991) (Map 4). Elevations within the watershed range from approximately 20 feet above sea level on the floor of the Green / Duwamish valley, to 4,500 feet above sea level at the headwaters of the Green River in the western Cascade Mountains. A USGS hillshade Digital Elevation Model is shown as Figure 3-3, below.

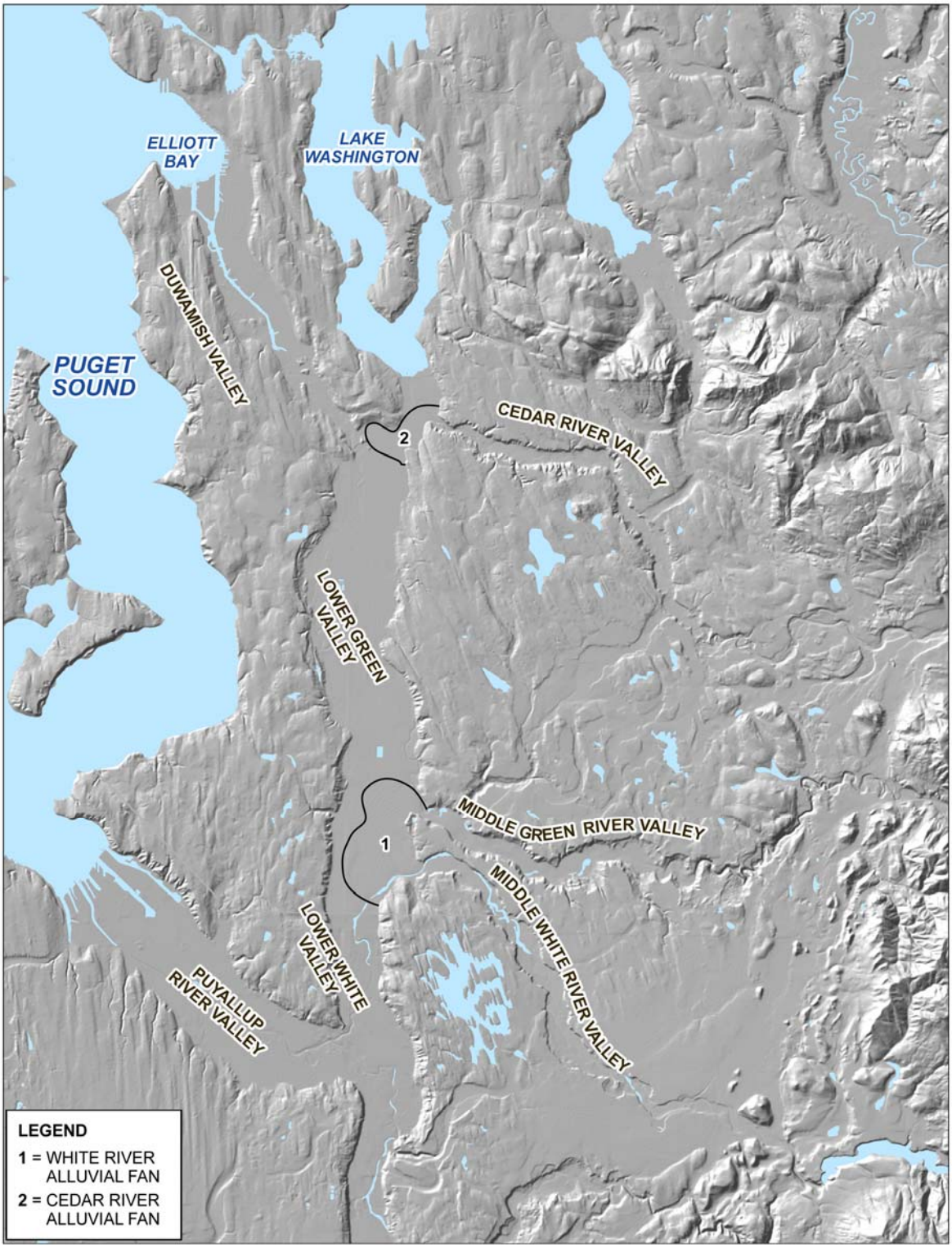


Figure 3-3. USGS hillshade graphic overview of the Green / Duwamish region

Topography in the vicinity of Tukwila is characterized by upland plateaus and the broad floor of the Green / Duwamish River Valley (Map 4). The surface of the upland plateaus rises as much as 400 feet above sea level. The upland areas exhibit low topographic relief with hills rising typically between 20 and 60 feet, poorly drained stream valleys, and local closed depressions (Woodward et al., 1995). The floor of the Lower Green / Duwamish Valley is relatively flat with valley bottom gradients typically ranging from 10 to 20 feet per mile.

3.2.4 Soils

The Natural Resource Conservation Service (NRCS) (formerly known as the SCS) has mapped soils in the King County area (Snyder et al., 1973). The results of the surveys are documented in Soil Survey reports, and mapped as spatial data in SSURGO GIS databases (Map 5).

Soils in and near the City of Tukwila and its PAA are strongly influenced by climate and geology as discussed above. Soils that developed in this region generally formed within: (1) alluvial materials in the valley bottoms, (2) recessional outwash materials on slopes and terraces, (3) glacial till materials on the nearby foothills, and (4) sedimentary bedrock.

Most of the city is mapped as Urban Land, indicating that they were covered with impervious surface or otherwise highly urbanized at the time of the survey, except for south of South 180th Street. Soils within the Lower Green River Valley are typically mapped as silt loam as the dominant grain size. The most commonly mapped valley soils are Nooksack silt loam, Newberg silt loam, and Woodinville silt loam, reflecting the alluvial nature of the sediments being deposited and reworked as the stream channels meandered around the valley floor.

Soils on top of the surrounding hills are typical of soils that have developed on till materials throughout the Puget Sound lowlands. Alderwood gravelly sandy loams (AmC. AgD, and AgC units shown on Map 5) are broadly mapped, and correspond well with the mapped glacial till materials on Map 3.

3.3 Ecosystem Processes

A number of ecosystem processes work together to form and maintain aquatic ecosystems. Based generally on the approach to ecosystem process characterization outlined in guidance by the Department of Ecology (Stanley et al., 2005), the key ecosystem processes discussed here are: delivery, movement, and loss of water (hydrology); sediment generation and transport; and nutrients, toxins, pathogens, and organics (water quality). Alterations or land use activities that occur across the landscape can affect ecosystem-wide processes and shoreline functions. Much watershed planning and assessment work has been conducted in the Green / Duwamish basin. A review of this work is useful in understanding the condition of the City's shoreline resources and identifying activities that influence those conditions but which may be beyond the City's shoreline and regulatory authority.

3.3.1 Hydrology

Water naturally enters a watershed through rain, snow, or movement of groundwater. Water moves within a watershed as surface water in rivers and streams, infiltrates and becomes groundwater, or is stored in wetlands, lakes, and floodplains. Hyporheic flow can occur as surface flow becomes shallow subsurface flow, moving downvalley through alluvial sediments. Water can also flow in the subsurface as groundwater. Ground and surface waters can interact as surface water infiltrates (recharge), or as groundwater reaches the surface (discharge).

In a natural system, the movement and storage of water is generally controlled by physical conditions such as climate (precipitation patterns and volumes), topography (gradient), land cover (vegetation) and the permeability or infiltration capacity of soils and the underlying surficial geology (Figure 3-4) (Stanley et al., 2005).

Hydrologic processes drive many other key processes and influence the following elements of the ecosystem:

- Channel Morphology;
- Water Quality; and
- Instream and riparian habitats.

3.3.1.1 Groundwater Movement

The glacial and alluvial materials that underlie much of the Green / Duwamish valley create a complex hydrogeologic system that includes recharge areas in the upland plain, and discharge areas in the Green / Duwamish valley. General groundwater and hydrology in the vicinity of Tukwila are described in Fabritz et al. (1998) and Woodward et al. (1995). Past investigations have identified three significant aquifers in this region:

- A shallow alluvial aquifer in alluvial sediments in the river valley (Qyal on Map 3);
- A deeper aquifer within advance outwash materials (Qva on Map 3). Much of the Qva aquifer underlies areas mapped as till (Qvt on Map 3); and
- A deeper aquifer that lies within the Glacial Silt layer discussed in the geology section, above.

The shallow aquifer in alluvial sediments is in direct connection to flow within the Green/Duwamish River. Groundwater enters the shallow Qyal aquifer via: (1) discharge from the adjacent upland plain, (2) recharge from floodplain areas, and (3) hyporheic (shallow subsurface flow adjacent and connected to surface flow the active channel) flow from the channel during high flows. According to King County data, overall flow patterns within the shallow aquifer are towards the river channel, and down valley (towards Puget Sound).

Glacial deposits comprise one or more aquifers and aquitards (i.e., low permeability geologic strata that function to restrict groundwater movement). These interspersed permeable and impermeable layers control subsurface water movement from the upland to the lowlands. Water that infiltrates into the ground generally flows downward until impeded by less permeable sediment and then flows laterally to a body of water or to a slope face where it may emerge as

springs or seeps on the hillside. A portion of the groundwater, however, will percolate downward through lower-permeability sediment, recharging underlying aquifers. Springs discharge along the steep slopes at the edge of the upland plateaus, primarily from recessional outwash, which overlies the till; Vashon advance outwash, which underlies the Vashon till and a deeper, pre-Vashon outwash (Woodward et al., 1995).

Lodgment till (Qvt) and recessional outwash (Qvr) from the Vashon glaciation mantle much of the upland area in the vicinity of Tukwila but are generally absent from the steeper slopes at the edge of the upland and in the lowland. Lodgment till is an unsorted mixture of sand, gravel, silt, and clay deposited at the base of a glacier that has been compacted to a very dense state by the great weight of the overriding ice. This type of till has very low permeability and typically acts to restrict the downward flow of groundwater and limit recharge to deeper aquifers. Recessional outwash was generally deposited in topographic lows on the till plain by meltwater streams emanating from the melting ice front. Recessional outwash generally consists of sand and gravel and is relatively permeable since it was not overlain by the ice sheet. Due to the varying permeabilities of each material, the distribution of till and outwash on the upland surface predominantly controls infiltration of precipitation and aquifer recharge (Woodward, et al., 1995).

3.3.1.2 Surface Runoff

The majority of surface flow in this area is focused in the Green/Duwamish River. In general, surface water flows toward the Green/Duwamish River from the east and west valley walls and then continues to the north in the channel to Elliott Bay. Flow rates and water levels through the City of Tukwila are controlled by hydrologic processes in the upper watershed and by tidal flux from Elliott Bay. Saltwater influence is typically thought to extend upstream to approximately RM 11, and tidal patterns extend to and past the I-405 bridge.

To provide an overview of the magnitude and timing of flows within the Green/Duwamish River, summary data from available US Geological Survey (USGS) gauging stations are presented below. These data are intended to illustrate seasonal patterns, inter-annual variation, and the daily influence of the tides. These data are summarized from available USGS stream gauges, including gauges at Auburn (12113000) at RM 32 and at Tukwila (12113350) near RM 12.

Monthly Average Flows

USGS data from the gauge at Auburn are shown below on Figure 3-4. This figure illustrates seasonal variability from the higher flow period from November to June, and the drier months from July to October.

For the period after the Howard Hanson Dam was installed (1962 to present), dry season monthly average flows range from approximately 150 cfs to 600 cfs. Wet season monthly average flows for this period range from 950 cfs to 5,650 cfs.

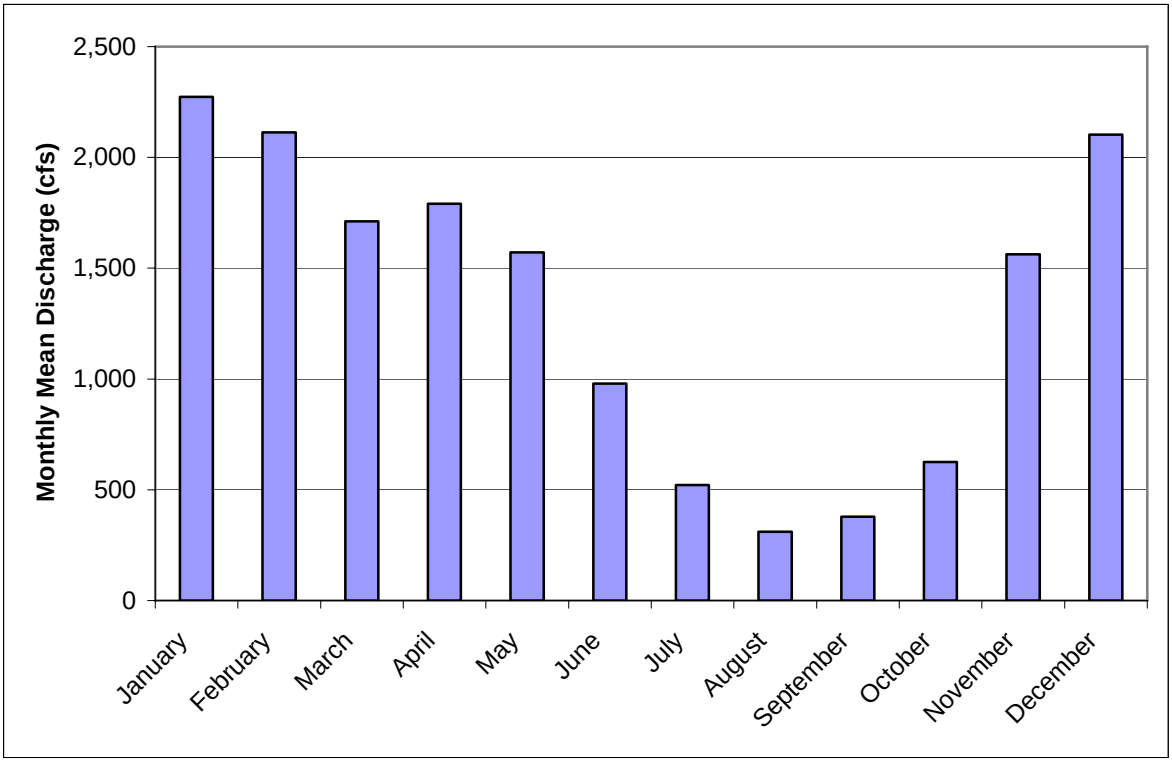


Figure 3-4. Monthly Average Discharge for the Green River at Auburn USGS Gauge 12113000 Based on data from 1962 to 2005 (post dam installation)

Daily Average Water Levels

The freshwater flows discussed above translate into differing water levels ('stage') within the Green/Duwamish River at the City of Tukwila. Figure 3-5, below, illustrates daily average water levels for the 2006 water year (October 1 – September 30). Average elevations (compared to NGVD 29) range from around 3 feet to as much as 18 feet. This pattern indicates the range between high runoff periods and low flow times of the year.

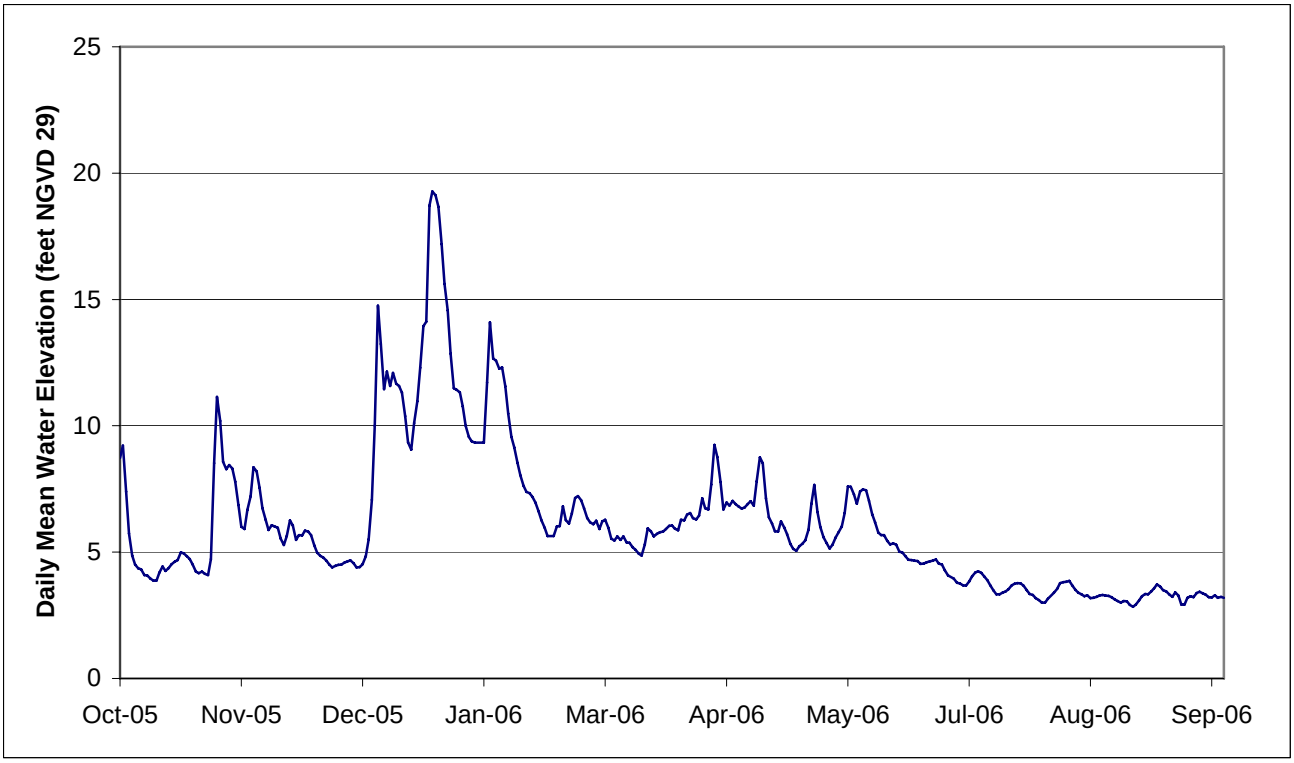


Figure 3-5. Daily average water level data at USGS gauge 12113350 at Tukwila for the 2006 water year

Daily Water Level

The daily action of the tides also influences water levels in the river. Figure 3-6 is offered to illustrate the range of instantaneous (e.g., every 15 minute) water levels during a two-week period, including a portion of a significant runoff event in December 2005. The variation between weeks shows how higher flows can mask the daily tidal signal. Once flows from the upper watershed drop, the daily tidal variation reemerges.

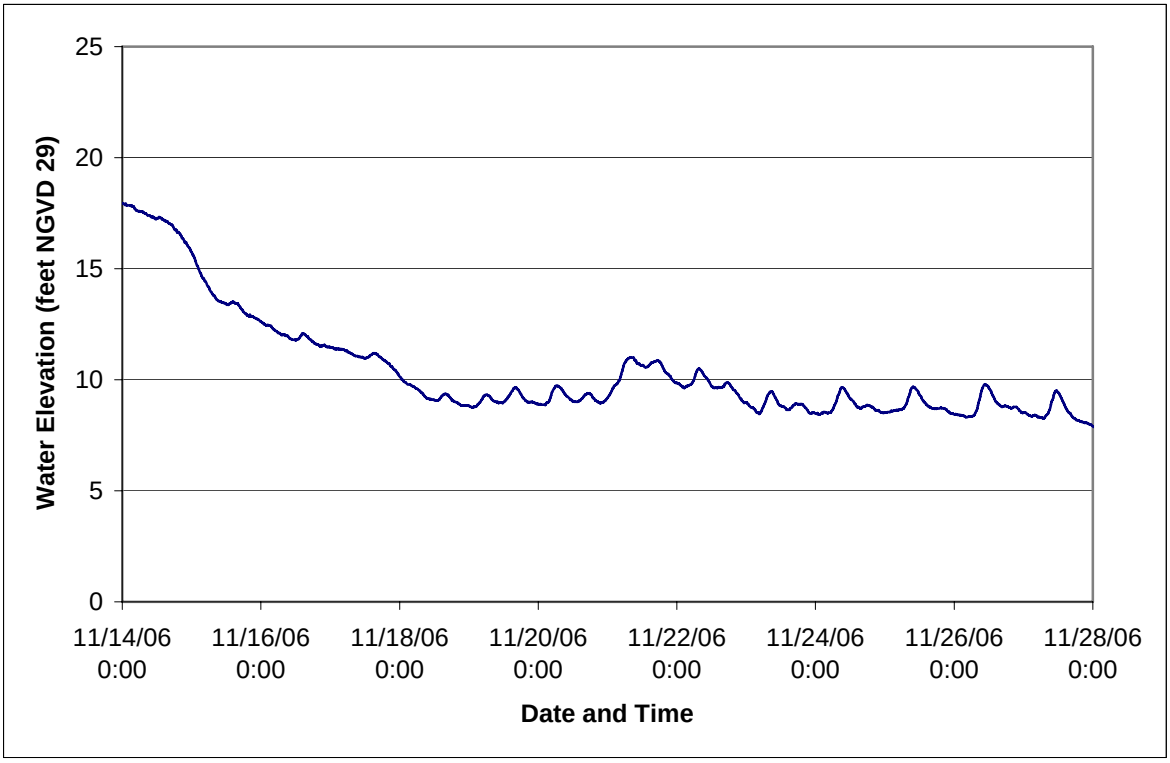


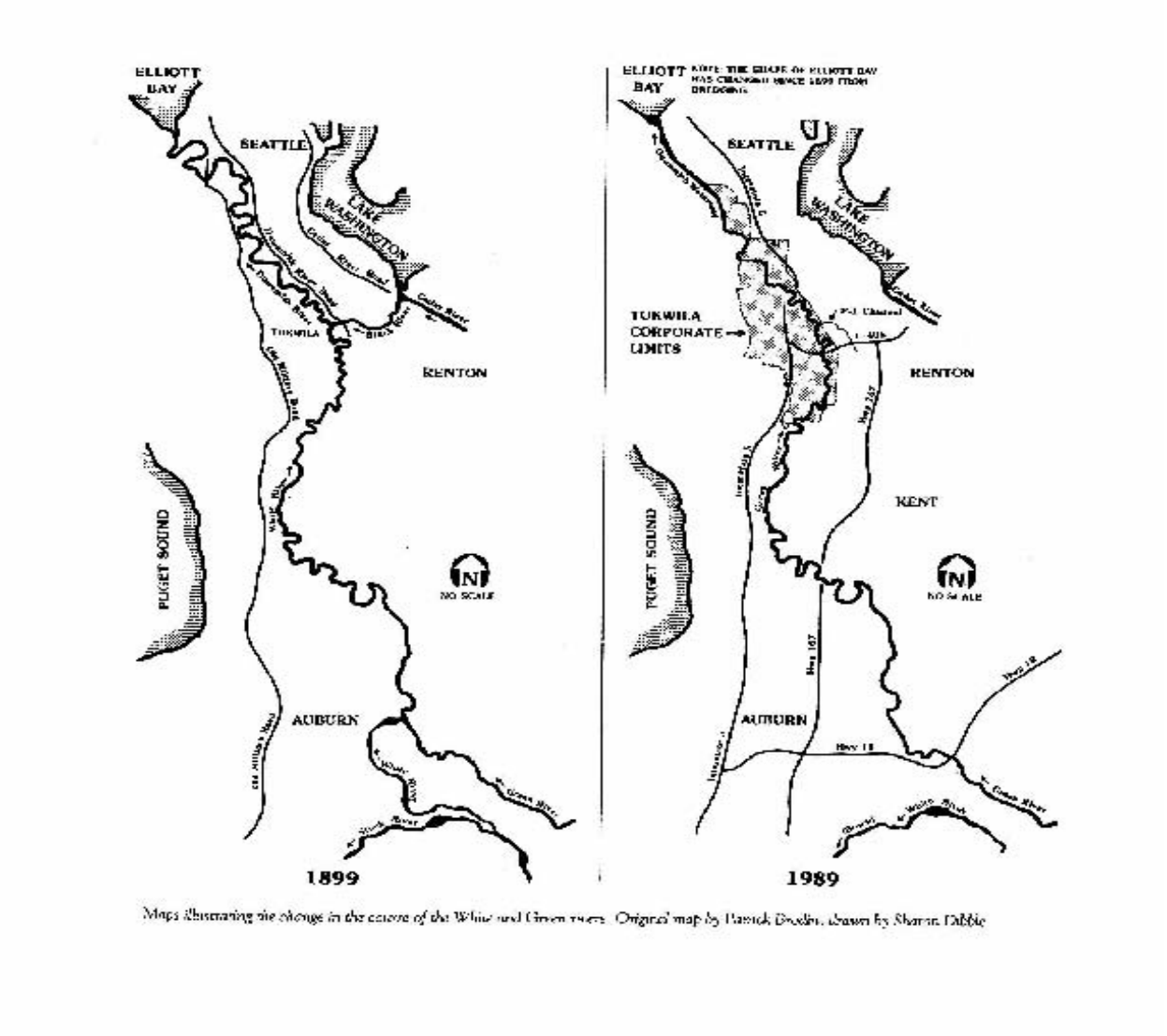
Figure 3-6. Instantaneous water level fluctuations at the USGS gauge 12113350 at Tukwila

3.3.1.3 Hydromodifications

There are four major alterations to natural hydrologic functioning in the Green/Duwamish River system: (1) historic changes to channel morphology, (2) changes in river flow regime, (3) changes in flow paths between upland and aquatic systems, and (4) changes in the rainfall-runoff characteristics of the drainage basins.

Historical channel changes for the Green/Duwamish River include major river shifts (avulsions) or diversions such as: (1) the avulsion and later permanent diversion of the White River, (2) the diversion of the Cedar River, and (3) the channelizing of the Green/Duwamish River. The diversions of the White and Cedar rivers reduced the volume of water that drains through the Duwamish River by approximately two-thirds (King County, 2006).

Prior to 1906, the White River naturally split into two branches on the south side of Auburn. The main branch of the river flowed northward to the Green / Duwamish River. The smaller branch flowed southward as the Stuck River, which joined the Puyallup River. In 1906, a significant flood event resulted in the White River moving into the course of the Stuck River. The White River was permanently diverted southward with the construction of diversion levees completed by the Corps of Engineers in 1914. Prior to the installation of the Ballard Locks, the Cedar River and Lake Washington discharged into the Green / Duwamish system via the Black River at RM 11. Since around 1916, the Cedar River has drained into Lake Washington after the lake was lowered, and the lower Cedar River channelized (Figure 3-7).



Maps illustrating the change in the course of the White and Green rivers. Original map by Patrick Dugdin, drawn by Sharon Dibble

Figure 3-7. Schematic view of structural changes to the river system draining through the Green/Duwamish River

In addition to the significant changes in contributing basin, the Green/Duwamish channel has also been directly modified. Changes in channel morphology have included straightening; channelizing; installation of levees, revetments, and shoreline protection measures; and construction of bridges and other river crossings. The levees were typically installed more than 50 years ago, and do not meet current engineering standards (King County, 2006). Portions of the Duwamish River that are used for navigation have been straightened and continue to be dredged (USACOE, 2006).

Natural surface and groundwater flow paths from the base of the steep valley walls out into the floodplain have been altered or disrupted by constructed flood control levees along portions of the Green / Duwamish River, placement of fill across much of the valley floor in the northern

portion of the city, and by road embankments, culverts, and drainage ditches constructed across the valley floor. Such constructed features disrupt hyporheic flow, which is typically shallow subsurface flow with a high degree of interaction with surface flow in or adjacent to river or stream channels.

Former channels of the Green/Duwamish River or its tributaries may influence hyporheic flow because more permeable soils commonly lie within the former channels. These former channels were abandoned as the river or stream suddenly changed locations. Sudden channel shifts (avulsions) are a natural stream process, but are also associated with the rapid influx of large volumes of sediment, such as from lahars flowing down from Mount Rainier.

Flow regime within the Green/Duwamish has been modified by: (1) the City of Tacoma's water supply dam, (2) the Howard A. Hanson Dam, and (3) the Black River Pump Station. The Tacoma withdrawal includes a 155 million gallon reservoir, and was installed near RM 61 in 1911. Up to 113 cfs can be withdrawn from the river to supply water to the City of Tacoma under Tacoma's first diversion water right. An ongoing project is modifying the existing system to allow for diversion of an additional 100 cfs under the second diversion water right, which was granted in 1986 (City of Tacoma website).

The Howard A. Hanson Dam was completed in 1962, primarily to provide flood control for the Lower Green River Valley. The dam is located at approximately RM 64, and provides usable storage of approximately 106,000 acre-feet. The Howard A. Hanson Dam is typically managed to bypass flows for much of the year, only storing flows either during floods or in the late spring to augment summer flows. Since the installation of the dam, no flows over 12,500 cfs at the USGS Gauge in Auburn have occurred. The management of the pool level is currently being modified as part of the Howard Hanson Dam Additional Storage Project to store more water than in the past. Additional storage is intended to provide water supply for Tacoma, Pierce County, and South King County, and to supplement river flows for fish.

Seven pump stations also modify flows into the Green and Duwamish rivers. Three of the pump stations, Black River, P-17, and Segale, are operated by the Green River Flood Control District, and four stations, Lift Stations 15, 17,18, and 19 are operated by the City of Tukwila. The Black River pump station is the largest station discharging flows to the Duwamish River. This station is approximately 1,000 feet upstream of the Green – Black River confluence, and is intended to both block floodwaters from the Green from inundating the Black River and Springbrook Creek, and also regulates flows from Springbrook Creek into the Duwamish River. The P-17 pump station drains the P-17 Pond that collects surface water from a majority of the Urban Center. The Segale pump station was installed to regulate soil saturation and piping during high river events but does not add new flows to the river. The remaining City pump stations only operate when gravity discharge to the river is prevented by high river events.

Land use and development have altered the natural rainfall to runoff characteristics of the Green/Duwamish River watershed. Timber harvesting, agriculture, and urban land uses have changed 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). The extent of land-use changes is evident when current aerial photographs are compared to historical photos, as shown on Maps 6 a-e.

3.3.2 Sediment Generation and Transport

The processes that govern the production, storage, and transport of sediment play a significant role in shaping the morphology and functioning of a riverine ecosystem. In natural river systems, sediment is delivered to the channel via overland flow, mass wasting (e.g., landslides, lahars), and channel migration (e.g., eroding the outside of a meander bend) (Stanley et al., 2005). The relative importance of the sediment generation and transport pathways is typically a result of the interaction between climate and physical features of the landscape, such as topography, geology, vegetation, and soils.

The movement of sediment into, through, and out of the riverine ecosystem influences the form and functions of shorelines of the Green/Duwamish River, including:

- Shoreline morphology;
- Hydrologic and hydraulic channel characteristics;
- Ability of surface and groundwater to interact; and
- Type and extent of aquatic habitat.

Sediment generation and transport processes function at a variety of scales. However, riverine ecosystems typically function to integrate processes over a large area. Therefore, in terms of overall shoreline functioning, sediment delivery processes are best understood and discussed at a watershed level.

Mass wasting (downslope movement of sediment as a result of gravity) is a significant source of both coarse and fine sediment to the upper and middle portions of the Green River system. The Green River gorge has incised into a mix of bedrock and relatively unconsolidated glacial drift materials, creating a relatively narrow floodplain with steep valley walls (Figure 3-3). Steep valley walls made of glacial drift materials can fail during wet periods or can be destabilized at the toe due to channel meandering. The WRIA 9 *Limiting Factors Report* discusses an example of a mass-wasting event near Flaming Geyser State Park that is thought to have contributed 50,000 cubic yards of material to the stream channel (Perkins, 1998 in Kerwin and Nelson, 2000). The Green River channel has meandered against the river-right (right side facing downstream) valley wall in several locations in the Kent-Auburn Valley, increasing the potential to capture and transport sediment downstream.

Sediment delivery processes within the Green River have been highly modified from the pre-European settlement time period. The avulsion (complete channel change) of the White River in 1906 to flow south to the Puyallup River eliminated a significant source of coarse and fine sediment from the Green / Duwamish River Valley. One estimate indicates that the White River supplied as much as 75 percent of the sediment load to the Lower Green River Valley (Mullineaux, 1970 in Kerwin and Nelson, 2000). Therefore, the movement of the White River into the southern alignment discharging into the Puyallup River has significantly decreased sediment load in the Green River system in the lower Green River.

In addition to the loss of the sediment input from the White River, the construction of the Howard A. Hanson Dam on the Green River has disrupted the delivery of coarse sediment from the upper watershed. The geometry of the reservoir is configured such that the coarse sediment load of the Green River is retained, while the suspended sediment load is passed downstream. This break in longitudinal sediment transport has resulted in changes to channel geometry and bed materials for approximately 24 river miles downstream of the dam (Kerwin and Nelson, 2000). Changes to the river as a result of the dam include channel entrenchment, channel straightening, and armoring of the channel bed. The armoring of the channel bed has implications for aquatic habitat, as spawning-sized gravels are transported downstream, leaving coarser than ideal conditions below the dam.

While the overall transport of coarse sediment to the Lower Green River has been reduced, land uses in the upper watershed, including timber harvesting and associated road construction, have generally accelerated production of fine sediment throughout the watershed. The removal of forest cover results in increased production of fine sediment as runoff volumes and peak flows are increased. Increased flows increase in channel erosion and channel destabilization. Further, removal of fine-root biomass increases the potential for mass-wasting (Kerwin and Nelson, 2000; King County, 2006). Increases in fine sediment loading can negatively impact aquatic habitat by filling in the interstitial spaces of channel bed gravels and reducing the exchange of water and oxygen between stream flow and the channel bed. Fine sediment can also act as a transport vector for nutrients, metals, and other pollutants.

The transport of fine sediment to and through the City of Tukwila is apparent in the Turning Basin at the head of the Duwamish River. The Turning Basin acts as a settling basin for fine sediment, and routine maintenance dredging is required to keep the channel deep enough for navigation. The next round of maintenance dredging by the U.S. Army Corps of Engineers (USACOE) is proposed in 2007, and is the subject of an Environmental Assessment produced by the USACOE in July 2006.

3.3.3 Water Quality

The quality of the water flowing through the Green / Duwamish River is the end result of the interaction of water with biota, soils, and urban and rural land use and infrastructure. Ecosystem processes that impact the source, concentration, and transport of mineral and organic constituents are: biotic uptake (e.g., plant growth), decomposition (e.g., plant death), adsorption (e.g., chemical binding), and dissolution (e.g., chemical unbinding). In general, elements cycle between dissolved and particulate forms in water to plants, animals, and soils; and back to the water column via decomposition.

Water quality processes influence the following shoreline functions:

- Elemental Cycling: including the delivery and storage of nutrients (nitrogen, phosphorus), metals, toxic compounds, and pathogens.
- Faunal Support/Habitat: biotic populations at all levels of food webs.

Processes that influence water quality occur over a variety of scales. As water moves through an ecosystem, it has the opportunity to cycle (deposit, entrain, and/or transport) mineral and organic

constituents that can affect water quality. The longer water is able to contact soil and vegetation, the more cycling will occur. Longer water contact times typically occur in low gradient areas in the landscape such as riverine and depressional wetland systems. Water contact time is shorter in areas where rivers have been channelized, and the floodplain filled and paved.

The City of Tukwila exists in the relatively flat, alluvial Lower Green/Duwamish Valley, in a location on the landscape that historically had potential to exert significant control on water quality. This control can be beneficial or adverse depending on land use. In the historic setting, riparian forests that dominated the valley bottom provided high surface roughness that interacted with precipitation, shallow groundwater, shallow subsurface flow, hyporheic flow, and floodwaters. The deltaic environment provided multiple channels and broad tide flats that offered significant opportunity to store sediment and nutrients.

Modifications to the channel and channel-forming processes have eliminated these landforms, resulting in a disconnection between the river and its floodplain. Therefore, the quality of the water flowing through the area has been changed by the installation of impervious surfaces and stormwater conveyance infrastructure, which generally results in faster runoff that has limited opportunity to interact with soils. Constituents that can negatively impact water quality (e.g., metals, oils and grease, nutrients, bacteria) can build up on impervious surfaces, to be washed off into aquatic resources during storm events.

The removal of streamside vegetation and installation of above-ground stormwater ponds can also increase water temperatures. Water temperature is a key parameter in the level of dissolved oxygen in flowing water, and in increased levels of bacteria. High summer water temperatures in the Green/Duwamish system have been identified as a significant issue by past investigators, and in some cases have apparently exceeded lethal levels, resulting in fish kills (Kerwin and Nelson, 2000).

Past monitoring within the Green River indicates that the Lower Green River (including Reach G-1) can be characterized as having fair to good water quality (Herrera, 2004). More recent monitoring has indicated that river waters have not always met state water quality standards for temperature, dissolved oxygen, and fecal coliform.[1]

3.3.3.1 Impaired Waters

Section 303(d) of the federal Clean Water Act requires Washington State to periodically prepare a list of all surface waters in the state for which beneficial uses of the water, such as drinking, recreation, aquatic habitat, and industrial use, are impaired by pollutants. In response to this requirement, the Washington State Department of Ecology maintains a database of streams where water quality is impaired, known as 303(d) listed water bodies. Ecology's 2002/2004 Water Quality Assessment identifies and reports on tested waterbody segments as they relate to

[1] An effort is currently underway to model water quality within the Green / Duwamish water system to support planning and development of Total Maximum Daily Loads (TMDLs) (e.g. clean-up studies). King County has contracted with Portland State University to develop a CE-QUAL-W2 model for the Green / Duwamish system (Kraft et al., 2004).

state water quality standards for a variety of parameters, including temperature, pH, dissolved oxygen, metals, etc. Not all streams or all stream reaches are tested as part of this process. Therefore, absence from the 303(d) list does not necessarily indicate that the waterbody is not impaired. Additionally, the 303(d) list includes data for all streams tested, including those that do not violate state water quality standards. Waterbody segments are classified as Category 1 through 5. Category 5 waters are polluted waters that require development of a clean up plan, or a Total Maximum Daily Load (TMDL) study. In November 2005, EPA approved the list of Category 5 waters for Washington State.

A review of the 303(d) list for the vicinity of the City of Tukwila indicates that portions of the Green / Duwamish River and some of its tributaries exceed state water quality standards and are classified as Category 5. Table 3-1 summarizes the waterbody, reach (per Department of Ecology definition based on water quality), and parameter(s) of concern.

Table 3-1. Washington State Department of Ecology 303(d) Category 5 Listed Water Bodies near Tukwila.

Waterbody	Category	Ecology Reach Description	Parameter
Duwamish River	5	Upper Turning Basin	pH DO
Green River	5	South of Black River Confluence	Temperature Fecal coliform DO
Black River/ Springbrook Creek	5	At BRPS	Fecal coliform DO

The information summarized in Table 3-1 indicates that there are high temperatures, high bacteria counts, and low levels of dissolved oxygen within the river itself. Also, high levels of bacteria and nutrients are identified in the tributaries to the Green / Duwamish system near the City of Tukwila.

3.3.4 Large Wood

Large wood (known as Large Woody Debris [LWD]) significantly influences the geomorphic form and ecological functioning of riverine ecosystems in the Pacific Northwest (Maser et al., 1988; Nakamura and Swanson, 1993; Collins and Montgomery, 2002; Abbe and Montgomery, 1996; Collins et al., 2002; Montgomery et al., 2003a; Montgomery et al., 2003b). LWD consists of logs or trees that have fallen into a river or stream. 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 as well as sediment), windthrow (trees, branches, or vegetation blown into a stream or river), or bank erosion (Stanley et al., 2005).

The presence, movement, storage, and decomposition of LWD influence the following shoreline functions:

- Delivery of wood and organics affects vegetation and habitat functions such as instream habitat structure (pools and riffles) and species diversity; and
- Riparian vegetation and LWD, provides habitat in the form of nesting, perching, and roosting as well as thermal protection, nutrients, and sources of food (terrestrial insects) to a variety of fish and wildlife species.

Investigations into historical conditions in the Green/ River Valleys indicate that LWD, including riparian forests and in-channel wood, was present as a significant structural element of the floodplain and delta ecosystem, prior to the major land use changes of the late 19th and 20th centuries (Collins and Sheikh, 2005). Significant land use changes in the Green/Duwamish River watersheds have reduced the source and potential contribution of LWD from the riparian area to the channel. Installation of dams in the upper watersheds has broken the transport patterns of wood from the upper to lower reaches. Timber harvesting, agriculture, and development of the alluvial valley have all significantly reduced the abundance and source of LWD in the Green/Duwamish River ecosystems as compared to historic conditions. Construction of levees and other shoreline modifications have limited the availability of riparian cover and LWD recruitment potential. Further, levee maintenance typically results in the removal of trees to protect the structural stability of the levee structure.

4.0 GREEN / DUWAMISH RIVER SHORELINE PLANNING AREA

This section provides reach-scale information for the City of Tukwila's Green / Duwamish River shorelines. Elements identified in the State guidelines (WAC 173-26-201(3)(c)), "Inventory shoreline conditions," are described at the shoreline planning area scale, which approximates the limits of regulatory jurisdiction under the SMA. This section focuses on existing conditions in the City's shorelines and is organized generally into two sections, Natural Environment and Built Environment. Elements of the natural environment include a description of tributary streams, wetlands, habitat, and regulated critical areas. Elements of the built environment include existing and planned land use patterns, infrastructure and shoreline modifications, parks and public access areas, and historic and cultural resources. Data gaps are discussed at the end of this chapter.

4.1 Green / Duwamish River Reaches

The portion of the Green River that flows through the City of Tukwila and its PAAs is addressed here as four reaches as shown in Table 4-1: G1 (Lower Green), G1-PAA (Lower Green PAA), G2 (Duwamish), and G2-PAA (Duwamish PAA), (Maps 6b, 6c, 6d, and 6e). Reaches are described moving from upstream to downstream (generally south to north) throughout this report.

Table 4-1. Green / Duwamish River Reaches

Reach	Length/River Miles	Shoreline Planning Area (acres)	General Location
G1-PAA	~1.3 miles (RM 16.0 to 17.3)	~36 acres	Tukwila South Potential Annexation Area (left bank only; right bank is in City of Kent)
G1	~5 miles (RM 16.0 to 11.0)	~282 acres	From upstream City boundary downstream to Black River / Green River confluence within the city limits (S. 204th Street to the north boundary of Ft. Dent Park).
G2	~7.3 miles (RM 11.0 to 3.7)	~503 Acres	From the Black River / Green River confluence downstream to the northern city limits near the 16th Avenue S. bridge.
G2-PAA	~0.6 miles (RM X to X)	~33 acres	Tukwila North Potential Annexation Area (left bank only).

A relatively wide, alluvial valley characterizes Reaches G1 and G1-PAA. However, due to flood control structures, reduction in flows, and filling from development there is no channel migration zone. The River is contained within the channel throughout the reach. The predominant land uses are commercial and retail related to the Southcenter shopping area (Tukwila Urban Center). Reach G1 is associated with a broader valley floor and only the western portion is located entirely within city limits (Map 6b). Reach G1-PAA is the Tukwila South potential annexation area and includes a mix of vacant, agricultural, residential, commercial, and light industrial uses (Map 6c).

The break between Reaches G1 and G2 occurs at RM 11, located at the confluence of the Green and Black Rivers. Reach G2 is generally characterized as a confined stream within a slightly narrower valley. Although residential and open space areas are present within G2 there is a high percentage of urban land uses and levees or otherwise hardened banks. Reach G2 makes up the majority (64 percent) of the Green / Duwamish River shoreline planning area in Tukwila (Map 6d). Reach G2-PAA is located in the City's northern potential annexation area. It includes the left bank of the river only (the right bank in this location is already part of the City) and is included in the City's Manufacturing / Industrial Center sub area (Map 6e).

4.2 Natural Environment

4.2.1 Tributaries

While the Green/Duwamish River is the only waterbody meeting the 20-cfs flow criteria to be considered a shoreline of the state in Tukwila, several smaller named and unnamed tributary channels contribute flow to the river within the City.[1] Named tributaries include: Riverton Creek, Southgate Creek, and Gilliam Creek (Map 4). These primary tributaries are subbasin watersheds that drain the slopes along the west valley ridge in the City. These channels originate from groundwater seeps or wetlands and are also influenced by stormwater runoff. In addition to these subbasin tributaries there are several smaller streams that are intercepted by stormwater pipes discharged into the river via constructed outfalls. Additional details on the primary tributaries are provided below.

4.2.1.1 Gilliam Creek

Gilliam Creek is an altered and relocated stream channel that originates near the boundary between SeaTac and Tukwila near South 158th Street. The stream flows from the upland plateau to the river within relatively natural channels, constructed channels, and piped conveyance systems. The stream drains along the south and north sides of State Route (SR) 518 and is intercepted by the WSDOT storm drainage infrastructure within Interstate 5. It enters a constructed channel along Southcenter Parkway and flows into the Lower Green River just south of the Interstate 405 bridge. A large flap-gate flood control structure is located at the creek's outfall to protect Tukwila's business district, known as the Tukwila Urban Center (TUC), from backflow during high flow levels in the river. Despite the flap gate, salmonids use the lower portions of Gilliam Creek.

4.2.1.2 Southgate Creek

Southgate Creek originates just east of Tukwila International Boulevard near South 137th Street. The stream flows within relatively natural channels but has piped sections that are potential barriers to fish movement. The lower portion of Southgate Creek is fish accessible from the Duwamish River and fish restoration projects have been implemented. When Interurban Avenue was widened, the stream crossing portion was rebuilt to allow a fish ladder, as required by

[1] During 2003 and 2004, the City prepared a citywide inventory of wetlands and streams as part of its Sensitive Areas Ordinance update.

WFDW. The NorMed restoration project provided some restoration of spawning habitat in the lower portion of the creek. Additionally, the City and private landowners have participated in salmonid supplementation efforts to promote restored fisheries in this stream.

The upper watershed portions of Southgate Creek are characterized by year round flow, even in dry summers.

4.2.1.3 Riverton Creek

Riverton Creek is a perennial stream that originates in a large wetland area east of Military Road South and South 128th Street. Due to past development, Riverton Creek flows through modified channels and has piped segments. The lower portion of the Creek's channel, east of Tukwila International Boulevard, was relocated years ago when the valley floor was developed for commercial buildings and highway construction (State Route 599).

The Creek is supported by groundwater seepage areas and provides base-flows and water quality capable of supporting resident and anadromous fish. Native cutthroat trout and coho salmon are present within the Riverton Creek drainage.

The Riverton Creek outfall to the river is channelized and had flap-gate control structures installed years ago. One flap-gate remains at the outfall currently. Just upstream of its outfall location at the Tukwila International Boulevard bridge, the creek flows through a tidally influenced pond constructed by WSDOT. The in-stream pond is considered a wetland that may provide beneficial habitat for anadromous salmonids that are able to enter the stream system. In Tukwila, Riverton Creek is a relatively high quality and functioning stream with a stable hydrologic regime. The historic habitat conditions have been altered but the Creek provides a source of cold water and fish habitat. The City has also conducted a salmonid supplementation program in the creek.

4.2.1.4 Other Stream Systems

Several streams located in the PAAs also contribute flow to the river. In the Tukwila South PAA (G1-PAA) on the west side, a stream drainage known as Johnson Creek conveys flows from the upland plateau and valley wetlands to its outfall just north of South 204th Street (approximately RM 18). Johnson Creek is considered a primary tributary having a contributing basin area of approximately 850 acres (Tukwila South Project Draft EIS, 2005). Within the PAA, Johnson Creek is characterized as an agricultural ditch with several ditched tributaries. It also has a floodgate control structure at its outfall to the Lower Green River. The majority of streams identified in the south PAA are characterized as historic watercourses that are now contained in manmade channels. Fish surveys conducted by King County and WDFW have identified Johnson Creek as a salmonid fish-bearing water (Tukwila South Project Draft EIS, 2005).

Other unnamed steam segments in the south Tukwila PAA originate from seeps on the western slope and have a combination of relatively natural flow channels and piped segments that, in general, discharge to storm drainage systems on the valley floor.

The north PAA is located on the west side just north of RM 5 and includes a historic stream known as Hamm Creek. Hamm Creek originates on the west hillside but within the PAA has

been routed into roadside ditches associated with State Route 599 and West Marginal Place South. Hamm Creek is a perennial stream that supports salmonid fish species. The Creek was piped to the river through a large land holding owned by Seattle City Light. Several years ago, private and public restoration efforts sponsored the "daylighting" of the piped segment of Hamm Creek. The restoration created an enhanced open channel from West Marginal Place South to the Duwamish River.

4.2.2 Wetlands

Wetland resources within the Green / Duwamish River basin portion of the City of Tukwila have been highly modified since the mid-1800s. In the Duwamish River estuary nearly all (97 percent) of the historic mudflats and tidal marshes have been either filled or dredged (Kerwin and Nelson, 2000). In general, the Lower Green River wetland ecosystems have been fragmented and otherwise degraded by past activities of diverting rivers out of the historic Green River watershed, diking and channelizing the Lower Green River, and changing land uses in the basin. Wetlands mapped in the City of Tukwila are shown on Map 4.

Many of the City's wetlands are fragmented areas divided by roads, major transportation corridors, and residential and commercial developments. Fragmentation of the wetlands has resulted in lower quality habitats with a high percentage of non-native, invasive species within the wetlands. The City's wetland inventory identifies relatively few wetlands within or adjacent to the Green / Duwamish River's shoreline planning area. The wetlands that remain within the shoreline planning area are predominantly palustrine emergent and palustrine scrub/shrub habitat types as classified using the US Fish & Wildlife Service wetland classification system (Cowardin et al., 1979). These wetlands have limited functions of detaining surface water flows, maintaining groundwater recharge/discharge interaction, providing habitat, and improving water quality. Some of these wetlands are spatially disconnected from the River.

A large and significant inventoried wetland system is located on the east side of the Lower Green River but is no longer connected to the river as floodplain either by open drainages or native habitats. This wetland area drains to the east, to the Springbrook Creek subbasin, and is generally located between Lower Green RM 13.4 and RM 14.4.

The City's wetland inventory does not extend into the PAAs. The Tukwila South Project Draft EIS (City of Tukwila, 2005b) includes results of site delineations for wetlands in that area. The project site contains 19 wetlands totaling approximately 48.7 acres on the site (some wetlands extend off site and two of these wetlands are within G-1 and are not part of the PAA, although they are part of the Tukwila South Project Site). Wetlands delineated include a variety of cover types, although most include or are dominated by forested cover or agricultural crops. Most wetlands are small and some are hydrologically isolated (City of Tukwila, 2005b).

The north PAA, generally located between RM 4 and RM 5 west of the Duwamish River, is mostly developed with only fringe areas of wetland habitat present. Several wetlands have been created along the Duwamish shoreline near the Turning Basin within the City, as part of salmon enhancement efforts. They function as off-channel habitats for salmon and other wildlife and have been planted with native plants appropriate to site conditions.

Several of the wetland systems within the City limits are considered regionally significant in functions and values given their area and position in the landscape. However, the larger wetlands that provide higher functions are located outside of the shoreline planning area. The numerous slope wetlands that exist on the west hillside above the river provide forested habitat and perennial water flows to maintain streams and habitat connections with the River. These wetlands are not located in close proximity to the River but do provide hydrologic support tributary streams and habitat corridors for wildlife.

4.2.3 Fish and Wildlife Presence

The City of Tukwila regulates Fish and Wildlife Habitat Conservation Areas under the Zoning portion of the Tukwila Municipal Code (TMC). TMC (18.45.150) defines Fish and wildlife habitat conservation areas as:

- Areas with which endangered, threatened, and sensitive species have a primary association;
- Habitats and species of local importance, including but not limited to bald eagle habitat, heron rookeries;
- Commercial and recreational shellfish areas;
- Kelp and eelgrass beds;
- Mudflats and marshes;
- Naturally occurring ponds under 20 acres and their submerged aquatic beds that provide fish or wildlife habitat;
- Waters of the State;
- State natural areas preserves and natural resource conservation areas; and
- Areas critical for habitat connectivity.

Fish species distribution maps (PHS) (WDFW, 2004) identify Priority Anadromous and Priority Resident Fish presence throughout the Green / Duwamish River. Every species of anadromous salmonid that is native to the west coast of North America (coho, Chinook, sockeye, and pink salmon and coastal cutthroat, steelhead, and bull trout/Dolly Varden char) as well as non-native (Atlantic salmon) were recently found in the Green / Duwamish watershed (Kerwin and Nelson, 2000). Chinook salmon are documented as occurring throughout the Green / Duwamish River within the City's shoreline planning area (Williams et al., 1975; Anchor, 2004). However, no salmon spawning apparently occurs in the river in the City limits due to a lack of adequate spawning habitat (Pentec, 2003).

The USFWS designated the Green River as critical habitat for bull trout (Federal Register, Vol. 70, No. 185) and NOAA Fisheries designated critical habitat for Chinook salmon (Federal Register, Vol. 70, No. 170). Primary bull trout habitat use within both reaches is for foraging, migration, and over-wintering. Small numbers of char (bull trout/Dolly Varden) have been documented using Reach G-2, Duwamish River.

On March 29, 2006, NOAA Fisheries proposed federal listing of Puget Sound ESU steelhead, which occur within the City's shoreline planning area. Review of the proposed listing, with a period of public comment and an investigation of possible "critical habitat" designation, is underway. A final decision regarding federal Puget Sound ESU steelhead listing is expected in 2007 (Federal Register, Vol. 71, No. 60).

In addition to fish species, the PHS maps indicate a great blue heron colony and bald eagle nesting activity near Tukwila but not within City limits. These habitat points are located to the south and west of the City limits within one mile. However, the Wildlife Heritage Point Species List and Mapping does include locations of osprey nesting within the City. The osprey is not a Priority Species but is a raptor and is classified by the Wildlife Heritage program as "Special Animal" (SA) (WDFW, 2004).

Photo 4-1. Tribal fishing near the Turning Basin.

4.2.4 Instream and Riparian Habitat Conditions

Baseline studies of existing habitat in the Green River have been prepared to support WRIA 9 salmon recovery planning efforts. Existing habitat conditions within Reaches G1 and G2 were described in *Lower Green River Baseline Habitat Survey Report* (Anchor, 2004). Both reaches are channelized within a system of revetments and levees including some bulkhead structures. The river is limited to the area within the revetments/levees, with some potential backwater areas. Additional information on the Duwamish River, particularly the transition zone, will be available from WRIA 9 in the future. Information from the data sheets prepared by Pentec Environmental in 2003 and supplemented by City staff in 2006 also provides information on riparian conditions.

The inventories and studies conducted within Reaches G-1 and G-2 describe riparian habitat as low- to medium-quality and dominated by non-native invasive plants (Anchor 2004 & Pentect 2003). Historic agricultural land use, channel modifications, and old revetments removed native

trees and shrubs from riparian areas. The maintenance and disturbance of these areas has allowed non-native plants including blackberry, Japanese knotweed, and reed canary grass to establish and dominate much of the River's banks. Native shrubs species including willow and red osier dogwood have persisted in areas where there are less intense land uses. In addition, there are segments that still retain mature black cottonwood, big leaf maple, and red alder trees within the riparian area. Overall, there are long segments of the River that have very little native vegetation or the cover is mixed with non-native and invasive species.

Further results of instream habitat surveys are summarized in Table 4-2. The shoreline inventory studies indicate there is very little LWD recruitment occurring in the River. Pool formation occurs at a low percentage and is predominantly associated with riprap along the river bends. Stream habitat diversity is low with glides being the primary bedform present. There are no spawning or potential gravel storage areas observed in the studies.

Table 4-2. Summary of Baseline Habitat Monitoring Results by Green River Reach

Parameter	Reach G1 (Anchor, 2004)	Reach G2 (Anchor, 2004)
Location	RM 16 to 11	RM 11 to 6
Average OHW width	28 m (92 ft)	50 m (164 ft)
Total pools per mile	1.6	0.9
Percent large pool by length	3 percent	4 percent
Percent large pool by area	<1 percent	0 percent
Dominant large pool forming factor	Rip-rap/bedrock	Rip-rap
Total Wood Pieces	174	202
Large pools formed by LWD	0	0
LWD/mile	40	38
Average percent armoring for both banks	36 percent	35 percent
Median canopy cover	57 percent	44 percent
Number of existing gravel storage areas	0	0
Number of potential gravel storage areas	0	0

Notes: (1) Large pools have a width greater than 50 percent of the OHW width, (2) Anchor report does not cover Green/Duwamish River below RM 6.

4.2.5 Flood Hazard Zones

Flood hazards within the Green/Duwamish River system have been significantly reduced from the historic condition by: (1) the movement of the White River into the Puyallup drainage, (2) the lowering of Lake Washington, which removed input from the Black and Cedar Rivers, (3) installation of the Howard A. Hanson Dam, and (4) the installation of levees and revetments along the channel banks. These alterations are described in Section 3. Portions of the levee system are now greater than 50 years old, and are unlikely to meet current engineering standards.

Since 1993, over $9 million have been spent on maintenance and repair of levees and revetments within the middle and lower reaches of the Green River. King County has identified several projects intended to repair levees, and mitigate potential future channel migration (King County, 2006). The communities along the Green River, including Tukwila, depend heavily on the levee system to mitigate flood hazard. Preliminary risk analyses indicate that the levee system prevents more than $60 million in flood-related damages on an average annual basis (King County, 2006).

FEMA produces and administers maps that support the National Flood Insurance program (known as Federal Insurance Rate Maps or FIRMs). These maps show special flood hazard areas (e.g, the 100-year floodplain). Existing FIRMs (1989) for the community of Tukwila indicate that the flood elevation with 1 percent annual probability is generally limited to the area within the levees throughout the City of Tukwila. There are also some low areas near the river that exist below the determined base flood elevation. King County is currently sponsoring a new floodplain study of the Green River system, which is scheduled to be complete in 2007 (King County, 2006).

As part of FEMA's Map Modernization program, the status of the levees in this area is currently being reviewed. The federally certified levees are located between I-405 and S. 180th Street and protect the Tukwila Urban Center. As a result of this review, some areas of the levee system could be de-certified by FEMA, which would have significant impacts on the extent of the mapped regulatory floodplain. These levees were typically constructed more than 50 years ago, and show signs of sloughing in oversteepened sections (Photo 4-2). High flows (including 1965, 1990, and 1996) resulted in levee destabilization in numerous locations, including the Segale levee in the Tukwila South PAA.

Photo 4-2. View of the left (west) bank of the Green/Duwamish River near RM 11.7 taken from the Green River trail on November 2, 2006.

4.2.6 Channel Migration Zones

Channel migration zones are used to indicate areas the active channel can be expected to occupy over time (Rapp and Abbe, 2003). Local geology, soils, channel bank conditions, and flow regime are the principal factors driving rates and trajectories of channel migration.

No formal channel migration zones have been mapped through the City of Tukwila because of the presence of levees and revetments throughout this reach of the Green/Duwamish. Little overall change in channel plan form has been detected since the late 1800s (Collins and Sheik, 2005). Therefore, while significant channel migration has certainly occurred in the past, land use and river management changes have reduced the potential for channel migration under existing conditions (King County, 2006).

While potential for channel migration in Tukwila is considered low or minimal, a general Channel Migration Zone analysis was performed for the purposes of Inventory and Characterization (WAC 173-26-201(3)(c)(vii).

The Green/Duwamish is a low-slope (less than 1 percent longitudinal slope) meandering river (sinuosity >1.4). This river morphology typically has the potential for significant channel migration either through lateral erosion/deposition processes or through meander cut-off (for example: Leopold, 1994; Knighton, 1998; Rapp and Abbe, 2000). Historically, it appears that the river system meandered over much of the valley floor (Collins and Sheikh, 2005).

As discussed in Chapter 3, significant changes to fluvial processes in the Green/Duwamish system have occurred in the last 150 years. These changes will influence future channel migration within the City. Significant changes include:

- Significant reduction in water discharge due to diversion and installation of the Howard Hanson Dam;
- Installation of levees and/or revetments along most of the channel banks in the City, including the federally-certified 205 levee system (Map 8);
- Installation of impervious surface and structures on the former floodplain behind the levees;
- Development of interlocal agreements to undertake flood fighting measures to preserve the current channel alignment; and
- The installation of significant north-south and east-west highways (e.g., I-5 and I-405).

The cumulative affect of these hydromodifications is that the Green/Duwamish River cannot migrate as it has in the past. The WRIA 9 limiting factors report indicates that the channel migration zone is limited to the area within the levees (Kerwin and Nelson, 2000). While this is likely the case, there are three mechanisms that could result in channel migration in the future:

- Liquefaction after a significant earthquake;
- Meander cut-off; and
- Small-scale levee and revetment slumps/failures.

Liquefaction

The entire alluvial valley and former delta has been mapped as being susceptible to liquefaction. An earthquake could compromise existing bank protection measures, and portions of the floodplain could subside. Flow could then engage those subsided areas resulting in channel avulsion. While this process could occur, the likelihood is tied to recurrence intervals of significant Seattle Fault or subsidence zone seismic events. Further, it is not possible to specifically map areas where the channel could migrate as a result of this process.

Meander Cut-Off

The meandering plan form of the river lends itself to migration as flood events overtop banks and water flows back into the channel, cutting off the existing meander bend. Inspecting recent aerial photos, there are some areas within the City that may be susceptible to meander cut off (Figure 4-1).

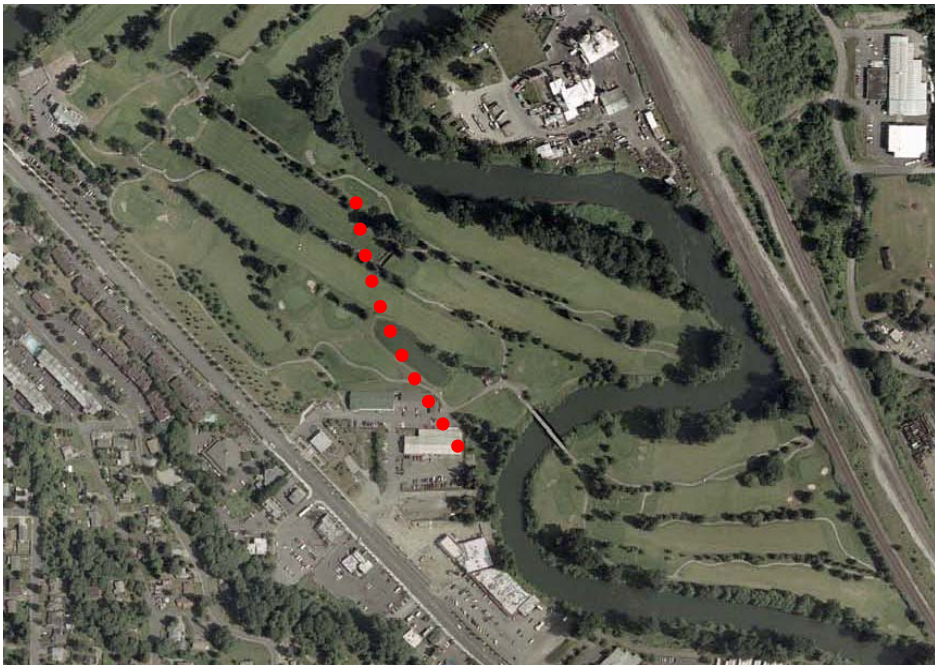


Figure 4-1. Potential meander cut-off example along the Green/Duwamish River in Tukwila
(Not to scale, north to top of page)

While the channel pattern lends itself to meander cut-off, the presence of significant levees and revetments and the low-slope, and therefore low-energy, fluvial environment make it unlikely that cut-off of this sort would occur. Additional topographic, hydraulic, and geotechnical studies would be required to quantify the potential for meander cut-off in the City.

Small Scale Bank Slumps/Failures

Smaller scale levee slump or toe failures are the most minor, but also the most likely form of channel migration within the Green/Duwamish River in Tukwila. Many of the levees and revetments, especially north of the 205 levee system, were installed decades ago, and may not conform to current engineering and/or materials standards. The King County Flood Hazard Management Plan (2006) identifies levees with relatively steep side slopes (e.g. 1 to 1.5:1 H:V) as having the potential to fail.

Long duration high flows in November 2006 resulted in some failures along the Lower Green River (Figure 4-2). While these failures are unlikely to result in significant change in channel plan form, these failures could be pervasive through sections of older levees or revetments, potentially resulting in flooding or negative impacts to water quality as fine sediment from the failing banks is entrained in the flow.

Figure 4-2. Slope erosion and slumping failure – Lower Green River (King County, 2006)

4.2.7 Aquifer Recharge Areas

Comprehensive mapping of aquifer recharge areas in the vicinity of Tukwila has not been prepared. The hydrogeologic setting of the Green/Duwamish Valley results in significant connection between surface and ground waters. Throughout the City, general shallow groundwater flow patterns in the shallow alluvial (Qal) aquifer appear to be (1) downvalley (towards Puget Sound) and (2) into the river (Woodward et al, 1995). Aquifer recharge is not likely a significant ecosystem process in this area (Fabritz et al, 1998). There are likely times where flow in the Green/Duwamish River moves into the floodplain via groundwater (e.g. high flow and/or high tide conditions). These conditions are likely not typical of the annual functioning of the system, and are limited to interaction within the shallow (Qal) aquifer.

4.2.8 Geologic Hazard Zones

In the City of Tukwila, Geologic Hazard Zones focus on the seismically and volcanically active geological setting, as well as the steep hillslopes that connect the upland plain to the alluvial valley. The Puget lowlands can be impacted by both subduction zone earthquakes, and intraplate fault earthquakes. For example, the Seattle Fault zone exists at and north of the City of Tukwila. Earthquakes in this region are typically considered the primary geologic hazard because of the potential to cause widespread destruction of infrastructure. Earthquakes near Tukwila can result in direct impacts to structures and liquefaction of floodplain and fill materials.

Washington State Department and Natural Resources (DNR) has developed a liquefaction susceptibility map that covers the City of Tukwila (Palmer et al., 2004). On this map, the majority of the alluvial Green Duwamish Valley is mapped as having Moderate to High or High susceptibility to liquefaction. Within the City of Tukwila, areas mapped as High liquefaction susceptibility appear to correlate to former river channel alignments.

The USGS has investigated the potential impacts of a significant lahar (mudflow) from Mount Rainier on the major river valleys that drain the mountain. This work suggests that the City of Tukwila could be influenced by future lahars, since it is within the area historically directly influenced by lahars (e.g., the Osceola mudflow). However, these events are thought to have a low probability. Tukwila is within the area that could be influenced by post-lahar sedimentation. This sedimentation within the stream channels could significantly change flow patterns, increase flooding, and change channel alignments (Hoblitt et al., 1998).

The City of Tukwila regulates steep slopes and former coal mining locations as areas of potential geologic instability. Geologic Hazard Maps developed by the City of Tukwila in 2004 show areas classified as Class 2 through 4, along with Renton Coal Formation and Coal Mine Hazard areas. Class 2 denotes areas of moderate landslide potential; where slopes are 15 to 40 percent and underlain by relatively permeable soils. Class 3 denotes areas of high landslide potential; where slopes are between 15 and 40 percent and underlain by relatively impermeable soils or by bedrock; also includes all areas with slopes greater than 40 percent. Class 4 denotes areas of very high landslide potential; including sloping areas with mappable zones of groundwater seepage, and including mappable landslide deposits regardless of slope (TMC 18.45.120). Many of the mapped areas of potential geologic instability are located along the cut and fill slopes

associated with the highways within the city. Within the shoreline planning area, Class 2 and 3 slopes are shown along the levee sideslopes, as these slopes typically exceed 15 percent.

4.3 Built Environment

4.3.1 Existing Land Use

Existing land use within the Green / Duwamish River Planning area was calculated from property information available on the King County Assessor's webpage (King County, 2006). Land use categories were aggregated into broad, more useful categories: retail/commercial, light and heavy industrial, recreational/open space, residential, and vacant land uses. Land use by parcels does not cover the full shoreline planning area, as open water and shoreline areas, as well as some rights-of-way, are not mapped. For this reason, percentages indicated below only represent the parcel land use for those parcels within the shoreline planning area.

Within the Reach G1 planning area, the land use pattern is predominantly a mix of retail/commercial (28.4 percent overall, higher than 70 percent in the Tukwila Urban Center area) and light and heavy industrial (35.2 percent) lands. Additional significant existing land uses include recreational/open space areas (14.6 percent), and vacant residential, commercial, and industrial areas (15.9 percent). Small amounts of low and moderate-density residential areas (less than 1 percent) are also present in this reach. Land use near the west side of the Tukwila South PAA reach is predominantly undeveloped, vacant, or actively farmed agricultural lands, with small areas associated with industrial activity.

The City's land use pattern in the Duwamish River reaches, G2 and G2-PAA, is mainly manufacturing and industrial (30.76 percent), the majority of which is downstream of the East Marginal Way South bridge. In the southern portion of Reach G2, the existing land use pattern is predominantly a mix of residential (13.6 percent), retail/commercial (6.2 percent), and public parks, recreational, and open space lands (18.8 percent).

As described in Section 1.3, Tukwila's current Shoreline Master Program establishes shoreline environment designations. All reaches of the Green/Duwamish River are currently designated Urban. The King County SMP designates the Green River shoreline Rural in G1-PAA and the Duwamish River shoreline Urban in G2-PAA.

The City's Zoning Map (TMC Title 18) and Comprehensive Plan Land Use Map mirror each other as far a designated land uses. The Comprehensive Plan provides policy guidance as a long range planning tool while the Zoning Code provides the day to day regulations that help implement the Comprehensive Plan (City of Tukwila, 2004 & 2005a). In the City's shoreline planning areas, and throughout the rest of Tukwila, the existing Zoning Code and Comprehensive Plan designations are the same (Map 9). Further description of Comprehensive Plan and Zoning designations can be found in Section 6.

4.3.2 Existing Public Access Sites

A primary goal of the Shoreline Master Plan is to provide for public access to shorelines. The City's 2001 *Parks, Golf, and Open Space Plan, 2001-2006* (City of Tukwila Department of

Parks and Recreation, 2001) describes the parks, golf courses, open spaces, and trails in the City's shoreline planning area, as shown on Map 10.

Several City and County parks and open space areas offer access to the Green / Duwamish River shoreline. Excluding regional trail systems, approximately 16.4 percent of the Green / Duwamish River shoreline planning area is developed as parks or designated open space.

King County owns and maintains the Duwamish/Green River Trail (River Trail), which passes through the City. The River Trail provides public access to the shoreline (but limited access to the water's edge) throughout much of the City. The River Trail begins near the intersection of 27th Avenue South and South 102nd Street within the northern extent of the City, and continues to the south, extending beyond the southern borders of the City and the Tukwila South PAA to the City of Auburn. Within the City limits, the River Trail generally follows the course of the Green River, but extends away from the river for two short stretches: along Interurban Avenue South from RM 7 to RM 7.6 and again from RM 9.4 to RM 10.4 (at the Foster Golf Course). The River Trail crosses the river five times within the City, with the majority of the trail along the western shoreline and three short segments along the eastern bank.

The River Trail connects a series of parks that border the Green River throughout the City. Upstream (south) of the Interstate 405 crossing to the southern border of the City and the Tukwila South PAA, there are limited park or other public access opportunities within reaches G1 and G1-PAA. Bicentennial Park (1.0 acre) and P-17 Pond Park (2.0 acres) are both integrated with the trail and provide additional recreational opportunity along the trail corridor. There are no public access locations with the exception of the trail within the G1-PAA planning area.

Between the Interstate 405 and Interstate 5 crossings, within portions of reaches G1 and G2, public access is provided via parks and golf courses in the shoreline. Foster Golf Links (67 acres), Riverfront Park (1.0 acre), and Fort Dent Park (King County, 54 acres) all provide significant shoreline access and recreation opportunities, and are linked via the regional trail system.

Small portions of the river downstream (north) of the Interstate 5 crossing are also designated as parks. In Reach G-2, Cecil Moses Park (2.0 acres) provides picnic tables and public restrooms and connects with the trail. Parks that provide physical and/or visual access to the river on the opposite shoreline from the trail include Duwamish Park (3.0 acres), Tukwila Community Center (12 acres), and Codiga Farm Pea Patch and Park (still under construction and not yet open to the public, 3.0 acres). In addition to shoreline access, these parks provide a variety of other active and passive recreational activities. Picnic tables, benches and exercise guides/facilities are interspersed at various points along the trail, in addition to those provided within the trail-adjacent parks.

Unofficial recreational fishing sites and fishing shelters are found at various locations of the entire Green/Duwamish shoreline in Tukwila.

There are currently no boat launch facilities on Tukwila's shoreline, but one is planned as part of a salmon enhancement project in reach G-2, the Codiga Farms site at River Mile 10.

4.3.3 Historic and Cultural Resources

The existing Tukwila Shoreline Master Program provides a general goal to identify, restore and preserve those features of historical/cultural, scientific, and educational value for use by the public (City of Tukwila, 1974). The City of Tukwila Comprehensive Plan (2005) also addresses historic preservation. The plan establishes a goal to maintain, preserve, and enhance the City's historic, cultural, and archeological resources to provide a sense of local identity and history to the community. Policies also direct the City to preserve and protect these sites from incompatible land uses and consider developing an official local designation status, which would recognize and protect designated sites.

As part of the Visioning Tukwila process that led to the development of Tukwila's Comprehensive Plan in 1995, different types of historic and cultural land uses within the City were identified, with specific sites for these uses identified on a map (City of Tukwila Historical Uses Map, January 1993). The broad categories that historical and cultural uses in the City of Tukwila were classified into include (1) Public Art; (2) Historical (including places associated with people, events, etc.); (3) River Channel History (including floodway, floodplains, river diversion, oxbow/meander, and diking); (4) Early Native American Sites; and (5) Archaeological Sites. Several of these historic and cultural sites are located within the Shoreline Planning Area, and are highlighted on Map 11. Due to the sensitive nature of some of the archaeological and Early Native American sites, these are not identified on the map. However, as shown in Photo 4-3, commemorative markers along the Duwamish/Green shoreline do reflect and represent Native American uses. In the south PAA, there is a house that is eligible for the National Register of Historic Places (the home of the Mess family who settled and farmed much of the land in this area in the mid-1800s).

The Washington State Department of Archeology and Historic Preservation maintains a database of sites that have been inventoried and cataloged by State Archeologists, as well as a database of sites that are protected by Washington's Historic Register (WHR) and the national register (NR). A search of the database for inventoried sites within the City's shoreline planning area revealed a series of sites of 'Pre-Contact' (Native American) and 'Historic' (Non-native American) nature. Sites inventoried with Native American significance in Tukwila included a broad range of artifacts, including: lithic scatters, mammal bones, a traditional fishing camp, a subsistence farming area, areas of charcoal, shells, chipped stone fragments, and a V-shaped fish trap in the river's main channel. Sites inventoried with 'Historic' significance included a historic camp and a historic railroad grade originally constructed in 1874 as part of the Columbia & Puget Sound Railroad. A search of the database for WHR and NR sites within the City's shoreline planning area revealed no designated sites. Several of the inventoried sites discussed above are noted to be potentially eligible for WHR and/or NR status. Given these findings, there is a high probability of additional archaeological resources near the shoreline of the Green/Duwamish River. These resources, if existing in the City and PAA, may have been removed or destroyed during construction of the levees, or they may be below areas previously disturbed by

construction. The City evaluates archeological and historical resources on a parcel-by-parcel basis during development review.

There is one site within the City's Green/Duwamish River planning area that is on King County's Local Landmarks List. The Fourteenth Avenue South Bridge, originally constructed in 1930 and designated by the County in 1996, spans the river near the northern extent of the City's limit.

Photo 4-3. Cultural landmark at Tukwila Community Center.

4.3.4 Impervious Areas

The amount of impervious area in the Green/Duwamish River shoreline planning area is related to the existing development pattern and land use surrounding the shoreline. The shoreline planning areas of the Duwamish River PAA, Duwamish River, and Lower Green River reaches are all fully developed, with existing development comprised largely of impervious materials (paved parking lots, roads, sidewalks, and buildings). The original SMP for Tukwila, however, did identify a 40-foot setback area from the mean high water mark of the river that was to remain largely undeveloped. In some shoreline areas this setback is greater than 40 feet and in some areas, where development likely predated the SMA, the setback area is less than 40 feet.

Impervious area within the G1 PAA is approximately 6 percent of the 36 acres within this southern planning area reach. Within Reach G1, the impervious area is approximately 36 percent of the 282 acres of shoreline planning area. Within Reach G2, the impervious area is approximately 26 percent of the 503 acres of shoreline planning area. Impervious surface area within the G2 PAA is approximately 9 percent of the nearly 33 acres that makes up the shoreline planning area.

Impervious area and the potential effects on water bodies receiving runoff are more usefully measured on a stormwater basin scale. The comprehensive Surface Water Management Plan (City of Tukwila, 2003) summarizes land uses and estimates percentage of land use for each of

the City's subbasins. Seven subbasins make up the approximately 12 square miles that drain to the Green River in the City and its PAA (City of Tukwila, 2003). The drainage area contains industrial, commercial, residential, and open space/recreational land uses. Land uses in the majority of the subbasin areas, except those used as open space and recreational areas, are fully developed and include significant levels of impervious cover typical to industrial, commercial, and residential areas, respectively.

4.3.5 Channel Bank Modifications

As described in previous sections, virtually all of the banks of the Green River within the City of Tukwila have been modified (Photos 4-2 and 4-4). While moderate-quality riparian vegetation exists predominantly in the northern portion (Duwamish River Reach) of the City, most portions of the Green/Duwamish system are constrained by dikes, levees, and/or revetments throughout the City and potential annexation areas. An average of approximately 35 percent of both banks are visibly armored with rip rap and other bank stabilization materials within the system (Anchor, 2004). Several docks associated with industrial/manufacturing facilities exist within the Duwamish River Reach. Bridge infrastructure has also modified the shoreline (see Section 4.3.6) In addition, small docks, bulkheads and over water decks exist in some of the residential and industrial areas in DW-2.

Photo 4-4. Green River Levee near Costco north of S. 180th St.

4.3.6 Roads and Bridges

There are a number of local, state, and interstate travel routes through the City providing strategic regional connections that pass within close proximity and span the Green/Duwamish River. Many other public roadways pass through or are aligned within the shoreline planning area of the Green/Duwamish; these roads provide local access to the businesses and residences found within the planning area (Map 12). Of the major arterials in the City, five are highlighted in this section due to their local and regional importance and interaction with the shoreline environments. These roadways are: West Valley Highway, Tukwila International Boulevard (formerly called Pacific Highway and also known as Highway 99), Interurban Avenue,

Southcenter Boulevard, and State Route 599. Discussion of Interstate Highways is limited to crossings of I-5 and I-405, as these are the only areas where these freeways are in close proximity to the Green/Duwamish River.

West Valley Highway is aligned along the eastern side of the Green River from south of the I-405 crossing to near South 188th Street. The two-to-four lane arterial is surrounded by a mix of office, industrial, and commercial uses, with some older single residential units and newer apartment structures.

Tukwila International Boulevard (Highway 99) was a precursor to Interstate 5 and still contains vestiges of the old highway with commercial activity mixed with a few residential buildings. Tukwila International Blvd. is only in close proximity to the shoreline planning area in the Duwamish River Reach, at and around the crossing noted in the bridges discussion below.

Interurban Avenue is isolated from most of the community but has good access to the interstate system. The two-to-four lane arterial is surrounded by a mix of office, industrial, commercial and significant recreational uses, and travels along and in close proximity to the River from the south end of Fort Dent Park to the I-5 overpass.

Southcenter Boulevard (from Interurban Avenue to Pacific Highway South) is the newest of the corridors and, unlike the others, it is characterized primarily by office and residential uses, with only limited commercial use. Southcenter Boulevard is in close proximity to the Lower Green River Reach at and around where it crosses the river near the arterial's intersection with Interurban Avenue.

State Route 599 passes between Highway 99 to the west and I-5 to the east, traveling along the Duwamish River Reach in the area opposite the river from the Allentown community. The highway is a major regional connector and experiences high traffic volumes, especially during rush-hour periods.

Ten bridges cross the Green River in Reach G1 and one bridge crosses in Reach G1-PAA. Moving upstream, from north to south, reach bridges include: pedestrian bridges for the Green River Trail at either end of Fort Dent Park; a five lane bridge for Interurban Avenue South; a four lane bridge providing on- and off-ramp access to Interstate 405; a five lane bridge for Southcenter Boulevard; an eight lane bridge for Interstate 405; a four lane bridge for Strander Boulevard; a bridge for a railroad spur from the Union Pacific rail corridor; a six lane bridge for South 108th Street; and a pedestrian bridge for the Green River Trail near the South 108th Street bridge. Within the G1-PAA planning area at the south end of the city, there is a four-lane bridge for South 200th Street.

Ten bridges cross the Duwamish River within reaches G2 and G2-PAA. Moving upstream from north to south, they include: a two lane draw bridge for 14th/16th Avenues South; a private Boeing access bridge near Francis Avenue South; a two lane bridge for South 102nd Street; a pedestrian bridge for the Green River Trail at South 112th Street; a five lane bridge for Tukwila – International Boulevard (also known as Pacific Highway South) that also includes a crossing for the Green River Trail; a two lane bridge for East Marginal Way South; a pedestrian bridge near South 119th Street and 42nd Avenue South; a two lane bridge for 42nd Avenue South; a ten lane

bridge for Interstate 5; a two lane bridge for 56th Avenue South; and a pedestrian and golf cart bridge for Foster Golf Course.

Photo 4-5. Bridges across Green River in Tukwila.

4.3.7 Utilities and Infrastructure

4.3.7.1 Wastewater

The City of Tukwila provides sanitary sewer service within portions of the City's boundaries (and to some small areas outside City boundaries). Remaining portions of the City are served by several other area sewer utilities, including Val Vue Sewer District in the central and northern portions of the Duwamish River Reach and Kent Sewer in a small southerly portion of the Lower Green River Reach (City of Tukwila, 2004). The City of Tukwila's Sewer Program is responsible for both maintaining it's own collection system and coordinating service throughout the City amongst other sewer utility providers. The City's system, and the Val Vue and Kent systems, are primarily collection systems that convey sewage to King County's regional sewage treatment plant in Renton (City of Tukwila, 2004). There are no known sewage outfalls within the City's Green/Duwamish River planning area.

In Reach G2, the Allentown Neighborhood on the east bank of the river near the 42nd Avenue South bridge, is currently undergoing a multi-phased project of sewer upgrades. Residential parcels along the shoreline in this area are currently served by privately owned and maintained on-site sewer systems. Tukwila Public Works is charged with connecting all residential parcels in the neighborhood to the public sewer system. The final phase of this was begun in March 2006 and will be completed by Spring 2007 (City of Tukwila, 2006). There are no other areas in the Green/Duwamish River shoreline planning area in Tukwila that are not served by public utilities.

4.3.7.2 Stormwater

The City of Tukwila also operates a stormwater management system that is funded through a city-wide storm/surface water utility district. The surface water management system, operated through the Public Works Department, manages surface and storm waters at a basin level across the seven basins identified in the City's *Comprehensive Surface Water Management Plan* (2003). This plan serves as a guide to the City's Public Works Department in implementing the surface/storm water specific policies set in the Comprehensive Land Use Plan. Key issues highlighted by the Comprehensive Land Use Plan include: requirements for new development, flood hazard reduction, the importance of using Washington State Department of Ecology stormwater standards, cooperation and coordination with adjoining jurisdictions, and securing funding for maintenance, education, and enforcement programs.

The City's existing surface/storm water system consists of a combination of regional and basin detention and treatment facilities, as well as some on site systems. The City's *Comprehensive Surface Water Management Plan* (2003) outlines the City's needs for drainage facilities and informs the development of the City's current Capital Improvement Program. Chapters 14.28 and 14.30 of the Tukwila Municipal Code establish the City's stormwater utility and stormwater standards for new development.

The City's storm-and surface water drainage system includes approximately 5,420 acres that drain to Riverton, Southgate, Gilliam Creeks, and ultimately to the Green/Duwamish (Map 4). The City is in the process of mapping all of its stormwater facilities in GIS format. To date, only the northern portion of the City is complete north (downstream) of the 42nd Avenue South Bridge, approximately 60 stormwater outfalls drain into the Green/Duwamish in the City.

4.3.7.3 Water Supply

The City of Tukwila provides water service within portions of the City limits through Tukwila Water Utility (City of Tukwila, 2004). The majority of the areas surrounding the Green/Duwamish Rivers are supplied by the City Utility; however small portions of the planning area are supplied by Seattle Water District and King County Water District #20 in the north, King County Water District 125 in central Tukwila, and Renton Water District Highline Water District provides service in the south part of the City, south of 180th along Southcenter Parkway in the south. King County Water District 20 provides water in the area of the northern PAA. The Highline Water District provides water in the area of the southern PAA. The City's service area is currently supplied entirely from the City of Seattle's water system through a long-term purveyor contract. Nearly all of the water supplied to Tukwila comes from the Cedar River Watershed through the 60-inch Cedar River Pipeline Number 4 on the south and the 48-inch West Seattle supply line on the north.

4.3.8 Contaminated Sites

The Department of Ecology maintains a statewide GIS database of facilities with suspected or confirmed contaminated sites, and facilities with the potential to introduce contaminants into the environment. The database was reviewed to identify any known sites in the Green/Duwamish River shoreline planning area in Tukwila. Twenty-two (22) sites are located in proximity to

Reach G1, including 14 listed as hazardous waste generators (of which 4 are active) and 5 noted to have underground storage tanks (UST) on site. None of the sites near Reach G1 were listed as contaminated or active clean-up sites. Nineteen (19) sites were identified in proximity to Reach G2, including 9 listed as hazardous waste generators (of which 3 are active) and 5 noted to have underground storage tanks (UST) on site. One active State Cleanup Site exists at the North Winds Weir Intertidal Restoration. Within Reach G1-PAA, one hazardous waste generator is located in proximity to the Lower Green River. There are no sites listed within the Reach G2-PAA planning area. Additionally, the Boeing A&M Development site (at 9725 E. Marginal Way) and the Davis Property (former Rhone Polenc) are listed by Ecology as RCRA Corrective Action Sites. One additional RCRA Corrective Action Site, the Boeing Plant 2 site, extends into Tukwila within Reach G2.

4.4 Inventory Data Gaps

This section describes specific data gaps or limitations identified during development of the shoreline inventory and characterization as required by Ecology's guidelines (WAC 173-26-201(3)(c)(viii)). This list should not be considered exhaustive. As additional information is developed, it may be instructive as the City considers future updates and amendments to its Shoreline Master Program.

- Soil mapping: The soil survey for King County (NRCS, formerly SCS) does not include the greater Seattle urbanized area, including the northern portion of Tukwila, as shown on Map 5.
- Coordinated mapping, monitoring, and management of groundwater resources on a regional scale is lacking;
- Channel migration hazard mapping has been completed on portions of the Green River but is not available for the City of Tukwila;
- Updated flood hazard mapping is underway by FEMA for the Green River, but is not yet available;
- The City is in the process of developing GIS data layers of its stormwater infrastructure, including all outfalls to the Green/Duwamish River – at this time only the northern portion of the City is complete;
- Comprehensive geotechnical information regarding the levees is currently being collected by King County and is not available;
- Revised King County Flood Study is underway, scheduled to be completed in 2007;
- Updated data regarding groundwater flow quantity and quality;
- Outcome of the levee certification process for FEMA map modernization;
- King County and Corps of Engineers Investigations examining levee conditions after the recent November 2006 high flow event;
- Updates to geologic information from the Final Seattle geology quadrangle (in prep);
- Duwamish Blueprint Study of the Transition Zone (part of ongoing WRIA 9 studies); and
- Sensitive areas in north PAA area.

5.0 ASSESSMENT OF SHORELINE FUNCTIONS AND RESTORATION OPPORTUNITY AREAS

The City of Tukwila exists at the important junction between the Lower Green River watershed and the Duwamish River estuary. This section summarizes shoreline functions of the Green / Duwamish River in the context of the inventory and characterization information described previously. This section also discusses opportunities and limitations to preserve and improve ecosystem processes and/or functions. Ecosystem processes introduced in Section 3 are discussed, and the processes' impacts on city/reach scale shoreline functions are listed. These processes are discussed at two scales, the watershed scale, and the city/reach scale. The changes to processes are generally discussed in relation to an undisturbed condition.

A qualitative assessment of the restoration potential for each function is briefly discussed. The restoration potential is described as low, moderate, or high, based on the feasibility within the existing developed infrastructure of the proposed restoration actions. These restoration projects may not necessarily be considered solely by the City. Watershed-scale restoration projects are often best supported by multiple stakeholders.

Example opportunities along the Green / Duwamish River are also offered in Section 5.2, below. This list of opportunities is not exhaustive; rather it represents the types of projects that have already been proposed within the shoreline planning area by the City, King County, or other entities.

5.1 Status of Shoreline Functions

The level of alteration and restoration potential of selected ecosystem functions and variables for the Green / Duwamish River are summarized in Table 5-1. The current status is compared to pre-disturbance conditions. Figure 5-1 shows the overall structure of the Table 5-1.

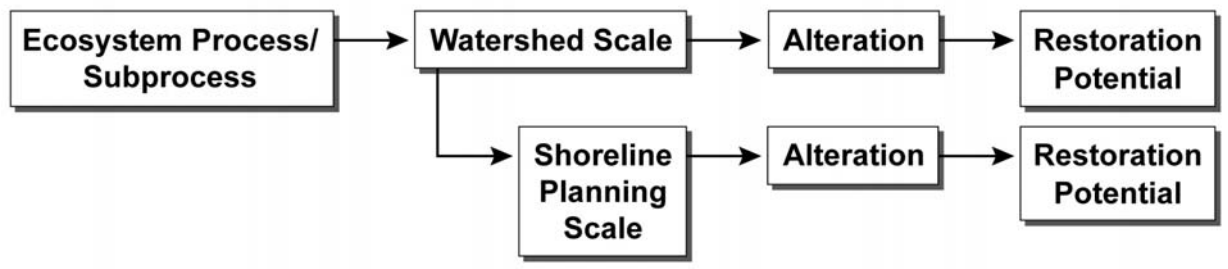


Figure 5-1. Structure of shoreline function discussion

Table 5-1. Green / Duwamish River Summary Assessment of Shoreline Functions

Ecosystem Process	Scale	Level of Alteration	Conservation / Restoration Potential
Hydrology: Flow Regime	Watershed	This process is significantly modified from the pre-disturbance condition. Installation of Hanson Dam, avulsion of the White River, lowering of Lake Washington, and the Tacoma Water Withdrawal change quantity, magnitude, and timing of flows.	Moderate Some changes to flow magnitude could be made in dam management (e.g., to provide occasional 'flushing flows' to mobilize larger channel bed materials, resulting in gravel distributions more similar to pre-disturbance conditions). Water diversion from river likely to continue or increase commensurate with population growth.
	City	Flow regime is best discussed at a watershed, rather than city/reach, scale.	Low The City can work with regional entities to support the development of flow management techniques that have the potential to accomplish multiple ecological and social goals.
Hydrology: Channel-Floodplain Interaction	Watershed	Throughout the watershed, this process is modified from the pre-disturbance condition. Historic channel entrenchment, the removal of coarse sediment load, and the changes in flow regime have reduced channel-floodplain interaction. Overall channel morphology has been simplified when compared to the historic condition.	Mixed In portions of the lower and middle reaches, and much of the upper reach of the Green River, the potential exists to partially reconnect the river with its floodplain via levee removal or setback. However, the urban centers (e.g., Auburn, Kent, Tukwila, Seattle) existing along the course of the river are dependent on flood protection levees or have filled the floodplain which significantly limits the potential for reconnection.
	City	Within the City of Tukwila, this process is highly modified as a result of flood protection structures (e.g., certified levees, river bank revetments, flood gates) and significant fill / development along the shoreline. These significant changes to channel morphology have reduced the overall area of aquatic habitat in the Green/Duwamish River.	Low The highly urban land uses surrounding the Green / Duwamish River limit the potential to reconnect the channel with its floodplain without significant modification to existing infrastructure and significant funding. There are few areas outside of the certified levees that can have high value or function for floodplain reconnection. Flood protection as provided by the levees remains a primary concern for the City. While channel-floodplain reconnection would present a significant challenge within Tukwila, there is the opportunity to increase the area and diversity of in-channel habitats. This can be accomplished by grading side and backwater channels within fill and former floodplain areas. This work may require the use of set-back levees to gain lateral area in the former floodplain.

Ecosystem Process	Scale	Level of Alteration	Conservation / Restoration Potential
Hydrology: Groundwater Recharge	Watershed	Throughout the watershed, groundwater recharge is an important ecosystem function that is modified from the pre-disturbance condition. Channelization and increases in impervious surfaces limit the potential for groundwater recharge in some locations. However, significant groundwater recharge does occur in recessional outwash and alluvial sediments, especially in the middle and upper reaches.	Moderate Protect surface water pathways. Protect open space and areas of native vegetation. Prevent spills/leaks Focus development away from aquifer recharge areas (e.g., Big Soos Creek Valley)
	City	Groundwater recharge does not appear to be a significant ecosystem process in the shoreline portion of the Green / Duwamish River. However, recharge can occur in relatively undeveloped upland areas within the Green / Duwamish drainage basin.	Low Protect existing streams, wetlands, upland buffers, and open space.
Sediment Delivery: Fluvial Sediment Transport	Watershed	This process is highly modified from the pre-disturbance condition. Installation of the Hanson Dam, channel avulsion, and changes in land use have collectively changed the volume and type of sediment being transported through the Green River ecosystem.	Moderate Upland BMPs can be effective at reducing fine sediment loading. Gravel can continue to be introduced below Hanson Dam to augment transport of certain size classes and potentially reverse channel entrenchment and armoring.
	City	This process is modified from the pre-disturbance condition. Coarse sediment delivery to the lower reach of the Green / Duwamish is low, and sediment transport patterns are impacted by high flows in the winter and tidal action in the former delta.	Low Fluvial sediment generation and transport is determined by factors and processes that function at a watershed scale. These processes are not restorable at the city scale.
Sediment Delivery: Upland sediment generation.	Watershed	This process is highly modified from the pre-disturbance condition. Overall changes in land use throughout the watershed have resulted in increased upland sediment generation as forest cover is removed and roads constructed. This sediment enters aquatic ecosystems, including the Green / Duwamish River, via land sliding and tributary flow	Moderate Forestland BMPs can be effective at lowering probability of hillslope failures. Upgrade of stormwater systems in urban areas can reduce sediment loading to the Green / Duwamish River system.
	City	This process is highly modified from the pre-disturbance condition. Fine sediment contribution to the river is increased due to build-up and wash-off from surrounding urban land uses.	Moderate Implement upland and stormwater BMPs to reduce fine sediment loading to the Green / Duwamish River.
Water Quality: Retention of Particulates	Watershed	This process is highly modified from the pre-disturbance condition. Channel-floodplain interactions have decreased, channel roughness has decreased, and supply of particulates has increased. Therefore, the opportunity to retain particulates (mineral or organic) through the system is significantly reduced	Moderate Riparian plantings can increase surface roughness. Upland BMPs can reduce source.

Ecosystem Process	Scale	Level of Alteration	Conservation / Restoration Potential
	City	Within the City of Tukwila, this process is highly modified. Levees and revetments in Reaches G-1 & G-2 are virtually constant along the riverbanks, limiting the potential to retain particulates in the fluvially dominated reaches. Particulates, including sediment, are retained in the tidally dominated reaches, as evidenced by the need to dredge the estuary turning basin.	Moderate An increase of channel area cross-section, off-channel restoration sites, and overall bank roughness (e.g., setback levees and riparian plantings) could provide a temporary or permanent increase in retention of particulates.
Water Quality: Nutrient Cycling	Watershed	This process is modified from the pre-disturbance condition. Watershed-scale modification to native plant communities has changed rates of net primary productivity and detritus turnover. In addition, development in the watershed has resulted in increased nutrient loading**.**	Moderate Plantings to restore upland and riparian forest; upland BMPs.
	City	This process is highly modified from the pre-disturbance condition within the City of Tukwila. As channel-floodplain interaction was reduced, the channel becomes a conduit for nutrients, and offers little opportunity for contact time with soils.	Moderate Set back levees, off-channel wetlands, and riparian plantings could increase water contact time with vegetation and soils, thereby increasing the potential for nutrient cycling.
Water Quality: Water Temperature	Watershed	This process is modified in the middle and upper reaches, and is highly modified in the lower reaches. High summer water temperatures in the Lower Green and Duwamish Rivers significantly reduce in-channel habitat conditions.	Moderate At the watershed scale, efforts could be made to increase vegetative cover over the river, and limit the temperature impacts of stormwater systems (e.g., ponds, impervious surfaces).
	City	This process is highly modified within the City of Tukwila. Fish kills have been reported due to lethally high summer water temperatures.	Low The city's location at the distal end of a large watershed limits its ability to moderate water temperature. High water temperatures are achieved as the river flows through 20 to 30 miles of degraded channel; these impacts cannot be fully mitigated within city boundaries.
Water Quality: Transition from fresh to salt water	Watershed	This process is modified in the Lower Green and Duwamish Rivers. Process exists, but area in which it occurs is highly modified. Removal of significant fresh water sources (White, Cedar, Lake Washington) changes fresh-to-salt dynamic process	Low At the watershed scale, efforts could be made to increase vegetative cover over the river and improve LWD recruitment, increase use of Low Impact Development and porous concrete, and expand water conservation incentive programs.
	City	This process is highly modified in Tukwila. Impervious surfaces, shoreline armoring, and impaired riparian vegetation have resulted in loss of transitional habitat.	Moderate Within the city scale, efforts can be focused on preserving, adding, and enhancing area within the channel, tributary, and near-channel areas. Set back levees, create off-channel wetlands and side- or back channels, and improve tributary access; rehabilitate riparian areas by replacing non-

Ecosystem Process	Scale	Level of Alteration	Conservation / Restoration Potential
			native and invasive vegetation with native plantings. Improvements to the City's stormwater system could also improve fresh water inputs.
LWD and Organics: Maintain Characteristic Plant Community	Watershed	This process is modified from the pre-disturbance condition. Timber harvesting, historic fires, agriculture, and development have changed plant communities throughout the watershed. Changes have been focused on areas where human populations are highest.	Moderate The timber harvesting rotations in the upper watershed can be managed to promote forest health. Enhancement of certain middle reach riparian areas could provide future LWD.
	City	This process is modified from the pre-disturbance condition. The majority of the shoreline within the City of Tukwila is currently dominated by non-native invasive weed species (Himalayan blackberry, reed canary-grass, and Japanese knotweed). Some higher quality areas of cottonwood, alder, and willow exist in riparian areas bordering open space, parkland, and residential zones.	Moderate Given the significant changes in flow regime and land use, it is not practicable to achieve the riparian forest that dominated the pre-disturbance channel and floodplain. Preserving native vegetation, promoting bio-engineering techniques, and replanting along the revetment banks could result in native shrub and tree species that would provide some channel cover and improve riparian habitat.
LWD and Organics: Source of LWD	Watershed	This process has been significantly modified from the pre-disturbance condition. Removal of riparian vegetation has resulted in fewer large trees in areas where they can interact with the active channel.	High Protecting existing riparian forest and enhancing non-forested shorelines can result in a sustainable source of large wood for aquatic systems. Use criteria to leave some in-channel LWD, rather than removing.
	City	This process has been significantly modified from the pre-disturbance condition. Some large cottonwoods and big leaf maples occur along the northern, older revetment system. Many of the remaining riparian trees along the southern TUC area may be removed to allow for levee re-certification.	Low Current levee maintenance guidelines specify that large trees be removed to preserve levee stability. Without change in management approach, source of LWD within the City is likely to decrease over time.

5.2 Restoration Projects and Identified Reach-Scale Opportunities

Previous work specific to the Green/Duwamish River has identified several site-specific or project-based conservation or restoration actions and opportunities in the City of Tukwila. Several of the projects were identified as part of the WRIA 9 salmon recovery planning efforts. The WRIA 9 Salmon Habitat Plan (WRIA 9, 2005) focuses on restoration of limited habitats throughout the watershed. Tukwila is located in the Lower Green River and Duwamish Estuary Subwatersheds. The focus in these areas includes estuary transition habitats and rearing habitats. The Plan identifies the following key habitat needs for each subwatershed:

Lower Green River Subwatershed

- Protect and restore side channels, off-channel wetlands, tributary mouths, and pools that provide shelter and habitat complexity for young salmon;
- Protect and restore natural sediment movement by reconnecting sediment sources to the river;
- Preserve groundwater inflow from the historical White River channel; and
- Modify the Black River Pump Station to improve fish passage.

Duwamish Estuary Subwatershed

- Restore vegetated shallow subtidal and intertidal habitats and brackish marshes by restoring dredged, armored, and filled areas;
- Increase shallow water and slow water "transition zone" habitat where salmon transform from freshwater to salt water fish;
- Improve sediment quality through the Lower Duwamish Waterway Superfund cleanup;
- Protect and restore water quality through point and nonpoint pollution source control;
- Restore off-channel refuge habitat and mainstem pools in Tukwila; and
- Improve natural sediment transport and deposition processes.

Recently initiated or completed projects and preliminary future actions are summarized in Table 5-2 below. Project locations are shown on Map 13.

Table 5-2. Projects and Opportunities for the Green River in the City of Tukwila

Identifier (Map 13)	Reach/RM	Action	Source
1	PAA G-2 RM 4.9	Hamm Creek stream and estuary restoration site *	King County/WRIA 9 (2005, WRIA 9 Project DUW-11)
2	G-2 RM 5.3	Kenco Marine intertidal habitat restoration site *	King County & Muckleshoot Indian Tribe
3	G-2 RM 5.4	Coastal America Turning Basin restoration / enhancement site *	

Identifier (Map 13)	Reach/RM	Action	Source
4	G-2 RM 6.2	North Wind Weir off-channel estuary wetland, intertidal habitat restoration site (near Cecil B. Moses Park) *	Elliot Bay/Duwamish Restoration Panel (2000) & King County/WRIA 9 (2005, Project DUW-10)
5	G-2 RM 6.6	Riverton Creek channel and tidal (WSDOT) wetland enhancements	King County/WRIA 9 (2005, Project DUW-8)
6	G-2 RM 7	Duwamish Gardens, off-channel habitat area (formerly called the Carasino property)	King County/WRIA 9/City of Tukwila
7	G-2 RM 8	Potential estuary restoration & enhancement at mouth of Southgate Creek	Privately owned land, opportunity not previously identified
8	G-2 RM 8.5	Codiga Farm off-channel, estuary wetland restoration site *	King County/WRIA 9 (2005)
9	G-2 RM 10	Foster Golf Course enhance riparian areas & create off-channel area	King County/WRIA 9 (2005, Project DUW-1), Anchor Environmental (2003)
10	G-1 RM 11	Improve confluence of Black River and Green River by restoring riparian corridor and creating emergent marsh	King County/WRIA 9 (2005, Project LG-18)
11	G-1 RM 11.5	Ft. Dent Park riparian area enhancement on east bank	King County/WRIA 9 (2005, Project LG-17)
12	G-1 RM 12.5	Remove existing flood control flap gate from mouth of Gilliam Creek and add fish ladder to restore fish passage but retain flood control	King County/WRIA 9 (2005, Project LG-16)
13	G-1 RM 12.7	Connect remnant river channel (Nelson wetland) with river to create off-channel refugia, possible spawning habitat	King County/WRIA 9 (2005, Project LG-15)
14	G-1 RM 12.8	Potential side channel creation in disconnected floodplain riverward side of levee at Riverview Plaza.	Opportunity identified by City as part of off-site wetland mitigation project
15	G-1 RM 14.4	Levee setback enhancement site, Desimone levee setback*	King County Drainage District
16	PAA G-1 RM 18	Off-channel wetland mitigation site	Tukwila South Project EIS (2005b & 2005c), King County/WRIA 9 (2005, Project LG-11)
17	PAA G-1 RM 18.4	Restore Johnson Creek and outlet to the River for fish access.	Tukwila South Project EIS (2005b & 2005c), King County/WRIA 9 (2005, Project LG-11)

Notes: Completed or initiated restoration projects *

6.0 PLANS, TRENDS, AND POTENTIAL USE CONFLICTS

State guidelines for SMP updates require that local jurisdictions analyze current and projected shoreline use patterns and trends and identify potential conflicts (WAC 173-26-2013)(d)(ii)). Potential conflicts in this context are focused on competing objectives or planning priorities between the overall SMA policy intent and other interests or regulatory requirements affecting shoreline resources.

6.1 Future Land and Shoreline Use

The existing land and shoreline use pattern in Tukwila is well established and highly urbanized. Existing land use, public access, and general pattern of development and infrastructure in the Green River shoreline planning area is described in Section 4. This section focuses on City and County plans and programs affecting the Green River shorelines in Tukwila.

6.1.1 Tukwila Comprehensive Plan and Zoning

The City of Tukwila plans for future land use in the City and designated potential annexation areas (PAAs). The City of Tukwila has developed a Comprehensive Plan (2005a) that provides goals, policies, and future land use designations. The Comprehensive Plan provides an overarching set of objectives, listed in order of priority:

1. To improve and sustain residential neighborhood quality and livability;
2. To redevelop and reinvigorate the Pacific Highway corridor;
3. To redevelop and reinvigorate the industrial uses along East Marginal Way; and
4. To develop a thriving Urban Center as a true regional concentration of employment**,** housing, shopping, and recreational opportunities. (City of Tukwila, 2005a)

The Comprehensive Plan Land Use Element is divided into several elements, including three that specifically address different geographic areas of the City: the Manufacturing/Industrial Center, Tukwila Urban Center, and Tukwila South. Additional planning efforts for these areas (including master plans, planned actions, and/or strategic implementation plans) are described further below.

The Lower Green River Reach (G1) is predominantly designated Tukwila Urban Center (32 percent) and Commercial/Light Industrial (27.8 percent, predominantly south of I-405). North of I-405 in this reach, designations include a mix of Low Density Residential, Medium Density Residential, Regional Commercial Mixed Use, and Commercial/Light Industrial. Other designations include Heavy Industrial. Significant portions of Low Density Residential areas within the reach's shoreline area are designated with a Public Recreation Overlay and are developed as Fort Dent Park, the Foster Golf Links and the Tukwila Community Center. Within the City's southern PAA, along the western Green River shoreline, all areas are designated as Tukwila Valley South. The Comprehensive Plan element generally envisions an extension of the commercial and industrial development on the valley floor for this area. For details on the specific locations of Comprehensive Plan designations, see Map 9.

The Comprehensive Plan designates areas in the Duwamish River reaches (G2 and G2-PAA) as predominantly a mix of Manufacturing Industrial Center/Heavy (37 percent of the designated reach planning area, predominantly downstream of the East Marginal Way South bridge)) and Low Density Residential (39.6 percent of the designated reach planning area, predominantly upstream of the East Marginal Way South bridge). Other designations in the Duwamish River reach include Manufacturing Industrial Center/Light, Commercial/Light Industrial, and Residential Commercial Center.

Zoning designations in the City of Tukwila follow the land use designations established in the City's Comprehensive Plan as described above. King County zoning along the Green River shoreline for the north unincorporated PAA is Industrial and for the south PAA is Agricultural.

6.1.2 Tukwila Manufacturing/Industrial Center

The Tukwila Manufacturing/Industrial Center (MIC) is one of eight regionally significant industrial and employment centers in the Central Puget Sound region. Designated as such by the Puget Sound Regional Council, the City has developed a specific element in its Comprehensive Plan and an Implementation Plan to guide redevelopment in the area. The Implementation Plan is structured as a Planned Action under SEPA and was adopted in 1998. A significant element of the plan is an updated MIC Shoreline Master Plan. This element was developed consistent with the Comprehensive Plan and is expected to be integrated as a component of the City-wide SMP Update. The element includes innovative approaches to combine shoreline redevelopment with environmental conservation, restoration, or enhancement actions. The plan also provides guidelines for integrating habitat enhancement with alternative bank stabilization designs, based in part on King County flood reduction policies and guidelines for bank stabilization (City of Tukwila, 1998). At the time the MIC Planned Action was adopted the City expected to update its SMP by 2000. Due to fluctuations in the Shoreline Regulations, the SMP Update was suspended in 2000 before the Planning Commission completed its review. The MIC Plan will be reviewed for any needed amendments during the course of this current SMP update.

Redevelopment in the MIC is also subject to design guidelines developed in 1992 by the Boeing Corporation, in coordination with the City, and described in *Duwamish Corridor Redevelopment Proposal/Design Guidelines* (Sugio Kobayashi Ullman Inc., 1992). The document, which became part of the MIC Planned Action, establishes goals, objectives, and guidelines for redevelopment of Boeing properties in the Duwamish corridor. Objectives include enhancement of the shoreline environment by replacing old riprap bulkheads with new, more environmentally friendly retention structures and native riparian vegetation. The plan also promotes increased public access as redevelopment occurs, primarily as public and employee-only (semi-public) access features and public shoreline access trails. Finally, the plan addresses remediation actions so that as redevelopment occurs, sites with contaminated soil and groundwater are identified and clean up plans are developed, consistent with state and federal laws. As this document is 14 years old, the City will be working with the Boeing Company to identify any needed amendments or revisions to the Redevelopment Proposal as part of the SMP update.

6.1.3 Tukwila Urban Center Plan

The Tukwila Urban Center Plan is under development in the City. The Comprehensive Plan includes an element addressing the Tukwila Urban Center. The Urban Center serves as a

regionally significant shopping center (including Southcenter Mall) with light industrial, office park, and transportation oriented development. The center is generally bounded by I-405, I-5, South 180th Street, and the Green River. Policies and implementation strategies for the Urban Center promote mixed-use commercial and residential development near the Green River, with an integrated network of park, trail, and recreational facilities.

6.1.4 Tukwila South Project

The Comprehensive Plan includes an element addressing Tukwila South, an area bounded generally by South 180th Street, I-5, the Green River, and South 204th Street. This area includes the southern designated potential annexation area, which is currently in unincorporated King County. The area is currently primarily a mix of agricultural and vacant lands, with a small amount of residential and industrial uses. The Comprehensive Plan element generally envisions an extension of the commercial and industrial development on the valley floor for this area. As elsewhere in the City, the Comprehensive Plan promotes mixed-use densities for residential development near the river, and maintenance and enhancement of the open space network along the Green River. The Comprehensive Plan also establishes the need for development of a master plan for any significant development and annexation of the Tukwila South Area.

A master plan has been proposed for this area by La Pianta LLC (City of Tukwila, 2005b and 2005c). In July 2005, a Final EIS was issued for the Tukwila South Project. The master plan proposes 14 million square feet of development in a large-scale, campus setting in the 498-acre Tukwila South area. The development is envisioned to create a major new employment hub with campus-style office and research complexes incorporated with an array of commercial, retail, residential, hotel, and recreational uses. The master plan, described in the Final EIS as being in accordance with the vision and polices of the Tukwila South component of the City's Comprehensive Plan, expects to develop over an Infrastructure Development Stage (3 years) and a Full Buildout Stage (horizon of 2030). The Infrastructure Development Stage would include the extension of major roadways (such as Southcenter Parkway) into the area, establishment of site grades throughout the area, installation of utilities and stormwater control facilities, and construction of sensitive areas mitigation as required for the master plan. The two action alternatives considered in the master plan envision between 10 million and 14 million square feet of development to occur in the area during the Full Buildout Stage.

6.1.5 King County Draft Flood Hazard Management Plan

Working with the Water and Land Resources Division, the King County Executive recently released the Proposed 2006 King County Flood Hazard Management Plan (KCFHMP). The KCFHMP identifies a series of countywide priority repairs and improvements that are needed within the coming decade. Within the City of Tukwila, portions of the levee system have previously been upgraded as part of the Tukwila 205 project. These projects extended from approximately RM 12.6 to 17.0 (King County, 2006). While these levees are more substantial than older portions of the levee, they also have portions that are steeper than 2H:1V. The remainder of the levees are typically too steep to remain stable under current flow conditions. The KCFHMP recommends an overall strategy of rehabilitating existing levees by widening channel width to allow for shallower levee sideslope angles (King County, 2006). Several specific projects are detailed in the draft report (e.g., Desimone levee, Segale levee).

A countywide flood control district is recommended as a means of funding the KCFHMP, combining the tax revenues of the existing River Improvement Fund, Inter-County River Improvement Fund, and Green River Flood Control Zone District with future revenue from additional countywide district areas. The KCFHMP is currently under consideration by the King County Council.

The existing River Improvement Fund is a countywide tax levy collected in both unincorporated and incorporated areas. Current annual revenue from the River Improvement Fund is approximately 2.6 million dollars, which is utilized by the King County Water and Land Resources Division to support river system improvement projects throughout King County.

6.1.6 Tukwila Parks, Golf and Open Space Plan

A primary goal of the Shoreline Master Plan is to provide for public access to shorelines. The City's 2001 *Parks, Golf, and Open Space Plan, 2001-2006* (City of Tukwila Department of Parks and Recreation, 2001) describes the parks, golf courses, open spaces, and trails (existing and proposed) in the City's shoreline planning area, as shown on Map 10. As described in Section 4, there is significant public trail access to the Green/Duwamish River in Tukwila. The Duwamish/Green River Trail provides access to the shoreline and links several waterfront parks throughout virtually the entire city, with the exception of the northern most portion of the Duwamish River in the Manufacturing/Industrial Center. As described above in this section, plans and policies for redevelopment along the shorelines in Tukwila promote enhanced public access to the river and expansion of the regional riverfront trail system.

6.2 Potential Opportunities and Conflicts

In the context of shoreline planning under the Shoreline Management Act and State guidelines (WAC 173-26), opportunities to conserve, enhance, or restore shoreline ecological functions should be identified and promoted. This inventory describes existing shoreline conditions and provides an assessment of ecosystem wide processes and shoreline functions. However, these findings should be considered in light of other planning and regulatory objectives established by the City and other entities.

6.2.1 Levee Maintenance and Management

Discussion of shoreline planning for the Green River in Tukwila must acknowledge the fact that, in light of the existing system of levees and revetments, the City cannot act alone. There are a variety of regulatory jurisdictions outside of the City with different responsibilities for maintenance and management of the levee system, including the U.S. Army Corps of Engineers (the Corps), the Federal Emergency Management Agency (FEMA), King County River and Floodplain Management Unit (acting as part of the Green River Flood Control Zone District), and private property owners. The City of Tukwila Public Works Department has overall responsibility for maintenance of the federally certified levee, which extends from about the I-405 crossing to S. 180th. The actual maintenance work on this levee is contracted by the City to King County. Further, there are a variety of stakeholders interested in the river itself.

The result is differing perspectives and competing objectives related to the levees and other sections of the shoreline. For example, in response to Endangered Species Act listings, a great

deal of work has occurred in planning for salmon recovery in the Pacific Northwest. As described in Section 5, the development of native tree and shrub species along the levees would increase riparian habitat ecological functioning of this reach of the Green/Duwamish River, benefiting salmonids as well as other species. However, the Corps of Engineers (responsible for certifying the federal levee) believes that the root system of these trees could destabilize levees, resulting in water piping (e.g., water infiltrating into and through levees along root pathways at higher rates than it could through root free soil) at high flows, and potential levee failure if trees fall. For the Vegetation Free Zone of the levee, current Corps guidance only allows grass as vegetative cover on the levees (USACOE, Engineering Manual 1110-2-301). Current guidance also specifies a root-free zone where plantings can occur, but roots will generally not penetrate this structural zone. Therefore, under current regulations, to meet the requirements for federal levee certification under PL 84-99, some existing vegetation will have to be removed and ongoing vegetation management will be required to maintain the levee certification. Under the SMA, removing trees and vegetation from the riparian zone of shoreline of the state is in conflict with policies for vegetation conservation and enhancement. A possible solution is to step back and re-slope the levees to create benches where vegetation can be planted that will not interfere with the levee prism as the levee system is reconstructed to improve its stability. This would require additional easement area beyond the existing maintenance easements that have been acquired along the length of the system.

The Corps process does anticipate that a balance may be needed to achieve multiple project objectives. In EP 500-1-1, Appendix E allows for regional variances to levee vegetation standards (Photo 6-1). King County is in active discussions with the Corps regarding application of this national policy in the Pacific Northwest (King County, 2006).

Photo 6-1. Mature cottonwood trees recently marked for potential removal at the top of the levee in Tukwila, near RM 14.

6.2.2 Habitat Restoration and Proposed Development

As mentioned above and elsewhere in this report, a great deal of work has occurred, primarily through the WRIA 9 Forum, to plan for salmon recovery. These efforts include a wide array of programs and site-specific projects documented in the WRIA 9 Salmon Habitat Plan (WRIA 9 Steering Committee, 2005), including the levee setbacks, off-channel habitat restoration, wetland and stream restoration, and riparian zone enhancements. Much of Tukwila is fully developed, with portions having a dense, urbanized land use pattern. The City's SMP, in place since 1974, establishes a 40-foot setback from the mean high water line. In many places, there is little more than this 40-foot zone that is not intensely developed. Some places have more open space and less development and thus have greater flexibility to accommodate potential habitat restoration actions. As outlined in Section 5.1 above, the City's vision for future land use includes maintenance and further development of its urban character, particularly its identity as a regionally significant center for manufacturing, industrial, and commercial development. A challenge lies ahead in determining how best to accommodate new and redevelopment near the shoreline in a manner consistent with SMA policy objectives and the State shoreline update guidelines (WAC 173-26).

The Tukwila South PAA serves to illustrate the complexity of meeting multiple goals and objectives for future development near the shoreline. A large portion of this area has been identified as a Green/Duwamish Ecosystem Restoration Project and potential action in the WRIA 9 Salmon Habitat Plan (Project LG-11). The Salmon Habitat Plan envisions acquisition of easements along the riverbank to accommodate levee improvements, vegetation enhancements, and off-channel habitat rehabilitation. The plan also targets restoration of the Johnson Creek Ditch and associated wetland complex to provide juvenile salmonid rearing habitat (WRIA 9 Steering Committee, 2005). As described in the Tukwila South Project EIS, components of the master plan for this area include mitigation and natural resource enhancement, including an off-channel habitat creation area and restoration of Johnson Creek Ditch (City of Tukwila, 2005b). However, the plan also envisions development of a research campus, office and commercial development, and mixed-use areas along the river. The proposed development is generally consistent with what the City has envisioned in its Comprehensive Plan. The challenge lies in how best to accommodate development that is consistent with both the Comprehensive Plan and the Shoreline Master Program.

7.0 CONCLUSIONS AND RECOMMENDATIONS

The City of Tukwila's Shoreline Master Program focuses on goals, policies, and regulations for the Green/Duwamish River, classified under the state Shoreline Management Act as a "shoreline of statewide significance." Like many rivers in the Puget Sound region, the course and dynamics of the Green/Duwamish River has changed significantly as a result of development and alteration of its watershed over the past century or so. Characteristic of many cities in the region, Tukwila has grown and become highly urbanized. Continued growth is anticipated and the City is planning for that growth. To a significant degree, the City has envisioned and maintained a development pattern that preserves public access to the Green River and assures setbacks of new buildings from the shoreline. Issues of concern are focused on uncertainties about the ability of existing levees and revetments to protect existing development from flood hazards. There are many opportunities for conservation and restoration actions in the City to restore or replace habitat while managing natural hazard areas. As the City moves forward with updating its SMP, it could consider the following broad recommendations:

- Continue land use planning and policies that promote conservation of open space and recreational lands in the shoreline;
- Continue planning, policies and development regulations that promote improvement of water quality through stormwater treatment;
- Continue coordination with King County, neighboring cities, and multi-jurisdictional entities (e.g., Green River Flood Control Zone District) to plan for and manage development in a manner sensitive to flood and landslide hazards;
- Continue coordination with multi-jurisdictional regional watershed planning efforts to identify and pursue ecosystem conservation and restoration actions; and
- Consider how potential protection, enhancement, and restoration opportunities will work in a watershed context to preserve and improve ecological functioning within this key riverine ecosystem.

8.0 REFERENCES

Abbe, T.B. and D.R. Montgomery, D.R. 1996. Large woody debris jams, channel hydraulics and habitat formation in large rivers. Regulated Rivers: Research & Management. 12: 201-221.

Anchor Environmental, LLC. 2004. Lower Green River Baseline Habitat Report. Prepared for WRIA 9.

City of Tukwila. 1974. Shoreline Master Plan. June 1974, Amended by Ordinance #1247 on March 16, 1982.

City of Tukwila. 1998. Tukwila Manufacturing / Industrial Center, Integrated GMA Implementation Plan and Final Environmental Impact Statement. Prepared by Department of Community Development. March 1998.

City of Tukwila. 2001. Parks, Golf and Open Space Plan 2001 – 2006 (Capital Improvement Program). Prepared by Department of Parks and Recreation.

City of Tukwila. 2003. Comprehensive Surface Water Management Plan. Prepared by CH2M Hill. November, 2003

City of Tukwila. 2004. Comprehensive Plan Map. (Adopted 1995, last updated 2004) (Up to date version of Comp Plan Map).

City of Tukwila. 2005a. Comprehensive Plan. December 5, 2005.

City of Tukwila. 2005b. Tukwila South Project Draft Environmental Impact Statement, Volumes I, II, & III. Prepared by Department of Community Development. April, 2005.

City of Tukwila. 2005c. Tukwila South Project Final Environmental Impact Statement. Prepared by Department of Community Development. July, 2005.

Collins, B.D. and A. Sheikh. 2005. Historical aquatic habitats in the Green and Duwamish River Valleys and the Elliot Bay Nearshore, King County, Washington. King County Department of Natural Resources and Parks.

Collins, B.D., Montgomery, D.R., and A.D. Haas. 2002. Historical changes in the distribution and functions of large wood in Puget Lowland Rivers. Canadian Journal of Fisheries and Aquatic Sciences. 59:66-76.

Cowardin, L.M., V. Carter, F.C. Golet, and E.T. LaRoe. 1979. Classification of Wetlands and Deepwater Habitats of the United States. FWS/OBS-79/31. U.S. Fish and Wildlife Service.

Dragovich, J.D., Pringle, P.T., and Walsh, T.J. (1994) Extent and geometry of the mid-Holocene Osceola Mudflow in the Puget Lowland – Implications for Holocene sedimentation and paleogeography. Washington Geology, v. 22, n. 3, p. 3-26.

Dunne, T., and L. Leopold. 1979. Water in Environmental Planning. W.H. Freeman and Company, New York, New York.

Federal Emergency Management Agency (FEMA). 1990. Floodplain mapping for the Green River.

Federal Emergency Management Agency (FEMA). 1994. Floodplain mapping for King County.

Federal Register, 2004, Volume 69, Number 122. Designation of Bull Trout Critical Habitat. National Marine Fisheries Service.

Federal Register. 2005a. Volume 70, Number 170. Endangered and Threatened Species; Designation of Critical Habitat for 12 Evolutionarily Significant Units of West Coast Salmon and Steelhead in Washington, Oregon, and Idaho. Friday, September 2, 2005.

Federal Register. 2005b. Volume 70, Number 185. Endangered and Threatened Wildlife and Plants; Designation of Critical Habitat for the Bull Trout. Monday, September 26, 2005.

Federal Register. Volume 71, Number 60. March 29, 2006. Proposed Rule, Petition Finding. Listing Endangered and Threatened Species and Designating Critical Habitat: 12–Month Finding on Petition to List Puget Sound Steelhead as an Endangered or Threatened Species under the Endangered Species Act.

Fresh, K.L., E. Casillas, L. Johnson, and D.L. Bottom. 2003. Role of the Estuary in the Recovery of Columbia River Basin Salmon and Steelhead: An Evaluation of Limiting Factors. NOAA Technical Memorandum. December 2003.

Fabritz, J., Massmann, J., and Booth, D. 1998. Duwamish Basin Groundwater Pathways: Development of a three-Dimensional, numerical groundwater flow model for the Duwamish River Basin. Center for Urban Water Resources Management Department of Civil & Environmental Engineering University of Washington, Seattle, Washington.

Galster, R.W., and W.T. Laprade. 1991. Geology of Seattle, Washington, United States of America. August 1991. Bulletin of the Association of Engineering Geologists. Vol. XXVIII, No. 3. College Station, Texas.

Green / Duwamish and Central Puget Sound Watershed Water Resource Inventory Area 9 Steering Committee (WRIA 9). August 2005. Salmon Habitat Plan – Making Our Watershed Fit for a King. Prepared for the WRIA 9 Forum. Seattle, Washington.

Herrera Environmental Consultants, Inc. 2004. Years 2001-2002 Water Quality Data Report – Green-Duwamish Watershed Water Quality Assessment. Prepared for King County Department of Natural Resources and Parks, Seattle, WA.

Hoblitt, R.P., .J.S. Walder, C.L. Driedger, K.M. Scott, P.T. Pringle, and J.W. Vallance. 1998. Volcano Hazards from Mount Rainier, Washington, Revised 1998. U.S. Geological Survey Open-File Report 98-428.

Kerwin, J., 2001. Salmon and Steelhead Habitat Limiting Factors Report for the Cedar-Sammamish Basin (WRIA 8). Washington Conservation Commission. Olympia. WA.

Kerwin, John. and Nelson, Tom S. (Eds). 2000. Habitat Limiting Factors and Reconnaissance Assessment Report. Green/Duwamish and Central Puget Sound Watersheds (WRIA 9 and Vashon Island). Washington Conservation Commission and the King County Department of Natural Resources.

King County. 2003. Lower Green River Corridor Assessment. Dated November 2003, King County Department of Natural Resources and Parks. 24 pp.

King County. 2006. Draft Flood Hazard Management Plan: King County, Washington. King County Department of Natural Resources and Parks, Water and Land Resources Division, Seattle, Washington.

Kraft, T., Annear, R.L., Berger, C., and S. A. Wells. 2004. Green River CE-QUAl-W2 Project: A hydrodynamic and water quality study of the Green River, King County, Washington. Prepared for King County Department of Natural Resources and Parks, Water and Land Resources Division.

Maser, C., Tarrant, R.F., Trappe, J.M., and J.F. Franklin. eds. 1988. From the forest to the sea: a story of fallen trees. Gen. Tech. Rep. PNW-GTR-229. 153p.

Montgomery, D.R., Bolton, S., Booth, D.B., and L. Wall. eds. 2003a. Restoration of Puget Sound Rivers. Center for Watershed and Streamside Studies, University of Washington Press, Seattle, WA.

Montgomery, D.R., Collins, B.D., Buffington, J.J., and T.B. Abbe. 2003b. Geomorphic Effects of Wood in Rivers.

Mullineaux, D.R. (1970) Geology of the Renton, Auburn, and Black Diamond quadrangles, King County, Washington. U.S. Geological Survey Professional Paper 672, 92 p.

Nakamura, F. and F. J. Swanson. 1993. Effects of coarse woody debris on morphology and sediment storage of a mountain stream system in Western Oregon. Earth Surface Processes and Landforms. Vol. 18 43-61.

National Climatic Data Center. Undated. Climate of Washington. Accessed online.

NOAA Fisheries. 2005. Final Critical Habitat Designations in Washington, Oregon, Idaho and California for Endangered and Threatened Pacific Salmon and Steelhead. Available: http://swr.nmfs.noaa.gov/chd/CH-FACT.PDF. Accessed: June 5, 2006.

Palmer, S.P., Magsino, S.L., Poelstra, J.L., Bilderback, E.L., Folger, D.S., and R.A. Niggeman. 2004. Liquefaction Susceptibility Map of King County, Washington.

Pentec Environmental. 2003. *DRAFT* Inventory of Shoreline Habitat and Riparian Conditions of the Green/Duwamish River Within the City of Tukwila. Prepared for City of Tukwila. January 7, 2003, Report: 12578-02.

R2 Resource Consultants. 2002. Final Green River Baseline Habitat Monitoring – 2001 Data Report. Prepared for the U.S. Army Corps of Engineers, Seattle District August 2002.

Rapp, C.F., and T.B. Abbe. 2003. A Framework for Delineating Channel Migration Zones: Washington State Department of Ecology Final Draft Publication #03-06-027, 66 p.

Shreffler, D.K., C.A. Simenstad, and R.M. Thom. 1992. Foraging by Juvenile Salmon in a Restored Estuarine Wetland. Estuaries 15(2):204-213

Snyder, D., P. Gale, and R. Pringle. 1973 Soil Survey of the King County Area, Washington. U.S.D.A. Soil Conservation Service. 100pp

Stanley, S., J. Brown, and S. Grigsby. 2005. Protecting Aquatic Ecosystems: A Guide for Puget Sound Planners to Understand Watershed Processes. Washington State Department of Ecology. Publication #05-06-013. Olympia, WA.

Sugio Kobayashi Ullman Inc. 1992. Duwamish Corridor Redevelopment. Prepared for the Boeing Company.

U.S. Army Corps of Engineers, Seattle District 2006. Environmental Assessment FY 2007-2011 Maintenance dredging turning basin and navigation channel Upper Duwamish Waterway CENWS-PM-PL-ER. July 13, 2006.

Valance, J.W. and K.M. Scott. 1996. The Osceola Mudflow from Mount Rainier: sedimentology and hazard implications of a huge clay-rich debris flow: Geol. Soc.America Bull,.

Washington Department of Archaeology and Historic Preservation (WDAHP). 2006. The Washington Information System for Architectural and Archaeological Records Data (WISAARD). http://www.oahp.wa.gov/pages/wisaardIntro.htm

Washington Department of Fish and Wildlife (WDFW). 2006. SalmonScape data. Available at: http://wdfw.wa.gov/mapping/salmonscape/index.html

Washington State Department of Ecology. Water Quality Assessment for Washington. 2002/2004 Candidate List.

Washington State Department of Fish and Wildlife (WDFW). 2005. Priority Species and Habitat Lists and StreamNet database. Olympia, Washington.

Williams, R.W., R.M. Laramie, J.J. James. 1975. A Catalog of Washington Streams and Salmon Utilization: Volume 1, Puget Sound Region. Washington State Department of Fisheries, Olympia, Washington.

Woodward, D.G., Packard, F.A., Dion, N.P., and Sumioka, S.S., 1995, Occurrence and quality of ground water in Southwestern King County, Washington: Water-Resources Investigations Report 92-4098, prepared in cooperation with State of Washington Department of Ecology, Regional Water Association of South King Co., and Seattle – King County Dept. of Public Health, Tacoma.

WRIA 9 Steering Committee. 2002. Near-term Action Agenda, Green/Duwamish River and Central Puget Sound Watershed, Water Resource Inventory Area 9. DRAFT.

Zehfuss, P.H. (2005) Distal Records of sandy Holocene lahars from Mount Rainier, Washington. [Ph.D. Thesis]: University of Washington, Seattle, WA, 160 p.