City of Shoreline

Middle Puget Sound, Seattle Golf Club and Bitter Lake Basins Characterization Report

May 2004

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CITY OF SHORELINE

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Prepared for:
City of Shoreline
Shoreline, WA

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Project #3320005

Middle Puget Sound Basins Characterization Report
TABLE OF CONTENTS

Appendices

LIST OF TABLES

LIST OF FIGURES

EXECUTIVE SUMMARY

The Washington State Growth Management Act (GMA) requires every county and city in Washington to adopt policies and regulations that designate and protect critical areas, subject to continuing review and evaluation by the jurisdiction that adopted them. Recognizing unique environments and local values, each jurisdiction's policies, regulations and nonregulatory programs should be specific to the community needs and available resources. Counties and cities are required to utilize best available science (BAS) in developing policies and regulations to protect the functions and values of critical areas.

Citizens of the City of Shoreline place high value on environmental resources and open spaces. The first step in developing local policies, regulations and programs to protect critical areas is their identification. The Stream and Wetland Inventory and Assessment, including nine basins characterization reports, is our first step to identify critical areas including streams and wetlands in the City. Tetra Tech/KCM, a local consulting firm, was contracted to conduct this study.

The Stream and Wetland Inventory and Assessment provide extensive up-to date information for the City of Shoreline's streams and wetlands. In order to support preparation of critical area and surface water policies and regulations based on the best available science (BAS) requirements, Tetra Tech/KCM described in various chapters the methodology used to obtain the information regarding the streams and wetland functions.

The Tri-County Urban Stream Baseline Evaluation Method (USBEM) was primarily used in the basin characterization protocol. The basin characterizations are thorough enough for the reader to review methods and results for the stream reaches that were identified within the various basins. It is evident that the basins are complex and that this study was an ambitious undertaking.

It should be noted that the Stream and Wetland Inventory and Assessment are intended to be diagnostic first steps in surface water and watershed basin planning. The information presented in this study will help understand the function and values of streams and wetlands within Shoreline, and provide a solid basis for identifying critical areas. More specific identification of wetlands would be difficult and may only be determined during development review. Completing and constantly updating the study data and analysis will advance the primary intent of this study, which is collecting environmental data to support policy, regulations, and watershed basin plans.

1. INTRODUCTION

This basin characterization report for the Middle Puget Sound, Seattle Golf Course and Bitter Lake drainage basins was developed as part of the City of Shoreline's Stream and Wetland Inventory and Assessment. Basin characterization reports were developed for all drainage basins in the City as part of the inventory and assessment. These basins include the following:

- Boeing Creek Basin
- Thornton Creek Basin
- McAleer Creek Basin
- Lyon Creek Basin
- Middle Puget Sound Basin North
- Middle Puget Sound Basin South
- Bitter Lake Basin
- West Lake Washington Basin
- Seattle Golf Course Basin.

This first part of this report focuses on the Middle Puget Sound North and South Basins, which are separated by the Boeing Creek Basin. A briefer evaluation of the much smaller Seattle Golf Course and Bitter Lake Basins is presented at the back of the document. These basins are included in this report because of their proximity to the Middle Puget Sound Basins, but are evaluated in less detail due to their small size. Only a small proportion of the Bitter Lake Basin lies within the City of Shoreline. Other basins that are being combined into single basin characterization reports are Thornton Creek with West Lake Washington and McAleer Creek with Lyon Creek. The accompanying appendices provide supporting information.

Each characterization report includes a description of streams, wetlands and habitat in the basin. The work for each basin consists of three phases:

- **Phase I**—Collecting existing information, identifying the stakeholders in the basin and developing a strategy to involve private property owners in the planning process
- **Phase II**—Collecting field data to use in characterizing each basin, including an inventory of streams and wetlands and an assessment of fish presence and habitat condition
- **Phase III**—Characterizing each basin regarding streams, wetlands, fish presence and habitat, fish barriers, riparian habitat, and preparing a report summarizing results of the inventory and assessment for the basin.

The information presented in this report will be used by the City to develop projects and/or policies to address problem areas identified in the report, to assist the City's overall

planning and permitting process, and to assist the City in complying with the Endangered Species and Clean Water Acts.

The citywide inventory and assessment was commissioned by the City of Shoreline and is partially funded by the Ronald Wastewater District and the King Conservation District.

PREVIOUS PLANNING EFFORTS AND STUDIES

Information from relevant documents was reviewed for integration into this basin characterization report. The original sources (listed in the reference list at the end of this report) should be consulted for comprehensive presentations of the overview provided here. A substantial amount of the information summarized in this report is taken from the following sources:

- *City of Shoreline Comprehensive Plan.* November 23, 1998.
- *King County Sensitive Areas Map Folio*. 1990.
- *Stormwater Study City of Shoreline GMA Comprehensive Plan/EIS.* KCM 1997.
- *Reconnaissance Report No. 21 – Middle Puget Sound Basin.* King County 1987.

PUBLIC INVOLVEMENT

Interested Shoreline residents participated in the development of this report. The City of Shoreline, which is leading the basin planning activities, facilitated mailings and public meetings. The following steps were included in the public participation process:

- Identify stakeholders within the basin, their interest, and their authority.
- Implement educational measures (e.g., newsletters, utility bill mailers, and public meetings).
- Involve residents in characterizing the basin.

The City of Shoreline held four public meetings and open houses to introduce and explain the Stream and Wetland Inventory and Assessment to City residents. One meeting was held for residents in each of the three major drainage basins including Boeing Creek (April 5, 2001), Thornton Creek (April 3, 2001) and McAleer Creek (April 10, 2001); one general meeting was held to explain the project with respect to all City drainage basins (April 11, 2001).

At each meeting, the City and Ronald Wastewater District set up explanatory stations to describe aspects of the Stream and Wetland Inventory and Assessment. Stations were staffed by City staff, Ronald Wastewater District personnel and consulting scientists. Participants were invited to submit their own observations, including wildlife sightings, evidence of significant erosion, flooding, or other problems and issues. Many of their observations were incorporated into the background information for this report. Appendix D contains handouts produced for the basin meetings.

Both the City of Shoreline and Ronald Wastewater District have ongoing programs to increase the environmental awareness of Shoreline residents, including working with elementary and high school students. The City of Shoreline employs a staff person whose primary responsibility is working with residents on environmental education issues.

On March 3, 2003, the City Council received the Draft Stream Basin Characterization Reports for their review. After a public testimony the Council referred this study to the Planning Commission to receive and review any new scientific information and to report to the Council its findings and recommendations.

On March 19, 2003, the Planning Commission Chair received a letter from the Washington Department of Fish and Wildlife (WDFW) that included several observations and raised potential issues regarding the subject reports and specifically two reaches of Thornton Creek including Peverly Pond. On March 20, 2003, Commissioners discussed the WDFW letter and concluded that a thorough review of the issues raised in the letter should be referred to the scientists who wrote the stream report for analysis and response.

The City of Shoreline asked Tetra Tech/KCM, Inc. to review the WDFW letter, examine scientific and other available material addressing Thornton Creek in context of Best Available Science (BAS) requirements, review Washington State Department of Transportation studies referenced in the WDFW letter, conduct additional evaluation of habitat quality in Thornton Creek Reach 8 (TC8), TC2, and Peverly Pond, and recommend to the City any potential need to modify the Stream Basin Characterization Report.

Tetra Tech/KCM, Inc. addressed the issues raised in the WDFW letter, conducted additional research, contacted Eva Wilder, WDFW scientist who raised several issues in the WDFW letter, and, with the support of City staff, conducted a biological evaluation of TC8, TC2, and Peverly Pond. Based on the scientific findings and analysis, they concluded that the information presented in the WDFW March 19 letter to the Planning Commission does not materially change what is contained in the draft Stream Basin Characterization report, specifically the Thornton Creek Basin Report.

The Planning Commission reviewed the additional information from Tetra Tech/KCM on November 20, 2003 and received public testimony. They continued their review on December 4, 2003 and again received additional testimony regarding Thornton Creek Reach 8 (TC8), TC2, and Peverly Pond. Rather than forwarding a recommendation to the City Council, the Commissioners provided staff with direction to remove the distinctions between "artificial open water course" and "open water course" within each of the Characterization Reports and to delineate and map more completely the wetland south of Twin Ponds (Figure 2-3). The City engaged again the services of Tetra Tech/KCM to use the Tri-County Urban Stream Baseline Evaluation Methodology (USBEM) on stream reaches that were classified as "artificial open water courses". Tetra Tech/KCM evaluation of the stream reaches and the maps are included in these reports.

2. STUDY AREA DESCRIPTION

Natural drainage in the City of Shoreline occurs in nine drainage basins (see Figure 2-1). The drainage basins called Middle Puget Sound North and Middle Puget Sound South are a part of the larger area draining directly into Puget Sound. The portion of the Puget Sound drainage that lies within the City of Shoreline encompasses about 1,250 acres north of the mouth of Boeing Creek and about 310 acres south of Boeing Creek. Although geologically and hydrologically similar, they are hydraulically separated. Differing land uses between the north and south basins warrant separate analyses of the two.

There are six major drainages within the basins: Upper Puget Sound North, Upper Puget Sound South, Innis Arden North, Innis Arden South, Highlands Creek and Storm Creek. The latter drains the largest area in the basins.

PLANNING UNITS

The first step in basin planning is to divide the basin into manageably sized planning units for analysis. The appropriate size of the planning units depends on the types of analyses to be performed. More detailed analyses require a smaller planning unit. The following analyses are included in the characterization report:

- Estimation of existing and future land use and corresponding percentage of impervious surface
- Analysis of land use as it relates to water and habitat quality
- Characterization of in-stream habitat quality
- Stream assessment, including water quality, flooding and erosion issues, riparian habitat, and fish passage barriers
- Description of major wetlands

Subbasins

The size of the watershed planning units (subbasins) delineated for the Middle Puget Sound Basins is between 0.5 and 1 square miles. According to the *Rapid Watershed Planning Handbook* (Center for Watershed Protection 1998), measures to classify and manage streams are appropriate management approaches for this size of planning units. The drainage characteristics for subbasins of this size are strongly influenced by the amount of impervious surface within the basin.

The boundaries of the Middle Puget Sound Basins and the basins of the Seattle Golf Club and Bitter Lake were created using several sources of information:

- **City of Seattle Basin Boundary**: This boundary was generated using topography from a 1993 aerial survey.
- **King County Drainage Map (1984)**: A drainage map created by King County was used to identify drainage based on existing stormwater drainage.

- **City of Shoreline**: Portions of the drainage boundary were field-verified by the City of Shoreline.
- **King County Aerial Survey (2001)**: Contour lines generated from a 2001 LIDAR aerial survey were used to verify topographic boundaries.

The Middle Puget Sound Basins are composed of dozens of small localized drainages. Twelve subbasins were delineated by topography for the significant drainage features within the basin. Of the 12 subbasins, the following have significant drainage features:

- MPSN-B (Innis Arden South Creek)
- MPSN-D (Innis Arden North Creek)
- MPSN-E (Storm Creek)
- MPSN-F (Upper Puget Sound North and Upper Puget Sound South)
- MPSS-B (Highlands Creek)

The Middle Puget Sound subbasins and the Seattle Golf Club and Bitter Lake Subbasins are shown in Figure 2-2. Subbasin MPSN-G consists of two separate creeks that drain north into Snohomish County. They are not necessarily part of the same subbasin, but were grouped together for this report.

Stream Reach Planning Units

Dividing a stream into reaches provides a structure for recording stream habitat information and for prioritizing improvement projects. Preliminary stream reaches were defined using topographic and hydrographic data from the City of Shoreline Geographic Information System (GIS). Uniform hydraulic characteristics such as channel gradient and alignment were used to develop the preliminary reaches, since stream reaches with uniform hydraulic characteristics generally have uniform fish habitat features.

The stream reaches mapped based on GIS data were refined using information gathered in a stream reconnaissance. During the reconnaissance, the preliminary stream reaches were verified for predominantly homogenous characteristics. Each stream segment, referred to as "open water course" in the map legend, was designated as a reach. This includes sections that are obviously ditched or channelized because they might presently serve or have the potential to serve the same functions and values as a natural stream. Some reaches were not entirely homogenous; a reach designated as an open water course, for example, may have small sections that are piped (piped water course). Reaches which were a combination of open water courses and piped were mapped based on the predominant characteristic within their reach boundaries.

The inventory conducted as part of the stream reconnaissance included a field survey of significant points such as fish passage barriers, stream alignment changes, flow branch and flow confluence locations, and selected stormwater catchbasins. A Leica GS50 global positioning system (GPS) receiver was used to record the locations of the surveyed features. The GPS database has been provided to the City of Shoreline. The results of the reconnaissance and survey were incorporated into the development of the planning units. The stream reaches for the major drainages within the basins are shown in Figure 2-3.

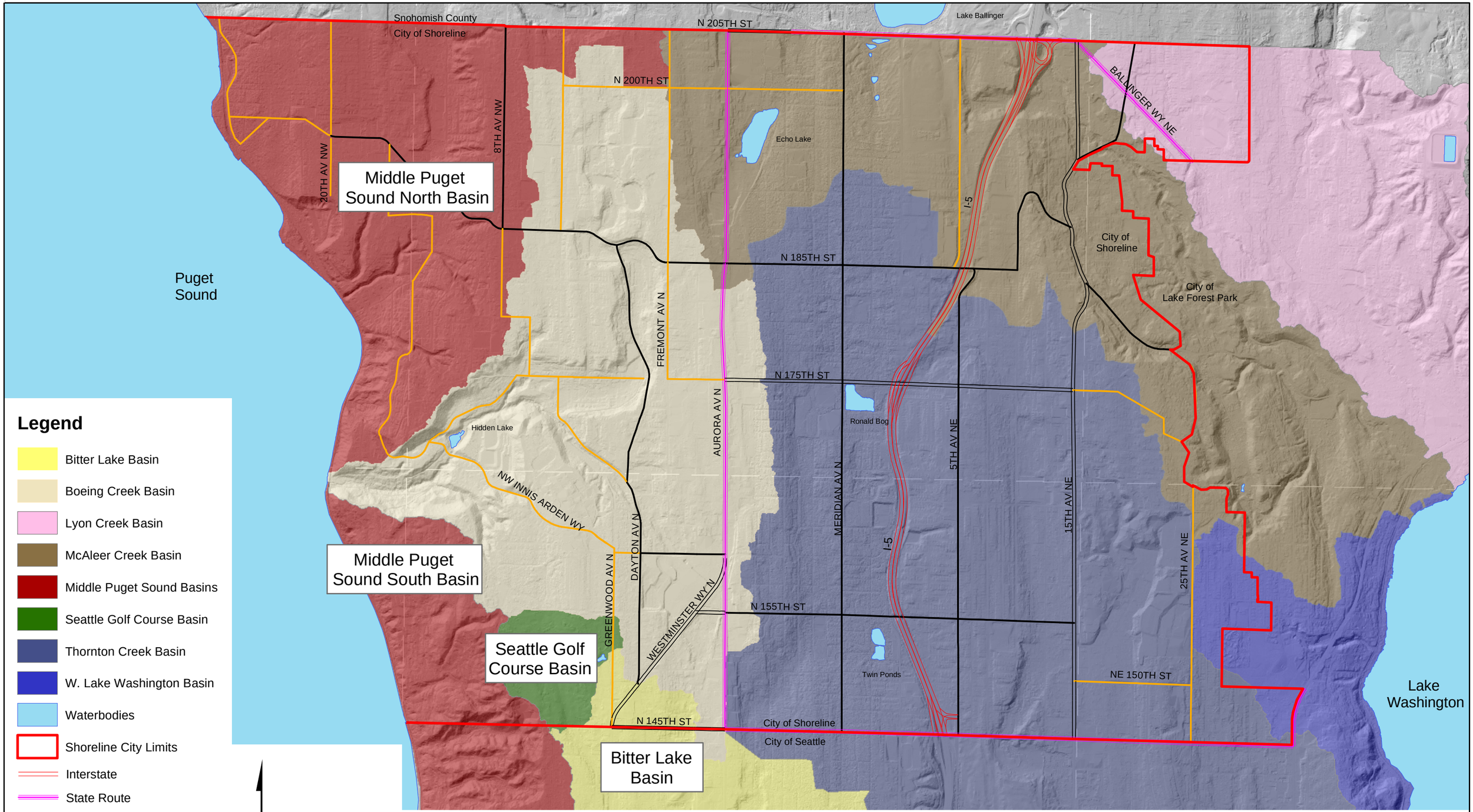

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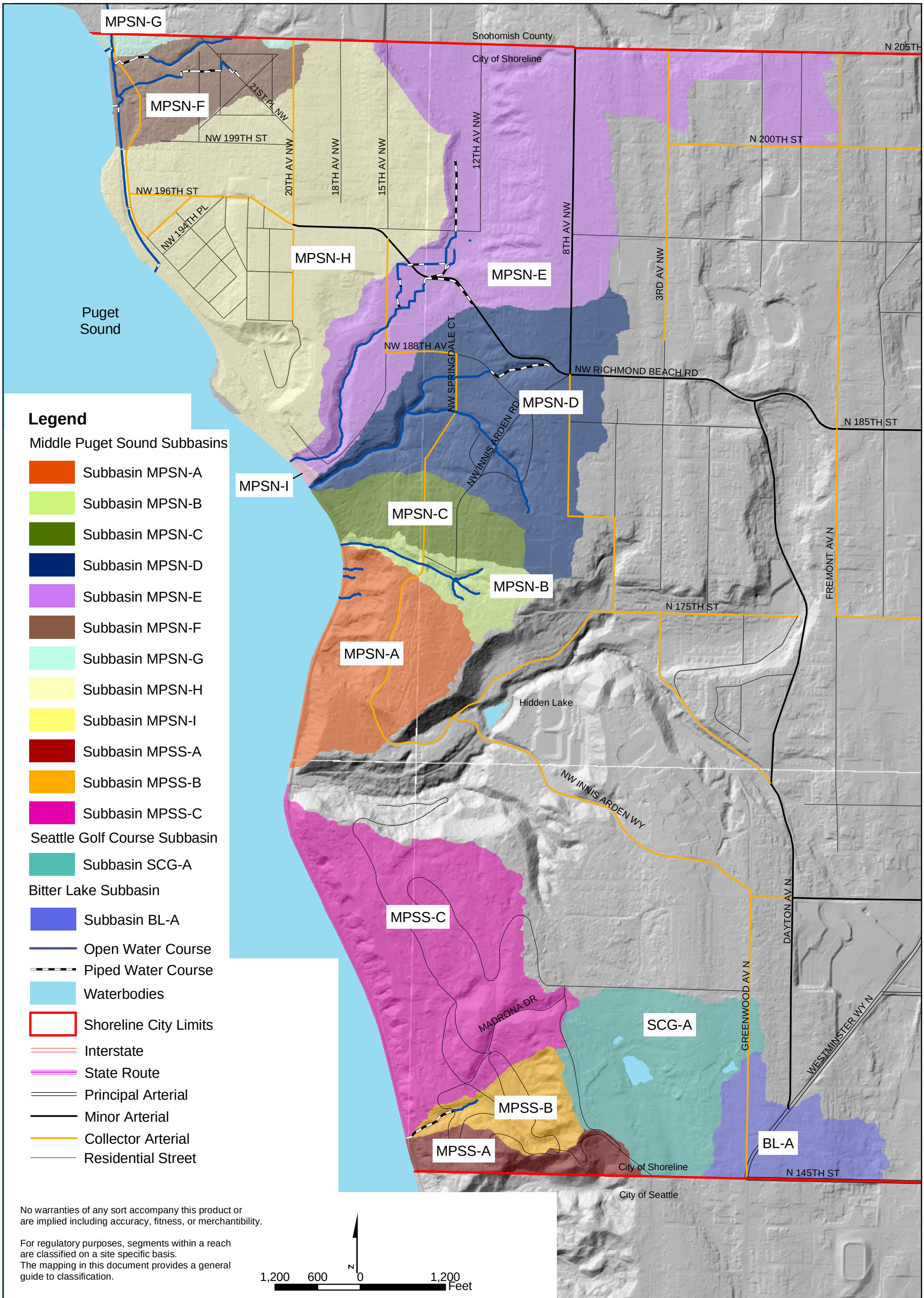
Figure 2-1
Drainage Basins



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For regulatory purposes, segments within a reach are classified on a site specific basis. The mapping in this document provides a general guide to classification.

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Figure 2-2
Subbasins

LAND USE

Existing Land Use

According to a 1997 estimate by Tetra Tech/KCM, the Middle Puget Sound North Basin is almost 90 percent developed, while the Middle Puget Sound South Basin is approximately 67 percent developed. Current land use is mostly single-family residential, followed by roads. Small areas are developed as multi-family, schools, commercial, and parks and open space (KCM 1997). Figure 2-4 shows the existing land use patterns in the basin. Variations in land use categories exist within the basins. For example, within The Highlands, single family residential land use is characterized by large homes on lots larger than 1 acre surrounded by areas of privately owned open space. In general, lot sizes increase from north to south within the basins, with the north central portion of the Middle Puget Sound North Basin containing the largest diversity of housing. Commercial areas are primarily along the Richmond Beach Road corridor.

Impervious Surface Area Percentage

Human alteration of the landscape, including clearing, grading, paving, building and landscaping changes the physical features that affect hydrologic and biological processes. Soil compaction and paving reduce the infiltration and storage capacity of soils, which in turn lessens groundwater recharge and base flows in streams. These high flow rates can cause flooding and destroy aquatic and riparian habitat by eroding banks, removing riparian vegetation, filling stream riffles and pools and creating debris jams. Heavy rains can lead to a runoff process called Horton overland flow, whereby the rainfall rate exceeds the infiltration rate, and the excess precipitation flows downhill over the surface. This type of flow results in water rapidly reaching a stream or built conveyance system, causing more frequent and much higher peak flow rates than would occur with the natural landscape. These flows increase the erosive force in the creeks and can result in bank failure and channel incision. Development not only increases peak flow rates, but also changes annual and seasonal runoff volumes. By quantifying the percentage of the basin that is covered with impervious surface, the rainfall-runoff relationship in the basin can be described, and appropriate mitigating measures can be implemented.

For this report, impervious area is expressed as total impervious area (TIA), which is defined as the amount of actual impervious area. Features included in TIA include roofs, roads, driveways, and any other surface that prevents water from infiltrating into the ground. This area is calculated by adding up or estimating all of the area of impervious surfaces within a basin. TIA is expressed as a percentage of the total surface area.

The TIA was computed for each subbasin using the ArcView GIS software program. Table 2-1 shows the estimated TIA for general land use types as defined by the City. Knowing the amount of each existing land use type, and knowing the percent impervious value for each land use type, it was possible to directly compute the average TIA for each subbasin, as shown in Table 2-2.

TABLE 2-1.
GENERAL LAND USE CATEGORIES AND ASSOCIATED PERCENT IMPERVIOUS VALUES

Land Use	Percent Impervious
Commercial	87
Residential/Multi-Family	73
Public Facilities	55
Institution	57
Transportation	70
Open Space	0
Parks/Cemetery	12
Residential (Lots Less Than 5,000 SF)	57
Residential (Lots 5,700 to 7,199 SF)	40
Residential (Lots 7,200 to 10,890 SF)	36
Residential (Lots 10,891 to 21,780 SF)	28
Residential (Lots 21,781 to 43,560 SF)	19
Residential (Lots more than 43,560 SF)	17

Source: City of Shoreline

TABLE 2-2
EXISTING PERCENT IMPERVIOUS VALUES
FOR MIDDLE PUGET SOUND SUBBASINS

Subbasin Identification	Percent Impervious
MPSN-A	27
MPSN-B	27
MPSN-C	33
MPSN-D	32
MPSN-E	36
MPSN-F	36
MPSN-G	39
MPSN-H	40
MPSN-I	51
MPSS-A	19
MPSS-B	20
MPSS-C	24

For this analysis, City of Shoreline staff obtained impervious surface data from a variety of sources. King County provided data for properties whose owners pay the surface water management utility fee. These properties encompass the commercial, multi-family residential, public facilities, parks/cemeteries, and institution land use categories. The County tallies the amount of impervious surface for commercial and institutional parcels to determine the utility fee.

For the single-family residential land use, City of Shoreline staff sampled six lot-size categories ranging from less than 5,000 square feet to larger than 43,560 square feet (1 acre). Staff analyzed 1999 aerial photos to determine the percentage of impervious

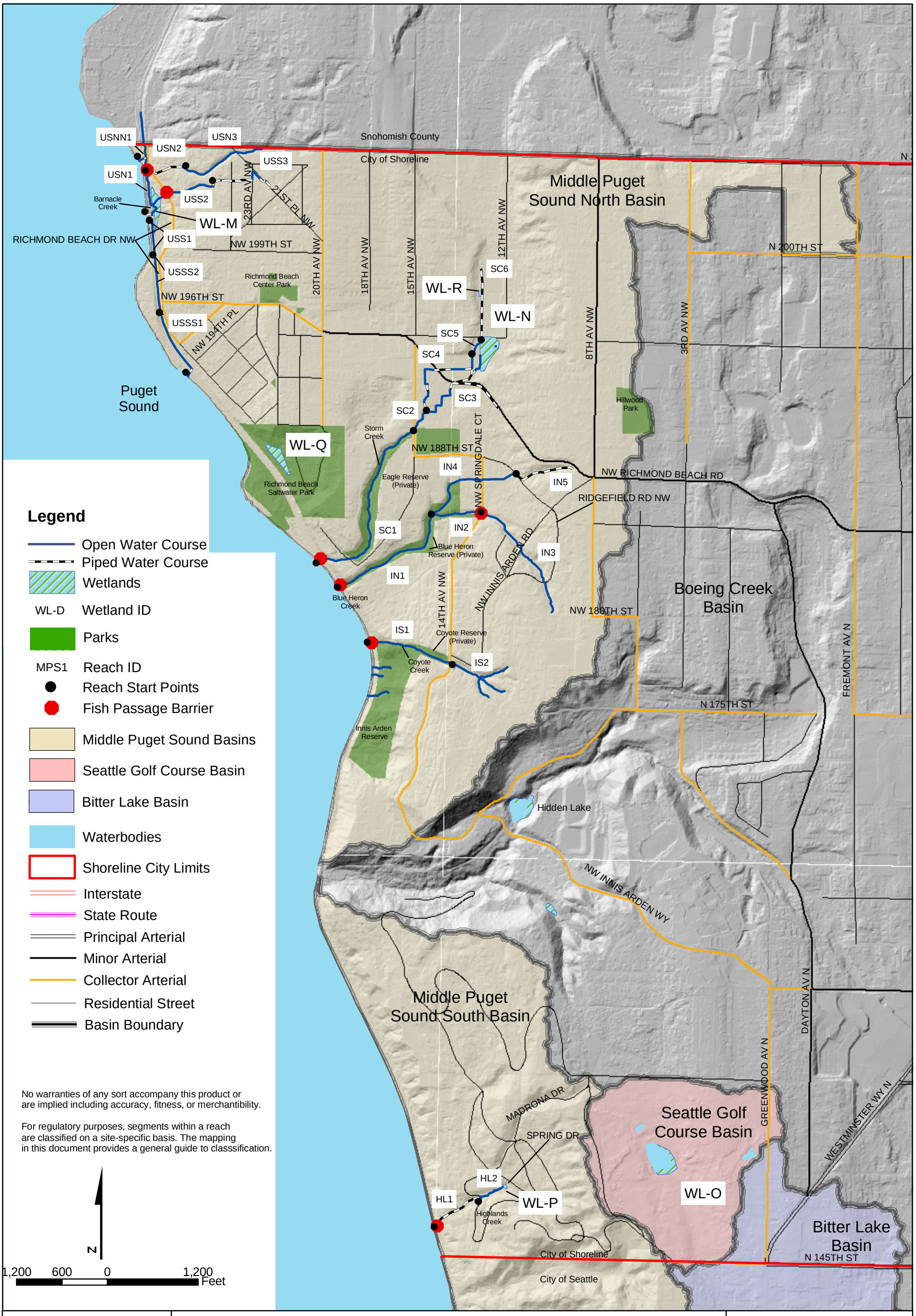

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Figure 2-3

Stream Reaches, Wetlands and Fish Passage Barriers

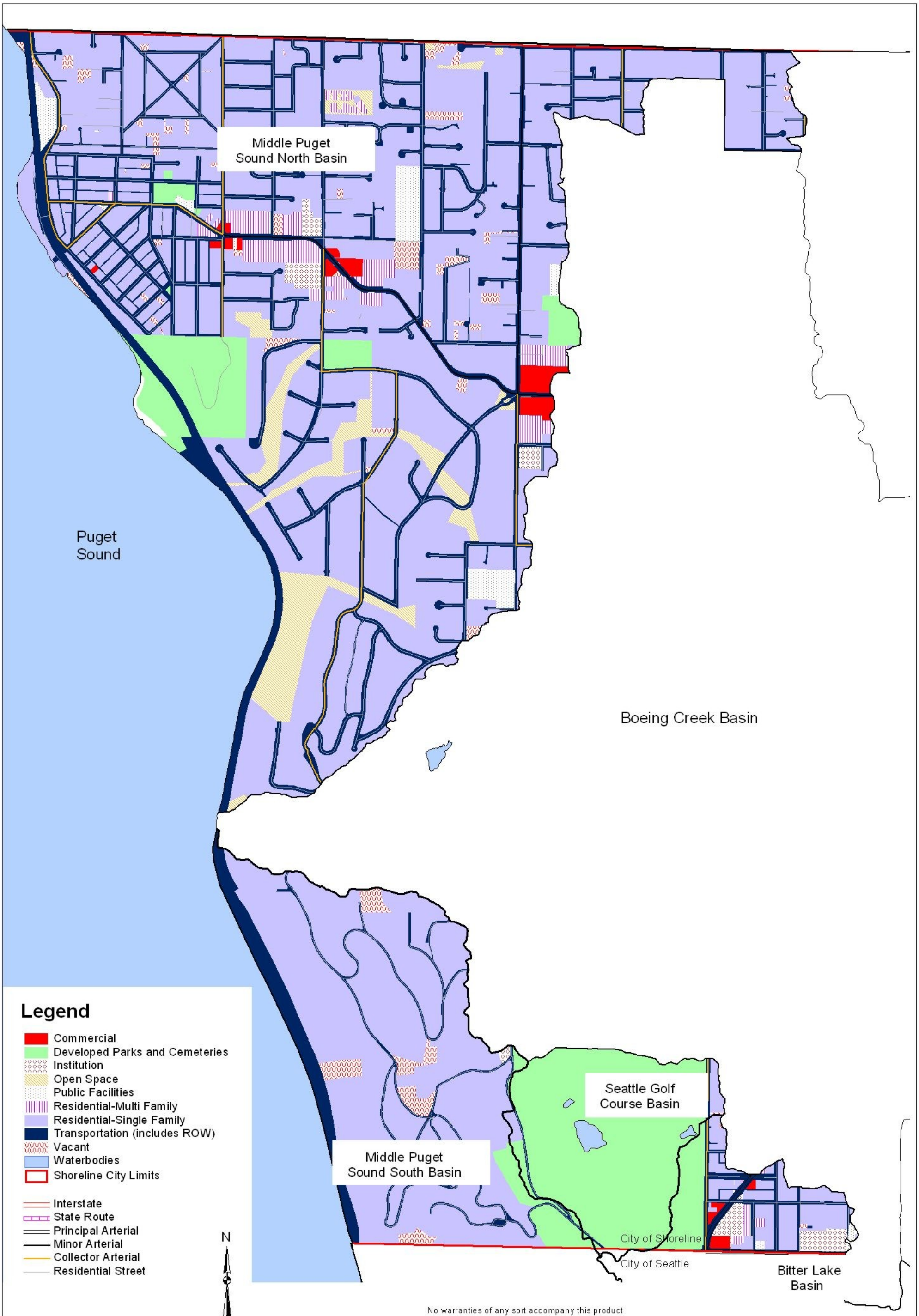

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Figure 2-4
Existing Land Use

surface for each of 130 residential parcels. From this analysis, staff calculated and applied a percent impervious factor for six residential lot sizes. These percentages were applied to the actual area of each single family lot in the basin to determine total impervious area for the single family land use type. For transportation, staff chose to use a percent impervious value of 70 percent, based on analysis by the Snohomish County Surface Water Management Division.

The weighted average of the existing percent impervious values for the Middle Puget Sound North Basin is 36 percent, with individual subbasin averages ranging from 19 percent to 51 percent. The weighting includes a factor for the subbasin area. Subbasins MPSN-I and MPSN-G have relatively high percent impervious, but since they are small basins the overall hydrologic and ecological effect on the basins is relatively small. The highest concentration of impervious surface is in the upper portions of Middle Puget Sound North. This is significant since runoff from this area affects the rest of the basin.

The weighted average of the existing percent impervious values for the Middle Puget Sound South Basin is 23 percent. This relatively low value, compared to other basins in the City, is primarily due to the lower density of residential development in the basin. Private covenants, as in the Highlands Community, have limited the amount and density of development in this basin. The lowest percentage of impervious surface occurs within Subbasin MPSS-A, which is a relatively undeveloped open space.

Future Land Use

The City's zoning plan specifies the current potential for future land use within the basin. Current zoning, illustrated in Figure 2-5, indicates that low density residential zoning (R-6) covers the largest area in most of the basins. Commercial areas are confined to two corridors along Richmond Beach Road and an area along Westminster Way. This small commercial area at the City's gateway where Greenwood Avenue North turns into Westminster Way amounts to a substantial percentage of the portion of the Bitter Lake Subbasin that extends into Shoreline.

With the exception of parks and open space, which are typically zoned residential but will not be developed in the future for that use, the City's current zoning plan was used to estimate the maximum potential increase in the amount of impervious surface. The zoning plan was chosen over the City's Comprehensive Plan to estimate future land use because it is consistent with the Comprehensive Plan Future Land Use Map but, unlike the Comprehensive Plan, is based on specific standards for maximum impervious surface area defined in the Shoreline Municipal Code. Table 2-3 lists the zoning categories and their associated maximum percent impervious values, as defined in Section 20.50.020 of the Shoreline Development Code. The future TIA analysis assumed that the basin would be fully built-out according to the maximum allowed impervious area as specified in the City's Development Code.

TABLE 2-3.
ZONING CATEGORIES AND ASSOCIATED
PERCENT IMPERVIOUS VALUES

Land Use	Percent Impervious
Developed Parks and Cemeteries	15
Open Space	0
Residential, 4 units/acre	45
Residential, 6 units/acre	50
Residential, 8 units/acre	65
Residential, 12 units/acre	75
Residential, 18 units/acre	85
Residential, 24 units/acre	85
Residential, 48 units/acre	90
Neighborhood Business	85
Office	85
Community Business	85
Regional Business	95
Industrial	95
Transportation ROW	70
North City Business District	95
Contract Zone	85

Source: City of Shoreline

The future percent impervious values for the subbasins in the Middle Puget Sound Basins were computed using the ArcView GIS software program. Future impervious surface area was calculated for each parcel in the Middle Puget Sound Basins based on the maximum allowed impervious surface percentage for that parcel's zone in the Shoreline Development Code, multiplied by the area of the parcel.

City parks and open space were given a future percent impervious value based on studies done in other jurisdictions and the professional opinion of staff. It was assumed that developed parks would see additional development of impervious surfaces to accommodate new park facilities and appurtenances, while open space areas would remain natural and free from new development. Table 2-4 lists the percent impervious in each subbasin for full build-out conditions using these assumptions.

The weighted average of future percent impervious values for the Middle Puget Sound North and South Basins are 51 and 47 percent, respectively. Under full buildout conditions, the percent impervious values in Middle Puget Sound North Subbasins increase an average of 16 percent from existing conditions. In the Middle Puget Sound South subbasins, the average increase is 24 percent. It should be noted that future buildout conditions are based on the maximum allowed impervious surface percentage under the Shoreline Development Code. Private covenants may limit the density of development. For example, the privately owned Innis Arden Reserve in Subbasin MPSN-A is zoned as single-family residential, but will most likely never be developed. Therefore in some cases the estimate of future percent impervious may be conservative.

Middle Puget Sound North Basin

Puget Sound

Boeing Creek Basin

Middle Puget Sound South Basin

Seattle Golf Course Basin

City of Shoreline

City of Seattle

Bitter Lake Basin

Legend

Future Land Use

- R-4; Residential, 4 units/acre
- R-6; Residential, 6 units/acre
- R-8; Residential, 8 units/acre
- R-12; Residential, 12 units/acre
- R-18; Residential, 18 units/acre
- R-24; Residential, 24 units/acre
- R-48; Residential, 48 units/acre
- O; Office
- NB; Neighborhood Business
- CB; Community Business
- RB; Regional Business
- I; Industrial
- CZ; Contract Zone
- Shoreline City Limits
- Waterbodies

- Interstate
- State Route
- Principal Arterial
- Minor Arterial
- Collector Arterial
- Residential Street

N

1200 0 1200 Feet

Representation of official zoning map adopted by City Ordinance No. 292. This map shows amendments through November 13, 2001.

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Figure 2-5
Future Land Use
Based on 2001 Zoning

TABLE 2-4.
FUTURE PERCENT IMPERVIOUS VALUES
FOR MIDDLE PUGET SOUND SUBBASINS
AT BUILDOUT

Subbasin Identification	Percent Impervious
MPSN-A	44
MPSN-B	45
MPSN-C	50
MPSN-D	49
MPSN-E	52
MPSN-F	54
MPSN-G	56
MPSN-H	52
MPSN-I	61
MPSS-A	42
MPSS-B	44
MPSS-C	49

The areas likely to experience the highest growth are in the northwest and central portions of the Middle Puget Sound North Basin and in the commercial area along Richmond Beach Road. Rainfall runoff from the highly impervious commercial areas may disproportionately influence stream and bank conditions in Storm and Blue Heron Creeks.

CLIMATE

The characteristic weather of the Middle Puget Sound Basins is typical of the mild, mid-latitude coastal climate of the Pacific Northwest, moderated by marine air from the Pacific Ocean. In the summer, temperature ranges from the 70s to the 90s during the day and drops to the 60s at night. In the winter, temperatures average in the 40s during the day and 30s at night, with occasional cold spells and temperatures in the low 20s.

Precipitation in the study area is influenced by the moist marine air, which, when lifted and cooled by the mountains as it moves inland, causes persistent cloudiness and precipitation, resulting in an average of about 40 inches of precipitation annually. Snowstorms occur rarely, often followed by warming temperatures and rain. The frozen ground is unable to absorb the snowmelt and rainfall, which can cause severe flooding, as during the 1996 holiday storm. Most of the rain falls during the wet season, approximately October to May, usually with low intensity but long duration. While the prevailing winds come from the southwest, there are occasional severe storms from the north.

GEOLOGY AND SOILS

Surveys of both surficial geology and soils were examined for this report. Surficial geology develops from geologic activity (glacial advance and retreat for example), while soils develop as the geologic units in the area weather. Since the soil layer in an area can be very thin in areas of erosion, the geologic layer is often found at the ground surface, and is often

incorrectly referred to as a soil layer. Since the geologic layer often dominates the infiltration and seepage characteristics of an area, as well as its tendency for erosion, a more complete description is provided below. Figure 2-6 shows the geologic units of the Middle Puget Sound Basins.

Geology

The terrain of the Middle Puget Sound Basins was formed as the result of glacial movement approximately 10,000 years ago. The advancement and retreating of glaciers created much of the Puget Sound area as it is today.

The basins consist of several small catchments on the western edge of the Seattle drift plain, a rolling plateau that drops irregularly toward Puget Sound. The retreat of the ice sheet from the Puget lowland left a sequence of lacustrine clay-silt, proglacial sand and gravel, and till in the western edge of the drift plain. Till covers most of the plateau surface and older sediments are exposed in the coastal bluffs and the hillslopes west of 8th Avenue NW. A large delta of postglacial sand and gravel overlies the till at Richmond Beach.

Water that has percolated into the surface of the drift plain emerges on the hillslopes above Richmond Beach, in Innis Arden and in the bluffs along Puget Sound. Combined with surface runoff, this water forms several creeks that flow toward the Sound, eroding small ravines in the sediments, especially in the looser sands and gravels. The till is more resistant, but it too is being eroded by stream action, especially where the creeks drop off the plateau to the beach.

Till is resistant to infiltration and provides the best locations for retention/detention mitigation projects. The sand and gravel layers have high infiltration rates and are best suited as locations for infiltration ponds. Caution should be used in locating infiltration ponds; surcharging the groundwater table in areas prone to slides can accelerate the erosion process or lead to a catastrophic landslide.

Soils

Soil types in the Middle Puget Sound Basins were summarized from the soil survey compiled in 1952 by the U.S. Soil Conservation Service (SCS). The predominant soil type in the Middle Puget Sound South Basin was Everett gravelly sandy loam (75 percent) with the remainder being Alderwood gravelly sandy loam. The predominant soil type in the Middle Puget Sound North Basin was split between two major soil types: Alderwood gravelly sandy loam (51 percent) and Everett gravelly sandy loam (42 percent). The rest of the soils had areas less than 4 percent of the total including, Carbondale muck, Coastal beach and Norma fine sandy loam. Carbondale muck is a hydric soil and frequently supports wetlands.

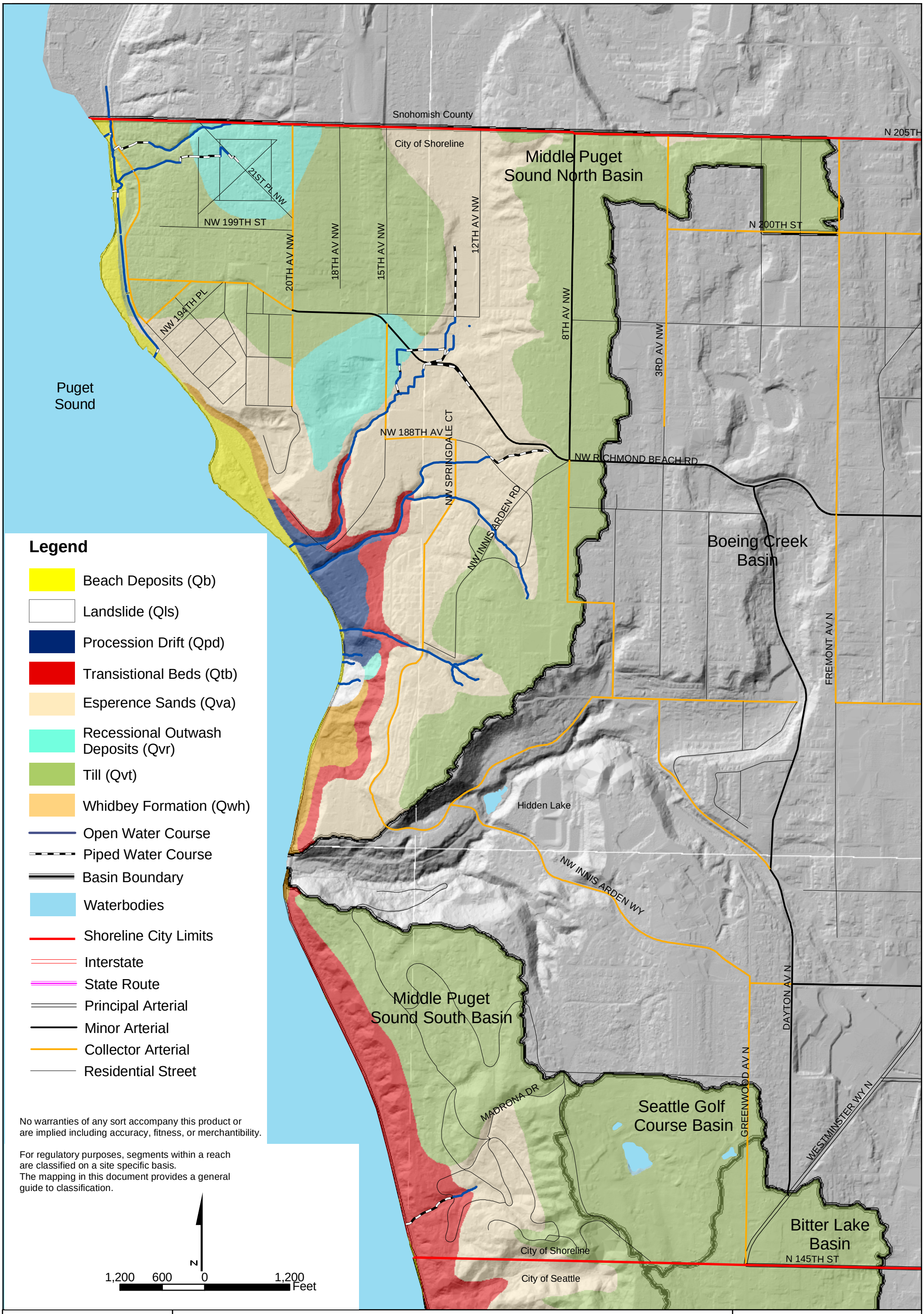

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Figure 2-6
Surficial Geology

3. DRAINAGE CHARACTERISTICS

The drainage system of the Middle Puget Sound Basins (North and South) is composed of six major drainage courses that are not hydraulically connected (Figure 2-3). The only major drainage course in Middle Puget Sound South is Highlands Creek. The drainages in Middle Puget Sound North are:

- Innis Arden North Creek
- Innis Arden South Creek
- Storm Creek
- Upper Puget Sound North
- Upper Puget Sound South.

Drainage in the Middle Puget Sound Basins begins as urban runoff or as seepage from hillsides (King County 1987). The headwaters of Upper Puget Sound and Storm Creek are located to the north in Snohomish County. All other streams originate from wetlands, hillside seeps and urban runoff. Each stream drainage is discussed in more detail below.

STREAM SYSTEMS

Highlands Creek

Highlands Creek, divided into Reaches HL1 and HL2, is entirely within the Highlands development, a gated community within the City limits. From its headwaters upstream of Olympic Drive, the stream flows west, adjacent and through private property, mostly in a pipe. The approximate length of the water course is 1,200 feet, of which 350 feet is an open water course and the rest is piped. Flow seems to originate primarily from groundwater and is relatively constant throughout the year.

Innis Arden South Creek

Innis Arden South begins as three or more branches (Reach IS2) that extend into ravines with relatively steep side slopes. These branches come together on private property near NW 175th Street. Flows in the upper portion of the creek are intermittent and are strongly affected by stormwater inflow. The stream gradients in this creek range from 4 to 8 percent in the upland areas, with slightly steeper gradients in the bluff region near Puget Sound (King County 1987). Below the confluence of these branches, the creek flows another 1,700 feet before entering Puget Sound. The bottom reach (IS1) flows through a private tract called the Coyote Reserve and through Innis Arden Reserve.

Innis Arden North Creek

Innis Arden North Creek begins as a north stem and a south stem. The north stem (Reaches IN4 and IN5) begins near the intersection of NW Richmond Beach Road and 8th Avenue NW. The north stem flows generally southwest until it joins with the south stem downstream of Springdale Court NW. The south stem (Reaches IN2 and IN3) begins

near the intersection of 10th Avenue NW and NW 180th Street and flows approximately 2,600 feet in a northwest direction until it joins with the north stem. Below the confluence of the stems, the creek (Reach IN1) flows generally southwest until it reaches Puget Sound. Much of this stream flows through the private Blue Heron Reserve. Innis Arden North Creek drains a larger area than Innis Arden South Creek and experiences larger flows.

Storm Creek

Storm Creek begins upstream of NW 195th Street and flows generally southwest to Puget Sound. Although the creek first daylights in the City of Shoreline, its headwaters are outside the City limits in Snohomish County. Several small unmapped tributaries enter the creek between NW 195th Street and NW Richmond Beach Road. One of the piped tributaries (Reach SC6) begins as seepage in a wetland area on undeveloped property just west of 12th Avenue NW. The other tributary inlets are likely additional drainages from the wetland area. To accommodate development, the stream was split (Reaches SC3 and SC4) in the vicinity of the Meadowbrook Apartment complex and joined again near NW 191st Street (Reach SC2). There are continual maintenance issues with the conveyance system in this area as a result of this alteration; flooding is commonplace during heavy rains.

Below NW 191st Street, the creek (Reach SC1) continues southwest for 3,000 feet through the privately owned Eagle Reserve in Innis Arden before entering Puget Sound. The stream is confined within a very steep ravine between the mouth and 17th Place NW. Severe erosion occurs in the lower sections of Storm Creek through the Eagle Reserve. Bank hardening and several weirs have been constructed to protect private property, a pump station and a sewer line crossing Storm Creek.

Upper Puget Sound

Upper Puget Sound is a drainage course locally known as Barnacle Creek (USN1). It has a north stem and a south stem that join together before flowing into Puget Sound. This stream flows through highly developed residential areas. The north stem (USN2 and USN3) begins upstream of NW 204th Street and flows west through developed areas. A 600-foot section of the stream is piped in this area. After the stream daylights downstream of Richmond Beach Drive NW, the stream enters a wet area east of the Burlington Northern Santa Fe (BNSF) Railroad and flows generally south. At an undefined location, the north stem joins with the south stem and flows through a culvert and into Puget Sound.

A channelized open water course is present along the BNSF Railroad east of the tracks. It appears that drainage collects along the east side of the railroad before exiting into Puget Sound through culverts underneath the railroad. Another channelized open water course (USS1) begins at approximately 194th Street NW and flows from the south to the north along the east side of the BNSF Railroad and joins Barnacle Creek at the culvert immediately upstream of the BNSF Railroad. This stream is strongly affected by stormwater inflow. The lower section of Barnacle Creek is tidally influenced upstream for a distance of about 20 feet.

Three additional sections of channelized open water courses were mapped for this report (USSS1, USSS2, and USNN1). USSS1 was mapped from its culvert outlet near NW 194th

Street to the NW 196th Street bridge over the BNSF Railroad. A divide at the bridge separates Reach USSS1 from Reach USSS2. Reach USSS2 begins at the NW 196th Street bridge (south divide) and ends at the subbasin divide at NW 198th Street (north divide). Water appears to collect in reach USSS2 and can flow over either the north or south divide when its surface elevation rises. The last channelized open water course section mapped along the BNSF Railroad (USNN1) begins in Snohomish County and flows south to a culvert just north of NW 204th Street. Most of the tributary area for this l open water course appears to be in Snohomish County.

4. HABITAT CHARACTERISTICS

This chapter addresses habitat characteristics in the Middle Puget Sound North and South Basins. Streams are described by individual reach. Fishery habitat is addressed, including definite and potential barriers to fish access. Significant wetlands are described. Riparian and terrestrial habitat are also addressed, as well as species of concern under state and federal regulations.

STREAM HABITAT

A stream reconnaissance in the spring and summer of 2001 evaluated the aquatic habitat of the streams in the Middle Puget Sound Basins. The Tri-County Urban Stream Baseline Evaluation Method (USBEM; R2 Resource Consultants 2000) was adapted for the stream reconnaissance of the Middle Puget Sound Basins. The USBEM provides a protocol for determining a stream's suitability as habitat for a selected salmonid species. Time and cost precluded utilizing the full protocol. The report and data of this assessment are provided in full in Appendix A. A summary of the aquatic habitat conditions within each reach is provided below.

Stream Channel Modifications

Most of the stream reaches are modified with a variety of structures, such as weirs, asphalt substrate, bank armoring, culverts, bridges and artificial pools. The Ronald Wastewater District encased a damaged sewer pipe in concrete as it crossed Reach SC1 approximately 800 feet upstream of the mouth. Figure 2-3 shows the locations of definite fish passage barriers. In many reaches, most of the native riparian vegetation has been removed for landscaping with ornamentals and grass or for home gardens. The level of channel and basin alteration is high for the basins as a whole and for all the reaches.

Benthic Invertebrate Analysis

Three benthic invertebrate samples were collected at suitable locations along Storm Creek only. The results of the sampling are presented in Table 4-1. All samples collected had a density of less than 150 organisms per square meter, made up of only 3 to 5 taxa or orders of invertebrates, most of which were tolerant to environmental stress and unstable habitats. The dominant taxon in each sample made up at least 40 percent of the total number of organisms, indicating poor diversity. All samples were rated poor relative to biointegrity based on the low diversity of species and dominance by more tolerant species.

TABLE 4-1.
DATA SUMMARY FOR BENTHIC INVERTEBRATE SAMPLING

Reach	Total No. of Organisms	Total No. of Taxa	EPT No.[a]	Benthic Invertebrate Bioassessment[b]
SC1	107	4	1	43
SC2	122	4	1	34
SC5	82	5	2	39

a. Number of taxa present in sample that are in the orders of Ephemeroptera, Plecoptera, and Tricoptera, or preferred salmon prey species.
b. Biomonitoring protocol for assessing benthic invertebrate communities developed by Aquatic Biology Associates, Inc. (March 1996). Rankings are as follows:
   - 90-100 Very High—Very high habitat complexity, biotic integrity, taxa richness, percent of cool adapted fauna, number of more specific microhabitat related taxa; low number of tolerant taxa
   - 80-89 High—High as above, low number of tolerant taxa
   - 60-79 Moderate—Moderate as above, some habitat limitations
   - 40-59 Low—Low as above, significant habitat and water quality limitations
   - <40 Severe—Severe departure from ideal conditions.

The benthic invertebrate bioassessment revealed that most samples (with index numbers less than 45) contained an invertebrate community composed of a very low diversity of species. The species present in the greatest numbers were those that are tolerant of toxic conditions. The reaches sampled were observed to have a high proportion of sandy, unstable substrate and a severely stressed habitat as a result of sediment input. Reach SC1 suffers from severe erosion problems due to high flows; however, it had the highest bioassessment value. Reaches SC2 and SC5 occur in highly developed areas. It is likely that these conditions, including streambed instability, prevent a diverse and rich benthic invertebrate community from becoming established.

Given the community structure observed, it is possible that other limiting factors are present, such as significant levels of pollutants, which would greatly diminish the ability of Ephemeroptera, Plecoptera, and Tricoptera to survive. This species diversity could also be an indication that, although habitat conditions are not suitable for a diverse assemblage of benthic invertebrates, they have the potential to become suitable with the proper enhancement and protection, including primarily peak flow reduction.

Definite conclusions cannot be made from this single sampling event. The City has an ongoing water quality monitoring program to accumulate more data regarding the health of City streams.

Reach Habitat Descriptions

Figure 2-3 shows the reaches of the Middle Puget Sound Creek system and indicates whether they are an open water course or piped water course. The stream habitat condition found in each reach during the stream reconnaissance using a customized version of the Tri-County Urban Stream Baseline Evaluation Method (R2 Resource Consultants 2000) is described below and in more detail in Appendix A.

Highlands Creek Reaches 1 and 2

Highlands Creek is a spring-fed stream that consists of two reaches (HL1 and HL2) extending from just west of Spring Drive to Puget Sound. A spring and associated wetland (WL-P) located between Cherry Loop and Spring Drive are the headwaters of Highlands Creek; no flows occur above that location except sheet flow during heavy rain storms. Below the spring, the channel (HL2) is poorly defined. Because of negligible flow, no data were collected for embeddedness or benthic invertebrates. Embeddedness can be described quantitatively or qualitatively. For this report, embeddedness is a qualitative measure of the amount of fine material clogging stream gravels and reduces spawning suitability. No pools were present, resulting in a poor rating for channel form and pool frequency. No pieces of large wood (LW) were observed. Large, dense conifers were present, as well as a number of ornamental and non-native species. For this reason, a fair rating was given for riparian conditions.

At Cherry Loop (HL1), the flow enters pipes, concrete pools and finally a tightline that carries flow to the beach. This reach is a piped water course.

Innis Arden South Creek Reach 1

During late summer of 2001, low flows (less than 1 inch) were present in Innis Arden South Creek Reach 1 (IS1), which extends from the creek's mouth at Puget Sound to 14th Avenue NW. This stream is locally known as Coyote Creek. This reach was found to have poor riparian condition, substrate composition, channel pattern, LW and pool frequency. Bank condition was fair. Embeddedness and benthic invertebrate data were not collected since substrate was primarily fines. The area is dominated by non-native species. Banks show evidence of slumping and eroding along more than 20 percent of the reach, and no pools or LW were observed.

West of 14th Avenue NW, the creek is confined in a deep ravine with no defined channel. Vegetation covered the entire ravine floor; water was not present.

At the lower end of the reach, the flow enters a plastic pipe for approximately 300 feet down an extremely high gradient ravine. Fish passage is not possible due to the piping. Removal of the piping may not result in increased passage, since extreme gradients and intermittent flows would remain. A culvert beneath the railroad may prevent fish entry into the creek during low tides. Another culvert, beneath 14th Avenue NW, could impede fish passage at low flows.

Innis Arden South Creek Reach 2

Innis Arden South Creek Reach 2 (IS2) extends from 14th Avenue NW upstream for approximately 400 feet and then splits into three or more branches. These branches come together at the private property on 1302 NW 175th Street. No water was present in any branch and it is likely that this reach is highly intermittent, having flows only after heavy rains and for a very short time following rain events. No pools or LW were observed in these branches of undefined bedform, although banks were fairly stabilized by thin, immature stands of native hardwoods. On the northern branch, blackberries were the dominant vegetation. For these reasons, the overall rating for this reach was poor.

East of 14th Avenue NW, the creek is confined in a deep ravine with no defined channel. Vegetation covered the entire ravine floor; water was not present.

Innis Arden North Creek Reach 1

Innis Arden North Creek Reach 1 (IN1), known locally as Blue Heron Creek, begins at Puget Sound and ends west of 14th Avenue NW. This reach is within the private open spaces of the Blue Heron Reserve east of the BNSF tracks. The stream in this reach is confined in a ravine with no defined bedform and few, shallow pools. Several landslide scars were observed. Ratings for all criteria were poor. The riparian species were primarily hardwoods and non-native species of immature size. The high level of sand and silt indicated poor benthic invertebrate habitat; samples were not taken due to unsuitable substrate.

Flow depth at the time of survey in April of 2001 was less than 2 inches. It likely decreases to no flow during summer months. The gradients recorded for IN1, IN2 and IN3 were 7.4 percent to 8.3 percent, which fish typically are able to ascend. However, given the lack of wood capable of forming step pools, juvenile and adult upstream migration may be hindered. A 36-inch culvert beneath the railroad may prevent passage during low flows or low tides.

Innis Arden North Creek Reach 2

Approximately 1,200 feet upstream of the mouth, this creek splits into two branches: the south branch Innis Arden North Creek containing Reach 2 (IN2) and Reach 3 (IN3) and the north branch Innis Arden North Creek containing Reach 4 (IN4) and Reach 5 (IN5).

Reach IN2 ends at Springdale Court NW and is primarily contained in the Blue Heron Reserve. This reach is confined in a high-gradient channel, is straightened, and has no pools and lacks channel roughness that large wood can typically provide. The riparian area is dominated by non-native species with sparse growth of native hardwoods and offering little potential for LW recruitment. Substrate was dominated by sand and silt with high levels of embeddedness. All criteria were rated poor at this reach, except bank condition, since more than 50 percent of the bank had some form of vegetation holding it in place. The culvert under Springdale Court NW is perched with a 5-foot drop and is impassable at all flows.

Innis Arden North Creek Reach 3

Innis Arden North Creek Reach 3 (IN3) extends upstream from NW Springdale Court to approximately NW 180th Street, crossing under NW Innis Arden Road. Like IN2, IN3 flows through a steep channel with few pools and little LW. Substrate had high levels of embeddedness. Upstream of NW Innis Arden Road, the channel is poorly defined, experiences only ephemeral flows and passes through residential areas with poor riparian cover. Culverts at Ridgefield Road NW and NW Innis Arden Road could impede fish passage at low flows.

Innis Arden North Creek Reach 4

Innis Arden North Creek Reach 4 (IN4) extends from the upstream end of reach IN1 to Ridgefield Road NW. No water was present in the reach during the time of survey and many of the in-stream data were not collected. The riparian area consisted of thin, immature stands of native conifers and hardwoods and no LW was observed. The channel was of undefined bedform, had no pools and was confined in a steep ravine for the portion not on private property. A few areas of slumping were evident, although vegetation was present along most of the banks, resulting in a fair rating for bank condition.

Seasonally low and intermittent flows prevent fish passage. Culverts are present beneath Springdale Court NW and Ridgefield Road NW. Since this reach only experiences seasonal flows, removal of any culverts would increase upstream habitat accessibility on a seasonal basis. Removal of the culverts, however, could increase function and value of downstream segments through the addition of allocanthous material. This is material derived from the canopy in the immediate vicinity of a stream, lake or wetland and typically consists of branches, twigs, leafs, pollen and insects.

Innis Arden North Creek Reach 5

Innis Arden North Creek Reach 5 (IN5) is entirely piped from Ridgefield Road NW to NW Richmond Beach Road.

Storm Creek Reach 1

Storm Creek Reach 1 (SC1) begins at the mouth of Storm Creek at Puget Sound and continues to 15th Avenue NW, passing through a private open space called the Eagle Creek Reserve owned by the Innis Arden Club, a neighborhood association. It is confined within a very steep ravine between the mouth and 17th Place NW; this short portion has almost vertical slopes made up of glacial till. It appears to be unstable, with evidence of frequent slides.

Above 17th Place NW, the creek runs through a narrow, undeveloped valley. Erosion is severe throughout this reach. Non-native species such as English ivy, laurel and holly have spread into parts of the preserve from adjoining property. There is a paved portion of the creek approximately 800 feet upstream from the mouth where Ronald Wastewater District repaired a faulty sewer line. This presents a potential fish passage barrier. The reach had many cascades. Riparian vegetation was mixed native and non-native species and the presence of LW was very low, with less than 0.15 key pieces per bank-full width. Silt and gravel were co-dominant substrates and embeddedness was rated fair. Due to landslides, banks were poorly defined in places and bank conditions were rated poor.

Storm Creek Reach 2

Storm Creek Reach 2 (SC2) begins at 15th Avenue NW and ends just north of NW 191st Street on private property at 19118 15th Avenue NW. Flows were less than 2 inches deep at the time of survey. Riparian areas consisted of non-native species, bank condition was poor due to hardening and no LW was observed. No pools were present and the channel was poorly defined having no pool-riffle complexes. Substrate was dominated by silt, but gravel

was present and embeddedness was fair. Two culverts, beneath 15th Avenue NW and NW 191st Street, were inaccessible for observation.

Storm Creek Reaches 3 and 4

Storm Creek Reaches 3 and 4 (SC3 and SC4) split from the upper end of Reach SC2, forming two branches. Reach SC3 extends about 400 feet north of NW Richmond Beach Road and ends east of the Meadowbrook Apartment complex near Wetland WL-N. Reach SC4 extends north and then east across NW Richmond Beach Road, then reconnects with SC3.

These reaches are in highly developed areas on each side of NW Richmond Beach Road and are alternately in pipes and open water courses as they run through apartment and residential complexes. Low flows were present during surveys (less than 1 inch deep). No pools or LW were evident. Substrate was primarily silt. Water temperature was 50 degrees F (March 30, 2004). Riparian species were predominantly non-native, including blackberry and grasses. Both of these channelized reaches were mapped as open water courses.

Storm Creek Reach 5

Storm Creek Reach 5 (SC5) is a short reach (300 feet) that begins north of the Meadowbrook Apartment Complex, where Reach SC4 ends. This reach collects flow from stormwater pipes exiting from Syre Elementary School and from NW 195th Street. In addition, this reach collects some flow exiting from Wetland WL-N to the east. Most of this reach was rock-lined by private owners and therefore rated poor for bank condition. No pools were observed. Embeddedness was rated poor and substrate consisted primarily of fines. A few small pieces of LW were present, but of unsuitable size to provide cover.

Fish passage may be constrained in this reach by low flows and by rock weirs constructed on private property. However, Washington Department of Fish and Wildlife (WDFW) staff trapped cutthroat trout in this reach during the summer of 1999 (Hennick 1999). The presence of these fish indicates their resilience to adverse living conditions. Even streams with poor habitat can and do support fish. Removal of fish migration barriers can still benefit fish, even when the habitat upstream is ranked as poor.

Storm Creek Reach 6

Storm Creek Reach 6 (SC6) runs from just south of North 195th Street to the property at 1233 NW 199th Place and is entirely piped. No data were collected here; this reach was mapped as a piped water course.

South Upper Puget Sound South Creek Reach 1

South Upper Puget Sound South Creek Reach 1 (USSS1) flows into Puget Sound through a culvert southwest of the intersection of NW 194th Place and Richmond Beach Drive NW. This channelized reach, approximately 3-feet wide, 1-inch deep and with a spall bottom, was mapped as an open water course and flows along the west side of the BNSF railroad tracks. There were no pools or LW. The most common vegetation associated with the reach is reed canarygrass, horsetail and blackberry. The reach extends to the NW 196th Street bridge over the railroad tracks, about 850 feet north of the outlet culvert.

South Upper Puget Sound South Creek Reach 2

South Upper Puget Sound South Creek Reach 2 (USSS2) is a channelized 800-foot stretch of open water course along the BNSF railroad tracks. Reach USSS2 begins at the NW 196th Street bridge and ends at the subbasin divide between MSN-F and MSN-H at NW 198th Street. Water appears to collect in Reach USSS2 and can flow over either north or south depending on the grade and water surface elevation. No pools or LW were evident; the bottom substrate was a mix of quarry spalls and silt. Again, reed canarygrass, horsetail and blackberry grow on the banks of this reach.

Upper Puget Sound South Creek Reach 1

Upper Puget Sound South Creek Reach 1 (USS1) is a channelized open water course that begins at the divide between Subbasins MSN-F and MSN-H. This reach extends north about 500 feet and flows into Reach USN1 just upstream of the culvert below the BNSF railroad tracks. Like the previous reaches, pools and LW were not evident; the 1-inch depth of water flowed north and eventually into WL-M.

Upper Puget Sound South Creek Reach 2

Upper Puget Sound South Creek Reach 2 (USS2) extends from 25th Avenue NW to Barnacle Creek (Reach USN1). Low flows (less than 1 inch deep) occurred during surveys of this reach, which is confined in steep ravines. Blackberries were the dominant riparian species, followed closely by ornamentals planted on and adjacent to private parcels. The channel was silty and had no pools or LW. While the latter criteria were rated poor, bank condition was rated fair.

Low flows and extreme gradients through the steep ravine are fish passage barriers. The wetland (WL-M) has a poorly defined channel confluence with Barnacle Creek, but under high tidal influence would allow access into the wetland area and the subsequent upstream portion of USS2. Extreme gradients may preclude fish from passing into the upper portion of the reach.

Upper Puget Sound South Creek Reach 3

Upper Puget Sound South Creek Reach 3 (USS3) extends from the upper end of Reach USS2 (25th Avenue NW) to 23rd Place NW. The reach ends about 150 feet northwest of the intersection of 23rd Place NW and 21st Place NW. This reach is entirely piped, with the exception of a small section of open water course between 23rd Avenue NW and 23rd Place NW.

North Upper Puget Sound North Creek Reach 1

North Upper Puget Sound North Creek Reach 1 (USNN1) begins in Snohomish County in the vicinity of Point Wells. This reach is a channelized open water course and flows south into Puget Sound through a culvert. The outlet culvert is just north of NW 204th Street. A portion of this reach continues south and connects with the upper portion of Reach USN1. Water depth was 1 inch and an oil sheen was evident. No pools or LW were associated with this reach. Water temperature was 54 degrees F (March 30, 2004). High flows or flows at high tide may drain south into Reach USN1.

Upper Puget Sound North Creek Reach 1

Upper Puget Sound North Creek Reach 1 (USN1), known locally as Barnacle Creek, is west of Richmond Beach Drive NW and is the outlet of the creek into the Puget Sound. The lower section of Barnacle Creek is tidally influenced upstream for a distance of approximately 20 feet. Railroad tracks border the stream for approximately 100 yards, eliminating vegetative cover from the stream bank. Channel substrate is dominated by sand with a gravel component. This narrow channel flows parallel and adjacent to a 0.5- to 1-acre wetland (WL-M) where riparian vegetation provides good cover. Tributaries to this stream run through backyards, where they are highly manipulated into manicured landscape. Trash and debris are present in a portion of the wetland area. Riparian vegetation is mixed, including young and mature coniferous and deciduous trees. Overall, the rating for this area is poor. (See the description of Wetland WL-M for more information.)

A culvert that conveys flow to Puget Sound from east of the railroad was fully submerged during surveys. It does not appear to be a fish passage barrier.

Upper Puget Sound North Creek Reach 2

Upper Puget Sound North Creek Reach 2 (USN2) extends eastward from Richmond Beach Drive NW and discharges to USN1 after passing under Richmond Beach Drive NW. It is entirely piped.

Upper Puget Sound North Creek Reach 3

Upper Puget Sound North Creek Reach 3 (USN3) is an open water course that runs through a steep ravine and is confined by residential development. All ratings for this reach were poor due to the area being highly developed. Vegetation was sparse and non-native vegetation was present. Banks were poorly vegetated and armored. No pools or LW were observed and substrate was primarily silt. It is likely that flow occurs throughout the year.

A 24-inch concrete culvert beneath NW 204th Street is not a fish passage barrier. A second culvert, upstream of NW 204th Street beneath a private access road, could impede fish passage. However, extreme gradients and low flows likely present a greater fish passage barrier than the presence of culverts. The lack of riparian vegetation precludes the natural process of step pool formation from LW.

FISHERIES

The following discussion summarizes the *Fish Utilization in City of Shoreline Streams* report (Appendix C) as it relates to the streams in the Middle Puget Sound Basins.

Stream walks were conducted on the Middle Puget Sound Streams in February, April, May, August and October of 2001 to assess fish utilization. The fisheries assessment focused on the presence of salmonids (resident cutthroat trout and anadromous salmon) within the basins. Figure 4-1 summarizes life cycle timing for fish in the Middle Puget Sound Streams and when certain species are in residence. Both coho salmon and searun cutthroat trout spend their first year rearing in the streams prior to outmigration. Resident cutthroat trout reside in the stream throughout their life cycle.

Unlike Boeing Creek, the Middle Puget Sound Basins have natural barriers to upstream migration. However, some of these basins could support resident cutthroat trout. Hennick (1999) reports trapping cutthroat trout in Storm Creek (SC5) during the summer of 1999. Barnacle Creek (USN1) and possibly Coyote Creek (IS1) do allow access to short sections of stream. The BNSF Railroad causes problems for fish access due to the configuration of the culvert outfalls.

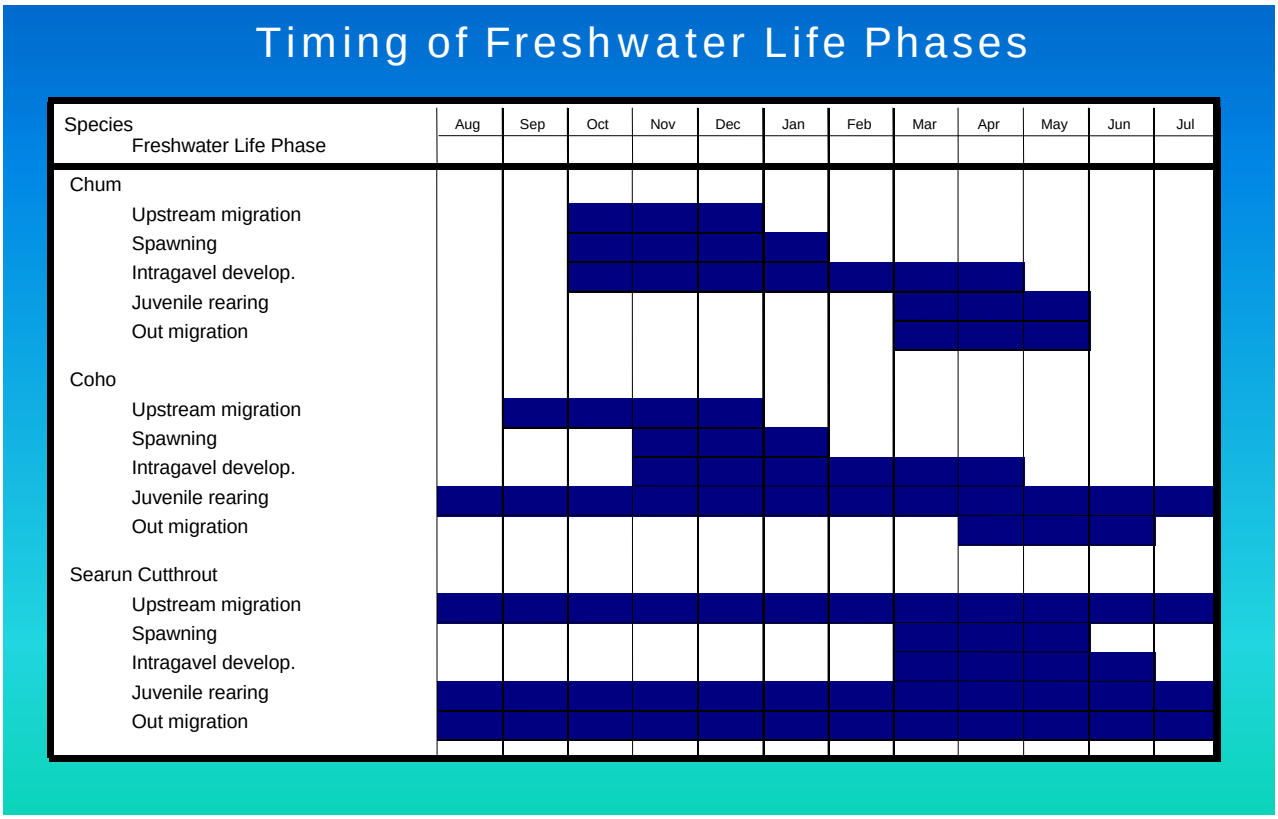


Figure 4-1. Life Cycle Timing for Fish in Middle Puget Sound Basins (Adapted from Williams 1995)

These basins play a critical role in filtering and controlling stormwater runoff and mitigating its impact on nearshore areas. They have significant and valuable riparian corridors in the reaches between the intensive housing and the area immediately adjacent to the beach. Three of the streams are protected as private open space. Additional migration barriers on some of the smaller drainages have been created by the culvert systems under the railroad tracks that follow the shoreline of Puget Sound within the City limits. However, several of the culverts under the railroad tracks could allow fish movement in and out of the culverts during high tide conditions. Further upstream movement is prevented by steep gradients. In addition, Reach USN1 at the extreme northern boundary of the City limits provides areas of habitat that can be utilized by juvenile salmonids that have moved into the saltwater and are foraging along the shallow beach areas during high tides. Forage species of fish and other organisms of importance as food for juvenile salmonids utilize these intertidal areas. The flow of freshwater into the shallow tidal areas and the recruitment of sands and gravel to the beaches is an important nearshore process influencing habitat in these areas.

In September 1995, two King County staff biologists examined Storm Creek Reach 1 (SC1) and Innis Arden North Creek Reach 1 (IN1) for fish presence and access barriers. Electrofishing did not produce any fish species. They indicated that both streams have barriers to upstream passage of adult salmonids at their mouths and lower reaches and did not have any spawning habitat (Hartley 1995).

High peak flows resulting from extensive impervious surface areas in the Middle Puget Sound Basins lead to bank erosion, sedimentation and the filling of pools and riffles in various stream reaches. In addition, general habitat for fish is relatively poor throughout both basins due to the BNSF railroad track culverts, steep natural gradients along the shoreline, other fish passage barriers, riparian encroachment and bank hardening.

Many reaches of open water courses support fish such as sculpin, dace and stickleback and possibly cutthroat trout, even though some of these reaches have poor to fair fish habitat. Cutthroat have evolved in the Northwest to occupy a variety of habitats including saltwater, lakes and streams. The City has not intensively sampled fish distribution in Shoreline or the Middle Puget Sound Basins. Based on other urban sampling programs, it is likely that cutthroat trout are present in several open water courses, especially those that have developed in-stream and near-bank vegetation and have dense riparian vegetation. The only reach in either basin where cutthroat trout have been documented is Reach SC5.

Fish Passage Barriers

Fish passage barriers preventing the movement of fish in a creek can be man-made, such as perched culverts along the railroad tracks and along IN2, or natural, such as the steep gradients prevalent along this part of the Puget Sound shoreline. Some barriers primarily impede upstream access; others impede upstream and downstream access equally. In Shoreline, upstream impediments generally don't impede downstream access. Barriers can be seasonal, affected by the level of flow in a reach. They can also be species and age-class specific. Adult coho and steelhead are more adept at accessing reaches with shallow water depths or swift flow than adult chum or chinook. Adult fish in general can navigate blockages more effectively than juvenile fish. Barriers can impede up and downstream

migration of anadromous species such as salmon, but can also block access to additional stream reaches for resident cutthroat trout and other non-salmonid species of fish such as sculpin and dace.

The Washington Department of Fish and Wildlife (1998) has a protocol for determining whether an impediment in a stream is a barrier to fish migration. This protocol involves measuring current velocity, grade, distance and depth of water over and immediately downstream of the impediment. Unless the structure is an obvious barrier such as a dam, observations without using the protocol are judgment calls; experts can disagree as to accessibility. This study did not use the WDFW protocols in assessing whether a reach is accessible. A comprehensive barrier assessment would require a full year of flow measurements. This study used best professional judgment when assessing whether a barrier presented an impediment to fish passage. Definite barriers were identified at the mouth of each stream in both basins, primarily associated with the BNSF railroad tracks. Reach USN1 (Barnacle Creek) is accessible for a short segment during high tide. The culvert under Richmond Beach Drive NW prevents further fish access. Table 4-2 summarizes definite and potential fish passage barriers identified in the Middle Puget Sound Basins. More detail is provided in the individual reach descriptions.

TABLE 4-2.
FISH PASSAGE BARRIERS
MIDDLE PUGET SOUND

Reach	Barrier	Description
Definite Barriers		
HL1	Gradient	Pipe and steep channel gradient prevents fish passage from Puget Sound
IS1	Gradient	Fish passage is prevented due to piping and steep channel gradient
IN1	Gradient	Steep channel gradient prevents fish passage from Puget Sound
IN2	Culvert	Perched culvert at NW Springdale Court prevent fish passage
SC1	Gradient	Fish passage is prevented due to steep channel gradient
USS2	Gradient	Steep channel gradient prevents fish passage from Puget Sound
USN2	Gradient	Steep channel gradient and Richmond Beach Drive culvert prevents fish passage from Puget Sound
Potential Barriers		
IS1	Culvert	Culvert at 14th Avenue NW may prevent fish passage
IN3	Culvert	Culverts at Innis Arden and Ridgefield Roads may prevent fish passage
IN4	Culvert and Low Flows	Culverts at NW Springdale Court and Ridgefield Road NW may prevent fish passage
SC1	Pipe Repair	Concrete repair and gabion installation over sewer pipeline may prevent fish passage
SC3	Weirs	Rock weirs may prevent fish passage at low flows
SC4	Weirs	Rock weirs may prevent fish passage at low flows
USN3	Culvert	Culvert upstream of NW 204th Street may prevent fish passage

WETLAND HABITAT

Wetlands are an essential part of a properly functioning watershed, benefiting both human and wildlife populations. Wetlands provide fish and wildlife with refuge and cover for nesting, mating, rearing, and foraging. They are also valuable to the surrounding human community for flood mitigation, storm abatement, sediment retention, aquifer recharge, water quality improvement and aesthetic qualities (Mitsch and Gosselink 1986). Shoreline's critical areas code establishes an overall goal of maintaining no net loss of the function, value and acreage of wetlands within the City.

Historically, wetlands were not viewed as having important value. When early settlers moved into the heavily wooded Puget Sound upland, arable land was at a premium in many areas. As home sites became more scarce, especially around urban areas, early residents were forced into less desirable locations. As a consequence, farmers diked and drained extensive expanses of wetlands throughout the Puget Sound area. Early residents and business owners began filling and draining wetlands for home and business sites. In some areas, it was necessary to pipe the water to prevent it from accumulating and discharge it to a local stream or ravine.

It is likely that a number of structures and facilities around Shoreline have been constructed on filled wetlands, including the playfield at Syre School near Reaches SC5 and SC6 and much of the area between Reaches SC3 and SC4, which includes the Meadow Brook Apartments. Much of the original shoreline of Puget Sound supported estuarine wetland that was subsequently filled with the building of the railroad. As these wetlands become filled and more construction occurred in the City, rainfall had a much smaller area to infiltrate into the soil or to flow to wetlands for storage. Previously, accumulated rainfall would have percolated down through the soil or been slowly released by the wetland to provide a base flow for local streams. This is important for fish and the aquatic ecosystem during the dry summer months. High peak flows now common in most Shoreline streams are in large part due to the filling of wetlands.

A wetland inventory was conducted in October and November of 2001 to identify significant unmapped wetlands within the City boundaries. This wetland inventory was not exhaustive, but addressed wetlands that were known from the City's GIS wetland layer (primarily wetlands identified from the National Wetland Inventory), wetlands that were subjects of development reports supplied by the City and wetlands readily identified from aerial photography. Each of these areas was visited and ground-truthed to determine whether it qualifies as a wetland. The report describing the wetland identification and classification of major wetlands and those wetlands for which the City had development reports is presented in Appendix B. The wetlands classified within the Middle Puget Sound Basins are summarized below. Figure 2-3 shows the wetland locations.

Wetland Classification Systems

Wetlands were classified according to the U.S. Fish and Wildlife Service classification system. The classification system which has no regulatory status is described below.

U.S. Fish and Wildlife Service Classification System

The U.S. Fish and Wildlife Service classification (Cowardin et. al 1979) places the wetland into a system category first, and then subcategorizes the wetland into a class based on the vegetation present. All wetlands that were identified in this study fall under the system category, "palustrine," which is defined as follows:

- Water regime not influenced by oceanic tides
- Persistent emergents, trees, shrubs, or emergent mosses covering 30 percent or more of the area.

Identified Shoreline wetlands were classified in the following classes based on vegetation:

- Aquatic Bed: Vegetation composed predominantly of plants that grow principally on or below the surface of the water for most of the growing season in most years
- Emergent Wetland: Vegetation composed predominantly of emergent, vascular species
- Forested Wetland: Vegetation composed predominantly of trees or shrubs that are 20 feet or taller
- Scrub-Shrub Wetland: Vegetation composed predominantly of trees or shrubs than are less than 20 feet tall.

Areas influenced by Puget Sound tides are classified as "estuarine" and were not identified for this report.

Wetland Descriptions

Six areas were identified as potential unmapped wetlands in the Middle Puget Sound Basins. Two of these areas, one along Richmond Beach Park and the other in the north of the Middle Puget Sound North Basin, were identified as wetland. Two previously mapped wetland areas were verified for size and location.

The majority of wetlands in the City are palustrine wetlands under the federal classification, since they have 30 percent or greater vegetation cover and are not influenced by oceanic tides. Wetland systems are common along and adjacent to the BNSF railroad tracks. This report does not address these wetlands. A description of each wetland assessed within both Middle Puget Sound Basins is presented below and summarized in Table 4-3.

Wetland M, Upper Puget Sound

It is unclear whether this wetland was previously mapped. Current mapping shows a wetland adjacent to the beach, but west of the railroad tracks. Wetland M is west of Richmond Beach Drive NW, east of the railroad tracks from NW 202nd Street to NW 199th Street and immediately west of the Richmond Beach Pump Station. It is a palustrine forested wetland and is associated with the Upper Puget Sound North and South Creeks. Barnacle Creek (USN1) meanders through the wetland where residents have created an informal boardwalk with construction debris laid across the creek in several places and over the wetland. In addition to willow, salmonberry and blackberry, watercress and water

parsley occur throughout the area. The size of this wetland is estimated to be a half-acre or larger.

TABLE 4-3.
WETLAND CLASSIFICATIONS

Site	Location	Size	Wetland Classes Present (Cowardin, et al. 1979)
M	Upper Puget Sound	0.5-1 acre	Palustrine Forested
N	NW 195th Street and 12th Avenue NW	1-2 acres	Palustrine Forested Palustrine Scrub-Shrub
O	Seattle Golf Course	2.1 acres	Palustrine Emergent Aquatic Bed
P	Highlands Creek	0.5 acre	Palustrine Emergent
Q	Richmond Beach Park	1 acre	Palustrine Forested Palustrine Emergent
R	19620 14th Avenue NW	>1 acre	Palustrine Forested

Wetland N, NW 195th Street and 12th Avenue NW

This wetland is south of NW 195th Street and west of 12th Avenue NW near NW Richmond Beach Road. It is approximately 2 acres in size. Two wetland classes are present—forested and scrub-shrub. Because of illegal clearing, they occupy primarily the periphery of the site. Willow, red alder, big leaf maple, and western red cedar are present in forested areas; other species present include salmonberry, Himalayan blackberry, nettles, reed canarygrass and Canadian thistle. The wetland is associated with Storm Creek and west of Reach 5. Due to the illegal clearing, the area has been invaded by reed canarygrass and blackberries and has numerous pieces of debris such as tires, plywood and trash. This wetland has both palustrine forested and palustrine scrub-shrub wetland types.

Wetland O, Seattle Golf Course

This wetland is around the margins of a lake on the Seattle Golf Course. Access to the golf course was not obtained. However, previous studies have reported that the wetland covers 2.1 acres.

Wetland P, Highlands Creek

This palustrine emergent wetland is the headwaters of Highlands Creek and occurs in an area heavily modified with ornamental ponds and fountains. This wetland is approximately 0.5 acres in area.

Wetland Q, Richmond Beach Park

This previously unmapped wetland was found near Richmond Beach Park on the east side of the railroad. The total area of the wetland is approximately 1 acre. Two wetland classes are present: forested and emergent. Alders and willows dominate the forested wetland areas, while emergent areas are dominated by cattails. Other abundant species present include Himalayan blackberries and horsetail. Soils were saturated, but there was less

than 40 percent open water. A small seep with buttercup growing in the wet soil exits the hillside several hundred feet up slope and east of the wetland and flows into the southern portion.

Wetland R, 19620 14th Avenue Northwest

This previously unmapped wetland is bordered by M.G. Syre Elementary school to the east and the residence at 19620 14th Avenue NW on the west. There is an approximate 30 to 40 percent slope between the residence and the wetland. Wetland R was probably associated with the adjacent historical Storm Creek channel that is partially piped at present. Surface water accumulates within this former channel and flows on top of and parallel to the piped portion. Originally delineated for the residence, the wetland extends further northwest and southeast of the parcel, making it difficult to determine its total size. Classified as a palustrine forested and broad-leaved deciduous wetland community, it is dominated by red alder and salmonberry.

RIPARIAN INFLUENCE AREAS

Riparian influence areas for this report include the areas bordering open water courses out to a distance of 300 feet from the upper bank. Spence (1996) identifies these areas as having the most effect on essential habitat functions for streams. This distance may vary depending on channel forming process affecting individual stream segments. Riparian trees and shrubs include western red cedar, red alder, willow elderberry, vine maple, salmonberry and devil's club. Skunk cabbage, buttercup, youth-on-age, fringecup, reed canarygrass and other herbaceous species comprise the ground cover.

Riparian areas vegetated with trees and shrubs provide essential benefits to the environment such as protecting water quality by filtering sediment out of stormwater runoff, retaining and controlling flood waters, stabilizing stream banks, and providing wildlife habitat, corridors and migratory pathways. In addition, vegetated riparian areas enhance fish habitat by shading streams providing large wood, and contributing insects and nutrients to the system.

Riparian influence areas were mapped for open water courses in the basin. Aerial photographs were used to identify existing land use within the 300-foot corridor. The riparian area for the Middle Puget Sound Basins is illustrated in Figure 4-2. The land use categories used for the mapping are as follows:

- Forest: More than 65 percent canopy closure; no impervious surface other than roads.
- Scrub/Shrub: More than 65 percent scrub-shrub habitat.
- Grass Parkland: Parks or large grassy areas with less than 10 percent total impervious or other land use type.
- Homes/Lawns: Sparse to no tree canopy and may be dominated by lawns and driveways
- Homes/Trees: Moderate to significant tree canopy; impervious surfaces include homes, driveways and roads.

- Impervious: Large parking lots, roads and roof tops. Contains less than 5 percent vegetation. This would include school buildings and large commercial and industrial buildings.
- Surface Water: Lakes and ponds within the corridor around the stream.

Since the riparian analysis was conducted adjacent to the open water courses , the proportion of the riparian area delineated to the total area surrounding each reach varies with the length of the water course within that reach. Table 4-4 lists the total corridor area associated with each reach, the area and percentage of riparian area found within the reach and the predominant channel type within a reach. Table 4-5 lists the total length of each reach along with the total length of open water course within that reach.

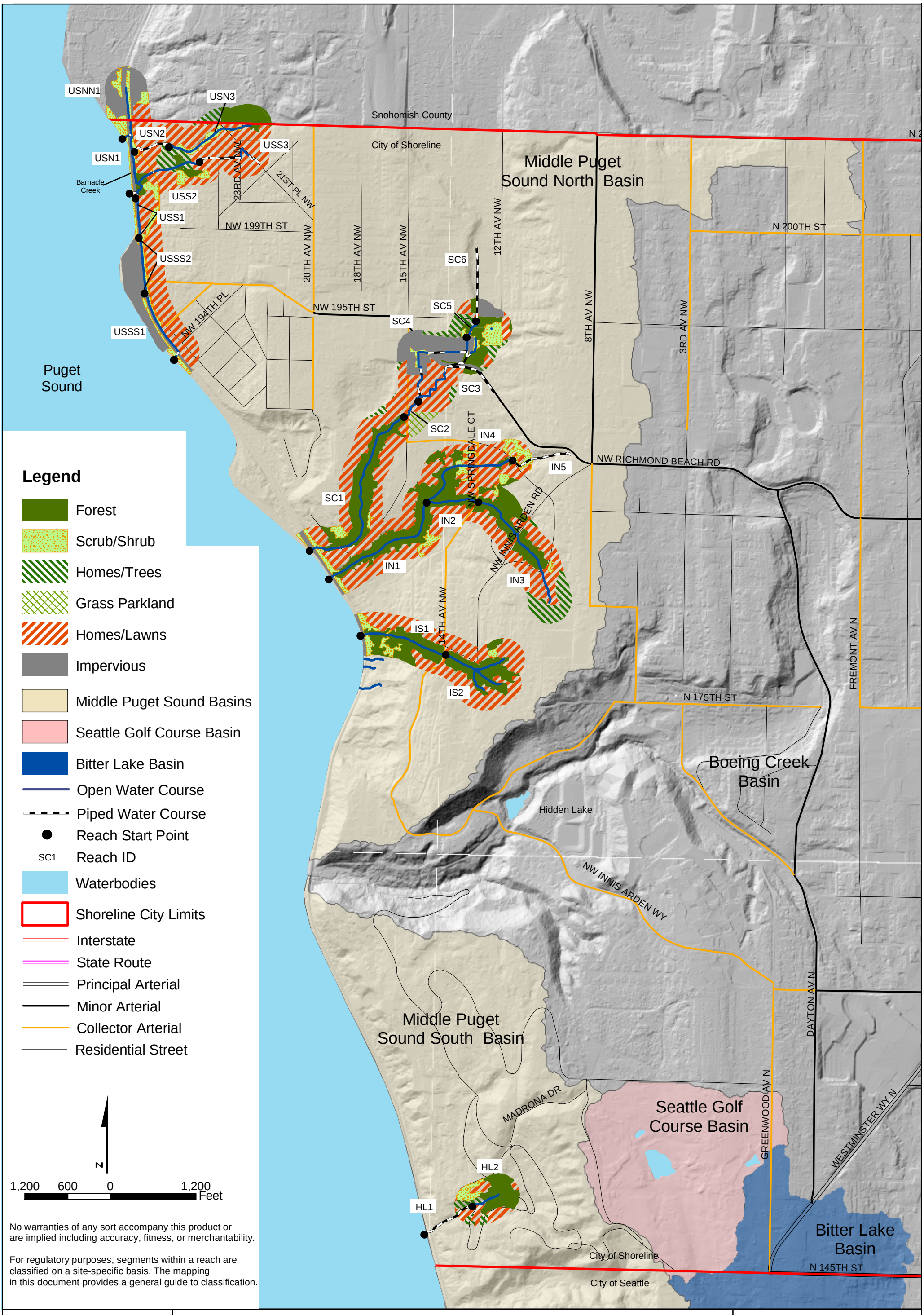
Tables 4-6 to 4-9 list the percentage of riparian land use for 50-, 100-, 200-, and 300-foot corridors along each reach. Most of the high-quality riparian habitat (forest and/or scrub-shrub) is along the Innis Arden Creeks and along reach SC1 of Storm Creek. Much of the high quality habitat is limited to within the first 100 feet of these reaches. Residential developments encroach on the stream system throughout the rest of the basin. Any areas of high quality habitat outside the private open space tracts are small isolated islands surrounded by residential and commercial development.

A common trend in riparian areas is that the amount of good riparian habitat generally decreases farther from the stream. With a few exceptions, this trend is evident within the Middle Puget Sound Basins as well.

The amount of high quality riparian habitat within the basins varies from stream to stream. For example, Blue Heron Creek (IN1) and Coyote Creek (IS1) have excellent riparian habitat within the 100-foot corridor surrounding the creeks, primarily due to the privately owned open spaces adjacent to the creeks. However, outside the reserves and away from the creek, the corridor consists mostly of homes with lawns that provide minimal habitat benefits.

Reach HL1 in the Highlands neighborhood is entirely piped. Reach HL2 has relatively good riparian habitat, with over half of the riparian corridor out to 200 feet and nearly half of the 200- to 300-foot corridor characterized as high quality. The remainder of the habitat is characterized as either homes/lawns or homes/trees.

The lower portion of Storm Creek also has excellent habitat as it flows through a privately owned reserve. As with Blue Heron Creek and Coyote Creek, homes with lawns dominate the riparian corridor outside the reserves. The upper reaches of Storm Creek are encroached upon by commercial and residential development and, therefore, have a much smaller percentage of high quality habitat. In addition, in the upper reaches, Storm Creek is modified and piped as it flows through the Richmond Beach Road area. Barnacle Creek (USN1) is dominated by residential development and only near the wetland area adjacent to Puget Sound does the habitat begin to improve.



No warranties of any sort accompany this product or are implied including accuracy, fitness, or merchantability.

For regulatory purposes, segments within a reach are classified on a site-specific basis. The mapping in this document provides a general guide to classification.

Tetra Tech / KCM
1917 1st Avenue
Seattle WA, 98101

Middle Puget Sound Basins Characterization Report

Figure 4-2
Riparian Influence Area Characterization

TABLE 4-4.
RIPARIAN INFLUENCE AREA WITHIN 300-FOOT CORRIDOR
FOR MIDDLE PUGET SOUND REACHES

Reach ID	Total Area Within 300-Foot Corridor (acres)	Reach Riparian Area (Acres)	Riparian Area as Percentage of Total (%)	Predominant Stream Type
HL1	26	0	0	Piped Water Course
HL2	11	11	100	Open Water Course
IS1	20	20	100	Open Water Course
IS2	25	25	100	Open Water Course
IN1	29	29	100	Open Water Course
IN2	16	16	100	Open Water Course
IN3	32	32	100	Open Water Course
IN4	28	28	100	Open Water Course
IN5	19	0	0	Piped Water Course
SC1	41	41	100	Open Water Course
SC2	11	11	100	Open Water Course
SC3	24	22	93	Open Water Course
SC4	26	21	78	Open Water Course
SC5	10	10	100	Open Water Course
SC6	20	0	0	Piped Water Course
USSS1	15	15	100	Open Water Course
USSS2	13	13	100	Open Water Course
USS1	9	9	100	Open Water Course
USS2	18	18	100	Open Water Course
USS3	19	9	47	Piped Water Course
USNN1	14	14	100	Open Water Course
USN1	10	10	100	Open Water Course
USN2	15	7	47	Piped Water Course
USN3	23	23	100	Open Water Course

TABLE 4-5.
LENGTH OF OPEN WATER COURSE PER REACH

Reach ID	Total Length of Reach (Feet)	Length of Open Water Course (Feet)	Open Water Course as Percentage of Total (%)	Predominant Channel Type
HL1	802	0	0	Piped Water Course
HL2	377	377	100	Open Water Course
IS1	1238	1238	100	Open Water Course
IS2	1756	1756	100	Open Water Course
IN1	1886	1886	100	Open Water Course
IN2	724	724	100	Open Water Course
IN3	1930	1930	100	Open Water Course
IN4	1595	1595	100	Open Water Course
IN5	917	0	0	Piped Water Course
SC1	2779	2671	96	Open Water Course
SC2	387	387	100	Open Water Course
SC3	1522	907	60	Open Water Course
SC4	1585	986	62	Open Water Course
SC5	303	303	100	Open Water Course
SC6	1004	0	0	Piped Water Course
USSS1	950	883	93	Open Water Course
USSS2	830	830	100	Open Water Course
USS1	568	486	86	Open Water Course
USS2	961	921	96	Open Water Course
USS3	1137	258	23	Piped Water Course
USSN1	1137	258	23	Open Water Course
USN1	814	730	90	Open Water Course
USN2	629	56	9	Piped Water Course
USN3	1251	1251	100	Open Water Course

TABLE 4-6.
RIPARIAN LAND USE BY PERCENT; 0- TO 50-FOOT CORRIDOR

Reach	Forest	Scrub-Shrub	Homes-Trees	Grassy Open Space	Homes-Lawns	Impervious	Surface Water
HL1	0.0	0.0	0.0	0.0	0.0	0.0	0.0
HL2	60.0	0.0	20.2	0.0	19.8	0.0	0.0
IS1	85.9	6.2	0.0	0.0	4.7	3.2	0.0
IS2	89.5	0.0	0.0	0.0	10.5	0.0	0.0
IN1	95.1	2.2	0.0	0.0	0.8	1.9	0.0
IN2	96.6	0.0	0.6	0.0	3.4	0.0	0.0
IN3	69.5	0.0	0.9	0.0	29.6	0.0	0.0
IN4	58.9	13.1	0.0	0.0	28.1	0.0	0.0
IN5	0.0	0.0	0.0	0.0	0.0	0.0	0.0
SC1	85.5	3.6	0.0	0.0	8.9	2.0	0.0
SC2	7.5	0.0	0.0	5.7	86.8	0.0	0.0
SC3	13.8	10.9	0.0	0.0	68.4	6.9	0.0
SC4	1.9	17.2	0.0	0.0	18.1	62.8	0.0
SC5	66.0	11.4	10.6	0.0	1.6	10.3	0.0
SC6	0.0	0.0	0.0	0.0	0.0	0.0	0.0
USSS1	0.0	25.3	0.0	0.0	34.0	40.7	0.0
USSS2	0.0	40.3	0.0	0.0	15.3	44.5	0.0
USS1	0.0	13.8	0.0	0.0	48.7	37.5	0.0
USS2	33.8	0.0	27.6	0.0	38.2	0.4	0.0
USS3	0.0	0.0	0.0	0.0	100.0	0.0	0.0
USNN1	0	49.1	0.0	0.0	9.8	41.1	0.0
USN1	32.9	32.4	0.0	0.0	6.3	28.4	0.0
USN2	0.0	0.0	49.5	0.0	50.5	0.0	0.0
USN3	4.9	52.5	10.4	0.0	50.5	0.0	0.0

TABLE 4-7.
RIPARIAN LAND USE BY PERCENT; 51- TO 100-FOOT CORRIDOR

Reach	Forest	Scrub-Shrub	Homes-Trees	Grassy Open Space	Homes-Lawns	Impervious	Surface Water
HL1	0.0	0.0	0.0	0.0	0.0	0.0	0.0
HL2	65.1	3.4	15.3	0.0	16.2	0.0	0.0
IS1	71.2	11.4	0.0	0.0	14.4	3.1	0.0
IS2	62.9	0.3	0.0	0.0	36.8	0.0	0.0
IN1	70.7	4.0	0.0	0.0	23.6	1.8	0.0
IN2	63.1	0.0	0.0	0.0	31.9	0.0	0.0
IN3	59.0	0.3	6.9	0.0	33.7	0.0	0.0
IN4	44.9	10.2	0.0	0.0	44.9	0.0	0.0
IN5	0.0	0.0	0.0	0.0	0.0	0.0	0.0
SC1	62.7	4.0	0.0	1.9	29.4	2.0	0.0
SC2	11.4	0.0	0.0	12.2	76.4	0.0	0.0
SC3	25.4	1.3	0.0	0.0	62.1	11.2	0.0
SC4	25.9	12.9	0.7	0.0	51.0	12.9	0.0
SC5	41.0	11.0	14.4	0.0	7.7	26.0	0.0
SC6	0.0	0.0	0.0	0.0	0.0	0.0	0.0
USSS1	0.0	17.6	0.0	0.0	47.3	35.0	0.0
USSS2	0.0	7.4	0.0	0.0	48.4	44.2	0.0
USS1	5.6	37.2	0.0	0.0	50.0	7.3	0.0
USS2	19.3	6.6	21.0	0.0	48.0	5.1	0.0
USS3	0.0	0.0	0.0	0.0	100.0	0.0	0.0
USNN1	0.0	32.3	0.0	0.0	26.4	41.3	0.0
USN1	18.0	38.2	0.0	0.0	32.5	11.3	0.0
USN2	0.0	7.2	42.6	0.0	50.2	5.0	0.0
USN3	16.6	2.3	14.3	0.0	66.7	0.0	0.0

TABLE 4-8.
RIPARIAN LAND USE BY PERCENT; 101- TO 200-FOOT CORRIDOR

Reach	Forest	Scrub-Shrub	Homes-Trees	Grassy Open Space	Homes-Lawns	Impervious	Surface Water
HL1	0.0	0.0	0.0	0.0	0.0	0.0	0.0
HL2	43.9	12.3	11.2	0.0	32.6	0.0	0.0
IS1	33.4	12.4	0.0	0.0	51.3	2.8	0.0
IS2	22.6	3.6	0.0	0.0	73.7	0.0	0.0
IN1	22.7	8.1	0.0	0.0	67.5	1.7	0.0
IN2	50.9	0.0	0.0	0.0	49.1	0.0	0.0
IN3	23.2	2.5	17.2	0.0	57.2	0.0	0.0
IN4	32.0	11.9	0.0	0.0	56.0	0.0	0.0
IN5	0.0	0.0	0.0	0.0	0.0	0.0	0.0
SC1	20.9	5.3	0.1	4.3	67.3	2.1	0.0
SC2	7.5	0.0	0.0	18.1	74.4	0.0	0.0
SC3	20.4	7.5	3.0	0.0	50.4	18.7	0.0
SC4	18.6	3.3	5.8	0.0	29.8	42.5	0.0
SC5	24.4	14.5	22.7	0.0	5.4	33.0	0.0
SC6	0.0	0.0	0.0	0.0	0.0	0.0	0.0
USSS1	0.0	4.1	0.0	0.0	53.6	42.3	0.0
USSS2	0.0	11.9	0.0	0.0	83.1	5.0	0.0
USS1	11.5	18.6	0.0	0.0	56.2	13.7	0.0
USS2	13.8	23.7	14.4	0.0	44.5	3.6	0.0
USS	0.0	0.0	0.0	0.0	100.0	0.0	0.0
USNN1	0.0	21.3	0.0	0.0	33.8	44.9	0.0
USN1	5.4	18.0	0.0	0.0	70.7	5.9	0.0
USN2	5.6	6.2	28.2	0.0	60.0	0.0	0.0
USN3	24.1	0.0	16.4	0.0	59.5	0.0	0.0

TABLE 4-9.
RIPARIAN LAND USE BY PERCENT; 201- TO 300-FOOT CORRIDOR

Reach	Forest	Scrub-Shrub	Homes-Trees	Grassy Open Space	Homes-Lawns	Impervious	Surface Water
HL1	0.0	0.0	0.0	0.0	0.0	0.0	0.0
HL2	30.4	15.3	16.8	0.0	37.5	0.0	0.0
IS1	24.0	8.3	0.0	0.0	65.1	2.6	0.0
IS2	13.9	0.1	0.0	0.0	86.0	0.0	0.0
IN1	18.9	6.0	0.0	0.0	73.2	1.8	0.0
IN2	37.9	2.2	0.0	0.0	59.9	0.0	0.0
IN3	14.9	0.8	27.0	0.0	57.4	0.0	0.0
IN4	23.2	12.3	0.0	0.0	64.5	0.0	0.0
IN5	0.0	0.0	0.0	0.0	0.0	0.0	0.0
SC1	12.7	5.2	3.2	6.7	70.4	1.8	0.0
SC2	9.4	0.0	1.1	20.8	68.7	0.0	0.0
SC3	10.4	8.0	20.4	7.7	29.6	23.8	0.0
SC4	18.6	4.7	2.7	0.0	29.8	26.8	0.0
SC5	21.4	17.0	17.4	0.0	10.6	33.5	0.0
SC6	0.0	0.0	0.0	0.0	0.0	0.0	0.0
USSS1	0.0	4.3	0.0	0.0	75.0	20.6	0.0
USSS2	0.0	6.2	0.0	0.0	57.5	36.3	0.0
USS1	9.4	25.6	0.0	0.0	49.7	15.3	0.0
USS2	0.1	15.3	7.9	0.0	73.6	3.0	0.0
USS3	0.1	2.5	0.0	0.0	97.4	0.0	0.0
USNN1	0.0	22.0	0.0	0.0	34.1	44.0	0.0
USN1	0.0	17.8	0.0	0.0	77.2	4.5	0.0
USN2	6.7	4.8	24.2	0.0	64.2	0.0	0.0
USN3	25.6	0.4	18.7	0.0	55.5	0.0	0.0

TERRESTRIAL HABITAT

The biota and ecology of the Middle Puget Sound Basins are influenced by such factors as the wet and moderate maritime climate, soil type and human activities. European descendants have been logging, mining, farming, fishing, shellfishing, industrializing and residing in and around the area since the middle of the 19th century. Native Americans lived in the Puget Sound area for thousands of years before their arrival. Specifically in the Middle Puget Sound Basins where the topography is severe, with many small stream systems in ravines, development significantly altered the landscape and hydrology. Removing vegetation and constructing homes, appurtenances and roadways prevented rainfall from infiltrating into the soil and aquifer. The result of this alteration was higher peak flows in streams occurring for a longer duration, coupled with much lower base flows. The increased peak flows contributed to incising the ravines, eroding banks and scouring stream beds, frequently steepening the gradients and discouraging fish access. Reduced base flows led to streams with little or no flow in summer.

The study area encompasses mainly coniferous forest within the western hemlock (*Tsuga Heterophylla*) forest zone. Also referred to as the Coastal Forest Zone, this area possesses climax vegetation of western hemlock and western red cedar. Historically, these trees probably covered much of the City of Shoreline and were the dominant vegetative type.

These stands of trees were logged and cleared by early and present-day residents. Stands of this timber were replaced by Douglas fir, which characterizes the sub-climax vegetative type in this zone and frequently occurs as the dominant tree over the large areas. Although these forests might be termed "secondary growth," the trees frequently attain ages of several hundred years. Eventually, if these stands were left to nature, the Douglas fir, which requires much sunlight for growth and reproduction, would shade itself out of its dominant role. Absent logging, the shade-tolerant cedar and hemlock grow to crowd out Douglas fir over hundreds of years.

Richmond Beach Park offers a unique blend of vegetation and public access to Puget Sound. The park slopes down to the west toward Puget Sound. The sandy soils are more exposed and drier due to the wind. Large parts of hillside have sloughed off toward the Sound, carrying vegetation with them. Considered a landslide hazard area with sparse vegetation, the dominant tree coverage comes from Douglas fir and Pacific madrone. Lodgepole pine occurs on top of the grassy hillsides. Scotch broom, a non-native species, grows throughout the park. There are many trails within the park. Blackened trunks show areas of past brush fires. Dunegrass is the dominant vegetation in sandy soils near the beach areas.

It is in these drier unstable slopes that western hemlock and western red cedar may never become firmly established. Other species such as the Douglas fir, Pacific madrone and lodgepole pine are better suited to survive these conditions and will continue to dominate the vegetation community.

According to local residents, a variety of wildlife inhabits the Middle Puget Sound Basins. Appendix E contains a list of birds seen in the Shoreview Park area in the adjacent Boeing Creek Basin. Many of these same birds could be expected in the more wooded areas of the Middle Puget Sound Basins such as Innis Arden, Blue Heron, Eagle and Coyote Reserves. Residents reported that a heron rookery was located in the Innis Arden Reserve in 1997. In addition, bald eagles and pileated woodpeckers are frequently seen in the reserve areas (personal communication, Pelly, Ray, April 5, 2001). In addition, there is an active heron rookery in the Blue Heron Reserve (personal communication, Moren, Sylvia, April 5, 2001). Bill Blaylock, a Middle Puget Sound North Basin resident, frequently sees pileated woodpeckers, bald eagles and great blue herons and occasionally sees peregrines and osprey (personal communication, Blaylock, Bill, March 19, 2002).

FEDERAL AND STATE REGULATED SPECIES

Table 4-10 includes the federally listed and candidate species that the U.S. Fish and Wildlife Service and National Marine Fisheries Service require to be addressed for Endangered Species Act (ESA) compliance. Table 4-11 summarizes state priority species that could occur in the Middle Puget Sound Basins. Priority species have no federal or state regulatory status. Appendix I includes Washington State listed and candidate species in addition to species of concern. A listing of Washington State priority habitats and species is included in Appendix J.

Of the federal species of concern, bald eagles have been documented in both the North and South Basins. Marbled murrelets have been documented in marine waters adjacent to the City.

TABLE 4-10.
FEDERALLY LISTED AND CANDIDATE SPECIES WITHIN THE CITY OF SHORELINE

Species	Federal and State Status
Fish Species	
Bull trout (*Salvelinus confluentus*), Coastal-Puget Sound distinct population segment (DPS)	FT/SC
Chinook salmon (*Oncorhynchus tshawytscha*), Puget Sound evolutionary significant unit (ESU)	FT/SC
Coho salmon (*Oncorhynchus kisutch*), Puget Sound/Strait of Georgia ESU	FC
Wildlife Species	
Bald eagle (*Haliaeetus leucocephalus*)	FT/ST
Marbled murrelet (*Brachyramphus marmoratus*)	FT/ST

Notes: FT = Federally listed threatened; ST = Washington State listed threatened
FC = Federal candidate; SC = Washington State candidate

TABLE 4-11.
STATE PRIORITY SPECIES—CITY OF SHORELINE

Amphibians/Reptiles
- Western Toad
- Western Pond Turtle

Mammals
- Myotis species
- Townsend's Big-Eared Bat

Fish
- Bull Trout
- Chinook Salmon
- Chum Salmon
- Resident/Searun Cutthroat
- Sockeye Salmon
- Coho Salmon
- Steelhead Trout

Birds
- Brandt's Cormorant
- Common Loon
- Marbled Murrelet
- Great Blue Heron
- Brant
- Bald Eagle
- Merlin
- Northern Goshawk
- Peregrine Falcon
- Pileated Woodpecker
- Purple Martin
- Band-Tailed Pidgeon

Of the state priority species, great blue herons and cutthroat trout are quite common in open water courses and in some wetlands in the City of Shoreline. There has not been an extensive survey of fish presence in the streams of the Middle Puget Sound Basins. Several cutthroat trout were trapped in Storm Creek (SC5) during the summer of 1999 (Herrick 1999). The band-tailed pigeon and pileated woodpecker are Washington State Priority Species. Pileated woodpecker is also a state candidate species. Candidate species are defined as those species under review for possible listing as endangered or threatened and are protected as state sensitive species.

Priority Habitat and Species (PHS) data collected by the Department of Fish and Wildlife were examined for this report. PHS species are not necessarily listed as endangered, threatened, or candidate species under the federal or state ESA. The PHS data include categories for resident fish species, streams where anadromous fish are present as well as their spawning and rearing areas, fish barriers, and the wildlife heritage database that identifies locations where wildlife species of concern have been observed. For the Middle Puget Sound North and South Basins, no streams were identified as priority habitat in the PHS database. However, priority species have been identified in the basins. Therefore, while the PHS database can be used as a tool in identifying priority habitat species, it should not be considered a comprehensive resource.

The Heritage Wildlife Database was consulted to determine the location of documented wildlife species in the Middle Puget Sound Basins. The only information regarding priority species contained in the database is a Northern Goshawk nest observed in Subbasin MSN-A, within the Richmond Beach Saltwater Park.

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Seattle Golf Club and Bitter Lake Basins Characterization Report

May 2004

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City of Shoreline
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Seattle Golf Club and Bitter Lake Basins Characterization Report
TABLE OF CONTENTS

LIST OF TABLES

INTRODUCTION

This report provides an overview of the Seattle Golf Course Basin and the portion of the Bitter Lake Basin that is within the City limits. For this report the two basins are named for the defining feature of each basin, Bitter Lake and the Seattle Golf and Country Club. Each basin is shown in Figure 2-1 of the *Middle Puget Sound Basins Characterization Report*. This report will reference text and figures in the *Middle Puget Sound Basins Characterization Report*, since much of the analysis in this report is similar to that addressing the Middle Puget Sound Basins. In addition, the reader is referred to the Middle Puget Sound report for summaries of public involvement, climate and habitat characteristics within the basin.

STUDY AREA DESCRIPTION

The Bitter Lake Basin and the Seattle Golf Course Basin are located in the southwest area of the City adjacent to the Middle Puget Sound South Basin and the Thornton Creek Basin (Figure 2-1). Topographically, the Bitter Lake Basin drains into Bitter Lake in the City of Seattle and then into Lake Washington. However no open water courses have been identified in this basin within the City limits. The Seattle Golf Course Basin is a closed depression that does not have a surface water outlet. Runoff in the basin collects in Wetland O and infiltrates into the groundwater table. The Bitter Lake Basin (BL-A) consists of approximately 54 acres within the City limits and the Seattle Golf Course Basin (SCG-A) consists of approximately 138 acres (Figure 2-2). Since no creeks were identified in the field, no stream reaches were identified and no further analysis was done for aquatic or riparian habitat.

Land Use

Land use in the Bitter Lake Basin is mostly residential, with small areas of commercial use; roads make up the largest impervious area in the basin. Since the basin within the City is small, it was not subdivided into smaller subbasins. In addition, since no drainage courses were identified in the basin, no stream reaches were designated. Land use in the Seattle Golf Club Basin consists of recreation.

Impervious Surface Area Percentage

Human alteration of the landscape, including clearing, grading, paving, building and landscaping changes the physical features that affect hydrologic and biological processes. Soil compaction and paving reduce the infiltration and storage capacity of soils, which in turn lessens groundwater recharge and base flows in streams. These high flow rates can cause flooding and destroy aquatic and riparian habitat by eroding banks, removing riparian vegetation, filling stream riffles and pools and creating debris jams. Heavy rains can lead to a runoff process called Horton overland flow, whereby the rainfall rate exceeds the infiltration rate, and the excess precipitation flows downhill over the surface. This type of flow results in water rapidly reaching a stream or built conveyance system, causing more frequent and much higher peak flow rates than would occur with the natural landscape. These flows increase the erosive force in the creeks and can result in bank failure and channel incision. Development not only increases peak flow rates, but also changes annual

and seasonal runoff volumes. By quantifying the percentage of the basin that is covered with impervious surface, the rainfall-runoff relationship in the basin can be described, and appropriate mitigating measures can be implemented.

For this report, impervious area is expressed as total impervious area (TIA), which is defined as the amount of actual impervious area. Features included in TIA include roofs, roads, driveways, and any other surface that prevents water from infiltrating into the ground. This area is calculated by adding up or estimating all of the area of impervious surfaces within a basin. TIA is expressed as a percentage of the total surface area.

The TIA was computed for both basins using the ArcView GIS software program. Table 1-1 shows the estimated TIA for general land use types as defined by the City. Knowing the amount of each existing land use type, and knowing the percent impervious value for each land use type, it was possible to directly compute the average TIA for each basin.

TABLE 1-1.
GENERAL LAND USE CATEGORIES AND ASSOCIATED PERCENT IMPERVIOUS VALUES

Land Use	Percent Impervious
Commercial	87
Residential/Multi-Family	73
Public Facilities	55
Institution	57
Transportation	70
Open Space	0
Parks/Cemetery	12
Residential (Lots Less Than 5,000 SF)	57
Residential (Lots 5,700 to 7,199 SF)	40
Residential (Lots 7,200 to 10,890 SF)	36
Residential (Lots 10,891 to 21,780 SF)	28
Residential (Lots 21,781 to 43,560 SF)	19
Residential (Lots more than 43,560 SF)	17

Source: City of Shoreline

For this analysis, City of Shoreline staff obtained impervious surface data from a variety of sources. King County provided data for properties whose owners pay the surface water management utility fee. These properties encompass the commercial, multi-family residential, public facilities, parks/cemeteries, and institution land use categories. The County tallies the amount of impervious surface for commercial and institutional parcels to determine the utility fee.

For the single-family residential land use, City of Shoreline staff sampled six lot-size categories ranging from less than 5,000 square feet to larger than 43,560 square feet (1 acre). Staff analyzed 1999 aerial photos to determine the percentage of impervious surface for each of 130 residential parcels. From this analysis, staff calculated and applied a percent impervious factor for six residential lot sizes. These percentages were applied to the actual area of each single family lot in the basin to determine total impervious area for the

single family land use type. For transportation, staff chose to use a percent impervious value of 70 percent, based on analysis by the Snohomish County Surface Water Management Division. Existing land use is decidedly single-family residential in the Bitter Lake Basin with a total impervious area of 39 percent. The Seattle Golf Club Basin with a recreational land use has a total impervious area of 4 percent.

Future Land Use

The City's zoning plan specifies the current potential for future land use within the basins. Current zoning, illustrated in Figure 2-5 of the *Middle Puget Sound Basins Characteristics Report*, indicates that low density residential (R6) covers most of the Bitter Lake Basin and low density residential (R4) covers the Seattle Golf Club Basin. The small commercial area at the City's gateway where Greenwood Avenue North turns into Westminster Way amounts to a substantial percentage of the portion of the Bitter Lake Basin that extends into Shoreline.

With the exception of parks and open space, which are typically zoned residential but will not be developed in the future for that use, the City's current zoning plan was used to estimate the maximum potential increase in the amount of impervious surface. The zoning plan was chosen over the City's Comprehensive Plan to estimate future land use because it is consistent with the Comprehensive Plan Future Land Use Map but, unlike the Comprehensive Plan, is based on specific standards for maximum impervious surface area defined in the Shoreline Municipal Code. Table 1-2 lists the zoning categories and their associated maximum percent impervious values, as defined in Section 20.50.020 of the Shoreline Development Code. The future TIA analysis assumed that the basin would be fully built-out according to the maximum allowed impervious area as specified in the City's Development Code.

The future percent impervious values for the two basins were computed using the ArcView GIS software program. Future impervious surface area was calculated for each parcel in the basins based on the maximum allowed impervious surface percentage for that parcel's zone in the Shoreline Development Code, multiplied by the area of the parcel. City parks and open space were given a future percent impervious value based on studies done in other jurisdictions and the professional opinion of staff. It was assumed that developed parks would see additional development of impervious surfaces to accommodate new park facilities and appurtenances, while open space areas would remain natural and free from new development. Future TIA for the Bitter Lake Basin was computed to be 52 percent. The future TIA for the Seattle Golf Course Basin amounted to 17 percent.

The increase in impervious area for the Seattle Golf Course Basin, from 4 to 17 percent, may be overestimated, since the estimate is based on maximum allowable build-out conditions. It is unlikely that additional impervious areas will occur in this basin to a significant degree. Based on the impervious area estimates, the Bitter Lake Basin should be expected to be densely developed. Effects from the impervious area are most likely to impact the drainage system within the City of Seattle, since the portion of the basin within the City of Shoreline is the uppermost portion of the basin.

TABLE 1-2.
ZONING CATEGORIES AND ASSOCIATED
PERCENT IMPERVIOUS VALUES

Land Use	Percent Impervious
Developed Parks and Cemeteries	15
Open Space	0
Residential, 4 units/acre	45
Residential, 6 units/acre	50
Residential, 8 units/acre	65
Residential, 12 units/acre	75
Residential, 18 units/acre	85
Residential, 24 units/acre	85
Residential, 48 units/acre	90
Neighborhood Business	85
Office	85
Community Business	85
Regional Business	95
Industrial	95
Transportation ROW	70
North City Business District	95
Contract Zone	85

Source: City of Shoreline

Drainage Characteristics

As mentioned earlier, no significant natural drainage was identified within the basins. No wetlands were identified in the Bitter Lake Basin. Stormwater conveyance in the Bitter Lake Basin is a combination of culverts under roads, smaller piped networks in newer residential areas, and open roadside ditches. Although streams were not identified in the field, historic streams or channels may exist within the basins. Further research and investigation should include use of historical aerial photos and interviews with long time residents to document the presence of possible historic stream channels.

Geology and Soils

The geology of the Bitter Lake and the Seattle Golf Course Basins consists almost exclusively of till. Figure 2-6 in the *Middle Puget Sound Basins Characterization Report* shows the geologic units of the Bitter Lake and the Seattle Golf Course Basins.

The Soil Conservation Service (1952) mapped Thornton Creek Basin along with Bitter Lake and the Seattle Golf Course Basins. The predominant soil type in the Bitter Lake Basin was Alderwood gravelly sandy loam. No other soils were present according to the Soil Conservation Service. The Seattle Golf Course Basin had only two soil types: Alderwood gravelly sandy loam (95 percent) and Everett (5 percent).

HABITAT CHARACTERISTICS

As mentioned previously, no stream, riparian or fisheries habitat was described for this report. A description of terrestrial habitat is provided in that section in *Middle Puget Sound Basins Characterization Report*. An analysis of the wetland contained in the Seattle Golf Course Basin is provided below.

Wetland Habitat

There is one identified wetland within the Seattle Golf Course Basin, designated as Wetland O on Figure 2-3 of the *Middle Puget Sound Basins Characterization Report*.

Wetland O, Seattle Golf Course

This wetland occurs around the margins of a lake on the Seattle Golf Course. Access to the golf course was not obtained. However, previous studies have reported that the wetland covers 2.1 acres.